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Compilation of the Melting Points Of the Metal Oxides

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Samuel J. Schneider

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Compilation of the Melting Points of the Metal Oxides

Samuel J. Schneider

A compilation has been made of the melting points of 70 metal oxides published prior to January 1963. Both the original melting point and the equivalent value based on the International Practical Temperature Scale of 1948 are presented. Included in the survey is information on pertinent experimental details such as the method of temperature measurement, purity, furnace type, and environmental conditions.

The melting points of the metal oxides are perhaps one of the most studied but least known of the physical properties. Seldom have two investigators completely agreed upon a single melting point value for a specific oxide. Many reported values were derived from excellent research and are quite reliable. Others are obviously in gross error. The result of this general disagreement has been that over the years a myriad of melting point values has been perpetuated through the literature. To complicate matters, necessary conversion from one temperature scale [1] to another has led to incorrect reporting of original data. Furthermore, various compilations of critical data have listed "best values" for the melting points of the metal oxides which often have been misinterpreted as unquestionably accurate and valid. At the present time our knowledge of the true melting points of the oxides can be regarded as in no less than a state of utter confusion.

The National Bureau of Standards has recently initiated a program of reevaluation of the melting points of the metal oxides. The program tentatively includes the acceptance of previously published values after experimental verification as well as accurate determinations of ill-defined or completely unknown melting points. The ultimate goal of the work is to have national and perhaps international recognition of the melting points of several specific oxides for use as calibration standards.

The initial effort in this program has been placed in making a comprehensive literature survey of previously published melting points of the various oxides. The results of this compilation of data are presented in table 1. The information given in table 1 was taken from the original published papers whenever possible. General surveys [1, 2, 3, 4] [2] are referred to only when the original source could not be established. Five primary sources [5, 6, 7, 8, 9] were used initially to obtain a bibliography of papers dealing with oxide melting point determinations. Reference to these papers in turn yielded another bibliography of reports which again supplied additional literature sources. The entire process was repeated until no new references were obtained. Through this cascading method of obtaining references it is believed that a majority of all published data on oxide melting points up to January 1963 is included in the present work.

The oxides given in table 1 are arranged alphabetically according to the chemical symbol of the metal element. Excluded from consideration are oxides which are not solids at room temperature. Only oxides having stoichiometric metal to oxygen ratios are listed. Identifying symbols such as mineral names, crystal symmetry, etc., are given only to those oxides which are known to have polymorphs that melt metastably. In instances where an oxide has more than one reported melting point, individual values are given in the order of increasing magnitude according to the value based on the International Practical Temperature Scale of 1948 (Text Revision of 1960) [10].

Several criteria must be carefully considered in obtaining accurate melting point data. These factors in a general way are reflected by the column headings of table 1. Because of the wide divergence of melting point values, it is believed worthwhile, and in order, to discuss briefly each of these criteria more than normally would seem warranted in a compilation of data.

Purity. The ultimate accuracy with which any melting point can be determined is directly associated with the purity of the material. It would seem that this fact need not be emphasized; however, reports are frequently found in the literature in which purity was not considered or even mentioned. Terms such as "chemically pure," "pure," and "reagent grade" are generally meaningless unless specifically defined. Reasonable estimates of the percentages and types of impurities must be known along with their possible effect upon the melting point. Sufficient attention also must be given to the effects of contamination of the sample by its container during actual experimentation.

Furnace type. For obvious reasons it is particularly important in determining melting points to insure against thermal gradients throughout the sample as well as between the sample and adjacent areas where actual temperature measurements are made. Uniformity of temperature can be completely assured only by the attainment of blackbody conditions, which, of course, can never be entirely realized in practice. Excellent papers by Gouffé [11] and by De Voss [12] give methods for estimating the effective spectral emittance of several types of enclosures and cavities.

Resistance-type furnaces such as the wire-wound quench or tube furnace can be constructed

[1] Temperature scale refers not to the symbols denoting temperature (°K, °C, and °F) but to an actual scale with defining fixed points and formulas for interpolating between such points.

