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NBS CIRCULAR 537

**Table of Dielectric Constants  
and Electric Dipole Moments of  
Substances in the Gaseous State**

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**UNITED STATES DEPARTMENT OF COMMERCE**

**NATIONAL BUREAU OF STANDARDS**

## Table of Dielectric Constants of Pure Liquids

by Arthur A. Maryott and Edgar R. Smith

As the first table of a series on dielectric properties, this Circular provides physicists and chemists with a convenient source for frequently needed data on dielectric constants of standard liquids, inorganic liquids, and organic liquids. The table covers only the low frequency, or "static," values.

The authors critically examined the available literature on more than 800 substances in order to provide "best" values of the dielectric constant. An estimate of accuracy is indicated by a simple scheme on the number of figures retained. Wherever feasible, the variation of dielectric constant with temperature is represented by a concise function; in other cases, values of dielectric constant are tabulated for a number of selected temperatures.

The section on standard liquids recommends as reference liquids ten substances for which the values of dielectric constant range from 1.2 to 80 and are considered to be accurate to 0.2 percent or better.

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# Table of Dielectric Constants and Electric Dipole Moments of Substances in the Gaseous State

Arthur A. Maryott and Floyd Buckley



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# TABLE OF DIELECTRIC CONSTANTS AND ELECTRIC DIPOLE MOMENTS OF SUBSTANCES IN THE GASEOUS STATE

Arthur A. Maryott and Floyd Buckley

Values of the dipole moments and other pertinent information are tabulated for approximately 350 substances in the vapor state. All values derived from measurements of dielectric constants have been recalculated by one of two systematic procedures in order to place the work of various investigators on a more comparable basis than exists in the literature. Values obtained independently from microwave spectroscopy and other methods are also included.

Values of the dielectric constants recommended for reference purposes are listed for helium, hydrogen, oxygen, argon, air, nitrogen and carbon dioxide. These selected values were derived from a consideration of radio frequency, microwave, and optical data.

## 1. Introduction

This tabulation of dielectric constants and electric dipole moments is a continuation of a program for the critical examination of the data of physics and chemistry, sponsored by the National Bureau of Standards in cooperation with the Committee on Tables of Constants and Numerical Data of the National Research Council and the Commission on Tables of Constants of the International Union of Chemistry. The first table of the series on dielectric properties, titled Table of Dielectric Constants of Pure Liquids, appeared as Circular 514 of the National Bureau of Standards.

Values of dielectric constant are listed explicitly only in the section on reference gases, which summarizes the more reliable data derived from optical, microwave, and radio frequency measurements for helium, hydrogen, oxygen, argon, air, nitrogen, and carbon dioxide. The particular values recommended for reference purposes are included.

For most of the substances appearing in the table of dipole moments, the data are expressed in terms appropriate to the Debye theory, and values of the dielectric constant can readily be calculated if desired. All values of the dipole moment obtained from measurements of the dielectric constant have been recalculated by one of two systematic procedures in order to place the

work of various investigators on a more comparable basis than exists in the original literature. Values of the dipole moment obtained by several reliable methods which are independent of the Debye theory are also included.

## 2. Reference Gases

### 2.1. Treatment of Data

Principal emphasis in the table of reference gases has been placed on data in the optical range of frequencies. With the exception of carbon dioxide which exhibits pronounced dielectric absorption in the infrared region, the low frequency or "static" values of the dielectric constant can be derived from the relation,<sup>1</sup>  $\epsilon = n_{\infty}^2$ , where the refractive index for infinite wavelength,  $n_{\infty}$ , is obtained from the optical dispersion formula. In a majority of cases, values of the dielectric constant measured at radio frequencies do not appear to be of sufficient accuracy to provide useful information for reference purposes. A limited amount of data of reliability comparable

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<sup>1</sup> According to Maxwell's relation, the square of the refractive index is equal to the product of the dielectric constant and the magnetic permeability. However, except for the measurements of refractive index on oxygen and air in the microwave region, the permeability is negligibly different from unity for all cases under consideration.

with the optical data has recently been provided by microwave refractometry.

The tabulated values  $(\epsilon-1)$  refer to the gas at a temperature of 20° C and a pressure of 1 atm, conditions which closely approximate those of a majority of the experimental investigations. It has been frequent practice to report data extrapolated to the conditions of S.T.P. (0° and 1 atm). As these values are not always exactly comparable, the tabulated values were derived with due consideration for the exact procedure for reduction employed in each case. Where it was necessary to correct the values for air to the carbon dioxide-free basis, the carbon dioxide content was assumed to be 0.03 mole percent.

The recommended value of  $(\epsilon-1)_{20^\circ, 1 \text{ atm}}$  for each gas represents the mean of all values listed in bold type. These values are regarded as having an accuracy in the neighborhood of 0.1 percent or better. Exceptions are helium and possibly carbon dioxide.

The values of the dielectric constant can be adjusted to somewhat different conditions of temperature and pressure by means of the equation,<sup>2</sup>

$$\frac{(\epsilon-1)_{t,p}}{(\epsilon-1)_{20^\circ, 1 \text{ atm}}} = \frac{P}{760[1+0.003411(t-20)]}, \quad (1)$$

where  $p$  is the pressure in millimeters of mercury, and  $t$  is the temperature in degrees Celsius. The errors associated with this equation probably do not exceed 0.1 percent for carbon dioxide and 0.02 percent for the remaining gases at temperatures between 10° and 30° and pressures between 700 and 800 millimeters.

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<sup>2</sup> Over a more extended range of temperature and pressure, the right hand side of equation (1) should be multiplied by the factor,  $(1+\beta_{t,p})/(1+\beta_{20^\circ,p})$ , to allow for deviations from the ideal gas law. As reliable values of the temperature dependent coefficient,  $\beta$ , have not been determined experimentally, (with the exception of air—cf. 39 Barrell), estimates of  $\beta$  may be made utilizing the Lorenz-Lorentz relation and compressibility data.

2.2. Table of Dielectric Constants of Reference Gases at 20°C and 1 Atmosphere

Substance	$(\epsilon-1) \cdot 10^6$	Reference	Substance	$(\epsilon-1) \cdot 10^6$	Reference	
Helium.....	Radio frequency		Air (dry, CO <sub>2</sub> free).....	Radio frequency		
	67.8	31 Watson		537.0	34 Watson	
	63.7	46 Hector		Microwave <sup>a</sup>	536.5	51.0 Birnbaum
	64.5	48 Jelatis			536.6	51 Essen
					536.6	53 Essen
Microwave		Optical				
65.6	51.0 Birnbaum	536.9	13 Koch			
65.2	53 Essen	535.8	19 Meggers			
Optical		536.0	20 Traub			
64.6	13 Koch	536.7	24 Quarder			
64.5	32 Cuthbertson	536.4	27 Lowery			
		536.5	31 Tausz			
		536.1	34 Koster			
		536.3	34 Perard			
		535.8	39 Barrell			
Hydrogen.....	Radio frequency		Nitrogen.....	Radio frequency		
	254.0	31 Watson		547.2	34 Watson	
	Microwave			Microwave	547.3	51.0 Birnbaum
	253.4	53 Essen			548.0	51 Essen
					548.0	53 Essen
Optical		Optical				
254.1	10.0 Cuthbertson	548.9	10.0 Cuthbertson			
253.6	13 Koch	548.7	13 Koch			
253.7	21 Kirn	547.2	31 Tausz			
254.3	31 Tausz					
Oxygen.....	Radio frequency		Carbon dioxide..	Radio frequency		
	494.3	34 Watson		921.5	34 Watson	
	496.2	48 Jelatis		Microwave	922.4	51.0 Birnbaum
	Microwave <sup>a</sup>				920.6	51 Essen
	494.9	51.0 Birnbaum				
	495.0	51 Essen				
	494.9	53 Essen				
Optical						
494.5	10.0 Cuthbertson					
493.5	27 Lowery					
494.7	31 Tausz					
494.4	32 Ladenberg					
Argon.....	Radio frequency					
	513.0	31 Watson				
	516.4	48 Jelatis				
	Microwave					
	517.7	51 Essen				
	Optical					
	516.8	10.1 Cuthbertson				
517.8	24 Quarder					
517.0	31 Tausz					
516.7	34 Damköhler					

Recommended Values of  $(\epsilon-1) \cdot 10^6$  at 20°C and 1 Atmosphere

	He	H <sub>2</sub>	O <sub>2</sub>	A	Air (dry, CO <sub>2</sub> free)	N <sub>2</sub>	CO <sub>2</sub>
Mean value <sup>b</sup> .....	65.0	253.8	494.7	517.2	536.4	548.0	922
Avg. dev.....	±.4	±.3	±.2	±.4	±.3	±.5	±1

<sup>a</sup> These values were derived from measurements of the refractive index after making allowance for the magnetic permeability of oxygen. The permeability of oxygen was calculated in accordance with the theory of Van Vleck (cf. D. E. Kerr, Propagation of Short Radio Waves, McGraw-Hill Book Company, Inc., chapter 8) and found to be 1.0000012 at a frequency of 9,000 megacycles per second (51.0 Birnbaum, 53 Essen) and 1.0000015 at a frequency of 24,000 Mc/s (53 Essen).

<sup>b</sup> Mean of all values listed in bold type.

### 3. Dipole Moments

#### 3.1. Treatment of Data

According to the Debye equation, the molar polarization,  $P$ , is given by

$$P = \frac{\epsilon - 1}{\epsilon + 2} V = \frac{4\pi N a}{3} + \frac{4\pi N \mu^2}{9kT}, \quad (2)$$

where

$\epsilon$  = dielectric constant

$V$  = molar volume

$a$  = molecular polarizability (optical plus infrared)

$\mu$  = dipole moment

$N$  = Avogadro's number

$k$  = Boltzmann's constant

$T$  = temperature, absolute ( $^{\circ}\text{K}$ ).

Values of the dipole moment were recalculated by one of the two following procedures.

##### (a) *Temperature-Variation Procedure.*

The molar polarization was assumed to be a linear function of  $1/T$ , i. e.,  $P = A + B/T$ , and  $A$  and  $B$  were evaluated by the method of least squares. Then  $\mu = 0.01281 \times 10^{-18} \sqrt{B}$  electrostatic units (esu) since  $B = 4\pi N \mu^2 / 9k$ . In the analysis of data, preference was given to this procedure. However, where the dipole moment appeared to show a definite dependence upon temperature, where the scope or precision of the data was too limited, or where the value found for  $A$  appeared unrealistic in comparison with the molar refraction, the following procedure was used.

(b) *Optical Procedure.* The value of the dipole moment was calculated at each temperature according to the relation,

$$\mu = 0.1281 \times 10^{-18} \sqrt{(P-A)T} \text{ esu,}$$

where  $A$  was assumed to be equal to the molar refraction for the sodium  $D$  line, unless otherwise specified. Average values are listed in the table unless the data indi-

cated a definite variation in dipole moment with temperature.

The table also includes values of the dipole moment obtained by several other methods, namely, Stark effect in microwave spectroscopy, Stark effect in radio-frequency spectroscopy, electric Stern-Gerlach experiment.

#### 3.2. Reliability of the Values of Dipole Moment

In general, values of the dipole moment calculated from measurements of dielectric constant by the temperature variation procedure and from the Stark effect in microwave spectroscopy are the most reliable and usually agree within about 2 percent. However, it is difficult to determine small values precisely by the dielectric method. Although the two methods do not lead to exactly comparable results on theoretical grounds,<sup>3</sup> this distinction is probably of minor significance in most cases.

