A11101 972365
NAT'L INST OF STANDARDS & TECH R.I.C.
A11101972365
/NSRDS-NBS
QC100 .U573 V22;2;1969 C.1 NBS-PUB-C 196

NSRDS-NBS 22 Volume II

NATIONAL STANDARD NSRDS REFERENCE DATA SYSTEM

Atomic Transition Probabilities

Sodium Through Calcium

U.S. DEPARTMENT OF COMMERCE

NATIONAL BUREAU OF STANDARDS

AUTHENTICATED U.S. GOVERNMENT INFORMATION GPO

UNITED STATES DEPARTMENT OF COMMERCE • Maurice H. Stans, *Secretary*
U. S. NATIONAL BUREAU OF STANDARDS • Lewis M. Branscomb, *Director*

Atomic Transition Probabilities

Volume II Sodium Through Calcium

A Critical Data Compilation

W. L. Wiese, M. W. Smith, and B. M. Miles
Institute for Basic Standards
National Bureau of Standards
Washington, D.C.

NSRDS–NBS 22

National Stand. Ref. Data Ser., Nat. Bur. Stand. (U.S.), 22, 306 pages (Oct. 1969)

CODEN: NSRDA

Issued October 1969

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C. 20402 - Price $4.50

NATIONAL BUREAU OF STANDARDS
JAN 12 1970
146210
QC100
.U573
No.22
1968
cop. 2

Library of Congress Catalog Card No. 65–60078

FOREWORD

The National Standard Reference Data System provides effective access to the quantitative data of phisical science, critically evaluated and compiled for convenience, and readily accessible through a variety of distribution channels. The System was established in 1963 by action of the President's Office of Science and Technology and the Federal Council for Science and Technology, with responsibility to administer it assigned to the National Bureau of Standards.

The System now comprises a complex of data centers and other activities, carried on in academic institutions and other laboratories both in and out of government. The independent operational status of existing critical data projects is maintained and encouraged. Data centers that are components of the NSRDS produce compilations of critically evaluated data, critical reviews of the state of quantitative knowledge in specialized areas, and computations of useful functions derived from standard reference data. In addition, the centers and projects establish criteria for evaluation and compilation of data and make recommendations on needed improvements in experimental techniques. They are normally closely associated with active research in the relevant field.

The technical scope of the NSRDS is indicated by the principal categories of data compilation projects now active or being planned: nuclear properties, atomic and molecular properties, solid state properties, thermodynamic and transport properties, chemical kinetics, and colloid and surface properties.

The NSRDS receives advice and planning assistance from the National Research Council of the National Academy of Sciences-National Academy of Engineering. An overall Review Committee considers the program as a whole and makes recommendations on policy, long-term planning, and international collaboration. Advisory Panels, each concerned with a single technical area, meet regularly to examine major portions of the program, assign relative priorities, and identify specific key problems in need of further attention. For selected specific topics, the Advisory Panels sponsor subpanels which make detailed studies of users' needs, the present state of knowledge, and existing data resources as a basis for recommending one or more data compilation activities. This assembly of advisory services contributes greatly to the guidance of NSRDS activities.

The NSRDS–NBS series of publications is intended primarily to include evaluated reference data and critical reviews of long-term interest to the scientific and technical community.

Lewis M. Branscomb, *Director*

CONTENTS

General Introduction

	Page
A. **INTRODUCTORY REMARKS**	i
B. **SCOPE OF THE TABLES**	i
C. **CRITICAL REVIEW OF THE DATA SOURCES AND METHOD OF EVALUATION**	i
1. General Review of the Problem	i
2. The Critical Factors for Determining Transition Probabilities	ii
a. Critical Factors in the Experimental Methods	ii
α. Measurements in Emission	ii
β. Measurements of Anomalous Dispersion	iii
γ. Lifetime Measurements	iii
b. Critical Factors in the Theoretical Methods	iii
α. Calculations Based on Self-Consistent Field (SCF) Wave Functions	iii
β. The Nuclear Charge-Expansion Method	iii
γ. The Coulomb Approximation	v
δ. *LS*-coupling	vii
c. Critical Factors for Forbidden Lines	viii
3. Exploitation of Systematic Trends	x
a. Dependence of *f*-values on Nuclear Charge *Z*	x
b. Systematic Trends of *f*-values Within Spectral Series	x
c. Homologous Atoms	x
d. Examples	x
4. Classification of Uncertainties	xiv
D. **GENERAL ARRANGEMENTS OF THE TABLES**	xv
E. **FUTURE PLANS AND ACKNOWLEDGMENTS**	xv
References	xv
Key to Abbreviations and Symbols Used in the Tables	xvi
Useful Relations	xvi
Conversion Factors	xvii

List of Tables

Spectrum		*Page*
Sodium	Na I	1
	Na II	8
	Na III	9
	Na IV	12
	Na V	14
	Na VI	16
	Na VII	19
	Na VIII	21
	Na IX	23
Magnesium	Mg I	25
	Mg II	29
	Mg III	31
	Mg IV	32
	Mg V	34
	Mg VI	35
	Mg VII	37
	Mg VIII	40
	Mg IX	42
	Mg X	44
	Mg XI	46
Aluminum	Al I	47
	Al II	51
	Al III	56
	Al IV	58
	Al V	59
	Al VI	60
	Al VII	61
	Al VIII	63
	Al IX	65
	Al X	67
	Al XI	69
	Al XII	70
Silicon	Si I	71
	Si II	76
	Si III	81
	Si IV	87
	Si V	91
	Si VI	92
	Si VII	93
	Si VIII	94
	Si IX	96
	Si X	98
	Si XI	101
	Si XII	103
Phosphorus	P I	105
	P II	110
	P III	114
	P IV	116
	P V	120
	P VI	121
	P VII	122
	P VIII	123
	P IX	124
	P X	127
	P XI	128
	P XII	130
	P XIII	131
Sulfur	S I	133
	S II	138
	S III	145
	S IV	148
	S V	150
	S VI	152
	S VII	154

List of Tables—Continued

Spectrum		*Page*
Sulfur—Continued		
	S VIII	154
	S IX	155
	S X	156
	S XII	157
Chlorine	Cl I	158
	Cl II	162
	Cl III	171
	Cl IV	177
	Cl V	179
	Cl VI	180
	Cl VII	182
	Cl VIII	184
	Cl IX	184
	Cl X	185
Argon	Ar I	187
	Ar II	201
	Ar III	211
	Ar IV	214
	Ar V	216
	Ar VI	218
	Ar VII	219
	Ar VIII	220
	Ar IX	222
	Ar X	222
	Ar XI	223
	Ar XIII	223
	Ar XIV	224
Potassium	K I	225
	K III	233
	K IV	234
	K V	236
	K VI	237
	K VII	239
	K VIII	240
	K IX	241
	K X	242
	K XI	243
	K XIV	244
Calcium	Ca I	245
	Ca II	250
	Ca IV	255
	Ca V	256
	Ca VI	257
	Ca VII	259
	Ca VIII	260
	Ca IX	261
	Ca X	263
	Ca XI	264
	Ca XII	265
	Ca XIII	266
	Ca XV	266
List of Recent Additional Material		268

ATOMIC TRANSITION PROBABILITIES*

(A critical data compilation)

Volume II

Elements Sodium through Calcium

W. L. Wiese, M. W. Smith, and B. M. Miles

Atomic transition probabilities for about 5,000 spectral lines of the second ten elements, based on all available literature sources, are critically compiled. The data are presented in separate tables for each element and stage of ionization. For each ion the transitions are arranged according to multiplets, supermultiplets, transition arrays, and increasing quantum numbers. Allowed and forbidden transitions are listed separately. For each line the transition probability for spontaneous emission, the absorption oscillator strength, and the line strength are given along with the spectroscopic designation, the wavelength, the statistical weights, and the energy levels of the upper and lower states. In addition, the estimated accuracy and the source are indicated. In short introductions, which precede the tables for each ion, the main justifications for the choice of the adopted data and for the accuracy rating are discussed. A general introduction contains a detailed discussion of the critical factors entering into each major experimental and theoretical method. It also includes a general critical assessment of the widely used Coulomb approximation, and a number of illustrative examples for the exploitation of regularities or systematic trends among oscillator strengths.

Key Words: Allowed and forbidden transitions; oscillator strengths; transition probabilities; sodium; magnesium; aluminum; silicon; phosphorus; sulfur; chlorine; argon; potassium; calcium.

A. INTRODUCTORY REMARKS

This is the second part of a continuing effort to critically evaluate and compile atomic transition probabilities. After completion of the first part which contained the available data for the elements hydrogen through neon [1], we scanned through the *f*-value** literature [2] for the heavier elements and found somewhat to our surprise that the numerical material on the elements with atomic numbers 11 through 20, i.e., up to the first element of the iron group, was rather extensive and appeared to be fairly well distributed throughout these spectra, including the higher stages of ionization. We therefore decided to systematically evaluate the data for these elements of the third period of the periodic system and in addition K and Ca. In the course of our preliminary survey we found several serious gaps and discrepancies in the data. Several research teams, in particular our own Plasma Spectroscopy Section at NBS, undertook the task to improve the situation for these spectra. Thanks to these efforts and to the availability of the Coulomb approximation by Bates and Damgaard [3], as well as to the exploitation of many evident regularities among atomic *f*-values [4], we are now able to present a fairly complete body of material of moderate accuracy. However, need for further improvement is quite evident on close inspection of the tables, especially for the important spectra of Si I, P I and P II. The still rather unsatisfactory status of the numerical data with regard to accuracy is probably best indicated by the fact that this extensive compilation contains only two allowed transitions classified as having an uncertainty of less than 3 percent, namely the Na-D lines.

*Supported by the Advanced Research Projects Agency of the Department of Defense, under Project DEFENDER.

B. SCOPE OF THE TABLES

In our present compilation we maintain the scope and format of our earlier Volume I [1], i.e., we present critically evaluated transition probabilities of allowed and forbidden discrete transitions of elements $Z=11$ through 20 including all stages of ionization for which we have data. As source material all the literature references contained in [2] plus some more recent papers have been used.

We have aimed again at presenting fairly reliable *f*-values for at least all the strong characteristic lines of the various atoms and ions in order to present a table of general usefulness. Specifically, we have tried to include at least the first half of the multiplets listed for each spectrum either in the "Revised Multiplet Table" [5], in the "Ultraviolet Multiplet Table" [6] or in the recent "Selected Tables of Atomic Spectra" [7].

Aside from this objective of listing the stronger lines, we have included all additional available material with uncertainties not exceeding 50 percent. Most of the final tabulations were undertaken during 1967 and the first half of 1968. Thus, essentially all literature through 1967 and in some cases even later work could be taken into account.

C. CRITICAL REVIEW OF THE DATA SOURCES AND METHOD OF EVALUATION

1. General Review of the Problem

The present status of our knowledge of atomic transition probabilities must still be considered as being far from ideal.

**Hereafter, we shall use the equivalent terms "transition probability, oscillator strength or *f*-value, and line strength" on an interchangeable basis. The numerical relationships between these quantities are given in the conversion table at the end of this General Introduction.

but some good progress has been made during the last few years. In particular, the increased availability and use of computers have made feasible much more refined theoretical approaches than would have been thought possible just a few years ago. Among the recent theoretical advances the multiconfigurational approach, also called the method of "superposition of configurations" (SOC), developed by Weiss [8, 9, 10] and others [11, 12, 13, 14] should be especially singled out. Another significant recent development has been the application of the nuclear charge-expansion method to the calculation of *f*-values by Dalgarno and his co-workers [15, 16, 17]. On the experimental side, the Hanle effect method of measuring accurate atomic lifetimes must be especially mentioned as a method brought into recent prominence by the productive work of several groups, notably by Lurio and others [18, 19]. Many other proven methods have progressed quite a bit by the introduction of modern data processing techniques, which have made the data much more amenable to statistical error treatments. Finally, the detection of many systematic trends and regularities among *f*-values (see also C.3) ties many independently determined data together for the first time and has thus established a reliable framework of values.

In Volume I we have already given a short description of the major experimental and theoretical methods from which the bulk of the data are obtained; thus we do not have to repeat this here. For detailed descriptions of the various approaches we would also like to refer to two recent review articles, namely a review of the theoretical approaches by Layzer and Garstang [20] including those for forbidden lines and a general discussion of the various experimental methods by one of us [21].

The central problem of this compilation is the evaluation of the reliability and accuracy of the available data. Since this aspect is so crucial, we want to discuss it in detail again and thus complement and add to the remarks we have already made in our earlier published volume.

First the principal four guide-posts should be stated by which we have evaluated the accuracy of the data. These are:

I. The author's evaluation of his uncertainties.
II. The degree of agreement between the results and other reliable material.
III. The author's consideration of all major critical assumptions and factors entering into the results.
IV. The degree of fit of the data into established regularities and systematic trends or consideration of possible reasons for deviations.

Only a few general comments may be made about points I and II. All further remarks on these points depend so much on the particular available material that they have to be relegated to the individual introductions for each spectrum. Our principal comment on the authors' estimates of their uncertainties is that we have sometimes found experimentalists to give only estimates of their statistical errors, but no allowance for any suspected systematic errors. On such occasions we have been more conservative with our estimates than the original authors. In many other instances authors have been simply too optimistic in their error estimates, as is borne out by the discrepancies of their results with other reliable material much outside the mutually estimated error limits, or by discrepancies with well-established systematic trends.

Point II, i.e., specific comparisons with other data, does not warrant any further general comment. Many of the introductions on the individual spectra contain special comments on this subject. An illustrative example of our comparison tables will be given later in some other connection (see table 7).

2. The Critical Factors for Determining Transition Probabilities

A detailed discussion is now in order on points III and IV. Since the success of an experiment or a calculation is mainly a question of how well the critical factors encountered in the particular method have been coped with, we have sorted out and collected below the major factors which need to be considered for the application of each of the major experimental and theoretical methods. This list should reflect the current state of our knowledge about the major problem areas in the various methods. In each available experiment or calculation, all these critical factors should have been considered, e.g., all the assumptions and approximations going into the method should have been examined for validity. Thus we may use these factors as a set of criteria by which to judge each paper: If they are properly treated or accounted for, a paper should pass: otherwise it should be rejected from this compilation. However, we found that at the present time we cannot judge the literature with such a rigid procedure, since we would then lose many of the available papers because, for example, it was sometimes not feasible to consider *all* critical factors. We have therefore relaxed our requirements and have often included slightly defective papers, where, for example, the authors have not properly accounted for all presently known sources of systematic errors but for most of them. In these cases we have of course adjusted the estimated errors or we have discarded the absolute scale of an experiment, if only this was defective, but have used the relative values.

a. Critical Factors in the Experimental Methods

α. Measurements in Emission—The largest number of experimental *f*-values have been obtained from measurements of the intensities of spectral lines which are emitted from plasmas under known conditions. With arc sources the spectra of Mg I, Si I and II, S I and II, Cl I and II, Ar I and II and Ca I, with shock tubes the spectra of S I and II, Cl I and II and Ar I and with a flame source the spectrum of K I have been studied. In evaluating these experiments we have especially investigated if the following critical assumptions and factors are satisfactorily taken into account by the authors:

(a) Existence of local thermodynamic equilibrium (LTE) or, for relative *f*-value measurements, existence of partial LTE.
(b) Absence of self-absorption.
(c) Consideration of demixing effects in arcs.
(d) Consideration of the effects of boundary layers in shock tubes, and the effects of inhomogeneous zones in sources assumed to be homogeneous.
(e) High density corrections in plasma sources.
(f) Consideration of the intensity contributions in the line wings and for the background below the lines.
(g) Adjustments for inherent uncertainties in the diagnostic methods (for example, for uncertainties in plasma line-broadening theory).

The largest uncertainties in the *f*-values result if the requirements (a), (b), and (c) are not fulfilled. However, in the case of self-absorption, i.e., for deviations from requirement (b), strong lines are affected much more than the weaker ones. If the points (d) through (g) are not properly

treated, then the effects on the transition probabilities are normally much smaller and hardly ever give rise to uncertainties above 50 percent.

Absorption experiments, which in this compilation are only encountered for the cases of Mg I and Ca I, are quite similar in their critical requirements to the above-discussed emission experiments and will therefore not be discussed further. At this point some comments are in order on the extensive transition probability tables by Corliss and Bozman [22]. The transition probabilities obtained by these authors are derived from the spectral line intensity measurements of Meggers et al. [23]. Since the primary objective of this work has been the measurement of line intensities on a uniform scale, but not the measurement of transition probabilities, several of the critical factors and assumptions listed above were not taken satisfactorily into account. Especially the nonconsideration of our points (d), (a), and (c), in that order, is probably responsible for many strong discrepancies observed between their material and other data, ranging in size up to factors of 20. Since we have other material, from fairly reliable sources, for practically all the lines treated by Corliss and Bozman, we have refrained from using any data from their tabulation.

β. Measurements of Anomalous Dispersion—We have employed the data from several anomalous dispersion measurements, performed with the hook method, for the spectra of Na I, Mg I, Al I, Si I, K I and Ca I. The most critical factors of this method are the assumptions going into the determination of the populations of the atomic energy levels from which the absorption of radiation takes place. We have however in all cases circumvented this potentially large source of systematic uncertainty by employing the results only on a relative scale, that is, by renormalizing the measured f-values to a scale different from the originally determined one.

γ. Lifetime Measurements—Lifetime measurements with the delayed coincidence and phase shift techniques as well as with the Hanle effect have been carried out for Na I, Mg I and II, Al I, Si I and II, P I and II, S I and II, Cl I, Ar I and II, K I and Ca I and II. The derived transition probabilities, even though there are only very few per spectrum, are among the most accurate ones available to date. The major critical factors of lifetime experiments are:

(a) Radiative cascading.
(b) Radiation trapping or imprisonment.
(c) Collisional depopulation of a level.
(d) Self-absorption in the spectral lines emitted by the light sources used for the excitation.
(e) Insufficient spectral resolution for the detection of the radiation.

Points (a) and (e) can become potential sources of systematic errors only if nonmonoenergetic electron beams are used with energies sufficiently above the threshold energy of the level to be observed, because in this case one has no way of selective excitation of the atomic energy levels. Thus, if lines emitted from other levels have accidentally the same or nearly the same wavelength as the transition to be investigated, they would also be admitted to the detector if the spectral resolution of the system is insufficient. Self-absorption in the light source used for the excitation (point (d)) may be critical in Hanle effect experiments, since it leads to a distortion in the measured shape of the output signal. Cascading and radiation trapping, (a) and (b), normally tend to lengthen the measured lifetime, while collisional depopulation (c) shortens it.

b. Critical Factors in the Theoretical Methods

Theoretical treatments have provided the large majority of the data for this compilation. They contribute greatly to all first and second spectra (with the exception of Ar I and Ca I) and are the exclusive source on all higher spectra.

For the theoretical approaches the situation differs from the experiments insofar as they cannot be subjected to a systematic error analysis, since there is no simple quantitative measure available for estimating the size of the uncertainties introduced by the various approximations in the theoretical models. However, comparisons with accurate experimental results, as well as analysis of the data in the light of apparent regularities and sum rules, and, finally, general consistency checks (for example, between the dipole length and velocity approximations of the transition integral) have accomplished a great deal towards exposing the critical factors and finding general criteria which must be met for obtaining reasonably reliable theoretical f-values. The two main criteria may be stated as follows:

(a) For transitions with equivalent electrons present in the upper or lower state the calculations should include the effects of configuration interaction, since in this case one cannot reasonably apply the independent-particle model to the jumping electron, but has to take into account correlation effects between the electrons.

(b) For transitions where the jumping electron is in a shell by itself, the initial and final levels should be checked for possible neighboring perturbing terms, in which case a configuration interaction treatment may become necessary. But, unless such a special situation is encountered, the standard one-electron approximations should be adequate, provided the transition integral is not subject to strong cancellation effects. The spectroscopic data should also be examined for indications of spin-orbit interaction before a particular coupling scheme is adopted.

α. Calculations Based on Self-Consistent Field (SCF) Wave Functions. The often-employed SCF calculations have been used in various levels of refinement, which may be arranged in a hierarchy of approximations such as presented in figure 1. Many comparisons with experiments have shown the following: First, for transitions between moderately or highly excited states, i.e., with the jumping electron in a shell by itself, the Hartree-Fock or the simplified Hartree-Fock-Slater approximations usually give adequate results, provided no cancellation in the transition integral and no perturbing terms are present. Secondly, for transitions involving orbits which strongly penetrate the core, polarization or relaxation of the core should also be taken into account. Thirdly, if in the case of shell-equivalent electrons (i.e., electrons with the same principal quantum number) the interaction with other electrons is very strong, i.e., if the independent-particle model breaks down, then the SCF approach should be used in conjunction with an extensive multi-configurational treatment (e.g., the superposition-of-configurations approach), or some equivalent procedure which adequately represents the detailed effects of electron correlations.

β. The Nuclear Charge-Expansion Method. This method has been recently applied to a number of transitions in simpler atomic systems. Many comparisons with experiments and other theoretical methods indicate that it produces normally rather accurate f-values for high values of the nuclear charge, i.e., for the highly charged ions in each sequence. This statement applies primarily to the multiplet f-values, while the individual line f-value may be affected by deviations from LS-coupling which generally increase for the

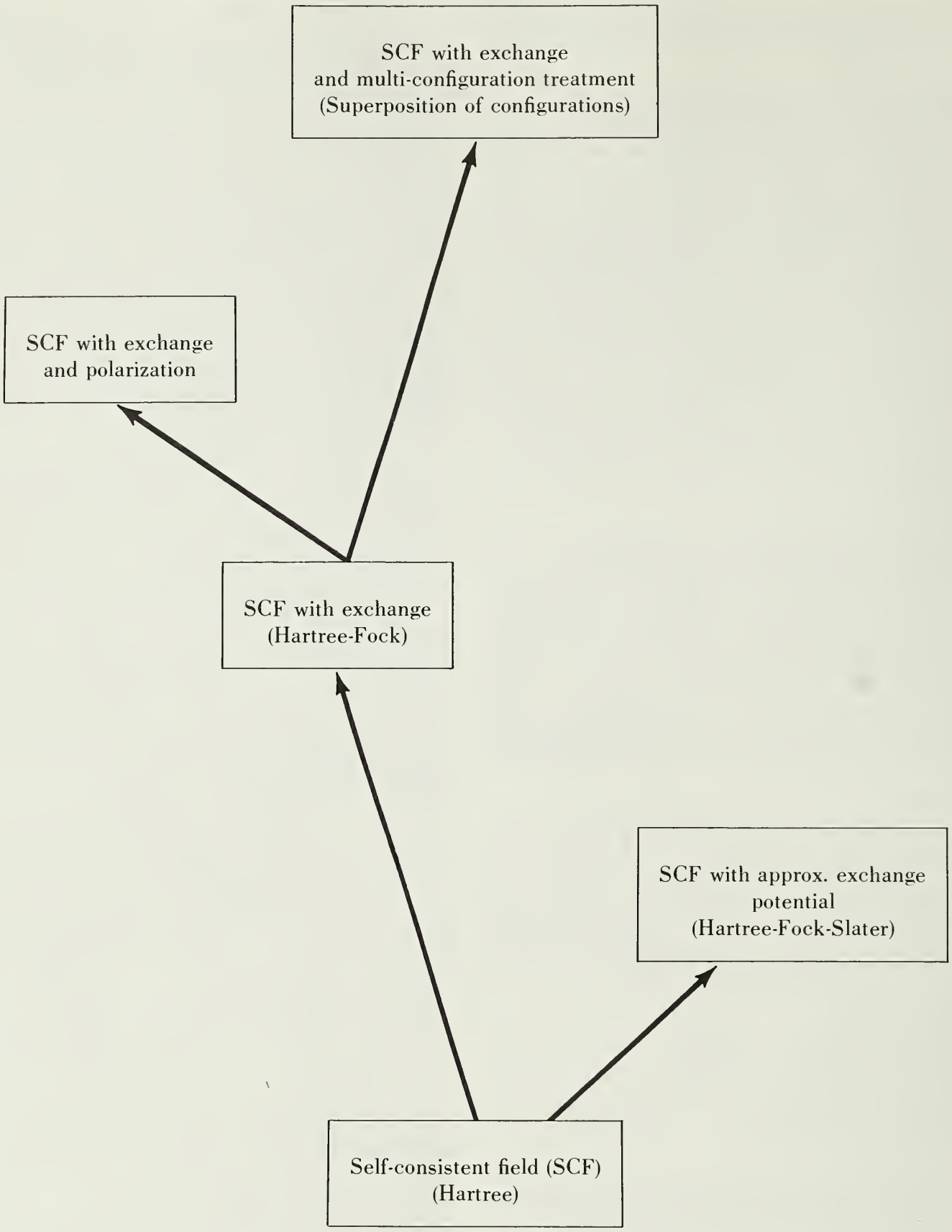

FIGURE 1. *Hierarchy of self-consistent field (SCF) approximations.*

highly charged ions. This is clearly observed in figures 4 and 5, given later in connection with the discussion on the nuclear charge dependence of f-values. But in figure 6 the few available data do not permit a definite conclusion at this time. The same figures indicate, on the other hand, that the charge expansion method is, in its present level of refinement, not satisfactory at the neutral ends of isoelectronic sequences, especially for those transitions where configuration effects are pronounced. A more complete treatment of these effects is clearly needed.

γ. *The Coulomb Approximation.* Some detailed remarks about the Coulomb approximation [3] are in order since we have extensively applied this very useful approximation to fill many glaring gaps in the data. The Coulomb approximation does very well indeed in its proper range of application. This may be best seen when it is subjected to the two possible checks mentioned earlier, namely, first to a comparison with the most accurate experimental data and secondly to the degree of fit into the systematic trends.

Let us first review the comparisons with accurate experimental data: The most accurate ones are from lifetime measurements where the uncertainties are typically 10 percent or less. We have therefore collected in table 1 all available comparisons between the Coulomb approximation (when it is not subject to significant cancellation) and either lifetime measurements or those other data which are based on an absolute scale obtained from lifetime measurements. We have ordered these data according to the complexity of the spectra and type of transitions. One may draw the following conclusions: for one-electron spectra (part a of table 1) the agreement is very close as expected; for more complex spectra (part b), but with the jumping electron in a shell by itself, the agreement is still quite good, even in the cases of Ar I and II, and it usually becomes better the less penetrating the orbits of the states are; but, finally, with equivalent electrons present, as in Mg I (part c), large deviations are apparent which are not surprising since this is really outside the range of application for this method.

TABLE 1a. *Comparison between data from the Coulomb approximation and from accurate experimental sources for one-electron spectra*

Spectrum	Transition	Multiplet f-value		Method and Authors*
		Coulomb Approx.	Experiment	
Na I	$3s-3p$	0.94	0.955	Life; Kibble et al.
			0.975	Life; Link.
			1.029	Life; Baylis.
	$3p-4d$	0.095	0.106	Life, and central field approx.; Karstensen and Schramm; Prokofév.
	$4p-4d$	0.97	0.91	Life, and central field approx.; Karstensen and Schramm; Prokofév.
Mg II	$3s-3p$	0.89	0.96	Life; Smith and Gallagher.
K I	$4s-4p$	0.99	0.954	Life; Link.
			1.02	Life; Schmieder et al.
Ca II	$4s-4p$	0.99	0.97	Life; Smith and Gallagher.
	$3d-4p$	0.049	0.053	Life; Smith and Gallagher.

*The complete references are listed in the tabulations for each spectrum.

TABLE 1b. *Comparison between data from the Coulomb approximation and from accurate experimental sources for transitions where the jumping electron is in a shell by itself*

Spectrum	Transition Array	Total line strength S		Method and Authors*
		Coulomb Approx.	Experiment	
Ar I	$4s-4p$	333	352	Life and stabilized arc; Klose, and Popenoe and Shumaker.
	$4p-6s$	17.5	12.2	Life and stabilized arc; Klose, Bues et al., Corliss and Shumaker (weak lines obtained from intermediate coupling calculations of Johnston).
Ar II	$4s-4p$	468	419	Life and stabilized arc; Bennett et al., Shumaker and Popenoe, Schnapauff (weak lines obtained from intermediate coupling calculations of Rudko and Tang, Statz et al., and Garstang).

*The complete references are listed in the tabulations for each spectrum.

TABLE 1c. *Comparison between data from the Coulomb approximation and from accurate experimental sources for transitions with shell-equivalent electrons*

Spectrum	Transition	Multiplet f-value		Method and Authors*
		Coulomb Approx.	Experiment	
Mg I	$3s^2\ {}^1S-3s3p\ {}^1P^\circ$	1.656	1.85	Life; Lurio.
			1.80	Life; Smith and Gallagher.
Ca I	$4s^2\ {}^1S-4s4p\ {}^1P^\circ$	1.83	1.79	Life; Lurio.
			1.74	Life; Smith and Gallagher.
			1.72	Life; Hulpke et al.
Al I	$3s^23p\ {}^2P^\circ-3s^23d\ {}^2D$	0.41	0.175	Life; Budick.
	$3s^23p\ {}^2P^\circ-3s^24s\ {}^2S$	0.05	0.121	Life; Demtröder.
Si II	$3s^23p\ {}^2P^\circ-3s^23d\ {}^2D$	0.57	0.57	Life; Lawrence and Savage.
	$3s^23p\ {}^2P^\circ-3s^24s\ {}^2S$	0.065	0.129	Life; Lawrence and Savage.
Si I	$3s^23p^2\ {}^3P-3s^23p3d\ {}^3D^\circ$	0.462	0.068	Life; Lawrence and Savage.
	$3s^23p^2\ {}^3P-3s^23p4s\ {}^3P^\circ$	0.051	0.155	Life and intermed. coupl. calc; Lawrence and Savage.
	${}^1D-{}^1P^\circ$	0.055	0.135	Life and intermed. coupl. calc; Lawrence and Savage.
	${}^1S-{}^1P^\circ$	0.056	0.100	Life and intermed. coupl. calc; Lawrence and Savage.

*The complete references are listed in the tabulations for each spectrum.

TABLE 2. *Estimated uncertainties for f-values obtained from the Coulomb approximation*

These estimates do not apply for cases with severe cancellation in the transition integral, for which the uncertainties are much higher. Transitions between states lower than the ones listed are considered outside the range of applicability of this approximation. The *f*-values for individual lines and multiplets may be sometimes less accurate due to departures from the normally applied *LS*-coupling (see C.2.b.δ.).

Transition			Estimated uncertainty (percent)	Isoelectronic sequences
$1s^2ms-$	$1s^2np$	$(m=2, 3 \ldots; n=2, 3 \ldots)$	10–20[1]	Lithium.
$mp-$	ns	$(m=2, 3 \ldots; n=2, 3 \ldots)$	10–20	
$mp-$	nd	$(m=2, 3 \ldots; n=3, 4 \ldots)$	10–20	
$1s^22smp-$	$1s^22snd$	$(m=3, 4 \ldots, n=3, 4 \ldots)$[2]	25	Beryllium.
$2pms-$	$2pnp$	$(m=3, 4 \ldots; n=3, 4 \ldots)$[2]	25	
$mp-$	nd	$(m=3, 4 \ldots; n=3, 4 \ldots)$	25	
$1s^22s^22p^umS-$	$1s^22s^22p^unp$	$(m=3, 4 \ldots; n=3, 4 \ldots)$		
	(a)	$u=1, 2, 3$	25	Boron, carbon, nitrogen, oxygen.
	(b)	$u=4, 5$	50	Fluorine, neon.
$mp-$	nd	$(m=3, 4 \ldots; n=3, 4 \ldots)$		
	(a)	$u=1, 2, 3$	25	Boron, carbon, nitrogen, oxygen.
	(b)	$u=4, 5$	50	Fluorine, neon.
$1s^22s^22p^6ms-$	$1s^22s^22p^6np$	$(m=3, 4 \ldots; n=3, 4 \ldots)$	20–50[1]	Sodium.
$mp-$	ns or nd	$(m=3, 4 \ldots; n=3, 4 \ldots)$	20–50	
$md-$	np or nf	$(m=3, 4 \ldots; n=4, 5 \ldots)$	20–50	
$mf-$	nd	$(m=4, 5 \ldots; n=5, 6 \ldots)$	20–50	
$1s^22s^22p^63sms-$	$1s^22s^22p^63snp$	$(m=4, 5 \ldots; n=4, 5 \ldots)$[2]	50	Magnesium.
$mp-$	ns or nd	$(m=4, 5 \ldots; n=4, 5 \ldots)$[2]	50	
$md-$	np or nf	$(m=3, 4 \ldots; n=4, 5 \ldots)$[3]	50	
$mf-$	nd	$(m=4, 5 \ldots; n=5, 6 \ldots)$	50	
$1s^22s^22p^63s^2md-$	$1s^22s^22p^63s^2np$ or nf	$(m=3, 4 \ldots; n=4, 5 \ldots)$	50	Aluminum.
$ms-$	np	$(m=4, 5 \ldots; n=4, 5 \ldots)$	50	
$mp-$	ns or nd	$(m=4, 5 \ldots; n=4, 5 \ldots)$	50	
$mf-$	nd	$(m=4, 5 \ldots; n=4, 5 \ldots)$	50	
$1s^22s^22p^63s^23p^umS-$	$1s^22s^22p^63s^23p^unp$			Silicon, phosphorus, sulfur, chlorine, argon.
		$(u=1, 2, 3, 4, 5; m=4, 5 \ldots; n=4, 5 \ldots)$	50	
$mp-$	ns or nd			
		$(u=1, 2, 3, 4, 5; m=4, 5 \ldots; n=4, 5 \ldots)$	50	

[1] Range depends on comparison material in isoelectronic sequence and goodness of fit into systematic trends.

[2] Configuration interaction studies indicate that configuration mixing effects, which are not included in the Coulomb approximation, may sometimes become significant for these transitions, especially for higher ions.

[3] $3d-4p$ triplets and $3d-4f$ singles only.

The Coulomb approximation results fit also remarkably well into the systematic trends. As some instructive examples we present figures 12, 14, 16, 19, 20, and 21 at the end of this general introduction, which are presented there in connection with other purposes. It is seen that the deviations of the Coulomb approximation results from the curve of best fit are hardly greater than 10 percent. Thus, to sum up, the Coulomb approximation has in its proper range of application consistently given good agreement when reliable experimental comparisons have been available, and it fits well into the regularities. Therefore its extensive use as well as its preference over some less accurate experimental methods appear to be very well warranted.

Based on these comparisons and consistency checks, as well as on the general rule that transitions between nonpenetrating orbits (like $3d-4f$) are more suitable for this approximation than those involving strongly core-penetrating orbits (like $3s-3p$), we have given the error assignments collected in table 2. We feel that these error estimates for the Coulomb approximation are quite conservative, but they should only be upgraded when further comparisons confirm the good agreement found up to now.

δ. *LS-coupling.* A special word of caution is in order on our extended use of *LS*-coupling to obtain individual line *f*-values in multiplets (as well as multiplet *f*-values in transition arrays) from the Coulomb approximation as well as

from other theoretical treatments. *LS*-coupling should gradually become a less-reliable approximation as spectra become more complex, and, on the other hand, as the stage of ionization increases. The increasing presence of intercombination lines in the third row atoms is, for example, a clear indication of increased spin-orbit interaction.

In several instances fairly precise experimental data on individual lines as well as theoretical values calculated in *LS* and intermediate coupling are available. In cases where intermediate coupling is expected to prevail, i.e., where the differences between the two coupling schemes are pronounced, the experimental values agree indeed much better with intermediate coupling theory [24, 25]. Of highest practical importance is the fact that in such cases the *f*-values of the stronger lines in multiplets are not nearly as much affected as the weaker lines for which the differences between the coupling schemes become then very pronounced.

For this critical compilation we have taken the risk to break down very many multiplet strengths into individual line *f*-values—since these are needed in most applications—by using the *LS*-coupling scheme when no other data were available. This has been done since the scarce experimental comparision material indicates that for most of the spectra included in this compilation *LS*-coupling appears to be a fair approximation. However, on the basis of the above mentioned observation that the stronger lines in multiplets are usually much less affected by departures from *LS*-coupling than the weaker components, we have differentiated between the strong and weak lines in multiplets and lowered our accuracy assignments for the weaker lines. In as much as this is a rather gross treatment of the data, we feel that many accuracy assignments for individual lines can only be regarded as provisional. We feel also that extended intermediate coupling calculations for many of the spectra presented are urgently needed to settle the question of how drastically departures from *LS*-coupling affect individual atomic transition probabilities.

c. Critical Factors for Forbidden Lines

As in the first volume, we have listed as forbidden lines all magnetic dipole, magnetic quadrupole and electric quadrupole transitions, that is, all transitions which do not fulfill the rigorous selection rules for electric dipole lines (thus, ordinary intercombination lines are tabulated under allowed transitions). Practically all material on forbidden lines comes from calculations; only very few experimental data are available as yet. Our principal sources have been the extensive calculations by Naqvi [26] as well as the work of Malville and Berger [27], Garstang [28, 29], Froese [30], Pasternack [31], and Czyzak and Krueger [32, 33]. These calculations are normally based on the general experssions for the line strengths of forbidden lines in the ground state configuration, which were for the p^2, p^3 and p^4 configurations given algebraically and tabulated by Shortley [34] et al., and were later extended by Naqvi [26] to the few transitions in the *sp*, *p*, and p^5 configurations.

The principal differences between the various calculations are the ways in which the most important atomic parameters are chosen. Since the latter represent the most critical factors affecting the results, we shall discuss the choice of these parameters now in detail:

(a) *The "spin-orbit," and "spin-spin and spin-other-orbit" integrals.* These integrals, usually designated by ζ and η, have been determined either empirically or by using available wave functions. Garstang has compared the empirical and theoretical values for some ions—the latter obtained from SCF functions with exchange—and has found differences of up to 20 percent for ζ and up to 30 percent for η. When a choice is available, we have given preference to the empirical values.

(b) *The term intervals.* Here one has the choice between using exclusively experimental energy values or combining some of these with the results of the Slater theory [35] for intermultiplet separations, that is, by employing the Slater parameters F_2. Differences between the two approaches arise mainly due to the effects of configuration interaction. These are neglected in all calculations and may cause deviations up to a factor of two. A study of Garstang [36] in 1956 led to the result that the exclusive use of observational material partially includes, at least in simple cases, the effects of configuration interaction, when the latter is otherwise not taken into account. Thus the work based on experimental term intervals has been adopted whenever available.

Naqvi [26] used in his calculations essentially the second of the above-mentioned approaches. He compared empirically determined Slater parameters F_2 for the various term intervals with theoretically derived values, and selected the one experimental parameter which was in best agreement with theory. Then he employed this particular F_2 and the Slater theory for the determination of all other term intervals. In view of the above-mentioned study by Garstang we have used from Naqvi's work normally only the transition probabilities based entirely on this parameter, i.e., based exclusively on observational material. For example, his data for the $2p^3$ configuration have not been applied when other sources have been available. On the other hand, Naqvi's calculations for the simpler *sp* configuration are all based an the empirical value for the one term interval there and should, therefore, take the effects of configuration interaction partially into account.

(c) *Transformation coefficients.* The atoms and ions under consideration are most closely represented by the intermediate coupling scheme, but for the calculations of transition probabilities the actual wave functions are more conveniently expressed in terms of *LS*-coupled wave functions. The transformation coefficients were first derived by Shortley et al. [34], and were later refined by several others, in particular by Naqvi [26]. Thus, Naqvi's results have been adopted whenever the choice of the transformation coefficients became important and when he accounted for the effects of configuration interaction in the above-mentioned manner. It is especially worth noting that by including the effects of spin-spin and spin-other-orbit interactions on the transformation coefficients of the $2p^4$ configuration, some results are changed by about 10 percent.

(d) *The integral* s_q *for electric quadrupole transitions.* This depends principally on the quality of the employed wave functions. We have preferred calculations with SCF wave functions over those with hydrogenic functions or screening constants and, among SCF calculations, we have preferred those with exchange effects included over those without exchange. The improvement with SCF wave functions against the former is estimated to be of the order of 20 percent. The uncertainty in s_q should generally be in the neighborhood of 20 percent.

Some useful remarks may also be made about comparisons of the calculated forbidden line strengths with recent experimental results. At the time when our first table of transition probabilities was completed in 1965, we knew of only one reliable comparison due to the fortunate circumstance that some forbidden [O I] lines have been observed

in the aurora, and their temporal variations have been measured. In the meantime, some more forbidden lines have been observed in the laboratory and some rather precise measurements of transition probability ratios have been achieved. With this new material, several instructive and important comparisons are possible, especially for [O I] and [S I]. Laboratory measurements of several transition probability ratios of forbidden lines have been made in emission by McConkey et al. [37], LeBlanc et al. [38], Liszka and Niewodniczanski [39], and Kvifte and Vegard [40] for [O I] and by McConkey et al. [41] for [S I]. A comparison of the experimental results with the calculated values [32, 42] and our recommended "best" values is given in table 3. The agreement is consistent with the error estimates given in the theoretical papers. Other recent experiments on [Pb] by Hults [43] and on [I] by Husain and Wiesenfeld [44] are also consistent with the theoretical error estimates. However, since only rather indirect comparisons can be undertaken for these, they will not be discussed here.

For some magnetic dipole transitions the line strengths are, near *LS*-coupling, essentially given by the numbers tabulated in table 4. The transition probabilities for these lines are then simply obtained from the relations given in the conversion table at the end of this general introduction if the wavelength of the line is known. The numbers indicated by an asterisk in table 4 are exact values, while all the other numbers change slightly when deviations from *LS*-coupling become significant. Naqvi has calculated—for all the configurations encountered for the atoms and ions listed in our table—the spectra at which the changes become noticeable. He finds that significant changes occur only for the $2p^2$ and $2p^4$ configurations. His results are graphically presented in figures 2 and 3. From these curves one may conveniently obtain the line strengths for some very highly charged ions like Cl XIII. These we have not listed, since there are presently no energy levels and therefore no wavelengths available, so that the transition probabilities cannot be tabulated as yet.

TABLE 3. *Transition probability ratios for some forbidden lines of* O I *and* S I

Line ratios	Experiment:				Theory: Garstang	Recommended in NSRDS–NBS 4
	LeBlanc et al.	McConkey et al.	Kvifte and Vegard	Liszka and Niewodniczanski		
O I:						
A(5577)/A(2972)	22(±2)	18.6	–	–	17.6	20.0
A(6363)/A(6300)	–	0.33	0.33	–	0.32	0.32
A(2972)/A(2958)	–	>200	–	45	210	180
		McConkey et al.			Czyzak and Krueger.	Recommended (this tabulation).
S I:						
A(7725)/A(4589)	–	5.1±0.7	–	–	5.09	5.09

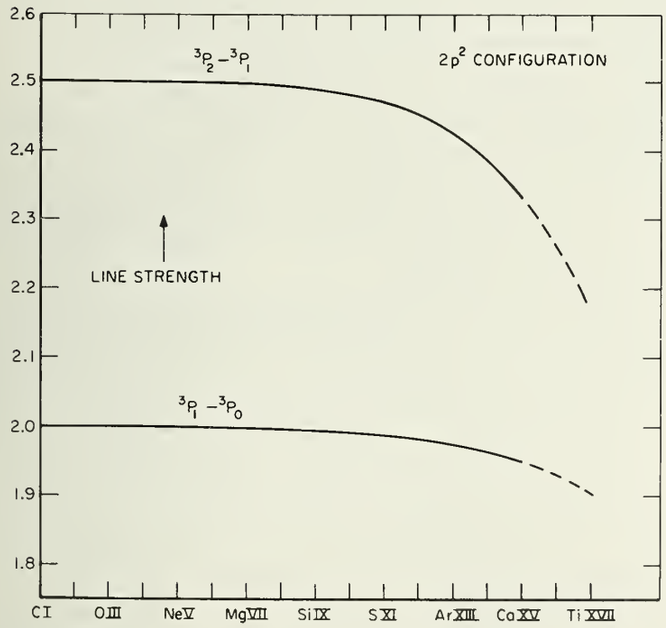

FIGURE 2. *Line strengths for the* $^3P_1-^3P_0$ *and* $^3P_2-^3P_1$ *magnetic dipole lines of the* $2p^2$ *configuration within the carbon isoelectronic sequence.*

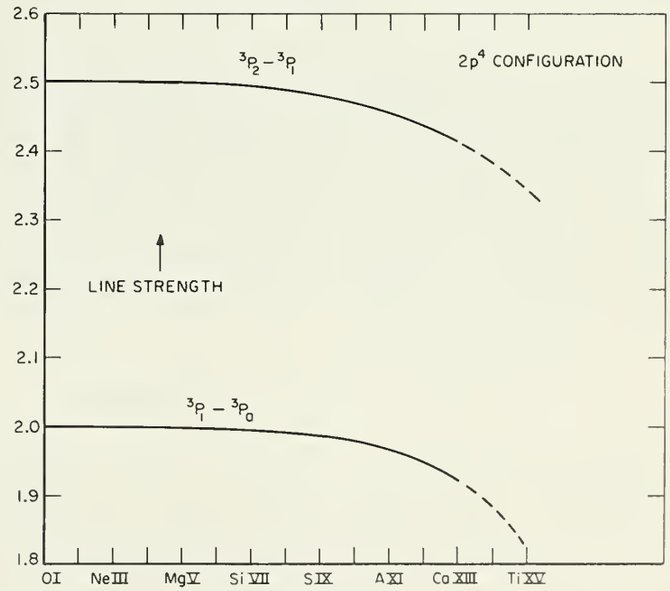

FIGURE 3. *Line strengths for the* $^3P_1-^3P_0$ *and* $^3P_2-^3P_1$ *magnetic dipole lines of the* $2p^4$ *configuration within the oxygen isoelectronic sequence.*

TABLE 4. *Line strength for some magnetic dipole lines near LS-coupling*

Configuration	Line	S_m(at. u)
$nsnp$*	$^3P^\circ_0-{}^3P^\circ_1$	2.00
	$^3P^\circ_1-{}^3P^\circ_2$	2.50
np	$^2P^\circ_{1/2}-{}^2P^\circ_{3/2}$	**1.33
np^2	$^3P_0-{}^3P_1$	2.00
	$^3P_1-{}^3P_2$	2.50
np^3	$^2D^\circ_{3/2}-{}^2D^\circ_{5/2}$	2.40
	$^2P^\circ_{1/2}-{}^2P^\circ_{3/2}$	1.33
np^4	$^3P_1-{}^3P_0$	2.00
	$^3P_2-{}^3P_1$	2.50
np^5	$^2P^\circ_{3/2}-{}^2P^\circ_{1/2}$	**1.33

*$n=2, 3 \ldots$
** Straight-number.

In analogy to the magnetic dipole lines discussed above, there exist also among electric quadrupole transitions a number of cases where the transition probabilities are essentially independent of the interaction parameters and depend critically only on the quadrupole integral s_q. These are the transitions $^1S_0-{}^1D_2$, $^3P_2-{}^3P_1$, and $^3P_2-{}^3P_0$ for the p^2 and p^4 configurations and $^2D^\circ_{5/2}-{}^2P^\circ_{3/2}$, $^2D^\circ_{3/2}-{}^2P^\circ_{3/2}$, $^2D^\circ_{5/2}-{}^2P^\circ_{1/2}$, for the p^3 configuration.

On the whole, the good agreement with the observations and the assessment of the critical factors indicates that uncertainties no greater than 25 to 50 percent for the forbidden lines have to be generally expected. For the particular magnetic dipole transitions tabulated in table 4 the uncertainties should be much smaller, since their values are almost independent of the choice of the interaction parameters, and also the effects of configuration interaction and deviations from *LS*-coupling do not enter sensitively into the numbers. Thus the line strengths, especially for ions of lower charge, are essentially exact values. But the respective transition probabilities, on the other hand, often suffer from uncertainties in the energy level data, especially for the higher ions. It is for this reason that we have generally not gone beyond "B" in our accuracy ratings for these transitions.

Within a given spectrum the electric quadrupole lines listed above should be the best available ones and they have been estimated to be accurate within 25 percent, while the rest of the quadrupole transitions should be accurate within 50 percent. Electric quadrupole lines have been normally rated to be of lower accuracy than magnetic dipole lines, since the uncertainties in the quadrupole integral must be added to the other uncertainties already present for the magnetic dipole lines.

3. Exploitation of Systematic Trends

During the course of our compilation work we noticed certain regularities in the data which we have then explored and analyzed in detail. We have subsequently detected many additional systematic trends, which establish now, for the first time, a frame-work of reliable *f*-values tied together by this regular behavior. The findings and conclusions of these regularity studies have been extensively discussed in several recent papers to which we refer for details [4]. Therefore we shall give here only a summary by presenting the main systematic trends exhibited in the data:

a. *Dependence of f-values on nuclear charge Z.* This dependence may be readily derived from conventional perturbation theory, with the result that *f* may be represented by a power series in Z^{-1}:

$$f=a_0+a_1Z^{-1}+a_2Z^{-2}+\ldots, \tag{1}$$

where the first term a_0 is a hydrogenic *f*-value [4], which vanishes for all transitions which do not involve a change in the principal quantum number. The earlier mentioned nuclear charge-expansion method, applied by Dalgarno and co-workers [15, 16, 17] to the determination of *f*-values, makes explicit use of this *Z*-dependence.

b. *Systematic trends of f-values within spectral series.* In the comparatively few cases where we have numerical material for at least several members of a spectral series, the *f*-values decrease rapidly for higher series members, in an analogous fashion as for hydrogen. The dependence of *f* on the principal quantum number *n*, or the effective quantum number n^*, is always a smooth one, even though for lower *n* the *f*-value is not always monotonically decreasing. For higher *n* the *f*-values gradually tend to obey the hydrogenic dependence $f\sim(n^*)^{-3}$.

c. *Homologous atoms.* The third principal regularity concerns homologous atoms, i.e., atoms with the same outer electron structure. Here we have found that for certain analogous groups of spectral lines the *f*-values remain approximately constant throughout a family of homologous atoms. For example, the resonance lines of the alkalies, i.e., $2s-2p$ for Li, $3s-3p$ for Na, $4s-4p$ for K etc. are all close to unity. This behavior is readily understood on the basis of the Wigner-Kirkwood partial *f*-sum rule. If it is assumed that most of the strength of a spectral series is concentrated in its leading transition or, in the general case, its transition array (for example $3s-3p$ has the dominant strength in a $3s-np$ series), then it follows that for this dominant transition array the mean *f*-value is approximately given by the number obtained from the partial *f*-sum rule. Furthermore, in all homologous atoms the breakdown of the total strength of the transition array into multiplets and individual lines remains the same as long as the coupling scheme remains constant. It follows therefore that for all lines of dominant transition arrays in homologous atoms the *f*-values should stay approximately constant.

These three above-stated regularities have been proven to be extremely useful for our compilation work, principally in the following two respects:

I. We were able to check many data for their degree of fit into apparent regularities and we have used their deviations or their fit as an additional guide for our accuracy estimates.

II. We could in a number of cases obtain new *f*-values by exploiting either the dependence of *f*-values on nuclear charge or the systematic trends of *f*-values within spectral series. Thus for a number of highly charged ions and for higher members of some spectral series of K I, where no other data were available, we have simply performed graphical interpolations between existing data or graphical extrapolations (figs. 9–21).

d. *Examples.* In order to further illustrate the usefulness of the regularities, we shall give now a few examples. First, we shall give some graphical presentations of the *Z*-dependence of *f*-values:

(1) The Mg-sequence transition $3s^2\,{}^1S-3s3p\,{}^1P^\circ$ (resonance line). The adopted data, with the exception of the point for Mg I, are from purely theoretical sources and fall quite smoothly into the expected *Z*-dependence as seen in figure 4. It is seen that the data of Crossley and Dalgarno [17], ob-

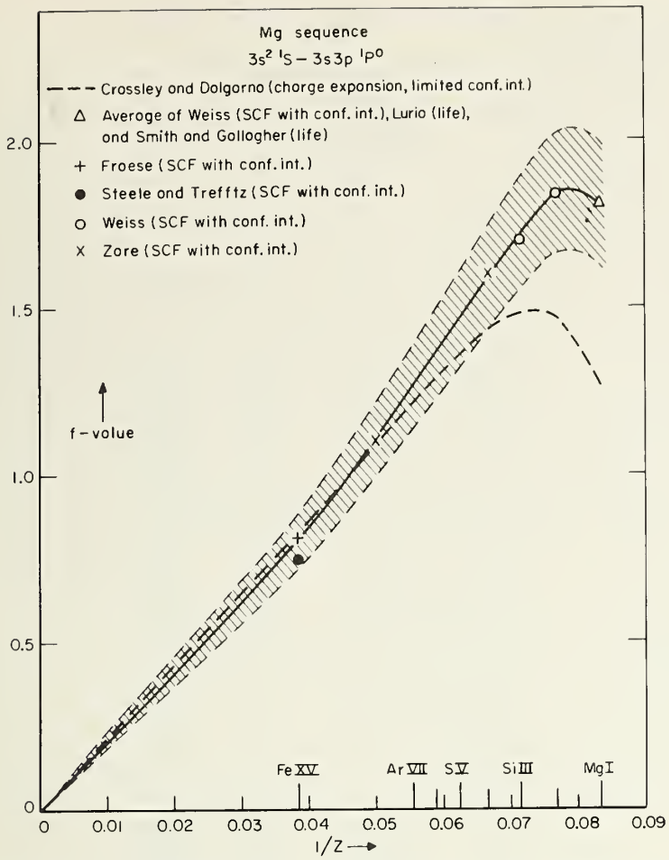

FIGURE 4. *f-value versus* 1/Z *for the* Mg-*sequence transition* $3s^2\ ^1S - 3s3p\ ^1P^\circ$.

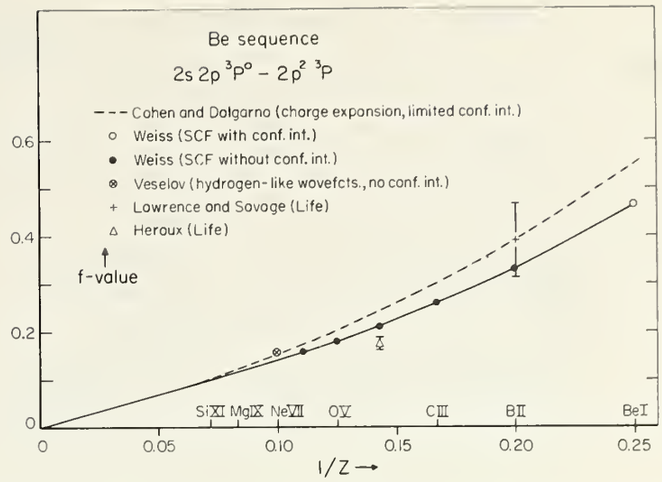

FIGURE 5. *f-value versus* 1/Z *for the* Be-*sequence transition* $2s2p\ ^3P^\circ - 2p^2\ ^3P$.

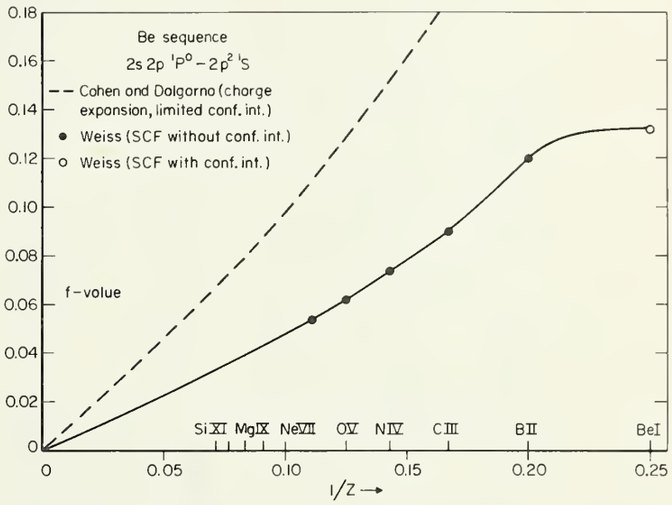

FIGURE 6. *f-value versus* 1/Z *for the* Be-*sequence transition* $2s2p\ ^1P^\circ - 2p^2\ ^1S$.

tained by the nuclear charge-expansion method, are apparently very adequate for the higher ions (we use them for Cl VI, Ar VII and K VIII) but deviate for the lower ions increasingly from the values obtained from more advanced theoretical methods [9, 11, 13, 14], as well as from the accurate lifetime experiments of Lurio [18], and Smith and Gallagher [19] for Mg I. In order to illustrate the size of our error estimate, we have shaded in figure 4 the area covered by the adopted uncertainty of 10 percent.

(2) As two other examples we present the Be-sequence multiplets $^1P^\circ - ^1S$ and $^3P^\circ - ^3P$ of the $2s2p - 2p^2$ array (figs. 5 and 6). For the highly charged ions Na VIII, Mg IX, Al X and Si XI, which are part of this compilation, we could employ the results of charge-expansion calculations by Cohen and Dalgarno [15] for the triplet as well as the singlet. These calculations include a limited treatment of configuration interaction. In the case of the triplet the results tie in very well with the best available data for the lower ions as is seen in figure 5. The other data are the Hartree-Fock calculations by Weiss (see ref. [1]), calculations based on hydrogen-like wave functions by Veselov [45], and lifetime experiments by Lawrence and Savage [46] and Heroux [47]. We have therefore, guided in part by this good agreement, assigned the conservatively estimated uncertainties of 25 percent to the results of the charge-expansion calculations for those higher ions which are relevant for this compilation.

For the singlet $2s2p\ ^1P^\circ - 2p^2\ ^1S$ we encounter, however, the very different situation given in figure 6. Here the charge-expansion calculations of Cohen and Dalgarno [15], used again for the ions Na VIII through Si XI, do not tie in at all with Weiss' calculations (see ref. [1]) for the lower ions and the neutral Be atom. Furthermore, the appearance of the Z-dependence curve has taken on a different shape. At first sight it is surprising that a triplet and singlet of the same transition array show such a different behavior, but on closer inspection the reason for this is somewhat apparent: While the upper state of the singlet transition, $2p^2\ ^1S$, may strongly interact with the ground state $2s^2\ ^1S$, there is, in the case of the triplet, $2p^2\ ^3P$, no other ^3P state which could be formed by two electrons in the $n=2$ shell. Thus while the ^1S state may be a strong mixture of the $2s^2$ and $2p^2$ configurations, as well as possibly significant interactions from other configurations, no such strong possibility of configuration interaction exists for the ^3P state within the $n=2$ shell. The points for the lower stages of ionization in figure 6 are therefore at present rather uncertain since both Weiss' and Cohen and Dalgarno's calculations include only limited configuration mixing. A more elaborate treatment is necessary since, in neutral Be and the lower ions, the $2p^2\ ^1S$ level is embedded in the $2sns\ ^1S$ series. But higher stages of ionization this level separates from the series, so that Cohen and Dalgarno's data should gradually become rather accurate for high values of Z. But since it is not clear at what point this occurs, we have lowered our accuracy estimates for these singlet transitions in the ions Na VIII through Si XI for the time being to "E", i.e., we do not rule out uncertainties as large or larger than 50 percent.

TABLE 5. *Comparison of multiplet* f-*values for homologous atoms in the dominant* s — p *transition arrays**

Transition		*f*-value	Uncertainty	*f*-value	Uncertainty
		Boron ($n=2$)		Aluminum ($n=3$)	
$(n+1)s-(n+1)p$	$^2S-^2P^\circ$	1.07	25%	1.41	25%
		Carbon ($n=2$)		Silicon ($n=3$)	
$np(n+1)s-np(n+1)p$	$^3P^\circ-^3D$	0.50	50%	0.61	50%
	$^3P^\circ-^3P$	0.31	50%	0.39	50%
	$^3P^\circ-^3S$	0.10	50%	0.13	50%
	$^1P^\circ-^1D$	0.42	50%	0.67	50%
	$^1P^\circ-^1S$	0.11	50%	0.12	50%
		Nitrogen ($n=2$)		Phosphorus ($n=3$)	
$np^2(n+1)s-np^2(n+1)p$	$^4P-^4D^\circ$	*0.36*	25%	0.57	50%
	$^4P-^4P^\circ$	*0.23*	25%	0.36	50%
	$^4P-^4S^\circ$	*0.088*	25%	0.13	50%
	$^2P-^2P^\circ$	*0.318*	25%	0.39	50%
		Oxygen ($n=2$)		Sulfur ($n=3$)	
$np^3(n+1)s-np^3(n+1)p$	$^5S^\circ-^5P$	*0.922*	10%	*1.1*	50%
	$^3S^\circ-^3P$	*0.898*	10%	*1.1*	50%
		Fluorine ($n=2$)		Chlorine ($n=3$)	
$np^4(n+1)s-np^4(n+1)p$	$^4P-^4P^\circ$	0.29	50%	0.30	50%
	$^4P-^4D^\circ$	0.53	50%	0.57	50%
	$^4P-^4S^\circ$	0.11	50%	0.12	50%
	$^2P-^2D^\circ$	0.53	50%	0.58	50%
	$^2P-^2S^\circ$	0.11	50%	0.11	50%
	$^2P-^2P^\circ$	0.34	50%	0.36	50%
		Neon ($n=2$)		Argon ($n=3$)	
$np^5(n+1)s-np^5(n+1)p$	$1s_2-2p_1^{**}$	*0.123*	10%	*0.133*	25%
	$1s_2-2p_2$	*0.164*	10%	*0.172*	25%
	$1s_2-2p_3$	*0.265*	25%	*0.431*	25%
	$1s_2-2p_4$	*0.158*	10%	*0.160*	25%
	$1s_2-2p_6$	*0.228*	10%	*0.125*	25%
	$1s_2-2p_8$	*0.047*	10%	*0.039*	25%
	$1s_3-2p_2$	*0.273*	10%	*0.341*	25%
	$1s_3-2p_4$	*0.394*	10%	*0.560*	25%
	$1s_3-2p_7$	*0.246*	10%	*0.095*	25%
	$1s_3-2p_{10}$	*0.073*	10%	*0.058*	25%
	$1s_4-2p_2$	*0.034*	10%	*0.016*	25%
	$1s_4-2p_3$	*0.157*	25%	*0.119*	25%
	$1s_4-2p_4$	*0.018*	10%	*0.0002*	25%
	$1s_4-2p_5$	*0.114*	25%	*0.121*	25%
	$1s_4-2p_6$	*0.050*	10%	*0.075*	25%
	$1s_4-2p_7$	*0.170*	10%	*0.273*	25%
	$1s_4-2p_8$	*0.245*	10%	*0.413*	25%
	$1s_4-2p_{10}$	*0.077*	10%	*0.084*	25%
	$1s_5-2p_2$	*0.040*	10%	*0.029*	25%
	$1s_5-2p_3$	*0.056*	25%	*0.030*	25%
	$1s_5-2p_4$	*0.014*	10%	*0.003*	25%
	$1s_5-2p_6$	*0.122*	10%	*0.239*	25%
	$1s_5-2p_7$	*0.027*	10%	*0.031*	25%
	$1s_5-2p_9$	*0.373*	10%	*0.510*	25%
	$1s_5-2p_{10}$	*0.085*	10%	*0.159*	25%

TABLE 5. *Comparison of multiplet* f-*values for homologous atoms in the dominant* s—p *transition arrays**—Continued

Transition		*f*-value	Uncertainty	*f*-value	Uncertainty	*f*-value	Uncertainty
		Lithium ($n=2$)		Sodium ($n=3$)		Potassium ($n=4$)	
$ns-np$	$^2S-^2P^\circ$	0.753	3%	0.982	3%	1.02	10%
$(n+1)s-(n+1)p$	$^2S-^2P^\circ$	1.23	10%	1.35	25%	1.5	50%
		Beryllium ($n=2$)		Magnesium ($n=3$)		Calcium ($n=4$)	
$ns(n+1)s-ns(n+1)p$	$^3S-^3P^\circ$	1.13	25%	1.41	25%	1.35	>50%***
	$^1S-^1P^\circ$	1.15	25%	1.24	25%	1.24	>50%***

*The data are either the adopted "best" values of this compilation or taken from our earlier Vol. I [1]. The numbers are set in italics when experimental data are involved.

**Paschen notation.

***Obtained from the Coulomb approximation. These data are considered quite uncertain and are therefore not listed in the tabulation.

TABLE 6. *Comparison of multiplet* f-*values for homolgous atoms in the dominant* p—d *transition arrays**

Transition		*f*-value	Uncertainty	*f*-value	Uncertainty
		Boron ($n=2$)		Aluminum ($n=3$)	
$(n+1)p-(n+1)d$	$^2P-^2D^\circ$	0.90	25%	0.71	25%
		Carbon ($n=2$)		Silicon ($n=3$)	
$np(n+1)p-np(n+1)d$	$^1P-^1D^\circ$	0.63	25%	0.48	50%
	$^3D-^3F^\circ$	0.70	25%	0.32	50%
	$^1P-^1P^\circ$	0.26	25%	0.00021	>50%
		Nitrogen ($n=2$)		Phosphorus ($n=3$)	
$np^2(n+1)p-np^2(n+1)d$	$^2S^\circ-^2P$	0.945	10%	0.30	50%
		Oxygen ($n=2$)		Sulfur ($n=3$)	
$np^3(n+1)p-np^3(n+1)d$	$^5P-^5D^\circ$	0.90	25%	*0.22*	50%
	$^3P-^3D^\circ$	0.75	25%	0.059	>50%

*The data are either the adopted "best" values of this compilation or taken from our earlier Vol. I [1]. The numbers are set in italics when experimental data are involved.

TABLE 7. *Comparison of* f-*values for some prominent transitions of* S I

Transition array	Multiplet	Coulomb approximation [3]	Miller [25]	Foster [48]	Bridges and Wiese [24]	Regularities in homologous atoms
$4s-4p$	$^5S^\circ-^5P$	1.0_3	—	—	1.5_3	1.1
	$^3S^\circ-^3P$	1.0_7	—	—	1.4_7	1.1
$4s-5p$	$^5S^\circ-^5P$	(*)	0.0057_5	0.0057_8	0.010_2	—
	$^3S^\circ-^3P$	(*)	0.0041_4	0.0043_9	0.0067_7	—
$4p-4d$	$^5P-^5D^\circ$	0.23_0	—	—	0.30_1	—
$4p-5d$	$^5P-^5D^\circ$	0.084_2	0.068_3	—	0.12_5	—

*Severe cancellation is encountered.

It should be noted that for all chosen examples further f-values for the still higher ions like P XII, S XIII, Cl XIV etc. may be immediately read off the figures. However, we have not employed this particular material in our present compilation since no energy levels and wave lengths are available as yet, so that the f-values cannot be converted to transition probabilities and line strengths. But in other cases where energy level data exist, we have exploited the apparent Z-dependence of f-values to obtain data for higher ions simply by graphical extrapolation. For all these cases we present at the end of this general introduction the relevant Z-dependence graphs which contain the individual data points for the lower ions (figs. 10–21).

The second regularity mentioned above was the systematic variation of f-values within spectral series. Extensive data for this type of regularity are available for several spectral series of Na I, Mg II, K I, and Ca II. A smooth variation of f-value with effective principal quantum number n^* is observed in many cases and speaks for the accuracy of the data. However, the f-values do not always decrease monotonically with increasing principal quantum number. Three examples, for K I, two with a monotonic decrease and one which shows an anomalous behavior, are given graphically in figures 7, 8 and 9 at the end of this general introduction (these graphs have been also utilized for obtaining extrapolated data). The anomalous behavior has been up to now only observed among the very first members of a spectral series.

The third regularity concerns homologous atoms. To illustrate this regularity, we have compared whenever possible the multiplet f-values of the leading transition arrays for $s-p$ and $p-d$ transitions for second and third row atoms as well as for K and Ca. The results, compiled in tables 5 and 6, are quite interesting. First, one observes that for practically all $s-p$ transitions the f-values increase slightly from the second row atoms to the corresponding third row atoms. For the two available cases which also contain fourth row atoms, namely the combinations, Li, Na, and K as well as Be, Mg, and Ca, no further increase in the f-value is noted between the third and fourth row atoms. But, as already mentioned, these increases are very small, so that within the approximate range of the partial f-sum rule prediction the f-values may be regarded as behaving according to this prediction, i.e., they remain essentially constant.

For most $p-d$ transitions on the other hand, this constancy of the f-value is not preserved. In most comparisons the respective f-values for the third row atoms decrease drastically. In at least two examples (Si I $^1P-^1P^\circ$, and S I $^3P-^3D^\circ$) this is definitely due to significant cancellation in the transition integral. It is suspected that such an interference effect is playing a significant role throughout all third row atoms for these particular transitions. Any cancellation effects are of course not considered in the partial f-sum rule application so that this would account for the apparent violation.

The regularities in the f-values of homologous atoms have sometimes influenced our choices of absolute scales. We discuss as an example the case of S I. In this instance we could have chosen the absolute scale for the prominent transitions in the visible and near infrared either from the Coulomb approximation [3], or from the shock-tube work by Miller [25], or from the arc experiments by Foster [48], and Bridges and Wiese [24]. The comparison of the data in table 7 shows a pronounced spread in the absolute values by about a factor of two. For the case of the $4s-4p$ transitions we may also obtain an absolute scale by extrapolating from the rather accurate data for the homologous $3s-3p$ transitions of O I, taking account of the fact that for all $4s-4p$ transitions the f-values increase slightly against the corresponding $3s-3p$ lines (see table 5). This scale is also listed in the comparison table 7.

After subjecting as usual all methods to an extensive analysis we arrived at our final choice mainly by considering the following facts: (a) the reliability of the Coulomb approximation for the $4s-4p$ transitions of third row elements is quite good, e.g., in the cases of Ar I and Ar II the deviations against the most accurate methods are within 25 percent or less (table 1); (b) the point at which arc and shock-tube results overlap almost coincides with the scale obtained from the Coulomb approximation; (c) the absolute scales in the arc and shock-tube experiments are much more uncertain than the relative numbers obtained from these experiments and do not rule out the scale obtained from the Coulomb approximation; (d) the almost constant factor between the arc results of Bridges and Wiese and the Coulomb-approximation results may be readily explained on account of large uncertainties present in the absolute experimental scale, but would be very difficult to interpret due to uncertainties in the theory, since several different transition arrays are involved for which the transition integrals are independently obtained; (e) last but not least the f-values predicted from the regularities from homologous atoms support strongly the scale obtained from the Coulomb approximation.

We have therefore chosen the scale of the Coulomb approximation as the best available one and assigned accuracy ratings of 50 percent to the individual (absolute) values.

4. Classification of Uncertainties

Before leaving the subject of the review of the data sources and our method of evaluation, we want to make some remarks about our final error estimates. (But the mechanics of the evaluation process has been explained in the introduction to Volume **I** [1] and will therefore not be repeated.) In particular, we would like to emphasize that at the present stage of our knowledge we find it impossible to assign individual error limits to each critically evaluated number. We therefore again stick to our earlier devised classification scheme, in which f-values are divided into several levels of accuracy which differ by steps of about factors of three. We use again the following arbitrary notation:

AA	for uncertainties within	1%
A	do	3%
B	do	10%
C	do	25%
D	do	50%
E	for uncertainties larger than	50%

The word uncertainty is used with the meaning "extent of possible error" or "possible deviation from the true value". We have included data of class "E", that is, very uncertain values, only in special cases. For example, we have used them when, for the most important and most characteristic lines of a spectrum, no better data were available, so that otherwise these important lines would have to be omitted. Also, we have retained class "E" f-values to keep multiplets complete. We have often made a further differentiation in the classification scheme by assigning plus or minus signs to some transitions, which serves to indicate that these lines are estimated to be significantly better or worse than the average values of this class. These should be therefore the first or last choice among similar lines.

To sum up, in our error estimates we were principally guided by the main four guide-posts stated earlier: first, by the estimates of the individual authors; second, by

the general agreement of the data with other material; third, by the author's consideration of the critical factors entering into the method; and fourth, when applicable, by the degree of fit of the data into the apparent systematic trends.

The final selections of the data depend so much on the particular material that the major justifications are given in the individual introductions for each spectrum.

D. GENERAL ARRANGEMENT OF THE TABLES

We have continued to use the same general arrangement which we have adopted in Volume **I**, since we have received many positive comments on it. In a few special cases we have adapted our arrangement to meet the particular situation existing in some spectra. Thus, for example, for Ar I we have presented, in addition to the *jl*-coupling notation, the Paschen notation, since it is widely used.

The wavelength and energy level data have usually been obtained from the standard spectroscopic sources, such as the tabulations of Mrs. Moore-Sitterly [5, 6, 7, 49]. In quite a number of cases she has generously furnished us with newer material from her vast literature files. Thus, for several forbidden lines our listed transition probabilities differ from the author's original values, since we use newer energy level data.

For a number of lines we had to calculate wavelengths from energy level differences. These are given in square brackets to distinguish them from the presumably more accurate observed material.

E. FUTURE PLANS AND ACKNOWLEDGMENTS

We intend to extend this critical compilation in the near future to selected heavier elements. The most likely targets will be the heavier alkalis and alkaline earths, and the elements of the iron group.

It is a pleasure to acknowledge the help and cooperation of many workers in this field. In particular we would like to express our sincere appreciation to all those who have contributed by sending us preprints or as yet unpublished material.

We also express our deep gratitude to Paul Voigt who assisted us very effectively in the early stages of this compilation. We would finally like to thank several colleagues at other institutions as well as at NBS, who upon our urging carried out special calculations or experiments to eliminate some of the most glaring defects in the data. We would like to mention especially the intermediate coupling calculations of R. Cowan and P. Murphy on Ar I; the "superposition of configuration" calculations of A. Weiss on Mg I, Al I, Al II, and Si II and III; the arc measurements of J. Richter and J. M. Bridges for Ar I, and J. B. Shumaker, Jr. for Ar II; and the lifetime measurements of J. Z. Klose for Ar I.

It is also a pleasure to acknowledge the competent help of Miss Judy Grabusnik in typing and proofreading the manuscript.

References

[1] Wiese, W. L., Smith, M. W., and Glennon, B. M., "Atomic Transition Probabilities—Hydrogen through Neon," NSRDS–National Bureau of Standards 4, Vol. **1** (U.S. Government Printing Office, Washington, D.C., 1966).

[2] Glennon, B. M., and Wiese, W. L., "Bibliography on Atomic Transition Probabilities," National Bureau of Standards Miscellaneous Publication 278, April (1966). Supplement, Dec. (1967) (U.S. Government Printing Office, Washington, D.C.).

[3] Bates, D. R., and Damgaard, A., Phil. Trans. Roy. Soc. London, Ser. **A242**, 101 (1949).

[4] Wiese, W. L., Proc. Beam Foil Spectroscopy Conf., Tucson, Arizona (Gordon and Breach Publ., New York, 1967). Wiese, W. L., and Weiss, A. W., Phys. Rev. **175**, 50–65 (1968).

[5] Moore, C. E., "A Multiplet Table of Astrophysical Interest, Revised Edition," National Bureau of Standards Tech. Note 36 (U.S. Government Printing Office, Washington, D.C., 1959).

[6] Moore, C. E., "An Ultraviolet Multiplet Table," National Bureau of Standards Circular 488, Sec. 1 (U.S. Government Printing Office, Washington, D.C., 1950).

[7] Moore, C. E., "Selected Tables of Atomic Spectra, Atomic Energy Levels and Multiplet Tables," NSRDS–National Bureau of Standards 3, Section 1 (1965), Section 2 (1967) (U.S. Government Printing Office, Washington, D.C.).

[8] Weiss, A. W., Phys. Rev. **162**, 71 (1967).

[9] Weiss, A. W., J. Chem. Phys. **47**, 3573 (1967).

[10] Weiss, A. W. (to be published).

[11] Zare, R. N., J. Chem. Phys. **47**, 3561 (1967).

[12] Fischer, C. F., J. Quant. Spectrosc. Radiat. Transfer **8**, 755 (1968). Astrophys. J. **151**, 759 (1968).

[13] Froese, C., Astrophys. J. **140**, 361 (1964).

[14] Steele, R., and Trefftz, E., J. Quant. Spectrosc. Radiat. Transfer **6**, 833 (1966).

[15] Cohen, M., and Dalgarno, A., Proc. Roy. Soc. London **A280**, 258 (1964).

[16] Dalgarno, A., and Parkinson, E. M., Proc. Roy. Soc. London **A301**, 253 (1967).

[17] Crossley, R. J. S., and Dalgarno, A., Proc. Roy. Soc. London **A286**, 510 (1965).

[18] Lurio, A., Phys. Rev. **136**, A376 (1964). Schmieder, R. W., Lurio, A., and Happer, W., Phys. Rev. **173**, 76–79 (1968).

[19] Smith, W. W., and Gallagher, A., Phys. Rev. **145**, 26 (1966).

[20] Layzer, D., and Garstang, R. H., "Theoretical Atomic Transition Probabilities," Annual Review of Astronomy and Astrophysics, Vol. **6** (Annual Reviews, Inc., Palo Alto, California, 1968).

[21] Wiese, W. L., "Methods of Experimental Physics," **7A**, ch. 2.1 (Academic Press, New York, 1968).

[22] Corliss, C. H., and Bozman, W. R., "Experimental Transition Probabilities for Spectral Lines of Seventy Elements," National Bureau of Standards Monograph 53 (U.S. Government Printing Office, Washington, D.C., 1962).

[23] Meggers, W. F., Corliss, C. H., and Scribner, B. F., "Tables of Spectral Line Intensities," National Bureau of Standards Monograph 32 (U.S. Government Printing Office, Washington, D.C., 1961).

[24] Bridges, J. M., and Wiese, W. L., Phys. Rev. **159**, 31 (1967).

[25] Miller, M. H., University of Maryland Technical Note BN 550, May (1968).

[26] Naqvi, A. M., Thesis Harvard (1951).

[27] Malville, J. M., and Berger, R. A., Planetary and Space Science **13**, 1131 (1965).

[28] Garstang, R. H., Ann. Astrophys. **25**, 109 (1962).

[29] Garstang, R. H., I.A.U. Symposium No. 34 on Planetary Nebulae held at Tatranska Lomnica, Czechoslovakia, Sept. (1967).

[30] Froese, C., Astrophys. J. **145**, 932 (1966).

[31] Pasternack, S., Astrophys. J. **92**, 129 (1940).

[32] Czyzak, S. J., and Krueger, T. K., Monthly Notices Roy. Astron. Soc. **126**, 177 (1963).

[33] Krueger, T. K., and Czyzak, S. J., Astrophys. J. **144**, 1194 (1966).

[34] Shortley, G., Aller, L. H., Baker, J. G., and Menzel, D. H., Astrophys. J. **93**, 178 (1941).

[35] Slater, J. C., Phys. Rev. **34**, 1293 (1929).

[36] Garstang, R. H., Proc. Cambridge Phil. Soc. **52**, 107 (1956).

[37] McConkey, J. W., Burns, D. J., Moran, K. A., and Emeleus, K. G., Phys. Letters **22**, 416 (1966).

[38] LeBlanc, F. J., Oldenberg, O., and Carleton, N. P., J. Chem. Phys. **45**, 2200 (1966).

[39] Liszka, L., and Niewodniczanski, H., Acta. Phys. Polon. **17**, 345 (1958).

[40] Kvifte, G., and Vegard, L., Geofys. Publikasjoner Norske Videnskaps-Akad. Oslo **17**, No. 1 (1947).

[41] McConkey, J. W., Burns, D. J., Moran, K. A., and Kernahan, J. A., Nature **217**, 538 (1968).

[42] Garstang, R. H., Fifteenth International Astrophysical Symposium, Liége, June (1968).

[43] Hults, M. E., J. Opt. Soc. Am. **56**, 1298 (1966).

[44] Husain, D., and Wiesenfeld, J. R., Nature **213**, 1227 (1967).

[45] Veselov, M. G., Zhur. Eksptl. i Teoret. Fiz. **19**, 959 (1949).

[46] Lawrence, G. M., and Savage, B. D., Phys. Rev. **141**, 67 (1966).

[47] Heroux, L., Phys. Rev. **153**, 156 (1967).

[48] Foster, E. W., Proc. Phys. Soc. London **A90**, 275 (1967).

[49] Moore, C. E., "Atomic Energy Levels," National Bureau of Standards Circular 467: Vol. **I** (1949); Vol. **II** (1952); Vol. **III** (1958) (U.S. Government Printing Office, Washington, D.C.).

KEY TO ABBREVIATIONS AND SYMBOLS USED IN THE TABLES

1. Symbols for indication of accuracy:
AA.....uncertainties within 1%
A.....uncertainties within 3%
B.....uncertainties within 10%
C.....uncertainties within 25%
D.....uncertainties within 50%
E.....uncertainties larger than 50%.

2. Abbreviations appearing in the source column of allowed transitions:
ls = LS-coupling
ca = Coulomb approximation
n = normalized to a different scale
interp. = data interpolated from regularities
extrap. = data extrapolated from regularities.

3. Types of forbidden lines:
e = electric quadrupole line
m = magnetic dipole line
$m.q.$ = magnetic quadrupole line.
(The total transition probability is obtained by adding the individual transition probabilities due to each type of radiation, provided there are no significant magnetic fields present, i.e., provided one may average over the magnetic quantum numbers m_i.)

4. Special symbols used in the wavelength and energy level columns:
Number in parenthesis under multiplet notation refers to running number of ref. [5] (Revised Multiplet Table). If letters "uv" are added, we refer to running number of ref. [6] (Ultraviolet Multiplet Table). If letters "UV" precede the number, we refer to ref. [7] (Si I, II, III, IV Multiplet Tables and Energy Levels).

Numbers in italics indicate multiplet values, i.e., weighted averages of line values.

Numbers in square brackets indicate approximate calculated or extrapolated values.

USEFUL RELATIONS

(A) Statistical Weights:

The statistical weights are related to the inner quantum number J_L (in one-electron spectra j) of a level (initial and final states of a *line*) by

$$g_L = 2J_L + 1,$$

and to the quantum numbers of a term (initial and final states of a *multiplet*) by

$$g_M = (2L+1)(2S+1).$$

(The "multiplet" values g_M may also be obtained by summing over all possible "line" values g_L. S is the resultant spin.)

(B) Relations between the strengths of lines and the total multiplet strength:

1. Line strength S:

$$S(i, k) = \sum_{J_i, J_k} S(J_i, J_k)$$

$$\text{or } S(\text{Multiplet}) = \sum S(\text{line})$$

(k denotes the upper and i the lower term).

2. Absorption oscillator strength:

$$f_{ik}^{\text{multiplet}} = \frac{1}{\bar{\lambda}_{ik} \sum_{J_i} (2J_i+1)} \sum_{J_k, J_i} (2J_i+1) \times \lambda(J_i, J_k) \times f(J_i, J_k)$$

The mean wavelength for the multiplet $\bar{\lambda}_{ik}$ may be obtained from the *weighted* energy levels. Usually the wavelength differences for the lines within a multiplet are very small, so that the wavelength factors may be neglected.

3. Transition probabilities

$$A_{ki}^{\text{multiplet}} = \frac{1}{(\bar{\lambda}_{ik})^3 \sum_{J_k} (2J_k+1)} \sum_{J_i, J_k} (2J_k+1) \times \lambda(J_i, J_k)^3 \times A(J_k, J_i)$$

Relative strengths $S(J_i, J_k)$ of the components of a multiplet are listed for the case of LS-coupling in Allen, C. W., "Astrophysical Quantities," 2d ed. (The Athlone Press, London, 1963); White, H. E. and Eliason, A. Y., Phys. Rev. **44**, 753 (1933); Shore, B. W. and Menzel, D. H. "Principles of Atomic Structure," p. 447 (John Wiley & Sons, Inc., New York, 1968); Goldberg, L., Astrophys. J. **82**, 1 (1935) and **84**, 11 (1936).

CONVERSION FACTORS

The factor in each box converts by multiplication the quantity above it into the one at its left.

	A_{ki}	f_{ik}	S
A_{ki}	1	$\frac{6.670_2 \times 10^{15}}{\lambda^2} \frac{g_i}{g_k}$	E_d $\frac{2.026_1 \times 10^{18}}{g_k \lambda^3}$ E_q $\frac{1.679_8 \times 10^{18}}{g_k \lambda^5}$ M_d $\frac{2.697_2 \times 10^{13}}{g_k \lambda^3}$
f_{ik}	$1.4992 \times 10^{-16} \lambda^2 \frac{g_k}{g_i}$	1	E_d $\frac{303.7_5}{g_i \lambda}$ E_q $\frac{251.8}{g_i \lambda^3}$ M_d $\frac{4.043_6 \times 10^{-3}}{g_i \lambda}$
S	E_d $4.935_6 \times 10^{-19} g_k \lambda^3$ E_q $5.953 \times 10^{-19} g_k \lambda^5$ M_d $3.707_6 \times 10^{-14} g_k \lambda^3$	E_d $3.292_1 \times 10^{-3} g_i \lambda$ E_q $3.971 \times 10^{-3} g_i \lambda^3$ M_d $247.3_0 g_i \lambda$	1

The line strength is given in atomic units, which are:
For electric dipole transitions (allowed-denoted by E_d):

$$a_0^2 e^2 = 7.187_3 \times 10^{-59} m^2 C^2$$

for electric quadrupole transitions (forbidden-denoted by E_q):

$$a_0^4 e^2 = 2.021_6 \times 10^{-79} m^4 C^2$$

for magnetic dipole transitions (forbidden-denoted by M_d):

$$e^2 h^2 / 16\pi^2 m_e^2 c^2 = 8.599 \times 10^{-63} J^2 Wb^{-2} m^4.$$

The transition probability is in units sec^{-1}, and the f-value is dimensionless. The wavelength λ is given in Angstrom units, and g_i and g_k are the statistical weights of the lower and upper state, respectively. For the atomic constants entering into the relations, we have used the latest recommendations of the National Academy of Sciences adopted by the National Bureau of Standards (NBS Handbook 102 (1967)).

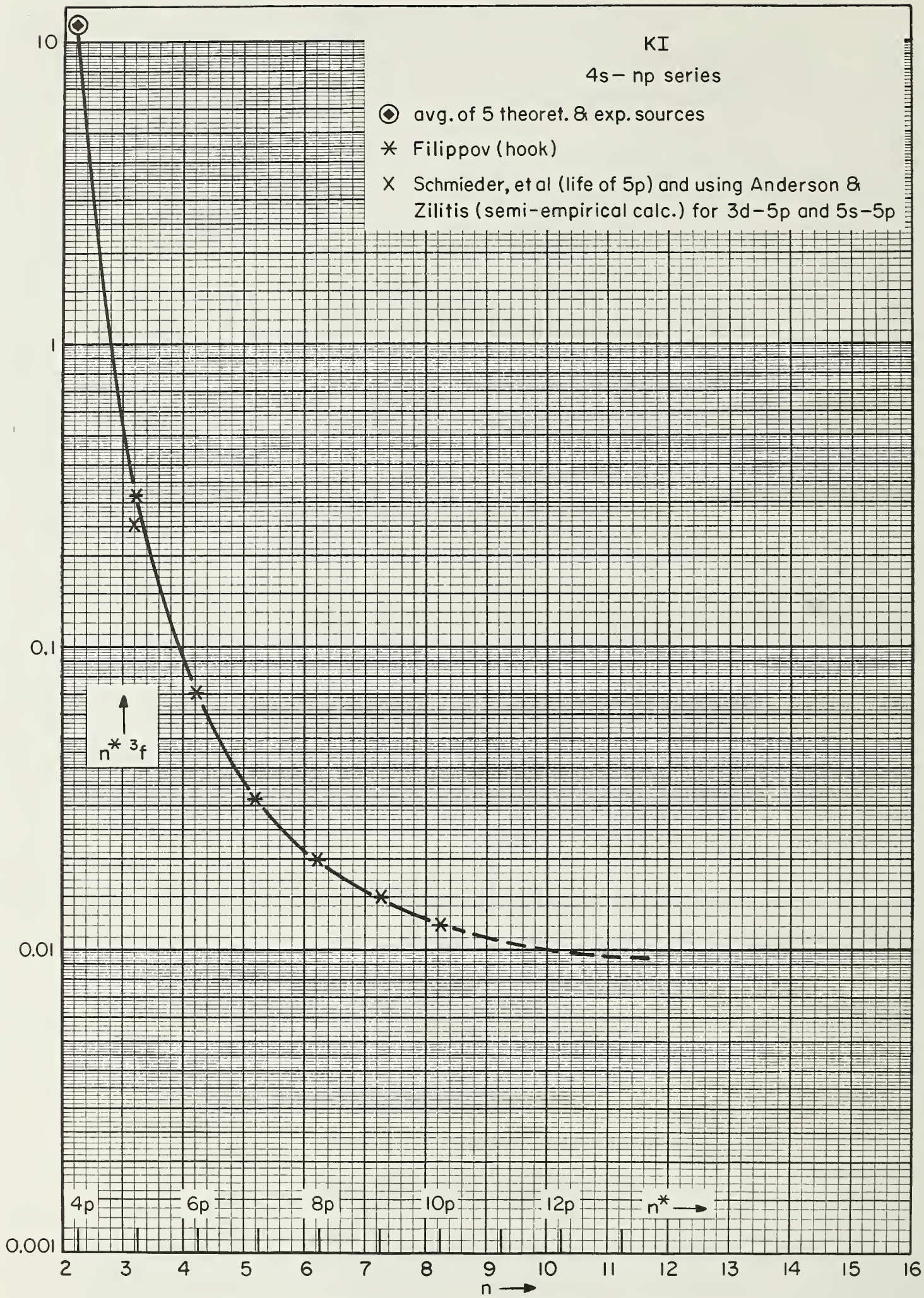

FIGURE 7. *Systematic trend of* f-*values within a spectral series.*

Plotted is $n^{*3}f$ versus n^* for the 4*s*-*np* series of *K* 1.

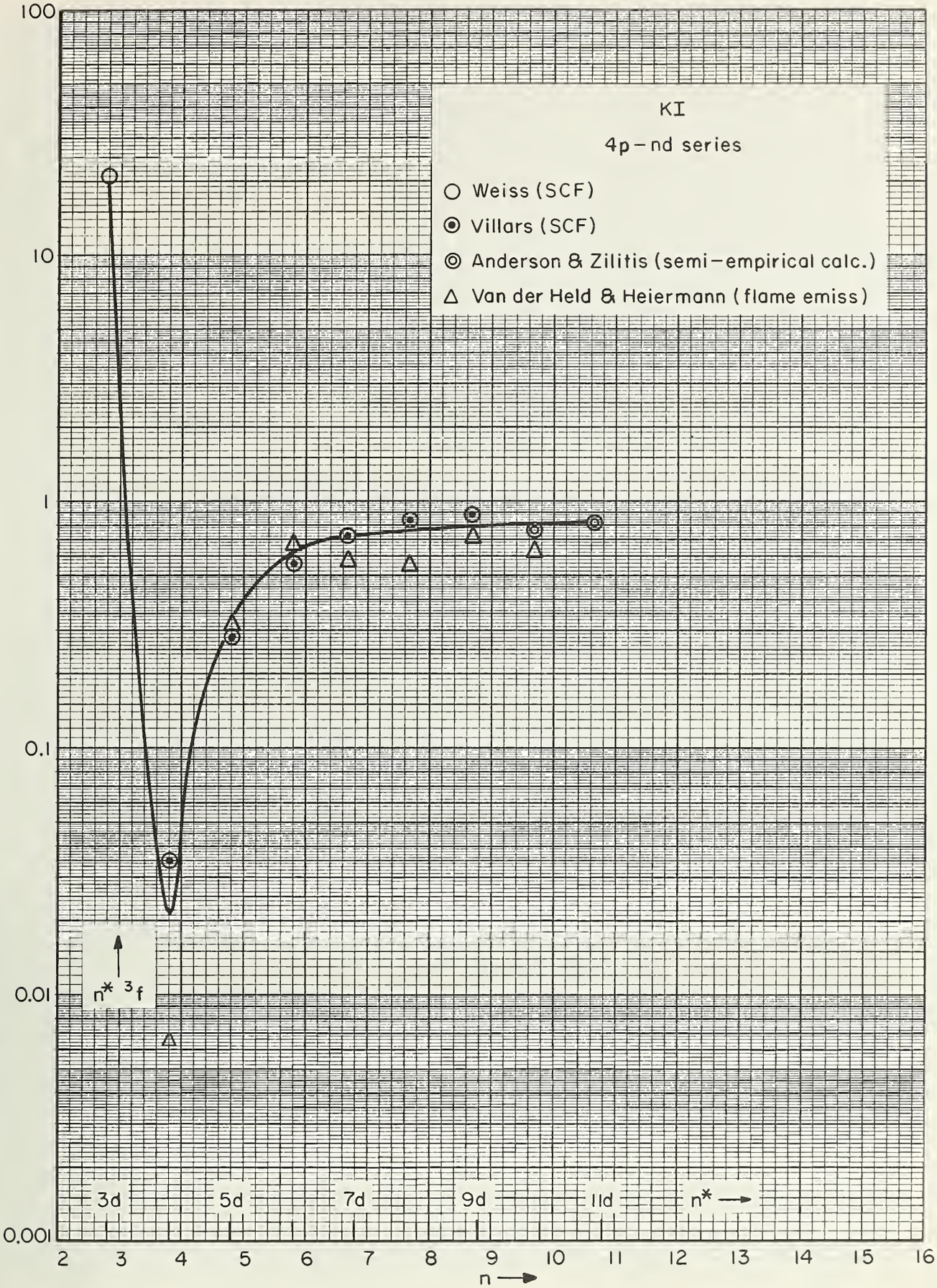

FIGURE 8. *Systematic trend of* f*-values within a spectral series showing anomalous behavior.*
Plotted is $n^{*3}f$ versus n^* for the $4p-nd$ series of K I.

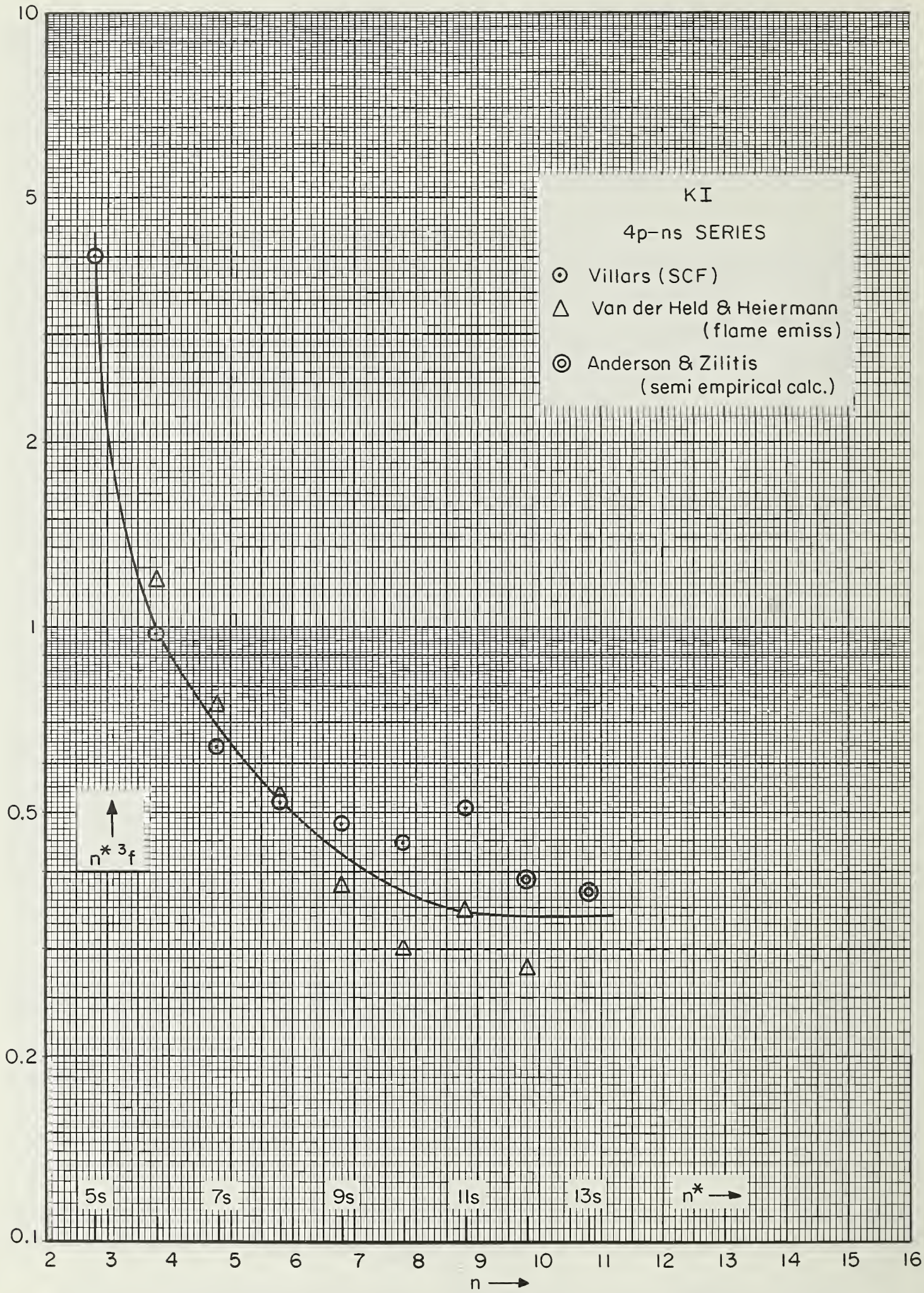

FIGURE 9. *Systematic trend of* f-*values within a spectral series.*
Plotted is $n^{*3}f$ versus n^* for the 4*p*-*ns* series of K I.

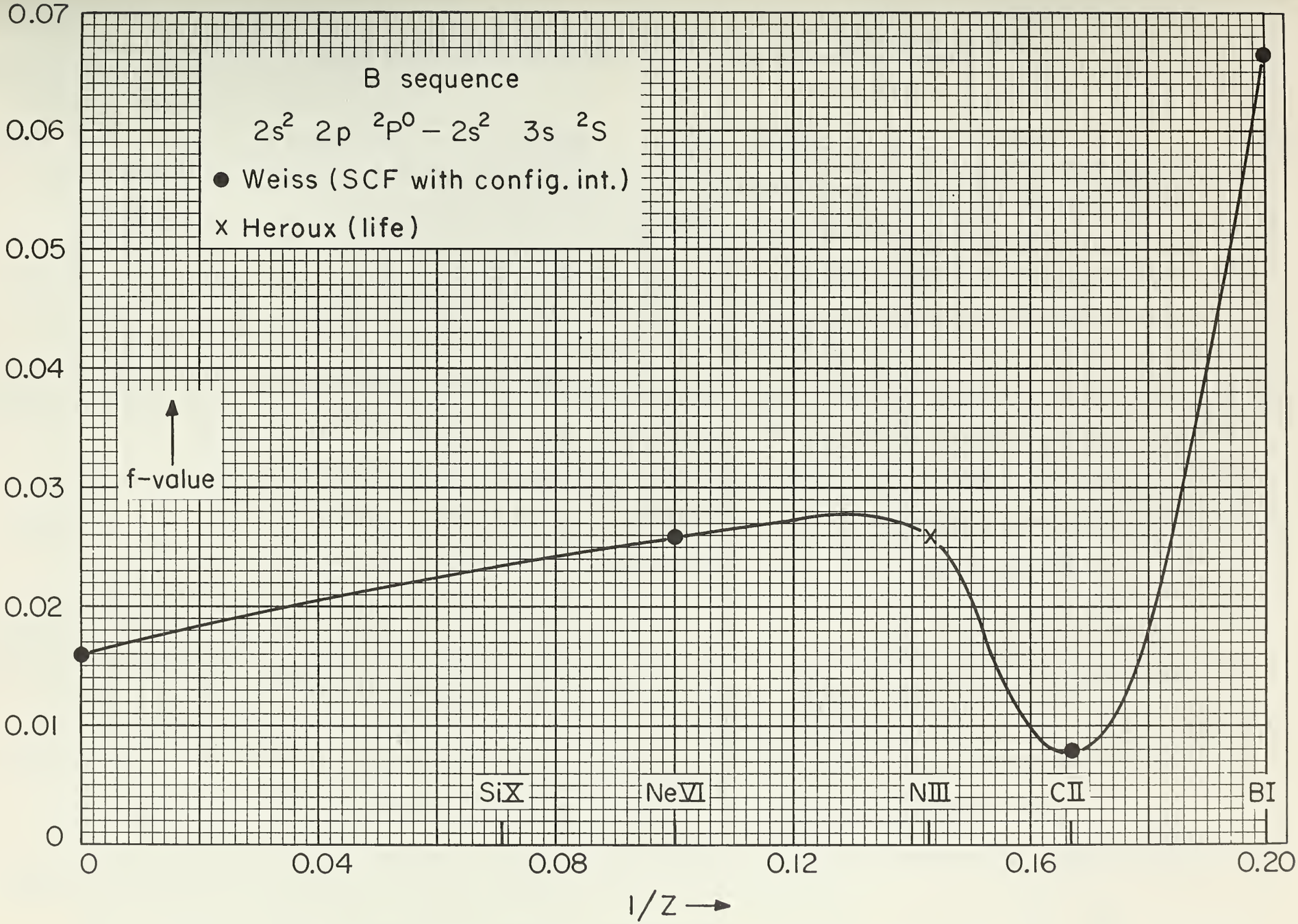

FIGURE 10. *f-value versus* 1/Z *for the* B-*sequence transition* $2s^22p\ ^2P^\circ - 2s^23s\ ^2S$.
The complete references are listed in the introductions for each of the spectra involved.

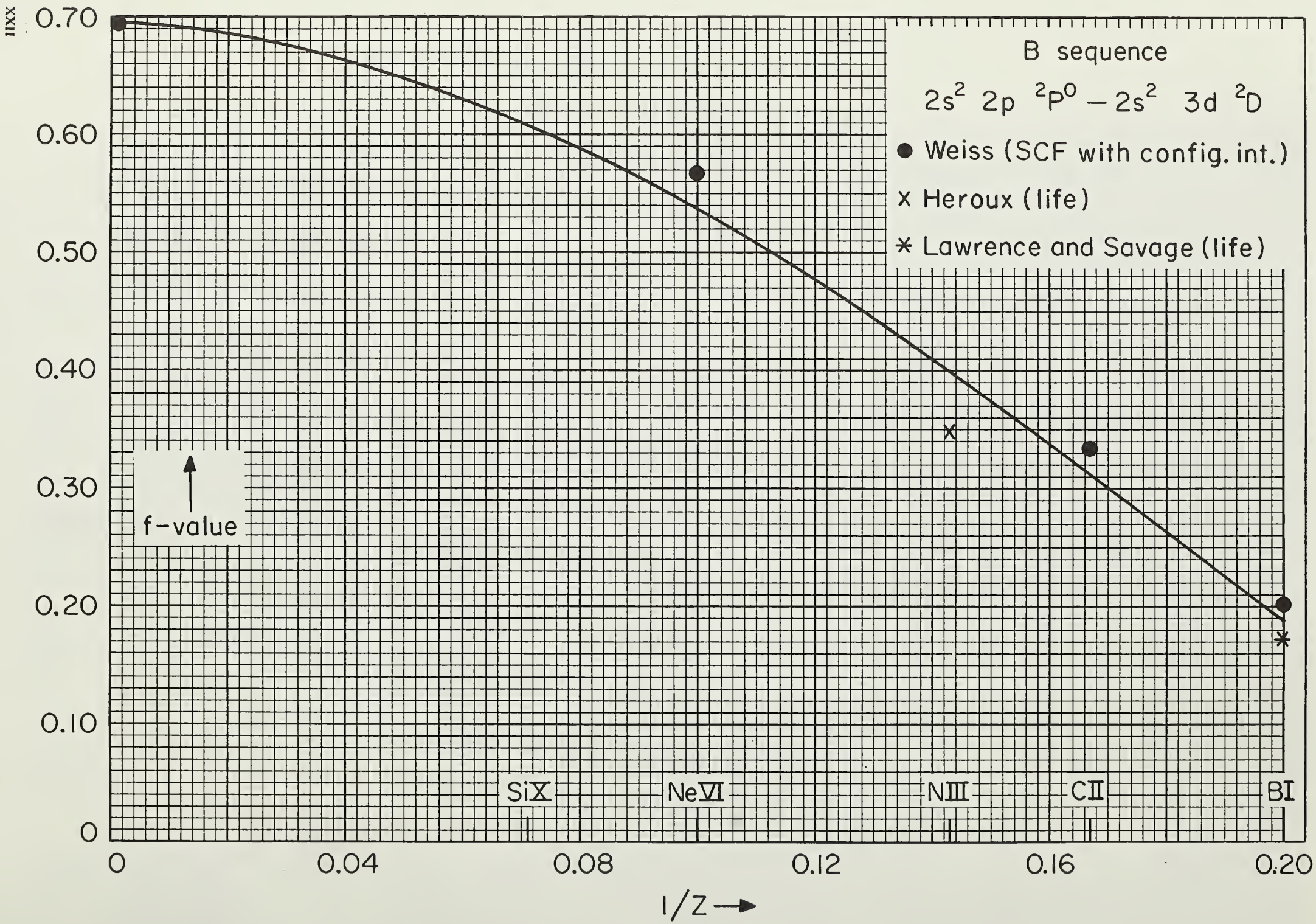

FIGURE 11. *f-value versus* 1/Z *for the* B-*sequence transition* $2s^22p\ ^2P^\circ - 2s^23d\ ^2D$.
The complete references are listed in the introductions for each of the spectra involved.

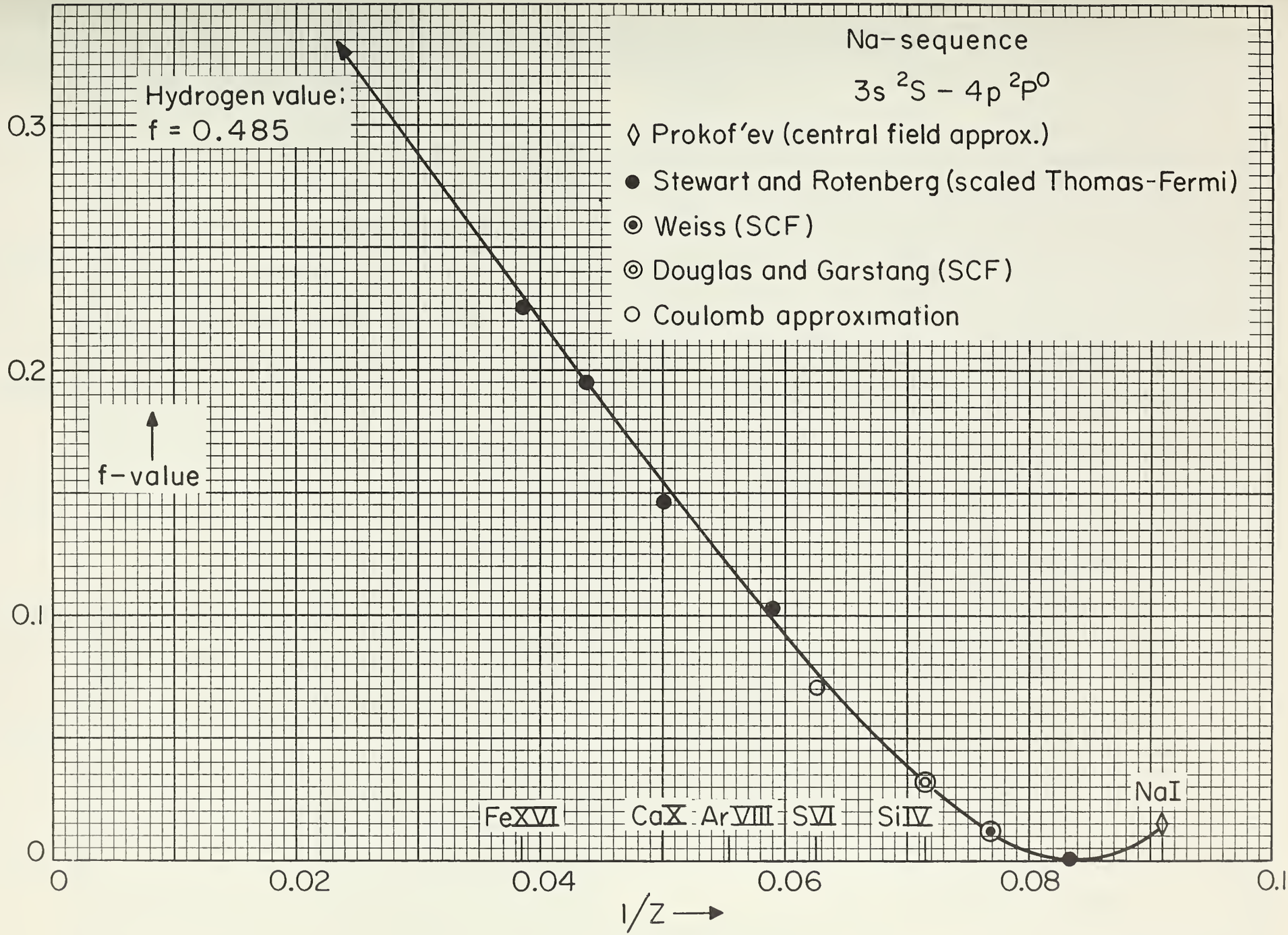

FIGURE 12. *f-value versus* 1/Z *for the* Na-*sequence transition* 3s $^2S-4p\ ^2P^o$.
The complete references are listed in the introductions for each of the spectra involved.

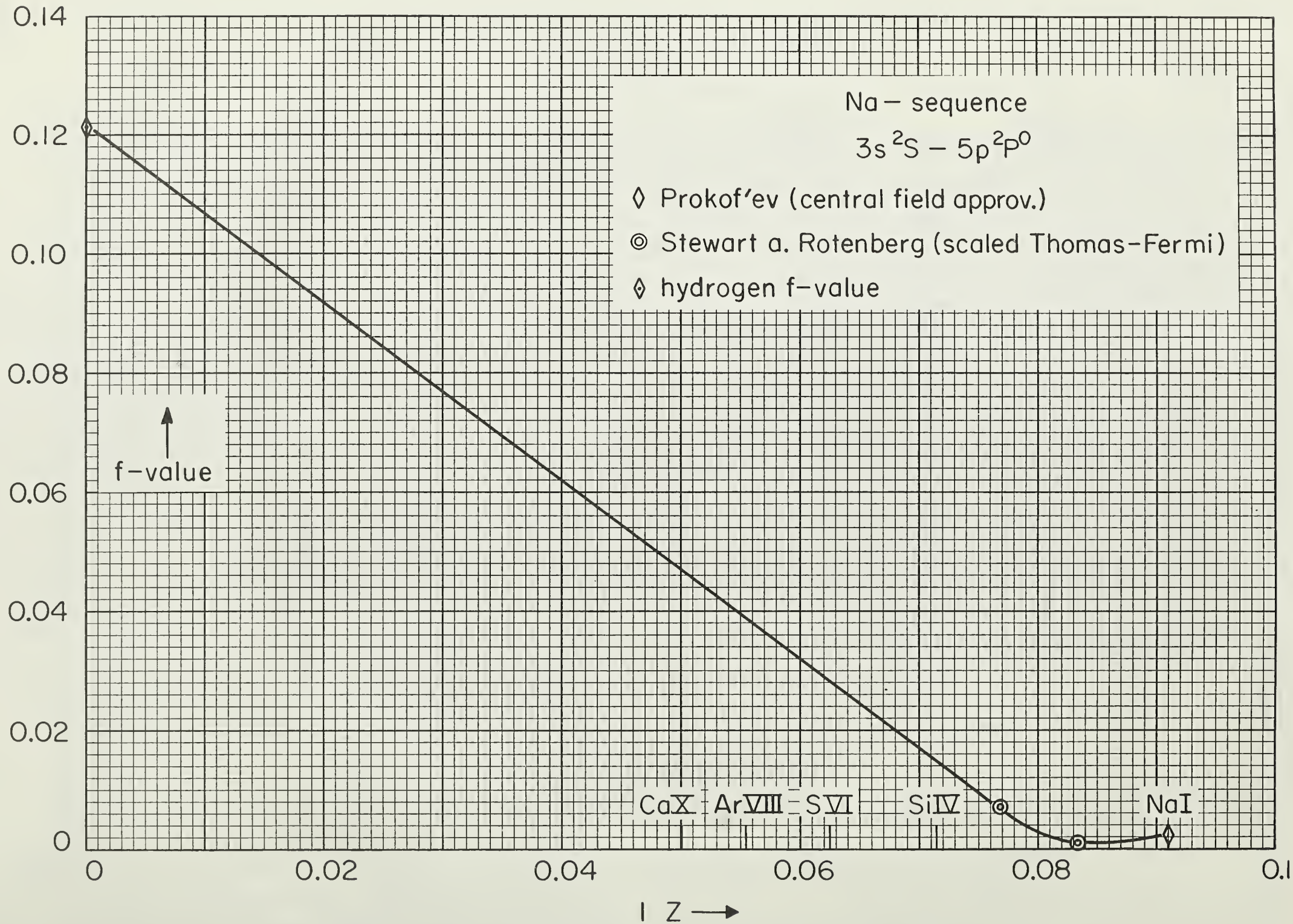

FIGURE 13. *f-value versus* 1/Z *for the* Na-*sequence transition* 3s $^2S-5p\ ^2P^\circ$.
The complete references are listed in the introductions for each of the spectra involved.

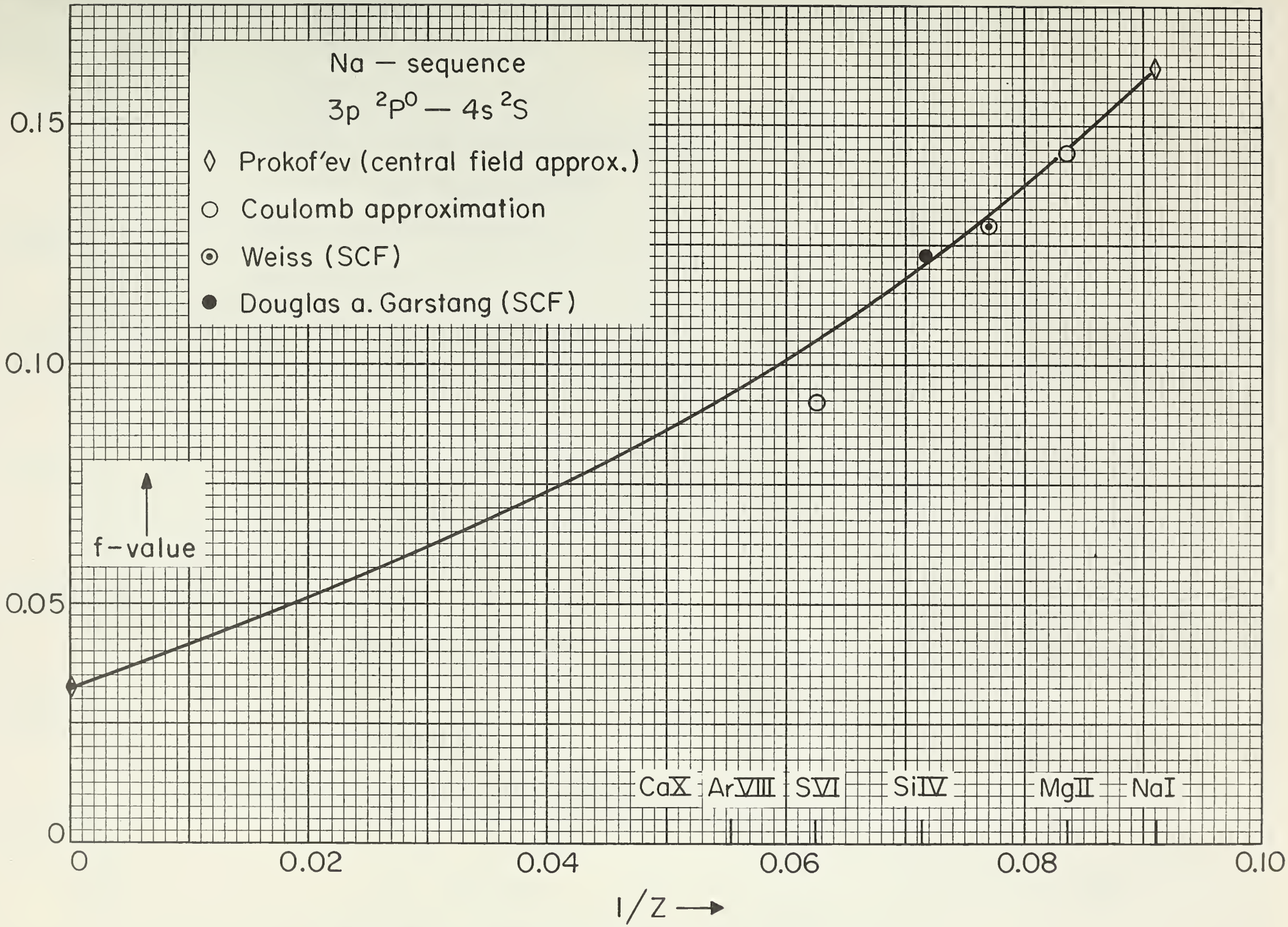

FIGURE 14. *f-value versus* 1/Z *for the* Na-*sequence transition* 3p $^2P^\circ - 4s\ ^2S$.
The complete references are listed in the introductions for each of the spectra involved.

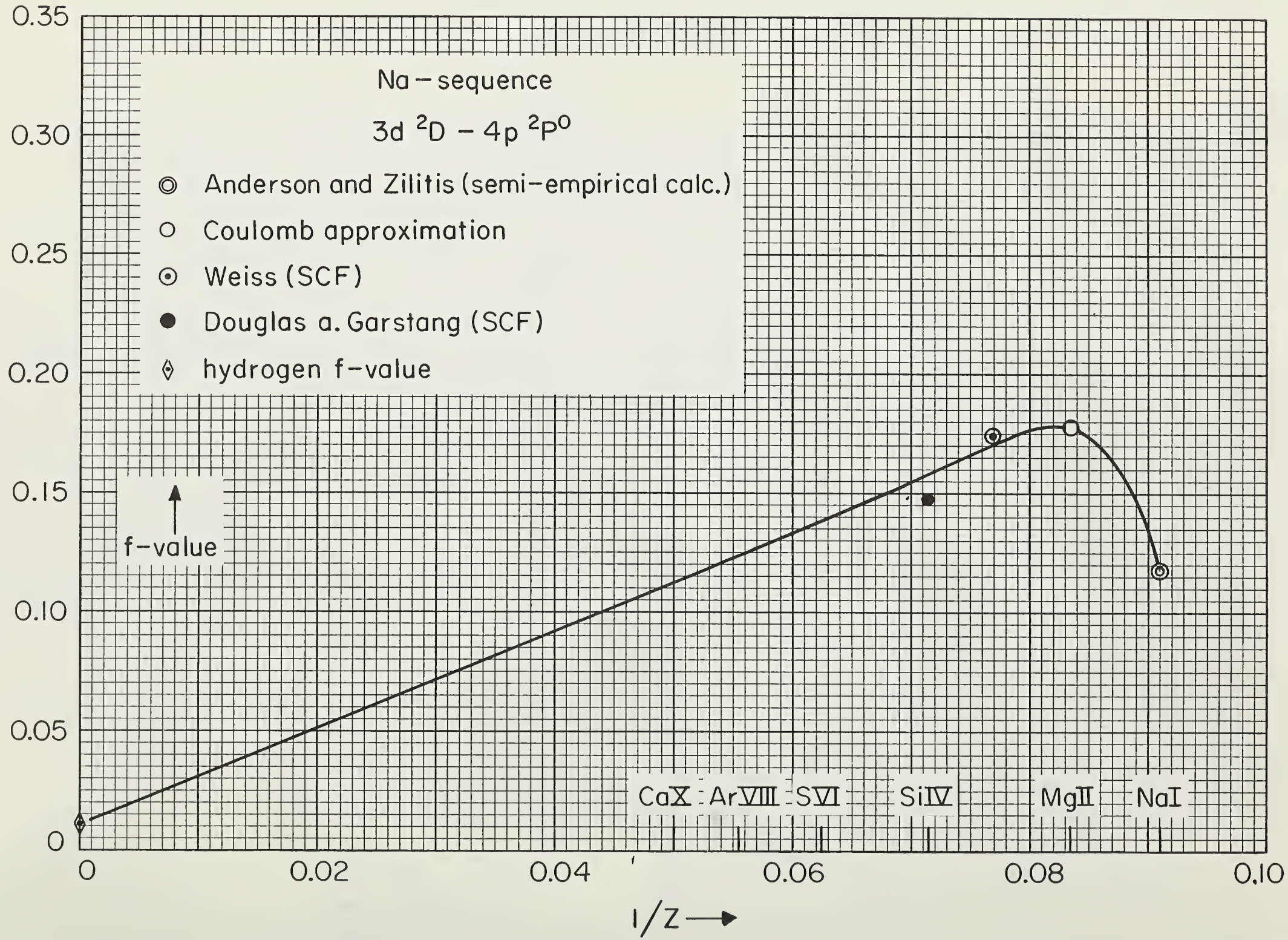

FIGURE 15. *f-value versus* 1/Z *for the* Na-*sequence transition* 3d ²D – 4p ²P°.
The complete references are listed in the introductions for each of the spectra involved.

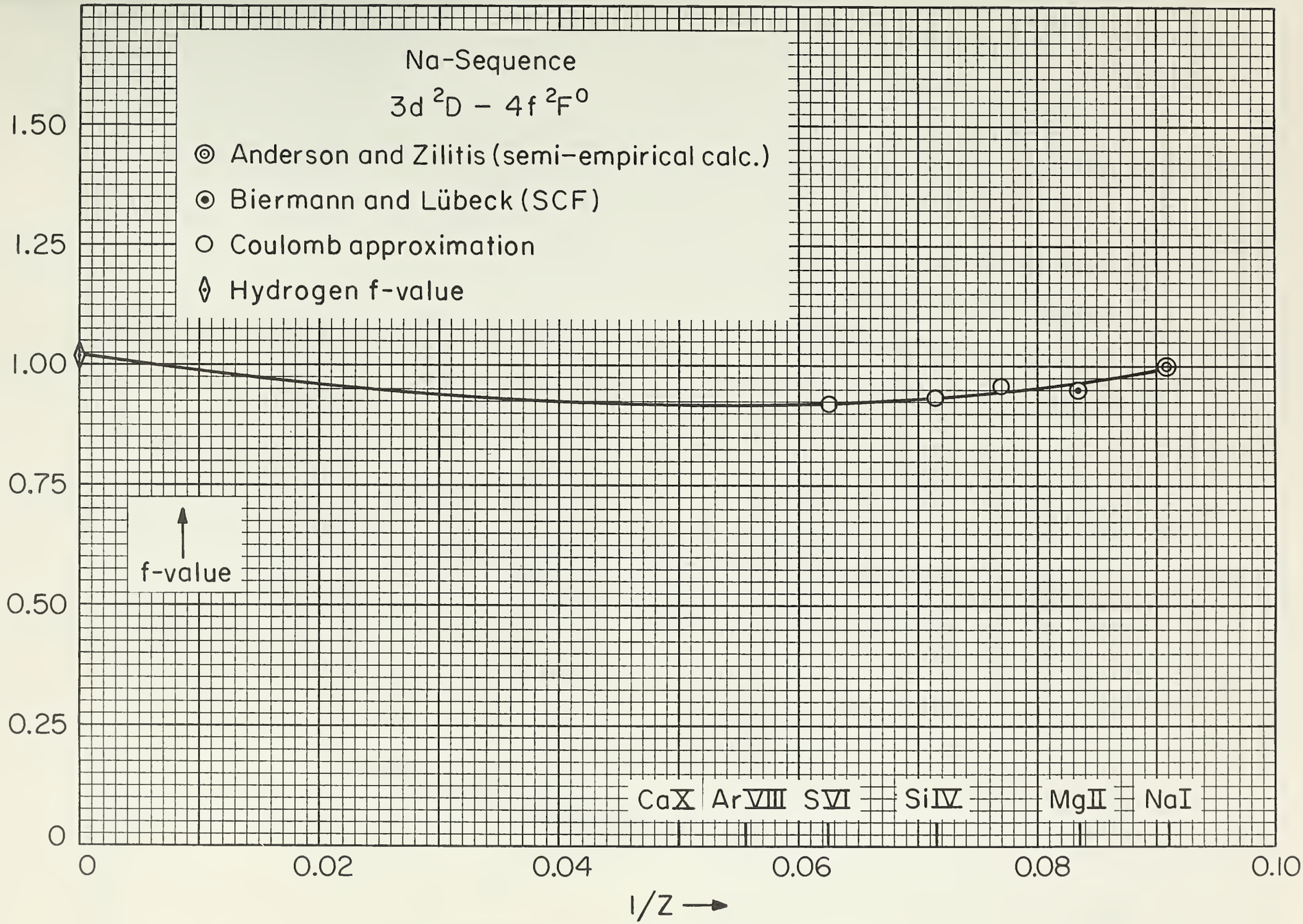

FIGURE 16. *f-value versus* 1/Z *for the* Na-*sequence transition* 3d ^{2}D–4f ^{2}F°.
The complete references are listed in the introductions for each of the spectra involved.

308-022 O-69—3

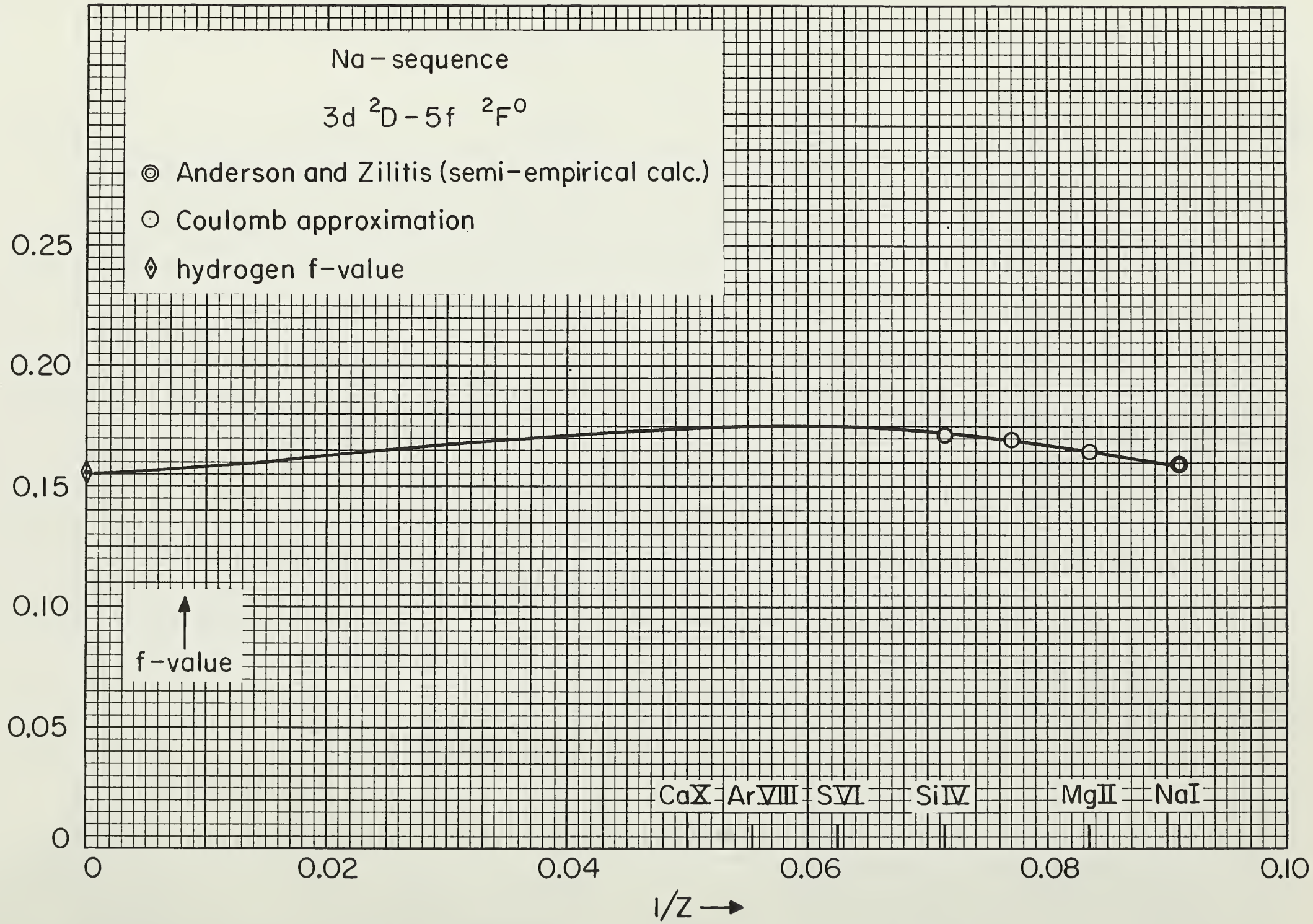

FIGURE 17. *f-value versus* 1/Z *for the* Na-*sequence transition* 3d ²D–5f ²F°.
The complete references are listed in the introductions for each of the spectra involved.

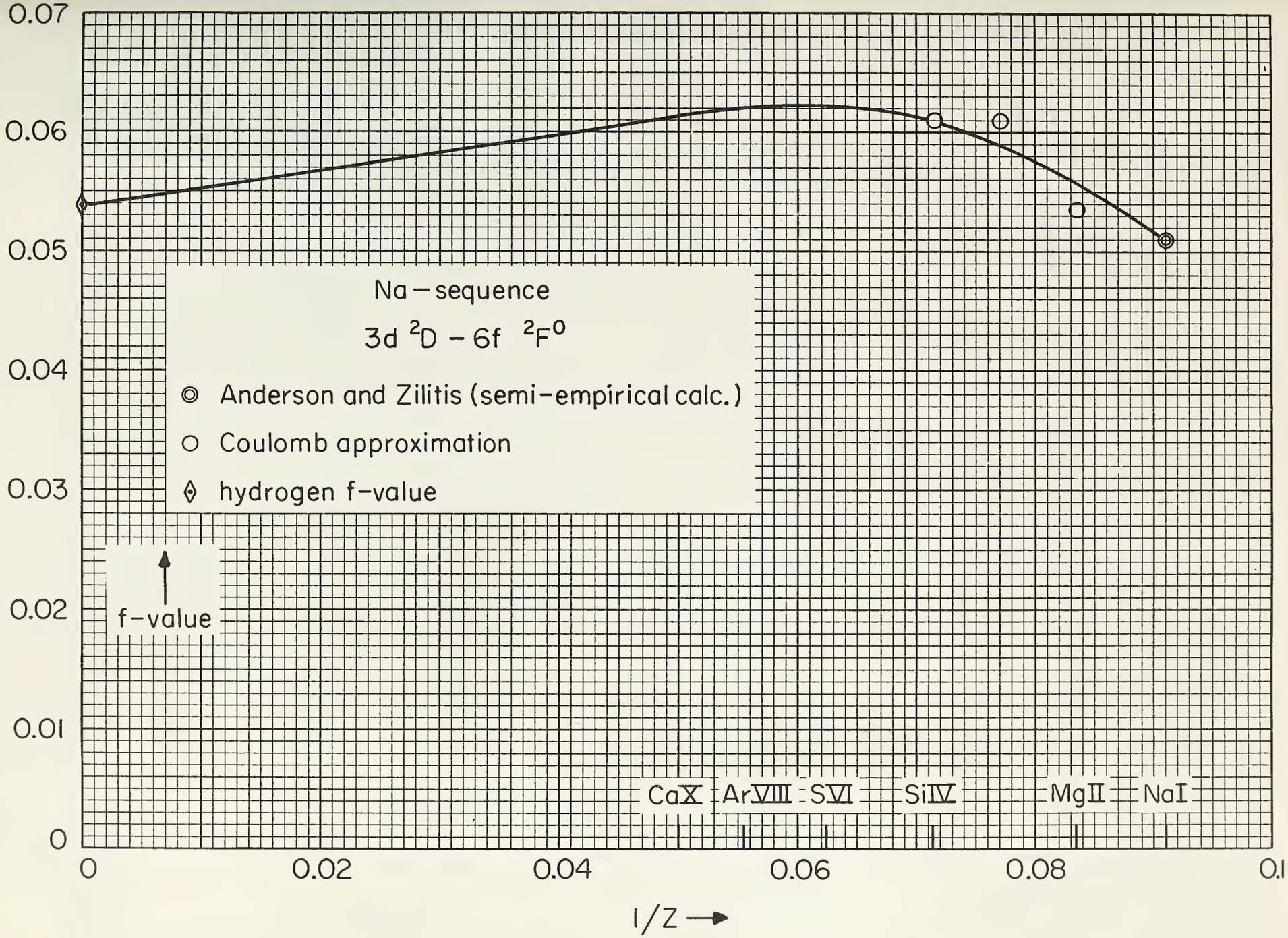

FIGURE 18. *f-value versus* 1/Z *for the* Na-*sequence transition* 3d ²D – 6f ²F°.
The complete references are listed in the introductions for each of the spectra involved.

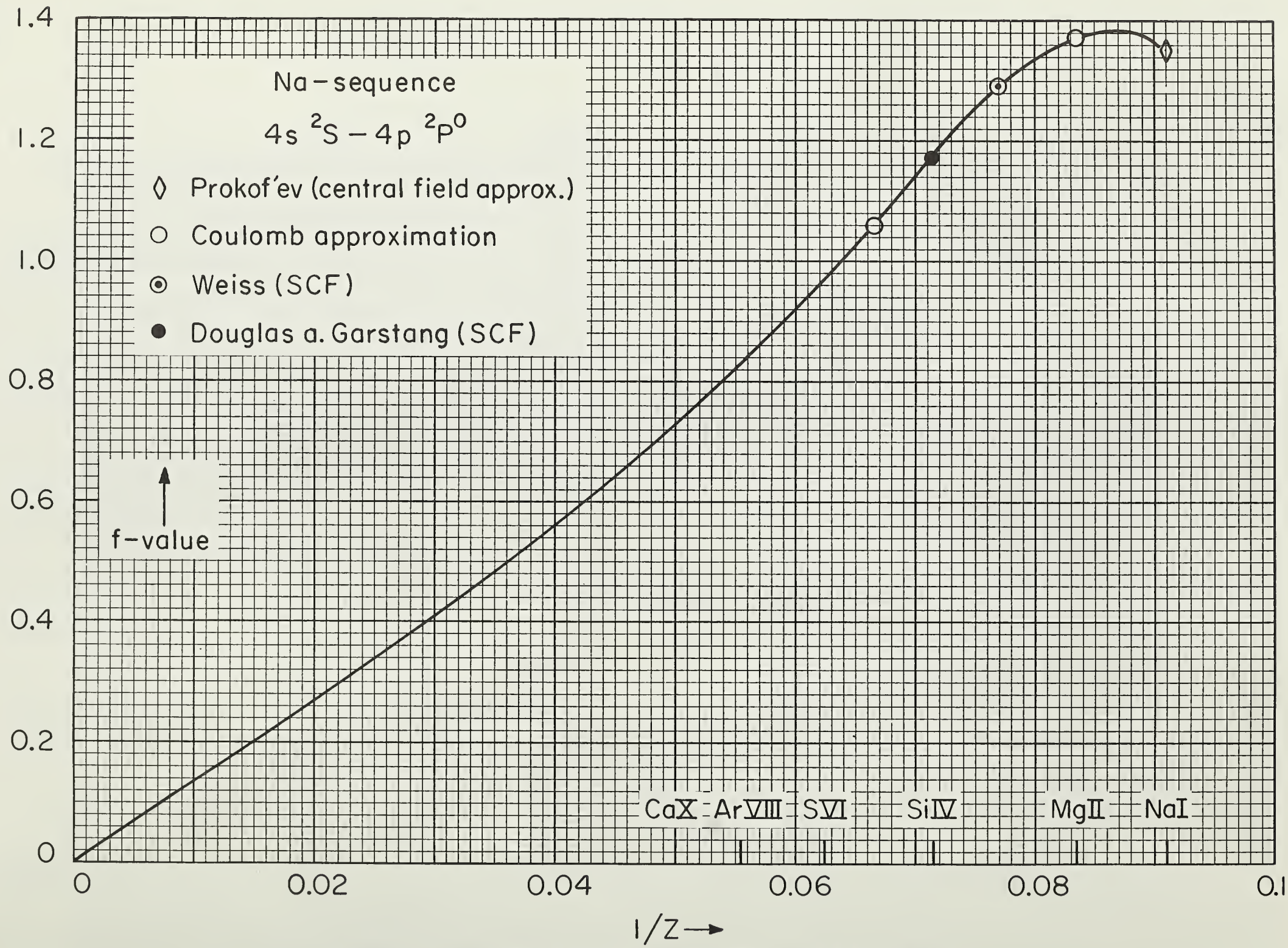

FIGURE 19. *f-value versus* 1/Z *for the* Na-*sequence transition* 4s $^2S-4p\ ^2P^o$.
The complete references are listed in the introductions for each of the spectra involved.

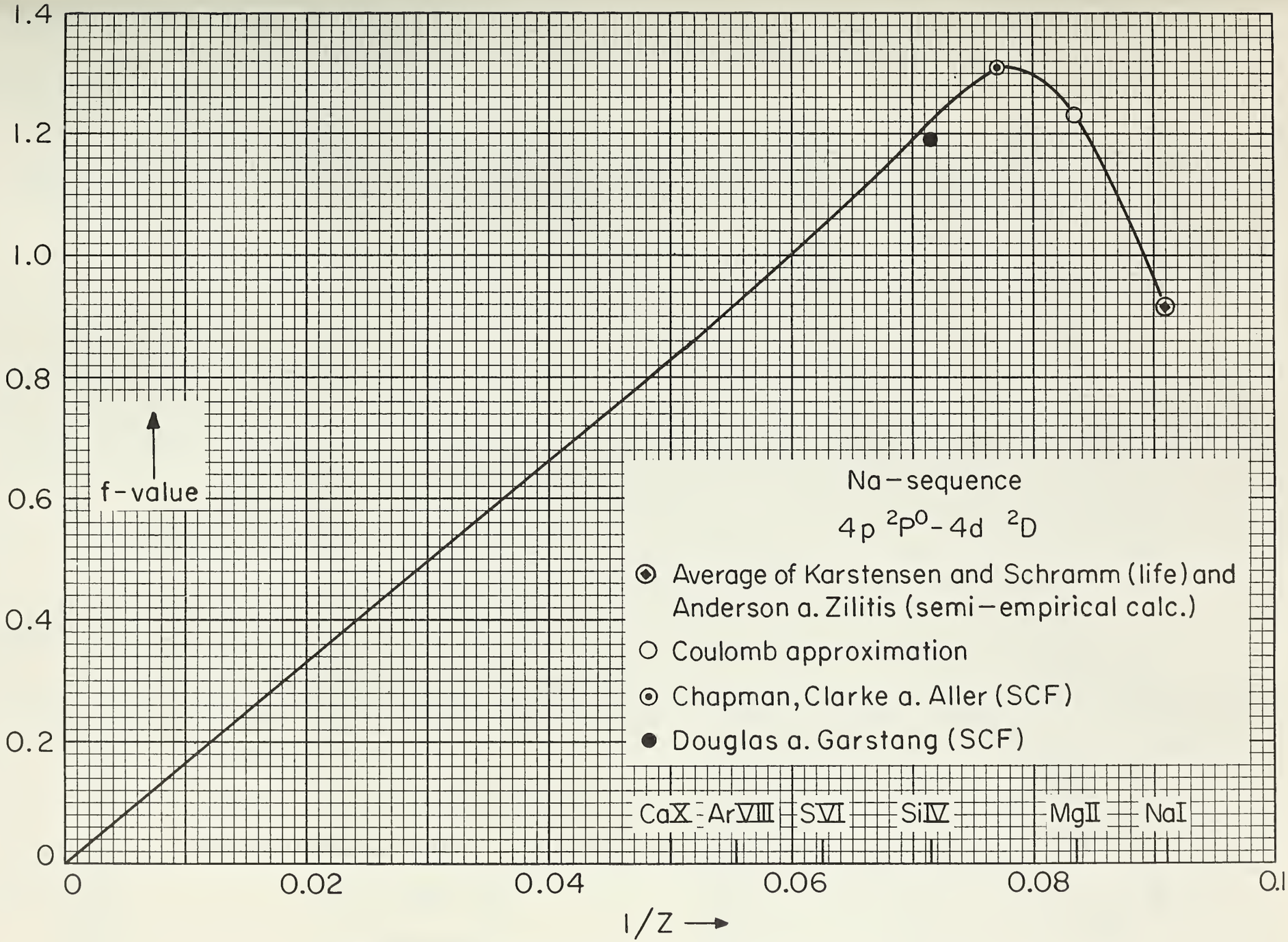

FIGURE 20. *f-value versus* 1/Z *for the* Na-*sequence transition* 4p $^2P^\circ$–4d ^2D.
The complete references are listed in the introductions for each of the spectra involved.

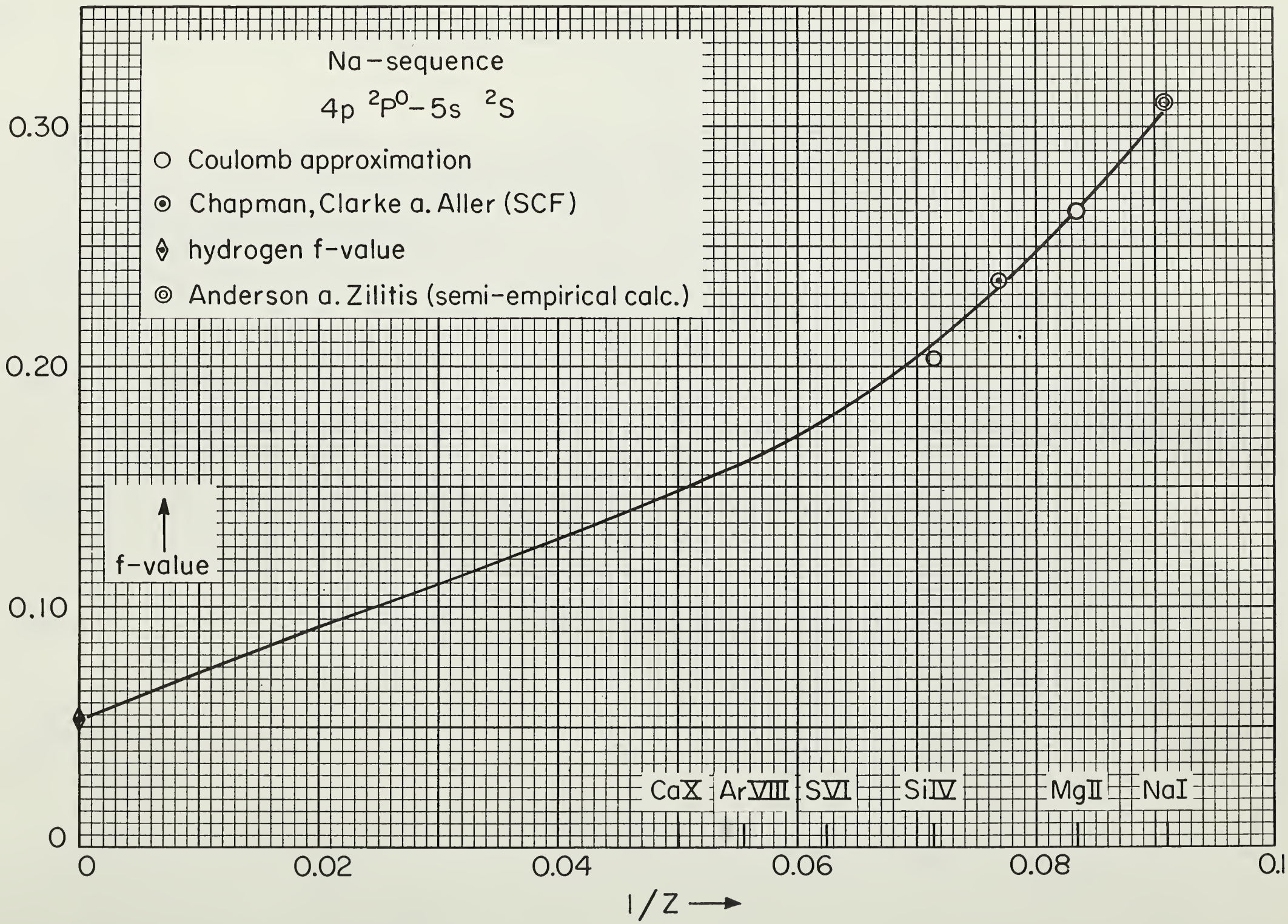

FIGURE 21. *f-value versus* 1/Z *for the* Na-*sequence transition* 4p $^2P^o-5s\ ^2S$.
The complete references are listed in the introductions for each of the spectra involved.