[2] Figures in brackets indicate the literature references at the end of this Monograph.

so as to have small gradients between the specimen and thermoelement. However, because of the close proximity of the specimen and thermoelement the deleterious effect of a gradient is usually negligible.

Whenever radiation pyrometry is employed for temperature measurements, near-blackbody conditions are considered to be a necessity. The induction furnace is generally one of the most suitable for approximating blackbody conditions. Temperature uniformity, with corresponding high emittance, is easily obtained through the use of inductively heated crucibles and cylinders. Another furnace frequently used for high-temperature application is the strip furnace. It usually consists of a narrow, short strip of refractory metal sometimes necked down at its center to provide a high-resistance area. Power is supplied to the strip through water-cooled leads. To facilitate temperature measurements, the strip is generally made into the shape of a V (or U). Specimens are generally placed at the apex of the V or at the midportion of a flat strip. Temperature measurements are made on areas immediately adjacent to the specimen.

The strip furnace provides an easy effective means of attaining high temperatures; however, it is not particularly conducive to accurate melting point determinations. Inherent with this furnace are the inevitable extreme thermal gradients throughout the specimen and area of measurement. Tungsten strip lamps used for calibration of optical pyrometers, although not strictly comparable, have thermal gradients along the filament which may amount to as much as 5 °C per millimeter [13]. Placement of a specimen on the strip will, in all probability, seriously alter the thermal gradient of the bare strip. The magnitude of this change will vary, depending upon such factors as the location, volume, thermal conductivity, and emissivity of the specimen.

It is a generally false assumption to consider that a V-shaped metal strip approximates a blackbody enclosure. As long as there is any deviation from isothermal conditions about the enclosure, blackbody conditions cannot be realized. However, brightness temperatures can approach true temperatures if the emittance of the strip is near unity. The use of a substance having a high natural emittance (i.e., graphite) as strip material is not always feasible.

Temperature measurement. The theory, use, and calibration of various temperature-measuring devices have been well documented [13, 14, 15, 16]. The optical pyrometer or thermocouple is only one part of an entire temperature-measuring system. Often, little attention has been given to the effect of auxiliary equipment or associated apparatus on temperature measurements. An inadequate reference junction of a thermocouple circuit can cause errors as serious as those produced by thermal gradients in a furnace. The effect of stray or induced voltage from furnace windings or other power sources can be very harmful and yet go undetected.

The position of windows or enclosures relative to the target area is extremely important in making brightness temperature measurements with an optical pyrometer. Gross errors are produced by the reflection of radiation by the windows, enclosures, or associated pieces into the field of view of the pyrometer. Indiscriminate use of published spectral emissivity values to convert brightness temperatures to true temperatures should be avoided. Emissivity refers to a property of an opaque material whose surface has been polished optically flat. Unless the target area of the pyrometer conforms to these conditions, errors will result. The emittance of any enclosure supposedly built as a blackbody is extremely dependent upon the nature of internal reflections. Even an enclosure in which the geometric design is suitable [3] can have low emittance if the internal reflections are predominantly specular rather than diffuse [12, 13].

Method. It is not uncommon to observe that oxides appear to melt over a range of temperatures with a marked hysteresis between the apparent melting and freezing points. The magnitude of the hysteresis may vary from negligible quantities to many degrees. Whatever the reason for the hysteresis, whether it be partial dissociation, influence of impurities, or other causes, the melting point must be defined with respect to experimental conditions. The melting point of an oxide can be specified as that temperature at which solid and liquid are in equilibrium for a given confining pressure and for given partial pressures of environmental gases.

Obvious difficulties are inherent in establishing the melting temperature. Experimentally it can be taken as the temperature at which the last solid disappears on heating at a sufficiently slow rate to insure temperature uniformity. Conversely, the freezing point is the temperature at which crystallization first begins. Dynamic methods such as differential thermal analysis and heating or cooling curves have the advantage of the utilization of heat effects but the distinct disadvantage of being rate-dependent. Cooling curve methods have been successfully applied in the determination of the freezing points of palladium, platinum, rhodium, and iridium (secondary reference points on the International Temperature Scale of 1948 [10]). Pronounced supercooling and superheating tendencies of many oxides make this method somewhat less applicable, although it may be the best available.