Values of the dipole moment determined from measurements of dielectric constants by the optical procedure should be regarded as upper limits because the assumption,  $A=R$  (molar refraction), ordinarily does not make adequate allowance for the infrared, or "atomic," polarization. If  $\mu_R$  and  $\mu_A$  are the values of the dipole moment that would be calculated using the molar refraction and the correct value of  $A$ , respectively, then  $\mu_R^2 = \mu_A^2 + 1.64 \times 10^{-40} (A-R)T$ . The accompanying chart shows the error associated with the optical procedure for values of  $(A-R)$  of the order usually expected.

<sup>3</sup> In the temperature variation procedure, it is assumed that  $dP/d(1/T) = \text{Constant}$ . Consequently, it is implied that the quantum correction to the Debye equation (27 Van Vleck) is negligibly small and the fraction of molecules in any excited states of significantly different dipole moment is also negligibly small. Values of the dipole moment obtained from microwave spectroscopy refer to a particular vibrational state.

$\frac{\mu_R - \mu_A}{\mu_R} \times 100$ for $T=300^\circ$					
A-R cc	0.5	1	2	4	6
$\mu_R \times 10^{18}$ esu					
0.5	5	11	28	107	.....
1	1.2	2.5	5	11	19
2	0.3	0.6	1.2	2.5	3.9
3	.1	.3	0.5	1.1	1.7
4	.1	.2	.3	0.6	0.9

The precision and accuracy that have been obtained with the molecular beam method are comparatively low. Data are tabulated only for the alkali halides which, until recently, had not been investigated by any other methods. The newly developed techniques of radio frequency spectroscopy would appear to offer greater promise in this direction although results to date are rather meager.

### 3.3. Explanation of the Table of Dipole Moments

COLUMN 1. ARRANGEMENT OF SUBSTANCES. The order of listing the inorganic substances is alphabetical according to the chemical formulas as customarily written. Formulas for the organic compounds are written with carbon first and hydrogen, if present, second. Symbols for all remaining elements then follow in alphabetical sequence. The order of listing these compounds is determined first by the number of carbon atoms, secondly by the number of hydrogen atoms, and finally by the symbols for the remaining elements in alphabetical order.

COLUMN 2.  $\mu$ —THE DIPOLE MOMENT. The uncertainties that frequently accompany the values of the dipole moment have the following significance.

a. Where the temperature variation procedure was employed, they are the uncertainties corresponding to the standard deviation in  $B$ , the slope of the Debye plot. They are included only where data were available at four or more temperatures.

b. Where the dipole moment was obtained by other methods, the uncertainties are those estimated by the authors.

COLUMN 3. "A"—the sum of the optical and infrared contributions to the molar polarization. The method employed to determine the dipole moment is indicated in this column according to the following scheme.

a. *Numerical Value of "A" Listed.* The measurements of dielectric constant were analyzed by the temperature variation procedure except in cases where the value of the dipole moment is listed as zero. In such cases the experimental data were generally inconclusive and the assignment of zero values was based primarily upon considerations of molecular symmetry. The standard deviation in "A" is included where the analysis involved data at four or more temperatures.

b. "....."—the dielectric constant measurements were analyzed by the optical procedure using for A the value of the molar refraction specified in column 4.

c. *M Stark.* The dipole moment was obtained from a study of the Stark effect on the microwave absorption spectrum (cf. 50.1 Shulman). The values usually refer to the ground vibrational state unless otherwise specified.

d. *R Stark.* This method utilizes a molecular beam technique in studying the Stark effect in radio frequency spectroscopy. (cf. 47 Hughes).

e. *Mol. Beam.* The dipole moment was obtained from the electric Stern-Gerlach experiment in which a molecular beam is deflected by an inhomogeneous electric field.

COLUMN 4.  $R$ —THE MOLAR REFRACTION. The values of the molar refraction refer to the sodium  $D$  line unless accompanied by a subscript giving the wavelength in millimicrons. A majority of these values were taken from the cited dielectric literature, but those inclosed in parentheses were obtained as follows:

$(R)_{\Sigma}$ —by summation of the atomic refractions for the sodium  $D$  line given in Landolt-Börnstein Tabellen, 5th ed.

$(R)_L$ —from data in Landolt-Börnstein Tabellen, 5th ed.

$(R)_T$ —from data in Physicochemical Constants of Pure Organic Substances,

J. Timmermans, Elsevier Publishing Co., Inc., New York, N. Y.

COLUMN 5. TEMPERATURE RANGE ( $^{\circ}K$ ).

$T_1; T_2$ —denotes observations at the temperatures  $T_1$  and  $T_2$ .

$T_1-T_2$ —denotes observations at three or more temperatures in the range  $T_1$  to  $T_2$ .

COLUMN 6. REFERENCES. Some additional references for which no data have been included are inclosed in brackets. The complete bibliography in chronological order appears at the end of this table.

## A. INORGANIC GASES

Substance		$\mu \times 10^{18}$ esu	A	R	Temperature ( $^{\circ}$ K)	Reference
AsCl <sub>3</sub>	Arsenic trichloride.....	1.59 $\pm$ .01	37.6 $\pm$ .2	(28.5) <sub>L</sub>	380-470	37 Grassi
AsF <sub>3</sub>	Arsenic trifluoride.....	2.815 $\pm$ .025	M Stark		.....	50.1 Shulman
AsH <sub>3</sub>	Arsine.....	0.16	14.5		226-373	27 Watson
AsH <sub>2</sub> D	Arsine-d.....	0.22 $\pm$ .02	M Stark		.....	51 Loomis
BCl <sub>3</sub>	Boron chloride.....	0.59 <sup>a</sup> $\pm$ .01	23.9 $\pm$ .3	(20.1 <sub>co</sub> ) <sub>L</sub>	308-450	37 Grassi
BF <sub>3</sub>	Boron fluoride.....	0	8.90	6.09 <sub>co</sub>	193; 298	36 Watson
		0	8.36		293-472	37 Linke
BH <sub>3</sub> CO	Borine carbonyl.....	1.795 <sup>b</sup>	M Stark		.....	49.2 Strandberg
B <sub>2</sub> H <sub>6</sub>	Diborane.....	0	14.46	12.91 <sub>co</sub>	193; 298	35 Ramaswamy
B <sub>3</sub> H <sub>6</sub> N <sub>3</sub>	Triazatriborine.....	ca 0	ca 23.8	20.2 <sub>co</sub>	298	35 Ramaswamy
B <sub>5</sub> H <sub>9</sub>	Pentaborane.....	2.13 $\pm$ .04	M Stark		.....	52 Hrostowski
BrCl	Bromine chloride.....	0.57 $\pm$ .02	M Stark		.....	50.1 Smith
BrF	Bromine fluoride.....	1.29	M Stark		.....	50.0 Smith
Br <sub>2</sub>	Bromine.....	0	17.7	(16.3 <sub>co</sub> ) <sub>L</sub>	293-412	33 Luft
ClF	Chlorine fluoride.....	0.88	M Stark		.....	49 Gilbert
ClF <sub>3</sub>	Chlorine trifluoride.....	0.554 $\pm$ .002	15.94 $\pm$ .11		273-356	52 Magnuson
CsCl	Cesium chloride.....	10.5 $\pm$ .25	R Stark		.....	51 Luce
CsF	Cesium fluoride.....	7.42 $\pm$ .47	R Stark		.....	49 Hughes
		7.89 <sup>c</sup> $\pm$ .17	R Stark		.....	49 Trischka
CsI	Cesium iodide.....	10.2	Mol. beam		873	36 Rodebush
GeCl <sub>4</sub>	Germanium tetrachloride...	0	38.0	31.5	369-501	38.0 Coop
GeH <sub>3</sub> Cl	Chlorogermane.....	2.03	.....	16.9	275-297	40 Smyth
		2.13	M Stark		.....	49 Dailey
HBr	Hydrogen bromide.....	0.80 $\pm$ .01	9.1 $\pm$ .2	(8.87 <sub>co</sub> ) <sup>d</sup>	218-599	24 Zahn
HCl	Hydrogen chloride.....	1.050 $\pm$ .004	7.63 $\pm$ .21	(6.51 <sub>co</sub> ) <sup>d</sup>	201-589	24 Zahn
		1.077 $\pm$ .019	6.63 $\pm$ .39		286-373	31 Braune
		1.081 $\pm$ .004	6.98 $\pm$ .14		291-517	38 Bell
						[27 von Braunmühl]
DCl	Deuterium chloride.....	1.085 $\pm$ .001	7.16 $\pm$ .04	(6.50 <sub>co</sub> ) <sup>d</sup>	291-517	38 Bell
HF	Hydrogen fluoride.....	1.91	.....	2.0	305-374	46.0 Hannay
		1.91	.....		296-333	48 Oriani
HI	Hydrogen iodide.....	0.42	13.5	(13.2 <sub>co</sub> ) <sub>L</sub>	245-346	24 Zahn
HN <sub>3</sub>	Hydrazoic acid.....	0.847 <sup>f</sup> $\pm$ .005	M Stark		.....	50 Amble
H <sub>2</sub> O	Water.....	1.85	3.9	3.67 <sub>co</sub>	423-483	32 Sanger
		1.844 $\pm$ .030	4.3 $\pm$ 1.8		383-484	35 Groves
		1.844 $\pm$ .007	4.0 $\pm$ .6		394-462	35 Stranathan
		1.850 $\pm$ .027	3.4 $\pm$ 1.7		384-522	42.1 Hurdis
		1.853 $\pm$ .011	3.8 $\pm$ .7		298-376	52 Birnbaum
						[48 Golden]
						[48 Crain]

<sup>a</sup> The finite moment is probably attributable to the presence of impurities as zero moment would be expected from structural considerations. <sup>b</sup>  $\mu=1.770$  for the excited vibrational state,  $\nu_1=1$ . <sup>c</sup>  $\mu=7.98 \pm 0.18$  for the first excited vibrational state. <sup>d</sup> T. Larson, Z. Physik 111, 391 (1938). <sup>f</sup> For the dipole component along the NNN axis.