SODIUM

Na I

Ground State $1s^22s^22p^63s\ ^2S_{1/2}$

Ionization Potential 5.138 eV = 41449.65 cm^{-1}

Allowed Transitions

List of tabulated lines:

Wavelength [Å]	No.	Wavelength [Å]	No.	Wavelength [Å]	No.
2433.8	16	4545.19	21	9990.3	64
2436.6	15	4664.81	31	9996.3	64
2440.0	14	4668.56	31	10176	73
2444.2	13	4668.6	31	10183	73
2449.4	12	4747.94	20	10290	63
2455.9	11	4751.82	20	10296	63
2464.4	10	4978.54	30	10566.0	72
2475.5	9	4982.8	30	10572	72
2490.70	8	4982.81	30	10572.3	72
2512.1	7	5148.84	19	10741	62
2543.8	6	5153.40	19	10746.4	49
2593.9	5	5682.63	29	10747	62
2680.4	4	5688.19	29	10749.3	49
2852.81	3	5688.21	29	10834.9	42
2853.01	3	5889.95	1	11190.2	71
3302.37	2	5895.92	1	11197	71
3302.98	2	6154.23	18	11197.2	71
4192.9	38	6160.75	18	11381.5	17
4195.9	38	6632.1	58	11403.8	17
4198.0	27	6680.0	57	11490	61
4201.0	27	6743.1	56	11498	61
4212.9	37	6827.3	55	12311.5	70
4215.9	37	6944.0	54	12320.0	70
4220.2	26	7113.0	53	12679.2	41
4223.2	26	7373.3	52	12695	86
4238.99	36	7810.0	51	12771	85
4242.08	36	8183.26	28	12867	84
4242.1	36	8194.79	28	12907.9	60
4249.41	25	8194.82	28	12917.3	60
4252.52	25	8650.3	50	12984	83
4273.64	35	8796	47	13132	82
4276.79	35	8942.96	46	13321	81
4276.8	35	9153.88	45	13574	80
4287.84	24	9465.94	44	13920	79
4291.01	24	9492.3	77	14414	78
4321.40	34	9497.7	77	14767.5	69
4324.6	34	9518.5	67	14779.7	69
4324.62	34	9523.9	67	14780	69
4341.49	23	9595.2	76	16373.9	59
4344.74	23	9600.8	76	16388.9	59
4390.03	33	9633.1	66	18465.3	40
4393.3	33	9638.7	66	22056.4	48
4393.34	33	9731.6	75	22083.7	48
4419.89	22	9737.3	75	23348.4	68
4423.25	22	9785.9	65	23379	68
4494.18	32	9791.6	65	23379.1	68
4497.66	32	9916.0	74	90880	39
4497.7	32	9921.9	74	91380	39
4541.63	21	9961.28	43		

Numerous determinations of the oscillator strengths for the famous D-lines of the $3s-3p$ doublet are available. It is surprising to find that even among the fairly recent values, differences of up to 30 percent exist (e.g., compare the multiplet oscillator strength value of 1.24 obtained from an anomalous dispersion method by Kvater [1] with a value of 0.96 obtained from a lifetime measurement by Kibble, et. al. [2]). The adopted value for the doublet is the average of the supposedly most refined versions of precise experimental and theoretical methods. Specifically it includes the results of a self-consistent field calculation including polarization effects by Biermann and Lübeck [3], a central field approximation by Prokof'ev [4], a magnetic rotation experiment by Stephenson [5], lifetime determinations with the phase-shift technique by Cunningham and Link [6], with the delayed coincidence method of Kibble, et. al. [2], and with the Hanle-effect method by Baylis [8]. An uncertainty of less than 3 percent for the averaged value is indicated by the good agreement among the various selected results.

Values for the $3s-4p$, $3s-5p$, $3s-6p$, $3p-4s$ and $4s-4p$ transitions are taken solely from the calculations of Prokof'ev [4], which are considered more advanced than any of the other available approaches. (It should be noted that differences between the various methods are usually only of the order of a few percent.) For the transitions $3s-np$, where n runs from 7 to 18, the semi-empirical calculations of Anderson and Zilitis [9], and the *relative* anomalous dispersion measurements of Filippov and Prokof'ev [10] are available. When multiplied by a factor of 0.0134, the values of Filippov and Prokof'ev are found to agree with those of Anderson and Zilitis to within 15 percent; therefore, an average of the normalized values of Filippov and Prokof'ev and the results of Anderson and Zilitis is taken for the above transitions. The lifetime measurement of the $4d$ level by Karstensen and Schramm [7] has been applied to the transitions $3p-4d$ and $4p-4d$, together with the above-quoted calculations by Prokof'ev [4] and Anderson and Zilitis [9]. Experiment and theory (i.e., the sum of the calculated transition probabilities) agree within 6 percent. The branching ratios are based solely on the calculated results.

For all other transitions, the only available sources are the Coulomb approximation and the semi-empirical calculations of Anderson and Zilitis. Agreement between the two methods is good in general; however, the semi-empirical method of Anderson and Zilitis is considered more refined and their values are used in all cases. For the $3p-6s$, $3p-4d$ and $3p-5d$ transitions, additional results are available from self-consistent field calculations by Chapman, et. al. [11]. These agree within a few percent with the adopted values.

References

[1] Kvater, G. S., Vestnik Leningrad Univ. Ser. Fiz. i Khim. No. 2, 135–141 (1947). (Translated in "Optical Transition Probabilities," Office of Technical Services, U.S. Dept. of Commerce, Washington, D.C.)
[2] Kibble, B. P., Copley, G., and Krause, L., Phys. Rev. **153**, 9–12 (1967).
[3] Biermann, L., and Lübeck, K., Z. Astrophys. **25**, 325–339 (1948).
[4] Prokof'ev, V. K., Z. Physik **58**, 255–267 (1929).
[5] Stephenson, G., Proc. Phys. Soc. London **A64**, 458–464 (1951).
[6] Cunningham, P. T., and Link, J. K., J. Opt. Soc. Am **57**, 1000–1007 (1967).
[7] Karstensen, F., and Schramm, J., Z. Physik **195**, 370–379 (1966).
[8] Baylis, W., Thesis Munich (1967) and to be published.
[9] Anderson, E. M., and Zilitis, V. A., Optics and Spectroscopy (U.S.S.R.) **16**, 99–101 (1964).
[10] Filippov, A., and Prokof'ev, V. K., Z. Physik **56**, 458–476 (1929).
[11] Chapman, R. D., Clarke, W. H., and Aller, L. H., Astrophys. J. **144**, 376–380 (1966).

Na I. Allowed Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
1	$3s-3p$	$^2S-^2P^\circ$ (1)	*5891.8*	0	*16968*	2	6	0.629	0.982	38.1	0.293	A	2, 3, 4, 5, 6, 8
			5889.95	0	16973	2	4	0.630	0.655	25.4	0.117	A	*ls*
			5895.92	0	16956	2	2	0.628	0.327	12.7	−0.184	A	*ls*
2	$3s-4p$	$^2S-^2P^\circ$ (2)	*3302.6*	0	*30271*	2	6	0.0292	0.0142	0.311	−1.55	C+	4
			3302.37	0	30273	2	4	0.0290	0.0094	0.207	−1.73	C+	*ls*
			3302.98	0	30267	2	2	0.0293	0.00477	0.104	−2.021	C+	*ls*

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
3	$3s-5p$	$^2S-^2P^\circ$ (1 uv)	*2852.8*	0	*35042*	2	6	0.0060	0.00221	0.0415	−2.355	C+	4
			2852.81	0	35043	2	4	0.0060	0.00147	0.0276	−2.53	C+	*ls*
			2853.01	0	35040	2	2	0.0060	7.4×10^{-4}	0.0138	−2.83	C+	*ls*
4	$3s-6p$	$^2S-^2P^\circ$ (2 uv)	*2680.4*	0	*37297*	2	6	0.00226	7.3×10^{-4}	0.0129	−2.84	C+	4
5	$3s-7p$	$^2S-^2P^\circ$ (3 uv)	*2593.9*	0	*38541*	2	6	0.00120	3.61×10^{-4}	0.0062	−3.140	C+	9, 10*n*
6	$3s-8p$	$^2S-^2P^\circ$ (4 uv)	*2543.8*	0	*39299*	2	6	6.6×10^{-4}	1.92×10^{-4}	0.00322	−3.416	C+	9, 10*n*
7	$3s-9p$	$^2S-^2P^\circ$ (5 uv)	*2512.1*	0	*39795*	2	6	4.05×10^{-4}	1.15×10^{-4}	0.00190	−3.64	C+	9, 10*n*
8	$3s-10p$	$^2S-^2P^\circ$ (6 uv)	2490.70	0	40137	2	6	2.76×10^{-4}	7.7×10^{-5}	0.00126	−3.81	C+	9, 10*n*
9	$3s-11p$	$^2S-^2P^\circ$	[2475.5]	0	40383	2	6	1.94×10^{-4}	5.3×10^{-5}	8.7×10^{-4}	−3.97	C+	9, 10*n*
10	$3s-12p$	$^2S-^2P^\circ$	[2464.4]	0	40566	2	6	1.44×10^{-4}	3.92×10^{-5}	6.4×10^{-4}	−4.105	C+	9, 10*n*
11	$3s-13p$	$^2S-^2P^\circ$	[2455.9]	0	40705	2	6	1.12×10^{-4}	3.03×10^{-5}	4.90×10^{-4}	−4.218	C+	9, 10*n*
12	$3s-14p$	$^2S-^2P^\circ$	[2449.4]	0	40814	2	6	8.6×10^{-5}	2.31×10^{-5}	3.73×10^{-4}	−4.335	C+	9, 10*n*
13	$3s-15p$	$^2S-^2P^\circ$	[2444.2]	0	40901	2	6	6.8×10^{-5}	1.84×10^{-5}	2.96×10^{-4}	−4.434	C+	9, 10*n*
14	$3s-16p$	$^2S-^2P^\circ$	[2440.0]	0	40971	2	6	5.6×10^{-5}	1.50×10^{-5}	2.41×10^{-4}	−4.52	C+	9, 10*n*
15	$3s-17p$	$^2S-^2P^\circ$	[2436.6]	0	41028	2	6	4.64×10^{-5}	1.24×10^{-5}	1.99×10^{-4}	−4.61	C+	9, 10*n*
16	$3s-18p$	$^2S-^2P^\circ$	[2433.8]	0	41076	2	6	3.87×10^{-5}	1.03×10^{-5}	1.65×10^{-4}	−4.69	C+	9, 10*n*
17	$3p-4s$	$^2P^\circ-^2S$ (3)	*11397*	*16968*	25740	6	2	0.251	0.163	36.7	−0.010	C	4
			11403.8	16973	25740	4	2	0.167	0.163	24.5	−0.186	C	*ls*
			11381.5	16956	25740	2	2	0.084	0.163	12.2	−0.487	C	*ls*
18	$3p-5s$	$^2P^\circ-^2S$ (5)	*6158.6*	*16968*	33201	6	2	0.072	0.0137	1.67	−1.085	C	9
			6160.75	16973	33201	4	2	0.0482	0.0137	1.11	−1.261	C	*ls*
			6154.23	16956	33201	2	2	0.0241	0.0137	0.56	−1.56	C	*ls*
19	$3p-6s$	$^2P^\circ-^2S$ (8)	*5151.9*	*16968*	36373	6	2	0.0330	0.00437	0.445	−1.58	C	9
			5153.40	16973	36373	4	2	0.0220	0.00437	0.297	−1.76	C	*ls*
			5148.84	16956	36373	2	2	0.0110	0.00437	0.148	−2.058	C	*ls*
20	$3p-7s$	$^2P^\circ-^2S$ (11)	*4750.6*	*16968*	38012	6	2	0.0178	0.00201	0.189	−1.92	C	9
			4751.82	16973	38012	4	2	0.0119	0.00201	0.126	−2.095	C	*ls*
			4747.94	16956	38012	2	2	0.0059	0.00201	0.063	−2.396	C	*ls*
21	$3p-8s$	$^2P^\circ-^2S$ (14)	*4544.2*	*16968*	38969	6	2	0.0108	0.00111	0.100	−2.177	C	9
			4545.19	16973	38969	4	2	0.0072	0.00111	0.066	−2.353	C	*ls*
			4541.63	16956	38969	2	2	0.00359	0.00111	0.0332	−2.65	C	*ls*
22	$3p-9s$	$^2P^\circ-^2S$ (16)	*4422.2*	*16968*	39575	6	2	0.0070	6.8×10^{-4}	0.060	−2.387	C	9
			4423.25	16973	39575	4	2	0.00466	6.8×10^{-4}	0.0398	−2.56	C	*ls*
			4419.89	16956	39575	2	2	0.00233	6.8×10^{-4}	0.0199	−2.86	C	*ls*

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
23	$3p-10s$	$^2P^\circ-{}^2S$	*4343.8*	*16968*	39983	6	2	0.00480	4.53×10^{-4}	0.0389	−2.57	C	9
			4344.74	16973	39983	4	2	0.00320	4.53×10^{-4}	0.0259	−2.74	C	*ls*
			4341.49	16956	39983	2	2	0.00160	4.53×10^{-4}	0.0129	−3.043	C	*ls*
24	$3p-11s$	$^2P^\circ-{}^2S$	*4289.5*	*16968*	40271	6	2	0.00357	3.28×10^{-4}	0.0278	−2.71	C	9
			4291.01	16973	40271	4	2	0.00238	3.28×10^{-4}	0.0185	−2.88	C	*ls*
			4287.84	16956	40271	2	2	0.00119	3.28×10^{-4}	0.0093	−3.183	C	*ls*
25	$3p-12s$	$^2P^\circ-{}^2S$	*4251.4*	*16968*	40482	6	2	0.00260	2.35×10^{-4}	0.0197	−2.85	C	9
			4252.52	16973	40482	4	2	0.00173	2.35×10^{-4}	0.0132	−3.027	C	*ls*
			4249.41	16956	40482	2	2	8.7×10^{-4}	2.35×10^{-4}	0.0066	−3.328	C	*ls*
26	$3p-13s$	$^2P^\circ-{}^2S$	*4222.3*	*16968*	40644	6	2	0.00212	1.89×10^{-4}	0.0158	−2.95	C	9
			[4223.2]	16973	40644	4	2	0.00141	1.89×10^{-4}	0.0105	−3.122	C	*ls*
			[4220.2]	16956	40644	2	2	7.1×10^{-4}	1.89×10^{-4}	0.0053	−3.423	C	*ls*
27	$3p-14s$	$^2P^\circ-{}^2S$	*4200.1*	*16968*	40769	6	2	0.00177	1.56×10^{-4}	0.0129	−3.029	C	9
			[4201.0]	16973	40769	4	2	0.00118	1.56×10^{-4}	0.0086	−3.205	C	*ls*
			[4198.0]	16956	40769	2	2	5.9×10^{-4}	1.56×10^{-4}	0.00431	−3.51	C	*ls*
28	$3p-3d$	$^2P^\circ-{}^2D$ (4)	*8191.1*	*16968*	29173	6	10	0.495	0.83	135	0.70	C	4
			8194.82	16973	29173	4	6	0.495	0.75	81	0.477	C	*ls*
			8183.26	16956	29173	2	4	0.413	0.83	44.7	0.220	C	*ls*
			8194.79	16973	29173	4	4	0.082	0.083	9.0	−0.479	C	*ls*
29	$3p-4d$	$^2P^\circ-{}^2D$ (6)	*5686.4*	*16968*	34549	6	10	0.131	0.106	11.9	−0.197	C+	4, 7
			5688.21	16973	34549	4	6	0.131	0.095	7.1	−0.420	C+	*ls*
			5682.63	16956	34549	2	4	0.109	0.106	3.97	−0.67	C+	*ls*
			5688.19	16973	34549	4	4	0.0219	0.0106	0.79	−1.373	C+	*ls*
30	$3p-5d$	$^2P^\circ-{}^2D$ (9)	*4981.4*	*16968*	37037	6	10	0.050	0.0311	3.06	−0.73	C	9
			4982.81	16973	37037	4	6	0.050	0.0280	1.84	−0.95	C	*ls*
			4978.54	16956	37037	2	4	0.0418	0.0311	1.02	−1.206	C	*ls*
			[4982.8]	16973	37037	4	4	0.0084	0.00311	0.204	−1.91	C	*ls*
31	$3p-6d$	$^2P^\circ-{}^2D$ (12)	*4667.5*	*16968*	38387	6	10	0.0257	0.0140	1.29	−1.076	C	9
			4668.56	16973	38387	4	6	0.0257	0.0126	0.77	−1.298	C	*ls*
			4664.81	16956	38387	2	4	0.0214	0.0140	0.430	−1.55	C	*ls*
			[4668.6]	16973	38387	4	4	0.00428	0.00140	0.086	−2.252	C	*ls*
32	$3p-7d$	$^2P^\circ-{}^2D$ (15)	*4496.6*	*16968*	39201	6	10	0.0151	0.0076	0.68	−1.341	C	9
			4497.66	16973	39201	4	6	0.0151	0.0069	0.406	−1.56	C	*ls*
			4494.18	16956	39201	2	4	0.0126	0.0076	0.225	−1.82	C	*ls*
			[4497.7]	16973	39201	4	4	0.00251	7.6×10^{-4}	0.0451	−2.52	C	*ls*
33	$3p-8d$	$^2P^\circ-{}^2D$ (17)	*4392.3*	*16968*	39729	6	10	0.0097	0.00466	0.404	−1.55	C	9
			4393.34	16973	39729	4	6	0.0097	0.00419	0.242	−1.78	C	*ls*
			4390.03	16956	39729	2	4	0.0081	0.00466	0.135	−2.031	C	*ls*
			[4393.3]	16973	39729	4	4	0.00161	4.66×10^{-4}	0.0270	−2.73	C	*ls*
34	$3p-9d$	$^2P^\circ-{}^2D$	*4323.5*	*16968*	40090	6	10	0.0066	0.00307	0.262	−1.73	C	9
			4324.62	16973	40090	4	6	0.0066	0.00276	0.157	−1.96	C	*ls*
			4321.40	16956	40090	2	4	0.0055	0.00307	0.087	−2.212	C	*ls*
			[4324.6]	16973	40090	4	4	0.00109	3.07×10^{-4}	0.0175	−2.91	C	*ls*

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
35	$3p-10d$	$^2P^\circ-^2D$	*4275.8*	*16968*	40349	6	10	0.00468	0.00214	0.181	−1.89	C	9
			4276.79	16973	40349	4	6	0.00469	0.00193	0.109	−2.112	C	*ls*
			4273.64	16956	40349	2	4	0.00391	0.00214	0.060	−2.369	C	*ls*
			[4276.8]	16973	40349	4	4	7.8×10^{-4}	2.14×10^{-4}	0.0121	−3.068	C	*ls*
36	$3p-11d$	$^2P^\circ-^2D$	*4241.1*	*16968*	40540	6	10	0.00347	0.00156	0.131	−2.029	C	9
			4242.08	16973	40540	4	6	0.00346	0.00140	0.078	−2.252	C	*ls*
			4238.99	16956	40540	2	4	0.00290	0.00156	0.0435	−2.51	C	*ls*
			[4242.1]	16973	40540	4	4	5.8×10^{-4}	1.56×10^{-4}	0.0087	−3.205	C	*ls*
37	$3p-12d$	$^2P^\circ-^2D$	*4215.0*	*16968*	40685	6	10	0.00264	0.00117	0.097	−2.154	C	9
			[4215.9]	16973	40685	4	6	0.00263	0.00105	0.058	−2.377	C	*ls*
			[4212.9]	16956	40685	2	4	0.00220	0.00117	0.0325	−2.63	C	*ls*
			[4215.9]	16973	40685	4	4	4.39×10^{-4}	1.17×10^{-4}	0.0065	−3.330	C	*ls*
38	$3p-13d$	$^2P^\circ-^2D$	*4195.0*	*16968*	40798	6	10	0.00204	9.0×10^{-4}	0.074	−2.269	C	9
			[4195.9]	16973	40798	4	6	0.00204	8.1×10^{-4}	0.0446	−2.491	C	*ls*
			[4192.9]	16956	40798	2	4	0.00170	9.0×10^{-4}	0.0248	−2.75	C	*ls*
			[4195.9]	16973	40798	4	4	3.40×10^{-4}	9.0×10^{-5}	0.00496	−3.445	C	*ls*
39	$3d-4p$	$^2D-^2P^\circ$	*91050*	29173	*30271*	10	6	0.00157	0.117	351	0.068	C	9
			[90880]	29173	30273	6	4	0.00142	0.117	211	−0.154	C	*ls*
			[91380]	29173	30267	4	2	0.00156	0.098	118	−0.407	C	*ls*
			[90880]	29173	30273	4	4	1.57×10^{-4}	0.0195	23.3	−1.108	C	*ls*
40	$3d-4f$	$^2D-^2F^\circ$	18465.3	29173	34587	10	14	0.140	1.00	610	0.99	C	9
41	$3d-5f$	$^2D-^2F^\circ$ (21)	12679.2	29173	37058	10	14	0.0471	0.159	66	0.201	C	9
42	$3d-6f$	$^2D-^2F^\circ$ (22)	10834.9	29173	38400	10	14	0.0224	0.055	19.7	−0.257	C	9
43	$3d-7f$	$^2D-^2F^\circ$ (23)	9961.28	29173	39209	10	14	0.0127	0.0264	8.7	−0.58	C	9
44	$3d-8f$	$^2D-^2F^\circ$ (24)	9465.94	29173	39734	10	14	0.0079	0.0149	4.64	−0.83	C	9
45	$3d-9f$	$^2D-^2F^\circ$ (25)	9153.88	29173	40094	10	14	0.0053	0.0093	2.79	−1.033	C	9
46	$3d-10f$	$^2D-^2F^\circ$ (26)	8942.96	29173	40352	10	14	0.00371	0.0062	1.83	−1.206	C	9
47	$3d-11f$	$^2D-^2F^\circ$ (27)	8796	29173	40539	10	14	0.00245	0.00414	1.22	−1.383	C	9
48	$4s-4p$	$^2S-^2P^\circ$	*22070*	25740	*30271*	2	6	0.062	1.35	197	0.431	C	4
			22056.4	25740	30273	2	4	0.062	0.90	131	0.255	C	*ls*
			22083.7	25740	30267	2	2	0.062	0.450	66	−0.046	C	*ls*
49	$4s-5p$	$^2S-^2P^\circ$ (18)	*10747*	25740	*35042*	2	6	0.0074	0.0385	2.72	−1.114	C	9
			10746.4	25740	35043	2	4	0.0074	0.0257	1.82	−1.289	C	*ls*
			10749.3	25740	35040	2	2	0.0074	0.0128	0.91	−1.59	C	*ls*
50	$4s-6p$	$^2S-^2P^\circ$ (19)	*8650.3*	25740	*37297*	2	6	0.00231	0.0078	0.444	−1.81	C	9
51	$4s-7p$	$^2S-^2P^\circ$ (20)	*7810.0*	25740	*38541*	2	6	0.00104	0.00284	0.146	−2.246	C	9

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
52	$4s-8p$	$^2S-^2P^\circ$	*7373.3*	25740	*39299*	2	6	5.6×10^{-4}	0.00136	0.066	−2.57	C	9
53	$4s-9p$	$^2S-^2P^\circ$	[7113.0]	25740	*39795*	2	6	3.36×10^{-4}	7.6×10^{-4}	0.0358	−2.82	C	9
54	$4s-10p$	$^2S-^2P^\circ$	[6944.0]	25740	40137	2	6	2.23×10^{-4}	4.84×10^{-4}	0.0221	−3.014	C	9
55	$4s-11p$	$^2S-^2P^\circ$	[6827.3]	25740	40383	2	6	1.53×10^{-4}	3.20×10^{-4}	0.0144	−3.194	C	9
56	$4s-12p$	$^2S-^2P^\circ$	[6743.1]	25740	40566	2	6	1.11×10^{-4}	2.27×10^{-4}	0.0101	−3.343	C	9
57	$4s-13p$	$^2S-^2P^\circ$	[6680.0]	25740	40705	2	6	8.5×10^{-5}	1.71×10^{-4}	0.0075	−3.466	C	9
58	$4s-14p$	$^2S-^2P^\circ$	[6632.1]	25740	40814	2	6	6.3×10^{-5}	1.25×10^{-4}	0.0055	−3.60	C	9
59	$4p-6s$	$^2P^\circ-^2S$	*16384*	*30271*	36373	6	2	0.0173	0.0232	7.5	−0.86	C	9
			16388.9	30273	36373	4	2	0.0115	0.0232	5.0	−1.033	C	*ls*
			16373.9	30267	36373	2	2	0.0058	0.0232	2.50	−1.334	C	*ls*
60	$4p-7s$	$^2P^\circ-^2S$	*12915*	*30271*	38012	6	2	0.0088	0.0073	1.86	−1.359	C	9
			12917.3	30273	38012	4	2	0.0058	0.0073	1.24	−1.53	C	*ls*
			12907.9	30267	38012	2	2	0.00292	0.0073	0.62	−1.84	C	*ls*
61	$4p-8s$	$^2P^\circ-^2S$	*11495*	*30271*	38968	6	2	0.0051	0.00340	0.77	−1.69	C	9
			[11498]	30273	38968	4	2	0.00343	0.00340	0.51	−1.87	C	*ls*
			[11490]	30267	38968	2	2	0.00172	0.00340	0.257	−2.168	C	*ls*
62	$4p-9s$	$^2P^\circ-^2S$	*10745*	*30271*	39575	6	2	0.00329	0.00190	0.403	−1.94	C	9
			[10747]	30273	39575	4	2	0.00219	0.00190	0.269	−2.119	C	*ls*
			[10741]	30267	39575	2	2	0.00110	0.00190	0.134	−2.420	C	*ls*
63	$4p-10s$	$^2P^\circ-^2S$	*10294*	*30271*	39983	6	2	0.00225	0.00119	0.242	−2.146	C	9
			[10296]	30273	39983	4	2	0.00150	0.00119	0.161	−2.322	C	*ls*
			[10290]	30267	39983	2	2	7.5×10^{-4}	0.00119	0.081	−2.62	C	*ls*
64	$4p-11s$	$^2P^\circ-^2S$	*9994.3*	*30271*	40271	6	2	0.00167	8.3×10^{-4}	0.164	−2.301	C	9
			[9996.3]	30273	40271	4	2	0.00111	8.3×10^{-4}	0.110	−2.477	C	*ls*
			[9990.3]	30267	40271	2	2	5.6×10^{-4}	8.3×10^{-4}	0.055	−2.78	C	*ls*
65	$4p-12s$	$^2P^\circ-^2S$	*9789.7*	*30271*	40482	6	2	0.00120	5.8×10^{-4}	0.112	−2.461	C	9
			[9791.6]	30273	40482	4	2	8.0×10^{-4}	5.8×10^{-4}	0.074	−2.64	C	*ls*
			[9785.9]	30267	40482	2	2	4.02×10^{-4}	5.8×10^{-4}	0.0372	−2.94	C	*ls*
66	$4p-13s$	$^2P^\circ-^2S$	*9636.8*	*30271*	40644	6	2	0.00100	4.63×10^{-4}	0.088	−2.56	C	9
			[9638.7]	30273	40644	4	2	6.6×10^{-4}	4.63×10^{-4}	0.059	−2.73	C	*ls*
			[9633.1]	30267	40644	2	2	3.33×10^{-4}	4.63×10^{-4}	0.0294	−3.033	C	*ls*
67	$4p-14s$	$^2P^\circ-^2S$	*9522.1*	*30271*	40769	6	2	8.5×10^{-4}	3.87×10^{-4}	0.073	−2.63	C	9
			[9523.9]	30273	40769	4	2	5.7×10^{-4}	3.87×10^{-4}	0.0485	−2.81	C	*ls*
			[9518.5]	30267	40769	2	2	2.85×10^{-4}	3.87×10^{-4}	0.0243	−3.111	C	*ls*
68	$4p-4d$	$^2P^\circ-^2D$	*23370*	*30271*	34549	6	10	0.067	0.91	420	0.74	C+	7, 9
			23379.1	30273	34549	4	6	0.067	0.82	252	0.52	C+	*ls*
			23348.4	30267	34549	2	4	0.056	0.91	140	0.260	C+	*ls*
			[23379]	30273	34549	4	4	0.0111	0.091	28.0	−0.439	C+	*ls*

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
69	$4p-5d$	$^2P^\circ-^2D$	*14776*	*30271*	37037	6	10	0.0260	0.142	41.4	−0.070	C+	9
			14779.7	30273	37037	4	6	0.0261	0.128	24.9	−0.291	C+	*ls*
			14767.5	30267	37037	2	4	0.0217	0.142	13.8	−0.55	C+	*ls*
			[14780]	30273	37037	4	4	0.00434	0.0142	2.76	−1.246	C+	*ls*
70	$4p-6d$	$^2P^\circ-^2D$	*12318*	*30271*	38387	6	10	0.0130	0.0493	12.0	−0.53	C+	9
			12320.0	30273	38387	4	6	0.0130	0.0444	7.2	−0.75	C+	*ls*
			12311.5	30267	38387	2	4	0.0108	0.0493	4.00	−1.006	C+	*ls*
			[12320]	30273	38387	4	4	0.00217	0.00493	0.80	−1.71	C+	*ls*
71	$4p-7d$	$^2P^\circ-^2D$	*11195*	*30271*	39201	6	10	0.0075	0.0235	5.2	−0.85	C+	9
			11197.2	30273	39201	4	6	0.0075	0.0212	3.13	−1.072	C+	*ls*
			11190.2	30267	39201	2	4	0.0063	0.0235	1.73	−1.328	C+	*ls*
			[11197]	30273	39201	4	4	0.00125	0.00235	0.347	−2.027	C+	*ls*
72	$4p-8d$	$^2P^\circ-^2D$	*10570*	*30271*	39729	6	10	0.00476	0.0133	2.78	−1.098	C+	9
			10572.3	30273	39729	4	6	0.00477	0.0120	1.67	−1.319	C+	*ls*
			10566.0	30267	39729	2	4	0.00397	0.0133	0.93	−1.58	C+	*ls*
			[10572]	30273	39729	4	4	7.9×10^{-4}	0.00133	0.185	−2.274	C+	*ls*
73	$4p-9d$	$^2P^\circ-^2D$	*10181*	*30271*	40090	6	10	0.00323	0.0084	1.68	−1.299	C	9
			[10183]	30273	40090	4	6	0.00323	0.0075	1.01	−1.52	C	*ls*
			[10176]	30267	40090	2	4	0.00270	0.0084	0.56	−1.77	C	*ls*
			[10183]	30273	40090	4	4	5.4×10^{-4}	8.4×10^{-4}	0.112	−2.475	C	*ls*
74	$4p-10d$	$^2P^\circ-^2D$	*9919.9*	*30271*	40349	6	10	0.00230	0.0057	1.11	−1.470	C	9
			[9921.9]	30273	40349	4	6	0.00230	0.0051	0.67	−1.69	C	*ls*
			[9916.0]	30267	40349	2	4	0.00192	0.0057	0.369	−1.95	C	*ls*
			[9921.9]	30273	40349	4	4	3.83×10^{-4}	5.7×10^{-4}	0.074	−2.65	C	*ls*
75	$4p-11d$	$^2P^\circ-^2D$	*9735.4*	*30271*	40540	6	10	0.00169	0.00400	0.77	−1.62	C	9
			[9737.3]	30273	40540	4	6	0.00169	0.00360	0.462	−1.84	C	*ls*
			[9731.6]	30267	40540	2	4	0.00141	0.00400	0.256	−2.097	C	*ls*
			[9737.3]	30273	40540	4	4	2.81×10^{-4}	4.00×10^{-4}	0.051	−2.80	C	*ls*
76	$4p-12d$	$^2P^\circ-^2D$	*9598.9*	*30271*	40685	6	10	0.00129	0.00296	0.56	−1.75	C	9
			[9600.8]	30273	40685	4	6	0.00128	0.00266	0.336	−1.97	C	*ls*
			[9595.2]	30267	40685	2	4	0.00107	0.00296	0.187	−2.228	C	*ls*
			[9600.8]	30273	40685	4	4	2.14×10^{-4}	2.96×10^{-4}	0.0374	−2.93	C	*ls*
77	$4p-13d$	$^2P^\circ-^2D$	*9495.9*	*30271*	40798	6	10	9.9×10^{-4}	0.00224	0.420	−1.87	C	9
			[9497.7]	30273	40798	4	6	0.00100	0.00202	0.253	−2.093	C	*ls*
			[9492.3]	30267	40798	2	4	8.3×10^{-4}	0.00224	0.140	−2.349	C	*ls*
			[9497.7]	30273	40798	4	4	1.66×10^{-4}	2.24×10^{-4}	0.0280	−3.048	C	*ls*
78	$5s-10p$	$^2S-^2P^\circ$	[14414]	33201	40137	2	6	1.64×10^{-4}	0.00153	0.145	−2.51	C	9
79	$5s-11p$	$^2S-^2P^\circ$	[13920]	33201	40383	2	6	1.10×10^{-4}	9.6×10^{-4}	0.088	−2.72	C	9
80	$5s-12p$	$^2S-^2P^\circ$	[13574]	33201	40566	2	6	7.9×10^{-5}	6.6×10^{-4}	0.059	−2.88	C	9
81	$5s-13p$	$^2S-^2P^\circ$	[13321]	33201	40705	2	6	6.0×10^{-5}	4.76×10^{-4}	0.0417	−3.021	C	9
82	$5s-14p$	$^2S-^2P^\circ$	[13132]	33201	40814	2	6	4.45×10^{-5}	3.45×10^{-4}	0.0298	−3.161	C	9
83	$5s-15p$	$^2S-^2P^\circ$	[12984]	33201	40901	2	6	3.48×10^{-5}	2.64×10^{-4}	0.0226	−3.277	C	9
84	$5s-16p$	$^2S-^2P^\circ$	[12867]	33201	40971	2	6	2.78×10^{-5}	2.07×10^{-4}	0.0175	−3.383	C	9
85	$5s-17p$	$^2S-^2P^\circ$	[12771]	33201	41028	2	6	2.33×10^{-5}	1.71×10^{-4}	0.0144	−3.466	C	9
86	$5s-18p$	$^2S-^2P^\circ$	[12695]	33201	41076	2	6	1.93×10^{-5}	1.40×10^{-4}	0.0117	−3.55	C	9

Na II

Ground State $1s^2 2s^2 2p^6\ ^1S_0$

Ionization Potential 47.29 eV = 381528 cm^{-1}

Allowed Transitions

Calculations by Kastner, Omidvar, and Underwood [1], employing Hartree-Fock wavefunctions and including intermediate coupling, are available. Since the calculations are based on a single-configuration approximation only, uncertainties of up to 50 percent are expected for the strong lines and even higher uncertainties for the weak lines, the latter being more affected by assumptions about the coupling.

Reference

[1] Kastner, S. O., Omidvar, K., and Underwood, J. H., Astrophys. J. **148**, 269–273 (1967).

Na II. Allowed Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
1	$2p^6 - 2p^5(^2P^\circ_{3/2})3s$	$^1S - ^3P^\circ$ (1 uv)	376.375	0	265693	1	3	1.5	0.0093	0.012	−2.03	E	1
2	$2p^6 - 2p^5(^2P^\circ_{1/2})3s$	$^1S - ^1P^\circ$ (2 uv)	372.069	0	268767	1	3	31	0.19	0.23	−0.72	D	1
3	$2p^6 - 2p^5(^2P^\circ_{3/2})3d$	$^1S - ^3P^\circ$	[302.44]	0	330641	1	3	1.4	0.0057	0.0057	−2.24	E	1
4	$2p^6 - 2p^5(^2P^\circ_{3/2})3d$	$^1S - ^1P^\circ$ (3 uv)	301.432	0	331749	1	3	9.5	0.039	0.039	−1.41	D	1
5	$2p^6 - 2p^5(^2P^\circ_{1/2})3d$	$^1S - ^3D^\circ$ (4 uv)	300.151	0	333167	1	3	30	0.12	0.12	−0.92	D	1

Ground State $1s^22s^22p^5\ ^2P^\circ_{3/2}$

Ionization Potential 71.65 eV = 578033 cm^{-1}

Allowed Transitions

List of tabulated lines:

Wavelength [Å]	No.	Wavelength [Å]	No.	Wavelength [Å]	No.
378.14	1	1970.6	14	2180.8	12
380.11	1	1976.4	13	2182.8	3
1752.7	9	1985.5	4	2194.8	12
1761.7	9	1995.6	14	2202.8	3
1763.8	9	2004.8	15	2214.2	3
1773.0	9	2005.2	4	2222.8	12
1782.9	9	2005.2	14	2225.3	7
1791.2	9	2011.9	13	2225.9	3
1801.3	9	2022.3	10	2230.3	3
1838.1	8	2028.6	10	2232.2	7
1844.3	8	2031.1	14	2239.5	3
1845.1	8	2036.9	15	2246.7	3
1849.6	8	2037.8	10	2251.5	3
1850.3	8	2045.5	10	2278.5	7
1855.9	8	2048.7	10	2285.7	7
1856.7	8	2051.9	10	2310.0	6
1861.2	8	2055.2	10	2367.3	6
1899.7	11	2058.8	10	2406.6	5
1918.5	11	2063.0	10	2459.4	5
1920.1	11	2065.3	10	2468.9	5
1926.3	11	2067.4	17	2474.7	2
1935.6	11	2073.3	17	2497.0	2
1939.3	11	2101.5	17	2510.3	2
1941.8	11	2107.7	17	2530.2	2
1942.2	13	2144.8	16	2542.9	2
1950.8	11	2151.2	16	2553.6	2
1951.2	4	2174.5	16	2563.3	2
1965.1	11				

For the $2s^22p^5\ ^2P^\circ - 2s2p^6\ ^2S$ multiplet, Cohen and Dalgarno [1] using the nuclear charge-expansion method and Bagus [2] using the self-consistent field approximation arrive at identical results. The quoted value may be nevertheless quite uncertain since configuration interaction effects with configurations involving electrons of the $n=3$ shell may be significant, but were not included in the calculations. Inasmuch as no other material is available, the Coulomb approximation has been used for a number of $3s-3p$ and $3p-3d$ transitions, where for atomic systems for similar complexity it has given fairly reliable values.

References

[1] Cohen, M., and Dalgarno, A., Proc. Roy. Soc. London **A280**, 258–270 (1964).
[2] Bagus, P. S., U.S. Atomic Energy Commission ANL–6959 (1964).

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
1	$2s^22p^5-2s2p^6$	$^2P^\circ-^2S$	*378.80*	*455*	264449	6	2	210	0.15	1.1	−0.05	D−	1, 2
			[378.14]	0	264449	4	2	130	0.14	0.72	−0.25	D−	*ls*
			[380.11]	1364	264449	2	2	66	0.14	0.36	−0.55	D−	*ls*
2	$2p^43s-2p^4(^3P)3p$	$^4P-^4P^\circ$	*2515.6*	*366694*	*406434*	12	12	2.4	0.23	23	0.44	D	*ca*
			[2497.0]	366165	406201	6	6	1.7	0.16	8.0	−0.02	D	*ls*
			[2530.2]	367052	406562	4	4	0.31	0.030	1.0	−0.92	E	*ls*
			[2542.9]	367562	406876	2	2	0.39	0.038	0.64	−1.12	E	*ls*
			[2474.7]	366165	406562	6	4	1.1	0.070	3.4	−0.38	D−	*ls*
			[2510.3]	367052	406876	4	2	2.0	0.097	3.2	−0.41	D−	*ls*
			[2553.6]	367052	406201	4	6	0.69	0.10	3.4	−0.40	D−	*ls*
			[2563.3]	367562	406562	2	4	0.96	0.19	3.2	−0.42	D−	*ls*
3		$^4P-^4D^\circ$	*2232.5*	*366694*	*411473*	12	20	3.6	0.44	39	0.72	D	*ca*
			[2230.3]	366165	410988	6	8	3.7	0.36	16	0.33	D	*ls*
			[2246.7]	367052	411548	4	6	2.4	0.28	8.2	0.05	D	*ls*
			[2251.5]	367562	411964	2	4	1.5	0.22	3.3	−0.36	D−	*ls*
			[2202.8]	366165	411548	6	6	1.1	0.080	3.5	−0.32	D−	*ls*
			[2225.9]	367052	411964	4	4	1.9	0.14	4.2	−0.25	D−	*ls*
			[2239.5]	367562	412202	2	2	3.0	0.22	3.3	−0.36	D−	*ls*
			[2182.8]	366165	411964	6	4	0.19	0.0090	0.39	−1.27	E	*ls*
			[2214.2]	367052	412202	4	2	0.61	0.022	0.65	−1.06	E	*ls*
4		$^4P-^4S^\circ$	*1971.5*	*366694*	417416	12	4	5.2	0.10	7.9	0.08	D	*ca*
			[1951.2]	366165	417416	6	4	2.7	0.10	3.9	−0.22	D	*ls*
			[1985.5]	367052	417416	4	4	1.7	0.10	2.6	−0.40	D	*ls*
			[2005.2]	367562	417416	2	4	0.82	0.10	1.3	−0.70	D	*ls*
5		$^2P-^2D^\circ$	*2458.9*	*373982*	*414638*	6	10	2.9	0.43	21	0.41	D	*ca*
			[2459.4]	373633	414281	4	6	3.0	0.40	13	0.20	D	*ls*
			[2468.9]	374681	415173	2	4	2.4	0.43	7.0	−0.07	D	*ls*
			[2406.6]	373633	415173	4	4	0.51	0.044	1.4	−0.75	E	*ls*
6		$^2P-^2S^\circ$	*2328.8*	*373982*	416910	6	2	3.4	0.091	4.2	−0.26	D	*ca*
			[2310.0]	373633	416910	4	2	2.3	0.092	2.8	−0.43	D	*ls*
			[2367.3]	374681	416910	2	2	1.1	0.090	1.4	−0.74	D	*ls*
7		$^2P-^2P^\circ$	*2247.4*	*373982*	*418464*	6	6	3.9	0.29	13	0.24	D	*ca*
			[2232.2]	373633	418418	4	4	3.3	0.24	7.2	−0.02	D	*ls*
			[2278.5]	374681	418557	2	2	2.4	0.19	2.8	−0.42	D	*ls*
			[2225.3]	373633	418557	4	2	1.3	0.048	1.4	−0.72	E	*ls*
			[2285.7]	374681	418418	2	4	0.59	0.093	1.4	−0.73	E	*ls*
8	$2p^43p-2p^4(^3P)3d$	$^4P^\circ-^4D$	*1852.0*	*406434*	*460431*	12	20	7.3	0.63	46	0.88	D	*ca*
			[1849.6]	406201	460268	6	8	7.2	0.49	18	0.47	D	*ls*
			[1856.7]	406562	460421	4	6	5.1	0.40	9.7	0.20	D	*ls*
			[1861.2]	406876	460606	2	4	3.0	0.31	3.8	−0.21	D−	*ls*
			[1844.3]	406201	460421	6	6	2.2	0.11	4.1	−0.18	D−	*ls*
			[1850.3]	406562	460606	4	4	3.9	0.20	4.9	−0.10	D−	*ls*
			[1855.9]	406876	460759	2	2	6.0	0.31	3.8	−0.21	D−	*ls*
			[1838.1]	406201	460606	6	4	0.38	0.013	0.46	−1.11	E	*ls*
			[1845.1]	406562	460759	4	2	1.2	0.032	0.77	−0.89	E	*ls*
9		$^4P^\circ-^4P$	*1767.4*	*406434*	*463015*	12	12	4.6	0.21	15	0.40	D	*ca*
			[1752.7]	406201	463257	6	6	3.3	0.15	5.2	−0.05	D	*ls*
			[1773.0]	406562	462964	4	4	0.61	0.029	0.67	−0.94	E	*ls*
			[1801.3]	406876	462391	2	2	0.73	0.035	0.42	−1.15	E	*ls*
			[1761.7]	406201	462964	6	4	2.0	0.063	2.2	−0.42	D−	*ls*
			[1791.2]	406562	462391	4	2	3.7	0.089	2.1	−0.45	D−	*ls*
			[1763.8]	406562	463257	4	6	1.4	0.095	2.2	−0.42	D−	*ls*
			[1782.9]	406876	462964	2	4	1.9	0.18	2.1	−0.44	D−	*ls*

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
10		$^4D^\circ-^4D$	*2041.9*	*411473*	*460431*	20	20	1.9	0.12	16	0.38	D	*ca*
			[2028.6]	410988	460268	8	8	1.7	0.10	5.5	−0.10	D	*ls*
			[2045.5]	411548	460421	6	6	1.1	0.069	2.8	−0.38	D	*ls*
			[2055.2]	411964	460606	4	4	0.76	0.048	1.3	−0.72	D−	*ls*
			[2058.8]	412202	460759	2	2	0.93	0.059	0.80	−0.93	D−	*ls*
			[2022.3]	410988	460421	8	6	0.37	0.017	0.91	−0.87	D−	*ls*
			[2037.8]	411548	460606	6	4	0.66	0.027	1.1	−0.79	D−	*ls*
			[2048.7]	411964	460759	4	2	0.94	0.030	0.80	−0.92	D−	*ls*
			[2051.9]	411548	460268	6	8	0.27	0.022	0.91	−0.88	D−	*ls*
			[2063.0]	411964	460421	4	6	0.42	0.040	1.1	−0.80	D−	*ls*
			[2065.3]	412202	460606	2	4	0.46	0.059	0.80	−0.93	D−	*ls*
11		$^4D^\circ-^4F$	*1947.1*	*411473*	*462832*	20	28	8.9	0.71	91	1.15	D	*ca*
			[1965.1]	410988	461877	8	10	8.8	0.64	33	0.71	D	*ls*
			[1939.3]	411548	463113	6	8	7.6	0.57	22	0.53	D	*ls*
			[1935.6]	411964	463628	4	6	7.0	0.59	15	0.37	D	*ls*
			[1950.8]	412202	463462	2	4	6.2	0.71	9.1	0.15	D−	*ls*
			[1918.5]	410988	463113	8	8	1.3	0.073	3.7	−0.23	D−	*ls*
			[1920.1]	411548	463628	6	6	2.2	0.12	4.7	−0.14	D−	*ls*
			[1941.8]	411964	463462	4	4	2.5	0.14	3.6	−0.25	D−	*ls*
			[1899.7]	410988	463628	8	6	0.094	0.0038	0.19	−1.52	E	*ls*
			[1926.3]	411548	463462	6	4	0.18	0.0068	0.26	−1.39	E	*ls*
12		$^4S^\circ-^4P$	*2192.3*	417416	*463015*	4	12	3.7	0.80	23	0.51	D	*ca*
			[2180.8]	417416	463257	4	6	3.6	0.38	11	0.18	D	*ls*
			[2194.8]	417416	462964	4	4	3.7	0.27	7.7	0.03	D	*ls*
			[2222.8]	417416	462391	4	2	3.5	0.13	3.8	−0.28	D	*ls*
13		$^2D^\circ-^2F$	*1995.9*	*414638*	*464740*	10	14	8.6	0.72	47	0.86	D	*ca*
			[2011.9]	414281	463969	6	8	8.4	0.68	27	0.61	D	*ls*
			[1976.4]	415173	465769	4	6	8.3	0.73	19	0.47	D	*ls*
			[1942.2]	414281	465769	6	6	0.60	0.034	1.3	−0.69	E	*ls*
14		$^2D^\circ-^2D$	*1999.7*	*414638*	*464646*	10	10	2.1	0.13	8.4	0.11	D	*ca*
			[1995.6]	414281	464392	6	6	2.0	0.12	4.7	−0.14	D	*ls*
			[2005.2]	415173	465028	4	4	1.9	0.11	3.0	−0.36	D	*ls*
			[1970.6]	414281	465028	6	4	0.23	0.0087	0.34	−1.28	E	*ls*
			[2031.1]	415173	464392	4	6	0.14	0.013	0.34	−1.28	E	*ls*
15		$^2S^\circ-^2P$	*2015.4*	416910	*466511*	2	6	4.5	0.83	11	0.22	D	*ca*
			[2004.8]	416910	466773	2	4	4.6	0.55	7.3	0.04	D	*ls*
			[2036.9]	416910	465988	2	2	4.4	0.28	3.7	−0.25	D	*ls*
16		$^2P^\circ-^2D$	*2164.7*	*418464*	*464646*	6	10	5.2	0.61	26	0.56	D	*ca*
			[2174.5]	418418	464392	4	6	5.3	0.56	16	0.35	D	*ls*
			[2151.2]	418557	465028	2	4	4.4	0.61	8.7	0.09	D	*ls*
			[2144.8]	418418	465028	4	4	0.87	0.0060	1.7	−1.62	E	*ls*
17		$^2P^\circ-^2P$	*2080.6*	*418464*	*466511*	6	6	3.3	0.21	8.7	0.10	D	*ca*
			[2067.4]	418418	466773	4	4	2.8	0.18	4.8	−0.14	D	*ls*
			[2107.7]	418557	465988	2	2	2.1	0.14	1.9	−0.55	D	*ls*
			[2101.5]	418418	465988	4	2	1.1	0.035	0.97	−0.85	E	*ls*
			[2073.3]	418557	466773	2	4	0.55	0.071	0.97	−0.85	E	*ls*

Na III

Forbidden Transitions

The line strength for the one transition in the ground state configuration is a straight number, tabulated for example by Naqvi [1]. The transition probability should also be quite accurate, since the energy level difference is accurately known.

Reference

[1] Naqvi, A. M., Thesis Harvard (1951).

Na III. Forbidden Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	Type of Transition	A_{ki}(sec^{-1})	S(at.u.)	Accuracy	Source
1	$2p^5-2p^5$	$^2P^\circ-^2P^\circ$	[73294]	0	1364	4	2	m	0.0456	1.33	A	1

Na IV

Ground State $1s^22s^22p^4\ ^3P_2$

Ionization Potential 98.88 eV = 797741 cm^{-1}

Allowed Transitions

The values are calculated from the charge-expansion method of Cohen and Dalgarno [1] which includes limited configuration mixing. An additional value for the $^1S-^1P^\circ$ transition is available from the calculations of Bolotin, Shironas, and Braiman [2], which also include limited configuration interaction. For this latter transition, the two methods agree fairly well and the results are averaged. In general, uncertainties should be within 50 percent.

References

[1] Cohen, M., and Dalgarno, A., Proc. Roy. Soc. London **A280**, 258–270 (1964).
[2] Bolotin, A. B., Shironas, I. I., and Braiman, M. Yu., Vilniaus, Valstybinio v. Kapsuko vardo universiteto Mokslo Darbai **33**, matematika fizika **9**, 107–112 (1960).

Na IV. Allowed Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
1	$2s^22p^4-2s2p^5$	$^3P-^3P^\circ$	*410.43*	*544*	*244190*	9	9	98	0.25	3.0	0.35	D	1
			[410.37]	0	243682	5	5	76	0.19	1.3	−0.02	D	*ls*
			[410.54]	1106	244688	3	3	24	0.062	0.25	−0.73	D−	*ls*
			[408.68]	0	244688	5	3	42	0.062	0.42	−0.51	D−	*ls*
			[409.61]	1106	245238	3	1	97	0.082	0.33	−0.61	D−	*ls*
			[412.24]	1106	243682	3	5	24	0.10	0.42	−0.52	D−	*ls*
			[411.33]	1576	244688	1	3	32	0.24	0.33	−0.62	D−	*ls*
2		$^1D-^1P^\circ$	[319.64]	[31118]	[343972]	5	3	170	0.16	0.83	−0.10	D	1
3		$^1S-^1P^\circ$	[360.76]	[66780]	[343972]	1	3	23	0.13	0.16	−0.89	D	1, 2

Forbidden Transitions

The sources used in deriving the adopted values are Naqvi [1], and Malville and Berger [2]. Naqvi's magnetic dipole values are used whenever the choice of transformation coefficients becomes more important than the effects of configuration interaction (see General Introduction). Malville and Berger have calculated values using "spin-orbit" and "spin-spin and spin-other-orbit integrals" calculated by Garstang (Monthly Notices Roy. Astron. Soc. **111**, 115 (1951)). The electric quadrupole moment s_q calculated by Malville and Berger has been used throughout and is considered better than Naqvi's, because it is obtained from self-consistent field wavefunctions, while Naqvi used screened hydrogenic wavefunctions. We have therefore modified Naqvi's $^3P_2-^3P_1$ and $^3P_{2,1}-^1D_2$ electric quadrupole values by substituting Malville and Berger's s_q.

References

[1] Naqvi, A. M., Thesis Harvard (1951).
[2] Malville, J. M. and Berger, R. A., Planetary and Space Science **13**, 1131 (1965).

Na IV. Forbidden Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	Type of Transition	A_{ki}(sec^{-1})	S(at.u.)	Accuracy	Source
1	$2p^4-2p^4$	$^3P-^3P$										
			[90391]	0	1106	5	3	*e*	1.90×10^{-8}	0.205	C−	1, 2
			[90391]	0	1106	5	3	*m*	0.0304	2.50	A	1
			[63435]	0	1576	5	1	*e*	1.48×10^{-7}	0.091	C−	2
			[21.27×10^4]	1106	1576	3	1	*m*	0.00561	2.00	B	1
2		$^3P-^1D$ (1F)										
			3319.3	0	[31118]	5	5	*e*	6.1×10^{-4}	7.3×10^{-4}	D−	1, 2
			3319.3	0	[31118]	5	5	*m*	0.56	0.00381	C	1
			3445.9	1106	[31118]	3	5	*e*	7.1×10^{-5}	1.0×10^{-4}	D−	1, 2
			3445.9	1106	[31118]	3	5	*m*	0.167	0.00127	C	1
			[3384.0]	1576	[31118]	1	5	*e*	3.0×10^{-5}	4.0×10^{-5}	D−	2
3		$^3P-^1S$										
			[1497.5]	0	[66780]	5	1	*e*	0.012	5.4×10^{-5}	D−	2
			[1522.7]	1106	[66780]	3	1	*m*	7.6	9.9×10^{-4}	C	2
4		$^1D-^1S$										
			[2803.3]	[31118]	[66780]	5	1	*e*	3.5	0.360	C−	2

Na V

Ground State $1s^2 2s^2 2p^3\ ^4S^\circ_{3/2}$

Ionization Potential 138.37 eV = 1116312 cm^{-1}

Allowed Transitions

List of tabulated lines:

Wavelength [Å]	No.	Wavelength [Å]	No.	Wavelength [Å]	No.
307.15	3	369.73	7	456.15	8
308.26	3	369.78	7	459.57	8
308.29	3	400.67	2	459.90	1
332.54	6	400.71	2	461.05	1
332.59	6	400.73	2	463.26	1
333.88	6	400.77	2	506.99	9
333.92	6	445.05	4	510.09	9
360.32	5	445.12	4	511.21	9
360.37	5	445.19	4	514.36	9
367.56	7				

Values for all the listed transitions are calculated from the nuclear charge-expansion method of Cohen and Dalgarno [1], which includes limited configuration mixing. Judged from graphical comparisons with other ions in the isoelectronic sequence and from the general success of Cohen and Dalgarno's method for similar atomic systems, uncertainties within 50 percent are indicated.

Reference

[1] Cohen, M., and Dalgarno, A., Proc. Roy. Soc. London **A280**, 258–270 (1964).

Na V. Allowed Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
1	$2s^2 2p^3 - 2s2p^4$	$^4S^\circ - ^4P$	*461.06*	0	*216892*	4	12	31	0.30	1.8	0.08	D	1
			[463.26]	0	215860	4	6	31	0.15	0.90	−0.22	D	*ls*
			[461.05]	0	216896	4	4	31	0.099	0.60	−0.40	D	*ls*
			[459.90]	0	217440	4	2	31	0.050	0.30	−0.70	D	*ls*
2		$^2D^\circ - ^2D$	*400.72*	[*47580*]	[*297130*]	10	10	72	0.17	2.3	0.23	D	1
			[400.73]	[47570]	[297116]	6	6	68	0.16	1.3	−0.02	D	*ls*
			[400.71]	[47595]	[297150]	4	4	65	0.16	0.83	−0.19	D	*ls*
			[400.67]	[47570]	[297150]	6	4	7.2	0.012	0.092	−1.14	E	*ls*
			[400.77]	[47595]	[297116]	4	6	4.8	0.017	0.092	−1.17	E	*ls*
3		$^2D^\circ - ^2P$	*307.89*	[*47580*]	[*372367*]	10	6	270	0.23	2.3	0.36	D	1
			[308.26]	[47570]	[371967]	6	4	240	0.23	1.4	0.14	D	*ls*
			[307.15]	[47595]	[373167]	4	2	270	0.19	0.77	−0.12	D	*ls*
			[308.29]	[47595]	[371967]	4	4	26	0.037	0.15	−0.83	E	*ls*
4		$^2P^\circ - ^2D$	*445.14*	[*72480*]	[*297130*]	6	10	11	0.056	0.49	−0.47	D	1
			[445.19]	[72493]	[297116]	4	6	11	0.049	0.29	−0.71	D	*ls*
			[445.05]	[72454]	[297150]	2	4	9.2	0.055	0.16	−0.96	D	*ls*
			[445.12]	[72493]	[297150]	4	4	1.9	0.0056	0.033	−1.65	E	*ls*

Na V. Allowed Transitions—Continued

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
5		$^2P^\circ-^2S$	*360.35*	[*72480*]	[*349987*]	6	2	150	0.10	0.71	−0.22	D	1
			[360.37]	[72493]	[349987]	4	2	100	0.099	0.47	−0.40	D	*ls*
			[360.32]	[72454]	[349987]	2	2	52	0.10	0.24	−0.70	D	*ls*
6		$^2P^\circ-^2P$	*333.46*	[*72480*]	[*372367*]	6	6	78	0.13	0.86	−0.11	D	1
			[333.92]	[72493]	[371967]	4	4	65	0.11	0.48	−0.36	D	*ls*
			[332.54]	[72454]	[373167]	2	2	52	0.087	0.19	−0.76	D−	*ls*
			[332.59]	[72493]	[373167]	4	2	26	0.022	0.096	−1.06	E	*ls*
			[333.88]	[72454]	[371967]	2	4	13	0.044	0.096	−1.06	E	*ls*
7	$2s2p^4-2p^5$	$^2D-^2P^\circ$	*369.01*	[*297130*]	[*568126*]	10	6	120	0.15	1.8	0.18	D	1
			[369.73]	[297116]	[567583]	6	4	110	0.15	1.1	−0.05	D	*ls*
			[367.56]	[297150]	[569211]	4	2	120	0.12	0.60	−0.32	D	*ls*
			[369.78]	[297150]	[567583]	4	4	12	0.025	0.12	−1.00	E	*ls*
8		$^2S-^2P^\circ$	*458.42*	[349987]	[*568126*]	2	6	7.0	0.066	0.20	−0.88	D	1
			[459.57]	[349987]	[567583]	2	4	6.8	0.043	0.13	−1.07	D	*ls*
			[456.15]	[349987]	[569211]	2	2	7.2	0.022	0.067	−1.36	D	*ls*
9		$^2P-^2P^\circ$	*510.83*	[*372367*]	[*568126*]	6	6	84	0.33	3.3	0.30	D	1
			[511.21]	[371967]	[567583]	4	4	68	0.27	1.8	0.03	D	*ls*
			[510.09]	[373167]	[569211]	2	2	56	0.22	0.73	−0.36	D−	*ls*
			[506.99]	[371967]	[569211]	4	2	29	0.055	0.37	−0.66	E	*ls*
			[514.36]	[373167]	[567583]	2	4	14	0.11	0.37	−0.66	E	*ls*

Na V

Forbidden Transitions

All the values for this ion have been taken from Pasternack [1]. The electric quadrupole values have been corrected by applying Naqvi's value [2] for the electric quadrupole moment s_q.

References

[1] Pasternack, S., Astrophys. J. **92**, 129 (1940).
[2] Naqvi, A. M., Thesis Harvard (1951).

Na V. Forbidden Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	Type of Transition	A_{ki}(sec^{-1})	S(at.u.)	Accuracy	Source
1	$2p^3-2p^3$	$^4S^\circ-^2D^\circ$										
			[2101.5]	0	[47570]	4	6	*m*	2.2×10^{-4}	4.54×10^{-7}	C−	1
			[2101.5]	0	[47570]	4	6	*e*	9.6×10^{-4}	1.4×10^{-4}	D−	1, 2
			[2100.4]	0	[47595]	4	4	*m*	0.012	1.65×10^{-5}	C−	1
			[2100.4]	0	[47595]	4	4	*e*	5.9×10^{-4}	5.7×10^{-5}	D−	1, 2
2		$^4S^\circ-^2P^\circ$										
			[1379.4]	0	[72493]	4	4	*m*	4.3	0.00167	C	1
			[1379.4]	0	[72493]	4	4	*e*	3.0×10^{-6}	3.6×10^{-8}	D−	1, 2
			[1380.2]	0	[72454]	4	2	*m*	1.7	3.31×10^{-4}	C	1
			[1380.2]	0	[72454]	4	2	*e*	7.5×10^{-6}	4.5×10^{-8}	D−	1, 2

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	Type of Transition	A_{ki}(sec^{-1})	S(at.u.)	Accuracy	Source
3		$^2D^\circ-^2D^\circ$										
			[40.0 × 10^5]	[47570]	[47595]	6	4	*m*	2.53 × 10^{-7}	2.40	B−	1, 2
			[40.0 × 10^5]	[47570]	[47595]	6	4	*e*	6.4 × 10^{-19}	0.0016	D−	1, 2
4		$^2D^\circ-^2P^\circ$ (1 F)										
			4011.2	[47570]	[72493]	6	4	*m*	0.67	0.0064	C	1
			4011.2	[47570]	[72493]	6	4	*e*	0.23	0.56	D	2
			4021.6	[47595]	[72454]	4	2	*m*	0.74	0.00357	C	1
			4021.6	[47595]	[72454]	4	2	*e*	0.19	0.24	D	2
			4017.5	[47570]	[72454]	6	2	*e*	0.13	0.16	D	2
			4015.3	[47595]	[72493]	4	4	*m*	1.2	0.0116	C	1
			4015.3	[47595]	[72493]	4	4	*e*	0.096	0.24	D	2
5		$^2P^\circ-^2P^\circ$										
			[25.6 × 10^5]	[72454]	[72493]	2	4	*m*	5.33 × 10^{-7}	1.33	B−	1, 2
			[25.6 × 10^5]	[72454]	[72493]	2	4	*e*	2.5 × 10^{-18}	6.6 × 10^{-4}	D−	1, 2

Na VI

Ground State $1s^22s^22p^2\ ^3P_0$

Ionization Potential 172.09 eV= 1388419 cm^{-1}

Allowed Transitions

List of tabulated lines:

Wavelength [Å]	No.	Wavelength [Å]	No.	Wavelength [Å]	No.
311.93	3	420.49	8	1516.0	12
312.61	3	421.49	8	1532.5	12
313.74	3	423.84	8	1550.6	12
317.64	5	440.27	10	1567.8	12
361.25	4	489.57	1	1608.5	14
362.44	6	491.25	1	1615.9	14
363.77	7	491.34	1	1630.3	14
364.46	7	494.07	1	1634.6	14
364.52	7	494.16	1	1649.4	14
366.10	7	494.38	1	1741.5	13
366.23	7	528.73	11	1747.5	13
366.28	7	630.65	9	1748.3	13
414.35	2	632.88	9	1763.3	13
415.55	2	638.21	9	1770.3	13
417.57	2				

Most data are obtained from the charge-expansion method of Cohen and Dalgarno [1] which includes limited configuration mixing. Graphical comparisons of this material within the isoelectronic sequence depicting the dependence of *f*-values on nuclear charge have been made, and the available experimental data for the lower ions, mostly from lifetime measurements, establish fairly definitely that the uncertainties should not exceed 50 percent. Analogous graphs for the data obtained from the Coulomb approximation indicate that these values are accurate within 25 percent.

Reference

[1] Cohen, M., and Dalgarno, A., Proc. Roy. Soc. London **A280**, 258–270 (1964).

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
1	$2s^22p^2-2s2p^3$	$^3P-^3D^\circ$	*492.80*	*1265*	*204187*	9	15	18	0.11	1.6	−0.00	D+	1
			[494.38]	1858	204131	5	7	18	0.092	0.75	−0.34	D+	*ls*
			[491.34]	698	204222	3	5	14	0.082	0.40	−0.61	D+	*ls*
			[489.57]	0	204260	1	3	10	0.11	0.18	−0.96	D−	*ls*
			[494.16]	1858	204222	5	5	4.4	0.016	0.13	−1.10	D−	*ls*
			[491.25]	698	204260	3	3	7.4	0.027	0.13	−1.09	D−	*ls*
			[494.07]	1858	204260	5	3	0.50	0.0011	0.0089	−2.26	E	*ls*
2		$^3P-^3P^\circ$	*416.53*	*1265*	241341	9	9	47	0.12	1.5	0.03	D	1
			[417.57]	1858	241341	5	5	35	0.090	0.62	−0.35	D	*ls*
			[415.55]	698	241341	3	3	11	0.029	0.12	−1.06	D−	*ls*
			[417.57]	1858	241341	5	3	19	0.031	0.21	−0.81	D−	*ls*
			[415.55]	698	241341	3	1	48	0.041	0.17	−0.91	D−	*ls*
			[415.55]	698	241341	3	5	12	0.051	0.21	−0.82	D−	*ls*
			[414.35]	0	241341	1	3	16	0.12	0.17	−0.92	D−	*ls*
3		$^3P-^3S^\circ$	*313.16*	*1265*	320589	9	3	290	0.14	1.3	0.10	D+	1
			[313.74]	1858	320589	5	3	160	0.14	0.72	−0.15	D+	*ls*
			[312.61]	698	320589	3	3	95	0.14	0.43	−0.38	D+	*ls*
			[311 93]	0	320589	1	3	31	0.14	0.14	−0.85	D+	*ls*
4		$^1D-^1D^\circ$	[361.25]	35358	312175	5	5	140	0.27	1.6	0.13	D	1
5		$^1D-^1P^\circ$	[317.64]	35358	350179	5	3	170	0.16	0.82	−0.10	D	1
6		$^1S-^1P^\circ$	[362.44]	74274	350179	1	3	47	0.28	0.33	−0.55	D−	1
7	$2s2p^3-2p^4$	$^3D^\circ-^3P$	*365.31*	*204187*	*477926*	15	9	120	0.14	2.5	0.32	D	1
			[366.10]	204131	477277	7	5	99	0.14	1.2	−0.01	D	*ls*
			[364.46]	204222	478597	5	3	86	0.10	0.62	−0.30	D	*ls*
			[363.77]	204260	479156	3	1	120	0.078	0.28	−0.63	D−	*ls*
			[366.23]	204222	477277	5	5	17	0.035	0.21	−0.76	D−	*ls*
			[364.52]	204260	478597	3	3	29	0.058	0.21	−0.76	D−	*ls*
			[366.28]	204260	477277	3	5	1.2	0.0039	0.014	−1.93	E	*ls*
8		$^3P^\circ-^3P$	*422.68*	241341	*477926*	9	9	29	0.078	0.98	−0.15	D	1
			[423.84]	241341	477277	5	5	22	0.059	0.41	−0.53	D	*ls*
			[421.49]	241341	478597	3	3	7.4	0.020	0.082	−1.22	E	*ls*
			[421.49]	241341	478597	5	3	13	0.034	0.14	−0.77	D−	*ls*
			[420.49]	241341	479156	3	1	30	0.026	0.11	−1.11	D−	*ls*
			[423.84]	241341	477277	3	5	7.5	0.033	0.14	−1.00	D−	*ls*
			[421.49]	241341	478597	1	3	9.9	0.079	0.11	−1.10	D−	*ls*
9		$^3S^\circ-^3P$	*635.58*	320589	*477926*	3	9	18	0.32	2.0	−0.02	D	1
			[638.21]	320589	477277	3	5	17	0.17	1.1	−0.29	D	*ls*
			[632.88]	320589	478597	3	3	18	0.11	0.67	−0.48	D	*ls*
			[630.65]	320589	479156	3	1	18	0.035	0.22	−0.98	D	*ls*
10		$^1D^\circ-^1D$	[440.27]	312175	539310	5	5	120	0.34	2.5	0.23	D	1
11		$^1P^\circ-^1D$	[528.73]	350179	539310	3	5	15	0.11	0.55	−0.48	D	1
12	$2p3s-2p(^2P^\circ)3p$	$^3P^\circ-^3P$											
			[1550.6]	808795	873287	5	5	3.99	0.144	3.67	−0.143	C	*ca, ls*
			[1532.5]	807324	872577	3	3	1.4	0.048	0.73	−0.84	D	*ca, ls*
			[1567.8]	808795	872577	5	3	2.14	0.0473	1.22	−0.63	C	*ca, ls*
			[1516.0]	807324	873287	3	5	1.42	0.081	1.22	−0.61	C	*ca, ls*

Na VI. Allowed Transitions—*Continued*

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
13	$2p3p-2p(^2P^\circ)3d$	$^3P-^3D^\circ$											
			[1747.5]	873287	930510	5	7	2.87	0.184	5.3	−0.036	C	*ca, ls*
			[1741.5]	872577	929999	3	5	2.19	0.166	2.85	−0.303	C	*ca, ls*
			[1763.3]	873287	929999	5	5	0.70	0.0327	0.95	−0.79	C	*ca, ls*
			[1748.3]	872577	929774	3	3	1.20	0.055	0.95	−0.78	C	*ca, ls*
			[1770.3]	873287	929774	5	3	0.077	0.0022	0.063	−1.97	E	*ca, ls*
14		$^3P-^3P^\circ$											
			[1649.4]	873287	933915	5	5	1.46	0.060	1.62	−0.52	C	*ca, ls*
			[1615.9]	872577	934463	3	3	0.52	0.0202	0.323	−1.218	C	*ca, ls*
			[1634.6]	873287	934463	5	3	0.83	0.0201	0.54	−1.000	C	*ca, ls*
			[1608.5]	872577	934745	3	1	2.10	0.0271	0.431	−1.090	C	*ca, ls*
			[1630.3]	872577	933915	3	5	0.50	0.0335	0.54	−1.000	C	*ca, ls*

Na VI

Forbidden Transitions

The sources adopted for this ion are Naqvi [1], Malville and Berger [2], and Froese [3]. Malville and Berger have utilized "spin-orbit" and "spin-spin and spin-other-orbit" integrals by Garstang (Monthly Notices Roy. Astron. Soc. **111,** 115 (1951)). Naqvi's and Malville and Berger's magnetic dipole transitions have generally been averaged since their methods are very similar. But for the $^3P-^1S$ transition, where configuration interaction is important, Malville and Berger's value, which is obtained empirically, has been preferred over that of Naqvi which is based purely on theory (see also General Introduction).

Since Froese's value of s_q, the electric quadrupole moment, is obtained by using the most advanced self-consistent field wave function calculations, we have modified Naqvi's and Malville and Berger's electric quadrupole values by her s_q.

References

[1] Naqvi, A. M. Thesis Harvard (1951).
[2] Malville, J. M., and Berger, R. A., Planetary and Space Science **13,** 1131 (1965).
[3] Froese, C., Astrophys. J. **145,** 932 (1966).

Na VI. Forbidden Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	Type of Transition	A_{ki}(sec^{-1})	S(at.u.)	Accuracy	Source
1	$2p^2-2p^2$	$^3P-^3P$										
			[14.32×10^4]	0	698	1	3	*m*	0.00612	2.00	B	1
			[53807]	0	1858	1	5	*e*	4.35×10^{-8}	0.058	C	2, 3
			[86183]	698	1858	3	5	*m*	0.0211	2.50	A	1
			[86183]	698	1858	3	5	*e*	9.3×10^{-9}	0.131	C	1, 3
2		$^3P-^1D$										
			[2827.4]	0	35358	1	5	*e*	5.1×10^{-5}	2.7×10^{-5}	D	2, 3
			[2884.3]	698	35358	3	5	*m*	0.441	0.00196	C	1, 2
			[2884.3]	698	35358	3	5	*e*	1.7×10^{-4}	1.0×10^{-4}	D	1, 3
			[2984.2]	1858	35358	5	5	*m*	1.20	0.0059	C	1, 2
			[2984.2]	1858	35358	5	5	*e*	0.0010	7.1×10^{-4}	D	1, 3

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	Type of Transition	A_{ki}(sec^{-1})	S(at.u.)	Accuracy	Source
3		$^3P-^1S$										
			[1359.1]	698	74274	3	1	m	13.4	0.00125	C	2
			[1380.9]	1858	74274	5	1	e	0.019	5.7×10^{-5}	D	2, 3
4		$^1D-^1S$										
			[2568.9]	35358	74274	5	1	e	3.59	0.239	C	2, 3

Na VII

Ground State $1s^22s^22p\ ^2P^\circ_{1/2}$

Ionization Potential 208.444 eV = 1681679 cm^{-1}

Allowed Transitions

List of tabulated lines:

Wavelength [Å]	No.	Wavelength [Å]	No.	Wavelength [Å]	No.
94.288	11	385.11	6	498.23	7
94.468	11	385.25	6	498.46	7
94.479	11	396.36	4	551.75	9
105.11	10	397.52	4	552.03	9
105.35	10	399.21	4	555.80	9
350.64	3	483.13	5	556.09	9
352.28	3	483.22	5	778.05	8
353.29	3	483.33	5	786.13	8
354.95	3	483.41	5	786.65	8
378.21	2	486.74	1	1752.2	12
381.30	2	491.86	1	1912.7	13
385.06	6	492.60	1	1917.1	13

Values for the majority of the transitions are calculated from the nuclear charge-expansion method of Cohen and Dalgarno [1] which includes limited configuration mixing. Graphical comparisons with other data for the lower ions of this isoelectronic sequence indicate that the uncertainties should be within 50 percent. For the $3s\ ^2S-3p\ ^2P^\circ$ transition an f-value from the charge-expansion calculations of Naqvi and Victor [2] is available, which links up well with reliable data available for the lower ions as is readily seen again from graphical comparison.

For the $2p\ ^2P^\circ-3s\ ^2S$ and $2p\ ^2P^\circ-3d\ ^2D$ multiplets we have obtained data by exploiting the dependence of f-values on nuclear charge: In these cases accurate data for several other ions of the boron sequence are available from extended self-consistent field calculations by Weiss [3] in which configuration mixing is fully included. Utilizing those values, which are also supported by some experimental results on lower ions, we have obtained the f-values of the two transitions simply by graphical interpolation.

References

[1] Cohen, M., and Dalgarno, A., Proc. Roy. Soc. London **A280**, 258–270 (1964).
[2] Naqvi, A. M., and Victor, G. A., Technical Documentary Report No. RTD TDR–63–3118 (1964).
[3] Weiss, A. W., private communication (1967).

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
1	$2s^22p-2s2p^2$	$^2P^\circ-^2D$	*490.20*	*1426*	*205426*	6	10	16	0.096	0.93	−0.24	D	1
			[492.60]	2139	205412	4	6	16	0.086	0.56	−0.46	D	*ls*
			[486.74]	0	205448	2	4	14	0.097	0.31	−0.71	D	*ls*
			[491.86]	2139	205448	4	4	2.6	0.0096	0.062	−1.42	E	*ls*
2		$^2P^\circ-^2S$	*380.27*	*1426*	264400	6	2	68	0.049	0.37	−0.53	D+	1
			[381.30]	2139	264400	4	2	46	0.050	0.25	−0.70	D+	*ls*
			[378.21]	0	264400	2	2	22	0.048	0.12	−1.02	D+	*ls*
3		$^2P^\circ-^2P$	*352.95*	*1426*	*284749*	6	6	120	0.23	1.6	0.14	D+	1
			[353.29]	2139	285189	4	4	100	0.19	0.89	−0.12	D+	*ls*
			[352.28]	0	283869	2	2	83	0.16	0.36	−0.49	D	*ls*
			[354.95]	2139	283869	4	2	41	0.039	0.18	−0.81	D−	*ls*
			[350.64]	0	285189	2	4	21	0.078	0.18	−0.81	D−	*ls*
4	$2s2p^2-2p^3$	$^4P-^4S^\circ$	*398.17*	[*116331*]	[367481]	12	4	120	0.095	1.5	0.06	D+	1
			[399.21]	[116987]	[367481]	6	4	56	0.089	0.70	−0.27	D+	*ls*
			[397.52]	[115920]	[367481]	4	4	40	0.096	0.50	−0.42	D+	*ls*
			[396.36]	[115187]	[367481]	2	4	24	0.11	0.30	−0.66	D+	*ls*
5		$^2D-^2D^\circ$	*483.28*	*205426*	*412345*	10	10	34	0.12	1.9	0.08	D+	1
			[483.33]	205412	412311	6	6	33	0.12	1.1	−0.14	D+	*ls*
			[483.22]	205448	412395	4	4	30	0.11	0.68	−0.36	D	*ls*
			[483.13]	205412	412395	6	4	3.4	0.0080	0.076	−1.32	E	*ls*
			[483.41]	205448	412311	4	6	2.3	0.012	0.076	−1.32	E	*ls*
6		$^2D-^2P^\circ$	*385.13*	*205426*	*465080*	10	6	55	0.073	0.93	−0.14	D	1
			[385.06]	205412	465111	6	4	50	0.074	0.56	−0.35	D	*ls*
			[385.25]	205448	465017	4	2	55	0.061	0.31	−0.61	D	*ls*
			[385.11]	205448	465111	4	4	5.5	0.012	0.062	−1.32	E	*ls*
7		$^2S-^2P^\circ$	*498.31*	264400	*465080*	2	6	10	0.12	0.38	−0.62	D	1
			[498.23]	264400	465111	2	4	10	0.076	0.25	−0.82	D	*ls*
			[498.46]	264400	465017	2	2	11	0.040	0.13	−1.10	D	*ls*
8		$^2P-^2D^\circ$	*783.72*	*284749*	*412345*	6	10	8.0	0.12	1.9	−0.14	D	1
			[786.65]	285189	412311	4	6	7.6	0.11	1.1	−0.36	D	*ls*
			[778.05]	283869	412395	2	4	6.8	0.12	0.63	−0.62	D	*ls*
			[786.13]	285189	412395	4	4	1.4	0.013	0.13	−1.28	E	*ls*
9		$^2P-^2P^\circ$	*554.54*	*284749*	*465080*	6	6	34	0.16	1.7	−0.02	D	1
			[555.80]	285189	465111	4	4	28	0.13	0.94	−0.28	D	*ls*
			[552.03]	283869	465017	2	2	23	0.10	0.38	−0.70	D	*ls*
			[556.09]	285189	465017	4	2	11	0.026	0.19	−0.98	D−	*ls*
			[551.75]	283869	465111	2	4	5.7	0.052	0.19	−0.98	D−	*ls*
10	$2p-(^1S)3s$	$^2P^\circ-^2S$	*105.27*	*1426*	951347	6	2	450	0.025	0.052	−0.82	C	interp
			[105.35]	2139	951347	4	2	300	0.025	0.035	−1.00	C	*ls*
			[105.11]	0	951347	2	2	150	0.025	0.017	−1.30	C	*ls*
11	$2p-(^1S)3d$	$^2P^\circ-^2D$	*94.409*	*1426*	1060651	6	10	2700	0.60	1.1	0.56	C	interp
			[94.468]	2139	1060699	4	6	2600	0.53	0.66	0.33	C	*ls*
			[94.288]	0	1060580	2	4	2200	0.60	0.37	0.08	C	*ls*
			[94.479]	2139	1060580	4	4	440	0.059	0.073	−0.63	E	*ls*
12	$3s-(^1S)3p$	$^2S-^2P^\circ$											
			[1752.2]	951347	1008418	2	4	3.32	0.306	3.53	−0.213	C	2, *ls*
13	$3p-(^1S)3d$	$^2P^\circ-^2D$											
			[1912.7]	1008418	1060699	4	6	2.20	0.181	4.56	−0.140	C	*ca*, *ls*
			[1917.1]	1008418	1060580	4	4	0.37	0.020	0.51	−1.09	D	*ca*, *ls*

Na VII

Forbidden Transitions

The line strength for the one transition in the ground state configuration is a straight number, tabulated for example by Naqvi [1]. The transition probability should also be quite accurate, since the energy level difference is accurately known.

Reference

[1] Naqvi, A. M., Thesis Harvard (1951).

Na VII. Forbidden Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	Type of Transition	A_{ki}(sec^{-1})	S(at.u.)	Accuracy	Source
1	$2p-(^1S)2p$	$^2P^\circ-^2P^\circ$	[46738]	0	2139	2	4	m	0.0878	1.33	A	1

Na VIII

Ground State $1s^22s^2\ ^1S_0$

Ionization Potential 264.155 eV = 2131139 cm^{-1}

Allowed Transitions

List of tabulated lines:

Wavelength [Å]	No.	Wavelength [Å]	No.	Wavelength [Å]	No.
77.267	6	497.80	3	2059.1	10
98.080	7	499.73	3	2558.2	16
411.15	2	788.75	1	2772.0	13
492.33	3	848.73	4	3021.0	15
492.91	5	1239.4	14	3108.9	17
493.97	3	1802.7	11	3182.3	8
495.76	3	1867.7	12	14401	9
496.25	3				

Garstang and Shamey [1] have obtained the f-value for the intercombination line $2\ ^1S_0-2\ ^3P_1$ by calculating the ratio of this line against the resonance transition in the intermediate coupling approximation and by using for the resonance line a value calculated according to Cohen and Dalgarno's method [2]. The data calculated from the charge-expansion method of Cohen and Dalgarno [2], which includes limited configuration mixing, are estimated to be usually accurate to 50 percent or better, while the charge-expansion method of Naqvi and Victor [3] should be less reliable when the effects of configuration interaction are strong, since these are neglected entirely. In assigning the accuracy estimates for these methods as well as for the Coulomb approximation we were to a great extent guided by studying the degree of fit of the data into the systematic trends along isoelectronic sequences.

References

[1] Garstang, R. H., and Shamey, L. J., Astrophys. J. **148,** 665–666 (1967).
[2] Cohen, M., and Dalgarno, A., Proc. Roy. Soc. London **A280,** 258–270 (1964).
[3] Naqvi, A. M., and Victor, G. A., Technical Documentary Report No. RTD TDR–63–3118 (1964).

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
1	$2s^2-2s(^2S)2p$	$^1S-^3P^\circ$											
			[788.75]	0	[126783]	1	3	6.4×10^{-4}	1.8×10^{-5}	4.7×10^{-5}	−4.74	D	1*n*
2		$^1S-^1P^\circ$	411.15	0	243223	1	3	45.5	0.346	0.468	−0.461	C	2
3	$2s2p-2p^2$	$^3P^\circ-^3P$	*496.06*	[*127593*]	[*329183*]	9	9	37	0.14	2.0	0.10	D+	2
			[496.25]	[128387]	[329899]	5	5	28	0.10	0.83	−0.30	D+	*ls*
			[495.76]	[126783]	[328494]	3	3	9.4	0.035	0.17	−0.98	D−	*ls*
			[499.73]	[128387]	[328494]	5	3	15	0.034	0.28	−0.77	D−	*ls*
			[497.80]	[126783]	[327667]	3	1	36	0.045	0.22	−0.87	D−	*ls*
			[492.33]	[126783]	[329899]	3	5	9.5	0.058	0.28	−0.76	D−	*ls*
			[493.97]	[126053]	[328494]	1	3	12	0.14	0.22	−0.85	D−	*ls*
4		$^1P^\circ-^1D$	[848.73]	243223	361046	3	5	8.0	0.14	1.2	−0.38	D−	2
5		$^1P^\circ-^1S$	[492.91]	243223	446099	3	1	73	0.088	0.43	−0.58	E	2
6	$2s^2-2s(^2S)3p$	$^1S-^1P^\circ$	[77.267]	0	1294214	1	3	2000	0.55	0.14	−0.26	E	3
7	$2s2p-2s(^2S)3s$	$^1P^\circ-^1S$	[98.080]	243223	1262799	3	1	140	0.0065	0.0063	−1.71	E	3
8	$2s3s-2s(^2S)3p$	$^1S-^1P^\circ$	[3182.3]	1262799	1294214	1	3	0.461	0.210	2.20	−0.68	C	3
9	$2p3s-2p(^2P^\circ)3p$	$^1P^\circ-^1P$	[14401]	1426049	1432991	3	3	0.00484	0.0150	2.14	−1.347	C	*ca*
10		$^1P^\circ-^1D$	[2059.1]	1426049	1474598	3	5	1.80	0.190	3.87	−0.244	C	*ca*
11		$^1P^\circ-^1S$	[1802.7]	1426049	1481521	3	1	2.70	0.0438	0.78	−0.88	C	*ca*
12	$2s3p-2s(^2S)3d$	$^1P^\circ-^1D$	[1867.7]	1294214	1347756	3	5	2.01	0.175	3.23	−0.280	C	*ca*
13	$2p3p-2p(^2P^\circ)3d$	$^1P-^1D^\circ$	[2772.0]	1432991	1469055	3	5	0.419	0.080	2.20	−0.62	C	*ca*
14		$^1P-^1P^\circ$	[1239.4]	1432991	1513677	3	3	3.02	0.069	0.85	−0.68	C	*ca*
15		$^1D-^1F^\circ$	[3021.0]	1474598	1507690	5	7	0.490	0.094	4.67	−0.328	C	*ca*
16		$^1D-^1P^\circ$	[2558.2]	1474598	1513677	5	3	0.0226	0.00133	0.056	−2.177	C	*ca*
17		$^1S-^1P^\circ$	[3108.9]	1481521	1513677	1	3	0.258	0.112	1.15	−0.95	C	*ca*

Na VIII

Forbidden Transitions

Naqvi's calculations [1] are the only available source. The results for the $^3P^\circ-^3P^\circ$ transitions are essentially independent of the choice of the interaction parameters. For the $^3P^\circ-^1P^\circ$ transitions, Naqvi uses empirical term intervals, i.e., the effects of configuration interaction should be partially included.

Reference

[1] Naqvi, A. M., Thesis Harvard (1951).

Na VIII. Forbidden Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	Type of Transition	A_{ki}(sec^{-1})	S(at.u.)	Accuracy	Source
1	$2s2p-2s(^2S)2p$	$^3P^\circ-^3P^\circ$										
			[13.70 × 10^4]	[126053]	[126783]	1	3	m	0.00699	2.00	B	1
			[62327]	[126783]	[128387]	3	5	m	0.0557	2.50	A	1
2		$^3P^\circ-^1P^\circ$										
			[853.46]	[126053]	243223	1	3	m	2.70	1.87 × 10^{-4}	C	1
			[858.81]	[126783]	243223	3	3	m	2.06	0.0145	C	1
			[870.05]	[128287]	243223	5	3	m	3.18	2.33 × 10^{-4}	C	1

Na IX

Ground State $1s^22s\ ^2S_{1/2}$

Ionization Potential 299.78 eV = 2418520 cm^{-1}

Allowed Transitions

List of tabulated lines:

Wavelength [Å]	No.	Wavelength [Å]	No.	Wavelength [Å]	No.
53.860	3	77.764	6	224.17	11
58.201	7	77.911	6	681.72	1
58.279	7	77.925	6	694.26	1
58.291	7	81.175	4	2487.7	8
58.952	5	81.350	4	2535.8	8
59.044	5	208.02	9	6841.8	10
70.615	2	223.79	11	7103.4	10
70.653	2	223.99	11	7218.2	10

For the transition $2s-2p$, the charge-expansion calculation of Cohen and Dalgarno [1] is chosen. An uncertainty of less than 10 percent is indicated from the graphical comparison of this value with the other material for the same transition within the isoelectronic sequence. Data for the other listed transitions have been obtained from the Coulomb approximation. Plots of the dependence of f-value on nuclear charge for all these transitions have been made and show that this material connects up very smoothly with the data for the lower ions as well as with the hydrogenic value for infinite nuclear charge. Based on this impressive agreement, accuracies of 10 percent (or 25 percent for some of the smaller values) are indicated.

Reference

[1] Cohen, M., and Dalgarno, A., Proc. Roy. Soc. London **A280**, 258–270 (1964).

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
1	$2s-2p$	$^2S-^2P^\circ$	*685.85*	0	*145805*	2	6	6.59	0.140	0.630	−0.553	B	1
			[681.72]	0	146688	2	4	6.71	0.0936	0.420	−0.728	B	*ls*
			[694.26]	0	144038	2	2	6.36	0.0459	0.210	−1.037	B	*ls*
2	$2s-3p$	$^2S-^2P^\circ$	*70.628*	0	*1415876*	2	6	1380	0.310	0.144	−0.208	B	*ca*
			[70.615]	0	1416130	2	4	1380	0.206	0.0960	−0.385	B	*ls*
			[70.653]	0	1415368	2	2	1380	0.103	0.0480	−0.686	B	*ls*
3	$2s-4p$	$^2S-^2P^\circ$	[53.860]	0	1856665	2	6	630	0.082	0.0292	−0.79	C+	*ca*
4	$2p-3s$	$^2P^\circ-^2S$	*81.292*	*145805*	1375944	6	2	705	0.0233	0.0374	−0.854	B	*ca*
			[81.350]	146688	1375944	4	2	470	0.0233	0.0250	−1.031	B	*ls*
			[81.175]	144038	1375944	2	2	236	0.0234	0.0125	−1.330	B	*ls*
5	$2p-4s$	$^2P^\circ-^2S$	*59.013*	*145805*	1840336	6	2	276	0.00480	0.0056	−1.54	C	*ca*
			[59.044]	146688	1840336	4	2	184	0.00480	0.00373	−1.72	C	*ls*
			[58.952]	144038	1840336	2	2	92	0.00482	0.00187	−2.016	C	*ls*
6	$2p-3d$	$^2P^\circ-^2D$	*77.819*	*145805*	*1430114*	6	10	4430	0.670	1.03	0.604	B	*ca*
			[77.911]	146688	1430204	4	6	4410	0.602	0.618	0.382	B	*ls*
			[77.764]	144038	1429980	2	4	3690	0.670	0.343	0.127	B	*ls*
			[77.925]	146688	1429980	4	4	735	0.0670	0.0687	−0.572	B	*ls*
7	$2p-4d$	$^2P^\circ-^2D$	*58.254*	*145805*	*1862432*	6	10	1620	0.137	0.158	−0.085	C+	*ca*
			[58.279]	146688	1862572	4	6	1620	0.124	0.095	−0.305	C+	*ls*
			[58.201]	144038	1862222	2	4	1360	0.138	0.053	−0.56	C+	*ls*
			[58.291]	146688	1862222	4	4	267	0.0137	0.0105	−1.261	C+	*ls*
8	$3s-3p$	$^2S-^2P^\circ$	*2503.5*	1375944	*1415876*	2	6	0.822	0.232	3.82	−0.333	B	*ca*
			[2487.7]	1375944	1416130	2	4	0.839	0.156	2.55	−0.506	B	*ls*
			[2535.8]	1375944	1415368	2	2	0.789	0.0761	1.27	−0.818	B	*ls*
9	$3s-4p$	$^2S-^2P^\circ$	[208.02]	1375944	1856665	2	6	171	0.334	0.457	−0.175	C+	*ca*
10	$3p-3d$	$^2P^\circ-^2D$	*7021.5*	*1415876*	*1430114*	6	10	0.0295	0.0363	5.04	−0.662	B	*ca*
			[7103.4]	1416130	1430204	4	6	0.0285	0.0323	3.02	−0.889	B	*ls*
			[6841.8]	1415368	1429980	2	4	0.0266	0.0373	1.68	−1.127	B	*ls*
			[7218.2]	1416130	1429980	4	4	0.00453	0.00353	0.336	−1.850	B	*ls*
11	$3p-4d$	$^2P^\circ-^2D$	*223.94*	*1415876*	*1862432*	6	10	456	0.57	2.53	0.53	C+	*ca*
			[223.99]	1416130	1862572	4	6	457	0.51	1.52	0.310	C+	*ls*
			[223.79]	1415368	1862222	2	4	380	0.57	0.84	0.057	C+	*ls*
			[224.17]	1416130	1862222	4	4	76	0.057	0.169	−0.64	C+	*ls*

MAGNESIUM

Mg I

Ground State $1s^2 2s^2 2p^6 3s^2\ ^1S_0$

Ionization Potential 7.644 eV = 61669.14 cm^{-1}

Allowed Transitions

List of tabulated lines:

Wavelength [Å]	No.	Wavelength [Å]	No.	Wavelength [Å]	No.
2025.82	4	3096.89	9	5528.40	10
2736.54	15	3329.92	11	7657.8	24
2776.69	3	3332.15	11	8806.76	6
2778.27	3	3336.67	11	8923.57	25
2779.83	3	3829.35	5	9255.78	19
2781.42	3	3832.30	5	9414.96	21
2782.97	3	3838.29	5	10811.1	20
2846.72	12	4351.91	16	10953.3	26
2848.34	12	4562.48	1	10957.3	26
2851.66	12	4571.10	1	10965.5	26
2852.13	2	4575.3	1	11828.2	8
2936.74	14	4702.99	13	12083.7	17
2938.47	14	5167.32	7	14877.6	18
2942.00	14	5172.68	7	15031	22
3091.07	9	5183.60	7	17108.7	23
3092.98	9				

For the intercombination line $3s^2\ ^1S_0 - 3s3p\ ^3P^\circ_1$, Boldt's [2] absorption tube measurement is averaged with Garstang's [1] theoretical result. The latter has been renormalized by using the *f*-value for the resonance line listed in this table. Garstang [1] has also calculated values for the two intercombination lines $3s^2\ ^1S_0 - 3s3p\ ^3P_{0,2}$, which arise by the interaction of the nuclear moments with the electrons. These values have also been renormalized in the same manner as above. In the case of the J = 0 to J = 2 transition, magnetic quadrupole radiation constitutes an important contribution to the total transition probability. (See Mg I—Forbidden Lines; see also the General Introduction for adding transition probabilities of various types of radiation.) It should be noted that the listed values for the nuclear-spin-induced transitions are for the isotope Mg^{25}; for natural magnesium, the relative isotopic abundances must be taken into account.

From the extensive material on the resonance line we have selected the results of Lurio [3] (lifetime measurement via Hanle-effect), Smith and Gallagher [4] (same method) and Weiss [5] (Hartree-Fock calculations in the dipole length approximation, with superposition of configurations). The average of the three values, which agree within 5 percent, has been adopted.

For the other lines, we have made use of three theoretical investigations and two experiments. The calculations by Weiss [5], Zare [7], and Trefftz [9] all employ the self-consistent field approach. They differ insofar as Weiss uses Hartree-Fock functions and superimposes many possible configurations; Zare also includes configuration mixing, but starts with the simpler, less accurate Hartree-Fock-Slater wavefunctions; and Trefftz uses Hartree-Fock wavefunctions but takes configuration mixing only partially into account. Weiss' approach must be considered as the most comprehensive one; thus we have used his values—averaged with experiment—in preference over the others and, when not available, have chosen Zare's results over those of Trefftz. Normally the three methods agree within 15 percent. Exceptions are transitions which involve the $3s3p\ ^1P^\circ$ state, where Zare's values are much larger than those of the other two authors. However, for two lines originating from this state where the experimental values of Kersten and Ornstein [8] are

available, Zare agrees better with the measurements than Trefftz. and the average of the experiment and Zare's result has been adopted.

The two experiments mentioned above are the anomalous dispersion measurements of Penkin and Shabanova [6] and emission intensity measurements of Kersten and Ornstein [8] with a low-current, free-burning arc. Both experiments yield relative f-values, which have been normalized by a least-squares fit to Weiss' theoretical results. The values of Penkin and Shabanova differ by no more than 15 percent from Weiss' results, which speaks for the reliability of the two methods. Therefore, averages from the two methods have been used when they overlap. The measurements of Kersten and Ornstein show a much larger scatter. Thus their results are only sparingly used.

References

[1] Garstang, R. H., J. Opt. Soc. Am. **52**, 845–851 (1962).
[2] Boldt, G., Z. Physik **150**, 205–214 (1958).
[3] Lurio, A., Phys. Rev. **136**, A376–A379 (1964).
[4] Smith, W. W., and Gallagher, A., Phys. Rev. **145**, 26–35 (1966).
[5] Weiss, A. W., J. Chem. Phys. **47**, 3573 (1967).
[6] Penkin, N. P., and Shabanova, L. N., Optics and Spectroscopy (U.S.S.R.) **12**, 1–5 (1962).
[7] Zare, R. N., J. Chem. Phys. **47**, 3561 (1967).
[8] Kersten, J. A. H., and Ornstein, L. S., Physica **8**, 1124–1136 (1941).
[9] Trefftz, E., Z. Astrophys. **28**, 67–78 (1950).

Mg I. Allowed Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
1	$3s^2-3s(^2S)3p$	$^1S-^3P^\circ$ (1)	[a]4562.48	0	21911	1	5	2.2×10^{-12}	3.5×10^{-12}	5.3×10^{-11}	−11.46	D−	1n
			4571.10	0	21870	1	3	4.3×10^{-6}	4.0×10^{-6}	6.1×10^{-5}	−5.40	D	1n, 2
			[a][4575.3]	0	21850	1	1	5.8×10^{-12}	1.8×10^{-12}	2.8×10^{-11}	−11.74	D−	1n
2		$^1S-^1P^\circ$ (1 uv)	2852.13	0	35051	1	3	4.95	1.81	17.0	0.258	B	3, 4, 5
3	$3s3p-3p^2$	$^3P^\circ-3P$ (6 uv)	*2779.9*	*21891*	*57853*	9	9	5.2	0.61	50	0.74	C+	5, 6n
			2779.83	21911	57874	5	5	3.92	0.455	20.8	0.357	C+	ls
			2779.83	21870	57833	3	3	1.31	0.152	4.17	−0.341	C	ls
			2782.97	21911	57833	5	3	2.16	0.151	6.9	−0.122	C	ls
			2781.42	21870	57813	3	1	5.3	0.204	5.6	−0.213	C	ls
			2776.69	21870	57874	3	5	1.31	0.252	6.9	−0.121	C	ls
			2778.27	21850	57833	1	3	1.76	0.61	5.6	−0.215	C	ls
4	$3s^2-3s(^2S)4p$	$^1S-^1P^\circ$ (2 uv)	2025.82	0	49347	1	3	1.2	0.22	1.5	−0.66	D	7
5	$3s3p-3s(^2S)3d$	$^3P^\circ-^3D$ (3)	*3835.3*	*21891*	47957	9	15	1.68	0.619	70.3	0.746	B	5, 6n
			3838.29	21911	47957	5	7	1.68	0.519	32.8	0.414	B	ls
			3832.30	21870	47957	3	5	1.27	0.465	17.6	0.145	B	ls
			3829.35	21850	47957	1	3	0.940	0.620	7.82	−0.208	B	ls
			3838.29	21911	47957	5	5	0.420	0.0928	5.86	−0.333	B	ls
			3832.30	21870	47957	3	3	0.703	0.155	5.86	−0.333	B	ls
			3838.29	21911	47957	5	3	0.047	0.0062	0.39	−1.51	D	ls
6		$^1P^\circ-^1D$ (7)	8806.76	35051	46403	3	5	0.14	0.28	24	−0.08	D	5
7	$3s3p-3s(^2S)4s$	$^3P^\circ-^3S$ (2)	*5178.3*	*21891*	41197	9	3	1.04	0.139	21.3	0.097	B	5, 6n
			5183.60	21911	41197	5	3	0.575	0.139	11.9	−0.158	B	ls
			5172.68	21870	41197	3	3	0.346	0.139	7.10	−0.380	B	ls
			5167.32	21850	41197	1	3	0.116	0.139	2.36	−0.857	B	ls

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
8		^{1}P°—^{1}S (6)	11828.2	35051	43503	3	1	0.26	0.18	21	−0.27	D	5
9	3*s*3*p*—3*s*(^{2}S)4*d*	^{3}P°—^{3}D (5)	*3095.0*	*21891*	54192	9	15	0.56	0.134	12.3	0.081	C	6*n*, 7
			3096.89	21911	54192	5	7	0.56	0.112	5.7	−0.252	C	*ls*
			3092.98	21870	54192	3	5	0.420	0.101	3.07	−0.52	C	*ls*
			3091.07	21850	54192	1	3	0.313	0.135	1.37	−0.87	C	*ls*
			3096.89	21911	54192	5	5	0.139	0.0200	1.02	−1.000	C	*ls*
			3092.98	21870	54192	3	3	0.233	0.0334	1.02	−1.000	C	*ls*
			3096.89	21911	54192	5	3	0.016	0.0013	0.068	−2.18	E	*ls*
10		^{1}P°—^{1}D (9)	5528.40	35051	53135	3	5	0.14	0.11	6.0	−0.48	D−	7, 8*n*
11	3*s*3*p*—3*s*(^{2}S)5*s*	^{3}P°—^{3}S (4)	*3334.5*	*21891*	51872	9	3	0.31	0.017	1.7	−0.82	D	8*n*
			3336.67	21911	51872	5	3	0.17	0.017	0.93	−1.07	D	*ls*
			3332.15	21870	51872	3	3	0.10	0.017	0.56	−1.29	D	*ls*
			3329.92	21850	51872	1	3	0.034	0.017	0.19	−1.77	D	*ls*
12	3*s*3*p*—3*s*(^{2}S)5*d*	^{3}P°—^{3}D (5 uv)	*2850.0*	*21891*	56968	9	15	0.27	0.055	4.7	−0.31	D−	7, 8*n*
			2851.66	21911	56968	5	7	0.27	0.047	2.2	−0.63	D−	*ls*
			2848.34	21870	56968	3	5	0.21	0.043	1.2	−0.89	D−	*ls*
			2846.72	21850	56968	1	3	0.15	0.055	0.52	−1.26	D−	*ls*
			2851.66	21911	56968	5	5	0.068	0.0083	0.39	−1.38	D−	*ls*
			2848.34	21870	56968	3	3	0.11	0.014	0.39	−1.38	D−	*ls*
			2851.66	21911	56968	5	3	0.0076	5.5×10^{-4}	0.026	−2.56	E	*ls*
13		^{1}P°—^{1}D (11)	4702.99	35051	56308	3	5	0.16	0.088	4.1	−0.58	D−	7, 8*n*
14	3*s*3*p*—3*s*(^{2}S)6*s*	^{3}P°—^{3}S (3 uv)	*2940.2*	*21891*	55892	9	3	0.16	0.0067	0.58	−1.22	D−	8*n*
			2942.00	21911	55892	5	3	0.086	0.0067	0.32	−1.47	D−	*ls*
			2938.47	21870	55892	3	3	0.052	0.0067	0.19	−1.70	D−	*ls*
			2936.74	21850	55892	1	3	0.017	0.0067	0.065	−2.17	D−	*ls*
15	3*s*3*p*—3*s*(^{2}S)6*d*	^{3}P°—^{3}D (9 uv)											
			2736.54	21911	58443	5	7	0.207	0.0326	1.47	−0.79	C	6*n*
16		^{1}P°—^{1}D (14)	4351.91	35051	58023	3	5	0.21	0.10	4.3	−0.52	D−	8*n*
17	3*s*3*d*—3*s*(^{2}S)4*f*	^{1}D—^{1}F° (26)	12083.7	46403	54676	5	7	0.170	0.52	103	0.415	C	9
18		^{3}D—^{3}F°	14877.6	47957	54677	15	21	0.105	0.487	358	0.86	C	9
19	3*s*3*d*—3*s*(^{2}S)5*f*	^{1}D—^{1}F° (27)	9255.78	46403	57204	5	7	0.089	0.16	24	−0.09	C	9
20		^{3}D—^{3}F° (37)	10811.1	47957	57204	15	21	0.0452	0.111	59	0.221	C	9
21	3*s*3*d*—3*s*(^{2}S)6*f*	^{3}D—^{3}F° (38)	9414.96	47957	58576	15	21	0.022	0.041	19	−0.21	C	9
22	3*s*4*s*—3*s*(^{2}S)4*p*	^{3}S—^{3}P°	*15031*	41197	*47848*	3	9	0.139	1.41	209	0.63	C+	7
23		^{1}S—^{1}P°	17108.7	43503	49347	1	3	0.094	1.24	70	0.093	C	7
24	3*s*4*s*—3*s*(^{2}S)5*p*	^{3}S—^{3}P° (22)	*7657.8*	41197	*54252*	3	9	0.0148	0.0390	2.95	−0.93	C−	9
25		^{1}S—^{1}P° (25)	8923.57	43503	54707	1	3	0.011	0.040	1.2	−1.40	D−	*ca*

Mg I. Allowed Transitions—*Continued*

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
26	$3s4p-3s(^2S)5d$	$^3P^\circ-^3D$ (35)	*10962*	*47848*	56968	9	15	0.044	0.13	43	0.08	D	*ca*
			10965.5	47851	56968	5	7	0.044	0.11	20	−0.25	D	*ls*
			10957.3	47844	56968	3	5	0.033	0.10	11	−0.52	D	*ls*
			10953.3	47841	56968	1	3	0.025	0.13	4.8	−0.88	D−	*ls*
			10965.5	47851	56968	5	5	0.011	0.020	3.6	−1.00	D−	*ls*
			10957.3	47844	56968	3	3	0.018	0.033	3.6	−1.00	D−	*ls*
			10965.5	47851	56968	5	3	0.0012	0.0013	0.24	−2.18	E	*ls*

[a] See introduction.

Mg I

Forbidden Transitions

The transition probability for that part of the $3s^2\,^1S_0-3s3p\,^3P_2$ transition which is magnetic quadrupole radiation (m.q.) is taken from calculations of Garstang [1]. Following a private communication by him, we have renormalized his published value (For the addition of transition probabilities arising from various types of radiation, see the General Introduction; also, for the relation of A_{ki} (m.q.) to other quantities, see [1].) The data for the $^3P^\circ-^3P^\circ$ and $^3P^\circ-^1P^\circ$ magnetic dipole transitions are from Naqvi's calculations [2]. The results for the $^3P^\circ-^3P^\circ$ transitions are essentially indpendent of the choice of interaction parameters and therefore more accurate than those for $^3P^\circ-^1P^\circ$. For the latter transitions, Naqvi uses empirical term intervals, i.e., the effects of configuration interaction should be partially included. For three $3s3p-3s4p$ electric quadrupole lines, transition probabilities have been calculated by Möller [3], which are consistent with experimental observations.

References

[1] Garstang, R. H., Astrophys. J. **148**, 579–584 (1967) and private communication (1967).
[2] Naqvi, A. M., Thesis Harvard (1951).
[3] Möller, N. H., Arkiv för Fysik **29**, 353–358 (1966).

Mg I. Forbidden Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	Type of Transition	A_{ki}(sec^{-1})	S(at.u.)	Accuracy	Source
1	$3s^2-3s(^2S)3p$	$^1S-^3P^\circ$										
			4562.48	0.000	21911.2	1	5	*m.q.*	2.8×10^{-4}	.....	E	1*n*
2	$3s3p-3s(^2S)3p$	$^3P^\circ-^3P^\circ$										
			[49.839×10^5]	21850.4	21870.5	1	3	*m*	1.45×10^{-7}	2.00	A	2
			[24.555×10^5]	21870.5	21911.2	3	5	*m*	9.11×10^{-7}	2.50	A	2
3		$^3P^\circ-^1P^\circ$										
			[7573.2]	21850.4	35051.3	1	3	*m*	1.10×10^{-6}	5.3×10^{-8}	C	2
			[7584.7]	21870.5	35051.3	3	3	*m*	0.0050	2.45×10^{-4}	C	2
			[7608.2]	21911.2	35051.3	5	3	*m*	1.35×10^{-6}	6.6×10^{-8}	C	2
4	$3s3p-3s(^2S)4p$	$^3P^\circ-^3P^\circ$										
			3854.97	21911.2	47844.4	5	3	*e*	53	81	D	3
			3853.96	21911.2	47851.2	5	5	*e*	25	63	D	3
			3848.91	21870.5	47844.4	3	3	*e*	18	27	D	3

Mg II

Ground State $1s^2 2s^2 2p^6 3s\ ^2S_{1/2}$

Ionization Potential 15.03 eV = 121267.41 cm^{-1}

Allowed Transitions

List of tabulated lines:

Wavelength [Å]	No.	Wavelength [Å]	No.	Wavelength [Å]	No.
1026.0	3	3538.8	17	4481.2	7
1239.9	2	3538.81	17	5264.3	22
1240.4	2	3549.52	18	6346.8	21
2660.8	10	3553.37	18	7877.05	13
2790.77	4	3613.78	12	7896.37	13
2795.53	1	3615.58	12	7896.4	13
2797.99	4	3848.2	8	8213.99	14
2798.0	4	3848.21	8	8234.64	14
2802.70	1	3850.39	8	9218.25	11
2928.63	5	4384.64	15	9244.27	11
2936.51	5	4390.56	15	9632.2	20
3104.8	9	4390.6	15	10914.2	6
3172.71	19	4427.99	16	10915.3	6
3175.78	19	4433.99	16	10951.8	6
3534.97	17				

The adopted value for the resonance line is an average of self-consistent field calculations including polarization and exchange effects, by Biermann and Lübeck [1], calculations employing a scaled Thomas-Fermi potential by Stewart and Rotenberg [2], and a lifetime experiment utilizing the Hanle effect by Smith and Gallagher [3]. The results of the three methods agree within a few percent. The other transitions covered by Biermann and Lübeck ($3p-3d$ and $3d-4f$) should also be quite accurate, i.e., within 10 percent. Less refined self-consistent field calculations (including exchange but neglecting polarization) have been undertaken for several other multiplets by Chapman, Clarke and Aller [4]. In the remaining two transitions treated by Stewart and Rotenberg ($3s-4p$ and $3s-5p$) and in all transitions involving the $5p$ state there appear to be considerable cancellation effects in the transition integral. Hence, accuracy ratings of "D" or "E" have been assigned to these transitions.

For Mg II, a member of the sodium isoelectronic sequence, it is possible to utilize extensively the dependence of oscillator strengths on nuclear charge for the intercomparison of analogous transitions. Thus, the degree of fit of the individual f-values into the systematic trends has served as one of the decisive factors for the choice of accuracy assignments.

References

[1] Biermann, L., and Lübeck, K., Z. Astrophys. **25**, 325–339 (1948).
[2] Stewart, J. C., and Rotenberg, M., Phys. Rev. **140**, 1508A–1519A (1965).
[3] Smith, W. W., and Gallagher, A., Phys. Rev. **145**, 26–35 (1966).
[4] Chapman, R. D., Clarke, W. H., and Aller, L. H., Astrophys. J. **144**, 376–380 (1966).

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
1	$3s-3p$	$^2S-^2P^\circ$ (1 uv)	*2797.9*	0	*35730*	2	6	2.67	0.940	17.3	0.274	B+	1, 2, 3
			2795.53	0	35761	2	4	2.68	0.627	11.5	0.098	B+	*ls*
			2802.70	0	35669	2	2	2.66	0.313	5.78	−0.203	B+	*ls*
2	$3s-4p$	$^2S-^2P^\circ$	*1240.1*	0	*80640*	2	6	0.0033	2.3×10^{-4}	0.0019	−3.34	E	2
			[1239.9]	0	80650	2	4	0.0033	1.5×10^{-4}	0.0012	−3.52	E	*ls*
			[1240.4]	0	80620	2	2	0.0033	7.7×10^{-5}	6.3×10^{-4}	−3.81	E	*ls*
3	$3s-5p$	$^2S-^2P^\circ$	*1026.0*	0	*97464*	2	6	0.0021	0.0010	0.0068	−2.70	D	2
4	$3p-3d$	$^2P^\circ-^2D$ (3 uv)	*2795.5*	*35730*	71491	6	10	4.71	0.920	50.8	0.742	B	1
			2797.99	35761	71491	4	6	4.70	0.828	30.5	0.520	B	*ls*
			2790.77	35669	71491	2	4	3.94	0.920	16.9	0.265	B	*ls*
			[2798.0]	35761	71491	4	4	0.783	0.0919	3.39	−0.435	B	*ls*
5	$3p-4s$	$^2P^\circ-^2S$ (2 uv)	*2933.8*	*35730*	69805	6	2	3.23	0.139	8.1	−0.079	C+	*ca*
			2936.51	35761	69805	4	2	2.15	0.139	5.4	−0.255	C+	*ls*
			2928.63	35669	69805	2	2	1.07	0.138	2.66	−0.56	C+	*ls*
6	$3d-4p$	$^2D-^2P^\circ$ (3)	*10926*	71491	*80640*	10	6	0.166	0.178	64	0.250	C	*ca*
			10914.2	71491	80650	6	4	0.150	0.178	38.4	0.029	C	*ls*
			10951.8	71491	80620	4	2	0.166	0.149	21.5	−0.225	C	*ls*
			10915.3	71491	80650	4	4	0.0162	0.0290	4.17	−0.94	C	*ls*
7	$3d-4f$	$^2D-^2F^\circ$ (4)	*4481.2*	71491	93800	10	14	2.25	0.950	140	0.978	B	1
8	$3d-5p$	$^2D-^2P^\circ$ (5)	*3849.1*	71491	*97464*	10	6	0.035	0.0047	0.60	−1.33	D	4
			3848.21	71491	97469	6	4	0.032	0.0047	0.36	−1.55	D	*ls*
			3850.39	71491	97455	4	2	0.035	0.0039	0.20	−1.81	D	*ls*
			[3848.2]	71491	97469	4	4	0.0035	7.8×10^{-4}	0.039	−2.51	D	*ls*
9	$3d-5f$	$^2D-^2F^\circ$ (6)	*3104.8*	71491	103690	10	14	0.81	0.164	16.8	0.215	C	*ca*
10	$3d-6f$	$^2D-^2F^\circ$ (4 uv)	*2660.8*	71491	109062	10	14	0.38	0.057	5.0	−0.24	D	*ca*
11	$4s-4p$	$^2S-^2P^\circ$ (1)	*9226.0*	69805	*80640*	2	6	0.358	1.37	83	0.438	C+	*ca*
			9218.25	69805	80650	2	4	0.359	0.91	55	0.262	C+	*ls*
			9244.27	69805	80620	2	2	0.356	0.456	27.8	−0.040	C+	*ls*
12	$4s-5p$	$^2S-^2P^\circ$ (2)	*3614.4*	69805	*97464*	2	6	0.0017	0.0010	0.024	−2.70	E	4
			3613.78	69805	97469	2	4	0.0018	6.9×10^{-4}	0.016	−2.86	E	*ls*
			3615.58	69805	97455	2	2	0.0017	3.4×10^{-4}	0.0081	−3.17	E	*ls*
13	$4p-4d$	$^2P^\circ-^2D$ (8)	*7889.9*	*80640*	93311	6	10	0.79	1.23	192	0.87	C+	*ca*
			7896.37	80650	93311	4	6	0.79	1.11	115	0.65	C+	*ls*
			7877.05	80620	93311	2	4	0.66	1.23	64	0.391	C+	*ls*
			[7896.4]	80650	93311	4	4	0.133	0.124	12.9	−0.305	C+	*ls*
14	$4p-5s$	$^2P^\circ-^2S$ (7)	*8231.6*	*80640*	92791	6	2	0.78	0.264	42.9	0.200	C+	*ca*
			8234.64	80650	92791	4	2	0.52	0.264	28.6	0.024	C+	*ls*
			8213.99	80620	92791	2	2	0.260	0.263	14.2	−0.279	C+	*ls*

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
15	$4p-5d$	$^2P^\circ-^2D$ (10)	*4388.6*	*80640*	103420	6	10	0.17	0.081	7.0	−0.31	D	4
			4390.56	80650	103420	4	6	0.17	0.074	4.3	−0.53	D	*ls*
			4384.64	80620	103420	2	4	0.14	0.083	2.4	−0.78	D	*ls*
			[4390.6]	80650	103420	4	4	0.017	0.0050	0.29	−1.70	D	*ls*
16	$4p-6s$	$^2P^\circ-^2S$ (9)	*4432.0*	*80640*	103197	6	2	0.321	0.0315	2.76	−0.72	C+	4
			4433.99	80650	103197	4	2	0.214	0.0315	1.84	−0.90	C+	*ls*
			4427.99	80620	103197	2	2	0.107	0.0315	0.92	−1.201	C+	*ls*
17	$4p-6d$	$^2P^\circ-^2D$ (12)	*3537.6*	*80640*	108900	6	10	0.059	0.019	1.3	−0.95	D	*ca*
			3538.81	80650	108900	4	6	0.059	0.017	0.77	−1.18	D	*ls*
			3534.97	80620	108900	2	4	0.050	0.019	0.43	−1.43	D	*ls*
			[3538.8]	80650	108900	4	4	0.0098	0.0018	0.086	−2.13	D	*ls*
18	$4p-7s$	$^2P^\circ-^2S$ (11)	*3552.1*	*80640*	108784	6	2	0.162	0.0102	0.72	−1.213	C	*ca*
			3553.37	80650	108784	4	2	0.108	0.0102	0.477	−1.390	C	*ls*
			3549.52	80620	108784	2	2	0.054	0.0102	0.238	−1.69	C	*ls*
19	$4p-8s$	$^2P^\circ-^2S$ (13)	*3174.8*	*80640*	112129	6	2	0.097	0.00490	0.307	−1.53	C	*ca*
			3175.78	80650	112129	4	2	0.065	0.00489	0.205	−1.71	C	*ls*
			3172.71	80620	112129	2	2	0.0325	0.00490	0.102	−2.009	C	*ls*
20	$4d-5f$	$^2D-^2F^\circ$ (15)	*9632.2*	93311	103690	10	14	0.413	0.80	255	0.91	C	*ca*
21	$4d-6f$	$^2D-^2F^\circ$ (16)	*6346.8*	93311	109062	10	14	0.216	0.183	38.2	0.263	C	*ca*
22	$4d-7f$	$^2D-^2F^\circ$ (17)	*5264.3*	93311	112301	10	14	0.125	0.073	12.6	−0.139	C	*ca*

Mg III

Ground State $1s^2 2s^2 2p^6\ ^1S_0$

Ionization Potential 80.12 eV = 646364 cm^{-1}

Allowed Transitions

Calculations by Kastner, Omidvar, and Underwood [1], employing Hartree-Fock wavefunctions and including intermediate coupling, are available. Since the calculations are based on a single-configuration approximation only, uncertainties of up to 50 percent are expected for the strong lines and even higher uncertainties for the weak lines, the latter being more affected by assumptions about the coupling.

Reference

[1] Kastner, S. O., Omidvar, K., and Underwood, J. H., Astrophys. J. **148**, 269–273 (1967).

Mg III. Allowed Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
1	$2p^6-2p^5(^2P^\circ_{3/2})3s$	$^1S-^3P^\circ$ (1 uv)	234.258	0	426877	1	3	4.5	0.011	0.0085	−1.96	E	1
2	$2p^6-2p^5(^2P^\circ_{1/2})3s$	$^1S-^1P^\circ$ (2 uv)	231.730	0	431539	1	3	87	0.21	0.16	−0.68	D	1
3	$2p^6-2p^5(^2P^\circ_{3/2})3d$	$^1S-^3P^\circ$	[188.53]	0	530430	1	3	2.5	0.0040	0.0025	−2.40	E	1
4	$2p^6-2p^5(^2P^\circ_{3/2})3d$	$^1S-^1P^\circ$ (3 uv)	187.194	0	534204	1	3	100	0.16	0.099	−0.80	D	1
5	$2p^6-2p^5(^2P^\circ_{1/2})3d$	$^1S-^3D^\circ$ (4 uv)	186.510	0	536157	1	3	170	0.27	0.17	−0.57	D	1

Mg IV

Ground State $1s^22s^22p^5\ ^2P^\circ_{3/2}$

Ionization Potential 109.29 eV = 881759 cm^{-1}

Allowed Transitions

List of tabulated lines:

Wavelength [Å]	No.	Wavelength [Å]	No.	Wavelength [Å]	No.
321.00	1	1459.6	4	1698.9	3
323.31	1	1490.4	4	1703.4	3
1230.3	5	1508.8	4	1874.6	2
1238.7	5	1525.2	7	1893.9	2
1245.2	5	1548.1	7	1906.7	2
1246.6	5	1641.0	3	1925.7	2
1253.7	5	1658.9	3	1936.9	2
1363.4	6	1680.0	3	1946.2	2
1375.4	6	1683.0	3	1956.6	2

The value for the $2s^22p^5\ ^2P^\circ-2s2p^6\ ^2S$ multiplet is calculated from the nuclear charge-expansion method of Cohen and Dalgarno [1]. It may be quite uncertain since configuration interaction effects with configurations involving electrons of the $n=3$ shell, which were not included in this calculation, may be significant. Inasmuch as no other material is available, the Coulomb approximation has been used for a number of $3s-3p$ and $3p-3d$ transitions, where for atomic systems of similar complexity it has given fairly reliable values.

Reference

[1] Cohen, M., and Dalgarno, A., Proc. Roy. Soc. London **A280**, 258–270 (1964).

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
1	$2s^22p^5-2s2p^6$	$^2P^\circ-^2S$	*321.77*	*742*	311527	6	2	260	0.14	0.86	−0.08	D	1
			[321.00]	0	311527	4	2	170	0.13	0.57	−0.28	D	*ls*
			[323.31]	2226	311527	2	2	87	0.14	0.29	−0.55	D	*ls*
2	$2p^43s-2p^4(^3P)3p$	$^4P-^4P^\circ$	*1911.5*	*544572*	*596886*	12	12	3.9	0.21	16	0.40	D	*ca*
			[1893.9]	543727	596527	6	6	2.8	0.15	5.6	−0.05	D	*ls*
			[1925.7]	545144	597072	4	4	0.50	0.028	0.71	−0.95	E	*ls*
			[1936.9]	545962	597590	2	2	0.61	0.035	0.44	−1.15	E	*ls*
			[1874.6]	543727	597072	6	4	1.8	0.065	2.4	−0.41	D−	*ls*
			[1906.7]	545144	597590	4	2	3.2	0.088	2.2	−0.45	D−	*ls*
			[1946.2]	545144	596527	4	6	1.1	0.094	2.4	−0.42	D−	*ls*
			[1956.6]	545962	597072	2	4	1.5	0.17	2.2	−0.47	D−	*ls*
3		$^4P-^4D^\circ$											
			[1683.0]	543727	603143	6	8	5.8	0.33	11	0.30	D	*ca, ls*
			[1698.9]	545144	604007	4	6	3.9	0.25	5.7	0.00	D	*ca, ls*
			[1703.4]	545962	604667	2	4	2.4	0.21	2.3	−0.38	D−	*ca, ls*
			[1658.9]	543727	604007	6	6	1.8	0.073	2.4	−0.36	D−	*ca, ls*
			[1680.0]	545144	604667	4	4	3.1	0.13	2.9	−0.28	D−	*ca, ls*
			[1641.0]	543727	604667	6	4	0.31	0.0083	0.27	−1.30	E	*ca, ls*
4		$^4P-^4S^\circ$	*1477.8*	*544572*	612240	12	4	8.6	0.094	5.5	0.05	D	*ca*
			[1459.6]	543727	612240	6	4	4.6	0.097	2.8	−0.24	D	*ls*
			[1490.4]	545144	612240	4	4	2.8	0.092	1.8	−0.43	D	*ls*
			[1508.8]	545962	612240	2	4	1.4	0.093	0.92	−0.73	D	*ls*
5	$2p^43p-{}^2P^4(^3P)3d$	$^4P^\circ-^4P$											
			[1245.2]	596527	676837	6	6	5.9	0.14	3.4	−0.08	D	*ca, ls*
			[1238.7]	597072	677805	4	4	1.1	0.026	0.43	−0.98	E	*ca, ls*
			[1230.3]	596527	677805	6	4	4.1	0.062	1.5	−0.43	D−	*ca, ls*
			[1253.7]	597072	676837	4	6	2.6	0.091	1.5	−0.44	D−	*ca, ls*
			[1246.6]	597590	677805	2	4	3.4	0.16	1.3	−0.49	D−	*ca, ls*
6		$^4D^\circ-^4F$											
			[1375.4]	604667	677355	4	4	4.5	0.13	2.3	−0.28	D	*ca, ls*
			[1363.4]	604007	677355	6	4	0.32	0.0059	0.16	−1.45	E	*ca, ls*
7		$^4S^\circ-^4P$											
			[1548.1]	612240	676837	4	6	6.4	0.34	7.0	0.13	D	*ca, ls*
			[1525.2]	612240	677805	4	4	6.7	0.23	4.7	−0.04	D	*ca, ls*

Mg IV

Forbidden Transitions

The line strength for the one transition in the ground state configuration is a straight number, tabulated for example by Naqvi [1]. The transition probability should also be quite accurate, since the energy level difference is accurately known.

Reference

[1] Naqvi, A. M., Thesis Harvard (1951).

Mg IV. Forbidden Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	Type of Transition	A_{ki}(sec^{-1})	S(at.u.)	Accuracy	Source
1	$2p^5-2p^5$	$^2P^\circ-^2P^\circ$	[44911]	0	2226	4	2	m	0.198	1.33	A	1

Mg V

Ground State $1s^22s^22p^4\ ^3P_2$

Ionization Potential 141.23 eV = 1139421 cm^{-1}

Allowed Transitions

The values are calculated from the change-expansion method of Cohen and Dalgarno [1] which includes limited configuration mixing. An additional value for the $^1S-^1P^\circ$ transition is available from the calculations of Bolotin, Shironas, and Braiman [2], which also include limited configuration interaction. For this latter transition, the two methods agree fairly well and the results are averaged. In general, uncertainties should be within 50 percent.

References

[1] Cohen, M., and Dalgarno, A., Proc. Roy. Soc. London **A280**, 258–270 (1964).
[2] Bolotin, A. B., Shironas, I. I., and Braiman, M. Yu., Vilniaus, Valstybinio v. Kapsuko vardo universiteto Mokslo Darbai **33**, matematika fizika **9**, 107–112 (1960).

Mg V. Allowed Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
1	$2s^22p^4-2s2p^5$	$^3P-^3P^\circ$	*353.16*	*873*	*284027*	9	9	120	0.22	2.3	0.30	D	1
			[353.09]	0	283211	5	5	88	0.17	0.96	−0.07	D	*ls*
			[353.30]	1780	284827	3	3	29	0.054	0.19	−0.79	D−	*ls*
			[351.09]	0	284827	5	3	50	0.055	0.32	−0.60	D−	*ls*
			[352.20]	1780	285708	3	1	120	0.075	0.26	−0.65	D−	*ls*
			[355.33]	1780	283211	3	5	29	0.091	0.32	−0.56	D−	*ls*
			[354.22]	2519	284827	1	3	40	0.22	0.26	−0.66	D−	*ls*
2		$^1D-^1P^\circ$	[276.58]	[36348]	[397906]	5	3	200	0.14	0.64	−0.15	D	1
3		$^1S-^1P^\circ$	[312.31]	[77712]	[397906]	1	3	27	0.12	0.12	−0.92	D	1, 2

Mg V

Forbidden Transitions

As in the case of Na IV the adopted values are taken from Naqvi [1], and Malville and Berger [2]. For a discussion on the selection of values see Na IV, since the same considerations have been applied.

References

[1] Naqvi, A. M., Thesis Harvard (1951).
[2] Malville, J. M., and Berger, R. A., Planetary and Space Science **13**, 1131 (1965).

Mg V. Forbidden Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	Type of Transition	A_{ki}(sec^{-1})	S(at.u.)	Accuracy	Source
1	$2p^4-2p^4$	$^3P-^3P$										
			[56164]	0	1780	5	3	*e*	1.16×10^{-7}	0.116	C−	1, 2
			[56164]	0	1780	5	3	*m*	0.127	2.50	A	1
			[39687]	0	2519	5	1	*e*	8.8×10^{-7}	0.052	C−	2
			[13.53×10^4]	1780	2519	3	1	*m*	0.0218	2.00	A	1
2		$^3P-^1D$										
			[2750.4]	0	[36348]	5	5	*e*	0.0017	7.9×10^{-4}	D−	1, 2
			[2750.4]	0	[36348]	5	5	*m*	1.90	0.0073	C	1
			[2892.0]	1780	[36348]	3	5	e	1.9×10^{-4}	1.1×10^{-4}	D−	1, 2
			[2892.0]	1780	[36348]	3	5	*m*	0.55	0.00245	C	1
			[2955.2]	2519	[36348]	1	5	*e*	6.7×10^{-5}	4.5×10^{-5}	D−	2
3		$^3P-^1S$										
			[1286.8]	0	[77712]	5	1	*e*	0.027	5.7×10^{-5}	D−	2
			[1317.0]	1780	[77712]	3	1	*m*	23	0.00195	C	2
4		$^1D-^1S$										
			[2416.8]	[36348]	[77712]	5	1	*e*	4.2	0.206	C−	2

Mg VI

Ground State $1s^22s^22p^3\ ^4S^\circ_{3/2}$

Ionization Potential 186.49 eV = 1504581 cm^{-1}

Allowed Transitions

Values for all the listed transitions are calculated from the nuclear charge-expansion method of Cohen and Dalgarno [1], which includes limited configuration mixing. Judged from graphical comparisons with other ions in the isoelectronic sequence and from the general success of Cohen and Dalgarno's method for similar atomic systems, uncertainties within 50 percent are indicated.

Reference

[1] Cohen, M., and Dalgarno, A., Proc. Roy. Soc. London **A280**, 258–270 (1964).

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
1	$2s^22p^3-2s2p^4$	$^4S^\circ-^4P$	*401.76*	0	*248906*	4	12	36	0.26	1.4	0.02	D	1
			[403.32]	0	247945	4	6	36	0.13	0.70	−0.28	D	*ls*
			[400.68]	0	249578	4	4	37	0.089	0.47	−0.45	D	*ls*
			[399.29]	0	250445	4	2	37	0.044	0.23	−0.75	D	*ls*
2		$^2D^\circ-^2D$	*349.15*	[*54158*]	[*340564*]	10	10	86	0.16	1.8	0.20	D	1
			[349.16]	[54150]	[340551]	6	6	79	0.14	1.0	−0.08	D	*ls*
			[349.15]	[54171]	[340584]	4	4	77	0.14	0.65	−0.25	D	*ls*
			[349.12]	[54150]	[340584]	6	4	8.6	0.010	0.072	−1.22	E	*ls*
			[349.19]	[54171]	[340551]	4	6	5.7	0.016	0.072	−1.19	E	*ls*
3		$^2D^\circ-^2P$	*269.92*	[*54158*]	[*424633*]	10	6	310	0.20	1.8	0.30	D	1
			[270.39]	[54150]	[423981]	6	4	280	0.21	1.1	0.10	D	*ls*
			[268.99]	[54171]	[425938]	4	2	310	0.17	0.60	−0.17	D	*ls*
			[270.41]	[54171]	[423981]	4	4	31	0.034	0.12	−0.87	E	*ls*
4		$^2P^\circ-^2D$	*387.94*	[*82791*]	[*340564*]	6	10	13	0.050	0.38	−0.52	D	1
			[388.02]	[82832]	[340551]	4	6	13	0.045	0.23	−0.74	D	*ls*
			[387.79]	[82710]	[340584]	2	4	11	0.051	0.13	−0.99	D	*ls*
			[387.97]	[82832]	[340584]	4	4	2.2	0.0049	0.025	−1.71	E	*ls*
5		$^2P^\circ-^2S$	*314.64*	[*82791*]	[400619]	6	2	180	0.090	0.56	−0.27	D	1
			[314.68]	[82832]	[400619]	4	2	120	0.089	0.37	−0.45	D	*ls*
			[314.56]	[82710]	[400619]	2	2	62	0.092	0.19	−0.74	D	*ls*
6		$^2P^\circ-^2P$	*292.53*	[*82791*]	[*424633*]	6	6	90	0.12	0.67	−0.14	D	1
			[293.13]	[82832]	[423981]	4	4	74	0.096	0.37	−0.42	D	*ls*
			[291.35]	[82710]	[425938]	2	2	61	0.078	0.15	−0.81	D	*ls*
			[291.46]	[82832]	[425938]	4	2	30	0.019	0.074	−1.12	E	*ls*
			[293.02]	[82710]	[423981]	2	4	15	0.038	0.074	−1.12	E	*ls*

Mg VI

Forbidden Transitions

For this ion all the values have been taken from Garstang [1], who has improved Pasternack's earlier calculations (Pasternack, S., Astrophys. J. **92**, 129 (1940)).

Reference

[1] Garstang, R. H., I.A.U. Symposium #34 on Planetary Nebulae held at Tatranska Lomnica, Czechoslovakia, Sept. (1967).

Mg VI. Forbidden Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	Type of Transition	A_{ki}(sec^{-1})	S(at.u.)	Accuracy	Source
1	$2p^3-2p^3$	$^4S^\circ-^2D^\circ$										
			[1846.7]	0	[54150]	4	6	m	0.0032	4.48×10^{-6}	C	1
			[1846.7]	0	[54150]	4	6	e	0.0022	1.69×10^{-4}	D	1
			[1846.0]	0	[54171]	4	4	m	0.12	1.12×10^{-4}	C	1
			[1846.0]	0	[54171]	4	4	e	0.0014	7.147×10^{-5}	D	1
2		$^4S^\circ-^2P^\circ$										
			[1207.3]	0	[82832]	4	4	m	13	0.00339	C	1
			[1207.3]	0	[82832]	4	4	e	2.7×10^{-6}	1.6×10^{-8}	D	1
			[1209.0]	0	[82710]	4	2	m	5.3	6.9×10^{-4}	C	1
			[1209.0]	0	[82710]	4	2	e	8.5×10^{-5}	2.6×10^{-7}	D	1
3		$^2D^\circ-^2D^\circ$										
			[47.6×10^5]	[54150]	[54171]	6	4	m	1.50×10^{-7}	2.40	B−	1
			[47.6×10^5]	[54150]	[54171]	6	4	e	2.0×10^{-20}	1.2×10^{-4}	D	1
4		$^2D^\circ-^2P^\circ$ (1F)	3485.5	[54150]	[82832]	6	4	m	2.1	0.0132	C	1
			3485.5	[54150]	[82832]	6	4	e	0.26	0.319	C	1
			3503.0	[54171]	[82710]	4	2	m	2.3	0.0073	C	1
			3503.0	[54171]	[82710]	4	2	e	0.23	0.144	C	1
			3500.4	[54150]	[82710]	6	2	e	0.15	0.094	C	1
			3488.1	[54171]	[82832]	4	4	m	3.7	0.0233	C	1
			3488.1	[54171]	[82832]	4	4	e	0.11	0.135	C	1
5		$^2P^\circ-^2P^\circ$										
			[81.94×10^4]	[82710]	[82832]	2	4	m	1.63×10^{-5}	1.33	B	1
			[81.94×10^4]	[82710]	[82832]	2	4	e	8.7×10^{-16}	7.7×10^{-4}	D	1

Mg VII

Ground State $1s^22s^22p^2\ ^3P_0$

Ionization Potential 224.90 eV = 1814430 cm^{-1}

Allowed Transitions

List of tabulated lines:

Wavelength [Å]	No.	Wavelength [Å]	No.	Wavelength [Å]	No.
276.15	3	431.32	1	1371.1	9
277.01	3	434.62	1	1378.7	9
278.40	3	434.71	1	1392.1	9
280.74	5	434.92	1	1396.3	9
319.02	4	1290.9	7	1410.0	9
320.50	6	1293.4	7	1470.4	8
363.74	2	1306.3	7	1487.0	8
365.24	2	1327.0	7	1487.9	8
367.67	2	1334.3	7	1496.6	8
429.13	1	1350.8	7	1507.5	8
431.22	1	1356.4	9	1517.4	8

Most data are obtained from the charge-expansion method of Cohen and Dalgarno [1] which includes limited configuration mixing. Graphical comparisons of this material within the isoelectronic sequence depicting the dependence of f-values on nuclear charge have been made, and the available experimental data for the lower ions, mostly from lifetime measurements, establish fairly definitely that the uncertainties should not exceed 50 percent. Analogous graphs for the data obtained from the Coulomb approximation indicate that these values are accurate within 25 percent.

Reference

[1] Cohen, M., and Dalgarno, A., Proc. Roy. Soc. London **A280**, 258–270 (1964).

Mg VII. Allowed Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
1	$2s^22p^2-2s2p^3$	$^3P-^3D^\circ$	*433.04*	*2008*	*232934*	9	15	22	0.10	1.3	−0.05	D+	1
			[434.92]	2939	232865	5	7	21	0.085	0.61	−0.37	D+	*ls*
			[431.32]	1127	232975	3	5	16	0.075	0.32	−0.65	D+	*ls*
			[429.13]	0	233027	1	3	12	0.099	0.14	−1.00	D	*ls*
			[434.71]	2939	232975	5	5	5.4	0.015	0.11	−1.12	D	*ls*
			[431.22]	1127	233027	3	3	9.3	0.026	0.11	−1.11	D	*ls*
			[434.62]	2939	233027	5	3	0.59	0.0010	0.0072	−2.30	E	*ls*
2		$^3P-^3P^\circ$	*366.42*	*2008*	274922	9	9	55	0.11	1.2	−0.00	D	1
			[367.67]	2939	274922	5	5	41	0.083	0.50	−0.38	D	*ls*
			[365.24]	1127	274922	3	3	14	0.028	0.10	−1.08	E	*ls*
			[367.67]	2939	274922	5	3	23	0.028	0.17	−0.85	D−	*ls*
			[365.24]	1127	274922	3	1	54	0.036	0.13	−0.97	D−	*ls*
			[365.24]	1127	274922	3	5	14	0.047	0.17	−0.85	D−	*ls*
			[363.74]	0	274922	1	3	18	0.11	0.13	−0.96	D−	*ls*
3		$^3P-^3S^\circ$	*277.69*	*2008*	362128	9	3	310	0.12	0.99	0.03	D+	1
			[278.40]	2939	362128	5	3	170	0.12	0.55	−0.22	D+	*ls*
			[277.01]	1127	362128	3	3	100	0.12	0.33	−0.44	D+	*ls*
			[276.15]	0	362128	1	3	35	0.12	0.11	−0.92	D+	*ls*
4		$^1D-^1D^\circ$	[319.02]	[41459]	[354923]	5	5	160	0.25	1.3	0.10	D	1
5		$^1D-^1P^\circ$	[280.74]	[41459]	[397655]	5	3	200	0.14	0.65	−0.15	D	1
6		$^1S-^1P^\circ$	[320.50]	[85647]	[397655]	1	3	53	0.25	0.26	−0.60	D−	1
7	$2p3s-2p(^2P^\circ)3p$	$^3P^\circ-^3P$	*1322.6*	*1049701*	*1125312*	9	9	6.6	0.174	6.8	0.195	C	*ca*
			[1334.3]	1050906	1125850	5	5	4.83	0.129	2.83	−0.190	C	*ls*
			[1306.3]	1048385	1124937	3	3	1.73	0.0442	0.57	−0.88	C	*ls*
			[1350.8]	1050906	1124937	5	3	2.58	0.0423	0.94	−0.67	C	*ls*
			[1327.0]	1048385	1123745	3	1	6.6	0.058	0.76	−0.76	C	*ls*
			[1290.9]	1048385	1125850	3	5	1.77	0.074	0.94	−0.65	C	*ls*
			[1293.4]	1047624	1124937	1	3	2.37	0.178	0.76	−0.75	C	*ls*
8	$2p3p-2p(^2P^\circ)3d$	$^3P-^3D^\circ$	*1488.2*	*1125312*	*1192507*	9	15	3.44	0.191	8.4	0.235	C	*ca*
			[1487.9]	1125850	1193061	5	7	3.44	0.160	3.92	−0.097	C	*ls*
			[1487.0]	1124937	1192185	3	5	2.59	0.143	2.10	−0.368	C	*ls*
			[1470.4]	1123745	1191753	1	3	1.98	0.192	0.93	−0.72	C	*ls*
			[1507.5]	1125850	1192185	5	5	0.83	0.0282	0.70	−0.85	C	*ls*
			[1496.6]	1124937	1191753	3	3	1.41	0.0474	0.70	−0.85	C	*ls*
			[1517.4]	1125850	1191753	5	3	0.090	0.0019	0.047	−2.03	E	*ls*
9		$^3P-^3P^\circ$	*1392.5*	*1125312*	*1197125*	9	9	2.39	0.070	2.87	−0.201	C	*ca*
			[1410.0]	1125850	1196770	5	5	1.73	0.052	1.20	−0.59	C	*ls*
			[1378.7]	1124937	1197469	3	3	0.62	0.0176	0.239	−1.277	C	*ls*
			[1396.3]	1125850	1197469	5	3	0.99	0.0174	0.399	−1.060	C	*ls*
			[1371.1]	1124937	1197872	3	1	2.51	0.0236	0.319	−1.150	C	*ls*
			[1392.1]	1124937	1196770	3	5	0.60	0.0290	0.399	−1.060	C	*ls*
			[1356.4]	1123745	1197469	1	3	0.86	0.071	0.319	−1.149	C	*ls*

Mg VII

Forbidden Transitions

The adopted values represent, as in the case of Na VI, the work of Naqvi [1], Malville and Berger [2], and Froese [3]. For the selection of values, the same considerations as for Na VI are applied, the one exception being that Froese's magnetic dipole values are also used. Since the observed energy levels are uncertain, it is felt that the "spin-orbit" and "spin-spin and spin-other-orbit" integrals ζ and η calculated from her theoretical energy levels will be as accurate as the experimental ones.

References

[1] Naqvi, A. M., Thesis Harvard (1951).
[2] Malville, J. M. and Berger, R. A., Planetary and Space Science **13**, 1131 (1965).
[3] Froese, C., Astrophys. J. **145**, 932 (1966).

Mg VII. Forbidden Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	Type of Transition	A_{ki}(sec^{-1})	S(at.u.)	Accuracy	Source
1	$2p^2-2p^2$	$^3P-^3P$										
			[88707]	0	1127	1	3	m	0.0258	2.00	A	1, 3
			[34016]	0	2939	1	5	e	2.67×10^{-7}	0.0362	C	3
			[55173]	1127	2939	3	5	m	0.0803	2.50	A	1, 3
			[55173]	1127	2939	3	5	e	5.3×10^{-8}	0.081	C	3
2		$^3P-^1D$										
			[2413.0]	0	[41429]	1	5	e	1.3×10^{-4}	3.1×10^{-5}	D	3
			[2480.5]	1127	[41429]	3	5	m	1.30	0.00368	C	1, 2, 3
			[2480.5]	1127	[41429]	3	5	e	4.1×10^{-4}	1.2×10^{-4}	D	3
			[2597.3]	2939	[41429]	5	5	m	3.39	0.0110	C	1, 2, 3
			[2597.3]	2939	[41429]	5	5	e	0.0023	8.1×10^{-4}	D	3
3		$^3P-^1S$										
			[1183.2]	1127	[85647]	3	1	m	37.2	0.00228	C	2, 3
			[1209.1]	2939	[85647]	5	1	e	0.042	6.5×10^{-5}	D	3
4		$^1D-^1S$										
			[2260.8]	[41429]	[85647]	5	1	e	4.18	0.147	C	3

Mg VIII

Ground State $1s^2 2s^2 2p\ ^2P^\circ_{1/2}$

Ionization Potential 265.957 eV = 2145679 cm^{-1}

Allowed Transitions

List of tabulated lines:

Wavelength [Å]	No.	Wavelength [Å]	No.	Wavelength [Å]	No.
74.858	11	342.23	6	436.68	1
75.034	11	342.25	6	436.73	1
75.044	11	342.42	6	442.08	7
82.598	10	352.38	4	442.37	7
82.824	10	353.84	4	486.05	9
311.78	3	356.60	4	486.40	9
313.73	3	428.34	5	490.81	9
315.02	3	428.37	5	491.17	9
317.01	3	428.60	5	680.31	8
335.25	2	428.64	5	689.67	8
339.01	2	430.47	1	690.34	8

Values for the majority of the transitions are calculated from the nuclear charge-expansion method of Cohen and Dalgarno [1], which includes limited configuration mixing. Graphical comparisons with other data for the lower ions of this isoelectronic sequence indicate that the uncertainties should be within 50 percent.