The method of visual observation of a specimen during heating is generally unacceptable as an accurate means of establishing the melting point. If the specimen is visible, it is quite probable that thermal gradients are present, thereby preventing

[3] A large ratio of internal area of cavity to area of opening is required. The ratio is sometimes expressed in terms of depth of cavity and diameter of opening.

accurate temperature measurements. The attainment of blackbody conditions renders the visual method ineffectual, inasmuch as the specimen would be indistinguishable from adjacent areas.

The static method in which a specimen is heated and cooled prior to examination has proved satisfactory in many instances. Temperature measurement is not as much a problem as with dynamic methods. Auxiliary equipment such as the microscope and X-ray diffraction can be readily applied to aid in determining the degree of melting.

Calibration points. The determination of a melting point can be only thought of as being obtained through the use of an integral system of various types of equipment and procedures. The mere use of previously calibrated thermocouples and pyrometers does not insure accurate measurement of temperature. It is highly desirable to calibrate the entire system against the known melting points of several standards. Insofar as possible, the overall characteristics of the standards should conform to those of the test material. Because of the present lack of recognized standards, calibration materials should generally be limited to those defining the International Practical Temperature Scale [10]. It is as undesirable to use substances having ill-defined melting points as it is to use standards which have different characteristics than those of the test material.

Environment. The effect of environmental gas as well as the confining pressure on the melting points of oxides has been generally disregarded or considered noninfluential. Extensive studies have been made only on those oxides (i.e., iron and manganese oxides) which are pronouncedly affected. It is conceivable that most oxides are distinctly influenced by various gas partial pressures more than previously realized and partial dissociation always occurs to some degree. If dissociation exists, an oxide can be expected to melt incongruently.

Melting point and temperature scale. Sosman [17], in his paper "Temperature Scales and Silicate Research," has extensively discussed the development of temperature scales, especially during the period 1907 to 1948. In essence, a single scale had not been recognized until about 1910 to 1914, when the Geophysical Temperature Scale [18] was established. In 1927, the first internationally recognized scale [19] was adopted. A major revision of the 1927 scale was made in 1948 [20], with subsequent text revision in 1960 [10]. Some of the principal fixed and secondary reference points of the three scales are given in table 2. The Geophysical Scale is, for consistency of data, still being used by a few investigators. The 1948 scale has entirely superseded the 1927 scale as being a closer approach to the thermodynamic scale. Numerical differences between the three scales generally amount to less than one degree at temperatures below the gold point. At higher temperatures, the variance becomes much greater. The Geophysical Scale has an upper limit at the melting point of platinum, defined as 1755 °C. Approximate differences between the Geophysical and 1948 scales at various temperatures can be obtained from appropriate plots of the data given in table 2. The 1927 scale above the gold point is based on the Wien radiation formula,[4] which is not strictly valid at extremely high temperatures. The 1948 scale utilizes the Planck equation [4] for temperatures above the gold point. The equation is applicable to indefinitely high temperatures.

Conversion from the 1927 scale to the 1948 scale, above the gold point, can be accomplished through the use of the following equation as derived by Corruccini [21].[5]

TABLE 2. *Some fixed and secondary points of the geophysical and international temperature scales*

Material	Property [a]	Int. 1927 [19]	Int. 1948 [10]	Geophysical [17]
		°C	°C	°C
Naphthalene	B.P.	217.96	218.0	217.95
Tin	M.P.	231.85	231.91	231.9
Benzophenone	B.P.	305.9	305.9	305.9
Cadmium	M.P.	320.9	321.03	320.9
Lead	M.P.	327.3	327.3	
Zinc	M.P.	419.45	419.505	419.4
Sulfur	B.P.	444.6	444.6	444.5
Antimony	M.P.	630.5	630.5	630.0
Silver	M.P.	960.5	960.8	960.2
Gold	M.P.	1063	1063	1062.6
Copper	M.P.	1083	1083	1082.8
Diopside	M.P.			1391.5
Nickel	M.P.		1453	1452.4
Palladium	M.P.	1555	1552	1549.5
Platinum	M.P.		1769	1755
Rhodium	M.P.		1960	
Iridium	M.P.		2443	
Tungsten	M.P.	3400	3380	

[a] The symbols B.P. and M.P. roughly signify boiling point and melting point, respectively. For exact designation of the property under consideration, reference should be made to the appropriate publication.