Substance		$\mu \times 10^{18}$ esu	A	R	Temperature (°K)	Reference	
DHO	Deuterium hydrogen oxide..	1.84 ± 0.01	M Stark		.....	49.3 Strandberg [48.0 Strandberg]	
D <sub>2</sub> O	Deuterium oxide.....	1.861 ± 0.016	3.6 ± 1.2	(3.63 <sub>00</sub> ) <sup>g</sup>	364-473	35 Groves	
		1.87 ± 0.02	M Stark		.....	52 Beard [48.1 Strandberg]	
H <sub>2</sub> S	Hydrogen sulfide.....	0.92 ± 0.01	9.96 ± 6.4	(9.25 <sub>00</sub> ) <sup>d</sup>	197-542	28 Zahn	
HDS	Hydrogen sulfide- <i>d</i> .....	1.02	M Stark		.....	50 Hillger	
Hg	Mercury.....	0	12.7	(12.7 <sub>00</sub> ) <sub>L</sub>	674-743	36 Wüsthoff [29 Kruger]	
HgBr <sub>2</sub>	Mercuric bromide.....	0	36.5	29.3 <sub>00</sub>	614-695	35 Braune	
HgCl <sub>2</sub>	Mercuric chloride.....	0	29.2	22.9 <sub>00</sub>	599-701	35 Braune	
HgI <sub>2</sub>	Mercuric iodide.....	0	48.3	41.6 <sub>00</sub>	568-701	35 Braune	
ICl	Iodine chloride.....	0.54 ± 0.01	30.9 ± 3		334-435	33 Luft	
		0.65 ± 0.07	( <sup>h</sup> )		.....	46 Townes	
KBr	Potassium bromide.....	9.1	Mol. beam		920	36 Rodebush	
KCl	Potassium chloride.....	6.3	Mol. beam		1023	34 Scheffers	
		8.0	Mol. beam		949	36 Rodebush	
KF	Potassium fluoride.....	7.33 ± 0.24	R Stark		.....	50 Grabner	
KI	Potassium iodide.....	6.8	Mol. beam		950	34 Scheffers	
		9.2	Mol. beam		898	36 Rodebush	
Kr	Krypton.....	0	6.26	6.27 <sub>00</sub>	298	36 Watson	
NF <sub>3</sub>	Nitrogen fluoride.....	0.22	9.02	7.03 <sub>00</sub>	193-368	35 Ramaswamy	
		0.25	9.12		193-368	36 Watson	
NH <sub>3</sub>	Ammonia.....	1.469 ± 0.006	5.3 ± 4	(5.54 <sub>00</sub> ) <sub>L</sub>	274-457	26 Zahn	
		1.477 ± 0.006	5.3 ± 4		274-423	35 de Bruyne	
		1.46	5.9		294-419	47 Le Fevre	
		1.438 ± 0.011	6.5 ± 7		279-403	48 van Isterbeek	
		1.468 ± 0.009	M Stark		.....	51 Coles [33 Uhlig] [36 Watson]	
ND <sub>3</sub>	Deuteroammonia.....	1.509 ± 0.005	4.3 ± 3		274-425	35 de Bruyne	
NO	Nitrogen oxide.....	0.07 ± 0.02	4.74 ± 0.07		235-477	33.0 Smyth	
		0.16	4.31	4.30 <sub>00</sub>	193; 298	34 Watson	
NOF	Nitrosyl fluoride.....	1.81	M Stark		.....	51.0 Magnuson	
NO <sub>2</sub>	Nitrogen dioxide.....	0.39	.....	7.63	297-397	33.0 Zahn	
		Dimer (N <sub>2</sub> O <sub>4</sub> ).....	0.55	.....	16.75	297-397	33.0 Zahn
		Monomer.....	0.58	.....	7.62	298	36 Williams
			.41			343	
			.30			398	
		Dimer (N <sub>2</sub> O <sub>4</sub> ).....	0	16.87	16.73	298-398	36 Williams
Monomer.....	0.32	.....	7.62 <sub>644</sub>	298-372	38 Schulz		

<sup>d</sup> T. Larson, Z. Physik 111, 391 (1938).<sup>g</sup> Cuthbertson, C. and Cuthbertson, M., Proc. Roy. Soc. (London) A155, 213 (1936).<sup>h</sup> Dipole moment calculated from the intensity of microwave absorption.

Substance		$\mu \times 10^{18}$ esu	A	R	Temperature (°K)	Reference
NO <sub>2</sub> —Con.	Dimer (N <sub>2</sub> O <sub>4</sub> ).....	0.42	.....	16.76 <sub>644</sub>	298-372	38 Schulz
NO <sub>2</sub> F	Nitryl fluoride.....	0.47	M Stark		.....	52 Smith
N <sub>2</sub> O	Dinitrogen oxide.....	0.14 ±.01	7.85 ±.05		293-454	34 Czerlinsky
		0.17	7.76	7.36 <sub>∞</sub>	193-298	34 Watson
		0.16	M Stark		.....	49 Coles
		0.166 ±.002	M Stark		.....	50.1 Shulman
						[27 von Braunmühl]
					[29.1 Ghosh]	
					[30 Schwingel]	
NaI	Sodium iodide.....	4.9	Mol. beam		950	34 Scheffers
Ne	Neon.....	0	1.001	(0.997 <sub>∞</sub> ) <sub>L</sub>	82;298	36 Watson
		0	1.000		298	48 Jelatis
O <sub>3</sub>	Ozone.....	0.52	8.1	(7.2 <sub>∞</sub> ) <sub>L</sub>	194-360	50 Epprecht
		0.65 ±.05	R Stark		.....	51 Hughes
OsO <sub>4</sub>	Osmium tetroxide.....	0	20.6	16.6	429-561	40.2 Linke
PCl <sub>3</sub>	Phosphorus trichloride....	0.78 ±.01	32.2 ±.2	(26.0) <sub>L</sub>	306-463	33 Grassi
PF <sub>3</sub>	Phosphorus trifluoride....	1.025 ±.005	M Stark		.....	50.1 Shulman
PF <sub>5</sub>	Phosphorus pentafluoride..	0	15.4	9.6	283-388	37 and 40.2 Linke
PH <sub>3</sub>	Phosphine.....	0.55	12.21	(10.8) <sub>L</sub>	226-373	27 Watson
PH <sub>2</sub> D	Phosphine- <i>d</i> .....	0.55 ±.01	M Stark		.....	51 Loomis
POF <sub>3</sub>	Phosphorus oxyfluoride....	1.735 ±.035	M Stark		.....	50 Senatore
		1.69 ±.05	M Stark		.....	52 Hawkins
		1.77 ±.02	M Stark		.....	52 Ghosh
PSF <sub>3</sub>	Phosphorus thiofluoride...	0.633 ±.02	M Stark		.....	52 Hawkins
SF <sub>6</sub>	Sulfur hexafluoride.....	0	16.5	11.31 <sub>∞</sub>	193;298	34 Watson
		0	16.8		301	38 Fuoss
		0	15.7		292	40.2 Linke
S <sub>2</sub> F <sub>10</sub>	Disulfur decafluoride.....	0	33.4		298	51 Hollies
SOCl <sub>2</sub>	Thionyl chloride.....	1.452 ±.004	25.2 ±.3	21.0 <sub>∞</sub>	288-407	39 Coop
SO <sub>2</sub>	Sulfur dioxide.....	1.633 ±.006	10.6 ±.4		266-444	26 Zahn
		1.590 ±.025	13.7 ±1.8		292-353	37 Smits
		1.631 ±.011	10.8 ±.8	9.54 <sub>∞</sub>	289-457	50.0 Le Fevre
		1.59 ±.01	M Stark		.....	51 Crable
					[51 Lovering]	
SO <sub>2</sub> Cl <sub>2</sub>	Sulfuryl chloride.....	1.81	26.4	20.7 <sub>∞</sub>	293-416	39 Coop
SO <sub>2</sub> F <sub>2</sub>	Sulfuryl fluoride.....	0.228 ±.004	M Stark		.....	52 Fristrom
SO <sub>3</sub>	Sulfur trioxide.....	0	12.20	10.55 <sub>∞</sub>	353-433	37 Smits
SbH <sub>2</sub> D	Stibine- <i>d</i> .....	0.116 ±.003	M Stark		.....	51 Loomis
SeF <sub>6</sub>	Selenium hexafluoride....	0	18.5	13.4	293	40.2 Linke
SiF <sub>4</sub>	Silicon tetrafluoride.....	0	13.75	8.38 <sub>∞</sub>	193;298	34 Watson

Substance		$\mu \times 10^{18}$ esu	A	R	Temperature (°K)	Reference
SiHCl <sub>3</sub>	Trichlorosilane.....	0.858 ±.001	27.0 ±.1		285-414	38 Brockway
SiHF <sub>3</sub>	Trifluorosilane.....	1.26 ±.02	M Stark		.....	52 Ghosh
SiH <sub>2</sub> Cl <sub>2</sub>	Dichlorosilane.....	1.167 ±.005	22.5 ±.2		291-397	38 Brockway
SiH <sub>3</sub> Br	Bromosilane.....	1.31 ±.03	M Stark		.....	50.1 Sharbaugh
SiH <sub>3</sub> Cl	Chlorosilane.....	1.292 ±.006	17.7 ±.3		288-402	38 Brockway
		1.31	M Stark		.....	49 Dailey
SiH <sub>3</sub> F	Fluorosilane.....	1.268 ±.013	M Stark		.....	50.0 Sharbaugh
SiH <sub>4</sub>	Silane.....	0	13.71	11.95 <sub>00</sub>	240; 298	34 Watson
Si <sub>2</sub> H <sub>6</sub>	Disilane.....	0	28.10	23.72 <sub>00</sub>	298	34 Watson
SnBr <sub>4</sub>	Stannic bromide.....	0	55.6	47.7 <sub>00</sub>	418-519	38.0 Coop
SnCl <sub>4</sub>	Stannic chloride.....	0	45.5	34.6 <sub>00</sub>	363-473	38.0 Coop
SnI <sub>4</sub>	Stannic iodide.....	0	81.4	70.1 <sub>00</sub>	526	38.0 Coop
TlCl	Thallium chloride.....	4.44	R Stark		.....	52 Carlson
TeF <sub>6</sub>	Tellurium hexafluoride....	0	22.7	15.0	292	40.2 Linke
TiCl <sub>4</sub>	Titanium tetrachloride....	0	41.3	37.8	373; 481	38.0 Coop
UF <sub>6</sub>	Uranium hexafluoride.....	0	30.7		293	48 Amplett
		0	31.5		313-356	51.1 Magnuson
Xe	Xenon.....	0	10.09	10.14 <sub>00</sub>	298	36 Watson

Substance		$\mu \times 10^{18}$ esu	A	R	Temperature (°K)	Reference
<b>C<sub>1</sub></b>						
CBr <sub>2</sub> F <sub>2</sub>	Dibromodifluoromethane....	1.02	.....	(22.1) $\Sigma$	302	38 Fuoss
CClF <sub>3</sub>	Chlorotrifluoromethane....	0.65 <sup>j</sup>	.....	(11.4) $\Sigma$	302	38 Fuoss
		0.39	15.7		273-420	50 Epprecht
CClN	Cyanogen chloride.....	2.802 ± 0.020	M Stark		.....	50.1 Shulman
CCl <sub>2</sub> F <sub>2</sub>	Dichlorodifluoromethane...	0.505 ± 0.002	20.23 ± 0.03		305-470	33.1 Smyth
		0.70 <sup>k</sup>	.....	(16.4) $\Sigma$	302	38 Fuoss
		0.55	19.7		300-410	50 Epprecht
CCl <sub>2</sub> O	Phosgene.....	1.19 ± 0.01	18.4 ± 0.4	(16.6 <sub>∞</sub> ) <sub>L</sub>	303-425	34.0 Smyth
CCl <sub>2</sub> S	Thiophosgene.....	0.29	25.7		303-414	39 Coop
CCl <sub>3</sub> F	Trichlorofluoromethane....	0.45 ± 0.03	23.9 ± 0.6		299-376	33.1 Smyth
		0.68 <sup>l</sup>	.....	(21.3) $\Sigma$	299	38 Fuoss
CCl <sub>3</sub> NO <sub>2</sub>	Trichloronitromethane.....	1.89	.....	(27.3) <sub>L</sub>	344	34.0 Smyth
CCl <sub>4</sub>	Carbon tetrachloride.....	0	28.14	(25.83 <sub>∞</sub> ) <sub>L</sub>	296; 368	36 Ramaswamy [26 Sanger] [36 Niini]
CF <sub>4</sub>	Carbon tetrafluoride.....	0	9.73	7.12 <sub>∞</sub>	193-368	35 Ramaswamy
		0	10.1		298; 368	36 Watson
		0	9.7		298	38 Fuoss
CN <sub>4</sub> O <sub>8</sub>	Tetranitromethane.....	0	38.6	36.0 <sub>546</sub>	355	38.0 Coop
CO	Carbon monoxide.....	0.097 ± 0.004	5.01 ± 0.03		90-391	28 Zahn
		0.10	4.98	4.89 <sub>∞</sub>	83; 298	34 Watson
		0.117 ± 0.005	4.65 ± 0.02		273-373	48 van Itterbeek [27 von Braunmühl]
CO <sub>2</sub>	Carbon dioxide.....	0	7.35	6.54 <sub>∞</sub>	298	36 Watson
COS	Carbonyl sulfide.....	0.67 ± 0.01	14.4 ± 0.2	(12.8 <sub>∞</sub> ) <sup>i</sup>	202-365	28 Zahn
		0.72	M Stark		.....	46 Dakin
		0.72	.....		265; 333	48 Jelatis
	C <sup>12</sup> O <sup>16</sup> S <sup>32</sup> .....	0.732 ± 0.007	M Stark		.....	49.0 Strandberg
	C <sup>13</sup> O <sup>16</sup> S <sup>32</sup> .....	0.722 ± 0.007	M Stark		.....	49.0 Strandberg
	C <sup>12</sup> O <sup>16</sup> S <sup>32</sup> .....	0.709 <sup>n</sup> ± 0.004	M Stark		.....	50.0 Shulman
	C <sup>12</sup> O <sup>16</sup> S <sup>34</sup> .....	( <sup>m</sup> )	.....		.....	50.0 Shulman
	C <sup>12</sup> O <sup>16</sup> S <sup>32</sup> .....	0.712 ± 0.004	M Stark		.....	51.2 Shoolery
COSe	Carbonyl selenide.....	0.754 <sup>o</sup>	M Stark		.....	49.1 Strandberg
CS <sub>2</sub>	Carbon disulfide.....	0	22.36	(20.37 <sub>∞</sub> ) <sub>L</sub>	325-489	30 Zahn [30 Schwingel] [36 Niini]
CHBrF <sub>2</sub>	Bromodifluoromethane.....	1.50	.....	(14.4) $\Sigma$	300	38 Fuoss
CHClF <sub>2</sub>	Chlorodifluoromethane.....	1.409 ± 0.003	14.9 ± 0.1		304-479	33.1 Smyth
		1.48	.....	(11.5) $\Sigma$	298	38 Fuoss