For the $2p\ ^2P^\circ - 3s\ ^2S$ and $2p\ ^2P^\circ - 3d\ ^2D$ multiplets we have obtained data by exploiting the dependence of f-values on nuclear charge: In these cases accurate data for several other ions of the boron sequence are available from extended self-consistent field calculations by Weiss [2] in which configuration mixing is fully included. Utilizing those values, which are also supported by some experimental results on lower ions, we have obtained the f-values of the two transitions simply by graphical interpolation.

References

[1] Cohen, M., and Dalgarno, A., Proc. Roy. Soc. London **A280**, 258–270 (1964).
[2] Weiss, A. W., private communication (1967).

No.	Transition Array	Multiplet	λ(A)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
1	$2s^22p-2s2p^2$	$^2P^\circ-^2D$	*434.62*	*2203*	*232290*	6	10	19	0.087	0.75	−0.28	D	1
			[436.73]	3304	232281	4	6	18	0.078	0.45	−0.51	D	*ls*
			[430.47]	0	232304	2	4	16	0.088	0.25	−0.75	D	*ls*
			[436.68]	3304	232304	4	4	3.0	0.0087	0.050	−1.46	E	*ls*
2		$^2P^\circ-^2S$	*337.75*	*2203*	298283	6	2	79	0.045	0.30	−0.57	D+	1
			[339.01]	3304	298283	4	2	52	0.045	0.20	−0.74	D+	*ls*
			[335.25]	0	298283	2	2	27	0.045	0.10	−1.05	D+	*ls*
3		$^2P^\circ-^2P$	*314.59*	*2203*	*320077*	6	6	140	0.21	1.3	0.10	D+	1
			[315.02]	3304	320742	4	4	120	0.17	0.72	−0.17	D+	*ls*
			[313.73]	0	318747	2	2	95	0.14	0.29	−0.55	D+	*ls*
			[317.01]	3304	318747	4	2	45	0.034	0.14	−0.87	D−	*ls*
			[311.78]	0	320742	2	4	23	0.068	0.14	−0.87	D−	*ls*
4	$2s2p^2-2p^3$	$^4P-^4S^\circ$	*354.67*	[*132428*]	[414380]	12	4	140	0.086	1.2	0.01	D+	1
			[356.60]	[133481]	[414380]	6	4	67	0.085	0.60	−0.29	D+	*ls*
			[353.84]	[131763]	[414380]	4	4	46	0.086	0.40	−0.46	D+	*ls*
			[352.38]	[130598]	[414380]	2	4	23	0.086	0.20	−0.76	D+	*ls*
5		$^2D-^2D^\circ$	*428.52*	*232290*	*465654*	10	10	39	0.11	1.5	0.04	D+	1
			[428.60]	232281	465598	6	6	36	0.099	0.84	−0.23	D+	*ls*
			[428.37]	232304	465738	4	4	35	0.096	0.54	−0.42	D+	*ls*
			[428.34]	232281	465738	6	4	3.9	0.0071	0.060	−1.37	E	*ls*
			[428.64]	232304	465598	4	6	2.6	0.011	0.060	−1.36	E	*ls*
6		$^2D-^2P^\circ$	*342.29*	*232290*	*524437*	10	6	63	0.067	0.75	−0.17	D	1
			[342.23]	232281	524486	6	4	57	0.067	0.45	−0.40	D	*ls*
			[342.42]	232304	524339	4	2	63	0.055	0.25	−0.66	D	*ls*
			[342.25]	232304	524486	4	4	6.3	0.011	0.050	−1.36	E	*ls*
7		$^2S-^2P^\circ$	*442.18*	298283	*524437*	2	6	12	0.10	0.30	−0.70	D	1
			[442.08]	298283	524486	2	4	12	0.069	0.20	−0.86	D	*ls*
			[442.37]	298283	524339	2	2	12	0.034	0.10	−1.17	D	*ls*
8		$^2P-^2D^\circ$	*686.92*	*320077*	*465654*	6	10	9.4	0.11	1.5	−0.18	D	1
			[690.34]	320742	465598	4	6	9.2	0.099	0.90	−0.40	D	*ls*
			[680.31]	318747	465738	2	4	8.0	0.11	0.50	−0.66	D	*ls*
			[689.67]	320742	465738	4	4	1.5	0.011	0.10	−1.36	E	*ls*
9		$^2P-^2P^\circ$	*489.33*	*320077*	*524437*	6	6	39	0.14	1.4	−0.08	D	1
			[490.81]	320742	524486	4	4	32	0.12	0.75	−0.32	D	*ls*
			[486.40]	318747	524339	2	2	26	0.094	0.30	−0.73	D	*ls*
			[491.17]	320742	524339	4	2	13	0.023	0.15	−1.04	D−	*ls*
			[486.05]	318747	524486	2	4	6.6	0.047	0.15	−1.03	D−	*ls*
10	$2p-(^1S)3s$	$^2P^\circ-^2S$	*82.748*	*2203*	1210689	6	2	700	0.024	0.039	−0.84	C	interp
			[82.824]	3304	1210689	4	2	460	0.024	0.026	−1.02	C	*ls*
			[82.598]	0	1210689	2	2	240	0.024	0.013	−1.32	C	*ls*
11	$2p-(^1S)3d$	$^2P^\circ-^2D$	*74.976*	*2203*	*1335965*	6	10	4300	0.61	0.90	0.56	C	interp
			[75.034]	3304	1336033	4	6	4300	0.55	0.54	0.34	C	*ls*
			[74.858]	0	1335863	2	4	3600	0.61	0.30	0.09	C	*ls*
			[75.044]	3304	1335863	4	4	720	0.061	0.060	−0.61	E	*ls*

Mg VIII

Forbidden Transitions

The line strength for the one transition in the ground state configuration is a straight number, tabulated for example by Naqvi [1]. The transition probability should also be quite accurate, since the energy level difference is accurately known.

Reference

[1] Naqvi, A. M., Thesis Harvard (1951).

Mg VIII. Forbidden Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	Type of Transition	A_{ki}(sec^{-1})	S(at.u.)	Accuracy	Source
1	$2p-(^1S)2p$	$^2P^\circ-^2P^\circ$	[30258]	0	3304	2	4	m	0.324	1.33	A	1

Mg IX

Ground State $1s^22s^2\ ^1S_0$

Ionization Potential 327.90 eV = 2645444 cm^{-1}

Allowed Transitions

List of tabulated lines:

Wavelength [Å]	No.	Wavelength [Å]	No.	Wavelength [Å]	No.
62.751	6	443.99	3	1883.4	10
77.737	7	445.94	3	2201.1	15
368.07	2	448.28	3	2428.2	12
439.06	5	704.48	1	2598.7	14
439.17	3	751.56	4	2814.2	8
441.10	3	1073.3	13	18707	9
443.37	3	1639.8	11		

Garstang and Shamey [1] have obtained the f-value for the intercombination line $2^1S_0-2^3P_1$ by calculating the ratio of this line against the resonance transition in the intermediate coupling approximation and by using for the resonance line a value calculated according to Cohen and Dalgarno's method [2]. The data calculated from the charge-expansion method of Cohen and Dalgarno [2], which includes limited configuration mixing, are estimated to be usually accurate to 50 percent or better, while the charge-expansion method of Naqvi and Victor [3] should be less reliable when the effects of configuration interaction are strong, since these are neglected entirely. In assigning the accuracy estimates for these methods as well as for the Coulomb approximation we were to a great extent guided by studying the degree of fit of the data into the systematic trends along isoelectronic sequences.

References

[1] Garstang, R. H., and Shamey, L. J., Astrophys. J. **148**, 665–666 (1967).
[2] Cohen, M., and Dalgarno, A., Proc. Roy. Soc. London **A280**, 258–270 (1964).
[3] Naqvi, A. M., and Victor, G. A., Technical Documentary Report No. RTD TDR–63–3118 (1964).

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
1	$2s^2-2s(^2S)2p$	$^1S-^3P^\circ$	[704.48]	0	[141948]	1	3	0.0013	2.9×10^{-5}	6.8×10^{-5}	−4.54	D	1*n*
2		$^1S-^1P^\circ$	[368.07]	0	271687	1	3	51	0.314	0.380	−0.50	C	2
3	$2s2p-2p^2$	$^3P^\circ-^3P$	*443.74*	[*143192*]	[*368547*]	9	9	41	0.12	1.6	$0.0\bar{3}$	D+	2
			[443.99]	[144420]	[369650]	5	5	31	0.092	0.67	−0.34	D+	*ls*
			[443.37]	[141948]	[367493]	3	3	10	0.030	0.13	−1.05	D−	*ls*
			[448.28]	[144420]	[367493]	5	3	16	0.030	0.22	−0.82	D−	*ls*
			[445.94]	[141948]	[366194]	3	1	41	0.041	0.18	−0.91	D−	*ls*
			[439.17]	[141948]	[369650]	3	5	11	0.051	0.22	−0.82	D−	*ls*
			[441.10]	[140786]	[367493]	1	3	14	0.12	0.18	−0.92	D−	*ls*
4		$^1P^\circ-^1D$	[751.56]	271687	404744	3	5	8.9	0.13	0.93	−0.41	D−	2
5		$^1P^\circ-^1S$	[439.06]	271687	499444	3	1	84	0.081	0.35	−0.61	E	2
6	$2s^2-2s(^2S)3p$	$^1S-^1P^\circ$	[62.751]	0	1593600	1	3	3300	0.58	0.12	−0.24	E	3
7	$2s2p-2s(^2S)3s$	$^1P^\circ-^1S$	[77.737]	271687	1558076	3	1	240	0.0072	0.0055	−1.67	E	3
8	$2s3s-2s(^2S)3p$	$^1S-^1P^\circ$	[2814.2]	1558076	1593600	1	3	0.54	0.191	1.77	−0.72	C	3
9	$2p3s-2p(^2P^\circ)3p$	$^1P^\circ-^1P$	[18707]	1742772	1748116	3	3	0.00177	0.0093	1.72	−1.55	C	*ca*
10		$^1P^\circ-^1D$	[1883.4]	1742772	1795868	3	5	1.88	0.167	3.10	−0.300	C	*ca*
11	$2s3p-2s(^2S)3d$	$^1P^\circ-^1D$	[1639.8]	1593600	1654583	3	5	2.34	0.157	2.55	−0.327	C	*ca*
12	$2p3p-2p(^2P^\circ)3d$	$^1P-^1D^\circ$	[2428.2]	1748116	1789287	3	5	0.498	0.073	1.76	−0.66	C	*ca*
13		$^1P-^1P^\circ$	[1073.3]	1748116	1841286	3	3	3.66	0.063	0.67	−0.72	C	*ca*
14		$^1D-^1F^\circ$	[2598.7]	1795868	1834337	5	7	0.61	0.086	3.67	−0.367	C	*ca*
15		$^1D-^1P^\circ$	[2201.1]	1795868	1841286	5	3	0.0289	0.00126	0.0456	−1.201	C	*ca*

Mg IX

Forbidden Transitions

Naqvi's calculations [1] are the only available source. The results for the $^3P^\circ-^3P^\circ$ transitions are essentially independent of the choice of the interaction parameters. For the $^3P^\circ-^1P^\circ$ transitions, Naqvi uses empirical term intervals, i.e., the effects of configuration interaction should be partially included.

Reference

[1] Naqvi, A. M., Thesis Harvard (1951).

Mg IX. Forbidden Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	Type of Transition	A_{ki}(sec^{-1})	S(at.u.)	Accuracy	Source
1	$2s2p-2s(^2S)2p$	$^3P^\circ-^3P^\circ$										
			[86035]	[140786]	[141948]	1	3	m	0.0282	2.00	A	1
			[40442]	[141948]	[144420]	3	5	m	0.204	2.50	A	1
2		$^3P^\circ-^1P^\circ$										
			[763.94]	[140786]	271687	1	3	m	7.1	3.52×10^{-4}	C	1
			[770.78]	[141948]	271687	3	3	m	391	0.0199	C	1
			[785.75]	[144420]	271687	5	3	m	8.2	4.40×10^{-4}	C	1

Mg X

Ground State $1s^22s\ ^2S_{1/2}$

Ionization Potential 367.36 eV = 2963810 cm^{-1}

Allowed Transitions

List of tabulated lines:

Wavelength [Å]	No.	Wavelength [Å]	No.	Wavelength [Å]	No.
44.050	3	63.314	5	609.85	1
47.231	6	65.672	4	625.28	1
47.310	6	65.847	4	2212.5	7
47.321	6	170.21	8	2278.7	7
57.876	2	181.60	10	5918.7	9
57.920	2	181.86	10	6229.6	9
63.152	5	182.03	10	6417.5	9
63.295	5				

For the transition $2s-2p$, the charge-expansion calculation of Cohen and Dalgarno [1] is chosen. An uncertainty of less than 10 percent is indicated from the graphical comparison of this value with the other material for the same transition within the isoelectronic sequence. Data for the other listed transitions have been obtained from the Coulomb approximation. Plots of the dependence of f-value on nuclear charge for all these transitions have been made and show that this material connects up very smoothly with the data for the lower ions as well as with the hydrogenic value for infinite nuclear charge. Based on this impressive agreement, accuracies of 10 percent (or 25 percent for some of the smaller values) are indicated.

Reference

[1] Cohen, M., and Dalgarno, A., Proc. Roy. Soc. London **A280**, 258–270 (1964).

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
1	$2s-2p$	$^2S-^2P^\circ$	*614.90*	0	*162627*	2	6	7.38	0.125	0.508	−0.602	B	1
			[609.85]	0	163976	2	4	7.57	0.0844	0.339	−0.773	B	*ls*
			[625.28]	0	159929	2	2	7.00	0.0410	0.169	−1.086	B	*ls*
2	$2s-3p$	$^2S-^2P^\circ$	*57.891*	0	*1727394*	2	6	2120	0.320	0.122	−0.194	B	*ca*
			[57.876]	0	1727832	2	4	2120	0.213	0.0813	−0.371	B	*ls*
			[57.920]	0	1726519	2	2	2120	0.107	0.0407	−0.670	B	*ls*
3	$2s-4p$	$^2S-^2P^\circ$	[44.050]	0	2270148	2	6	970	0.085	0.0246	−0.77	C+	*ca*
4	$2p-3s$	$^2P^\circ-^2S$	*65.789*	*162627*	1682648	6	2	1030	0.0223	0.0290	−0.874	B	*ca*
			[65.847]	163976	1682648	4	2	685	0.0223	0.0193	−1.050	B	*ls*
			[65.672]	159929	1682648	2	2	346	0.0224	0.00967	−1.349	B	*ls*
5	$2p-3d$	$^2P^\circ-^2D$	*63.249*	*162627*	*1743692*	6	10	6710	0.671	0.838	0.605	B	*ca*
			[63.295]	163976	1743880	4	6	6700	0.603	0.503	0.382	B	*ls*
			[63.152]	159929	1743410	2	4	5610	0.671	0.279	0.128	B	*ls*
			[63.314]	163976	1743410	4	4	1120	0.0670	0.0559	−0.572	B	*ls*
6	$2p-4d$	$^2P^\circ-^2D$	*47.284*	*162627*	*2277489*	6	10	2200	0.123	0.115	−0.132	C+	*ca*
			[47.310]	163976	2277694	4	6	2200	0.111	0.069	−0.353	C+	*ls*
			[47.231]	159929	2277182	2	4	1840	0.123	0.0383	−0.61	C+	*ls*
			[47.321]	163976	2277182	4	4	368	0.0124	0.0077	−1.305	C+	*ls*
7	$3s-3p$	$^2S-^2P^\circ$	*2234.1*	1682648	*1727394*	2	6	0.942	0.211	3.11	−0.375	B	*ca*
			[2212.5]	1682648	1727832	2	4	0.968	0.142	2.07	−0.547	B	*ls*
			[2278.7]	1682648	1726519	2	2	0.890	0.0693	1.04	−0.858	B	*ls*
8	$3s-4p$	$^2S-^2P^\circ$	[170.21]	1682648	2270148	2	6	268	0.350	0.392	−0.155	C+	*ca*
9	$3p-3d$	$^2P^\circ-^2D$	*6134.0*	*1727394*	*1743692*	6	10	0.0358	0.0337	4.08	−0.694	B	*ca*
			[6229.6]	1727832	1743880	4	6	0.0342	0.0299	2.45	−0.922	B	*ls*
			[5918.7]	1726519	1743410	2	4	0.0332	0.0349	1.36	−1.156	B	*ls*
			[6417.5]	1727832	1743410	4	4	0.00521	0.00322	0.272	−1.890	B	*ls*
10	$3p-4d$	$^2P^\circ-^2D$	*181.79*	*1727394*	*2277489*	6	10	690	0.57	2.06	0.53	C+	*ca*
			[181.86]	1727832	2277694	4	6	690	0.52	1.24	0.318	C+	*ls*
			[181.60]	1726519	2277182	2	4	580	0.58	0.69	0.064	C+	*ls*
			[182.03]	1727832	2277182	4	4	115	0.057	0.137	−0.64	C+	*ls*

Mg XI

Ground State $1s^2\ ^1S_0$

Ionization Potential 1761.23 eV = 14209200 cm^{-1}

Allowed Transitions

The values for this ion are calculated from the charge-expansion method of Dalgarno and Parkinson [1]. From comparisons with the more refined variational calculations by Weiss [2] for lower members of this isoelectronic sequence, uncertainties are estimated not to exceed 10 percent. It should be pointed out that essentially identical results are obtained by extrapolating the data of Weiss towards the high members of the isoelectronic sequence (See fig. I of [2]).

References

[1] Dalgarno, A., and Parkinson, E. M., Proc. Roy. Soc. London **A301**, 253–260 (1967).
[2] Weiss, A. W., J. Research Nat. Bur. Standards **71A** 163–168 (1967).

Mg XI. Allowed Transitions

No.	Transition Array	Multiplet	λ(A)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
1	$1s^2-1s2p$	$^1S-^1P^\circ$	[9.1682]	0	10907300	1	3	1.97×10^5	0.745	0.0225	−0.128	B	1
2	$1s^2-1s3p$	$^1S-^1P^\circ$	[7.8503]	0	12738400	1	3	5.50×10^4	0.152	0.00394	−0.818	B	1
3	$1s^2-1s4p$	$^1S-^1P^\circ$	[7.4732]	0	13381100	1	3	2.27×10^4	0.0569	0.00140	−1.245	B	1
4	$1s^2-1s5p$	$^1S-^1P^\circ$	[7.3096]	0	13680600	1	3	1.15×10^4	0.0277	6.66×10^{-4}	−1.558	B	1

ALUMINUM

Al I

Ground State $1s^22s^22p^63s^23p\ ^2P^\circ_{1/2}$

Ionization Potential 5.984 eV = 48279.16 cm^{-1}

Allowed Transitions

List of tabulated lines:

Wavelength [Å]	No.	Wavelength [Å]	No.	Wavelength [Å]	No.
2118.3	14	2367.05	5	8772.87	16
2123.36	14	2372.07	6	8773.9	16
2123.4	14	2373.12	5	8773.90	16
2129.66	13	2373.35	5	8828.91	25
2134.7	13	2378.40	6	8841.28	25
2134.73	13	2567.98	3	8912.90	24
2145.56	12	2575.10	3	8923.56	24
2150.7	12	2575.40	3	8925.50	24
2150.70	12	2652.48	4	10768.4	22
2168.83	11	2660.39	4	10782.0	22
2174.07	11	3082.15	1	10786.8	22
2174.11	11	3092.71	1	10873.0	23
2199.18	10	3092.84	1	10891.7	23
2204.62	10	3944.01	2	11253.2	15
2204.67	9	3961.52	2	11254.9	15
2210.06	9	5557.06	20	11255	15
2210.13	9	5557.95	20	13123.4	18
2258.01	8	6696.02	19	13150.8	18
2263.46	7	6698.67	19	16719.0	21
2263.74	8	7835.31	17	16750.6	21
2269.10	7	7836.1	17	16763.4	21
2269.22	7	7836.13	17		

The adopted values for this atom are taken from two theoretical and three experimental papers. The theoretical sources are the self-consistent field calculations by Biermann and Lübeck [5] which include polarization and exchange effects, and the calculations of Weiss [2], in which various possible configurations are superimposed and Hartree-Fock wavefunctions are employed. Weiss has carried out his calculations in both the dipole length and dipole velocity approximations and agreement between the two is usually good; in all the cases where his results are applied, the length values are chosen as suggested by the author as being probably more reliable [2].

The experiments consist of anomalous dispersion measurements by Penkin and Shabanova [4] for the $3p$-ns and $3p$-nd series and lifetime determinations of the $3d$ state by Budick [1] by means of the Hanle effect and of the $4s$ state by Demtröder [3] by means of the phase shift method, all expected to provide accurate values. (This is Demtröder's only lifetime measurement for Al I. His other results [3] are from less accurate absorption measurements.) Penkin and Shabanova's relative values have been normalized in two ways which lead to identical scales: (1) normalization to the average of Weiss' and Demtröder's value for the $3p$-$4s$ transition, (2) normalization to Budick's value for the $3p$-$3d$ transition. (Weiss' value for this transition is not nearly as reliable as for $3p$-$4s$.)

Finally, it should be noted that the spectroscopic designations of the d states are questionable: the principal quantum number of these states probably should be reduced by one in each case.

References

[1] Budick, B., Bull. Am. Phys. Soc. **11**, 456 (1966).
[2] Weiss, A. W., to be published (1969).
[3] Demtröder, W., Z. Physik **166**, 42–55 (1962).
[4] Penkin, N. P., and Shabanova, L. N., Optics and Spectroscopy (U.S.S.R.) **18**, 504 (1965).
[5] Biermann, L., and Lübeck, K., Z. Astrophys. **25**, 325–339 (1948).

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
1	$3s^23p-3s^2(^1S)3d$	$^2P^\circ-^2D$ (3)	*3089.2*	*75*	*32436*	6	10	0.73	0.175	10.7	0.021	C+	1
			3092.71	112	32437	4	6	0.73	0.158	6.4	−0.199	C+	*ls*
			3082.15	0	32435	2	4	0.61	0.175	3.55	−0.456	C+	*ls*
			3092.84	112	32435	4	4	0.12	0.018	0.71	−1.16	D	*ls*
2	$3s^23p-3s^2(^1S)4s$	$^2P^\circ-^2S$ (1)	*3955.7*	*75*	25348	6	2	1.47	0.115	9.0	−0.161	C+	2, 3
			3961.52	112	25348	4	2	0.98	0.115	6.0	−0.337	C+	*ls*
			3944.01	0	25348	2	2	0.493	0.115	2.99	−0.64	C+	*ls*
3	$3s^23p-3s^2(^1S)4d$	$^2P^\circ-^2D$ (2 uv)	*2572.8*	*75*	*38932*	6	10	0.264	0.0437	2.22	−0.58	C	4*n*
			2575.10	112	38934	4	6	0.264	0.0393	1.33	−0.80	C	*ls*
			2567.98	0	38929	2	4	0.221	0.0437	0.74	−1.058	C	*ls*
			2575.40	112	38929	4	4	0.044	0.0044	0.15	−1.76	D	*ls*
4	$3s^23p-3s^2(^1S)5s$	$^2P^\circ-^2S$ (1 uv)	*2657.8*	*75*	37689	6	2	0.397	0.0140	0.73	−1.076	C	4*n*
			2660.39	112	37689	4	2	0.264	0.0140	0.490	−1.252	C	*ls*
			2652.48	0	37689	2	2	0.133	0.0140	0.245	−1.55	C	*ls*
5	$3s^23p-3s^2(^1S)5d$	$^2P^\circ-^2D$ (4 uv)	*2371.1*	*75*	*42236*	6	10	0.85	0.120	5.6	−0.143	C	4*n*
			2373.12	112	42238	4	6	0.85	0.108	3.38	−0.365	C	*ls*
			2367.05	0	42234	2	4	0.71	0.120	1.87	−0.62	C	*ls*
			2373.35	112	42234	4	4	0.14	0.012	0.38	−1.32	D	*ls*
6	$3s^23p-3s^2(^1S)6s$	$^2P^\circ-^2S$ (3 uv)	*2376.3*	*75*	42144	6	2	0.143	0.00403	0.189	−1.62	C	4*n*
			2378.40	112	42144	4	2	0.095	0.00403	0.126	−1.79	C	*ls*
			2372.07	0	42144	2	2	0.0478	0.00403	0.063	−2.094	C	*ls*
7	$3s^23p-3s^2(^1S)6d$	$^2P^\circ-^2D$ (5 uv)	*2267.2*	*75*	*44168*	6	10	0.76	0.098	4.39	−0.231	C	4*n*
			2269.10	112	44169	4	6	0.76	0.088	2.63	−0.453	C	*ls*
			2263.46	0	44166	2	4	0.64	0.098	1.46	−0.71	C	*ls*
			2269.22	112	44166	4	4	0.13	0.0098	0.29	−1.41	D	*ls*
8	$3s^23p-3s^2(^1S)7s$	$^2P^\circ-^2S$ (6 uv)	*2261.8*	*75*	44273	6	2	0.113	0.00288	0.129	−1.76	C	4*n*
			2263.74	112	44273	4	2	0.075	0.00288	0.086	−1.94	C	*ls*
			2258.01	0	44273	2	2	0.0377	0.00288	0.0428	−2.240	C	*ls*
9	$3s^23p-3s^2(^1S)7d$	$^2P^\circ-^2D$ (7 uv)	*2208.3*	*75*	*45345*	6	10	0.54	0.066	2.88	−0.402	C	4*n*
			2210.06	112	45346	4	6	0.54	0.059	1.72	−0.63	C	*ls*
			2204.67	0	45345	2	4	0.453	0.066	0.96	−0.88	C	*ls*
			2210.13	112	45344	4	4	0.090	0.0066	0.19	−1.58	D	*ls*
10	$3s^23p-3s^2(^1S)8s$	$^2P^\circ-^2S$ (8 uv)	*2202.8*	*75*	45457	6	2	0.052	0.00127	0.055	−2.118	C	4*n*
			2204.62	112	45457	4	2	0.0349	0.00127	0.0369	−2.294	C	*ls*
			2199.18	0	45457	2	2	0.0175	0.00127	0.0184	−2.60	C	*ls*
11	$3s^23p-3s^2(^1S)8d$	$^2P^\circ-^2D$ (9 uv)	*2172.3*	*75*	*46094*	6	10	0.366	0.0431	1.85	−0.59	C	4*n*
			2174.07	112	46094	4	6	0.365	0.0388	1.11	−0.81	C	*ls*
			2168.83	0	46093	2	4	0.306	0.0431	0.62	−1.064	C	*ls*
			2174.11	112	46093	4	4	0.061	0.0043	0.12	−1.76	D	*ls*
12	$3s^23p-3s^2(^1S)9d$	$^2P^\circ-^2D$	*2149.0*	*75*	*46594*	6	10	0.279	0.0322	1.37	−0.71	C	4*n*
			2150.70	112	46594	4	6	0.279	0.0290	0.82	−0.94	C	*ls*
			2145.56	0	46593	2	4	0.233	0.0322	0.455	−1.191	C	*ls*
			[2150.7]	112	46593	4	4	0.046	0.0032	0.091	−1.89	D	*ls*

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
13	$3s^23p-3s^2(^1S)10d$	$^2P^\circ-^2D$	*2133.1*	*75*	*46941*	*6*	*10*	0.182	0.0207	0.87	−0.91	C	4*n*
			2134.73	112	46942	4	6	0.181	0.0186	0.52	−1.128	C	*ls*
			2129.66	0	46941	2	4	0.152	0.0207	0.290	−1.383	C	*ls*
			[2134.7]	112	46941	4	4	0.030	0.0021	0.058	−2.08	D	*ls*
14	$3s^23p-3s$	$^2P^\circ-^2D$	*2121.7*	*75*	47192	6	10	0.123	0.0138	0.58	−1.082	C	4*n*
			2123.36	112	47192	4	6	0.122	0.0124	0.347	−1.305	C	*ls*
			2118.3	0	47192	2	4	0.103	0.0138	0.192	−1.56	C	*ls*
			[2123.4]	112	47192	4	4	0.020	0.0014	0.039	−2.26	D	*ls*
15	$3s^23d-3s^2(^1S)4f$	$^2D-^2F^\circ$ (8)	*11254*	*32436*	41319	10	14	0.177	0.471	175	0.67	C	2
			11254.9	32437	41319	6	8	0.178	0.450	100	0.431	C	*ls*
			11253.2	32435	41319	4	6	0.166	0.472	70	0.276	C	*ls*
			[11255]	32437	41319	6	6	0.012	0.023	5.0	−0.87	D	*ls*
16	$3s^23d-3s^2(^1S)5f$	$^2D-^2F^\circ$ (9)	*8773.4*	*32436*	43831	10	14	0.11	0.17	49	0.23	D−	*ca*
			8773.90	32437	43831	6	8	0.10	0.16	28	−0.02	D−	*ls*
			8772.87	32435	43831	4	6	0.098	0.17	20	−0.17	D−	*ls*
			[8773.9]	32437	43831	6	6	0.0069	0.0080	1.4	−1.32	E	*ls*
17	$3s^23d-3s^2(^1S)6f$	$^2D-^2F^\circ$ (10)	*7835.5*	*32436*	45195	10	14	0.061	0.079	20	−0.10	D−	*ca*
			7836.13	32437	45195	6	8	0.062	0.076	12	−0.34	D−	*ls*
			7835.31	32435	45195	4	6	0.057	0.079	8.2	−0.50	D−	*ls*
			[7836.1]	32437	45195	6	6	0.0041	0.0038	0.59	−1.64	E	*ls*
18	$3s^24s-3s^2(^1S)4p$	$^2S-^2P^\circ$ (4)	*13132*	25348	*32961*	2	6	0.182	1.41	122	0.450	C	2
			13123.4	25348	32966	2	4	0.182	0.94	81	0.274	C	*ls*
			13150.8	25348	32950	2	2	0.181	0.470	40.7	−0.027	C	*ls*
19	$3s^24s-3s^2(^1S)5p$	$^2S-^2P^\circ$ (5)	*6697.0*	25348	*40276*	2	6	0.0169	0.0340	1.50	−1.167	C−	5
			6696.02	25438	40278	2	4	0.0169	0.0227	1.00	−1.343	C−	*ls*
			6698.67	25348	40272	2	2	0.0169	0.0113	0.50	−1.65	C−	*ls*
20	$3s^24s-3s^2(^1S)6p$	$^2S-^2P^\circ$ (6)	*5557.4*	25348	*43337*	2	6	0.00425	0.0059	0.216	−1.93	C−	5
			5557.06	25348	43338	2	4	0.00425	0.00394	0.144	−2.103	C−	*ls*
			5557.95	25348	43335	2	2	0.00425	0.00197	0.072	−2.405	C−	*ls*
21	$3s^24p-3s^2(^1S)4d$	$^2P^\circ-^2D$	*16743*	*32961*	*38932*	6	10	0.101	0.71	235	0.63	C	2
			16750.6	32966	38934	4	6	0.101	0.64	141	0.408	C	*ls*
			16719.0	32950	38929	2	4	0.085	0.71	78	0.152	C	*ls*
			16763.4	32966	38929	4	4	0.017	0.071	16	−0.55	D	*ls*
22	$3s^24p-3s^2(^1S)5d$	$^2P^\circ-^2D$ (13)	*10779*	*32961*	*42236*	6	10	0.0048	0.014	3.0	−1.08	D	*ca*
			10782.0	32966	42238	4	6	0.0050	0.013	1.8	−1.28	D	*ls*
			10768.4	32950	42234	2	4	0.0040	0.014	0.99	−1.55	D	*ls*
			10786.8	32966	42234	4	4	8.0×10^{-4}	0.0014	0.20	−2.25	E	*ls*
23	$3s^24p-3s^2(^1S)6s$	$^2P^\circ-^2S$ (12)	*10887*	*32961*	42144	6	2	0.034	0.020	4.3	−0.92	D	*ca*
			10891.7	32966	42144	4	2	0.022	0.020	2.9	−1.10	D	*ls*
			10873.0	32950	42144	4	2	0.011	0.020	1.4	−1.40	D	*ls*
24	$3s^24p-3s^2(^1S)6d$	$^2P^\circ-^2D$ (14)	*8920.6*	*32961*	*44168*	6	10	0.0011	0.0021	0.37	−1.90	D	*ca*
			8923.56	32966	44169	4	6	0.0011	0.0019	0.22	−2.12	D	*ls*
			8912.90	32950	44166	2	4	0.0010	0.0021	0.11	−2.38	D	*ls*
			8925.50	32966	44166	4	4	1.3×10^{-4}	2.2×10^{-4}	0.026	−3.06	E	*ls*

Al I. Allowed Transitions—*Continued*

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
25	$3s^24p-3s^2(^1S)7s$	$^2P^\circ-^2S$ (15)	*8837.8*	*32961*	44273	6	2	0.017	0.0065	1.1	−1.41	D	*ca*
			8841.28	32966	44273	4	2	0.011	0.0065	0.76	−1.59	D	*ls*
			8828.91	32950	44273	2	2	0.0056	0.0065	0.38	−1.89	D	*ls*

Al I

Forbidden Transitions

The line strength for the one transition in the ground state configuration is a straight number, tabulated for example by Naqvi [1]. The transition probability should also be quite accurate, since the energy level difference is accurately known.

Reference

[1] Naqvi, A. M., Thesis Harvard (1951).

Al I. Forbidden Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	Type of Transition	A_{ki}(sec^{-1})	S(at.u.)	Accuracy	Source
1	$3p-(^1S)3p$	$^2P^\circ-^2P^\circ$	[89.230×10^4]	0.00	112.04	2	4	*m*	1.26×10^{-5}	1.33	A	1

Al II

Ground State $1s^2 2s^2 2p^6 3s^2\ {}^1S_0$

Ionization Potential 18.823 eV = 151860.4 cm^{-1}

Allowed Transitions

List of tabulated lines:

Wavelength [Å]	No.	Wavelength [Å]	No.	Wavelength [Å]	No.
1047.9	17	1965.4	10	5999.76	37
1048.6	17	1989.85	9	6001.81	37
1050.0	17	2015.4	6	6006.42	37
1189.2	15	2192.6	5	6061.11	40
1190.1	15	2194.2	5	6066.38	39
1191.9	15	2195.4	5	6068.46	39
1350.2	18	2195.5	5	6073.23	39
1539.74	16	2816.19	13	6226.18	23
1670.81	1	2994.26	30	6231.5	23
1719.46	8	2995.54	30	6231.78	23
1721.28	8	2998.16	30	6243.2	23
1721.3	8	3088.52	32	6243.36	23
1724.98	8	3649.1	26	6335.74	20
1725.1	8	3651.1	26	6816.69	24
1760.1	2	3651.10	26	6823.48	24
1762.0	2	3655.0	26	6837.14	24
1763.79	2	3655.00	26	6917.93	42
1763.95	2	3703.22	31	6919.96	25
1765.8	2	3731.95	28	7042.06	21
1767.60	2	3733.91	28	7056.60	21
1855.95	12	3738.00	28	7063.64	21
1858.05	12	3866.16	29	7449.42	38
1862.34	12	3900.68	3	7471.41	19
1904.3	11	4663.1	14	7624.48	36
1906.5	11	5388.48	35	7627.85	36
1906.6	11	5593.23	27	7635.33	36
1906.7	11	5613.19	43	8354.35	33
1910.0	11	5853.62	34	8359.23	33
1911.0	11	5861.4	34	8359.57	33
1931.05	4	5861.53	34	8362.4	33
1958.4	10	5867.3	34	8363.30	33
1958.9	7	5867.6	34	8363.52	33
1960.7	10	5867.81	34	8640.70	22
1965.3	10	5971.94	41		

Weiss' [1] values have been calculated by means of the method of superposition of configurations, employing Hartree-Fock wavefunctions as a starting point. The calculations have been carried out both in the dipole length and dipole velocity approximations. Zare [2] has performed similar calculations, also in the length and velocity forms, using however, the simpler, less accurate Hartree-Fock-Slater wavefunctions, in which exchange effects are only approximately taken into account. The dipole length values of refs. [1] or [2] are selected, being probably more reliable than the velocity values, as suggested by the authors. Crossley and Dalgarno's values [3] have been obtained from a charge-expansion technique which includes configuration mixing in a limited way. There is usually good agreement for those transitions where the various calculations overlap. In these cases we have chosen Weiss' results over Zare's values and these in turn over ref. [3].

The accuracy estimate has been reduced where there is significant disagreement between the length and velocity forms or where there appears to be cancellation in the transition integral.

References

[1] Weiss, A. W., J. Chem. Phys. **47**, 3573 (1967).
[2] Crossley, R. J. S., and Dalgarno, A., Proc. Roy. Soc. London **A286**, 510–518 (1965).
[3] Zare, R. N., J. Chem. Phys. **47**, 3561 (1967).

Al II. Allowed Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
1	$3s^2-3s(^2S)3p$	$^1S-^1P^\circ$ (2 uv)	1670.81	0	59850	1	3	14.6	1.84	10.1	0.265	B	1
2	$3s3p-3p^2$	$^3P^\circ-^3P$ (5 uv)	*1764.0*	*37517*	*94207*	9	9	13.1	0.61	32.0	0.74	C+	1
			1763.95	37579	94268	5	5	9.8	0.458	13.3	0.360	C+	*ls*
			1763.79	37454	94147	3	3	3.29	0.153	2.67	−0.338	C	*ls*
			1767.60	37579	94147	5	3	5.4	0.153	4.44	−0.116	C	*ls*
			[1765.8]	37454	94085	3	1	13.1	0.204	3.55	−0.213	C	*ls*
			[1760.1]	37454	94268	3	5	3.30	0.255	4.44	−0.116	C	*ls*
			[1762.0]	37392	94147	1	3	4.38	0.61	3.55	−0.215	C	*ls*
3		$^1P^\circ-^1D$ (1)	3900.68	59850	85479	3	5	0.0048	0.0018	0.070	−1.27	E	1
4		$^1P^\circ-^1S$	1931.05	59850	111637	3	1	10.8	0.202	3.85	−0.218	C	1
5	$3s(^2S)3d-3p(^2P^\circ)3d$	$^3D-^3F^\circ$	*2193.8*	*95548*	*141116*	15	21	3.1	0.31	34	0.67	D	2
			[2192.6]	95547	141141	7	9	3.2	0.30	15	0.32	D	*ls*
			[2194.2]	95548	141108	5	7	2.7	0.28	10	0.15	D	*ls*
			[2195.5]	95549	141082	3	5	2.6	0.31	6.8	−0.03	D	*ls*
			[2194.2]	95547	141108	7	7	0.36	0.026	1.3	−0.74	D−	*ls*
			[2195.5]	95548	141082	5	5	0.50	0.036	1.3	−0.74	D−	*ls*
			[2195.4]	95547	141082	7	5	0.014	7.1×10^{-4}	0.036	−2.30	E	*ls*
6		$^3D-^3D^\circ$	*2015.4*	*95548*	*145150*	15	15	4.1	0.25	25	0.57	D	2
7		$^3D-^3P^\circ$	*1958.9*	*95548*	*146598*	15	9	6.8	0.24	23	0.55	D	3
8	$3s3p-3s(^2S)3d$	$^3P^\circ-^3D$ (6 uv)	*1723.2*	*37517*	*95548*	9	15	12.1	0.901	46.0	0.909	B	1
			[1725.1]	37579	95547	5	7	12.1	0.757	21.5	0.578	B	*ls*
			[1721.3]	37454	95548	3	5	9.14	0.676	11.5	0.307	B	*ls*
			1719.46	37392	95549	1	3	6.79	0.903	5.11	−0.044	B	*ls*
			[1725.1]	37579	95548	5	5	3.02	0.135	3.83	−0.171	B	*ls*
			1721.28	37454	95549	3	3	5.07	0.225	3.83	−0.171	B	*ls*
			1724.98	37579	95549	5	3	0.34	0.0090	0.26	−1.35	D	*ls*
9		$^1P^\circ-^1D$ (8 uv)	1989.85	59850	110088	3	5	14.7	1.45	28.5	0.64	C+	1
10	$3p^2-3p(^2P^\circ)3d$	$^3P-^3D^\circ$	*1963.0*	*94207*	*145150*	9	15	12	1.2	70	1.03	D	2
			[1965.3]	94268	145152	5	7	13	1.0	33	0.70	D	*ls*
			[1960.7]	94147	145148	3	5	9.1	0.88	17	0.42	D	*ls*
			[1958.4]	94085	145148	1	3	7.0	1.2	7.8	0.08	D−	*ls*
			[1965.4]	94268	145148	5	5	3.1	0.18	5.8	−0.05	D−	*ls*
			[1960.7]	94147	145148	3	3	5.2	0.30	5.8	−0.05	D−	*ls*
			[1965.4]	94268	145148	5	3	0.35	0.012	0.39	−1.22	E	*ls*
11		$^3P-^3P^\circ$	*1908.7*	*94207*	*146598*	9	9	8.1	0.44	25	0.60	D	2
			[1910.9]	94268	146599	5	5	5.8	0.32	10	0.20	D	*ls*
			[1906.6]	94147	146597	3	3	2.0	0.11	2.1	−0.48	D−	*ls*
			[1911.0]	94268	146597	5	3	3.4	0.11	3.5	−0.26	D−	*ls*
			[1906.7]	94147	146595	3	1	8.2	0.15	2.8	−0.35	D−	*ls*
			[1906.5]	94147	146599	3	5	2.0	0.19	3.5	−0.24	D−	*ls*
			[1904.3]	94085	146597	1	3	2.7	0.45	2.8	−0.35	D−	*ls*

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
12	$3s3p-3s(^2S)4s$	$^3P^\circ-^3S$ (4 uv)	*1860.3*	*37517*	91271	9	3	7.44	0.129	7.09	0.065	B	1
			1862.34	37579	91271	5	3	4.12	0.129	3.94	−0.190	B	*ls*
			1858.05	37454	91271	3	3	2.48	0.129	2.36	−0.412	B	*ls*
			1855.95	37392	91271	1	3	0.832	0.129	0.788	−0.889	B	*ls*
13		$^1P^\circ-^1S$	2816.19	59850	95348	3	1	3.83	0.152	4.22	−0.341	C−	1
14	$3p^2-3s(^2S)4p$	$^1D-^1P^\circ$	[4663.1]	85479	106918	5	3	0.53	0.104	8.0	−0.284	C	3
15	$3s3p-3s(^2S)4d$	$^3P^\circ-^3D$	*1191.0*	*37517*	*121481*	9	15	1.7	0.059	2.1	−0.28	D	3
			[1191.9]	37579	121480	5	7	1.7	0.050	0.98	−0.60	D	*ls*
			[1190.1]	37454	121481	3	5	1.3	0.044	0.52	−0.88	D	*ls*
			[1189.2]	37392	121481	1	3	0.93	0.059	0.23	−1.23	D−	*ls*
			[1191.9]	37579	121481	5	5	0.42	0.0089	0.17	−1.35	D−	*ls*
			[1190.1]	37454	121481	3	3	0.70	0.015	0.17	−1.35	D−	*ls*
			[1191.9]	37579	121481	5	3	0.046	5.9×10^{-4}	0.012	−2.53	E	*ls*
16		$^1P^\circ-^1D$ (10 uv)	1539.74	59850	124792	3	5	8.8	0.52	7.9	0.19	D	3
17	$3s3p-3s(^2S)5d$	$^3P^\circ-^3D$	*1049.3*	*37517*	132820	9	15	0.64	0.018	0.55	−0.80	D	3
			[1050.0]	37579	132820	5	7	0.64	0.015	0.26	−1.13	D	*ls*
			[1048.6]	37454	132820	3	5	0.48	0.013	0.14	−1.40	D	*ls*
			[1047.9]	37392	132820	1	3	0.36	0.018	0.061	−1.75	D−	*ls*
			[1050.0]	37579	132820	5	5	0.16	0.0027	0.046	−1.88	D−	*ls*
			[1048.6]	37454	132820	3	3	0.27	0.0044	0.046	−1.88	D−	*ls*
			[1050.0]	37579	132820	5	3	0.018	1.8×10^{-4}	0.0031	−3.05	E	*ls*
18		$^1P^\circ-^1D$	[1350.2]	59850	133914	3	5	4.8	0.22	2.9	−0.19	E	3
19	$3s3d-3s(^2S)4f$	$^1D-^1F^\circ$ (21)	7471.41	110088	123468	5	7	0.94	1.1	140	0.74	D	*ca*
20	$3s3d-3s(^2S)5p$	$^1D-^1P^\circ$ (22)	6335.74	110088	125867	5	3	0.14	0.050	5.2	−0.60	D	*ca*
21	$3s4s-3s(^2S)4p$	$^3S-^3P^\circ$ (3)	*7049.3*	91271	*105453*	3	9	0.58	1.31	91	0.59	C+	3
			7042.06	91271	105468	3	5	0.59	0.73	51	0.340	C+	*ls*
			7056.60	91271	105438	3	3	0.58	0.435	30.3	0.116	C+	*ls*
			7063.64	91271	105424	3	1	0.58	0.145	10.1	−0.362	C+	*ls*
22		$^1S-^1P^\circ$ (4)	8640.70	95348	106918	1	3	0.286	0.96	27.3	−0.018	C	3
23	$3s4p-3s(^2S)4d$	$^3P^\circ-^3D$ (10)	*6237.4*	*105453*	*121481*	9	15	1.1	1.1	200	1.00	D	*ca*
			6243.36	105468	121480	5	7	1.1	0.96	93	0.68	D	*ls*
			6231.78	105438	121481	3	5	0.84	0.86	50	0.41	D	*ls*
			6226.18	105424	121481	1	3	0.62	1.1	22	0.04	D−	*ls*
			[6243.2]	105468	121481	5	5	0.28	0.17	17	−0.07	D−	*ls*
			[6231.5]	105438	121481	3	3	0.47	0.28	17	−0.08	D−	*ls*
			[6243.2]	105468	121481	5	3	0.031	0.011	1.1	−1.26	E	*ls*
24	$3s4p-3s(^2S)5s$	$^3P^\circ-^3S$ (9)	*6830.1*	*105453*	120090	9	3	1.0	0.24	49	0.33	D	*ca*
			6837.14	105468	120090	5	3	0.57	0.24	27	0.08	D	*ls*
			6823.48	105438	120090	3	3	0.34	0.24	16	−0.14	D	*ls*
			6816.69	105424	120090	1	3	0.11	0.24	5.4	−0.62	D	*ls*
25		$^1P^\circ-^1S$ (15)	6919.96	106918	121365	3	1	0.96	0.23	16	−0.16	D	*ca*

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
26	$3s4p-3s(^2S)5d$	$^3P^\circ-^3D$ (12)	*3653.0*	*105453*	132820	9	15	0.27	0.091	9.9	−0.09	D	*ca*
			3655.00	105468	132820	5	7	0.27	0.077	4.6	−0.41	D	*ls*
			3651.10	105438	132820	3	5	0.21	0.069	2.5	−0.68	D	*ls*
			[3649.1]	105424	132820	1	3	0.15	0.092	1.1	−1.04	D−	*ls*
			[3655.0]	105468	132820	5	5	0.069	0.014	0.83	−1.15	D−	*ls*
			[3651.1]	105438	132820	3	3	0.12	0.023	0.83	−1.16	D−	*ls*
			[3655.0]	105468	132820	5	3	0.0076	9.1×10^{-4}	0.055	−2.34	E	*ls*
27		$^1P^\circ-^1D$ (16)	5593.23	106918	133914	3	5	1.1	0.85	47	0.41	D	*ca*
28	$3s4p-3s(^2S)6s$	$^3P^\circ-^3S$ (11)	*3735.9*	*105453*	132213	9	3	0.39	0.027	3.0	−0.61	D	*ca*
			3738.00	105468	132213	5	3	0.21	0.027	1.7	−0.87	D	*ls*
			3733.91	105438	132213	3	3	0.13	0.027	1.0	−1.09	D	*ls*
			3731.95	105424	132213	1	3	0.043	0.027	0.33	−1.57	D	*ls*
29		$^1P^\circ-^1S$ (17)	3866.16	106918	132776	3	1	0.37	0.028	1.1	−1.08	D	*ca*
30	$3s4p-3s(^2S)6d$	$^3P^\circ-^3D$ (14)	*2996.8*	*105453*	138812	9	15	0.11	0.025	2.2	−0.65	D	*ca*
			2998.16	105468	138812	5	7	0.11	0.021	1.0	−0.98	D	*ls*
			2995.54	105438	138812	3	5	0.085	0.019	0.56	−1.24	D	*ls*
			2994.26	105424	138812	1	3	0.062	0.025	0.25	−1.60	D−	*ls*
			2998.16	105468	138812	5	5	0.027	0.0037	0.18	−1.73	D−	*ls*
			2995.54	105438	138812	3	3	0.046	0.0062	0.18	−1.73	D−	*ls*
			2998.16	105468	138812	5	3	0.0031	2.5×10^{-4}	0.012	−2.90	E	*ls*
31		$^1P^\circ-^1D$ (18)	3703.22	106918	139287	3	5	0.38	0.13	4.8	−0.41	D	*ca*
32	$3s4p-3s(^2S)7d$	$^1P^\circ-^1D$ (20)	3088.52	106918	142607	3	5	0.15	0.036	1.1	−0.97	D	*ca*
33	$3s4d-3s(^2S)5f$	$^3D-^3F^\circ$ (40)	*8358.2*	*121481*	*133442*	15	21	0.50	0.74	310	1.05	D	*ca*
			8354.35	121480	133447	7	9	0.50	0.67	130	0.67	D	*ls*
			8359.57	121481	133440	5	7	0.44	0.65	89	0.51	D	*ls*
			8363.52	121481	133435	3	5	0.42	0.74	61	0.35	D	*ls*
			8359.23	121480	133440	7	7	0.055	0.058	11	−0.39	D−	*ls*
			8363.30	121481	133435	5	5	0.078	0.082	11	−0.39	D−	*ls*
			[8362.4]	121480	133435	7	5	0.0022	0.0017	0.32	−1.92	E	*ls*
34	$3s4d-3s(^2S)6f$	$^3D-^3F^\circ$ (41)	*5859.7*	*121481*	*138542*	15	21	0.24	0.17	49	0.41	D	*ca*
			5853.62	121480	138559	7	9	0.24	0.15	21	0.02	D	*ls*
			5861.53	121481	138536	5	7	0.22	0.15	15	−0.12	D	*ls*
			5867.81	121481	138519	3	5	0.20	0.17	9.8	−0.29	D	*ls*
			[5861.4]	121480	138536	7	7	0.026	0.013	1.8	−1.04	D−	*ls*
			[5867.6]	121481	138519	5	5	0.036	0.019	1.8	−1.02	D−	*ls*
			[5867.3]	121480	138519	7	5	0.0010	3.8×10^{-4}	0.051	−2.58	E	*ls*
35	$3s5s-3s(^2S)7p$	$^1S-^1P^\circ$ (34)	5388.48	121365	139917	1	3	0.012	0.016	0.28	−1.80	D	*ca*
36	$3s5p-3s(^2S)6d$	$^3P^\circ-^3D$ (91)	*7632.1*	*125713*	138812	9	15	0.089	0.13	29	0.07	D	*ca*
			7635.33	125719	138812	5	7	0.090	0.11	14	−0.26	D	*ls*
			7627.85	125706	138812	3	5	0.065	0.095	7.2	−0.55	D	*ls*
			7624.48	125701	138812	1	3	0.050	0.13	3.3	−0.89	D−	*ls*
			7635.33	125719	138812	5	5	0.022	0.019	2.4	−1.02	D−	*ls*
			7627.85	125706	138812	3	3	0.037	0.032	2.4	−1.02	D−	*ls*
			7635.33	125719	138812	5	3	0.0025	0.0013	0.16	−2.19	E	*ls*

Al II. Allowed Transitions—*Continued*

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
37	$3s5p-3s(^2S)7d$	$^3P^\circ-^3D$ (93)	*6004.4*	*125713*	142363	9	15	0.034	0.031	5.5	−0.55	D	*ca*
			6006.42	125719	142363	5	7	0.034	0.026	2.6	−0.89	D	*ls*
			6001.81	125706	142363	3	5	0.026	0.023	1.4	−1.16	D	*ls*
			5999.76	125701	142363	1	3	0.019	0.031	0.61	−1.51	D−	*ls*
			6006.42	125719	142363	5	5	0.0085	0.0046	0.45	−1.64	D−	*ls*
			6001.81	125706	142363	3	3	0.014	0.0076	0.45	−1.64	D−	*ls*
			6006.42	125719	142363	5	3	9.2×10^{-4}	3.0×10^{-4}	0.030	−2.82	E	*ls*
38		$^1P^\circ-^1D$ (98)	7449.42	125867	142607	3	5	0.12	0.16	12	−0.32	D	*ca*
39	$3s5p-3s(^2S)8s$	$^3P^\circ-^3S$ (92)	*6071.1*	*125713*	*142180*	9	3	0.076	0.014	2.5	−0.90	D	*ca*
			6073.23	125719	142180	5	3	0.042	0.014	1.4	−1.15	D	*ls*
			6068.46	125706	142180	3	3	0.025	0.014	0.84	−1.38	D	*ls*
			6066.38	125701	142180	1	3	0.0085	0.014	0.28	−1.85	D	*ls*
40		$^1P^\circ-^1S$ (99)	6061.11	125867	142361	3	1	0.076	0.014	0.84	−1.38	D	*ca*
41	$3s5p-3s(^2S)8d$	$^1P^\circ-^1D$ (100)	5971.94	125867	144780	3	5	0.049	0.044	2.6	−0.88	D	*ca*
42	$3s5d-3s(^2S)6f$	$^1D-^1F^\circ$ (75)	6917.93	133914	139243	5	7	0.16	0.16	18	−0.10	D	*ca*
43	$3s5d-3s(^2S)7f$	$^1D-^1F^\circ$ (77)	5613.19	133914	142602	5	7	0.070	0.046	4.3	−0.64	D	*ca*

Al II

Forbidden Transitions

Naqvi's calculations [1] are the only available source. The results for the $^3P^\circ-^3P^\circ$ transitions are essentially independent of the choice of the interaction parameters. For the $^3P^\circ-^1P^\circ$ transitions, Naqvi uses empirical term intervals, i.e., the effects of configuration interaction should be partially included.

Reference

[1] Naqvi, A. M., Thesis Harvard (1951).

Al II. Forbidden Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	Type of Transition	A_{ki}(sec^{-1})	S(at.u.)	Accuracy	Source
1	$3s3p-3s(^2S)3p$	$^3P^\circ-^3P^\circ$										
			[16.18×10^5]	37392.0	37453.8	1	3	*m*	4.24×10^{-6}	2.00	B	1
			[79.66×10^4]	37453.8	37579.3	3	5	*m*	2.67×10^{-5}	2.50	B	1
2		$^3P^\circ-^1P^\circ$										
			[4451.6]	37392.0	59849.7	1	3	*m*	0.00288	2.83×10^{-5}	C	1
			[4463.9]	37453.8	59849.7	3	3	*m*	0.57	0.0056	C	1
			[4489.0]	37579.3	59849.7	5	3	*m*	0.00351	3.53×10^{-5}	C	1

Al III

Ground State $1s^22s^22p^63s\ ^2S_{1/2}$

Ionization Potential 28.44 eV = 229453.99 cm^{-1}

Allowed Transitions

List of tabulated lines:

Wavelength [Å]	No.	Wavelength [Å]	No.	Wavelength [Å]	No.
560.390	3	1862.78	1	4357.24	15
695.817	2	1935.9	7	4364.59	15
696.212	2	3283.11	16	4512.54	11
1162.6	9	3287.37	16	4528.91	11
1352.8	8	3601.62	6	4529.18	11
1379.6	5	3601.92	6	4701.65	14
1384.2	5	3612.35	6	4903.71	17
1605.7	4	3702.09	12	5260.91	19
1611.88	4	3713.10	12	5696.47	10
1611.90	4	3980.56	18	5722.65	10
1854.72	1	4150.1	13		

Self-consistent field calculations including exchange effects have been carried out by Weiss [1] and by Chapman, Clarke, and Aller [3] for several multiplets of this ion. Weiss' values have been calculated with both the dipole length and dipole velocity formulas which agree usually within a few percent. Stewart and Rotenberg [2], who developed a method employing a scaled Thomas-Fermi potential, have applied this to several Al III transitions, including $3s$-$5p$, which is not covered by the other authors. Good agreement exists among the various calculations, including the Coulomb approximation, for the few cases where they overlap. Cancellation occurs in varying degrees for the $3s$-$4p$, $3s$-$5p$, $5p$-$6d$, and $5p$-$7d$ transitions, which are mostly covered by the Coulomb approximation. In these cases the accuracy rating has been reduced. We have adopted the values of Weiss [1], i.e., the average of his dipole length and dipole velocity values, when we had a choice between different calculations. Furthermore, the results of Refs. [2] and [3] were chosen in preference to the Coulomb approximation.

Weiss [1] has also carried out calculations for the doublet ratios of those transitions for which he has calculated absolute f-values. His results indicate that the doublet ratios follow LS-coupling quite well, in direct disagreement with the experimental results of Kisiel [4] who has measured the intensity ratios of various transitions connected with the $3p$ state. It appears that Kisiel has failed to adequately investigate the effects of self-absorption which are probably quite important in this experiment.

For Al III, a member of the sodium isoelectronic sequence, it is possible to utilize extensively the dependence of oscillator strengths on nuclear charge for the intercomparison of analogous transitions. Thus, the degree of fit of the individual f-values into the systematic trends has served as one of the decisive factors for the choice of accuracy assignments.

References

[1] Weiss, A. W., to be published (1969).
[2] Stewart, J. C., and Rotenberg, M., Phys. Rev. **140**, 1508A–1519A (1965).
[3] Chapman, R. D., Clarke, W. H., and Aller, L. H., Astrophys. J. **144**, 376–380 (1966).
[4] Kisiel, A., Acta Phys. Polon. **23**, 167–175 (1963).

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
1	$3s-3p$	$^2S-^2P^\circ$ (1 uv)	*1857.4*	0	*53839*	2	6	5.64	0.875	10.7	0.243	B	1
			1854.72	0	53917	2	4	5.67	0.585	7.14	0.066	B	*ls*
			1862.78	0	53684	2	2	5.60	0.291	3.57	−0.235	B	*ls*
2	$3s-4p$	$^2S-^2P^\circ$ (2 uv)	*695.97*	0	*143684*	2	6	0.52	0.011	0.052	−1.64	D	1
			695.817	0	143712	2	4	0.53	0.0076	0.035	−1.82	D	*ls*
			696.212	0	143632	2	2	0.51	0.0037	0.017	−2.13	D	*ls*
3	$3s-5p$	$^2S-^2P^\circ$ (3 uv)	560.390	0	178455	2	6	0.48	0.0068	0.025	−1.87	D	2
4	$3p-3d$	$^2P^\circ-^2D$	*1609.9*	*53839*	*115956*	6	10	14.5	0.937	29.8	0.750	B	1
			1611.90	53917	115955	4	6	14.4	0.843	17.9	0.528	B	*ls*
			1605.7	53684	115957	2	4	12.1	0.939	9.93	0.274	B	*ls*
			1611.88	53917	115957	4	4	2.42	0.0942	2.00	−0.424	B	*ls*
5	$3p-4s$	$^2P^\circ-^2S$	*1382.7*	*53839*	126163	6	2	13.5	0.129	3.51	−0.111	C+	1
			[1384.2]	53917	126163	4	2	8.9	0.129	2.34	−0.287	C+	*ls*
			[1379.6]	53684	126163	2	2	4.51	0.129	1.17	−0.59	C+	*ls*
6	$3d-4p$	$^2D-^2P^\circ$ (1)	*3605.4*	*115956*	*143684*	10	6	1.49	0.174	20.7	0.242	C+	1
			3601.62	115955	143712	6	4	1.34	0.174	12.4	0.020	C+	*ls*
			3612.35	115957	143632	4	2	1.48	0.145	6.9	−0.236	C+	*ls*
			3601.92	115957	143712	4	4	0.150	0.0291	1.38	−0.93	C+	*ls*
7	$3d-4f$	$^2D-^2F^\circ$	[1935.9]	*115956*	167612	10	14	12.2	0.96	61	0.98	C+	*ca*
8	$3d-5f$	$^2D-^2F^\circ$	[1352.8]	*115956*	189875	10	14	4.40	0.169	7.5	0.228	C	*ca*
9	$3d-6f$	$^2D-^2F^\circ$	[1162.6]	*115956*	201970	10	14	2.1	0.061	2.3	−0.21	D	*ca*
10	$4s-4p$	$^2S-^2P^\circ$ (2)	*5705.9*	126163	*143684*	2	6	0.878	1.29	48.3	0.412	B	1
			5696.47	126163	143712	2	4	0.882	0.859	32.2	0.235	B	*ls*
			5722.65	126163	143632	2	2	0.870	0.427	16.1	−0.069	B	*ls*
11	$4p-4d$	$^2P^\circ-^2D$ (3)	*4523.2*	*143684*	*165786*	6	10	2.56	1.31	117	0.90	C+	3
			4529.18	143712	165785	4	6	2.54	1.17	70	0.67	C+	*ls*
			4512.54	143632	165787	2	4	2.15	1.31	38.9	0.418	C+	*ls*
			4528.91	143712	165787	4	4	0.426	0.131	7.8	−0.281	C+	*ls*
12	$4p-5s$	$^2P^\circ-^2S$ (4)	*3709.2*	*143684*	170636	6	2	3.42	0.235	17.2	0.149	C+	3
			3713.10	143712	170636	4	2	2.27	0.235	11.5	−0.027	C+	*ls*
			3702.09	143632	170636	2	2	1.14	0.235	5.7	−0.328	C+	*ls*
13	$4d-5f$	$^2D-^2F^\circ$ (5)	*4150.1*	*165786*	189875	10	14	2.19	0.79	108	0.90	C+	3
14	$4f-5d$	$^2F^\circ-^2D$ (6)	4701.65	167612	188876	14	10	0.079	0.019	4.1	−0.58	D	*ca*
15	$5p-6d$	$^2P^\circ-^2D$ (9)	*4362.0*	*178455*	201374	6	10	0.084	0.040	3.5	−0.62	D	*ca*
			4364.59	178470	201374	4	6	0.082	0.035	2.0	−0.85	D	*ls*
			4357.24	178430	201374	2	4	0.070	0.040	1.2	−1.10	D	*ls*
			4364.59	178470	201374	4	4	0.014	0.0039	0.23	−1.80	D	*ls*

Al III. Allowed Transitions—*Continued*

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
16	$5p-7d$	$^2P^\circ-^2D$ (10)	*3285.8*	*178455*	208880	6	10	0.011	0.0030	0.19	−1.74	D	*ca*
			3287.37	178470	208880	4	6	0.011	0.0026	0.11	−1.98	D	*ls*
			3283.11	178430	208880	2	4	0.0093	0.0030	0.065	−2.22	D	*ls*
			3287.37	178470	208880	4	4	0.0018	2.9×10^{-4}	0.013	−2.94	D	ls
17	$5d-7f$	$^2D-^2F^\circ$ (11)	4903.71	188876	209261	10	14	0.351	0.177	28.6	0.248	C	*ca*
18	$5d-8f$	$^2D-^2F^\circ$ (12)	3980.56	188876	213992	10	14	0.229	0.076	10.0	−0.119	C	*ca*
19	$5f-7d$	$^2F^\circ-^2D$ (13)	5260.91	189875	208880	14	10	0.0280	0.0083	2.01	−0.93	C	*ca*

Al IV

Ground State $1s^22s^22p^6\ ^1S_0$

Ionization Potential 119.96 eV = 967783 cm^{-1}

Allowed Transitions

Calculations by Kastner, Omidvar, and Underwood [1], employing Hartree-Fock wavefunctions and including intermediate coupling, are available. Since the calculations are based on a single-configuration approximation only, uncertainties of up to 50 percent are expected for the strong lines and even higher uncertainties for the weak lines, the latter being more affected by assumptions about the coupling.

Reference

[1] Kastner, S. O., Omidvar, K., and Underwood, J. H., Astrophys. J. **148**, 269–273 (1967).

Al IV. Allowed Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
1	$2p^6-2p^5(^2P^\circ_{3/2})3s$	$^1S-^3P^\circ$	[161.69]	0	618478	1	3	13	0.015	0.0080	−1.82	E	1
2	$2p^6-2p^5(^2P^\circ_{1/2})3s$	$^1S-^1P^\circ$	[160.07]	0	624721	1	3	170	0.20	0.11	−0.70	D	1
3	$2p^6-2p^5(^2P^\circ_{3/2})3d$	$^1S-^3P^\circ$	[131.65]	0	759601	1	3	4.7	0.0037	0.0016	−2.43	E	1
4	$2p^6-2p^5(^2P^\circ_{3/2})3d$	$^1S-^1P^\circ$	[130.37]	0	767041	1	3	630	0.48	0.21	−0.32	D	1
5	$2p^6-2p^5(^2P^\circ_{1/2})3d$	$^1S-^3D^\circ$	[129.73]	0	770836	1	3	340	0.26	0.11	−0.59	D	1

Al V

Ground State $1s^2 2s^2 2p^5\ ^2P^\circ_{3/2}$

Ionization Potential 153.77 eV = 1240600 cm^{-1}

Allowed Transitions

The value for the $2s^2 2p^5\ ^2P^\circ - 2s2p^6\ ^2S$ multiplet is calculated from the nuclear charge-expansion method of Cohen and Dalgarno [1]. It may be quite uncertain since configuration interaction effects with configurations involving the $n=3$ shell electrons, which were not included in this calculation, may be significant.

Reference

[1] Cohen, M., and Dalgarno, A., Proc. Roy. Soc. London **A280**, 258–270 (1964).

Al V. Allowed Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
1	$2s^2 2p^5 - 2s2p^6$	$^2P^\circ - ^2S$	*279.59*	*1147*	358810	6	2	320	0.12	0.68	−0.14	D	1
			[278.70]	0	358810	4	2	210	0.12	0.45	−0.32	D	*ls*
			[281.40]	3440	358810	2	2	100	0.12	0.23	−0.62	D	*ls*

Al V

Forbidden Transitions

The line strength for the one transition in the ground state configuration is a straight number, tabulated for example by Naqvi [1]. The transition probability should also be quite accurate, since the energy level difference is accurately known.

Reference

[1] Naqvi, A. M., Thesis Harvard (1951).

Al V. Forbidden Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	Type of Transition	A_{ki}(sec^{-1})	S(at.u.)	Accuracy	Source
1	$2p^5 - 2p^5$	$^2P^\circ - ^2P^\circ$	[29062]	0	3440	4	2	*m*	0.731	1.33	A	1

308-022 O-69—7

Al VI

Ground State $1s^2 2s^2 2p^4\ ^3P_2$

Ionization Potential 190.42 eV = 1536300 cm^{-1}

Allowed Transitions

The values are calculated from the charge-expansion method of Cohen and Dalgarno [1] which includes limited configuration mixing. From comparisons with other ions in the isoelectronic sequence, uncertainties should be within 50 percent.

Reference

[1] Cohen, M., and Dalgarno, A., Proc. Roy. Soc. London **A280**, 258–270 (1964).

Al VI. Allowed Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
1	$2s^2 2p^4 - 2s2p^5$	$^3P - ^3P^\circ$	*309.68*	*1338*	*324249*	9	9	140	0.21	1.9	0.28	D	1
			[309.60]	0	323002	5	5	110	0.16	0.79	−0.10	D	*ls*
			[309.85]	2736	325470	3	3	36	0.052	0.16	−0.81	D	*ls*
			[307.25]	0	325470	5	3	61	0.051	0.26	−0.59	D	*ls*
			[308.56]	2736	326822	3	1	140	0.069	0.21	−0.64	D	*ls*
			[312.24]	2736	323002	3	5	35	0.084	0.26	−0.60	D	*ls*
			[310.91]	3831	325470	1	3	47	0.21	0.21	−0.68	D	*ls*
2		$^1D - ^1P^\circ$	[243.76]	41600	451840	5	3	240	0.13	0.51	−0.19	D	1
3		$^1S - ^1P^\circ$	[275.35]	88670	451840	1	3	36	0.12	0.11	−0.92	D	1

Al VI

Forbidden Transitions

As in the case of Na IV the adopted values are taken from Naqvi [1], and Malville and Berger [2]. For a discussion on the selection of values see Na IV, since the same considerations have been applied.

References

[1] Naqvi, A. M., Thesis Harvard (1951).
[2] Malville, J. M., and Berger, R. A., Planetary and Space Science **13**, 1131 (1965).

Al VI. Forbidden Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	Type of Transition	A_{ki}(sec^{-1})	S(at.u.)	Accuracy	Source
1	$2p^4-2p^4$	$^3P-^3P$										
			[36540]	0	2736	5	3	*e*	6.1×10^{-7}	0.071	C−	1, 2
			[36540]	0	2736	5	3	*m*	0.461	2.50	B	1
			[26096]	0	3831	5	1	*e*	4.3×10^{-6}	0.0310	C−	2
			[91300]	2736	3831	3	1	*m*	0.0708	2.00	B	1, 2
2		$^3P-^1D$										
			[2403.1]	0	41600	5	5	*e*	0.0037	8.8×10^{-4}	D−	1, 2
			[2403.1]	0	41600	5	5	*m*	5.2	0.0133	C	1
			[2572.3]	2736	41600	3	5	*e*	3.7×10^{-4}	1.3×10^{-4}	D−	1, 2
			[2572.3]	2736	41600	3	5	*m*	1.40	0.00443	C	1
			[2646.9]	3831	41600	1	5	*e*	1.3×10^{-4}	5.1×10^{-5}	C−	2
3		$^3P-^1S$										
			[1127.8]	0	88670	5	1	*e*	0.056	6.1×10^{-5}	D−	2
			[1163.7]	2736	88670	3	1	*m*	61	0.00356	C	2
4		$^1D-^1S$										
			[2123.8]	41600	88670	5	1	*e*	4.8	0.123	C−	2

Al VII

Ground State $1s^22s^22p^3\ ^4S^\circ_{3/2}$

Ionization Potential 241.38 eV = 1947390 cm^{-1}

Allowed Transitions

Values for all the listed transitions are calculated from the nuclear charge-expansion method of Cohen and Dalgarno [1], which includes limited configuration mixing. Judged from graphical comparisons with other ions in the isoelectronic sequence and from the general success of Cohen and Dalgarno's method for similar atomic systems, uncertainties within 50 percent are indicated.

Reference

[1] Cohen, M., and Dalgarno, A., Proc. Roy. Soc. London **A280**, 258–270 (1964).

Al VII. Allowed Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
1	$2s^22p^3-2s2p^4$	$^4S^\circ-^4P$	*355.05*	0	*281647*	4	12	41	0.24	1.1	−0.02	D	1
			[356.89]	0	280200	4	6	41	0.12	0.55	−0.32	D	*ls*
			[353.78]	0	282660	4	4	42	0.079	0.37	−0.50	D	*ls*
			[352.16]	0	283960	4	2	42	0.039	0.18	−0.81	D	*ls*
2		$^2D^\circ-^2D$	*309.08*	*60736*	*384280*	10	10	96	0.14	1.4	0.15	D	1
			[309.12]	60760	384260	6	6	89	0.13	0.78	−0.11	D	*ls*
			[309.01]	60700	384310	4	4	86	0.12	0.50	−0.32	D	*ls*
			[309.07]	60760	384310	6	4	9.6	0.0092	0.056	−1.26	E	*ls*
			[309.06]	60700	384260	4	6	6.4	0.014	0.056	−1.25	E	*ls*

Al VII. Allowed Transitions — *Continued*

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
3		$^2D^\circ - ^2P$	*240.19*	*60736*	*477077*	10	6	340	0.18	1.4	0.26	D	1
			[240.77]	60760	476090	6	4	300	0.18	0.84	0.03	D	*ls*
			[239.03]	60700	479050	4	2	350	0.15	0.47	−0.22	D	*ls*
			[240.74]	60700	476090	4	4	34	0.029	0.093	−0.94	D	*ls*
4		$^2P^\circ - ^2D$	*343.52*	*93180*	*384280*	6	10	15	0.046	0.31	−0.56	D	1
			[343.65]	93270	384260	4	6	16	0.042	0.19	−0.77	D	*ls*
			[343.28]	93000	384310	2	4	13	0.044	0.10	−1.06	D	*ls*
			[343.60]	93270	384310	4	4	0.021	0.0046	0.021	−1.74	E	*ls*
5		$^2P^\circ - ^2S$	*279.19*	*93180*	451360	6	2	210	0.082	0.45	−0.31	D	1
			[279.26]	93270	451360	4	2	140	0.082	0.30	−0.48	D	*ls*
			[279.05]	93000	451360	2	2	70	0.082	0.15	−0.79	D	*ls*
6		$^2P^\circ - ^2P$	*260.49*	*93180*	*477077*	6	6	100	0.10	0.54	−0.22	D	1
			[261.22]	93270	476090	4	4	85	0.087	0.30	−0.46	D	*ls*
			[259.03]	93000	479050	2	2	70	0.070	0.12	−0.85	D	*ls*
			[259.22]	93270	479050	4	2	35	0.018	0.060	−1.14	E	*ls*
			[261.04]	93000	476090	2	4	17	0.035	0.060	−1.15	E	*ls*

Al VII

Forbidden Transitions

All the values for this ion have been taken from Pasternack [1]. The electric quadrupole values have been corrected by applying Naqvi's value [2] for the electric quadrupole moment s_q.

References

[1] Pasternack, S., Astrophys. J. **92**, 129 (1940).
[2] Naqvi, A. M., Thesis Harvard (1951).

Al VII. Forbidden Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	Type of Transition	A_{ki}(sec^{-1})	S(at.u.)	Accuracy	Source
1	$2p^3 - 2p^3$	$^4S^\circ - ^2D^\circ$										
			[1645.8]	0	60760	4	6	*m*	0.0046	4.56×10^{-6}	C−	1
			[1645.8]	0	60760	4	6	*e*	0.0018	7.8×10^{-5}	D−	1, 2
			[1647.4]	0	60700	4	4	*m*	0.26	1.72×10^{-4}	C−	1
			[1647.4]	0	60700	4	4	*e*	0.0011	3.3×10^{-5}	D−	1, 2
2		$^4S^\circ - ^2P^\circ$										
			[1072.2]	0	93270	4	4	*m*	29	0.0053	C	1
			[1072.2]	0	93270	4	4	*e*	1.8×10^{-5}	6.2×10^{-8}	D−	1, 2
			[1075.3]	0	93000	4	2	*m*	12	0.00111	C	1
			[1075.3]	0	93000	4	2	*e*	4.4×10^{-5}	7.5×10^{-8}	D−	1, 2

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	Type of Transition	A_{ki}(sec^{-1})	S(at.u.)	Accuracy	Source
3		$^2D^\circ-^2D^\circ$										
			[16.7 × 10^5]	60700	60760	4	6	*m*	2.33 × 10^{-6}	2.40	B	2
			[16.7 × 10^5]	60700	60760	4	6	*e*	1.2 × 10^{-17}	5.4 × 10^{-4}	D−	1, 2
4		$^2D^\circ-^2P^\circ$ (1F)										
			3074.0	60760	93270	6	4	*m*	4.6	0.0198	C	1
			3074.0	60760	93270	6	4	*e*	0.31	0.20	D	2
			3093.4	60700	93000	4	2	*m*	5.1	0.0112	C	1
			3093.4	60700	93000	4	2	*e*	0.25	0.086	D	2
			3098.7	60760	93000	6	2	*e*	0.17	0.058	D	2
			3068.8	60700	93270	4	4	*m*	8.5	0.0366	C	1
			3068.8	60700	93270	4	4	*e*	0.13	0.085	D	2
5		$^2P^\circ-^2P^\circ$										
			[37.03 × 10^4]	93000	93270	2	4	*m*	1.77 × 10^{-4}	1.33	B	2
			[37.03 × 10^4]	93000	93270	2	4	*e*	1.6 × 10^{-14}	2.6 × 10^{-4}	D−	1, 2

Al VIII

Ground State $1s^22s^22p^2\ ^3P_0$

Ionization Potential 284.53 eV = 2295500 cm^{-1}

Allowed Transitions

List of tabulated lines:

Wavelength [Å]	No.	Wavelength [Å]	No.	Wavelength [Å]	No.
247.39	3	325.32	2	387.97	1
248.46	3	328.20	2	1111.6	8
250.14	3	381.11	1	1118.7	8
251.34	5	383.66	1	1131.1	8
285.47	4	383.76	1	1206.3	7
287.04	6	387.67	1	1223.5	7
323.49	2	387.78	1	1280.4	7

Most data are obtained from the charge-expansion method of Cohen and Dalgarno [1] which includes limited configuration mixing. Graphical comparisons of this material within the isoelectronic sequence depicting the dependence of *f*-values on nuclear charge have been made, and the available experimental data for the lower ions, mostly from lifetime measurements, establish fairly definitely that the uncertainties should not exceed 50 percent. Analogous graphs for the data obtained from the Coulomb approximation indicate that these values are accurate within 25 percent.

Reference

[1] Cohen, M., and Dalgarno, A., Proc. Roy. Soc. London **A280**, 258–270 (1964).

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
1	$2s^22p^2-2s2p^3$	$^3P-^3D^\circ$	*385.76*	*3047*	*262273*	*9*	*15*	*24*	0.087	1.0	−0.11	D+	1
			[387.97]	4440	262190	5	7	23	0.074	0.47	−0.43	D+	*ls*
			[383.76]	1740	262320	3	5	18	0.066	0.25	−0.70	D+	*ls*
			[381.11]	0	262390	1	3	13	0.088	0.11	−1.06	D	*ls*
			[387.78]	4440	262320	5	5	5.8	0.013	0.083	−1.19	D	*ls*
			[383.66]	1740	262390	3	3	9.9	0.022	0.083	−1.18	D	*ls*
			[387.67]	4440	262390	5	3	0.65	8.8×10^{-4}	0.0056	−2.36	E	*ls*
2		$^3P-^3P^\circ$	*326.71*	*3047*	309130	9	9	62	0.099	0.96	−0.05	D	1
			[328.20]	4440	309130	5	5	46	0.074	0.40	−0.43	D	*ls*
			[325.32]	1740	309130	3	3	16	0.025	0.080	−1.12	E	*ls*
			[328.20]	4440	309130	5	3	25	0.024	0.13	−0.92	D−	*ls*
			[325.32]	1740	309130	3	1	65	0.034	0.11	−0.99	D−	*ls*
			[325.32]	1740	309130	3	5	15	0.040	0.13	−0.92	D−	*ls*
			[323.49]	0	309130	1	3	22	0.10	0.11	−1.00	D−	*ls*
3		$^3P-^3S^\circ$	*249.27*	*3047*	404220	9	3	350	0.11	0.81	0.00	D+	1
			[250.14]	4440	404220	5	3	190	0.11	0.45	−0.26	D+	*ls*
			[248.46]	1740	404220	3	3	120	0.11	0.27	−0.48	D+	*ls*
			[247.39]	0	404220	1	3	40	0.11	0.090	−0.96	D+	*ls*
4		$^1D-^1D^\circ$	[285.47]	[46690]	[396990]	5	5	170	0.21	1.0	0.02	D	1
5		$^1D-^1P^\circ$	[251.34]	[46690]	[444550]	5	3	230	0.13	0.53	−0.19	D	1
6		$^1S-^1P^\circ$	[287.04]	[96170]	[444550]	1	3	60	0.22	0.21	−0.66	D−	1
7	$2p3s-2p(^2P^\circ)3p$	$^3P^\circ-^3S$	*1252.5*	*1322337*	1402180	9	3	6.2	0.0485	1.80	−0.360	C	*ca*
			[1280.4]	1324080	1402180	5	3	3.22	0.0474	1.00	−0.63	C	*ls*
			[1223.5]	1320450	1402180	3	3	2.21	0.0497	0.60	−0.83	C	*ls*
			[1206.3]	1319280	1402180	1	3	0.77	0.050	0.200	−1.301	C	*ls*
8	$2p3p-2p(^2P^\circ)3d$	$^3S-^3P^\circ$	*1124.7*	1402180	*1491089*	3	9	4.65	0.265	2.94	−0.100	C	*ca*
			[1131.1]	1402180	1490590	3	5	4.56	0.146	1.63	−0.358	C	*ls*
			[1118.7]	1402180	1491570	3	3	4.73	0.089	0.98	−0.57	C	*ls*
			[1111.6]	1402180	1492140	3	1	4.82	0.0298	0.327	−1.049	C	*ls*

Al VIII

Forbidden Transitions

The adopted values represent, as in the case of Na VI, the work of Naqvi [1], Malville and Berger [2], and Froese [3]. For the selection of values, the same considerations as for Na VI are applied, the one exception being that Froese's magnetic dipole values are also used. Since the observed energy levels are uncertain, it is felt that the "spin-orbit" and "spin-spin and spin-other-orbit" integrals ζ and η calculated from her theoretical energy levels will be as accurate as the experimental ones.

References

[1] Naqvi, A. M., Thesis Harvard (1951).
[2] Malville, J. M., and Berger, R. A., Planetary and Space Science **13**, 1131 (1965).
[3] Froese, C., Astrophys. J. **145**, 932 (1966).

Al VIII. Forbidden Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	Type of Transition	A_{ki}(sec^{-1})	S(at.u.)	Accuracy	Source
1	$2p^2-2p^2$	$^3P-^3P$										
			[57456]	0	1740	1	3	m	0.0948	2.00	A	1, 3
			[22516]	0	4440	1	5	e	1.38×10^{-6}	0.0237	C	3
			[37027]	1740	4440	3	5	m	0.265	2.49	B	1, 3
			[37027]	1740	4440	3	5	e	2.55×10^{-7}	0.053	C	3
2		$^3P-^1D$										
			[2141.1]	0	[46690]	1	5	e	2.5×10^{-4}	3.4×10^{-5}	D	3
			[2224.0]	1740	[46690]	3	5	m	3.34	0.0068	C	1, 2, 3
			[2224.0]	1740	[46690]	3	5	e	8.6×10^{-4}	1.4×10^{-4}	D	3
			[2366.1]	4440	[46690]	5	5	m	8.3	0.0204	C	1, 2, 3
			[2366.1]	4440	[46690]	5	5	e	0.0044	9.8×10^{-4}	D	3
3		$^3P-^1S$										
			[1059.0]	1740	[96170]	3	1	m	92	0.00407	C	2, 3
			[1090.2]	4440	[96170]	5	1	e	0.088	8.1×10^{-5}	D	3
4		$^1D-^1S$										
			[2020.4]	[46690]	[96170]	5	1	e	4.79	0.096	C	3

Al IX

Ground State $1s^22s^22p\ ^2P^\circ_{1/2}$

Ionization Potential 330.1 eV = 2663340 cm^{-1}

Allowed Transitions

List of tabulated lines:

Wavelength [Å]	No.	Wavelength [Å]	No.	Wavelength [Å]	No.
60.896	11	305.10	2	397.24	7
61.069	11	308.01	6	397.61	7
61.078	11	308.23	6	433.97	9
66.621	10	316.86	4	434.42	9
66.839	10	318.56	4	439.68	9
280.15	3	321.11	4	440.14	9
282.52	3	384.59	5	603.21	8
284.04	3	384.85	5	614.29	8
286.48	3	385.03	1	614.97	8
300.62	2	392.42	1		

Values for the majority of the transitions are calculated from the nuclear charge-expansion method of Cohen and Dalgarno [1], which includes limited configuration mixing. Graphical comparisons with other data for the lower ions of this isoelectronic sequence indicate that the uncertainties should be within 50 percent.

For the $2p\ ^2P^\circ-3s\ ^2S$ and $2p\ ^2P^\circ-3d\ ^2D$ multiplets we have obtained data by exploiting the dependence of f-values on nuclear charge: In these cases accurate data for several other ions of the boron sequence are available from extended self-consistent field calculations by Weiss [2] in which configuration mixing is fully included. Utilizing those values, which are also supported by some experimental results on lower ions, we have obtained the f-values of the two transitions simply by graphical interpolation.

References

[1] Cohen, M., and Dalgarno, A., Proc. Roy. Soc. London **A280**, 258–270 (1964).
[2] Weiss, A. W., private communication (1967).

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
1	$2s^22p-2s2p^2$	$^2P^\circ-^2D$	*389.92*	*3260*	259720	6	10	21	0.079	0.61	−0.32	D	1
			[392.42]	4890	259720	4	6	21	0.072	0.37	−0.54	D	*ls*
			[385.03]	0	259720	2	4	18	0.079	0.20	−0.80	D	*ls*
			[392.42]	4890	259720	4	4	3.4	0.0079	0.041	−1.50	E	*ls*
2		$^2P^\circ-^2S$	*303.59*	*3260*	332650	6	2	87	0.040	0.24	−0.62	D+	1
			[305.10]	4890	332650	4	2	57	0.040	0.16	−0.80	D+	*ls*
			[300.62]	0	332650	2	2	30	0.040	0.080	−1.10	D+	*ls*
3		$^2P^\circ-^2P$	*283.53*	*3260*	*355953*	6	6	160	0.20	1.1	0.08	D+	1
			[284.04]	4890	356950	4	4	130	0.16	0.61	−0.19	D+	*ls*
			[282.52]	0	353960	2	2	110	0.13	0.24	−0.59	D+	*ls*
			[286.48]	4890	353960	4	2	52	0.032	0.12	−0.89	D	*ls*
			[280.45]	0	356950	2	4	28	0.065	0.12	−0.89	D	*ls*
4	$2s2p^2-2p^3$	$^4P-^4S^\circ$	*319.54*	[*148963*]	[461910]	12	4	150	0.077	0.97	−0.03	D+	1
			[321.11]	[150490]	[461910]	6	4	75	0.077	0.49	−0.34	D+	*ls*
			[318.56]	[148000]	[461910]	4	4	50	0.076	0.32	−0.52	D+	*ls*
			[316.86]	[146310]	[461910]	2	4	25	0.077	0.16	−0.81	D+	*ls*
5		$^2D-^2D^\circ$	*384.75*	259720	*519632*	10	10	43	0.095	1.2	−0.02	D+	1
			[384.85]	259720	519560	6	6	40	0.088	0.67	−0.28	D+	*ls*
			[384.59]	259720	519740	4	4	38	0.085	0.43	−0.47	D+	*ls*
			[384.59]	259720	519740	6	4	4.3	0.0063	0.048	−1.42	E	*ls*
			[384.85]	259720	519560	4	6	2.8	0.0095	0.048	−1.42	E	*ls*
6		$^2D-^2P^\circ$	*308.08*	259720	*584310*	10	6	70	0.060	0.61	−0.22	D	1
			[308.01]	259720	584390	6	4	64	0.061	0.37	−0.44	D	*ls*
			[308.23]	259720	584150	4	2	69	0.049	0.20	−0.71	D	*ls*
			[308.01]	259720	584390	4	4	7.1	0.010	0.041	−1.40	E	*ls*
7		$^2S-^2P^\circ$	*397.36*	332650	*584310*	2	6	13	0.095	0.25	−0.72	D	1
			[397.24]	332650	584390	2	4	14	0.063	0.17	−0.90	D	*ls*
			[397.61]	332650	584150	2	2	13	0.032	0.083	−1.19	D	*ls*
8		$^2P-^2D^\circ$	*610.95*	*355953*	*519632*	6	10	11	0.099	1.2	−0.23	D	1
			[614.97]	356950	519560	4	6	10	0.089	0.72	−0.45	D	*ls*
			[603.21]	353960	519740	2	4	9.2	0.10	0.40	−0.70	D	*ls*
			[614.29]	356950	519740	4	4	1.7	0.0099	0.080	−1.40	E	*ls*
9		$^2P-^2P^\circ$	*437.91*	*355953*	*584310*	6	6	44	0.13	1.1	−0.11	D	1
			[439.68]	356950	584390	4	4	36	0.11	0.61	−0.36	D	*ls*
			[434.42]	353960	584150	2	2	30	0.084	0.24	−0.77	D	*ls*
			[440.14]	356950	584150	4	2	14	0.021	0.12	−1.08	D−	*ls*
			[433.97]	353960	584390	2	4	7.4	0.042	0.12	−1.08	D−	*ls*
10	$2p-(^1S)3s$	$^2P^\circ-^2S$	*66.766*	*3260*	1501020	6	2	1000	0.023	0.030	−0.86	C	interp
			[66.839]	4890	1501020	4	2	680	0.023	0.020	−1.04	C	*ls*
			[66.621]	0	1501020	2	2	340	0.023	0.010	−1.34	C	*ls*
11	$2p-(^1S)3d$	$^2P^\circ-^2D$	*61.012*	*3260*	*1642284*	6	10	6700	0.62	0.75	0.57	C	interp
			[61.069]	4890	1642380	4	6	6700	0.56	0.45	0.35	C	*ls*
			[60.896]	0	1642140	2	4	5600	0.62	0.25	0.09	C	*ls*
			[61.078]	4890	1642140	4	4	1100	0.062	0.050	−0.61	D	*ls*

Al IX.

Forbidden Transitions

The line strength for the one transition in the ground state configuration is a straight number, tabulated for example by Naqvi [1]. The transition probability should also be quite accurate, since the energy level difference is accurately known.

Reference

[1] Naqvi, A. M., Thesis Harvard (1951).

Al IX. Forbidden Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	Type of Transition	A_{ki}(sec^{-1})	S(at.u.)	Accuracy	Source
1	$2p-(^1S)2p$	$^2P^\circ-^2P^\circ$	[20444]	0	4890	2	4	m	1.05	1.33	A	1

Al X

Ground State $1s^2 2s^2\ ^1S_0$

Ionization Potential 398.5 eV = 3215340 cm^{-1}

Allowed Transitions

Garstang and Shamey [1] have obtained the f-value for the intercombination line $2^1S_0-2^3P_1$ by calculating the ratio of this line against the resonance transition in the intermediate coupling approximation and by using for the resonance line a value calculated according to Cohen and Dalgarno's method [2]. The data calculated from the charge-expansion method of Cohen and Dalgarno, [2] which includes limited configuration mixing, are estimated to be usually accurate to 50 percent or better, while the charge-expansion method of Naqvi and Victor [3] should be less reliable when the effects of configuration interaction are strong, since these are neglected entirely. In assigning the accuracy estimates for these methods as well as for the Coulomb approximation we were to a great extent guided by studying the degree of fit of the data into the systematic trends along isoelectronic sequences.

References

[1] Garstang, R. H., and Shamey, L. J., Astrophys. J. **148**, 665–666 (1967).
[2] Cohen, M., and Dalgarno, A., Proc. Roy. Soc. London **A280**, 258–270 (1964).
[3] Naqvi, A. M., and Victor, G. A., Technical Documentary Report No. RTD TDR-63-3118 (1964).

Al X. Allowed Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
1	$2s^2-2s(^2S)2p$	$^1S-^3P^\circ$											
			[638.81]	0	[156540]	1	3	0.0026	4.7×10^{-5}	9.6×10^{-5}	−4.33	D	1*n*
2		$^1S-^1P^\circ$	[332.89]	0	300400	1	3	57	0.287	0.314	−0.54	C	2
3	$2s2p-2p^2$	$^3P^\circ-^3P$	*400.90*	[*158386*]	[*407823*]	9	9	49	0.12	1.4	0.03	D+	2
			[401.19]	[160200]	[409460]	5	5	36	0.089	0.58	−0.35	D+	*ls*
			[400.43]	[156540]	[406270]	3	3	13	0.030	0.12	−1.05	D−	*ls*
			[406.39]	[160200]	[406270]	5	3	19	0.028	0.19	−0.85	D−	*ls*
			[403.62]	[156540]	[404300]	3	1	49	0.040	0.16	−0.92	D−	*ls*
			[395.38]	[156540]	[409460]	3	5	12	0.049	0.19	−0.83	D−	*ls*
			[397.74]	[154850]	[406270]	1	3	17	0.12	0.16	−0.92	D−	*ls*
4		$^1P^\circ-^1D$	[673.67]	300400	448840	3	5	10	0.12	0.77	−0.44	D−	2
5		$^1P^\circ-^1S$	[395.46]	300400	553270	3	1	95	0.074	0.29	−0.65	E	2
6	$2s^2-2s(^2S)3p$	$^1S-^1P^\circ$	[51.979]	0	1923850	1	3	4800	0.58	0.10	−0.24	E	3
7	$2s2p-2s(^2S)3s$	$^1P^\circ-^1S$	[63.134]	300400	1884330	3	1	380	0.0075	0.0047	−1.65	E	3
8	$2s3s-2s(^2S)3p$	$^1S-^1P^\circ$	[2529.6]	1884330	1923850	1	3	0.60	0.174	1.45	−0.76	C	3
9	$2p3s-2p(^2P^\circ)3p$	$^1P^\circ-^1P$	[26659]	2090980	2094730	3	3	5.0×10^{-4}	0.0054	1.41	−1.79	C	*ca*
10		$^1P^\circ-^1D$	[1744.0]	2090980	2148320	3	5	1.93	0.147	2.53	−0.356	C	*ca*
11	$2s3p-2s(^2S)3d$	$^1P^\circ-^1D$	[1462.0]	1923850	1992250	3	5	2.68	0.143	2.07	−0.368	C	*ca*
12	$2p3p-2p(^2P^\circ)3d$	$^1P-^1D^\circ$	[2175.1]	2094730	2140690	3	5	0.56	0.067	1.43	−0.70	C	*ca*
13		$^1D-^1F^\circ$	[2285.5]	2148320	2192060	5	7	0.72	0.079	2.96	−0.403	C	*ca*

Al X
Forbidden Transitions

Naqvi's calculations [1] are the only available source. The results for the $^3P^\circ-^3P^\circ$ transitions are essentially independent of the choice of the interaction parameters. For the $^3P^\circ-^1P^\circ$ transitions, Naqvi uses empirical term intervals, i.e., the effects of configuration interaction should be partially included.

Reference

[1] Naqvi, A. M., Thesis Harvard (1951).

Al X. Forbidden Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	Type of Transition	A_{ki}(sec^{-1})	S(at.u.)	Accuracy	Source
1	$2s2p-2s(^2S)2p$	$^3P^\circ-^3P^\circ$										
			[59156]	[154850]	[156540]	1	3	*m*	0.0869	2.00	A	1
			[27315]	[156540]	[160200]	3	5	*m*	0.662	2.50	A	1
2		$^3P^\circ-^1P^\circ$										
			[687.05]	[154850]	300400	1	3	*m*	17.5	6.3×10^{-4}	C	1
			[695.12]	[156540]	300400	3	3	*m*	710	0.0266	C	1
			[713.27]	[160200]	300400	5	3	*m*	19.6	7.9×10^{-4}	C	1

Al XI

Ground State $1s^2 2s\ ^2S_{1/2}$

Ionization Potential 441.9 eV = 3564900 cm^{-1}

Allowed Transitions

For the transition $2s-2p$, the charge-expansion calculation of Cohen and Dalgarno [1] is chosen. An uncertainty of less than 10 percent is indicated from the graphical comparison of this value with the other material for the same transition within the isoelectronic sequence. Data for the other listed transitions have been obtained from the Coulomb approximation. Plots of the dependence of the f-value on nuclear charge for all these transitions have been made and show that this material connects up very smoothly with the data for the lower ions as well as with the hydrogenic value for infinite nuclear charge. Based on this impressive agreement, accuracies of 10 percent (or 25 percent for some of the smaller values) are indicated.

Reference

[1] Cohen, M., and Dalgarno, A., Proc. Roy. Soc. London **A280**, 258–270 (1964).

Al XI. Allowed Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
1	$2s-2p$	$^2S-^2P^\circ$	*556.03*	0	*179847*	2	6	8.35	0.116	0.425	−0.634	B	1
			[549.99]	0	181820	2	4	8.62	0.0782	0.283	−0.806	B	*ls*
			[568.50]	0	175900	2	2	7.83	0.0379	0.142	−1.120	B	*ls*
2	$2s-3p$	$^2S-^2P^\circ$	*48.311*	0	*2069937*	2	6	3140	0.330	0.105	−0.180	B	*ca*
			[48.297]	0	2070520	2	4	3150	0.220	0.0700	−0.357	B	*ls*
			[48.338]	0	2068770	2	2	3140	0.110	0.0350	−0.658	B	*ls*
3	$2p-3s$	$^2P^\circ-^2S$	*54.330*	*179847*	2020460	6	2	1460	0.0215	0.0231	−0.889	B	*ca*
			[54.388]	181820	2020460	4	2	970	0.0215	0.0154	−1.066	B	*ls*
			[54.213]	175900	2020460	2	2	490	0.0216	0.00770	−1.365	B	*ls*
4	$2p-3d$	$^2P^\circ-^2D$	*52.398*	*179847*	*2088316*	6	10	9800	0.672	0.696	0.606	B	*ca*
			[52.446]	181820	2088540	4	6	9780	0.605	0.418	0.384	B	*ls*
			[52.299]	175900	2087980	2	4	8210	0.674	0.232	0.130	B	*ls*
			[52.461]	181820	2087980	4	4	1630	0.0672	0.0464	−0.571	B	*ls*
5	$2p-4d$	$^2P^\circ-^2D$	[39.150]	*179847*	2734140	6	10	3210	0.123	0.095	−0.132	C+	*ca*
6	$3s-3p$	$^2S-^2P^\circ$	*2020.5*	2020460	*2069937*	2	6	1.06	0.194	2.58	−0.410	B	*ca*
			[1997.6]	2020460	2070520	2	4	1.09	0.131	1.72	−0.582	B	*ls*
			[2069.3]	2020460	2068770	2	2	0.983	0.0631	0.860	−0.900	B	*ls*
7	$3p-3d$	$^2P^\circ-^2D$	*5439.5*	*2069937*	*2088316*	6	10	0.0424	0.0314	3.37	−0.725	B	*ca*
			[5547.9]	2070520	2088540	4	6	0.0399	0.0276	2.02	−0.957	B	*ls*
			[5204.2]	2068770	2087980	2	4	0.0402	0.0327	1.12	−1.184	B	*ls*
			[5725.8]	2070520	2087980	4	4	0.00607	0.00298	0.225	−1.924	B	*ls*
8	$3p-4d$	$^2P^\circ-^2D$	[150.56]	*2069937*	2734140	6	10	1020	0.58	1.72	0.54	C+	*ca*

Al XII

Ground State $1s^2\ ^1S_0$

Ionization Potential 2085.46 eV = 16825000 cm^{-1}

Allowed Transitions

The values for this ion are calculated from the charge-expansion method of Dalgarno and Parkinson [1]. From comparisons with the more refined variational calculations by Weiss [2] for lower members of this isoelectronic sequence, uncertainties are estimated not to exceed 10 percent. It should be pointed out that essentially identical results are obtained by extrapolating the data of Weiss towards the high members of the isoelectronic sequence (see fig. I [2]).

References

[1] Dalgarno, A., and Parkinson, E. M., Proc. Roy. Soc. London **A301**, 253–260 (1967).
[2] Weiss, A. W., J. Research Nat. Bur. Standards **71A**, 163–168 (1967).

Al XII. Allowed Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
1	$1s^2-1s2p$	$^1S-^1P^\circ$	[7.7568]	0	12891900	1	3	2.78×10^5	0.752	0.0192	−0.124	B	1
2	$1s^2-1s3p$	$^1S-^1P^\circ$	[6.6345]	0	15072700	1	3	7.72×10^4	0.153	0.00334	−0.815	B	1
3	$1s^2-1s4p$	$^1S-^1P^\circ$	[6.3137]	0	15838600	1	3	3.19×10^4	0.0573	0.00119	−1.242	B	1

SILICON

Si I

Ground State $1s^22s^22p^63s^23p^2\,{}^3P_0$

Ionization Potential 8.151 eV = 65747.5 cm^{-1}

Allowed Transitions

List of tabulated lines:

Wavelength [Å]	No.	Wavelength [Å]	No.	Wavelength [Å]	No.
2207.98	2	4947.61	25	7970.31	31
2210.89	2	5006.06	24	8035.62	31
2211.74	2	5597.94	17	8074.57	31
2216.67	2	5622.22	17	8093.24	32
2218.06	2	5645.61	61	8680.08	27
2218.92	2	5665.55	16	9413.51	14
2438.77	4	5684.48	17	10288.9	11
2443.36	4	5690.43	16	10371.3	11
2452.12	4	5701.11	16	10585.1	11
2506.90	3	5708.40	16	10603.4	10
2514.32	3	5754.22	16	10661.0	10
2516.11	3	5772.15	20	10689.7	28
2519.20	3	5780.38	15	10694.3	28
2524.11	3	5793.07	15	10727.4	28
2528.51	3	5797.86	15	10749.4	10
2881.58	6	5806.28	15	10784.6	28
2970.36	5	5859.20	15	10786.9	10
2987.65	5	5872.71	15	10827.1	10
3006.74	1	5948.55	19	10843.9	26
3020.00	1	6331.95	18	10869.5	13
3905.52	8	6518.73	35	10882.8	28
4102.94	7	6553.9	35	10976.3	28
4721.57	23	6555.46	35	10979.3	10
4738.83	23	6560.56	35	11984.2	9
4747.99	22	6624.2	35	11991.6	9
4755.28	22	6631.05	35	12031.5	9
4772.79	22	6721.85	33	12103.5	9
4782.99	23	6976.52	34	12270.7	9
4792.21	22	7003.57	34	12395.8	9
4792.32	22	7005.88	34	15361.2	29
4805.44	21	7016.74	34	15557.8	29
4817.59	22	7083.95	34	15884.4	29
4818.06	21	7097.47	34	15888.4	12
4821.17	21	7680.27	30	15960.0	29
4823.31	21	7918.39	31	16060.0	29
4866.88	21	7932.35	31	16094.8	29
4869.07	21	7944.00	31		

The results of the intermediate coupling calculations by Garstang and Dawe [1] for two intercombination lines in the $3s^23p^2-3s3p^3$ array should be quite uncertain, since these authors have normalized their values by means of a transition integral averaged from the Coulomb approximation and Varsavsky's [6] screening approximation, which do not contain the important configuration interaction effects. The lifetime measurements of Savage and Lawrence [2, 3] with the phase shift technique provide an accurate absolute scale for several other transitions. The

intermediate coupling calculations of Lawrence [3] and the results of the anomalous dispersion experiment of Slavenas [4] have been normalized to this scale. The two normalized sets of data agree within a few percent. Finally, numerical values are available for two lines from the wall-stabilized arc experiment of Hey [5]; but the uncertainties are hardly smaller than 50 percent because of the occurrence of demixing effects in this type of arc, which were not taken into account.

Since the above-listed sources provide data for only nine multiplets, the Coulomb approximation has been extensively applied to this spectrum in order to have many prominent lines represented. On the basis of the comparison material available for analogous transitions of neighboring atoms and on the basis of the general success of the Coulomb approximation, accuracy assignments of 50 percent are normally indicated for the selected lines. But, in as much as these comparisons are quite insufficient, the present assignments can only be regarded as provisional, especially since deviations from *LS*-coupling may be expected for the individual lines, too.

References

[1] Garstang, R. H., and Dawe, J. A., The Observatory **82**, 210–211 (1962).
[2] Savage, B. D. and Lawrence, G. M., Astrophys. J. **146**, 940–943 (1966).
[3] Lawrence, G. M., Astrophys. J. **148**, 261–268 (1967).
[4] Slavenas, I. Yu. Yu., Optics and Spectroscopy (U.S.S.R.) **16**, 214–216 (1964).
[5] Hey, P., Z. Physik **157**, 79–88 (1959).
[6] Varsavsky, C. M., Astrophys. J. Suppl. Ser. **6**, #53, 75 (1961).

Si I. Allowed Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
1	$3s^23p^2-3s3p^3$	$^3P-^5S^\circ$ (0.01)											
			3020.00	223	33326	5	5	3.3×10^{-5}	4.5×10^{-6}	2.2×10^{-4}	−4.65	E	1
			3006.74	77	33326	3	5	1.1×10^{-5}	2.5×10^{-6}	7.4×10^{-5}	−5.12	E	1
2		$^3P-^3D^\circ$ (UV 3)	*2214.7*	*150*	*45303*	9	15	0.55	0.068	4.46	−0.213	C	2
			2216.67	223	45322	5	7	0.55	0.057	2.08	−0.55	C	*ls*
			2210.89	77	45294	3	5	0.416	0.051	1.11	−0.82	C	*ls*
			2207.98	0	45276	1	3	0.311	0.068	0.496	−1.167	C	*ls*
			2218.06	223	45294	5	5	0.138	0.0102	0.372	−1.292	C	*ls*
			2211.74	77	45276	3	3	0.232	0.0170	0.372	−1.292	C	*ls*
			2218.92	223	45276	5	3	0.015	6.8×10^{-4}	0.025	−2.47	E	*ls*
3	$3p^2-3p(^2P^\circ)4s$	$^3P-^3P^\circ$ (UV 1)	*2518.3*	*150*	*39860*	9	9	1.64	0.155	11.6	0.145	C+	3, 4*n*
			2516.11	223	39955	5	5	1.21	0.115	4.76	−0.240	C+	3, 4*n*
			2519.20	77	39760	3	3	0.422	0.0402	1.00	−0.92	C+	3, 4*n*
			2528.51	223	39760	5	3	0.69	0.0394	1.64	−0.71	C+	3, 4*n*
			2524.11	77	39683	3	1	1.66	0.053	1.32	−0.80	C+	3, 4*n*
			2506.90	77	39955	3	5	0.417	0.065	1.62	−0.71	C+	3, 4*n*
			2514.32	0	39760	1	3	0.55	0.157	1.30	−0.80	C+	3, 4*n*
4		$^3P-^1P^\circ$ (UV 2)											
			2452.12	223	40992	5	3	0.0060	3.2×10^{-4}	0.013	−2.80	D−	3
			2443.36	77	40992	3	3	0.0069	6.2×10^{-4}	0.015	−2.73	D−	3
			2438.77	0	40992	1	3	0.0074	0.0020	0.016	−2.70	D−	3
5		$^1D-^3P^\circ$ (1)											
			2970.36	6299	39955	5	5	2.3×10^{-4}	3.1×10^{-4}	0.0015	−3.81	D	3
			2987.65	6299	39760	5	3	0.022	0.0018	0.088	−2.05	D	3
6		$^1D-^1P^\circ$ (UV 43)	2881.58	6299	40992	5	3	1.75	0.131	6.2	−0.184	C	3, 4*n*
7		$^1S-^3P^\circ$ (2)	4102.94	15394	39760	1	3	0.0016	0.0012	0.017	−2.91	D	3, 5

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
8		$^1S-^1P^\circ$ (3)	3905.52	15394	40992	1	3	0.145	0.100	1.28	−1.000	C	3
9	$3p4s-3p(^2P^\circ)4p$	$^3P^\circ-^3D$ (4)	*12047*	*39860*	*48161*	9	15	0.17	0.61	220	0.74	D	*ca*
			12031.5	39955	48264	5	7	0.17	0.52	100	0.41	D	*ls*
			11984.2	39760	48102	3	5	0.13	0.46	54	0.14	D	*ls*
			11991.6	39683	48020	1	3	0.094	0.61	24	−0.21	D	*ls*
			12270.7	39955	48102	5	5	0.040	0.091	18	−0.34	D	*ls*
			12103.5	39760	48020	3	3	0.068	0.15	18	−0.35	D	*ls*
			12395.8	39955	48020	5	3	0.0043	0.0060	1.2	−1.52	E	*ls*
10		$^3P^\circ-^3P$ (5)	*10790*	*39860*	*49128*	9	9	0.22	0.39	130	0.55	D	*ca*
			10827.1	39955	49189	5	5	0.17	0.29	52	0.16	D	*ls*
			10749.4	39760	49061	3	3	0.056	0.097	10	−0.54	D−	*ls*
			10979.3	39955	49061	5	3	0.089	0.097	18	−0.31	D−	*ls*
			10786.9	39760	49028	3	1	0.22	0.13	14	−0.41	D−	*ls*
			10603.4	39760	49189	3	5	0.057	0.16	17	−0.32	D−	*ls*
			10661.0	39683	49061	1	3	0.076	0.39	14	−0.41	D−	*ls*
11		$^3P^\circ-^3S$ (6)	*10482*	*39860*	49400	9	3	0.24	0.13	40	0.07	D	*ca*
			10585.1	39955	49400	5	3	0.13	0.13	23	−0.19	D	*ls*
			10371.3	39760	49400	3	3	0.081	0.13	13	−0.41	D	*ls*
			10288.9	39683	49400	1	3	0.027	0.13	4.4	−0.89	D	*ls*
12		$^1P^\circ-^1P$ (11.12)	15888.4	40992	47284	3	3	0.081	0.31	48	−0.03	D	*ca*
13		$^1P^\circ-^1D$ (13)	10869.5	40992	50189	3	5	0.23	0.67	72	0.30	D	*ca*
14		$^1P^\circ-^1S$ (14)	9413.51	40992	51612	3	1	0.27	0.12	11	−0.44	D	*ca*
15	$3p4s-3p(^2P^\circ)5p$	$^3P^\circ-^3D$ (9)	*5800.9*	*39860*	*57094*	9	15	0.017	0.015	2.5	−0.87	D	*ca*
			5797.86	39955	57198	5	7	0.018	0.013	1.2	−1.19	D	*ls*
			5793.07	39760	57017	3	5	0.013	0.011	0.62	−1.48	D	*ls*
			5780.38	39683	56978	1	3	0.0098	0.015	0.28	−1.82	D	*ls*
			5859.20	39955	57017	5	5	0.0042	0.0022	0.21	−1.96	E	*ls*
			5806.28	39760	56978	3	3	0.0072	0.0037	0.21	−1.95	E	*ls*
			5872.71	39955	56978	5	3	4.7×10^{-4}	1.4×10^{-4}	0.014	−3.15	E	*ls*
16		$^3P^\circ-^3P$ (10)	*5698.7*	*39860*	*57403*	9	9	0.038	0.018	3.1	−0.79	D	*ca*
			5708.40	39955	57468	5	5	0.028	0.014	1.3	−1.15	D	*ls*
			5690.43	39760	57329	3	3	0.0095	0.0046	0.26	−1.86	D−	*ls*
			5754.22	39955	57329	5	3	0.015	0.0045	0.43	−1.65	D−	*ls*
			5701.11	39760	57296	3	1	0.037	0.0060	0.34	−1.74	D−	*ls*
			5645.61	39760	57468	3	5	0.0097	0.0077	0.43	−1.64	D−	*ls*
			5665.55	39683	57329	1	3	0.013	0.018	0.34	−1.74	D−	*ls*
17		$^3P^\circ-^3S$ (11)	*5653.9*	*39860*	*57542*	9	3	0.049	0.0078	1.3	−1.15	D	*ca*
			5684.48	39955	57542	5	3	0.026	0.0077	0.72	−1.41	D	*ls*
			5622.22	39760	57542	3	3	0.016	0.0077	0.43	−1.64	D	*ls*
			5597.94	39683	57542	1	3	0.0054	0.0076	0.14	−2.12	D	*ls*
18		$^1P^\circ-^1P$ (14.01)	6331.95	40992	56780	3	3	1.0×10^{-4}	6.1×10^{-5}	0.0038	−3.74	E	*ca*
19		$^1P^\circ-^1D$ (16)	5948.55	40992	57798	3	5	0.022	0.019	1.1	−1.24	D	*5*
20		$^1P^\circ-^1S$ (17)	5772.15	40992	58312	3	1	0.081	0.014	0.77	−1.38	D	*ca*

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
21	$3p4s-3p(^2P^\circ)6p$	$^3P^\circ-^3D$ (11.04)	*4822.1*	*39860*	*60592*	9	15	0.011	0.0062	0.89	−1.25	D	*ca*
			4818.06	39955	60705	5	7	0.011	0.0053	0.42	−1.58	D	*ls*
			4821.17	39760	60496	3	5	0.0080	0.0046	0.22	−1.86	D	*ls*
			4805.44	39683	60487	1	3	0.0060	0.0063	0.099	−2.20	D	*ls*
			4866.88	39955	60496	5	5	0.0026	9.2×10^{-4}	0.074	−2.34	E	*ls*
			4823.31	39760	60487	3	3	0.0045	0.0016	0.074	−2.32	E	*ls*
			4869.07	39955	60487	5	3	2.9×10^{-4}	6.1×10^{-5}	0.0049	−3.52	E	*ls*
22		$^3P^\circ-^3P$ (11.05)	*4783.8*	*39860*	*60758*	9	9	0.023	0.0078	1.1	−1.15	D	*ca*
			4792.32	39955	60816	5	5	0.017	0.0058	0.46	−1.54	D	*ls*
			4772.79	39760	60707	3	3	0.0057	0.0020	0.092	−2.22	D−	*ls*
			4817.59	39955	60707	5	3	0.0091	0.0019	0.15	−2.02	D−	*ls*
			4792.21	39760	60622	3	1	0.022	0.0025	0.12	−2.12	D−	*ls*
			4747.99	39760	60816	3	5	0.0057	0.0032	0.15	−2.02	D−	*ls*
			4755.28	39683	60707	1	3	0.0075	0.0077	0.12	−2.11	D−	*ls*
23		$^3P^\circ-^3S$ (11.06)	*4761.3*	*39860*	60857	9	3	0.030	0.0034	0.48	−1.51	D	*ca*
			4782.99	39955	60857	5	3	0.017	0.0034	0.27	−1.77	D	*ls*
			4738.83	39760	60857	3	3	0.010	0.0034	0.16	−1.99	D	*ls*
			4721.57	39683	60857	1	3	0.0034	0.0034	0.053	−2.47	D	*ls*
24		$^1P^\circ-^1D$ (17.08)	5006.06	40992	60962	3	5	0.028	0.018	0.88	−1.27	D	*ca*
25		$^1P^\circ-^1S$ (17.09)	4947.61	40992	61198	3	1	0.042	0.0051	0.25	−1.82	D	*ca*
26	$3p4p-3p(^2P^\circ)4d$	$^1P-^1D^\circ$ (31)	10843.9	47284	56503	3	5	0.16	0.48	51	0.16	D	*ca*
27		$^1P-^1P^\circ$ (32.02)	8680.08	47284	58802	3	3	1.9×10^{-4}	2.1×10^{-4}	0.018	−3.20	E	*ca*
28		$^3D-^3F^\circ$ (53)	*10720*	*48161*	*57489*	15	21	0.13	0.32	170	0.68	D	*ca*
			10727.4	48264	57584	7	9	0.12	0.26	64	0.26	D	*ls*
			10694.3	48102	57451	5	7	0.12	0.28	49	0.15	D	*ls*
			10689.7	48020	57372	3	5	0.12	0.33	35	0.00	D	*ls*
			10882.8	48264	57451	7	7	0.015	0.026	6.5	−0.74	E	*ls*
			10784.6	48102	57372	5	5	0.022	0.038	6.7	−0.72	E	*ls*
			10976.3	48264	57372	7	5	5.5×10^{-4}	7.1×10^{-4}	0.18	−2.30	E	*ls*
29	$3p4p-3p(^2P^\circ)5s$	$^3D-^3P^\circ$ (42.21)	*15960*	*48161*	*54425*	15	9	0.083	0.19	150	0.45	D	*ca*
			15960.0	48264	54528	7	5	0.070	0.19	70	0.12	D	*ls*
			16094.8	48102	54314	5	3	0.060	0.14	37	−0.15	D	*ls*
			16060.0	48020	54245	3	1	0.083	0.11	17	−0.48	D	*ls*
			15557.8	48102	54528	5	5	0.013	0.047	12	−0.63	D	*ls*
			15884.4	48020	54314	3	3	0.020	0.076	12	−0.64	D	*ls*
			15361.2	48020	54528	3	5	9.3×10^{-4}	0.0055	0.83	−1.78	E	*ls*
30	$3p4p-3p(^2P^\circ)5d$	$^1P-^1D^\circ$ (36)	7680.27	47284	60301	3	5	0.062	0.092	7.0	−0.56	D	*ca*
31		$^3D-^3F^\circ$ (57)	*7941.6*	*48161*	*60753*	15	21	0.063	0.083	33	0.10	D	*ca*
			7944.00	48264	60849	7	9	0.049	0.059	11	−0.38	D	*ls*
			7932.35	48102	60705	5	7	0.054	0.071	9.3	−0.45	D	*ls*
			7918.39	48020	60645	3	5	0.054	0.085	6.6	−0.59	D	*ls*
			8035.62	48264	60705	7	7	0.0067	0.0065	1.2	−1.34	E	*ls*
			7970.31	48102	60645	5	5	0.010	0.0096	1.3	−1.32	E	*ls*
			8074.57	48264	60645	7	5	2.7×10^{-4}	1.9×10^{-4}	0.035	−2.88	E	*ls*
32	$3p4p-3p(^2P^\circ)6s$	$^1P-^1P^\circ$ (34)	8093.24	47284	59637	3	3	0.015	0.015	1.2	−1.35	D	*ca*

Si I. Allowed Transitions—*Continued*

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
33	$3p4p-3p(^2P^\circ)6d$	$^1P-^1D^\circ$ (38)	6721.85	47284	62157	3	5	0.034	0.038	2.5	−0.94	D	*ca*
34		$^3D-^3F^\circ$ (60)	*7004.3*	*48161*	*62438*	15	21	0.027	0.028	9.7	−0.38	D	*ca*
			7005.88	48264	62534	7	9	0.027	0.026	4.2	−0.74	D	*ls*
			7003.57	48102	62377	5	7	0.024	0.025	2.9	−0.90	D	*ls*
			6976.52	48020	62350	3	5	0.023	0.028	1.9	−1.08	D	*ls*
			7083.95	48264	62377	7	7	0.0029	0.0022	0.36	−1.81	D−	*ls*
			7016.74	48102	62350	5	5	0.0042	0.0031	0.36	−1.81	D−	*ls*
			7097.47	48264	62350	7	5	1.1×10^{-4}	6.1×10^{-5}	0.010	−3.37	E	*ls*
35	$3p4p-3p(^2P^\circ)7d$	$^3D-^3F^\circ$ (60.06)	*6552.1*	*48161*	*63419*	15	21	0.0069	0.0062	2.0	−1.03	D−	*ca*
			6555.46	48264	63515	7	9	0.0069	0.0057	0.86	−1.40	D−	*ls*
			6560.56	48102	63341	5	7	0.0060	0.0055	0.59	−1.56	D−	*ls*
			6518.73	48020	63356	3	5	0.0059	0.0062	0.40	−1.73	D−	*ls*
			6631.05	48264	63341	7	7	7.3×10^{-4}	4.8×10^{-4}	0.074	−2.47	E	*ls*
			[6553.9]	48102	63356	5	5	0.0011	6.9×10^{-4}	0.074	−2.46	E	*ls*
			[6624.2]	48264	63356	7	5	2.9×10^{-5}	1.4×10^{-5}	0.0021	−4.01	E	*ls*

Si I

Forbidden Transitions

The sources adopted for this ion are Naqvi [1], and Malville and Berger [2]. Malville and Berger have utilized "spin-orbit" and "spin-spin and spin-other-orbit" integrals by Garstang (Monthly Notices Roy. Astron. Soc. **111**, 115 (1951)). Naqvi's and Malville and Berger's magnetic dipole transitions have generally been averaged since their methods are very similar. But for the $^3P-^1S$ transition, where configuration interaction is important, Malville and Berger's value, which is obtained empirically, has been preferred over that of Naqvi which is based purely on theory (see also General Introduction). For the electric quadrupole moment s_q we have always employed Malville and Berger's results.

References

[1] Naqvi, A. M., Thesis Harvard (1951).
[2] Malville, J. M. and Berger, R. A., Planetary and Space Science **13**, 1131–1136 (1965).

Si I. Forbidden Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	Type of Transition	A_{ki}(sec^{-1})	S(at.u.)	Accuracy	Source
1	$3p^2-3p^2$	$^3P-^3P$										
			[12.964×10^5]	0.000	77.115	1	3	*m*	8.25×10^{-6}	2.00	A	1
			[44.799×10^4]	0.000	223.157	1	5	*e*	3.56×10^{-10}	19.1	C−	2
			[68.455×10^4]	77.115	223.157	3	5	*m*	4.20×10^{-5}	2.50	A	1
			[68.455×10^4]	77.115	223.157	3	5	*e*	9.7×10^{-11}	43.3	C−	1, 2
2		$^3P-^1D$ (0.01F)										
			15871.6	0.00	6298.85	1	5	*e*	6.2×10^{-7}	0.0019	D−	2
			16068.3	77.115	6298.85	3	5	*m*	9.7×10^{-4}	7.5×10^{-4}	C	1, 2
			16068.3	77.115	6298.85	3	5	*e*	4.0×10^{-6}	0.013	D−	1, 2
			16454.5	223.157	6298.85	5	5	*m*	0.00271	0.00224	C	1, 2
			16454.5	223.157	6298.85	5	5	*e*	2.5×10^{-5}	0.091	D−	1, 2

308-022 O-69—8

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	Type of Transition	A_{ki}(sec^{-1})	S(at.u.)	Accuracy	Source
3		^{3}P—^{1}S (1F)										
			6526.78	77.115	15394.4	3	1	*m*	0.0355	3.66×10^{-4}	C—	2
			6589.61	223.157	15394.4	5	1	*e*	0.0011	0.0084	D—	2
4		^{1}D—^{1}S (2F)	10991.4	6298.85	15394.4	5	1	*e*	0.80	76	D—	2

Si II

Ground State $1s^22s\,^22p^63s\,^23p\,^2P^\circ_{1/2}$

Ionization Potential 16.35 eV = 131838.4 cm^{-1}

Allowed Transitions

List of tabulated lines:

Wavelength [Å]	No.	Wavelength [Å]	No.	Wavelength [Å]	No.
989.867	8	2072.7	13	4128.07	15
992.675	8	2072.70	13	4130.89	15
992.69	8	2328.51	1	4130.9	15
1020.70	9	2334.40	1	4621.5	26
1023.69	9	2334.61	1	4896.8	31
1190.42	4	2344.20	1	4902.65	31
1193.28	4	2350.17	1	5041.03	19
1194.50	4	2500.93	17	5055.98	19
1197.39	4	2501.97	17	5056.31	19
1246.74	5	2502.0	17	5113.17	14
1248.43	5	2608.90	10	5466.6	25
1251.16	5	2612.99	10	5568.36	30
1260.42	6	2620.89	10	5575.97	30
1264.73	6	2722.25	23	5957.56	20
1265.02	6	2726.70	23	5978.93	20
1304.37	3	2904.28	16	6347.10	18
1309.27	3	2905.69	16	6371.36	18
1526.72	7	2905.7	16	6679.65	27
1533.45	7	3203.87	21	6818.45	28
1649.52	11	3210.0	21	6829.8	28
1654.30	11	3210.03	21	6829.82	28
1654.31	11	3333.14	22	7113.45	29
1808.00	2	3339.82	22	7125.84	29
1816.92	2	3853.66	12	7848.80	24
1817.45	2	3856.02	12	7849.7	24
2072.02	13	3862.60	12	7849.72	24

Aside from the Coulomb approximation, four theoretical sources have been selected which all employ the same basic principles, but with different degrees of refinement. Weiss' [2] calculations must be considered the most comprehensive ones since he has used the "superposition-of-configurations" approach with a large number of interacting configurations and Hartree-Fock wavefunctions as a starting point. Values have been calculated in both the dipole length and dipole velocity approximations; the length values are chosen in all cases as being probably the more reliable [2]. Garstang and Shamey [1], as well as Froese-Fischer [6], have carried out their calculations by including limited configuration interaction and using Hartree-Fock functions as a starting point. Garstang and Shamey [1] have also taken into account intermediate coupling. Froese's [5] results for the $3d-5f$ and $3d-6f$ transitions are based on self-consistent field calculations: however, her values are modified to account for configuration interaction with the $3s3p^2\ {}^2D$ term by multiplying them by the square of the mixing coefficient as given in Froese and Underhill [7]. Weiss' values have always been chosen where available in preference to the other calculations.

Two experimental papers by Savage and Lawrence [3] and Hey [4] have also been utilized. Savage and Lawrence [3] have carried out lifetime determinations of several states by means of the phase shift technique. Of their numbers we have used only the value for the $4s$ state, which is within a few percent of the theoretical result obtained by Weiss. Their measured lifetime of the $4f$ level is within 20 percent of the sum of the adopted theoretical transition probabilities for $3s3p^2-3s^24f$ and $3s^23d-3s^24f$. The other lifetimes measured are either extremely short, so that experimental errors become fairly large, or are not cascade-free ($3d$-level) and hence have not been used. Hey [4] has determined transition probabilities from intensity measurements in a wall-stabilized arc. His absolute values may be uncertain by as much as 50 percent, primarily because of the possible demixing effects. In those cases where theory and his experiment overlap, the results have been averaged.

References

[1] Garstang, R. H., and Shamey, L. J., to be published in Proc. Symposium on Magnetic and Other Peculiar and Metallic-Line Stars.

[2] Weiss, A. W., to be published (1969).

[3] Savage, B. D., and Lawrence, G. M., Astrophys. J. **146**, 940–943 (1966).

[4] Hey, P., Z. Physik **157**, 79–88 (1959).

[5] Froese, C., private communication (1965).

[6] Froese-Fischer, C., Astrophys. J. **151**, 759–764 (1968).

[7] Froese, C., and Underhill, A. B., Astrophys., J. **146**, 301–313 (1966).

Si II. Allowed Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
1	$3s^23p-3s3p^2$	${}^2P^\circ-{}^4P$ (UV 0.01)											
			2334.61	287	43108	4	6	4.3×10^{-5}	5.3×10^{-6}	1.6×10^{-4}	−4.67	E	1
			2328.51	0	42933	2	4	1.9×10^{-9}	3.1×10^{-10}	4.8×10^{-9}	−9.21	E	1
			2344.20	287	42933	4	4	4.0×10^{-5}	3.3×10^{-6}	1.0×10^{-4}	−4.88	E	1
			2334.40	0	42824	2	2	1.1×10^{-4}	9.0×10^{-6}	1.4×10^{-4}	−4.74	E	1
			2350.17	287	42824	4	2	6.8×10^{-5}	2.8×10^{-6}	8.7×10^{-5}	−4.95	E	1
2		${}^2P^\circ-{}^2D$ (UV 1)	*1814.0*	*191*	*55319*	6	10	0.078	0.0064	0.23	−1.42	E	2
			1816.92	287	55325	4	6	0.079	0.0059	0.14	−1.63	E	*ls*
			1808.00	0	55310	2	4	0.066	0.0064	0.077	−1.89	E	*ls*
			1817.45	287	55310	4	4	0.013	6.3×10^{-4}	0.015	−2.60	E	*ls*
3		${}^2P^\circ-{}^2S$ (UV 3)	*1307.6*	*191*	76666	6	2	11	0.090	2.4	−0.27	D	2
			1309.27	287	76666	4	2	7.0	0.090	1.6	−0.44	D	*ls*
			1304.37	0	76666	2	2	3.6	0.091	0.78	−0.74	D	*ls*

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
4		$^2P^\circ-^2P$ (UV 5)	*1195.5*	*191*	*83837*	6	6	43	0.91	22	0.74	D	2
			1194.50	287	84005	4	4	35	0.76	12	0.48	D	*ls*
			1193.28	0	83802	2	2	29	0.61	4.9	0.09	D	*ls*
			1197.39	287	83802	4	2	14	0.15	2.4	−0.22	D	*ls*
			1190.42	0	84005	2	4	7.2	0.31	2.4	−0.22	D	*ls*
5	$3s3p^2-3p^3$	$^4P-^4S^\circ$ (UV 8)	*1249.5*	*43002*	123034	12	4	38	0.29	14	0.54	D	2
			1251.16	43108	123034	6	4	19	0.29	7.2	0.24	D	*ls*
			1248.43	42933	123034	4	4	13	0.29	4.8	0.07	D	*ls*
			1246.74	42824	123034	2	4	6.3	0.29	2.4	−0.23	D	*ls*
6	$3s^23p-3s^2(^1S)3d$	$^2P^\circ-^2D$ (UV 4)	*1263.3*	*191*	*79349*	6	10	30	1.2	30	0.85	D	2
			1264.73	287	79355	4	6	30	1.1	18	0.63	D	*ls*
			1260.42	0	79339	2	4	25	1.2	9.9	0.38	D	*ls*
			1265.02	287	79339	4	4	5.0	0.12	2.0	−0.32	E	*ls*
7	$3s^23p-3s^2(^1S)4s$	$^2P^\circ-^2S$ (UV 2)	*1531.2*	*191*	65501	6	2	11.1	0.130	3.94	−0.108	C	2, 3
			1533.45	287	65501	4	2	7.4	0.130	2.63	−0.284	C	*ls*
			1526.72	0	65501	2	2	3.73	0.130	1.31	−0.59	C	*ls*
8	$3s^23p-3s^2(^1S)4d$	$^2P^\circ-^2D$ (UV 6)	*991.74*	*191*	*101024*	6	10	8.0	0.20	3.9	0.08	D	2
			992.675	287	101025	4	6	8.0	0.18	2.3	−0.15	D	*ls*
			989.867	0	101023	2	4	6.7	0.20	1.3	−0.40	D	*ls*
			[992.69]	287	101023	4	4	1.3	0.020	0.26	−1.10	E	*ls*
9	$3s^23p-3s^2(^1S)5s$	$^2P^\circ-^2S$ (UV 5.01)	*1022.7*	*191*	97972	6	2	4.1	0.021	0.43	−0.90	D	6
			1023.69	287	97972	4	2	2.7	0.021	0.29	−1.08	D	*ls*
			1020.70	0	97972	2	2	1.3	0.021	0.14	−1.38	D	*ls*
10	$3s3p^2-3s^2(^1S)4p$	$^4P-^2P^\circ$											
			2620.89	43108	81252	6	4	1.6×10^{-4}	1.1×10^{-5}	5.7×10^{-4}	−4.18	E	1
			2612.99	42933	81192	4	2	2.9×10^{-5}	1.5×10^{-6}	5.2×10^{-5}	−5.22	E	1
			2608.90	42933	81252	4	4	2.9×10^{-6}	3.0×10^{-7}	1.0×10^{-5}	−5.92	E	1
11	$3s3p^2-3s^2(^1S)4f$	$^4P-^2F^\circ$											
			1654.31	43108	103556	6	8	4.6×10^{-4}	2.5×10^{-5}	8.2×10^{-4}	−3.82	E	1
			1649.52	42933	103556	4	6	6.5×10^{-5}	4.0×10^{-6}	8.7×10^{-5}	−4.80	E	1
			1654.30	43108	103556	6	6	2.9×10^{-5}	1.2×10^{-6}	3.9×10^{-5}	−5.14	E	1
12	$3s3p^2-3s^2(^1S)4p$	$^2D-^2P^\circ$ (1)	*3858.0*	*55319*	*81232*	10	6	0.28	0.038	4.8	−0.43	D+	2, 4
			3856.02	55325	81252	6	4	0.25	0.038	2.9	−0.65	D+	*ls*
			3862.60	55310	81192	4	2	0.28	0.031	1.6	−0.90	D+	*ls*
			3853.66	55310	81252	4	4	0.028	0.0062	0.32	−1.61	E	*ls*
13	$3s3p^2-3s^2(^1S)4f$	$^2D-^2F^\circ$ (UV 9)	*2072.4*	*55319*	103556	10	14	1.0	0.092	6.3	−0.04	D	2
			2072.70	55325	103556	6	8	1.0	0.088	3.6	−0.28	D	*ls*
			2072.02	55310	103556	4	6	0.96	0.092	2.5	−0.43	D	*ls*
			[2072.7]	55325	103556	6	6	0.068	0.0044	0.18	−1.58	E	*ls*
14		$^2P-^2F^\circ$											
			5113.17	84005	103556	4	6	1.3×10^{-4}	7.5×10^{-5}	0.0050	−3.52	E	1
15	$3s^23d-3s^2(^1S)4f$	$^2D-^2F^\circ$ (3)	*4129.9*	*79349*	103556	10	14	1.42	0.51	69	0.71	C	2, 4
			4130.89	79355	103556	6	8	1.42	0.483	39.4	0.462	C	*ls*
			4128.07	79339	103556	4	6	1.32	0.51	27.6	0.310	C	*ls*
			[4130.9]	79355	103556	6	6	0.094	0.024	2.0	−0.84	E	*ls*

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
16	$3s^23d-3s^2(^1S)5f$	$^2D-^2F^\circ$ (UV 17)	*2905.2*	*79349*	113760	10	14	0.71	0.13	12	0.10	D	5, 7
			2905.69	79355	113760	6	8	0.71	0.12	6.9	−0.14	D	*ls*
			2904.28	79339	113760	4	6	0.67	0.13	4.8	−0.29	D	*ls*
			[2905.7]	79355	113760	6	6	0.048	0.0060	0.35	−1.44	E	*ls*
17	$3s^23d-3s^2(^1S)6f$	$^2D-^2F^\circ$ (UV 18)	*2501.6*	*79349*	119312	10	14	0.41	0.054	4.4	−0.27	D	5, 7
			2501.97	79355	119312	6	8	0.41	0.051	2.5	−0.51	D	*ls*
			2500.93	79339	119312	4	6	0.38	0.053	1.8	−0.67	D	*ls*
			[2502.0]	79355	119312	6	6	0.027	0.0026	0.13	−1.82	E	*ls*
18	$3s^24s-3s^2(^1S)4p$	$^2S-^2P^\circ$ (2)	*6355.1*	65501	*81232*	2	6	0.70	1.26	53	0.401	C	2, 4
			6347.10	65501	81252	2	4	0.70	0.84	35.3	0.225	C	*ls*
			6371.36	65501	81192	2	2	0.69	0.422	17.7	−0.074	C	*ls*
19	$3s^24p-3s^2(^1S)4d$	$^2P^\circ-^2D$ (5)	*5051.1*	*81232*	*101024*	6	10	1.2	0.74	74	0.65	D+	2, 4
			5055.98	81252	101025	4	6	1.2	0.66	44	0.42	D+	*ls*
			5041.03	81192	101023	2	4	0.98	0.74	25	0.17	D+	*ls*
			5056.31	81252	101023	4	4	0.19	0.074	4.9	−0.53	E	*ls*
20	$3s^24p-3s^2(^1S)5s$	$^2P^\circ-^2S$ (4)	*5972.1*	*81232*	97972	6	2	1.2	0.22	26	0.12	D	4, 6
			5978.93	81252	97972	4	2	0.81	0.22	17	−0.06	D	*ls*
			5957.56	81192	97972	2	2	0.42	0.22	8.7	−0.36	D	*ls*
21	$3s^24p-3s^2(^1S)5d$	$^2P^\circ-^2D$ (7)	*3208.0*	*81232*	112395	6	10	0.46	0.12	7.5	−0.14	D	*ca*
			3210.03	81252	112395	4	6	0.46	0.11	4.5	−0.37	D	*ls*
			3203.87	81192	112395	2	4	0.39	0.12	2.5	−0.62	D	*ls*
			[3210.0]	81252	112395	4	4	0.077	0.012	0.50	−1.32	E	*ls*
22	$3s^24p-3s^2(^1S)6s$	$^2P^\circ-^2S$ (6)	*3337.6*	*81232*	111185	6	2	0.46	0.026	1.7	−0.81	D	*ca*
			3339.82	81252	111185	4	2	0.30	0.025	1.1	−1.00	D	*ls*
			3333.14	81192	111185	2	2	0.15	0.025	0.55	−1.30	D	*ls*
23	$3s^24p-3s^2(^1S)7s$	$^2P^\circ-^2S$ (UV 19)	*2725.3*	*81232*	117915	6	2	0.24	0.0089	0.48	−1.27	D	*ca*
			2726.70	81252	117915	4	2	0.16	0.0089	0.32	−1.45		*ls*
			2722.25	81192	117915	2	2	0.080	0.0089	0.16	−1.75	D	*ls*
24	$3s^24d-3s^2(^1S)5f$	$^2D-^2F^\circ$ (7.02)	*7849.6*	*101024*	113760	10	14	0.42	0.54	140	0.73	D	*ca*
			7849.72	101025	113760	6	8	0.42	0.51	80	0.49	D	*ls*
			7848.80	101023	113760	4	6	0.39	0.54	56	0.33	D	*ls*
			[7849.7]	101025	113760	6	6	0.028	0.026	4.0	−0.81	E	*ls*
25	$3s^24d-3s^2(^1S)6f$	$^2D-^2F^\circ$ (7.03)	*5466.6*	*101024*	119312	10	14	0.26	0.16	29	0.20	D	*ca*
26	$3s^24d-3s^2(^1S)7f$	$^2D-^2F^\circ$ (7.05)	*4621.5*	*101024*	122656	10	14	0.16	0.072	11	−0.14	D	*ca*
27	$3s^24f-3s^2(^1S)6d$	$^2F^\circ-^2D$ (7.12)	6679.65	103556	118523	14	10	0.014	0.0068	2.1	−1.02	D	*ca*
28	$3s^25p-3s^2(^1S)6d$	$^2P^\circ-^2D$ (7.20)	*6826.4*	*103878*	118523	6	10	0.13	0.15	20	−0.05	D	*ca*
			6829.82	103886	118523	4	6	0.13	0.13	12	−0.27	D	*ls*
			6818.45	103861	118523	2	4	0.11	0.15	6.7	−0.52	D	*ls*
			[6829.8]	103886	118523	4	4	0.021	0.014	1.3	−1.25	E	*ls*

Si II. Allowed Transitions—*Continued*

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
29	$3s^25p-3s^2(^1S)7s$	$^2P^\circ-^2S$ (7.19)	*7122.1*	*103878*	117915	6	2	0.15	0.038	5.3	−0.64	D	*ca*
			7125.84	103886	117915	4	2	0.098	0.037	3.5	−0.83	D	*ls*
			7113.45	103861	117915	2	2	0.051	0.038	1.8	−1.12	D	*ls*
30	$3s^25p-3s^2(^1S)8s$	$^2P^\circ-^2S$ (7.21)	*5573.5*	*103878*	121815	6	2	0.088	0.014	1.5	−1.08	D−	*ca*
			5575.97	103886	121815	4	2	0.057	0.013	0.97	−1.28	D−	*ls*
			5568.36	103861	121815	2	2	0.029	0.013	0.49	−1.59	D−	*ls*
31	$3s^25p-3s^2(^1S)9s$	$^2P^\circ-^2S$ (7.23)	*4900.8*	*103878*	124277	6	2	0.053	0.0064	0.62	−1.42	D−	*ca*
			4902.65	103886	124277	4	2	0.035	0.0064	0.41	−1.59	D−	*ls*
			[4896.8]	103861	124277	2	2	0.018	0.0065	0.21	−1.89	D−	*ls*

Si II

Forbidden Transitions

The line strength for the one transition in the ground state configuration is a straight number, tabulated for example by Naqvi [1]. The transition probability should also be quite accurate, since the energy level difference is accurately known.

Reference

[1] Naqvi, A. M., Thesis Harvard (1951).

Si II. Forbidden Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	Type of Transition	A_{ki}(sec^{-1})	S(at.u.)	Accuracy	Source
1	$3p-(^1S)3p$	$^2P^\circ-^2P^\circ$	[34.795×10^4]	0.00	287.32	2	4	*m*	2.13×10^{-4}	1.33	A	1

Si III

Ground State $1s^2 2s^2 2p^6 3s^2\ {}^1S_0$

Ionization Potential 33.46 eV = 269940.6 cm^{-1}

Allowed Transitions

List of tabulated lines:

Wavelength [Å]	No.	Wavelength [Å]	No.	Wavelength [Å]	No.
566.613	11	1417.24	4	4665.87	30
671.718	23	1435.78	10	4683.02	30
672.293	23	1588.95	9	4683.80	30
673.477	23	1778.72	5	4716.65	43
690.689	25	1783.08	5	4730.52	30
823.408	24	1783.15	5	5451.46	29
883.398	15	1786.37	5	5451.96	29
993.519	19	1786.44	5	5473.05	29
994.787	19	1786.52	5	5490.11	29
997.389	19	1838.47	38	5539.93	29
1108.37	12	1839.59	38	5579.94	29
1109.94	12	1842.06	38	5596.9	57
1109.97	12	1842.55	21	5597.90	57
1113.17	12	1856.06	39	5599.25	57
1113.20	12	2449.48	45	5600.00	57
1113.23	12	2528.47	46	5600.95	57
1140.55	17	2541.82	3	5601.46	57
1141.58	17	2546.09	8	5693.8	48
1142.28	17	2559.21	26	5695.52	48
1144.31	17	3043.8	44	5696.50	48
1144.96	17	3043.93	44	5703.12	48
1145.67	17	3045.08	44	5704.60	48
1155.00	16	3045.1	44	5716.29	48
1155.96	16	3046.28	44	5739.73	28
1156.78	16	3185.13	37	5810.19	58
1158.10	16	3230.50	36	6169.84	56
1160.26	16	3233.95	36	6314.46	51
1161.58	16	3241.62	36	6521.49	55
1206.51	1	3486.91	42	6522.6	55
1206.53	13	3569.67	53	6522.63	55
1207.52	14	3590.47	35	6524.36	55
1294.54	2	3681.40	54	6524.8	55
1296.73	2	3682.15	54	6831.56	52
1298.89	2	3682.25	54	6834.08	52
1298.96	2	3791.41	34	6834.38	52
1301.15	2	3796.11	34	7461.89	40
1303.32	2	3796.2	34	7462.35	40
1312.59	20	3806.54	34	7462.62	40
1328.81	18	3806.7	34	7465.6	40
1341.47	7	4338.50	22	7465.67	40
1341.50	7	4341.40	33	7466.32	40
1342.35	7	4377.63	47	7612.36	49
1342.39	7	4468.45	31	8262.57	50
1342.43	7	4494.05	31	8265.64	50
1343.39	7	4552.62	27	8267.75	50
1362.37	6	4554.00	31	8269.32	50
1363.46	6	4567.82	27	8271.38	50
1363.50	6	4574.76	27	8271.94	50
1365.25	6	4619.66	30	8341.93	32
1365.29	6	4638.28	30	9799.91	41
1365.34	6				

Weiss' [1] values have been calculated by means of the method of superposition of configurations, employing Hartree-Fock wavefunctions as a starting point. The calculations have been carried out both in the dipole length and dipole velocity approximations. Zare [3] has performed similar calculations, also in the length and velocity forms, using however, the simpler, less accurate Hartree-Fock-Slater wavefunctions, in which exchange effects are only approximately taken into account. The dipole length values of [1] or [3] are selected, being probably more reliable than the velocity values, as suggested by the authors. Crossley and Dalgarno's values [2] have been obtained from a charge-expansion technique which includes configuration mixing in a limited way. There is usually good agreement for those transitions where the various calculations overlap. In these cases we have chosen Weiss' results over Zare's values and these in turn over [2]. The accuracy estimate has been reduced where there is significant disagreement between the length and velocity forms or where there appears to be cancellation in the transition integral.

References

[1] Weiss, A. W., J. Chem. Phys. **47**, 3573 (1967).
[2] Crossley, R. J. S., and Dalgarno, A., Proc. Roy. Soc. London **A286**, 510–518 (1965).
[3] Zare, R. N., J. Chem. Phys. **47**, 3561 (1967).