[4] (Wien)

$$\log_e \frac{J_t}{J_{Au}} = \frac{C_2}{\lambda}\left[\frac{1}{1336} - \frac{1}{(t+273)}\right] \tag{1}$$

If $\lambda(t+273)$ is less than 0.3 cm deg the resulting error is less than 1 °C.

(Planck)

$$\frac{J_t}{J_{Au}} = \frac{\exp\left[\frac{C_2}{\lambda(t_{Au}+T_0)}\right]-1}{\exp\left[\frac{C_2}{\lambda(t+T_0)}\right]-1} \tag{2}$$

where

J_{Au} and J_t = radiant energies per unit wavelength interval emitted per unit time by unit area of a blackbody at temperature t and at the gold point t_{Au}.
λ = wavelength (approximately 0.65×10^{-4} cm for most optical pyrometers)
C_2 = second radiation constant =
1.432 cm deg (1927) or
1.438 cm deg (1948)
T_0 = 273.15 deg.

[5] The equation is derived by equating the right side of eq (1) with the logarithm of the right side of eq (2), expressing in exponential form and substituting appropriate values for T_0, C_2, and t_{Au} (1063 °C).

$$\frac{\exp\left[\frac{1.438}{1336.15\lambda}\right]-1}{\exp\left[\frac{1.438}{(T+273.15)\lambda}\right]-1}$$

$$=\exp\left[\frac{1.432}{\lambda}\left(\frac{1}{1336}-\frac{1}{T'+273}\right)\right]$$

where

λ=wavelength (approximately 0.65×10^{-4} cm for most optical pyrometers)
T=a temperature above the gold point, °C (Int. 1948)
T'=a temperature above the gold point, °C (Int. 1927).

Approximate conversion from other temperature scales in use prior to 1927 can be accomplished in a similar manner. To ease calculations only Wien's relationship is utilized. The resulting equation necessary for the conversion is:

$$\frac{1.438}{\lambda}\left[\frac{1}{1336}-\frac{1}{(T+273)}\right]$$
$$=\frac{C_2'}{\lambda'}\left[\frac{1}{(t_{Au}'+273)}-\frac{1}{(T'+273)}\right]$$

where

C_2'=second radiation constant originally employed
T=a temperature above the gold point, °C (Int. 1948)
T'=a temperature above the gold point, °C (original scale)
t_{Au}'=gold point originally employed (generally 1063 °C)
λ and λ'=wavelength (λ and λ' can be assumed to be equal).

In the present work, all original melting points have been converted, whenever possible, to values based on the 1948 temperature scale by methods previously described. Unfortunately, some published papers fail to state the temperature scale utilized. Conversion to the 1948 scale was impossible in these instances unless the scale could be unambiguously assumed from information such as the date of publication or listed calibration temperatures and radiation constant.

Comments. Other than for the obvious purpose of the compilation of critical data, the present survey has another important function, in that it vividly illustrates the variance of melting point values found in the literature. No attempt will be made for the present to select one value over another as being absolutely correct. It is quite difficult to ascertain completely the validity of published data without additional experimental work. However, it is believed appropriate to make pertinent comments about the less obvious shortcomings inherent in any published work and to designate the preferred values with an asterisk.

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TABLE 1[1]