<sup>i</sup> H. Huxley and H. Lowery, Proc. Roy. Soc. (London) A182, 207 (1943). <sup>j</sup>  $\mu=0.45$  if  $A=15.7$ . <sup>k</sup>  $\mu=0.56$  if  $A=20.0$ . <sup>l</sup>  $\mu=0.53$  if  $A=23.9$ . <sup>m</sup> Moments of C<sup>13</sup>O<sup>16</sup>S<sup>32</sup> and C<sup>12</sup>O<sup>16</sup>S<sup>34</sup> reported to be the same within 0.2%. <sup>n</sup>  $\mu=0.700 \pm 0.004$  for the excited vibrational state,  $v_2=1$ . <sup>o</sup> For the first excited vibrational states,  $\mu=0.728$  (stretching) and 0.730 (bending).

Substance		$\mu \times 10^{18}$ esu	A	R	Temperature (°K)	Reference
<b>C<sub>1</sub>—Con.</b>						
CHCl <sub>2</sub> F	Dichlorofluoromethane.....	1.293 ± .006	17.2 ± .3		305-424	33.1 Smyth
		1.41	.....	(16.5) <sub>Σ</sub>	303	38 Fuoss
CHCl <sub>3</sub>	Chloroform.....	1.02	24.8	(21.0 <sub>∞</sub> ) <sub>L</sub>	298; 368	36 Ramaswamy
		1.013 ± .001	25.28 ± .05	21.4	301-427	41 Maryott [26 Sanger] [28 Sircir]
CHF <sub>3</sub>	Fluoroform.....	1.60	8.8	6.98 <sub>∞</sub>	193-368	35 Ramaswamy
		1.645 ± .009	M Stark		.....	51.2 Shoolery
CHN	Hydrogen cyanide.....	2.91 ± .05	11.8 ± 5.3		292-424	31 Braune
		2.95 ± .01	6.2 ± 1.2		301-470	34.0 Smyth
		3.00	.....	(6.3) <sub>T</sub>	298; 368	36 Watson
		2.957 <sup>y</sup> ± .025	M Stark		.....	50.2 Shulman [30 Fredenhagen]
CHNO	Isocyanic acid.....	1.592 <sup>p</sup> ± .015	M Stark		.....	51.0 Shoolery
CDNO	Isocyanic acid- <i>d</i> .....	1.619 <sup>p</sup> ± .015	M Stark		.....	51.0 Shoolery
CHNS	Isothiocyanic acid.....	1.72 <sup>q</sup>	M Stark		.....	50 Beard
CH <sub>2</sub> Br <sub>2</sub>	Dibromomethane.....	1.43 ± .03	23.5 ± 1.3	(20.7 <sub>∞</sub> ) <sub>L</sub>	338-427	41 Maryott [28 Mahanti]
CH <sub>2</sub> CINO <sub>2</sub>	Chloronitromethane.....	2.91	.....	17.4	412-484	42.1 Hurdis
CH <sub>2</sub> Cl <sub>2</sub>	Dichloromethane.....	1.54	18.7	(16.0 <sub>∞</sub> ) <sub>L</sub>	297; 368	36 Ramaswamy
		1.57 ± .01	20.0 ± .7	16.6	301-427	41 Maryott [26 Sanger] [28 Mahanti] [36 Niini]
CH <sub>2</sub> F <sub>2</sub>	Difluoromethane.....	1.93	M Stark		.....	52 Lide
CH <sub>2</sub> O	Formaldehyde.....	2.27	.....	7.0	420-520	43 Hurdis
		2.17 ± .02	M Stark		.....	49 Bragg
		2.34 ± .02	M Stark		.....	51.2 Shoolery
CH <sub>2</sub> O <sub>2</sub>	Formic acid.....	1.52	.....	8.5	345-423	31.0 Zahn
		ca 1.4	.....		310-347	38.2 Coop
CH <sub>3</sub> Br	Bromomethane.....	0	32		310-347	38.2 Coop
		1.80 ± .02	15.2 ± 1.1		306-406	34.1 Smyth
		1.81	.....	(14.6) <sub>Σ</sub>	297; 368	36 Ramaswamy
		1.76 ± .04	17.8 ± 1.3		291-416	37.0 Groves
CH <sub>3</sub> Cl	Chloromethane.....	1.797 ± .015	M Stark		.....	50.1 Shulman [35 Mahanti]
		1.87 ± .01	13.5 ± .5	(11.2 <sub>∞</sub> ) <sub>L</sub>	290-456	30 Fuchs
		1.87 ± .01	14.1 ± .5		298-418	32 Sanger

<sup>p</sup> For the dipole component along the NCO axis.

<sup>q</sup> For the dipole component along the SCN axis.

<sup>y</sup> For the excited vibrational state,  $\nu_2=1$ .

Substance		$\mu \times 10^{18}$ esu	A	R	Temperature (°K)	Reference
<b>C<sub>1</sub>—Con.</b>						
CH <sub>3</sub> Cl	Chloromethane (Con.).....	1.89 1.87 ± 0.03 1.869 ± 0.010	..... M Stark M Stark	(11.7) <sub>Σ</sub>	296; 368 ..... .....	36 Ramaswamy 49 Karplus 50.1 Shulman [28 Sircir] [35 Mahanti]
CH <sub>3</sub> F	Fluoromethane.....	1.81 ± 0.01 <sup>a</sup> 1.85	9.6 ± 0.6 7.2	(6.7) <sub>Σ</sub>	224-498 193-368	34.1 Smyth 36 Ramaswamy
CH <sub>3</sub> I	Iodomethane.....	1.60 ± 0.01 1.62 1.67 1.647 ± 0.014	20.1 ± 0.5 ..... ..... M Stark	(19.3) <sub>L</sub>	305-494 301; 368 295; 337 .....	34.1 Smyth 36 Ramaswamy 37.0 Groves 50.1 Shulman [35 Mahanti]
CH <sub>3</sub> NO	Formamide.....	3.25	.....	10.6	425-449	32.0 Zahn
CH <sub>3</sub> NO <sub>2</sub>	Nitromethane.....	3.44 ± 0.01 3.57	18.6 ± 0.7 .....	..... 12.5	339-494 373-470	34.0 Smyth 37.0 Groves
CH <sub>4</sub>	Methane.....	0	6.53	6.45 <sub>∞</sub>	193; 298	34 Watson [26 Sanger] [33 Uhlig]
CH <sub>4</sub> O	Methanol.....	1.70 ± 0.01 1.70 ± 0.01 1.70 1.706 ± 0.004	7.8 ± 0.6 9.7 ± 0.4 8.1 7.6 ± 0.2	(8.2) <sub>L</sub>	345-502 308-482 302; 368 298-479	29 Miles 35.0 Kubo 36 Ramaswamy 38 Stranathan
CH <sub>5</sub> N	Methyl amine.....	1.24 ± 0.03 1.26 1.35 ± 0.04 1.30 ± 0.01	13.4 ± 1.0 13.7 9.7 ± 1.6 10.6 ± 0.5	10.3	338-458 298; 368 288-417 293-420	32 Sanger 36 Ramaswamy 37.1 Groves 47 Le Fevre [31 Ghosh]
CH <sub>6</sub> Si	Methyl silane.....	0.73	M Stark	.....	.....	50 Lide
CH <sub>6</sub> Sn	Methyl stannane.....	0.68 ± 0.03	M Stark	.....	.....	51 Lide
<b>C<sub>2</sub></b>						
C <sub>2</sub> ClF <sub>5</sub>	Chloropentafluoroethane...	0.80	.....	(15.8) <sub>Σ</sub>	300	38 Fuoss
C <sub>2</sub> Cl <sub>2</sub> F <sub>4</sub>	1,2-Dichlorotetrafluoroethane.....	0.80	.....	(21.5) <sub>L</sub>	299	38 Fuoss
C <sub>2</sub> F <sub>6</sub>	Hexafluoroethane.....	0	17.2	(10.8) <sub>Σ</sub>	296	38 Fuoss
C <sub>2</sub> N <sub>2</sub>	Cyanogen.....	0	20.1	11.9 <sub>∞</sub>	239; 298	36 Watson [31 Braune]
C <sub>2</sub> HBr	Bromoacetylene.....	0.0 <sup>e</sup>	18.64	(17.2) <sub>Σ</sub>	289-354	38 Brockway

<sup>e</sup> Although the structure is not symmetrical, the dipole moment appears to be virtually zero.