Si III. Allowed Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
1	$3s^2-3s(^2S)3p$	$^1S-^1P^\circ$ (UV 2)	1206.51	0	82884	1	3	25.9	1.70	6.74	0.230	B	1
2	$3s3p-3p^2$	$^3P^\circ-^3P$ (UV 4)	*1298.9*	*52984*	*129971*	9	9	22.3	0.564	21.7	0.706	B	1
			1298.96	53115	130101	5	5	16.7	0.423	9.04	0.325	B	*ls*
			1298.89	52853	129842	3	3	5.58	0.141	1.81	−0.374	B	*ls*
			1303.32	53115	129842	5	3	9.18	0.140	3.01	−0.155	B	*ls*
			1301.15	52853	129708	3	1	22.2	0.188	2.41	−0.249	B	*ls*
			1294.54	52853	130101	3	5	5.62	0.235	3.01	−0.152	B	*ls*
			1296.73	52725	129842	1	3	7.46	0.565	2.41	−0.248	B	*ls*
3		$^1P^\circ-^1D$ (UV 6.09)	2541.82	82884	122215	3	5	0.32	0.052	1.3	−0.81	D	1
4		$^1P^\circ-^1S$ (UV 9)	1417.24	82884	153444	3	1	26.0	0.261	3.66	−0.106	C	1
5	$3s(^2S)3d-3p(^2P^\circ)3d'$	$^3D-^3F^\circ$ (UV 35)	*1782.0*	*142945*	*199061*	15	21	4.3	0.28	25	0.62	D	2
			1778.72	142944	199164	7	9	4.4	0.27	11	0.28	D	*ls*
			1783.15	142946	199026	5	7	3.8	0.25	7.4	0.10	D	*ls*
			1786.52	142948	198923	3	5	3.6	0.28	5.0	−0.08	D	*ls*
			1783.08	142944	199026	7	7	0.47	0.023	0.93	−0.79	D−	*ls*
			1786.44	142946	198923	5	5	0.66	0.032	0.93	−0.80	D−	*ls*
			1786.37	142944	198923	7	5	0.018	6.3×10^{-4}	0.026	−2.36	E	*ls*
6		$^3D-^3P^\circ$ (UV 38)	*1364.3*	*142945*	*216241*	15	9	12	0.19	13	0.45	D+	3
			1365.25	142944	216190	7	5	9.7	0.19	6.1	0.12	D+	*ls*
			1363.46	142946	216289	5	3	8.5	0.14	3.2	−0.15	D+	*ls*
			1362.37	142948	216350	3	1	11	0.10	1.4	−0.52	D−	*ls*
			1365.29	142946	216190	5	5	1.8	0.049	1.1	−0.61	D−	*ls*
			1363.50	142948	216289	3	3	2.9	0.082	1.1	−0.61	D−	*ls*
			1365.34	142948	216190	3	5	0.11	0.0053	0.072	−1.80	E	*ls*

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
7		^{3}D–^{3}D° (UV 39)	*1342.2*	*142945*	*217452*	15	15	10	0.27	18	0.61	D	2
			1341.47	142944	217489	7	7	9.0	0.24	7.5	0.23	D	*ls*
			1342.39	142946	217440	5	5	7.0	0.19	4.2	−0.02	D	*ls*
			1343.39	142948	217386	3	3	7.5	0.20	2.7	−0.22	D	*ls*
			1342.35	142944	217440	7	5	1.6	0.030	0.94	−0.68	D−	*ls*
			1343.39	142946	217386	5	3	2.5	0.041	0.90	−0.69	D−	*ls*
			1341.50	142946	217489	5	7	1.1	0.043	0.94	−0.67	D−	*ls*
			1342.43	142948	217440	3	5	1.5	0.068	0.90	−0.69	D−	*ls*
8		^{1}D–^{1}D° (UV 56)	2546.09	165765	205029	5	5	0.61	0.060	2.5	−0.52	D	2
9		^{1}D–^{1}P° (UV 59)	1588.95	165765	228700	5	3	11	0.25	6.5	0.10	D+	3
10		^{1}D–^{1}F° (UV 61)	1435.78	165765	235414	5	7	21	0.89	21	0.65	D	2
11	$3s^2$–$3s(^2S)4p$	^{1}S–^{1}P° (UV 3)	566.613	0	176487	1	3	3.2	0.046	0.085	−1.34	E	3
12	$3s3p$–$3s(^2S)3d$	^{3}P°–^{3}D (UV 5)	*1111.6*	*52984*	*142945*	9	15	28.8	0.890	29.3	0.904	B	1
			1113.23	53115	142944	5	7	28.7	0.748	13.7	0.573	B	*ls*
			1109.97	52853	142946	3	5	21.7	0.668	7.32	0.302	B	*ls*
			1108.37	52725	142948	1	3	16.2	0.893	3.26	−0.049	B	*ls*
			1113.20	53115	142946	5	5	7.17	0.133	2.44	−0.177	B	*ls*
			1109.94	52853	142948	3	3	12.1	0.223	2.44	−0.175	B	*ls*
			1113.17	53115	142948	5	3	0.80	0.0089	0.16	−1.35	D	*ls*
13		^{1}P°–^{1}D (UV 11)	1206.53	82884	165765	3	5	48.9	1.78	21.2	0.728	B	1
14	$3p^2$–$3p(^2P°)3d'$	^{1}D–^{1}D° (UV 22)	1207.52	122215	205029	5	5	19	0.41	8.2	0.31	D	2
15		^{1}D–^{1}F° (UV 27)	883.398	122215	235414	5	7	63	1.0	15	0.70	D	2
16		^{3}P–^{3}P° (UV 31)	*1159.2*	*129971*	*216241*	9	9	22	0.44	15	0.60	D	2
			1161.58	130101	216190	5	5	16	0.32	6.2	0.20	D	*ls*
			1156.78	129842	216289	3	3	5.2	0.11	1.2	−0.48	D−	*ls*
			1160.26	130101	216289	5	3	9.1	0.11	2.1	−0.26	D−	*ls*
			1155.96	129842	216350	3	1	22	0.15	1.7	−0.35	D−	*ls*
			1158.10	129842	216190	3	5	5.5	0.18	2.1	−0.27	D−	*ls*
			1155.00	129708	216289	1	3	7.5	0.45	1.7	−0.35	D−	*ls*
17		^{3}P–^{3}D° (UV 32)	*1143.1*	*129971*	*217452*	9	15	39	1.3	43	1.07	D	2
			1144.31	130101	217489	5	7	39	1.1	20	0.74	D	*ls*
			1141.58	129842	217440	3	5	30	0.98	11	0.47	D	*ls*
			1140.55	129708	217386	1	3	22	1.3	4.8	0.11	D−	*ls*
			1144.96	130101	217440	5	5	9.7	0.19	3.6	−0.02	D−	*ls*
			1142.28	129842	217386	3	3	16	0.32	3.6	−0.02	D−	*ls*
			1145.67	130101	217386	5	3	1.1	0.013	0.24	−1.19	E	*ls*
18		^{1}S–^{1}P° (UV 48)	1328.81	153444	165765	1	3	27	2.1	9.3	0.33	D	3
19	$3s3p$–$3s(^2S)4s$	^{3}P°–^{3}S (UV 6)	*996.09*	*52984*	153377	9	3	23.6	0.117	3.45	0.022	B	1
			997.389	53115	153377	5	3	13.1	0.117	1.92	−0.233	B	*ls*
			994.787	52853	153377	3	3	7.89	0.117	1.15	−0.455	B	*ls*
			993.519	52725	153377	1	3	2.64	0.117	0.383	−0.932	B	*ls*

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
20		$^1P^\circ-{}^1S$ (UV 10)	1312.59	82884	159070	3	1	5.6	0.048	0.62	−0.84	D	1
21	$3p^2-3s(^2S)4p$	$^1D-{}^1P^\circ$ (UV 20)	1842.55	122215	176487	5	3	2.61	0.080	2.42	−0.398	C	3
22		$^1S-{}^1P^\circ$ (3)	4338.50	153444	176487	1	3	0.147	0.125	1.78	−0.90	C	3
23	$3s3p-3s(^2S)4d$	$^3P^\circ-{}^3D$ (UV 6.01)	*672.88*	*52984*	*201599*	9	15	0.67	0.0075	0.15	−1.17	E	3
			673.477	53115	201599	5	7	0.66	0.0063	0.070	−1.50	E	*ls*
			672.293	52853	201598	3	5	0.49	0.0056	0.037	−1.77	E	*ls*
			671.718	52725	201598	1	3	0.38	0.0077	0.017	−2.11	E	*ls*
			673.477	53115	201598	5	5	0.16	0.0011	0.012	−2.26	E	*ls*
			672.293	52853	201598	3	3	0.27	0.0018	0.012	−2.27	E	*ls*
			673.477	53115	201598	5	3	0.018	7.5×10^{-5}	8.3×10^{-4}	−3.43	E	*ls*
24		$^1P^\circ-{}^1D$ (UV 12)	823.408	82884	204331	3	5	6.6	0.112	0.91	−0.474	C	3
25	$3s3p-3s(^2S)5d$	$^1P^\circ-{}^1D$ (UV 14)	690.689	82884	227665	3	5	0.58	0.0069	0.047	−1.68	E	3
26	$3s3d-3s(^2S)4f$	$^1D-{}^1F^\circ$ (UV 55)	2559.21	165965	204828	5	7	7.7	1.1	45	0.73	D−	*ca*
27	$3s4s-3s(^2S)4p$	$^3S-{}^3P^\circ$ (2)	*4560.1*	153377	*175300*	3	9	1.26	1.18	53	0.55	C+	3
			4552.62	153377	175336	3	5	1.26	0.65	29.4	0.290	C+	*ls*
			4567.82	153377	175263	3	3	1.25	0.392	17.7	0.070	C+	*ls*
			4574.76	153377	175230	3	1	1.25	0.131	5.9	−0.406	C+	*ls*
28		$^1S-{}^1P^\circ$ (4)	5739.73	159070	176487	1	3	0.47	0.70	13	−0.16	D+	3
29	$3p4s'-3p(^2P^\circ)4p'$	$^3P^\circ-{}^3D$ (12.08)	*5472.8*	*226676*	*244943*	9	15	0.79	0.59	96	0.73	D	*ca*
			5473.05	226820	245087	5	7	0.79	0.50	45	0.40	D	*ls*
			5451.46	226527	244866	3	5	0.60	0.45	24	0.13	D	*ls*
			5451.96	226400	244737	1	3	0.46	0.61	11	−0.21	D	*ls*
			5539.93	226820	244866	5	5	0.19	0.088	8.0	−0.36	D−	*ls*
			5490.11	226527	244737	3	3	0.33	0.15	8.0	−0.35	D−	*ls*
			5579.94	226820	244737	5	3	0.021	0.0058	0.53	−1.54	E	*ls*
30		$^3P^\circ-{}^3P$ (13)	*4674.2*	*226676*	*248064*	9	9	1.3	0.42	58	0.58	D	*ca*
			4683.02	226820	248168	5	5	0.95	0.31	24	0.19	D	*ls*
			4665.87	226527	247954	3	3	0.32	0.10	4.8	−0.52	D−	*ls*
			4730.52	226820	247954	5	3	0.52	0.10	8.1	−0.30	D−	*ls*
			4683.80	226527	247872	3	1	1.3	0.14	6.4	−0.38	D−	*ls*
			4619.66	226527	248168	3	5	0.33	0.18	8.1	−0.27	D−	*ls*
			4638.28	226400	247954	1	3	0.43	0.42	6.4	−0.38	D−	*ls*
31		$^3P^\circ-{}^3S$ (15)	*4524.2*	*226676*	248773	9	3	1.4	0.14	19	0.10	D	*ca*
			4554.00	226820	248773	5	3	0.76	0.14	11	−0.15	D	*ls*
			4494.05	226527	248773	3	3	0.46	0.14	6.2	−0.38	D	*ls*
			4468.45	226400	248773	1	3	0.16	0.14	2.1	−0.85	D	*ls*
32		$^1P^\circ-{}^1D$ (44)	8341.93	235951	247935	3	5	0.26	0.46	38	0.14	D	*ca*
33		$^1P^\circ-{}^1S$ (46)	4341.40	235951	258979	3	1	1.8	0.17	7.2	−0.30	D	*ca*

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
34	$3s4p-3s(^2S)4d$	$^3P^\circ-^3D$ (5)	*3801.4*	*175300*	*201599*	9	15	3.4	1.2	140	1.03	D	*ca*
			3806.54	175336	201599	5	7	3.4	1.0	65	0.71	D	*ls*
			3796.11	175263	201598	3	5	2.6	0.93	35	0.45	D	*ls*
			3791.41	175230	201598	1	3	2.0	1.3	16	0.11	D	*ls*
			[3806.7]	175336	201598	5	5	0.88	0.19	12	−0.02	D−	*ls*
			[3796.2]	175263	201598	3	3	1.5	0.32	12	−0.02	D−	*ls*
			[3806.7]	175336	201598	5	3	0.095	0.012	0.78	−1.22	E	*ls*
35		$^1P^\circ-^1D$ (7)	3590.47	176487	204331	3	5	3.9	1.2	44	0.57	D	*ca*
36	$3s4p-3s(^2S)5s$	$^3P^\circ-^3S$ (6)	*3237.8*	*175300*	206176	9	3	4.0	0.21	20	0.28	D	*ca*
			3241.62	175336	206176	5	3	2.3	0.21	11	0.03	D	*ls*
			3233.95	175263	206176	3	3	1.3	0.21	6.7	−0.20	D	*ls*
			3230.50	175230	206176	1	3	0.45	0.21	2.2	−0.68	D	*ls*
37		$^1P^\circ-^1S$ (8)	3185.13	176487	207874	3	1	3.8	0.19	6.1	−0.24	D	*ca*
38	$3s4p-3s(^2S)6s$	$^3P^\circ-^3S$ (UV 65)	*1840.8*	*175300*	229623	9	3	1.7	0.028	1.5	−0.60	D	*ca*
			1842.06	175336	229623	5	3	0.93	0.028	0.86	−0.85	D	*ls*
			1839.59	175263	229623	3	3	0.55	0.028	0.51	−1.08	D	*ls*
			1838.47	175230	229623	1	3	0.18	0.028	0.17	−1.55	D	*ls*
39		$^1P^\circ-^1S$ (UV 70)	1856.06	176487	230364	5	3	1.6	0.027	0.50	−1.08	D	*ca*
40	$3s4d-3s(^2S)5p$	$^3D-^3P^\circ$ (8.03)	*7464.5*	*201599*	*214992*	15	9	0.65	0.33	120	0.69	D	*ca*
			7466.32	201599	214989	7	5	0.54	0.32	56	0.36	D	*ls*
			7462.62	201598	214995	5	3	0.49	0.24	30	0.08	D	*ls*
			7461.89	201598	214995	3	1	0.63	0.18	13	−0.27	D	*ls*
			7465.67	201598	214989	5	5	0.097	0.081	10	−0.39	D	*ls*
			7462.35	201598	214995	3	3	0.16	0.14	10	−0.38	D	*ls*
			[7465.6]	201598	214989	3	5	0.0065	0.0091	0.67	−1.56	E	*ls*
41		$^1D-^1P^\circ$ (8.08)	9799.91	204331	214995	5	3	0.39	0.34	55	0.23	D	*ca*
42	$3s4d-3s(^2S)5f$	$^3D-^3F^\circ$ (8.06)	3486.91	*201599*	*230270*	15	21	1.8	0.45	78	0.83	D	*ca*
43		$^1D-^1F^\circ$ (8.09)	4716.65	204331	225526	5	7	2.8	1.3	100	0.81	D	*ca*
44	$3s4d-3s(^2S)6p$	$^3D-^3P^\circ$ (8.07)	*3044.6*	*201599*	*234434*	15	9	0.22	0.019	2.8	−0.55	D	*ca*
			3043.93	201599	234442	7	5	0.19	0.019	1.3	−0.89	D	*ls*
			3045.08	201598	234428	5	3	0.17	0.014	0.70	−1.15	D	*ls*
			3046.28	201598	234415	3	1	0.22	0.010	0.31	−1.52	D	*ls*
			[3043.8]	201598	234442	5	5	0.033	0.0046	0.23	−1.64	D−	*ls*
			[3045.1]	201598	234428	3	3	0.055	0.0076	0.23	−1.64	D−	*ls*
			[3043.8]	201598	234442	3	5	0.0023	5.3×10^{-4}	0.016	−2.80	E	*ls*
45	$3s4d-3s(^2S)6f$	$^3D-^3F^\circ$ (UV 78)	2449.48	*201599*	*242411*	15	21	1.2	0.15	18	0.35	D−	*ca*
46		$^1D-^1F^\circ$ (UV 81)	2528.47	204331	243869	5	7	0.81	0.11	4.5	−0.27	D−	*ca*
47	$3s4f-3s(^2S)5d$	$^1F^\circ-^1D$ (8.13)	4377.63	204828	227665	7	5	0.085	0.017	1.8	−0.91	D	*ca*

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
48		$^3F^\circ-^3D$ (8.17)	*5707.5*	*209570*	*227086*	21	15	0.20	0.071	28	0.17	D	*ca*
			5716.29	209600	227089	9	7	0.19	0.074	12	−0.18	D	*ls*
			5704.60	209559	227084	7	5	0.18	0.063	8.3	−0.36	D	*ls*
			5696.50	209531	227081	5	3	0.20	0.060	5.6	−0.52	D	*ls*
			5703.12	209559	227089	7	7	0.016	0.0076	1.0	−1.27	D−	*ls*
			5695.52	209531	227084	5	5	0.022	0.011	1.0	−1.26	D−	*ls*
			[5693.8]	209531	227089	5	7	4.5×10^{-4}	3.1×10^{-4}	0.029	−2.81	E	*ls*
49	$3s5p-3s(^2S)5d$	$^1P^\circ-^1D$ (10.01)	7612.36	214532	227665	3	5	1.1	1.5	120	0.66	D	*ca*
50		$^3P^\circ-^3D$ (10.06)	*8266.3*	*214992*	*227086*	9	15	0.93	1.6	390	1.16	D	*ca*
			8262.57	214989	227089	5	7	0.91	1.3	180	0.81	D	*ls*
			8269.32	214995	227084	3	5	0.70	1.2	97	0.56	D	*ls*
			8271.94	214995	227081	1	3	0.51	1.6	43	0.20	D	*ls*
			8265.64	214989	227084	5	5	0.23	0.24	32	0.08	D	*ls*
			8271.38	214995	227081	3	3	0.38	0.39	32	0.07	D	*ls*
			8267.75	214989	227081	5	3	0.026	0.016	2.2	−1.10	E	*ls*
51	$3s5p-3s(^2S)6s$	$^1P^\circ-^1S$ (10.02)	6314.46	214532	230364	3	1	1.2	0.25	15	−0.13	D	*ca*
52		$^3P^\circ-^3S$ (10.07)	*6832.9*	*214992*	229623	9	3	1.3	0.31	63	0.45	D	*ca*
			6831.56	214989	229623	5	3	0.74	0.31	35	0.19	D	*ls*
			6834.08	214995	229623	3	3	0.44	0.31	21	−0.03	D	*ls*
			6834.38	214995	229623	1	3	0.15	0.31	7.0	−0.51	D	*ls*
53	$3s5p-3s(^2S)7s$	$^1P^\circ-^1S$ (10.04)	3569.67	214532	242538	3	1	0.58	0.037	1.3	−0.96	D	*ca*
54		$^3P^\circ-^3S$ (10.09)	*3681.8*	*214992*	242145	9	3	0.61	0.041	4.5	−0.43	D	*ca*
			3681.40	214989	242145	5	3	0.33	0.041	2.5	−0.69	D	*ls*
			3682.15	214995	272145	3	3	0.20	0.041	1.5	−0.91	D	*ls*
			3682.25	214995	242145	1	3	0.067	0.041	0.50	−1.39	D	*ls*
55	$3s5d-3s(^2S)6f$	$^3D-^3F^\circ$ (17)	*6523.5*	*227086*	*242411*	15	21	0.38	0.34	110	0.71	D	*ca*
			6524.36	227089	242412	7	9	0.39	0.32	48	0.35	D	*ls*
			6522.63	227084	242411	5	7	0.34	0.31	33	0.19	D	*ls*
			6521.49	227081	242411	3	5	0.32	0.34	22	0.01	D	*ls*
			[6524.8]	227089	242411	7	7	0.043	0.027	4.1	−0.72	D−	*ls*
			[6522.6]	227084	242411	5	5	0.060	0.038	4.1	−0.72	D−	*ls*
			[6524.8]	227089	242411	7	5	0.0018	8.0×10^{-4}	0.12	−2.25	E	*ls*
56		$^1D-^1F^\circ$ (22)	6169.84	227665	243869.	5	7	0.12	0.099	10	−0.30	D	*ca*
57	$3s5d-3s(^2S)7p$	$^3D-^3P^\circ$ (18)	*5600.1*	*227086*	*244938*	15	9	0.10	0.029	7.9	−0.36	D	*ca*
			5599.25	227089	244943	7	5	0.086	0.029	3.7	−0.69	D	*ls*
			5600.95	227084	244933	5	3	0.077	0.022	2.0	−0.96	D	*ls*
			5601.46	227081	244929	3	1	0.10	0.016	0.88	−1.32	D−	*ls*
			5597.90	227084	244943	5	5	0.015	0.0072	0.66	−1.44	D−	*ls*
			5600.00	227081	244933	3	3	0.025	0.012	0.66	−1.44	D−	*ls*
			[5596.9]	227081	244943	3	5	0.0010	8.0×10^{-4}	0.044	−2.62	E	*ls*
58.		$^1D-^1P^\circ$ (23)	5810.19	227665	244871	5	3	0.078	0.024	2.3	−0.92	D	*ca*

Si III

Forbidden Transitions

Naqvi's calculations [1] are the only available source. The results for the $^3P^\circ - ^3P^\circ$ transitions are essentially independent of the choice of the interaction parameters. For the $^3P^\circ - ^1P^\circ$ transitions, Naqvi uses empirical term intervals, i.e., the effects of configuration interaction should be partially included.

Reference

[1] Naqvi, A. M., Thesis Harvard (1951).

Si III. Forbidden Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	Type of Transition	A_{ki}(sec^{-1})	S(at.u.)	Accuracy	Source
1	$3s3p - 3s(^2S)3p$	$^3P^\circ - ^3P^\circ$										
			[77.74 × 10⁴]	52724.7	52853.3	1	3	m	3.83×10^{-5}	2.00	A	1
			[38.201 × 10⁴]	52853.3	53115.0	3	5	m	2.42×10^{-4}	2.50	A	1
2		$^3P^\circ - ^1P^\circ$										
			[3314.7]	52724.7	82884.4	1	3	m	0.0182	7.4×10^{-5}	C	1
			[3328.9]	52853.3	82884.4	3	3	m	2.22	0.0091	C	1
			[3358.2]	53115.0	82884.4	5	3	m	0.0219	9.2×10^{-5}	C	1

Si IV

Ground State $1s^22s^22p^63s\ ^2S_{1/2}$

Ionization Potential 45.14 eV = 364093.1 cm^{-1}

Allowed Transitions

List of tabulated lines:

Wavelength [Å]	No.	Wavelength [Å]	No.	Wavelength [Å]	No.
437.849	5	1533.22	21	4038.06	37
438.734	5	1672.61	23	4088.85	13
457.818	2	1722.53	8	4116.10	13
458.155	2	1727.38	8	4212.41	31
515.118	4	1796.16	19	4314.10	26
516.348	4	1796.17	19	4328.18	26
559.533	7	1797.50	19	4403.73	41
560.980	7	2120.18	15	4411.65	35
645.759	12	2127.47	15	4416.51	35
749.941	11	2287.04	20	4602.58	38
815.049	3	2366.76	27	4611.27	38
818.129	3	2370.99	27	4950.11	33
860.551	9	2482.82	25	5304.97	39
860.560	9	2485.38	25	5309.49	39
861.118	9	2675.2	22	6667.56	28
1066.63	10	2723.81	32	6701.21	28
1122.49	6	2971.52	34	6998.36	40
1128.33	6	3149.56	17	7047.94	29
1128.34	6	3165.71	17	7068.41	29
1210.65	14	3241.57	30	7630.50	36
1211.76	14	3241.58	30	7654.56	36
1228.35	16	3244.19	30	8240.61	42
1230.80	16	3762.44	18	8957.25	24
1393.76	1	3773.15	18	9018.16	24
1402.77	1	4031.39	37		

Self-consistent field calculations including polarization and exchange effects by Douglas and Garstang [1] are available for several multiplets of this ion. The values are expected to be accurate to within 25 percent, except for the transitions $3s-4p$ and $3p-4d$ where large cancellation effects occur in the transition integral. Similar but less refined calculations by Chapman, Clarke, and Aller [2] are adopted for those transitions which Douglas and Garstang have not covered.

For Si IV, a member of the sodium isoelectronic sequence, it is possible to utilize extensively the dependence of oscillator strengths on nuclear charge for the intercomparison of analogous transitions. Thus, the degree of fit of the individual f-values into the systematic trends has served as one of the decisive factors for the choice of accuracy assignments.

References

[1] Douglas, A. S., and Garstang, R. H., Proc. Cambridge Phil. Soc. **58**, 377–381 (1962).
[2] Chapman, R. D., Clarke, W. H., and Aller, L. H., Astrophys. J. **144**, 376–380 (1966).

Si IV. Allowed Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
1	$3s-3p$	$^2S-^2P^\circ$ (UV 1)	*1396.7*	0	*71595*	2	6	9.15	0.803	7.38	0.206	B	1
			1393.76	0	71749	2	4	9.20	0.536	4.92	0.030	B	*ls*
			1402.77	0	71288	2	2	9.03	0.266	2.46	−0.274	B	*ls*
2	$3s-4p$	$^2S-^2P^\circ$ (UV 2)	*457.93*	0	*218375*	2	6	3.5	0.033	0.10	−1.18	D	1
			457.818	0	218429	2	4	3.6	0.023	0.068	−1.34	D	*ls*
			458.155	0	218267	2	2	3.6	0.011	0.034	−1.66	D	*ls*
3	$3p-4s$	$^2P^\circ-^2S$ (UV 4)	*817.10*	*71595*	193979	6	2	36.8	0.123	1.98	−0.132	C+	1
			818.129	71749	193979	4	2	24.4	0.123	1.32	−0.308	C+	*ls*
			815.049	71288	193979	2	2	12.3	0.123	0.66	−0.61	C+	*ls*
4	$3p-5s$	$^2P^\circ-^2S$ (UV 6)	*515.93*	*71595*	265418	6	2	12	0.016	0.17	−1.01	D	*ca*
			516.348	71749	265418	4	2	8.2	0.016	0.11	−1.18	D	*ls*
			515.118	71288	265418	2	2	4.1	0.016	0.055	−1.49	D	*ls*
5	$3p-6s$	$^2P^\circ-^2S$ (UV 8)	*438.44*	*71595*	299677	6	2	6.4	0.0061	0.053	−1.44	D	*ca*
			438.734	71749	299677	4	2	4.2	0.0061	0.035	−1.61	D	*ls*
			437.849	71288	299677	2	2	2.2	0.0062	0.018	−1.91	D	*ls*
6	$3p-3d$	$^2P^\circ-^2D$ (UV 3)	*1126.4*	*71595*	*160375*	6	10	26.4	0.84	18.6	0.70	C+	1
			1128.34	71749	160374	4	6	26.3	0.75	11.2	0.477	C+	*ls*
			1122.49	71288	160376	2	4	22.2	0.84	6.2	0.225	C+	*ls*
			1128.33	71749	160376	4	4	4.37	0.083	1.24	−0.479	C+	*ls*
7	$3p-4d$	$^2P^\circ-^2D$ (UV 5)	*560.50*	*71595*	250008	6	10	1.0	0.0081	0.090	−1.31	D−	1
			560.980	71749	250008	4	6	1.0	0.0073	0.054	−1.53	D−	*ls*
			559.533	71288	250008	2	4	0.87	0.0081	0.030	−1.79	D−	*ls*
			560.980	71749	250008	4	4	0.17	8.1×10^{-4}	0.0060	−2.49	D−	*ls*
8	$3d-4p$	$^2D-^2P^\circ$ (UV 10)	*1724.1*	*160375*	*218375*	10	6	5.5	0.148	8.4	0.170	C	1
			1722.53	160374	218429	6	4	4.96	0.147	5.0	−0.055	C	*ls*
			1727.38	160376	218267	4	2	5.5	0.123	2.80	−0.308	C	*ls*
			1722.53	160376	218429	4	4	0.55	0.0247	0.56	−1.005	C	*ls*
9	$3d-5p$	$^2D-^2P^\circ$ (UV 12)	*860.74*	*160375*	*276554*	10	6	1.8	0.012	0.33	−0.93	D	*ca*
			860.551	160374	276579	6	4	1.6	0.012	0.20	−1.15	D	*ls*
			861.118	160376	276504	4	2	1.8	0.0098	0.11	−1.41	D	*ls*
			860.560	160376	276579	4	4	0.18	0.0020	0.022	−2.11	D	*ls*

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
10	$3d-4f$	$^2D-^2F^\circ$ (UV 11)	1066.63	*160375*	*254128*	10	14	39.1	0.93	32.8	0.97	C+	*ca*
11	$3d-5f$	$^2D-^2F^\circ$ (UV 13)	749.941	*160375*	293719	10	14	14.5	0.171	4.23	0.233	C	*ca*
12	$3d-6f$	$^2D-^2F^\circ$ (UV 15)	645.759	*160375*	315230	10	14	7.0	0.061	1.3	−0.21	D	*ca*
13	$4s-4p$	$^2S-^2P^\circ$ (1)	*4097.9*	193979	218375	2	6	1.56	1.17	31.7	0.369	B	1
			4088.85	193979	218429	2	4	1.56	0.784	21.1	0.195	B	*ls*
			4116.10	193979	218267	2	2	1.54	0.391	10.6	−0.107	B	*ls*
14	$4s-5p$	$^2S-^2P^\circ$ (UV 16)	*1211.0*	193979	*276554*	2	6	0.36	0.024	0.19	−1.32	D	*ca*
			1210.65	193979	276579	2	4	0.36	0.016	0.12	−1.51	D	*ls*
			1211.76	193979	276504	2	2	0.37	0.0082	0.066	−1.78	D	*ls*
15	$4p-5s$	$^2P^\circ-^2S$ (UV 18)	*2125.0*	*218375*	265418	6	2	9.0	0.203	8.5	0.086	C+	*ca*
			2127.47	218429	265418	4	2	6.0	0.204	5.7	−0.089	C+	*ls*
			2120.18	218267	265418	2	2	3.00	0.202	2.82	−0.394	C+	*ls*
16	$4p-6s$	$^2P^\circ-^2S$ (UV 20)	*1230.0*	*218375*	299677	6	2	3.92	0.0296	0.72	−0.75	C	*ca*
			1230.80	218429	299677	4	2	2.60	0.0295	0.478	−0.93	C	*ls*
			1228.35	218267	299677	2	2	1.30	0.0294	0.238	−1.231	C	*ls*
17	$4p-4d$	$^2P^\circ-^2D$ (2)	*3160.3*	*218375*	250008	6	10	4.75	1.19	74	0.85	C+	1
			3165.71	218429	250008	4	6	4.75	1.07	44.6	0.63	C+	*ls*
			3149.56	218267	250008	2	4	4.02	1.20	24.8	0.380	C+	*ls*
			3165.71	218429	250008	4	4	0.79	0.119	4.96	−0.322	C+	*ls*
18	$4d-5p$	$^2D-^2P^\circ$ (3)	*3766.0*	250008	*276554*	10	6	2.37	0.303	37.5	0.481	C	2
			3762.44	250008	276579	6	4	2.14	0.303	22.5	0.260	C	*ls*
			3773.15	250008	276504	4	2	2.36	0.252	12.5	0.003	C	*ls*
			3762.44	250008	276579	4	4	0.240	0.051	2.53	−0.69	C	*ls*
19	$4d-6p$	$^2D-^2P^\circ$ (UV 23)	*1796.6*	250008	*305668*	10	6	0.87	0.0254	1.50	−0.60	C	*ca*
			1796.16	250008	305682	6	4	0.78	0.0253	0.90	−0.82	C	*ls*
			1797.50	250008	305641	4	2	0.87	0.0210	0.497	−1.076	C	*ls*
			1796.17	250008	305682	4	4	0.087	0.00421	0.100	−1.77	C	*ls*
20	$4d-5f$	$^2D-^2F^\circ$ (UV 22)	2287.04	250008	293719	10	14	6.4	0.70	53	0.85	C	*ca*
21	$4d-6f$	$^2D-^2F^\circ$ (UV 24)	1533.22	250008	315230	10	14	3.57	0.176	8.9	0.246	C	*ca*
22	$4f-5d$	$^2F^\circ-^2D$ (UV 25)	*2675.2*	*254128*	291498	14	10	0.280	0.0215	2.65	−0.52	C	*ca*
23	$4f-6d$	$^2F^\circ-^2D$ (UV 27)	1672.61	*254128*	313915	14	10	0.12	0.0036	0.28	−1.30	D	*ca*
24	$5s-5p$	$^2S-^2P^\circ$ (3.01)	*8977.4*	265418	*276554*	2	6	0.420	1.52	90	0.483	C	*ca*
			8957.25	265418	276579	2	4	0.421	1.01	60	0.307	C	*ls*
			9018.16	265418	276504	2	2	0.413	0.50	29.9	0.003	C	*ls*
25	$5s-6p$	$^2S-^2P^\circ$ (UV 29)	*2483.7*	265418	*305668*	2	6	0.066	0.018	0.30	−1.44	D	*ca*
			2482.82	265418	305682	2	4	0.066	0.012	0.20	−1.62	D	*ls*
			2485.38	265418	305641	2	2	0.066	0.0061	0.10	−1.91	D	*ls*

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
26	$5p-6s$	$^2P^\circ-^2S$ (4)	*4323.5*	*276554*	299677	6	2	3.21	0.300	25.6	0.255	C	2
			4328.18	276579	299677	4	2	2.14	0.300	17.1	0.077	C	*ls*
			4314.10	276504	299677	2	2	1.08	0.300	8.5	−0.222	C	*ls*
27	$5p-7s$	$^2P^\circ-^2S$ (UV 31)	*2370.0*	*276554*	318743	6	2	1.47	0.0412	1.93	−0.61	C	*ca*
			2370.99	276579	318743	4	2	0.98	0.0413	1.29	−0.78	C	*ls*
			2366.67	276504	318743	2	2	0.490	0.0411	0.64	−1.085	C	*ls*
28	$5p-5d$	$^2P^\circ-^2D$ (3.02)	*6689.8*	*276554*	291498	6	10	1.36	1.52	201	0.96	C	*ca*
			6701.21	276579	291498	4	6	1.36	1.37	121	0.74	C	*ls*
			6667.56	276504	291498	2	4	1.14	1.52	67	0.484	C	*ls*
			6701.21	276579	291498	4	4	0.226	0.152	13.4	−0.216	C	*ls*
29	$5d-6p$	$^2D-^2P^\circ$ (4.01)	*7055.2*	291498	*305668*	10	6	1.00	0.448	104	0.65	C	*ca*
			7047.94	291498	305682	6	4	0.90	0.447	62	0.428	C	*ls*
			7068.41	291498	305641	4	2	1.00	0.374	34.8	0.175	C	*ls*
			7047.94	291498	305682	4	4	0.100	0.074	6.9	−0.53	C	*ls*
30	$5d-7p$	$^2D-^2P^\circ$ (5.01)	*3242.4*	291498	*322330*	10	6	0.412	0.0390	4.16	−0.409	C	*ca*
			3241.58	291498	322338	6	4	0.371	0.0390	2.50	−0.63	C	*ls*
			3244.19	291498	322313	4	2	0.410	0.0324	1.38	−0.89	C	*ls*
			3241.57	291498	322338	4	4	0.0413	0.0065	0.277	−1.59	C	*ls*
31	$5d-6f$	$^2D-^2F^\circ$ (5)	4212.41	291498	315230	10	14	1.72	0.64	89	0.81	C	2
32	$5d-7f$	$^2D-^2F^\circ$ (UV 32)	2723.81	291498	328200	10	14	1.1	0.17	15	0.23	D	*ca*
33	$5f-6d$	$^2F^\circ-^2D$ (5.02)	4950.11	293719	313915	14	10	0.205	0.054	12.3	−0.123	C	*ca*
34	$5f-7d$	$^2F^\circ-^2D$ (UV 33)	2971.52	293719	327362	14	10	0.10	0.0095	1.3	−0.88	D	*ca*
35	$6s-7p$	$^2S-^2P^\circ$ (8)	*4413.2*	299677	*322330*	2	6	0.018	0.015	0.45	−1.52	D	*ca*
			4411.65	299677	322338	2	4	0.018	0.010	0.30	−1.70	D	*ls*
			4416.51	299677	322313	2	2	0.018	0.0052	0.15	−1.98	D	*ls*
36	$6p-7s$	$^2P^\circ-^2S$ (9)	*7646.1*	*305668*	318743	6	2	1.34	0.391	59	0.370	C	*ca*
			7654.56	305682	318743	4	2	0.88	0.387	40.0	0.189	C	*ls*
			7630.50	305641	318743	2	2	0.440	0.384	19.3	−0.115	C	*ls*
37	$6p-8s$	$^2P^\circ-^2S$ (11)	*4035.7*	*305668*	330440	6	2	0.65	0.053	4.24	−0.498	C	*ca*
			4038.06	305682	330440	4	2	0.435	0.053	2.83	−0.67	C	*ls*
			4031.39	305641	330440	2	2	0.217	0.053	1.41	−0.97	C	*ls*
38	$6p-7d$	$^2P^\circ-^2D$ (10)	*4608.3*	*305668*	327362	6	10	0.020	0.011	0.98	−1.18	D	*ca*
			4611.27	305682	327362	4	6	0.020	0.0095	0.58	−1.42	D	*ls*
			4602.58	305641	327362	2	4	0.018	0.011	0.34	−1.65	D	*ls*
			4611.27	305682	327362	4	4	0.0033	0.0011	0.064	−2.37	D	*ls*
39	$6d-8p$	$^2D-^2P^\circ$ (13)	*5306.4*	313915	*332755*	10	6	0.209	0.053	9.3	−0.276	C	*ca*
			5304.97	313915	332760	6	4	0.190	0.053	5.6	−0.498	C	*ls*
			5309.49	313915	332744	4	2	0.210	0.0443	3.10	−0.75	C	*ls*
			5304.97	313915	332760	4	4	0.0210	0.0089	0.62	−1.449	C	*ls*
40	$6d-7f$	$^2D-^2F^\circ$ (12)	6998.36	313915	328200	10	14	0.55	0.56	130	0.75	C	*ca*

Si IV. Allowed Transitions—*Continued*

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
41	$6d-8f$	$^2D-^2F^\circ$ (14)	4403.73	313915	336617	10	14	0.41	0.17	24	0.23	D	*ca*
42	$6f-7d$	$^2F^\circ-^2D$ (15)	8240.61	315230	327362	14	10	0.126	0.092	34.8	0.110	C	*ca*

Si V

Ground State $1s^22s^22p^6\ ^1S_0$

Ionization Potential 166.73 eV = 1345100 cm^{-1}

Allowed Transitions

Calculations by Kastner, Omidvar, and Underwood [1], employing Hartree-Fock wavefunctions and including intermediate coupling, are available. Since the calculations are based on a single-configuration approximation only, uncertainties of up to 50 percent are expected for the strong lines and even higher uncertainties for the weak lines, the latter being more affected by assumptions about the coupling.

Reference

[1] Kastner, S. O., Omidvar, K., and Underwood, J. H., Astrophys. J. **148**, 269–273 (1967).

Si V. Allowed Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
1	$2p^6-2p^5(^2P^\circ_{3/2})3s$	$^1S-^3P^\circ$	[118.97]	0	840560	1	3	33	0.021	0.0082	−1.68	E	1
2	$2p^6-2p^5(^2P^\circ_{1/2})3s$	$^1S-^1P^\circ$	[117.86]	0	848460	1	3	300	0.19	0.074	−0.72	D	1
3	$2p^6-2p^5(^2P^\circ_{3/2})3d$	$^1S-^3P^\circ$	[98.209]	0	1018240	1	3	8.8	0.0038	0.0012	−2.42	E	1
4	$2p^6-2p^5(^2P^\circ_{3/2})3d$	$^1S-^1P^\circ$	[97.143]	0	1029410	1	3	2000	0.84	0.27	−0.08	D	1
5	$2p^6-2p^5(^2P^\circ_{1/2})3d$	$^1S-^3D^\circ$	[96.439]	0	1036930	1	3	480	0.20	0.063	−0.70	D	1

308-022 O-69—9

Si VI

Ground State $1s^2 2s^2 2p^5\ ^2P^\circ_{3/2}$

Ionization Potential 205.11 eV = 1654800 cm^{-1}

Allowed Transitions

The value for the $2s^2 2p^5\ ^2P^\circ - 2s2p^6\ ^2S$ multiplet is calculated from the nuclear charge-expansion method of Cohen and Dalgarno [1]. It may be quite uncertain since configuration interaction effects with configurations involving the $n=3$ shell electrons, which were not included in this calculation, may be significant.

Reference

[1] Cohen, M., and Dalgarno, A., Proc. Roy. Soc. London **A280**, 258–270 (1964).

Si VI. Allowed Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
1	$2s^2 2p^5 - 2s2p^6$	$^2P^\circ - ^2S$	*247.04*	*1700*	406500	6	2	370	0.11	0.55	−0.18	D	1
			[246.00]	0	406500	4	2	250	0.11	0.37	−0.36	D	*ls*
			[249.13]	5100	406500	2	2	120	0.11	0.18	−0.66	D	*ls*

Si VI

Forbidden Transitions

The line strength for the one transition in the ground state configuration is a straight number, tabulated for example by Naqvi [1]. The transition probability should also be quite accurate, since the energy level difference is accurately known.

Reference

[1] Naqvi, A. M., Thesis Harvard (1951).

Si VI. Forbidden Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	Type of Transition	A_{ki}(sec^{-1})	S(at.u.)	Accuracy	Source
1	$2p^5 - 2p^5$	$^2P^\circ - ^2P^\circ$	[19603]	0	5100	4	2	*m*	2.38	1.33	A	1

Si VII

Ground State $1s^2 2s^2 2p^4\ ^3P_2$

Ionization Potential 246.41 eV = 1988000 cm^{-1}

Allowed Transitions

The values are calculated from the charge-expansion method of Cohen and Dalgarno [1] which includes limited configuration mixing. From comparisons with other ions in the isoelectronic sequence, uncertainties should be within 50 percent.

Reference

[1] Cohen, M., and Dalgarno, A., Proc. Roy. Soc. London **A280**, 258–270 (1964).

Si VII. Allowed Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
1	$2s^2 2p^4 - 2s2p^5$	$^3P - ^3P^\circ$	*275.46*	*1962*	*364994*	9	9	160	0.18	1.5	0.21	D	1
			[275.35]	0	363170	5	5	120	0.14	0.62	−0.15	D	*ls*
			[275.67]	4030	366780	3	3	39	0.044	0.12	−0.88	D	*ls*
			[272.64]	0	366780	5	3	70	0.047	0.21	−0.63	D	*ls*
			[274.18]	4030	368760	3	1	170	0.063	0.17	−0.72	D	*ls*
			[278.44]	4030	363170	3	5	39	0.076	0.21	−0.64	D	*ls*
			[276.85]	5570	366780	1	3	54	0.19	0.17	−0.72	D	*ls*
2		$^1D - ^1P^\circ$	[217.83]	47000	506080	5	3	270	0.12	0.42	−0.22	D	1
3		$^1S - ^1P^\circ$	[246.12]	99780	506080	1	3	41	0.11	0.090	−0.96	D	1

Si VII

Forbidden Transitions

As in the case of Na IV the adopted values are taken from Naqvi [1], and Malville and Berger [2]. For a discussion on the selection of values see Na IV, since the same considerations have been applied.

References

[1] Naqvi, A. M., Thesis, Harvard (1951).
[2] Malville, J. M. and Berger, R. A., Planetary and Space Science **13**, 1131–1136 (1965).

Si VII. Forbidden Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	Type of Transition	A_{ki}(sec^{-1})	S(at.u.)	Accuracy	Source
1	$2p^4-2p^4$	$^3P-^3P$										
			[24807]	0	4030	5	3	*e*	2.70×10^{-6}	0.0452	C–	1, 2
			[24807]	0	4030	5	3	*m*	1.46	2.49	B	1, 2
			[17948]	0	5570	5	1	*e*	1.82×10^{-5}	0.0202	C–	2
			[64920]	4030	5570	3	1	*m*	0.196	2.00	B	1, 2
2		$^3P-^1D$										
			[2127.0]	0	47000	5	5	*e*	0.0074	9.6×10^{-4}	D–	1, 2
			[2127.0]	0	47000	5	5	*m*	12.7	0.0226	C	1
			[2326.5]	4030	47000	3	5	*e*	6.8×10^{-4}	1.4×10^{-4}	D–	1, 2
			[2326.5]	4030	47000	3	5	*m*	3.24	0.0076	C	1
			[2413.0]	5570	47000	1	5	*e*	2.5×10^{-4}	6.1×10^{-5}	D–	2
3		$^3P-^1S$										
			[1002.2]	0	99780	5	1	*e*	0.11	6.3×10^{-5}	D–	2
			[1044.4]	4030	99780	3	1	*m*	148	0.0063	C	2
4		$^1D-^1S$										
			[1894.7]	47000	99780	5	1	*e*	5.5	0.080	C–	2

Si VIII

Ground State $1s^22s^22p^3\ ^4S^\circ_{3/2}$

Ionization Potential 303.07 eV = 2445110 cm^{-1}

Allowed Transitions

Values for all the listed transitions are calculated from the nuclear charge-expansion method of Cohen and Dalgarno [1], which includes limited configuration mixing. Judged from graphical comparisons with other ions in the isoelectronic sequence and from the general success of Cohen and Dalgarno's method for similar atomic systems, uncertainties within 50 percent are indicated.

Reference

[1] Cohen, M., and Dalgarno, A., Proc. Roy. Soc. London **A280**, 258–270 (1964).

Si VIII. Allowed Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
1	$2s^22p^3-2s2p^4$	$^4S^\circ-^4P$	*317.68*	0	*314782*	4	12	49	0.22	0.93	−0.06	D	1
			[319.83]	0	312670	4	6	49	0.11	0.47	−0.36	D	*ls*
			[316.20]	0	316260	4	4	50	0.074	0.31	−0.53	D	*ls*
			[314.31]	0	318160	4	2	52	0.039	0.16	−0.81	D	*ls*
2		$^2D^\circ-^2D$	*277.00*	[*67308*]	[*428324*]	10	10	110	0.13	1.2	0.11	D	1
			[277.10]	[67420]	[428300]	6	6	110	0.12	0.67	−0.14	D	*ls*
			[276.84]	[67140]	[428360]	4	4	100	0.12	0.43	−0.32	D	*ls*
			[277.05]	[67420]	[428360]	6	4	11	0.0088	0.048	−1.28	E	*ls*
			[276.89]	[67140]	[428300]	4	6	7.6	0.013	0.048	−1.28	E	*ls*

Si VIII. Allowed Transitions—*Continued*

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
3		$^2D^\circ-^2P$	*216.18*	[*67308*]	[*529877*]	10	6	400	0.17	1.2	0.23	D	1
			[216.92]	[67420]	[528420]	6	4	360	0.17	0.72	0.01	D	*ls*
			[214.75]	[67140]	[532790]	4	2	410	0.14	0.40	−0.25	D	*ls*
			[216.79]	[67140]	[528420]	4	4	40	0.028	0.080	−0.95	E	*ls*
4		$^2P^\circ-^2D$	*308.06*	[*103707*]	[*428324*]	6	10	17	0.041	0.25	−0.61	D	1
			[308.26]	[103900]	[428300]	4	6	17	0.037	0.15	−0.83	D	*ls*
			[307.65]	[103320]	[428360]	2	4	14	0.041	0.083	−1.09	D	*ls*
			[308.20]	[103900]	[428360]	4	4	2.9	0.0042	0.017	−1.77	E	*ls*
5		$^2P^\circ-^2S$	*250.84*	[*103707*]	[502360]	6	2	240	0.075	0.37	−0.35	D	1
			[250.97]	[103900]	[502360]	4	2	160	0.076	0.25	−0.52	D	*ls*
			[250.60]	[103320]	[502360]	2	2	77	0.073	0.12	−0.84	D	*ls*
6		$^2P^\circ-^2P$	*234.65*	[*103707*]	[*529877*]	6	6	120	0.097	0.45	−0.24	D	1
			[235.56]	[103900]	[528420]	4	4	97	0.081	0.25	−0.49	D	*ls*
			[232.85]	[103320]	[532790]	2	2	80	0.065	0.10	−0.89	D	*ls*
			[233.16]	[103900]	[532790]	4	2	40	0.016	0.050	−1.19	D−	*ls*
			[235.24]	[103320]	[528420]	2	4	19	0.032	0.050	−1.19	D−	*ls*

Si VIII

Forbidden Transitions

All the values for this ion have been taken from Pasternack [1]. The electric quadrupole values have been corrected by applying Naqvi's value [2] for the electric quadrupole moment s_q.

References

[1] Pasternack, S., Astrophys. J. **92**, 129 (1940).
[2] Naqvi, A. M., Thesis Harvard (1951).

Si VIII. Forbidden Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	Type of Transition	A_{ki}(sec^{-1})	S(at.u.)	Accuracy	Source
1	$2p^3-2p^3$	$^4S^\circ-^2D^\circ$										
			[1483.2]	0	[67420]	4	6	*m*	0.019	1.38×10^{-5}	C−	1
			[1483.2]	0	[67420]	4	6	*e*	0.0083	2.1×10^{-4}	D−	1, 2
			[1489.4]	0	[67140]	4	4	*m*	1.1	5.4×10^{-4}	C−	1
			[1489.4]	0	[67140]	4	4	*e*	0.0053	9.3×10^{-5}	D−	1, 2
2		$^4S^\circ-^2P^\circ$										
			[967.87]	0	[103320]	4	2	*m*	29	0.00195	C	1
			[967.87]	0	[103320]	4	2	*e*	3.4×10^{-4}	3.5×10^{-7}	D−	1, 2
			[962.46]	0	[103900]	4	4	*m*	69	0.0091	C	1
			[962.46]	0	[103900]	4	4	*e*	1.4×10^{-4}	2.8×10^{-7}	D−	1, 2
3		$^2D^\circ-^2D^\circ$										
			[35.70×10^4]	[67140]	[67420]	4	6	*m*	2.37×10^{-4}	2.40	B	1, 2
			[35.70×10^4]	[67140]	[67420]	4	6	*e*	7.7×10^{-14}	0.0016	D−	1, 2

Si VIII. Forbidden Transitions—*Continued*

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	Type of Transition	A_{ki}(sec^{-1})	S(at.u.)	Accuracy	Source
4		$^2D^\circ - ^2P^\circ$										
			[2740.4]	[67420]	[103900]	6	4	*m*	11	0.0336	C	1
			[2740.4]	[67420]	[103900]	6	4	*e*	0.38	0.14	D	2
			[2763.1]	[67140]	[103320]	4	2	*m*	12	0.0188	C	1
			[2763.1]	[67140]	[103320]	4	2	*e*	0.31	0.060	D	2
			[2784.7]	[67420]	[103320]	6	2	*e*	0.20	0.040	D	2
			[2719.5]	[67140]	[103900]	4	4	*m*	20	0.060	C	1
			[2719.5]	[67140]	[103900]	4	4	*e*	0.17	0.059	D	2
5		$^2P^\circ - ^2P^\circ$										
			[17.24 × 10^4]	[103320]	[103900]	2	4	*m*	0.00175	1.33	B	1, 2
			[17.24 × 10^4]	[103320]	[103900]	2	4	*e*	7.1 × 10^{-14}	2.6 × 10^{-5}	D−	1, 2

Si IX

Ground State $1s^2 2s^2 2p^2\ ^3P_0$

Ionization Potential 350.96 eV = 2831470 cm^{-1}

Allowed Transitions

Most data are obtained from the charge-expansion method of Cohen and Dalgarno [1] which includes limited configuration mixing. Graphical comparisons of this material within the isoelectronic sequence depicting the dependence of *f*-values on nuclear charge have been made, and the available experimental data for the lower ions, mostly from life time measurements, establish fairly definitely that the uncertainties should not exceed 50 percent.

Reference

[1] Cohen, M., and Dalgarno, A., Proc. Roy. Soc. London **A280**, 258–270 (1964).

Si IX. Allowed Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
1	$2s^2 2p^2 - 2s2p^3$	$^3P - ^3D^\circ$	*347.40*	*4452*	*292306*	9	15	28	0.084	0.86	−0.12	D+	1
			[349.96]	6460	292210	5	7	27	0.069	0.40	−0.46	D+	*ls*
			[345.10]	2590	292360	3	5	21	0.062	0.21	−0.73	D+	*ls*
			[341.95]	0	292440	1	3	16	0.085	0.096	−1.07	D−	*ls*
			[349.77]	6460	292360	5	5	6.8	0.013	0.072	−1.19	D−	*ls*
			[345.01]	2590	292440	3	3	12	0.021	0.072	−1.20	D−	*ls*
			[349.67]	6460	292440	5	3	0.76	8.3 × 10^{-4}	0.0048	−2.38	E	*ls*
2		$^3P - ^3P^\circ$	*294.44*	*4452*	344080	9	9	70	0.091	0.79	−0.09	D	1
			[296.19]	6460	344080	5	5	51	0.068	0.33	−0.47	D	*ls*
			[292.83]	2590	344080	3	3	18	0.023	0.066	−1.16	D	*ls*
			[296.19]	6460	344080	5	3	29	0.023	0.11	−0.94	D	*ls*
			[292.83]	2590	344080	3	1	71	0.030	0.088	−1.05	D	*ls*
			[292.83]	2590	344080	3	5	18	0.038	0.11	−0.94	D	*ls*
			[290.63]	0	344080	1	3	24	0.092	0.088	−1.04	D	*ls*

Si IX. Allowed Transitions—*Continued*

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
3		$^3P-^3S^\circ$	*225.97*	*4452*	446980	9	3	390	0.10	0.67	−0.05	D+	1
			[227.00]	6460	446980	5	3	210	0.099	0.37	−0.31	D+	*ls*
			[225.03]	2590	446980	3	3	130	0.099	0.22	−0.53	D+	*ls*
			[223.72]	0	446980	1	3	45	0.10	0.074	−1.00	D+	*ls*
4		$^1D-^1D^\circ$	[258.10]	[52960]	[440410]	5	5	200	0.20	0.85	0.00	D	1
5		$^1D-^1P^\circ$	[227.35]	[52960]	[492820]	5	3	250	0.12	0.44	−0.22	D	1
6		$^1S-^1P^\circ$	[259.71]	[107780]	[492820]	1	3	66	0.20	0.17	−0.70	D−	1

Si IX

Forbidden Transitions

The adopted values represents, as in the case of Na VI, the work of Naqvi [1], Malville and Berger [2], and Froese [3]. For the selection of values, the same considerations as for Na VI are applied, the one exception being that Froese's magnetic dipole values are also used. Since the observed energy levels are uncertain, it is felt that the ζ and η calculated from her theoretical energy levels will be as accurate as the experimental ones.

References

[1] Naqvi, A. M., Thesis Harvard (1951).
[2] Malville, J. M. and Berger, R. A., Planetary and Space Science **13**, 1131–1136 (1965).
[3] Froese, C., Astrophys. J. **145**, 932–935 (1966).

Si IX. Forbidden Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	Type of Transition	A_{ki}(sec^{-1})	S(at.u.)	Accuracy	Source
1	$2p^2-2p^2$	$^3P-^3P$										
			[38600]	0	2590	1	3	*m*	0.311	1.99	B	1
			[15476]	0	6460	1	5	*e*	6.1×10^{-6}	0.0162	C	3
			[25833]	2590	6460	3	5	*m*	0.779	2.49	B	1, 3
			[25833]	2590	6460	3	5	*e*	1.05×10^{-6}	0.0360	C	3
2		$^3P-^1D$										
			[1888.2]	0	[52960]	1	5	*e*	5.0×10^{-4}	3.6×10^{-5}	D	3
			[1985.3]	2590	[52960]	3	5	*m*	8.0	0.0117	C	1, 2, 3
			[1985.3]	2590	[52960]	3	5	*e*	0.0018	1.6×10^{-4}	D	3
			[2149.9]	6460	[52960]	5	5	*m*	18.9	0.0348	C	1, 2, 3
			[2149.9]	6460	[52960]	5	5	*e*	0.0083	0.0011	D	3
3		$^3P-^1S$										
			[950.66]	2590	[107780]	3	1	*m*	210	0.0067	C	2, 3
			[986.97]	6460	[107780]	5	1	*e*	0.17	9.6×10^{-5}	D	3
4		$^1D-^1S$										
			[1824.2]	[52960]	[107780]	5	1	*e*	5.4	0.065	C	3

Si x

Ground State $1s\,^2 2s^2 2p\,^2P^\circ_{1/2}$

Ionization Potential 401.3 eV = 3237400 cm^{-1}

Allowed Transitions

List of tabulated lines:

Wavelength [Å]	No.	Wavelength [Å]	No.	Wavelength [Å]	No.
50.524	10	280.03	6	360.63	7
50.691	10	280.32	6	361.13	7
50.703	10	287.25	4	391.85	9
253.81	3	289.28	4	392.43	9
256.58	3	292.31	4	398.50	9
258.39	3	347.43	1	399.11	9
261.27	3	348.71	5	540.95	8
272.00	2	349.00	5	553.71	8
277.27	2	356.07	1	554.45	8

Values for the majority of the transitions are calculated from the nuclear charge-expansion method of Cohen and Dalgarno [1], which includes limited configuration mixing. Graphical comparisons with other data for the lower ions of this isoelectronic sequence indicate that the uncertainties should be within 50 percent.

For the $2p^2P^\circ - 3d^2D$ multiplet we have obtained data by exploiting the dependence of f-values on nuclear charge: In this case accurate data for several other ions of the boron sequence are available from extended self-consistent field calculations by Weiss [2] in which configuration mixing is fully included. Utilizing those values, which are also supported by some experimental results on lower ions, we have obtained for this ion the f-value of the above multiplet simply by graphical interpolation.

References

[1] Cohen, M., and Dalgarno, A., Proc. Roy. Soc. London **A280**, 258–270 (1964).
[2] Weiss, A. W., private communication (1967).

Si x. Allowed Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
1	$2s^22p - 2s2p^2$	$^2P^\circ - ^2D$	*353.14*	*4660*	287830	6	10	23	0.073	0.51	−0.36	D	1
			[356.07]	6990	287830	4	6	23	0.066	0.31	−0.58	D	*ls*
			[347.43]	0	287830	2	4	21	0.074	0.17	−0.83	D	*ls*
			[356.07]	6990	287830	4	4	3.8	0.0073	0.034	−1.53	E	*ls*
2		$^2P^\circ - ^2S$	*275.49*	*4660*	367650	6	2	97	0.037	0.20	−0.65	D+	1
			[277.27]	6990	367650	4	2	62	0.036	0.13	−0.84	D+	*ls*
			[272.00]	0	367650	2	2	34	0.037	0.067	−1.13	D+	*ls*

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
3		$^2P^\circ-^2P$	*257.79*	*4660*	*392580*	6	6	180	0.18	0.90	0.03	D+	1
			[258.39]	6990	394000	4	4	150	0.15	0.50	−0.22	D+	*ls*
			[256.58]	0	389740	2	2	120	0.12	0.20	−0.62	D+	*ls*
			[261.27]	6990	389740	4	2	57	0.029	0.10	−0.94	D+	*ls*
			[253.81]	0	394000	2	4	31	0.060	0.10	−0.92	D+	*ls*
4	$2s2p^2-2p^3$	$^4P-^4S^\circ$	*290.44*	[*165888*]	[510190]	12	4	170	0.071	0.81	−0.07	D+	1
			[292.31]	[168090]	[510190]	6	4	83	0.071	0.41	−0.37	D+	*ls*
			[289.28]	[164500]	[510190]	4	4	56	0.071	0.27	−0.55	D+	*ls*
			[287.25]	[162060]	[510190]	2	4	30	0.074	0.14	−0.83	D+	*ls*
5		$^2D-^2D^\circ$	*348.89*	287830	*574456*	10	10	48	0.087	1.0	−0.06	D+	1
			[349.00]	287830	574360	6	6	44	0.081	0.56	−0.31	D+	*ls*
			[348.71]	287830	574600	4	4	43	0.078	0.36	−0.51	D+	*ls*
			[348.71]	287830	574600	6	4	4.8	0.0058	0.040	−1.46	E	*ls*
			[349.00]	287830	574360	4	6	3.2	0.0087	0.040	−1.46	E	*ls*
6		$^2D-^2P^\circ$	*280.13*	287830	[*644813*]	10	6	78	0.055	0.51	−0.26	D	1
			[280.03]	287830	[644940]	6	4	72	0.056	0.31	−0.47	D	*ls*
			[280.32]	287830	[644560]	4	2	78	0.046	0.17	−0.74	D	*ls*
			[280.03]	287830	[644940]	4	4	7.8	0.0092	0.034	−1.43	E	*ls*
7		$^2S-^2P^\circ$	*360.80*	367650	[*644813*]	2	6	15	0.088	0.21	−0.75	D	1
			[360.63]	367650	[644940]	2	4	15	0.059	0.14	−0.93	D	*ls*
			[361.13]	367650	[644560]	2	2	15	0.029	0.070	−1.24	D	*ls*
8		$^2P-^2D^\circ$	*549.83*	*392580*	*574456*	6	10	12	0.092	1.0	−0.26	D	1
			[554.45]	394000	574360	4	6	12	0.082	0.60	−0.48	D	*ls*
			[540.95]	389740	574600	2	4	11	0.093	0.33	−0.73	D	*ls*
			[553.71]	394000	574600	4	4	2.0	0.0092	0.067	−1.43	E	*ls*
9		$^2P-^2P^\circ$	*396.46*	*392580*	[*644813*]	6	6	50	0.12	0.92	−0.14	D	1
			[398.50]	394000	[644940]	4	4	41	0.097	0.51	−0.41	D	*ls*
			[392.43]	389740	[644560]	2	2	34	0.077	0.20	−0.81	D	*ls*
			[399.11]	394000	[644560]	4	2	16	0.019	0.10	−1.12	D	*ls*
			[391.85]	389740	[644940]	2	4	8.4	0.039	0.10	−1.11	D	*ls*
10	$2p-(^1S)3d$	$^2P^\circ-^2D$	*50.636*	*4660*	*1979542*	6	10	9800	0.63	0.63	0.58	C	interp
			[50.691]	6990	1979730	4	6	9800	0.57	0.38	0.36	C	*ls*
			[50.524]	0	1979260	2	4	8200	0.63	0.21	0.10	C	*ls*
			[50.703]	6990	1979260	4	4	1600	0.063	0.042	−0.60	D	*ls*

Si x

Forbidden Transitions

List of tabulated lines:

Wavelength [Å]	No.	Wavelength [Å]	No.	Wavelength [Å]	No.
431.15	5	501.10	4	3794.0	8
435.73	5	795.10	3	4525.7	8
439.21	5	810.83	3	14302	1
442.65	5	835.14	3	16579	2
443.97	5	941.89	7	23468	9
451.16	5	981.26	7	27848	2
486.40	4	1252.8	6	40972	2
492.25	4				

For all the values on this ion Garstang [1] is the only available source. The transition probability of the magnetic dipole transition in the ground state $2p$ configuration should be quite accurate, since it does not depend on the interaction parameters. The rest of the magnetic dipole values should be good to within 25 percent since the energy levels are experimentally known.

The electric quadrupole integral s_q was determined by two independent methods: (a) extrapolation within the isoelectronic sequence and (b) by using the Coulomb approximation. The two results agreed in predicting an s_q of 0.20.

Reference

[1] Garstang, R. H., Ann. Astrophys. **25**, 109 (1962).

Si x. Forbidden Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	Type of Transition	A_{ki}(sec^{-1})	S(at.u.)	Accuracy	Source
1	$2p-(^1S)2p$	$^2P^\circ-^2P^\circ$										
			[14302]	0	6990	2	4	m	3.07	1.33	A	1
			[14302]	0	6990	2	4	e	1.5×10^{-5}	0.021	D	1
2	$2s2p^2-2s2p^2$	$^4P-^4P$										
			[40972]	[162060]	[164500]	2	4	m	0.32	3.26	C	1
			[40972]	[162060]	[164500]	2	4	e	7.6×10^{-9}	0.0021	D	1
			[16579]	[162060]	[168090]	2	6	e	4.2×10^{-6}	0.019	D	1
			[27848]	[164500]	[168090]	4	6	m	0.74	3.56	C	1
			[27848]	[164500]	[168090]	4	6	e	4.4×10^{-7}	0.026	D	1
3		$^4P-^2D$										
			[795.10]	[162060]	287830	2	4	m	4.8	3.58×10^{-4}	C	1
			[795.10]	[162060]	287830	2	4	e	0.024	1.8×10^{-5}	D	1
			[810.83]	[164500]	287830	4	4	m	18	0.00142	C	1
			[810.83]	[164500]	287830	4	4	e	0.0010	8.3×10^{-7}	D	1
			[835.14]	[168090]	287830	6	4	m	5.7	4.92×10^{-4}	C	1
			[835.14]	[168090]	287830	6	4	e	0.29	2.8×10^{-4}	D	1
			[795.10]	[162060]	287830	2	6	e	0.0038	4.3×10^{-6}	D	1
			[810.83]	[164500]	287830	4	6	m	10	0.00119	C	1
			[810.83]	[164500]	287830	4	6	e	0.26	3.3×10^{-4}	D	1
			[835.14]	[168090]	287830	6	6	m	47	0.0061	C	1
			[835.14]	[168090]	287830	6	6	e	0.080	1.2×10^{-4}	D	1

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	Type of Transition	A_{ki}(sec^{-1})	S(at.u.)	Accuracy	Source
4		$^4P-^2S$										
			[486.40]	[162060]	367650	2	2	*m*	60	5.1×10^{-4}	C	1
			[492.25]	[164500]	367650	4	2	*m*	240	0.00212	C	1
			[492.25]	[164500]	367650	4	2	*e*	0.0072	2.5×10^{-7}	D	1
			[501.10]	[168090]	367650	6	2	*e*	0.15	5.6×10^{-6}	D	1
5		$^4P-^2P$										
			[439.21]	[162060]	389740	2	2	*m*	13	8.2×10^{-5}	C	1
			[443.97]	[164500]	389740	4	2	*m*	7.6	4.93×10^{-5}	C	1
			[443.97]	[164500]	389740	4	2	*e*	0.10	2.0×10^{-6}	D	1
			[451.16]	[168090]	389740	6	2	*e*	0.057	1.3×10^{-6}	D	1
			[431.15]	[162060]	394000	2	4	*m*	5.0	5.9×10^{-5}	C	1
			[431.15]	[162060]	394000	2	4	*e*	0.027	9.5×10^{-7}	D	1
			[435.73]	[164500]	394000	4	4	*m*	8.4	1.03×10^{-4}	C	1
			[435.73]	[164500]	394000	4	4	*e*	0.097	3.6×10^{-6}	D	1
			[442.65]	[168090]	394000	6	4	*m*	13	1.67×10^{-4}	C	1
			[442.65]	[168090]	394000	6	4	*e*	0.043	1.7×10^{-6}	D	1
6		$^2D-^2S$										
			[1252.8]	287830	367650	4	2	*m*	0.16	2.33×10^{-5}	C	1
			[1252.8]	287830	367650	4	2	*e*	9.0	0.033	D	1
			[1252.8]	287830	367650	6	2	*e*	13	0.049	D	1
7		$^2D-^2P$										
			[981.26]	287830	389740	4	2	*m*	14	9.8×10^{-4}	C	1
			[981.26]	287830	389740	4	2	*e*	0.67	7.3×10^{-4}	D	1
			[981.26]	287830	389740	6	2	*e*	1.3	0.0014	D	1
			[941.89]	287830	394000	4	4	*m*	26	0.00322	C	1
			[941.89]	287830	394000	4	4	*e*	0.053	9.4×10^{-5}	D	1
			[941.89]	287830	394000	6	4	*m*	15	0.00186	C	1
			[941.89]	287830	394000	6	4	*e*	0.0075	1.3×10^{-5}	D	1
8		$^2S-^2P$										
			[4525.7]	367650	389740	2	2	*m*	11	0.076	C	1
			[3794.0]	367650	394000	2	4	*m*	4.6	0.0373	C	1
			[3794.0]	367650	394000	2	4	*e*	2.0×10^{-4}	3.7×10^{-4}	D	1
9		$^2P-^2P$										
			[23468]	389740	394000	2	4	*m*	0.67	1.28	C	1
			[23468]	389740	394000	2	4	*e*	1.2×10^{-6}	0.020	D	1

Si XI

Ground State $1s^22s^2\ ^1S_0$

Ionization Potential 476.0 eV = 3840470 cm^{-1}

Allowed Transitions

Garstang and Shamey [1] have obtained the *f*-value for the intercombination line $2^1S_0-2^3P_1$ by calculating the ratio of this line against the resonance transition in the intermediate coupling approximation and by using for the resonance line a value calculated according to Cohen and Dalgarno's method [2]. The data calculated from the charge-expansion method of Cohen and Dalgarno, [2] which includes limited configuration mixing, are estimated to be usually accurate to 50 percent or better, while the charge-expansion method of Naqvi and Victor [3] should be less

reliable when the effects of configuration interaction are strong, since these are neglected entirely. In assigning the accuracy estimates for these methods as well as for the Coulomb approximation we were to a great extent guided by studying the degree of fit of the data into the systematic trends along isoelectronic sequences.

References

[1] Garstang, R. H., and Shamey, L. J., Astrophys. J. **148**, 665–666 (1967).
[2] Cohen, M., and Dalgarno, A., Proc. Roy. Soc. London **A280**, 258–270 (1964).
[3] Naqvi, A. M., and Victor, G. A., Technical Documentary Report No. RTD TDR–63–3118 (1964).

Si XI. Allowed Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
1	$2s^2-2s(^2S)2p$	$^1S-^3P^\circ$	[582.89]	0	[171560]	1	3	0.0050	7.6×10^{-5}	1.4×10^{-4}	−4.12	D	1*n*
2		$^1S-^1P^\circ$	[303.58]	0	329400	1	3	64	0.264	0.264	−0.58	C	2
3	$2s2p-2p^2$	$^3P^\circ-^3P$	*365.08*	[*174208*]	[*448122*]	9	9	51	0.10	1.1	−0.05	D+	2
			[365.42]	[176810]	[450470]	5	5	38	0.076	0.46	−0.42	D+	*ls*
			[364.50]	[171560]	[445910]	3	3	13	0.026	0.092	−1.11	D−	*ls*
			[371.61]	[176810]	[445910]	5	3	20	0.025	0.15	−0.90	D−	*ls*
			[368.38]	[171560]	[443020]	3	1	49	0.033	0.12	−1.00	D−	*ls*
			[358.54]	[171560]	[450470]	3	5	13	0.042	0.15	−0.90	D−	*ls*
			[361.31]	[169140]	[445910]	1	3	17	0.10	0.12	−1.00	D−	*ls*
4		$^1P^\circ-^1D$	[609.76]	329400	493400	3	5	11	0.11	0.64	−0.48	D−	2
5		$^1P^\circ-^1S$	[359.41]	329400	607630	3	1	100	0.068	0.24	−0.69	E	2
6	$2s^2-2s(^2S)3p$	$^1S-^1P^\circ$	[43.763]	0	2285040	1	3	7200	0.62	0.089	−0.21	E	3
7	$2s2p-2s(^2S)3s$	$^1P^\circ-^1S$	[52.299]	329400	2241480	3	1	580	0.0079	0.0041	−1.63	E	3
8	$2s3s-2s(^2S)3p$	$^1S-^1P^\circ$	[2295.0]	2241480	2285040	1	3	0.68	0.160	1.21	−0.80	C	3
9	$2s3p-2s(^2S)3d$	$^1P^\circ-^1D$	[1316.3]	2285040	2361010	3	5	3.04	0.132	1.71	−0.402	C	*ca*
10	$2p3p-2p(^2P^\circ)3d$	$^1D-^1F^\circ$	[2040.6]	2532140	2581130	5	7	0.83	0.073	2.44	−0.438	C	*ca*

Si XI

Forbidden Transitions

The transition probability for that part of the $2s^2\,^1S_0-2s2p\,^3P_2$ transition which is magnetic quadrupole radiation is taken from calculations of Garstang [1]. We have renormalized his result using for the resonance line a transition integral calculated by the method of Cohen and Dalgarno [2] (see also Allowed Transitions; for the addition of transition probabilities arising from various types of radiation, see the General Introduction; for the relation of A_{ki} (m.q.) to other quantities [1]).

Naqvi's calculations [3] are the only available source for the other transitions. The results for the $^3P^\circ - ^3P^\circ$ lines are essentially independent of the choice of the interaction parameters. For the $^3P^\circ - ^1P^\circ$ transitions, Naqvi uses empirical term intervals, i.e., the effects of configuration interaction should be partially included.

References

[1] Garstang, R. H., Astrophys. J. **148**, 579–584 (1967).
[2] Cohen, M. and Dalgarno, A., Proc. Roy. Soc. London **A280**, 258–270 (1964).
[3] Naqvi, A. M., Thesis Harvard (1951).

Si XI. Forbidden Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	Type of Transition	A_{ki}(sec^{-1})	S(at.u.)	Accuracy	Source
1	$2s^2 - 2s(^2S)2p$	$^1S - ^3P^\circ$										
			565.58	0	[176810]	1	5	*m.q.*	0.14	.....	E	1, 2
2	$2s2p - 2s(^2S)2p$	$^3P^\circ - ^3P^\circ$										
			[41311]	[169140]	[171560]	1	3	*m*	0.255	2.00	A	3
			[19042]	[171560]	[176810]	3	5	*m*	1.95	2.50	A	3
3		$^3P^\circ - ^1P^\circ$										
			[623.99]	[169140]	329400	1	3	*m*	39.2	0.00106	C	3
			[633.55]	[171560]	329400	3	3	*m*	1220	0.0346	C	3
			[655.35]	[176810]	329400	5	3	*m*	42.5	0.00133	C	3

Si XII

Ground State $1s^22s\ ^2S_{1/2}$

Ionization Potential 523.2 eV = 4221460 cm^{-1}

Allowed Transitions

For the transition $2s - 2p$, the charge-expansion calculation of Cohen and Dalgarno [1] is chosen. An uncertainty of less than 10 percent is indicated from the graphical comparison of this value with the other material for the same transition within the isoelectronic sequence. Data for the other listed transitions have been obtained from the Coulomb approximation. Plots of the dependence of f-value on nuclear charge for all these transitions have been made and show that this material connects up very smoothly with the data for the lower ions as well as with the hydrogenic value for infinite nuclear charge. Based on this impressive agreement, accuracies of 10 percent (or 25 percent for some of the smaller values) are indicated.

References

[1] Cohen, M., and Dalgarno, A., Proc. Roy. Soc. London **A280**, 258–270 (1964).

Si XII. Allowed Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
1	$2s-2p$	$^2S-^2P^\circ$	*506.35*	0	*197493*	2	6	9.36	0.108	0.360	−0.666	B	1
			[499.28]	0	200290	2	4	9.77	0.0730	0.240	−0.836	B	*ls*
			[521.10]	0	191900	2	2	8.59	0.0350	0.120	−1.155	B	*ls*
2	$2p-3s$	$^2P^\circ-^2S$	*45.598*	*197493*	2390580	6	2	1990	0.0207	0.0186	−0.906	B	*ca*
			[45.656]	200290	2390580	4	2	1320	0.0207	0.0124	−1.082	B	*ls*
			[45.482]	191900	2390580	2	2	668	0.0207	0.00620	−1.383	B	*ls*
3	$2p-3d$	$^2P^\circ-^2D$	*44.118*	*197493*	*2464134*	6	10	1.39×10^4	0.675	0.588	0.607	B	*ca*
			[44.165]	200290	2464530	4	6	1.38×10^4	0.607	0.353	0.385	B	*ls*
			[44.021]	191900	2463540	2	4	1.16×10^4	0.676	0.196	0.131	B	*ls*
			[44.184]	200290	2463540	4	4	2300	0.0674	0.0392	−0.569	B	*ls*

PHOSPHORUS

P I

Ground State $1s^2 2s^2 2p^6 3s^2 3p^3\ {}^4S^\circ_{3/2}$

Ionization Potential 10.484 eV = 84580 cm^{-1}

Allowed Transitions

List of tabulated lines:

Wavelength [Å]	No.	Wavelength [Å]	No.	Wavelength [Å]	No.
1534.7	4	5098.20	16	7486.79	24
1534.73	4	5100.96	16	7496.23	24
1671.68	1	5109.62	16	7505.76	24
1674.61	1	5149.46	15	7563.63	24
1679.71	1	5154.84	15	7600.7	24
1719.00	3	5162.28	15	7834.2	25
1725.85	3	5166.8	16	7917.84	25
1774.99	2	5189.9	15	7953.9	25
1782.87	2	5222.1	15	8002.63	25
1787.68	2	5258.1	15	8046.79	25
1858.91	7	5262.07	19	8090.08	25
1859.43	7	5293.53	19	8139.1	25
2135.47	6	5345.86	19	8190.4	25
2136.18	6	5378.32	19	8637.62	20
2149.14	6	5458.31	18	8741.54	20
2152.94	10	5477.75	18	9175.85	13
2154.08	10	5548.49	18	9304.88	13
2222.57	5	6673.71	21	9525.78	13
2223.35	5	6717.42	21	9563.45	12
2234.95	5	6979.76	23	9593.54	12
2235.73	5	6985.2	23	9608.97	12
2242.53	5	7001.54	23	9734.74	12
2533.99	9	7017.32	23	9750.73	12
2535.61	9	7051.93	23	9790.08	14
2553.25	9	7084.2	23	9796.79	12
2554.90	9	7102.21	23	9903.74	14
2659.4	8	7154.03	23	9976.65	12
2675.31	8	7158.37	22	10084.2	14
2677.13	8	7165.45	22	10204.7	14
2686.17	8	7175.12	22	10511.4	11
2688.00	8	7176.66	22	10529.5	11
4978.11	17	7197.83	22	10581.5	11
5015.86	17	7235.49	22	10596.9	11
5045.40	16	7268.33	22	10681.4	11
5059.20	16	7282.38	22	10769	11
5061.91	16	7343.11	22	10813.0	11
5079.37	17	7459.80	24	10974	11

Varsavsky's value [1] for the $3s^2 3p^3\ {}^4S^\circ - 3s3p^4\ {}^4P$ multiplet, calculated by means of a screening approximation which neglects the important effects of configuration interaction, should be quite uncertain—probably too high as judged from other comparisons. Results of lifetime measurements and intermediate coupling calculations by Lawrence [2] have been adopted for many lines in the uv region. The measured lifetimes have been used by Lawrence to provide an absolute

scale for the calculated transition probabilities. The f-values of transitions involving a change in spin (intercombination lines) are expected to be rather uncertain, since they are quite small.

The above two sources cover only a small portion of the known multiplets of this atom. Thus the Coulomb approximation has been extensively employed in order to have at least some of the remaining prominent lines represented. Since there is very little comparison material available for analogous transitions, these values should be used cautiously, particularly those transitions with accuracy assignments of "E", since severe cancellation in the transition integral occurs for the latter. Additional uncertainties in these data may be due to deviations from LS-coupling. There are indications from the energy level spacings that some deviations may be encountered.

References

[1] Varsavsky, C. M., Astrophys. J. Suppl. Ser. **6**, 75–108 (1961).
[2] Lawrence, G. M., Astrophys. J. **148**, 261–268 (1967).

P I. Allowed Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
1	$3s^23p^3-3s3p^4$	$^4S^\circ-^4P$ (2 uv)	*1676.6*	0	*59643*	4	12	11	1.4	30	0.74	E	1
			1679.71	0	59535	4	6	11	0.68	15	0.43	E	*ls*
			1674.61	0	59716	4	4	11	0.45	10	0.26	E	*ls*
			1671.68	0	59820	4	2	11	0.23	5.0	−0.04	E	*ls*
2	$3p^3-3p^2(^3P)4s$	$^4S^\circ-^4P$ (1 uv)	*1779.7*	0	*56190*	4	12	2.16	0.307	7.2	0.089	C	2
			1774.99	0	56340	4	6	2.17	0.154	3.59	−0.210	C	2
			1782.87	0	56090	4	4	2.14	0.102	2.39	−0.389	C	2
			1787.68	0	55939	4	2	2.13	0.051	1.20	−0.69	C	2
3		$^4S^\circ-^2P$											
			1719.00	0	58174	4	4	0.0026	1.2×10^{-4}	0.0026	−3.32	E	2
			1727.85	0	57877	4	2	0.0015	3.4×10^{-5}	7.6×10^{-4}	−3.87	E	2
4	$3p^3-3p^2(^1D)4s'$	$^4S^\circ-^2D$											
			1534.73	0	65157	4	6	4.4×10^{-4}	2.3×10^{-5}	4.7×10^{-4}	−4.04	E	2
			[1534.7]	0	65157	4	4	8.2×10^{-5}	2.9×10^{-6}	5.9×10^{-5}	−4.94	E	2
5	$3p^3-3p^2(^3P)4s$	$^2D^\circ-^4P$ (3 uv)											
			2223.35	11376	56340	6	6	8.8×10^{-4}	6.5×10^{-5}	0.0029	−3.41	E	2
			2234.95	11362	56090	4	4	0.0013	9.7×10^{-5}	0.0029	−3.41	E	2
			2235.73	11376	56090	6	4	0.0062	3.1×10^{-4}	0.014	−2.73	E	2
			2242.53	11362	55939	4	2	0.0040	1.5×10^{-4}	0.0045	−3.22	E	2
			2222.57	11362	56340	4	6	5.4×10^{-5}	6.0×10^{-6}	1.8×10^{-4}	−4.62	E	2
6		$^2D^\circ-^2P$ (4 uv)	*2140.4*	*11370*	*58075*	10	6	3.06	0.126	8.9	0.100	C	2
			2136.18	11376	58174	6	4	2.83	0.129	5.4	−0.111	C	2
			2149.14	11362	57877	4	2	3.18	0.110	3.12	−0.357	C	2
			2135.47	11362	58174	4	4	0.211	0.0144	0.406	−1.240	C	2
7	$3p^3-3p^2(^1D)4s'$	$^2D^\circ-^2D$ (5 uv)	*1859.2*	*11370*	65157	10	10	2.81	0.145	8.9	0.161	C	2
			1859.43	11376	65157	6	6	2.64	0.137	5.0	−0.085	C	2
			1858.91	11362	65157	4	4	2.54	0.132	3.22	−0.277	C	2
			1859.43	11376	65157	6	4	0.226	0.0078	0.287	−1.330	C	2
			1858.91	11362	65157	4	6	0.232	0.0180	0.441	−1.143	C	2

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
8	$3p^3-3p^2(^3P)4s$	$^2P^\circ-^4P$ (7 uv)											
			2677.13	18748	56090	4	4	0.0013	1.4×10^{-4}	0.0049	−3.25	E	2
			2686.17	18722	55939	2	2	3.9×10^{-4}	4.2×10^{-5}	7.5×10^{-4}	−4.08	E	2
			[2659.4]	18748	56340	4	6	4.1×10^{-7}	6.5×10^{-8}	2.3×10^{-6}	−6.59	E	2
			2675.31	18722	56090	2	4	2.7×10^{-4}	5.8×10^{-5}	0.0010	−3.94	E	2
			2688.00	18748	55939	4	2	4.1×10^{-4}	2.2×10^{-5}	7.9×10^{-4}	−4.06	E	2
9		$^2P^\circ-^2P$ (8 uv)	*2541.4*	*18739*	*58075*	6	6	1.11	0.108	5.4	−0.188	C	2
			2535.61	18748	58174	4	4	0.95	0.092	3.06	−0.434	C	2
			2553.25	18722	57877	2	2	0.71	0.069	1.17	−0.86	C	2
			2554.90	18748	57877	4	2	0.300	0.0147	0.494	−1.231	C	2
			2533.99	18722	58174	2	4	0.200	0.0385	0.64	−1.114	C	2
10	$3p^3-3p^2(^1D)4s'$	$^2P^\circ-^2D$ (9 uv)	*2153.7*	*18739*	65157	6	10	0.61	0.071	3.02	−0.371	C	2
			2154.08	18748	65157	4	6	0.58	0.061	1.72	−0.61	C	2
			2152.94	18722	65157	2	4	0.485	0.067	0.96	−0.87	C	2
			2154.08	18748	65157	4	4	0.173	0.0120	0.341	−1.319	C	2
11	$3p^24s-3p^2(^3P)4p$	$^4P-^4D^\circ$ (1)	*10604*	*56190*	*65618*	12	20	0.20	0.57	240	0.84	D	*ca*
			10581.5	56340	65787	6	8	0.21	0.47	99	0.45	D	*ls*
			10529.5	56090	65585	4	6	0.15	0.37	51	0.17	D	*ls*
			10511.4	55939	65450	2	4	0.088	0.29	20	−0.24	D	*ls*
			10813.0	56340	65585	6	6	0.060	0.10	22	−0.20	D	*ls*
			10681.4	56090	65450	4	4	0.11	0.19	26	−0.13	D	*ls*
			10596.9	55939	65373	2	2	0.17	0.29	20	−0.24	D	*ls*
			[10974]	56340	65450	6	4	0.0095	0.011	2.5	−1.16	E	*ls*
			[10769]	56090	65373	4	2	0.033	0.029	4.1	−0.94	E	*ls*
12		$^4P-^4P^\circ$ (2)	*9744.9*	*56190*	*66449*	12	12	0.26	0.36	140	0.64	D	*ca*
			9796.79	56340	66544	6	6	0.18	0.26	50	0.19	D	*ls*
			9734.74	56090	66360	4	4	0.035	0.049	6.3	−0.71	E	*ls*
			9608.97	55939	66343	2	2	0.044	0.062	3.9	−0.91	E	*ls*
			9976.65	56340	66360	6	4	0.11	0.11	22	−0.18	D	*ls*
			9750.73	56090	66343	4	2	0.22	0.15	20	−0.21	D	*ls*
			9563.45	56090	66544	4	6	0.081	0.17	21	−0.17	D	*ls*
			9593.54	55939	66360	2	4	0.11	0.31	19	0.21	D	*ls*
13		$^4P-^4S^\circ$ (3)	*9391.5*	*56190*	66835	12	4	0.29	0.13	47	0.18	D	*ca*
			9525.78	56340	66835	6	4	0.14	0.13	24	−0.12	D	*ls*
			9304.88	56090	66835	4	4	0.096	0.13	15	−0.30	D	*ls*
			9175.85	55939	66835	2	4	0.050	0.13	7.6	−0.60	D−	*ls*
14		$^2P-^2P^\circ$ (4)	*10023*	*58075*	*68049*	6	6	0.27	0.39	77	0.37	D	*ca*
			10084.2	58174	68088	4	4	0.21	0.32	43	0.11	D	*ls*
			9903.74	57877	67971	2	2	0.18	0.26	17	−0.29	D	*ls*
			10204.7	58174	67971	4	2	0.083	0.065	8.7	−0.59	D−	*ls*
			9790.08	57877	68088	2	4	0.045	0.13	8.3	−0.59	D−	*ls*
15	$3p^24s-3p^2(^3P)5p$	$^4P-^4D^\circ$											
			5162.28	56340	75705	6	8	0.032	0.017	1.7	−0.99	E	*ca, ls*
			5154.84	56090	75484	4	6	0.015	0.0091	0.62	−1.44	E	*ca, ls*
			5149.46	55939	75353	2	4	0.0066	0.0052	0.18	−1.98	E	*ca, ls*
			[5222.1]	56340	75484	6	6	0.0058	0.0024	0.24	−1.85	E	*ca, ls*
			[5189.9]	56090	75353	4	4	0.0075	0.0030	0.21	−1.92	E	*ca, ls*
			[5258.1]	56340	75353	6	4	5.7×10^{-4}	1.6×10^{-4}	0.016	−3.03	E	*ca, ls*

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
16		$^4P-^4P^\circ$	*5098.3*	*56190*	*75799*	12	12	0.042	0.016	3.3	−0.71	E	*ca*
			5109.62	56340	75905	6	6	0.034	0.013	1.3	−1.10	E	*ls*
			5100.96	56090	75689	4	4	0.0046	0.0018	0.12	−2.14	E	*ls*
			5059.20	55939	75700	2	2	0.0063	0.0024	0.080	−2.32	E	*ls*
			[5166.8]	56340	75689	6	4	0.014	0.0037	0.38	−1.65	E	*ls*
			5098.20	56090	75700	4	2	0.029	0.0057	0.38	−1.64	E	*ls*
			5045.40	56090	75905	4	6	0.016	0.0090	0.60	−1.44	E	*ls*
			5061.91	55939	75689	2	4	0.015	0.012	0.39	−1.63	E	*ls*
17		$^4P-^4S^\circ$	*5041.0*	*56190*	76022	12	4	0.059	0.0075	1.5	−1.04	E	*ca*
			5079.37	56340	76022	6	4	0.029	0.0074	0.75	−1.35	E	*ls*
			5015.86	56090	76022	4	4	0.020	0.0077	0.51	−1.51	E	*ls*
			4978.11	55939	76022	2	4	0.011	0.0079	0.26	−1.80	E	*ls*
18		$^2P-^2D^\circ$	*5475.8*	*58075*	*76332*	6	10	0.052	0.039	4.2	−0.63	E	*ca*
			5477.75	58174	76425	4	6	0.057	0.038	2.8	−0.81	E	*ls*
			5458.31	57877	76192	2	4	0.038	0.034	1.2	−1.17	E	*ls*
			5548.49	58174	76192	4	4	0.0066	0.0031	0.22	−1.91	E	*ls*
19		$^2P-^2P^\circ$	*5328.4*	*58075*	*76837*	6	6	0.087	0.037	3.9	−0.65	E	*ca*
			5345.86	58174	76875	4	4	0.073	0.031	2.2	−0.90	E	*ls*
			5293.53	57877	76762	2	2	0.058	0.024	0.84	−1.32	E	*ls*
			5378.32	58174	76762	4	2	0.027	0.0060	0.42	−1.62	E	*ls*
			5262.07	57877	76875	2	4	0.015	0.013	0.44	−1.60	E	*ls*
20	$3p^24p-3p^2(^3P)4d$	$^2S^\circ-^2P$	*8706.9*	64240	*75722*	2	6	0.087	0.30	17	−0.23	D	*ca*
			8741.54	64240	75676	2	4	0.091	0.21	12	−0.38	D	*ls*
			8637.62	64240	75814	2	2	0.079	0.089	5.1	−0.75	D	*ls*
21	$3p^24p-3p^2(^3P)5d$	$^2S^\circ-^2P$	*6702.8*	64240	*79155*	2	6	0.048	0.097	4.3	−0.71	E	*ca*
			6717.42	64240	79122	2	4	0.050	0.067	3.0	−0.87	E	*ls*
			6673.71	64240	79220	2	2	0.045	0.030	1.3	−1.22	E	*ls*
22		$^4D^\circ-^4F$	*7181.4*	*65618*	*79539*	20	28	0.053	0.057	27	0.06	E	*ca*
			7175.12	65787	79721	8	10	0.033	0.032	6.0	−0.60	E	*ls*
			7176.66	65585	79515	6	8	0.047	0.049	6.9	−0.53	E	*ls*
			7165.45	65450	79402	4	6	0.050	0.058	5.5	−0.65	E	*ls*
			7158.37	65373	79339	2	4	0.051	0.078	3.7	−0.81	E	*ls*
			7282.38	65787	79515	8	8	0.0081	0.0065	1.2	−1.29	E	*ls*
			7235.49	65585	79402	6	6	0.017	0.013	1.9	−1.11	E	*ls*
			7197.83	65450	79339	4	4	0.020	0.016	1.5	−1.20	E	*ls*
			7343.11	65787	79402	8	6	6.5×10^{-4}	4.0×10^{-4}	0.076	−2.50	E	*ls*
			7268.33	65585	79339	6	4	0.0015	7.7×10^{-4}	0.11	−2.33	E	*ls*
23		$^4D^\circ-^4D$											
			7102.21	65787	79864	8	8	0.0036	0.0027	0.51	−1.66	E	*ca, ls*
			7051.93	65585	79762	6	6	0.0037	0.0028	0.39	−1.78	E	*ca, ls*
			7017.32	65450	79697	4	4	0.0032	0.0024	0.22	−2.02	E	*ca, ls*
			7154.03	65787	79762	8	6	0.0013	7.6×10^{-4}	0.14	−2.21	E	*ca, ls*
			[7084.2]	65585	79697	6	4	0.0029	0.0015	0.21	−2.05	E	*ca, ls*
			7001.54	65585	79864	6	8	5.4×10^{-4}	5.3×10^{-4}	0.073	−2.50	E	*ca, ls*
			[6985.2]	65450	79762	4	6	0.0014	0.0016	0.14	−2.20	E	*ca, ls*
			6979.76	65373	79697	2	4	0.0020	0.0029	0.13	−2.24	E	*ca, ls*

P I. Allowed Transitions—*Continued*

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
24		$^4P^\circ - {}^4D$											
			7505.76	66544	79864	6	8	0.018	0.020	3.0	−0.92	E	*ca*, *ls*
			7459.80	66360	79762	4	6	0.018	0.022	2.2	−1.05	E	*ca*, *ls*
			7486.79	66343	79697	2	4	0.013	0.021	1.1	−1.37	E	*ca*, *ls*
			7563.63	66544	79762	6	6	0.0079	0.0068	1.0	−1.39	E	*ca*, *ls*
			7496.23	66360	79697	4	4	0.016	0.014	1.4	−1.26	E	*ca*, *ls*
			[7600.7]	66544	79697	6	4	0.0016	9.2×10^{-4}	0.14	−2.26	E	*ca*, *ls*
25	$3p^24p - 3p^2(^3P)6s$	$^4D^\circ - {}^4P$	*8055.2*	*65618*	*78029*	20	12	0.030	0.017	9.2	−0.46	D−	*ca*
			8046.79	65787	78211	8	6	0.023	0.017	3.6	−0.86	D−	*ls*
			8090.08	65585	77942	6	4	0.020	0.013	2.0	−1.11	D−	*ls*
			[8190.4]	65450	77656	4	2	0.015	0.0075	0.81	−1.52	E	*ls*
			7917.84	65585	78211	6	6	0.0053	0.0049	0.77	−1.53	E	*ls*
			8002.63	65450	77942	4	4	0.010	0.0097	1.0	−1.41	E	*ls*
			[8139.1]	65373	77656	2	2	0.015	0.015	0.81	−1.52	E	*ls*
			[7834.2]	65450	78211	4	6	5.8×10^{-4}	8.1×10^{-4}	0.083	−2.49	E	*ls*
			[7953.9]	65373	77942	2	4	0.0016	0.0030	0.16	−2.22	E	*ls*

P I

Forbidden Transitions

All the values for this atom are taken from the work of Czyzak and Krueger [1], since they have included the important effects of configuration interaction and have used self-consistent field wavefunctions with exchange to obtain their value of s_q. (For a more complete discussion see the General Introduction).

Reference

[1] Czyzak, S. J. & Krueger, T. K., Monthly Notices Roy. Astron. Soc. **126**, 177–194 (1963).

P I. Forbidden Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	Type of Transition	A_{ki}(sec^{-1})	S(at.u.)	Accuracy	Source
1	$3p^3 - 3p^3$	$^4S^\circ - {}^2D^\circ$ (1F)										
			8787.6	0.0	11376.4	4	6	*m*	9.1×10^{-6}	1.37×10^{-6}	C	1
			8787.6	0.0	11376.4	4	6	*e*	1.9×10^{-4}	0.035	D	1
			8799.1	0.0	11360.8	4	4	*m*	1.77×10^{-4}	1.79×10^{-5}	C	1
			8799.1	0.0	11360.8	4	4	*e*	1.2×10^{-4}	0.015	D	1
2		$^4S^\circ - {}^2P^\circ$ (2F)										
			5332.4	0.0	18748.0	4	4	*m*	0.108	0.00243	C	1
			5332.4	0.0	18748.0	4	4	*e*	3.3×10^{-7}	3.4×10^{-6}	D	1
			5339.7	0.0	18722.7	4	2	*m*	0.0426	4.81×10^{-4}	C	1
			5339.7	0.0	18722.7	4	2	*e*	4.7×10^{-6}	2.4×10^{-5}	D	1
3		$^2D^\circ - {}^2D^\circ$										
			[64.09×10^5]	11360.8	11376.4	4	6	*m*	4.10×10^{-8}	2.40	B	1
			[64.09×10^5]	11360.8	11376.4	4	6	*e*	7.7×10^{-18}	0.30	D	1

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	Type of Transition	A_{ki}(sec^{-1})	S(at.u.)	Accuracy	Source
4		$^2D^\circ-^2P^\circ$										
			[13562]	11376.4	18748.0	6	4	*m*	0.0190	0.0070	C	1
			[13562]	11376.4	18748.0	6	4	*e*	0.094	103	C	1
			[13580]	11360.8	18722.7	4	2	*m*	0.0211	0.00392	C	1
			[13580]	11360.8	18722.7	4	2	*e*	0.080	44.1	C	1
			[13609]	11376.4	18722.7	6	2	*e*	0.053	29.5	C	1
			[13533]	11360.8	18748.0	4	4	*m*	0.0341	0.0125	C	1
			[13533]	11360.8	18748.0	4	4	*e*	0.0405	43.8	C	1
5		$^2P^\circ-^2P^\circ$										
			[39.515 × 10^5]	18722.7	18748.0	2	4	*m*	1.45 × 10^{-7}	1.33	B	1
			[39.515 × 10^5]	18722.7	18748.0	2	4	*e*	5.9 × 10^{-17}	0.14	D	1

P II

Ground State $1s^22s^22p^63s^23p^2\ ^3P_0$

Ionization Potential 19.72 eV = 159100 cm^{-1}

Allowed Transitions

List of tabulated lines:

Wavelength [Å]	No.	Wavelength [Å]	No.	Wavelength [Å]	No.
1301.87	2	4530.81	10	5316.07	4
1304.47	2	4533.96	11	5344.75	4
1304.68	2	4554.83	12	5378.20	18
1305.48	2	4565.27	12	5386.88	4
1309.87	2	4582.17	10	5409.72	4
1310.70	2	4588.04	9	5425.91	4
1532.51	1	4589.86	9	5450.74	18
1535.90	1	4602.08	9	5483.55	18
1536.39	1	4626.70	9	5499.73	4
1542.29	1	4628.77	12	5507.19	18
1543.09	1	4658.31	9	5541.14	18
1543.61	1	4698.16	9	5583.27	18
4385.35	16	4823.68	17	5588.34	19
4402.09	10	4864.42	17	5727.71	19
4414.28	11	4927.20	17	5764.46	19
4417.30	10	4935.62	15	6024.18	3
4420.71	8	4943.53	17	6034.04	3
4424.07	11	4954.39	17	6043.12	3
4463.00	11	4969.71	17	6055.50	20
4466.13	10	5040.80	13	6087.82	3
4467.98	11	5152.23	5	6165.59	3
4475.26	10	5191.41	5	6232.29	3
4483.68	11	5253.52	7	7735.06	21
4499.24	14	5296.13	5	7845.63	6

For the two uv transitions listed, the radiative lifetime measurements of Savage and Lawrence [1] performed with the phase shift technique are available. Corrections for cascading from higher excited states have been applied by these authors.

Since no other theoretical or experimental data are available for this spectrum as yet, the Coulomb approximation has been extensively used in order to have some of the more prominent lines tabulated. On the basis of the comparison material available for analogous transitions of neighboring atoms and because of the general success of the Coulomb approximation, accuracy estimates of 50 percent for the selected lines appear to be in order. But, in as much as these comparisons are still quite insufficient, the present accuracy assignments can be regarded only as provisional. There are furthermore indications from energy level spacings that this spectrum may show significant deviations from LS-coupling. Since LS-coupling had to be used for the breakdown into multiplets and lines, this may introduce additional uncertainties, especially in the weaker lines.

Reference

[1] Savage, B. D., and Lawrence, G. M., Astrophys. J. **146**, 940–943 (1966).

P II. Allowed Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
1	$3s^23p^2-3s3p^3$	$^3P-^3D^\circ$ (1 uv)	*1539.2*	*316*	*65285*	9	15	0.128	0.0076	0.346	−1.165	C+	1
			1542.29	469	65308	5	7	0.127	0.0063	0.161	−1.50	C+	*ls*
			1535.90	165	65273	3	5	0.096	0.0057	0.086	−1.77	C+	*ls*
			1532.51	0	65252	1	3	0.072	0.0076	0.038	−2.12	D	*ls*
			1543.09	469	65273	5	5	0.032	0.0011	0.029	−2.25	D	*ls*
			1536.39	165	65252	3	3	0.054	0.0019	0.029	−2.24	D	*ls*
			1543.61	469	65252	5	3	0.0035	7.6×10^{-5}	0.0019	−3.42	E	*ls*
2		$^3P-^3P^\circ$ (2 uv)	*1307.7*	*316*	*76788*	9	9	1.56	0.0400	1.55	−0.444	C	1
			1310.70	469	76765	5	5	1.17	0.0301	0.65	−0.82	C	*ls*
			1304.68	165	76813	3	3	0.392	0.0100	0.129	−1.52	C	*ls*
			1309.87	469	76813	5	3	0.65	0.0100	0.215	−1.301	C	*ls*
			1304.47	165	76824	3	1	1.57	0.0134	0.172	−1.396	C	*ls*
			1305.48	165	76765	3	5	0.392	0.0167	0.215	−1.300	C	*ls*
			1301.87	0	76813	1	3	0.53	0.0401	0.172	−1.397	C	*ls*
3	$3p4s-3p(^2P^\circ)4p$	$^3P^\circ-^3D$	*6052.0*	*86940*	*103459*	9	15	0.67	0.61	110	0.74	D	*ca*
			6043.12	87125	103669	5	7	0.68	0.52	52	0.42	D	*ls*
			6024.18	86745	103340	3	5	0.51	0.46	28	0.14	D	*ls*
			6034.04	86598	103166	1	3	0.37	0.61	12	−0.21	D	*ls*
			6165.59	87125	103340	5	5	0.16	0.091	9.3	−0.34	D−	*ls*
			6087.82	86745	103166	3	3	0.27	0.15	9.2	−0.34	D−	*ls*
			6232.29	87125	103166	5	3	0.017	0.0060	0.62	−1.52	E	*ls*
4		$^3P^\circ-^3P$	*5406.2*	*86940*	*105432*	9	9	0.93	0.41	65	0.56	D	*ca*
			5425.91	87125	105550	5	5	0.69	0.31	27	0.19	D	*ls*
			5386.88	86745	105303	3	3	0.23	0.10	5.4	−0.51	D−	*ls*
			5499.73	87125	105303	5	3	0.37	0.10	9.1	−0.30	D−	*ls*
			5409.72	86745	105225	3	1	0.93	0.14	7.2	−0.39	D−	*ls*
			5316.07	86745	105550	3	5	0.24	0.17	9.0	−0.29	D−	*ls*
			5344.75	86598	105303	1	3	0.32	0.41	7.2	−0.39	D−	*ls*

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
5		$^3P^\circ - ^3S$	*5244.6*	*86940*	106002	9	3	1.0	0.14	22	0.11	D	*ca*
			5296.13	87125	106002	5	3	0.55	0.14	12	−0.16	D	*ls*
			5191.41	86745	106002	3	3	0.35	0.14	7.1	−0.38	D	*ls*
			5152.23	86598	106002	1	3	0.12	0.14	2.4	−0.85	D	*ls*
6		$^1P^\circ - ^1P$	7845.63	88894	101636	3	3	0.33	0.30	23	−0.04	D	*ca*
7		$^1P^\circ - ^1D$	5253.52	88894	107924	3	5	1.0	0.72	37	0.33	D	*ca*
8		$^1P^\circ - ^1S$	4420.71	88894	111509	3	1	1.6	0.15	6.7	−0.34	D	*ca*
9	$3p4p - 3p(^2P^\circ)4d$	$^3D - ^3F^\circ$	*4598.5*	*103459*	*125199*	15	21	2.0	0.88	200	1.12	D	*ca*
			4602.08	103669	125392	7	9	1.9	0.79	84	0.74	D	*ls*
			4588.04	103340	125130	5	7	1.7	0.77	58	0.58	D	*ls*
			4589.86	103166	124948	3	5	1.6	0.87	39	0.42	D	*ls*
			4658.31	103669	125130	7	7	0.21	0.069	7.4	−0.31	D−	*ls*
			4626.70	103340	124948	5	5	0.30	0.097	7.4	−0.31	D−	*ls*
			4698.16	103669	124948	7	5	0.0084	0.0020	0.22	−1.85	E	*ls*
10		$^3P - ^3D^\circ$	*4484.5*	*105432*	*127725*	9	15	1.3	0.67	89	0.78	D	*ca*
			4475.26	105550	127889	5	7	1.3	0.55	41	0.44	D	*ls*
			4530.81	105303	127368	3	5	1.0	0.52	23	0.19	D	*ls*
			4402.09	105225	127935	1	3	0.73	0.64	9.3	−0.19	D−	*ls*
			4582.17	105550	127368	5	5	0.33	0.10	7.9	−0.28	D−	*ls*
			4417.30	105303	127935	3	3	0.55	0.16	7.0	−0.32	D−	*ls*
			4466.13	105550	127935	5	3	0.036	0.0065	0.48	−1.49	E	*ls*
11		$^3P - ^3P^\circ$	*4463.8*	*105432*	*127828*	9	9	0.73	0.22	29	0.30	D	*ca*
			4463.00	105550	127951	5	5	0.54	0.16	12	−0.09	D	*ls*
			4483.68	105303	127600	3	3	0.19	0.056	2.5	−0.78	D−	*ls*
			4533.96	105550	127600	5	3	0.31	0.057	4.2	−0.55	D−	*ls*
			4424.07	105303	127900	3	1	0.73	0.072	3.1	−0.67	D−	*ls*
			4414.28	105303	127951	3	5	0.18	0.089	3.9	−0.57	D−	*ls*
			4467.98	105225	127600	1	3	0.25	0.22	3.3	−0.65	D−	*ls*
12		$^3S - ^3P^\circ$	*4580.4*	106002	*127828*	3	9	0.96	0.91	41	0.43	D	*ca*
			4554.83	106002	127951	3	5	0.96	0.50	22	0.17	D	*ls*
			4628.77	106002	127600	3	3	0.97	0.31	14	−0.03	D	*ls*
			4565.27	106002	127900	3	1	0.96	0.10	4.5	−0.52	D−	*ls*
13		$^1D - ^1D^\circ$	5040.80	107924	127756	5	5	0.40	0.15	13	−0.12	D	*ca*
14		$^1D - ^1F^\circ$	4499.24	107924	130143	5	7	1.4	0.60	44	0.47	D	*ca*
15		$^1S - ^1P^\circ$	4935.62	111509	131764	1	3	0.63	0.69	11	−0.16	D	*ca*
16	$3p4p - 3p(^2P^\circ)5s$	$^1P - ^1P^\circ$	4385.35	101636	124433	3	3	0.40	0.12	5.0	−0.46	D	*ca*
17		$^3D - ^3P^\circ$	*4942.5*	*103459*	*123686*	15	9	0.78	0.17	42	0.41	D	*ca*
			4943.53	103669	123892	7	5	0.63	0.16	19	0.06	D	*ls*
			4969.71	103340	123456	5	3	0.58	0.13	11	−0.19	D	*ls*
			4954.39	103166	123345	3	1	0.78	0.096	4.7	−0.54	D−	*ls*
			4864.42	103340	123892	5	5	0.11	0.040	3.2	−0.70	D−	*ls*
			4927.20	103166	123456	3	3	0.19	0.070	3.4	−0.68	D−	*ls*
			4823.68	103166	123892	3	5	0.0075	0.0043	0.21	−1.89	E	*ls*

P II. Allowed Transitions—*Continued*

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
18		$^3P-^3P^\circ$	*5476.7*	*105432*	*123686*	9	9	0.44	0.20	32	0.25	D	*ca*
			5450.74	105550	123892	5	5	0.33	0.15	13	−0.13	D	*ls*
			5507.19	105303	123456	3	3	0.11	0.052	2.8	−0.81	D−	*ls*
			5583.27	105550	123456	5	3	0.19	0.053	4.8	−0.58	D−	*ls*
			5541.14	105303	123345	3	1	0.45	0.070	3.8	−0.68	D−	*ls*
			5378.20	105303	123892	3	5	0.11	0.081	4.3	−0.62	D−	*ls*
			5483.55	105225	123456	1	3	0.15	0.20	3.7	−0.69	D−	*ls*
19		$^3S-^3P^\circ$	*5653.3*	106002	*123686*	3	9	0.15	0.21	12	−0.19	D	*ca*
			5588.34	106002	123892	3	5	0.15	0.11	6.3	−0.46	D	*ls*
			5727.71	106002	123456	3	3	0.15	0.073	4.1	−0.66	D	*ls*
			5764.46	106002	123345	3	1	0.15	0.025	1.4	−1.13	D−	*ls*
20		$^1D-^1P^\circ$	6055.50	107924	124433	5	3	0.69	0.23	23	−0.06	D	*ca*
21		$^1S-^1P^\circ$	7735.06	111509	124433	1	3	0.11	0.29	7.5	−0.53	D	*ca*

P II

Forbidden Transitions

The adopted values have been derived from the theoretical work of Naqvi [1], and Czyzak and Krueger [2]. Since their methods are essentially alike, Naqvi's and Czyzak and Krueger's magnetic dipole transitions have generally been averaged, except for the $^3P-^1S$ transition where configuration interaction is important. In this case Czyzak and Krueger's empirically derived value has been preferred over Naqvi's, which is based purely on theory (see also General Introduction).

For the electric quadrupole transitions only Czyzak and Krueger's values are used since their s_q is obtained by using advanced self-consistent field wavefunctions with exchange effects included.

References

[1] Naqvi, A. M., Thesis Harvard (1951).
[2] Czyzak, S. J. and Krueger, T. K., Monthly Notices Roy. Astron. Soc. **126**, 177–194 (1963).

P II. Forbidden Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	Type of Transition	A_{ki}(sec^{-1})	S(at.u.)	Accuracy	Source
1	$3p^2-3p^2$	$^3P-^3P$										
			[60.663 × 10⁴]	0.0	164.8	1	3	*m*	8.05×10^{-5}	2.00	A	1
			[21.316 × 10⁴]	0.0	469.0	1	5	*e*	6.0×10^{-9}	7.9	C	2
			[32.864 × 10⁴]	164.8	469.0	3	5	*m*	3.80×10^{-4}	2.50	A	1
			[32.864 × 10⁴]	164.8	469.0	3	5	*e*	1.54×10^{-9}	17.6	C	2
2		$^3P-^1D$ (1F)										
			11255	0.0	8882.6	1	5	*e*	3.3×10^{-6}	0.0018	D	2
			11483.2	164.8	8882.6	3	5	*m*	0.0063	0.00176	C	1, 2
			11483.2	164.8	8882.6	3	5	*e*	2.2×10^{-5}	0.013	D	2
			11898.2	469.0	8882.6	5	5	*m*	0.0169	0.0053	C	1, 2
			11898.2	469.0	8882.6	5	5	*e*	1.3×10^{-4}	0.091	D	2

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	Type of Transition	A_{ki}(sec^{-1})	S(at.u.)	Accuracy	Source
3		^{3}P—^{1}S (2F)	4669.5	164.8	21576.2	3	1	*m*	0.220	8.3×10^{-4}	C	2
			4736.6	469.0	21576.2	5	1	*e*	0.0063	0.0089	D	2
4		^{1}D—^{1}S (3F)	7869.5	8882.6	21576.2	5	1	*e*	2.0	35	D	2

P III

Ground State $1s^22s^22p^63s^23p^2P^\circ_{1/2}$

Ionization Potential 30.156 eV = 243290.0 cm^{-1}

Allowed Transitions

List of tabulated lines:

Wavelength [Å]	No.	Wavelength [Å]	No.	Wavelength [Å]	No.
1334.87	1	3802.08	5	4057.39	2
1344.34	1	3895.03	4	4059.27	2
1344.90	1	3904.79	4	4080.04	2
3219.32	6	3922.72	4	4222.15	3
3233.62	6	3933.38	4	4246.68	3
3280.22	8	3951.51	4	4587.91	9
3717.63	5	3957.64	4	5203.86	7
3744.22	5	3997.17	4		

Varsavsky's value [1] for the $3s^23p\ ^2P^\circ—3s3p^2\ ^2D$ multiplet, which has been calculated by means of a screening approximation which neglects the important effects of configuration interaction, should be quite uncertain—probably too high as judged from other comparisons. Since there are no other sources available, the Coulomb approximation has been applied to other prominent lines in this spectrum. Judging from comparisons with analogous transitions in other atoms, accuracies within 50 percent may be expected for the selected lines.

Reference

[1] Varsavsky, C. M., Astrophys. J. Suppl. Ser. **6**, No. 53, 75–108 (1961).

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
1	$3s^2 3p - 3s3p^2$	$^2P^\circ - {}^2D$ (1 uv)	*1341.2*	*373*	*74933*	6	10	14	0.64	17	0.59	E	1
			1344.34	560	74945	4	6	14	0.56	10	0.35	E	*ls*
			1334.87	0	74915	2	4	12	0.65	5.7	0.11	E	*ls*
			1344.90	560	74915	4	4	2.3	0.062	1.1	−0.60	E	*ls*
2	$3d - (^1S)4p$	$^2D - {}^2P^\circ$ (1)	*4066.2*	*116881*	*141467*	10	6	1.0	0.15	20	0.17	D−	*ca*
			4059.27	116885	141513	6	4	0.90	0.15	12	−0.05	D−	*ls*
			4080.04	116874	141376	4	2	0.99	0.12	6.7	−0.31	D−	*ls*
			4057.39	116874	141513	4	4	0.10	0.025	1.3	−1.00	D−	*ls*
3	$4s - (^1S)4p$	$^2S - {}^2P^\circ$ (3)	*4230.4*	117835	*141467*	2	6	1.5	1.2	33	0.37	D	*ca*
			4222.15	117835	141513	2	4	1.5	0.78	22	0.19	D	*ls*
			4246.68	117835	141376	2	2	1.4	0.39	11	−0.11	D	*ls*
4	$3s3p4s - 3s3p(^3P^\circ)4p$	$^4P^\circ - {}^4P$ (9)	*3943.5*	*184811*	*210162*	12	12	1.7	0.40	63	0.69	D	*ca*
			3957.64	185045	210306	6	6	1.2	0.29	22	0.23	D	*ls*
			3933.38	184639	210056	4	4	0.23	0.054	2.8	−0.66	E	*ls*
			3922.72	184453	209939	2	2	0.30	0.068	1.8	−0.87	E	*ls*
			3997.17	185045	210056	6	4	0.76	0.12	9.6	−0.14	D−	*ls*
			3951.51	184639	209939	4	2	1.4	0.17	8.8	−0.17	D−	*ls*
			3895.03	184639	210306	4	6	0.54	0.19	9.5	−0.13	D−	*ls*
			3904.79	184453	210056	2	4	0.75	0.34	8.8	−0.17	D−	*ls*
5		$^4P^\circ - {}^4S$ (10)	*3768.5*	*184811*	211339	12	4	2.1	0.15	22	0.25	D	*ca*
			3802.08	185045	211339	6	4	0.97	0.14	11	−0.07	D	*ls*
			3744.22	184639	211339	4	4	0.68	0.14	7.0	−0.25	D	*ls*
			3717.63	184453	211339	2	4	0.34	0.14	3.5	−0.55	D	*ls*
6	$4p - (^1S)4d$	$^2P^\circ - {}^2D$ (4)	*3228.8*	*141467*	172429	6	10	4.6	1.2	77	0.86	D	*ca*
			3233.62	141513	172429	4	6	4.6	1.1	46	0.64	D	*ls*
			3219.32	141376	172429	2	4	3.9	1.2	26	0.38	D	*ls*
			3233.62	141513	172429	4	4	0.77	0.12	5.2	−0.31	D−	*ls*
7	$4d - (^1S)5p$	$^2D - {}^2P^\circ$ (5)											
			5203.86	172429	191640	6	4	0.79	0.22	22	0.11	D	*ca, ls*
			5203.86	172429	191640	4	4	0.088	0.036	2.5	−0.84	E	*ca, ls*
8	$4d - (^1S)5f$	$^2D - {}^2F^\circ$ (6)	3280.22	172429	202906	10	14	1.8	0.40	43	0.60	D	*ca*
9	$4f - (^1S)5d$	$^2F^\circ - {}^2D$ (7)	4587.91	178653	200443	14	10	0.11	0.026	5.4	−0.45	D	*ca*

P III

Forbidden Transitions

The line strength for the one transition in the ground state configuration is a straight number, tabulated for example by Naqvi [1]. The transition probability should also be quite accurate, since the energy level difference is accurately known.

Reference

[1] Naqvi, A. M., Thesis Harvard (1951).

P III. Forbidden Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	Type of Transition	A_{ki}(sec^{-1})	S(at.u.)	Accuracy	Source
1	$3p-(^1S)3p$	$^2P^\circ-^2P^\circ$	[17.865 × 10^4]	0.0	559.6	2	4	m	0.00157	1.33	A	1

P IV

Ground State $1s^22s^22p^63s^2\ ^1S_0$

Ionization Potential 51.354 eV = 414312 cm^{-1}

Allowed Transitions

List of tabulated lines:

Wavelength [Å]	No.	Wavelength [Å]	No.	Wavelength [Å]	No.
368.01	25	847.72	14	1065.7	9
368.32	25	849.80	14	1066.6	9
368.96	25	850.39	14	1086.9	8
388.32	10	851.09	14	1088.6	8
424.06	26	855.05	12	1091.4	8
443.81	23	859.73	13	1094.4	21
444.25	23	860.49	13	1118.6	4
444.27	23	861.53	13	1589.0	22
445.16	23	863.31	13	1640.6	3
445.17	23	865.01	13	1691.8	7
445.18	23	866.81	13	1845.6	6
522.01	24	907.60	16	1847.5	5
628.983	19	908.05	15	3347.72	27
629.914	19	950.669	1	3364.44	27
631.765	19	963.97	18	3371.10	27
756.53	17	1025.58	2	3717.03	29
776.37	20	1028.13	2	3717.63	29
823.177	11	1030.55	2	3719.3	29
824.733	11	1033.14	2	3727.6	29
827.932	11	1035.54	2	3728.67	29
845.97	14	1065.5	9	4249.57	28
847.02	14				

Zare's values [1] have been calculated by means of the method of superposition of configurations, employing Hartree-Fock-Slater wavefunctions as a starting point. The calculations have been carried out in both the dipole length and dipole velocity representations; the length values are chosen in all cases as being probably more reliable. Crossley and Dalgarno's values [2] have been obtained from nuclear charge-expansion calculations which include configuration mixing in a limited way. Zare's method must be considered the more refined of the two calculations. Hence his data have been chosen whenever there was a choice. In many cases, the degree of fit of the data into the apparent f-value dependences on nuclear charge could be utilized as an addi-

tional criterion in arriving at the accuracy estimates. The accuracy assignments for any transition involving the $3s3d\,^1D$, $3p3d\,^1D$, or $3p^2\,^1D$ energy levels have been reduced since reliability of these energy levels is quite doubtful. Hence, for transitions involving these states, the listed line strength will be more reliable than either the oscillator strength or the transition probability, since the latter two quantities depend on the wavelength of the transition.

References

[1] Zare, R. N., J. Chem. Phys. **47**, 3561 (1967).
[2] Crossley, R. J. S., and Dalgarno, A., Proc. Roy. Soc. London **A286**, 510–518 (1965).

P IV. Allowed Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
1	$3s^2-3s(^2S)3p$	$^1S-^1P^\circ$ (1 uv)	950.669	0	105190	1	3	39.4	1.60	5.01	0.204	B	1
2	$3s3p-3p^2$	$^3P^\circ-^3P$ (2 uv)	*1030.5*	*68374*	*165411*	9	9	30.2	0.481	14.7	0.64	C +	2
			1030.55	68607	165646	5	5	22.6	0.360	6.1	0.255	C +	*ls*
			1030.55	68139	165178	3	3	7.5	0.120	1.22	−0.444	C +	*ls*
			1035.54	68607	165178	5	3	12.4	0.120	2.04	−0.222	C +	*ls*
			1033.14	68139	164935	3	1	29.9	0.160	1.63	−0.319	C +	*ls*
			1025.58	69139	165646	3	5	7.7	0.201	2.04	−0.220	C +	*ls*
			1028.13	67912	165178	1	3	10.1	0.482	1.63	−0.317	C +	*ls*
3		$^1P^\circ-^1D$	[1640.6]	105190	166144	3	5	1.8	0.12	1.9	−0.44	E	1
4		$^1P^\circ-^1S$	[1118.6]	105190	194589	3	1	32.4	0.203	2.24	−0.215	C −	1
5	$3s(^2S)3d-3p(^2P^\circ)3d$	$^1D-^1F^\circ$	[1847.5]	[222142]	[276270]	5	7	7.3	0.53	16	0.42	D −	2
6		$^1D-^1D^\circ$	[1845.6]	[222142]	[276325]	5	5	1.2	0.063	1.9	−0.50	D −	2
7		$^1D-^1P^\circ$	[1691.8]	[222142]	281251	5	3	2.6	0.068	1.9	−0.47	D −	1
8		$^3D-^3P^\circ$	*1090.0*	189389	*281133*	15	9	18	0.19	10	0.46	D +	1
			[1091.4]	189389	281011	7	5	15	0.19	4.8	0.13	D +	*ls*
			[1088.6]	189389	281251	5	3	14	0.14	2.6	−0.15	D +	*ls*
			[1086.9]	189389	281391	3	1	18	0.11	1.1	−0.50	D +	*ls*
			[1091.4]	189389	281011	5	5	2.7	0.048	0.86	−0.62	D +	*ls*
			[1088.6]	189389	281251	3	3	4.5	0.080	0.86	−0.62	D +	*ls*
			[1088.6]	189389	281251	5	3	0.30	0.0032	0.057	−1.80	D +	*ls*
9		$^3D-^3D^\circ$	*1065.8*	189389	*283211*	15	15	16	0.27	14	0.61	D	2
			[1065.7]	189389	283221	7	7	14	0.24	5.8	0.21	D	*ls*
			[1065.5]	189389	283239	5	5	11	0.18	3.2	−0.05	D	*ls*
			[1066.6]	189389	283142	3	3	12	0.20	2.1	−0.22	D	*ls*
			[1065.5]	189389	283239	7	5	2.4	0.030	0.73	−0.68	D −	*ls*
			[1066.6]	189389	283142	5	3	3.9	0.040	0.70	−0.70	D −	*ls*
			[1065.7]	189389	283221	5	7	1.7	0.042	0.73	−0.68	D −	*ls*
			[1065.5]	189389	283239	3	5	2.3	0.067	0.70	−0.70	D −	*ls*
10	$3s^2-3s(^2S)4p$	$^1S-^1P^\circ$	[388.32]	0	257520	1	3	15	0.10	0.13	−0.00	D −	1
11	$3s3p-3s(^2S)3d$	$^3P^\circ-^3D$ (3 uv)	*826.34*	*68374*	189389	9	15	46.7	0.796	19.5	0.855	B	1
			827.932	68607	189389	5	7	46.4	0.668	9.10	0.524	B	*ls*
			824.733	68139	189389	3	5	35.2	0.598	4.87	0.254	B	*ls*
			823.177	67912	189389	1	3	26.3	0.801	2.17	−0.096	B	*ls*
			827.932	68607	189389	5	5	11.6	0.119	1.62	−0.225	C	*ls*
			824.733	68139	189389	3	3	19.5	0.199	1.62	−0.224	C	*ls*
			827.932	68607	189389	5	3	1.3	0.0079	0.11	−1.40	D	*ls*
12		$^1P^\circ-^1D$ (5 uv)	[855.05]	105190	[222142]	3	5	84	1.5	13	0.65	D	1

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
13	$3p^2-3p(^2P^\circ)3d$	$^3P-^3P^\circ$	*864.14*	*165411*	*281133*	9	9	35	0.39	10	0.55	D	2
			[866.81]	165646	281011	5	5	26	0.29	4.2	0.16	D	*ls*
			[861.53]	165178	281251	3	3	8.8	0.098	0.83	−0.53	D−	*ls*
			[865.01]	165646	281251	5	3	15	0.098	1.4	−0.31	D−	*ls*
			[860.49]	165178	281391	3	1	35	0.13	1.1	−0.41	D−	*ls*
			[863.31]	165178	281011	3	5	8.8	0.16	1.4	−0.32	D−	*ls*
			[859.73]	164935	281251	1	3	12	0.39	1.1	−0.41	D−	*ls*
14		$^3P-^3D^\circ$	*848.90*	*165411*	*283211*	9	15	64	1.2	29	1.03	D	2
			[849.80]	165646	283321	5	7	66	1.0	14	0.70	D	*ls*
			[847.02]	165178	283239	3	5	48	0.86	7.2	0.41	D	*ls*
			[845.97]	164935	283142	1	3	36	1.1	3.2	0.04	D−	*ls*
			[850.39]	165646	283239	5	5	16	0.17	2.4	−0.07	D−	*ls*
			[847.72]	165178	283142	3	3	27	0.29	2.4	−0.06	D−	*ls*
			[851.09]	165646	283142	5	3	1.8	0.011	0.16	−1.26	E	*ls*
15		$^1D-^1F^\circ$	[908.05]	166144	[276270]	5	7	35	0.61	9.1	0.48	E	2
16		$^1D-^1D^\circ$	[907.60]	166144	[276325]	5	5	31	0.39	5.8	0.29	E	2
17		$^1D-^1P^\circ$	[756.53]	166144	298327	5	3	4.1	0.021	0.26	−0.98	E	1
18		$^1S-^1P^\circ$	[963.97]	194589	298327	1	3	29.0	1.21	3.84	0.083	C	1
19	$3s3p-3s(^2S)4s$	$^3P^\circ-^3S$ (4 uv)	*630.86*	*68374*	226889	9	3	49.2	0.098	1.83	−0.055	C	1
			631.765	68607	226889	5	3	27.3	0.098	1.02	−0.310	C	*ls*
			629.914	68139	226889	3	3	16.5	0.098	0.61	−0.53	C	*ls*
			628.983	67912	226889	1	3	5.5	0.098	0.203	−1.009	C	*ls*
20		$^1P^\circ-^1S$	[776.37]	105190	233995	3	1	24.2	0.073	0.56	−0.66	C−	1
21	$3p^2-3s(^2S)4p$	$^1D-^1P^\circ$	[1094.4]	166144	257520	5	3	5.6	0.061	1.1	−0.52	E	1
22		$^1S-^1P^\circ$	[1589.0]	194589	257520	1	3	0.18	0.021	0.11	−1.69	D	1
23	$3s3p-3s(^2S)4d$	$^3P^\circ-^3D$	*444.71*	*68374*	*293242*	9	15	0.75	0.0037	0.049	−1.48	E	1
			[445.16]	68607	293247	5	7	0.75	0.0031	0.023	−1.81	E	*ls*
			[444.25]	68139	293239	3	5	0.55	0.0027	0.012	−2.09	E	*ls*
			[443.81]	67912	293234	1	3	0.42	0.0037	0.0054	−2.43	E	*ls*
			[445.17]	68607	293239	5	5	0.19	5.6×10^{-4}	0.0041	−2.55	E	*ls*
			[444.27]	68139	293234	3	3	0.32	9.3×10^{-4}	0.0041	−2.55	E	*ls*
			[445.18]	68607	293234	5	3	0.021	3.7×10^{-5}	2.7×10^{-4}	−3.73	E	*ls*
24		$^1P^\circ-^1D$	[522.01]	105190	296758	3	5	0.74	0.0050	0.026	−1.82	E	1
25	$3s3p-3s(^2S)5d$	$^3P^\circ-^3D$	*368.64*	*68374*	*339638*	9	15	20	0.070	0.76	−0.20	D	1
			[368.96]	68607	339636	5	7	20	0.058	0.35	−0.54	D	*ls*
			[368.32]	68139	339639	3	5	15	0.052	0.19	−0.81	D	*ls*
			[368.01]	67912	339642	1	3	11	0.069	0.084	−1.16	D−	*ls*
			[368.96]	68607	339639	5	5	5.1	0.010	0.063	−1.30	D−	*ls*
			[368.32]	68139	339642	3	3	8.5	0.017	0.063	−1.29	D−	*ls*
			[368.96]	68607	339642	5	3	0.56	6.9×10^{-4}	0.0042	−2.46	E	*ls*
26		$^1P^\circ-^1D$	[424.06]	105190	[341005]	3	5	0.11	4.8×10^{-4}	0.0020	−2.84	E	1
27	$3s4s-3s(^2S)4p$	$^3S-^3P^\circ$ (1)	*3355.9*	226889	*256679*	3	9	2.11	1.07	35.4	0.51	C+	1
			3347.72	226889	256751	3	5	2.13	0.60	19.7	0.255	C+	*ls*
			3364.44	226889	256603	3	3	2.09	0.355	11.8	0.027	C+	*ls*
			3371.10	226889	256544	3	1	2.1	0.12	3.9	−0.45	D	*ls*
28		$^1S-^1P^\circ$ (2)	4249.57	233995	257520	1	3	0.84	0.69	9.6	−0.161	C	1

P IV. Allowed Transitions—*Continued*

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
29	$3s4d-3s(^2S)5p$	$^3D-^3P^\circ$ (3)											
			[3719.3]	293247	320126	7	5	2.0	0.30	26	0.32	D	*ca*, *ls*
			3728.67	293239	320053	5	3	1.8	0.23	14	0.06	D	*ca*, *ls*
			3717.63	293239	320126	5	5	0.36	0.075	4.6	−0.43	D−	*ca*, *ls*
			[3727.6]	293234	320053	3	3	0.60	0.12	4.6	−0.44	D−	*ca*, *ls*
			3717.03	293234	320126	3	5	0.024	0.0084	0.31	−1.60	E	*ca*, *ls*

P IV

Forbidden Transitions

Naqvi's calculations [1] are the only available source. The results for the $^3P^\circ-^3P^\circ$ transitions are essentially independent of the choice of the interaction parameters. For the $^3P^\circ-^1P^\circ$ transitions, Naqvi uses empirical term intervals, i.e., the effects of configuration interaction should be partially included.

Reference

[1] Naqvi, A. M., Thesis Harvard (1951).

P IV. Forbidden Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	Type of Transition	A_{ki}(sec^{-1})	S(at.u.)	Accuracy	Source
1	$3s3p-3s(^2S)3p$	$^3P^\circ-^3P^\circ$										
			[43.963 × 10⁴]	67911.6	68139.0	1	3	*m*	2.12×10^{-4}	2.00	A	1
			[21.343 × 10⁴]	68139.0	68607.4	3	5	*m*	0.00139	2.50	A	1
2		$^3P^\circ-^1P^\circ$										
			[2681.7]	67911.6	105190	1	3	*m*	0.078	1.67×10^{-4}	C	1
			[2698.2]	68139.0	105190	3	3	*m*	6.3	0.0137	C	1
			[2732.7]	68607.4	105190	5	3	*m*	0.092	2.09×10^{-4}	C	1

P V

Ground State $1s^2 2s^2 2p^6 3s\ ^2S_{1/2}$

Ionization Potential 65.007 eV = 524462.9 cm^{-1}

Allowed Transitions

List of tabulated lines:

Wavelength [Å]	No.	Wavelength [Å]	No.	Wavelength [Å]	No.
255.60	3	544.91	5	1118.0	1
255.69	3	673.86	7	1128.0	1
328.47	2	673.91	7	1379.7	12
328.77	2	865.46	4	1385.2	12
410.06	9	871.37	4	2424.3	11
410.08	9	871.45	4	2440.8	11
475.60	8	997.53	6	2441.1	11
475.62	8	997.64	6	3175.16	10
542.57	5	1000.4	6	3204.06	10

The only source available for this ion are the charge-expansion calculations of Crossley and Dalgarno [1] which include limited configuration mixing. Graphical comparisons of this work with more refined values within the isoelectronic sequence indicate an accuracy of 25 percent or better. A number of additional values have been obtained from studies of the *f*-value dependence on nuclear charge. The reliable material available for other ions of this isoelectronic sequence in these cases permits the determination of reliable values for P V simply by graphical interpolation.

Reference

[1] Crossley, R. J. S., and Dalgarno, A., Proc. Roy. Soc. London **A286**, 510–518 (1965).

P V. Allowed Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
1	$3s-3p$	$^2S-^2P^\circ$	*1121.3*	0	*89181*	2	6	11.9	0.67	4.95	0.127	C	1
			[1118.0]	0	89446	2	4	12.0	0.448	3.30	−0.048	C	*ls*
			[1128.0]	0	88652	2	2	11.6	0.222	1.65	−0.353	C	*ls*
2	$3s-4p$	$^2S-^2P^\circ$	*328.57*	0	*304350*	2	6	11	0.055	0.12	−0.96	D+	interp
			[328.47]	0	304445	2	4	11	0.037	0.080	−1.13	D+	*ls*
			[328.77]	0	304161	2	2	11	0.018	0.040	−1.44	D+	*ls*
3	$3s-5p$	$^2S-^2P^\circ$	*255.63*	0	*391195*	2	6	7.5	0.22	0.037	−1.36	D	interp
			[255.60]	0	391242	2	4	7.6	0.015	0.025	−1.52	D	*ls*
			[255.69]	0	391102	2	2	7.3	0.0071	0.012	−1.85	D	*ls*
4	$3p-3d$	$^2P^\circ-^2D$	*869.39*	*89181*	*204204*	6	10	36.7	0.69	11.9	0.62	C	1
			[871.37]	89446	204208	4	6	36.2	0.62	7.1	0.394	C	*ls*
			[865.46]	88652	204197	2	4	31.0	0.70	3.97	0.146	C	*ls*
			[871.45]	89446	204197	4	4	6.0	0.069	0.79	−0.56	C	*ls*

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
5	$3p-4s$	$^2P^\circ-^2S$	*544.13*	*89181*	272961	6	2	74	0.11	1.2	−0.18	C	interp
			[544.91]	89446	272961	4	2	49	0.11	0.79	−0.36	C	*ls*
			[542.57]	88652	272961	2	2	25	0.11	0.39	−0.66	C	*ls*
6	$3d-4p$	$^2D-^2P^\circ$	*998.54*	*204204*	*304350*	10	6	17	0.15	4.9	0.18	C	interp
			[997.64]	204208	304445	6	4	15	0.15	2.9	−0.05	C	*ls*
			[1000.4]	204197	304161	4	2	16	0.12	1.6	−0.32	C	*ls*
			[997.53]	204197	304445	4	4	1.7	0.025	0.33	−1.00	C	*ls*
7	$3d-4f$	$^2D-^2F^\circ$	*673.90*	*204204*	352595	10	14	97	0.92	20	0.96	C+	interp
			[673.91]	204208	352595	6	8	91	0.83	11	0.70	C+	*ls*
			[673.86]	204197	352595	4	6	88	0.90	8.0	0.56	C+	*ls*
			[673.91]	204208	352595	6	6	6.3	0.043	0.57	−0.59	C+	*ls*
8	$3d-5f$	$^2D-^2F^\circ$	*475.61*	*204204*	414459	10	14	36	0.17	2.7	0.23	C	interp
			[475.62]	204208	414459	6	8	35	0.16	1.5	−0.02	C	*ls*
			[475.60]	204197	414459	4	6	35	0.18	1.1	−0.14	C	*ls*
			[475.62]	204208	414459	6	6	2.4	0.0082	0.077	−1.31	C	*ls*
9	$3d-6f$	$^2D-^2F^\circ$	*410.07*	*204204*	448062	10	14	17	0.061	0.82	−0.21	C	interp
			[410.08]	204208	448062	6	8	17	0.058	0.47	−0.46	C	*ls*
			[410.06]	204197	448062	4	6	16	0.061	0.33	−0.61	C	*ls*
			[410.08]	204208	448062	6	6	1.1	0.0028	0.023	−1.77	C	*ls*
10	$4s-4p$	$^2S-^2P^\circ$ (1)	*3184.9*	272961	*304350*	2	6	2.32	1.06	22.2	0.326	C	*ca*
			3175.16	272961	304445	2	4	2.34	0.71	14.8	0.151	C	*ls*
			3204.06	272961	304161	2	2	2.28	0.351	7.4	−0.154	C	*ls*
11	$4p-4d$	$^2P^\circ-^2D$	*2435.3*	*304350*	*345401*	6	10	7.4	1.1	53	0.82	C	interp
			[2440.8]	304445	345403	4	6	7.4	1.0	32	0.60	C	*ls*
			[2424.3]	304161	345398	2	4	6.4	1.1	18	0.34	C	*ls*
			[2441.1]	304445	345398	4	4	1.2	0.11	3.5	−0.36	C	*ls*
12	$4p-5s$	$^2P^\circ-^2S$	*1383.3*	*304350*	376639	6	2	20	0.19	5.2	0.06	C	interp
			[1385.2]	304445	376639	4	2	13	0.19	3.5	−0.12	C	*ls*
			[1379.7]	304161	376639	2	2	6.6	0.19	1.7	−0.42	C	*ls*

P VI

Ground State $1s^22s^22p^6\ ^1S_0$

Ionization Potential 220.414 eV = 1778250 cm^{-1}

Allowed Transitions

Calculations by Kastner, Omidvar, and Underwood [1], employing Hartree-Fock wavefunctions and including intermediate coupling, are available. Since the calculations are based on a single-configuration approximation only, uncertainties of up to 50 percent are expected for the strong lines and even higher uncertainties for the weak lines, the latter being more affected by assumptions about the coupling.

Reference

[1] Kastner, S. O., Omidvar, K., and Underwood, J. H., Astrophys. J. **148**, 269–273 (1967).

P VI. Allowed Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
1	$2p^6-2p^5(^2P^\circ_{3/2})3s$	$^1S-^3P^\circ$	[91.471]	0	1093240	1	3	74	0.028	0.0084	−1.55	E	1
2	$2p^6-2p^5(^2P^\circ_{1/2})3s$	$^1S-^1P^\circ$	[90.647]	0	1103180	1	3	490	0.18	0.054	−0.74	D	1
3	$2p^6-2p^5(^2P^\circ_{3/2})3d$	$^1S-^3P^\circ$	[76.534]	0	1306610	1	3	16	0.0042	0.0011	−2.38	E	1
4	$2p^6-2p^5(^2P^\circ_{3/2})3d$	$^1S-^1P^\circ$	[75.648]	0	1321910	1	3	4700	1.2	0.30	0.08	D	1
5	$2p^6-2p^5(^2P^\circ_{1/2})3d$	$^1S-^3D^\circ$	[74.951]	0	1334210	1	3	670	0.17	0.042	−0.77	D	1

P VII

Ground State $1s^22s^22p^5\ ^2P^\circ_{3/2}$

Ionization Potential 263.31 eV = 2124300 cm^{-1}

Allowed Transitions

The value for the $2s^22p^5\ ^2P^\circ-2s2p^6\ ^2S$ multiplet is calculated from the nuclear charge-expansion method of Cohen and Dalgarno [1]. It may be quite uncertain since configuration interaction effects with configurations involving the $n=3$ shell electrons, which were not included in this calculation, may be significant.

Reference

[1] Cohen, M., and Dalgarno, A., Proc. Roy. Soc. London **A280**, 258–270 (1964).

P VII. Allowed Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
1	$2s^22p^5-2s2p^6$	$^2P^\circ-^2S$	*221.09*	*2423*	454732	6	2	420	0.10	0.45	−0.22	D	1
			[219.91]	0	454732	4	2	290	0.10	0.30	−0.40	D	*ls*
			[223.48]	7268	454732	2	2	140	0.10	0.15	−0.70	D	*ls*

P VII

Forbidden Transitions

The line strength for the one transition in the ground state configuration is a straight number, tabulated for example by Naqvi [1]. The transition probability should also be quite accurate, since the energy level difference is accurately known.

Reference

[1] Naqvi, A. M., Thesis Harvard (1951).

P VII. Forbidden Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	Type of Transition	A_{ki}(sec^{-1})	S(at.u.)	Accuracy	Source
1	$2p^5-2p^5$	$^2P^\circ-^2P^\circ$	[13755]	0	7268	4	2	m	6.89	1.33	A	1

P VIII

Ground State $1s^2 2s^2 2p^4\ ^3P_2$

Ionization Potential 309.26 eV = 2495000 cm^{-1}

Allowed Transitions

The values are calculated from the charge-expansion method of Cohen and Dalgarno [1] which includes limited configuration mixing. From comparisons with other ions in the isoelectronic sequence, uncertainties should be within 50 percent.

Reference

[1] Cohen, M., and Dalgarno, A., Proc. Roy. Soc. London **A280**, 258–270 (1964).

P VIII. Allowed Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
1	$2s^22p^4-2s2p^5$	$^3P-^3P^\circ$	*247.77*	*2789*	*406389*	9	9	190	0.18	1.3	0.21	D	1
			[247.64]	0	403806	5	5	140	0.13	0.54	−0.17	D	*ls*
			[248.04]	5757	408913	3	3	49	0.045	0.11	−0.87	D	*ls*
			[244.55]	0	408913	5	3	83	0.045	0.18	−0.65	D	*ls*
			[246.32]	5757	411736	3	1	190	0.058	0.14	−0.76	D	*ls*
			[251.23]	5757	403806	3	5	46	0.073	0.18	−0.66	D	*ls*
			[249.32]	7826	408913	1	3	61	0.17	0.14	−0.77	D	*ls*
2		$^1D-^1P^\circ$	[196.76]	[52450]	[560680]	5	3	310	0.11	0.35	−0.26	D	1
3		$^1S-^1P^\circ$	[222.37]	[110970]	[560680]	1	3	46	0.10	0.075	−1.00	D	1

P VIII

Forbidden Transitions

As in the case of Na IV the adopted values are taken from Naqvi [1], and Malville and Berger [2]. For a discussion on the selection of values see Na IV, since the same considerations have been applied.

References

[1] Naqvi, A. M. Thesis Harvard (1951).
[2] Malville, J. M. and Berger, R. A., Planetary and Space Science **13**, 1131–1136 (1965).

P VIII. Forbidden Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	Type of Transition	A_{ki}(sec^{-1})	S(at.u.)	Accuracy	Source
1	$2p^4-2p^4$	$^3P-^3P$										
			[17365]	0	5757	5	3	*e*	1.09×10^{-5}	0.0306	C–	1, 2
			[17365]	0	5757	5	3	*m*	4.28	2.49	B	1
			[12774]	0	7826	5	1	*e*	6.8×10^{-5}	0.0138	C–	2
			[48319]	5757	7826	3	1	*m*	0.476	1.99	B	1
2		$^3P-^1D$										
			[1906.6]	0	[52450]	5	5	*e*	0.014	0.0011	D–	1, 2
			[1906.6]	0	[52450]	5	5	*m*	28.7	0.0369	C	1
			[2141.0]	5757	[52450]	3	5	*e*	0.0011	1.5×10^{-4}	D–	1, 2
			[2141.0]	5757	[52450]	3	5	*m*	6.8	0.0124	C	1
			[2240.3]	7826	[52450]	1	5	*e*	4.6×10^{-4}	7.7×10^{-5}	D–	2
3		$^3P-^1S$										
			[901.14]	0	[110970]	5	1	*e*	0.18	6.3×10^{-5}	D–	2
			[950.45]	5757	[110970]	3	1	*m*	340	0.0108	C	2
4		$^1D-^1S$										
			[1708.8]	[52450]	[110970]	5	1	*e*	6.2	0.054	C–	2

P IX

Ground State $1s^22s^22p^3\ ^4S^\circ_{3/2}$

Ionization Potential 371.6 eV = 2997600 cm^{-1}

Allowed Transitions

List of tabulated lines:

Wavelength [Å]	No.	Wavelength [Å]	No.	Wavelength [Å]	No.
194.61	3	234.94	7	283.25	1
197.03	3	235.22	7	283.96	8
197.25	3	250.05	2	285.36	1
211.17	6	250.37	2	289.28	8
211.60	6	250.40	2	289.53	1
214.02	6	250.72	2	308.65	9
214.46	6	278.06	4	314.77	9
227.75	5	278.82	4	314.95	9
228.25	5	279.21	4	321.33	9
231.69	7				

Values for all the listed transitions are calculated from the nuclear charge-expansion method of Cohen and Dalgarno [1], which includes limited configuration mixing. Judged from graphical comparisons with other ions in the isoelectronic sequence and from the general success of Cohen and Dalgarno's method for similar atomic systems, uncertainties within 50 percent are indicated.

Reference

[1] Cohen, M., and Dalgarno, A., Proc. Roy. Soc. London **A280**, 258–270 (1964).