Oxide	Reference	Purity[2]	Furnace type	Temperature measurement	Method
Ag_2O	Kracek [3]	Not stated	Not stated	Not stated	Not stated
	Shun-ichiro Iijima [22]	Not stated	Not stated	Not stated	Weight loss measurements
Al_2O_3	Tiede and Birnbrauer [23].	Not stated	Arc	Optical pyrometer sighted on specimen.	Observation of specimen during heating.
	Geller and Yavorsky [24].	Three samples: (a) Soda free, 0.05% carbon; (b) 0.01% impurities; (c) <0.01% each of seven metals.	Resistance; ThO_2–CeO_2 heating elements.	Optical pyrometer sighted on specimen.	Observation of pyramid-shaped specimen during heating. Rounded corners indicated melting.
	Ruff and Lauschke [25].	Commercially pure	Resistance; graphite tube heating element.	Optical pyrometer sighted on specimen.	Observation of specimen during heating.
	Weigel and Kaysser [26].	Two samples: (a) Not stated (b) Alkali free.	Resistance; graphite tube heating element.	Optical pyrometer sighted on specimen.	Observation of specimen during heating.
	Mark [27]	Not stated	Resistance; graphite tube heating element.	Optical pyrometer sighted on specimen.	Observation of specimen during heating.
	Diamond and Schneider [28].	About 99.9%	Solar	Optical pyrometer sighted on specimen.	Observation of bar-shaped specimen during cooling.
	Geller and Bunting [29].	99.98%	Resistance	Optical pyrometer sighted on specimen.	Observation of specimen during heating.
	Lambertson and Gunzel [30].	99.5%	Resistance; W heating element.	Optical pryometer sighted on specimen. Specimen not visible.	Examination of specimen after heating.
	Ruff [31]	Pure	Resistance; graphite tube heating element.	Optical pyrometer sighted on specimen.	Observation of specimen during heating.
	Bunting [32]	99.95%	Induction; Ir alloy susceptor, button-shaped.	Optical pyrometer sighted on small cavity in susceptor adjacent to specimen cavity.	Examination of specimen after heating.
	McNally, Peters, and Ribbe [33].	Not stated	Induction; graphite tube susceptor.	Optical pyrometer sighted on specimen.	Observation of specimen suspended in furnace during heating.
	Ruff and Goecke [34]	Not stated	Resistance; graphite tube heating element.	Optical pyrometer sighted on specimen.	Observation of cone-shaped specimen during heating. Fusion of cone tip indicated melting.
	Lang, Knudsen, Filmore, and Roth [35].	99.9%	Resistance; graphite tube heating element.	Optical pyrometer sighted on specimen.	Observation of pyramid-shaped specimen during heating. Deformation of pyramid tip indicated melting.
	v. Wartenberg, Linde, and Junq [36].	Pure	Flame; oil-oxygen	Optical pyrometer sighted on specimen.	Observation of specimen suspended in furnace during heating.

See footnotes at end of table.

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Calibration Points		Environment	Original Temp. Scale [3]	Melting Points		Comments	Oxide
Materials	Temp.			Original	Int. 1948 [4]		
	°C			°C	°C		
Not stated		Not stated	Not stated	191 dissociates		Survey; not original data.	Ag_2O
Not stated		Not stated	(Int. 1927)	230 dissociates	230		
Not stated		Vacuum	Not stated	1890		[5]; partial dissociation probably occurred.	Al_2O_3
60Pt-40Rh 80Pt-20Rh 90Pt-10Rh 100Pt	1940 1905 1845 1773.5	(Air)	Int. 1927	2000 to 2030	1994 to 2024	([5])	
Au CaF_2	1062.4 1398	(a) Air at 7.5 mm Hg (b) Air at 7.7 mm Hg	C_2=1.437 cm deg	(a) 2005 (b) 2008	2005 2008	[5]; partial dissociation probably occurred; reaction between specimen and graphite support probable.	
Ag Au Pd Pt Rh Ir	960.5 1063 1557 1770 1970 2415	(a1) Nitrogen at 1 atm (a2) Air (b1) Reducing (b2) Air	C_2=1.44 cm deg	(a1) 2007±4 (a2) 2010 (b1) 2001 (b2) 2005 to 2010	2009±4 2012 2003 2007 to 2012	[5]; reaction between specimen and charcoal support probable.	
Not stated		Neutral	(Int. 1948)	2020	2020	[5]; reflection errors possible.	
None		Air	Int. 1948	2025	2025	[5]; emissivity stated by authors to be about unity.	
Pt 90Pt-10Rh	Not stated Not stated	Air	Int. 1927	2035 ±10	2029 ±10	[5]; reflection errors possible	
Pt	(1769)	Helium	(Int. 1948)	2034 ±16	2034 ±16		
Pt	1755	Not stated	C_2=1.46 cm deg	2010 ±10	2035 ±10	[5]; reaction between specimen and graphite support probable.	
Not stated		(Air)	Int. 1927	2045 ±25	2038 ± 25	Temperature uniformity between specimen and target area of pyrometer not verified.	
Al_2O_3	2044	Air, argon, nitrogen	Int. 1948	2043 ±10	2043 ±10	([5])	
Au Pt	1071 1757	Nitrogen	(C_2=1.48 cm deg).	2020	2044	[5]; reaction between specimen and graphite support probable.	
Al_2O_3 BeO	2035 2510	Argon	Int. 1948	2049	2049	([5])	
Pt Mo	Not stated Not stated	Air	(Int, 1927)	2055	2049	([5])	