Substance		$\mu \times 10^{18}$ esu	A	R	Temperature (°K)	Reference
<b>C<sub>2</sub>—Con.</b>						
C <sub>2</sub> HCl	Chloroacetylene.....	0.446 ± 0.05	15.3 ± 1.1	(14.3) <sub>Σ</sub>	287-363	38 Brockway
		0.44 ± 0.1	M Stark		.....	49 Westenber
C <sub>2</sub> HCl <sub>5</sub>	Pentachloroethane.....	0.95 ± 0.03	35.4 ± 1.8	(35.6) <sub>L</sub>	400-517	49 Thomas
C <sub>2</sub> H <sub>2</sub>	Acetylene.....	0	9.97		196-461	25 Smyth
		0	9.84	8.58 <sub>∞</sub>	193; 298	34 Watson
C <sub>2</sub> H <sub>2</sub> Cl <sub>2</sub>	<i>cis</i> -Dichloroethylene.....	1.90 ± 0.02	19.9 ± 1.6	(20.3) <sub>T</sub>	301-427	41 Maryott
C <sub>2</sub> H <sub>2</sub> Cl <sub>2</sub> F <sub>2</sub>	1,1-Dichloro-2,2-difluoroethane.....	1.34	.....	21.2	334	52 Smyth
		1.35	.....		345	
		1.36	.....		357	
		1.39	.....		384	
		1.40	.....		395	
		1.44	.....		428	
		1.45	.....		455	
		1.47	.....		474	
C <sub>2</sub> H <sub>2</sub> Cl <sub>2</sub> O	Chloroacetyl chloride.....	2.23 ± 0.06	22.5 ± 3.7	21.8	358-529	32.1 Zahn
C <sub>2</sub> H <sub>2</sub> Cl <sub>3</sub> F	1,2,2-Trichloro-1-fluoroethane.....	1.38	.....	25.7	379	52 Smyth
		1.41	.....		417	
		1.42	.....		442	
		1.44	.....		475	
		1.44	.....		512	
C <sub>2</sub> H <sub>2</sub> Cl <sub>4</sub>	1,1,2,2-Tetrachloroethane	1.36	.....	(30.6) <sub>L</sub>	401-436	35.0 Smyth
		1.32 ± 0.03	32.4 ± 1.2		378-501	47 Thomas
C <sub>2</sub> H <sub>2</sub> F <sub>2</sub>	1,1-Difluoroethylene.....	1.37 ± 0.02	M Stark		.....	49 Roberts
C <sub>2</sub> H <sub>2</sub> O	Ketene.....	1.45	.....	11.0	398-446	46.3 Hannay
		1.414 ± 0.10	M Stark		.....	51 Johnson
C <sub>2</sub> HDO	Ketene- <i>d</i> .....	1.423 ± 0.15	M Stark		.....	51 Johnson
C <sub>2</sub> D <sub>2</sub> O	Ketene- <i>d</i> <sub>2</sub> .....	1.442 ± 0.13	M Stark		.....	51 Johnson
C <sub>2</sub> H <sub>3</sub> Br	Bromoethylene.....	1.415 ± 0.01	19.14 ± 0.06	18.5	295-413	38 Hugill
C <sub>2</sub> H <sub>3</sub> Cl	Chloroethylene.....	1.449 ± 0.03	16.18 ± 1.2	15.6	287-413	38 Hugill
C <sub>2</sub> H <sub>3</sub> ClF <sub>2</sub>	1-Chloro-1,1-difluoroethane.....	2.21	.....	(16.1) <sub>Σ</sub>	300	38 Fuoss
		2.14	20.3		357-507	52 Smyth
C <sub>2</sub> H <sub>3</sub> ClO	Acetyl chloride.....	2.72 ± 0.04	16.7 ± 3.7	16.8	320-483	32.1 Zahn
C <sub>2</sub> H <sub>3</sub> ClO <sub>2</sub>	Methyl chloroformate.....	2.41	.....	(17.9) <sub>Σ</sub>	308	38 Mizushima
		2.43	.....		351	
		2.31	.....		413	
		1.55	.....		481	

Substance		$\mu \times 10^{18}$ esu	A	R	Temperature (°K)	Reference
<b>C<sub>2</sub>—Con.</b>						
C <sub>2</sub> H <sub>3</sub> Cl <sub>3</sub>	1,1,1-Trichloroethane.....	1.79 ± 0.02	27.0 ± 1.0		301-395	41 Maryott
		1.77	.....	26.1	336-399	41.1 Wiswall
	1,1,2-Trichloroethane.....	1.22 ± 0.02	33.3 ± 0.6		340-517	49 Thomas
C <sub>2</sub> H <sub>3</sub> F <sub>3</sub>	1,1,1-Trifluoroethane.....	2.35	.....	(11.1) <sub>Σ</sub>	298	38 Fuoss
		2.321 ± 0.034	M Stark		.....	50.1 Shulman
C <sub>2</sub> H <sub>3</sub> I	Iodoethylene.....	1.30	.....	23.5	290-413	38 Hugill
C <sub>2</sub> H <sub>3</sub> N	Acetonitrile.....	3.84	.....	(11.1) <sub>L</sub>	298; 368	36 Ramaswamy
		3.96 ± 0.03	11.1 ± 3.1		354-463	37.0 Groves
		3.97	M Stark		.....	50 Coles
C <sub>2</sub> H <sub>4</sub>	Ethylene.....	0	10.79		237-461	25 Smyth
		0	10.74	10.3 <sub>∞</sub>	193; 298	34 Watson
C <sub>2</sub> H <sub>4</sub> BrCl	1-Bromo-2-chloroethane....	1.16	.....	24.0	339	32.3 Zahn
		1.21	.....		368	
		1.35	.....		436	
C <sub>2</sub> H <sub>4</sub> Br <sub>2</sub>	1,2-Dibromoethane.....	1.02	.....	27.0	339	32.3 Zahn
		1.07	.....		368	
		1.12	.....		405	
		1.19	.....		436	
		0.97	.....	(27.0)	357	40.0 Linke
		1.06	.....		374	
		1.14	.....		419	
		1.17	.....		458	
		1.23	.....		509	
		1.26	.....		531	
		0.91	.....	(27.0)	339	41 Bloom
		0.97	.....		369	[32 Greene]
		1.04	.....		408	
		1.10	.....		437	
		1.14	.....		467	
	1.19	.....		496		
C <sub>2</sub> H <sub>4</sub> ClF	1-Chloro-2-fluoroethane...	1.84	.....	(16.4) <sub>Σ</sub>	309	52 Smyth
		1.86	.....		329	
		1.91	.....		371	
		1.97	.....		418	
		1.97	.....		481	
	1.97	.....		506		
C <sub>2</sub> H <sub>4</sub> ClNO <sub>2</sub>	1-Chloro-1-nitroethane....	3.27 ± 0.05	27.5 ± 4.5	21.9	415-468	42.1 Hurdis
C <sub>2</sub> H <sub>4</sub> Cl <sub>2</sub>	1,1-Dichloroethane.....	2.06 ± 0.02	21.8 ± 1.4	21.2	301-427	41 Maryott
						[29.0 Ghosh]

Substance		$\mu \times 10^{18}$ esu	A	R	Temperature ( $^{\circ}$ K)	Reference
<b>C<sub>2</sub>—Con.</b>						
C <sub>2</sub> H <sub>4</sub> Cl <sub>2</sub>	1,2-Dichloroethane.....	1.19	.....	(21.0) <sub>L</sub>	305	31.1 Zahn
		1.32	.....		341	
		1.39	.....		376	
		1.48	.....		419	
		1.54	.....		456	
		1.56	.....		485	
		1.63	.....		544	
		1.28	.....	(21.0) <sub>L</sub>	334	32 Sanger
		1.54	.....		453	
		1.24	.....	(21.0) <sub>L</sub>	308	41 Bloom
		1.31	.....		335	
		1.39	.....		372	
		1.45	.....		406	
		1.51	.....		441	
		1.56	.....		481	
		1.60	.....		525	
		1.24	.....	(21.0) <sub>L</sub>	307	42 Watanabe
		1.33	.....		353	[29.0 Ghosh]
		1.42	.....		385	[32 Greene]
		1.46	.....		412	
C <sub>2</sub> H <sub>4</sub> O	Ethylene oxide.....	1.90	11.4	(10.9) <sub>Σ</sub>	290-449	28 Stuart
		1.91	.....		297; 368	36 Ramaswamy
		1.88 ± 0.1	M Stark		.....	51 Cunningham
C <sub>2</sub> H <sub>4</sub> O <sub>2</sub>	Acetaldehyde.....	2.72	.....	11.6	300-455	32.1 Zahn
		2.72	.....		420; 469	43 Hurdis
C <sub>2</sub> H <sub>4</sub> O <sub>2</sub>	Acetic acid.....	1.74	.....	12.9	450-494	31.0 Zahn
C <sub>2</sub> H <sub>4</sub> S	Ethylene sulfide.....	1.84 ± 0.2	M Stark	.....	.....	51 Cunningham
C <sub>2</sub> H <sub>5</sub> Br	Bromoethane.....	2.03 ± 0.1	21.2 ± 0.4	(18.3 <sub>00</sub> ) <sub>L</sub>	303-441	34.1 Smyth
		2.02 ± 0.04	20.3 ± 2.5	19.1	292-443	37.0 Groves [35 Mahanti] [36 Niini]
C <sub>2</sub> H <sub>5</sub> Cl	Chloroethane.....	2.06	17.8		292-455	30 Fuchs
		2.03 ± 0.03	20.9 ± 2.7		298-418	32 Sanger
		2.07	.....	(16.3) <sub>Σ</sub>	296; 368	36 Ramaswamy
		1.98	.....		292; 359	48 Jelatis [28 Sircir] [36 Niini]
C <sub>2</sub> H <sub>5</sub> ClO	2-Chloroethanol.....	1.78	.....	17.8	339-435	32.0 Zahn
		2.03	.....	(18.0) <sub>Σ</sub>	347-507	52 Smyth
C <sub>2</sub> H <sub>5</sub> ClO	Chloromethoxymethane.....	1.78	.....	17.8	339-435	32.0 Zahn
		2.03	.....	(18.0) <sub>Σ</sub>	347-507	52 Smyth

Substance		$\mu \times 10^{18}$ esu	A	R	Temperature (°K)	Reference
<b>C<sub>2</sub>—Con.</b>						
C <sub>2</sub> H <sub>5</sub> F	Fluoroethane.....	1.92 ±.01	12.5 ±.7	(11.3) <sub>Σ</sub>	236-535	34.1 Smyth
C <sub>2</sub> H <sub>5</sub> I	Iodoethane.....	1.92 ±.03	25.3 ±1.9		348-463	34.1 Smyth
		1.90	.....	24.3	293; 337	37.0 Groves [35 Mahanti] [36 Niini]
C <sub>2</sub> H <sub>5</sub> NO <sub>2</sub>	Nitroethane.....	3.54 ±.02	24.3 ±2.3	17.0	365-461	37.0 Groves
		3.70 ±.04	15.9 ±4.2		398-484	42.1 Hurdis
	Ethyl nitrite.....	2.38	.....	(17.9) <sub>L</sub>	290	34 Czerlinsky
C <sub>2</sub> H <sub>6</sub>	Ethane.....	0	11.21		200-470	25 Smyth
		0	11.15	11.07 <sub>∞</sub>	193; 298	34 Watson
C <sub>2</sub> H <sub>6</sub> AlCl	Dimethylaluminum chloride <sup>†</sup>					41.0 Wiswall
C <sub>2</sub> H <sub>6</sub> O	Methyl ether.....	1.30	15.1		292-453	28 Stuart
		1.30 ±.02	15.4 ±.8		298-418	32 Sanger
		1.29	15.0		297; 369	36 Ramaswamy
		1.31 ±.04	13.4 ±2.0	13.3	290-428	37.1 Groves
	Ethanol.....	1.69	.....	(12.8) <sub>L</sub>	351-499	29 Miles
		1.70 ±.01	13.0 ±.4		298-450	32 Knowles
		1.68 ±.02	14.3 ±1.3		308-483	35.0 Kubo
C <sub>2</sub> H <sub>6</sub> O <sub>2</sub>	Ethylene glycol.....	2.28	.....	14.4	417-506	32.0 Zahn
C <sub>2</sub> H <sub>6</sub> O <sub>2</sub> S	Dimethyl sulfone.....	4.49	.....	18.3 <sub>546</sub>	424-526	39 Coop
C <sub>2</sub> H <sub>6</sub> S	Ethanethiol.....	1.58 ±.00	18.7 ±.1	(19.2) <sub>T</sub>	308-478	36.0 Kubo
C <sub>2</sub> H <sub>7</sub> N	Ethyl amine.....	1.22 ±.02	17.9 ±.8	14.7	303-447	50 Barclay [31 Ghosh]
	Dimethyl amine.....	0.97 ±.01	17.4 ±.3	15.1	298-418	32 Sanger
		1.03	15.8		288-427	37.1 Groves
		1.03 ±.01	15.0 ±.5		292-440	47 LeFevre [31 Ghosh]
C <sub>2</sub> H <sub>8</sub> N <sub>2</sub>	Ethylene diamine.....	1.99	.....	(18.2) <sub>L</sub>	355; 429	32.0 Zahn
<b>C<sub>3</sub></b>						
C <sub>3</sub> HF <sub>3</sub>	3,3,3-Trifluoropropyne....	2.36 ±.04	M Stark		.....	51 Shoolery
C <sub>3</sub> HN	Cyanoacetylene.....	3.6 ±.2	M Stark		.....	50 Westenberg
C <sub>3</sub> H <sub>3</sub> N	Acrylonitrile.....	3.83 ±.01	20.3 ±1.5	15.6	387-509	43 Hurdis
C <sub>3</sub> H <sub>4</sub>	Propyne.....	0.72	15.6	14.0 <sub>∞</sub>	298; 368	36 Watson
		0.78	.....	14.0	298; 348	38 Krieger
		0.75 ±.01	M Stark		.....	52 Ghosh
	1,2-Propanediene.....	0	16.6	15.1 <sub>∞</sub>	298; 368	36 Watson

<sup>†</sup> No reliable value of the dipole moment could be obtained because of molecular association.