P IX. Allowed Transitions

No.	ransition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
1	$2s^22p^3-2s2p^4$	$^4S^\circ-^4P$	*287.07*	0	*348350*	4	12	56	0.21	0.78	−0.08	D	1
			[289.53]	0	345390	4	6	54	0.10	0.39	−0.40	D	*ls*
			[285.36]	0	350440	4	4	57	0.069	0.26	−0.56	D	*ls*
			[283.25]	0	353050	4	2	58	0.035	0.13	−0.85	D−	*ls*
2		$^2D^\circ-^2D$	*250.45*	*73505*	*472784*	10	10	130	0.12	0.98	0.08	D	1
			[250.72]	73730	472580	6	6	120	0.11	0.55	−0.18	D	*ls*
			[250.05]	73167	473090	4	4	110	0.11	0.35	−0.36	D	*ls*
			[250.40]	73730	473090	6	4	13	0.0079	0.039	−1.32	E	*ls*
			[250.37]	73167	472580	4	6	8.4	0.012	0.039	−1.32	E	*ls*
3		$^2D^\circ-^2P$	*196.35*	*73505*	*582810*	10	6	440	0.15	0.98	0.18	D	1
			[197.25]	73730	580710	6	4	390	0.15	0.59	−0.05	D	*ls*
			[194.61]	73167	587010	4	2	450	0.13	0.33	−0.28	D	*ls*
			[197.03]	73167	580710	4	4	43	0.025	0.065	−1.00	E	*ls*
4		$^2P^\circ-^2D$	*278.80*	*114106*	*472784*	6	10	20	0.039	0.21	−0.63	D	1
			[279.21]	114430	472580	4	6	20	0.035	0.13	−0.85	D	*ls*
			[278.06]	113457	473090	2	4	16	0.038	0.070	−1.12	D	*ls*
			[278.82]	114430	473090	4	4	3.3	0.0038	0.014	−1.82	E	*ls*
5		$^2P^\circ-^2S$	*228.08*	*114106*	552540	6	2	260	0.069	0.31	−0.38	D	1
			[228.25]	114430	552540	4	2	180	0.070	0.21	−0.55	D	*ls*
			[227.75]	113457	552540	2	2	86	0.067	0.10	−0.87	D	*ls*
6		$^2P^\circ-^2P$	*213.35*	*114106*	*582810*	6	6	130	0.090	0.38	−0.27	D	1
			[214.46]	114430	580710	4	4	110	0.074	0.21	−0.53	D	*ls*
			[211.17]	113457	587010	2	2	90	0.060	0.084	−0.92	D−	*ls*
			[211.60]	114430	587010	4	2	45	0.015	0.042	−1.22	D−	*ls*
			[214.02]	113457	580710	2	4	22	0.030	0.042	−1.22	D−	*ls*
7	$2s2p^4-2p^5$	$^2D-^2P^\circ$	*233.87*	*472784*	*900380*	10	6	210	0.10	0.78	0.00	D	1
			[234.94]	472580	898220	6	4	180	0.10	0.47	−0.22	D	*ls*
			[231.69]	473090	904700	4	2	210	0.085	0.26	−0.47	D	*ls*
			[235.22]	473090	898220	4	4	20	0.017	0.052	−1.17	E	*ls*
8		$^2S-^2P^\circ$	*287.49*	552540	*900380*	2	6	12	0.045	0.086	−1.05	D	1
			[289.28]	552540	898220	2	4	12	0.030	0.057	−1.22	D	*ls*
			[283.96]	552540	904700	2	2	13	0.016	0.029	−1.49	D	*ls*
9		$^2P-^2P^\circ$	*314.89*	*582810*	*900380*	6	6	150	0.23	1.4	0.14	D	1
			[314.95]	580710	898220	4	4	130	0.19	0.78	−0.12	D	*ls*
			[314.77]	587010	904700	2	2	100	0.15	0.31	−0.52	D	*ls*
			[308.65]	580710	904700	4	2	55	0.039	0.16	−0.81	D−	*ls*
			[321.33]	587010	898220	2	4	24	0.076	0.16	−0.81	D−	*ls*

P IX

Forbidden Transitions

Naqvi's [1] calculations are the only available source.

Reference

[1] Naqvi, A. M., Thesis Harvard (1951).

P IX. Forbidden Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	Type of Transition	A_{ki}(sec^{-1})	S(at.u.)	Accuracy	Source
1	$2p^3-2p^3$	$^4S^\circ-^2D^\circ$										
			[1356.3]	0	73730	4	6	*m*	0.0441	2.45×10^{-5}	C−	1
			[1356.3]	0	73730	4	6	*e*	0.014	2.2×10^{-4}	D−	1
			[1366.7]	0	73167	4	4	*m*	10.9	0.00412	C−	1
			[1366.7]	0	73167	4	4	*e*	0.0083	9.4×10^{-5}	D−	1
2		$^4S^\circ-^2P^\circ$										
			[881.39]	0	113457	4	2	*m*	57	0.00288	C−	1
			[881.39]	0	113457	4	2	*e*	7.1×10^{-4}	4.5×10^{-7}	D−	1
			[873.90]	0	114430	4	4	*m*	127	0.0126	C−	1
			[873.90]	0	114430	4	4	*e*	0.0030	3.6×10^{-6}	D−	1
3		$^2D^\circ-^2D^\circ$										
			[17.76×10^4]	73167	73730	4	6	*m*	0.00193	2.40	B	1
			[17.76×10^4]	73167	73730	4	6	*e*	2.6×10^{-12}	0.0016	D−	1
4		$^2D^\circ-^2P^\circ$										
			[2456.3]	73730	114430	6	4	*m*	17.3	0.0380	C−	1
			[2456.3]	73730	114430	6	4	*e*	0.49	0.10	D	1
			[2481.3]	73167	113457	4	2	*m*	18.5	0.0210	C−	1
			[2481.3]	73167	113457	4	2	*e*	0.40	0.044	D	1
			[2516.4]	73730	113457	6	2	*e*	0.25	0.030	D	1
			[2422.7]	73167	114430	4	4	*m*	32.5	0.069	C−	1
			[2422.7]	73167	114430	4	4	*e*	0.22	0.043	D	1
5		$^2P^\circ-^2P^\circ$										
			[10.27×10^4]	113457	114430	2	4	*m*	0.00828	1.33	B	1
			[10.27×10^4]	113457	114430	2	4	*e*	2.6×10^{-11}	7.0×10^{-4}	D−	1

P X

Ground State $1s^22s^22p^2\ ^3P_0$

Ionization Potential 424.3 eV = 3423000 cm^{-1}

Allowed Transitions

Most data are obtained from the charge-expansion method of Cohen and Dalgarno [1] which includes limited configuration mixing. Graphical comparisons of this material within the iso-

electronic sequence depicting the dependence of f-values on nuclear charge have been made, and the available experimental data for the lower ions, mostly from lifetime measurements, establish fairly definitely that the uncertainties should not exceed 50 percent.

Reference

[1] Cohen, M., and Dalgarno, A., Proc. Roy. Soc. London **A280**, 258–270 (1964).

P x. Allowed Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
1	$2s^22p^2-2s2p^3$	$^3P-^3D^\circ$	*315.42*	*5897*	*322937*	9	15	31	0.077	0.72	−0.16	D+	1
			[318.26]	8580	322790	5	7	31	0.065	0.34	−0.49	D+	*ls*
			[312.87]	3390	323010	3	5	24	0.058	0.18	−0.76	D+	*ls*
			[309.44]	0	323160	1	3	18	0.079	0.080	−1.10	D	*ls*
			[318.04]	8580	323010	5	5	7.6	0.011	0.060	−1.26	D	*ls*
			[312.72]	3390	323160	3	3	13	0.019	0.060	−1.24	D	*ls*
			[317.88]	8580	323160	5	3	0.84	7.6×10^{-4}	0.0040	−2.42	E	*ls*
2		$^3P-^3P^\circ$											
			[269.48]	8580	379660	5	5	58	0.063	0.28	−0.50	D	1, *ls*
			[265.77]	3390	379660	3	5	20	0.035	0.093	−0.98	D−	1, *ls*
3		$^3P-^3S^\circ$	*206.52*	*5897*	490100	9	3	440	0.093	0.57	−0.08	D+	1
			[207.68]	8580	490100	5	3	240	0.094	0.32	−0.33	D+	*ls*
			[205.46]	3390	490100	3	3	150	0.094	0.19	−0.55	D+	*ls*
			[204.04]	0	490100	1	3	50	0.094	0.063	−1.03	E	*ls*
4		$^1D-^1D^\circ$	[235.27]	59330	484377	5	5	220	0.19	0.72	−0.02	D	1
5		$^1D-^1P^\circ$	[207.57]	59330	541090	5	3	280	0.11	0.37	−0.26	D	1
6		$^1S-^1P^\circ$	[237.16]	119430	541090	1	3	76	0.19	0.15	−0.72	D−	1

P x

Forbidden Transitions

The adopted values represent, as in the case of Na VI, the work of Naqvi [1], Malville and Berger [2], and Froese [3]. For the selection of values, the same considerations as for Na VI are applied, the one exception being that Froese's magnetic dipole values are also used. Since the observed energy levels are uncertain, it is felt that the ζ and η calculated from her theoretical energy levels will be as accurate as the experimental ones.

References

[1] Naqvi, A. M., Thesis Harvard (1951).
[2] Malville, J. M., and Berger, R. A., Planetary and Space Science **13**, 1131–1136 (1965).
[3] Froese, C., Astrophys. J. **145**, 932–935 (1966).

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	Type of Transition	A_{ki}(sec^{-1})	S(at.u.)	Accuracy	Source
1	$2p^2-2p^2$	$^3P-^3P$										
			[29491]	0	3390	1	3	*m*	0.698	1.99	B	1, 2, 3
			[11652]	0	8580	1	5	*e*	1.75×10^{-5}	0.0112	C	3
			[19263]	3390	8580	3	5	*m*	1.87	2.48	B	1, 2, 3
			[19263]	3390	8580	3	5	*e*	3.12×10^{-6}	0.0247	C	3
2		$^3P-^1D$										
			[1685.5]	0	59330	1	5	*e*	9.2×10^{-4}	3.7×10^{-5}	D	3
			[1787.6]	3390	59330	3	5	*m*	16.8	0.0178	C	1, 2, 3
			[1787.6]	3390	59330	3	5	*e*	0.0034	1.9×10^{-4}	D	3
			[1970.4]	8580	59330	5	5	*m*	37.3	0.053	C	1, 2, 3
			[1970.4]	8580	59330	5	5	*e*	0.015	0.0013	D	3
3		$^3P-^1S$										
			[861.77]	3390	119430	3	1	*m*	405	0.0096	C	2, 3
			[902.12]	8580	119430	5	1	*e*	0.31	1.1×10^{-4}	D	3
4		$^1D-^1S$										
			[1663.9]	59330	119430	5	1	*e*	5.8	0.0437	C	3

P XI

Ground State $1s^22s^22p\ ^2P^\circ_{1/2}$

Ionization Potential 479.4 eV = 3867500 cm^{-1}

Allowed Transitions

Values for the majority of the transitions are calculated from the nuclear charge-expansion method of Cohen and Dalgarno [1], which includes limited configuration mixing. Graphical comparisons with other data for the lower ions of this isoelectronic sequence indicate that the uncertainties should be within 50 percent.

For the $2p\ ^2P^\circ-3s\ ^2S$ and $2p\ ^2P^\circ-3d\ ^2D$ multiplets we have obtained data by exploiting the dependence of *f*-values on nuclear charge: In these cases accurate data for several other ions of the boron sequence are available from extended self-consistent field calculations by Weiss [2] in which configuration mixing is fully included. Utilizing those values, which are also supported by some experimental results on lower ions, we have obtained the *f*-values of the two transitions simply by graphical interpolation.

References

[1] Cohen, M., and Dalgarno, A., Proc. Roy. Soc. London **A280**, 258–270 (1964).
[2] Weiss, A. W., private communication (1967).

P XI. Allowed Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
1	$2s^22p-2s2p^2$	$^2P^\circ-^2D$	*321.83*	*6467*	317190	6	10	26	0.068	0.43	−0.39	D	1
			[325.21]	9700	317190	4	6	26	0.061	0.26	−0.61	D	*ls*
			[315.27]	0	317190	2	4	23	0.067	0.14	−0.87	D	*ls*
			[325.21]	9700	317190	4	4	4.3	0.0068	0.029	−1.57	E	*ls*
2		$^2P^\circ-^2S$	*251.98*	*6467*	403330	6	2	110	0.034	0.17	−0.69	D +	1
			[254.05]	9700	403330	4	2	68	0.033	0.11	−0.88	D +	*ls*
			[247.94]	0	403330	2	2	38	0.035	0.057	−1.15	D	*ls*
3		$^2P^\circ-^2P$	*236.27*	*6467*	*429707*	6	6	200	0.16	0.76	−0.02	D +	1
			[236.99]	9700	431650	4	4	160	0.13	0.42	−0.28	D +	*ls*
			[234.84]	0	425820	2	2	130	0.11	0.17	−0.66	D +	*ls*
			[240.32]	9700	425820	4	2	61	0.027	0.084	−0.97	E	*ls*
			[231.67]	0	431650	2	4	34	0.055	0.084	−0.96	E	*ls*
4	$2s2p^2-2p^3$	$^4P-^4S^\circ$	*265.80*	[*183283*]	[559500]	12	4	180	0.065	0.68	−0.11	D +	1
			[268.02]	[186400]	[559500]	6	4	89	0.064	0.34	−0.42	D +	*ls*
			[264.41]	[181300]	[559500]	4	4	63	0.066	0.23	−0.58	D +	*ls*
			[262.05]	[177900]	[559500]	2	4	31	0.064	0.11	−0.89	D +	*ls*
5	$2p-(^1S)3s$	$^2P^\circ-^2S$	*46.134*	*6467*	2174060	6	2	2100	0.022	0.020	−0.88	C	interp
			[46.203]	9700	2174060	4	2	1400	0.022	0.013	−1.06	C	*ls*
			[45.997]	0	2174060	2	2	700	0.022	0.0067	−1.36	D	*ls*
6	$2p-(^1S)3d$	$^2P^\circ-^2D$	*42.710*	*6467*	*2347866*	6	10	1.4×10^4	0.64	0.54	0.58	C	interp
			[42.764]	9700	2348130	4	6	1.4×10^4	0.57	0.32	0.36	C	*ls*
			[42.599]	0	2347470	2	4	1.2×10^4	0.64	0.18	0.11	C	*ls*
			[42.776]	9700	2347470	4	4	2300	0.064	0.036	−0.59	D	*ls*

P XI

Forbidden Transitions

The line strength for the one transition in the ground state configuration is a straight number, tabulated for example by Naqvi [1]. The transition probability should also be quite accurate, since the energy level difference is accurately known.

Reference

[1] Naqvi, A. M., Thesis Harvard (1951).

P XI. Forbidden Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	Type of Transition	A_{ki}(sec^{-1})	S(at.u.)	Accuracy	Source
1	$2p-(^1S)2p$	$^2P^\circ-^2P^\circ$	[10306]	0	9700	2	4	*m*	8.19	1.33	A	1

P XII

Ground State $1s^2 2s^2\ ^1S_0$

Ionization Potential 560.3 eV = 4520500 cm^{-1}

Allowed Transitions

Garstang and Shamey [1] have obtained the f-value for the intercombination line $2\ ^1S_0 - 2\ ^3P^\circ_1$ by calculating the ratio of this line against the resonance transition in the intermediate coupling approximation and by using for the resonance line a value calculated according to Cohen and Dalgarno's method [2]. The data calculated from the charge-expansion method of Cohen and Dalgarno [2], which includes limited configuration mixing, are estimated to be usually accurate to 50 percent or better, while the charge-expansion method of Naqvi and Victor [3] should be less reliable when the effects of configuration interaction are strong, since these are neglected entirely. In assigning the accuracy estimates for these methods as well as for the Coulomb approximation we were to a great extent guided by studying the degree of fit of the data into the systematic trends along isoelectronic sequences.

References

[1] Garstang, R. H., and Shamey, L. J., Astrophys. J. **148**, 665–666 (1967).
[2] Cohen, M., and Dalgarno, A., Proc. Roy. Soc. London **A280**, 258–270 (1964).
[3] Naqvi, A. M., and Victor, G. A., Technical Documentary Report No. RTD TDR–63–3118 (1964).

P XII. Allowed Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
1	$2s^2-2s(^2S)2p$	$^1S-^3P^\circ$	[536.51]	0	[186390]	1	3	0.0086	1.1×10^{-4}	2.0×10^{-4}	−3.96	D	1*n*
2		$^1S-^1P^\circ$	[278.68]	0	358840	1	3	70	0.245	0.225	−0.61	C	2
3	$2s2p-2p^2$	$^3P^\circ-^3P$	[335.57]	[192990]	[490990]	5	5	43	0.072	0.40	−0.44	D+	2, *ls*
			[328.30]	[186390]	[490990]	3	5	15	0.040	0.13	−0.92	D+	2, *ls*
4		$^1P^\circ-^1D$	[557.57]	358840	538190	3	5	13	0.10	0.55	−0.52	D−	2
5	$2s^2-2s(^2S)3p$	$^1S-^1P^\circ$	[37.345]	0	2677740	1	3	1.1×10^4	0.66	0.81	−0.18	E	3
6	$2s2p-2s(^2S)3s$	$^1P^\circ-^1S$	[44.045]	358840	2629250	3	1	850	0.0083	0.0036	−1.60	E	3
7	$2s3s-2s(^2S)3p$	$^1S-^1P^\circ$	[2061.6]	2629250	2677740	1	3	0.79	0.152	1.03	−0.82	C	3
8	$2p3s-2p(^2P^\circ)3p$	$^1P^\circ-^1D$	[1407.5]	2876720	2947770	3	5	2.59	0.128	1.78	−0.416	C	*ca*
9	$2s3p-2s(^2S)3d$	$^1P^\circ-^1D$	[1208.5]	2677740	2760490	3	5	3.28	0.120	1.43	−0.444	C	*ca*
10	$2p3p-2p(^2P^\circ)3d$	$^1D-^1F^\circ$	[1906.9]	2947770	3000210	5	7	0.86	0.065	2.05	−0.488	C	*ca*
11		$^1D-^1P^\circ$	[1568.1]	2947770	3011540	5	3	0.0443	9.8×10^{-4}	0.0253	−2.310	C	*ca*

P XII

Forbidden Transitions

Naqvi's calculations [1] are the only available source. The results for the $^3P^\circ - ^3P^\circ$ transitions are essentially independent of the choice of the interaction parameters. For the $^3P^\circ - ^1P^\circ$ transitions, Naqvi uses empirical term intervals, i.e., the effects of configuration interaction should be partially included.

Reference

[1] Naqvi, A. M., Thesis Harvard (1951).

P XII. Forbidden Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	Type of Transition	A_{ki}(sec^{-1})	S(at.u.)	Accuracy	Source
1	$2s2p-2s(^2S)2p$	$^3P^\circ - ^3P^\circ$										
			[31242]	[183190]	[186390]	1	3	m	0.590	2.00	B	1
			[15147]	[186390]	[192990]	3	5	m	3.88	2.50	A	1
2		$^3P^\circ - ^1P^\circ$										
			[569.31]	[183190]	358840	1	3	m	77	0.00158	C	1
			[579.88]	[186390]	358840	3	3	m	1940	0.0421	C	1
			[602.95]	[192990]	358840	5	3	m	81	0.00197	C	1

P XIII

Ground State $1s^22s\ ^2S_{1/2}$

Ionization Potential 611.45 eV = 4933060 cm^{-1}

Allowed Transitions

For the transition $2s-2p$, the charge-expansion calculation of Cohen and Dalgarno [1] is chosen. An uncertainty of less than 10 percent is indicated from the graphical comparison of this value with the other material for the same transition within the isoelectronic sequence. Data for the other listed transitions have been obtained from the Coulomb approximation. Plots of the dependence of f-value on nuclear charge for all these transitions have been made and show that this material connects up very smoothly with the data for the lower ions as well as with the hydrogenic value for infinite nuclear charge. Based on this impressive agreement, accuracies of 10 percent (or 25 percent for some of the smaller values) are indicated.

Reference

[1] Cohen, M., and Dalgarno, A., Proc. Roy. Soc. London **A280**, 258–270 (1964).

P XIII. Allowed Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
1	$2s-2p$	$^2S-^2P^\circ$	*464.24*	0	*215407*	2	6	10.4	0.100	0.307	−0.699	B	1
			[456.10]	0	219250	2	4	10.9	0.0683	0.205	−0.865	B	*ls*
			[481.42]	0	207720	2	2	9.26	0.0322	0.102	−1.191	B	*ls*
2	$2s-3p$	$^2S-^2P^\circ$	*35.110*	0	*2848230*	2	6	6180	0.343	0.0792	−0.164	B	*ca*
			[35.086]	0	2850150	2	4	6190	0.229	0.0528	−0.339	B	*ls*
			[35.157]	0	2844390	2	2	6150	0.114	0.0264	−0.642	B	*ls*
3	$2p-3s$	$^2P^\circ-^2S$	*38.767*	*215407*	2794900	6	2	2610	0.0196	0.0150	−0.930	B	*ca*
			[38.825]	219250	2794900	4	2	1730	0.0196	0.0100	−1.106	B	*ls*
			[38.652]	207720	2794900	2	2	877	0.0196	0.00500	−1.407	B	*ls*
4	$2p-3d$	$^2P^\circ-^2D$	*37.655*	*215407*	*2871076*	6	10	1.90×10^4	0.675	0.502	0.607	B	*ca*
			[37.702]	219250	2871620	4	6	1.90×10^4	0.606	0.301	0.385	B	*ls*
			[37.558]	207720	2870260	2	4	1.60×10^4	0.675	0.167	0.130	B	*ls*
			[37.721]	219250	2870260	4	4	3160	0.0674	0.0335	−0.569	B	*ls*
5	$3s-3p$	$^2S-^2P^\circ$	*1875.1*	2794900	*2848230*	2	6	0.953	0.151	1.86	−0.520	B	*ca*
			[1810.0]	2794900	2850150	2	4	1.06	0.104	1.24	−0.682	B	*ls*
			[2020.0]	2794900	2844390	2	2	0.762	0.0466	0.620	−1.031	B	*ls*
6	$3p-3d$	$^2P^\circ-^2D$	*4375.9*	*2848230*	*2871076*	6	10	0.0583	0.0279	2.41	−0.776	B	*ca*
			[4656.4]	2850150	2871620	4	6	0.0485	0.0236	1.45	−1.025	B	*ls*
			[3864.4]	2844390	2870260	2	4	0.0705	0.0316	0.803	−1.199	B	*ls*
			[4971.3]	2850150	2870260	4	4	0.00664	0.00246	0.161	−2.007	B	*ls*

SULFUR

S I

Ground State $1s^2 2s^2 2p^6 3s^2 3p^4\ ^3P_2$

Ionization Potential 10.357 eV = 83559.3 cm^{-1}

Allowed Transitions

List of tabulated lines:

Wavelength [Å]	No.	Wavelength [Å]	No.	Wavelength [Å]	No.
1277.3	10	1474.39	7	7696.73	32
1283.8	10	1474.57	7	8449.54	33
1286.7	10	1483.04	7	8451.55	33
1295.66	9	1483.23	7	8452.14	33
1296.17	9	1485.61	3	8670.19	29
1302.34	9	1487.15	7	8670.65	29
1302.87	9	1666.69	13	8671.37	29
1303.11	9	1687.49	2	8679.00	29
1303.42	22	1706.38	12	8679.70	29
1305.89	9	1706.9,	12	8680.47	29
1316.57	20	1707.13	12	8693.24	29
1316.6	20	1782.26	19	8693.98	29
1323.5	20	1807.34	6	8694.70	29
1323.52	20	1819.2	18	8874.53	24
1326.64	20	1820.36	6	8880.1	24
1381.57	1	1826.26	6	8880.70	24
1385.52	1	1900.27	5	8882.47	24
1388.46	1	1914.68	5	8884.23	24
1389.16	1	2168.9	11	9035.92	30
1392.61	1	2190.6	17	9036.32	30
1396.15	1	3015.7	16	9036.73	30
1401.54	21	4694.13	27	9038.72	30
1409.37	21	4695.45	27	9039.27	30
1412.90	21	4696.25	27	9039.5	30
1425.10	4	5278.10	28	9212.91	25
1425.2	4	5278.70	28	9228.11	25
1425.23	4	5278.99	28	9237.49	25
1433.33	4	6403.58	34	10455.5	26
1437.01	4	6408.13	34	10456.8	26
1444.32	8	6415.50	34	10459.5	26
1448.25	15	6743.58	31	11403	23
1452.6	8	6748.79	31	11406	23
1471.82	14	6757.16	31	11453	23
1472.5	14	7679.60	32	11464	23
1474.01	7	7686.13	32	11472	23

For the vacuum uv portion of the spectrum, two experimental data sources are available. Müller [1] has carried out a wall-stabilized arc experiment for many lines in this region; since his absolute values agree within a few percent with the scale provided by the lifetime measurements of Savage and Lawrence [4] employing the phase shift technique, we have in this case not renormalized these values to the lifetime scale as we have usually done. Lawrence [2] has performed intermediate coupling calculations for all possible transitions in the $3p^4 - 3p^3 4s$ array; these numbers are normalized by means of the scale provided by the lifetime experiment of Savage and Lawrence [4] above. Lawrence's values are chosen whenever Müller is not available. In the visible region of the spectrum, transition probabilities have been measured by Bridges and Wiese [3] using

a wall-stabilized arc, by Foster [6] with a vortex arc and by Miller [5] with a conventional shock-tube. All three experiments agree well on a relative basis, but the absolute scale of Bridges and Wiese is about a factor of two higher than that of the other two authors. The absolute values are estimated to be of only moderate accuracy, of the order of 20 to 50 percent, due to difficulties in determining the populations of the atomic states from which the emission takes place. We have therefore renormalized the data of Bridges and Wiese, which are more complete than the others, to the scale provided by the Coulomb approximation. This scale is just about in between the two experimental scales and it fits extremely well into the f-value regularities observed for homologous atoms. The Coulomb approximation is employed for the remainder of the transitions listed and is expected to give results with uncertainties within 50 percent, except for those transitions involving shell-equivalent electrons.

References

[1] Müller, D., Z. Naturforsch. **23a**, 1707–1716 (1968).
[2] Lawrence, G. M., Astrophys. J. **148**, 261–268 (1967).
[3] Bridges, J. M., and Wiese, W. L., Phys. Rev. **159**, 31–38 (1967).
[4] Savage, B. D., and Lawrence, G. M., Astrophys. J. **146**, 940–943 (1966).
[5] Miller, M. H., Thesis Maryland (1968) and to be published.
[6] Foster, E. W., Proc. Phys. Soc. London **A90**, 275–282 (1967).

S I. Allowed Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki} (10^8 sec^{-1})	f_{ik}	S(at. u.)	log gf	Accuracy	Source
1	$3s^23p^4-3s3p^5$	$^3P-^3P^\circ$ (7 uv)	*1388.7*	*196*	*72206*	9	9	0.012	3.4×10^{-4}	0.014	−2.51	D	1
			1388.46	0	72026	5	5	0.0055	1.6×10^{-4}	0.0037	−3.10	D	1
			1389.16	397	72383	3	3	0.0017	4.9×10^{-5}	6.7×10^{-4}	−3.83	D	1
			1381.57	0	72383	5	3	0.0054	9.3×10^{-5}	0.0021	−3.33	D	1
			1385.52	397	72572	3	1	0.013	1.2×10^{-4}	0.0016	−3.44	D	1
			1396.15	397	72026	3	5	0.0057	2.8×10^{-4}	0.0039	−3.08	D	1
			1392.61	574	72383	1	3	0.0052	4.5×10^{-4}	0.0021	−3.35	D	1
2		$^1S-^1P^\circ$	1687.49	22181	81441	1	3	0.94	0.12	0.67	−0.92	D	1
3	$3p^4-3p^3(^4S^\circ)3d$	$^3P-^5D^\circ$ (4 uv)											
			1485.61	574	67886	1	3	0.023	0.0023	0.011	−2.64	D	1
4		$^3P-^3D^\circ$ (5 uv)	*1429.1*	*196*	*70169*	9	15	3.6	0.18	7.8	0.21	D	1
			1425.10	0	70171	5	7	3.5	0.15	3.5	−0.12	D	1, *ls*
			1433.33	397	70167	3	5	2.7	0.14	2.0	−0.38	D	1, *ls*
			1437.01	574	70166	1	3	2.0	0.19	0.90	−0.72	D	1
			1425.23	0	70167	5	5	0.89	0.027	0.63	−0.87	D−	1, *ls*
			1433.33	397	70166	3	3	1.6	0.048	0.68	−0.84	D−	1, *ls*
			[1425.2]	0	70166	5	3	0.099	0.0018	0.042	−2.05	E	1, *ls*
5	$3p^4-3p^3(^4S^\circ)4s$	$^3P-^5S^\circ$ (1 uv)											
			1900.27	0	52624	5	5	6.6×10^{-4}	3.6×10^{-5}	0.0011	−3.74	D	1
			1914.68	397	52624	3	5	1.9×10^{-4}	1.7×10^{-5}	3.2×10^{-4}	−4.29	D	1
6		$^3P-^3S^\circ$ (2 uv)	*1813.7*	*196*	55331	9	3	7.1	0.12	6.3	0.03	C	1
			1807.34	0	55331	5	3	4.1	0.12	3.6	−0.22	C	1
			1820.36	397	55331	3	3	2.2	0.11	2.0	−0.48	C	1
			1826.26	574	55331	1	3	0.73	0.11	0.66	−0.96	C	1
7	$3p^4-3p^3(^2D^\circ)4s'$	$^3P-^3D^\circ$ (3 uv)	*1478.5*	*196*	*67832*	9	15	1.7	0.094	4.1	−0.07	D	1, 2
			1474.01	0	67843	5	7	1.6	0.075	1.8	−0.43	D	1
			1483.04	397	67826	3	5	1.2	0.066	0.97	−0.70	D	1, 2
			1487.15	574	67817	1	3	0.89	0.089	0.44	−1.05	D	1
			1474.39	0	67826	5	5	0.57	0.019	0.45	−1.02	D	1, 2
			1483.23	397	67817	3	3	0.75	0.025	0.36	−1.12	D	1, 2
			1474.57	0	67817	5	3	0.068	0.0013	0.032	−2.19	D	1, 2

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
8		^{3}P–^{1}D°											
			1444.32	0	69239	5	5	0.026	8.1×10^{-4}	0.019	−2.39	D	1
			[1452.6]	397	69239	3	5	0.0035	1.8×10^{-4}	0.0026	−3.27	D	2
9	$3p^4-3p^3(^2P°)4s''$	^{3}P–^{3}P° (9 uv)	*1299.2*	*196*	*77166*	9	9	5.7	0.15	5.6	0.13	D	1, 2
			1295.66	0	77181	5	5	4.8	0.12	2.6	−0.22	D	1
			1302.87	397	77151	3	3	1.1	0.028	0.36	−1.07	D	2
			1296.17	0	77151	5	3	2.4	0.037	0.79	−0.73	D	1
			1303.11	397	77136	3	1	4.8	0.041	0.53	−0.91	D	1
			1302.34	397	77181	3	5	1.3	0.056	0.72	−0.77	D	2
			1305.89	574	77151	1	3	1.7	0.13	0.56	−0.89	D	2
10		^{3}P–^{1}P°											
			[1277.3]	0	78290	5	3	0.0012	1.8×10^{-5}	3.7×10^{-4}	−4.05	D	2
			[1283.8]	397	78290	3	3	7.8×10^{-7}	1.9×10^{-8}	2.4×10^{-7}	−7.24	D	2
			[1286.7]	574	78290	1	3	1.7×10^{-5}	1.3×10^{-6}	5.4×10^{-6}	−5.89	D	2
11	$3p^4-3p^3(^4S°)4s$	^{1}D–^{3}S°											
			[2168.9]	9239	55331	5	3	4.9×10^{-4}	2.1×10^{-5}	7.4×10^{-4}	−3.98	D	2
12	$3p^4-3p^3(^2D°)4s'$	^{1}D–^{3}D° (10 uv)											
			1706.38	9239	67843	5	7	0.0012	7.5×10^{-5}	0.0021	−3.43	D	1
			[1706.9]	9239	67826	5	5	1.6×10^{-5}	7.0×10^{-7}	2.0×10^{-5}	−5.46	D	2
			1707.13	9239	67817	5	3	0.0050	1.3×10^{-4}	0.0037	−3.19	D	1
13		^{1}D–^{1}D° (11 uv)	1666.69	9239	69239	5	5	5.8	0.24	6.6	0.08	C	1
14	$3p^4-3p^3(^2P°)4s''$	^{1}D–^{3}P°											
			1471.82	9239	77181	5	5	0.025	8.1×10^{-4}	0.020	−2.39	D	1
			[1472.5]	9239	77151	5	3	0.0053	1.0×10^{-4}	0.0025	−3.30	D	2
15		^{1}D–^{1}P° (12 uv)	1448.25	9239	78290	5	3	6.9	0.13	3.1	−0.19	D	1
16	$3p^4-3p^3(^4S°)4s$	^{1}S–^{3}S°											
			[3015.7]	22181	55331	1	3	1.2×10^{-4}	4.9×10^{-5}	4.9×10^{-4}	−4.31	D	2
17	$3p^4-3p^3(^2D°)4s'$	^{1}S–^{3}D°											
			[2190.6]	22181	67817	1	3	0.0042	9.1×10^{-4}	0.0065	−3.04	D	2
18	$3p^4-3p^3(^2P°)4s''$	^{1}S–^{3}P°											
			[1819.2]	22181	77151	1	3	6.3×10^{-4}	9.4×10^{-5}	5.6×10^{-4}	−4.03	D	2
19		^{1}S–^{1}P° (13 uv)	1782.26	22181	78290	1	3	1.5	0.22	1.3	−0.66	D	1
20	$3p^4-3p^3(^4S°)4d$	^{3}P–^{3}D° (8 uv)	*1320.0*	*196*	*75955*	9	15	0.94	0.041	1.6	−0.43	D	1
			1316.57	0	75957	5	7	0.96	0.035	0.76	−0.76	D	1, *ls*
			1323.52	397	75953	3	5	0.69	0.030	0.39	−1.05	D	1, *ls*
			1326.64	574	75952	1	3	0.45	0.036	0.16	−1.44	D	1
			[1316.6]	0	75953	5	5	0.24	0.0063	0.14	−1.50	D	1, *ls*
			[1323.5]	397	75952	3	3	0.38	0.010	0.13	−1.52	D	1, *ls*
			[1316.6]	0	75952	5	3	0.027	4.2×10^{-4}	0.0091	−2.68	E	1, *ls*
21	$3p^4-3p^3(^4S°)5s$	^{3}P–^{3}S° (6 uv)	*1405.3*	*196*	71353	9	3	1.6	0.016	0.65	−0.84	D	1
			1401.54	0	71353	5	3	0.91	0.016	0.37	−1.10	D	1
			1409.37	397	71353	3	3	0.50	0.015	0.21	−1.35	D	1
			1412.90	574	71353	1	3	0.16	0.014	0.065	−1.85	D	1

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
22	$3p^4-3p^3(^4S^\circ)6s$	$^3P-^3S^\circ$											
			1303.42	0	76721	5	3	1.9	0.029	0.62	−0.84	D	1
23	$3p^33d-3p^3(^4S^\circ)4f$	$^5D^\circ-^5F$ (19)	*11464*	*67885*	[76653]	25	35	0.18	0.50	470	1.10	E	*ca*
			11453	67878	[76653]	9	11	0.18	0.44	150	0.60	E	*ls*
			11472	67890	[76653]	7	9	0.15	0.39	100	0.43	E	*ls*
			[11406]	67888	[76653]	5	7	0.13	0.35	65	0.24	E	*ls*
			[11403]	67886	[76653]	3	5	0.10	0.34	38	0.01	E	*ls*
			11464	67885	[76653]	1	3	0.085	0.50	19	−0.30	E	*ls*
			11453	67878	[76653]	9	9	0.031	0.060	20	−0.27	E	*ls*
			11472	67890	[76653]	7	7	0.055	0.11	29	−0.12	E	*ls*
			[11406]	67888	[76653]	5	5	0.074	0.14	27	−0.14	E	*ls*
			[11403]	67886	[76653]	3	3	0.087	0.17	19	−0.30	E	*ls*
			11453	67878	[76653]	9	7	0.0026	0.0040	1.4	−1.44	E	*ls*
			11472	67890	[76653]	7	5	0 0073	0.010	2.7	−1.14	E	*ls*
			[11406]	67888	[76653]	5	3	0.012	0.014	2.7	−1.14	E	*ls*
24	$3p^33d-3p^3(^4S^\circ)5f$	$^5D^\circ-^5F$ (21)	*8880.1*	*67885*	79143	25	35	0.10	0.17	120	0.63	E	*ca*
			8874.53	67878	79143	9	11	0.10	0.15	39	0.13	E	*ls*
			8884.23	67890	79143	7	9	0.083	0.13	26	−0.05	E	*ls*
			8882.47	67888	79143	5	7	0.069	0.11	17	−0.25	E	*ls*
			8880.70	67886	79143	3	5	0.056	0.11	9.7	−0.48	E	*ls*
			[8880.1]	67885	79143	1	3	0.047	0.17	4.8	−0.78	E	*ls*
			8874.53	67878	79143	9	9	0.017	0.020	5.2	−0.75	E	*ls*
			8884.23	67890	79143	7	7	0.030	0.035	7.3	−0.60	E	*ls*
			8882.47	67888	79143	5	5	0.040	0.047	6.9	−0.63	E	*ls*
			8880.70	67886	79143	3	3	0.047	0.055	4.8	−0.78	E	*ls*
			8874.53	67878	79143	9	7	0.0014	0.0013	0.35	−1.93	E	*ls*
			8884.23	67890	79143	7	5	0.0040	0.0034	0.69	−1.63	E	*ls*
			8882.47	67888	79143	5	3	0.0067	0.0047	0.69	−1.63	E	*ls*
25	$3p^34s-3p^3(^4S^\circ)4p$	$^5S^\circ-^5P$ (1)	*9223.4*	52624	*63463*	5	15	0.29	1.1	170	0.74	D+	3*n*
			9212.91	52624	63475	5	7	0.30	0.53	80	0.42	D+	3*n*
			9228.11	52624	63457	5	5	0.28	0.36	55	0.26	D+	3*n*
			9237.49	52624	63446	5	3	0.28	0.22	33	0.04	D+	3*n*
26		$^3S^\circ-^3P$ (3)	*10456*	55331	*64892*	3	9	0.22	1.1	110	0.52	D+	3*n*
			10455.5	55331	64893	3	5	0 22	0.60	62	0.26	D+	*ls*
			10459.5	55331	64889	3	3	0.22	0.36	37	0.03	D+	*ls*
			10456.8	55331	64892	3	1	0.22	0.12	12	−0.44	D+	*ls*
27	$3p^34s-3p^3(^4S^\circ)5p$	$^5S^\circ-^5P$ (2)	*4695.1*	52624	*73917*	5	15	0.0074	0.0074	0.57	−1.43	D+	3*n*
			4694.13	52624	73921	5	7	0.0076	0.0035	0.27	−1.76	D+	*ls*
			4695.45	52624	73915	5	5	0.0074	0.0025	0.19	−1.90	D+	*ls*
			4696.25	52624	73912	5	3	0.0072	0.0014	0.11	−2.15	D	*ls*
28		$^3S^\circ-^3P$ (4)	*5278.7*	55331	*74270*	3	9	0.0038	0.0048	0.25	−1.94	D+	3*n*
			5278.99	55331	74269	3	5	0.0038	0.0026	0.14	−2.10	D+	*ls*
			5278.70	55331	74270	3	3	0.0038	0.0016	0.083	−2.32	D+	*ls*
			5278.10	55331	74272	3	1	0.0038	5.3×10^{-4}	0.028	−2.80	D	*ls*
29	$3p^34p-3p^3(^4S^\circ)4d$	$^5P-^5D^\circ$ (6)	*8684.2*	*63463*	*74975*	15	25	0.12	0.22	93	0.52	D+	3*n*
			8694.70	63475	74973	7	9	0.11	0.16	33	0.05	D+	*ls*
			8680.47	63457	74974	5	7	0.075	0.12	17	−0.23	D+	*ls*
			8671.37	63446	74975	3	5	0.040	0.076	6.5	−0.64	D	*ls*
			8693.98	63475	74974	7	7	0.038	0.043	8.7	−0.52	D	*ls*
			8679.70	63457	74975	5	5	0.068	0.077	11	−0.41	D+	*ls*
			8670.65	63446	74976	3	3	0.087	0.098	8.4	−0.53	D	*ls*
			8693.24	63475	74975	7	5	0.0074	0.0060	1.2	−1.38	D−	*ls*
			8679.00	63457	74976	5	3	0.029	0.020	2.8	−1.00	D−	*ls*
			8670.19	63446	74977	3	1	0.12	0.043	3.7	−0.89	D−	*ls*

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
30		^{3}P–^{3}D° (13)	*9036.7*	*64892*	*75955*	9	15	0.029	0.059	16	−0.27	D	*ca*
			9035.92	64893	75957	5	7	0.029	0.049	7.3	−0.61	D	*ls*
			9036.32	64889	75953	3	5	0.022	0.044	3.9	−0.88	D	*ls*
			9038.72	64892	75952	1	3	0.016	0.059	1.7	−1.23	D−	*ls*
			9039.27	64893	75953	5	5	0.0072	0.0088	1.3	−1.36	D−	*ls*
			9036.73	64889	75952	3	3	0.012	0.015	1.3	−1.36	D−	*ls*
			[9039.5]	64893	75952	5	3	8.0×10^{-4}	5.9×10^{-4}	0.087	−2.53	E	*ls*
31	$3p^34p$ – $3p^3(^4S°)5d$	^{5}P–^{5}D° (8)	*6751.2*	*63463*	78271	15	25	0.079	0.090	30	0.13	D+	*3n*
			6757.16	63475	78271	7	9	0.080	0.070	11	−0.31	D+	*ls*
			6748.79	63457	78271	5	7	0.053	0.050	5.6	−0.60	D+	*ls*
			6743.58	63446	78271	3	5	0.028	0.032	2.1	−1.02	D	*ls*
			6757.16	63475	78271	7	7	0.026	0.018	2.8	−0.90	D	*ls*
			6748.79	63457	78271	5	5	0.046	0.032	3.5	−0.80	D	*ls*
			6743.58	63446	78271	3	3	0.059	0.041	2.7	−0.92	D	*ls*
			6757.16	63475	78271	7	5	0.0053	0.0026	0.40	−1.75	E	*ls*
			6748.79	63457	78271	5	3	0.020	0.0081	0.90	−1.39	E	*ls*
			6743.58	63446	78271	3	1	0.079	0.018	1.2	−1.27	D−	*ls*
32	$3p^34p$ – $3p^3(^4S°)6s$	^{5}P–^{5}S° (7)	*7689.6*	*63463*	76464	15	5	0.061	0.018	6.8	−0.57	D	*ca*
			7696.73	63475	76464	7	5	0.028	0.018	3.1	−0.91	D	*ls*
			7686.13	63457	76464	5	5	0.020	0.018	2.2	−1.06	D	*ls*
			7679.60	63446	76464	3	5	0.012	0.018	1.3	−1.28	D	*ls*
33		^{3}P–^{3}S° (14)	*8451.6*	*64892*	76721	9	3	0.050	0.018	4.5	−0.79	D	*ca*
			8452.14	64893	76721	5	3	0.028	0.018	2.5	−1.04	D	*ls*
			8449.54	64889	76721	3	3	0.017	0.018	1.5	−1.26	D	*ls*
			8451.55	64892	76721	1	3	0.0057	0.018	0.51	−1.74	D−	*ls*
34	$3p^34p$ – $3p^3(^4S°)7s$	^{5}P–^{5}S° (9)	*6410.5*	*63463*	79058	15	5	0.029	0.0059	1.9	−1.05	D	*ca*
			6415.50	63475	79058	7	5	0.013	0.0059	0.87	−1.39	D	*ls*
			6408.13	63457	79058	5	5	0.0095	0.0059	0.62	−1.53	D	*ls*
			6403.58	63446	79058	3	5	0.0057	0.0059	0.37	−1.75	D−	*ls*

S I

Forbidden Transitions

The adopted values have been derived from Naqvi [1], and Czyzak and Krueger [2]. Since their methods are essentially alike, Naqvi's and Czyzak and Krueger's magnetic dipole transitions have normally been averaged, except for the $^3P-^1S$ transition where configuration interaction is important. In this case Czyzak and Krueger's empirically derived value has been preferred over Naqvi's, which is based purely on theory (see also General Introduction). McConkey, Burns, Moran, and Kernahan [3] have measured the relative intensities of the $^1D_2-^1S_0$ and the $^3P_1-^1S_0$ lines obtaining a ratio of 5.1 ± 0.7 in perfect agreement with Czyzak and Krueger's theoretical ratio of 5.09.

References

[1] Naqvi, A. M., Thesis Harvard (1951).
[2] Czyzak, S. J. & Krueger, T. K., Monthly Notices Roy. Astron. Soc. **126**, 177–194 (1963).
[3] McConkey, J. W., Burns, D. J., Moran, K. A. and Kernahan, J. A., Nature **217**, 538–539 (1968).

SI. Forbidden Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	Type of Transition	A_{ki}(sec^{-1})	S(at.u.)	Accuracy	Source
1	$3p^4-3p^4$	$^3P-^3P$										
			[25.239×10^4]	0.00	396.11	5	3	*e*	8.4×10^{-9}	15.4	C	2
			[25.239×10^4]	0.00	396.11	5	3	*m*	0.00140	2.50	A	1
			[17.427×10^4]	0.00	573.66	5	1	*e*	7.1×10^{-8}	6.8	C	2
			[56.307×10^4]	396.11	573.66	3	1	*m*	3.02×10^{-4}	2.00	A	1
2		$^3P-^1D$ (1F)										
			10819.8	0.00	9238.52	5	5	*e*	2.1×10^{-4}	0.094	D	2
			10819.8	0.00	9238.52	5	5	*m*	0.0275	0.0065	C	1, 2
			11305.8	396.11	9238.52	3	5	*e*	2.5×10^{-5}	0.014	D	2
			11305.8	396.11	9238.52	3	5	*m*	0.0080	0.00215	C	1, 2
			11540.1	573.66	9238.52	1	5	*e*	5.0×10^{-6}	0.0030	D	2
3		$^3P-^1S$ (2F)										
			4506.9	0.00	22180.0	5	1	*e*	0.0073	0.0081	D	2
			4589.26	396.11	22180.0	3	1	*m*	0.35	0.00125	C	2
4		$^1D-^1S$ (3F)										
			7725.04	9238.52	22180.0	5	1	*e*	1.78	29.1	C	2

SII

Ground State $1s^22s^22p^63s^23p^3\ ^4S^\circ_{3/2}$

Ionization Potential 23.4 eV = 188824.5 cm^{-1}

Allowed Transitions

List of tabulated lines:

Wavelength [Å]	No.	Wavelength [Å]	No.	Wavelength [Å]	No.
1124.39	3	3860.64	22	4153.10	19
1125.00	3	3892.32	22	4162.70	19
1131.05	3	3923.48	23	4165.11	26
1131.65	3	3933.29	23	4168.41	19
1234.14	2	3939.49	20	4174.04	26
1250.50	1	3946.98	20	4180.7	26
1253.79	1	3950.42	20	4189.71	26
1259.53	1	3963.13	20	4189.71	19
3317.70	18	3970.69	20	4213.5	19
3547.9	24	3971.2	20	4217.23	19
3567.17	24	3979.86	25	4249.92	27
3616.92	24	3990.94	20	4255.01	19
3639.1	24	3998.79	25	4257.42	27
3783.16	29	4003.89	20	4259.18	27
3792.46	22	4009.39	23	4267.80	21
3802.65	22	4028.79	20	4269.76	21
3809.67	22	4032.81	25	4278.54	21
3821.0	22	4050.11	20	4282.63	21
3850.93	22	4142.29	19	4291.45	21
3860.15	29	4145.10	19	4294.43	21

List of tabulated lines—*Continued*

Wavelength [Å]	No.	Wavelength [Å]	No.	Wavelength [Å]	No.
4318.69	21	4901.30	31	5509.67	8
4333.84	21	4908.5	10	5518.74	34
4342.84	30	4917.15	14	5526.22	5
4391.84	30	4924.08	9	5536.77	5
4402.86	30	4925.32	9	5556.01	8
4432.41	30	4942.47	9	5559.06	34
4456.43	30	4991.94	9	5564.94	8
4463.58	30	5006.71	33	5578.85	5
4483.42	30	5009.54	9	5606.11	5
4486.66	30	5014.03	14	5616.63	5
4524.68	17	5027.19	4	5639.96	13
4524.95	17	5032.41	9	5645.62	8
4552.38	17	5047.28	14	5646.98	13
4656.74	11	5103.30	9	5659.95	5
4681.32	10	5126.13	33	5664.73	5
4700.21	32	5142.33	4	5819.22	13
4716.23	11	5198.89	33	6305.51	6
4729.45	31	5201.00	16	6312.68	7
4742.4	10	5201.32	16	7885.26	28
4779.11	10	5212.6	16	7967.43	12
4792.02	31	5212.61	16	8005.24	28
4804.12	10	5320.70	15	8018.70	28
4815.52	11	5345.67	15	8093.25	28
4819.60	31	5345.7	15	8133.02	28
4819.60	32	5362.69	34	8222.15	28
4824.07	32	5400.67	34	8223.16	28
4835.85	31	5428.64	8	8233.30	28
4883.73	31	5432.77	8	8314.73	12
4885.63	14	5453.81	8		
4900.47	31	5473.59	8		

Müller [1] has measured the *f*-values for three multiplets in the vacuum uv portion of this spectrum using a wall-stabilized arc. His absolute values have been renormalized to the scale provided by the lifetime determinations of Savage and Lawrence [5] employing the phase shift technique.

In the visible region, Bridges and Wiese [2] have carried out a wall-stabilized arc experiment for several lines, while Miller [3] has performed measurements with a conventional shock tube. Garstang [4] has calculated relative line strengths in intermediate coupling for all possible transitions in the $4s$—$4p$ array. The experimental approaches, which do not provide very accurate absolute values, are slightly renormalized to the scale obtained from the Coulomb approximation for the prominent $4s\,^4P_{5/2}-4p\,^4D^\circ_{7/2}$ line (λ5454). The relative values of all three methods are in good agreement and, where available, the normalized results are averaged (an exception is the $4s\,^4P-4p\,^4S^\circ$ multiplet; here the two experiments agree, but deviate strongly from theory; it seems likely that the classification is here erroneous).

The Coulomb approximation is employed for many other transitions in this ion; it should be pointed out, however, that these values may have large uncertainties due to significant departures from *LS* coupling. The departures will affect the weaker lines within these multiplets more strongly.

References

[1] Müller, D., Z. Naturforsch. **23a**, 1707–1716 (1968).
[2] Bridges, J. M., and Wiese, W. L., Phys. Rev. **159**, 31–38 (1967).
[3] Miller, M. H., Thesis Maryland (1968) and to be published.
[4] Garstang, R. H., Monthly Notices Roy. Astron. Soc. **114**, 118–133 (1954).
[5] Savage, B. D., and Lawrence, G. M., Astrophys. J. **146**, 940–943 (1966).

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
1	$3s^23p^3-3s3p^4$	$^4S^\circ-^4P$ (1 uv)	*1256.1*	0	*79612*	4	12	0.39	0.028	0.46	−0.95	C	1*n*
			1259.53	0	79395	4	6	0.34	0.012	0.20	−1.32	C	1*n*
			1253.79	0	79758	4	4	0.42	0.010	0.17	−1.40	C	1*n*
			1250.50	0	79968	4	2	0.46	0.0054	0.089	−1.67	C	1*n*
2		$^2P^\circ-^2P$ (7 uv)											
			1234.14	24573	105599	4	4	0.048	0.0011	0.018	−2.36	D+	1*n*
3	$3p^3-3p^2(^3P)4s$	$^2P^\circ-^2P$ (8 uv)	*1127.0*	*24557*	*113286*	6	6	4.0	0.076	1.7	−0.34	D	1*n*
			1125.00	24573	113461	4	4	3.1	0.059	0.87	−0.63	D	1*n*
			1131.05	24524	112937	2	2	2.7	0.051	0.38	−0.99	D	1*n*
			1131.65	24573	112937	4	2	1.1	0.011	0.16	−1.36	D	1*n*
			1124.39	24524	113461	2	4	0.84	0.032	0.24	−1.19	D	1*n*
4	$3s3p^4-3s^23p^24p$	$^2P-^2S^\circ$ (1)											
			5027.19	105599	125485	4	2	0.26	0.048	3.2	−0.72	D+	2*n*, 3*n*
			5142.33	106044	125485	2	2	0.19	0.074	2.5	−0.83	D'	3*n*
5	$3p^23d-3p^2(^3P)4p$	$^4F-^4D^\circ$ (11)											
			5606.11	110766	128599	10	8	0.30	0.11	21	0.04	D+	2*n*, 3*n*
			5659.95	110313	127976	6	4	0.34	0.11	12	−0.18	D+	2*n*, 3*n*
			5664.73	110177	127825	4	2	0.38	0.091	6.8	−0.44	D+	2*n*, 3*n*
			5526.22	110508	128599	8	8	0.081	0.037	5.4	−0.53	D	3*n*
			5578.85	110313	128233	6	6	0.074	0.034	3.8	−0.69	D	3*n*
			5616.63	110177	127976	4	4	0.083	0.039	2.9	−0.81	D	3*n*
			5536.77	110177	128233	4	6	0.066	0.045	3.3	−0.74	D	3*n*
6		$^4D-^4P^\circ$ (19)											
			6305.51	114279	130134	8	6	0.18	0.078	13	−0.20	D	2*n*
7		$^2F-^2D^\circ$ (26)											
			6312.68	114804	130641	6	4	0.20	0.080	10	−0.32	D	2*n*
8	$3p^24s-3p^2(^3P)4p$	$^4P-^4D^\circ$ (6)	*5468.3*	*110005*	*128287*	12	20	0.81	0.60	130	0.86	D+	2*n*, 3*n*, 4*n*
			5453.81	110268	128599	6	8	0.78	0.46	50	0.44	D+	2*n*, 3*n*, 4*n*
			5432.77	109831	128233	4	6	0.61	0.41	29	0.21	D+	2*n*, 3*n*, 4*n*
			5428.64	109561	127976	2	4	0.38	0.34	12	−0.17	D+	2*n*, 3*n*, 4*n*
			5564.94	110268	128233	6	6	0.16	0.076	8.3	−0.34	D+	2*n*, 3*n*, 4*n*
			5509.67	109831	127976	4	4	0.39	0.18	13	−0.14	D+	2*n*, 3*n*, 4*n*
			5473.59	109561	127825	2	2	0.74	0.33	12	−0.18	D+	2*n*, 3*n*, 4*n*
			5645.62	110268	127976	6	4	0.018	0.0056	0.63	−1.47	D	4*n*
			5556.01	109831	127825	4	2	0.15	0.036	2.6	−0.84	D	3*n*, 4*n*
9		$^4P-^4P^\circ$ (7)	*5003.9*	*110005*	*129984*	12	12	0.89	0.33	66	0.60	D	2*n*, 3*n*, 4*n*
			5032.41	110268	130134	6	6	0.66	0.25	25	0.18	D+	2*n*, 3*n*, 4*n*
			4991.94	109831	129858	4	4	0.15	0.056	3.7	−0.65	D	3*n*, 4*n*
			4942.47	109561	129788	2	2	0.15	0.055	1.8	−0.96	D	3*n*, 4*n*
			5103.30	110268	129858	6	4	0.50	0.13	13	−0.11	D	3*n*, 4*n*
			5009.54	109831	129788	4	2	0.70	0.13	8.7	−0.28	D	3*n*, 4*n*
			4924.08	109831	130134	4	6	0.22	0.12	7.7	−0.32	D	3*n*, 4*n*
			4925.32	109561	129858	2	4	0.24	0.17	5.6	−0.47	D	3*n*, 4*n*

No.	Transition Array	Multiplet	λ(A)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
10		^{4}P–^{2}D° (8)											
			4779.11	110268	131187	6	6	0.011	0.0037	0.35	−1.65	D	4*n*
			4804.12	109831	130641	4	4	5.9×10^{-4}	2.1×10^{-4}	0.013	−3.09	D	4*n*
			4681.32	109831	131187	4	6	0.0030	0.0015	0.091	−2.23	D	4*n*
			4742.4	109561	130641	2	4	0.0012	8.3×10^{-4}	0.026	−2.78	D	4*n*
			[4908.5]	110268	130641	6	4	0.0031	7.4×10^{-4}	0.072	−2.35	D	4*n*
11		^{4}P–^{4}S° (9)	*4755.1*	*110005*	131029	12	4	0.99	0.11	21	0.12	D+	2*n*, 3*n*
			4815.52	110268	131029	6	4	0.64	0.15	14	−0.05	D+	2*n*, 3*n*
			4716.23	109831	131029	4	4	0.23	0.076	4.7	−0.52	D+	2*n*, 3*n*
			4656.74	109561	131029	2	4	0.12	0.078	2.4	−0.81	D	3*n*
12		^{2}P–^{2}S° (12)	*8195.1*	*113286*	125485	6	2	0.24	0.080	13	−0.32	D	4*n*
			8314.73	113461	125485	4	2	0.16	0.085	9.3	−0.47	D	4*n*
			7967.43	112937	125485	2	2	0.080	0.076	4.0	−0.82	D	4*n*
13		^{2}P–^{2}D° (14)	*5653.6*	*113286*	*130969*	6	10	0.75	0.60	67	0.56	D	2*n*, 3*n*, 4*n*
			5639.96	113461	131187	4	6	0.75	0.54	40	0.33	D	4*n*
			5646.98	112937	130641	2	4	0.68	0.65	24	0.11	D	4*n*
			5819.22	113461	130641	4	4	0.085	0.043	3.3	−0.76	D+	2*n*, 3*n*, 4*n*
14		^{2}P–^{2}P° (15)	*4981.2*	*113286*	*133356*	6	6	0.85	0.32	31	0.28	D	3*n*, 4*n*
			5014.03	113461	133400	4	4	0.72	0.27	18	0.03	D	3*n*, 4*n*
			4917.15	112937	133269	2	2	0.55	0.20	6.4	−0.40	D	3*n*, 4*n*
			5047.28	113461	133269	4	2	0.32	0.060	4.0	−0.62	D	4*n*
			4885.63	112937	133400	2	4	0.13	0.090	2.9	−0.74	D	4*n*
15	$3p^24s'$ – $3p^2(^3P)4d$	^{2}D–^{2}F° (38)	*5331.3*	*121529*	*140281*	10	14	0.85	0.51	89	0.71	D+	2*n*, 3*n*, 4*n*
			5320.70	121529	140319	6	8	0.84	0.48	50	0.46	D+	2*n*, 3*n*, 4*n*
			5345.67	121528	140230	4	6	0.75	0.48	34	0.28	D+	2*n*, 3*n*, 4*n*
			[5345.7]	121529	140230	6	6	0.11	0.045	4.8	−0.57	D+	2*n*, 3*n*, 4*n*
16		^{2}D–^{2}D° (39)	*5208.0*	*121529*	*140725*	10	10	0.79	0.32	55	0.51	D	3*n*, 4*n*
			5212.61	121529	140709	6	6	0.72	0.29	30	0.24	D	3*n*, 4*n*
			5201.00	121528	140750	4	4	0.68	0.28	19	0.05	D	3*n*, 4*n*
			5201.32	121529	140750	6	4	0.065	0.018	1.8	−0.97	D	3*n*, 4*n*
			[5212.6]	121528	140709	4	6	0.098	0.060	4.1	−0.62	D	3*n*, 4*n*
17		^{2}D–^{2}P° (40)	*4534.1*	*121529*	*143578*	10	6	1.2	0.21	32	0.32	D	3*n*, 4*n*
			4524.95	121529	143623	6	4	0.98	0.20	18	0.08	D	3*n*, 4*n*
			4552.38	121528	143489	4	2	1.3	0.20	12	−0.10	D	4*n*
			4524.68	121528	143623	4	4	0.093	0.029	1.7	−0.94	D	3*n*, 4*n*
18	$3p^24p$ – $3p^2(^3P)4d$	^{2}S°–^{2}P (42)											
			3317.70	125485	[155618]	2	2	1.3	0.21	4.7	−0.37	E	*ca*, *ls*
19		^{4}D°–^{4}F (44)	*4159.6*	*128287*	*152321*	20	28	2.3	0.84	230	1.23	D−	*ca*
			4162.70	128599	152615	8	10	2.3	0.76	83	0.78	D−	*ls*
			4153.10	128233	152305	6	8	2.0	0.70	57	0.62	D−	*ls*
			4145.10	127976	152094	4	6	1.8	0.69	38	0.44	D−	*ls*
			4142.29	127825	151959	2	4	1.7	0.86	24	0.24	D−	*ls*
			4217.23	128599	152305	8	8	0.33	0.088	9.8	−0.15	E	*ls*
			4189.71	128233	152094	6	6	0.57	0.15	12	−0.04	E	*ls*
			4168.41	127976	151959	4	4	0.66	0.17	9.5	−0.16	E	*ls*
			4255.01	128599	152094	8	6	0.022	0.0045	0.50	−1.45	E	*ls*
			4213.5	128233	151959	6	4	0.047	0.0083	0.69	−1.30	E	*ls*

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
20		$^4D^\circ-^4D$ (45)	*3995.8*	*128287*	*153306*	20	20	0.60	0.14	38	0.46	D−	*ca*
			4028.79	128599	153414	8	8	0.51	0.12	13	−0.00	D−	*ls*
			3990.94	128233	153283	6	6	0.35	0.083	6.6	−0.30	E	*ls*
			3963.13	127976	153202	4	4	0.24	0.058	3.0	−0.64	E	*ls*
			3946.98	127825	153154	2	2	0.31	0.072	1.9	−0.84	E	*ls*
			4050.11	128599	153283	8	6	0.11	0.021	2.2	−0.78	E	*ls*
			4003.89	128233	153202	6	4	0.21	0.034	2.7	−0.69	E	*ls*
			3970.69	127976	153154	4	2	0.31	0.036	1.9	−0.84	E	*ls*
			[3971.2]	128233	153414	6	8	0.087	0.027	2.1	−0.79	E	*ls*
			3950.42	127976	153283	4	6	0.14	0.050	2.6	−0.70	E	*ls*
			3939.49	127825	153202	2	4	0.15	0.072	1.9	−0.84	E	*ls*
21		$^4P^\circ-^4D$ (49)	*4286.6*	*129984*	*153306*	12	20	1.7	0.77	130	0.96	D−	*ca*
			4294.43	130134	153414	6	8	1.7	0.61	52	0.56	D−	*ls*
			4267.80	129858	153283	4	6	1.2	0.48	27	0.28	E	*ls*
			4269.76	129788	153202	2	4	0.70	0.38	11	−0.12	E	*ls*
			4318.69	130134	153283	6	6	0.49	0.14	12	−0.08	E	*ls*
			4282.63	129858	153202	4	4	0.89	0.24	14	−0.01	E	*ls*
			4278.54	129788	153154	2	2	1.4	0.38	11	−0.12	E	*ls*
			4333.84	130134	153202	6	4	0.082	0.15	1.3	−1.03	E	*ls*
			4291.45	129858	153154	4	2	0.28	0.038	2.2	−0.81	E	*ls*
22		$^4P^\circ-^4P$ (50)	*3851.1*	*129984*	*155943*	12	12	0.87	0.20	30	0.37	D−	*ca*
			3892.32	130134	155818	6	6	0.63	0.14	11	−0.06	D−	*ls*
			[3821.0]	129858	156029	4	4	0.12	0.026	1.3	−0.98	E	*ls*
			3792.46	129788	156148	2	2	0.15	0.032	0.80	−1.19	E	*ls*
			3860.64	130134	156029	6	4	0.40	0.060	4.6	−0.44	E	*ls*
			3802.65	129858	156148	4	2	0.74	0.080	4.0	−0.49	E	*ls*
			3850.93	129858	155818	4	6	0.27	0.091	4.6	−0.44	E	*ls*
			3809.67	129788	156029	2	4	0.38	0.16	4.1	−0.49	E	*ls*
23		$^2D^\circ-^2F$ (55)	*3931.6*	*130969*	*156397*	10	14	2.1	0.67	87	0.83	D−	*ca*
			3933.29	131187	156604	6	8	2.0	0.63	49	0.58	D−	*ls*
			3923.48	130641	156121	4	6	2.0	0.68	35	0.44	E	*ls*
			4009.39	131187	156121	6	6	0.14	0.034	2.7	−0.70	E	*ls*
24		$^2D^\circ-^2D$ (56)	*3596.9*	*130969*	*158763*	10	10	0.38	0.074	8.8	−0.13	D−	*ca*
			3616.92	131187	158827	6	6	0.36	0.070	5.0	−0.38	D−	*ls*
			3567.17	130641	158666	4	4	0.35	0.067	3.1	−0.57	D−	*ls*
			[3639.1]	131187	158666	6	4	0.039	0.0052	0.37	−1.51	E	*ls*
			[3547.9]	130641	158827	4	6	0.025	0.0071	0.33	−1.55	E	*ls*
25		$^4S^\circ-^4P$ (59)	*4012.7*	131029	*155943*	4	12	1.2	0.85	45	0.53	D−	*ca*
			4032.81	131029	155818	4	6	1.2	0.43	23	0.24	D−	*ls*
			3998.79	131029	156029	4	4	1.2	0.28	15	0.05	E	*ls*
			3979.86	131029	156148	4	2	1.2	0.14	7.2	−0.26	E	*ls*
26	$3p^24p'-3p^2(^1D)4d'$	$^2F^\circ-^2F$ (64)	*4179.1*	*140281*	*164203*	14	14	0.79	0.21	40	0.46	D−	*ca*
			4189.71	140319	164181	8	8	0.74	0.20	22	0.19	D−	*ls*
			4165.11	140230	164232	6	6	0.74	0.19	16	0.06	D−	*ls*
			4180.7	140319	164232	8	6	0.037	0.0072	0.79	−1.24	E	*ls*
			4174.04	140230	164181	6	8	0.028	0.0096	0.79	−1.24	E	*ls*
27		$^2D^\circ-^2F$ (66)	*4258.1*	*140725*	*164203*	10	14	1.5	0.57	80	0.76	D−	*ca*
			4259.18	140709	164181	6	8	1.5	0.55	46	0.52	D−	*ls*
			4257.42	140750	164232	4	6	1.4	0.57	32	0.36	E	*ls*
			4249.92	140709	164232	6	6	0.10	0.027	2.3	−0.79	E	*ls*

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
28	$3p^24d-3p^2(^3P)5p$	$^4F-^4D^\circ$ (68)	*8204.6*	*152321*	*164506*	28	20	0.14	0.10	77	0.46	D−	*ca*
			8223.16	152615	164773	10	8	0.12	0.098	27	−0.01	D−	*ls*
			8233.30	152305	164447	8	6	0.12	0.089	19	−0.15	E	*ls*
			8223.16	152094	164252	6	4	0.12	0.080	13	−0.32	E	*ls*
			8222.15	151959	164119	4	2	0.15	0.076	8.3	−0.51	E	*ls*
			8018.70	152305	164773	8	8	0.013	0.013	2.7	−0.99	E	*ls*
			8093.25	152094	164447	6	6	0.024	0.024	3.8	−0.84	E	*ls*
			8133.02	151959	164252	4	4	0.029	0.029	3.1	−0.94	E	*ls*
			7885.26	152094	164773	6	8	6.4×10^{-4}	8.0×10^{-4}	0.12	−2.32	E	*ls*
			8005.24	151959	164447	4	6	0.0013	0.0019	0.20	−2.12	E	*ls*
29	$3p^24p-3p^2(^3P)5s$	$^2S^\circ-^2P$ (41)	*3808.4*	125485	*151735*	2	6	0.15	0.10	2.5	−0.70	D−	*ca*
			3783.16	125485	151911	2	4	0.15	0.064	1.6	−0.89	D−	*ls*
			3860.15	125485	151384	2	2	0.16	0.036	0.92	−1.14	E	*ls*
30		$^4D^\circ-^4P$ (43)	*4456.9*	*128287*	*150718*	20	12	0.76	0.14	40	0.48	D	*3n,ca*
			4463.58	128599	150996	8	6	0.53	0.12	14	−0.02	D	*3n*
			4483.42	128233	150531	6	4	0.31	0.062	5.5	−0.43	D	*3n*
			4486.66	127976	150258	4	2	0.66	0.10	5.9	−0.40	D	*3n*
			4391.84	128233	150996	6	6	0.16	0.046	4.0	−0.56	E	*ca, ls*
			4432.41	127976	150531	4	4	0.29	0.087	5.1	−0.46	E	*ca, ls*
			4456.43	127825	150258	2	2	0.47	0.14	4.1	−0.56	E	*ca, ls*
			4342.84	127976	150996	4	6	0.018	0.0075	0.43	−1.52	E	*ca, ls*
			4402.86	127825	150531	2	4	0.046	0.027	0.77	−1.27	E	*ca, ls*
31		$^4P^\circ-^4P$ (46)	*4821.6*	*129984*	*150718*	12	12	0.54	0.19	36	0.36	D−	*ca*
			4792.02	130134	150996	6	6	0.37	0.13	12	−0.12	D−	*ls*
			4835.85	129858	150531	4	4	0.072	0.025	1.6	−0.99	E	*ls*
			4883.73	129788	150258	2	2	0.091	0.032	1.0	−1.19	E	*ls*
			4901.30	130134	150531	6	4	0.24	0.058	5.6	−0.46	E	*ls*
			4900.47	129858	150258	4	2	0.45	0.081	5.3	−0.49	E	*ls*
			4729.45	129858	150996	4	6	0.16	0.080	5.0	−0.49	E	*ls*
			4819.60	129788	150531	2	4	0.23	0.16	5.0	−0.50	E	*ls*
32		$^2D^\circ-^2P$ (52)	*4814.2*	*130969*	*151735*	10	6	0.85	0.18	28	0.25	D−	*ca*
			4824.07	131187	151911	6	4	0.76	0.18	17	0.02	D−	*ls*
			4819.60	130641	151384	4	2	0.86	0.15	9.5	−0.22	E	*ls*
			4700.21	130641	151911	4	4	0.084	0.028	1.7	−0.95	E	*ls*
33		$^4S^\circ-^4P$ (57)	*5077.6*	131029	*150718*	4	12	0.18	0.21	14	−0.08	D−	*ca*
			5006.71	131029	150996	4	6	0.17	0.098	6.5	−0.41	D−	*ls*
			5126.13	131029	150531	4	4	0.18	0.069	4.7	−0.56	E	*ls*
			5198.89	131029	150258	4	2	0.18	0.036	2.4	−0.85	E	*ls*
34		$^2P^\circ-^2P$ (61)	*5439.5*	*133356*	*151735*	6	6	0.50	0.22	24	0.13	D−	*ca*
			5400.67	133400	151911	4	4	0.40	0.18	13	−0.15	D−	*ls*
			5518.74	133269	151384	2	2	0.32	0.15	5.4	−0.53	E	*ls*
			5559.06	133400	151384	4	2	0.16	0.037	2.7	−0.83	E	*ls*
			5362.69	133269	151911	2	4	0.081	0.070	2.5	−0.86	E	*ls*

Forbidden Transitions

All the values for this ion are taken from Czyzak and Krueger [1], since they have included the important effects of configuration interaction and have used self-consistent field wavefunctions with exchange to obtain their value of s_q. (For a more complete discussion see General Introduction.)

Reference

[1] Czyzak, S. J., and Krueger, T. K., Monthly Notices Roy. Astron. Soc. **126**, 177–194 (1963).

SII. Forbidden Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	Type of Transition	A_{ki}(sec^{-1})	S(at.u.)	Accuracy	Source
1	$3p^3-3p^3$	$^4S^\circ-^2D^\circ$ (2F)										
			6716.42	0.0	14884.8	4	6	*m*	3.63×10^{-5}	2.45×10^{-6}	C	1
			6716.42	0.0	14884.8	4	6	*e*	4.3×10^{-4}	0.021	D	1
			6730.78	0.0	14853.0	4	4	*m*	1.56×10^{-4}	7.1×10^{-6}	C	1
			6730.78	0.0	14853.0	4	4	*e*	2.7×10^{-4}	0.0090	D	1
2		$^4S^\circ-^2P^\circ$ (1F)										
			4068.60	0.0	24571.6	4	4	*m*	0.341	0.00341	C	1
			4068.60	0.0	24571.6	4	4	*e*	1.3×10^{-6}	3.5×10^{-6}	D	1
			4076.35	0.0	24524.9	4	2	*m*	0.134	6.7×10^{-4}	C	1
			4076.35	0.0	24524.9	4	2	*e*	1.4×10^{-5}	1.8×10^{-5}	D	1
3		$^2D^\circ-^2D^\circ$										
			[31.44×10^5]	14853.0	14884.8	4	6	*m*	3.47×10^{-7}	2.40	B	1
			[31.44×10^5]	14853.0	14884.8	4	6	*e*	1.5×10^{-16}	0.17	D	1
4		$^2D^\circ-^2P^\circ$ (3F)										
			10317.7	14884.8	24571.6	6	4	*m*	0.060	0.0098	C	1
			10317.7	14884.8	24571.6	6	4	*e*	0.154	42.9	C	1
			10336.0	14853.0	24524.9	4	2	*m*	0.067	0.0054	C	1
			10336.0	14853.0	24524.9	4	2	*e*	0.131	18.4	C	1
			10369.7	14884.8	24524.9	6	2	*e*	0.087	12.4	C	1
			10284.3	14853.0	24571.6	4	4	*m*	0.108	0.0174	C	1
			10284.3	14853.0	24571.6	4	4	*e*	0.067	18.2	C	1
5		$^2P^\circ-^2P^\circ$										
			[21.41×10^5]	24524.9	24571.6	2	4	*m*	9.14×10^{-7}	1.33	C+	1
			[21.41×10^5]	24524.9	24571.6	2	4	*e*	8.9×10^{-16}	0.096	D	1

Ground State $1s^2 2s^2 2p^6 3s^2 3p^2\ ^3P_0$

Ionization Potential 35.0 eV = 282752 cm^{-1}

Allowed Transitions

List of tabulated lines:

Wavelength [Å]	No.	Wavelength [Å]	No.	Wavelength [Å]	No.
1190.17	1	2856.02	10	3750.74	2
1194.02	1	2863.53	10	3752.9	2
1194.40	1	2872.00	10	3778.90	8
1200.97	1	2897.5	10	3831.85	8
1201.71	1	2904.31	10	3837.80	8
1202.10	1	2947.2	10	3838.32	8
2443.3	13	2949.2	12	3860.64	8
2460.50	13	2950.23	12	3899.09	8
2489.59	13	2962.7	12	3900.0	6
2496.24	13	2964.80	12	3920.37	6
2499.08	13	2985.98	12	3928.62	6
2508.15	13	2998.8	12	3961.55	6
2636.88	14	3231.10	4	3983.77	6
2665.40	14	3233.24	4	3985.97	6
2680.47	14	3234.17	4	4253.59	7
2691.68	14	3324.01	3	4284.99	7
2702.76	14	3324.87	3	4332.71	7
2709.9	11	3367.18	3	4340.30	7
2714.1	11	3369.49	3	4354.56	5
2718.88	11	3370.38	3	4361.53	7
2721.40	14	3387.13	3	4364.73	5
2726.82	15	3632.02	2	4418.84	7
2731.10	11	3656.61	9	4439.87	5
2741.01	11	3662.01	9	4467.83	5
2756.89	11	3709.37	2	4478.48	5
2775.25	11	3710.42	2	4499.29	5
2785.49	15	3717.78	9	4527.96	5
2797.39	15	3747.90	2		

Varsavsky [1] has calculated a value for one multiplet of this ion using the screening-approximation method; this number should be quite uncertain (probably too high, as judged from comparisons in other ions), since the possibly important effects of configuration interaction have been neglected entirely. For numerous other transitions, including those involving shell-equivalent electrons, the Coulomb approximation has been employed in order to have data available for some of the more prominent lines in this spectrum. From the general success of this method and from comparisons with analogous transitions in other ions, uncertainties of 50 percent are normally expected; however, the uncertainties should be somewhat larger for those transitions involving shell-equivalent electrons.

Reference

[1] Varsavsky, C. M., Astrophys. J. Suppl. Ser. **6**, No. 53, 75 (1961).

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
1	$3s^23p^2-3s3p^3$	^{3}P−^{3}D° (1 uv)	*1197.5*	*562*	*84066*	9	15	17	0.62	22	0.75	E	1
			1200.97	833	84100	5	7	17	0.51	10	0.40	E	*ls*
			1194.02	297	84046	3	5	13	0.46	5.4	0.14	E	*ls*
			1190.17	0	84019	1	3	9.6	0.61	2.4	−0.21	E	*ls*
			1201.71	833	84046	5	5	4.2	0.091	1.8	−0.34	E	*ls*
			1194.40	297	84019	3	3	7.1	0.15	1.8	−0.34	E	*ls*
			1202.10	833	84019	5	3	0.47	0.0061	0.12	−1.52	E	*ls*
2	$3p3d-3p(^2P°)4p$	^{3}P°−^{3}D (1)	*3680.7*	*143118*	*170279*	9	15	0.010	0.0034	0.37	−1.52	E	*ca*
			3632.02	143124	170649	5	7	0.010	0.0029	0.17	−1.84	E	*ls*
			3709.37	143116	170067	3	5	0.0075	0.0026	0.094	−2.11	E	*ls*
			3747.90	143096	169770	1	3	0.0054	0.0034	0.042	−2.47	E	*ls*
			3710.42	143124	170067	5	5	0.0025	5.2×10^{-4}	0.031	−2.59	E	*ls*
			3750.74	143116	169770	3	3	0.0041	8.6×10^{-4}	0.032	−2.59	E	*ls*
			[3752.9]	143124	169770	5	3	2.7×10^{-4}	3.4×10^{-5}	0.0021	−3.77	E	*ls*
3		^{3}P°−^{3}P (2)	*3346.2*	*143118*	*172994*	9	9	0.32	0.053	5.3	−0.32	E	*ca*
			3324.87	143124	173192	5	5	0.24	0.039	2.2	−0.71	E	*ls*
			3369.49	143116	172786	3	3	0.077	0.013	0.44	−1.41	E	*ls*
			3370.38	143124	172786	5	3	0.13	0.013	0.73	−1.18	E	*ls*
			3387.13	143116	172631	3	1	0.30	0.017	0.58	−1.28	E	*ls*
			3324.01	143116	173192	3	5	0.079	0.022	0.72	−1.18	E	*ls*
			3367.18	143096	172786	1	3	0.10	0.052	0.58	−1.28	E	*ls*
4		^{3}P°−^{3}S (3)	*3233.4*	*143118*	174036	9	3	1.3	0.070	6.7	−0.20	E	*ca*
			3234.17	143124	174036	5	3	0.75	0.070	3.7	−0.46	E	*ls*
			3233.24	143116	174036	3	3	0.45	0.070	2.2	−0.68	E	*ls*
			3231.10	143096	174036	1	3	0.15	0.070	0.75	−1.15	E	*ls*
5		^{3}D°−^{3}D (7)	*4425.3*	*147688*	*170279*	15	15	0.11	0.031	6.8	−0.33	E	*ca*
			4364.73	147745	170649	7	7	0.097	0.028	2.8	−0.71	E	*ls*
			4467.83	147691	170067	5	5	0.072	0.021	1.6	−0.97	E	*ls*
			4499.29	147550	169770	3	3	0.076	0.023	1.0	−1.16	E	*ls*
			4478.48	147745	170067	7	5	0.016	0.0034	0.35	−1.62	E	*ls*
			4527.96	147691	169770	5	3	0.025	0.0046	0.34	−1.64	E	*ls*
			4354.56	147691	170649	5	7	0.012	0.0049	0.35	−1.61	E	*ls*
			4439.87	147550	170067	3	5	0.016	0.0077	0.34	−1.63	E	*ls*
6		^{3}D°−^{3}P (8)	*3950.5*	*147688*	*172994*	15	9	0.73	0.10	20	0.19	E	*ca*
			3928.62	147745	173192	7	5	0.59	0.098	8.9	−0.16	E	*ls*
			3983.77	147691	172786	5	3	0.51	0.073	4.8	−0.44	E	*ls*
			3985.97	147550	172631	3	1	0.68	0.054	2.1	−0.79	E	*ls*
			3920.37	147691	173192	5	5	0.11	0.025	1.6	−0.91	E	*ls*
			3961.55	147550	172786	3	3	0.17	0.041	1.6	−0.91	E	*ls*
			[3900.0]	147550	173192	3	5	0.0072	0.0027	1.1	−2.09	E	*ls*
7	$3p4s-3p(^2P°)4p$	^{3}P°−^{3}D (4)	*4287.1*	*146960*	*170279*	9	15	1.2	0.55	70	0.70	D	*ca*
			4253.59	147146	170649	5	7	1.2	0.47	33	0.37	D	*ls*
			4284.99	146737	170067	3	5	0.90	0.41	17	0.09	D	*ls*
			4332.71	146696	169770	1	3	0.64	0.54	7.7	−0.27	D−	*ls*
			4361.53	147146	170067	5	5	0.28	0.081	5.8	−0.39	D−	*ls*
			4340.30	146737	169770	3	3	0.48	0.14	5.8	−0.39	D−	*ls*
			4418.84	147146	169770	5	3	0.030	0.0053	0.39	−1.57	E	*ls*
8		^{3}P°−^{3}P (5)	*3840.0*	*146960*	*172994*	9	9	1.7	0.38	43	0.53	D	*ca*
			3838.32	147146	173192	5	5	1.3	0.28	18	0.14	D	*ls*
			3837.80	146737	172786	3	3	0.42	0.092	3.5	−0.56	D	*ls*
			3899.09	147146	172786	5	3	0.67	0.092	5.9	−0.34	D	*ls*
			3860.64	146737	172631	3	1	1.6	0.12	4.7	−0.44	D	*ls*
			3778.90	146737	173192	3	5	0.44	0.16	5.8	−0.33	D	*ls*
			3831.85	146696	172786	1	3	0.56	0.37	4.7	−0.43	D	*ls*

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
9		^{3}P°–^{3}S (6)	*3692.3*	*146960*	174036	9	3	1.9	0.13	14	0.06	D	*ca*
			3717.78	147146	174036	5	3	1.0	0.13	7.8	−0.20	D	*ls*
			3662.01	146737	174036	3	3	0.64	0.13	4.6	−0.42	D	*ls*
			3656.61	146696	174036	1	3	0.21	0.13	1.5	−0.89	D−	*ls*
10	3*p*4*p*–3*p*(^{2}P°)4*d*	^{3}D–^{3}F° (15 uv)	*2865.7*	*170279*	*205164*	15	21	5.7	0.99	140	1.17	D	*ca*
			2863.53	170649	205561	7	9	5.7	0.90	59	0.80	D	*ls*
			2856.02	170067	205071	5	7	5.1	0.87	41	0.64	D	*ls*
			2872.00	169770	204579	3	5	4.7	0.97	28	0.46	D	*ls*
			2904.31	170649	205071	7	7	0.61	0.077	5.2	−0.27	D−	*ls*
			[2897.5]	170067	204579	5	5	0.86	0.86	5.1	−0.27	D−	*ls*
			[2947.2]	170649	204579	7	5	0.024	0.0022	0.15	−1.81	E	*ls*
11		^{3}D–^{3}D° (16 uv)	*2740.6*	*170279*	*206757*	15	15	1.6	0.18	24	0.42	D	*ca*
			2756.89	170649	206911	7	7	1.4	0.16	9.9	0.04	D	*ls*
			2731.10	170067	206672	5	5	1.1	0.12	5.4	−0.22	D	*ls*
			2718.88	169770	206539	3	3	1.2	0.13	3.5	−0.41	D	*ls*
			2775.25	170649	206672	7	5	0.24	0.019	1.2	−0.87	D−	*ls*
			2741.01	170067	206539	5	3	0.39	0.026	1.2	−0.88	D−	*ls*
			[2714.1]	170067	206911	5	7	0.18	0.027	1.2	−0.87	D−	*ls*
			[2709.9]	169770	206672	3	5	0.24	0.043	1.2	−0.88	D−	*ls*
12		^{3}P–^{3}D° (14) (18 uv)	*2961.0*	*172994*	*206757*	9	15	4.0	0.88	77	0.90	D	*ca*
			2964.80	173192	206911	5	7	4.0	0.74	36	0.57	D	*ls*
			2950.23	172786	206672	3	5	3.0	0.66	19	0.30	D	*ls*
			[2949.2]	172631	206539	1	3	2.2	0.88	8.5	−0.06	D−	*ls*
			2985.98	173192	206672	5	5	0.99	0.13	6.5	−0.18	D−	*ls*
			[2962.7]	172786	206539	3	3	1.7	0.22	6.4	−0.18	D−	*ls*
			[2998.8]	173192	206539	5	3	0.11	0.0088	0.44	−1.36	E	*ls*
13	3*p*4*p*–3*p*(^{2}P°)5*s*	^{3}D–^{3}P° (17 uv)	*2495.6*	*170279*	*210338*	15	9	3.0	0.17	21	0.41	D	*ca*
			2496.24	170649	210698	7	5	2.5	0.17	9.7	0.07	D	*ls*
			2508.15	170067	209926	5	3	2.3	0.13	5.4	−0.18	D	*ls*
			2499.08	169770	209773	3	1	3.1	0.097	2.4	−0.53	D−	*ls*
			2460.50	170067	210698	5	5	0.45	0.041	1.7	−0.69	D−	*ls*
			2489.59	169770	209926	3	3	0.77	0.072	1.8	−0.67	D−	*ls*
			[2443.3]	169770	210698	3	5	0.030	0.0045	0.11	−1.87	E	*ls*
14		^{3}P–^{3}P° (19 uv)	*2677.0*	*172994*	*210338*	9	9	1.9	0.20	16	0.26	D	*ca*
			2665.40	173192	210698	5	5	1.4	0.15	6.4	−0.14	D	*ls*
			2691.68	172786	209926	3	3	0.46	0.050	1.3	−0.82	D	*ls*
			2721.40	173192	209926	5	3	0.77	0.051	2.3	−0.59	D	*ls*
			2702.76	172786	209773	3	1	1.9	0.068	1.8	−0.69	D	*ls*
			2638.88	172786	210698	3	5	0.45	0.079	2.1	−0.63	D	*ls*
			2680.47	172631	209926	1	3	0.62	0.20	1.8	−0.70	D	*ls*
15		^{3}S–^{3}P° (20 uv)	*2753.9*	174036	*210338*	3	9	0.61	0.21	5.7	−0.20	D	*ca*
			2726.82	174036	210698	3	5	0.60	0.11	3.0	−0.47	D	*ls*
			2785.49	174036	209926	3	3	0.61	0.071	2.0	−0.67	D	*ls*
			2797.39	174036	209773	3	1	0.63	0.024	0.66	−1.14	D−	*ls*

S III

Forbidden Transitions

The adopted values have been derived from Naqvi [1], and Czyzak and Krueger [2]. Since their methods are essentially alike, Naqvi's and Czyzak and Krueger's magnetic dipole transitions have normally been averaged, except for the $^3P-^1S$ transition where configuration interaction is important. In this case Czyzak and Krueger's empirically derived value has been preferred over Naqvi's, which is based purely on theory (see also General Introduction).

References

[1] Naqvi, A. M., Thesis Harvard (1951).
[2] Czyzak, S. J., and Krueger, T. K., Monthly Notices Roy. Astron. Soc. **126**, 177–194 (1963).

S III. Forbidden Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	Type of Transition	A_{ki}(sec^{-1})	S(at.u.)	Accuracy	Source
1	$3p^2-3p^2$	$^3P-^3P$										
			[33.638 × 10⁴]	0.0	297.2	1	3	*m*	4.72×10^{-4}	2.00	A	1
			[12.009 × 10⁴]	0.0	832.5	1	5	*e*	4.69×10^{-8}	3.49	C	2
			[18.676 × 10⁴]	297.2	832.5	3	5	*m*	0.00207	2.50	A	1
			[18.676 × 10⁴]	297.2	832.5	3	5	*e*	1.16×10^{-8}	7.9	C	2
2		$^3P-^1D$ (1F)										
			[8831.5]	0.0	11320	1	5	*e*	9.1×10^{-6}	0.0014	D	2
			9069.4	297.2	11320	3	5	*m*	0.0248	0.00343	C	1, 2
			9069.4	297.2	11320	3	5	*e*	6.1×10^{-5}	0.011	D	2
			9532.1	832.5	11320	5	5	*m*	0.064	0.0103	C	1, 2
			9532.1	832.5	11320	5	5	*e*	3.3×10^{-4}	0.077	D	2
3		$^3P-^1S$ (2F)										
			3721.8	297.2	27163	3	1	*m*	0.85	0.00162	C	2
			3796.7	832.5	27163	5	1	*e*	0.016	0.0077	D	2
4		$^1D-^1S$ (3F)										
			6312.1	11320	27163	5	1	*e*	2.54	15.2	C	2

S IV

Ground State $1s^22s^22p^63s^23p\ ^2P^\circ_{1/2}$

Ionization Potential 47.29 eV = 381541.4 cm^{-1}

Allowed Transitions

The screening-approximation calculations of Varsavsky [1] for the $3s^23p\ ^2P^\circ-3s3p^2\ ^2D$ multiplet are considered to be rather uncertain (probably too high, as judged from comparisons in other ions) since the important effects of configuration mixing are neglected entirely. Gruzdev and Prokofev [2] have carried out Coulomb approximation calculations modified with the Seaton correction for the $3p\ ^2P^\circ-4s\ ^2S$ multiplet; these results should be reliable to within 25 percent, as judged from plots depicting *f*-value dependence on nuclear charge.

References

[1] Varsavsky, C. M., Astrophys. J. Suppl. Ser. **6**, No. 53, 75 (1961).
[2] Gruzdev, P. F., and Prokofev, V. K., Optics and Spectroscopy (U.S.S.R.) **21**, 151–152 (1966).

S IV. Allowed Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
1	$3s^23p-3s3p^2$	$^2P^\circ-^2D$ (1 uv)	*1069.6*	*633*	*94130*	6	10	20	0.57	12	0.53	E	1
			1072.99	950	94148	4	6	20	0.52	7.3	0.32	E	*ls*
			1062.67	0	94102	2	4	17	0.59	4.1	0.07	E	*ls*
			1073.52	950	94102	4	4	3.3	0.057	0.81	−0.64	E	*ls*
2	$3p-(^1S)4s$	$^2P^\circ-^2S$	*553.10*	*633*	181432	6	2	61	0.094	1.03	−0.249	C	2
			[554.07]	950	181432	4	2	40.8	0.094	0.69	−0.425	C	*ls*
			551.17	0	181432	2	2	20.6	0.094	0.341	−0.73	C	*ls*
3	$4s-(^1S)4p$	$^2S-^2P^\circ$ (1)	*3104.1*	181432	*213647*	2	6	2.6	1.1	23	0.35	D+	*ca*
			3097.46	181432	213717	2	4	2.6	0.74	15	0.17	D+	*ls*
			3117.75	181432	213507	2	2	2.5	0.37	7.5	−0.13	D+	*ls*

S IV. Forbidden Transitions

The line strength for the one transition in the ground state configuration is a straight number, tabulated for example by Naqvi [1]. The transition probability should also be quite accurate, since the energy level difference is accurately known.

Reference

[1] Naqvi, A. M., Thesis Harvard (1951).

S IV. Forbidden Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	Type of Transition	A_{ki}(sec^{-1})	S(at. u.)	Accuracy	Source
1	$3p-(^1S)3p$	$^2P^\circ-^2P^\circ$	[10.521×10^4]	0.0	950.2	2	4	*m*	0.00770	1.33	A	1

S V

Ground State $1s^2 2s^2 2p^6 3s^2\ {}^1S_0$

Ionization Potential 72.5 eV = 584700 cm^{-1}

Allowed Transitions

List of tabulated lines:

Wavelength [Å]	No.	Wavelength [Å]	No.	Wavelength [Å]	No.
437.37	8	680.90	7	852.185	2
438.19	8	681.68	7	854.792	2
439.65	8	686.11	6	857.872	2
658.262	5	686.95	6	860.462	2
659.853	5	688.07	6	883.54	4
663.155	5	689.85	6	884.45	4
676.21	7	691.74	6	885.77	4
677.35	7	693.53	6	900.90	3
678.12	7	786.476	1	902.83	3
680.36	7	849.241	2	905.89	3

The charge-expansion technique of Crossley and Dalgarno [1], which includes limited configuration mixing, has been employed for the majority of the transitions in this spectrum. Gruzdev and Prokofev [2] have carried out Coulomb approximation calculations, modified with the Seaton correction, for the $3s3p\ {}^3P^\circ - 3s4s\ {}^3S$ multiplet. For many of these transitions, the dependence of oscillator strength on nuclear charge has served as an aid in estimating accuracies.

For the resonance line we have chosen an interpolated value in preference to the result by Crossley and Dalgarno, since their number for S V does not fit too closely into the very firmly established systematic trend for this transition against nuclear charge (See fig. 4 of the General Introduction).

References

[1] Crossley, R. J. S., and Dalgarno, A., Proc. Roy. Soc. London **A286**, 510 (1965).

[2] Gruzdev, P. F., and Prokofev, V. K., Optics and Spectroscopy (U.S.S.R.) **21**, 151–152 (1966).

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
1	$3s^2-3s(^2S)3p$	$^1S-^1P^\circ$ (1 uv)	786.476	0	127149	1	3	52.5	1.46	3.78	0.164	B	interp
2	$3s3p-3p^2$	$^3P^\circ-^3P$ (2 uv)	*854.85*	[*83819*]	[*200798*]	9	9	41.8	0.458	11.6	0.62	C+	1
			854.792	[84200]	[201186]	5	5	31.3	0.343	4.83	0.234	C+	*ls*
			854.792	[83433]	[200417]	3	3	10.5	0.115	0.97	−0.462	C	*ls*
			860.462	[84200]	[200417]	5	3	17.1	0.114	1.61	−0.244	C	*ls*
			857.872	[83433]	[200000]	3	1	41.4	0.152	1.29	−0.341	C	*ls*
			849.241	[83433]	[201186]	3	5	10.7	0.192	1.61	−0.240	C	*ls*
			852.185	[83071]	[200417]	1	3	14.1	0.460	1.29	−0.337	C	*ls*
3	$3s(^2S)3d-3p(^2P^\circ)3d$	$^3D-^3P^\circ$	*904.31*	[234987]	[*345569*]	15	9	22	0.16	7.3	0.39	D	1
			[905.89]	[234987]	[345376]	7	5	19	0.16	3.4	0.06	D	*ls*
			[902.83]	[234987]	[345750]	5	3	17	0.12	1.8	−0.22	D	*ls*
			[900.90]	[234987]	[345987]	3	1	22	0.091	0.81	−0.56	D−	*ls*
			[905.89]	[234987]	[345376]	5	5	3.3	0.041	0.61	−0.69	D−	*ls*
			[902.83]	[234987]	[345750]	3	3	5.6	0.068	0.61	−0.69	D−	*ls*
			[905.89]	[234987]	[345376]	3	5	0.22	0.0045	0.041	−1.87	E	*ls*
4		$^3D-^3D^\circ$	*884.29*	[234987]	[*348072*]	15	15	21	0.24	11	0.56	D	1
			[883.54]	[234987]	[348168]	7	7	19	0.22	4.4	0.18	D	*ls*
			[884.45]	[234987]	[348051]	5	5	14	0.17	2.5	−0.07	D	*ls*
			[885.77]	[234987]	[347883]	3	3	16	0.18	1.6	−0.26	D	*ls*
			[884.45]	[234987]	[348051]	7	5	3.2	0.027	0.55	−0.72	D−	*ls*
			[885.77]	[234987]	[347883]	5	3	5.2	0.036	0.53	−0.74	D−	*ls*
			[883.54]	[234987]	[348168]	5	7	2.3	0.038	0.55	−0.72	D−	*ls*
			[884.45]	[234987]	[348051]	3	5	3.1	0.061	0.53	−0.74	D−	*ls*
5	$3s3p-3s(^2S)3d$	$^3P^\circ-^3D$ (3 uv)	*661.52*	[*83819*]	[234987]	9	15	64.4	0.704	13.8	0.802	B	1
			663.155	[84200]	[234987]	5	7	63.9	0.590	6.44	0.470	B	*ls*
			659.853	[83433]	[234987]	3	5	48.7	0.529	3.45	0.201	B	*ls*
			658.262	[83071]	[234987]	1	3	36.2	0.706	1.53	−0.151	B	*ls*
			663.155	[84200]	[234987]	5	5	16.0	0.105	1.15	−0.280	B	*ls*
			659.853	[83433]	[234987]	3	3	27.0	0.176	1.15	−0.277	B	*ls*
			663.155	[84200]	[234987]	5	3	1.8	0.0070	0.077	−1.45	D	*ls*
6	$3p^2-3p(^2P^\circ)3d$	$^3P-^3P^\circ$	*690.75*	[*200798*]	[*345569*]	9	9	50	0.36	7.3	0.51	D	1
			[693.53]	[201186]	[345376]	5	5	36	0.26	3.0	0.11	D	*ls*
			[688.07]	[200417]	[345750]	3	3	13	0.090	0.61	−0.57	D	*ls*
			[691.74]	[201186]	[345750]	5	3	20	0.088	1.0	−0.36	D	*ls*
			[686.95]	[200417]	[345987]	3	1	51	0.12	0.81	−0.44	D	*ls*
			[689.85]	[200417]	[345376]	3	5	12	0.15	1.0	−0.36	D	*ls*
			[686.11]	[200000]	[345750]	1	3	17	0.36	0.81	−0.44	D	*ls*
7		$^3P-^3D^\circ$	*679.01*	[*200798*]	[*348072*]	9	15	86	0.99	20	0.95	D	1
			[680.36]	[201186]	[348168]	5	7	85	0.83	9.3	0.62	D	*ls*
			[677.35]	[200417]	[348051]	3	5	65	0.75	5.0	0.35	D	*ls*
			[676.21]	[200000]	[347883]	1	3	48	0.99	2.2	0.00	D	*ls*
			[680.90]	[201186]	[348051]	5	5	22	0.15	1.7	−0.12	D	*ls*
			[678.12]	[200417]	[347883]	3	3	37	0.25	1.7	−0.12	D	*ls*
			[681.68]	[201186]	[347883]	5	3	2.3	0.0098	0.11	−1.31	E	*ls*
8	$3s3p-3s(^2S)4s$	$^3P^\circ-^3S$ (4 uv)	*438.88*	[*83819*]	[311670]	9	3	100	0.096	1.25	−0.063	C	2
			439.65	[84200]	[311670]	5	3	55	0.096	0.65	−0.319	C	*ls*
			438.19	[83433]	[311670]	3	3	33.3	0.096	0.415	−0.54	C	*ls*
			437.37	[83071]	[311670]	1	3	11.2	0.096	0.138	−1.018	C	*ls*

S V

Forbidden Transitions

Naqvi's calculations [1] are the only available source. The results for the $^3P^\circ - ^3P^\circ$ transitions are essentially independent of the choice of the interaction parameters. For the $^3P^\circ - ^1P^\circ$ transitions, Naqvi uses emperical term intervals, i.e., the effects of configuration interaction should be partially included.

Reference

[1] Naqvi, A. M., Thesis Harvard (1951).

S V. Forbidden Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	Type of Transition	A_{ki}(sec^{-1})	S(at.u.)	Accuracy	Source
1	$3s3p-3s(^2S)3p$	$^3P^\circ - ^3P^\circ$										
			[27.62 × 10⁴]	[83071]	[83433]	1	3	*m*	8.53 × 10⁻⁴	2.00	B	1
			[13.03 × 10⁴]	[83433]	[84200]	3	5	*m*	0.00610	2.50	B	1
2		$^3P^\circ - ^1P^\circ$										
			[2268.0]	[83071]	127149	1	3	*m*	0.236	3.06 × 10⁻⁴	C−	1
			[2286.8]	[83433]	127149	3	3	*m*	14.0	0.0186	C−	1
			[2327.6]	[84200]	127149	5	3	*m*	0.273	3.83 × 10⁻⁴	C−	1

S VI

Ground State $1s^22s^22p^63s\ ^2S_{1/2}$

Ionization Potential 88.029 eV = 710194 cm^{-1}

Allowed Transitions

List of tabulated lines:

Wavelength [Å]	No.	Wavelength [Å]	No.	Wavelength [Å]	No.
191.48	3	464.654	7	944.517	1
191.56	3	648.50	6	971.36	12
248.985	2	648.64	6	975.70	12
249.271	2	650.43	6	1975.5	11
283.50	9	706.480	4	1992.5	11
328.51	8	712.682	4	1993.5	11
388.940	5	712.844	4	2587.4	10
390.859	5	933.382	1	2618.3	10

The only source available for this ion are the charge-expansion calculations of Crossley and Dalgarno [1] which include limited configuration mixing. Graphical comparisons of this work with more refined values within the isoelectronic sequence indicate accuracies within 25 percent. A number of additional values have been obtained from studies of the *f*-value dependence on nuclear charge. The reliable material available for other ions of this isoelectronic sequence in these cases permits the determination of reliable values simply by graphical interpolation.

Reference

[1] Crossley, R. J. S., and Dalgarno, A., Proc. Roy. Soc., London **A286**, 510–518 (1965).

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
1	$3s-3p$	$^2S-^2P^\circ$ (1 uv)	*937.07*	0	*106716*	2	6	16.1	0.64	3.92	0.107	C	1
			933.382	0	107137	2	4	16.3	0.425	2.61	−0.071	C	*ls*
			944.517	0	105874	2	2	15.7	0.211	1.31	−0.375	C	*ls*
2	$3s-4p$	$^2S-^2P^\circ$ (2 uv)	*249.09*	0	*401469*	2	6	25.6	0.071	0.117	−0.85	C	*ca*
			248.985	0	401621	2	4	25.4	0.0471	0.077	−1.026	C	*ls*
			249.271	0	401164	2	2	26.1	0.0244	0.0400	−1.312	C	*ls*
3	$3s-5p$	$^2S-^2P^\circ$	*191.51*	0	*522175*	2	6	17	0.028	0.035	−1.25	D	interp
			[191.48]	0	522248	2	4	17	0.018	0.023	−1.44	D	*ls*
			[191.56]	0	522030	2	2	17	0.0095	0.012	−1.72	D−	*ls*
4	$3p-3d$	$^2P^\circ-^2D$ (3 uv)	*710.62*	*106716*	*247439*	6	10	49.1	0.62	8.7	0.57	C	1
			712.682	107137	247452	4	6	48.5	0.55	5.2	0.346	C	*ls*
			706.480	105874	247420	2	4	41.7	0.62	2.90	0.096	C	*ls*
			712.844	107137	247420	4	4	8.1	0.062	0.58	−0.61	D	*ls*
5	$3p-4s$	$^2P^\circ-^2S$ (4 uv)	*390.22*	*106716*	362983	6	2	121	0.092	0.71	−0.258	C	*ca*
			390.859	107137	362983	4	2	81	0.093	0.477	−0.431	C	*ls*
			388.940	105874	362983	2	2	40.3	0.091	0.234	−0.74	C	*ls*
6	$3d-4p$	$^2D-^2P^\circ$	*649.22*	*247439*	*401469*	10	6	37	0.14	3.0	0.15	C	interp
			[648.64]	247452	401621	6	4						
			[650.43]	247420	401164	4	2	33	0.14	1.8	−0.08	C	*ls*
			[648.50]	247420	401621	4	4	37	0.12	1.0	−0.32	C	*ls*
								3.7	0.023	0.20	−1.04	D	*ls*
7	$3d-4f$	$^2D-^2F^\circ$ (5 uv)	464.654	*247439*	462653	10	14	202	0.92	14.0	0.96	C+	*ca*
8	$3d-5f$	$^2D-^2F^\circ$	*328.51*	*247439*	551848	10	14	75	0.17	1.8	0.23	C	interp
9	$3d-6f$	$^2D-^2F^\circ$	*283.50*	*247439*	600170	10	14	37	0.062	0.58	−0.21	C	interp
10	$4s-4p$	$^2S-^2P^\circ$	*2597.6*	362983	*401469*	2	6	3.2	0.97	17	0.29	C	interp
			[2587.4]	362983	401621	2	4	3.2	0.65	11	0.11	C	*ls*
			[2618.3]	362983	401164	2	2	3.2	0.33	5.7	−0.18	C	*ls*
11	$4p-4d$	$^2P^\circ-^2D$	*1986.9*	*401469*	*451799*	6	10	10	1.0	39	0.78	C	interp
			[1992.5]	401621	451808	4	6	9.8	0.88	23	0.55	C	*ls*
			[1975.5]	401164	451785	2	4	8.5	1.0	13	0.30	C	*ls*
			[1993.5]	401621	451785	4	4	1.7	0.099	2.6	−0.40	D	*ls*
12	$4p-5s$	$^2P^\circ-^2S$	*974.25*	*401469*	504112	6	2	38	0.18	3.5	0.03	C	interp
			[975.70]	401621	504112	4	2	25	0.18	2.3	−0.14	C	*ls*
			[971.36]	401164	504112	2	2	13	0.19	1.2	−0.42	C	*ls*

S VII

Ground State $1s^2 2s^2 2p^6\ ^1S_0$

Ionization Potential 280.99 eV = 2266990 cm^{-1}

Allowed Transitions

Calculations by Kastner, Omidvar, and Underwood [1], employing Hartree-Fock wavefunctions and including intermediate coupling, are available. Since the calculations are based on a single–configuration approximation only, uncertainties of up to 50 percent are expected for the strong lines and even higher uncertainties for the weak lines, the latter being more affected by assumptions about the coupling.

Reference

[1] Kastner, S. O., Omidvar, K., and Underwood, J. H., Astrophys. J. **148**, 269–273 (1967).

S VII. Allowed Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
1	$2p^6 - 2p^5(^2P^\circ_{3/2})3s$	$^1S - ^3P^\circ$	[72.663]	0	1376220	1	3	150	0.036	0.0086	−1.44	E	1
2	$2p^6 - 2p^5(^2P^\circ_{1/2})3s$	$^1S - ^1P^\circ$	[72.029]	0	1388330	1	3	730	0.17	0.040	−0.77	D	1
3	$2p^6 - 2p^5(^2P^\circ_{3/2})3d$	$^1S - ^3P^\circ$	[61.547]	0	1624770	1	3	26	0.0045	9.1×10^{-4}	−2.35	E	1
4	$2p^6 - 2p^5(^2P^\circ_{3/2})3d$	$^1S - ^1P^\circ$	[60.804]	0	1644630	1	3	8400	1.4	0.28	0.15	D	1
5	$2p^6 - 2p^5(^2P^\circ_{1/2})3d$	$^1S - ^3D^\circ$	[60.161]	0	1662210	1	3	980	0.16	0.032	−0.80	D	1

S VIII

Ground State $1s^2 2s^2 2p^5\ ^2P^\circ_{3/2}$

Ionization Potential 328.80 eV = 2652720 cm^{-1}

Allowed Transitions

The value for the $2s^2 2p^5\ ^2P^\circ - 2s2p^6\ ^2S$ multiplet is calculated from the nuclear charge-expansion method of Cohen and Dalgarno [1]. It may be quite uncertain since configuration interaction effects with configurations involving the $n = 3$ shell electrons, which were not included in this calculation, may be significant.

Reference

[1] Cohen, M., and Dalgarno, A., Proc. Roy. Soc. London **A280**, 258–270 (1964).

S VIII. Allowed Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
1	$2s^22p^5-2s2p^6$	$^2P^\circ-^2S$	*199.91*	*3377*	503590	6	2	480	0.096	0.38	−0.24	D	1
			[198.57]	0	503590	4	2	320	0.096	0.25	−0.42	D	*ls*
			[202.65]	10130	503590	2	2	160	0.097	0.13	−0.71	D	*ls*

S VIII

Forbidden Transitions

The line strength for the one transition in the ground state configuration is a straight number, tabulated for example by Naqvi [1]. The transition probability should also be quite accurate, since the energy level difference is accurately known.

Reference

[1] Naqvi, A. M., Thesis Harvard (1951).

S VIII. Forbidden Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	Type of Transition	A_{ki}(sec^{-1})	S(at.u.)	Accuracy	Source
1	$2p^5-2p^5$	$^2P^\circ-^2P^\circ$ (1F)	9917.9	0	10130	4	2	*m*	18.6	1.33	A	1

S IX

Ground State $1s^22s^22p^4\ ^3P_2$

Ionization Potential 378.95 eV = 3057300 cm^{-1}

Forbidden Transitions

As in the case of Na IV the adopted values are taken from Naqvi [1], and Malville and Berger [2]. For a discussion on the selection of values see Na IV, since the same criteria have been applied.

References

[1] Naqvi, A. M., Thesis Harvard (1951).
[2] Malville, J. M. and Berger, R. A., Planetary and Space Science **13**, 1131 (1965).

S IX. Forbidden Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	Type of Transition	A_{ki}(sec^{-1})	S(at.u.)	Accuracy	Source
1	$2p^4-2p^4$	$^3P-^3P$										
			[12544]	0	7970	5	3	e	3.83×10^{-5}	0.0213	C−	1,2
			[12544]	0	7970	5	3	m	11.3	2.48	B	1
			[9404.8]	0	10630	5	1	e	2.2×10^{-4}	0.0096	C−	2
			[37584]	7970	10630	3	1	m	1.01	1.99	B	1
2		$^3P-^1D$										
			[1724.1]	0	[58000]	5	5	e	0.026	0.0012	D−	1,2
			[1724.1]	0	[58000]	5	5	m	61	0.058	C	1
			[1998.8]	7970	[58000]	3	5	e	0.0018	1.7×10^{-4}	D−	1,2
			[1998.8]	7970	[58000]	3	5	m	13.2	0.0196	C	1
			[2110.4]	10630	[58000]	1	5	e	7.6×10^{-4}	9.5×10^{-5}	D−	2
3		$^3P-^1S$										
			[817.66]	0	[122300]	5	1	e	0.33	7.2×10^{-5}	D−	2
			[874.66]	7970	[122300]	3	1	m	710	0.0176	C	2
4		$^1D-^1S$										
			[1555.2]	[58000]	[122300]	5	1	e	6.9	0.0374	C−	2

S X

Ground State $1s^22s^22p^3\ ^4S^\circ_{3/2}$

Ionization Potential 447.0? eV = 3606000? cm^{-1}

Forbidden Transitions

The line strength for the one transition listed in the table is a straight number, tabulated for example by Naqvi [1]. The transition probability should also be quite accurate, since the energy level difference is accurately known.

Reference

[1] Naqvi, A. M., Thesis Harvard (1951).

S X. Forbidden Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	Type of Transition	A_{ki}(sec^{-1})	S(at.u.)	Accuracy	Source
1	$2p^3-2p^3$	$^2P^\circ-^2P^\circ$	[66650]	[122230]	[123730]	2	4	m	0.0303	1.33	A	1

S XII

Ground State $1s^22s^22p\ ^2P^\circ_{1/2}$

Ionization Potential ?

Forbidden Transitions

The line strength for the one transition in the ground state configuration is a straight number, tabulated for example by Naqvi [1]. The transition probability is not as accurate, since the energy level difference is not accurately known.

Reference

[1] Naqvi, A. M., Thesis Harvard (1951).

S XII. Forbidden Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	Type of Transition	A_{ki}(sec^{-1})	S(at.u.)	Accuracy	Source
1	$2p-(^1S)2p$	$^2P^\circ-^2P^\circ$ (1F)	7536	0	[13266]	2	4	m	21.0	1.33	B	1

CHLORINE

Cl I

Ground State $1s^2 2s^2 2p^6 3s^2 3p^5\ ^2P^\circ_{3/2}$

Ionization Potential 12.97 eV = 104591 cm^{-1}

Allowed Transitions

List of tabulated lines:

Wavelength [Å]	No.	Wavelength [Å]	No.	Wavelength [Å]	No.
1188.77	3	4475.31	18	7878.22	6
1201.36	3	4491.05	15	7899.28	29
1335.72	2	4526.20	28	7915.09	29
1347.24	2	4545.38	17	7924.62	7
1351.66	2	4578.17	17	7935.00	30
1363.45	2	4580.47	9	7976.95	29
1373.12	1	4601.00	28	7980.58	5
1379.53	1	4623.96	15	7997.80	6
1389.69	1	4654.05	25	8084.48	16
1389.96	1	4661.22	22	8085.54	16
1396.53	1	4674.40	27	8086.67	16
4104.78	22	4677.76	26	8087.67	16
4147.20	22	4691.53	24	8194.35	5
4209.68	19	4721.24	25	8212.00	5
4226.44	21	4740.71	24	8333.29	5
4264.59	19	4796.76	25	8375.95	5
4280.43	18	4818.42	23	8428.25	5
4323.35	21	4818.64	27	8550.46	12
4337.80	18	4852.70	24	8575.25	5
4363.30	19	4976.62	14	8585.96	5
4369.52	19	5099.80	14	8686.28	13
4371.55	18	5140.35	14	8948.01	4
4379.90	18	7256.63	8	9073.15	11
4387.55	21	7414.10	7	9121.10	4
4389.76	18	7537.06	8	9191.67	4
4390.38	20	7702.89	29	9288.82	10
4402.58	18	7717.57	7	9393.81	4
4403.03	17	7744.94	8	9486.89	4
4438.48	17	7769.18	29	9584.77	4
4445.83	18	7771.10	29	9592.20	10
4446.11	17	7821.35	29	9632.37	11
4469.37	28	7830.76	29	9702.35	4
				9875.95	10

Lawrence [1] has carried out intermediate coupling calculations for three multiplets in the vacuum uv region involving the 4*s* state. These values are normalized via a lifetime measurement of this state by him [1], in which he applied the phase shift technique. Hofmann [2] has measured oscillator strengths for the same multiplets using a wall-stabilized arc; his values for the $^2P^\circ - {}^2P$ and $^2P^\circ - {}^2D$ multiplets are renormalized to Lawrence's [1] lifetime and the results averaged with Lawrence's calculated values. For the $^2P^\circ - {}^4P$ intercombination multiplet, Hofmann's renormalized values are used exclusively where available; for the other lines, Lawrence's calculated values are taken.

In the visible region, emission experiments are available. Foster [4] and Hey [5] employed vortex and wall-stabilized arcs, respectively, while Bengtson [3] used a conventional shock tube. Usually there is good agreement where the three experiments overlap and in these cases the results have been averaged. For the case of the $4s\,^4P-4p\,^4D^\circ$ multiplet, only the weaker lines measured by Bengtson are chosen since the stronger lines of this multiplet seem to be affected by self-absorption. For several lines Foster [4] has made use of Kiess' intensity data to obtain absolute transition probabilities; the accuracy estimate has then been reduced.

The Coulomb approximation has been employed for several multiplets of the $4s$-$4p$ and $4p$-$4d$ arrays; it compares usually quite well with the measurements, when theory and experiment overlap.

References

[1] Lawrence, G. M., Astrophys. J. **148**, 261–268 (1967).
[2] Hofmann, W., Z. Naturforsch. **22a**, 2097–2101 (1967).
[3] Bengtson, R. D., Thesis Maryland (1968) and to be published.
[4] Foster, E. W., Proc. Phys. Soc. London **A80**, 882–893 (1962).
[5] Hey, P., Z. Physik **157**, 79–88 (1959).

Cl I. Allowed Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
1	$3p^5-3p^4(^3P)4s$	$^2P^\circ-^4P$ (1 uv)											
			1389.69	0	71954	4	6	0.0023	1.0×10^{-4}	0.0018	−3.40	D	1
			1396.53	881	72484	2	4	0.015	8.8×10^{-4}	0.0081	−2.75	D	2*n*
			1379.53	0	72484	4	4	0.11	0.0031	0.057	−1.91	D	2*n*
			1389.96	881	72823	2	2	0.017	4.9×10^{-4}	0.0045	−3.01	D	1
			1373.12	0	72823	4	2	0.0029	4.1×10^{-5}	7.4×10^{-4}	−3.79	D	2*n*
2		$^2P^\circ-^2P$ (2 uv)	*1348.8*	*294*	*74434*	6	6	4.94	0.135	3.59	−0.092	C+	1, 2*n*
			1347.24	0	74221	4	4	4.19	0.114	2.02	−0.341	C+	1, 2*n*
			1351.66	881	74861	2	2	3.23	0.088	0.79	−0.75	C+	1, 2*n*
			1335.72	0	74861	4	2	1.74	0.0233	0.409	−1.031	C	1
			1363.45	881	74221	2	4	0.75	0.0418	0.375	−1.078	C+	1, 2*n*
3	$3p^5-3p^4(^1D)4s'$	$^2P^\circ-^2D$	*1193.0*	*294*	*84116*	6	10	2.47	0.088	2.07	−0.277	C	1, 2*n*
			1188.77	0	84116	4	6	2.33	0.074	1.16	−0.53	C	1, 2*n*
			1201.36	881	84117	2	4	2.39	0.103	0.82	−0.69	C	1, 2*n*
			1188.77	0	84117	4	4	0.271	0.0057	0.090	−1.64	C	1, 2*n*
4	$3p^44s-3p^4(^3P)4p$	$^4P-^4P^\circ$ (1)	*9270.5*	*72276*	*83060*	12	12	0.23	0.30	110	0.56	D	*ca*
			9121.10	71954	82915	6	6	0.17	0.22	39	0.12	D	*ls*
			9393.81	72484	83127	4	4	0.031	0.042	5.1	−0.78	E	*ls*
			9486.89	72823	83361	2	2	0.039	0.052	3.3	−0.98	E	*ls*
			8948.01	71954	83127	6	4	0.12	0.095	17	−0.24	D−	*ls*
			9191.67	72484	83361	4	2	0.21	0.13	16	−0.28	D−	*ls*
			9584.77	72484	82915	4	6	0.066	0.14	17	−0.26	D−	*ls*
			9702.35	72823	83127	2	4	0.091	0.26	16	−0.29	D−	*ls*
5		$^4P-^4D^\circ$ (2)	*8413.1*	*72276*	*84159*	12	20	0.27	0.48	160	0.76	D	3*n*, *ca*
			8375.95	71954	83890	6	8	0.28	0.39	64	0.37	D	*ls*
			8585.96	72484	84128	4	6	0.19	0.31	35	0.09	D	*ls*
			8575.25	72823	84481	2	4	0.12	0.27	15	−0.27	D	3, *ls*
			8212.00	71954	84128	6	6	0.079	0.080	13	−0.32	D	3, *ls*
			8333.29	72484	84481	4	4	0.16	0.16	18	−0.19	D	*ls*
			8428.25	72823	84684	2	2	0.24	0.25	14	−0.30	D	3, *ls*
			7980.58	71954	84481	6	4	0.016	0.010	1.6	−1.22	E	*ls*
			8194.35	72484	84684	4	2	0.050	0.025	2.7	−1.00	E	3, *ls*

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
6		$^4P-^2D^\circ$ (3)											
			7878.22	71954	84644	6	6	0.018	0.017	2.6	−0.99	D	3
			7997.80	72484	84984	4	4	0.021	0.020	2.1	−1.10	D	3
7		$^4P-^2P^\circ$ (4)											
			7414.10	71954	85438	6	4	0.047	0.026	3.8	−0.81	D	3
			7717.57	72484	85438	4	4	0.030	0.027	2.7	−0.97	D	3
			7924.62	72823	85438	2	4	0.021	0.040	2.1	−1.10	D	3
8		$^4P-^4S^\circ$ (5)	*7430.1*	*72276*	85731	12	4	0.38	0.11	31	0.12	D+	3, *ca*
			7256.63	71954	85731	6	4	0.19	0.10	14	−0.22	D+	3, *ls*
			7547.06	72484	85731	4	4	0.13	0.11	11	−0.36	D+	3, *ls*
			7744.94	72823	85731	2	4	0.065	0.12	6.0	−0.62	D+	3, *ls*
9	$3p^44s-3p^4(^1D)4p'$	$^4P-^2P^\circ$											
			4580.47	72484	94310	4	4	0.0018	5.7×10^{-4}	0.034	−2.65	D−	4
10	$3p^44s-3p^4(^3P)4p$	$^2P-^2D^\circ$ (11)	*9662.9*	*74434*	*84780*	6	10	0.25	0.58	110	0.54	D	*ca*
			9592.20	74221	84644	4	6	0.24	0.50	63	0.30	D	*ls*
			9875.95	74861	84984	2	4	0.19	0.56	37	0.05	D	*ls*
			9288.82	74221	84984	4	4	0.044	0.057	7.0	−0.64	E	*ls*
11		$^2P-^2S^\circ$ (12)	*9251.6*	*74434*	85240	6	2	0.27	0.11	21	−0.16	D	*ca*
			9073.15	74221	85240	4	2	0.19	0.12	14	−0.33	D	*ls*
			9632.37	74861	85240	2	2	0.083	0.12	7.3	−0.62	D	*ls*
12		$^2P-^2P^\circ$ (13)											
			8550.46	74221	85913	4	2	0.019	0.010	1.2	−1.40	D−	3
13		$^2P-^4S^\circ$ (14)											
			8686.28	74221	85731	4	4	0.039	0.044	5.0	−0.75	D	3
14	$3p^44s-3p^4(^1D)4p'$	$^2P-^2P^\circ$											
			4976.62	74221	94310	4	4	0.0035	0.0013	0.085	−2.28	D+	3, 4
			5099.80	74861	94465	2	2	0.0085	0.0033	0.11	−2.18	D	4
			5140.35	74861	94310	2	4	0.0025	0.0020	0.067	−2.40	D−	4
15		$^2P-^2D^\circ$											
			4623.96	74861	96482	2	4	0.0045	0.0029	0.088	−2.24	D+	3, 4
			4491.05	74221	96482	4	4	0.0048	0.0015	0.086	−2.22	D+	3, 4
16		$^2D-^2D^\circ$	*8085.8*	*84116*	*96480*	10	10	0.42	0.41	110	0.61	D	3, *ca*
			8086.67	84116	96478	6	6	0.40	0.39	62	0.37	D	*ls*
			8085.54	84117	96482	4	4	0.38	0.38	40	0.18	D	*ls*
			8084.48	84116	96482	6	4	0.042	0.028	4.4	−0.77	E	*ls*
			8087.67	84117	96478	4	6	0.028	0.041	4.4	−0.79	E	*ls*
17	$3p^44s-3p^4(^3P)5p$	$^4P-^4P^\circ$ (6)											
			4438.48	71954	94478	6	6	0.014	0.0041	0.36	−1.61	D	3, 4
			4403.03	71954	94659	6	4	0.0074	0.0014	0.12	−2.08	D	3, 4
			4446.11	72484	94969	4	2	0.0044	6.5×10^{-4}	0.038	−2.58	D	4
			4545.38	72484	94478	4	6	5.1×10^{-4}	2.4×10^{-4}	0.014	−3.02	D−	4
			4578.17	72823	94659	2	4	0.0017	0.0011	0.032	−2.67	D	3, 4

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
18		$^4P-^4D^\circ$ (7)	*4408.5*	*72276*	*94953*	12	20	0.011	0.0052	0.91	−1.20	D+	3, 4, 5
			4389.76	71954	94728	6	8	0.013	0.0050	0.43	−1.52	C−	3, 4, 5
			4475.31	72484	94823	4	6	0.0043	0.0019	0.11	−2.12	D+	3, 4
			4445.83	72823	95309	2	4	0.0023	0.0014	0.040	−2.56	D	4
			4371.55	71954	94823	6	6	0.0015	4.3×10^{-4}	0.037	−2.59	D+	3, 4
			4379.90	72484	95309	4	4	0.012	0.0035	0.20	−1.85	D+	3, 4
			4402.58	72823	95531	2	2	0.0058	0.0017	0.049	−2.47	D+	3, 4
			4280.43	71954	95309	6	4	0.0016	2.9×10^{-4}	0.025	−2.76	D−	4
			4337.80	72484	95531	4	2	0.0026	3.7×10^{-4}	0.021	−2.83	D−	4
19		$^4P-^2D^\circ$ (8)											
			4363.30	72484	95396	4	6	0.0067	0.0029	0.16	−1.94	D+	3, 4
			4369.52	72823	95702	2	4	0.0070	0.0040	0.12	−2.10	D+	3, 4
			4264.59	71954	95396	6	6	0.0017	4.6×10^{-4}	0.039	−2.56	D+	3, 4
			4209.68	71954	95702	6	4	0.0041	7.3×10^{-4}	0.060	−2.36	D+	3, 4
20		$^4P-^2S^\circ$											
			4390.38	72823	95593	2	2	0.0079	0.0023	0.066	−2.34	D+	3, 4
21		$^4P-^4S^\circ$ (9)	*4284.8*	*72276*	95608	12	4	0.021	0.0019	0.32	−1.64	D+	3, 4
			4226.44	71954	95608	6	4	0.0055	9.8×10^{-4}	0.082	−2.23	D+	3, 4
			4323.35	72484	95608	4	4	0.011	0.0031	0.18	−1.91	D+	3, 4
			4387.55	72823	95608	2	4	0.0036	0.0021	0.060	−2.38	D+	3, 4
22		$^4P-^2P^\circ$											
			4104.78	71954	96309	6	4	0.0020	3.4×10^{-4}	0.027	−2.69	D−	4
			4147.20	72484	96590	4	2	0.0038	4.9×10^{-4}	0.027	−2.71	D	4
23		$^2P-^4P^\circ$											
			4818.42	74221	94969	4	2	0.0039	6.8×10^{-4}	0.043	−2.57	D	4
24		$^2P-^4D^\circ$											
			4852.70	74221	94823	4	6	0.0023	0.0012	0.078	−2.32	D+	3, 4
			4740.71	74221	95309	4	4	0.0042	0.0014	0.088	−2.25	D+	3, 4
			4691.53	74221	95531	4	2	0.011	0.0018	0.11	−2.14	D+	3, 4
25		$^2P-^2D^\circ$	*4741.6*	*74434*	*95518*	6	10	0.0038	0.0021	0.20	−1.90	D+	3, 4
			4721.24	74221	95396	4	6	0.0021	0.0011	0.065	−2.36	D+	3, 4
			4796.76	74861	95702	2	4	0.0019	0.0013	0.041	−2.58	D−	4
			4654.05	74221	95702	4	4	0.0049	0.0016	0.098	−2.19	D+	3, 4
26		$^2P-^2S^\circ$											
			4677.76	74221	95593	4	2	0.0054	8.9×10^{-4}	0.055	−2.45	D+	3, 4
27		$^2P-^4S^\circ$											
			4674.40	74221	95608	4	4	0.0020	6.6×10^{-4}	0.040	−2.58	D+	3, 4
			4818.64	74861	95608	2	4	0.0019	0.0013	0.042	−2.58	D	4
28		$^2P-^2P^\circ$ (15)	*4550.6*	*74434*	*96403*	6	6	0.054	0.017	1.5	−0.99	D+	3, 4, 5
			4526.20	74221	96309	4	4	0.041	0.013	0.75	−1.28	C−	3, 4, 5
			4601.00	74861	96590	2	2	0.039	0.012	0.37	−1.62	C−	3, 4, 5
			4469.37	74221	96590	4	2	0.016	0.0024	0.14	−2.02	D	3, 4
			4661.22	74861	96309	2	4	0.010	0.0065	0.20	−1.89	D	3, 4

Cl I. Allowed Transitions—*Continued*

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log *gf*	Accuracy	Source
29	$3p^44p-3p^4(^3P)4d$	$^4P^\circ-^4D$	*7852.7*	*83060*	*95791*	12	20	0.10	0.15	48	0.26	D	3, *ca*
			7821.35	82915	95696	6	8	0.095	0.12	18	−0.14	D	3, *ls*
			7899.28	83127	95782	4	6	0.058	0.082	8.5	−0.48	D	3, *ls*
			7976.95	83361	95893	2	4	0.041	0.078	4.1	−0.81	D−	3, *ls*
			7769.18	82915	95782	6	6	0.045	0.040	6.2	−0.62	D	3, *ls*
			7830.76	83127	95893	4	4	0.069	0.063	6.5	−0.60	D	3, *ls*
			7915.09	83361	95991	2	2	0.061	0.058	3.0	−0.94	D−	3, *ls*
			7702.89	82915	95893	6	4	0.0054	0.0032	0.49	−1.72	E	3, *ls*
			7771.10	83127	95991	4	2	0.024	0.011	1.1	−1.36	E	3, *ls*
30		$^4D^\circ-^4F$	7935.00	83890	96490	6	8	0.046	0.058	9.1	−0.46	D	3, *ca*, *ls*

Cl I

Forbidden Transitions

The line strength for the one transition in the ground state configuration is a straight number, tabulated for example by Naqvi [1]. The transition probability should also be quite accurate, since the energy level difference is accurately known.

Reference

[1] Naqvi, A. M., Thesis Harvard (1951).

Cl I. Forbidden Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	Type of Transition	A_{ki}(sec^{-1})	S(at.u.)	Accuracy	Source
1	$3p^5-3p^5$	$^2P^\circ-^2P^\circ$	[11.328×10^4]	0	882.50	4	2	*m*	0.0123	1.33	A	1

Cl II

Ground State $1s^22s^22p^63s^23p^4\ ^3P_2$

Ionization Potential 23.80 eV = 192000 cm^{-1}

Allowed Transitions

List of tabulated lines:

Wavelength [Å]	No.	Wavelength [Å]	No.	Wavelength [Å]	No.
1063.83	1	1079.08	1	2498.53	57
1068.0	1	2427.79	55	2502.75	57
1071.05	1	2430.16	55	2543.98	56
1071.76	1	2434.10	55	2544.84	56
1075.2	1	2496.04	57	2545.5	56

Wavelength [Å]	No.	Wavelength [Å]	No.	Wavelength [Å]	No.
2546.94	56	3860.80	30	4544.48	11
2547.76	56	3860.98	30	4569.42	47
2549.85	56	3861.40	30	4572.13	47
2666.46	58	3861.95	45	4739.42	8
2667.36	58	3862.6	45	4740.40	14
2906.25	33	3864.60	45	4755.64	8
3022.93	32	3865.2	45	4765.30	8
3147.86	5	3868.62	45	4768.68	26
3161.44	6	3883.80	48	4771.09	26
3175.9	36	3904.0	37	4771.66	28
3176.3	36	3906.9	37	4778.93	26
3182.3	36	3913.92	37	4781.32	26
3182.7	36	3916.70	37	4781.82	8
3188.4	36	3917.57	37	4785.44	26
3189.04	36	3929.0	37	4794.54	17
3231.75	40	3929.7	37	4797.1	26
3306.45	31	3954.21	44	4798.40	8
3307.90	31	3990.19	41	4810.06	17
3308.7	31	3996.3	41	4811.57	52
3315.44	31	4001.9	41	4819.46	17
3316.86	31	4020.06	41	4819.79	8
3329.12	31	4026.7	41	4822.3	52
3505.44	35	4036.53	41	4827.0	52
3508.94	35	4124.00	49	4836.79	8
3509.39	35	4130.86	49	4857.04	52
3513.22	35	4131.4	49	4863.1	52
3513.69	35	4132.48	24	4879.0	52
3522.14	35	4133.66	49	4893.1	7
3526.13	35	4135.5	49	4896.77	20
3568.04	43	4147.09	49	4900.3	25
3576.00	43	4155.2	49	4904.76	20
3587.78	43	4185.61	27	4907.17	25
3596.9	43	4188.82	27	4914.32	20
3597.3	38	4191.59	27	4917.72	20
3601.4	38	4195.11	27	4922.14	20
3603.72	43	4204.54	27	4924.28	7
3604.51	43	4208.03	27	4924.83	25
3605.9	38	4215.0	54	4925.17	7
3606.6	38	4223.0	54	4933.2	20
3610.8	38	4224.92	54	4936.99	7
3615.09	38	4228.7	54	4943.24	10
3618.88	42	4234.09	46	4970.12	7
3639.19	42	4234.8	54	4995.52	7
3648.07	42	4235.49	51	5068.10	19
3781.23	39	4235.49	54	5078.25	19
3798.80	34	4241.38	46	5098.34	19
3805.24	34	4251.3	50	5099.30	19
3809.51	34	4253.51	46	5103.04	19
3810.10	34	4258.8	50	5104.08	19
3818.40	34	4261.22	50	5113.36	19
3829.27	4	4264.4	50	5175.85	13
3830.8	34	4270.61	50	5217.93	18
3843.26	12	4276.51	50	5221.34	18
3845.42	30	4291.76	21	5392.12	23
3845.69	30	4304.07	21	5423.25	2
3845.84	30	4307.42	21	5423.52	2
3850.97	30	4334.1	21	5424.36	2
3851.38	30	4336.26	21	5443.42	2
3851.69	30	4343.62	21	5444.25	2
3854.75	45	4399.14	29	5444.99	2

Wavelength [Å]	No.	Wavelength [Å]	No.	Wavelength [Å]	No.
5456.27	2	6759.42	15	8360.63	3
5457.02	2	6841.86	15	8364.0	3
5457.47	2	6850.21	15	8385.0	3
5568.81	53	6924.2	15	8385.7	3
5634.83	9	6932.4	15	8394.2	3
6094.65	22	6952.13	15		
6399.41	16	8355.6	3		

Lawrence [1] has accurately measured the lifetime of the first excited state with the delayed-coincidence method. Using *LS*-coupling, we have derived the *f*-values for all components of the resonance multiplet. Foster [3] and Hey [4] have measured some *f*-values with vortex and wall-stabilized arcs respectively, while Bengtson [2] has performed emission intensity measurements with a conventional shock tube. When their measurements and the Coulomb approximation overlap, the individual deviations from the adopted averages are within 25 percent.

For numerous other transitions, including those involving shell-equivalent electrons, the Coulomb approximation has been employed in order to have data available for some of the more prominent lines in this spectrum. From the general success of this method and from comparisons with analogous transitions in other ions, uncertainties of 50 percent are normally expected. Bengtson [2] has measured one multiplet involving shell-equivalent electrons for which the Coulomb approximation was calculated ($3p^33d\,^5D^\circ - 3p^34p\,^5P$) and the results are almost identical. However, this close agreement could be accidental and the uncertainties should in general be somewhat larger for transitions involving shell-equivalent electrons.

References

[1] Lawrence, G. M., private communication (1968) and to be published.
[2] Bengtson, R. D., Thesis Maryland (1968) and to be published.
[3] Foster, E. W., Proc. Phys. Soc. London **A80**, 882–893 (1962).
[4] Hey, P., Z. Physik **157**, 79–88 (1959).