TABLE 1[1]

Oxide	Reference	Purity [2]	Furnace type	Temperature measurement	Method
Al_2O_3—Con.	Kanolt [37]	Fe—0.001% Cu—none SiO_2—0.001% Chloride—0.005% Sulfate—0.001%	Resistance; graphite tube heating element.	Optical pyrometer sighted on blackbody cavity immersed in specimen.	Thermal analysis, heating curves.
As_2O_3 Monoclinic type.	Smits and Beljaar [38]	Not stated	$NaNO_3$-$NaNO_2$ bath	Pt resistance thermometer	Intersection of vapor pressure curve.
	Welch and Duschak [39].	C. P. grade	Not stated	Copper-constantan thermocouple.	Thermal analysis, heating curves; also examination of specimen after heating.
	Rushton and Daniels [40].	Not stated	Resistance; iron pot heating element.	Copper-constantan thermocouple.	Intersection of vapor pressure curves.
B_2O_3	Kracek, Morey, and Merwin [41].	100 ± 0.1%	Resistance; quench type, wire-wound ceramic tube heating element.	Thermocouple	Examination with microscope of quenched specimen after heating. Last trace of crystals indicated melting point.
	McCulloch [42]	99.6%	Not stated	Not stated	Observation of specimen during heating.
BaO	Schumacher [43]	Not stated	Resistance; boat-shaped W strip heating element.	Optical pyrometer sighted on W strip adjacent to specimen. Spectral emissivity equals 0.431.	Observation of specimen during heating.
BeO	Tiede and Birnbrauer [23].	Not stated	Arc	Optical pyrometer sighted on specimen.	Observation of specimen during heating.
	Ruff and Lauschke [25].	Pure	Resistance; graphite tube heating element.	Optical pyrometer sighted on specimen.	Observation of specimen during heating.
	Lang, Knudsen, Filmore, and Roth [35].	99.9+%	Resistance; graphite tube heating element.	Optical pyrometer sighted on specimen.	Observation of pyramid shaped specimen during heating. Deformation of pyramid tip indicated melting.
	v. Wartenberg, Reusch, and Saran [44].	Commercially pure	Flame; gas-oxygen	Optical pyrometer	Observation of specimen during heating. Rounded corners of suspended specimen indicated melting.
	v. Wartenberg and Werth [45].	Commercially pure	(Flame); "ZrO_2 oven"	Optical pyrometer	Not stated.
	Ol'Shanskiĭ [46]	Not stated	Resistance; quench type, graphite tube heating element.	Optical pyrometer sighted on hole in side of heating element.	Examination of quenched specimen after heating. Formation of round balls indicated melting.
	Ruff [31]	Pure	Resistance; carbon tube heating element.	Optical pyrometer sighted on specimen.	Observation of specimen during heating.
Bi_2O_3	Belladen [47]	Not stated	Resistance	Pt-PtRh thermocouple immersed in specimen.	Thermal analysis, cooling curves.
	Gattow and Schroder [131]	100±0.1%	Not stated	Pt-PtRh thermocouple immersed in specimen.	Thermal analysis, cooling curves.

See footnotes at end of table.