Substance		$\mu \times 10^{18}$ esu	A	R	Temperature (°K)	Reference	
<b>C<sub>3</sub>—Con.</b>							
C <sub>3</sub> H <sub>4</sub> Cl <sub>2</sub>	1,3-Dichloropropene <sup>a</sup> (b.p. 104°).....	1.79	.....	25.4	397-478	49 Oriani	
	1,3-Dichloropropene <sup>a</sup> (b.p. 112°).....	1.81	.....	25.5	395-503	49 Oriani	
	2,3-Dichloropropene.....	1.74	.....	25.5	397	49 Oriani	
		1.77	.....		518		
C <sub>3</sub> H <sub>4</sub> O	Propenal (Acrolein).....	3.04	.....	16.1	377-478	46.3 Hannay	
C <sub>3</sub> H <sub>5</sub> Cl	<i>cis</i> -1-Chloro-1-propene....	1.71	.....	20.4	345-476	46.2 Hannay	
	<i>trans</i> -1-Chloro-1-propene..	1.97	.....	20.4	345-476	46.2 Hannay	
	2-Chloro-1-propene.....	1.66 ±.02	21.8 ±1.1	20.4	339-469	46.2 Hannay	
	3-Chloro-1-propene (Allyl chloride).....	1.90 ±.01	20.1 ±.8		308-480	37.0 Kubo	
		1.98	.....	20.4	377-480	46.2 Hannay	
C <sub>3</sub> H <sub>5</sub> ClO	Chloroacetone.....	2.21	.....	21.2	336	32.1 Zahn	
		2.22	.....		379		
		2.24	.....		414		
		2.29	.....		454		
C <sub>3</sub> H <sub>5</sub> ClO <sub>2</sub>	Ethyl chloroformate.....	2.59	.....	(22.6) <sub>Σ</sub>	308	38 Mizushima	
		2.50	.....		350		
		1.82	.....		411		
		1.47	.....		480		
C <sub>3</sub> H <sub>5</sub> N	Propionitrile.....	4.05 ±.04	16.9 ±4.7		351-469	37.0 Groves	
		4.00	.....	15.8	395-477	43 Hurdis	
C <sub>3</sub> H <sub>6</sub>	Cyclopropane.....	0	14.28	(13.9) <sub>Σ</sub>	297; 368	36 Ramaswamy	
		Propene.....	0.35 ±.01	15.7 ±.1		246-476	33 McAlpine
			0.34	15.9	15.2 <sub>00</sub>	193-298	34 Watson
C <sub>3</sub> H <sub>6</sub> ClNO <sub>2</sub>	1-Chloro-1-nitropropane...	3.52	.....	26.3	416-493	42.1 Hurdis	
C <sub>3</sub> H <sub>6</sub> Cl <sub>2</sub>	1,2-Dichloropropane.....	1.46	.....	25.6	345	49 Oriani	
		1.53	.....		394		
		1.63	.....		466		
		1.68	.....		506		
	1,3-Dichloropropane.....	2.08 ±.02	27.4 ±.9	(25.8) <sub>Σ</sub>	374-485	35.0 Smyth	
	2,2-Dichloropropane.....	2.27	.....	25.8	300-372	41 Maryott	
C <sub>3</sub> H <sub>6</sub> O	Allyl alcohol.....	1.60 ±.04	19.3 ±1.9	(17.0) <sub>L</sub>	329-479	35.1 Kubo	
	Propionaldehyde.....	2.72 ±.03	16.4 ±2.2	16.0	354-509	43 Hurdis	
	Acetone.....	2.89	.....		292-456	28 Stuart	
		2.88	.....	16.2	301-455	32.1 Zahn	
	2.87	.....		298; 368	36 Ramaswamy		
					[36 Niini]		

<sup>a</sup> *cis-trans* isomers.

Substance		$\mu \times 10^{18}$ esu	A	R	Temperature (°K)	Reference
<b>C<sub>3</sub>—Con.</b>						
C <sub>3</sub> H <sub>6</sub> O <sub>2</sub>	Propionic acid.....	1.75	.....	17.4	430-486	31.0 Zahn
	Ethyl formate.....	1.93 ± 0.03	20.2 ± 2.0	17.8	292-435	32.2 Zahn
	Methyl acetate.....	1.72	.....	17.6	327-517	32.2 Zahn
C <sub>3</sub> H <sub>6</sub> O <sub>3</sub>	Dimethyl carbonate.....	1.72 ± 0.02	17.5 ± 0.9	(19.4) <sub>Σ</sub>	308-482	38 Mizushima
		0.90	.....		328	37.1 Kubo
		.93	.....		350	
		.98	.....		412	
	1.05	.....	479			
	Trioxane.....	2.08 ± 0.01	M Stark	.....		51 Amble
C <sub>3</sub> H <sub>7</sub> Br	1-Bromopropane.....	2.18	.....	23.7	348-441	37.0 Groves [35 Mahanti]
	2-Bromopropane.....	2.21	.....	24.1	287-380	37.0 Groves
C <sub>3</sub> H <sub>7</sub> Cl	1-Chloropropane.....	2.05 ± 0.01	25.3 ± 0.6	20.8	338-458	32 Sanger [35 Mahanti] [36 Niini]
	2-Chloropropane.....	2.17	.....	(21.1) <sub>T</sub>	288-383	37.0 Groves
	1-Iodopropane.....	2.04	.....	28.9	337; 374	37.0 Groves [35 Mahanti]
C <sub>3</sub> H <sub>7</sub> NO <sub>2</sub>	1-Nitropropane.....	3.60	.....	21.4	343-466	37.0 Groves
		3.72	.....		382-457	41.1 Wiswall
	2-Nitropropane.....	3.73	.....	21.6	392-455	41.1 Wiswall
C <sub>3</sub> H <sub>8</sub>	Propane.....	0	16.07		227-486	33 McAlpine
		0	16.05	15.73 <sub>∞</sub>	240; 298	34 Watson
C <sub>3</sub> H <sub>8</sub> O	Methoxyethane.....	1.23 ± 0.02	20.0 ± 0.7	17.7	303-369	49 Moore
	1-Propanol.....	1.69 ± 0.03	16.6 ± 1.6	(17.4) <sub>L</sub>	376-505	29 Miles
		1.67 ± 0.05	17.4 ± 2.6		308-481	35.1 Kubo
		1.60 ± 0.03	20.7 ± 1.6	(17.5) <sub>L</sub>	307-482	35.0 Kubo
	2-Propanol.....	1.69 ± 0.02	17.7 ± 1.1		289-468	37 Stranathan
C <sub>3</sub> H <sub>8</sub> O <sub>2</sub>	Dimethoxymethane (Methylal)	0.77	.....	(19.3) <sub>L</sub>	307	36.1 Kubo
		0.87	.....		352	
		1.00	.....		407	
		1.17	.....		482	
C <sub>3</sub> H <sub>9</sub> Al	Trimethyl aluminum <sup>F</sup> .....				360-398	41.0 Wiswall
C <sub>3</sub> H <sub>9</sub> N	n-Propylamine.....	1.17 ± 0.02	23.2 ± 0.6	19.4	334-432	51 Barclay
C <sub>3</sub> H <sub>9</sub> N	Trimethylamine.....	0.61 ± 0.03	21.5 ± 0.6		338-458	32 Sanger
		0.67	20.2	19.4	289-418	37.1 Groves
		0.65 ± 0.01	20.0 ± 0.3		294-441	47 LeFevre [31 Ghosh]

<sup>F</sup> No reliable value of the dipole moment could be obtained because of molecular association.

Substance		$\mu \times 10^{18}$ esu	A	R	Temperature (°K)	Reference
<b>C<sub>4</sub></b>						
C <sub>4</sub> H <sub>2</sub> N <sub>2</sub>	Fumaronitrile.....	0	29.7	19.8 <sub>546</sub>	410	41 Bloom
C <sub>4</sub> H <sub>4</sub> N <sub>2</sub>	Succinonitrile.....	3.47	.....	(20.4) <sub>L</sub>	443	41 Bloom
		3.54	.....		478	
		3.59	.....		513	
C <sub>4</sub> H <sub>4</sub> O	Furan.....	0.661 ± 0.06	M Stark	.....	.....	51 Sirvetz
C <sub>4</sub> H <sub>4</sub> O <sub>2</sub>	Diketene.....	3.53	.....	20.1	433-516	43 Hurdis
C <sub>4</sub> H <sub>4</sub> S	Thiophene.....	0.56 ± 0.06	24.4 ± 1.1	(24.3) <sub>L</sub>	329-474	36.0 Kubo
C <sub>4</sub> H <sub>5</sub> Cl	4-Chloro-1,2-butadiene....	2.02	.....	25.3	394-491	46.2 Hannay
C <sub>4</sub> H <sub>5</sub> N	Methacrylonitrile.....	3.69	.....	20.2	395-473	46.3 Hannay
	<i>trans</i> -Crotonitrile.....	4.50	.....	20.8	409-516	43 Hurdis
C <sub>4</sub> H <sub>6</sub>	1-Butyne.....	0.80	.....	18.7	298-398	38 Krieger
	1,3-Butadiene.....	0	21.8	21.6	299-462	43 Hannay
C <sub>4</sub> H <sub>6</sub> O	Crotonaldehyde.....	3.67	.....	21.5	412-519	43 Hurdis
	Methacrylaldehyde (Methacrolein).....	2.68	.....	21.0	366-466	46.3 Hannay
C <sub>4</sub> H <sub>6</sub> O <sub>2</sub>	Biacetyl.....	1.30	.....	20.6	329	32.3 Zahn
		1.35	.....		359	
		1.39	.....		391	
		1.43	.....		426	
		1.48	.....		461	
		1.55	.....		504	
		1.10	.....	20.6	328	41 Bloom
		1.17	.....		362	
	1.23	.....		398		
	1.29	.....		438		
	1.34	.....		478		
C <sub>4</sub> H <sub>6</sub> O <sub>3</sub>	Acetic anhydride.....	ca 2.8	.....	(22.4) <sub>L</sub>	320-540	33.1 Zahn
C <sub>4</sub> H <sub>6</sub> S	Divinyl sulfide.....	1.20	.....	27.6	400-461	46.2 Hannay
C <sub>4</sub> H <sub>7</sub> Cl	1-Chloro-2-methylpropene (Isocrotyl chloride).....	1.95 ± 0.03	27.2 ± 1.8	25.0	358-523	43 Hurdis
	3-Chloro-2-methyl-1- propene (Methallyl chlo- ride).....	1.85	.....	25.1	377-477	46.2 Hannay
C <sub>4</sub> H <sub>7</sub> N	Butyronitrile.....	4.07	.....	21.2	339-443	37.0 Groves
C <sub>4</sub> H <sub>8</sub>	1-Butene.....	0.38 ± 0.01	20.1 ± 2		274-466	25 Smyth
		0.30	21.5	19.74 <sub>∞</sub>	298; 368	36 Watson
	<i>trans</i> -2-Butene.....	0	21.42	19.85 <sub>∞</sub>	298; 368	36 Watson
	2-Methylpropene.....	0.49	20.9	19.85 <sub>∞</sub>	298; 368	36 Watson
C <sub>4</sub> H <sub>8</sub> Cl <sub>2</sub>	1,4-Dichlorobutane.....	2.22	.....	30.3	433-507	49 Oriani
C <sub>4</sub> H <sub>8</sub> O	Butyraldehyde.....	2.72	.....	20.6	354-412	43 Hurdis