Cl II. Allowed Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
1	$3s^23p^4-3s3p^5$	$^3P-^3P^\circ$ (1 uv)	*1071.3*	*343*	*93685*	9	9	1.12	0.0193	0.61	−0.76	C	1
			1071.05	0	93367	5	5	0.84	0.0144	0.254	−1.143	C	*ls*
			1071.76	697	93999	3	3	0.280	0.00482	0.051	−1.84	C	*ls*
			1063.83	0	93999	5	3	0.477	0.00485	0.085	−1.62	C	*ls*
			[1068.0]	697	94333	3	1	1.13	0.0064	0.068	−1.72	C	*ls*
			1079.08	697	93367	3	5	0.274	0.0080	0.085	−1.62	C	*ls*
			[1075.2]	996	93999	1	3	0.369	0.0192	0.068	−1.72	C	*ls*
2	$3p^33d-3p^3(^4S^\circ)4p$	$^5D^\circ-^5P$ (2)	*5438.3*	*110298*	*128686*	25	15	0.25	0.065	29	0.21	D	2
			5423.25	110296	128730	9	7	0.18	0.062	9.9	−0.26	D	2, *ls*
			5443.42	110297	128663	7	5	0.15	0.047	6.0	−0.48	D	2, *ls*
			5456.27	110300	128622	5	3	0.084	0.022	2.0	−0.95	D	*ls*
			5423.52	110297	128730	7	7	0.037	0.016	2.0	−0.95	D	2, *ls*
			5444.25	110300	128663	5	5	0.095	0.047	4.2	−0.63	D	2, *ls*
			5457.02	110302	128622	3	3	0.11	0.048	2.6	−0.84	D	*ls*
			5424.36	110300	128730	5	7	0.0056	0.0035	0.31	−1.76	E	2, *ls*
			5444.99	110302	128663	3	5	0.024	0.020	1.1	−1.23	D−	2, *ls*
			5457.47	110304	128622	1	3	0.048	0.064	1.2	−1.19	D−	*ls*

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
3		$^3D^\circ-^3P$ (5)	*8368.2*	*119813*	*131763*	15	9	0.13	0.082	34	0.09	E	*ca*
			8360.63	119810	131767	7	5	0.11	0.081	16	−0.25	E	*ls*
			[8364.0]	119799	131755	5	3	0.096	0.060	8.3	−0.52	E	*ls*
			[8385.0]	119842	131768	3	1	0.13	0.045	3.7	−0.87	E	*ls*
			[8355.6]	119799	131767	5	5	0.019	0.020	2.8	−0.99	E	*ls*
			[8394.2]	119842	131755	3	3	0.032	0.034	2.8	−0.99	E	*ls*
			[8385.7]	119842	131767	3	5	0.0013	0.0022	0.19	−2.17	E	*ls*
4	$3p^33d'-3p^3(^2D^\circ)4p'$	$^1D^\circ-^1F$ (9)	3829.27	121499	147606	5	7	0.0095	0.0029	0.19	−1.83	E	*ca*
5		$^1D^\circ-^1D$ (10)	3147.86	121499	153257	5	5	0.14	0.021	1.1	−0.98	E	*ca*
6		$^1F^\circ-^1D$ (11)	3161.44	121635	153257	7	5	0.23	0.024	1.8	−0.77	E	*ca*
7		$^3F^\circ-^3D$ (12)	*4970.2*	*126276*	*146396*	21	15	0.14	0.038	13	−0.10	E	*ca*
			4995.52	126457	146469	9	7	0.13	0.039	5.7	−0.46	E	*ls*
			4970.12	126219	146334	7	5	0.13	0.034	3.9	−0.62	E	*ls*
			4925.17	126032	146330	5	3	0.15	0.032	2.6	−0.80	E	*ls*
			4936.99	126219	146469	7	7	0.012	0.0042	0.48	−1.53	E	*ls*
			4924.28	126032	146334	5	5	0.016	0.0059	0.48	−1.53	E	*ls*
			[4893.1]	126032	146469	5	7	3.3×10^{-4}	1.7×10^{-4}	0.014	−3.08	E	*ls*
8		$^3F^\circ-^3F$ (13)	*4792.9*	*126276*	*147140*	21	21	0.056	0.019	6.4	−0.39	E	*ca*
			4819.79	126457	147198	9	9	0.051	0.018	2.6	−0.79	E	*ls*
			4781.82	126219	147126	7	7	0.047	0.016	1.8	−0.95	E	*ls*
			4755.64	126032	147054	5	5	0.050	0.017	1.3	−1.07	E	*ls*
			4836.79	126457	147126	9	7	0.0044	0.0012	0.17	−1.96	E	*ls*
			4798.40	126219	147054	7	5	0.0062	0.0015	0.17	−1.97	E	*ls*
			4765.30	126219	147198	7	9	0.0035	0.0015	0.17	−1.97	E	*ls*
			4739.42	126032	147126	5	7	0.0045	0.0021	0.16	−1.98	E	*ls*
9		$^1P^\circ-^1P$ (23)	5634.83	127727	145469	3	3	0.095	0.045	2.5	−0.87	E	*ca*
10	$3p^33d''-3p^3(^2P^\circ)4p''$	$^1P^\circ-^1D$ (47)	4943.24	139350	159574	3	5	0.0028	0.0017	0.083	−2.29	E	*ca*
11		$^1P^\circ-^1P$ (48)	4544.48	139350	161348	3	3	0.082	0.025	1.1	−1.12	E	*ca*
12		$^1P^\circ-^1S$ (49)	3843.26	139350	165362	3	1	0.42	0.031	1.2	−1.03	E	*ca*
13		$^1D^\circ-^1D$ (50)	5175.85	140259	159574	5	5	0.039	0.016	1.3	−1.10	E	*ca*
14		$^1D^\circ-^1P$ (51)	4740.40	140259	161348	5	3	0.24	0.048	3.7	−0.62	E	*ca*
15		$^3F^\circ-^3D$ (54)	*6835.7*	*144139*	*158768*	21	15	0.14	0.070	33	0.17	E	*ca*
			6759.42	143996	158786	9	7	0.13	0.069	14	−0.20	E	*ls*
			6850.21	144175	158769	7	5	0.12	0.062	9.7	−0.36	E	*ls*
			6952.13	144344	158724	5	3	0.13	0.058	6.7	−0.53	E	*ls*
			6841.86	144175	158786	7	7	0.011	0.0077	1.2	−1.27	E	*ls*
			[6932.4]	144344	158769	5	5	0.015	0.011	1.2	−1.27	E	*ls*
			[6924.2]	144344	158786	5	7	3.1×10^{-4}	3.1×10^{-4}	0.035	−2.81	E	*ls*
16		$^3P^\circ-^3P$ (58)											
			6399.41	146043	161635	5	5	0.040	0.024	2.6	−0.91	E	*ca*, *ls*

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
17	$3p^34s-3p^3(^4S^\circ)4p$	$^5S^\circ-^5P$ (1)	*4806.1*	107879	*128686*	5	15	1.14	1.19	94	0.77	C	2, 3, 4, *ca*
			4794.54	107879	128730	5	7	1.18	0.57	44.9	0.455	C	2, 3, 4, *ca*, *ls*
			4810.06	107879	128663	5	5	1.13	0.392	31.0	0.292	C	2, 3, *ca*, *ls*
			4819.46	107879	128622	5	3	1.11	0.232	18.4	0.064	C	2, 3, *ca*, *ls*
18		$^3S^\circ-^3P$ (3)	*5220.6*	112608	*131763*	3	9	0.77	0.94	48.7	0.450	C	2, 3, *ca*
			5217.93	112608	131767	3	5	0.77	0.52	27.0	0.193	C	*ls*
			5221.34	112608	131755	3	3	0.77	0.315	16.2	−0.025	C	*ls*
			5217.93	112608	131768	3	1	0.77	0.11	5.4	−0.50	D	*ls*
19	$3p^34s'-3p^3(^2D^\circ)4p'$	$^3D^\circ-^3D$ (16)	*5092.2*	*126758*	*146396*	15	15	0.86	0.33	84	0.70	D	*ca*
			5078.25	126783	146469	7	7	0.77	0.30	35	0.32	D	*ls*
			5103.04	126743	146334	5	5	0.59	0.23	19	0.06	D	*ls*
			5099.30	126725	146330	3	3	0.64	0.25	13	−0.12	D	*ls*
			5113.36	126783	146334	7	5	0.13	0.037	4.4	−0.59	D−	*ls*
			5104.08	126743	146330	5	3	0.21	0.050	4.2	−0.60	D−	*ls*
			5068.10	126743	146469	5	7	0.097	0.052	4.4	−0.58	D−	*ls*
			5098.34	126725	146334	3	5	0.13	0.084	4.2	−0.60	D−	*ls*
20		$^3D^\circ-^3F$ (17)	*4906.3*	*126758*	*147140*	15	21	0.90	0.45	110	0.83	D	2, *ca*
			4896.77	126783	147198	7	9	0.88	0.41	46	0.46	D	2, *ca*, *ls*
			4904.76	126743	147126	5	7	0.81	0.41	33	0.31	D	*ls*
			4917.72	126725	147054	3	5	0.75	0.45	22	0.13	D	*ls*
			4914.32	126783	147126	7	7	0.10	0.036	4.1	−0.60	D−	*ls*
			4922.14	126743	147054	5	5	0.14	0.051	4.1	−0.59	D−	*ls*
			[4933.2]	126783	147054	7	5	0.0041	0.0011	0.12	−2.11	E	*ls*
21		$^3D^\circ-^3P$ (19)	*4326.0*	*126758*	*149874*	15	9	1.0	0.17	36	0.41	D	2, *ca*
			4343.62	126783	149798	7	5	0.84	0.17	17	0.08	D	2, *ca*, *ls*
			4307.42	126743	149952	5	3	0.76	0.13	9.0	−0.19	D−	*ls*
			4291.76	126725	150019	3	1	1.0	0.094	4.0	−0.55	D−	*ls*
			4336.26	126743	149798	5	5	0.15	0.042	3.0	−0.68	D−	*ls*
			4304.07	126725	149952	3	3	0.25	0.071	3.0	−0.67	D−	*ls*
			[4334.1]	126725	149798	3	5	0.010	0.0047	0.20	−1.85	E	*ls*
22		$^1D^\circ-^1P$ (26)	6094.65	129065	145469	5	3	0.53	0.18	18	−0.05	D	*ca*
23		$^1D^\circ-^1F$ (28)	5392.12	129065	147606	5	7	0.89	0.54	48	0.43	D	2, *ca*
24		$^1D^\circ-^1D$ (29)	4132.48	129065	153257	5	5	1.6	0.41	28	0.32	D	*ca*
25	$3p^34s''-3p^3(^2P^\circ)4p''$	$^3P^\circ-^3S$ (39)	*4917.4*	*137841*	158177	9	3	0.97	0.11	17	0.02	D	*ca*
			4924.83	137878	158177	5	3	0.52	0.11	9.2	−0.25	D	*ls*
			4907.17	137804	158177	3	3	0.32	0.11	5.5	−0.47	D	*ls*
			[4900.3]	137770	158177	1	3	0.11	0.11	1.8	−0.94	D	*ls*
26		$^3P^\circ-^3D$ (40)	*4778.5*	*137841*	*158768*	9	15	1.0	0.59	83	0.72	D	*ca*
			4781.32	137878	158786	5	7	1.0	0.49	39	0.39	D	*ls*
			4768.68	137804	158769	3	5	0.77	0.44	21	0.12	D	*ls*
			4771.09	137770	158724	1	3	0.57	0.58	9.2	−0.23	D−	*ls*
			4785.44	137878	158769	5	5	0.26	0.088	6.9	−0.36	D−	*ls*
			4778.93	137804	158724	3	3	0.43	0.15	6.9	−0.36	D−	*ls*
			[4797.1]	137878	158724	5	3	0.028	0.0058	0.46	−1.54	E	*ls*

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
27		$^3P^\circ-^3P$ (43)	*4200.8*	*137841*	*161646*	9	9	1.5	0.39	49	0.55	D	*ca*
			4208.03	137878	161635	5	5	1.1	0.29	20	0.17	D	*ls*
			4191.59	137804	161655	3	3	0.37	0.098	4.1	−0.53	D−	*ls*
			4204.54	137878	161655	5	3	0.62	0.098	6.8	−0.31	D−	*ls*
			4188.82	137804	161671	3	1	1.5	0.13	5.4	−0.41	D−	*ls*
			4195.11	137804	161635	3	5	0.37	0.16	6.8	−0.31	D−	*ls*
			4185.61	137770	161655	1	3	0.50	0.39	5.4	−0.41	D−	*ls*
28		$^1P^\circ-^1D$ (45)	4771.66	138623	159574	3	5	1.0	0.59	28	0.25	D	*ca*
29		$^1P^\circ-^1P$ (46)	4399.14	138623	161348	3	3	1.3	0.38	17	0.06	D	*ca*
30	$3p^34p-3p^3(^4S^\circ)4d$	$^5P-^5D^\circ$ (25)	*3855.6*	*128686*	*154622*	15	25	2.7	1.0	190	1.18	D	*ca*
			3860.80	128730	154624	7	9	2.7	0.77	68	0.73	D	*ls*
			3850.97	128663	154623	5	7	1.8	0.56	35	0.45	D	*ls*
			3845.42	128622	154620	3	5	0.94	0.35	13	0.02	D	*ls*
			3860.98	128730	154623	7	7	0.89	0.20	18	0.14	D	*ls*
			3851.38	128663	154620	5	5	1.6	0.35	22	0.24	D	*ls*
			3845.69	128622	154618	3	3	2.0	0.45	17	0.13	D	*ls*
			3861.40	128730	154620	7	5	0.18	0.028	2.5	−0.70	D−	*ls*
			3851.69	128663	154618	5	3	0.67	0.090	5.7	−0.35	D−	*ls*
			3845.84	128622	154617	3	1	2.7	0.20	7.6	−0.22	D−	*ls*
31		$^3P-^3D^\circ$ (37)	*3321.2*	*131763*	*161873*	9	15	1.4	0.40	39	0.55	D	*ca*
			3329.12	131767	161797	5	7	1.5	0.34	19	0.23	D	*ls*
			3315.44	131755	161908	3	5	1.1	0.29	9.6	−0.05	D	*ls*
			3307.90	131768	161990	1	3	0.78	0.38	4.2	−0.42	D−	*ls*
			3316.86	131767	161908	5	5	0.36	0.059	3.2	−0.53	D−	*ls*
			3306.45	131755	161990	3	3	0.58	0.095	3.1	−0.54	D−	*ls*
			[3308.7]	131767	161990	5	3	0.039	0.0038	0.21	−1.72	E	*ls*
32	$3p^34p'-3p^3(^2D^\circ)4d'$	$^1P-^1D^\circ$ (57)	3022.93	145469	178539	3	5	0.60	0.14	4.1	−0.38	D	*ca*
33		$^1P-^1P^\circ$ (14 uv)	2906.25	145469	179867	3	3	0.86	0.11	3.1	−0.48	D	*ca*
34		$^3D-^3F^\circ$ (62)	*3805.9*	*146396*	*172671*	15	21	1.8	0.53	100	0.90	D	*ca*
			3805.24	146469	172741	7	9	1.8	0.51	44	0.55	D	*ls*
			3798.80	146334	172650	5	7	1.6	0.49	31	0.39	D	*ls*
			3809.51	146330	172573	3	5	1.5	0.55	21	0.22	D	*ls*
			3818.40	146469	172650	7	7	0.20	0.044	3.9	−0.51	D−	*ls*
			3810.10	146334	172573	5	5	0.28	0.062	3.9	−0.51	D−	*ls*
			[3830.8]	146469	172573	7	5	0.0080	0.0013	0.11	−2.05	E	*ls*
35		$^3D-^3D^\circ$ (64)	*3517.0*	*146396*	*174829*	15	15	1.6	0.29	51	0.64	D	*ca*
			3522.14	146469	174853	7	7	1.4	0.26	21	0.26	D	*ls*
			3509.39	146334	174821	5	5	1.1	0.20	12	0.00	D	*ls*
			3513.22	146330	174786	3	3	1.2	0.22	7.6	−0.18	D	*ls*
			3526.13	146469	174821	7	5	0.24	0.032	2.6	−0.64	D−	*ls*
			3513.69	146334	174786	5	3	0.39	0.044	2.5	−0.66	D−	*ls*
			3505.44	146334	174853	5	7	0.17	0.045	2.6	−0.65	D−	*ls*
			3508.94	146330	174821	3	5	0.24	0.072	2.5	−0.66	D−	*ls*
36		$^3D-^3P^\circ$ (65)	*3186.1*	*146396*	*177782*	15	9	0.38	0.034	5.4	−0.29	D	*ca*
			3189.04	146469	177817	7	5	0.19	0.020	1.5	−0.85	D	*ls*
			[3182.7]	146334	177754	5	3	0.39	0.035	1.8	−0.76	D	*ls*
			[3188.4]	146330	177694	3	1	0.52	0.026	0.83	−1.10	D−	*ls*
			[3176.3]	146334	177817	5	5	0.076	0.011	0.60	−1.24	D−	*ls*
			[3182.3]	146330	177754	3	3	0.13	0.020	0.61	−1.23	D−	*ls*
			[3175.9]	146330	177817	3	5	0.0051	0.0013	0.040	−2.42	E	*ls*

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
37		^{3}F–^{3}F° (68)	*3916.8*	*147140*	*172671*	21	21	0.88	0.20	55	0.63	D	*ca*
			3913.92	147198	172741	9	9	0.82	0.19	22	0.23	D	*ls*
			3916.70	147126	172650	7	7	0.74	0.17	15	0.07	D	*ls*
			3917.57	147054	172573	5	5	0.78	0.18	12	−0.05	D	*ls*
			[3929.0]	147198	172650	9	7	0.70	0.13	1.5	−0.95	E	*ls*
			[3929.7]	147126	172573	7	5	0.097	0.016	1.5	−0.95	E	*ls*
			[3904.0]	147126	172741	7	9	0.055	0.016	1.4	−0.95	E	*ls*
			[3906.9]	147054	172650	5	7	0.070	0.022	1.4	−0.95	E	*ls*
38		^{3}F–^{3}D° (70)	*3611.5*	*147140*	*174829*	21	15	0.17	0.024	6.1	−0.29	D	*ca*
			3615.09	147198	174853	9	7	0.16	0.025	2.6	−0.66	D	*ls*
			[3610.8]	147126	174821	7	5	0.16	0.022	1.8	−0.82	D	*ls*
			[3605.9]	147054	174786	5	3	0.18	0.021	1.2	−0.99	D	*ls*
			[3606.6]	147126	174853	7	7	0.014	0.0027	0.23	−1.72	E	*ls*
			[3601.4]	147054	174821	5	5	0.020	0.0038	0.23	−1.72	E	*ls*
			[3597.3]	147054	174853	5	7	4.0×10^{-4}	1.1×10^{-4}	0.0064	−3.27	E	*ls*
39		^{1}F–^{1}F° (72)	3781.23	147606	174045	7	7	0.87	0.19	16	0.12	D	*ca*
40		^{1}F–^{1}D° (73)	3231.75	147606	178539	7	5	0.12	0.014	1.0	−1.02	D	*ca*
41		^{3}P–^{3}D° (76)	*4007.2*	*149874*	*174829*	9	15	0.82	0.33	39	0.47	D	*ca*
			3990.19	149798	174853	5	7	0.84	0.28	18	0.15	D	*ls*
			4020.06	149952	174821	3	5	0.62	0.25	10	−0.12	D	*ls*
			4036.53	150019	174786	1	3	0.46	0.34	4.5	−0.47	D−	*ls*
			[3996.3]	149798	174821	5	5	0.21	0.050	3.3	−0.60	D−	*ls*
			[4026.7]	149952	174786	3	3	0.35	0.084	3.3	−0.60	D−	*ls*
			[4001.9]	149798	174786	5	3	0.023	0.0033	0.22	−1.78	E	*ls*
42		^{3}P–^{3}S° (77)	*3629.9*	*149874*	177423	9	3	2.1	0.14	15	0.10	D	*ca*
			3618.88	149798	177423	5	3	1.2	0.14	8.5	−0.15	D	*ls*
			3639.19	149952	177423	3	3	0.72	0.14	5.2	−0.37	D	*ls*
			3648.07	150019	177423	1	3	0.24	0.14	1.7	−0.84	D	*ls*
43		^{3}P–^{3}P° (78)	*3583.2*	*149874*	*177782*	9	9	1.6	0.30	32	0.43	D	*ca*
			3568.04	149798	177817	5	5	1.2	0.22	13	0.05	D	*ls*
			[3596.9]	149952	177754	3	3	0.39	0.076	2.7	−0.64	D−	*ls*
			3576.00	149798	177754	5	3	0.66	0.075	4.4	−0.42	D−	*ls*
			3603.72	149952	177694	3	1	1.6	0.10	3.7	−0.51	D−	*ls*
			3587.78	149952	177817	3	5	0.39	0.13	4.5	−0.42	D−	*ls*
			3604.51	150019	177754	1	3	0.52	0.31	3.6	−0.51	D−	*ls*
44		^{1}D–^{1}D° (82)	3954.21	153257	178539	5	5	1.1	0.26	17	0.11	D	*ca*
45	$3p^34p''$–$3p^3(^2P°)4d''$	^{3}D–^{3}F° (84)	*3864.6*	*158768*	*184644*	15	21	2.7	0.84	160	1.10	D	*ca*
			3868.62	158786	184628	7	9	2.7	0.77	68	0.73	D	*ls*
			3861.95	158769	184655	5	7	2.4	0.74	47	0.57	D	*ls*
			3854.75	158724	184658	3	5	2.2	0.83	32	0.40	D	*ls*
			3864.60	158786	184655	7	7	0.30	0.066	5.9	−0.33	D−	*ls*
			[3862.6]	158769	184658	5	5	0.41	0.092	5.9	−0.33	D−	*ls*
			[3865.2]	158786	184658	7	5	0.012	0.0019	0.17	−1.88	E	*ls*
46	$3p^34p$–$3p^3(^4S°)5s$	^{5}P–^{5}S° (24)	*4246.8*	*128686*	152233	15	5	1.8	0.16	34	0.39	D	*ca*
			4253.51	128730	152233	7	5	0.84	0.16	16	0.06	D	*ls*
			4241.38	128663	152233	5	5	0.60	0.16	11	−0.09	D	*ls*
			4234.09	128622	152233	3	5	0.36	0.16	6.8	−0.31	D	*ls*

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
47		^{3}P–^{3}S° (35)	*4571.5*	*131763*	153633	9	3	1.6	0.17	23	0.18	D	*ca*
			4572.13	131767	153633	5	3	0.92	0.17	13	−0.06	D	*ls*
			4569.42	131755	153633	3	3	0.55	0.17	7.8	−0.29	D	*ls*
			4572.13	131768	153633	1	3	0.18	0.17	2.6	−0.76	D	*ls*
48	$3p^34p'$ – $3p^3(^2D°)5s'$	^{1}P–^{1}D° (55)	3883.80	145469	171209	3	5	0.33	0.13	4.8	−0.42	D	*ca*
49		^{3}D–^{3}D° (60)	*4140.1*	*146396*	*170550*	15	15	0.59	0.15	31	0.36	D	*ca*
			4147.09	146469	170576	7	7	0.53	0.14	13	−0.02	D	*ls*
			4130.86	146334	170535	5	5	0.41	0.11	7.2	−0.28	D	*ls*
			4133.66	146330	170515	3	3	0.45	0.11	4.7	−0.47	D	*ls*
			[4155.2]	146469	170535	7	5	0.092	0.017	1.6	−0.92	D−	*ls*
			[4135.5]	146334	170515	5	3	0.15	0.023	1.6	−0.94	D−	*ls*
			4124.00	146334	170576	5	7	0.066	0.023	1.6	−0.93	D−	*ls*
			[4131.4]	146330	170535	3	5	0.089	0.038	1.5	−0.94	D−	*ls*
50		^{3}F–^{3}D° (66)	*4271.7*	*147140*	*170550*	21	15	0.83	0.16	48	0.53	D	*ca*
			4276.51	147198	170576	9	7	0.76	0.16	21	0.16	D	*ls*
			4270.61	147126	170535	7	5	0.74	0.14	14	0.00	D	*ls*
			4261.22	147054	170515	5	3	0.83	0.14	9.5	−0.17	D	*ls*
			[4264.4]	147126	170576	7	7	0.066	0.018	1.8	−0.90	D−	*ls*
			[4258.8]	147054	170535	5	5	0.092	0.025	1.8	−0.90	D−	*ls*
			[4251.3]	147054	170576	5	7	0.0019	7.1×10^{-4}	0.050	−2.45	E	*ls*
51		^{1}F–^{1}D° (71)	4235.49	147606	171209	7	5	0.80	0.15	15	0.03	D	*ca*
52		^{3}P–^{3}D° (74)	*4836.5*	*149874*	*170550*	9	15	0.33	0.20	28	0.25	D	*ca*
			4811.57	149798	170576	5	7	0.34	0.17	13	−0.08	D	*ls*
			4857.04	149952	170535	3	5	0.25	0.15	7.2	−0.35	D	*ls*
			[4879.0]	150019	170515	1	3	0.19	0.20	3.2	−0.70	D−	*ls*
			[4822.3]	149798	170535	5	5	0.085	0.030	2.4	−0.83	D−	*ls*
			[4863.1]	149952	170515	3	3	0.14	0.050	2.4	−0.82	D−	*ls*
			[4827.0]	149798	170515	5	3	0.0095	0.0020	0.16	−2.00	E	*ls*
53		^{1}D–^{1}D° (80)	5568.81	153257	171209	5	5	0.50	0.23	21	0.07	D	*ca*
54	$3p^34p''$ – $3p^3(^2P°)5s''$	^{3}D–^{3}P° (83)	*4229.6*	*158768*	*182411*	15	9	0.98	0.16	33	0.37	D	*ca*
			4224.92	158786	182449	7	5	0.82	0.16	15	0.04	D	*ls*
			4235.49	158769	182372	5	3	0.74	0.12	8.3	−0.23	D	*ls*
			[4234.8]	158724	182338	3	1	0.99	0.088	3.7	−0.58	D−	*ls*
			[4223.0]	158769	182449	5	5	0.15	0.039	2.7	−0.71	D−	*ls*
			[4228.7]	158724	182372	3	3	0.25	0.066	2.8	−0.70	D−	*ls*
			[4215.0]	158724	182449	3	5	0.0098	0.0043	0.18	−1.88	E	*ls*
55	$3p^34p$ – $3p^3(^4S°)5d$	^{5}P–^{5}D° (11 uv)											
			2434.10	128730	169800	7	9	0.72	0.082	4.6	−0.24	D−	*ca, ls*
			2430.16	128663	169800	5	7	0.48	0.059	2.4	−0.53	D−	*ca, ls*
			2427.79	128622	169800	3	5	0.25	0.037	0.89	−0.95	D−	*ca, ls*
			2434.10	128730	169800	7	7	0.24	0.021	1.2	−0.83	D−	*ca, ls*
			2430.16	128663	169800	5	5	0.42	0.037	1.5	−0.73	D−	*ca, ls*
56		^{3}P–^{3}D° (13 uv)	*2548.6*	*131763*	*171000*	9	15	0.78	0.13	9.5	0.05	D−	*ca*
			2549.85	131767	170974	5	7	0.76	0.10	4.4	−0.28	D−	*ls*
			2546.94	131755	171006	3	5	0.58	0.094	2.4	−0.55	D−	*ls*
			2544.84	131768	171052	1	3	0.43	0.13	1.1	−0.90	D−	*ls*
			2547.76	131767	171006	5	5	0.19	0.019	0.79	−1.03	E	*ls*
			2543.98	131755	171052	3	3	0.33	0.032	0.79	−1.02	E	*ls*
			[2545.5]	131767	171052	5	3	0.022	0.0013	0.053	−2.20	E	*ls*

Cl II. Allowed Transitions—*Continued*

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
57	$3p^34p-3p^3(^4S^\circ)6s$	$^5P-^5S^\circ$ (10 uv)	*2500.8*	*128686*	168674	15	5	0.67	0.021	2.6	−0.50	D	*ca*
			2502.75	128730	168674	7	5	0.31	0.021	1.2	−0.83	D	*ls*
			2498.53	128663	168674	5	5	0.22	0.021	0.86	−0.98	D	*ls*
			2496.04	128622	168674	3	5	0.13	0.021	0.51	−1.20	D	*ls*
58		$^3P-^3S^\circ$ (12 uv)	*2667.0*	*131763*	169247	9	3	0.61	0.022	1.7	−0.71	D	*ca*
			2667.36	131767	169247	5	3	0.34	0.022	0.97	−0.96	D	*ls*
			2666.46	131755	169247	3	3	0.21	0.022	0.58	−1.18	D	*ls*
			2667.36	131768	169247	1	3	0.069	0.022	0.19	−1.66	D	*ls*

Cl II

Forbidden Transitions

The adopted values have been derived from Naqvi [1], and Czyzak and Krueger [2]. Since their methods are essentially alike, Naqvi's and Czyzak and Krueger's magnetic dipole transitions have normally been averaged, except for the $^3P-^1S$ transition where configuration interaction is important. In this case Czyzak and Krueger's empirically derived value has been preferred over Naqvi's, which is based purely on theory (see also General Introduction).

References

[1] Naqvi, A. M., Thesis Harvard (1951).

[2] Czyak, S. J. & Krueger, T. K., Monthly Notices Roy. Astron. Soc. **126**, 177–194 (1963).

Cl II. Forbidden Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	Type of Transition	A_{ki}(sec^{-1})	S(at. u.)	Accuracy	Source
1	$3p^4-3p^4$	$^3P-^3P$										
			[14.34×10^4]	0	697	5	3	*e*	6.0×10^{-8}	6.5	C	2
			[14.34×10^4]	0	697	5	3	*m*	0.00762	2.50	A	1
			[10.04×10^4]	0	996	5	1	*e*	4.78×10^{-7}	2.90	C	2
			[33.44×10^4]	697	996	3	1	*m*	0.00144	2.00	A	1
2		$^3P-^1D$ (1F)										
			8579.5	0	11652	5	5	*e*	5.5×10^{-4}	0.076	D	2
			8579.5	0	11652	5	5	*m*	0.103	0.0121	C	1, 2
			9125.8	697	11652	3	5	*e*	5.8×10^{-5}	0.011	D	2
			9125.8	697	11652	3	5	*m*	0.0293	0.00413	C	1, 2
			[9381.8]	996	11652	1	5	*e*	1.2×10^{-5}	0.0026	D	2
3		$^3P-^1S$ (2F)										
			3583.2	0	[27900]	5	1	*e*	0.018	0.0063	D	2
			3675.0	697	[27900]	3	1	*m*	1.34	0.00247	C	2
4		$^1D-^1S$ (3F)										
			6152.9	11652	[27900]	5	1	*e*	2.29	12.0	C	2

Cl III

Ground State $1s^22s^22p^63s^23p^3\ ^4S^\circ_{3/2}$

Ionization Potential 39.90 eV = 321936 cm^{-1}

Allowed Transitions

List of tabulated lines:

Wavelength [Å]	No.	Wavelength [Å]	No.	Wavelength [Å]	No.
1005.28	1	2439.9	29	2991.82	15
1008.78	1	2442.47	26	3104.46	10
1015.02	1	2447.14	26	3139.34	10
1798.0	2	2448.58	26	3191.45	10
1808.51	2	2468.5	17	3244.44	12
1810.3	2	2469.20	17	3259.32	12
1817.73	2	2471.07	18	3283.41	9
1822.50	2	2477.4	17	3289.80	9
1824.6	2	2481.8	17	3300.9	9
1828.40	2	2484.27	17	3320.57	12
1832.08	2	2485.1	17	3329.06	9
1833.31	2	2486.91	27	3336.16	12
1897.8	3	2504.23	17	3340.42	9
1898.9	3	2510.92	17	3386.22	14
1901.61	3	2519.45	17	3387.60	9
1912.90	3	2531.76	23	3392.89	14
1914.1	3	2532.48	23	3393.45	14
1916.5	3	2533.9	27	3400.2	14
1917.87	3	2540.9	23	3530.03	13
1920.3	3	2542.7	17	3553.3	13
2231.2	25	2562.5	27	3560.68	13
2253.07	25	2577.13	20	3602.10	8
2255.7	25	2580.67	20	3612.85	8
2268.95	25	2601.16	16	3622.69	8
2278.34	25	2603.59	16	3656.95	8
2283.93	25	2609.50	16	3670.28	8
2291.38	25	2616.97	16	3682.05	8
2291.8	25	2618.78	16	3683.39	6
2291.8	21	2620.05	24	3688.0	5
2298.51	21	2624.71	24	3705.45	8
2340.64	21	2632.67	24	3707.34	5
2347.7	21	2633.18	16	3720.45	11
2359.67	28	2639.1	20	3725.7	6
2359.9	28	2648.8	16	3741.7	8
2370.37	28	2651.19	16	3748.81	11
2372.7	18	2661.65	19	3759.0	6
2379.47	26	2662.3	19	3824.47	5
2379.8	18	2663.2	19	3850.8	11
2387.3	18	2665.54	19	3991.50	4
2394.73	18	2669.6	19	4018.50	4
2403.32	26	2670.5	19	4059.07	4
2409.4	18	2675.7	16	4087.2	4
2416.42	26	2682.5	22	4104.23	4
2419.5	18	2691.4	19	4106.83	4
2422.47	26	2691.52	22	4124.1	4
2434.8	18	2699.6	19	4591.1	7
2435.8	29	2710.37	22	4604.5	7
2436.1	29	2965.56	15	4608.21	7
2439.69	29	2970.67	15		

308-022 O-69—14

Varsavsky [1] has calculated a value for one multiplet of this ion using the screening-approximation method; this number should be quite uncertain (probably too high, as judged from comparisons in other ions), since the possibly important effects of configuration interaction have been neglected entirely. For numerous other transitions, including those involving shell-equivalent electrons, the Coulomb approximation has been employed in order to have data available for some of the more prominent lines in this spectrum. From the general success of this method and from comparisons with analogous transitions in other ions, uncertainties of 50 percent are normally expected; however, the uncertainties should be somewhat larger for those transitions involving shell-equivalent electrons.

Reference

[1] Varsavsky, C. M., Astrophys. J. Suppl. Ser. **6**, No. 53, 75 (1961).

Cl III. Allowed Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
1	$3s^23p^3-3s3p^4$	$^4S^\circ-^4P$ (1 uv)	*1011.3*	0	*98883*	4	12	26	1.2	16	0.68	E	1
			1015.02	0	98520	4	6	25	0.58	7.8	0.37	E	*ls*
			1008.78	0	99130	4	4	26	0.39	5.2	0.19	E	*ls*
			1005.28	0	99475	4	2	26	0.20	2.6	−0.10	E	*ls*
2	$3p^23d-3p^2(^3P)4p$	$^4F-^4D^\circ$ (7 uv)	*1825.7*	*147077*	*201850*	28	20	1.8	0.065	11	0.26	E	*ca*
			1822.50	147498	202368	10	8	1.7	0.067	4.0	−0.18	E	*ls*
			1828.40	147073	201765	8	6	1.5	0.057	2.7	−0.34	E	*ls*
			1832.08	146750	201332	6	4	1.5	0.050	1.8	−0.53	E	*ls*
			1833.31	146526	201073	4	2	1.8	0.046	1.1	−0.73	E	*ls*
			1808.51	147073	202368	8	8	0.19	0.0094	0.45	−1.12	E	*ls*
			1817.73	146750	201765	6	6	0.32	0.016	0.58	−1.02	E	*ls*
			[1824.6]	146526	201332	4	4	0.37	0.018	0.44	−1.13	E	*ls*
			[1798.0]	146750	202368	6	8	0.0096	6.2×10^{-4}	0.022	−2.43	E	*ls*
			[1810.3]	146526	201765	4	6	0.018	0.0013	0.031	−2.28	E	*ls*
3		$^4D-^4P^\circ$ (8 uv)	*1908.1*	*151907*	*204316*	20	12	1.7	0.054	6.8	0.03	E	*ca*
			1901.61	151954	204541	8	6	1.3	0.054	2.7	−0.36	E	*ls*
			1912.90	151849	204124	6	4	1.0	0.038	1.4	−0.64	E	*ls*
			1917.87	151880	204022	4	2	0.83	0.023	0.58	−1.04	E	*ls*
			[1897.8]	151849	204541	6	6	0.30	0.016	0.61	−1.01	E	*ls*
			[1914.1]	151880	204124	4	4	0.53	0.029	0.73	−0.93	E	*ls*
			[1920.3]	151946	204022	2	2	0.83	0.046	0.58	−1.04	E	*ls*
			[1898.9]	151880	204541	4	6	0.033	0.0027	0.068	−1.97	E	*ls*
			[1916.5]	151946	204124	2	4	0.083	0.0091	0.11	−1.74	E	*ls*
4		$^4P-^4P^\circ$ (7)	*4045.8*	*179599*	*204316*	12	12	0.19	0.048	7.6	−0.24	E	*ca*
			3991.50	179495	204541	6	6	0.14	0.033	2.6	−0.70	E	*ls*
			[4087.2]	179664	204124	4	4	0.025	0.0063	0.34	−1.60	E	*ls*
			[4124.1]	179781	204022	2	2	0.031	0.0078	0.21	−1.81	E	*ls*
			4059.07	179495	204124	6	4	0.086	0.014	1.1	−1.07	E	*ls*
			4104.23	179664	204022	4	2	0.16	0.020	1.1	−1.11	E	*ls*
			4018.50	179664	204541	4	6	0.059	0.021	1.1	−1.07	E	*ls*
			4106.83	179781	204124	2	4	0.078	0.039	1.1	−1.11	E	*ls*
5		$^2D-^2P^\circ$ (9)	*3776.4*	*182656*	*209136*	10	6	0.75	0.097	12	−0.02	E	*ca*
			3824.47	183043	209183	6	4	0.64	0.093	7.0	−0.25	E	*ls*
			3707.34	182076	209042	4	2	0.75	0.077	3.8	−0.51	E	*ls*
			[3688.0]	182076	209183	4	4	0.076	0.015	0.75	−1.21	E	*ls*
6	$3p^23d'-3p^2(^1D)4p'$	$^2D-^2P^\circ$ (12)	*3712.1*	*195083*	*222022*	10	6	0.34	0.043	5.2	−0.37	E	*ca*
			3683.39	194960	222101	6	4	0.31	0.043	3.1	−0.59	E	*ls*
			[3759.0]	195268	221863	4	2	0.33	0.035	1.7	−0.86	E	*ls*
			[3725.7]	195268	222101	4	4	0.034	0.0071	0.35	−1.55	E	*ls*

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
7		^{2}F–^{2}D° (13)	*4602.6*	*196148*	*217875*	14	10	0.33	0.075	16	0.02	E	*ca*
			4608.21	196156	217850	8	6	0.31	0.074	9.0	−0.22	E	*ls*
			[4591.1]	196138	217913	6	4	0.33	0.070	6.3	−0.38	E	*ls*
			[4604.5]	196138	217850	6	6	0.016	0.0050	0.45	−1.53	E	*ls*
8	$3p^24s$–$3p^2(^3P)4p$	^{4}P–^{4}D° (1)	*3629.0*	*174294*	*201850*	12	20	1.7	0.56	80	0.83	D	*ca*
			3602.10	174614	202368	6	8	1.7	0.45	32	0.43	D	*ls*
			3612.85	174094	201765	4	6	1.2	0.35	17	0.14	D	*ls*
			3622.69	173736	201332	2	4	0.70	0.27	6.6	−0.26	D	*ls*
			3682.05	174614	201765	6	6	0.48	0.098	7.2	−0.23	D	*ls*
			3670.28	174094	201332	4	4	0.86	0.17	8.4	−0.16	D	*ls*
			3656.95	173736	201073	2	2	1.4	0.27	6.5	−0.26	D	*ls*
			[3741.7]	174614	201332	6	4	0.077	0.011	0.79	−1.19	E	*ls*
			3705.45	174094	201073	4	2	0.26	0.027	1.3	−0.97	E	*ls*
9		^{4}P–^{4}P° (2)	*3330.9*	*174294*	*204316*	12	12	2.2	0.36	48	0.64	D	*ca*
			3340.42	174614	204541	6	6	1.5	0.25	17	0.18	D	*ls*
			3329.06	174094	204124	4	4	0.29	0.048	2.1	−0.72	E	*ls*
			[3300.9]	173736	204022	2	2	0.37	0.060	1.3	−0.92	E	*ls*
			3387.60	174614	204124	6	4	0.93	0.11	7.2	−0.19	D	*ls*
			3340.42	174094	204022	4	2	1.8	0.15	6.6	−0.22	D	*ls*
			3283.41	174094	204541	4	6	0.68	0.16	7.1	−0.18	D	*ls*
			3289.80	173736	204124	2	4	0.93	0.30	6.6	−0.22	D	*ls*
10		^{4}P–^{4}S° (3)	*3160.1*	*174294*	205939	12	4	2.6	0.13	16	0.19	D	*ca*
			3191.45	174614	205939	6	4	1.2	0.13	7.9	−0.12	D	*ls*
			3139.34	174094	205939	4	4	0.86	0.13	5.2	−0.30	D	*ls*
			3104.46	173736	205939	2	4	0.44	0.13	2.6	−0.59	D	*ls*
11		^{2}P–^{2}D° (5)	*3739.4*	*178841*	*205583*	6	10	1.6	0.57	42	0.53	D	*ca*
			3720.45	179076	205947	4	6	1.7	0.52	25	0.32	D	*ls*
			3748.81	178370	205037	2	4	1.3	0.57	14	0.05	D	*ls*
			[3850.8]	179076	205037	4	4	0.25	0.055	2.8	−0.65	D−	*ls*
12		^{2}P–^{2}P° (6)	*3300.9*	*178841*	*209136*	6	6	2.3	0.38	25	0.36	D	*ca*
			3320.57	179076	209183	4	4	1.9	0.32	14	0.11	D	*ls*
			3259.32	178370	209042	2	2	1.6	0.26	5.5	−0.29	D	*ls*
			3336.16	179076	209042	4	2	0.76	0.064	2.8	−0.59	D	*ls*
			3244.44	178370	209183	2	4	0.41	0.13	2.8	−0.59	D	*ls*
13	$3p^24s'$–$3p^2(^1D)4p$	^{2}D–^{2}F° (10)	*3543.8*	*188413*	*216631*	10	14	2.3	0.60	70	0.78	D	*ca*
			3530.03	188390	216710	6	8	1.8	0.46	32	0.44	D	*ls*
			3560.68	188448	216525	4	6	1.7	0.48	22	0.28	D	*ls*
			[3553.3]	188390	216525	6	6	0.12	0.023	16	−0.87	D	*ls*
14		^{2}D–^{2}D° (11)	*3394.2*	*188413*	*217875*	10	10	2.0	0.35	39	0.54	D	*ca*
			3393.45	188390	217850	6	6	1.9	0.33	22	0.30	D	*ls*
			3392.89	188448	217913	4	4	1.9	0.32	14	0.11	D	*ls*
			3386.22	188390	217913	6	4	0.21	0.024	1.6	−0.84	D−	*ls*
			[3400.2]	188448	217850	4	6	0.14	0.036	1.6	−0.85	D−	*ls*
15		^{2}D–^{2}P° (11uv)	*2975.4*	*188413*	*222022*	10	6	3.1	0.25	24	0.39	D	*ca*
			2965.56	188390	222101	6	4	2.7	0.24	14	0.16	D	*ls*
			2991.82	188448	221863	4	2	3.0	0.20	7.9	−0.10	D	*ls*
			2970.67	188448	222101	4	4	0.30	0.040	1.6	−0.79	D−	*ls*

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
16	$3p^24p-3p^2(^3P)4d$	$^4D^\circ-^4F$ (12uv)	*2614.7*	*201850*	*240096*	20	28	6.5	0.93	160	1.27	D	*ca*
			2616.97	202368	240568	8	10	6.6	0.85	58	0.83	D	*ls*
			2609.50	201765	240075	6	8	5.7	0.77	40	0.67	D	*ls*
			2603.59	201332	239730	4	6	5.0	0.76	26	0.48	D	*ls*
			2601.16	201073	239506	2	4	4.6	0.94	16	0.28	D	*ls*
			2651.19	202368	240075	8	8	0.92	0.097	6.7	−0.11	D−	*ls*
			2633.18	201765	239730	6	6	1.6	0.16	8.6	−0.01	D−	*ls*
			2618.78	201332	239506	4	4	1.8	0.19	6.5	−0.12	D−	*ls*
			[2675.7]	202368	239730	8	6	0.060	0.0048	0.34	−1.41	E	*ls*
			[2648.8]	201765	239506	6	4	0.13	0.0088	0.46	−1.28	E	*ls*
17		$^4D^\circ-^4D$ (13uv)	*2503.5*	*201850*	*241794*	20	20	1.8	0.17	28	0.53	D	*ca*
			2519.45	202368	242046	8	8	1.5	0.15	10	0.07	D	*ls*
			2504.23	201765	241685	6	6	1.0	0.098	4.8	−0.23	D	*ls*
			2484.27	201332	241572	4	4	0.73	0.068	2.2	−0.47	D	*ls*
			2469.20	201073	241559	2	2	0.93	0.085	1.4	−0.77	D−	*ls*
			[2542.7]	202368	241685	8	6	0.33	0.024	1.6	−0.71	D−	*ls*
			2510.92	201765	241572	6	4	0.63	0.040	2.0	−0.62	D−	*ls*
			[2485.1]	201332	241559	4	2	0.91	0.042	1.4	−0.77	D−	*ls*
			[2481.8]	201765	242046	6	8	0.26	0.032	1.6	−0.71	D−	*ls*
			[2477.4]	201332	241685	4	6	0.43	0.059	1.9	−0.63	D−	*ls*
			[2468.5]	201073	241572	2	4	0.46	0.085	1.4	−0.77	D−	*ls*
18		$^4D^\circ-^4P$ (14uv)	*2431.7*	*201850*	*242973*	20	12	0.21	0.011	1.8	−0.65	D	*ca*
			2471.07	202368	242823	8	6	0.16	0.011	0.74	−1.04	D	*ls*
			2419.5	201765	243081	6	4	0.13	0.0079	0.38	−1.32	D	*ls*
			[2387.3]	201332	243207	4	2	0.11	0.0047	0.15	−1.73	D−	*ls*
			[2434.8]	201765	242823	6	6	0.038	0.0034	0.16	−1.69	D−	*ls*
			2394.73	201332	243081	4	4	0.070	0.0060	0.19	−1.62	D−	*ls*
			[2372.7]	201073	243207	2	2	0.11	0.0094	0.15	−1.73	D−	*ls*
			[2409.4]	201332	242823	4	6	0.0043	5.6×10^{-4}	0.018	−2.65	E	*ls*
			[2379.8]	201073	243081	2	4	0.011	0.0019	0.029	−2.43	E	*ls*
19		$^4P^\circ-^4D$ (16uv)	*2668.2*	*204316*	*241794*	12	20	4.8	0.85	90	1.01	D	*ca*
			2665.54	204541	242046	6	8	4.8	0.68	36	0.61	D	*ls*
			2661.65	204124	241685	4	6	3.4	0.54	19	0.33	D	*ls*
			[2662.3]	204022	241572	2	4	2.0	0.43	7.5	−0.07	D−	*ls*
			[2691.4]	204541	241685	6	6	1.4	0.15	8.2	−0.04	D−	*ls*
			[2669.6]	204124	241572	4	4	2.6	0.27	9.6	0.04	D−	*ls*
			[2663.2]	204022	241559	2	2	4.0	0.43	7.5	−0.07	D−	*ls*
			[2699.6]	204541	241572	6	4	0.23	0.017	0.91	−0.99	E	*ls*
			[2670.5]	204124	241559	4	2	0.80	0.043	1.5	−0.77	E	*ls*
20		$^2D^\circ-^2F$ (18uv)	*2581.6*	*205583*	*244318*	10	14	4.6	0.65	55	0.81	D	*ca*
			2580.67	205947	244685	6	8	4.7	0.63	32	0.58	D	*ls*
			2577.13	205037	243828	4	6	4.3	0.65	22	0.41	D	*ls*
			[2639.1]	205947	243828	6	6	0.29	0.031	1.6	−0.73	E	*ls*
21		$^2D^\circ-^2D$ (19 uv)	*2324.3*	*205583*	*248606*	10	10	4.5	0.37	28	0.57	D	*ca*
			2340.64	205947	248658	6	6	4.2	0.35	16	0.32	D	*ls*
			2298.51	205037	248528	4	4	4.2	0.33	10	0.12	D	*ls*
			[2347.7]	205947	248528	6	4	0.47	0.026	1.2	−0.81	D	*ls*
			[2291.8]	205037	248658	4	6	0.34	0.040	1.2	−0.80	D	*ls*
22		$^4S^\circ-^4P$ (20 uv)	*2700.2*	205939	*242973*	4	12	3.5	1.2	41	0.66	D	*ca*
			2710.37	205939	242823	4	6	3.5	0.57	20	0.36	D	*ls*
			2691.52	205939	243081	4	4	3.5	0.38	14	0.18	D	*ls*
			[2682.5]	205939	243207	4	2	3.5	0.19	6.8	−0.12	D−	*ls*

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
23		$^2P^\circ-^2D$ (22 uv)	*2533.6*	*209136*	*248606*	6	10	5.4	0.86	43	0.71	D	*ca*
			2532.48	209183	248658	4	6	5.3	0.77	26	0.49	D	*ls*
			2531.76	209042	248528	2	4	4.4	0.85	14	0.23	D	*ls*
			[2540.9]	209183	248528	4	4	0.88	0.085	2.9	−0.47	E	*ls*
24	$3p^24p'-3p^2(^1D)4d'$	$^2F^\circ-^2D$ (23 uv)	*2629.9*	*216631*	*254655*	14	10	0.43	0.032	3.9	−0.35	D	*ca*
			2632.67	216710	254683	8	6	0.41	0.032	2.2	−0.59	D	*ls*
			2624.71	216525	254613	6	4	0.44	0.030	1.6	−0.74	D	*ls*
			2620.05	216525	254683	6	6	0.021	0.0022	0.11	−1.89	E	*ls*
25	$3p^24p-3p^2(^3P)5s$	$^4D^\circ-^4P$ (15 uv)	*2281.0*	*201850*	*245691*	20	12	3.4	0.16	24	0.50	D	*ca*
			2283.93	202368	246137	8	6	2.7	0.16	9.6	0.11	D	*ls*
			2291.38	201765	245392	6	4	2.2	0.12	5.2	−0.16	D	*ls*
			[2291.8]	201332	244952	4	2	1.8	0.070	2.1	−0.55	D−	*ls*
			2253.07	201765	246137	6	6	0.61	0.046	2.1	−0.56	D−	*ls*
			2268.95	201332	245392	4	4	1.1	0.086	2.6	−0.46	D−	*ls*
			2278.34	201073	244952	2	2	1.8	0.14	2.1	−0.56	D−	*ls*
			[2231.2]	201332	246137	4	6	0.067	0.0075	0.22	−1.52	E	*ls*
			[2255.7]	201073	245392	2	4	0.17	0.027	0.39	−1.28	E	*ls*
26		$^4P^\circ-^4P$ (17 uv)	*2416.9*	*204316*	*245691*	12	12	2.0	0.18	17	0.33	D	*ca*
			2403.32	204541	246137	6	6	1.4	0.12	5.9	−0.13	D	*ls*
			2422.47	204124	245392	4	4	0.28	0.025	0.79	−1.01	E	*ls*
			2442.47	204022	244952	2	2	0.35	0.032	0.51	−1.20	E	*ls*
			2447.14	204541	245392	6	4	0.94	0.056	2.7	−0.47	D−	*ls*
			2448.58	204124	244952	4	2	1.8	0.080	2.6	−0.50	D−	*ls*
			2379.47	204124	246137	4	6	0.62	0.078	2.5	−0.50	D−	*ls*
			2416.42	204022	245392	2	4	0.88	0.15	2.4	−0.51	D−	*ls*
27		$^4S^\circ-^4P$ (21 uv)	*2515.6*	205939	*245691*	4	12	0.69	0.20	6.5	−0.11	D	*ca*
			2486.91	205939	246137	4	6	0.68	0.095	3.1	−0.42	D	*ls*
			[2533.9]	205939	245392	4	4	0.69	0.067	2.2	−0.57	D	*ls*
			[2562.5]	205939	244952	4	2	0.70	0.034	1.2	−0.86	D	*ls*
28	$3p^24p'-3p^2(^1D)5s'$	$^2F^\circ-^2D$ (24 uv)	*2366.5*	*216631*	*258888*	14	10	2.9	0.17	19	0.39	D	*ca*
			2370.37	216710	258886	8	6	2.8	0.18	11	0.16	D	*ls*
			2359.67	216525	258891	6	4	3.0	0.17	7.7	0.00	D	*ls*
			[2359.9]	216525	258886	6	6	0.14	0.012	0.55	−1.15	E	*ls*
29		$^2D^\circ-^2D$ (26 uv)	*2438.3*	*217875*	*258888*	10	10	2.1	0.19	15	0.27	D	*ca*
			2436.1	217850	258886	6	6	2.0	0.18	8.5	0.02	D	*ls*
			2439.69	217913	258891	4	4	1.9	0.17	5.5	−0.17	D	*ls*
			[2435.8]	217850	258891	6	4	0.21	0.013	0.60	−1.12	E	*ls*
			[2439.9]	217913	258886	4	6	0.14	0.019	0.61	−1.12	E	*ls*

Cl III

Forbidden Transitions

All the values for this ion are taken from Czyzak and Krueger [1], since they have included the important effects of configuration interaction and have used self-consistent field wavefunctions with exchange to obtain their value of s_q. (For a more complete discussion see General Introduction.)

Reference

[1] Czyzak, S. J. and Krueger, T. K., Monthly Notices Roy. Astron. Soc. **126**, 177–194 (1963).

Cl III. Forbidden Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	Type of Transition	A_{ki}(sec^{-1})	S(at.u.)	Accuracy	Source
1	$3p^3-3p^3$	$^4S^\circ-^2D^\circ$ (1F)										
			5517.66	0.0	18118.6	4	6	*m*	1.46×10^{-4}	5.5×10^{-6}	C	1
			5517.66	0.0	18118.6	4	6	*e*	8.6×10^{-4}	0.016	D	1
			5537.6	0.0	18053	4	4	*m*	0.0065	1.64×10^{-4}	C	1
			5537.6	0.0	18053	4	4	*e*	5.5×10^{-4}	0.0068	D	1
2		$^4S^\circ-^2P^\circ$ (2F)										
			3342.7	0.0	29907	4	4	*m*	0.96	0.0053	C	1
			3342.7	0.0	29907	4	4	*e*	4.9×10^{-6}	4.8×10^{-6}	D	1
			3353.4	0.0	29812	4	2	*m*	0.374	0.0065	C	1
			3353.4	0.0	29812	4	2	*e*	4.0×10^{-5}	2.0×10^{-5}	D	1
3		$^2D^\circ-^2D^\circ$										
			[15.24×10^5]	18053	18118.6	4	6	*m*	3.05×10^{-6}	2.40	B	1
			[15.24×10^5]	18053	18118.6	4	6	*e*	4.9×10^{-15}	0.14	D	1
4		$^2D^\circ-^2P^\circ$ (3F)										
			8481.6	18118.6	29907	6	4	*m*	0.169	0.0153	C	1
			8481.6	18118.6	29907	6	4	*e*	0.195	20.4	C	1
			8501.8	18053	29812	4	2	*m*	0.186	0.0085	C	1
			8501.8	18053	29812	4	2	*e*	0.165	8.7	C	1
			8550.5	18118.6	29812	6	2	*e*	0.108	5.9	C	1
			8433.7	18053	29907	4	4	*m*	0.306	0.0272	C	1
			8433.7	18053	29907	4	4	*e*	0.084	8.6	C	1
5		$^2P^\circ-^2P^\circ$										
			[10.5×10^5]	29812	29907	2	4	*m*	7.7×10^{-6}	1.33	C+	1
			[10.5×10^5]	29812	29907	2	4	*e*	1.9×10^{-14}	0.058	D	1

Ground State $1s^22s^22p^63s^23p^2\ ^3P_0$

Ionization Potential 53.5 eV = 431226 cm^{-1}

Allowed Transitions

List of tabulated lines:

Wavelength [Å]	No.	Wavelength [Å]	No.	Wavelength [Å]	No.
973.22	1	1534.4	4	2751.2	3
977.56	1	1539.3	4	2770.7	3
977.89	1	1600.0	5	2782.4	3
984.95	1	1617.4	5	2835.4	3
985.25	1	1625.5	5	3063.1	2
986.09	1	1632.3	5	3071.4	2
1500.4	4	1638.8	5	3076.7	2
1510.6	4	1650.3	5	3106.0	2
1528.7	4	2701.3	3	3167.9	2
1532.2	4	2724.0	3	3213.8	2

Varsavsky [1] has calculated a value for one multiplet of this ion using the screening-approximation method; this number should be quite uncertain (probably too high, as judged from comparisons in other ions), since the possibly important effects of configuration interaction have been neglected entirely. For several other transitions the Coulomb approximation has been employed in order to have some data on the more prominent lines in this spectrum. From the general success of this method and from comparisons with analogous transitions in other ions, uncertainties of 50 percent are expected; however these estimates should be regarded as provisional.

Reference

[1] Varsavsky, C. M., Astrophys. J. Suppl. Ser. **6**. No. 53, 75 (1961).

Cl IV. Allowed Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
1	$3s^23p^2-3s3p^3$	$^3P-^3D^\circ$	*981.27*	*909*	*102818*	9	15	23	0.55	16	0.69	E	1
			[984.95]	1341	102869	5	7	23	0.46	7.5	0.36	E	*ls*
			[977.56]	491	102787	3	5	17	0.41	4.0	0.09	E	*ls*
			[973.22]	0	102752	1	3	13	0.56	1.8	−0.25	E	*ls*
			[985.25]	1341	102787	5	5	5.5	0.080	1.3	−0.40	E	*ls*
			[977.89]	491	102752	3	3	9.4	0.13	1.3	−0.41	E	*ls*
			[986.09]	1341	102752	5	3	0.63	0.0055	0.089	−1.56	E	*ls*
2	$3p4s-3p(^2P^\circ)4p$	$^3P^\circ-^3D$	*3082.2*	*215948*	*248372*	9	15	2.3	0.54	49	0.69	D	*ca*
			[3076.7]	216468	248961	5	7	2.3	0.45	23	0.35	D	*ls*
			[3063.1]	215389	248026	3	5	1.7	0.40	12	0.08	D	*ls*
			[3071.4]	215026	247575	1	3	1.3	0.53	5.4	−0.28	D−	*ls*
			[3167.9]	216468	248026	5	5	0.52	0.079	4.1	−0.40	D−	*ls*
			[3106.0]	215389	247575	3	3	0.92	0.13	4.1	−0.41	D−	*ls*
			[3213.8]	216468	247575	5	3	0.055	0.0051	0.27	−1.59	E	*ls*

Cl IV. Allowed Transitions—*Continued*

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
3		$^3P^\circ-^3P$	*2767.6*	*215948*	*252070*	9	9	3.1	0.36	29	0.51	D	*ca*
			[2782.4]	216468	252397	5	5	2.3	0.26	12	0.11	D	*ls*
			[2751.2]	215389	251726	3	3	0.78	0.088	2.4	−0.58	D	*ls*
			[2835.4]	216468	251726	5	3	1.2	0.086	4.0	−0.37	D	*ls*
			[2770.7]	215389	251471	3	1	3.0	0.12	3.2	−0.44	D	*ls*
			[2701.3]	215389	252397	3	5	0.82	0.15	4.0	−0.35	D	*ls*
			[2724.0]	215026	251726	1	3	1.1	0.36	3.2	−0.44	D	*ls*
4	$3p4p-3p(^2P^\circ)5s$	$^3D-^3P^\circ$	*1531.9*	*248372*	*313649*	15	9	7.5	0.16	12	0.38	D	*ca*
			[1532.2]	248961	314225	7	5	6.3	0.16	5.6	0.05	D	*ls*
			[1539.3]	248026	312991	5	3	5.6	0.12	3.0	−0.22	D	*ls*
			[1534.4]	247575	312747	3	1	7.3	0.086	1.3	−0.59	D−	*ls*
			[1510.6]	248026	314225	5	5	1.2	0.040	1.0	−0.70	D−	*ls*
			[1528.7]	247575	312991	3	3	1.9	0.066	1.0	−0.70	D−	*ls*
			[1500.4]	247575	314225	3	5	0.080	0.0045	0.067	−1.87	E	*ls*
5		$^3P-^3P^\circ$	*1623.9*	*252070*	*313649*	9	9	4.6	0.18	8.8	0.21	D	*ca*
			[1617.4]	252397	314225	5	5	3.5	0.14	3.7	−0.15	D	*ls*
			[1632.3]	251726	312991	3	3	1.1	0.045	0.73	−0.87	D−	*ls*
			[1650.3]	252397	312991	5	3	1.8	0.044	1.2	−0.66	D	*ls*
			[1638.8]	251726	312747	3	1	4.5	0.061	0.98	−0.74	D−	*ls*
			[1600.0]	251726	314225	3	5	1.2	0.076	1.2	−0.64	D	*ls*
			[1625.5]	251471	312991	1	3	1.5	0.18	0.98	−0.74	D−	*ls*

Cl IV

Forbidden Transitions

The adopted values have been derived from Naqvi [1], and Czyzak and Krueger [2]. Since their methods are essentially alike, Naqvi's and Czyzak and Krueger's magnetic dipole transitions have been averaged, except for the $^3P-^1S$ transition where configuration interaction is important. In this case Czyzak and Krueger's empirically derived value has been preferred over Naqvi's, which is based purely on theory (see also General Introduction).

References

[1] Naqvi, A. M., Thesis Harvard (1951).
[2] Czyzak, S. J., and Krueger, T. K., Monthly Notices Roy. Astron. Soc. **126**, 177–194 (1963).

Cl IV. Forbidden Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	Type of Transition	A_{ki}(sec^{-1})	S(at.u.)	Accuracy	Source
1	$3p^2-3p^2$	$^3P-^3P$										
			[20.36 × 10⁴]	0	491	1	3	*m*	0.00213	2.00	B	1, 2
			[74551]	0	1341	1	5	*e*	2.77×10^{-7}	19.0	C	2
			[11.76 × 10⁴]	491	1341	3	5	*m*	0.00825	2.49	B	1, 2
			[11.76 × 10⁴]	491	1341	3	5	*e*	6.3×10^{-8}	4.25	C	2
2		$^3P-^1D$ (1F)										
			[7262.3]	0	13766	1	5	*e*	2.2×10^{-5}	0.0013	D	2
			7530.54	491	13766	3	5	*m*	0.080	0.0063	C	1, 2
			7530.54	491	13766	3	5	*e*	1.5×10^{-4}	0.11	D	2
			8045.63	1341	13766	5	5	*m*	0.196	0.0189	C	1, 2
			8045.63	1341	13766	5	5	*e*	7.7×10^{-4}	0.077	D	2

Cl IV. Forbidden Transitions—*Continued*

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	Type of Transition	A_{ki}(sec^{-1})	S(at.u.)	Accuracy	Source
3		^{3}P−^{1}S (2F)										
			3118.3	491	32550	3	1	*m*	2.61	0.00293	C	2
			3203.3	1341	32550	5	1	*e*	0.038	0.0077	D	2
4		^{1}D−^{1}S (3F)										
			5323.29	13766	32550	5	1	*e*	3.2	8.0	D	2

Cl V

Ground State $1s^22s^22p^63s^23p\ ^2P^\circ_{1/2}$

Ionization Potential 67.80 eV = 547000 cm^{-1}

Allowed Transitions

The screening-approximation calculations of Varsavsky [1] for the $3s^23p\ ^2P^\circ - 3s3p^2\ ^2D$ multiplet are considered to be rather uncertain (probably too high, as judged from comparisons in other ions) since the important effects of configuration mixing are neglected entirely. Gruzdev and Prokofev [2] have carried out Coulomb approximation calculations modified with the Seaton correction for the $3p\ ^2P^\circ - 4s\ ^2S$ multiplet; these results should be reliable to within 25 percent, as judged from plots depicting *f*-value dependence on nuclear charge.

References

[1] Varsavsky, C. M., Astrophys. J. Suppl. Ser. **6**, No. 53, 75 (1961).

[2] Gruzdev, P. F., and Prokofev, V. K., Optics and Spectroscopy (U.S.S.R.) **21**, 151–152 (1966).

Cl V. Allowed Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log *gf*	Accuracy	Source
1	$3s^23p-3s3p^2$	$^2P^\circ-^2D$	*890.61*	*995*	*113277*	6	10	26	0.52	9.2	0.49	E	1
			[894.34]	1492	113306	4	6	26	0.47	5.5	0.27	E	*ls*
			[883.13]	0	113234	2	4	23	0.53	3.1	0.03	E	*ls*
			[894.92]	1492	113234	4	4	4.3	0.052	0.61	−0.68	E	*ls*
2	$3p-(^1S)4s$	$^2P^\circ-^2S$	*391.67*	*995*	256313	6	2	119	0.091	0.70	−0.263	C	2
			[392.43]	1492	256313	4	2	79	0.091	0.470	−0.439	C	*ls*
			[390.15]	0	256313	2	2	40.0	0.091	0.234	−0.74	C	*ls*

Cl v

Forbidden Transitions

The line strength for the one transition in the ground state configuration is a straight number, tabulated for example by Naqvi [1]. The transition probability should also be quite accurate, since the energy level difference is accurately known.

Reference

[1] Naqvi, A. M., Thesis Harvard (1951).

Cl v. Forbidden Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	Type of Transition	A_{ki}(sec^{-1})	S(at.u.)	Accuracy	Source
1	$3p-(^1S)3p$	$^2P^\circ-^2P^\circ$	[67000]	0	1492	2	4	m	0.0298	1.33	A	1

Cl vi

Ground State $1s^22s^22p^63s^2\ ^1S_0$

Ionization Potential 96.7 eV = 780000 cm^{-1}

Allowed Transitions

List of tabulated lines:

Wavelength [Å]	No.	Wavelength [Å]	No.	Wavelength [Å]	No.
323.36	8	571.38	6	756.26	4
324.99	8	571.41	7	756.34	4
325.16	8	573.46	6	756.50	4
550.36	5	576.43	6	757.82	4
552.00	5	577.44	6	757.91	4
552.04	5	580.44	6	763.84	3
555.48	5	671.37	1	768.47	3
555.57	5	724.13	2	768.55	3
555.62	5	727.54	2	773.79	3
565.48	7	730.29	2	773.88	3
566.64	7	730.48	2	774.05	3
567.52	7	733.89	2		
570.02	7	736.75	2		
570.52	7	755.47	4		
570.89	6	755.63	4		

The charge-expansion technique of Crossley and Dalgarno [1], which includes limited configuration mixing, has been employed for the majority of the transitions in this spectrum; while Gruzdev and Prokofev [2] have carried out Coulomb approximation calculations modified with the Seaton correction for the $3s3p\ ^3P^\circ-3s4s\ ^3S$ multiplet. For many of these transitions, the dependence of oscillator strength on nuclear charge has served as an aid in estimating accuracies.

References

[1] Crossley, R. J. S., and Dalgarno, A., Proc. Roy. Soc. London **A286**, 510 (1965).
[2] Gruzdev, P. F., and Prokofev, V. K., Optics and Spectroscopy (U.S.S.R.) **21**, 151–152 (1966).

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
1	$3s^2-3s(^2S)3p$	$^1S-^1P^\circ$	[671.37]	0	148949	1	3	63.2	1.28	2.83	0.107	B	1
2	$3s3p-3p^2$	$^3P^\circ-^3P$	*730.42*	[*99286*]	[*236193*]	9	9	54	0.434	9.4	0.59	C+	1
			[730.29]	[99865]	[236797]	5	5	40.8	0.326	3.92	0.212	C+	*ls*
			[730.48]	[98700]	[235596]	3	3	13.5	0.108	0.78	−0.489	C	*ls*
			[736.75]	[99865]	[235596]	5	3	22.1	0.108	1.31	−0.268	C	*ls*
			[733.89]	[98700]	[234960]	3	1	53	0.143	1.04	−0.368	C	*ls*
			[724.13]	[98700]	[236797]	3	5	14.0	0.183	1.31	−0.260	C	*ls*
			[727.54]	[98147]	[235596]	1	3	18.2	0.434	1.04	−0.363	C	*ls*
3	$3s(^2S)3d-3p(^2P^\circ)3d$	$^3D-^3P^\circ$	*771.04*	[*279870*]	[*409565*]	15	9	28	0.15	5.6	0.35	D	1
			[774.05]	[279888]	[409079]	7	5	23	0.15	2.6	0.02	D	*ls*
			[768.55]	[279860]	[409975]	5	3	21	0.11	1.4	−0.26	D	*ls*
			[763.84]	[279845]	[410762]	3	1	28	0.082	0.62	−0.61	D	*ls*
			[773.88]	[279860]	[409079]	5	5	4.1	0.037	0.47	−0.73	D	*ls*
			[768.47]	[279845]	[409975]	3	3	7.0	0.062	0.47	−0.73	D	*ls*
			[773.79]	[279845]	[409079]	3	5	0.27	0.0041	0.031	−1.91	E	*ls*
4		$^3D-^3D^\circ$	*756.30*	[*279870*]	[*412092*]	15	15	27	0.23	8.6	0.54	D	1
			[755.63]	[279888]	[412228]	7	7	24	0.21	3.6	0.17	D	*ls*
			[756.34]	[279860]	[412075]	5	5	19	0.16	2.0	−0.10	D	*ls*
			[757.82]	[279845]	[411802]	3	3	20	0.17	1.3	−0.29	D	*ls*
			[756.50]	[279888]	[412075]	7	5	4.2	0.026	0.45	−0.74	D−	*ls*
			[757.91]	[279860]	[411802]	5	3	6.7	0.034	0.43	−0.77	D−	*ls*
			[755.47]	[279860]	[412228]	5	7	3.0	0.036	0.45	−0.74	D−	*ls*
			[756.26]	[279845]	[412075]	3	5	4.1	0.058	0.43	−0.76	D−	*ls*
5	$3s3p-3s(^2S)3d$	$^3P^\circ-^3D$	*553.76*	[*99286*]	[*279870*]	9	15	81.9	0.628	10.3	0.752	B	1
			[555.48]	[99865]	[279888]	5	7	81.2	0.526	4.81	0.420	B	*ls*
			[552.00]	[98700]	[279860]	3	5	61.9	0.471	2.57	0.150	B	*ls*
			[550.36]	[98147]	[279845]	1	3	46.2	0.629	1.14	−0.201	B	*ls*
			[555.57]	[99865]	[279860]	5	5	20.3	0.0938	0.858	−0.329	B	*ls*
			[552.04]	[98700]	[279845]	3	3	34.4	0.157	0.858	−0.327	B	*ls*
			[555.62]	[99865]	[279845]	5	3	2.3	0.0063	0.057	−1.51	D	*ls*
6	$3p^2-3p(^2P^\circ)3d$	$^3P-^3P^\circ$	*576.79*	[*236193*]	[*409565*]	9	9	65	0.32	5.5	0.46	D	1
			[580.44]	[236797]	[409079]	5	5	48	0.24	2.3	0.08	D	*ls*
			[573.46]	[235596]	[409975]	3	3	16	0.081	0.46	−0.61	D−	*ls*
			[577.44]	[236797]	[409975]	5	3	27	0.080	0.76	−0.40	D−	*ls*
			[570.89]	[235596]	[410762]	3	1	66	0.11	0.61	−0.48	D−	*ls*
			[576.43]	[235596]	[409079]	3	5	16	0.13	0.76	−0.41	D−	*ls*
			[571.38]	[234960]	[409975]	1	3	22	0.32	0.61	−0.49	D−	*ls*
7		$^3P-^3D^\circ$	*568.51*	[*236193*]	[*412092*]	9	15	110	0.89	15	0.90	D	1
			[570.02]	[236797]	[412228]	5	7	110	0.75	7.0	0.57	D	*ls*
			[566.64]	[235596]	[412075]	3	5	85	0.68	3.8	0.31	D	*ls*
			[565.48]	[234960]	[411802]	1	3	63	0.91	1.7	−0.04	D−	*ls*
			[570.52]	[236797]	[412075]	5	5	28	0.14	1.3	−0.15	D−	*ls*
			[567.52]	[235596]	[411802]	3	3	48	0.23	1.3	−0.16	D−	*ls*
			[571.41]	[236797]	[411802]	5	3	3.0	0.0088	0.083	−1.36	E	*ls*
8	$3s3p-3s(^2S)4s$	$^3P^\circ-^3S$	*324.55*	[*99286*]	[407404]	9	3	171	0.090	0.87	−0.092	C	2
			[325.16]	[99865]	[407404]	5	3	95	0.090	0.482	−0.347	C	*ls*
			[324.99]	[99700]	[407404]	3	3	57	0.090	0.289	−0.57	C	*ls*
			[323.36]	[98147]	[407404]	1	3	19.1	0.090	0.096	−1.046	C	*ls*

Cl VI

Forbidden Transitions

Naqvi's calculations [1] are the only available source. The results for the $^3P^\circ - ^3P^\circ$ transitions are essentially independent of the choice of the interaction parameters. For the $^3P^\circ - ^1P^\circ$ transitions, Naqvi uses empirical term intervals, i.e., the effects of configuration interaction should be partially included.

Reference

[1] Naqvi, A. M., Thesis Harvard (1951).

Cl VI. Forbidden Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	Type of Transition	A_{ki}(sec^{-1})	S(at.u.)	Accuracy	Source
1	$3s3p - 3s(^2S)3p$	$^3P^\circ - ^3P^\circ$										
			[18.08 × 10⁴]	[98147]	[98700]	1	3	*m*	0.00304	2.00	C+	1
			[85810]	[98700]	[99865]	3	5	*m*	0.0213	2.50	C+	1
2		$^3P^\circ - ^1P^\circ$										
			[1968.4]	[98147]	148949	1	3	*m*	0.62	5.3×10^{-4}	C−	1
			[1990.1]	[98700]	148949	3	3	*m*	27.8	0.0244	C−	1
			[2036.7]	[99865]	148949	5	3	*m*	0.70	6.6×10^{-4}	C−	1

Cl VII

Ground State $1s^22s^22p^63s\ ^2S_{1/2}$

Ionization Potential 114.27 eV = 921902 cm^{-1}

Allowed Transitions

List of tabulated lines:

Wavelength [Å]	No.	Wavelength [Å]	No.	Wavelength [Å]	No.
196.12	2	598.21	3	2178.8	9
196.39	2	604.79	3	2212.0	9
207.75	8	605.05	3		
240.85	7	722.13	11		
293.25	4	725.73	11		
294.89	4	800.70	1		
340.27	6	813.00	1		
455.13	5	1668.2	10		
455.28	5	1686.4	10		
456.56	5	1687.6	10		

Two sources of data are available for this ion: the calculations of Stewart and Rotenberg [1], employing a scaled Thomas-Fermi potential, and the charge-expansion formulation of Crossley and Dalgarno [2], which includes limited configuration mixing. Graphical comparisons of both works with more refined values within the isoelectronic sequence indicate accuracies within 25 percent. A number of additional values have been obtained from studies of the f-value dependence on nuclear charge. The reliable material available for other ions of this isoelectronic sequence in these cases permits the determination of reliable values simply by graphical interpolation.

References

[1] Stewart, J. C., and Rotenberg, M., Phys. Rev. **140**, 1508A–1519A (1965).
[2] Crossley, R. J. S., and Dalgarno, A., Proc. Roy. Soc. London **A286**, 510–518 (1965).

Cl VII. Allowed Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
1	$3s-3p$	$^2S-^2P^\circ$	*804.76*	0	*124261*	2	6	21.5	0.63	3.32	0.100	C	1
			[800.70]	0	124891	2	4	21.7	0.418	2.20	−0.078	C	*ls*
			[813.00]	0	123001	2	2	21.1	0.209	1.12	−0.379	C	*ls*
2	$3s-4p$	$^2S-^2P^\circ$	*196.21*	0	*509656*	2	6	59	0.102	0.132	−0.69	C	1
			[196.12]	0	509885	2	4	59	0.068	0.088	−0.87	C	*ls*
			[196.39]	0	509197	2	2	59	0.0340	0.0440	−1.167	C	*ls*
3	$3p-3d$	$^2P^\circ-^2D$	*602.59*	*124261*	*290210*	6	10	61	0.55	6.6	0.52	C	2
			[604.79]	124891	290239	4	6	61	0.498	3.97	0.299	C	*ls*
			[598.21]	123001	290166	2	4	52	0.56	2.21	0.049	C	*ls*
			[605.05]	124891	290166	4	4	10	0.055	0.44	−0.66	D	*ls*
4	$3p-4s$	$^2P^\circ-^2S$	*294.34*	*124261*	464003	6	2	230	0.10	0.58	−0.22	C	interp
			[294.89]	124891	464003	4	2	150	0.10	0.39	−0.40	C	*ls*
			[293.25]	123001	464003	2	2	76	0.098	0.19	−0.71	C	*ls*
5	$3d-4p$	$^2D-^2P^\circ$	*455.69*	*290210*	*509656*	10	6	70	0.13	2.0	0.11	C	interp
			[455.28]	290239	509885	6	4	64	0.13	1.2	−0.11	C	*ls*
			[456.56]	290166	509197	4	2	71	0.11	0.67	−0.36	C	*ls*
			[455.13]	290166	509885	4	4	7.0	0.022	0.13	−1.06	D	*ls*
6	$3d-4f$	$^2D-^2F^\circ$	*340.27*	*290210*	*584093*	10	14	380	0.92	10	0.96	C+	interp
7	$3d-5f$	$^2D-^2F^\circ$	*240.85*	*290210*	*705404*	10	14	140	0.17	1.3	0.23	C	interp
8	$3d-6f$	$^2D-^2F^\circ$	*207.75*	*290210*	771549	10	14	68	0.062	0.42	−0.21	C	interp
9	$4s-4p$	$^2S-^2P^\circ$	*2189.8*	464003	*509656*	2	6	4.1	0.89	13	0.25	C	interp
			[2178.8]	464003	509885	2	4	4.3	0.61	8.7	0.09	C	*ls*
			[2212.0]	464003	509197	2	2	4.0	0.30	4.3	−0.22	C	*ls*
10	$4p-4d$	$^2P^\circ-^2D$	*1680.4*	*509656*	*569166*	6	10	14	0.98	33	0.77	C	interp
			[1686.4]	509885	569182	4	6	14	0.90	20	0.56	C	*ls*
			[1668.2]	509197	569142	2	4	12	1.0	11	0.30	C	*ls*
			[1687.6]	509885	569142	4	4	2.3	0.099	2.2	−0.40	D	*ls*
11	$4p-5s$	$^2P^\circ-^2S$	*724.53*	*509656*	647677	6	2	65	0.17	2.4	0.01	C	interp
			[725.73]	509885	646677	4	2	42	0.17	1.6	−0.17	C	*ls*
			[722.13]	509197	647677	2	2	22	0.17	0.80	−0.47	C	*ls*

Cl VIII

Ground State $1s^2 2s^2 p^6\ ^1S_0$

Ionization Potential 348.3 eV = 2810000 cm^{-1}

Allowed Transitions

Calculations by Kastner, Omidvar, and Underwood [1], employing Hartree-Fock wavefunctions and including intermediate coupling, are available. Since the calculations are based on a single-configuration approximation only, uncertainties of up to 50 percent are expected for the strong lines and even higher uncertainties for the weak lines, the latter being more affected by assumptions about the coupling.

Reference

[1] Kastner, S. O., Omidvar, K., and Underwood, J. H., Astrophys. J. **148**, 269–273 (1967).

Cl VIII. Allowed Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
1	$2p^6 - 2p^5(^2P^\circ_{3/2})3s$	$^1S - ^3P^\circ$	[59.191]	0	1689450	1	3	280	0.044	0.0086	−1.36	E	1
2	$2p^6 - 2p^5(^2P^\circ_{1/2})3s$	$^1S - ^1P^\circ$	[58.673]	0	1704360	1	3	970	0.15	0.029	−0.82	D	1
3	$2p^6 - 2p^5(^2P^\circ_{3/2})3d$	$^1S - ^3P^\circ$	[50.700]	0	1972390	1	3	45	0.0052	8.7×10^{-4}	−2.28	E	1
4	$2p^6 - 2p^5(^2P^\circ_{3/2})3d$	$^1S - ^1P^\circ$	[50.074]	0	1997040	1	3	1.4×10^4	1.6	0.26	0.20	D	1
5	$2p^6 - 2p^5(^2P^\circ_{1/2})3d$	$^1S - ^3D^\circ$	[49.487]	0	2020730	1	3	1500	0.17	0.028	−0.77	D	1

Cl IX

Ground State $1s^2 2s^2 2p^5\ ^2P^\circ_{3/2}$

Ionization Potential 400.7 eV = 3233000 cm^{-1}

Allowed Transitions

The value for the $2s^2 2p^5\ ^2P^\circ - 2s2p^6\ ^2S$ multiplet is calculated from the nuclear charge-expansion method of Cohen and Dalgarno [1]. It may be quite uncertain since configuration interaction effects with configurations involving the $n = 3$ shell electrons, which were not included in this calculation, may be significant.

Reference

[1] Cohen, M., and Dalgarno, A., Proc. Roy. Soc. London **A280**, 258–270 (1964).

Cl IX. Allowed Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
1	$2s^22p^5-2s2p^6$	$^2P^\circ-^2S$	*182.19*	*4533*	553400	6	2	540	0.089	0.32	−0.27	D	1
			[180.70]	0	553400	4	2	360	0.088	0.21	−0.45	D	*ls*
			[185.25]	13600	553400	2	2	180	0.090	0.11	−0.74	D	*ls*

Cl IX

Forbidden Transitions

The line strength for the one transition in the ground state configuration is a straight number, tabulated for example by Naqvi [1]. The transition probability should also be quite accurate, since the energy level difference is accurately known.

Reference

[1] Naqvi, A. M., Thesis Harvard (1951).

Cl IX. Forbidden Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	Type of Transition	A_{ki}(sec^{-1})	S(at.u.)	Accuracy	Source
1	$2p^5-2p^5$	$^2P^\circ-^2P^\circ$	[7350.9]	0	13600	4	2	*m*	45.2	1.33	A	1

Cl X

Ground State $1s^22s^22p^4\ ^3P_2$

Ionization Potential 455.3 eV = 3673000 cm^{-1}

Allowed Transitions

The values are calculated from the charge-expansion method of Cohen and Dalgarno [1] which includes limited configuration mixing. From comparisons with other ions in the isoelectronic sequence, uncertainties should be within 50 percent.

Reference

[1] Cohen, M., and Dalgarno, A., Proc. Roy. Soc. London **A280**, 258–270 (1964).

Cl x. Allowed Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki} (10^8 sec^{-1})	f_{ik}	S(at. u.)	log gf	Accuracy	Source
1	$2s^22p^4-2s2p^5$	$^3P-^3P^\circ$											
			[205.34]	0	[487000]	5	5	180	0.11	0.38	−0.26	D	1, *ls*
			[210.03]	10880	[487000]	3	5	57	0.063	0.13	−0.72	D	1, *ls*

Cl x

Forbidden Transitions

As in the case of Na IV the adopted values are taken from Naqvi [1], and Malville and Berger [2]. For a discussion on the selection of values see Na IV, since the same criteria have been applied.

References

[1] Naqvi, A. M., Thesis Harvard (1951).

[2] Malville, J. M., and Berger, R. A., Planetary and Space Science **13**, 1131 (1965).

Cl x. Forbidden Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	Type of Transition	A_{ki}(sec^{-1})	S(at.u.)	Accuracy	Source
1	$2p^4-2p^4$	$^3P-^3P$										
			[9188.7]	0	10880	5	3	*e*	1.30×10^{-4}	0.0152	C−	1, 2
			[9188.7]	0	10880	5	3	*m*	28.6	2.47	B	1
2		$^3P-^1D$										
			[1639.3]	0	[61000]	5	5	*e*	0.036	0.0013	D−	1, 2
			[1639.3]	0	[61000]	5	5	*m*	109	0.089	C	1
			[1995.2]	10880	[61000]	3	5	*e*	0.0020	1.9×10^{-4}	D−	1, 2
			[1995.2]	10880	[61000]	3	5	*m*	20.4	0.0301	C	1
3		$^3P-^1S$										
			[767.40]	0	[130310]	5	1	*e*	0.51	8.1×10^{-5}	D−	2
			[837.31]	10880	[130310]	3	1	*m*	1410	0.0307	C	2
4		$^1D-^1S$										
			[1442.8]	[61000]	[130310]	5	1	*e*	7.7	0.0287	C−	2

ARGON
Ar I

Ground State $1s^2 2s^2 2p^6 3s^2 3p^6\ ^1S_0$

Ionization Potential 15.755 eV = 127109.9 cm^{-1}

Allowed Transitions

List of tabulated lines:

Wavelength [Å]	No.	Wavelength [Å]	No.	Wavelength [Å]	No.
866.80	2	4510.73	76	5194.02	378
869.75	6	4522.32	68	5210.49	361
876.06	1	4544.75	413	5214.77	364
879.95	5	4554.32	359	5216.28	397
1048.22	4	4584.96	409	5221.27	360
1066.66	3	4586.61	408	5241.09	365
3406.18	97	4587.21	407	5246.24	392
3461.08	88	4589.29	75	5249.20	391
3554.30	82	4596.10	74	5252.79	363
3563.29	90	4628.44	73	5254.47	312
3567.66	77	4642.15	401	5286.07	317
3572.30	96	4647.49	400	5290.00	390
3606.52	87	4702.32	72	5309.52	318
3632.68	86	4746.82	386	5317.73	372
3634.46	85	4752.94	387	5373.50	366
3643.12	84	4768.68	301	5393.27	398
3649.83	95	4798.74	415	5410.48	367
3659.53	83	4835.97	414	5421.35	375
3670.67	93	4836.70	395	5439.99	334
3675.23	94	4876.26	358	5442.24	304
3770.37	89	4886.29	410	5451.65	333
3834.68	92	4887.95	357	5457.42	377
3894.66	91	4894.69	356	5459.65	303
3947.50	58	4921.04	411	5467.16	376
3948.98	59	4937.72	412	5473.46	340
4044.42	66	4956.75	402	5490.12	307
4045.96	67	4989.95	403	5492.09	382
4054.53	65	5032.03	405	5495.87	302
4158.59	57	5048.81	374	5506.11	306
4164.18	56	5054.18	336	5524.96	225
4181.88	71	5056.53	335	5528.97	393
4190.71	55	5060.08	388	5534.49	384
4191.03	70	5070.99	406	5540.87	224
4198.32	64	5073.08	300	5552.77	394
4200.67	54	5078.03	305	5558.70	216
4251.18	53	5087.09	389	5559.66	323
4259.36	80	5104.74	404	5572.54	233
4266.29	63	5118.21	309	5574.22	324
4272.17	62	5127.80	308	5581.87	226
4300.10	61	5151.39	298	5588.72	232
4333.56	78	5152.30	217	5597.48	327
4335.34	79	5162.29	299	5606.73	215
4345.17	77	5177.54	396	5618.01	344
4363.79	60	5187.75	218	5620.92	343
4424.00	69	5192.72	362	5623.78	328

308-022 O-69—15

Wavelength [Å]	No.	Wavelength [Å]	No.	Wavelength [Å]	No.
5635.58	311	6119.66	320	6888.17	158
5637.33	369	6121.86	331	6925.01	263
5639.12	399	6127.42	227	6937.67	135
5641.39	310	6128.73	330	6951.46	163
5648.69	380	6145.44	260	6960.23	165
5649.26	381	6155.24	346	6965.43	31
5650.70	214	6165.12	259	6992.17	262
5659.13	379	6170.17	345	7030.25	272
5681.90	316	6173.10	238	7067.22	30
5683.73	315	6179.41	325	7068.73	274
5700.87	314	6212.50	245	7086.70	284
5712.51	368	6215.94	261	7107.48	273
5739.52	239	6230.93	244	7125.83	288
5772.11	247	6243.40	329	7147.04	29
5773.99	371	6244.73	266	7158.83	287
5783.54	240	6248.41	236	7162.57	168
5789.48	246	6278.65	242	7206.98	291
5790.40	370	6296.87	267	7229.93	149
5802.08	313	6307.66	243	7265.17	155
5834.26	248	6309.14	235	7270.66	142
5843.77	373	6364.89	234	7272.93	39
5860.31	271	6369.58	241	7285.44	178
5882.62	270	6384.72	269	7311.72	277
5888.58	337	6416.31	268	7316.01	295
5912.09	140	6431.56	275	7350.78	294
5916.58	229	6466.55	250	7353.18	276
5927.11	223	6481.14	347	7353.32	148
5928.81	339	6493.97	152	7372.12	141
5940.86	348	6513.85	349	7383.98	38
5942.67	338	6538.11	145	7392.97	281
5943.89	222	6596.12	144	7412.33	171
5964.48	251	6598.68	352	7422.26	172
5968.32	351	6604.02	146	7425.29	176
5971.60	350	6604.85	151	7435.33	280
5981.90	231	6632.09	279	7436.25	143
5987.30	220	6656.88	265	7471.17	37
5988.13	322	6660.68	278	7484.24	156
5994.66	321	6664.05	150	7503.87	52
5999.00	230	6677.28	40	7510.42	177
6005.73	383	6684.73	254	7514.65	36
6013.68	221	6698.47	159	7618.33	182
6025.15	353	6698.88	282	7628.86	183
6032.13	219	6719.22	249	7635.11	28
6043.22	228	6722.88	257	7670.04	147
6052.73	138	6752.84	137	7704.81	161
6059.37	139	6754.37	253	7723.76	27
6064.76	326	6756.10	258	7724.21	44
6081.25	385	6766.61	166	7798.55	154
6085.86	237	6779.93	332	7868.20	283
6090.79	319	6818.29	252	7891.08	162
6098.81	342	6827.25	256	7916.45	286
6101.16	355	6851.88	264	7948.18	43
6104.58	354	6871.29	136	7965.08	285
6105.64	255	6879.59	157	8006.16	35
6113.46	341	6887.10	164	8014.79	26

Wavelength [Å]	No.	Wavelength [Å]	No.	Wavelength [Å]	No.
8016.74	290	11441.8	198	14093.6	118
8037.23	297	11467.5	113	14596.3	19
8046.13	153	11488.1	45	14634.1	18
8053.31	160	11580.4	10	14739.1	114
8066.60	289	11668.7	116	14786.3	417
8103.69	34	11719.5	106	14876.6	416
8115.31	25	11733.3	7	15046.4	134
8151.86	293	11943.5	8	15172.3	199
8203.42	292	12026.6	119	15302.3	16
8264.52	51	12112.2	102	15329.6	105
8384.73	174	12139.8	123	15353.5	202
8408.21	50	12343.7	108	15402.6	15
8424.65	33	12356.8	11	15555.5	126
8490.30	170	12402.9	111	15734.9	206
8521.44	49	12439.2	100	15776.6	201
8605.78	175	12456.1	190	15816.8	23
8620.46	167	12487.6	188	15899.9	20
8667.94	42	12554.4	101	15989.3	213
8761.69	181	12621.8	200	16122.7	103
8784.61	169	12702.4	133	16180.0	205
8799.08	173	12733.6	189	16264.1	209
8962.19	180	12746.3	204	16436.9	14
9057.51	296	12802.7	107	16520.1	110
9075.42	179	12933.3	203	16549.8	13
9122.97	24	12956.6	99	16739.8	208
9194.64	187	13008.5	207	16940.4	115
9224.50	48	13214.7	98	17823.3	17
9291.53	186	13231.4	193	20317.0	212
9354.22	47	13273.1	128	20616.5	125
9657.78	32	13313.4	122	20812.0	22
9784.50	46	13367.1	211	21332.2	121
10470.1	41	13406.6	9	21534.9	131
10478.0	185	13499.2	197	22039.2	120
10506.5	12	13504.0	104	22077.4	124
10673.6	184	13543.8	192	23133.4	130
10683.4	191	13573.6	210	23844.8	21
10950.7	117	13599.2	127	23967.5	129
11078.9	109	13622.4	112		
11248.4	195	13678.5	132		
11393.7	194	13825.7	196		

A wealth of numerical data exists on the oscillator strengths of the Ar I spectrum. Numerous emission intensity measurements, performed mostly with stabilized arcs, as well as some lifetime determinations and several calculations based on intermediate coupling theory, have been recently reported in the literature.

Most of the work on Ar I has centered on the prominent red and blue lines, i.e., the $4s-4p$ and $4s-5p$ transition arrays. While the majority of the recent data agree very well on a relative basis, considerable discrepancies exist on the absolute scale. At present two different absolute scales, which are about 25 to 35 percent apart, appear to be supported by several experiments on each side, and at this time both possibilities deserve serious consideration.

One scale is clustered around the fairly extensive lifetime measurements of $4p$ and $5p$ levels by Klose [12, 13] performed with a delayed coincidence method. This scale is, within a range of about ± 10 percent, found also from the arc experiments of Popenoe and Shumaker [10] and Wiese

[14], from another less extensive lifetime experiment, again performed with the delayed coincidence technique, by Osherovich and Veroleinen [15], and from the Coulomb approximation [16].*

The other absolute scale, which is about 25 to 35 percent lower, is supported by the recent stabilized arc experiments of Bues et al. [5], Wende [4], and Richter [24] and by the shock-tube experiment of Coates and Gaydon [18]. To complicate matters, a recent lifetime measurement of two $4p$ levels by Landman [19] with the Hanle-effect technique—which has usually produced reliable results—lies about half-way in between these two scales, leaning a little toward the first scale (the two Landman values are about 10 to 13 percent lower than those derived from the first scale).

Aside from the above mentioned work, many other emission experiments with arcs are available; but we have not considered these for the absolute scale after noticing that they either show an appreciable scatter in the relative data when compared to any of the above experiments (which are, on a relative basis, all in good agreement), or they contain assumptions and data used for the diagnostics which are considered outdated now.

After a very detailed analysis we have decided to adopt the first scale as best represented by Klose's lifetime measurements. In our opinion this scale at present appears to be the least objectionable one; but it needs to be pointed out again that we do not consider this issue settled yet. We have chosen this scale for the following principal reasons:

First, Klose's lifetime data for four $4p$ and seven $5p$ levels (the latter in conjunction with theoretical data) represent a self-consistent set of data.

Second, there is no readily apparent reason why Klose's measured lifetimes are too short as would be required by the other scale. There are two principal mechanisms which could cause his lifetimes to be too short, namely, (a) depopulation by collisions and, (b) cascading from those higher levels which decay faster than the $4p$ levels because they have a direct connection to the ground state. The latter mechanism would apply principally to the $5s$ and $3d$ levels. Detailed quantitative estimates [20] show, however, that under Klose's conditions collisional depopulation is negligible and the cascading from those higher fast-decaying levels which are directly linked with the ground state is so severely modified by radiation trapping (imprisonment) that the effective lifetimes of these states become much longer than the measured ones.

Third, the Coulomb approximation, in conjunction with intermediate coupling theory [21], produces within a few percent the same lifetimes as measured by Klose for the $4p$ levels. This is exactly the same situation as encountered for the analogous case of the $3s-3p$ array of Ne I, where the Coulomb approximation has given accurate numbers. In addition, the Coulomb approximation, when applied to some other prominent transition arrays of Ar I where no cancellation occurs, such as $4p-3d$ and $4p-5s$, is also in these cases consistent with the experimental data based on Klose's scale. Furthermore, the adopted absolute scale for the $4s-4p$ array of argon fits much better into the apparent regularities for atomic f-values than the other possible scale with the smaller f-values.

Fourth, a possible explanation for the cause of the discrepancy between the two scales has been advanced by one of us some time ago [14] which also supports the adopted scale. The principal argument is based on the observation that in most emission intensity measurements the authors fail to include the intensity contributed by the line wings which may readily amount to about 15 to 20 percent. In the usually very dense arc plasmas the spectral lines are appreciably broadened. Thus the far wing contributions, which are extremely difficult to measure, should be taken into account by a theoretical estimate based on Stark broadening theory to obtain consistency with either the lifetime results or calculated transition probabilities. This line wing correction has been included only in the arc experiments of Shumaker and Popenoe [3, 10] and Wiese [14], both of which are in agreement with Klose's scale. If this correction were applied to the other arc experiments, it would have the effect of increasing the results by about 15 to 20 percent or more and thus bring them into reasonably close agreement with the scale adopted here.

In spite of the foregoing arguments, we feel that there may still be other equally important causes contributing to this discrepancy, since the line wing correction cannot explain certain inconsistencies observed by several authors within their arc experiments (see, e.g., ref. [5]). In view of this still somewhat uncertain situation we have been very conservative with our error estimates for this spectrum.

Now some details on the chosen numerical values:

Our starting point has been Klose's lifetime measurements [12] for the $4p$ levels with which we have renormalized Shumaker and Popenoe's [3] transition probabilities for the $4s-4p$ array. (The

normalization factor is 0.926.) The Shumaker and Popenoe values, it might be pointed out, fulfill the J-file sum rule very well. Calculated f-values by Garstang and Van Blerkom [21] for the $4s-4p$ array based on intermediate coupling theory and an absolute scale provided by the Coulomb approximation agree generally quite well with this scale. For the $4s-5p$ transitions, the prominent blue lines, we have chosen the averaged values of those recent sets of stabilized-arc data by Wende [4], Bues et al. [5], and Corliss and Shumaker [6], with appropriate renormalization factors. The first two authors cover the entire $4s-5p$ array, while Corliss and Shumaker have measured only about half of the lines in a wall-stabilized arc. The three sets of data agree very well on a relative basis, in most cases within 15 percent. To obtain the absolute scale, we have then connected these $4s-5p$ data with the $4s-4p$ array. Unfortunately, not too many links between the two transition arrays exist. Out of these we have chosen the arc measurements of Popenoe and Shumaker [10], which cover a few lines of both arrays. In particular, the 4300 Å line ($4s-5p$) and the 6965 Å line ($4s-4p$) were extensively measured by these authors, and Corliss and Shumaker [6] use this value for the 4300 Å line as the basis for their other results. We have therefore first renormalized the data of Corliss and Shumaker with the same factor applied earlier to the Shumaker and Popenoe values for the $4s-4p$ lines (since these measurements were based on the 6965 Å ($4s-4p$) line). Then the material of Bues et al., and Wende was put on this same absolute scale by determining and applying the respective mean arithmetic factors against the renormalized Corliss and Shumaker values; these factors are 1.250 for Bues et al., and 1.329 for Wende.

From our principal connection between the $4s-4p$ and $4s-5p$ arrays based on the 4300 Å and 6965 Å lines, a transition probability ratio of 0.059 may be derived for these two lines. For comparison, the arc measurements of Bott [17] produce a ratio of 0.050, while Coates and Gaydon [18] with a shocktube obtain 0.062. It is also interesting to note that for another possible link, this one between the 4300 Å and 7147 Å lines, the here-obtained ratio of 0.61 is again bracketed by those obtained by Coates and Gaydon (0.45) and Bues et al. (0.69).

The adopted $4s-5p$ transition probabilities, combined with theoretical data for the far-infrared $5s-5p$ and $3d-5p$ transitions [11, 13], are completely consistent with the lifetime data for seven $5p$ levels measured by Klose [12].

For many other lines in the visible and near ultraviolet we have primarily drawn on the (renormalized) material of Bues et al. [5], and Malone and Corcoran [8]. The latter used a radio frequency induction coupled plasma source; their renormalization factor is 1.159. In the many cases, where in addition to the material of Bues et al., data from Corliss and Shumaker were also available, we have given preference to the values of Bues et al., since these were obtained photoelectrically with a stabilized arc while Corliss and Shumaker's data were usually derived from an analysis of the relative intensity measurements of Dieke and Crosswhite [22]. For some $4p-6s$ lines we have listed the calculated absolute values of Johnston [7], based on intermediate coupling theory. We have not used any of his other material, since the transition integrals are very small, indicating cancellation, and his values usually disagree strongly with Bues et al., or Corliss and Shumaker, when comparisons are possible. We have also not used the results of Desai and Corcoran [23], obtained with a radio frequency plasma source, since—in comparison with other experimental values [5, 6]—they seem to show a dependence on the upper energy level of the transition involved.

For numerous infrared lines, we have employed the relative arc measurements of Wiese et al. [9], which are normalized again to Klose's scale. In the case of the $4p-5s$ array, we could complete the data by using also the intermediate coupling calculations of Murphy [11]. These theoretical data, presented on their own absolute scale, are in fairly good agreement with the arc measurements, in many cases within 30 percent.

In order to have a number of transition arrays complete or nearly complete, which is quite useful for checks with the J-file sum rule, we have listed in our compilation a number of mostly weak lines which we normally do not include in these compilations (lines of class "E"). We feel that none of these listed lines are very uncertain, i.e., we consider most of them probably to be within a factor of two of the true values.

Finally, for the two principal resonance lines in the vacuum uv, $3p-4s$, we have taken the average of a lifetime result by Lawrence [1] obtained with the delayed-coincidence method and a value reported by Lewis [2] who has analyzed natural line width measurements, which essentially constitute lifetime measurements, too. For several other lines in the vacuum uv we have deduced transition probabilities from Lawrence's lifetime measurements by subtracting out the smaller contributions, ranging from about 6 percent to 40 percent, of numerous infrared transitions starting

from the same upper levels. To do this, we applied the arc measurements of Wiese et al. [9], and the intermediate coupling calculations of Murphy [11].

References

[1] Lawrence, G. M., Phys. Rev. **175**, 40–44 (1968).
[2] Lewis, E. L., Proc. Phys. Soc. London **92**, 817–825 (1967).
[3] Shumaker, Jr., J. B. and Popenoe, C. H., J. Opt. Soc. Am. **57**, 8–10 (1967).
[4] Wende, B., Z. Physik **213**, 341–351 (1968).
[5] Bues, I., Haag, T., and Richter, J., Technical Report Inst. Experimentalphysik, Kiel Universitaet (1966–67).
[6] Corliss, C. H., and Shumaker, Jr., J. B., J. Res. NBS **71A** (Phys. and Chem.) No. 6, 575–581 (1967).
[7] Johnston, P. D., Proc. Phys. Soc. London **92**, 896–908 (1967).
[8] Malone, B. S., and Corcoran, W. H., J. Quant. Spectrosc. Radiat. Transfer. **6**, 443–449 (1966).
[9] Wiese, W. L., Bridges, J. M., Kornblith, R. L., and Kelleher, D. E. (to be published).
[10] Popenoe, C. H., and Shumaker, Jr., J. B., J. Res. NBS **69A** (Phys. and Chem.) No. 6, 495–509 (1965).
[11] Murphy, P. W., J. Opt. Soc. Am. **58**, 1200–1208 (1968).
[12] Klose, J. Z., J. Opt. Soc. Am. **57**, 1242–1244 (1967).
[13] Klose, J. Z., J. Opt. Soc. Am. **58**, 1509–1512 (1968).
[14] Wiese, W. L., Proc. Eighth International Conference on Phenomena in Ionized Gases, Vienna, Austria, 447 (Springer Verlag, Vienna, 1967).
[15] Osherovich, A. L. & Veroleinen, Ya.F., Vestnik Leningrad, Univ. Fiz. i Khim. No. 1, 140–141 (1967).
[16] Bates, D. R. & Damgaard, A., Phil. Trans. Roy. Soc. London, Ser. A. **242**, 101–122 (1949).
[17] Bott, J. F., Phys. Fluids **9**, 1540–1547 (1966).
[18] Coates, P. B. & Gaydon, A. G., Proc. Roy. Soc. London **A293**, 452–468 (1966).
[19] Landman, D. A., Phys. Rev. **173**, 33–39 (1968).
[20] See, e.g., Wiese, W. L., Chapter 2.1 Vol. **7A**, Methods of Experimental Physics, Academic Press, New York (1968).
[21] Garstang, R. H. and Van Blerkom, J., J. Opt. Soc. Am. **55**, 1054–1057 (1965).
[22] Dieke, G. H. and Crosswhite, H. M., Ordance Project No. TB2-0001 (488) (Dec. 1954).
[23] Desai, S. V., and Corcoran, W. H., J. Quant. Spectrosc. Radiat. Transfer **8**, 1721–1730 (1968).
[24] Richter, J., Z. Astrophys. **61**, 57–66 (1965).

Note Added in Proof:* New lifetime measurements by Veroleinen and Osherovich [Optics and Spectroscopy (U.S.S.R.) **25, 258–259 (1968)] for five *4p* levels are in very close agreement with our adopted absolute scale. If these results would be applied to the same *4p* levels for which we have used Klose's data [12], our absolute scale would shift by 2 percent towards higher transition probabilities.

Ar I. Allowed Transitions

No.	Transition		λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
	jl-coupling	Paschen											
1	$3p^6\,{}^1S-3d[\frac{3}{2}]^\circ$	$1p_0-3d_2$	876.06	0	114148	1	3	2.70	0.093	0.269	−1.032	C+	1, 9*n*
2	$3p^6\,{}^1S-3d'[\frac{3}{2}]^\circ$	$1p_0-3s'_1$	866.80	0	115367	1	3	3.13	0.106	0.302	−0.97	C+	1, 9*n*
3	$3p^6\,{}^1S-4s[\frac{3}{2}]^\circ$	$1p_0-1s_4$	1066.66	0	93751	1	3	1.19	0.061	0.214	−1.215	C+	1, 2
4	$3p^6\,{}^1S-4s'[\frac{1}{2}]^\circ$	$1p_0-1s_2$	1048.22	0	95400	1	3	5.1	0.254	0.88	−0.60	C+	1, 2
5	$3p^6\,{}^1S-5s[\frac{3}{2}]^\circ$	$1p_0-2s_4$	879.95	0	113643	1	3	0.77	0.0268	0.078	−1.57	C	1, 9*n*, 11
6	$3p^6\,{}^1S-5s'[\frac{1}{2}]^\circ$	$1p_0-2s_2$	869.75	0	114975	1	3	0.350	0.0119	0.0341	−1.92	C	1, 9*n*, 11
7	$3d[\frac{1}{2}]^\circ-4f[\frac{3}{2}]$	$3d_6-4X$	11733.3	111668	120188	1	3	0.0067	0.0416	1.60	−1.381	C	9*n*
8	$3d[\frac{1}{2}]^\circ-4f[\frac{3}{2}]$	$3d_5-4X$	11943.5	111818	120188	3	8	0.046	0.26	31	−0.11	D+	9*n*
9	$3d[\frac{7}{2}]^\circ-4f[\frac{9}{2}]$	$3d'_4-4V$	13406.6	112750	120207	9	20	0.065	0.39	150	0.55	D	9*n*
10	$3d[\frac{7}{2}]^\circ-4f'[\frac{7}{2}]$	$3d_4-4W$	11580.4	113020	121653	7	16	0.00346	0.0159	4.24	−0.95	C	9*n*
11	$3d[\frac{3}{2}]^\circ-4f[\frac{5}{2}]$	$3d_3-4Y$	12356.8	112139	120230	5	12	0.035	0.19	39	−0.02	D	9*n*
12	$3d[\frac{3}{2}]^\circ-4f'[\frac{5}{2}]$	$3d_3-4Z$	10506.5	112139	121654	5	12	0.0158	0.063	10.9	−0.50	C	9*n*
13	$3d[\frac{3}{2}]^\circ-4f[\frac{3}{2}]$	$3d_2-4X$	16549.8	114148	120188	3	8	0.016	0.18	29	−0.27	D−	9*n*
14	$3d[\frac{3}{2}]^\circ-4f[\frac{5}{2}]$	$3d_2-4Y$	16436.9	114148	120230	3	5	0.059	0.40	65	0.08	D	9*n*
15	$3d[\frac{5}{2}]^\circ-4f[\frac{9}{2}]$	$3d'_1-4V$	15402.6	113717	120207	7	9	0.014	0.064	23	−0.36	D−	9*n*
16	$3d[\frac{5}{2}]^\circ-4f[\frac{7}{2}]$	$3d'_1-4U$	15302.3	113717	120250	7	16	0.054	0.43	150	0.48	D−	9*n*

No.	Transition: *jl*-coupling	Transition: Paschen	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
17	$3d'[\frac{5}{2}]^\circ-4f[\frac{7}{2}]$	$3s_1''''-4U$	17823.3	114641	120250	5	7	0.0084	0.056	16	−0.55	E	9*n*
18	$3d'[\frac{5}{2}]^\circ-4f'[\frac{7}{2}]$	$3s_1'''-4W$	14634.1	114822	121653	7	16	0.090	0.66	220	0.66	D−	9*n*
19	$3d'[\frac{3}{2}]^\circ-4f'[\frac{5}{2}]$	$3s_1''-4Z$	14596.3	114805	121654	5	12	0.053	0.41	98	0.30	D−	9*n*
20	$3d'[\frac{3}{2}]^\circ-4f'[\frac{5}{2}]$	$3s_1'-4Z$	15899.9	115367	121654	3	5	0.077	0.49	76	0.17	D	9*n*
21	$3d[\frac{7}{2}]^\circ-5p[\frac{5}{2}]$	$3d_4'-3p_9$	23844.8	112750	116943	9	7	0.012	0.079	56	−0.15	D	9*n*
22	$3d[\frac{3}{2}]^\circ-5p[\frac{5}{2}]$	$3d_3-3p_9$	20812.0	112139	116943	5	7	8.5×10^{-4}	0.0077	2.6	−1.41	D−	9*n*
23	$3d[\frac{3}{2}]^\circ-5p'[\frac{1}{2}]$	$3d_3-3p_2$	15816.8	112139	118460	5	3	9.8×10^{-4}	0.0022	0.57	−1.96	E	9*n*
24	$4s[\frac{3}{2}]^\circ-4p[\frac{1}{2}]$	$1s_5-2p_{10}$	9122.97	93144	104102	5	3	0.212	0.159	23.8	−0.100	C	3*n*
25	$4s[\frac{3}{2}]^\circ-4p[\frac{5}{2}]$	$1s_5-2p_9$	8115.31	93144	105463	5	7	0.366	0.51	68	0.407	C	3*n*
26	$4s[\frac{3}{2}]^\circ-4p[\frac{5}{2}]$	$1s_5-2p_8$	8014.79	93144	105617	5	5	0.096	0.092	12.2	−0.337	C	3*n*
27	$4s[\frac{3}{2}]^\circ-4p[\frac{3}{2}]$	$1s_5-2p_7$	7723.76	93144	106087	5	3	0.057	0.0306	3.89	−0.82	C	3*n*
28	$4s[\frac{3}{2}]^\circ-4p[\frac{3}{2}]$	$1s_5-2p_6$	7635.11	93144	106238	5	5	0.274	0.239	30.1	0.077	C	3*n*
29	$4s[\frac{3}{2}]^\circ-4p'[\frac{3}{2}]$	$1s_5-2p_4$	7147.04	93144	107132	5	3	0.0065	0.00299	0.351	−1.83	C	3*n*
30	$4s[\frac{3}{2}]^\circ-4p'[\frac{3}{2}]$	$1s_5-2p_3$	7067.22	93144	107290	5	5	0.0395	0.0296	3.44	−0.83	C	3*n*
31	$4s[\frac{3}{2}]^\circ-4p'[\frac{1}{2}]$	$1s_5-2p_2$	6965.43	93144	107496	5	3	0.067	0.0292	3.35	−0.84	C	3*n*
32	$4s[\frac{3}{2}]^\circ-4p[\frac{1}{2}]$	$1s_4-2p_{10}$	9657.78	93751	104102	3	3	0.060	0.084	8.0	−0.60	C	3*n*
33	$4s[\frac{3}{2}]^\circ-4p'[\frac{5}{2}]$	$1s_4-2p_8$	8424.65	93751	105617	3	5	0.233	0.413	34.4	0.093	C	3*n*
34	$4s[\frac{3}{2}]^\circ-4p[\frac{3}{2}]$	$1s_4-2p_7$	8103.69	93751	106087	3	3	0.277	0.273	21.8	−0.087	C	3*n*
35	$4s[\frac{3}{2}]^\circ-4p[\frac{3}{2}]$	$1s_4-2p_6$	8006.16	93751	106238	3	5	0.0468	0.075	5.9	−0.65	C	3*n*
36	$4s[\frac{3}{2}]^\circ-4p[\frac{1}{2}]$	$1s_4-2p_5$	7514.65	93751	107054	3	1	0.430	0.121	9.0	−0.440	C	3*n*
37	$4s[\frac{3}{2}]^\circ-4p'[\frac{3}{2}]$	$1s_4-2p_4$	7471.17	93751	107132	3	3	2.5×10^{-4}	2.1×10^{-4}	0.015	−3.20	C−	3*n*
38	$4s[\frac{3}{2}]^\circ-4p'[\frac{3}{2}]$	$1s_4-2p_3$	7383.98	93751	107290	3	5	0.087	0.119	8.6	−0.447	C	3*n*
39	$4s[\frac{3}{2}]^\circ-4p'[\frac{1}{2}]$	$1s_4-2p_2$	7272.93	93751	107496	3	3	0.0200	0.0159	1.14	−1.321	C	3*n*
40	$4s[\frac{3}{2}]^\circ-4p'[\frac{1}{2}]$	$1s_4-2p_1$	6677.28	93751	108723	3	1	0.00241	5.4×10^{-4}	0.0354	−2.79	C	3*n*
41	$4s'[\frac{1}{2}]^\circ-4p[\frac{1}{2}]$	$1s_3-2p_{10}$	10470.1	94554	104102	1	3	0.0117	0.058	1.99	−1.237	C	3*n*
42	$4s'[\frac{1}{2}]^\circ-4p[\frac{3}{2}]$	$1s_3-2p_7$	8667.94	94554	106087	1	3	0.0280	0.095	2.70	−1.022	C	3*n*
43	$4s'[\frac{1}{2}]^\circ-4p'[\frac{3}{2}]$	$1s_3-2p_4$	7948.18	94554	107132	1	3	0.196	0.56	14.6	−0.252	C	3*n*
44	$4s'[\frac{1}{2}]^\circ-4p'[\frac{1}{2}]$	$1s_3-2p_2$	7724.21	94554	107496	1	3	0.127	0.341	8.7	−0.467	C	3*n*
45	$4s'[\frac{1}{2}]^\circ-4p[\frac{1}{2}]$	$1s_2-2p_{10}$	11488.1	95400	104102	3	3	0.0025	0.0049	0.56	−1.83	C−	3*n*
46	$4s'[\frac{1}{2}]^\circ-4p[\frac{5}{2}]$	$1s_2-2p_8$	9784.50	95400	105617	3	5	0.0161	0.0385	3.72	−0.94	C	3*n*
47	$4s'[\frac{1}{2}]^\circ-4p[\frac{3}{2}]$	$1s_2-2p_7$	9354.22	95400	106087	3	3	0.0115	0.0151	1.39	−1.344	C	3*n*
48	$4s'[\frac{1}{2}]^\circ-4p[\frac{3}{2}]$	$1s_2-2p_6$	9224.50	95400	106138	3	5	0.059	0.125	11.4	−0.426	C	3*n*
49	$4s'[\frac{1}{2}]^\circ-4p'[\frac{3}{2}]$	$1s_2-2p_4$	8521.44	95400	107132	3	3	0.147	0.160	13.5	−0.319	C	3*n*
50	$4s'[\frac{1}{2}]^\circ-4p'[\frac{3}{2}]$	$1s_2-2p_3$	8408.21	95400	107290	3	5	0.244	0.431	35.8	0.112	C	3*n*
51	$4s'[\frac{1}{2}]^\circ-4p'[\frac{1}{2}]$	$1s_2-2p_2$	8264.52	95400	107496	3	3	0.168	0.172	14.0	−0.287	C	3*n*
52	$4s'[\frac{1}{2}]^\circ-4p'[\frac{1}{2}]$	$1s_2-2p_1$	7503.87	95400	108723	3	1	0.472	0.133	9.8	−0.399	C	3*n*
53	$4s[\frac{3}{2}]^\circ-5p[\frac{1}{2}]$	$1s_5-3p_{10}$	4251.18	93144	116660	5	3	0.00113	1.84×10^{-4}	0.0129	−3.036	C	4*n*, 5*n*, 6*n*
54	$4s[\frac{3}{2}]^\circ-5p[\frac{5}{2}]$	$1s_5-3p_9$	4200.67	93144	116943	5	7	0.0103	0.00382	0.264	−1.72	C	4*n*, 5*n*
55	$4s[\frac{3}{2}]^\circ-5p[\frac{5}{2}]$	$1s_5-3p_8$	4190.71	93144	116999	5	5	0.00254	6.7×10^{-4}	0.0461	−2.475	C	5*n*
56	$4s[\frac{3}{2}]^\circ-5p[\frac{3}{2}]$	$1s_5-3p_7$	4164.18	93144	117151	5	3	0.00295	4.60×10^{-4}	0.0315	−2.64	C	4*n*, 5*n*, 6*n*
57	$4s[\frac{3}{2}]^\circ-5p[\frac{3}{2}]$	$1s_5-3p_6$	4158.59	93144	117184	5	5	0.0145	0.00376	0.257	−1.73	C	4*n*, 5*n*, 6*n*
58	$4s[\frac{3}{2}]^\circ-5p'[\frac{3}{2}]$	$1s_5-3p_3$	3947.50	93144	118469	5	5	6.3×10^{-4}	1.47×10^{-4}	0.0096	−3.134	C	4*n*, 5*n*
59	$4s[\frac{3}{2}]^\circ-5p'[\frac{1}{2}]$	$1s_5-3p_2$	3948.98	93144	118460	5	3	0.00467	6.6×10^{-4}	0.0426	−2.481	C	4*n*, 5*n*
60	$4s[\frac{3}{2}]^\circ-5p[\frac{1}{2}]$	$1s_4-3p_{10}$	4363.79	93751	116660	3	3	1.5×10^{-4}	4.3×10^{-5}	0.0018	−3.89	D	4*n*, 5*n*, 6*n*
61	$4s[\frac{3}{2}]^\circ-5p[\frac{5}{2}]$	$1s_4-3p_8$	4300.10	93751	116999	3	5	0.00394	0.00182	0.077	−2.263	C	4*n*, 5*n*, 6*n*
62	$4s[\frac{3}{2}]^\circ-5p[\frac{3}{2}]$	$1s_4-3p_7$	4272.17	93751	117151	3	3	0.0084	0.00230	0.097	−2.161	C	4*n*, 5*n*, 6*n*
63	$4s[\frac{3}{2}]^\circ-5p[\frac{3}{2}]$	$1s_4-3p_6$	4266.29	93751	117184	3	5	0.00333	0.00151	0.064	−2.344	C	4*n*, 5*n*, 6*n*
64	$4s[\frac{3}{2}]^\circ-5p[\frac{1}{2}]$	$1s_4-3p_5$	4198.32	93751	117563	3	1	0.0276	0.00243	0.101	−2.137	C	4*n*, 5*n*
65	$4s[\frac{3}{2}]^\circ-5p'[\frac{3}{2}]$	$1s_4-3p_4$	4054.53	93751	118407	3	3	2.71×10^{-4}	6.7×10^{-5}	0.00267	−3.70	C−	4*n*, 5*n*
66	$4s[\frac{3}{2}]^\circ-5p'[\frac{3}{2}]$	$1s_4-3p_3$	4044.42	93751	118469	3	5	0.00346	0.00141	0.056	−2.374	C	4*n*, 5*n*
67	$4s[\frac{3}{2}]^\circ-5p'[\frac{1}{2}]$	$1s_4-3p_2$	4045.96	93751	118460	3	3	4.38×10^{-4}	1.08×10^{-4}	0.00430	−3.489	C	4*n*, 5*n*

No.	Transition: *jl*-coupling	Transition: Paschen	λ(A)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
68	$4s'[\frac{1}{2}]^\circ-5p[\frac{1}{2}]$	$1s_3-3p_{10}$	4522.32	94554	116660	1	3	9.5×10^{-4}	8.7×10^{-4}	0.0130	−3.060	C	4n, 5n, 6n
69	$4s'[\frac{1}{2}]^\circ-5p[\frac{3}{2}]$	$1s_3-3p_7$	4424.00	94554	117151	1	3	8.4×10^{-5}	7.4×10^{-5}	0.0011	−4.13	D	4n, 5n, 6n
70	$4s'[\frac{1}{2}]^\circ-5p'[\frac{3}{2}]$	$1s_3-3p_4$	4191.03	94554	118407	1	3	0.0056	0.00442	0.061	−2.355	C	5n
71	$4s'[\frac{1}{2}]^\circ-5p'[\frac{1}{2}]$	$1s_3-3p_2$	4181.88	94554	118460	1	3	0.0058	0.00456	0.063	−2.341	C	4n, 5n
72	$4s'[\frac{1}{2}]^\circ-5p[\frac{1}{2}]$	$1s_2-3p_{10}$	4702.32	95400	116660	3	3	0.00113	3.75×10^{-4}	0.0174	−2.95	C	4n, 5n, 6n
73	$4s'[\frac{1}{2}]^\circ-5p[\frac{5}{2}]$	$1s_2-3p_8$	4628.44	95400	116999	3	5	4.25×10^{-4}	2.28×10^{-4}	0.0104	−3.165	C−	4n, 5n, 6n
74	$4s'[\frac{1}{2}]^\circ-5p[\frac{3}{2}]$	$1s_2-3p_7$	4596.10	95400	117151	3	3	0.00102	3.23×10^{-4}	0.0147	−3.014	C	4n, 5n, 6n
75	$4s'[\frac{1}{2}]^\circ-5p[\frac{3}{2}]$	$1s_2-3p_6$	4589.29	95400	117184	3	5	5.1×10^{-5}	2.7×10^{-5}	0.0012	−4.09	D	4n, 5n, 6n
76	$4s'[\frac{1}{2}]^\circ-5p[\frac{1}{2}]$	$1s_2-3p_5$	4510.73	95400	117563	3	1	0.0123	0.00125	0.056	−2.426	C	4n, 5n, 6n
77	$4s'[\frac{1}{2}]^\circ-5p'[\frac{3}{2}]$	$1s_2-3p_4$	4345.17	95400	118407	3	3	0.00313	8.9×10^{-4}	0.0380	−2.57	C	4n, 5n, 6n
78	$4s'[\frac{1}{2}]^\circ-5p'[\frac{3}{2}]$	$1s_2-3p_3$	4333.56	95400	118469	3	5	0.0060	0.00282	0.121	−2.073	C	4n, 5n
79	$4s'[\frac{1}{2}]^\circ-5p'[\frac{1}{2}]$	$1s_2-3p_2$	4335.34	95400	118460	3	3	0.00387	0.00109	0.0467	−2.485	C	4n, 5n
80	$4s'[\frac{1}{2}]^\circ-5p'[\frac{1}{2}]$	$1s_2-3p_1$	4259.36	95400	118871	3	1	0.0415	0.00376	0.158	−1.95	C	4n, 5n, 6n
81	$4s[\frac{3}{2}]^\circ-6p[\frac{5}{2}]$	$1s_5-4p_9$	3567.66	93144	121165	5	7	0.0012	3.2×10^{-4}	0.019	−2.80	D	8n
82	$4s[\frac{3}{2}]^\circ-6p[\frac{3}{2}]$	$1s_5-4p_6$	3554.30	93144	121271	5	5	0.0029	5.5×10^{-4}	0.032	−2.56	D	8n
83	$4s[\frac{3}{2}]^\circ-6p[\frac{1}{2}]$	$1s_4-4p_{10}$	3659.53	93751	121069	3	3	4.7×10^{-4}	9.4×10^{-5}	0.0034	−3.55	D	8n
84	$4s[\frac{3}{2}]^\circ-6p[\frac{5}{2}]$	$1s_4-4p_8$	3643.12	93751	121192	3	5	2.6×10^{-4}	8.6×10^{-5}	0.0031	−3.59	D	8n
85	$4s[\frac{3}{2}]^\circ-6p[\frac{3}{2}]$	$1s_4-4p_7$	3634.46	93751	121257	3	3	0.0014	2.8×10^{-4}	0.010	−3.08	D	8n
86	$4s[\frac{3}{2}]^\circ-6p[\frac{3}{2}]$	$1s_4-4p_6$	3632.68	93751	121271	3	5	7.0×10^{-4}	2.3×10^{-4}	0.0083	−3.16	D	8n
87	$4s[\frac{3}{2}]^\circ-6p[\frac{1}{2}]$	$1s_4-4p_5$	3606.52	93751	121470	3	1	0.0081	5.3×10^{-4}	0.019	−2.80	D	8n
88	$4s[\frac{3}{2}]^\circ-6p'[\frac{3}{2}]$	$1s_4-4p_3$	3461.08	93751	122635	3	5	7.1×10^{-4}	2.1×10^{-4}	0.0073	−3.20	D	8n
89	$4s'[\frac{1}{2}]^\circ-6p[\frac{1}{2}]$	$1s_3-4p_{10}$	3770.37	94554	121069	1	3	7.4×10^{-4}	4.7×10^{-4}	0.0059	−3.33	D	8n
90	$4s'[\frac{1}{2}]^\circ-6p'[\frac{3}{2}]$	$1s_3-4p_4$	3563.29	94554	122610	1	3	0.0013	7.4×10^{-4}	0.0087	−3.13	D	8n
91	$4s'[\frac{1}{2}]^\circ-6p[\frac{1}{2}]$	$1s_2-4p_{10}$	3894.66	95400	121069	3	3	6.1×10^{-4}	1.4×10^{-4}	0.0053	−3.38	D	8n
92	$4s'[\frac{1}{2}]^\circ-6p[\frac{1}{2}]$	$1s_2-4p_5$	3834.68	95400	121470	3	1	0.0080	5.9×10^{-4}	0.022	−2.75	D	8n
93	$4s'[\frac{1}{2}]^\circ-6p'[\frac{3}{2}]$	$1s_2-4p_3$	3670.67	95400	122635	3	5	3.3×10^{-4}	1.1×10^{-4}	0.0040	−3.48	D	8n
94	$4s'[\frac{1}{2}]^\circ-6p'[\frac{1}{2}]$	$1s_2-4p_2$	3675.23	95400	122601	3	3	5.2×10^{-4}	1.1×10^{-4}	0.0038	−3.48	D	8n
95	$4s'[\frac{1}{2}]^\circ-6p'[\frac{1}{2}]$	$1s_2-4p_1$	3649.83	95400	122791	3	1	0.0085	5.7×10^{-4}	0.020	−2.77	D	8n
96	$4s'[\frac{1}{2}]^\circ-7p[\frac{1}{2}]$	$1s_2-5p_5$	3572.30	95400	123385	3	1	0.0054	3.4×10^{-4}	0.012	−2.99	D	8n
97	$4s'[\frac{1}{2}]^\circ-7p'[\frac{1}{2}]$	$1s_2-5p_1$	3406.18	95400	124750	3	1	0.0041	2.4×10^{-4}	0.0080	−3.14	D	8n
98	$4p[\frac{1}{2}]-3d[\frac{1}{2}]^\circ$	$2p_{10}-3d_6$	13214.7	104102	111668	3	1	0.091	0.079	10	−0.63	D	9n
99	$4p[\frac{1}{2}]-3d[\frac{1}{2}]^\circ$	$2p_{10}-3d_5$	12956.6	104102	111818	3	3	0.083	0.21	27	−0.20	D	9n
100	$4p[\frac{1}{2}]-3d[\frac{3}{2}]^\circ$	$2p_{10}-3d_3$	12439.2	104102	112139	3	5	0.055	0.21	26	−0.20	D	9n
101	$4p[\frac{5}{2}]-3d[\frac{5}{2}]^\circ$	$2p_9-3d_1''$	12554.4	105463	113426	7	5	0.0014	0.0024	0.68	−1.77	D	9n
102	$4p[\frac{5}{2}]-3d[\frac{5}{2}]^\circ$	$2p_9-3d_1'$	12112.2	105463	113717	7	7	0.035	0.077	21	−0.27	D	9n
103	$4p[\frac{5}{2}]-3d[\frac{1}{2}]^\circ$	$2p_8-3d_5$	16122.7	105617	111818	5	3	4.4×10^{-4}	0.0010	0.27	−2.30	D−	9n
104	$4p[\frac{5}{2}]-3d[\frac{7}{2}]^\circ$	$2p_8-3d_4$	13504.0	105617	113020	5	7	0.12	0.47	100	0.37	D	9n
105	$4p[\frac{5}{2}]-3d[\frac{3}{2}]^\circ$	$2p_8-3d_3$	15329.6	105617	112139	5	5	0.0014	0.0049	1.2	−1.61	E	9n
106	$4p[\frac{5}{2}]-3d[\frac{3}{2}]^\circ$	$2p_8-3d_2$	11719.5	105617	114148	5	3	0.0107	0.0132	2.55	−1.180	C	9n
107	$4p[\frac{5}{2}]-3d[\frac{5}{2}]^\circ$	$2p_8-3d_1''$	12802.7	105617	113426	5	5	0.064	0.16	33	−0.10	D	9n
108	$4p[\frac{5}{2}]-3d[\frac{5}{2}]^\circ$	$2p_8-3d_1'$	12343.7	105617	113717	5	7	0.022	0.071	14	−0.45	D	9n
109	$4p[\frac{5}{2}]-3d'[\frac{5}{2}]^\circ$	$2p_8-3s_1'''$	11078.9	105617	114641	5	5	0.0093	0.0172	3.13	−1.066	C	9n
110	$4p[\frac{3}{2}]-3d[\frac{3}{2}]^\circ$	$2p_7-3d_3$	16520.1	106087	112139	3	5	0.0029	0.020	3.3	−1.22	D	9n
111	$4p[\frac{3}{2}]-3d[\frac{3}{2}]^\circ$	$2p_7-3d_2$	12402.9	106087	114148	3	3	0.12	0.27	32	−0.09	D	9n
112	$4p[\frac{3}{2}]-3d[\frac{5}{2}]^\circ$	$2p_7-3d_1''$	13622.4	106087	113426	3	5	0.082	0.38	51	0.06	D−	9n
113	$4p[\frac{3}{2}]-3d'[\frac{3}{2}]^\circ$	$2p_7-3s_1''$	11467.5	106087	114805	3	5	0.00415	0.0136	1.54	−1.388	C	9n
114	$4p[\frac{3}{2}]-3d[\frac{7}{2}]^\circ$	$2p_6-3d_4$	14739.1	106238	113020	5	7	9.9×10^{-4}	0.0045	1.1	−1.65	D	9n
115	$4p[\frac{3}{2}]-3d[\frac{3}{2}]^\circ$	$2p_6-3d_3$	16940.4	106238	112139	5	5	0.028	0.12	34	−0.22	D	9n
116	$4p[\frac{3}{2}]-3d'[\frac{3}{2}]^\circ$	$2p_6-3s_1''$	11668.7	106238	114805	5	5	0.0423	0.086	16.6	−0.367	C	9n
117	$4p[\frac{3}{2}]-3d'[\frac{3}{2}]^\circ$	$2p_6-3s_1'$	10950.7	106238	115367	5	3	0.00445	0.00480	0.87	−1.62	C	9n

No.	Transition: *jl*-coupling	Transition: Paschen	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
118	$4p[\frac{1}{2}]-3d[\frac{3}{2}]^\circ$	$2p_5-3d_2$	14093.6	107054	114148	1	3	0.048	0.43	20	−0.37	D	9*n*
119	$4p[\frac{1}{2}]-3d'[\frac{3}{2}]^\circ$	$2p_5-3s'_1$	12026.6	107054	115367	1	3	0.0047	0.031	1.2	−1.51	D	9*n*
120	$4p'[\frac{3}{2}]-3d[\frac{1}{2}]^\circ$	$2p_4-3d_6$	22039.2	107132	111668	3	1	0.0014	0.0033	0.71	−2.00	D−	9*n*
121	$4p'[\frac{3}{2}]-3d[\frac{1}{2}]^\circ$	$2p_4-3d_5$	21332.2	107132	111818	3	3	3.6×10^{-4}	0.0025	0.52	−2.12	D−	9*n*
122	$4p'[\frac{3}{2}]-3d'[\frac{5}{2}]^\circ$	$2p_4-3s''''_1$	13313.4	107132	114641	3	5	0.15	0.65	85	0.29	D	9*n*
123	$4p'[\frac{3}{2}]-3d'[\frac{3}{2}]^\circ$	$2p_4-3s'_1$	12139.8	107132	115367	3	3	0.051	0.11	14	−0.48	D	9*n*
124	$4p'[\frac{3}{2}]-3d[\frac{1}{2}]^\circ$	$2p_3-3d_5$	22077.4	107290	111818	5	3	0.0016	0.0068	2.5	−1.47	D	9*n*
125	$4p'[\frac{3}{2}]-3d[\frac{3}{2}]^\circ$	$2p_3-3d_3$	20616.5	107290	112139	5	5	0.0044	0.028	9.6	−0.85	D−	9*n*
126	$4p'[\frac{3}{2}]-3d[\frac{5}{2}]^\circ$	$2p_3-3d'_1$	15555.5	107290	113717	5	7	1.1×10^{-4}	5.8×10^{-4}	0.15	−2.54	D−	9*n*
127	$4p'[\frac{3}{2}]-3d'[\frac{5}{2}]^\circ$	$2p_3-3s''''_1$	13599.2	107290	114641	5	5	0.025	0.070	16	−0.46	D−	9*n*
128	$4p'[\frac{3}{2}]-3d'[\frac{5}{2}]^\circ$	$2p_3-3s'''_1$	13273.1	107290	114822	5	7	0.17	0.61	130	0.48	D−	9*n*
129	$4p'[\frac{1}{2}]-3d[\frac{1}{2}]^\circ$	$2p_2-3d_6$	23967.5	107496	111668	3	1	0.0041	0.012	2.8	−1.44	D−	9*n*
130	$4p'[\frac{1}{2}]-3d[\frac{1}{2}]^\circ$	$2p_2-3d_5$	23133.4	107496	111818	3	3	0.0019	0.015	3.5	−1.35	D	9*n*
131	$4p'[\frac{1}{2}]-3d[\frac{3}{2}]^\circ$	$2p_2-3d_3$	21534.9	107496	112139	3	5	0.0012	0.013	2.9	−1.41	D	9*n*
132	$4p'[\frac{1}{2}]-3d'[\frac{3}{2}]^\circ$	$2p_2-3s''_1$	13678.5	107496	114805	3	5	0.070	0.33	44	−0.00	D−	9*n*
133	$4p'[\frac{1}{2}]-3d'[\frac{3}{2}]^\circ$	$2p_2-3s'_1$	12702.4	107496	115367	3	3	0.080	0.19	24	−0.24	D	9*n*
134	$4p'[\frac{1}{2}]-3d'[\frac{3}{2}]^\circ$	$2p_1-3s'_1$	15046.4	108723	115367	1	3	0.058	0.59	29	−0.23	D	9*n*
135	$4p[\frac{1}{2}]-4d[\frac{1}{2}]^\circ$	$2p_{10}-4d_6$	6937.67	104102	118512	3	1	0.0321	0.0077	0.53	−1.64	C	5*n*
136	$4p[\frac{1}{2}]-4d[\frac{1}{2}]^\circ$	$2p_{10}-4d_5$	6871.29	104102	118651	3	3	0.0290	0.0205	1.39	−1.211	C	5*n*
137	$4p[\frac{1}{2}]-4d[\frac{3}{2}]^\circ$	$2p_{10}-4d_3$	6752.84	104102	118907	3	5	0.0201	0.0229	1.53	−1.163	C	5*n*
138	$4p[\frac{1}{2}]-4d'[\frac{5}{2}]^\circ$	$2p_{10}-4s''''_1$	6052.73	104102	120619	3	5	0.0020	0.0018	0.11	−2.27	D+	5*n*
139	$4p[\frac{1}{2}]-4d'[\frac{3}{2}]^\circ$	$2p_{10}-4s''_1$	6059.37	104102	120601	3	5	0.00423	0.00388	0.232	−1.93	C	5*n*. 6*n*
140	$4p[\frac{1}{2}]-4d'[\frac{3}{2}]^\circ$	$2p_{10}-4s'_1$	5912.09	104102	121012	3	3	0.0105	0.0054	0.320	−1.79	C	5*n*. 6*n*
141	$4p[\frac{5}{2}]-4d[\frac{7}{2}]^\circ$	$2p_9-4d'_4$	7372.12	105436	119024	7	9	0.020	0.021	3.5	−0.84	D+	5*n*
142	$4p[\frac{5}{2}]-4d[\frac{7}{2}]^\circ$	$2p_9-4d_4$	7270.66	106436	119213	7	7	0.0011	8.4×10^{-4}	0.14	−2.23	D	5*n*
143	$4p[\frac{5}{2}]-4d[\frac{3}{2}]^\circ$	$2p_9-4d_3$	7436.25	105436	118907	7	5	0.0028	0.0016	0.28	−1.94	D	5*n*
144	$4p[\frac{5}{2}]-4d'[\frac{5}{2}]^\circ$	$2p_9-4s''''_1$	6596.12	105436	120619	7	5	2.4×10^{-4}	1.1×10^{-4}	0.017	−3.11	D	6*n*
145	$4p[\frac{5}{2}]-4d'[\frac{5}{2}]^\circ$	$2p_9-4s'''_1$	6538.11	105436	120754	7	7	0.0011	7.2×10^{-4}	0.11	−2.30	D+	5*n*
146	$4p[\frac{5}{2}]-4d'[\frac{3}{2}]^\circ$	$2p_9-4s''_1$	6604.02	105436	120601	7	5	0.0029	0.0013	0.20	−2.03	D+	5*n*
147	$4p[\frac{5}{2}]-4d[\frac{1}{2}]^\circ$	$2p_8-4d_5$	7670.04	105617	118651	5	3	0.0029	0.0015	0.19	−2.12	D	5*n*
148	$4p[\frac{5}{2}]-4d[\frac{7}{2}]^\circ$	$2p_8-4d_4$	7353.32	105617	119213	5	7	0.010	0.012	1.4	−1.24	D+	5*n*
149	$4p[\frac{5}{2}]-4d[\frac{5}{2}]^\circ$	$2p_8-4d'_1$	7229.93	105617	119445	5	5	6.9×10^{-4}	5.4×10^{-4}	0.064	−2.57	D	5*n*
150	$4p[\frac{5}{2}]-4d'[\frac{5}{2}]$	$2p_8-4s''''_1$	6664.05	105617	120619	5	5	0.0016	0.0011	0.12	−2.28	D+	5*n*
151	$4p[\frac{5}{2}]-4d'[\frac{5}{2}]^\circ$	$2p_8-4s'''_1$	6604.85	105617	120754	5	7	1.4×10^{-4}	1.3×10^{-4}	0.014	−3.19	D	5*n*
152	$4p[\frac{5}{2}]-4d'[\frac{3}{2}]^\circ$	$2p_8-4s'_1$	6493.97	105617	121012	5	3	3.1×10^{-4}	1.2×10^{-4}	0.013	−3.22	D	6*n*
153	$4p[\frac{3}{2}]-4d[\frac{1}{2}]^\circ$	$2p_7-4d_6$	8046.13	106087	118512	3	1	0.0117	0.00379	0.301	−1.94	C	5*n*
154	$4d[\frac{3}{2}]-4d[\frac{3}{2}]^\circ$	$2p_7-4d_3$	7798.55	106087	119807	3	5	9.1×10^{-4}	0.0014	0.11	−2.38	D+	5*n*
155	$4p[\frac{3}{2}]-4d[\frac{3}{2}]^\circ$	$2p_7-4d_2$	7265.17	106087	119848	3	3	0.0018	0.0015	0.10	−2.36	D	5*n*
156	$4p[\frac{3}{2}]-4d[\frac{5}{2}]^\circ$	$2p_7-4d'_1$	7484.24	106087	119445	3	5	0.0035	0.0049	0.37	−1.83	D+	5*n*
157	$4p[\frac{3}{2}]-4d'[\frac{5}{2}]^\circ$	$2p_7-4s''''_1$	6879.59	106087	120619	3	5	0.0019	0.0023	0.16	−2.16	D+	5*n*
158	$4p[\frac{3}{2}]-4d'[\frac{3}{2}]^\circ$	$2p_7-4s''_1$	6888.17	106087	120601	3	5	0.0026	0.0031	0.21	−2.04	D+	5*n*
159	$4p[\frac{3}{2}]-4d'[\frac{3}{2}]^\circ$	$2p_7-4s'_1$	6698.47	106087	121012	3	3	2.6×10^{-4}	1.7×10^{-4}	0.012	−3.29	D	5*n*
160	$4p[\frac{3}{2}]-4d[\frac{1}{2}]^\circ$	$2p_6-4d_5$	8053.31	106238	118651	5	3	0.0090	0.0053	0.70	−1.58	C	5*n*
161	$4p[\frac{3}{2}]-4d[\frac{7}{2}]^\circ$	$2p_6-4d_4$	7704.81	106238	119213	5	7	6.6×10^{-4}	8.2×10^{-4}	0.10	−2.39	D	5*n*
162	$4p[\frac{3}{2}]-4d[\frac{3}{2}]^\circ$	$2p_6-4d_3$	7891.08	106238	118907	5	5	0.0099	0.0092	1.20	−1.337	C	5*n*
163	$4p[\frac{3}{2}]-4d'[\frac{5}{2}]^\circ$	$2p_6-4s''''_1$	6951.46	106238	120619	5	5	0.0023	0.0016	0.19	−2.09	D	5*n*
164	$4p[\frac{3}{2}]-4d'[\frac{5}{2}]^\circ$	$2p_6-4s'''_1$	6887.10	106238	120754	5	7	0.0014	0.0014	0.16	−2.16	D+	5*n*
165	$4p[\frac{3}{2}]-4d'[\frac{3}{2}]^\circ$	$2p_6-4s''_1$	6960.23	106238	120601	5	5	0.0025	0.0018	0.21	−2.04	D	5*n*
166	$4p[\frac{3}{2}]-4d'[\frac{3}{2}]^\circ$	$2p_6-4s'_1$	6766.61	106238	121012	5	3	0.0042	0.0017	0.19	−2.07	D+	5*n*
167	$4p[\frac{1}{2}]-4d[\frac{1}{2}]^\circ$	$2p_5-4d_5$	8620.46	107054	118651	1	3	0.0096	0.0321	0.91	−1.493	C	5*n*
168	$4p[\frac{1}{2}]-4d'[\frac{3}{2}]^\circ$	$2p_5-4s'_1$	7162.57	107054	121012	1	3	6.0×10^{-4}	0.0014	0.033	−2.85	D	5*n*
169	$4p'[\frac{3}{2}]-4d[\frac{1}{2}]^\circ$	$2p_4-4d_6$	8784.61	107132	118512	3	1	0.0025	9.5×10^{-4}	0.082	−2.55	D	5*n*

No.	Transition: *jl*-coupling	Transition: Paschen	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
170	$4p'[\frac{3}{2}]-4d[\frac{3}{2}]^\circ$	$2p_4-4d_3$	8490.30	107132	118907	3	5	0.0010	0.0019	0.16	−2.25	D	5*n*
171	$4p'[\frac{3}{2}]-4d'[\frac{5}{2}]^\circ$	$2p_4-4s_1'''$	7412.33	107132	120619	3	5	0.0041	0.0057	0.42	−1.77	D+	5*n*
172	$4p'[\frac{3}{2}]-4d'[\frac{3}{2}]^\circ$	$2p_4-4s_1''$	7422.26	107132	120601	3	5	6.9×10^{-4}	9.5×10^{-4}	0.070	−2.55	D	5*n*
173	$4p'[\frac{3}{2}]-4d[\frac{1}{2}]^\circ$	$2p_3-4d_5$	8799.08	107290	118651	5	3	0.0048	0.0033	0.48	−1.78	D+	5*n*
174	$4p'[\frac{3}{2}]-4d[\frac{7}{2}]^\circ$	$2p_3-4d_4$	8384.73	107290	119213	5	7	0.0025	0.0036	0.50	−1.74	D	5*n*
175	$4p'[\frac{3}{2}]-4d[\frac{3}{2}]^\circ$	$2p_3-4d_3$	8605.78	107290	118907	5	5	0.0108	0.0120	1.70	−1.222	C	5*n*
176	$4p'[\frac{3}{2}]-4d'[\frac{5}{2}]^\circ$	$2p_3-4s_1'''$	7425.29	107290	120754	5	7	0.0032	0.0037	0.45	−1.73	D	5*n*
177	$4p'[\frac{3}{2}]-4d'[\frac{3}{2}]^\circ$	$2p_3-4s_1''$	7510.42	107290	120601	5	5	0.0047	0.0040	0.49	−1.70	D	6*n*
178	$4p'[\frac{3}{2}]-4d'[\frac{3}{2}]^\circ$	$2p_3-4s_1'$	7285.44	107290	121012	5	3	0.0013	6.0×10^{-4}	0.072	−2.52	D	5*n*
179	$4p'[\frac{1}{2}]-4d[\frac{1}{2}]^\circ$	$2p_2-4d_6$	9075.42	107496	118512	3	1	0.013	0.0051	0.46	−1.82	D	5*n*
180	$4p'[\frac{1}{2}]-4d[\frac{1}{2}]^\circ$	$2p_2-4d_5$	8962.19	107496	118651	3	3	0.0017	0.0020	0.18	−2.22	D+	5*n*
181	$4p'[\frac{1}{2}]-4d[\frac{3}{2}]^\circ$	$2p_2-4d_3$	8761.69	107496	118907	3	5	0.0099	0.019	1.6	−1.24	D+	5*n*
182	$4p'[\frac{1}{2}]-4d'[\frac{5}{2}]^\circ$	$2p_2-4s_1''''$	7618.33	107496	120619	3	5	0.0030	0.0044	0.33	−1.88	D	5*n*
183	$4p'[\frac{1}{2}]-4d'[\frac{3}{2}]^\circ$	$2p_2-4s_1''$	7628.86	107496	120601	3	5	0.0030	0.0044	0.33	−1.88	D	5*n*
184	$4p[\frac{1}{2}]-5s[\frac{3}{2}]^\circ$	$2p_{10}-2s_5$	10673.6	104102	113469	3	5	0.049	0.14	15	−0.38	D−	11
185	$4p[\frac{1}{2}]-5s[\frac{3}{2}]$	$2p_{10}-2s_4$	10478.0	104102	113643	3	3	0.0274	0.0451	4.67	−0.87	C	9*n*
186	$4p[\frac{1}{2}]-5s'[\frac{1}{2}]^\circ$	$2p_{10}-2s_3$	9291.53	104102	114862	3	1	0.0366	0.0158	1.45	−1.324	C	9*n*
187	$4p[\frac{1}{2}]-5s'[\frac{1}{2}]^\circ$	$2p_{10}-2s_2$	9194.64	104102	114975	3	3	0.0198	0.0251	2.28	−1.123	C	9*n*
188	$4p[\frac{5}{2}]-5s[\frac{3}{2}]^\circ$	$2p_9-2s_5$	12487.6	105463	113469	7	5	0.12	0.19	56	0.12	D−	9*n*
189	$4p[\frac{5}{2}]-5s[\frac{3}{2}]$	$2p_8-2s_5$	12733.6	105617	113469	5	5	0.012	0.030	6.3	−0.82	D	9*n*
190	$4p[\frac{5}{2}]-5s[\frac{3}{2}]^\circ$	$2p_8-2s_4$	12456.1	105617	113643	5	3	0.10	0.14	28	−0.15	D−	9*n*
191	$4p[\frac{5}{2}]-5s'[\frac{1}{2}]^\circ$	$2p_8-2s_2$	10683.4	105617	114975	5	3	0.0021	0.0022	0.39	−1.96	E	11
192	$4p[\frac{3}{2}]-5s[\frac{3}{2}]^\circ$	$2p_7-2s_5$	13543.8	106087	113469	3	5	0.0046	0.021	2.8	−1.20	E	11
193	$4p[\frac{3}{2}]-5s[\frac{3}{2}]^\circ$	$2p_7-2s_4$	13231.4	106087	113643	3	3	0.046	0.12	16	−0.44	D−	11
194	$4p[\frac{3}{2}]-5s'[\frac{1}{2}]^\circ$	$2p_7-2s_3$	11393.7	106087	114862	3	1	0.0249	0.0162	1.82	−1.313	C	9*n*
195	$4p[\frac{3}{2}]-5s'[\frac{1}{2}]^\circ$	$2p_7-2s_2$	11248.4	106087	114975	3	3	0.0028	0.0054	0.60	−1.79	E	11
196	$4p[\frac{3}{2}]-5s[\frac{3}{2}]$	$2p_6-2s_5$	13825.7	106238	113469	5	5	0.033	0.095	22	−0.32	D−	11
197	$4p[\frac{3}{2}]-5s[\frac{3}{2}]^\circ$	$2p_6-2s_4$	13499.2	106238	113643	5	3	0.027	0.045	10	−0.65	D−	11
198	$4p[\frac{3}{2}]-5s'[\frac{1}{2}]^\circ$	$2p_6-2s_2$	11441.8	106238	114975	5	3	0.0156	0.0184	3.46	−1.036	C	9*n*
199	$4p[\frac{1}{2}]-5s[\frac{3}{2}]^\circ$	$2p_5-2s_4$	15172.3	107054	113643	1	3	0.015	0.15	7.5	−0.82	D	9*n*
200	$4p[\frac{1}{2}]-5s'[\frac{1}{2}]^\circ$	$2p_5-2s_2$	12621.8	107054	114975	1	3	0.0038	0.027	1.1	−1.57	E	11
201	$4p'[\frac{3}{2}]-5s[\frac{3}{2}]^\circ$	$2p_4-2s_5$	15776.6	107132	113469	3	5	5.9×10^{-4}	0.0037	0.58	−1.95	E	11
202	$4p'[\frac{3}{2}]-5s[\frac{3}{2}]^\circ$	$2p_4-2s_4$	15353.5	107132	113643	3	3	0.0045	0.016	2.4	−1.32	E	11
203	$4p'[\frac{3}{2}]-5s'[\frac{1}{2}]^\circ$	$2p_4-2s_3$	12933.3	107132	114862	3	1	0.11	0.091	12	−0.56	D	9*n*
204	$4p'[\frac{3}{2}]-5s'[\frac{1}{2}]^\circ$	$2p_4-2s_2$	12746.3	107132	114975	3	3	0.022	0.053	6.7	−0.80	D	9*n*
205	$4p'[\frac{3}{2}]-5s[\frac{3}{2}]^\circ$	$2p_3-2s_5$	16180.0	107290	113469	5	5	0.0014	0.0055	1.5	−1.56	D	9*n*
206	$3p'[\frac{3}{2}]-5s[\frac{3}{2}]^\circ$	$2p_3-2s_4$	15734.9	107290	113643	5	3	3.3×10^{-4}	7.3×10^{-4}	0.19	−2.44	D−	9*n*
207	$4p'[\frac{3}{2}]-5s'[\frac{1}{2}]^\circ$	$2p_3-2s_2$	13008.5	107290	114975	5	3	0.10	0.15	33	−0.12	D	9*n*
208	$4p'[\frac{1}{2}]-5s[\frac{3}{2}]^\circ$	$2p_2-2s_5$	16739.8	107496	113469	3	5	0.0035	0.024	4.0	−1.14	D−	9*n*
209	$4p'[\frac{1}{2}]-5s[\frac{3}{2}]^\circ$	$2p_2-2s_4$	16264.1	107496	113643	3	3	3.4×10^{-4}	0.0013	0.22	−2.41	D−	9*n*
210	$4p'[\frac{1}{2}]-5s'[\frac{1}{2}]^\circ$	$2p_2-2s_3$	13573.6	107496	114862	3	1	0.051	0.047	6.3	−0.85	D−	11
211	$4p'[\frac{1}{2}]-5s'[\frac{1}{2}]^\circ$	$2p_2-2s_2$	13367.1	107496	114975	3	3	0.034	0.090	12	−0.57	D−	11
212	$4p'[\frac{1}{2}]-5s[\frac{3}{2}]^\circ$	$2p_1-2s_4$	20317.0	108723	113643	1	3	0.0018	0.033	2.2	−1.48	D	9*n*
213	$4p'[\frac{1}{2}]-5s'[\frac{1}{2}]^\circ$	$2p_1-2s_2$	15989.3	108723	114975	1	3	0.021	0.24	12	−0.62	D−	9*n*
214	$4p[\frac{1}{2}]-5d[\frac{1}{2}]^\circ$	$2p_{10}-5d_6$	5650.70	104102	121794	3	1	0.0333	0.0053	0.297	−1.80	C	5*n*
215	$4p[\frac{1}{2}]-5d[\frac{1}{2}]^\circ$	$2p_{10}-5d_5$	5606.73	104102	121933	3	3	0.0229	0.0108	0.60	−1.489	C	5*n*
216	$4p[\frac{1}{2}]-5d[\frac{3}{2}]^\circ$	$2p_{10}-5d_3$	5558.70	104102	122087	3	5	0.0148	0.0114	0.63	−1.466	C	5*n*
217	$4p[\frac{1}{2}]-5d'[\frac{5}{2}]^\circ$	$2p_{10}-5s_1''''$	5152.30	104102	123506	3	5	0.0011	7.2×10^{-4}	0.037	−2.67	D	5*n*
218	$4p[\frac{1}{2}]-5d'[\frac{3}{2}]^\circ$	$2p_{10}-5s_1''$	5187.75	104102	123373	3	5	0.0138	0.0092	0.476	−1.55	C	5*n*, 6*n*
219	$4p[\frac{5}{2}]-5d[\frac{7}{2}]^\circ$	$2p_9-5d_4'$	6032.13	105463	122036	7	9	0.0246	0.0173	2.40	−0.91	C	5*n*, 6*n*
220	$4p[\frac{5}{2}]-5d[\frac{7}{2}]^\circ$	$2p_9-5d_4$	5987.30	105463	122160	7	7	0.0013	6.9×10^{-4}	0.095	−2.32	D	5*n*
221	$4p[\frac{5}{2}]-5d[\frac{3}{2}]^\circ$	$2p_9-5d_3$	6013.68	105463	122087	7	5	0.0015	5.7×10^{-4}	0.078	−2.40	D+	5*n*
222	$4p[\frac{5}{2}]-5d[\frac{5}{2}]^\circ$	$2p_9-5d_1''$	5943.89	105463	122282	7	5	3.8×10^{-4}	1.4×10^{-4}	0.020	−3.01	D−	5*n*
223	$4p[\frac{5}{2}]-5d[\frac{5}{2}]^\circ$	$2p_9-5d_1'$	5927.11	105463	122330	7	7	3.9×10^{-4}	2.1×10^{-4}	0.028	−2.83	D+	5*n*