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Calibration Points		Environment	Original Temp. Scale [3]	Melting Points		Comments	Oxide
Materials	Temp.			Original	Int. 1948 [4]		
	°C			°C	°C		
Sb	630	(a) Vacuum at 2 mm Hg.		2050	2072 *	Partial dissociation probably occurred at reduced pressure.	Al_2O_3—Con.
Cu-Ag eutectic.	779	(b) Hydrogen					
Ag	960.5						
Cu	1083						
Diopside	1391						
Pt	1755						
Not stated		66.1 mm Hg	(Int. 1927)	312.3 Triple point.	312.3 *		As_2O_3 Monoclinic type.
Water	(100 °C)	Not stated	Not stated	313		Pressure at melting not stated; melting point should be designated as triple point.	
Napbtbalene	Not stated						
Benzopbenone.	Not stated						
Not stated		Not stated	Not stated	315		Pressure at melting not stated; melting point sbould be designated as triple point.	
Not stated		(Air)	(Geophysical)	450±2	450±2*		B_2O_3
Not stated	Not stated	Not stated	Not stated	460 to 470		Reaction between specimen and SiO_2 container probable.	
Not stated		Hydrogen at 0.2 atmospheres.	C_2=1.433 cm deg.	1923	1918	[5]; temperature uniformity between specimen and target area of pyrometer not verified; reflection errors probable.	BaO
Not stated		Vacuum	Not stated	2400 ± 100		([5])	BeO
Au	1062.4	Air at 15 mm Hg	C_2=1.437 cm deg.	2410	2410	[5]; reaction between specimen and grapbite support probable.	
CaF_2	1398						
Al_2O_3	2035	Argon	Int. 1948	2452	2452	([5])	
BeO	2510						
Not stated		Oxidizing	(Int. 1927)	2520±30	2508±30	([5])	
Not stated		Oxidizing	(Int. 1927)	2570	2557		
Not stated		Nitrogen	(Int. 1948)	2570±30	2570±30	Specimen dropped tbrougb beated furnace; tbermal lag between specimen and measured temperature probable.	
Pt	1755	Nitrogen at 4 to 10 mm Hg.	C_2=1.46 cm deg.	2525	2573	Reaction between specimen and graphite support probable.	
Not stated		Not stated	Not stated	817			Bi_2O_3
Not stated		(Air)	(Int. 1948)	824±2	824±2		

TABLE 1 [1]

Oxide	Reference	Purity [2]	Furnace type	Temperature measurement	Method
Bi_2O_3—Con.	Guertler [48]	Not stated	Not stated	Thermocouple immersed in specimen.	Thermal analysis, cooling curves.
	Levin and McDaniel [49].	Si and Fe<0.01% Al and Pb<0.001% Ag, Ca, Cr, Mg, and Mn <0.0001%.	Resistance; quench type, Pt alloy wire-wound ceramic tube heating element.	Pt-90Pt10Rh thermocouple adjacent to specimen.	Examination with microscope of quenched specimen after heating.
CaO	Schumacher [43]	C.P. grade	Resistance; boat-shaped W strip heating element.	Optical pyrometer sighted on W strip adjacent to specimen; spectral emissivity equals 0.418.	Observation of specimen during heating.
	Kanolt [37]	Na and K—nil Mg—trace H_2S metals—nil Cl—0.004% Sulfate—nil	Resistance; graphite tube heating element.	Optical pyrometer sighted on blackbody cavity immersed in specimen. Also, specimen acted as blackbody enclosure.	Thermal analysis, heating curves.
	Ol'Shanskii [46]	Not stated	Resistance; quench type, graphite tube heating element.	Optical pyrometer sighted on hole in side of heating element.	Examination of quenched specimen after heating. Formation of round balls indicated melting.
	Doman, Barr, McNally, and Alper [50].	Not stated	Not stated	Not stated	Not stated
CdO	Roth [51]	Si—0.001 to 0.01% Al, B, Ca, Cu, Fe, Mg and Pb—0.0001 to 0.001% Ag—<0.0001%	Resistance; quench type, Pt alloy wire-wound ceramic tube heating element.	Pt-90Pt10Rh thermocouple adjacent to specimen.	Examination of quenched specimen after heating.
CeO_2	Ruff [31]	Not stated	Resistance; carbon tube heating element.	Optical pyrometer sighted on specimen.	Observation of specimen during heating.
	v. Wartenberg and Gurr [52].	Not stated	Flame; acetylene-O_2	Not stated	Observation of specimen during heating.
	Trombe [2]	Not stated	Not stated	Not stated	Not stated
CoO	v. Wartenberg, Reusch, and Saran [44].	Ni Free	Flame; oil	Optical pyrometer sighted on specimen.	Observation of specimen suspended in furnace during heat. Rounded corners indicated melting.
	v. Wartenberg and Prophet [53].	99.9%	Flame; oxyhydrogen or gas-air.	Optical pyrometer	Not stated
	v. Wartenberg and Gurr [52].	Pure	Not stated	Optical pyrometer	Not stated
Cr_2O_3	Ruff [31]	Not stated	Resistance; carbon tube heating element.	Optical pyrometer sighted on specimen.	Observation of specimen during heating.
	Kanolt [37]	Iron—0.01% Chromate—trace Sulphate—0.005%.	Resistance; graphite tube heating element.	Optical pyrometer sighted on blackbody cavity immersed in specimen.	Thermal analysis, heating curves.