Substance		$\mu \times 10^{18}$ esu	A	R	Temperature (°K)	Reference
<b>C<sub>4</sub>—Con.</b>						
C <sub>4</sub> H <sub>8</sub> O <sub>2</sub>	Ethyl acetate.....	1.78 ± 0.00	24.4 ± 2	22.3	302-467	32.2 Zahn
	1,4-Dioxane.....	0	24.5	(21.6) <sub>L</sub>	337-487	34 Schwingel
		0	26.0		329-479	36.3 Kubo
C <sub>4</sub> H <sub>9</sub> Br	1-Bromobutane.....	2.08 ± 0.05	35.0 ± 3.3	28.3	352-474	37.0 Groves
	2-Bromobutane.....	2.23	.....	28.4	343	37.0 Groves
C <sub>4</sub> H <sub>9</sub> Cl	1-Chlorobutane.....	2.05 ± 0.01	28.6 ± 6		315-480	35.1 Smyth
		2.14	.....	25.4	288-375	37.0 Groves
	1-Chloro-2-methylpropane..	2.00 ± 0.07	28.0 ± 4.9	25.4	345-407	41.1 Wiswall
	2-Chloro-2-methylpropane..	2.13	.....	25.9	314-354	41.1 Wiswall
	2-Chlorobutane.....	2.04 ± 0.05	31.2 ± 3.3	25.7	336-392	41.1 Wiswall
C <sub>4</sub> H <sub>9</sub> I	1-Iodobutane.....	2.12	.....	33.5	349;415	37.0 Groves
C <sub>4</sub> H <sub>9</sub> NO <sub>2</sub>	1-Nitrobutane.....	3.59	.....	26.2	373-470	37.0 Groves
	2-Methyl-2-nitropropane..	3.71	.....	26.1	379-449	41.1 Wiswall
C <sub>4</sub> H <sub>10</sub>	n-Butane.....	0	20.68	20.20 <sub>∞</sub>	298; 368	36 Watson
	2-Methylpropane.....	0	20.87	20.18 <sub>∞</sub>	298; 368	36 Watson
C <sub>4</sub> H <sub>10</sub> O	Ethyl ether.....	1.15 ± 0.00	25.8 ± 2	(22.1 <sub>∞</sub> ) <sub>L</sub>	289-455	28 Stuart
		1.11 ± 0.02	27.6 ± 7		313-433	32 Sanger
		1.19 ± 0.01	23.3 ± 5	22.5	288-476	37.1 Groves
		1.13 ± 0.01	26.0 ± 3		303-371	49 Moore
						[30 Fuchs]
					[36 Niini]	
					[40 Hobbs]	
	1-Butanol.....	1.67 ± 0.02	21.9 ± 7	(22.1) <sub>L</sub>	385-490	29 Miles
		1.65 ± 0.08	22.9 ± 4.3		329-481	35.1 Kubo
	2-Methylpropanol.....	1.64 ± 0.01	22.5 ± 6	(22.2) <sub>L</sub>	328-481	35.0 Kubo
C <sub>4</sub> H <sub>10</sub> S	Ethyl sulfide.....	1.54 ± 0.05	27.2 ± 2.6	(28.5) <sub>L</sub>	308-474	36.0 Kubo
C <sub>4</sub> H <sub>11</sub> N	n-Butylamine.....	1.00 ± 0.06	34.1 <sup>x</sup> ± 2.2	24.5	350-433	51 Barclay
	Diethylamine.....	0.92 ± 0.03	25.7 ± 1.0	24.3	334-413	50 Barclay
						[31 Ghosh]
<b>C<sub>5</sub></b>						
C <sub>5</sub> H <sub>5</sub> N	4-Cyano-1,3-butadiene.....	3.90	.....	26.4	427-464	46.3 Hannay
C <sub>5</sub> H <sub>6</sub>	1,3-Cyclopentadiene.....	0.53	.....	21.8	344-452	46.1 Hannay
C <sub>5</sub> H <sub>8</sub>	1-Pentyne.....	0.86	.....	23.0	298-398	38 Krieger
	trans-1,3-Pentadiene.....	0.68	.....	25.3	389-469	43 Hannay
	2-Methyl-1,3-butadiene (isoprene).....	0.38	.....	25.2	358-477	43 Hannay
C <sub>5</sub> H <sub>8</sub> O <sub>2</sub>	Acetyl acetone.....	3.05	.....	26.4	322-477	33.1 Zahn

<sup>x</sup> The unexpectedly large difference between A and R, as compared to other amines, suggests that the listed value of the dipole moment may be somewhat too low.

Substance		$\mu \times 10^{18}$ esu	A	R	Temperature (°K)	Reference
<b>C<sub>5</sub>—Con.</b>						
C <sub>5</sub> H <sub>9</sub> N	Valeronitrile.....	4.12 ± 0.03	26.2 ± 3.5	25.2	423-522	35 Groves
C <sub>5</sub> H <sub>10</sub> O <sub>3</sub>	Diethyl carbonate.....	1.10 ± 0.03	28.6 ± .9	28.6	352-477	36.2 Kubo
C <sub>5</sub> H <sub>11</sub> Br	1-Bromopentane.....	2.20	.....	(33.1) <sub>Σ</sub>	392; 484	32 Smyth
C <sub>5</sub> H <sub>11</sub> Cl	1-Chloropentane.....	2.16	.....	30.3	351; 381	37.0 Groves
C <sub>5</sub> H <sub>12</sub>	Pentane.....	0	25.2	(24.30) <sub>L</sub>	307-384	35.0 Kubo
C <sub>5</sub> H <sub>12</sub> O <sub>2</sub>	Diethoxyethane (Ethylal)..	1.26 <sup>t</sup>	.....	(28.6) <sub>T</sub>	329	36.2 Kubo
		1.27	.....		352	
		1.32	.....		409	
		1.32	.....		476	
C <sub>5</sub> H <sub>12</sub> O <sub>4</sub>	Tetramethyl ortho- carbonate [C(OCH <sub>3</sub> ) <sub>4</sub> ]. ....	0.89	.....	32	374	30 Fuchs
		1.00	.....		456	
<b>C<sub>6</sub></b>						
C <sub>6</sub> H <sub>2</sub> Cl <sub>2</sub> O <sub>2</sub>	2,5-Dichloro-1,4-benzo- quinone.....	0	46.3	38.4 <sub>546</sub>	454; 518	38.0 Coop
C <sub>6</sub> H <sub>4</sub> BrF	<i>p</i> -Bromofluorobenzene.....	0.53 <sup>u</sup>	.....	33.7	436-524	42.0 Hurdis
C <sub>6</sub> H <sub>4</sub> ClNO <sub>2</sub>	<i>o</i> -Chloronitrobenzene.....	4.64	.....	36.9	477	37.2 Groves
	<i>m</i> -Chloronitrobenzene.....	3.73	.....	36.9	483	37.2 Groves
	<i>p</i> -Chloronitrobenzene.....	2.83	.....	36.9	483	37.2 Groves
C <sub>6</sub> H <sub>4</sub> Cl <sub>2</sub>	<i>o</i> -Dichlorobenzene.....	2.52 ± 0.03	35.2 ± 1.8		445-523	42.0 Hurdis
		2.48	.....	35.9	354-424	49 Moore
						[37.2 Groves]
	<i>m</i> -Dichlorobenzene.....	1.72	.....	36.0	413; 458	37.2 Groves
	<i>p</i> -Dichlorobenzene.....	0	38.1	36.0	434	37.2 Groves
C <sub>6</sub> H <sub>4</sub> FI	<i>p</i> -Fluoriodobenzene.....	0.89	.....	39.2	470; 492	42.0 Hurdis
C <sub>6</sub> H <sub>4</sub> FNO <sub>2</sub>	<i>p</i> -Fluoronitrobenzene.....	2.87	.....	32.4	488-524	42.0 Hurdis
C <sub>6</sub> H <sub>4</sub> F <sub>2</sub>	<i>m</i> -Difluorobenzene.....	1.62	.....	25.9	353-423	49 Moore
C <sub>6</sub> H <sub>4</sub> N <sub>2</sub> O <sub>4</sub>	<i>p</i> -Dinitrobenzene.....	0	46.5	38.3	473-528	38.0 Coop
C <sub>6</sub> H <sub>4</sub> O <sub>2</sub>	<i>p</i> -Benzoquinone.....	0	36.6	28.3 <sub>546</sub>	393-520	38.0 Coop
C <sub>6</sub> H <sub>5</sub> Br	Bromobenzene.....	1.70 ± 0.01	37.2 ± .6		374-483	35 Groves
		1.77	.....	34.0	456	42.0 Hurdis
C <sub>6</sub> H <sub>5</sub> Cl	Chlorobenzene.....	1.70 ± 0.04	34.7 ± 2.1		360-495	34 Groves
		1.71 ± 0.01	31.5 ± .7		374-518	35 McAlpine
		1.72	.....	31.1	436	42.0 Hurdis
		1.67 ± 0.05	35.6 ± 2.4		354-427	49 Moore

<sup>t</sup> Alternatively,  $P = 34.7 \pm 2.5 + \frac{7,719 \pm 970}{T}$  and  $\mu = 1.13 \pm 0.07$ .

<sup>u</sup> Alternatively,  $P = 36.4 \pm 1.1 + \frac{462 \pm 520}{T}$  and  $\mu = 0.28$ .