No.	Transition: *jl*-coupling	Transition: Paschen	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log *gf*	Accuracy	Source
224	$4p[\frac{5}{2}]-5d'[\frac{5}{2}]^\circ$	$2p_9-5s_1''''$	5540.87	105463	123506	7	5	4.3×10^{-4}	1.4×10^{-4}	0.018	−3.01	D	5*n*
225	$4p[\frac{5}{2}]-5d'[\frac{5}{2}]^\circ$	$2p_9-5s_1'''$	5524.96	105463	123557	7	7	0.0018	8.1×10^{-4}	0.10	−2.25	D+	5*n*
226	$4p[\frac{5}{2}]-5d'[\frac{3}{2}]^\circ$	$2p_9-5s_1''$	5581.87	105463	123373	7	5	5.8×10^{-4}	1.9×10^{-4}	0.025	−2.88	D+	5*n*
227	$4p[\frac{5}{2}]-5d[\frac{1}{2}]^\circ$	$2p_8-5d_5$	6127.42	105617	121933	5	3	0.0011	3.9×10^{-4}	0.039	−2.72	D+	5*n*
228	$4p[\frac{5}{2}]-5d[\frac{7}{2}]^\circ$	$2p_8-5d_4$	6043.22	105617	122160	5	7	0.0153	0.0117	1.17	−1.233	C	5*n*
229	$4p[\frac{5}{2}]-5d[\frac{3}{2}]^\circ$	$2p_8-5d_2$	5916.58	105617	122514	5	3	6.1×10^{-4}	1.9×10^{-4}	0.019	−3.02	D	5*n*
230	$4p[\frac{5}{2}]-5d[\frac{5}{2}]^\circ$	$2p_8-5d_1''$	5999.00	105617	122282	5	5	0.0015	8.1×10^{-4}	0.080	−2.39	D	5*n*
231	$4p[\frac{5}{2}]-5d[\frac{5}{2}]^\circ$	$2p_8-5d_1'$	5981.90	105617	122330	5	7	1.3×10^{-4}	9.8×10^{-5}	0.0096	−3.31	D−	5*n*
232	$4p[\frac{5}{2}]-5d'[\frac{5}{2}]^\circ$	$2p_8-5s_1''''$	5588.72	105617	123506	5	5	0.0016	7.3×10^{-4}	0.067	−2.44	D+	5*n*
233	$4p[\frac{5}{2}]-5d'[\frac{5}{2}]^\circ$	$2p_8-5s_1'''$	5572.54	105617	123557	5	7	0.0069	0.00450	0.413	−1.65	C	5*n*
234	$4p[\frac{3}{2}]-5d[\frac{1}{2}]^\circ$	$2p_7-5d_6$	6364.89	106087	121794	3	1	0.0058	0.0012	0.074	−2.46	D+	5*n*
235	$4p[\frac{3}{2}]-5d[\frac{1}{2}]^\circ$	$2p_7-5d_5$	6309.14	106087	121933	3	3	7.9×10^{-4}	4.7×10^{-4}	0.029	−2.85	D	5*n*
236	$4p[\frac{3}{2}]-5d[\frac{3}{2}]^\circ$	$2p_7-5d_3$	6248.41	106087	122087	3	5	7.1×10^{-4}	6.9×10^{-4}	0.043	−2.68	D	5*n*
237	$4p[\frac{3}{2}]-5d[\frac{3}{2}]^\circ$	$2p_7-5d_2$	6085.86	106087	122514	3	3	9.4×10^{-5}	5.2×10^{-5}	0.0031	−3.81	D	6*n*
238	$4p[\frac{3}{2}]-5d[\frac{5}{2}]^\circ$	$2p_7-5d_1''$	6173.10	106087	122282	3	5	0.0070	0.0067	0.406	−1.70	C	5*n*
239	$4p[\frac{3}{2}]-5d'[\frac{5}{2}]^\circ$	$2p_7-5s_1''''$	5739.52	106087	123506	3	5	0.0091	0.0075	0.43	−1.65	D	5*n*
240	$4p[\frac{3}{2}]-5d'[\frac{3}{2}]^\circ$	$2p_7-5s_1''$	5783.54	106087	123373	3	5	8.4×10^{-4}	7.0×10^{-4}	0.040	−2.68	D−	5*n*
241	$4p[\frac{3}{2}]-5d[\frac{1}{2}]^\circ$	$2p_6-5d_5$	6369.58	106238	121933	5	3	0.0044	0.0016	0.17	−2.10	D+	5*n*
242	$4p[\frac{3}{2}]-5d[\frac{7}{2}]^\circ$	$2p_6-5d_4$	6278.65	106238	122160	5	7	2.1×10^{-4}	1.7×10^{-4}	0.018	−3.07	D	5*n*
243	$4p[\frac{3}{2}]-5d[\frac{3}{2}]^\circ$	$2p_6-5d_3$	6307.66	106238	122087	5	5	0.0063	0.0038	0.39	−1.73	D+	5*n*
244	$4p[\frac{3}{2}]-5d[\frac{5}{2}]^\circ$	$2p_6-5d_1''$	6230.93	106238	122282	5	5	1.3×10^{-4}	7.6×10^{-5}	0.0078	−3.42	D	6*n*
245	$4p[\frac{3}{2}]-5d[\frac{5}{2}]^\circ$	$2p_6-5d_1'$	6212.50	106238	122330	5	7	0.0041	0.0033	0.34	−1.78	D+	5*n*
246	$4p[\frac{3}{2}]-5d'[\frac{5}{2}]^\circ$	$2p_6-5s_1''''$	5789.48	106238	123506	5	5	4.8×10^{-4}	2.4×10^{-4}	0.023	−2.92	D	5*n*
247	$4p[\frac{3}{2}]-5d'[\frac{5}{2}]^\circ$	$2p_6-5s_1'''$	5772.11	106238	123557	5	7	0.0021	0.0015	0.14	−2.14	D	5*n*
248	$4p[\frac{3}{2}]-5d'[\frac{3}{2}]^\circ$	$2p_6-5s_1''$	5834.26	106238	123373	5	5	0.0052	0.00268	0.257	−1.88	C	5*n*, 6*n*
249	$4p[\frac{1}{2}]-5d[\frac{1}{2}]^\circ$	$2p_5-5d_5$	6719.22	107054	121933	1	3	0.0025	0.0051	0.11	−2.29	D	5*n*
250	$4p[\frac{1}{2}]-5d[\frac{3}{2}]^\circ$	$2p_5-5d_2$	6466.55	107054	122514	1	3	0.0016	0.0029	0.062	−2.53	D	5*n*
251	$4p[\frac{1}{2}]-5d'[\frac{3}{2}]^\circ$	$2p_5-5s_1'$	5964.48	107054	123816	1	3	8.0×10^{-4}	0.0013	0.025	−2.89	D	5*n*
252	$4p'[\frac{3}{2}]-5d[\frac{1}{2}]^\circ$	$2p_4-5d_6$	6818.29	107132	121794	3	1	0.0021	4.9×10^{-4}	0.033	−2.83	D	5*n*
253	$4p'[\frac{3}{2}]-5d[\frac{1}{2}]^\circ$	$2p_4-5d_5$	6754.37	107132	121933	3	3	0.0022	0.0015	0.10	−2.35	D	5*n*
254	$4p'[\frac{3}{2}]-5d[\frac{3}{2}]^\circ$	$2p_4-5d_3$	6684.73	107132	122087	3	5	4.1×10^{-4}	4.6×10^{-4}	0.030	−2.86	D	5*n*
255	$4p'[\frac{3}{2}]-5d'[\frac{5}{2}]^\circ$	$2p_4-5s_1''''$	6105.64	107132	123506	3	5	0.0126	0.0117	0.71	−1.455	C	5*n*
256	$4p'[\frac{3}{2}]-5d[\frac{1}{2}]^\circ$	$2p_3-5d_5$	6827.25	107290	121933	5	3	0.0025	0.0011	0.12	−2.28	D	5*n*
257	$4p'[\frac{3}{2}]-5d[\frac{7}{2}]^\circ$	$2p_3-5d_4$	6722.88	107290	122160	5	7	3.3×10^{-4}	3.1×10^{-4}	0.035	−2.81	D	5*n*
258	$4p'[\frac{3}{2}]-5d[\frac{3}{2}]^\circ$	$2p_3-5d_3$	6756.10	107290	122087	5	5	0.0038	0.0026	0.29	−1.88	D+	5*n*
259	$4p'[\frac{3}{2}]-5d'[\frac{5}{2}]^\circ$	$2p_3-5s_1''''$	6165.12	107290	123506	5	5	0.00103	5.9×10^{-4}	0.060	−2.53	C	5*n*
260	$4p'[\frac{3}{2}]-5d'[\frac{5}{2}]^\circ$	$2p_3-5s_1'''$	6145.44	107290	123557	5	7	0.0079	0.0063	0.63	−1.50	C	5*n*
261	$4p'[\frac{3}{2}]-5d'[\frac{3}{2}]^\circ$	$2p_3-5s_1''$	6215.94	107290	123373	5	5	0.0059	0.0034	0.35	−1.77	D+	5*n*
262	$4p'[\frac{1}{2}]-5d[\frac{1}{2}]^\circ$	$2p_2-5d_6$	6992.17	107496	121794	3	1	0.0078	0.0019	0.13	−2.24	D+	5*n*
263	$4p'[\frac{1}{2}]-5d[\frac{1}{2}]^\circ$	$2p_2-5d_5$	6925.01	107496	121933	3	3	0.0012	8.9×10^{-4}	0.061	−2.57	D+	5*n*
264	$4p'[\frac{1}{2}]-5d[\frac{3}{2}]^\circ$	$2p_2-5d_3$	6851.88	107496	122087	3	5	7.0×10^{-4}	8.2×10^{-4}	0.056	−2.61	D	5*n*
265	$4p'[\frac{1}{2}]-5d[\frac{3}{2}]^\circ$	$2p_2-5d_2$	6656.88	107496	122514	3	3	3.2×10^{-4}	2.1×10^{-4}	0.014	−3.20	D	6*n*
266	$4p'[\frac{1}{2}]-5d'[\frac{5}{2}]^\circ$	$2p_2-5s_1''''$	6244.73	107496	123506	3	5	2.1×10^{-4}	2.0×10^{-4}	0.013	−3.22	D	5*n*
267	$4p'[\frac{1}{2}]-5d'[\frac{3}{2}]^\circ$	$2p_2-5s_1''$	6296.87	107496	123373	3	5	0.0094	0.0093	0.58	−1.55	D+	5*n*
268	$4p[\frac{1}{2}]-6s[\frac{3}{2}]^\circ$	$2p_{10}-3s_5$	6416.31	104102	119683	3	5	0.0121	0.0124	0.79	−1.429	C	5*n*
269	$4p[\frac{1}{2}]-6s[\frac{3}{2}]^\circ$	$2p_{10}-3s_4$	6384.72	104102	119760	3	3	0.00439	0.00268	0.169	−2.095	C	5*n*
270	$4p[\frac{1}{2}]-6s'[\frac{1}{2}]^\circ$	$2p_{10}-3s_3$	5882.62	104102	121097	3	1	0.0128	0.00221	0.129	−2.178	C	5*n*
271	$4p[\frac{1}{2}]-6s'[\frac{1}{2}]^\circ$	$2p_{10}-3s_2$	5860.31	104102	121161	3	3	0.00285	0.00147	0.085	−2.357	C	5*n*, 6*n*
272	$4p[\frac{5}{2}]-6s[\frac{3}{2}]^\circ$	$2p_9-3s_5$	7030.25	105463	119683	7	5	0.0278	0.0147	2.38	−0.99	C	5*n*
273	$4p[\frac{5}{2}]-6s[\frac{3}{2}]^\circ$	$2p_8-3s_5$	7107.48	105617	119683	5	5	0.0047	0.0035	0.41	−1.75	D+	5*n*
274	$4p[\frac{5}{2}]-6s[\frac{3}{2}]^\circ$	$2p_8-3s_4$	7068.73	105617	119760	5	3	0.021	0.0094	1.09	−1.33	D+	5*n*
275	$4p[\frac{5}{2}]-6s'[\frac{1}{2}]^\circ$	$2p_8-3s_2$	6431.56	105617	121161	5	3	5.3×10^{-4}	2.0×10^{-4}	0.021	−3.00	D	5*n*
276	$4p[\frac{3}{2}]-6s[\frac{3}{2}]^\circ$	$2p_7-3s_5$	7353.18	106087	119683	3	5	0.0021	0.0028	0.21	−2.08	E	7
277	$4p[\frac{3}{2}]-6s[\frac{3}{2}]^\circ$	$2p_7-3s_4$	7311.72	106087	119760	3	3	0.018	0.014	1.0	−1.37	D+	5*n*

No.	Transition: *jl*-coupling	Transition: Paschen	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
278	$4p[\frac{3}{2}]-6s'[\frac{1}{2}]^\circ$	$2p_7-3s_3$	6660.68	106087	121097	3	1	0.0081	0.0018	0.12	−2.27	D	5*n*
279	$4p[\frac{3}{2}]-6s'[\frac{1}{2}]^\circ$	$2p_7-3s_2$	6632.09	106087	121161	3	3	5.5×10^{-4}	3.6×10^{-4}	0.024	−2.97	D	5*n*
280	$4p[\frac{3}{2}]-6s[\frac{3}{2}]^\circ$	$2p_6-3s_5$	7435.33	106238	119683	5	5	0.0094	0.0078	0.95	−1.41	D+	5*n*
281	$4p[\frac{3}{2}]-6s[\frac{3}{2}]^\circ$	$2p_6-3s_4$	7392.97	106238	119760	5	3	0.0075	0.0037	0.45	−1.73	D+	5*n*
282	$4p[\frac{3}{2}]-6s'[\frac{1}{2}]^\circ$	$2p_6-3s_2$	6698.88	106238	121161	5	3	0.0017	6.8×10^{-4}	0.075	−2.47	D+	5*n*
283	$4p[\frac{1}{2}]-6s[\frac{3}{2}]^\circ$	$2p_5-3s_4$	7868.20	107054	119760	1	3	0.00365	0.0102	0.263	−1.99	C	5*n*
284	$4p[\frac{1}{2}]-6s'[\frac{1}{2}]^\circ$	$2p_5-3s_2$	7086.70	107054	121161	1	3	0.0016	0.0036	0.083	−2.45	D+	5*n*
285	$4p'[\frac{3}{2}]-6s[\frac{3}{2}]^\circ$	$2p_4-3s_5$	7965.08	107132	119683	3	5	3.4×10^{-4}	5.4×10^{-4}	0.042	−2.79	E	7
286	$4p'[\frac{3}{2}]-6s[\frac{3}{2}]^\circ$	$2p_4-3s_4$	7916.45	107132	119760	3	3	0.0013	0.0012	0.093	−2.45	D+	5*n*
287	$4p'[\frac{3}{2}]-6s'[\frac{1}{2}]^\circ$	$2p_4-3s_3$	7158.83	107132	121097	3	1	0.022	0.0055	0.39	−1.78	D+	5*n*
288	$4p'[\frac{3}{2}]-6s'[\frac{1}{2}]^\circ$	$2p_4-3s_2$	7125.83	107132	121161	3	3	0.0063	0.0048	0.34	−1.84	D+	5*n*
289	$4p'[\frac{3}{2}]-6s[\frac{3}{2}]^\circ$	$2p_3-3s_5$	8066.60	107290	119683	5	5	0.0015	0.0015	0.20	−2.13	D+	5*n*
290	$4p'[\frac{3}{2}]-6s[\frac{3}{2}]^\circ$	$2p_3-3s_4$	8016.74	107290	119760	5	3	4.2×10^{-5}	2.4×10^{-5}	0.0032	−3.92	E	7
291	$4p'[\frac{3}{2}]-6s'[\frac{1}{2}]^\circ$	$2p_3-3s_2$	7206.98	107290	121161	5	3	0.0258	0.0121	1.43	−1.218	C	5*n*
292	$4p'[\frac{1}{2}]-6s[\frac{3}{2}]^\circ$	$2p_2-3s_5$	8203.42	107496	119683	3	5	0.0016	0.0027	0.22	−2.09	E	7
293	$4p'[\frac{1}{2}]-6s[\frac{3}{2}]^\circ$	$2p_2-3s_4$	8151.86	107496	119760	3	3	3.3×10^{-4}	3.3×10^{-4}	0.026	−3.00	E	7
294	$4p'[\frac{1}{2}]-6s'[\frac{1}{2}]^\circ$	$2p_2-3s_3$	7350.78	107496	121097	3	1	0.012	0.0032	0.23	−2.02	D+	5*n*
295	$4p'[\frac{1}{2}]-6s'[\frac{1}{2}]^\circ$	$2p_2-3s_2$	7316.01	107496	121161	3	3	0.010	0.0080	0.58	−1.62	D+	5*n*
296	$4p'[\frac{1}{2}]-6s[\frac{3}{2}]^\circ$	$2p_1-3s_4$	9057.51	108723	119760	1	3	9.7×10^{-4}	0.0036	0.11	−2.44	E	7
297	$4p'[\frac{1}{2}]-6s'[\frac{1}{2}]^\circ$	$2p_1-3s_2$	8037.23	108723	121161	1	3	0.00374	0.0109	0.288	−1.96	C	5*n*
298	$4p[\frac{1}{2}]-6d[\frac{1}{2}]^\circ$	$2p_{10}-6d_6$	5151.39	104102	123509	3	1	0.0249	0.00330	0.168	−2.004	C	5*n*
299	$4p[\frac{1}{2}]-6d[\frac{1}{2}]^\circ$	$2p_{10}-6d_5$	5162.29	104102	123468	3	3	0.0198	0.0079	0.403	−1.63	C	5*n*
300	$4p[\frac{1}{2}]-6d[\frac{3}{2}]^\circ$	$2p_{10}-6d_3$	5073.08	104102	123809	3	5	6.1×10^{-4}	3.9×10^{-4}	0.020	−2.93	D	6*n*
301	$4p[\frac{1}{2}]-6d'[\frac{3}{2}]^\circ$	$2p_{10}-6s_1''$	4768.68	104102	125067	3	5	0.0090	0.0051	0.24	−1.82	D	5*n*
302	$4p[\frac{5}{2}]-6d[\frac{7}{2}]^\circ$	$2p_9-6d_4'$	5495.87	105463	123653	7	9	0.0176	0.0102	1.30	−1.46	C	5*n*
303	$4p[\frac{5}{2}]-6d[\frac{7}{2}]^\circ$	$2p_9-6d_4$	5459.65	105463	123774	7	7	4.0×10^{-4}	1.8×10^{-4}	0.022	−2.90	D	5*n*
304	$4p[\frac{5}{2}]-6d[\frac{5}{2}]^\circ$	$2p_9-6d_1'$	5442.24	105463	123833	7	7	9.7×10^{-4}	4.3×10^{-4}	0.054	−2.52	D	6*n*
305	$4p[\frac{5}{2}]-6d'[\frac{5}{2}]^\circ$	$2p_9-6s_1'''$	5078.03	105463	125150	7	7	4.9×10^{-4}	1.9×10^{-4}	0.022	−2.88	E	6*n*
306	$4p[\frac{5}{2}]-6d[\frac{7}{2}]^\circ$	$2p_8-6d_4$	5506.11	105617	123774	5	7	0.0037	0.0023	0.21	−1.93	D+	5*n*
307	$4p[\frac{5}{2}]-6d[\frac{5}{2}]^\circ$	$2p_8-6d_1''$	5490.12	105617	123827	5	5	8.9×10^{-4}	4.0×10^{-4}	0.036	−2.70	D	6*n*
308	$4p[\frac{5}{2}]-6d'[\frac{5}{2}]^\circ$	$2p_8-6s_1''''$	5127.80	105617	125113	5	5	3.4×10^{-4}	1.3×10^{-4}	0.011	−3.19	D	5*n*
309	$4p[\frac{5}{2}]-6d'[\frac{5}{2}]^\circ$	$2p_8-6s_1'''$	5118.21	105617	125150	5	7	0.0028	0.0015	0.13	−2.11	D+	5*n*
310	$4p[\frac{3}{2}]-6d[\frac{3}{2}]^\circ$	$2p_7-6d_3$	5641.39	106087	123809	3	5	9.1×10^{-4}	7.2×10^{-4}	0.040	−2.67	D	6*n*
311	$4p[\frac{3}{2}]-6d[\frac{5}{2}]^\circ$	$2p_7-6d_1''$	5635.58	106087	123827	3	5	0.0010	7.9×10^{-4}	0.044	−2.63	D	6*n*
312	$4p[\frac{3}{2}]-6d'[\frac{5}{2}]^\circ$	$2p_7-6s_1''''$	5254.47	106087	125113	3	5	0.0038	0.0026	0.14	−2.11	E	6*n*
313	$4p[\frac{3}{2}]-6d[\frac{1}{2}]^\circ$	$2p_6-6d_5$	5802.08	106238	123468	5	3	0.0044	0.0013	0.13	−2.18	D	5*n*
314	$4p[\frac{3}{2}]-6d[\frac{7}{2}]^\circ$	$2p_6-6d_4$	5700.87	106238	123774	5	7	0.0061	0.0042	0.39	−1.68	D	5*n*
315	$4p[\frac{3}{2}]-6d[\frac{5}{2}]^\circ$	$2p_6-6d_1''$	5683.73	106238	123827	5	5	0.0021	0.0010	0.097	−2.29	D	5*n*
316	$4p[\frac{3}{2}]-6d[\frac{5}{2}]^\circ$	$2p_6-6d_1'$	5681.90	106238	123833	5	7	0.0021	0.0014	0.13	−2.15	D	5*n*
317	$4p[\frac{3}{2}]-6d'[\frac{5}{2}]^\circ$	$2p_6-6s_1'''$	5286.07	106238	125150	5	7	0.0010	5.9×10^{-4}	0.051	−2.53	E	6*n*
318	$4p[\frac{3}{2}]-6d'[\frac{3}{2}]^\circ$	$2p_6-6s_1''$	5309.52	106238	125067	5	5	0.0012	4.9×10^{-4}	0.043	−2.61	E	6*n*
319	$4p[\frac{1}{2}]-6d[\frac{1}{2}]^\circ$	$2p_5-6d_5$	6090.79	107054	123468	1	3	0.0031	0.0052	0.10	−2.28	D	5*n*
320	$4p'[\frac{3}{2}]-6d[\frac{1}{2}]^\circ$	$2p_4-6d_5$	6119.66	107132	123468	3	3	5.3×10^{-4}	3.0×10^{-4}	0.018	−3.05	D+	5*n*
321	$4p'[\frac{3}{2}]-6d[\frac{3}{2}]^\circ$	$2p_4-6d_3$	5994.66	107132	123809	3	5	2.7×10^{-4}	2.4×10^{-4}	0.014	−3.14	D	6*n*
322	$4p'[\frac{3}{2}]-6d[\frac{5}{2}]^\circ$	$2p_4-6d_1''$	5988.13	107132	123827	3	5	6.4×10^{-4}	5.7×10^{-4}	0.034	−2.77	D−	5*n*
323	$4p'[\frac{3}{2}]-6d'[\frac{5}{2}]^\circ$	$2p_4-6s_1''''$	5559.66	107132	125113	3	5	0.0023	0.0018	0.099	−2.27	D+	5*n*
324	$4p'[\frac{3}{2}]-6d'[\frac{3}{2}]^\circ$	$2p_4-6s_1''$	5574.22	107132	125067	3	5	4.8×10^{-4}	3.7×10^{-4}	0.021	−2.95	D	5*n*
325	$4p'[\frac{3}{2}]-6d[\frac{1}{2}]^\circ$	$2p_3-6d_5$	6179.41	107290	123468	5	3	6.9×10^{-4}	2.4×10^{-4}	0.024	−2.92	D	5*n*
326	$4p'[\frac{3}{2}]-6d[\frac{7}{2}]^\circ$	$2p_3-6d_4$	6064.76	107290	123774	5	7	6.0×10^{-4}	4.6×10^{-4}	0.046	−2.64	D	5*n*
327	$4p'[\frac{3}{2}]-6d'[\frac{5}{2}]^\circ$	$2p_3-6s_1'''$	5597.48	107290	125150	5	7	0.0044	0.0029	0.27	−1.84	E	6*n*
328	$4p'[\frac{3}{2}]-6d'[\frac{3}{2}]^\circ$	$2p_3-6s_1''$	5623.78	107290	125067	5	5	0.0015	7.1×10^{-4}	0.066	−2.45	D−	5*n*
329	$4p'[\frac{1}{2}]-6d[\frac{1}{2}]^\circ$	$2p_2-6d_6$	6243.40	107496	123509	3	1	0.0014	2.6×10^{-4}	0.016	−3.10	D	5*n*
330	$4p'[\frac{1}{2}]-6d[\frac{3}{2}]^\circ$	$2p_2-6d_3$	6128.73	107496	123809	3	5	9.0×10^{-4}	8.4×10^{-4}	0.051	−2.60	D	6*n*
331	$4p'[\frac{1}{2}]-6d[\frac{5}{2}]^\circ$	$2p_2-6d_1''$	6121.86	107496	123827	3	5	1.4×10^{-4}	1.3×10^{-4}	0.0079	−3.41	D	6*n*
332	$4p'[\frac{1}{2}]-6d[\frac{1}{2}]^\circ$	$2p_1-6d_5$	6779.93	108723	123468	1	3	0.00126	0.00261	0.058	−2.58	C	6*n*

No.	Transition: *jl*-coupling	Transition: Paschen	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
333	$4p[\frac{1}{2}]-7s[\frac{3}{2}]^\circ$	$2p_{10}-4s_5$	5451.65	104102	122440	3	5	0.0049	0.0036	0.20	−1.96	D+	5*n*
334	$4p[\frac{1}{2}]-7s[\frac{3}{2}]^\circ$	$2p_{10}-4s_4$	5439.99	104102	122479	3	3	0.0020	8.7×10^{-4}	0.047	−2.58	D+	5*n*
335	$4p[\frac{1}{2}]-7s'[\frac{1}{2}]^\circ$	$2p_{10}-4s_3$	5056.53	104102	123873	3	1	0.0059	7.5×10^{-4}	0.038	−2.65	D	5*n*
336	$4p[\frac{1}{2}]-7s'[\frac{1}{2}]^\circ$	$2p_{10}-4s_2$	5054.18	104102	123882	3	3	0.0047	0.0018	0.089	−2.27	D	5*n*
337	$4p[\frac{5}{2}]-7s[\frac{3}{2}]^\circ$	$2p_9-4s_5$	5888.58	105463	122440	7	5	0.0134	0.00498	0.68	−1.458	C	5*n*
338	$4p[\frac{5}{2}]-7s[\frac{3}{2}]^\circ$	$2p_8-4s_5$	5942.67	105617	122440	5	5	0.0019	9.8×10^{-4}	0.096	−2.31	D	5*n*
339	$4p[\frac{5}{2}]-7s[\frac{3}{2}]^\circ$	$2p_8-4s_4$	5928.81	105617	122479	5	3	0.011	0.0034	0.33	−1.77	D+	5*n*
340	$4p[\frac{5}{2}]-7s'[\frac{1}{2}]^\circ$	$2p_8-4s_2$	5473.46	105617	123882	5	3	0.0021	5.7×10^{-4}	0.052	−2.55	D	5*n*
341	$4p[\frac{3}{2}]-7s[\frac{3}{2}]^\circ$	$2p_7-4s_5$	6113.46	106087	122440	3	5	4.9×10^{-4}	4.6×10^{-4}	0.028	−2.86	D+	5*n*
342	$4p[\frac{3}{2}]-7s[\frac{3}{2}]^\circ$	$2p_7-4s_4$	6098.81	106087	122479	3	3	0.0054	0.0030	0.18	−2.05	D+	5*n*
343	$4p[\frac{3}{2}]-7s'[\frac{1}{2}]^\circ$	$2p_7-4s_3$	5620.92	106087	123873	3	1	0.0038	6.0×10^{-4}	0.033	−2.74	D	5*n*
344	$4p[\frac{3}{2}]-7s'[\frac{1}{2}]^\circ$	$2p_7-4s_2$	5618.01	106087	123882	3	3	0.0022	0.0010	0.057	−2.51	D	5*n*
345	$4p[\frac{3}{2}]-7s[\frac{3}{2}]^\circ$	$2p_6-4s_5$	6170.17	106238	122440	5	5	0.0052	0.00297	0.301	−1.83	C	5*n*
346	$4p[\frac{3}{2}]-7s[\frac{3}{2}]^\circ$	$2p_6-4s_4$	6155.24	106238	122479	5	3	0.0053	0.0018	0.18	−2.04	D	5*n*
347	$4p[\frac{1}{2}]-7s[\frac{3}{2}]^\circ$	$2p_5-4s_4$	6481.14	107054	122479	1	3	9.8×10^{-4}	0.0019	0.040	−2.72	D	5*n*
348	$4p[\frac{1}{2}]-7s'[\frac{1}{2}]^\circ$	$2p_5-4s_2$	5940.86	107054	123882	1	3	0.0012	0.0019	0.037	−2.72	D	5*n*
349	$4p'[\frac{3}{2}]-7s[\frac{3}{2}]^\circ$	$2p_4-4s_4$	6513.85	107132	122479	3	3	5.6×10^{-4}	3.6×10^{-4}	0.023	−2.97	D	6*n*
350	$4p'[\frac{3}{2}]-7s'[\frac{1}{2}]^\circ$	$2p_4-4s_3$	5971.60	107132	123873	3	1	0.011	0.0020	0.12	−2.22	D+	5*n*
351	$4p'[\frac{3}{2}]-7s'[\frac{1}{2}]^\circ$	$2p_4-4s_2$	5968.32	107132	123882	3	3	0.0019	9.9×10^{-4}	0.058	−2.53	D	5*n*
352	$4p'[\frac{3}{2}]-7s[\frac{3}{2}]^\circ$	$2p_3-4s_5$	6598.68	107290	122440	5	5	3.8×10^{-4}	2.5×10^{-4}	0.027	−2.90	D	6*n*
353	$4p'[\frac{3}{2}]-7s'[\frac{1}{2}]^\circ$	$2p_3-4s_2$	6025.15	107290	123882	5	3	0.0094	0.0031	0.30	−1.81	D+	5*n*
354	$4p'[\frac{1}{2}]-7s'[\frac{1}{2}]^\circ$	$2p_2-4s_3$	6104.58	107496	123873	3	1	0.0035	6.6×10^{-4}	0.040	−2.70	D	5*n*
355	$4p'[\frac{1}{2}]-7s'[\frac{1}{2}]^\circ$	$2p_2-4s_2$	6101.16	107496	123882	3	3	0.0034	0.0019	0.12	−2.24	D+	5*n*
356	$4p[\frac{1}{2}]-7d[\frac{1}{2}]^\circ$	$2p_{10}-7d_6$	4894.69	104102	124527	3	1	0.019	0.0023	0.11	−2.16	D	5*n*
357	$4p[\frac{1}{2}]-7d[\frac{1}{2}]^\circ$	$2p_{10}-7d_5$	4887.95	104102	124555	3	3	0.014	0.0049	0.24	−1.84	D	5*n*
358	$4p[\frac{1}{2}]-7d[\frac{3}{2}]^\circ$	$2p_{10}-7d_3$	4876.26	104102	124604	3	5	0.0081	0.0048	0.23	−1.84	D	5*n*
359	$4p[\frac{1}{2}]-7d'[\frac{3}{2}]^\circ$	$2p_{10}-7s_1''$	4554.32	104102	126053	3	5	4.0×10^{-4}	2.1×10^{-4}	0.0093	−3.20	E	6*n*
360	$4p[\frac{5}{2}]-7d[\frac{7}{2}]^\circ$	$2p_9-7d_4'$	5221.27	105463	124610	7	9	0.0092	0.0048	0.58	−1.47	D	6*n*
361	$4p[\frac{5}{2}]-7d[\frac{7}{2}]^\circ$	$2p_9-7d_4$	5210.49	105463	124650	7	7	0.0011	4.6×10^{-4}	0.055	−2.50	D−	6*n*
362	$4p[\frac{5}{2}]-7d[\frac{5}{2}]^\circ$	$2p_9-7d_1'$	5192.72	105463	124715	7	7	1.3×10^{-4}	5.3×10^{-5}	0.0063	−3.43	D−	5*n*
363	$4p[\frac{5}{2}]-7d[\frac{7}{2}]^\circ$	$2p_8-7d_4$	5252.79	105617	124650	5	7	0.0056	0.0032	0.28	−1.79	D−	6*n*
364	$4p[\frac{5}{2}]-7d[\frac{3}{2}]^\circ$	$2p_8-7d_2$	5214.77	105617	124788	5	3	0.0022	5.3×10^{-4}	0.046	−2.58	D−	6*n*
365	$4p[\frac{5}{2}]-7d[\frac{5}{2}]^\circ$	$2p_8-7d_1''$	5241.09	105617	124692	5	5	0.0014	5.6×10^{-4}	0.049	−2.55	D−	6*n*
366	$4p[\frac{3}{2}]-7d[\frac{5}{2}]^\circ$	$2p_7-7d_1''$	5373.50	106087	124692	3	5	0.0028	0.0020	0.11	−2.22	D−	6*n*
367	$4p[\frac{3}{2}]-7d[\frac{5}{2}]^\circ$	$2p_6-7d_1'$	5410.48	106238	124715	5	7	0.0021	0.0013	0.12	−2.19	D−	6*n*
368	$4p[\frac{1}{2}]-7d[\frac{1}{2}]^\circ$	$2p_5-7d_5$	5712.51	107054	124555	1	3	9.1×10^{-4}	0.0013	0.025	−2.89	D−	6*n*
369	$4p[\frac{1}{2}]-7d[\frac{3}{2}]^\circ$	$2p_5-7d_2$	5637.33	107054	124788	1	3	9.5×10^{-4}	0.0014	0.025	−2.85	D−	6*n*
370	$4p'[\frac{3}{2}]-7d[\frac{1}{2}]^\circ$	$2p_3-7d_5$	5790.40	107290	124555	5	3	3.5×10^{-4}	1.1×10^{-4}	0.010	−3.26	D	5*n*
371	$4p'[\frac{3}{2}]-7d[\frac{3}{2}]^\circ$	$2p_3-7d_3$	5773.99	107290	124604	5	5	0.0011	5.5×10^{-4}	0.053	−2.56	D	5*n*
372	$4p'[\frac{3}{2}]-7d'[\frac{5}{2}]^\circ$	$2p_3-7s_1'''$	5317.73	107290	126090	5	7	0.0027	0.0016	0.14	−2.09	E	6*n*
373	$4p'[\frac{1}{2}]-7d[\frac{3}{2}]^\circ$	$2p_2-7d_3$	5843.77	107496	124604	3	5	3.4×10^{-4}	2.9×10^{-4}	0.017	−3.06	D	5*n*
374	$4p[\frac{1}{2}]-8s[\frac{3}{2}]^\circ$	$2p_{10}-5s_5$	5048.81	104102	123903	3	5	0.0048	0.0031	0.15	−2.04	D	5*n*
375	$4p[\frac{5}{2}]-8s[\frac{3}{2}]^\circ$	$2p_9-5s_5$	5421.35	105463	123903	7	5	0.0062	0.0020	0.24	−1.86	D	6*n*
376	$4p[\frac{5}{2}]-8s[\frac{3}{2}]^\circ$	$2p_8-5s_5$	5467.16	105617	123903	5	5	7.9×10^{-4}	3.5×10^{-4}	0.032	−2.76	D	5*n*
377	$4p[\frac{5}{2}]-8s[\frac{3}{2}]^\circ$	$2p_8-5s_4$	5457.42	105617	123936	5	3	0.0037	9.9×10^{-4}	0.089	−2.31	D	5*n*
378	$4p[\frac{3}{2}]-8s'[\frac{1}{2}]^\circ$	$2p_7-5s_3$	5194.02	106087	125335	3	1	0.0081	0.0011	0.056	−2.49	D	5*n*
379	$4p[\frac{3}{2}]-8s[\frac{3}{2}]^\circ$	$2p_6-5s_5$	5659.13	106238	123903	5	5	0.0027	0.0013	0.12	−2.19	D	5*n*
380	$4p[\frac{3}{2}]-8s[\frac{3}{2}]^\circ$	$2p_6-5s_4$	5648.69	106238	123936	5	3	0.0013	3.8×10^{-4}	0.035	−2.73	D	5*n*
381	$4p'[\frac{3}{2}]-8s[\frac{3}{2}]^\circ$	$2p_4-5s_4$	5949.26	107132	123936	3	3	0.0016	8.4×10^{-4}	0.049	−2.60	D	5*n*
382	$4p'[\frac{3}{2}]-8s'[\frac{1}{2}]^\circ$	$2p_4-5s_3$	5492.09	107132	125335	3	1	0.0058	8.7×10^{-4}	0.047	−2.58	E	6*n*
383	$4p'[\frac{3}{2}]-8s[\frac{3}{2}]^\circ$	$2p_3-5s_4$	6005.73	107290	123936	5	3	0.0015	4.7×10^{-4}	0.047	−2.63	D+	5*n*
384	$4p'[\frac{3}{2}]-8s'[\frac{1}{2}]^\circ$	$2p_3-5s_2$	5534.49	107290	125353	5	3	0.0028	7.7×10^{-4}	0.070	−2.42	D+	5*n*
385	$4p'[\frac{1}{2}]-8s[\frac{3}{2}]^\circ$	$2p_2-5s_4$	6081.25	107496	123936	3	3	7.8×10^{-4}	4.3×10^{-4}	0.026	−2.89	D	5*n*

No.	Transition: *jl*-coupling	Transition: Paschen	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
386	$4p[\frac{1}{2}]-8d[\frac{1}{2}]^\circ$	$2p_{10}-8d_6$	4746.82	104102	125163	3	1	0.0037	4.2×10^{-4}	0.020	−2.90	E	6*n*
387	$4p[\frac{1}{2}]-8d[\frac{1}{2}]^\circ$	$2p_{10}-8d_5$	4752.94	104102	125136	3	3	0.0047	0.0016	0.075	−2.32	E	6*n*
388	$4p[\frac{5}{2}]-8d[\frac{7}{2}]^\circ$	$2p_9-8d'_4$	5060.08	105463	125220	7	9	0.0039	0.0019	0.22	−1.87	E	6*n*
389	$4p[\frac{5}{2}]-8d[\frac{7}{2}]^\circ$	$2p_8-8d_4$	5087.09	105617	125270	5	7	0.0017	9.4×10^{-4}	0.079	−2.33	E	6*n*
390	$4p[\frac{3}{2}]-8d[\frac{1}{2}]^\circ$	$2p_6-8d_5$	5290.00	106238	125136	5	3	9.4×10^{-4}	2.4×10^{-4}	0.021	−2.92	E	6*n*
391	$4p[\frac{3}{2}]-8d[\frac{3}{2}]^\circ$	$2p_6-8d_3$	5249.20	106238	125283	5	5	8.2×10^{-4}	3.4×10^{-4}	0.029	−2.77	E	6*n*
392	$4p[\frac{3}{2}]-8d[\frac{5}{2}]^\circ$	$2p_6-8d'_1$	5246.24	106238	125294	5	7	0.0012	6.6×10^{-4}	0.057	−2.48	E	6*n*
393	$4p[\frac{1}{2}]-8d[\frac{1}{2}]^\circ$	$2p_5-8d_5$	5528.97	107054	125136	1	3	0.0012	0.0017	0.031	−2.77	E	6*n*
394	$4p'[\frac{3}{2}]-8d[\frac{1}{2}]^\circ$	$2p_4-8d_5$	5552.77	107132	125136	3	3	8.2×10^{-4}	3.8×10^{-4}	0.021	−2.94	E	6*n*
395	$4p[\frac{1}{2}]-9s[\frac{3}{2}]^\circ$	$2p_{10}-6s_5$	4836.70	104102	124772	3	5	0.00106	6.2×10^{-4}	0.0296	−2.73	C	6*n*
396	$4p[\frac{5}{2}]-9s[\frac{3}{2}]^\circ$	$2p_9-6s_5$	5177.54	105463	124772	7	5	0.0025	7.3×10^{-4}	0.087	−2.29	D	5*n*
397	$4p[\frac{5}{2}]-9s[\frac{3}{2}]^\circ$	$2p_8-6s_4$	5216.28	105617	124783	5	3	0.0014	3.4×10^{-4}	0.029	−2.77	D−	6*n*
398	$4p[\frac{3}{2}]-9s[\frac{3}{2}]^\circ$	$2p_6-6s_5$	5393.27	106238	124772	5	5	0.0010	4.5×10^{-4}	0.040	−2.65	D−	6*n*
399	$4p[\frac{1}{2}]-9s[\frac{3}{2}]^\circ$	$2p_5-6s_4$	5639.12	107054	124783	1	3	0.0022	0.0031	0.058	−2.50	D−	6*n*
400	$4p[\frac{1}{2}]-9d[\frac{1}{2}]^\circ$	$2p_{10}-9d_5$	4647.49	104102	125613	3	3	0.0013	4.2×10^{-4}	0.020	−2.90	E	6*n*
401	$4p[\frac{1}{2}]-9d[\frac{3}{2}]^\circ$	$2p_{10}-9d_3$	4642.15	104102	125638	3	5	0.0010	5.4×10^{-4}	0.025	−2.79	E	6*n*
402	$4p[\frac{5}{2}]-9d[\frac{7}{2}]^\circ$	$2p_9-9d'_4$	4956.75	105463	125632	7	9	0.0019	9.0×10^{-4}	0.10	−2.20	E	6*n*
403	$4p[\frac{5}{2}]-9d[\frac{7}{2}]^\circ$	$2p_8-9d_4$	4989.95	105617	125652	5	7	0.0011	5.6×10^{-4}	0.046	−2.55	E	6*n*
404	$4p[\frac{3}{2}]-9d[\frac{5}{2}]^\circ$	$2p_7-9d''_1$	5104.74	106087	125672	3	5	9.1×10^{-4}	5.9×10^{-4}	0.030	−2.75	E	6*n*
405	$4p[\frac{5}{2}]-10s[\frac{3}{2}]^\circ$	$2p_9-7s_5$	5032.03	105463	125330	7	5	8.5×10^{-4}	2.3×10^{-4}	0.027	−2.79	E	6*n*
406	$4p[\frac{5}{2}]-10s[\frac{3}{2}]^\circ$	$2p_8-7s_4$	5070.99	105617	125332	5	3	0.0027	6.3×10^{-4}	0.053	−2.50	E	6*n*
407	$4p[\frac{1}{2}]-10d[\frac{1}{2}]^\circ$	$2p_{10}-10d_6$	4587.21	104102	125896	3	1	0.0051	5.4×10^{-4}	0.024	−2.79	E	6*n*
408	$4p[\frac{1}{2}]-10d[\frac{1}{2}]^\circ$	$2p_{10}-10d_5$	4586.61	104102	125899	3	3	0.0024	7.6×10^{-4}	0.034	−2.64	E	6*n*
409	$4p[\frac{1}{2}]-10d[\frac{3}{2}]^\circ$	$2p_{10}-10d_3$	4584.96	104102	125907	3	5	0.0017	8.9×10^{-4}	0.040	−2.57	E	6*n*
410	$4p[\frac{5}{2}]-10d[\frac{7}{2}]^\circ$	$2p_9-10d'_4$	4886.29	105463	125923	7	9	0.0012	5.5×10^{-4}	0.062	−2.42	E	6*n*
411	$4p[\frac{5}{2}]-10d[\frac{7}{2}]^\circ$	$2p_5-10d_4$	4921.04	105617	125933	5	7	6.1×10^{-4}	3.1×10^{-4}	0.025	−2.81	E	6*n*
412	$4p[\frac{5}{2}]-11s[\frac{3}{2}]^\circ$	$2p_9-8s_5$	4937.72	105463	125709	7	5	3.8×10^{-4}	9.9×10^{-5}	0.011	−3.16	E	6*n*
413	$4p[\frac{1}{2}]-11d[\frac{1}{2}]^\circ$	$2p_{10}-11d_5$	4544.75	104102	126099	3	3	8.6×10^{-4}	2.7×10^{-4}	0.012	−3.09	E	6*n*
414	$4p[\frac{5}{2}]-11d[\frac{7}{2}]^\circ$	$2p_9-11d'_4$	4835.97	105463	126135	7	9	9.7×10^{-4}	4.4×10^{-4}	0.049	−2.51	E	6*n*
415	$4p[\frac{5}{2}]-12d[\frac{7}{2}]^\circ$	$2p_9-12d'_4$	4798.74	105463	126296	7	9	9.2×10^{-4}	4.1×10^{-4}	0.045	−2.54	E	6*n*
416	$5s[\frac{3}{2}]^\circ-4f[\frac{3}{2}]$	$2s_5-4X$	14876.6	113469	120188	5	8	6.0×10^{-4}	0.0032	0.77	−1.80	D−	9*n*
417	$5s[\frac{3}{2}]^\circ-4f[\frac{5}{2}]$	$2s_5-4Y$	14786.3	113469	120230	5	12	0.0021	0.017	4.1	−1.07	D	9*n*

Ar II

Ground State $1s^2 2s^2 2p^6 3s^2 3p^5\ ^2P^\circ_{3/2}$

Ionization Potential 27.63 eV = 222848.2 cm^{-1}

Allowed Transitions

List of tabulated lines:

Wavelength [Å]	No.	Wavelength [Å]	No.	Wavelength [Å]	No.
718.091	3	3476.75	34	3765.27	63
723.361	3	3487.32	38	3770.52	63
725.550	3	3491.24	34	3780.84	37
730.929	3	3491.54	34	3786.38	6
737.457	2	3499.48	8	3796.60	61
740.270	2	3509.78	34	3799.38	37
745.323	2	3514.39	34	3803.17	61
748.198	2	3517.89	8	3808.58	6
919.782	1	3520.00	38	3809.46	63
932.053	1	3521.26	38	3819.02	60
3000.44	44	3535.32	34	3825.68	60
3028.91	50	3545.60	45	3826.81	37
3093.40	50	3545.84	55	3830.39	6
3139.02	36	3548.52	38	3841.52	37
3161.37	54	3550.03	43	3844.57	23
3169.67	36	3559.51	45	3844.74	37
3181.04	36	3561.03	55	3845.41	21
3194.23	35	3562.19	55	3850.58	22
3204.32	46	3565.03	39	3855.16	47
3212.52	36	3576.61	38	3868.52	52
3225.97	35	3581.61	38	3872.14	37
3236.81	49	3582.36	38	3875.26	5
3243.69	36	3588.45	38	3880.34	37
3249.80	36	3600.22	58	3891.40	5
3263.57	35	3603.46	39	3891.98	5
3273.32	46	3622.14	63	3900.62	37
3281.70	36	3639.83	59	3911.57	37
3293.64	49	3650.89	64	3914.77	5
3307.23	49	3655.28	48	3922.36	23
3350.93	57	3656.05	42	3925.72	73
3361.75	57	3669.61	63	3928.63	22
3365.54	57	3671.01	58	3931.24	5
3366.59	49	3678.27	63	3932.55	52
3370.93	39	3680.06	59	3944.27	5
3376.44	57	3706.94	7	3946.10	73
3379.46	40	3709.92	42	3952.73	51
3388.53	53	3714.74	6	3958.38	41
3397.90	40	3717.17	42	3968.36	5
3414.46	56	3718.21	62	3974.48	21
3421.62	39	3720.43	63	3974.75	20
3429.62	56	3724.52	62	3979.36	52
3430.42	40	3729.31	22	3988.16	41
3432.59	56	3737.89	62	3992.05	5
3454.10	34	3750.49	6	3994.79	33
3464.13	45	3763.50	37	4011.20	66

Wavelength [Å]	No.	Wavelength [Å]	No.	Wavelength [Å]	No.
4013.86	5	4370.75	17	5017.63	25
4033.82	65	4371.33	4	5062.04	18
4035.46	32	4375.95	29	5141.79	16
4038.81	5	4379.67	19	5145.32	25
4042.90	32	4383.75	28	5215.11	25
4052.92	33	4400.10	4	5286.90	25
4057.67	21	4400.99	4	5724.33	24
4060.6	21	4420.91	4	5843.78	24
4065.11	41	4426.01	19	5950.91	24
4072.01	32	4430.19	19	6077.43	24
4076.64	65	4431.00	4	6103.55	13
4076.94	68	4448.88	75	6138.66	10
4079.58	32	4460.56	4	6212	24
4082.39	20	4481.81	17	6243.13	10
4103.91	65	4535.49	72	6399.22	10
4103.91	68	4545.05	27	6483.08	13
4112.82	20	4547.76	69	6638.23	9
4131.73	31	4564.42	71	6639.74	9
4147.38	21	4579.35	29	6643.72	9
4156.09	65	4587.90	28	6666.36	12
4178.37	19	4589.90	30	6684.31	9
4179.30	65	4609.56	30	6756.55	9
4201.97	20	4637.25	30	6808.53	11
4218.67	68	4657.89	27	6861.27	12
4222.64	70	4721.59	71	6863.54	9
4226.99	74	4726.86	26	6886.62	9
4228.16	20	4735.91	18		
4237.22	31	4764.86	27		
4255.60	67	4806.02	18		
4266.53	19	4847.82	18		
4275.16	70	4865.92	71		
4277.52	31	4879.86	26		
4282.90	19	4889.03	27		
4300.65	15	4904.75	14		
4331.20	19	4933.21	18		
4332.03	4	4952.92	25		
4337.07	74	4965.07	26		
4348.06	19	4972.16	18		
4352.20	4	5009.33	18		
4362.07	17	5017.16	16		

For some vacuum uv lines of this spectrum we could utilize the radiative lifetime measurements of Lawrence [1], based on the delayed-coincidence technique, and the intermediate-coupling calculations of Statz et al. [2], based on Hartree-Fock wavefunctions in the radial integral.

In the visible region, many experimental and theoretical determinations of transition probabilities have been carried out. As a common absolute basis for much of our tabulated data in this region, we have chosen the accurate lifetime determinations of the $4p$ levels by Bennett et al. [7]. This experiment is considered the most advanced of the three recent lifetime measurements (Bakos et al. [8] and Matilsky and Hesser [9]) since, in contrast to the others, it completely eliminates cascading effects by using electron excitation of the atomic states at the corresponding threshold energies.

Of the other experiments which provide many individual transition probabilities, we have adopted the recent wall-stabilized arc measurements of Shumaker and Popenoe [3] and Schnapauff [5]. (Schnapauff has also employed in some cases a hollow cathode as a light source.) Shumaker and Popenoe's values have been chosen, where available, in preference to those of Schnapauff (with whom they are normally in good agreement), because they employ more advanced data processing and evaluating techniques. The expected increased precision appears to be reflected in their results which provide a better fulfillment of the J-file sum rule for the $4s-4p$ array and exhibit the apparent slow variation of the radial transition integral in this array. Shumaker and Popenoe's values are also in better agreement with the theoretical calculations described below and their measured absolute scale is very close (within about 10%) to our adopted scale provided by the lifetime measurements of Bennett et al. [7]. However, as a single exception, values for the $4s\,^4P-4p\,^4S^o$ multiplet do not satisfy the J-file sum rule very well and, consequently, we have reduced our accuracy estimates for these lines.

For many other lines of moderate strength in the visible where no reliable measurements are available, we have applied the intermediate-coupling calculations of Statz et al. [2], described above, as well as those of Rudko and Tang [4] and Garstang [6]. Both the results of Statz et al., and Garstang have been placed on the absolute scale described above. Finally, it should be mentioned that the Coulomb approximation is expected to provide a fairly reliable radial transition integral for many other lines, but since the individual line strengths probably would be unreliable due to the suspected breakdown of LS-coupling, we have refrained from tabulating these.

References

[1] Lawrence, G. M., Twentieth Gaseous Electronics Conference, San Francisco (1967) (to be published).

[2] Statz, H., Horrigan, F. A., Koozekanani, S. H., Tang, C. L., and Koster, G. F., J. App. Physics **36**, 2278–2286 (1965); and Koster, G. F., Statz, H., and Tang, C. L., J. App. Physics **39**, 4045–4046 (1968).

[3] Shumaker, J. B., Jr., and Popenoe, C. H., J. Opt. Soc. Am. **59** (1969) (to be published).

[4] Rudko, R. I., and Tang, C. L., J. App. Physics **38**, 4731–4739 (1967); and **39**, 4046 (1968); and Marantz, H., thesis Cornell University.

[5] Schnapauff, R., Z. Astrophys. **68**, 431–444 (1968).

[6] Garstang, R. H., Monthly Notices Roy. Astron. Soc. **114**, 118–133 (1954).

[7] Bennett, W. R., Jr., Kindlmann, P. J., and Mercer, G. N., Applied Optics Supplement 2 of Chemical Lasers 34–57 (1965).

[8] Bakos, J., Szigeti, J., and Varga, L., Phys. Letters **20**, 503–504 (1966).

[9] Matilsky, T. A., and Hesser, J. E., J. Opt. Soc. Am. **59**, 579–582 (1969).

Ar II. Allowed Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
1	$3s^23p^5-3s3p^6$	$^2P^o-^2S$ (1 uv)	*923.84*	*477*	108721	6	2	2.08	0.0089	0.162	−1.272	C	1
			919.782	0	108721	4	2	1.41	0.0089	0.108	−1.449	C	*ls*
			932.053	1431	108721	2	2	0.67	0.0088	0.054	−1.75	C	*ls*
2	$3p^5-3p^4(^3P)4s$	$^2P^o-^4P$ (3 uv)											
			748.198	1431	135086	2	4	0.059	9.9×10^{-4}	0.0049	−2.70	E	2
			740.270	0	135086	4	4	0.31	0.0025	0.025	−2.00	E	2
			745.323	1431	135602	2	2	0.073	6.1×10^{-4}	0.0030	−2.91	E	2
			737.457	0	135602	4	2	0.038	1.5×10^{-4}	0.0015	−3.22	E	2
3		$^2P^o-^2P$ (4 uv)	*724.09*	*477*	*138582*	6	6	28	0.22	3.1	0.12	D	2
			723.361	0	138244	4	4	23	0.18	1.7	−0.14	D	2
			725.550	1431	139258	2	2	19	0.15	0.72	−0.52	D	2
			718.091	0	139258	4	2	9.5	0.037	0.35	−0.83	D	2
			730.929	1431	138244	2	4	4.5	0.072	0.35	−0.84	D	2

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
4	$3p^43d-3p^4(^3P)4p$	$^4D-^4P^\circ$ (1)	*4388.2*	*132475*	*155257*	20	12	0.440	0.076	22.0	0.182	C	3*n*
			4400.99	132327	155043	8	6	0.322	0.070	8.1	−0.252	C	3*n*
			4371.33	132481	155351	6	4	0.233	0.0445	3.84	−0.57	C	3*n*
			4332.03	132631	155708	4	2	0.20	0.028	1.6	−0.95	C−	3*n*
			4431.00	132481	155043	6	6	0.110	0.0324	2.83	−0.71	C	3*n*
			4400.10	132631	155351	4	4	0.164	0.0476	2.76	−0.72	C	3*n*
			4352.20	132738	155708	2	2	0.228	0.065	1.85	−0.89	C	3*n*
			4460.56	132631	155043	4	6	0.0156	0.0070	0.410	−1.55	C	3*n*
			4420.91	132738	155351	2	4	0.033	0.019	0.56	−1.42	C−	3*n*
5		$^4D-^4D^\circ$ (2)	*3967.6*	*132475*	*157672*	20	20	0.115	0.0272	7.1	−0.264	C	3*n*
			4013.86	132327	157234	8	8	0.107	0.0258	2.73	−0.69	C	3*n*
			3968.36	132481	157673	6	6	0.0467	0.0110	0.86	−1.180	C	3*n*
			3914.77	132631	158168	4	4	0.0320	0.0074	0.379	−1.53	C	3*n*
			3891.40	132738	158428	2	2	0.039	0.0089	0.23	−1.75	C−	3*n*
			3944.27	132327	157673	8	6	0.0403	0.0070	0.73	−1.252	C	3*n*
			3891.98	132481	158168	6	4	0.073	0.011	0.85	−1.18	C−	3*n*
			3875.26	132631	158428	4	2	0.076	0.0086	0.44	−1.46	C−	3*n*
			4038.81	132481	157234	6	8	0.0127	0.00414	0.330	−1.60	C	3*n*
			3992.05	132631	157673	4	6	0.0153	0.0055	0.288	−1.66	C	3*n*
			3931.24	132738	158168	2	4	0.020	0.0093	0.24	−1.73	C−	3*n*
6		$^4D-^2D^\circ$ (3)											
			3786.38	132327	158730	8	6	0.012	0.0019	0.19	−1.82	C−	3*n*
			3714.74	132481	159393	6	4	0.0065	9.0×10^{-4}	0.066	−2.27	D−	4
			3808.58	132481	158730	6	6	0.0073	0.0016	0.12	−2.02	C−	3*n*
			3830.39	132631	158730	4	6	0.0062	0.0020	0.10	−2.10	D−	4
			3750.49	132738	159393	2	4	0.0027	0.0011	0.028	−2.66	D−	4
7		$^4D-^2P^\circ$ (4)											
			3706.94	132738	159706	2	2	0.0070	0.0014	0.035	−2.55	D−	4
8		$^4D-^4S^\circ$ (5)											
			3499.48	132481	161049	6	4	0.0053	6.5×10^{-4}	0.045	−2.41	D−	4
			3517.89	132631	161049	4	4	0.0020	3.7×10^{-4}	0.017	−2.83	D−	4
9		$^4F-^4D^\circ$ (20)											
			6643.72	142186	157234	10	8	0.167	0.088	19.3	−0.056	C	3*n*
			6684.31	142717	157673	8	6	0.113	0.057	10.0	−0.341	C	3*n*
			6638.23	143108	158168	6	4	0.129	0.057	7.4	−0.466	C	3*n*
			6639.74	143371	158428	4	2	0.181	0.060	5.2	−0.62	C	3*n*
			6886.62	142717	157234	8	8	0.0098	0.0070	1.26	−1.252	C	3*n*
			6863.54	143108	157673	6	6	0.0218	0.0154	2.09	−1.034	C	3*n*
			6756.55	143371	158168	4	4	0.0091	0.0062	0.55	−1.61	C−	3*n*
10		$^4F-^2D^\circ$ (21)											
			6243.13	142717	158730	8	6	0.029	0.013	2.1	−0.98	C−	3*n*
			6138.66	143108	159393	6	4	0.010	0.0038	0.46	−1.64	C−	3*n*
			6399.22	143108	158730	6	6	0.0055	0.0034	0.43	−1.69	C−	3*n*
11		$^2P-^2D^\circ$ (24)											
			6808.53	144710	159393	2	4	0.0064	0.0089	0.40	−1.75	C−	3*n*
12		$^2P-^2P^\circ$ (25)											
			6861.27	145669	160239	4	4	0.0242	0.0171	1.54	−1.165	C	3*n*
			6666.36	144710	159706	2	2	0.071	0.047	2.1	−1.03	C−	3*n*

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
13		$^2P-^2S^\circ$ (27)	*6351.5*	*145349*	161089	6	2	0.118	0.0238	2.99	−0.85	C	3*n*
			6483.08	145669	161089	4	2	0.101	0.0318	2.72	−0.90	C	3*n*
			6103.55	144710	161089	2	2	0.012	0.0067	0.27	−1.87	C−	3*n*
14	$3p^4(^3P)3d-3p^4(^1D)4p'$	$^2F-^2F^\circ$ (34)											
			4904.75	150148	170530	6	8	0.045	0.022	2.1	−0.88	D	5*n*
15		$^2F-^2D^\circ$ (36)											
			4300.65	150148	173393	6	6	0.061	0.017	1.4	−0.99	D	5*n*
16		$^2D-^2F^\circ$ (37)											
			5141.79	151087	170530	6	8	0.095	0.050	5.1	−0.52	C	5*n*
			5017.16	150475	170401	4	6	0.231	0.131	8.6	−0.281	C	3*n*
17		$^2D-^2D^\circ$ (39)											
			4481.81	151087	173393	6	6	0.494	0.149	13.2	−0.049	C	5*n*
			4370.75	150475	173348	4	4	0.65	0.186	10.7	−0.128	C	3*n*
			4362.07	150475	173393	4	6	0.057	0.024	1.4	−1.02	D	5*n*
18	$3p^44s-3p^4(^3P)4p$	$^4P-^4P^\circ$ (6)	*4875.0*	*134750*	*155257*	12	12	0.93	0.332	64	0.60	C	3*n*
			4806.02	134242	155043	6	6	0.79	0.274	26.0	0.216	C+	3*n*
			4933.21	135086	155354	4	4	0.143	0.052	3.39	−0.68	C+	3*n*
			4972.16	135602	155708	2	2	0.096	0.0356	1.16	−1.148	C	3*n*
			4735.91	134242	155354	6	4	0.58	0.130	12.2	−0.108	C	3*n*
			4847.82	135086	155708	4	2	0.85	0.150	9.6	−0.222	C	3*n*
			5009.33	135086	155043	4	6	0.147	0.083	5.5	−0.479	C	3*n*
			5062.04	135602	155354	2	4	0.221	0.170	5.7	−0.469	C+	3*n*
19		$^4P-^4D^\circ$ (7)	*4361.4*	*134750*	*157672*	12	20	1.14	0.54	93	0.81	C	3*n*
			4348.06	134242	157234	6	8	1.24	0.469	40.2	0.449	C	3*n*
			4426.01	135086	157673	4	6	0.83	0.366	21.3	0.166	C	3*n*
			4430.19	135602	158168	2	4	0.53	0.312	9.1	−0.205	C	3*n*
			4266.53	134242	157673	6	6	0.156	0.0426	3.59	−0.59	C	3*n*
			4331.20	135086	158168	4	4	0.56	0.158	9.0	−0.199	C	3*n*
			4379.67	135602	158428	2	2	1.04	0.299	8.6	−0.233	C	3*n*
			4178.37	134242	158168	6	4	0.013	0.0023	0.19	−1.86	C−	3*n*
			4282.90	135086	158428	4	2	0.120	0.0165	0.93	−1.180	C	3*n*
20		$^4P-^2D^\circ$ (8)											
			4082.39	134242	158730	6	6	0.027	0.0067	0.54	−1.40	C−	3*n*
			4112.82	135086	159393	4	4	0.0082	0.0021	0.11	−2.08	C−	3*n*
			3974.75	134242	159393	6	4	0.0041	6.5×10^{-4}	0.051	−2.41	D−	4
			4228.16	135086	158730	4	6	0.130	0.052	2.91	−0.68	C	3*n*
			4201.97	135602	159393	2	4	0.035	0.019	0.51	−1.42	D−	4
21		$^4P-^2P^\circ$ (9)											
			3974.48	135086	160239	4	4	0.0068	0.0016	0.084	−2.19	D−	4
			4147.38	135602	159706	2	2	1.8×10^{-4}	4.6×10^{-5}	0.0013	−4.04	E	2*n*
			3845.41	134242	160239	6	4	0.0091	0.0013	0.10	−2.11	D−	4
			[4060.6]	135086	158706	4	2	3.2×10^{-5}	4.0×10^{-6}	2.1×10^{-4}	−4.80	E	2*n*
			4057.67	135602	160239	2	4	0.0038	0.0019	0.050	−2.42	E	2*n*
22		$^4P-^4S^\circ$ (10)	*3801.4*	*134750*	161049	12	4	1.4	0.10	15	0.08	D	3*n*
			3729.31	134242	161049	6	4	0.60	0.083	6.1	−0.30	D	3*n*
			3850.58	135086	161049	4	4	0.47	0.10	5.3	−0.40	D	3*n*
			3928.63	135602	161049	2	4	0.30	0.14	3.6	−0.55	D	3*n*

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
23		$^4P-^2S^\circ$ (11)											
			3844.57	135086	161089	4	2	0.0071	7.9×10^{-4}	0.040	−2.50	E	2*n*
			3922.36	135602	161089	2	2	0.0019	4.4×10^{-4}	0.011	−3.06	E	2*n*
24		$^2P-^4P^\circ$ (12)											
			5843.78	138244	155351	4	4	3.8×10^{-4}	1.9×10^{-4}	0.015	−3.12	E	2*n*
			6077.43	139258	155708	2	2	9.8×10^{-4}	5.4×10^{-4}	0.022	−2.97	E	2*n*
			5724.33	138244	155708	4	2	0.0014	3.4×10^{-4}	0.026	−2.87	E	2*n*
			5950.91	138244	155043	4	6	7.0×10^{-4}	5.6×10^{-4}	0.044	−2.65	E	2*n*
			6212	139258	155351	2	4	2.1×10^{-5}	2.4×10^{-5}	9.9×10^{-4}	−4.32	E	2*n*
25		$^2P-^4D^\circ$ (13)											
			5145.32	138244	157673	4	6	0.097	0.058	3.91	−0.63	C	3*n*
			5286.90	139258	158168	2	4	0.0156	0.0131	0.455	−1.58	C	3*n*
			5017.63	138244	158168	4	4	0.0085	0.0032	0.21	−1.89	C−	3*n*
			5215.11	139258	158428	2	2	1.6×10^{-4}	6.5×10^{-5}	0.0022	−3.89	E	2*n*
			4952.92	138244	158428	4	2	3.2×10^{-5}	5.9×10^{-6}	3.8×10^{-4}	−4.63	E	2*n*
26		$^2P-^2D^\circ$ (14)	*4897.5*	*138582*	*158995*	6	10	0.79	0.471	45.6	0.451	C	3*n*
			4879.86	138244	158730	4	6	0.78	0.418	26.8	0.223	C	3*n*
			4965.07	139258	159393	2	4	0.347	0.256	8.4	−0.291	C	3*n*
			4726.86	138244	159393	4	4	0.50	0.167	10.4	−0.175	C	3*n*
27		$^2P-^2P^\circ$ (15)	*4654.4*	*138582*	*160061*	6	6	1.00	0.325	29.9	0.290	C+	3*n*
			4545.05	138244	160239	4	4	0.413	0.128	7.66	−0.291	B	3*n*
			4889.03	139258	159706	2	2	0.159	0.057	1.83	−0.94	C	3*n*
			4657.89	138244	159706	4	2	0.81	0.132	8.1	−0.277	C	3*n*
			4764.86	139258	160239	2	4	0.575	0.391	12.3	−0.107	B	3*n*
28		$^2P-^4S^\circ$ (16)											
			4383.75	138244	161049	4	4	0.011	0.0032	0.18	−1.89	C−	3*n*
			4587.90	139258	161049	2	4	1.4×10^{-4}	8.8×10^{-5}	0.0027	−3.75	E	2*n*
29		$^2P-^2S^\circ$ (17)	*4441.8*	*138582*	161089	6	2	1.10	0.108	9.5	−0.188	C	3*n*
			4375.95	138244	161089	4	2	0.200	0.0287	1.65	−0.94	C	3*n*
			4579.35	139258	161089	2	2	0.82	0.258	7.8	−0.287	C	3*n*
30	$3p^44s'-3p^4(^1D)4p'$	$^2D-^2F^\circ$ (31)	*4602.3*	*148753*	*170475*	10	14	0.91	0.403	61	0.61	C−	5*n*
			4609.56	148842	170530	6	8	0.91	0.387	35.2	0.366	C	5*n*
			4589.90	148620	170401	4	6	0.82	0.389	23.5	0.192	C	5*n*
			4637.25	148842	170401	6	6	0.090	0.029	2.7	−0.76	D	5*n*
31		$^2D-^2P^\circ$ (32)	*4225.0*	*148753*	*172415*	10	6	1.3	0.20	28	0.30	D	4
			4277.52	148842	172214	6	4	1.0	0.18	15	0.03	D	4
			4131.73	148620	172816	4	2	1.4	0.18	9.7	−0.14	D	4
			4237.22	148620	172214	4	4	0.21	0.057	3.2	−0.64	D	4
32		$^2D-^2D^\circ$ (33)	*4060.3*	*148753*	*173375*	10	10	1.0	0.25	34	0.40	D	4, 5*n*
			4072.01	148842	173393	6	6	0.57	0.142	11.4	−0.070	C	5*n*
			4042.90	148620	173348	4	4	1.4	0.34	18	0.13	D	4
			4079.58	148842	173348	6	4	0.26	0.043	3.5	−0.59	D	4
			4035.46	148620	173393	4	6	0.045	0.016	0.88	−1.19	D	5*n*
33	$3p^44s''-3p^4(^1S)4p''$	$^2S-^2P^\circ$ (101)	*4033.4*	167308	*192094*	2	6	1.5	1.1	30	0.34	E	6*n*
			4052.92	167308	191975	2	4	1.5	0.75	20	0.18	E	6*n*
			3994.79	167308	192333	2	2	1.6	0.37	9.8	−0.13	E	6*n*

No.	Transition Array	Multiplet	λ(A)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
34	$3p^44p-3p^4(^3P)4d$	$^4P^\circ-^4D$ (44)											
			3491.54	155043	183676	6	8	3.0	0.73	50	0.64	D	4
			3514.39	155351	183797	4	6	1.23	0.342	15.8	0.136	C	5*n*
			3535.32	155708	183986	2	4	0.82	0.31	7.2	−0.21	D	4
			3476.75	155043	183797	6	6	1.34	0.243	16.7	0.164	C	5*n*
			3491.24	155351	183986	4	4	2.2	0.40	18	0.20	D	4
			3509.78	155708	184192	2	2	2.5	0.46	11	−0.04	D	4
			3454.10	155043	183986	6	4	0.45	0.054	3.7	−0.49	D	4
35		$^4P^\circ-^4F$ (46)											
			3194.23	155043	186340	6	4	0.24	0.024	1.5	−0.84	D−	4
			3225.97	155351	186340	4	4	0.046	0.0072	0.30	−1.54	D−	4
			3263.57	155708	186340	2	4	0.35	0.11	2.4	−0.66	D−	4
36		$^4P^\circ-^4P$ (47)	*3181.4*	*155257*	*186681*	12	12	2.0	0.30	38	0.56	D	4
			3139.02	155043	186891	6	6	1.0	0.15	9.2	−0.05	D	4
			3212.52	155351	186470	4	4	0.096	0.015	0.63	−1.22	D	4
			3281.70	155708	186171	2	2	0.73	0.12	2.5	−0.62	D	4
			3181.04	155043	186470	6	4	0.63	0.064	4.0	−0.42	D	4
			3243.69	155351	186171	4	2	2.0	0.16	6.7	−0.19	D	4
			3169.67	155351	186891	4	6	0.82	0.19	7.7	−0.12	D	4
			3249.80	155708	186470	2	4	1.0	0.32	6.8	−0.19	D	4
37		$^4D^\circ-^4D$ (54)	*3822.4*	*157672*	*183826*	20	20	0.65	0.14	36	0.45	D	4, 5*n*
			3780.84	157234	183676	8	8	0.94	0.20	20	0.20	D	4
			3826.81	157673	183797	6	6	0.15	0.033	2.5	−0.70	D	5*n*
			3872.14	158168	183986	4	4	0.19	0.043	2.2	−0.76	D	4
			3880.34	158428	184192	2	2	0.22	0.050	1.3	−1.00	D	4
			3763.50	157234	183797	8	6	0.14	0.022	2.2	−0.75	D	5*n*
			3799.38	157673	183986	6	4	0.23	0.033	2.5	−0.70	D	4
			3841.52	158168	184192	4	2	0.27	0.030	1.5	−0.92	D	4
			3844.74	157673	183676	6	8	0.047	0.014	1.1	−1.08	D	4
			3900.62	158168	183797	4	6	0.082	0.028	1.4	−0.95	D	4
			3911.57	158428	183986	2	4	0.088	0.040	1.0	−1.10	D	4
38		$^4D^\circ-^4F$ (56)											
			3588.45	157234	185093	8	10	3.39	0.82	77	0.82	C	5*n*
			3576.61	157673	185625	6	8	2.77	0.71	50	0.63	C	5*n*
			3582.36	158168	186074	4	6	3.72	1.07	51	0.63	C	5*n*
			3581.61	158428	186340	2	4	1.8	0.69	16	0.14	D	4
			3521.26	157234	185625	8	8	0.23	0.043	4.0	−0.46	D	5*n*
			3520.00	157673	186074	6	6	0.80	0.15	10	−0.05	D	5*n*
			3548.52	158168	186340	4	4	1.1	0.21	9.7	−0.08	D	4
			3487.32	157673	186340	6	4	0.027	0.0033	0.23	−1.70	D	4
39		$^4D^\circ-^4P$ (57)											
			3370.93	157234	186891	8	6	0.059	0.0075	0.67	−1.22	D	4
			3421.62	157673	186891	6	6	0.093	0.016	1.1	−1.02	D	4
			3603.46	158428	186171	2	2	0.065	0.013	0.30	−1.59	D	4
			3565.03	158428	186470	2	4	1.1	0.42	9.8	−0.08	D	4
40		$^4D^\circ-^2F$ (59)											
			3379.46	157234	186816	8	8	0.020	0.0034	0.30	−1.57	D−	4
			3430.42	157673	186816	6	8	0.058	0.014	0.92	−1.08	D−	4
			3397.90	158168	187589	4	6	0.027	0.0070	0.31	−1.55	D−	4
41		$^2D^\circ-^4D$ (65)											
			3988.16	158730	183797	6	6	0.050	0.012	0.94	−1.14	D−	4
			4065.11	159393	183986	4	4	0.015	0.0037	0.20	−1.83	D−	4
			3958.38	158730	183986	6	4	0.033	0.0052	0.40	−1.51	D−	4

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
42		$^2D^\circ-{}^4F$ (67)											
			3717.17	158730	185625	6	8	0.030	0.0083	0.61	−1.30	D−	4
			3656.05	158730	186074	6	6	0.13	0.026	1.9	−0.81	D	5*n*
			3709.92	159393	186340	4	4	0.053	0.011	0.53	−1.36	D−	4
43		$^2D^\circ-{}^4P$ (68)											
			3550.03	158730	186891	6	6	0.024	0.0045	0.32	−1.57	D−	4
44		$^2D^\circ-{}^2D$ (69)											
			3000.44	159393	192712	4	4	1.5	0.20	8.0	−0.10	D	4
45		$^2D^\circ-{}^2F$ (70)	*3551.1*	*158995*	*187147*	10	14	3.9	1.0	120	1.00	D	4
			3559.51	158730	186816	6	8	3.9	0.99	69	0.77	D	4
			3545.60	159393	187589	4	6	3.4	0.96	45	0.58	D	4
			3464.13	158730	187589	6	6	0.37	0.067	4.6	−0.40	D	4
46		$^2D^\circ-{}^2P$ (71)											
			3273.32	159393	189935	4	2	0.37	0.030	1.3	−0.92	D	4
			3204.32	159393	190592	4	4	0.40	0.062	2.6	−0.61	D	4
47		$^2P^\circ-{}^4P$ (81)											
			3855.16	160239	186171	4	2	0.015	0.0017	0.085	−2.17	D−	4
48		$^2P^\circ-{}^2F$ (82)											
			3655.28	160239	187589	4	6	0.23	0.069	3.3	−0.56	D−	4
49		$^2P^\circ-{}^2P$ (83)	*3298.1*	*160061*	*190373*	6	6	2.7	0.45	29	0.43	D	4
			3293.64	160239	190592	4	4	1.7	0.28	12	0.05	D	4
			3307.23	159706	189935	2	2	3.4	0.56	12	0.05	D	4
			3366.59	160239	189935	4	2	0.41	0.035	1.5	−0.85	D	4
			3236.81	159706	190592	2	4	0.52	0.16	3.5	−0.49	D	4
50		$^2P^\circ-{}^2D$											
			3093.40	160239	192557	4	6	4.4	0.95	39	0.58	D	4
			3028.91	159706	192712	2	4	2.3	0.63	13	0.10	D	4
51		$^4S^\circ-{}^4F$ (89)											
			3952.73	161049	186340	4	4	0.35	0.082	4.3	−0.48	D−	4
52		$^4S^\circ-{}^4P$ (90)	*3900.3*	161049	*186681*	4	12	1.5	1.1	54	0.64	D	4
			3868.52	161049	186891	4	6	1.9	0.64	33	0.41	D	4
			3932.55	161049	186470	4	4	1.1	0.26	13	0.02	D	4
			3979.36	161049	186171	4	2	1.3	0.15	8.1	−0.22	D	4
53		$^2S^\circ-{}^2P$ (96)											
			3388.53	161089	190592	2	4	1.9	0.65	15	0.11	D	4
54		$^2S^\circ-{}^2D$											
			3161.37	161089	192712	2	4	1.8	0.54	11	0.03	D−	4
55	$3p^44p'-3p^4(^1D)4d'$	$^2F^\circ-{}^2G$ (106)	*3554.5*	*170475*	*198600*	14	18	4.0	0.98	160	1.14	D	4
			3561.03	170530	198604	8	10	4.0	0.95	89	0.88	D	4
			3545.84	170401	198595	6	8	3.9	0.98	69	0.77	D	4
			3562.19	170530	198595	8	8	0.15	0.029	2.7	−0.63	D	4

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
56		$^2F^\circ-^2D$ (107)	*3409.0*	*170475*	*199801*	14	10	0.31	0.039	6.1	−0.26	D	4
			3429.62	170530	199680	8	6	0.22	0.029	2.6	−0.63	D	4
			3432.59	170401	199982	6	4	0.32	0.038	2.6	−0.64	D	4
			3414.46	170401	199680	6	6	0.077	0.013	0.91	−1.11	D	4
57		$^2F^\circ-^2F$ (109)	*3365.5*	*170475*	*200180*	14	14	1.6	0.27	42	0.58	D	4
			3376.44	170530	200139	8	8	1.5	0.26	23	0.32	D	4
			3350.93	170401	200235	6	6	1.5	0.25	17	0.18	D	4
			3365.54	170530	200235	8	6	0.13	0.017	1.5	−0.87	D	4
			3361.75	170401	200139	6	8	0.039	0.0088	0.59	−1.28	D	4
58		$^2P^\circ-^2P$ (115)											
			3600.22	172214	199525	4	4	2.2	0.43	20	0.24	D	4
			3671.01	172214	199447	4	2	0.71	0.072	3.5	−0.54	D	4
59		$^2P^\circ-^2D$ (116)											
			3639.83	172214	199680	4	6	1.4	0.42	20	0.23	D	4
			3680.06	172816	199982	2	4	1.2	0.49	12	−0.01	D	4
60		$^2D^\circ-^2P$ (128)											
			3825.68	173393	199525	6	4	0.76	0.11	8.4	−0.18	D	4
			3819.02	173348	199525	4	4	0.0036	7.9×10^{-4}	0.040	−2.50	D	4
61		$^2D^\circ-^2D$ (129)											
			3803.17	173393	199680	6	6	1.5	0.33	24	0.30	D	4
			3796.60	173348	199680	4	6	0.25	0.081	4.1	−0.49	D	4
62		$^2D^\circ-^2F$ (131)	*3729.6*	*173375*	*200180*	10	14	2.3	0.67	82	0.83	D	4
			3737.89	173393	200139	6	8	2.3	0.64	47	0.58	D	4
			3718.21	173348	200235	4	6	2.0	0.62	30	0.39	D	4
			3724.52	173393	200235	6	6	0.34	0.071	5.2	−0.37	D	4
63	$3p^44p-3p^4(^3P)5s$	$^4P^\circ-^4P$ (42)	*3734.0*	*155257*	*182030*	12	12	1.1	0.23	34	0.44	D	4
			3765.27	155043	181594	6	6	0.98	0.21	15	0.10	D	4
			3720.43	155354	182222	4	4	0.17	0.035	1.7	−0.85	D	4
			3669.61	155708	182951	2	2	0.13	0.026	0.63	−1.28	D	4
			3678.27	155043	182222	6	4	0.25	0.034	2.5	−0.69	D	4
			3622.14	155354	182951	4	2	0.64	0.063	3.0	−0.60	D	4
			3809.46	155354	181594	4	6	0.44	0.14	7.2	−0.25	D	4
			3770.52	155708	182222	2	4	0.41	0.17	4.3	−0.47	D	4
64		$^4P^\circ-^2P$ (43)											
			3650.89	155708	183091	2	4	0.12	0.048	1.2	−1.02	D−	4
65		$^4D^\circ-^4P$ (52)											
			4103.91	157234	181594	8	6	1.2	0.23	25	0.26	D	4
			4033.82	158168	182951	4	2	0.98	0.12	6.3	−0.32	D	4
			4179.30	157673	181594	6	6	0.13	0.034	2.8	−0.69	D	4
			4156.09	158168	182222	4	4	0.39	0.10	5.5	−0.40	D	4
			4076.64	158428	182951	2	2	0.80	0.20	5.3	−0.40	D	4
66		$^4D^\circ-^2P$ (53)											
			4011.20	158168	183091	4	4	0.031	0.0075	0.40	−1.52	D−	4
67		$^2D^\circ-^4P$ (63)											
			4255.60	158730	182222	6	4	0.021	0.0038	0.32	−1.64	D−	4

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
68		$^2D^\circ-^2P$ (64)	*4102.1*	*158995*	*183366*	10	6	1.5	0.22	30	0.34	D	4
			4103.91	158730	183091	6	4	1.3	0.22	18	0.12	D	4
			4076.94	159393	183915	4	2	0.99	0.12	6.6	−0.32	D	4
			4218.67	159393	183091	4	4	0.36	0.096	5.3	−0.42	D	4
69		$^2P^\circ-^4P$ (76)											
			4547.76	160239	182222	4	4	0.077	0.024	1.4	−1.02	D−	4
70		$^2P^\circ-^2P$ (77)											
			4222.64	160239	183915	4	2	0.69	0.092	5.1	−0.43	D	4
			4275.16	159706	183091	2	4	0.26	0.14	4.0	−0.55	D	4
71		$^4S^\circ-^4P$ (85)	*4764.9*	161049	*182030*	4	12	0.17	0.18	11	−0.14	D	4
			4865.92	161049	181594	4	6	0.15	0.080	5.1	−0.49	D	4
			4721.59	161049	182222	4	4	0.15	0.050	3.1	−0.70	D	4
			4564.42	161049	182951	4	2	0.29	0.045	2.7	−0.74	D	4
72		$^4S^\circ-^2P$ (86)											
			4535.49	161049	183091	4	4	0.074	0.023	1.4	−1.04	D−	4
73	$3p^44p'-3p^4(^1D)5s'$	$^2F^\circ-^2D$ (105)											
			3946.10	170530	195865	8	6	1.4	0.25	25	0.30	D	4
			3925.72	170401	195867	6	4	1.4	0.22	17	0.12	D	4
74		$^2P^\circ-^2D$ (113)											
			4226.99	172214	195865	4	6	0.41	0.16	9.2	−0.19	D	4
			4337.07	172816	195867	2	4	0.34	0.19	5.5	−0.42	D	4
75		$^2D^\circ-^2D$ (127)											
			4448.88	173393	195865	6	6	0.65	0.19	17	0.06	D	4

Ar II

Forbidden Transitions

The line strength for the one transition in the ground state configuration is a straight number, tabulated for example by Naqvi [1]. The transition probability should also be quite accurate, since the energy level difference is accurately known.

Reference

[1] Naqvi, A. M., Thesis Harvard (1951).

Ar II. Forbidden Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	Type of Transition	A_{ki}(sec^{-1})	S(at.u.)	Accuracy	Source
1	$3p^5-3p^5$	$^2P^\circ-^2P^\circ$	[69842]	0	1431.41	4	2	*m*	0.0526	1.33	A	1

Ground State $1s^22s^22p^63s^23p^4\ ^3P_2$

Ionization Potential 40.90 eV = 329965.80 cm^{-1}

Allowed Transitions

List of tabulated lines:

Wavelength [Å]	No.	Wavelength [Å]	No.	Wavelength [Å]	No.
871.099	1	2345.17	6	3344.72	10
875.534	1	2484.11	4	3352.2	10
878.728	1	2493.0	4	3358.49	10
879.622	1	2499.9	4	3361.3	10
883.179	1	2508.91	4	3368.8	10
887.404	1	2518.2	4	3391.85	7
1669.1	2	2524.5	4	3424.3	7
1669.3	2	2533.92	4	3438.0	7
1669.67	2	2631.90	5	3471.4	7
1673.2	2	2632.4	5	3472.6	9
1673.43	2	2660.2	5	3480.55	9
1673.5	2	2677.9	5	3498.1	7
1675.6	2	2678.38	5	3498.3	7
1675.64	2	2724.84	5	3499.67	9
1914.40	3	2743.9	5	3500.5	9
1914.7	3	3024.05	11	3502.7	9
1915.56	3	3027.1	11	3503.58	9
1918.1	3	3037.0	11	3511.7	9
1918.6	3	3054.82	11		
1919.5	3	3064.77	11		
2242.29	6	3078.15	11		
2248.7	6	3285.85	8		
2263.2	6	3301.88	8		
2282.21	6	3311.25	8		
2297.1	6	3336.13	10		

Lawrence [1] has accurately measured the lifetime of the first excited state with the delayed-coincidence method. Using *LS*-coupling, we have derived the *f*-values for all components of the resonance multiplet. For numerous other transitions, including those involving shell-equivalent electrons, the Coulomb approximation has been employed in order to have data available for some of the more prominent lines in this spectrum. From the general success of this method and from comparisons with analogous transitions in other ions, uncertainties of 50 percent are normally expected; however, the uncertainties should be somewhat larger for those transitions involving shell-equivalent electrons.

Reference

[1] Lawrence, G. M., private communication (1968) and to be published.

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
1	$3s^23p^4-3s3p^5$	$^3P-^3P^\circ$ (1 uv)	*879.06*	*545*	*114303*	9	9	2.82	0.0327	0.85	−0.53	C	1
			878.728	0	113801	5	5	2.11	0.0245	0.354	−0.91	C	*ls*
			879.622	1112	114798	3	3	0.70	0.0082	0.071	−1.61	C	*ls*
			871.099	0	114798	5	3	1.21	0.0082	0.118	−1.387	C	*ls*
			875.534	1112	115328	3	1	2.84	0.0109	0.094	−1.485	C	*ls*
			887.404	1112	113801	3	5	0.68	0.0135	0.118	−1.393	C	*ls*
			883.179	1570	114798	1	3	0.92	0.0323	0.094	−1.491	C	*ls*
2	$3p^33d-3p^3(^4S^\circ)4p$	$^5D^\circ-^5P$ (6 uv)											
			1669.67	144907	204797	9	7	1.7	0.054	2.7	−0.31	E	*ca. ls*
			1673.43	144893	204649	7	5	1.2	0.036	1.4	−0.59	E	*ca. ls*
			1675.64	144886	204563	5	3	0.76	0.019	0.53	−1.02	E	*ca. ls*
			[1669.3]	144893	204797	7	7	0.43	0.018	0.70	−0.90	E	*ca. ls*
			[1673.5]	144893	204649	5	5	0.76	0.032	0.88	−0.80	E	*ca. ls*
			[1675.6]	144883	204563	3	3	0.97	0.041	0.68	−0.91	E	*ca. ls*
			[1669.1]	144886	204797	5	7	0.062	0.0036	0.10	−1.74	E	*ca. ls*
			[1673.2]	144883	204649	3	5	0.20	0.014	0.23	−1.39	E	*ca. ls*
3		$^3D^\circ-^3P$ (7 uv)	*1915.6*	*156943*	*209145*	15	9	2.1	0.071	6.7	0.03	E	*ca*
			1914.40	156918	209152	7	5	1.8	0.071	3.1	−0.31	E	*ls*
			1915.56	156925	209127	5	3	1.6	0.053	1.7	−0.58	E	*ls*
			[1918.1]	157031	209166	3	1	2.1	0.039	0.75	−0.93	E	*ls*
			[1914.7]	156925	209152	5	5	0.32	0.018	0.56	−1.05	E	*ls*
			[1919.5]	157031	209127	3	3	0.54	0.030	0.56	−1.05	E	*ls*
			[1918.6]	157031	209152	3	5	0.021	0.0020	0.037	−2.23	E	*ls*
4	$3p^33d'-3p^3(^2D^\circ)4p'$	$^3F^\circ-^3F$ (8 uv)	*2504.1*	*186606*	*226529*	21	21	0.31	0.029	5.1	−0.21	E	*ca*
			2484.11	186402	226646	9	9	0.30	0.027	2.0	−0.61	E	*ls*
			2508.91	186657	226503	7	7	0.26	0.025	1.4	−0.76	E	*ls*
			2533.92	186903	226356	5	5	0.27	0.026	1.1	−0.88	E	*ls*
			[2493.0]	186402	226503	9	7	0.025	0.0018	0.14	−1.78	E	*ls*
			[2518.2]	186657	226356	7	5	0.034	0.0023	0.14	−1.79	E	*ls*
			[2499.9]	186657	226646	7	9	0.020	0.0024	0.14	−1.78	E	*ls*
			[2524.5]	186903	226503	5	7	0.025	0.0033	0.14	−1.79	E	*ls*
5		$^3D^\circ-^3D$ (9 uv)	*2690.3*	*188108*	*225268*	15	15	0.48	0.052	7.0	−0.10	E	*ca*
			2724.84	188714	225403	7	7	0.42	0.047	3.0	−0.48	E	*ls*
			2678.38	187823	225148	5	5	0.34	0.036	1.6	−0.74	E	*ls*
			2631.90	187171	225155	3	3	0.37	0.039	1.0	−0.93	E	*ls*
			[2743.9]	188714	225148	7	5	0.073	0.0059	0.37	−1.39	E	*ls*
			[2677.9]	187823	225155	5	3	0.12	0.0078	0.35	−1.41	E	*ls*
			[2660.2]	187823	225403	5	7	0.055	0.0081	0.36	−1.39	E	*ls*
			[2632.4]	187171	225148	3	5	0.075	0.013	0.34	−1.41	E	*ls*
6		$^3D^\circ-^3P$ (10 uv)	*2304.8*	*188108*	*231483*	15	9	0.65	0.031	3.5	−0.33	E	*ca*
			2345.17	188714	231342	7	5	0.54	0.032	1.7	−0.66	E	*ls*
			2282.21	187823	231627	5	3	0.49	0.023	0.87	−0.94	E	*ls*
			2242.29	187171	231755	3	1	0.67	0.017	0.37	−1.30	E	*ls*
			[2297.1]	187823	231342	5	5	0.098	0.0077	0.29	−1.41	E	*ls*
			[2248.7]	187171	231627	3	3	0.17	0.013	0.28	−1.42	E	*ls*
			[2263.2]	187171	231342	3	5	0.0066	8.5×10^{-4}	0.019	−2.60	E	*ls*
7	$3d^33d''-3p^3(^2P^\circ)4p''$	$^3P^\circ-^3P$ (6)	*3432.6*	*214152*	*243276*	9	9	0.25	0.044	4.4	−0.41	E	*ca*
			3391.85	213951	243425	5	5	0.19	0.033	1.8	−0.79	E	*ls*
			[3471.4]	214347	243146	3	3	0.060	0.011	0.37	−1.49	E	*ls*
			[3424.3]	213951	243146	5	3	0.10	0.011	0.61	−1.26	E	*ls*
			[3498.3]	214347	242924	3	1	0.24	0.015	0.50	−1.36	E	*ls*
			[3438.0]	214347	243425	3	5	0.062	0.018	0.62	−1.26	E	*ls*
			[3498.1]	214568	243147	1	3	0.079	0.044	0.50	−1.36	E	*ls*

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	$\log gf$	Accuracy	Source
8	$3p^34s-3p^3(^4S^\circ)4p$	$^5S^\circ-^5P$ (1)	*3296.6*	174375	*204701*	5	15	2.0	0.99	54	0.69	D	*ca*
			3285.85	174375	204797	5	7	2.0	0.46	25	0.37	D	*ls*
			3301.88	174375	204649	5	5	2.0	0.33	18	0.22	D	*ls*
			3311.25	174375	204564	5	3	2.0	0.20	11	−0.01	D	*ls*
9	$3p^34s'-3p^3(^2D^\circ)4p'$	$^3D^\circ-^3D$ (2)	*3492.1*	*196640*	*225268*	15	15	1.7	0.32	54	0.68	D	*ca*
			3480.55	196680	225403	7	7	1.6	0.28	23	0.29	D	*ls*
			3503.58	196614	225148	5	5	1.2	0.22	13	0.04	D	*ls*
			3499.67	196589	225155	3	3	1.3	0.24	8.1	−0.15	D	*ls*
			[3511.7]	196680	225148	7	5	0.26	0.035	2.8	−0.61	D−	*ls*
			[3502.7]	196614	225155	5	3	0.43	0.047	2.7	−0.63	D−	*ls*
			[3472.6]	196614	225403	5	7	0.20	0.049	2.8	−0.61	D−	*ls*
			[3500.5]	196589	225148	3	5	0.26	0.078	2.7	−0.63	D−	*ls*
10		$^3D^\circ-^3F$ (3)	*3344.8*	*196640*	*226529*	15	21	2.0	0.46	76	0.84	D	*ca*
			3336.13	196680	226646	7	9	2.0	0.43	33	0.47	D	*ls*
			3344.72	196614	226503	5	7	1.8	0.41	23	0.31	D	*ls*
			3358.49	196589	226356	3	5	1.6	0.46	15	0.14	D	*ls*
			[3352.2]	196680	226503	7	7	0.22	0.037	2.8	−0.59	D−	*ls*
			[3361.3]	196614	226356	5	5	0.30	0.051	2.8	−0.59	D−	*ls*
			[3368.8]	196680	226356	7	5	0.0085	0.0010	0.081	−2.15	E	*ls*
11	$3p^34s''-3p^3(^2P)4p''$	$^3P^\circ-^3D$ (4)	*3041.4*	*207382*	*240252*	9	15	2.5	0.58	52	0.72	D	*ca*
			3024.05	207233	240292	5	7	2.6	0.49	24	0.39	D	*ls*
			3054.82	207532	240258	3	5	1.9	0.44	13	0.11	D	*ls*
			3078.15	207673	240151	1	3	1.4	0.58	5.9	−0.24	D−	*ls*
			[3027.1]	207233	240258	5	5	0.64	0.088	4.4	−0.36	D−	*ls*
			3064.77	207532	240151	3	3	1.0	0.15	4.4	−0.36	D−	*ls*
			[3037.0]	207233	240151	5	3	0.070	0.0058	0.29	−1.54	E	*ls*

Ar III

Forbidden Transitions

The adopted values have been derived from Naqvi [1], and Czyzak and Krueger [2]. Since their methods are essentially alike, Naqvi's and Czyzak and Krueger's magnetic dipole transitions have been averaged, except for the $^3P-^1S$ transition where configuration interaction is important. In this case Czyzak and Krueger's empirically derived value has been preferred over Naqvi's, which is based purely on theory (see also General Introduction).

References

[1] Naqvi, A. M., Thesis Harvard (1951).
[2] Czyzak, S. J. & Krueger, T. K., Monthly Notices Roy. Astron. Soc. **126**, 177–194 (1963).

Ar III. Forbidden Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	Type of Transition	A_{ki}(sec^{-1})	S(at.u.)	Accuracy	Source
1	$3p^4-3p^4$	$^3P-^3P$										
			[89896]	0.00	1112.1	5	3	*e*	3.62×10^{-7}	3.80	C	2
			[89896]	0.00	1112.1	5	3	*m*	0.0308	2.49	B	1
			[63669]	0.00	1570.20	5	1	*e*	2.72×10^{-6}	1.69	C	2
			[21.823×10^4]	1112.1	1570.20	3	1	*m*	0.00519	2.00	A	1
2		$^3P-^1D$ (1F)										
			7135.80	0.00	14010.0	5	5	*e*	0.0014	0.077	D	2
			7135.80	0.00	14010.0	5	5	*m*	0.0321	0.00216	C	1, 2
			7751.06	1112.1	14010.0	3	5	*e*	1.3×10^{-4}	0.011	D	2
			7751.06	1112.1	14010.0	3	5	*m*	0.083	0.0072	C	1, 2
			[8036.5]	1570.20	14010.0	1	5	*e*	2.9×10^{-5}	0.0029	D	2
3		$^3P-^1S$ (2F)										
			3005.1	0.00	33265.7	5	1	*e*	0.043	0.0062	D	2
			3109.0	1112.1	33265.7	3	1	*m*	4.02	0.00448	C	2
4		$^1D-^1S$ (3F)										
			5191.82	14010.0	33265.7	5	1	*e*	3.10	7.0	C	2

Ar IV

Ground State $1s^22s^22p^63s^23p^3\ ^4S^\circ_{3/2}$

Ionization Potential 59.79 eV = 482400 cm^{-1}

Allowed Transitions

List of tabulated lines:

Wavelength [Å]	No.	Wavelength [Å]	No.	Wavelength [Å]	No.
840.029	1	2640.34	3	2809.44	2
843.772	1	2682.6	3	2818.3	2
850.602	1	2757.92	5	2830.3	2
2562.1	3	2776.26	2	2852.0	2
2565.5	3	2782.9	5	2874.4	2
2568.1	3	2784.47	5	2913.0	4
2608.06	3	2788.96	2	2926.3	4
2615.7	3	2797.1	2	3037.98	4

Lawrence [1] has accurately measured the lifetime of the first excited state with the delayed-coincidence method. Using *LS*-coupling, we have derived the *f*-values for all components of the resonance multiplet. For several other transitions the Coulomb approximation has been employed in order to have some data on the more prominent lines in this spectrum. From the general success of this method and from comparisons with analogous transitions in other ions, uncertainties of 50 percent are expected; however these estimates should be regarded as provisional.

Reference

[1] Lawrence, G. M., private communication (1968) and to be published.

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
1	$3s^23p^3-3s3p^4$	$^4S^\circ-^4P$ (1 uv)	*846.54*	0	*118128*	4	12	2.67	0.086	0.96	−0.463	C	1
			850.602	0	117564	4	6	2.63	0.0429	0.480	−0.77	C	*ls*
			843.772	0	118515	4	4	2.70	0.0288	0.320	−0.94	C	*ls*
			840.029	0	119044	4	2	2.73	0.0145	0.160	−1.237	C	*ls*
2	$3p^24s-3p^2(^3P)4p$	$^4P-^4D^\circ$ (4 uv)	*2810.9*	*251325*	*286890*	12	20	2.6	0.51	57	0.79	D	*ca*
			2809.44	251972	287556	6	8	2.6	0.41	23	0.39	D	*ls*
			2788.96	250907	286752	4	6	1.9	0.32	12	0.11	D	*ls*
			2776.26	250219	286229	2	4	1.1	0.26	4.7	−0.29	D−	*ls*
			[2874.4]	251972	286752	6	6	0.73	0.091	5.1	−0.27	D−	*ls*
			[2830.3]	250907	286229	4	4	1.4	0.16	6.0	−0.19	D−	*ls*
			[2797.1]	250219	285960	2	2	2.2	0.26	4.7	−0.29	D−	*ls*
			[2818.3]	251972	286229	6	4	0.13	0.010	0.57	−1.21	E	*ls*
			[2852.0]	250907	285960	4	2	0.41	0.025	0.94	−0.99	E	*ls*
3		$^4P-^4P^\circ$ (5 uv)	*2617.5*	*251325*	*289518*	12	12	3.2	0.33	34	0.60	D	*ca*
			2640.34	251972	289835	6	6	2.2	0.23	12	0.14	D	*ls*
			2608.06	250907	289238	4	4	0.43	0.044	1.5	−0.75	E	*ls*
			[2565.5]	250219	289126	2	2	0.57	0.056	0.94	−0.95	E	*ls*
			[2682.6]	251972	289238	6	4	1.4	0.097	5.2	−0.23	D−	*ls*
			[2615.7]	250907	289126	4	2	2.7	0.14	4.7	−0.26	D−	*ls*
			[2568.1]	250907	289835	4	6	1.0	0.15	5.1	−0.22	D−	*ls*
			[2562.1]	250219	289238	2	4	1.4	0.28	4.7	−0.25	D−	*ls*
4		$^2P-^2D^\circ$ (2)	*2925.4*	*256930*	*291103*	6	10	2.4	0.52	30	0.49	D	*ca*
			[2913.0]	257349	291668	4	6	2.5	0.47	18	0.27	D	*ls*
			[2926.3]	256093	290256	2	4	2.0	0.51	9.9	0.01	D	*ls*
			3037.98	257349	290256	4	4	0.36	0.050	2.0	−0.70	E	*ls*
5	$3p^24s'-3p^2(^1D)4p'$	$^2D-^2F^\circ$ (6 uv)	*2769.2*	*268159*	*304260*	10	14	2.7	0.44	40	0.64	D	*ca*
			2757.92	268151	304400	6	8	2.8	0.42	23	0.40	D	*ls*
			2784.47	268171	304074	4	6	2.5	0.44	16	0.24	D	*ls*
			[2782.9]	268151	304074	6	6	0.18	0.021	1.1	−0.90	E	*ls*

Ar IV

Forbidden Transitions

All the values for this ion are taken from Czyzak and Krueger [1], since they have included the important effects of configuration interaction and have used self-consistent field wavefunctions with exchange to obtain their value of s_q. (For a more complete discussion see General Introduction.)

Reference

[1] Czyzak, S. J. & Krueger, T. K., Monthly Notices Roy. Astron. Soc. **126**, 177–194 (1963).

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	Type of Transition	A_{ki}(sec^{-1})	S(at.u.)	Accuracy	Source
1	$3p^3-3p^3$	$^4S^\circ-^2D^\circ$ (1F)										
			4711.33	0.00	21219.5	4	6	*m*	0.00160	3.72×10^{-5}	C	1
			4711.33	0.00	21219.5	4	6	*e*	0.0080	0.066	D	1
			4740.20	0.00	21090.3	4	4	*m*	0.072	0.00113	C	1
			4740.20	0.00	21090.3	4	4	*e*	0.0051	0.029	D	1
2		$S^\circ-^2P^\circ$										
			[2853.6]	0.00	35032.3	4	4	*m*	2.55	0.0088	C	1
			[2853.6]	0.00	35032.3	4	4	*e*	1.6×10^{-5}	7.0×10^{-6}	D	1
			[2868.2]	0.00	34855.4	4	2	*m*	0.97	0.00170	C	1
			[2868.2]	0.00	34855.4	4	2	*e*	1.2×10^{-4}	2.8×10^{-5}	D	1
3		$^2D^\circ-^2D^\circ$										
			[77.38×10^4]	21090.3	21219.5	4	6	*m*	2.33×10^{-5}	2.40	A	1
			[77.38×10^4]	21090.3	21219.5	4	6	*e*	1.1×10^{-13}	0.11	D	1
4		$^2D^\circ-^2P^\circ$ (2F)										
			7237.26	21219.5	35032.3	6	4	*m*	0.444	0.0249	C	1
			7237.26	21219.5	35032.3	6	4	*e*	0.226	10.7	C	1
			7262.76	21090.3	34855.4	4	2	*m*	0.488	0.0139	C	1
			7262.76	21090.3	34855.4	4	2	*e*	0.190	4.57	C	1
			7332.0	21219.5	34855.4	6	2	*e*	0.122	3.08	C	1
			7170.62	21090.3	35032.3	4	4	*m*	0.81	0.0445	C	1
			7170.62	21090.3	35032.3	4	4	*e*	0.098	4.42	C	1
5		$^2P^\circ-^2P^\circ$										
			[56.51×10^4]	34855.4	35032.3	2	4	*m*	4.97×10^{-5}	1.33	A	
			[56.51×10^4]	34855.4	35032.3	2	4	*e*	4.1×10^{-13}	0.055	D	1

Ar V

Ground State $1s^22s^22p^63s^23p^2\ ^3P_0$

Ionization Potential 75.0 eV = 605100 cm^{-1}

Allowed Transitions

A value is available for one multiplet of this ion from the screening-approximation calculations of Varsavsky [1]. This result should be quite uncertain (probably too high, as judged from comparisons in other ions), since the possibly important effects of configuration interaction have not been taken into account.

Reference

[1] Varsavsky, C. M., Astrophys. J. Suppl. Ser. **6**, No. 53, 75 (1961).

Ar V. Allowed Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
1	$3s^23p^2-3s3p^3$	$^3P-^3D^\circ$ (1 uv)	*830.94*	*1384*	*121730*	9	15	29	0.50	12	0.66	E	1
			834.878	2032	121810	5	7	29	0.42	5.8	0.32	E	*ls*
			827.055	765	121678	3	5	22	0.38	3.1	0.06	E	*ls*
			822.159	0	121632	1	3	17	0.51	1.4	−0.29	E	*ls*
			[835.80]	2032	121678	5	5	7.2	0.075	1.0	−0.43	E	*ls*
			[827.36]	765	121632	3	3	12	0.13	1.0	−0.42	E	*ls*
			[836.12]	2032	121632	5	3	0.80	0.0051	0.070	−1.60	E	*ls*

Ar V

Forbidden Transitions

The adopted values have been derived from Naqvi [1], and Czyzak and Krueger [2]. Since their methods are essentially alike, Naqvi's and Czyzak and Krueger's magnetic dipole transitions have normally been averaged, except for the $^3P-^1S$ transition where configuration interaction is important. In this case Czyzak and Krueger's empirically derived value has been preferred over Naqvi's, which is based purely on theory (see also General Introduction).

References

[1] Naqvi, A. M., Thesis Harvard (1951).
[2] Czyzak, S. J. & Krueger, T. K., Monthly Notices Roy. Astron. Soc. **126**, 177–194 (1963).

Ar V. Forbidden Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	Type of Transition	A_{ki}(sec^{-1})	S(at.u.)	Accuracy	Source
1	$3p^2-3p^2$	$^3P-^3P$										
			[13.07 × 10^4]	0	765	1	3	*m*	0.00805	2.00	A	1
			[49199]	0	2032	1	5	*e*	1.33 × 10^{-6}	1.14	C	2
			[78905]	765	2032	3	5	*m*	0.0273	2.49	B	1
			[78905]	765	2032	3	5	*e*	2.79 × 10^{-7}	2.54	C	2
2		$^3P-^1D$ (1F)										
			6131.0	0	16301	1	5	*e*	4.9 × 10^{-5}	0.0013	D	2
			6435.10	765	16301	3	5	*m*	0.223	0.0110	C	1, 2
			6435.10	765	16301	3	5	*e*	3.5 × 10^{-4}	0.011	D	2
			7005.67	2032	16301	5	5	*m*	0.52	0.0329	C	1, 2
			7005.67	2032	16301	5	5	*e*	0.0016	0.079	D	2
3		$^3P-^1S$										
			[2691.1]	765	37914	3	1	*m*	6.8	0.00493	C	2
			[2786.1]	2032	37914	5	1	*e*	0.081	0.0081	D	2
4		$^1D-^1S$ (2F)	4625.54	16301	37914	5	1	*e*	3.8	4.8	D	2

Ar VI

Ground State $1s^2 2s^2 2p^6 3s^2 3p\ ^2P^\circ_{1/2}$

Ionization Potential 91.3 eV = 736600 cm^{-1}

Allowed Transitions

The screening-approximation calculations of Varsavsky [1] for the $3s^2 3p\ ^2P^\circ - 3s3p^2\ ^2D$ multiplet are considered to be rather uncertain (probably too high, as judged from comparisons in other ions) since the important effects of configuration mixing are neglected entirely. Gruzdev and Prokofev [2] have carried out Coulomb approximation calculations modified with the Seaton correction for the $3p\ ^2P^\circ - 4s\ ^2S$ multiplet; these results should be reliable to within 25 percent, as judged from plots depicting f-value dependence on nuclear charge.

References

[1] Varsavsky, C. M., Astrophys. J. Suppl. Ser. **6**, No. 53, 75 (1961).
[2] Gruzdev, P. F., and Prokofev, V. K., Optics and Spectroscopy (U.S.S.R.) **21**, 151–152 (1966).

Ar VI. Allowed Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
1	$3s^2 3p - 3s3p^2$	$^2P^\circ - ^2D$	*763.00*	*1473*	*132534*	6	10	33	0.48	7.3	0.46	E	1
			[767.06]	2210	132578	4	6	33	0.44	4.4	0.25	E	*ls*
			[754.93]	0	132468	2	4	28	0.48	2.4	−0.02	E	*ls*
			[767.71]	2210	132468	4	4	5.4	0.048	0.48	−0.72	E	*ls*
2	$3p - (^1S)4s$	$^2P^\circ - ^2S$	*293.42*	*1473*	342286	6	2	205	0.088	0.51	−0.277	C	2
			[294.05]	2210	342286	4	2	136	0.088	0.341	−0.453	C	*ls*
			[292.15]	0	342286	2	2	69	0.088	0.169	−0.75	C	*ls*

Ar VI

Forbidden Transitions

The line strength for the one transition in the ground state configuration is a straight number, tabulated for example by Naqvi [1]. The transition probability should also be quite accurate, since the energy level difference is accurately known.

Reference

[1] Naqvi, A. M., Thesis Harvard (1951).

Ar VI. Forbidden Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	Type of Transition	A_{ki}(sec^{-1})	S(at.u.)	Accuracy	Source
1	$3p - (^1S)3p$	$^2P^\circ - ^2P^\circ$	[45237]	0	2210	2	4	m	0.097	1.33	A	1

Ar VII

Ground State $1s^2 2s^2 2p^6 3s^2\ {}^1S_0$

Ionization Potential 124.0 eV = 1000400 cm^{-1}

Allowed Transitions

The charge-expansion technique of Crossley and Dalgarno [1], which includes limited configuration mixing, has been employed for the majority of the transitions in this spectrum; while Gruzdev and Prokofev [2] have carried out Coulomb approximation calculations modified with the Seaton correction for the $3s3p\ {}^3P^\circ - 3s4s\ {}^3S$ multiplet. For many of these transitions, the dependence of oscillator strength on nuclear charge has served as an aid in estimating accuracies.

References

[1] Crossley, R. J. S., and Dalgarno, A., Proc. Roy. Soc. London **A286**, 510 (1965).

[2] Gruzdev, P. F., and Prokofev, V. K., Optics and Spectroscopy (U.S.S.R.) **21**, 151–152 (1966).

Ar VII. Allowed Transitions

No.	Transition Array	Multiplet	γ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at. u.)	log gf	Accuracy	Source
1	$3s^2 - 3s(^2S)3p$	${}^1S - {}^1P^\circ$	[585.75]	0	170720	1	3	78.3	1.21	2.33	0.083	B	1
2	$3s3p - 3p^2$	${}^3P^\circ - {}^3P$	*637.30*	[*114744*]	[*271657*]	9	9	67	0.408	7.7	0.56	C+	1
			[637.05]	[115581]	[272554]	5	5	50	0.306	3.21	0.185	C+	*ls*
			[637.47]	[113900]	[270770]	3	3	16.7	0.102	0.64	−0.51	C	*ls*
			[644.38]	[115581]	[270770]	5	3	27.0	0.101	1.07	−0.297	C	*ls*
			[641.32]	[113900]	[269829]	3	1	66	0.136	0.86	−0.389	C	*ls*
			[630.30]	[113900]	[272554]	3	5	17.3	0.172	1.07	−0.287	C	*ls*
			[634.22]	[113095]	[270770]	1	3	22.8	0.412	0.86	−0.385	C	*ls*
3	$3s3p - 3s(^2S)3d$	${}^3P^\circ - {}^3D$	*477.55*	[*114744*]	[*324147*]	9	15	99.2	0.565	8.00	0.706	B	1
			[479.38]	[115581]	[324184]	5	7	98.0	0.473	3.73	0.374	B	*ls*
			[475.66]	[113900]	[324136]	3	5	75.3	0.426	2.00	0.107	B	*ls*
			[473.97]	[113095]	[324079]	1	3	56.4	0.570	0.889	−0.244	B	*ls*
			[479.49]	[115581]	[324136]	5	5	24.5	0.0845	0.667	−0.374	B	*ls*
			[475.78]	[113900]	[324079]	3	3	41.8	0.142	0.667	−0.371	B	*ls*
			[479.62]	[115581]	[324079]	5	3	2.7	0.0056	0.044	−1.55	D	*ls*
4	$3s3p - 3s(^2S)4s$	${}^3P^\circ - {}^3S$	*250.41*	[*114744*]	[514083]	9	3	278	0.087	0.65	−0.106	C	2
			[250.94]	[115581]	[541083]	5	3	154	0.087	0.359	−0.362	C	*ls*
			[249.89]	[113900]	[541083]	3	3	93	0.087	0.215	−0.58	C	*ls*
			[249.38]	[113095]	[514083]	1	3	31.1	0.087	0.071	−1.060	C	*ls*

Ar VII

Forbidden Transitions

Naqvi's calculations [1] are the only available source. The results for the ${}^3P^\circ - {}^3P^\circ$ transitions are essentially independent of the choice of the interaction parameters. For the ${}^3P^\circ - {}^1P^\circ$ transitions, Naqvi uses empirical term intervals, i.e., the effects of configuration interaction should be partially included.

Reference

[1] Naqvi, A. M., Thesis Harvard (1951).

308-022 O-69—17

Ar VII. Forbidden Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	Type of Transition	A_{ki}(sec^{-1})	S(at.u.)	Accuracy	Source
1	$3s3p-3s(^2S)3p$	$^3P^\circ-^3P^\circ$	[12.42 × 10⁴]	[113095]	[113900]	1	3	*m*	0.00939	2.00	B	1
			[59470]	[113900]	[115581]	3	5	*m*	0.0641	2.50	B	1
2		$^3P^\circ-^1P^\circ$	[1735.4]	[113095]	170720	1	3	*m*	1.34	7.8×10^{-4}	C−	1
			[1759.9]	[113900]	170720	3	3	*m*	48.8	0.0296	C−	1
			[1813.6]	[115581]	170720	5	3	*m*	1.47	9.7×10^{-4}	C−	1

Ar VIII

Ground State $1s^22s^22p^63s\ ^2S_{1/2}$

Ionization Potential 143.46 eV = 1157400 cm^{-1}

Allowed Transitions

List of tabulated lines:

Wavelength [Å]	No.	Wavelength [Å]	No.	Wavelength [Å]	No.
120.09	3	337.09	6	545.90	11
120.16	3	337.26	6	700.24	1
158.92	2	338.22	6	713.81	1
159.17	2	519.43	4	1444.4	10
184.30	8	526.45	4	1463.9	10
229.44	5	526.87	4	1465.5	10
230.88	5	542.94	11	1875.2	9
260.30	7			1910.9	9

The only source available for this ion are the charge-expansion calculations of Crossley and Dalgarno [1] which include limited configuration mixing. Graphical comparisons of this work with more refined values within the isoelectronic sequence indicate accuracies within 25 percent. A number of additional values have been obtained from studies of the f-value dependence on nuclear charge. The reliable material available for other ions of this isoelectronic sequence in these cases permits the determination of reliable values simply by graphical interpolation.

Reference

[1] Crossley, R. J. S., and Dalgarno, A., Proc. Roy. Soc. London **A286**, 510–518 (1965).

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
1	$3s-3p$	$^2S-^2P^\circ$	*704.87*	0	*141870*	2	6	25.4	0.57	2.63	0.057	C	1
			[700.24]	0	142776	2	4	25.8	0.380	1.75	−0.119	C	*ls*
			[713.81]	0	140058	2	2	24.5	0.187	0.88	−0.427	C	*ls*
2	$3s-4p$	$^2S-^2P^\circ$	*159.01*	0	*628905*	2	6	110	0.12	0.13	−0.62	C	interp
			[158.92]	0	629237	2	4	110	0.083	0.087	−0.78	C	*ls*
			[159.17]	0	628240	2	2	110	0.041	0.043	−1.09	C	*ls*
3	$3s-5p$	$^2S-^2P^\circ$	*120.11*	0	*832542*	2	6	60	0.039	0.031	−1.11	D	interp
			[120.09]	0	832691	2	4	61	0.027	0.021	−1.27	D	*ls*
			[120.16]	0	832245	2	2	58	0.013	0.010	−1.59	D	*ls*
4	$3p-3d$	$^2P^\circ-^2D$	*524.12*	*141870*	*332667*	6	10	73	0.50	5.2	0.477	C	1
			[526.45]	142776	332727	4	6	72	0.450	3.12	0.255	C	*ls*
			[519.43]	140058	332576	2	4	63	0.51	1.73	0.009	C	*ls*
			[526.87]	142776	332576	4	4	12	0.050	0.35	−0.70	D	*ls*
5	$3p-4s$	$^2P^\circ-^2S$	*230.39*	*141870*	575910	6	2	350	0.093	0.42	−0.25	C	interp
			[230.88]	142776	575910	4	2	230	0.092	0.28	−0.43	C	*ls*
			[229.44]	140058	575910	2	2	120	0.093	0.14	−0.73	C	*ls*
6	$3d-4p$	$^2D-^2P^\circ$	*337.57*	*332667*	*628905*	10	6	120	0.12	1.3	0.08	C	interp
			[337.26]	332727	629237	6	4	100	0.12	0.78	−0.14	C	*ls*
			[338.22]	332576	628240	4	2	110	0.097	0.43	−0.41	C	*ls*
			[337.09]	332576	629237	4	4	12	0.020	0.087	−1.10	D	*ls*
7	$3d-4f$	$^2D-^2F^\circ$	*260.30*	*332667*	*716837*	10	14	650	0.92	7.9	0.96	C+	interp
8	$3d-5f$	$^2D-^2F^\circ$	*184.30*	*332667*	*875265*	10	14	240	0.17	1.0	0.23	C	interp
9	$4s-4p$	$^2S-^2P^\circ$	*1887.0*	575910	*628905*	2	6	5.1	0.82	10	0.21	C	interp
			[1875.2]	575910	629237	2	4	5.1	0.54	6.7	0.03	C	*ls*
			[1910.9]	575910	628240	2	2	4.8	0.26	3.3	−0.28	C	*ls*
10	$4p-4d$	$^2P^\circ-^2D$	*1457.5*	*628905*	*697517*	6	10	17	0.92	26	0.74	C	interp
			[1463.9]	629237	697548	4	6	17	0.83	16	0.52	C	*ls*
			[1444.4]	628240	697471	2	4	15	0.91	8.7	0.26	C	*ls*
			[1465.5]	629237	697471	4	4	2.7	0.088	1.7	−0.45	D	*ls*
11	$4p-5s$	$^2P^\circ-^2S$	*544.91*	*628905*	812422	6	2	110	0.16	1.7	−0.02	C	interp
			[545.90]	629237	812422	4	2	68	0.15	1.1	−0.22	C	*ls*
			[542.94]	628240	812422	2	2	36	0.16	0.57	−0.49	C	*ls*

Ar IX

Ground State $1s^22s^22p^6\ ^1S_0$

Ionization Potential 422.6 eV

Allowed Transitions

Calculations by Kastner, Omidvar, and Underwood [1], employing Hartree-Fock wave functions and including intermediate coupling, are available. Since the calculations are based on a single-configuration approximation only, uncertainties of up to 50 percent are expected for the strong lines and even higher uncertainties for the weak lines, the latter being more affected by assumptions about the coupling.

Reference

[1] Kastner, S. O., Omidvar, K., and Underwood, J. H., Astrophys. J. **148**, 269–273 (1967).

Ar IX. Allowed Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
1	$2p^6-2p^5(^2P^\circ_{3/2})3s$	$^1S-^3P^\circ$	[49.180]	0	2033350	1	3	480	0.052	0.0084	−1.28	E	1
2	$2p^6-2p^5(^2P^\circ_{1/2})3s$	$^1S-^1P^\circ$	[48.730]	0	2052120	1	3	1300	0.14	0.022	−0.85	D	1

Ar X

Ground State $1s^22s^22p^5\ ^2P^\circ_{3/2}$

Ionization Potential ?

Forbidden Transitions

The line strength for the one transition in the ground state configuration is a straight number, tabulated for example by Naqvi [1]. The transition probability is not as accurate, since the energy level difference is not accurately known.

Reference

[1] Naqvi, A. M., Thesis Harvard (1951).

Ar X. Forbidden Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	Type of Transition	A_{ki}(sec^{-1})	S(at.u.)	Accuracy	Source
1	$2p^5-2p^5$	$^2P^\circ-^2P^\circ$ (1F)	5536	0	[18059]	4	2	m	106	1.33	B	1

Ar XI

Ground State $1s^22s^22p^4\ ^3P_2$

Ionization Potential ?

Forbidden Transitions

The sources used in deriving the adopted values are Naqvi [1], and Malville and Berger [2]. The electric quadrupole value of Naqvi has been modified by substituting Malville and Berger's quadrupole moment s_q, since this is obtained from self-consistent field wave functions, while Naqvi used the less elaborate screened hydrogenic wave functions.

References

[1] Naqvi, A. M., Thesis Harvard (1951).
[2] Malville, J. M. and Berger, R. A., Planetary and Space Science **13**, 1131 (1965).

Ar XI. Forbidden Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	Type of Transition	A_{ki}(sec^{-1})	S(at.u.)	Accuracy	Source
1	$2p^4-2p^4$	$^3P-^3P$ (1F)										
			6919	0	14449	5	3	e	3.9×10^{-4}	0.011	D	1, 2
			6919	0	14449	5	3	m	66.5	2.45	B	1

Ar XIII

Ground State $1s^22s^22p^2\ ^3P_0$

Ionization Potential ?

Forbidden Transitions

Krueger and Czyzak's [1] values have been used for this ion, except for the magnetic dipole $^3P_{0,1}-^3P_{1,3}$ transitions where Naqvi's [2] results have been applied. Some wavelength data are from observed coronal lines. The electric quadrupole moment (s_q) is based on self-consistent field wave functions with exchange.

References

[1] Krueger, T. K. and Czyzak, S. J., Astrophys. J. **144**, 1194–1202 (1966).
[2] Naqvi, A. M., Thesis Harvard (1951).

Ar XIII. Forbidden Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	Type of Transition	A_{ki}(sec^{-1})	S(at.u.)	Accuracy	Source
1	$2p^2-2p^2$	$^3P-^3P$										
			[9960]	0	[10040]	1	3	m	17.9	1.97	B−	2
			[4579]	0	[21835]	1	5	e	7.9×10^{-4}	0.0047	C−	1
			8475.7	[10040]	[21835]	3	5	m	21.5	2.43	B	2
			8475.7	[10040]	[21835]	3	5	e	7.4×10^{-5}	0.0097	C	1
		$^3P-^1D$										
			[1165]	0	[85840]	1	5	e	0.0022	1.4×10^{-5}	D−	1
			[1319]	[10040]	[85840]	3	5	m	242	0.103	C	1
			[1319]	[10040]	[85840]	3	5	e	0.035	4.2×10^{-4}	D	1
			[1562]	[21835]	[85840]	5	5	m	420	0.296	C	1
			[1562]	[21835]	[85840]	5	5	e	0.10	0.0028	D	1
		$^3P-^1S$										
			[675.3]	[10040]	[158100]	3	1	m	3030	0.0346	C	1
			[733.7]	[21835]	[158100]	5	1	e	2.7	3.4×10^{-4}	D	1
		$^1D-^1S$										
			[1383]	[85840]	[158100]	5	1	e	5.5	0.017	D	1

Ar XIV

Ground State $1s^22s^22p\ ^2P^\circ_{1/2}$

Ionization Potential ?

Forbidden Transitions

The line strength for the one transition in the ground state configuration is a straight number, tabulated for example by Naqvi [1]. The transition probability should also be quite accurate, since the energy level difference is accurately known

Reference

[1] Naqvi, A. M., Thesis Harvard (1951).

Ar XIV. Forbidden Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	Type of Transition	A_{ki}(sec^{-1})	S(at.u.)	Accuracy	Source
1	$2p-2p$	$^2P^\circ-^2P^\circ$	4412.4	0	22657	2	4	m	104	1.33	A	1

POTASSIUM

K I

Ground State $1s^2 2s^2 2p^6 3s^2 3p^6 4s\ ^2S_{1/2}$

Ionization Potential 4.339 eV = 35009.78 cm^{-1}

Allowed Transitions

List of tabulated lines:

Wavelength [Å]	No.	Wavelength [Å]	No.	Wavelength [Å]	No.
2927.5	24	6964.18	35	10904	73
2942.7	23	6964.69	35	10925	81
2963.2	22	7541.5	66	10927	73
2992.2	21	7618.9	65	10948	81
3034.8	20	7664.91	15	11022.3	10
3101.9	19	7698.98	15	11237	72
3217.15	18	7722.3	64	11261	72
3217.62	18	7865.5	63	11270	80
3246.38	17	8037.3	8	11294	80
3247.41	17	8038.9	8	11690.2	34
4044.15	16	8039.3	8	11744	71
4047.21	16	8072.5	62	11769.7	34
4741.6	33	8192.5	7	11770	71
4744.4	42	8194.1	7	11772.8	34
4754.6	33	8194.6	7	11793	79
4757.4	42	8250.2	14	11820	79
4786.9	32	8251.7	14	12432.2	25
4791.0	41	8390.3	61	12522.1	25
4800.2	32	8391.5	61	12526	58
4804.3	41	8417.3	6	12540	58
4850.0	31	8419.0	6	12580	70
4856.1	40	8419.8	6	12610	70
4863.6	31	8503.5	13	12659	78
4869.8	40	8505.3	13	12690	78
4942.0	30	8763.6	5	13377.9	2
4950.8	39	8765.4	5	13382	2
4956.1	30	8766.8	5	13397.1	2
4965.0	39	8902.2	12	14153	69
5084.3	29	8904.1	12	14191	69
5097.2	38	8923.5	60	14293	77
5099.2	29	8925.6	60	14332	77
5112.2	38	9347.0	4	14807	50
5323.4	28	9349.1	4	14810	50
5339.8	28	9351.4	4	14811	50
5343.1	37	9595.60	11	15163	9
5359.6	37	9597.76	11	15163.1	9
5359.7	37	9950.5	59	15168.4	9
5782.4	27	9955.2	59	15203	49
5801.8	27	10479	3	15205	49
5812.2	36	10484	3	15207	49
5831.7	36	10487	3	15768	48
5831.9	36	10672	74	15770	48
6911.1	26	10686	82	15772	48
6936.27	35	10693	74	15984	56
6938.8	26	10707	82	16622	47

Wavelength [Å]	No.	Wavelength [Å]	No.	Wavelength [Å]	No.
16625	47	20685	45	31591	1
16628	47	20690	45	36363	67
16963	55	20701	45	36613	67
17939	68	21945	53	37072	75
18000	68	27068	57	37333	75
18029	46	27185	44	37348	75
18033	46	27193	44	62068	43
18038	46	27206	57	62110	43
18229	76	27226	44	62436	43
18292	76	31162	52	136900	51
18298	76	31381	1		
18627	54	31404	1		

The value for the $4s-4p$ resonance doublet is the average of three experimental and two theoretical determinations. The experiments include an absolute anomalous dispersion measurement by Ostrovskii and Penkin [2] and lifetime determinations using the phase-shift method by Link [3] and the Hanle effect by Schmieder, et al. [4]. The theoretical approaches considered the most refined available are a self-consistent field calculation (SCF), done in both the length and velocity approximations and including core-relaxation effects, by Weiss [5] and a similar SCF calculation, but instead including core polarization effects, by Hameed et al. [6]. Very good agreement among the averaged values suggests an accuracy within 10 percent.

For the $4s-np$ series the anomalous dispersion measurements of Filippov [7] are chosen in preference to the available theoretical calculations which are considered unreliable due to cancellation in the radial integral for these transitions. Filippov's values are normalized such that his value for the $4s-4p$ transition agrees with the above adopted value. Based mainly on the reliability of Filippov's values for the similar $3s-np$ series in Na I, the accuracy for these transitions is estimated to be within 25 percent. Values for a few of the higher members of this series are obtained by graphical extrapolation. Schmieder, et al. [4] have measured the lifetime of the $5p$ state which confirms Filippov's adopted value for $4s-5p$ (see fig. 7 in the General Introduction), if Anderson and Zilitis' [1] results are used to take account of the $5s-5p$ and $3d-5p$ transitions.

Weiss has included the $4p-3d$ transition in his SCF calculations described above. Dipole length and velocity approximations agree well and their average is within 10 percent of the value calculated by Villars [8] using the SCF approach and including a polarization potential.

Values for most of the members for the $4p-ns$ and $4p-nd$ series are available from Villar's SCF calculations and from the absolute flame intensity measurements of Van der Held and Heierman [9]. For the $4p-ns$ series, agreement is usually good and the results have been averaged (see fig. 9 in General Introduction). For the $4p-nd$ series the values are obtained by graphically averaging the two results (fig. 8 in General Introduction). Whenever these sources are not available for these series, the semi-empirical calculations of Anderson and Zilitis [1] are employed or the results are obtained by means of extrapolation or interpolation.

For all other transitions in the remaining series, the semi-empirical calculations of Anderson and Zilitis are adopted with accuracies expected to be within 50 percent.

References

[1] Anderson, E. M., and Zilitis, V. A., Optics and Spectroscopy (U.S.S.R.) **16**, 99–101 (1964).
[2] Ostrovskii, Yu. I., and Penkin, N. P., Optics and Spectroscopy (U.S.S.R.) **12**, 379 (1962).
[3] Link, J. K., J. Opt. Soc. Am. **56**, 1195–1199 (1966).
[4] Schmieder, R. W., Lurio, A., and Happer, W., Phys. Rev. **173**, 76–79 (1968).
[5] Weiss, A. W., J. Res. NBS **71A** (Phys. and Chem.) No. 2, 157–162 (1967).
[6] Hameed, S., Herzenberg, A., and James, M. G., J. Phys. B (Proc. Phys. Soc.) Ser. 2, **1**, 822–830 (1968).
[7] Filippov, A. N., Zhur. Eksptl. i. Teoret. Fiz. **3**, 520–523 (1933) (translated in "Optical Transition Probabilities," Vol. **1**).
[8] Villars, D. S., J. Opt. Soc. Am. **42**, 552–558 (1952).
[9] Van der Held, E. F. M., and Heierman, J. H., Physica **3**, 31–41 (1936).