Substance	$\mu \times 10^{18}$ esu	A	R	Temperature (°K)	Reference		
<b>C<sub>6</sub>—Con.</b>							
C <sub>6</sub> H <sub>5</sub> ClO	o-Chlorophenol.....	1.24	.....	(32.7) <sub>Σ</sub>	421	40.1 Linke	
		1.30	.....		492		
		1.37	.....		563		
C <sub>6</sub> H <sub>5</sub> F	p-Chlorophenol.....	2.11	.....	(32.7) <sub>Σ</sub>	430-550	40.1 Linke	
		Fluorobenzene.....	1.58 ± 0.2	26.0 ± 0.9			344-507
C <sub>6</sub> H <sub>5</sub> I	Iodobenzene.....	1.60	.....	26.0	351-423	49 Moore	
		1.70	.....	39.2	433-487	42.0 Hurdis	
C <sub>6</sub> H <sub>5</sub> NO <sub>2</sub>	Nitrobenzene.....	4.27	.....	(32.7) <sub>L</sub>	402-523	34 Groves	
		4.22 ± 0.05	37.2 ± 5.4		442-549	35 McAlpine	
C <sub>6</sub> H <sub>6</sub>	Benzene.....	0	26.9	(26.2) <sub>L</sub>	326-480	33 McAlpine	
		0	26.2		346-522	34 Groves	
		0	27.1		296; 368	36 Ramaswamy	
		0	27.1		413	42.1 Hurdis	
C <sub>6</sub> H <sub>6</sub> O	Phenol.....	1.45	.....	28.0	450	37.2 Groves	
C <sub>6</sub> H <sub>7</sub> N	Aniline.....	1.53	.....	30.6	459	37.2 Groves	
C <sub>6</sub> H <sub>8</sub> N <sub>2</sub>	o-Phenylenediamine.....	1.53	.....	(34.9) <sub>Σ</sub>	506-596	40.1 Linke	
		m-Phenylenediamine.....	1.81	.....	(34.9) <sub>Σ</sub>	504; 556	40.1 Linke
		p-Phenylenediamine.....	1.53	.....	(34.9) <sub>Σ</sub>	505; 564	40.1 Linke
C <sub>6</sub> H <sub>10</sub>	1-Hexyne.....	0.89	.....	27.6	298-398	38 Krieger	
		2-Ethyl-1,3-butadiene....	0.45	.....	29.8	384-479	46.1 Hannay
		3-Methyl-1,3-pentadiene...	0.63	.....	29.8	399-487	46.1 Hannay
		2-Methyl-1,3-pentadiene...	0.65	.....	30.4	399-497	46.1 Hannay
		2,3-Dimethyl-1,3-butadiene	0.52	.....	29.8	371-484	43 Hannay
		Cyclohexene.....	0.55	.....	(27.0) <sub>T</sub>	308-480	37.0 Kubo
C <sub>6</sub> H <sub>10</sub> O <sub>3</sub>	Ethyl acetoacetate.....	2.98	.....	32.6	394-431	33.1 Zahn	
C <sub>6</sub> H <sub>12</sub> N <sub>2</sub>	Dimethylketazine.....	1.53 ± 0.01	39.3 ± 0.3	36	349-505	41 Bloom	
C <sub>6</sub> H <sub>12</sub> O <sub>2</sub>	Amyl formate.....	1.90 ± 0.03	35.8 ± 1.9	31.8	376-516	32.2 Zahn	
C <sub>6</sub> H <sub>12</sub> O <sub>3</sub>	Paraldehyde.....	1.43 ± 0.04	45.2 ± 1.5	33.1	386-473	50.1 Le Fevre	
C <sub>6</sub> H <sub>14</sub>	n-Hexane.....	0	30.0		337-484	34.2 Smyth	
		0	29.9	29.9	352; 384	35.0 Kubo	
C <sub>6</sub> H <sub>14</sub> O	Propyl ether.....	1.30	.....	31.7	368-448	32 Sanger	
		1.21	32.3		331-473	37.1 Groves	
C <sub>6</sub> H <sub>14</sub> O <sub>2</sub>	1,1-Diethoxyethane (Acetal).....	1.11	.....	(33.2) <sub>Σ</sub>	328	36.2 Kubo	
		1.12	.....		352		
		1.13	.....		410		
		1.22	.....		476		
C <sub>6</sub> H <sub>15</sub> N	Triethylamine.....	0.66 ± 0.04	33.0 ± 0.8	33.1	373-453	50 Barclay [31 Ghosh]	

Substance	$\mu \times 10^{18}$ esu	A	R	Temperature (°K)	Reference
<b>C<sub>7</sub></b>					
C <sub>7</sub> H <sub>4</sub> N <sub>2</sub> O <sub>2</sub> <i>p</i> -Cyanonitrobenzene.....	ca 0	ca 47.5	38.6 <sub>546</sub>	482-524	38.0 Coop
C <sub>7</sub> H <sub>5</sub> N Benzonitrile.....	4.42	.....	31.6	383-525	34 Groves
C <sub>7</sub> H <sub>7</sub> F <i>o</i> -Fluorotoluene.....	1.37	.....	31.0	351-423	49 Moore
<i>m</i> -Fluorotoluene.....	1.86	.....	31.0	363-423	49 Moore
<i>p</i> -Fluorotoluene.....	2.00	.....	31.0	351-423	49 Moore
C <sub>7</sub> H <sub>7</sub> NO <sub>3</sub> <i>o</i> -Nitroanisole.....	4.83	.....	39.6	477	37.2 Groves
<i>m</i> -Nitroanisole.....	4.55	.....	39.6	476	37.2 Groves
<i>p</i> -Nitroanisole.....	5.26	.....	39.6	478	37.2 Groves
C <sub>7</sub> H <sub>8</sub> Toluene.....	0.36 ± 0.03	32.2 ± 0.4	(31.1) <sub>L</sub>	357-482	33 McAlpine
	0.36 ± 0.02	30.9 ± 0.2		349-456	39 Baker
C <sub>7</sub> H <sub>8</sub> O Anisole.....	1.38	.....	(33.0) <sub>L</sub>	403	37.2 Groves
C <sub>7</sub> H <sub>9</sub> NO <i>o</i> -Ansidine.....	1.61	.....	(35.9) <sub>Σ</sub>	464-571	40.1 Linke
C <sub>7</sub> H <sub>12</sub> 1-Heptyne.....	0.87	.....	32.3	348; 398	38 Krieger
C <sub>7</sub> H <sub>14</sub> Methylcyclohexane.....	0	33.0	(32.5) <sub>L</sub>	370; 456	39 Baker
C <sub>7</sub> H <sub>14</sub> O Cyclohexyl methyl ether...	1.35	.....	33.9	406-473	37.2 Groves
C <sub>7</sub> H <sub>14</sub> O <sub>2</sub> Amyl acetate.....	1.75 ± 0.04	37.5 ± 2.1	36.2	376-517	32.2 Zahn
C <sub>7</sub> H <sub>15</sub> Br 1-Bromoheptane.....	2.16	.....	42.3	373-434	35.1 Smyth
C <sub>7</sub> H <sub>16</sub> <i>n</i> -Heptane.....	0	34.9	(34.6) <sub>T</sub>	348-501	34.2 Smyth
	0	34.2		384	35.0 Kubo
<b>C<sub>8</sub></b>					
C <sub>8</sub> H <sub>4</sub> N <sub>2</sub> <i>p</i> -Dicyanobenzene.....	0	48.4	36.5	473-524	38.0 Coop
C <sub>8</sub> H <sub>8</sub> Styrene.....	ca 0	ca 37.6	36.4	442; 462	46.1 Hannay
C <sub>8</sub> H <sub>8</sub> O Acetophenone.....	3.02 ± 0.02	37.9 ± 1.7	36.3	410-493	35 Groves
C <sub>8</sub> H <sub>8</sub> O <sub>2</sub> 2,5-Dimethyl-1,4-benzoquinone.....	0	47.4	38.4 <sub>546</sub>	415-519	38.0 Coop
C <sub>8</sub> H <sub>10</sub> Ethylbenzene.....	0.59 ± 0.01	35.8 ± 0.1	(35.7) <sub>L</sub>	349-455	39 Baker
<i>o</i> -Xylene.....	0.62	37.7 <sup>v</sup>	35.8	413-512	42.0 Hurdis
<i>p</i> -Xylene.....	0	37.7	36.0	447	42.0 Hurdis
C <sub>8</sub> H <sub>10</sub> O Phenetole.....	1.45	.....	37.6	415; 473	37.2 Groves
C <sub>8</sub> H <sub>11</sub> N <i>N</i> -Dimethylaniline.....	1.68	.....	40.8	455	37.2 Groves
C <sub>8</sub> H <sub>12</sub> O <sub>2</sub> Ethyl sorbate.....	2.07	.....	43.3	507	46.3 Hannay
Tetramethylcyclobutane-1,3-dione.....	0	46.9	37.7 <sub>546</sub>	363-423	38.0 Coop
C <sub>8</sub> H <sub>14</sub> O <sub>4</sub> Diethyl succinate.....	2.35	.....	42.3	430	32.0 Zahn
	2.38	.....		467	
	2.41	.....		519	
C <sub>8</sub> H <sub>16</sub> Ethylcyclohexane.....	0	40.0	(37.1) <sub>L</sub>	370; 456	39 Baker
C <sub>8</sub> H <sub>18</sub> <i>n</i> -Octane.....	0	40.2	(39.2) <sub>L</sub>	433	42.1 Hurdis
C <sub>8</sub> H <sub>18</sub> O <i>n</i> -Butyl ether.....	1.17	43.4	40.8	385-455	37.1 Groves

<sup>v</sup> Assumed to be the same as for *p*-xylene.

Substance		$\mu \times 10^{18}$ esu	A	R	Temperature (°K)	Reference
<b>C<sub>9</sub></b>						
C <sub>9</sub> H <sub>10</sub> O <sub>2</sub>	Ethyl benzoate.....	2.00	.....	42.6	405-505	35 Groves
C <sub>9</sub> H <sub>12</sub>	Isopropylbenzene.....	0.79	.....	(40.4) <sub>L</sub>	411; 455	39 Baker
C <sub>9</sub> H <sub>18</sub>	Isopropylcyclohexane.....	0	43.3	(41.6) <sub>Σ</sub>	391; 456	39 Baker
<b>C<sub>10</sub></b>						
C <sub>10</sub> H <sub>14</sub>	<i>t</i> -Butylbenzene.....	0.83	.....	45.0	456; 477	39 Baker
C <sub>10</sub> H <sub>14</sub> BeO <sub>4</sub>	Beryllium acetylacetonate..	0	86.0	60.5 <sub>546</sub>	458-528	38.0 Coop
C <sub>10</sub> H <sub>20</sub>	<i>t</i> -Butylcyclohexane.....	0	49.9	(46.2) <sub>Σ</sub>	411; 456	39 Baker
<b>C<sub>11</sub></b>						
C <sub>11</sub> H <sub>16</sub>	<i>p</i> - <i>tert</i> -Butyltoluene <sup>w</sup> .....				477	39 Baker
<b>C<sub>12</sub></b>						
C <sub>12</sub> H <sub>8</sub> Br <sub>2</sub> O	4,4'-Dibromodiphenyl ether	1.02	.....	70.0	517	38.1 Coop
C <sub>12</sub> H <sub>9</sub> BrO	4-Bromodiphenyl ether.....	1.98	.....	61.0	516	38.1 Coop
C <sub>12</sub> H <sub>9</sub> NO <sub>3</sub>	4-Nitrodiphenyl ether.....	4.54	.....	62.2	499; 516	38.1 Coop
C <sub>12</sub> H <sub>10</sub> O	Diphenyl ether.....	1.23	.....	52.8	444; 483	38.1 Coop
		1.43	.....		486	37.2 Groves
<b>C<sub>13</sub></b>						
C <sub>13</sub> H <sub>11</sub> BrO	<i>p</i> -Bromophenyl- <i>p</i> -tolyl ether	2.45	.....	67.1	502; 518	38.1 Coop
<b>C<sub>14</sub></b>						
C <sub>14</sub> H <sub>14</sub> O	Di- <i>p</i> -tolyl ether.....	1.54	.....	62.7	502	38.1 Coop
<b>C<sub>15</sub></b>						
C <sub>15</sub> H <sub>21</sub> AlO <sub>6</sub>	Aluminum acetylacetonate..	0	130.8	91.1 <sub>546</sub>	502; 520	38.0 Coop
C <sub>15</sub> H <sub>21</sub> CrO <sub>6</sub>	Chromium acetylacetonate..	0	135.5	95.3 <sub>578</sub>	509; 520	38.0 Coop
C <sub>15</sub> H <sub>21</sub> FeO <sub>6</sub>	Ferric acetylacetonate....	0	146.6	91.5 <sub>546</sub>	502	38.0 Coop
<b>C<sub>20</sub></b>						
C <sub>20</sub> H <sub>28</sub> O <sub>8</sub> Th	Thorium acetylacetonate...	0	200	127.5 <sub>546</sub>	511	38.0 Coop

<sup>w</sup> Data show anomalies which preclude a reliable determination of the molar polarization.

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