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at. u.)	log gf	Accuracy	Source
1	$3d-5p$	$^2D-^2P^\circ$	*31453*	*21535.4*	*24713.9*	10	6	0.016	0.14	140	0.15	D	1
			[31381]	21534.4	24720.2	6	4	0.014	0.14	84	−0.08	D	*ls*
			[31591]	21536.8	24701.4	4	2	0.015	0.11	47	−0.36	D	*ls*
			[31404]	21536.8	24720.2	4	4	0.0015	0.022	9.3	−1.06	D	*ls*
2	$3d-6p$	$^2D-^2P^\circ$	*13384*	*21535.4*	*29004.9*	10	6	0.0041	0.0066	2.9	−1.18	D	1
			13377.9	21534.4	29007.7	6	4	0.0037	0.0066	1.7	−1.40	D	*ls*
			13397.1	21536.8	28999.3	4	2	0.0041	0.0055	0.97	−1.66	D	*ls*
			[13382]	21536.8	29007.7	4	4	4.1×10^{-4}	0.0011	0.19	−2.36	D	*ls*
3	$3d-7p$	$^2D-^2P^\circ$	*10482*	*21535.4*	*31073.0*	10	6	0.0019	0.0019	0.66	−1.72	D	1
			[10479]	21534.4	31074.5	6	4	0.0017	0.0019	0.39	−1.94	D	*ls*
			[10487]	21536.8	31070.0	4	2	0.0019	0.0016	0.22	−2.20	D	*ls*
			[10484]	21536.8	31074.5	4	4	1.9×10^{-4}	3.2×10^{-4}	0.044	−2.90	D	*ls*
4	$3d-8p$	$^2D-^2P^\circ$	*9348.6*	*21535.4*	*32229.2*	10	6	0.0011	8.4×10^{-4}	0.26	−2.08	D	1
			[9347.0]	21534.4	32230.1	6	4	9.6×10^{-4}	8.4×10^{-4}	0.16	−2.30	D	*ls*
			[9351.4]	21536.8	32227.4	4	2	0.0011	7.0×10^{-4}	0.086	−2.55	D	*ls*
			[9349.1]	21536.8	32230.1	4	4	1.1×10^{-4}	1.4×10^{-4}	0.017	−3.25	D	*ls*
5	$3d-9p$	$^2D-^2P^\circ$	*8764.8*	*21535.4*	*32941.5*	10	6	6.7×10^{-4}	4.6×10^{-4}	0.13	−2.34	D	1
			[8763.6]	21534.4	32942.1	6	4	6.0×10^{-4}	4.6×10^{-4}	0.080	−2.56	D	*ls*
			[8766.8]	21536.8	32940.3	4	2	6.7×10^{-4}	3.8×10^{-4}	0.044	−2.81	D	*ls*
			[8765.4]	21536.8	32942.1	4	4	6.7×10^{-5}	7.7×10^{-5}	0.0089	−3.51	D	*ls*
6	$3d-10p$	$^2D-^2P^\circ$	*8418.2*	*21535.4*	*33411.1*	10	6	4.4×10^{-4}	2.8×10^{-4}	0.078	−2.55	D	1
			[8417.3]	21534.4	33411.5	6	4	4.0×10^{-4}	2.8×10^{-4}	0.047	−2.77	D	*ls*
			[8419.8]	21536.8	33410.3	4	2	4.4×10^{-4}	2.4×10^{-4}	0.026	−3.03	D	*ls*
			[8419.0]	21536.8	33411.5	4	4	4.4×10^{-5}	4.7×10^{-5}	0.0052	−3.72	D	*ls*
7	$3d-11p$	$^2D-^2P^\circ$	*8193.3*	*21535.4*	*33737.1*	10	6	3.1×10^{-4}	1.9×10^{-4}	0.050	−2.73	D	1
			[8192.5]	21534.4	33737.4	6	4	2.8×10^{-4}	1.9×10^{-4}	0.030	−2.95	D	*ls*
			[8194.6]	21536.8	33736.6	4	2	3.1×10^{-4}	1.6×10^{-4}	0.017	−3.21	D	*ls*
			[8194.1]	21536.8	33737.4	4	4	3.1×10^{-5}	3.1×10^{-5}	0.0034	−3.90	D	*ls*
8	$3d-12p$	$^2D-^2P^\circ$	*8038.1*	*21535.4*	*33972.7*	10	6	2.3×10^{-4}	1.3×10^{-4}	0.035	−2.88	D	1
			[8037.3]	21534.4	33972.9	6	4	2.0×10^{-4}	1.3×10^{-4}	0.021	−3.11	D	*ls*
			[8039.3]	21536.8	33972.3	4	2	2.3×10^{-4}	1.1×10^{-4}	0.012	−3.36	D	*ls*
			[8038.9]	21536.8	33972.9	4	4	2.3×10^{-5}	2.2×10^{-5}	0.0023	−4.06	D	*ls*
9	$3d-4f$	$^2D-^2F^\circ$	*15165*	*21535.4*	28127.7	10	14	0.16	0.75	370	0.88	D	1
			15163.1	21534.4	28127.7	6	8	0.15	0.71	210	0.63	D	*ls*
			15168.4	21536.8	28127.7	4	6	0.15	0.75	150	0.48	D	*ls*
			[15163]	21534.4	28127.7	6	6	0.010	0.036	11	−0.67	D	*ls*
10	$3d-5f$	$^2D-^2F^\circ$ (9)	11022.3	*21535.4*	30605.6	10	14	0.066	0.17	61	0.23	D	1
11	$3d-6f$	$^2D-^2F^\circ$ (10)	*9596.5*	*21535.4*	31953.0	10	14	0.035	0.068	22	−0.17	D	1
			9595.60	21534.4	31953.0	6	8	0.035	0.065	12	−0.41	D	*ls*
			9597.76	21536.8	31953.0	4	6	0.033	0.068	8.6	−0.57	D	*ls*
			9595.60	21534.4	31953.0	6	6	0.0024	0.0032	0.61	−1.71	D	*ls*
12	$3d-7f$	$^2D-^2F^\circ$	*8903.0*	*21535.4*	32764.5	10	14	0.021	0.035	10	−0.45	D	1
			[8902.2]	21534.4	32764.5	6	8	0.021	0.034	5.9	−0.70	D	*ls*
			[8904.1]	21536.8	32764.5	4	6	0.020	0.035	4.1	−0.85	D	*ls*
			[8902.2]	21534.4	32764.5	6	6	0.0014	0.0017	0.30	−1.99	D	*ls*

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at. u.)	log gf	Accuracy	Source
13	$3d-8f$	$^2D-^2F^\circ$	*8504.2*	*21535.4*	33291.0	10	14	0.014	0.021	5.9	−0.68	D	1
			[8503.5]	21534.4	33291.0	6	8	0.014	0.020	3.4	−0.92	D	*ls*
			[8505.3]	21536.8	33291.0	4	6	0.013	0.021	2.4	−1.08	D	*ls*
			[8503.5]	21534.4	33291.0	6	6	9.2×10^{-4}	0.0010	0.17	−2.22	D	*ls*
14	$3d-9f$	$^2D-^2F^\circ$	*8250.9*	*21535.4*	33652.0	10	14	0.0095	0.014	3.7	−0.87	D	1
			[8250.2]	21534.4	33652.0	6	8	0.0096	0.013	2.1	−1.11	D	*ls*
			[8251.7]	21536.8	33652.0	4	6	0.0089	0.014	1.5	−1.26	D	*ls*
			[8250.2]	21534.4	33652.0	6	6	6.4×10^{-4}	6.5×10	0.11	−2.41	D	*ls*
15	$4s-4p$	$^2S-^2P^\circ$ (1)	*7676.2*	0.0	*13023.7*	2	6	0.385	1.02	51.6	0.310	B+	2, 3, 4, 5, 6
			7664.91	0.0	13042.9	2	4	0.387	0.682	34.4	0.135	B+	*ls*
			7698.98	0.0	12985.2	2	2	0.382	0.339	17.2	−0.169	B+	*ls*
16	$4s-5p$	$^2S-^2P^\circ$ (3)	*4045.2*	0.0	*24713.9*	2	6	0.0124	0.0091	0.242	−1.74	C	7*n*
			4044.15	0.0	24720.2	2	4	0.0124	0.0061	0.161	−1.91	C	*ls*
			4047.21	0.0	24701.4	2	2	0.0124	0.00305	0.081	−2.215	C	*ls*
17	$4s-6p$	$^2S-^2P^\circ$ (4)	*3446.7*	0.0	*29004.9*	2	6	0.00168	9.0×10^{-4}	0.0204	−2.74	C	7*n*
			3446.38	0.0	29007.7	2	4	0.00168	6.0×10^{-4}	0.0136	−2.92	C	*ls*
			3447.41	0.0	28999.3	2	6	0.00168	2.99×10^{-4}	0.0068	−3.223	C	*ls*
18	$4s-7p$	$^2S-^2P^\circ$ (1 uv)	*3217.3*	0.0	*31073.0*	2	6	4.60×10^{-4}	2.14×10^{-4}	0.00453	−3.369	C	7*n*
			3217.15	0.0	31074.5	2	4	4.61×10^{-4}	1.43×10^{-4}	0.00303	−3.54	C	*ls*
			3217.62	0.0	31070.0	2	2	4.57×10^{-4}	7.1×10^{-5}	0.00150	−3.85	C	*ls*
19	$4s-8p$	$^2S-^2P^\circ$ (2 uv)	*3101.9*	0.0	*32229.0*	2	6	1.84×10^{-4}	8.0×10^{-5}	0.00164	−3.80	C	7*n*
20	$4s-9p$	$^2S-^2P^\circ$ (3 uv)	*3034.8*	0.0	*32941.5*	2	6	9.4×10^{-5}	3.90×10^{-5}	7.8×10^{-4}	−4.108	C	7*n*
21	$4s-10p$	$^2S-^2P^\circ$ (4 uv)	*2992.2*	0.0	*33411.1*	2	6	5.4×10^{-5}	2.19×10^{-5}	4.31×10^{-4}	−4.359	C	7*n*
22	$4s-11p$	$^2S-^2P^\circ$ (5 uv)	*2963.2*	0.0	*33737.1*	2	6	3.3×10^{-5}	1.3×10^{-5}	2.5×10^{-4}	−4.59	D	extrap.
23	$4s-12p$	$^2S-^2P^\circ$ (6 uv)	*2942.7*	0.0	*33972.7*	2	6	2.4×10^{-5}	9.2×10^{-6}	1.8×10^{-4}	−4.74	D	extrap.
24	$4s-13p$	$^2S-^2P^\circ$	*2927.5*	0.0	*34148.5*	2	6	1.7×10^{-5}	6.7×10^{-6}	1.3×10^{-4}	−4.87	D	extrap.
25	$4p-5s$	$^2P^\circ-^2S$ (5)	*12492*	*13023.7*	21026.8	6	2	0.235	0.183	45.1	0.041	C	8
			12522.1	13042.9	21026.8	4	2	0.156	0.183	30.2	−0.136	C	*ls*
			12432.2	12985.2	21026.8	2	2	0.079	0.183	15.0	−0.437	C	*ls*
26	$4p-6s$	$^2P^\circ-^2S$	*6929.5*	*13023.7*	27450.7	6	2	0.082	0.0196	2.69	−0.93	C	8, 9
			[6938.8]	13042.9	27450.7	4	2	0.054	0.0196	1.78	−1.108	C	*ls*
			[6911.1]	12985.2	27450.7	2	2	0.0272	0.0196	0.89	−1.409	C	*ls*
27	$4p-7s$	$^2P^\circ-^2S$	*5795.3*	*13023.7*	30274.3	6	2	0.0369	0.0062	0.71	−1.430	C	8, 9
			[5801.8]	13042.9	30274.3	4	2	0.0246	0.0062	0.474	−1.61	C	*ls*
			[5782.4]	12985.2	30274.3	2	2	0.0123	0.0062	0.235	−1.91	C	*ls*
28	$4p-8s$	$^2P^\circ-^2S$	*5334.3*	*13023.7*	31756.0	6	2	0.0189	0.00269	0.283	−1.79	C	8, 9
			[5339.8]	13042.9	31756.0	4	2	0.0126	0.00269	0.189	−1.97	C	*ls*
			[5323.4]	12985.2	31756.0	2	2	0.0063	0.00268	0.094	−2.271	C	*ls*

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at. u.)	log gf	Accuracy	Source
29	$4p-9s$	$^2P^\circ-^2S$	*5094.3*	*13023.7*	32648.2	6	2	0.0105	0.00136	0.137	−2.088	C	8, 9
			[5099.2]	13042.9	32648.2	4	2	0.0070	0.00136	0.092	−2.263	C	*ls*
			[5084.3]	12985.2	32648.2	2	2	0.00350	0.00136	0.0454	−2.57	C	*ls*
30	$4p-10s$	$^2P^\circ-^2S$	*4951.4*	*13023.7*	33214.4	6	2	0.0064	7.8×10^{-4}	0.077	−2.327	C−	8, 9
			[4956.1]	13042.9	33214.4	4	2	0.00425	7.8×10^{-4}	0.051	−2.50	C−	*ls*
			[4942.0]	12985.2	33214.4	2	2	0.00213	7.8×10^{-4}	0.0254	−2.81	C−	*ls*
31	$4p-11s$	$^2P^\circ-^2S$	*4859.0*	*13023.7*	33598.2	6	2	0.0043	5.1×10^{-4}	0.049	−2.51	C−	interp.
			[4863.6]	13042.9	33598.2	4	2	0.0029	5.1×10^{-4}	0.033	−2.69	C−	*ls*
			[4850.0]	12985.2	33598.2	2	2	0.0014	5.1×10^{-4}	0.016	−2.99	C−	*ls*
32	$4p-12s$	$^2P^\circ-^2S$	*4795.7*	*13023.7*	33869.7	6	2	0.00310	3.57×10^{-4}	0.0338	−2.61	C−	1, 9
			[4800.2]	13042.9	33869.7	4	2	0.00207	3.57×10^{-4}	0.0225	−2.78	C−	*ls*
			[4786.9]	12985.2	33869.7	2	2	0.00103	3.57×10^{-4}	0.0112	−3.083	C−	*ls*
32	$4p-13s$	$^2P^\circ-^2S$	*4750.3*	*13023.7*	34069.3	6	2	0.0024	2.7×10^{-4}	0.025	−2.79	C−	extrap.
			[4754.6]	13042.9	34069.3	4	2	0.0016	2.7×10^{-4}	0.017	−2.97	C−	*ls*
			[4741.6]	12985.2	34069.3	2	2	8.0×10^{-4}	2.7×10^{-4}	0.0084	−3.27	C−	*ls*
34	$4p-3d$	$^2P^\circ-^2D$ (6)	*11745*	*13023.7*	*21535.4*	6	10	0.262	0.90	209	0.73	C	5, 8
			11772.8	13042.9	21534.4	4	6	0.259	0.81	125	0.51	C	*ls*
			11690.2	12985.2	21536.8	2	4	0.220	0.90	69	0.255	C	*ls*
			11769.7	13042.9	21536.8	4	4	0.0434	0.090	14.0	−0.444	C	*ls*
35	$4p-4d$	$^2P^\circ-^2D$ (7)	*6955.2*	*13023.7*	*27397.4*	6	10	3.1×10^{-4}	3.7×10^{-4}	0.051	−2.65	E	8*n*, 9*n*
			6964.69	13042.9	27397.0	4	6	3.1×10^{-4}	3.4×10^{-4}	0.031	−2.87	E	*ls*
			6936.27	12985.2	27398.1	2	4	2.6×10^{-4}	3.7×10^{-4}	0.017	−3.13	E	*ls*
			6964.18	13042.9	27398.1	4	4	5.1×10^{-5}	3.7×10^{-5}	0.0034	−3.83	E	*ls*
36	$4p-5d$	$^2P^\circ-^2D$	*5825.3*	*13023.7*	*30185.4*	6	10	0.0033	0.0028	0.32	−1.77	D	8*n*, 9*n*
			[5831.9]	13042.9	30185.2	4	6	0.0032	0.0025	0.19	−2.00	D	*ls*
			[5812.2]	12985.2	30185.7	2	4	0.0028	0.0029	0.11	−2.24	D	*ls*
			[5831.7]	13042.9	30185.7	4	4	5.4×10^{-4}	2.7×10^{-4}	0.021	−2.97	D	*ls*
37	$4p-6d$	$^2P^\circ-^2D$	*5354.1*	*13023.7*	*31695.6*	6	10	0.0046	0.0033	0.35	−1.70	D	8*n*, 9*n*
			[5359.7]	13042.9	31695.5	4	6	0.0046	0.0030	0.21	−1.92	D	*ls*
			[5343.1]	12985.2	31695.8	2	4	0.0040	0.0034	0.12	−2.17	D	*ls*
			[5359.6]	13042.9	31695.8	4	4	7.6×10^{-4}	3.3×10^{-4}	0.023	−2.88	D	*ls*
38	$4p-7d$	$^2P^\circ-^2D$	*5107.2*	*13023.7*	32598.5	6	10	0.0035	0.0023	0.23	−1.86	D	8*n*, 9*n*
			[5112.2]	13042.9	32598.5	4	6	0.0035	0.0021	0.14	−2.08	D	*ls*
			[5097.2]	12985.2	32598.5	2	4	0.0029	0.0023	0.077	−2.34	D	*ls*
			[5112.2]	13042.9	32598.5	4	4	5.7×10^{-4}	2.2×10^{-4}	0.015	−3.06	D	*ls*
39	4	$^2P^\circ-^2D$	*4960.2*	*13023.7*	33178.4	6	10	0.0026	0.0016	0.16	−2.02	D	8*n*, 9*n*
			[4965.0]	13042.9	33178.4	4	6	0.0026	0.0015	0.096	−2.22	D	*ls*
			[4950.8]	12985.2	33178.4	2	4	0.0022	0.0016	0.053	−2.49	D	*ls*
			[4965.0]	13042.9	33178.4	4	4	4.6×10^{-4}	1.7×10^{-4}	0.011	−3.17	D	*ls*

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at. u.)	log gf	Accuracy	Source
40	$4p-9d$	$^2P^\circ-^2D$	*4865.2*	*13023.7*	33572.1	6	10	0.0020	0.0012	0.12	−2.14	D	$8n, 9n$
			[4869.8]	13042.9	33572.1	4	6	0.0021	0.0011	0.072	−2.36	D	*ls*
			[4856.1]	12985.2	33572.1	2	4	0.0018	0.0013	0.040	−2.59	D	*ls*
			[4869.8]	13042.9	33572.1	4	4	3.5×10^{-4}	1.2×10^{-4}	0.0080	−3.32	D	*ls*
41	$4p-10d$	$^2P^\circ-^2D$	*4799.9*	*13023.7*	33851.8	6	10	0.0016	9.0×10^{-4}	0.085	−2.27	D	$1n, 9n$
			[4804.3]	13042.9	33851.8	4	6	0.0016	8.1×10^{-4}	0.051	−2.49	D	*ls*
			[4791.0]	12985.2	33851.8	2	4	0.0013	8.9×10^{-4}	0.028	−2.75	D	*ls*
			[4804.3]	13042.9	33851.8	4	4	2.6×10^{-4}	9.0×10^{-5}	0.0057	−3.44	D	*ls*
42	$4p-11d$	$^2P^\circ-^2D$	*4753.1*	*13023.7*	34056.9	6	10	0.0012	6.6×10^{-4}	0.062	−2.40	D	1
			[4757.4]	13042.9	34056.9	4	6	0.0012	5.9×10^{-4}	0.037	−2.63	D	*ls*
			[4744.4]	12985.2	34056.9	2	4	9.8×10^{-4}	6.6×10^{-4}	0.021	−2.88	D	*ls*
			[4757.4]	13042.9	34056.9	4	4	1.9×10^{-4}	6.6×10^{-5}	0.0041	−3.58	D	*ls*
43	$4d-6p$	$^2D-^2P^\circ$	*62191*	*27397.4*	*29004.9*	10	6	0.0086	0.30	610	0.48	D	1
			[62068]	27397.0	29007.7	6	4	0.0078	0.30	370	0.26	D	*ls*
			[62436]	27398.1	28999.3	4	2	0.0083	0.24	200	−0.02	D	*ls*
			[62110]	27398.1	29007.7	4	4	8.7×10^{-4}	0.050	41	−0.70	D	*ls*
44	$4d-7p$	$^2D-^2P^\circ$	*27199*	*27397.4*	*31073.0*	10	6	0.0029	0.019	17	−0.72	D	1
			[27185]	27397.0	31074.5	6	4	0.0025	0.019	10	−0.94	D	*ls*
			[27226]	27398.1	31070.0	4	2	0.0029	0.016	5.7	−1.19	D	*ls*
			[27193]	27398.1	31074.5	4	4	2.8×10^{-4}	0.0031	1.1	−1.91	D	*ls*
45	$4d-8p$	$^2D-^2P^\circ$	*20691*	*27397.4*	*32229.0*	10	6	0.0015	0.0059	4.0	−1.23	D	1
			[20685]	27397.0	32230.1	6	4	0.0014	0.0059	2.4	−1.45	D	*ls*
			[20701]	27398.1	32227.4	4	2	0.0015	0.0048	1.3	−1.72	D	*ls*
			[20690]	27398.1	32230.1	4	4	1.5×10^{-4}	9.9×10^{-4}	0.27	−2.40	D	*ls*
46	$4d-9p$	$^2D-^2P^\circ$	*18032*	*27397.4*	*32941.5*	10	6	9.2×10^{-4}	0.0027	1.6	−1.57	D	1
			[18029]	27397.0	32942.1	6	4	8.3×10^{-4}	0.0027	0.96	−1.79	D	*ls*
			[18038]	27398.1	32940.3	4	2	9.1×10^{-4}	0.0022	0.53	−2.06	D	*ls*
			[18033]	27398.1	32942.1	4	4	9.5×10^{-5}	4.6×10^{-4}	0.11	−2.74	D	*ls*
47	$4d-10p$	$^2D-^2P^\circ$	*16624*	*27397.4*	*33411.1*	10	6	6.0×10^{-4}	0.0015	0.82	−1.82	D	1
			[16622]	27397.0	33411.5	6	4	5.4×10^{-4}	0.0015	0.49	−2.05	D	*ls*
			[16628]	27398.1	33410.3	4	2	6.0×10^{-4}	0.0012	0.27	−2.32	D	*ls*
			[16625]	27398.1	33411.5	4	4	6.1×10^{-5}	2.5×10^{-4}	0.055	−3.00	D	*ls*
48	$4d-11p$	$^2D-^2P^\circ$	*15769*	*27397.4*	*33737.1*	10	6	4.2×10^{-4}	9.5×10^{-4}	0.49	−2.02	D	1
			[15768]	27397.0	33737.4	6	4	3.7×10^{-4}	9.3×10^{-4}	0.29	−2.25	D	*ls*
			[15772]	27398.1	33736.6	4	2	4.1×10^{-4}	7.7×10^{-4}	0.16	−2.51	D	*ls*
			[15770]	27398.1	33737.4	4	4	4.3×10^{-5}	1.6×10^{-4}	0.033	−3.19	D	*ls*
49	$4d-12p$	$^2D-^2P^\circ$	*15204*	*27397.4*	*33972.7*	10	6	3.1×10^{-4}	6.4×10^{-4}	0.32	−2.19	D	1
			[15203]	27397.0	33972.9	6	4	2.7×10^{-4}	6.3×10^{-4}	0.19	−2.42	D	*ls*
			[15207]	27398.1	33972.3	4	2	3.2×10^{-4}	5.5×10^{-4}	0.11	−2.66	D	*ls*
			[15205]	27398.1	33972.9	4	4	3.0×10^{-5}	1.0×10^{-4}	0.021	−3.40	D	*ls*
50	$4d-13p$	$^2D-^2P^\circ$	*14808*	*27397.4*	*34148.5*	10	6	2.3×10^{-4}	4.6×10^{-4}	0.22	−2.34	D	1
			[14807]	27397.0	34148.6	6	4	2.1×10^{-4}	4.6×10^{-4}	0.13	−2.56	D	*ls*
			[14811]	27398.1	34148.2	4	2	2.3×10^{-4}	3.8×10^{-4}	0.075	−2.82	D	*ls*
			[14810]	27398.1	34148.6	4	4	2.3×10^{-5}	7.6×10^{-5}	0.015	−3.52	D	*ls*
51	$4d-4f$	$^2D-^2F^\circ$	*136900*	*27397.4*	28127.7	10	14	8.9×10^{-4}	0.35	1600	0.54	D	1

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at. u.)	log gf	Accuracy	Source
52	$4d-5f$	$^2D-^2F^\circ$	*31162*	*27397.4*	30605.6	10	14	0.020	0.40	410	0.60	D	1
53	$4d-6f$	$^2D-^2F^\circ$	*21945*	*27397.4*	31953.0	10	14	0.014	0.14	100	0.15	D	1
54	$4d-7f$	$^2D-^2F^\circ$	*18627*	*27397.4*	32764.5	10	14	0.0088	0.064	39	−0.19	D	1
55	$4d-8f$	$^2D-^2F^\circ$	*16963*	*27397.4*	33291.0	10	14	0.0060	0.036	20	−0.44	D	1
56	$4d-9f$	$^2D-^2F^\circ$	*15984*	*27397.4*	33652.0	10	14	0.0043	0.023	12	−0.64	D	1
57	$5s-5p$	$^2S-^2P^\circ$	*27114*	21026.8	*24713.9*	2	6	0.045	1.5	270	0.48	D	1
			[27068]	21026.8	24720.2	2	4	0.046	1.0	180	0.30	D	*ls*
			[27206]	21026.8	24701.4	2	2	0.045	0.50	90	0.00	D	*ls*
58	$5s-6p$	$^2S-^2P^\circ$	*12531*	21026.8	*29004.9*	2	6	0.0045	0.032	2.6	−1.20	D	1
			[12526]	21026.8	29007.7	2	4	0.0045	0.021	1.7	−1.38	D	*ls*
			[12540]	21026.8	28999.3	2	2	0.0045	0.011	0.87	−1.68	D	*ls*
59	$5s-7p$	$^2S-^2P^\circ$	*9951.3*	21026.8	*31073.0*	2	6	0.0014	0.0060	0.39	−1.92	D	1
			[9950.5]	21026.8	31074.5	2	4	0.0014	0.0040	0.26	−2.10	D	*ls*
			[9955.2]	21026.8	31070.0	2	2	0.0014	0.0020	0.13	−2.40	D	*ls*
60	$5s-8p$	$^2S-^2P^\circ$	*8924.4*	21026.8	*32229.0*	2	6	5.9×10^{-4}	0.0021	0.13	−2.37	D	1
			[8923.5]	21026.8	32230.1	2	4	5.9×10^{-4}	0.0014	0.083	−2.55	D	*ls*
			[8925.6]	21026.8	32227.4	2	2	5.9×10^{-4}	7.1×10^{-4}	0.042	−2.85	D	*ls*
61	$5s-9p$	$^2S-^2P^\circ$	*8390.7*	21026.8	*32941.5*	2	6	3.2×10^{-4}	0.0010	0.056	−2.69	D	1
			[8390.3]	21026.8	32942.1	2	4	3.2×10^{-4}	6.7×10^{-4}	0.037	−2.87	D	*ls*
			[8391.5]	21026.8	32940.3	2	2	3.2×10^{-4}	3.3×10^{-4}	0.019	−3.17	D	*ls*
62	$5s-10p$	$^2S-^2P^\circ$	*8072.5*	21026.8	*33411.1*	2	6	1.9×10^{-4}	5.7×10^{-4}	0.030	−2.94	L	1
63	$5s-11p$	$^2S-^2P^\circ$	*7865.5*	21026.8	*33737.1*	2	6	1.3×10^{-4}	3.5×10^{-4}	0.018	−3.15	D	1
64	$5s-12p$	$^2S-^2P^\circ$	*7722.3*	21026.8	*33972.7*	2	6	8.9×10^{-5}	2.4×10^{-4}	0.012	−3.32	D	1
65	$5s-13p$	$^2S-^2P^\circ$	*7618.9*	21026.8	*34148.5*	2	6	6.5×10^{-5}	1.7×10^{-4}	0.0085	−3.47	D	1
66	$5s-14p$	$^2S-^2P^\circ$	*7541.5*	21026.8	*34283.1*	2	6	4.9×10^{-5}	1.3×10^{-4}	0.0063	−3.60	D	1
67	$5p-6s$	$^2P^\circ-^2S$	*36529*	*24713.9*	27450.7	6	2	0.048	0.32	230	0.28	D	1
			[36613]	24720.2	27450.7	4	2	0.032	0.32	150	0.11	D	*ls*
			[36363]	24701.4	27450.7	2	2	0.016	0.32	77	−0.19	D	*ls*
68	$5p-7s$	$^2P^\circ-^2S$	*17979*	*24713.9*	30274.3	6	2	0.017	0.027	9.6	−0.79	D	1
			[18000]	24720.2	30274.3	4	2	0.011	0.027	6.4	−0.97	D	*ls*
			[17939]	24701.4	30274.3	2	2	0.0056	0.027	3.2	−1.27	D	*ls*
69	$5p-8s$	$^2P^\circ-^2S$	*14178*	*24713.9*	31765.0	6	2	0.0087	0.0087	2.4	−1.28	D	1
			[14191]	24720.2	31765.0	4	2	0.0058	0.0087	1.6	−1.46	D	*ls*
			[14153]	24701.4	31765.0	2	2	0.0029	0.0087	0.81	−1.76	D	*ls*
70	$5p-9s$	$^2P^\circ-^2S$	*12600*	*24713.9*	32648.2	6	2	0.0052	0.0041	1.0	−1.61	D	1
			[12610]	24720.2	32648.2	4	2	0.0034	0.0041	0.68	−1.79	D	*ls*
			[12580]	24701.4	32648.2	2	2	0.0017	0.0041	0.34	−2.09	D	*ls*

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at. u.)	log gf	Accuracy	Source
71	$5p-10s$	$^2P^\circ-^2S$	*11761*	*24713.9*	33214.4	6	2	0.0033	0.0023	0.54	−1.85	D	1
			[11770]	24720.2	33214.4	4	2	0.0022	0.0023	0.36	−2.03	D	*ls*
			[11744]	24701.4	33214.4	2	2	0.0011	0.0023	0.18	−2.33	D	*ls*
72	$5p-11s$	$^2P^\circ-^2S$	*11253*	*24713.9*	33598.2	6	2	0.0023	0.0015	0.33	−2.06	D	1
			[11261]	24720.2	33598.2	4	2	0.0015	0.0015	0.22	−2.23	D	*ls*
			[11237]	24701.4	33598.2	2	2	7.7×10^{-4}	0.0015	0.11	−2.53	D	*ls*
73	$5p-12s$	$^2P^\circ-^2S$	*10919*	*24713.9*	33869.7	6	2	0.0016	9.6×10^{-4}	0.21	−2.24	D	1
			[10927]	24720.2	33869.7	4	2	0.0011	9.6×10^{-4}	0.14	−2.42	D	*ls*
			[10904]	24701.4	33869.7	2	2	5.4×10^{-4}	9.6×10^{-4}	0.069	−2.72	D	*ls*
74	$5p-13s$	$^2P^\circ-^2S$	*10686*	*24713.9*	34069.3	6	2	0.0012	6.6×10^{-4}	0.14	−2.40	D	1
			[10693]	24720.2	34069.3	4	2	7.7×10^{-4}	6.6×10^{-4}	0.093	−2.58	D	*ls*
			[10672]	24701.4	34069.3	2	2	3.9×10^{-4}	6.6×10^{-4}	0.046	−2.88	D	*ls*
75	$5p-4d$	$^2P^\circ-^2D$	*37255*	*24713.9*	*27397.4*	6	10	0.035	1.2	880	0.86	D	1
			[37348]	24720.2	27397.0	4	6	0.034	1.1	530	0.64	D	*ls*
			[37072]	24701.4	27398.1	2	4	0.029	1.2	290	0.38	D	*ls*
			[37333]	24720.2	27398.1	4	4	0.0057	0.12	59	−0.32	D	*ls*
76	$5p-5d$	$^2P^\circ-^2D$	*18272*	*24713.9*	*30185.4*	6	10	9.3×10^{-4}	0.0078	2.8	−1.33	D	1
			[18298]	24720.2	30185.2	4	6	9.4×10^{-4}	0.0071	1.7	−1.55	D	*ls*
			[18229]	24701.4	30185.7	2	4	7.8×10^{-4}	0.0077	0.93	−1.81	D	*ls*
			[18292]	24720.2	30185.7	4	4	1.6×10^{-4}	7.9×10^{-4}	0.19	−2.50	D	*ls*
77	$5p-6d$	$^2P^\circ-^2D$	*14319*	*24713.9*	*31695.6*	6	10	2.9×10^{-6}	1.5×10^{-5}	0.0042	−4.05	D−	1
			[14332]	24720.2	31695.5	4	6	2.9×10^{-6}	1.3×10^{-5}	0.0025	−4.28	D−	*ls*
			[14293]	24701.4	31695.8	2	4	2.4×10^{-6}	1.5×10^{-5}	0.0014	−4.52	D−	*ls*
			[14332]	24720.2	31695.8	4	4	4.8×10^{-7}	1.5×10^{-6}	2.8×10^{-4}	−5.22	D−	*ls*
78	$5p-7d$	$^2P^\circ-^2D$	*12679*	*24713.9*	32598.5	6	10	1.2×10^{-4}	4.6×10^{-4}	0.12	−2.56	D	1
			[12690]	24720.2	32598.5	4	6	1.2×10^{-4}	4.2×10^{-4}	0.070	−2.78	D	*ls*
			[12659]	24701.4	32598.5	2	4	9.7×10^{-5}	4.6×10^{-4}	0.039	−3.03	D	*ls*
			[12690]	24720.2	32598.5	4	4	1.9×10^{-5}	4.6×10^{-5}	0.0078	−3.73	D	*ls*
79	$5p-8d$	$^2P^\circ-^2D$	*11811*	*24713.9*	33178.4	6	10	1.7×10^{-4}	6.0×10^{-4}	0.14	−2.44	D	1
			[11820]	24720.2	33178.4	4	6	1.7×10^{-4}	5.4×10^{-4}	0.084	−2.67	D	*ls*
			[11793]	24701.4	33178.4	2	4	1.4×10^{-4}	6.0×10^{-4}	0.047	−2.92	D	*ls*
			[11820]	24720.2	33178.4	4	4	2.9×10^{-5}	6.0×10^{-5}	0.0093	−3.62	D	*ls*
80	$5p-9d$	$^2P^\circ-^2D$	*11286*	*24713.9*	33572.1	6	10	1.8×10^{-4}	5.7×10^{-4}	0.13	−2.47	D	1
			[11294]	24720.2	33572.1	4	6	1.8×10^{-4}	5.1×10^{-4}	0.076	−2.69	D	*ls*
			[11270]	24701.4	33572.1	2	4	1.5×10^{-4}	5.7×10^{-4}	0.042	−2.94	D	*ls*
			[11294]	24720.2	33572.1	4	4	3.0×10^{-5}	5.7×10^{-5}	0.0085	−3.64	D	*ls*
81	$5p-10d$	$^2P^\circ-^2D$	*10940*	*24713.9*	33851.8	6	10	1.6×10^{-4}	4.8×10^{-4}	0.10	−2.54	D	1
			[10948]	24720.2	33851.8	4	6	1.6×10^{-4}	4.3×10^{-4}	0.062	−2.76	D	*ls*
			[10925]	24701.4	33851.8	2	4	1.3×10^{-4}	4.8×10^{-4}	0.035	−3.02	D	*ls*
			[10948]	24720.2	33851.8	4	4	2.7×10^{-5}	4.8×10^{-5}	0.0069	−3.72	D	*ls*
82	$5p-11d$	$^2P^\circ-^2D$	*10700*	*24713.9*	34056.9	6	10	1.4×10^{-4}	4.1×10^{-4}	0.087	−2.61	D	1
			[10707]	24720.2	34056.9	4	6	1.4×10^{-4}	3.7×10^{-4}	0.052	−2.83	D	*ls*
			[10686]	24701.4	34056.9	2	4	1.2×10^{-4}	4.1×10^{-4}	0.029	−3.09	D	*ls*
			[10707]	24720.2	34056.9	4	4	2.4×10^{-5}	4.1×10^{-5}	0.0058	−3.78	D	*ls*

K III

Ground State $1s^22s^22p^63s^23p^5\ ^2P^\circ_{3/2}$

Ionization Potential 46 eV = 369000 cm^{-1}

Allowed Transitions

List of tabulated lines:

Wavelength [Å]	No.	Wavelength [Å]	No.	Wavelength [Å]	No.
765.644	1	2992.24	3	3289.06	5
778.528	1	3023.4	3	3322.40	2
2550.02	4	3052.07	3	3358.5	2
2635.11	4	3056.84	3	3364.22	6
2689.90	4	3061.2	6	3420.82	2
2877.4	3	3201.95	6	3421.83	5
2938.45	3	3209.34	6	3448.0	2
2954.3	3	3254.0	5	3468.32	2
2986.20	3	3278.79	2	3513.88	2

Bagus [1] has calculated a value for one multiplet of this ion using the self-consistent field method; this number should be uncertain since the possibly important effects of configuration interaction have been neglected entirely. For several other transitions the Coulomb approximation has been employed in order to have some data available for the more prominent lines in this spectrum. From the general success of this method and from comparisons with analogous transitions in other ions, uncertainties of 50 percent are expected; however these estimates should be regarded as provisional.

Reference

[1] Bagus, P. S., U.S. Atomic Energy Commission ANL–6959 (1964).

K III. Allowed Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at. u.)	log gf	Accuracy	Source
1	$3s^23p^5-3s3p^6$	$^2P^\circ-^2S$ (1 uv)	*769.89*	*721*	130609	6	2	73	0.22	3.3	0.11	E	1
			765.644	0	130609	4	2	50	0.22	2.2	−0.06	E	*ls*
			778.528	2162	130609	2	2	23	0.21	1.1	−0.37	E	*ls*
2	$3p^44s-3p^4(^3P)4p$	$^4P-^4P^\circ$ (1)	*3375.2*	*208184*	*237803*	12	12	1.8	0.30	40	0.56	D	*ca*
			3322.40	207422	237512	6	6	1.3	0.21	14	0.10	D	*ls*
			3420.82	208688	237912	4	4	0.23	0.040	1.8	−0.80	E	*ls*
			[3448.0]	209461	238455	2	2	0.28	0.050	1.1	−1.00	E	*ls*
			3278.79	207422	237912	6	4	0.86	0.092	6.0	−0.26	D−	*ls*
			[3358.5]	208688	238455	4	2	1.5	0.13	5.6	−0.30	D−	*ls*
			3468.32	208688	237512	4	6	0.48	0.13	5.9	−0.28	D−	*ls*
			3513.88	209461	237912	2	4	0.65	0.24	5.6	−0.32	D−	*ls*
3		$^4P-^4D^\circ$ (2) (7 uv)	*3005.1*	*208184*	*241451*	12	20	2.5	0.56	67	0.83	D	*ca*
			2992.24	207422	240830	6	8	2.5	0.45	27	0.43	D	*ls*
			3052.07	208688	241444	4	6	1.7	0.35	14	0.15	D	*ls*
			3056.84	209461	242165	2	4	1.0	0.28	5.6	−0.25	D−	*ls*
			2938.45	207422	241444	6	6	0.77	0.10	5.8	−0.22	D−	*ls*
			2986.20	208688	242165	4	4	1.3	0.18	7.1	−0.14	D−	*ls*
			[3023.4]	209461	242527	2	2	2.1	0.29	5.7	−0.24	D−	*ls*
			[2877.4]	207422	242165	6	4	0.14	0.012	0.66	−1.15	E	*ls*
			[2954.3]	208688	242527	4	2	0.44	0.029	1.1	−0.94	E	*ls*

K III. Allowed Transitions—*Continued*

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
4		$^2P-^2D^\circ$ (8 uv)	*2600.5*	*208184*	*246626*	12	4	3.8	0.13	13	0.19	D	*ca*
			2550.02	207422	246626	6	4	2.0	0.13	6.5	−0.11	D	*ls*
			2635.11	208688	246626	4	4	1.2	0.13	4.5	−0.28	D	*ls*
			2689.90	209461	246626	2	4	0.60	0.13	2.3	−0.59	D	*ls*
5		$^2P-^2D^\circ$ (4)	*3329.6*	*213227*	*243252*	6	10	1.9	0.53	35	0.50	D	*ca*
			3289.06	212725	243121	4	6	2.0	0.49	21	0.29	D	*ls*
			3421.83	214232	243448	2	4	1.5	0.53	12	0.03	D	*ls*
			[3254.0]	212725	243448	4	4	0.35	0.055	2.4	−0.66	E	*ls*
6		$^2P-^2P^\circ$ (5)	*3204.4*	*213227*	*244425*	6	6	2.2	0.34	22	0.31	D	*ca*
			3201.95	212725	243947	4	4	1.8	0.28	12	0.05	D	*ls*
			3209.34	214232	245382	2	2	1.5	0.23	4.9	−0.34	D	*ls*
			[3061.2]	212725	245382	4	2	0.88	0.062	2.5	−0.61	D−	*ls*
			3364.22	214232	243947	2	4	0.32	0.11	2.4	−0.66	D−	*ls*

K III.

Forbidden Transitions

The line strength for the one transition in the ground state configuration is a straight number, tabulated for example by Naqvi [1]. The transition probability should also be quite accurate, since the energy level difference is accurately known.

Reference

[1] Naqvi, A. M., Thesis Harvard (1951).

K III. Forbidden Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	Type of Transition	A_{ki}(sec^{-1})	S(at.u.)	Accuracy	Source
1	$3p^5-3p^5$	$^2P^\circ-^2P^\circ$	[46240]	0	2162	4	2	*m*	0.181	1.33	A	1

K IV

Ground State $1s^22s^22p^63s^23p^4\ ^3P_2$

Ionization Potential 60.90 eV = 491300 cm^{-1}

Allowed Transitions

A value is available for one multiplet of this ion from the screening-approximation calculations of Varsavsky [1]. This result should be quite uncertain (probably too high, as judged from comparisons in other ions), since the possibly important effects of configuration interaction have not been taken into account.

Reference

[1] Varsavsky, C. M., Astrophys. J. Suppl. Ser. **6**, No. 53, 75 (1961).

K IV. Allowed Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
1	$3s^23p^4-3s3p^5$	$^3P-^3P^o$	*745.66*	*816*	*134926*	9	9	87	0.72	16	0.81	E	1
			[745.26]	0	134181	5	5	64	0.53	6.5	0.42	E	*ls*
			[746.35]	1673	135659	3	3	21	0.18	1.3	−0.27	E	*ls*
			[737.14]	0	135659	5	3	37	0.18	2.2	−0.05	E	*ls*
			[741.95]	1673	136453	3	1	84	0.23	1.7	−0.18	E	*ls*
			[754.67]	1673	134181	3	5	21	0.30	2.2	−0.05	E	*ls*
			[749.99]	2324	135659	1	3	27	0.69	1.7	−0.16	E	*ls*

K IV

Forbidden Transitions

As in the case of Na IV the adopted values are taken from Naqvi [1], and Malville and Berger [2]. For a discussion on the selection of values see Na IV, since the same criteria have been applied.

References

[1] Naqvi, A. M., Thesis Harvard (1951).
[2] Malville, J. M. and Berger, R. A., Planetary and Space Science **13**, 1131 (1965).

K IV. Forbidden Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	Type of Transition	A_{ki}(sec^{-1})	S(at.u.)	Accuracy	Source
1	$3p^4-3p^4$	$^3P-^3P$										
			[59757]	0	1673	5	3	*e*	1.77×10^{-6}	2.41	C−	1, 2
			[59757]	0	1673	5	3	*m*	0.105	2.49	B	1
			[43018]	0	2324	5	1	*e*	1.22×10^{-5}	1.07	C−	2
			[15.36×10^4]	1673	2324	3	1	*m*	0.0148	1.99	B	1
2		$^3P-^1D$ (1F)										
			6101.83	0	16384.0	5	5	*e*	0.0032	0.080	D−	1, 2
			6101.83	0	16384.0	5	5	*m*	0.83	0.0351	C	1, 2
			6794.8	1673	16384.0	3	5	*e*	2.6×10^{-4}	0.011	D−	1, 2
			6794.8	1673	16384.0	3	5	*m*	0.201	0.0117	C	1, 2
			[7110.4]	2324	16384.0	1	5	*e*	6.0×10^{-5}	0.0032	D−	2
3		$^3P-^1S$										
			[2593.5]	0	38546	5	1	*e*	0.086	0.0060	D−	2
			[2711.2]	1673	38546	3	5	*m*	10.4	0.0077	C	2
4		$^1D-^1S$ (2F)										
			4510.9	16384.0	38546	5	1	*e*	3.9	4.34	C−	2

K v

Ground State $1s^2 2s^2 2p^6 3s^2 3p^3\ {}^4S^\circ_{3/2}$

Ionization Potential 82.6 eV

Allowed Transitions

A value is available for one multiplet of this ion from the screening-approximation calculations of Varsavsky [1]. This result should be quite uncertain (probably too high, as judged from comparisons in other ions), since the possibly important effects of configuration interaction have not been taken into account.

Reference

[1] Varsavsky, C. M., Astrophys. J. Suppl. Ser. **6**, No. 53, 75 (1961).

K v. Allowed Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
1	$3s^2 3p^3 - 3s3p^4$	${}^4S^\circ - {}^4P$	*727.44*	0	*137468*	4	12	40	0.96	9.2	0.58	E	1
			[731.86]	0	136639	4	6	40	0.48	4.6	0.28	E	*ls*
			[724.42]	0	138042	4	4	41	0.32	3.1	0.11	E	*ls*
			[720.43]	0	138806	4	2	41	0.16	1.5	−0.19	E	*ls*

K v

Forbidden Transitions

For this ion all the values have been taken from Garstang [1] who has applied refined methods for calculating the magnetic dipole and electric quadrupole line strengths.

Reference

[1] Garstang, R. H., I.A.U. Symposium #34 on Planetary Nebulae held at Tatranska Lomnica, Czechoslovakia, Sept. (1967).

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	Type of Transition	A_{ki}(sec^{-1})	S(at.u.)	Accuracy	Source
1	$3p^3-3p^3$	$^4S^\circ-^2D^\circ$ (1F)										
			4122.63	0	24249.5	4	6	*m*	0.0025	3.90×10^{-5}	C	1
			4122.63	0	24249.5	4	6	*e*	0.0044	0.019	D	1
			4163.30	0	24012.7	4	4	*m*	0.109	0.00117	C	1
			4163.30	0	24012.7	4	4	*e*	0.0027	0.0080	D	1
2		$^4S^\circ-^2P^\circ$										
			[2495.3]	0	40064	4	4	*m*	6.5	0.0150	C	1
			[2495.3]	0	40064	4	4	*e*	7.2×10^{-5}	1.7×10^{-5}	D	1
			[2515.3]	0	39745	4	2	*m*	2.4	0.00283	C	1
			[2515.3]	0	39745	4	2	*e*	5.1×10^{-4}	6.1×10^{-5}	D	1
3		$^2D^\circ-^2D^\circ$										
			[42.22×10^4]	24012.7	24249.5	4	6	*m*	1.43×10^{-4}	2.40	A	1
			[42.22×10^4]	24012.7	24249.5	4	6	*e*	3.2×10^{-12}	0.15	D	1
4		$^2D^\circ-^2P^\circ$ (2F)										
			6316.6	24249.5	40064	6	4	*m*	1.1	0.0411	C	1
			6316.6	24249.5	40064	6	4	*e*	0.36	8.6	C	1
			6349.5	24012.7	39745	4	2	*m*	1.2	0.0228	C	1
			6349.5	24012.7	39745	4	2	*e*	0.30	3.69	C	1
			6446.5	24249.5	39745	6	2	*e*	0.19	2.52	C	1
			6223.4	24012.7	40064	4	4	*m*	2.1	0.075	C	1
			6223.4	24012.7	40064	4	4	*e*	0.16	3.56	C	1
5		$^2P^\circ-^2P^\circ$										
			[31.3×10^4]	39745	40064	2	4	*m*	2.91×10^{-4}	1.33	B	1
			[31.3×10^4]	39745	40064	2	4	*e*	9.2×10^{-12}	0.066	D	1

Kvi

Ground State $1s^22s^22p^63s^23p^2\ ^3P_0$

Ionization Potential 99.7 eV = 804513 cm^{-1}

Allowed Transitions

A value is available for one multiplet of this ion from the screening-approximation calculations of Varsavsky [1]. This result should be quite uncertain (probably too high, as judged from comparisons in other ions), since the possibly important effects of configuration interaction have not been taken into account.

Reference

[1] Varsavsky, C. M., Astrophys. J. Suppl. Ser. **6**, No. 53, 75 (1961).

K VI. Allowed Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
1	$3s^23p^2-3s3p^3$	$^3P-^3D^\circ$	*720.13*	*2001*	*140865*	9	15	35	0.46	9.8	0.62	E	1
			[724.42]	2924	140966	5	7	35	0.39	4.6	0.29	E	*ls*
			[716.00]	1131	140796	3	5	28	0.35	2.5	0.02	E	*ls*
			[710.51]	0	140743	1	3	21	0.47	1.1	−0.33	E	*ls*
			[725.31]	2924	140796	5	5	8.7	0.069	0.82	−0.46	E	*ls*
			[716.27]	1131	140743	3	3	15	0.12	0.82	−0.44	E	*ls*
			[725.59]	2924	140743	5	3	0.97	0.0046	0.055	−1.64	E	*ls*

K VI

Forbidden Transitions

As in the case of Na IV the adopted values are taken from Naqvi [1], and Malville and Berger [2]. For a discussion on the selection of values see Na IV, since the same criteria have been applied.

References

[1] Naqvi, A. M., Thesis Harvard (1951).
[2] Malville, J. M., and Berger, R. A., Planetary and Space Science **13**, 1131 (1965).

K VI. Forbidden Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	Type of Transition	A_{ki}(sec^{-1})	S(at.u.)	Accuracy	Source
1	$3p^2-3p^2$	$^3P-^3P$										
			[88390]	0	1131	1	3	*m*	0.0259	1.99	B	1
			[34190]	0	2924	1	5	*e*	5.4×10^{-6}	0.75	C−	2
			[55760]	1131	2924	3	5	*m*	0.0772	2.48	B	1
			[55760]	1131	2924	3	5	*e*	1.05×10^{-6}	1.68	C−	1, 2
2		$^3P-^1D$ (1F)										
			[5269.2]	0	18973	1	5	*e*	1.1×10^{-4}	0.0013	D−	2
			5603.2	1131	18973	3	5	*m*	0.54	0.0177	C	1, 2
			5603.2	1131	18973	3	5	*e*	7.4×10^{-4}	0.012	D−	1, 2
			6229.3	2924	18973	5	5	*m*	1.17	0.052	C	1, 2
			6229.3	2924	18973	5	5	*e*	0.0030	0.085	D−	1, 2
3		$^3P-^1S$										
			[2367]?	1131	[43374]?	3	1	*m*	15.7	0.0077	C−	2
			[2471]?	2924	[43374]?	5	1	*e*	0.14	0.0077	D−	2
4		$^1D-^1S$ (2F)										
			4097?	18973	[43374]?	5	1	*e*	4.1	2.8	D−	2

K VII

Ground State $1s^22s^22p^63s^23p\ ^2P^\circ_{1/2}$

Ionization Potential 118 eV = 950200 cm^{-1}

Allowed Transitions

The screening-approximation calculations of Varsavsky [1] for the $3s^23p\ ^2P^\circ - 3s3p^2\ ^2D$ multiplet are considered to be rather uncertain (probably too high, as judged from comparisons in other ions) since the important effects of configuration mixing are neglected entirely. Gruzdev and Prokofev [2] have carried out Coulomb approximation calculations modified with the Seaton correction for the $3p\ ^2P^\circ - 4s\ ^2S$ multiplet; these results should be reliable to within 25 percent, as judged from plots depicting f-value dependence on nuclear charge.

References

[1] Varsavsky, C. M., Astrophys. J. Suppl. Ser. **6**, No. 53, 75 (1961).
[2] Gruzdev, P. F., and Prokofev, V. K., Optics and Spectroscopy (U.S.S.R.) **21**, 151–152 (1966).

K VII. Allowed Transitions

No.	Transition Array	Multiplet	γ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at. u.)	log gf	Accuracy	Source
1	$3s^23p-3s3p^2$	$^2P^\circ-^2D$	*667.13*	*2086*	*151982*	6	10	40	0.44	5.8	0.42	E	1
			[671.50]	3129	152049	4	6	39	0.40	3.5	0.20	E	*ls*
			[658.41]	0	151882	2	4	34	0.44	1.9	−0.06	E	*ls*
			[672.26]	3129	151882	4	4	6.5	0.044	0.39	−0.75	E	*ls*
2	$3p-(^1S)4s$	$^2P^\circ-^2S$	*228.72*	*2086*	439297	6	2	325	0.085	0.384	−0.292	C	2
			[229.27]	3129	439297	4	2	216	0.085	0.257	−0.469	C	*ls*
			[227.64]	0	439297	2	2	109	0.085	0.127	−0.77	C	*ls*

K VII

Forbidden Transitions

The line strength for the one transition in the ground state configuration is a straight number, tabulated for example by Naqvi [1]. The transition probability should also be quite accurate, since the energy level difference is accurately known.

Reference

[1] Naqvi, A. M., Thesis Harvard (1951).

K VII. Forbidden Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	Type of Transition	A_{ki}(sec^{-1})	S(at.u.)	Accuracy	Source
1	$3p-(^1S)3p$	$^2P^\circ-^2P^\circ$	[31950]	0	3129	2	4	m	0.275	1.33	A	1

K VIII

Ground State $1s^2 2s^2 2p^6 3s^2\ {}^1S_0$

Ionization Potential 155 eV = 1247000 cm^{-1}

Allowed Transitions

The charge-expansion technique of Crossley and Dalgarno [1], which includes limited configuration mixing, has been employed for the majority of the transitions in this spectrum; while Gruzdev and Prokofev [2] have carried out Coulomb approximation calculations modified with the Seaton correction for the $3s3p\ {}^3P^\circ - 3s4s\ {}^3S$ multiplet. For many of these transitions, the dependence of oscillator strength on nuclear charge has served as an aid in estimating accuracies.

References

[1] Crossley, R. J. S., and Dalgarno, A., Proc. Roy. Soc. London **A286**, 510 (1965).
[2] Gruzdev, P. F., and Prokofev, V. K., Optics and Spectroscopy (U.S.S.R.) **21**, 151–152 (1966).

K VIII. Allowed Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at. u.)	log gf	Accuracy	Source
1	$3s^2-3s(^2S)3p$	${}^1S-{}^1P^\circ$	[519.37]	0	192540	1	3	94.0	1.14	1.95	0.057	B	1
2	$3s3p-3p^2$	${}^3P^\circ-{}^3P$	*564.85*	*130274*	*307313*	9	9	81	0.388	6.5	0.54	C+	1
			[564.47]	131452	308608	5	5	61	0.292	2.71	0.164	C+	*ls*
			[565.12]	129080	306035	3	3	20.2	0.097	0.54	−0.54	C	*ls*
			[572.79]	131452	306035	5	3	32.3	0.095	0.90	−0.323	C	*ls*
			[569.51]	129080	304669	3	1	79	0.128	0.72	−0.416	C	*ls*
			[557.02]	129080	308608	3	5	21.1	0.164	0.90	−0.308	C	*ls*
			[561.59]	127968	306035	1	3	27.5	0.389	0.72	−0.410	C	*ls*
3	$3s3p-3s(^2S)3d$	${}^3P^\circ-{}^3D$	*420.51*	*130274*	*368082*	9	15	116	0.511	6.37	0.663	B	1
			[422.51]	131452	368132	5	7	114	0.427	2.97	0.329	B	*ls*
			[418.45]	129080	368060	3	5	87.9	0.385	1.59	0.063	B	*ls*
			[416.60]	127968	368004	1	3	66.1	0.516	0.708	−0.287	B	*ls*
			[422.64]	131452	368060	5	5	28.5	0.0763	0.531	−0.419	B	*ls*
			[418.54]	129080	368004	3	3	48.9	0.128	0.531	−0.416	B	*ls*
			[422.74]	131452	368004	5	3	3.2	0.0051	0.035	−1.59	D	*ls*
4		${}^1P^\circ-{}^1D$	[464]	192540	[408000]	3	5	160	0.87	4.0	0.42	D	1
5	$3s3p-3s(^2S)4s$	${}^3P^\circ-{}^3S$	*199.45*	*130274*	631654	9	3	423	0.084	0.496	−0.121	C	2
			[199.92]	131452	631654	5	3	234	0.084	0.276	−0.377	C	*ls*
			[198.98]	129080	631654	3	3	142	0.084	0.165	−0.60	C	*ls*
			[198.54]	127968	631654	1	3	47.4	0.084	0.055	−1.076	C	*ls*

K VIII

Forbidden Transitions

Naqvi's calculations [1] are the only available source. The results for the ${}^3P^\circ-{}^3P^\circ$ transitions are essentially independent of the choice of the interaction parameters. For the ${}^3P^\circ-{}^1P^\circ$ transitions, Naqvi uses empirical term intervals, i.e., the effects of configuration interaction should be partially included.

Reference

[1] Naqvi, A. M., Thesis Harvard (1951).

K VIII. Forbidden Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	Type of Transition	A_{ki}(sec^{-1})	S(at.u.)	Accuracy	Source
1	$3s3p-3s(^2S)3p$	$^3P^\circ-^3P^\circ$										
			[89900]	127968	129080	1	3	m	0.0247	2.00	A	1
			[42147]	129080	131452	3	5	m	0.180	2.50	A	1
2		$^3P^\circ-^1P^\circ$										
			[1548.7]	127968	192540	1	3	m	3.51	0.00145	C	1
			[1575.8]	129080	192540	3	3	m	93	0.0404	C	1
			[1637.0]	131452	192540	5	3	m	3.71	0.00181	C	1

K IX

Ground State $1s^22s^22p^63s\ ^2S_{1/2}$

Ionization Potential 175.94 eV = 1419425 cm^{-1}

Allowed Transitions

List of tabulated lines:

Wavelength [Å]	No.	Wavelength [Å]	No.	Wavelength [Å]	No.
131.65	2	260.05	5	621.41	1
131.90	2	260.83	5	636.40	1
145.73	7	451.01	10	1273.4	9
184.59	4	453.96	10	1294.6	9
185.88	4	459.50	3	1297.2	9
205.83	6	466.95	3	1647.1	8
259.86	5	467.59	3	1687.1	8

The only source available for this ion are the charge-expansion calculations of Crossley and Dalgarno [1] which include limited configuration mixing. Graphical comparisons of this work with more refined values within the isoelectronic sequence indicate accuracies within 25 percent. A number of additional values have been obtained from studies of the f-value dependence on nuclear charge. The reliable material available for other ions of this isoelectronic sequence in these cases permits the determination of reliable values simply by graphical interpolation.

Reference

[1] Crossley, R. J. S., and Dalgarno, A., Proc. Roy. Soc. London **A286**, 510–518 (1965).

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at. u.)	log gf	Accuracy	Source
1	$3s-3p$	$^2S-^2P^\circ$	*629.29*	0	*159670*	2	6	30.1	0.54	2.22	0.033	C	1
			[621.41]	0	160925	2	4	31.2	0.362	1.48	−0.140	C	*ls*
			[636.40]	0	157159	2	2	29.1	0.177	0.74	−0.451	C	*ls*
2	$3s-4p$	$^2S-^2P^\circ$	*131.73*	0	*759135*	2	6	180	0.14	0.12	−0.55	C	interp
			[131.65]	0	759615	2	4	180	0.092	0.080	−0.74	C	*ls*
			[131.90]	0	758174	2	2	180	0.046	0.040	−1.04	C	*ls*
3	$3p-3d$	$^2P^\circ-^2D$	*464.50*	*159670*	*374963*	6	10	85	0.459	4.21	0.440	C	1
			[466.95]	160925	375080	4	6	84	0.411	2.53	0.216	C	*ls*
			[459.50]	157159	374788	2	4	73	0.463	1.40	−0.033	C	*ls*
			[467.59]	160925	374788	4	4	14	0.046	0.28	−0.74	D	*ls*
4	$3p-4s$	$^2P^\circ-^2S$	*185.45*	*159670*	698902	6	2	520	0.090	0.33	−0.27	C	interp
			[185.88]	160925	698902	4	2	350	0.090	0.22	−0.44	C	*ls*
			[184.59]	157159	698902	2	2	180	0.091	0.11	−0.74	C	*ls*
5	$3d-4p$	$^2D-^2P^\circ$	*260.30*	*374963*	*759135*	10	6	200	0.12	1.0	0.08	C	interp
			[260.05]	375080	759615	6	4	170	0.12	0.60	−0.14	C	*ls*
			[260.83]	374788	758174	4	2	190	0.096	0.33	−0.42	C	*ls*
			[259.86]	374788	759615	4	4	19	0.020	0.067	−1.10	D	*ls*
6	$3d-4f$	$^2D-^2F^\circ$	*205.83*	*374963*	*860808*	10	14	1000	0.92	6.2	0.96	C+	interp
7	$3d-5f$	$^2D-^2F^\circ$	*145.73*	*374963*	*1061150*	10	14	380	0.17	0.82	0.23	C	interp
8	$4s-4p$	$^2S-^2P^\circ$	*1660.2*	698902	*759135*	2	6	6.2	0.77	8.4	0.19	C	interp
			[1647.1]	698902	759615	2	4	6.3	0.52	5.6	0.02	C	*ls*
			[1687.1]	698902	758174	2	2	5.9	0.25	2.8	−0.30	C	*ls*
9	$4p-4d$	$^2P^\circ-^2D$	*1287.6*	*759135*	*836798*	6	10	21	0.86	22	0.71	C	interp
			[1294.6]	759615	836861	4	6	20	0.76	13	0.48	C	*ls*
			[1273.4]	758174	836703	2	4	18	0.87	7.3	0.24	C	*ls*
			[1297.2]	759615	836703	4	4	3.5	0.088	1.5	−0.45	D	*ls*
10	$4p-5s$	$^2P^\circ-^2S$	*452.97*	*759135*	979901	6	2	150	0.15	1.3	−0.05	C	interp
			[453.96]	759615	979901	4	2	96	0.15	0.89	−0.22	C	*ls*
			[451.01]	758174	979901	2	2	50	0.15	0.45	−0.52	C	*ls*

K X

Ground State $1s^22s^22p^6\ ^1S_0$

Ionization Potential 503.8 eV = 4064300 cm^{-1}

Allowed Transitions

Calculations by Kastner, Omidvar, and Underwood [1], employing Hartree-Fock wave functions and including intermediate coupling, are available. Since the calculations are based on a single-configuration approximation only, uncertainties of up to 50 percent are expected for the strong lines and even higher uncertainties for the weak lines, the latter being more affected by assumptions about the coupling.

Reference

[1] Kastner, S. O., Omidvar, K., and Underwood, J. H., Astrophys. J. **148**, 269–273 (1967).

Kx. Allowed Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
1	$2p^6-2p^5(^2P^\circ_{3/2})3s$	$^1S-^3P^\circ$	[41.540]	0	2407300	1	3	770	0.060	0.0082	−1.22	E	1
2	$2p^6-2p^5(^2P^\circ_{1/2})3s$	$^1S-^1P^\circ$	[41.147]	0	2430300	1	3	1600	0.12	0.016	−0.92	D	1
3	$2p^6-2p^5(^2P^\circ_{3/2})3d$	$^1S-^3P^\circ$	[36.229]	0	2760200	1	3	110	0.0065	7.8×10^{-4}	−2.19	E	1
4	$2p^6-2p^5(^2P^\circ_{3/2})3d$	$^1S-^1P^\circ$	[35.779]	0	2794900	1	3	3.3×10^4	1.9	0.22	0.28	D	1
5	$2p^6-2p^5(^2P^\circ_{1/2})3d$	$^1S-^3D^\circ$	[35.307]	0	2832300	1	3	3900	0.22	0.026	−0.66	D	1

K XI

Ground State $1s^22s^22p^5\ ^2P^\circ_{3/2}$

Ionization Potential ?

Forbidden Transitions

The line strength for the one transition in the ground state configuration is a straight number, tabulated for example by Naqvi [1]. The transition probability should also be quite accurate, since the energy level difference is accurately known.

Reference

[1] Naqvi, A. M., Thesis Harvard (1951).

K XI. Forbidden Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	Type of Transition	A_{ki}(sec^{-1})	S(at.u.)	Accuracy	Source
1	$2p^5-2p^5$	$^2P^\circ-^2P^\circ$	[4256.4]	0	23475	4	2	m	231	1.33	A	1

Ground State $1s^2 2s^2 2p^2\ ^3P_0$

Ionization Potential ?

Forbidden Transitions

Krueger and Czyzak's [1] values have been used for this ion, except for the magnetic dipole $^3P_{0,1}-^3P_{1,3}$ transitions where Naqvi's [2] results have been applied. Some wavelength data are from observed coronal lines. The electric quadrupole moment (s_q) is based on self-consistent field wave functions with exchange.

References

[1] Krueger, T. K., and Czyzak, S. J., Astrophys. J. **144**, 1194–1202 (1966).
[2] Naqvi, A. M., Thesis Harvard (1951).

K XIV. Forbidden Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	Type of Transition	A_{ki}(sec^{-1})	S(at.u.)	Accuracy	Source
1	$2p^2-2p^2$	$^3P-^3P$										
			[7474]	0	[13380]	1	3	m	42.2	1.96	B−	2
			[3545]	0	[28210]	1	5	e	0.00222	0.00370	C−	1
			6740	[13380]	[28210]	3	5	m	42.1	2.39	B	2
			6740	[13380]	[28210]	3	5	e	1.79×10^{-4}	0.0074	C	1
		$^3P-^1D$										
			[1033]	0	[96810]	1	5	e	0.0051	1.8×10^{-5}	D−	1
			[1199]	[13380]	[96810]	3	5	m	412	0.131	C	1
			[1199]	[13380]	[96810]	3	5	e	0.056	4.2×10^{-4}	D	1
			[1458]	[28210]	[96810]	5	5	m	650	0.373	C	1
			[1458]	[28210]	[96810]	5	5	e	0.14	0.0028	D	1
		$^3P-^1S$										
			[625.3]	[13380]	[173310]	3	1	m	5200	0.0469	C	1
			[689.2]	[28210]	[173310]	5	1	e	3.5	3.2×10^{-4}	D	1
		$^1D-^1S$										
			[1307]	[96810]	[173310]	5	1	e	5.9	0.013	D	1

CALCIUM

Ca I

Ground State $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2\ {}^1S_0$

Ionization Potential 6.11 eV = 49305.72 cm^{-1}

Allowed Transitions

List of tabulated lines:

Wavelength [Å]	No.	Wavelength [Å]	No.	Wavelength [Å]	No.
2150.80	29	3630.97	32	4585.96	1
2200.73	28	3644.41	32	4586.1	1
2275.46	14	3644.77	32	4685.27	36
2398.56	27	3644.99	32	4878.13	2
2541.40	13	3673.42	11	5041.62	7
2617.66	12	3675.29	11	5188.85	33
2721.65	26	3678.21	11	5260.39	24
2994.96	15	3748.35	10	5261.71	24
2997.31	15	3750.29	10	5262.24	24
2999.64	15	3753.34	10	5264.24	24
3000.86	15	3870.48	8	5265.56	24
3006.86	15	3872.54	8	5270.27	24
3009.21	15	3872.56	8	5512.98	20
3102.35	42	3875.78	8	5581.97	23
3107.39	42	3875.8	8	5588.76	23
3117.65	42	3875.80	8	5590.12	23
3136.02	40	3948.90	34	5594.47	23
3140.79	40	3957.05	34	5598.49	23
3141.16	40	3973.71	34	5601.29	23
3150.75	40	4092.63	5	5602.85	23
3151.27	40	4094.93	5	5857.45	19
3151.64	40	4094.96	5	6102.72	31
3164.60	41	4098.53	5	6122.22	31
3169.84	41	4098.57	5	6156.02	3
3180.52	41	4098.6	5	6161.29	3
3209.96	38	4108.53	9	6162.17	31
3215.17	38	4226.73	17	6163.76	3
3215.34	38	4283.01	18	6166.44	3
3225.90	38	4289.36	18	6169.06	3
3226.15	38	4298.99	18	6169.56	3
3226.32	38	4302.53	18	6439.07	21
3269.08	39	4307.74	18	6449.81	22
3274.67	39	4318.65	18	6455.60	22
3286.07	39	4355.08	6	6462.57	21
3344.51	35	4425.44	30	6471.66	21
3350.21	35	4434.96	30	6493.78	21
3350.36	35	4435.69	30	6499.65	21
3361.92	35	4454.78	30	6508.85	21
3362.14	35	4455.89	30	6572.78	16
3362.28	35	4456.61	30	6717.69	4
3468.48	37	4526.94	25		
3474.76	37	4578.55	1		
3487.60	37	4581.40	1		
3624.11	32	4581.47	1		
3630.75	32	4585.87	1		

For this spectrum we have exclusively used experimental material since even recent theoretical efforts [10, 11] have not provided a consistent set of data. The f-value for the resonance line has been taken from three lifetime experiments, namely the Hanle effect measurements of Lurio, de Zafra, and Goshen [6], as well as Smith and Gallagher [7], and the phase-shift measurements of Hulpke, Paul, and Paul [8]. The very close agreement of the three results suggests the averaged value should be uncertain by no more than 10 percent. Another lifetime result, this one by Karstensen and Schramm [12], using delayed coincidence techniques for the $4f\,^1F^\circ$ level, allows a determination of the transition probability for the $3d\,^1D-4f\,^1F^\circ$ line, but in a less direct manner, since the contribution of the $4d\,^1D-4f\,^1F^\circ$ line had to be estimated via a Bates-Damgaard calculation and subtracted. Fairly precise relative oscillator strengths are available for a few lines from the anomalous dispersion experiments of Filippov and Kremenevsky [3], Prokof 'ev [5], and Shabanova [9] and for a larger number of lines from the work of Ostrovskii and Penkin [4]. The relative values are normalized to the value chosen for the resonance line. Further data could be taken from an emission experiment with a stabilized arc by Köstlin [2] and an absorption experiment by Olsen, Routly, and King [1]. The relative values of Olsen et al. have been normalized to Ostrovskii and Penkin's value for the 4289 Å line which in turn has been normalized to the above adopted value for the resonance line. (This simple normalization procedure leads here to the same result as a least-squares fit between the overlapping data of Olsen et al. and Ostrovskii and Penkin.) A detailed comparison of the data of Olsen et al. with all other available material indicates a wavelength dependence of Olsen's data for wavelengths greater than 4600 Å; hence, these values have not been used for these wavelengths except where no other source is available.

References

[1] Olsen, K. H., Routly, P. M., and King, R. B., Astrophys. J. **130**, 688–692 (1959).
[2] Köstlin, H., Z. Physik **178**, 200–215 (1964).
[3] Filippov, A., and Kremenevsky, N., Physik. Z. Sowjetunion **1**, 299–301 (1932).
[4] Ostrovskii, Yu. I., and Penkin, N. P., Optics and Spectroscopy (U.S.S.R.) **10**, 219–222 (1961).
[5] Prokof 'ev, V. K., Z. Physik **50**, 701–715 (1928).
[6] Lurio, A., de Zafra, R. L., and Goshen, R. J., Phys. Rev. **134**, A1198–A1203 (1964).
[7] Smith, W. W., and Gallagher, A., Phys. Rev. **145**, 26–35 (1966).
[8] Hulpke, E., Paul, E., and Paul, W., Z. Physik **177**, 257–268 (1964).
[9] Shabanova, L. N., Optics and Spectroscopy (U.S.S.R.) **15**, 450–451 (1963).
[10] Friedrich, H., and Trefftz, E., J. Quant. Spectrosc. Radiat. Transfer **9**, 333–359 (1969).
[11] Weiss, A. W., private communication (1968).
[12] Karstensen, F., and Schramm, J. Z. Astrophys. **68**, 214–221 (1968).

Ca I. Allowed Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at.u.)	log gf	Accuracy	Source
1	$4s3d-4s(^2S)4f$	$^3D-^3F^\circ$ (23)	*4582.7*	*20356*	*42171*	15	21	0.226	0.099	22.5	0.172	C	1*n*, 2
			4585.87	20371	42171	7	9	0.229	0.093	9.8	−0.186	C	1*n*, *ls*
			4581.40	20349	42171	5	7	0.209	0.092	6.9	−0.337	C	1*n*, *ls*
			4578.55	20335	42170	3	5	0.176	0.092	4.16	−0.56	C	1*n*, *ls*
			4585.96	20371	42171	7	7	0.025	0.0079	0.83	−1.26	D	*ls*
			4581.47	20349	42170	5	5	0.035	0.011	0.83	−1.26	D	*ls*
			[4586.1]	20371	42170	7	5	9.8×10^{-4}	2.2×10^{-4}	0.023	−2.81	E	*ls*
2		$^1D-^1F^\circ$ (35)	4878.13	21850	42344	5	7	0.188	0.094	7.5	−0.328	C	12
3	$4s3d-4s(^2S)5p$	$^3D-^3P^\circ$ (20)	*6167.7*	*20356*	*36565*	15	9	0.22	0.076	23	0.06	D	2
			6169.56	20371	36575	7	5	0.19	0.076	11	−0.27	D	*ls*
			6169.06	20349	36555	5	3	0.17	0.057	5.8	−0.55	D	*ls*
			6166.44	20335	36548	3	1	0.22	0.042	2.6	−0.90	D−	*ls*
			6161.29	20349	36575	5	5	0.033	0.019	1.9	−1.02	D−	*ls*
			6163.76	20335	36555	3	3	0.056	0.032	1.9	−1.02	D−	*ls*
			6156.02	20335	36575	3	5	0.0023	0.0021	0.13	−2.20	E	*ls*

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at. u.)	log gf	Accuracy	Source
4		^{1}D − ^{1}P° (32)	6717.69	21850	36732	5	3	0.12	0.049	5.4	−0.61	E	1*n*
5	4*s*3*d*−4*s*(^{2}S)5*f*	^{3}D − ^{3}F° (25)	*4096.0*	*20356*	44763	15	21	0.13	0.046	9.3	−0.16	D	1*n*
			4098.53	20371	44763	7	9	0.13	0.041	3.9	−0.54	D	1*n*
			4094.93	20349	44763	5	7	0.12	0.041	2.8	−0.69	D	1*n*
			4092.63	20335	44763	3	5	0.11	0.048	1.9	−0.84	D	1*n*
			4098.57	20371	44763	7	7	0.015	0.037	0.35	−1.59	D−	*ls*
			4094.96	20349	44763	5	5	0.021	0.0052	0.35	−1.59	D−	*ls*
			[4098.6]	20371	44763	7	5	5.8×10^{-4}	1.0×10^{-4}	0.0098	−3.15	E	*ls*
6		^{1}D − ^{1}F° (37)	4355.08	21850	44805	5	7	0.19	0.074	5.3	−0.43	D	1*n*
7	4*s*3*d*−4*s*(^{2}S)6*p*	^{1}D − ^{1}P° (34)	5041.62	21850	41679	5	3	0.33	0.076	6.3	−0.42	D	2
8	4*s*3*d*−4*s*(^{2}S)6*f*	^{3}D − ^{3}F° (26)	*3873.5*	*20356*	46165	15	21	0.075	0.024	4.5	−0.44	D	1*n*
			3875.78	20371	46165	7	9	0.079	0.023	2.1	−0.79	D	1*n*, *ls*
			3872.54	20349	46165	5	7	0.054	0.017	1.1	−1.07	D	1*n*, *ls*
			3870.48	20335	46165	3	5	0.072	0.027	1.0	−1.09	D	1*n*
			3875.80	20371	46165	7	7	0.0089	0.0020	0.18	−1.85	D−	1*n*, *ls*
			3872.56	20349	46165	5	5	0.0098	0.0022	0.14	−1.96	D−	1*n*, *ls*
			[3875.8]	20371	46165	7	5	3.5×10^{-4}	5.7×10^{-5}	0.0051	−3.40	E	1*n*, *ls*
9		^{1}D − ^{1}F° (39)	4108.53	21850	46182	5	7	0.90	0.32	22	0.20	D	1*n*
10	4*s*3*d*−4*s*(^{2}S)7*f*	^{3}D − ^{3}F° (27)	*3751.3*	*20356*	47006	15	21	0.040	0.012	2.2	−0.74	D	1*n*
			3753.34	20371	47006	7	9	0.041	0.011	0.95	−1.11	D	1*n*, *ls*
			3750.29	20349	47006	5	7	0.034	0.010	0.62	−1.30	D	1*n*, *ls*
			3748.35	20335	47006	3	5	0.034	0.012	0.44	−1.44	D	1*n*, *ls*
			3753.34	20371	47006	7	7	0.0044	9.3×10^{-4}	0.080	−2.19	D−	1*n*, *ls*
			3750.29	20349	47006	5	5	0.0062	0.0013	0.080	−2.19	D−	1*n*, *ls*
			3753.34	20371	47006	7	5	1.7×10^{-4}	2.6×10^{-5}	0.0022	−3.74	E	1*n*, *ls*
11	4*s*3*d*−4*s*(^{2}S)8*f*	^{3}D − ^{3}F° (28)	*3676.2*	*20356*	47550	15	21	0.025	0.0072	1.3	−0.97	D	1*n*
			3678.21	20371	47550	7	9	0.023	0.0061	0.52	−1.37	D	1*n*, *ls*
			3675.29	20349	47550	5	7	0.022	0.0062	0.38	−1.51	D	1*n*, *ls*
			3673.42	20335	47550	3	5	0.022	0.0075	0.27	−1.65	D	1*n*
			3678.21	20371	47550	7	7	0.0026	5.3×10^{-4}	0.045	−2.43	D−	1*n*, *ls*
			3675.29	20349	47550	5	5	0.0038	7.7×10^{-4}	0.047	−2.41	D−	1*n*, *ls*
			3678.21	20371	47550	7	5	1.0×10^{-4}	1.5×10^{-5}	0.0013	−3.98	E	1*n*, *ls*
12	4*s*^{2}−3*d*(^{2}D)4*p*′	^{1}S − ^{3}D° (3 uv)											
			2617.66	0	38192	1	3	1.6×10^{-4}	5.0×10^{-5}	4.3×10^{-4}	−4.30	D−	3*n*
13		^{1}S − ^{3}P° (4 uv)											
			2541.40	0	39335	1	3	1.7×10^{-4}	5.0×10^{-5}	4.2×10^{-4}	−4.30	D−	3*n*
14		^{1}S − ^{1}P° (6 uv)	2275.46	0	43933	1	3	0.301	0.070	0.52	−1.155	C+	3*n*, 4*n*
15	4*s*4*p*−3*d*^{2}	^{3}P° − ^{3}P (17)	*3003.2*	*15263*	*48551*	9	9	1.08	0.146	13.0	0.119	C	1*n*, 2
			3006.86	15316	48564	5	5	0.75	0.101	5.0	−0.297	C	1*n*, *ls*
			2999.64	15210	48538	3	3	0.279	0.0376	1.11	−0.95	C	1*n*, *ls*
			3009.21	15316	48538	5	3	0.430	0.0350	1.73	−0.76	C	1*n*, *ls*
			3000.86	15210	48524	3	1	1.58	0.071	2.10	−0.67	C	1*n*, *ls*
			2997.31	15210	48564	3	5	0.241	0.054	1.60	−0.79	C	1*n*, *ls*
			2994.96	15158	48538	1	3	0.367	0.148	1.46	−0.83	C	1*n*, *ls*

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at. u.)	log gf	Accuracy	Source
16	$4s^2-4s(^2S)4p$	$^1S-^3P^\circ$ (1)											
			6572.78	0	15210	1	3	2.6×10^{-5}	5.1×10^{-5}	0.0011	−4.29	D+	4*n*, 5*n*
17		$^1S-^1P^\circ$ (2)	4226.73	0	23652	1	3	2.18	1.75	24.4	0.243	B+	6, 7, 8
18	$4s4p-4p^2$	$^3P^\circ-^3P$ (5)	*4300.8*	*15263*	*38508*	9	9	1.81	0.50	64	0.65	C+	1*n*, 2, 4*n*
			4302.53	15316	38552	5	5	1.36	0.377	26.7	0.275	C+	1*n*, 4*n*, *ls*
			4298.99	15210	38465	3	3	0.466	0.129	5.5	−0.412	C+	1*n*, 4*n*, *ls*
			4318.65	15316	38465	5	3	0.74	0.124	8.8	−0.208	C+	1*n*, 4*n*, *ls*
			4307.74	15210	38418	3	1	1.99	0.185	7.9	−0.256	C+	1*n*, 4*n*, *ls*
			4283.01	15210	38552	3	5	0.434	0.199	8.4	−0.224	C+	1*n*, 4*n*, *ls*
			4289.36	15158	38465	1	3	0.60	0.498	7.0	−0.303	C+	1*n*, 4*n*, *ls*
19		$^1P^\circ-^1D$ (47)	5857.45	23652	40720	3	5	0.66	0.57	33	0.23	D	2
20		$^1P^\circ-^1S$ (48)	5512.98	23652	41786	3	1	1.1	0.17	9.3	−0.29	E	1*n*
21	$4s3d-3d(^2D)4p'$	$^3D-^3F^\circ$ (18)	*6460.3*	*20356*	*35831*	15	21	0.54	0.47	150	0.85	D	2
			6439.07	20371	35897	7	9	0.53	0.42	62	0.47	D	*ls*
			6462.57	20349	35819	5	7	0.47	0.41	44	0.31	D	*ls*
			6493.78	20335	35730	3	5	0.44	0.46	30	0.14	D	*ls*
			6471.66	20371	35819	7	7	0.059	0.037	5.5	−0.59	D−	*ls*
			6499.65	20349	35730	5	5	0.081	0.051	5.5	−0.59	D−	*ls*
			6508.85	20371	35730	7	5	0.0024	0.0011	0.16	−2.11	E	*ls*
22		$^3D-^1D^\circ$ (19)											
			6455.60	20349	35835	5	5	0.014	0.0090	0.96	−1.35	E	1*n*
			6449.81	20335	35835	3	5	0.090	0.094	6.0	−0.55	D	2
23		$^3D-^3D^\circ$ (21)	*5592.5*	*20356*	*38232*	15	15	0.56	0.26	73	0.59	D	2
			5588.76	20371	38259	7	7	0.49	0.23	30	0.21	D	*ls*
			5594.47	20349	38219	5	5	0.38	0.18	17	−0.05	D	*ls*
			5598.49	20335	38192	3	3	0.43	0.20	11	−0.22	D	*ls*
			5601.29	20371	38219	7	5	0.086	0.029	3.7	−0.69	D−	*ls*
			5602.85	20349	38192	5	3	0.14	0.040	3.7	−0.70	D−	*ls*
			5581.97	20349	38259	5	7	0.060	0.039	3.6	−0.71	D−	*ls*
			5590.12	20335	38219	3	5	0.083	0.065	3.6	−0.71	D−	*ls*
24		$^3D-^3P^\circ$ (22)	*5266.7*	*20356*	*39338*	15	9	0.60	0.15	39	0.35	D	2
			5270.27	20371	39340	7	5	0.50	0.15	18	0.02	D	*ls*
			5265.56	20349	39335	5	3	0.44	0.11	9.5	−0.26	D	*ls*
			5262.24	20335	39333	3	1	0.60	0.083	4.3	−0.60	D−	*ls*
			5264.24	20349	39340	5	5	0.091	0.038	3.3	−0.72	D−	*ls*
			5261.71	20335	39335	3	3	0.15	0.062	3.2	−0.73	D−	*ls*
			5260.39	20335	39340	3	5	0.0061	0.0042	0.22	−1.90	E	*ls*
25		$^1D-^1P^\circ$ (36)	4526.94	21850	43933	5	3	0.41	0.075	5.6	−0.43	D	1*n*
26	$4s^2-4s(^2S)5p$	$^1S-^1P^\circ$ (2 uv)	2721.65	0	36732	1	3	0.0027	9.0×10^{-4}	0.0081	−3.05	D	3*n*

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at. u.)	log gf	Accuracy	Source
27	$4s^2-4s(^2S)6p$	$^1S-^1P^\circ$ (5 uv)	2398.56	0	41679	1	3	0.167	0.0433	0.342	−1.364	C+	3*n*, 4*n*
28	$4s^2-4s(^2S)7p$	$^1S-^1P^\circ$ (7 uv)	2200.73	0	45425	1	3	0.153	0.0333	0.241	−1.478	C	9*n*
29	$4s^2-4s(^2S)8p$	$^1S-^1P^\circ$ (8 uv)	2150.80	0	46480	1	3	0.061	0.0126	0.089	−1.90	C	9*n*
30	$4s4p-4s(^2S)4d$	$^3P^\circ-^3D$ (4)	*4445.0*	*15263*	*37754*	9	15	0.85	0.418	55	0.58	C+	1*n*, 2, 4*n*
			4454.78	15316	37757	5	7	0.86	0.357	26.2	0.252	C+	1*n*, 4*n*, *ls*
			4434.96	15210	37752	3	5	0.63	0.312	13.7	−0.029	C+	1*n*, 4*n*, *ls*
			4425.44	15158	37748	1	3	0.468	0.412	6.0	−0.385	C+	1*n*, 4*n*, *ls*
			4455.89	15316	37752	5	5	0.208	0.062	4.55	−0.51	C+	1*n*, 4*n*, *ls*
			4435.69	15210	37748	3	3	0.356	0.105	4.60	−0.50	C+	1*n*, 4*n*, *ls*
			4456.61	15316	37748	5	3	0.0245	0.00437	0.321	−1.66	C+	1*n*, 4*n*, *ls*
31	$4s4p-4s(^2S)5s$	$^3P^\circ-^3S$ (3)	*6141.9*	*15263*	31539	9	3	0.66	0.125	22.8	0.051	C	2, 4*n*
			6162.17	15316	31539	5	3	0.354	0.121	12.3	−0.218	C	4*n*, *ls*
			6122.22	15210	31539	3	3	0.231	0.130	7.9	−0.409	C	4*n*, *ls*
			6102.72	15158	31539	1	3	0.077	0.129	2.59	−0.89	C	4*n*, *ls*
32	$4s4p-4s(^2S)5d$	$^3P^\circ-^3D$ (9)	*3637.6*	*15263*	*42746*	9	15	0.370	0.122	13.2	0.041	C+	1*n*, 2, 4*n*
			3644.41	15316	42747	5	7	0.355	0.099	5.9	−0.305	C+	1*n*, 4*n*, *ls*
			3630.75	15210	42745	3	5	0.297	0.098	3.51	−0.53	C+	1*n*, 4*n*, *ls*
			3624.11	15158	42743	1	3	0.212	0.125	1.49	−0.90	C+	1*n*, 4*n*, *ls*
			3644.77	15316	42745	5	5	0.094	0.0188	1.13	−1.027	C+	1*n*, 4*n*, *ls*
			3630.97	15210	42743	3	3	0.153	0.0302	1.08	−1.043	C+	1*n*, 4*n*, *ls*
			3644.99	15316	42743	5	3	0.0095	0.00114	0.068	−2.244	C+	1*n*, 4*n*, *ls*
33		$^1P^\circ-^1D$ (49)	5188.85	23652	42919	3	5	0.40	0.27	14	−0.09	D	2
34	$4s4p-4s(^2S)6s$	$^3P^\circ-^3S$ (6)	*3965.4*	*15263*	40474	9	3	0.305	0.0240	2.82	−0.67	C	1*n*, 4*n*
			3973.71	15316	40474	5	3	0.175	0.0248	1.62	−0.91	C	1*n*, 4*n*
			3957.05	15210	40474	3	3	0.098	0.0231	0.90	−1.159	C	1*n*, 4*n*
			3948.90	15158	40474	1	3	0.0334	0.0234	0.304	−1.63	C	1*n*, 4*n*
35	$4s4p-4s(^2S)6d$	$^3P^\circ-^3D$ (11)	*3356.1*	*15263*	*45051*	9	15	0.239	0.067	6.7	−0.220	C	1*n*, 4*n*
			3361.92	15316	45052	5	7	0.223	0.053	2.93	−0.58	C	1*n*, 4*n*
			3350.21	15210	45050	3	5	0.178	0.050	1.65	−0.82	C	1*n*, 4*n*
			3344.51	15158	45049	1	3	0.151	0.076	0.84	−1.119	C	1*n*, 4*n*
			3362.14	15316	45050	5	5	0.065	0.0110	0.61	−1.260	C	1*n*, 4*n*
			3350.36	15210	45049	3	3	0.111	0.0187	0.62	−1.251	C	1*n*, 4*n*
			3362.28	15316	45049	5	3	0.0059	6.0×10^{-4}	0.0332	−2.52	C	4*n*
36		$^1P^\circ-^1D$ (51)	4685.27	23652	44990	3	5	0.080	0.044	2.0	−0.88	D	2

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at. u.)	log gf	Accuracy	Source
37	$4s4p-4s(^2S)7s$	$^3P^\circ-^3S$ (10)	*3481.1*	*15263*	43981	9	3	0.14	0.0082	0.85	−1.13	D	1*n*
			3487.60	15316	43981	5	3	0.078	0.0085	0.49	−1.37	D	1*n*
			3474.76	15210	43981	3	3	0.046	0.0083	0.28	−1.60	D	1*n*
			3468.48	15158	43981	1	3	0.013	0.0071	0.081	−2.15	D	1*n*
38	$4s4p-4s(^2S)7d$	$^3P^\circ-^3D$ (13)	*3220.5*	*15263*	*46305*	9	15	0.15	0.040	3.8	−0.44	D	1*n*
			3225.90	15316	46306	5	7	0.16	0.035	1.9	−0.76	D	1*n*
			3215.17	15210	46304	3	5	0.11	0.028	0.89	−1.08	D	1*n*
			3209.96	15158	46302	1	3	0.073	0.034	0.36	−1.47	D	1*n*
			3226.16	15316	46304	5	5	0.040	0.0062	0.33	−1.51	D	1*n*
			3215.34	15210	46302	3	3	0.051	0.0079	0.25	−1.63	D	1*n*
			3236.32	15316	46302	5	3	0.0042	4.0×10^{-4}	0.021	−2.70	E	*ls*
39	$4s4p-4s(^2S)8s$	$^3P^\circ-^3S$ (12)	*3280.3*	*15263*	45739	9	3	0.094	0.0050	0.49	−1.35	D	1*n*
			3286.07	15316	45739	5	3	0.053	0.0051	0.28	−1.59	D	1*n*
			3274.67	15210	45739	3	3	0.030	0.0048	0.16	−1.84	D	1*n*
			3269.08	15158	45739	1	3	0.0094	0.0045	0.048	−2.35	D	1*n*
40	$4s4p-4s(^2S)8d$	$^3P^\circ-^3D$ (15)	*3145.8*	*15263*	*47042*	9	15	0.078	0.019	1.8	−0.77	D	1*n*
			3150.75	15316	47045	5	7	0.086	0.018	0.93	−1.05	D	1*n*
			3140.79	15210	47040	3	5	0.049	0.012	0.37	−1.44	D	1*n*
			3136.02	15158	47036	1	3	0.041	0.018	0.19	−1.74	D	1*n*
			3151.27	15316	47040	5	5	0.018	0.0027	0.14	−1.87	D	1*n*
			3141.16	15210	47036	3	3	0.030	0.0044	0.14	−1.88	D	1*n*
			3151.64	15316	47036	5	3	0.0022	1.9×10^{-4}	0.010	−3.02	E	*ls*
41	$4s4p-4s(^2S)9s$	$^3P^\circ-^3S$ (14)	*3175.2*	*15263*	46748	9	3	0.055	0.0028	0.26	−1.60	D	1*n*
			3180.52	15316	46748	5	3	0.029	0.0026	0.14	−1.89	D	1*n*
			3169.84	15210	46748	3	3	0.020	0.0030	0.094	−2.05	D	1*n*
			3164.60	15158	46748	1	3	0.0053	0.0024	0.025	−2.62	D	1*n*
42	$4s4p-4s(^2S)10s$	$^3P^\circ-^3S$ (16)	*3112.5*	*15263*	47382	9	3	0.034	0.0016	0.15	−1.84	D	1*n*
			3117.65	15316	47382	5	3	0.017	0.0015	0.077	−2.12	D	1*n*
			3107.39	15210	47382	3	3	0.010	0.0015	0.046	−2.35	D	1*n*
			3102.35	15158	47382	1	3	0.0062	0.0027	0.028	−2.57	D	1*n*

Ca II

Ground State $1s^22s^22p^63s^23p^64s\ ^2S_{1/2}$

Ionization Potential 11.87 eV = 95748.0 cm^{-1}

Allowed Transitions

List of tabulated lines:

Wavelength [Å]	No.	Wavelength [Å]	No.	Wavelength [Å]	No.
1287.2	10	1330.9	8	1455.5	28
1288.2	10	1368.4	7	1460.2	28
1304.6	9	1369.5	7	1461.2	27
1305.7	9	1433.1	6	1466.0	27
1329.8	8	1434.3	6	1468.3	26

Wavelength [Å]	No.	Wavelength [Å]	No.	Wavelength [Å]	No.
1473.1	26	1814.6	18	4220.13	32
1477.3	25	1815.04	18	5001.49	34
1482.1	25	1838.08	4	5019.98	34
1488.8	24	1840.21	4	5021.14	34
1493.7	24	1843.6	14	5285.34	31
1504.2	23	1851.10	14	5307.30	31
1509.2	23	2103.24	17	8203.2	33
1525.3	22	2112.76	17	8250.2	33
1530.4	22	2113.19	17	8256.1	33
1553.5	5	2128.73	2	8498.02	1
1555.1	5	2131.43	2	8542.09	1
1555.3	21	2132.25	2	8662.14	1
1560.6	21	2197.79	13	9856.7	30
1600.5	20	2208.61	13	9933.3	30
1606.1	20	3158.87	16	11836.4	29
1606.2	20	3179.33	16	11947.0	29
1642.8	3	3181.28	16		
1643.8	3	3706.03	12		
1644.4	3	3736.90	12		
1673.8	19	3933.66	11		
1680.0	19	3968.47	11		
1680.1	19	4097.12	35		
1691.7	15	4109.83	35		
1698.1	15	4110.33	35		
1807.74	18	4206.21	32		

The great majority of the values are taken from the extensive calculations of Trefftz [1] which are based on the self-consistent field method and include core polarization effects. Her results for the $3d-4p$ and $4s-4p$ transitions are supported by excellent agreement (2–5%) with similar calculations of Weiss [3] (SCF with core relaxation) and Douglas and Garstang [4] (SCF with core polarization). For the $4s-4p$ transition, an experimental value is available from the lifetime measurements by Gallagher [2] employing the Hanle effect, which agrees with 10 percent with the theoretical results. Thus the average of the measured value and Trefftz' calculated result is adopted.

References

[1] Trefftz, E., private communication (1968) and to be published.
[2] Gallagher, A., Phys. Rev. **157**, 24–30 (1967).
[3] Weiss, A. W., J. Res. NBS **71A** (Phys. and Chem.) 157–162 (1967).
[4] Douglas, A. S., and Garstang, R. H., Proc. Cambridge Phil. Soc. **58**, 377–381 (1962).

Ca II. Allowed Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at. u.)	log gf	Accuracy	Source
1	$3d-4p$	$^2D-^2P^\circ$ (2)	*8579.1*	*13687*	*25340*	10	6	0.109	0.072	20.3	−0.143	C	1
			8542.09	13711	25414	6	4	0.099	0.072	12.2	−0.365	C	*ls*
			8662.14	13650	25192	4	2	0.106	0.060	6.8	−0.62	C	*ls*
			8498.02	13650	25414	4	4	0.0111	0.0121	1.35	−1.315	C	*ls*
2	$3d-5p$	$^2D-^2P^\circ$ (3 uv)	*2131.5*	*13687*	*60587*	10	6	0.020	8.1×10^{-4}	0.057	−2.09	D	1
			2131.43	13711	60613	6	4	0.018	8.1×10^{-4}	0.034	−2.31	D	*ls*
			2132.25	13650	60535	4	2	0.020	6.8×10^{-4}	0.019	−2.57	D	*ls*
			2128.73	13650	60613	4	4	0.0020	1.4×10^{-4}	0.0038	−3.25	D	*ls*

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at. u.)	log gf	Accuracy	Source
3	$3d-6p$	$^2D-^2P^\circ$ (5 uv)	*1644.1*	*13687*	*74510*	10	6	0.014	3.3×10^{-4}	0.018	−2.48	D	1
			1644.4	13711	74522	6	4	0.013	3.4×10^{-4}	0.011	−2.69	D	*ls*
			1643.8	13650	74486	4	2	0.014	2.8×10^{-4}	0.0060	−2.95	D	*ls*
			1642.8	13650	74522	4	4	0.0014	5.5×10^{-5}	0.0012	−3.66	D	*ls*
4	$3d-4f$	$^2D-^2F^\circ$ (4 uv)	*1839.2*	*13687*	68057	10	14	2.61	0.185	11.2	0.267	C	1
			1840.21	13711	68057	6	8	2.60	0.176	6.4	0.024	C	*ls*
			1838.08	13650	68057	4	6	2.44	0.185	4.48	−0.131	C	*ls*
			1840.21	13711	68057	6	6	0.173	0.0088	0.320	−1.277	C	*ls*
5	$3d-5f$	$^2D-^2F^\circ$ (6 uv)	*1554.2*	*13687*	78028	10	14	1.70	0.086	4.40	−0.066	C	1
			1555.1	13711	78028	6	8	1.69	0.082	2.51	−0.308	C	*ls*
			1553.5	13650	78028	4	6	1.59	0.086	1.76	−0.463	C	*ls*
			1555.1	13711	78028	6	6	0.113	0.00410	0.126	−1.61	C	*ls*
6	$3d-6f$	$^2D-^2F^\circ$ (7 uv)	*1433.3*	*13687*	83458	10	14	1.08	0.0465	2.19	−0.333	C	1
			1434.3	13711	83458	6	8	1.07	0.0441	1.25	−0.58	C	*ls*
			1433.1	13650	83458	4	6	1.01	0.0466	0.88	−0.73	C	*ls*
			1434.3	13711	83458	6	6	0.072	0.00222	0.063	−1.88	C	*ls*
7	$3d-7f$	$^2D-^2F^\circ$	*1369.1*	*13687*	86728	10	14	0.71	0.0280	1.26	−0.55	C	1
			[1369.5]	13711	86728	6	8	0.71	0.0266	0.72	−0.80	C	*ls*
			[1368.4]	13650	86728	4	6	0.66	0.0277	0.50	−0.96	C	*ls*
			[1369.5]	13711	86728	6	6	0.0473	0.00133	0.0360	−2.098	C	*ls*
8	$3d-8f$	$^2D-^2F^\circ$	*1330.5*	*13687*	88848	10	14	0.490	0.0182	0.80	−0.74	C	1
			[1330.9]	13711	88848	6	8	0.491	0.0174	0.457	−0.98	C	*ls*
			[1329.8]	13650	88848	4	6	0.459	0.0182	0.320	−1.138	C	*ls*
			[1330.9]	13711	88848	6	6	0.0328	8.7×10^{-4}	0.0229	−2.282	C	*ls*
9	$3d-9f$	$^2D-^2F^\circ$	*1305.3*	*13687*	90300	10	14	0.350	0.0125	0.54	−0.90	C	1
			[1305.7]	13711	90300	6	8	0.352	0.0120	0.309	−1.143	C	*ls*
			[1304.6]	13650	90300	4	6	0.328	0.0126	0.216	−1.298	C	*ls*
			[1305.7]	13711	90300	6	6	0.0234	6.0×10^{-4}	0.0154	−2.444	C	*ls*
10	$3d-10f$	$^2D-^2F^\circ$	*1287.8*	*13687*	91338	10	14	0.259	0.0090	0.382	−1.046	C	1
			[1288.2]	13711	91338	6	8	0.258	0.0086	0.218	−1.287	C	*ls*
			[1287.2]	13650	91338	4	6	0.242	0.0090	0.153	−1.444	C	*ls*
			[1288.2]	13711	91338	6	6	0.0172	4.28×10^{-4}	0.0109	−2.59	C	*ls*
11	$4s-4p$	$^2S-^2P^\circ$ (1)	*3945.2*	0	*25340*	2	6	1.48	1.04	27.0	0.318	C+	1, 2
			3933.66	0	25414	2	4	1.50	0.69	18.0	0.140	C+	*ls*
			3968.47	0	25192	2	2	1.46	0.344	9.0	−0.162	C+	*ls*
12	$4p-5s$	$^2P^\circ-^2S$ (3)	*3726.5*	*25340*	52167	6	2	2.49	0.173	12.7	0.016	C	1
			3736.90	25414	52167	4	2	1.65	0.173	8.5	−0.160	C	*ls*
			3706.03	25192	52167	2	2	0.84	0.173	4.22	−0.461	C	*ls*
13	$4p-6s$	$^2P^\circ-^2S$ (8 uv)	*2205.0*	*25340*	70678	6	2	0.93	0.0227	0.99	−0.87	C	1
			2208.61	25414	70678	4	2	0.62	0.0227	0.66	−1.042	C	*ls*
			2197.79	25192	70678	2	2	0.313	0.0227	0.328	−1.343	C	*ls*
14	$4p-7s$	$^2P^\circ-^2S$ (10 uv)	*1848.1*	*25340*	79450	6	2	0.463	0.0079	0.288	−1.324	C	1
			1851.10	25414	79450	4	2	0.308	0.0079	0.193	−1.50	C	*ls*
			1843.6	25192	79450	2	2	0.155	0.0079	0.096	−1.80	C	*ls*

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at. u.)	log gf	Accuracy	Source
15	$4p-8s$	$^2P^\circ-^2S$	*1696.0*	*25340*	84303	6	2	0.269	0.00387	0.130	−1.63	C	1
			[1698.1]	25414	84303	4	2	0.179	0.00387	0.087	−1.81	C	*ls*
			[1691.7]	25192	84303	2	2	0.090	0.00387	0.0431	−2.111	C	*ls*
16	$4p-4d$	$^2P^\circ-^2D$ (4)	*3172.6*	*25340*	*56851*	6	10	3.62	0.91	57	0.74	C	1
			3179.33	25414	56859	4	6	3.59	0.82	34.2	0.52	C	*ls*
			3158.87	25192	56839	2	4	3.05	0.91	19.0	0.260	C	*ls*
			3181.28	25414	56839	4	4	0.60	0.091	3.80	−0.439	C	*ls*
17	$4p-5d$	$^2P^\circ-^2D$ (9 uv)	*2109.6*	*25340*	*72727*	6	10	1.10	0.122	5.1	−0.135	C	1
			2112.76	25414	72731	4	6	1.10	0.110	3.06	−0.357	C	*ls*
			2103.24	25192	72722	2	4	0.93	0.123	1.70	−0.61	C	*ls*
			2113.19	25414	72722	4	4	0.182	0.0122	0.340	−1.312	C	*ls*
18	$4p-6d$	$^2P^\circ-^2D$ (11 uv)	*1812.1*	*25340*	*80526*	6	10	0.490	0.0402	1.44	−0.62	C	1
			1815.04	25414	80528	4	6	0.486	0.0360	0.86	−0.84	C	*ls*
			1807.74	25192	80523	2	4	0.412	0.0403	0.480	−1.094	C	*ls*
			[1814.6]	25414	80523	4	4	0.081	0.00402	0.096	−1.79	C	*ls*
19	$4p-7d$	$^2P^\circ-^2D$	*1677.9*	*25340*	*84937*	6	10	0.266	0.0187	0.62	−0.95	C	1
			[1680.0]	25414	84938	4	6	0.265	0.0168	0.372	−1.173	C	*ls*
			[1673.8]	25192	84935	2	4	0.224	0.0188	0.207	−1.425	C	*ls*
			[1680.1]	25414	84935	4	4	0.0441	0.00187	0.0413	−2.126	C	*ls*
20	$4p-8d$	$^2P^\circ-^2D$	*1604.2*	*25340*	*87677*	6	10	0.162	0.0104	0.330	−1.205	C	1
			[1606.1]	25414	87676	4	6	0.161	0.0094	0.198	−1.425	C	*ls*
			[1600.5]	25192	87674	2	4	0.136	0.0104	0.110	−1.68	C	*ls*
			[1606.2]	25414	87674	4	4	0.0269	0.00104	0.0220	−2.381	C	*ls*
21	$4p-9d$	$^2P^\circ-^2D$	*1558.8*	*25340*	*89491*	6	10	0.105	0.0064	0.197	−1.416	C	1
			[1560.6]	25414	89491	4	6	0.105	0.0057	0.118	−1.64	C	*ls*
			[1555.3]	25192	89490	2	4	0.089	0.0064	0.066	−1.89	C	*ls*
			[1560.6]	25414	89490	4	4	0.0175	6.4×10^{-4}	0.0131	−2.59	C	*ls*
22	$4p-10d$	$^2P^\circ-^2D$	*1528.7*	*25340*	*90756*	6	10	0.073	0.00428	0.129	−1.59	C	1
			[1530.4]	25414	90756	4	6	0.073	0.00382	0.077	−1.82	C	*ls*
			[1525.3]	25192	90755	2	4	0.061	0.00428	0.0430	−2.068	C	*ls*
			[1530.4]	25414	90755	4	4	0.0122	4.27×10^{-4}	0.0086	−2.77	C	*ls*
23	$4p-11d$	$^2P^\circ-^2D$	*1507.5*	*25340*	91674	6	10	0.053	0.00302	0.090	−1.74	C	1
			[1509.2]	25414	91674	4	6	0.053	0.00272	0.054	−1.96	C	*ls*
			[1504.2]	25192	91674	2	4	0.0446	0.00303	0.0300	−2.218	C	*ls*
			[1509.2]	25414	91674	4	4	0.0088	3.02×10^{-4}	0.0060	−2.92	C	*ls*
24	$4p-12d$	$^2P^\circ-^2D$	*1492.1*	*25340*	92361	6	10	0.0399	0.00222	0.065	−1.88	C	1
			[1493.7]	25414	92361	4	6	0.0395	0.00198	0.0390	−2.101	C	*ls*
			[1488.8]	25192	92361	2	4	0.0333	0.00221	0.0217	−2.355	C	*ls*
			[1493.7]	25414	92361	4	4	0.0066	2.20×10^{-4}	0.00433	−3.056	C	*ls*
25	$4p-13d$	$^2P^\circ-^2D$	*1480.5*	*25340*	92885	6	10	0.0305	0.00167	0.0488	−2.000	C	1
			[1482.1]	25414	92885	4	6	0.0304	0.00150	0.0293	−2.222	C	*ls*
			[1477.3]	25192	92885	2	4	0.0256	0.00168	0.0163	−2.474	C	*ls*
			[1482.1]	25414	92885	4	4	0.0051	1.67×10^{-4}	0.00325	−3.175	C	*ls*

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at. u.)	log gf	Accuracy	Source
26	$4p-14d$	$^2P^\circ-^2D$	*1471.5*	*25340*	93300	6	10	0.0240	0.00130	0.0378	−2.108	C	1
			[1473.1]	25414	93300	4	6	0.0240	0.00117	0.0227	−2.330	C	*ls*
			[1468.3]	25192	93300	2	4	0.0202	0.00130	0.0126	−2.59	C	*ls*
			[1473.1]	25414	93300	4	4	0.00399	1.30×10^{-4}	0.00252	−3.284	C	*ls*
27	$4p-15d$	$^2P^\circ-^2D$	*1464.4*	*25340*	93629	6	10	0.0192	0.00103	0.0298	−2.209	C	1
			[1466.0]	25414	93629	4	6	0.0192	9.3×10^{-4}	0.0179	−2.429	C	*ls*
			[1461.2]	25192	93629	2	4	0.0161	0.00103	0.0099	−2.69	C	*ls*
			[1466.0]	25414	93629	4	4	0.00320	1.03×10^{-4}	0.00199	−3.385	C	*ls*
28	$4p-16d$	$^2P^\circ-^2D$	*1458.7*	*25340*	93896	6	10	0.0156	8.3×10^{-4}	0.0239	−2.303	C	1
			[1460.2]	25414	93896	4	6	0.0155	7.4×10^{-4}	0.0143	−2.53	C	*ls*
			[1455.5]	25192	93896	2	4	0.0131	8.3×10^{-4}	0.0080	−2.78	C	*ls*
			[1460.2]	25414	93896	4	4	0.00259	8.3×10^{-5}	0.00159	−3.479	C	*ls*
29	$5s-5p$	$^2S-^2P^\circ$ (5)	*11873*	52167	*60587*	2	6	0.23	1.5	110	0.48	D	*ca*
			11836.4	52167	60613	2	4	0.23	0.98	76	0.29	D	*ls*
			11947.0	52167	60535	2	2	0.23	0.49	38	−0.01	D	*ls*
30	$5p-6s$	$^2P^\circ-^2S$ (12)	*9907.1*	*60587*	70678	6	2	0.58	0.28	55	0.23	D	*ca*
			9933.3	60613	70678	4	2	0.38	0.28	37	0.05	D	*ls*
			9856.7	60535	70678	2	2	0.19	0.28	18	−0.25	D	*ls*
31	$5p-7s$	$^2P^\circ-^2S$ (14)	*5299.9*	*60587*	79450	6	2	0.23	0.033	3.4	−0.70	D	*ca*
			5307.30	60613	79450	4	2	0.15	0.033	2.3	−0.88	D	*ls*
			5285.34	60535	79450	2	2	0.078	0.033	1.1	−1.18	D	*ls*
32	$5p-8s$	$^2P^\circ-^2S$ (16)	*4215.4*	*60587*	84303	6	2	0.13	0.011	0.95	−1.18	D	*ca*
			4220.13	60613	84303	4	2	0.085	0.011	0.63	−1.36	D	*ls*
			4206.21	60535	84303	2	2	0.043	0.011	0.32	−1.66	D	*ls*
33	$5p-5d$	$^2P^\circ-^2D$ (13)	*8235.0*	*60587*	*72727*	6	10	0.61	1.0	170	0.78	C−	*ca*
			8250.2	60613	72731	4	6	0.61	0.93	100	0.57	C−	*ls*
			8203.2	60535	72722	2	4	0.51	1.0	56	0.30	C−	*ls*
			8256.1	60613	72722	4	4	0.10	0.10	11	−0.40	C−	*ls*
34	$5p-6d$	$^2P^\circ-^2D$ (15)	*5013.9*	*60587*	*80526*	6	10	0.24	0.15	15	−0.05	D	*ca*
			5019.98	60613	80528	4	6	0.23	0.13	8.8	−0.28	D	*ls*
			5001.49	60535	80523	2	4	0.20	0.15	4.9	−0.52	D	*ls*
			5021.14	60613	80523	4	4	0.039	0.015	0.98	−1.22	D	*ls*
35	$5p-7d$	$^2P^\circ-^2D$ (17)	*4105.6*	*60587*	*84937*	6	10	0.12	0.050	4.0	−0.52	D	*ca*
			4109.83	60613	84938	4	6	0.12	0.045	2.4	−0.74	D	*ls*
			4097.12	60535	84935	2	4	0.099	0.050	1.3	−1.00	D	*ls*
			4110.33	60613	84935	4	4	0.019	0.0049	0.27	−1.71	D	*ls*

Ca II

Forbidden Transitions

The line strength for the magnetic dipole $3d-3d$ transition is a straight number, tabulated for example by Osterbrock [1]. The transition probability should also be quite accurate, since the energy level difference is accurately known. Osterbrock's electric quadrupole values are regarded as quite uncertain since in cases where more recent data are available he has not compared very well.

Reference

[1] Osterbrock, D. E., Astrophys. J. **114**, 469–472 (1951).

Ca II. Forbidden Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	Type of Transition	A_{ki}(sec^{-1})	S(at.u.)	Accuracy	Source
1	$3d-(^1S)3d$	$^2D-^2D$	[16.477 × 10^5]	13650.2	13710.9	4	6	m	2.41 × 10^{-6}	2.40	A	1
2	$4s-(^1S)3d$	$^2S-^2D$ (1F)										
			7291.46	0.00	13710.9	2	6	e	1.3	96	E	1
			7323.88	0.00	13650.2	2	4	e	1.3	65	E	1

Ca IV

Ground State $1s^22s^22p^63s^23p^5\ ^2P^\circ_{3/2}$

Ionization Potential 67 eV = 542000 cm^{-1}

Allowed Transitions

A value is available for one multiplet of this ion from the screening-approximation calculations of Varsavsky [1]. This result should be quite uncertain (probably too high, as judged from comparisons in other ions), since the possibly important effects of configuration interaction have not been taken into account.

Reference

[1] Varsavsky, C. M., Astrophys. J. Suppl. Ser. **6**, No. 53, 75 (1961).

Ca IV. Allowed Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at. u.)	log gf	Accuracy	Source
1	$3s^23p^5-3s3p^6$	$^2P^\circ-^2S$	*660.54*	*1038*	152430	6	2	170	0.37	4.8	0.35	E	1
			[656.04]	0	152430	4	2	120	0.37	3.2	0.17	E	*ls*
			[669.73]	3115	152430	2	2	54	0.36	1.6	−0.14	E	*ls*

Ca IV

Forbidden Transitions

The line strength for the one transition in the ground state configuration is a straight number, tabulated for example by Naqvi [1]. The transition probability should also be quite accurate, since the energy level difference is accurately known.

Reference

[1] Naqvi, A. M., Thesis Harvard (1951).

Ca IV. Forbidden Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	Type of Transition	A_{ki}(sec^{-1})	S(at.u.)	Accuracy	Source
1	$3p^5-3p^5$	$^2P^\circ-^2P^\circ$	[32090]	0	3115	4	2	m	0.543	1.33	A	1

Ca V

Ground State $1s^22s^22p^63s^23p^4\ ^3P_2$

Ionization Potential 84.39 eV = 680800 cm^{-1}

Allowed Transitions

A value is available for one multiplet of this ion from the screening-approximation calculations of Varsavsky [1]. This result should be quite uncertain (probably too high, as judged from comparisons in other ions), since the possibly important effects of configuration interaction have not been taken into account.

Reference

[1] Varsavsky, C. M., Astrophys. J. Suppl. Ser. **6**, No. 53, 75 (1961).

Ca V. Allowed Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at. u.)	log gf	Accuracy	Source
1	$3s^23p^4-3s3p^5$	$^3P-^3P^\circ$	*647.01*	*1165*	*155721*	9	9	100	0.63	12	0.75	E	1
			[646.56]	0	154664	5	5	76	0.48	5.1	0.38	E	*ls*
			[647.87]	2404	156756	3	3	25	0.16	1.0	−0.32	E	*ls*
			[637.93]	0	156756	5	3	44	0.16	1.7	−0.10	E	*ls*
			[643.12]	2404	157897	3	1	110	0.22	1.4	−0.18	E	*ls*
			[656.77]	2404	154664	3	5	24	0.26	1.7	−0.11	E	*ls*
			[651.55]	3276	156756	1	3	34	0.65	1.4	−0.19	E	*ls*

Ca V

Forbidden Transitions

As in the case of Na IV the adopted values are taken from Naqvi [1], and Malville and Berger [2]. For a discussion on the selection of values see Na IV, since the same criteria have been applied.

References

[1] Naqvi, A. M., Thesis Harvard (1951).
[2] Malville, J. M., and Berger, R. A., Planetary and Space Science **13**, 1131 (1965).

Ca V. Forbidden Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	Type of Transition	A_{ki}(sec^{-1})	S(at.u.)	Accuracy	Source
1	$3p^4-3p^4$	$^3P-^3P$										
			[41551]	0	2406.0	5	3	e	7.1×10^{-6}	1.57	C−	1, 2
			[41551]	0	2406.0	5	3	m	0.311	2.48	B	1, 2
			[30517]	0	3276	5	1	e	4.5×10^{-5}	0.71	C−	2
			[11.49×10^4]	2406.0	3276	3	1	m	0.0354	1.99	B	1, 2
2		$^3P-^1D$ (1F)										
			5309.18	0	18830.1	5	5	e	0.0063	0.079	D−	1, 2
			5309.18	0	18830.1	5	5	m	1.93	0.054	C	1, 2
			6086.92	2406.0	18830.1	3	5	e	4.6×10^{-4}	0.011	D−	1, 2
			6086.92	2406.0	18830.1	3	5	m	0.431	0.0180	C	1, 2
			[6427.4]	3276	18830.1	1	5	e	1.1×10^{-4}	0.0037	D−	2
3		$^3P-^1S$										
			[2280.0]	0	43847	5	1	e	0.16	0.0057	D−	2
			[2412.3]	2406.0	43847	3	1	m	24	0.0125	C	2
4		$^1D-^1S$ (2F)										
			3996.3	18830.1	43847	5	1	e	4.6	2.79	C−	2

Ca VI

Ground State $1s^22s^22p^63s^23p^3\ ^4S^\circ_{3/2}$

Ionization Potential 109 eV

Allowed Transitions

A value is available for one multiplet of this ion from the screening-approximation calculations of Varsavsky [1]. This result should be quite uncertain (probably too high, as judged from comparisons in other ions), since the possibly important effects of configuration interaction have not been taken into account.

Reference

[1] Varsavsky, C. M., Astrophys. J. Suppl. Ser. **6**, No. 53, 75 (1961).

Ca VI. Allowed Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at. u.)	log gf	Accuracy	Source
1	$3s^23p^3-3s3p^4$	$^4S^\circ-^4P$	*637.10*	0	*156960*	4	12	48	0.88	7.4	0.55	E	1
			[641.88]	0	155792	4	6	47	0.44	3.7	0.25	E	*ls*
			[633.81]	0	157775	4	4	50	0.30	2.5	0.08	E	*ls*
			[629.59]	0	158833	4	2	49	0.14	1.2	−0.25	E	*ls*

Ca VI

Forbidden Transitions

For this ion, the only available source is Pasternack [1].

Reference

[1] Pasternack, S., Astrophys. J. **92**, 129-155 (1940).

Ca VI. Forbidden Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	Type of Transition	A_{ki}(sec^{-1})	S(at.u.)	Accuracy	Source
1	$3p^3-3p^3$	$^4S^\circ-^2D^\circ$ (1F)										
			3646.3	0	[27417]	4	6	*m*	0.0066	7.1×10^{-5}	C−	1
			3646.3	0	[27417]	4	6	*e*	0.013	0.030	D−	1
			3702.7	0	[27000]	4	4	*m*	0.28	0.00211	C−	1
			3702.7	0	[27000]	4	4	*e*	0.0081	0.013	D−	1
2		$^4S^\circ-^2P^\circ$										
			[2206.3]	0	[45310]	4	4	*m*	12	0.0191	C	1
			[2206.3]	0	[45310]	4	4	*e*	2.9×10^{-4}	3.6×10^{-5}	D−	1
			[2233.7]	0	[44754]	4	2	*m*	4.8	0.00397	C	1
			[2233.7]	0	[44754]	4	2	*e*	0.0020	1.3×10^{-4}	D−	1
3		$^2D^\circ-^2D^\circ$										
			[24.0×10^4]	[27000]	[27417]	4	6	*m*	7.83×10^{-4}	2.40	B	1
			[24.0×10^4]	[27000]	[27417]	4	6	*e*	8.2×10^{-11}	0.23	D−	1
4		$^2D^\circ-^2P^\circ$ (2F)										
			5587.2	[27417]	[45310]	6	4	*m*	2.1	0.054	C	1
			5587.2	[27417]	[45310]	6	4	*e*	0.78	10.	D−	1
			5631.0	[27000]	[44754]	4	2	*m*	2.3	0.0305	C	1
			5631.0	[27000]	[44754]	4	2	*e*	0.64	4.3	D−	1
			5766.4	[27417]	[44754]	6	2	*e*	0.39	3.0	D−	1
			5460.0	[27000]	[45310]	4	4	*m*	3.9	0.094	C	1
			5460.0	[27000]	[45310]	4	4	*e*	0.35	4.0	D−	1
5		$^2P^\circ-^2P^\circ$										
			[17.98×10^4]	[44754]	[45310]	2	4	*m*	0.00154	1.33	B	1
			[17.98×10^4]	[44754]	[45310]	2	4	*e*	2.2×10^{-10}	0.098	D−	1

Ca VII

Ground State $1s^22s^22p^63s^23p^2\ ^3P_0$

Ionization Potential 128 eV = 1030000 cm^{-1}

Allowed Transitions

A value is available for one multiplet of this ion from the screening-approximation calculations of Varsavsky [1]. This result should be quite uncertain (probably too high, as judged from comparisons in other ions), since the possibly important effects of configuration interaction have not been taken into account.

Reference

[1] Varsavsky, C. M., Astrophys. J. Suppl. Ser. **6**, No. 53, 75 (1961).

Ca VII. Allowed Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at. u.)	log gf	Accuracy	Source
1	$3s^23p^2-3s3p^3$	$^3P-^3D^\circ$	*634.72*	*2803*	*160354*	9	15	42	0.43	8.0	0.59	E	1
			[639.15]	4070	160527	5	7	41	0.35	3.7	0.24	E	*ls*
			[630.51]	1627	160228	3	5	32	0.32	2.0	−0.02	E	*ls*
			[624.38]	0	160160	1	3	25	0.43	0.89	−0.37	E	*ls*
			[640.38]	4070	160228	5	5	10	0.064	0.67	−0.49	E	*ls*
			[630.78]	1627	160160	3	3	18	0.11	0.67	−0.48	E	*ls*
			[640.66]	4070	160160	5	3	1.1	0.0042	0.044	−1.68	E	*ls*

Ca VII

Forbidden Transitions

Since their methods are essentially the same, the averaged values of Naqvi [1], Malville and Berger [2], and Krueger and Czyzak [3] have been normally used for the magnetic dipole lines. Naqvi has not been included for the $^3P-^1S$ transition, where the effects of configuration interaction become important (see General Introduction). All values for the electric quadrupole transition probabilities have been taken from Krueger and Czyzak, since their electric dipole moment s_q has been obtained by using self-consistent field wavefunctions with exchange.

References

[1] Naqvi, A. M., Thesis Harvard (1951).
[2] Malville, J. M. and Berger, R. A., Planetary and Space Science **13**, 1131 (1965).
[3] Krueger, T. K. and Czyzak, S. J., Astrophys. J. **144**, 1194 (1966).

CaVII. Forbidden Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	Type of Transition	A_{ki}(sec^{-1})	S(at.u.)	Accuracy	Source
1	$3p^2-3p^2$	$^3P-^3P$										
			[61450]	0	1627	1	3	*m*	0.0771	1.99	B	1
			[24460]	0	[4087]	1	5	*e*	1.9×10^{-5}	0.50	D	3
			[40640]	1627	[4087]	3	5	*m*	0.199	2.47	B	1
			[40640]	1627	[4087]	3	5	*e*	3.3×10^{-6}	1.1	D	3
2		$^3P-^1D$ (1F)										
			[4571.8]	0	[21867]	1	5	*e*	1.8×10^{-4}	0.0011	D	3
			[4939.3]	1627	[21867]	3	5	*m*	1.25	0.0280	C	1, 2, 3
			[4939.3]	1627	[21867]	3	5	*e*	0.0015	0.013	D	3
			5621.4	[4087]	[21867]	5	5	*m*	2.56	0.084	C	1, 2, 3
			5621.4	[4087]	[21867]	5	5	*e*	0.0053	0.089	D	3
3		$^3P-^1S$										
			[2133.8]?	1627	[48477]?	3	1	*m*	33.2	0.0120	C−	2, 3
			[2252.1]?	[4087]	[48477]?	5	1	*e*	0.27	0.0093	D−	3
		$^1D-^1S$ (2F)										
			[3756.9]?	[2186.9]	[48477]?	5	1	*e*	4.4	2.0	D−	3

Ca VIII

Ground State $1s^22s^22p^63s^23p\ ^2P^\circ_{1/2}$

Ionization Potential 147 eV = 1189000 cm^{-1}

Allowed Transitions

The screening-approximation calculations of Varsavsky [1] for the $3s^23p\ ^2P^\circ-3s3p^2\ ^2D$ multiplet are considered to be rather uncertain (probably too high, as judged from comparisons in other ions) since the important effects of configuration mixing are neglected entirely. Gruzdev and Prokofev [2] have carried out Coulomb approximation calculations modified with the Seaton correction for the $3p\ ^2P^\circ-4s\ ^2S$ multiplet; these results should be reliable to within 25 percent, as judged from plots depicting *f*-value dependence on nuclear charge.

References

[1] Varsavsky, C. M., Astrophys. J. Suppl. Ser. **6**, No. 53, 75 (1961).
[2] Gruzdev, P. F., and Prokofev, V. K., Optics and Spectroscopy (U.S.S.R.) **21**, 151–152 (1966).

Ca VIII. Allowed Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at. u.)	log *gf*	Accuracy	Source
1	$3s^23p-3s3p^2$	$^2P^\circ-^2D$	*592.22*	*2870*	*171726*	6	10	47	0.41	4.8	0.39	E	1
			[596.93]	4305	171828	4	6	46	0.37	2.9	0.17	E	*ls*
			[582.84]	0	171573	2	4	41	0.42	1.6	−0.08	E	*ls*
			[597.84]	4305	171573	4	4	7.6	0.041	0.32	−0.79	E	*ls*
2	$3p-(^1S)4s$	$^2P^\circ-^2S$	*183.68*	*2870*	547308	6	2	480	0.081	0.294	−0.313	C	2
			[184.16]	4305	547308	4	2	320	0.081	0.196	−0.489	C	*ls*
			[182.71]	0	547308	2	2	160	0.081	0.097	−0.79	C	*ls*

Ca VIII

Forbidden Transitions

The line strength for the one transition in the ground state configuration is a straight number, tabulated for example by Naqvi [1]. The transition probability should also be quite accurate, since the energy level difference is accurately known.

Reference

[1] Naqvi, A. M., Thesis Harvard (1951).

Ca VIII. Forbidden Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	Type of Transition	A_{ki}(sec^{-1})	S(at.u.)	Accuracy	Source
1	$3p-(^1S)3p$	$^2P^\circ-^2P^\circ$	[23222]	0	4305	2	4	m	0.716	1.33	A	1

Ca IX

Ground State $1s^22s^22p^63s^2\ ^1S_0$

Ionization Potential 188 eV = 1519000 cm^{-1}

Allowed Transitions

List of tabulated lines:

Wavelength [Å]	No.	Wavelength [Å]	No.	Wavelength [Å]	No.
100.65	7	161.98	5	398.7	4
100.96	7	162.37	5	466.23	1
100.97	7	163.23	5	498.00	2
129.20	6	371.90	3	503.28	2
129.42	6	373.80	3	506.16	2
129.45	6	373.98	3	507.09	2
129.93	6	378.09	3	512.06	2
129.97	6	378.38	3	515.57	2
129.99	6	378.57	3		

The two available sources for this ion are the calculations of Zare [1], which include configuration interaction employing Hartree-Fock-Slater wave functions as a starting point, and the charge-expansion method of Crossley and Dalgarno [2] which also includes configuration interaction but in a more limited way. For many of these transitions, the dependence of oscillator strength on nuclear charge has served as an aid in estimating accuracies.

References

[1] Zare, R. N., J. Chem. Phys. **47**, 3561–3572 (1967).
[2] Crossley, R. J. S., and Dalgarno, A., Proc. Roy. Soc. London **A286**, 510 (1965).

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at. u.)	log gf	Accuracy	Source
1	$3s^2-3s(^2S)3p$	$^1S-^1P^\circ$	[466.23]	0	214488	1	3	112	1.09	1.68	0.037	B	1
2	$3s3p-3p^2$	$^3P^\circ-^3P$	*506.69*	*145764*	*343122*	9	9	95	0.366	5.5	0.52	C+	2
			[506.16]	147370	344935	5	5	72	0.275	2.29	0.138	C+	*ls*
			[507.09]	144130	341333	3	3	23.7	0.091	0.458	−0.56	C	*ls*
			[515.57]	147370	341333	5	3	37.5	0.090	0.76	−0.347	C	*ls*
			[512.06]	144130	339420	3	1	92	0.121	0.61	−0.440	C	*ls*
			[498.00]	144130	344935	3	5	24.9	0.155	0.76	−0.333	C	*ls*
			[503.28]	142635	341333	1	3	32.3	0.368	0.61	−0.434	C	*ls*
3	$3s3p-3s(^2S)3d$	$^3P^\circ-^3D$	*376.00*	*145764*	*411723*	9	15	152	0.54	6.0	0.69	C	1
			[378.09]	147370	411858	5	7	150	0.450	2.80	0.352	C	*ls*
			[373.80]	144130	411652	3	5	116	0.406	1.50	0.086	C	*ls*
			[371.90]	142635	411525	1	3	88	0.55	0.67	−0.260	C	*ls*
			[378.38]	147370	411652	5	5	37.4	0.080	0.50	−0.398	C	*ls*
			[373.98]	144130	411525	3	3	65	0.135	0.50	−0.393	C	*ls*
			[378.57]	147370	411525	5	3	4.1	0.0053	0.033	−1.58	E	*ls*
4		$^1P^\circ-^1D$	[398.7]	214488	[465300]	3	5	220	0.89	3.5	0.43	D	1
5	$3s3p-3s(^2S)4s$	$^3P^\circ-^3S$	*162.80*	*145764*	760002	9	3	680	0.090	0.436	−0.092	C	1
			[163.23]	147370	760002	5	3	376	0.090	0.242	−0.347	C	*ls*
			[162.37]	144130	760002	3	3	229	0.090	0.145	−0.57	C	*ls*
			[161.98]	142635	760002	1	3	77	0.091	0.0484	−1.041	C	*ls*
6	$3s3p-3s(^2S)4d$	$^3P^\circ-^3D$	*129.69*	*145764*	*916852*	9	15	510	0.22	0.83	0.29	D	1
			[129.93]	147370	916990	5	7	510	0.18	0.39	−0.04	D	*ls*
			[129.42]	144130	916780	3	5	390	0.16	0.21	−0.31	D	*ls*
			[129.20]	142635	916652	1	3	290	0.22	0.092	−0.67	D−	*ls*
			[129.97]	147370	916780	5	5	130	0.032	0.069	−0.79	D−	*ls*
			[129.45]	144130	916652	3	3	220	0.054	0.069	−0.79	D−	*ls*
			[129.99]	147370	916652	5	3	14	0.0022	0.0046	−1.97	E	*ls*
7	$3s3p-3s(^2S)5d$	$^3P^\circ-^3D$											
			[100.96]	147370	1137880	5	7	240	0.051	0.085	−0.59	D	1, *ls*
			[100.65]	144130	1137720	3	5	180	0.046	0.046	−0.86	D	1, *ls*
			[100.97]	147370	1137720	5	5	60	0.0091	0.015	−1.34	D	1, *ls*

Ca IX

Forbidden Transitions

Naqvi's calculations [1] are the only available source. The results for the $^3P^\circ-^3P^\circ$ transitions are essentially independent of the choice of the interaction parameters. For the $^3P^\circ-^1P^\circ$ transitions, Naqvi uses empirical term intervals, i.e., the effects of configuration interaction should be partially included.

Reference

[1] Naqvi, A. M., Thesis Harvard (1951).

Ca IX. Forbidden Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	Type of Transition	A_{ki}(sec^{-1})	S(at.u.)	Accuracy	Source
1	$3s3p-3s(^2S)3p$	$^3P^\circ-^3P^\circ$										
			[66870]	142635	144130	1	3	*m*	0.0601	2.00	A	1
			[30860]	144130	147370	3	5	*m*	0.459	2.50	A	1
2		$^3P^\circ-^1P^\circ$										
			[1391.7]	142635	214488	1	3	*m*	7.5	0.00225	C	1
			[1421.3]	144130	214488	3	3	*m*	158	0.050	C	1
			[1489.9]	147370	214488	5	3	*m*	7.7	0.00282	C	1

Ca X

Ground State $1s^22s^22p^63s\ ^2S_{1/2}$

Ionization Potential 211.29 eV = 1704660 cm^{-1}

Allowed Transitions

List of tabulated lines:

Wavelength [Å]	No.	Wavelength [Å]	No.	Wavelength [Å]	No.
110.96	2	206.75	5	557.74	1
111.20	2	207.39	5	574.01	1
118.20	7	369.29	10	1137.0	9
151.83	4	371.90	10	1159.1	9
153.01	4	411.69	3	1162.1	9
167.00	6	419.76	3	1462.6	8
206.57	5	420.49	3	1504.5	8

Two sources of data are available for this ion: the calculations of Stewart and Rotenberg [1], employing a scaled Thomas-Fermi potential, and the charge-expansion formulation of Crossley and Dalgarno [2], which includes limited configuration mixing. Graphical comparisons of both works with more refined values within the isoelectronic sequence indicate accuracies within 25 percent. A number of additional values have been obtained from studies of the f-value dependence on nuclear charge. The reliable material available for other ions of this isoelectronic sequence in these cases permits the determination of reliable values simply by graphical interpolation.

References

[1] Stewart, J. C., and Rotenberg, M., Phys. Rev. **140**, 1508A–1519A (1965).
[2] Crossley, R. J. S., and Dalgarno, A., Proc. Roy. Soc. London **A286**, 510–518 (1965).

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at. u.)	log gf	Accuracy	Source
1	$3s-3p$	$^2S-^2P^\circ$	*563.06*	0	*177601*	2	6	37.2	0.53	1.96	0.025	C	1
								37.5	0.350	1.29	−0.155	C	*ls*
			[557.74]	0	179295	2	4	35.4	0.175	0.66	−0.456	C	*ls*
			[574.01]	0	174214	2	2						
2	$3s-4p$	$^2S-^2P^\circ$	*111.04*	0	*900575*	2	6	261	0.145	0.106	−0.54	C	1
			[110.96]	0	901210	2	4	263	0.097	0.071	−0.71	C	*ls*
			[111.20]	0	899305	2	2	261	0.0483	0.0354	−1.015	C	*ls*
3	$3p-3d$	$^2P^\circ-^2D$	*417.08*	*177601*	*417361*	6	10	97	0.420	3.46	0.401	C	2
			[419.76]	179295	417527	4	6	95	0.376	2.08	0.177	C	*ls*
			[411.69]	174214	417113	2	4	83	0.424	1.15	−0.072	C	*ls*
			[420.49]	179295	417113	4	4	16	0.042	0.23	−0.78	D	*ls*
4	$3p-4s$	$^2P^\circ-^2S$	*152.62*	*177601*	832838	6	2	740	0.086	0.26	0.29	C	interp
			[153.01]	179295	832838	4	2	480	0.084	0.17	0.47	C	*ls*
			[151.83]	174214	832838	2	2	250	0.087	0.087	0.76	C	*ls*
5	$3d-4p$	$^2D-^2P^\circ$	*206.95*	*417361*	*900575*	10	6	290	0.11	0.75	0.04	C	interp
			[206.75]	417527	901210	6	4	260	0.11	0.45	−0.18	C	*ls*
			[207.39]	417113	899305	4	2	280	0.092	0.25	−0.43	C	*ls*
			[206.57]	417113	901210	4	4	29	0.018	0.050	−1.14	D	*ls*
6	$3d-4f$	$^2D-^2F^\circ$	*167.00*	*417361*	*1016167*	10	14	1600	0.93	5.1	0.97	C+	interp
7	$3d-5f$	$^2D-^2F^\circ$	*118.20*	*417361*	*1263357*	10	14	580	0.17	0.66	0.23	C	interp
8	$4s-4p$	$^2S-^2P^\circ$	*1476.3*	832838	*900575*	2	6	7.3	0.72	7.0	0.16	C	interp
			[1462.6]	832838	901210	2	4	7.6	0.49	4.7	−0.01	C	*ls*
			[1504.5]	832838	899305	2	2	6.8	0.23	2.3	−0.34	C	*ls*
9	$4p-4d$	$^2P^\circ-^2D$	*1151.8*	*900575*	*987394*	6	10	25	0.83	19	0.70	C	interp
			[1159.1]	901210	987484	4	6	24	0.72	11	0.46	C	*ls*
			[1137.0]	899305	987259	2	4	22	0.84	6.3	0.23	C	*ls*
			[1162.1]	901210	987259	4	4	4.2	0.085	1.3	−0.47	D	*ls*
10	$4p-5s$	$^2P^\circ-^2S$	*371.03*	*900575*	1170098	6	2	220	0.15	1.1	−0.05	C	interp
			[371.90]	901210	1170098	4	2	140	0.15	0.73	−0.22	C	*ls*
			[369.29]	899305	1170098	2	2	74	0.15	0.37	−0.52	C	*ls*

Ca XI

Ground State $1s^2 2s^2 2p^6\ ^1S_0$

Ionization Potential 591.8 eV = 4774300 cm^{-1}

Allowed Transitions

Calculations by Kastner, Omidvar, and Underwood [1], employing Hartree-Fock wave functions and including intermediate coupling, are available. Since the calculations are based on a single-configuration approximation only, uncertainties of up to 50 percent are expected for the strong lines and even higher uncertainties for the weak lines, the latter being more affected by assumptions about the coupling.

Reference

[1] Kastner, S. O., Omidvar, K., and Underwood, J. H., Astrophys. J. **148**, 269–273 (1967).

Ca XI. Allowed Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	A_{ki}(10^8 sec^{-1})	f_{ik}	S(at. u.)	log gf	Accuracy	Source
1	$2p^6-2p^5(^2P^\circ_{3/2})3s$	$^1S-^3P^\circ$	[35.576]	0	2810900	1	3	1200	0.066	0.0077	−1.18	E	1
2	$2p^6-2p^5(^2P^\circ_{1/2})3s$	$^1S-^1P^\circ$	[35.213]	0	2839900	1	3	2000	0.11	0.013	−0.96	D	1
3	$2p^6-2p^5(^2P^\circ_{3/2})3d$	$^1S-^3P^\circ$	[31.257]	0	3199300	1	3	170	0.0074	7.6×10^{-4}	−2.13	E	1
4	$2p^6-2p^5(^2P^\circ_{3/2})3d$	$^1S-^1P^\circ$	[30.867]	0	3239700	1	3	4.9×10^4	2.1	0.21	0.32	D	1
5	$2p^6-2p^5(^2P^\circ_{1/2})3d$	$^1S-^3D^\circ$	[30.448]	0	3284300	1	3	6200	0.26	0.026	−0.59	D	1

Ca XII

Ground State $1s^22s^22p^5\ ^2P^\circ_{3/2}$

Ionization Potential 655 eV

Forbidden Transitions

The line strength for the one transition in the ground state configuration is a straight number, tabulated for example by Naqvi [1]. The transition probability should also be quite accurate, since the energy level difference is accurately known.

Reference

[1] Naqvi, A. M., Thesis Harvard (1951).

Ca XII. Forbidden Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	Type of Transition	A_{ki}(sec^{-1})	S(at.u.)	Accuracy	Source
1	$2p^5-2p^5$	$^2P^\circ-^2P^\circ$ (1 F)	3329.5	0	30028	4	2	m	486	1.33	A	1

Ca XIII

Ground State $1s^2 2s^2 2p^4\ {}^3P_2$

Ionization Potential

Forbidden Transitions

Krueger and Czyzak's [1] values have been used for this ion, except for the magnetic dipole ${}^3P_{0,1} - {}^3P_{1,3}$ transitions where Naqvi's [2] results have been applied. Some wavelength data are from observed coronal lines. The electric quadrupole moment (s_q) is based on self-consistent field wave functions with exchange.

References

[1] Krueger, T. K. and Czyzak, S. J., Astrophys. J. **144**, 1194–1202 (1966).
[2] Naqvi, A. M. Thesis Harvard (1951).

Ca XII. Forbidden Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	Type of Transition	A_{ki}(sec^{-1})	S(at.u.)	Accuracy	Source
1	$2p^4 - 2p^4$	${}^3P - {}^3P$ (1F)										
			4086.5	0	24464	5	3	e	0.00362	0.0074	C	1
			4086.5	0	24464	5	3	m	317	2.41	B	2
			[3484]	0	[28660]	5	1	e	0.0111	0.00340	C−	1
			[23810]	24464	[28660]	3	1	m	3.84	1.92	B−	2
		${}^3P - {}^1D$										
			[1124]	0	[89000]	5	5	e	0.30	0.0016	D−	1
			[1124]	0	[89000]	5	5	m	850	0.223	C−	1
			[1550]	24464	[89000]	3	5	e	0.0089	2.4×10^{-4}	D−	1
			[1550]	24464	[89000]	3	5	m	111	0.077	C−	1
			[1658]	[28660]	[89000]	1	5	e	0.0068	2.5×10^{-4}	D	1
		${}^3P - {}^1S$										
			[560.2]	0	[178500]	5	1	e	1.2	3.9×10^{-5}	D−	1
			[649.4]	24464	[178500]	3	1	m	8200	0.083	C−	1
		${}^1D - {}^1S$										
			[1117]	[89000]	[178500]	5	1	e	7.4	0.0076	D	1

Ca XV

Ground State $1s^2 2s^2 2p^2\ {}^3P_0$

Ionization Potential ?

Forbidden Transitions

Krueger and Czyzak's [1] values have been used for this ion, except for the magnetic dipole ${}^3P_{0,1} - {}^3P_{1,3}$ transitions where Naqvi's [2] results have been applied. Some wavelength data are from observed coronal lines. The electric quadrupole moment (s_q) is based on self-consistent field wave functions with exchange.

References

[1] Krueger, T. K. and Czyzak, S. J., Astrophys. J. **144**, 1194–1202 (1966).
[2] Naqvi, A. M. Thesis Harvard (1951).

Ca XV. Forbidden Transitions

No.	Transition Array	Multiplet	λ(Å)	E_i(cm^{-1})	E_k(cm^{-1})	g_i	g_k	Type of Transition	A_{ki}(sec^{-1})	S(at.u.)	Accuracy	Source
1	$2p^2-2p^2$	$^3P-^3P$										
			5694.44	0	17556	1	3	m	94.9	1.95	B	2
			[2783.8]	0	35911	1	5	e	0.0060	0.00297	C	1
			5446.44	17556	35911	3	5	m	77.8	2.33	B	2
			5446.44	17556	35911	3	5	e	4.00×10^{-4}	0.0057	C	1
2		$^3P-^1D$										
			[916.7]	0	[109070]	1	5	e	0.015	2.8×10^{-5}	D−	1
			[1093]	17556	[109070]	3	5	m	670	0.163	C−	1
			[1093]	17556	[109070]	3	5	e	0.087	4.0×10^{-4}	D−	1
			[1367]	35911	[109070]	5	5	m	960	0.455	C−	1
			[1367]	35911	[109070]	5	5	e	0.19	0.0026	D−	1
3		$^3P-^1S$										
			[581.3]	17556	[189570]	3	1	m	8500	0.062	C−	1
			[650.8]	35911	[189570]	5	1	e	4.4	3.0×10^{-4}	D−	1
4		$^1D-^1S$										
			[1242]	[109070]	[189570]	5	1	e	5.9	0.010	D	1

308-022 O-69—20

LIST OF RECENT ADDITIONAL MATERIAL

(New material which would have been considered if received before cut-off date)

Spectrum	References	Spectrum	References
Na I	1, 2, 10	P IV	11
Mg I	9, 11	Ar I	7
Mg II	10	K I	10
Al I	3	Ca I	11
Al II	11	Ca II	10
Si I	4, 5, 6, 8		
Si II	4		
Si III	4, 11		
Si IV	12		

References and Comments

[1] Hameed, S., Herzenberg, A., and James, M. G., J. Phys. B (Proc. Phys. Soc.) Ser. 2, **1**, 822–830 (1968).
Na I
Self-consistent field calculations with core polarization for the resonance transition. Results agree within a few percent with our tabulated value.

[2] Wolff, R. J., and Davis, S. P., J. Opt. Soc. Am. **58**, 490–495 (1968).
Na I
Lifetime of $3p\,^2P^\circ$ state. Agrees exactly with our listed number.

[3] Cunningham, P. T., J. Opt. Soc. Am. **58**, 1507–1509 (1968).
Al I
Phase-shift lifetime of $4s\,^2S_{1/2}$ and $3d\,^2D$ states. Supports within 2–4 percent our adopted absolute scale.

[4] Hofmann, W., Max Planck Institut für Physik und Astrophysik MPI–PAE/Extraterr. (January, 1969). Si I, II, III
Vacuum uv stabilized-arc experiment. Agreement with our tabulated data is quite good for Si I, although Hofmann has values for many more lines. The absolute values appear to be low for Si II, but the relative values agree quite well with ours. Does not agree with our listed value (and systematic trends) for Si III.

[5] Schulz-Gulde, E., J. Quant. Spectrosc. Radiat. Transfer **9**, 13–29 (1969).
Si I, II
Wall-stabilized arc experiment. The values are in poor agreement with our listed values and the calculations of refs. [6] and [8] below. We recommend these new experimental values over those of refs. [6] and [8] and our tabulated data.

[6] Armstrong, Jr., L., and Liebermann, R., J. Quant. Spectrosc. Radiat. Transfer **9**, 123–128 (1969).
Si I
Intermediate coupling calculations with absolute scale from wavefunctions with self-consistent field type potential. Should be considered along with ref. [8] when values are not available from ref. [5].

[7] Veroleinen, Ya. F., and Osherovich, A. L., Optics and Spectroscopy (U.S.S.R.) **25**, 258–259 (1968).
Ar I
Delayed-coincidence lifetimes. See comment under Ar I.

[8] Warner, B., Monthly Notices Roy. Astron. Soc. **139**, 1–34 (1968)
Si I
Intermediate coupling calculations with wavefunctions from Thomas-Fermi-Dirac potential and with configuration mixing. Should be considered along with ref. [6] when values are not available from ref. [5].

[9] Warner, B., Monthly Notices Roy. Astron. Soc. **139**, 103–113 (1968).
Mg I
Calculations similar to those of ref. [8]. Results agree usually very well with our values.

[10] Warner, B., Monthly Notices Roy. Astron. Soc. **139**, 115–128 (1968).
Na I, Mg II, K I, Ca II
Calculations similar to those of ref. [8]. The results agree within a few percent with our values.

[11] Warner, B., Monthly Notices Roy. Astron. Soc. **140**, 53–59 (1968).
Mg I, Al II, Si III, P IV, Ca I
Intermediate coupling calculations with Thomas-Fermi-Dirac wavefunctions. Results usually agree well with our listed data where one would expect.

[12] Warner, B., Monthly Notices Roy. Astron. Soc. **141**, 273–276 (1968).
Si IV
Calculations based on scaled Thomas-Fermi wavefunctions. The agreement with our tabulated material is excellent.

NATIONAL BUREAU OF STANDARDS

The National Bureau of Standards [1] was established by an act of Congress March 3, 1901. Today, in addition to serving as the Nation's central measurement laboratory, the Bureau is a principal focal point in the Federal Government for assuring maximum application of the physical and engineering sciences to the advancement of technology in industry and commerce. To this end the Bureau conducts research and provides central national services in four broad program areas. These are: (1) basic measurements and standards, (2) materials measurements and standards, (3) technological measurements and standards, and (4) transfer of technology.

The Bureau comprises the Institute for Basic Standards, the Institute for Materials Research, the Institute for Applied Technology, the Center for Radiation Research, the Center for Computer Sciences and Technology, and the Office for Information Programs.

THE INSTITUTE FOR BASIC STANDARDS provides the central basis within the United States of a complete and consistent system of physical measurement; coordinates that system with measurement systems of other nations; and furnishes essential services leading to accurate and uniform physical measurements throughout the Nation's scientific community, industry, and commerce. The Institute consists of an Office of Measurement Services and the following technical divisions:

Applied Mathematics—Electricity—Metrology—Mechanics—Heat—Atomic and Molecular Physics—Radio Physics [2]—Radio Engineering [2]—Time and Frequency [2]—Astrophysics [2]—Cryogenics.[2]

THE INSTITUTE FOR MATERIALS RESEARCH conducts materials research leading to improved methods of measurement standards, and data on the properties of well-characterized materials needed by industry, commerce, educational institutions, and Government; develops, produces, and distributes standard reference materials; relates the physical and chemical properties of materials to their behavior and their interaction with their environments; and provides advisory and research services to other Government agencies. The Institute consists of an Office of Standard Reference Materials and the following divisions:

Analytical Chemistry—Polymers—Metallurgy—Inorganic Materials—Physical Chemistry.

THE INSTITUTE FOR APPLIED TECHNOLOGY provides technical services to promote the use of available technology and to facilitate technological innovation in industry and Government; cooperates with public and private organizations in the development of technological standards, and test methodologies; and provides advisory and research services for Federal, state, and local government agencies. The Institute consists of the following technical divisions and offices:

Engineering Standards—Weights and Measures—Invention and Innovation—Vehicle Systems Research—Product Evaluation—Building Research—Instrument Shops—Measurement Engineering—Electronic Technology—Technical Analysis.

THE CENTER FOR RADIATION RESEARCH engages in research, measurement, and application of radiation to the solution of Bureau mission problems and the problems of other agencies and institutions. The Center consists of the following divisions:

Reactor Radiation—Linac Radiation—Nuclear Radiation—Applied Radiation.

THE CENTER FOR COMPUTER SCIENCES AND TECHNOLOGY conducts research and provides technical services designed to aid Government agencies in the selection, acquisition, and effective use of automatic data processing equipment; and serves as the principal focus for the development of Federal standards for automatic data processing equipment, techniques, and computer languages. The Center consists of the following offices and divisions:

Information Processing Standards—Computer Information—Computer Services—Systems Development—Information Processing Technology.

THE OFFICE FOR INFORMATION PROGRAMS promotes optimum dissemination and accessibility of scientific information generated within NBS and other agencies of the Federal government; promotes the development of the National Standard Reference Data System and a system of information analysis centers dealing with the broader aspects of the National Measurement System, and provides appropriate services to ensure that the NBS staff has optimum accessibility to the scientific information of the world. The Office consists of the following organizational units:

Office of Standard Reference Data—Clearinghouse for Federal Scientific and Technical Information [3]—Office of Technical Information and Publications—Library—Office of Public Information—Office of International Relations.

---

[1] Headquarters and Laboratories at Gaithersburg, Maryland, unless otherwise noted; mailing address Washington, D.C. 20234.
[2] Located at Boulder, Colorado 80302.
[3] Located at 5285 Port Royal Road, Springfield, Virginia 22151.

NBS TECHNICAL PUBLICATIONS

PERIODICALS

JOURNAL OF RESEARCH reports National Bureau of Standards research and development in physics, mathematics, chemistry, and engineering. Comprehensive scientific papers give complete details of the work, including laboratory data, experimental procedures, and theoretical and mathematical analyses. Illustrated with photographs, drawings, and charts.

Published in three sections, available separately:

• Physics and Chemistry

Papers of interest primarily to scientists working in these fields. This section covers a broad range of physical and chemical research, with major emphasis on standards of physical measurement, fundamental constants, and properties of matter. Issued six times a year. Annual subscription: Domestic, $6.00; foreign, $7.25*.

• Mathematical Sciences

Studies and compilations designed mainly for the mathematician and theoretical physicist. Topics in mathematical statistics, theory of experiment design, numerical analysis, theoretical physics and chemistry, logical design and programming of computers and computer systems. Short numerical tables. Issued quarterly. Annual subscription: Domestic, $5.00; foreign, $6.25*.

• Engineering and Instrumentation

Reporting results of interest chiefly to the engineer and the applied scientist. This section includes many of the new developments in instrumentation resulting from the Bureau's work in physical measurement, data processing, and development of test methods. It will also cover some of the work in acoustics, applied mechanics, building research, and cryogenic engineering. Issued quarterly. Annual subscription: Domestic, $5.00; foreign, $6.25*.

TECHNICAL NEWS BULLETIN

The best single source of information concerning the Bureau's research, developmental, cooperative and publication activities, this monthly publication is designed for the industry-oriented individual whose daily work involves intimate contact with science and technology—*for engineers, chemists, physicists, research managers, product-development managers, and company executives.* Annual subscription: Domestic, $3.00; foreign, $4.00*.

*Difference in price is due to extra cost of foreign mailing.

NONPERIODICALS

Applied Mathematics Series. Mathematical tables, manuals, and studies.

Building Science Series. Research results, test methods, and performance criteria of building materials, components, systems, and structures.

Handbooks. Recommended codes of engineering and industrial practice (including safety codes) developed in cooperation with interested industries, professional organizations, and regulatory bodies.

Special Publications. Proceedings of NBS conferences, bibliographies, annual reports, wall charts, pamphlets, etc.

Monographs. Major contributions to the technical literature on various subjects related to the Bureau's scientific and technical activities.

National Standard Reference Data Series. NSRDS provides quantitative data on the physical and chemical properties of materials, compiled from the world's literature and critically evaluated.

Product Standards. Provide requirements for sizes, types, quality and methods for testing various industrial products. These standards are developed cooperatively with interested Government and industry groups and provide the basis for common understanding of product characteristics for both buyers and sellers. Their use is voluntary.

Technical Notes. This series consists of communications and reports (covering both other agency and NBS-sponsored work) of limited or transitory interest.

Federal Information Processing Standards Publications. This series is the official publication within the Federal Government for information on standards adopted and promulgated under the Public Law 89-306, and Bureau of the Budget Circular A-86 entitled, Standardization of Data Elements and Codes in Data Systems.

CLEARINGHOUSE

The Clearinghouse for Federal Scientific and Technical Information, operated by NBS, supplies unclassified information related to Government-generated science and technology in defense, space, atomic energy, and other national programs. For further information on Clearinghouse services, write:

Clearinghouse
U.S. Department of Commerce
Springfield, Virginia 22151

Order NBS publications from: Superintendent of Documents
Government Printing Office
Washington, D.C. 20402

(cut here)

Announcement of New Publications in

National Standard Reference Data Series

Superintendent of Documents,
Government Printing Office,
Washington, D.C. 20402

Dear Sir:

Please add my name to the announcement list of new publications to be issued in the series: National Standard Reference Data Series—National Bureau of Standards.

Name.....

Company.....

Address.....

City..... State..... Zip Code.....

(Notification key N-337)

Publications in the National Standard Reference Data Series
National Bureau of Standards

You may use this listing as your order form by checking the proper box of the publication(s) you desire or by providing the full identification of the publication you wish to purchase. The full letter symbols with each publication number and full title of the publication and author must be given in your order, e.g., NSRDS–NBS–17, Tables of Molecular Vibrational Frequencies, Part 3, by T. Shimanouchi.

Pay for publications by check, money order, or Superintendent of Documents coupons or deposit account. Make checks and money orders payable to Superintendent of Documents. Foreign remittances should be made either by international money order or draft on an American bank. Postage stamps are not acceptable.

No charge is made for postage to destinations in the United States and possessions, Canada, Mexico, and certain Central and South American countries. To other countries, payments for documents must cover postage. Therefore, one-fourth of the price of the publication should be added for postage.

Send your order together with remittance to Superintendent of Documents, Government Printing Office, Washington, D.C. 20402.

(cut here)

- ☐ NSRDS–NBS 1, **National Standard Reference Data System—Plan of Operation,** by E. L. Brady and M. B. Wallenstein, 1964 (15 cents).
- ☐ NSRDS–NBS 2, **Thermal Properties of Aqueous Uni-univalent Electrolytes,** by V. B. Parker, 1965 (45 cents).
- ☐ NSRDS–NBS 3, Sec. 1, **Selected Tables of Atomic Spectra, Atomic Energy Levels and Multiplet Tables,** Si II, Si III, Si IV, by C. E. Moore, 1965 (35 cents).
- ☐ NSRDS–NBS 3, Sec. 2, **Selected Tables of Atomic Spectra, Atomic Energy Levels and Multiplet Tables,** Si I, by C. E. Moore, 1967 (20 cents).
- ☐ NSRDS–NBS 4, **Atomic Transition Probabilities, Volume 1, Hydrogen Through Neon,** by W. L. Wiese, M. W. Smith and B. M. Glennon, 1966 ($2.50).
- ☐ NSRDS–NBS 5, **The Band Spectrum of Carbon Monoxide,** by P. H. Krupenie, 1966 (70 cents).
- ☐ NSRDS–NBS 6, **Tables of Molecular Vibrational Frequencies, Part 1,** by T. Shimanouchi, 1967 (40 cents).
- ☐ NSRDS–NBS 7, **High Temperature Properties and Decomposition of Inorganic Salts, Part 1, Sulfates,** by K. H. Stern and E. L. Weise, 1966 (35 cents).
- ☐ NSRDS–NBS 8, **Thermal Conductivity of Selected Materials,** by R. W. Powell, C. Y. Ho, and P. E. Liley, 1966 ($1).
- ☐ NSRDS–NBS 9, **Bimolecular Gas Phase Reactions,** by A. F. Trotman-Dickenson and G. S. Milne, 1967 ($2).
- ☐ NSRDS–NBS 10, **Selected Values of Electric Dipole Moments for Molecules in the Gas Phase,** by R. D. Nelson, Jr., D. R. Lide, Jr., and A. A. Maryott, 1967 (40 cents).
- ☐ NSRDS–NBS 11, **Tables of Molecular Vibrational Frequencies, Part 2,** by T. Shimanouchi, 1967 (30 cents).
- ☐ NSRDS–NBS 12, **Tables for the Rigid Asymmetric Rotor: Transformation Coefficients From Symmetric to Asymmetric Bases and Expectation Values of P_z^2, P_z^4, and P_z^6,** by R. H. Schwendeman, 1968 (60 cents).
- ☐ NSRDS–NBS 13, **Hydrogenation of Ethylene on Metallic Catalysts,** by J. Horiuti and K. Miyahara, 1968 ($1).
- ☐ NSRDS–NBS 14, **X-Ray Wavelengths and X-Ray Atomic Energy Levels,** by J. A. Bearden, 1967 (40 cents).
- ☐ NSRDS–NBS 15, **Molten Salts, Vol. 1. Electrical Conductance, Density, and Viscosity Data,** by G. Janz, F. W. Dampier, G. R. Lakshiminarayanan, P. K. Lorenz, and R. P. T. Tomkins, 1968 ($3).
- ☐ NSRDS–NBS 16, **Thermal Conductivity of Selected Materials, Part 2,** by C. Y. Ho, R. W. Powell, and P. E. Liley, 1968 ($2).
- ☐ NSRDS–NBS 17, **Tables of Molecular Vibration Frequencies, Part 3,** by T. Shimanouchi, 1968 (30 cents).
- ☐ NSRDS–NBS 18, **Critical Analysis of the Heat-Capacity Data of the Literature and Evaluation of Thermodynamic Properties of Copper, Silver, and Gold From 0 to 300 K,** by G. T. Furukawa, W. G. Saba, and M. L. Reilly, 1968 (40 cents).
- ☐ NSRDS–NBS 19, **Thermodynamic Properties of Ammonia as an Ideal Gas,** by L. Haar, 1968 (20 cents).
- ☐ NSRDS–NBS 20, **Gas Phase Reaction Kinetics of Neutral Oxygen Species,** by H. S. Johnston, 1968 (45 cents).
- ☐ NSRDS–NBS 21, **Kinetic Data on Gas Phase Unimolecular Reactions,** by S. W. Benson and H. E. O'Neal (in press).

U.S. GOVERNMENT PRINTING OFFICE : 1969 OL—308-022