See footnotes at end of table.

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Calibration Points		Environment	Original Temp. Scale [3]	Melting Points		Comments	Oxide
Materials	Temp.			Original	Int. 1948 [4]		
	°C			°C	°C		
Not stated		Not stated	Not stated	820±2			Bi_2O_3—Con.
NaCl Au	800.4 1063	Air	Int. 1948	825±3	825±3*		
Not stated		Hydrogen at 0.2 atm	C_2=1.433 cm deg.	2576	2565	[5]; temperature uniformity between specimen and target area of pyrometer not verified; reflection errors probable.	CaO
Sb Cu-Ag Eutectic. Ag Cu Diopside Pt	630 779 960.5 1083 1391 1755	Hydrogen	([6])	2572	2614*		
Not stated		Nitrogen	(Int. 1948)	2620	2620	Specimen dropped through heated furnace; thermal lag between specimen and measured temperature probable.	
Not stated		Not stated	(Int. 1948)	2630	2630	Melting point taken from abstract.	
Not stated		Not stated	Int. 1948	>1500	>1500	Author noted that CdO sublimes rapidly.	CdO
Pt	1755	Not stated	C_2=1.46 cm deg.	1950	1973	Reaction between specimen and ZrO_2 support probable.	CeO_2
Not stated		Air	(Int. 1927)	>2600	>2600		
Not stated		Not stated	Not stated	2800		Survey; not original data.	
Not stated		Oxidizing	(Int. 1927)	1800±20	1795±20	([6])	CoO
Not stated		Air	(Int. 1927)	1810	1805	Oxidation state of cobalt not investigated.	
Not stated		Air	(Int. 1927)	1935	1929	Authors stated this melting point to be in error; see preceding reference [53] for corrected value.	
Pt	1755	Nitrogen at (a) 30 mm Hg (b) 1 atmosphere.	C_2=1.46 cm deg.	(a) 1830 to 2080 (b) 1960	1849 to 2107 1983	[5]; reaction between specimen and graphite support probable. Author concluded reduction of specimen occurred.	Cr_2O_3
Sb Cu-Ag Eutectic. Ag Cu Diopside Pt	630 779 960.5 1083 1391 1755	Vacuum	([6])	1990	2011	Oxidation state of chromium not investigated. Reduction is probable.	

Oxide	Reference	Purity [2]	Furnace type	Temperature measurement	Method
Cr_2O_3—Con.	Wilde and Rees [54]	Not stated	Resistance; graphite tube heating element.	Photoelectric pyrometer sighted on specimen.	Thermal analysis, heating curves. Also, observation of specimen during heating.
	Bunting [55]	99.9%	Induction; Ir alloy susceptor, button-shaped.	Optical pyrometer sighted on small cavity adjacent to specimen cavity.	Examination of specimen after heating.
	Bunting [32]	C. P. grade	Induction; Ir susceptor, button-shaped.	Optical pyrometer sighted on small cavity adjacent to specimen cavity.	Examination of specimen after heating.
	v. Wartenberg and Reusch [56].	Analytical grade	(Flame); "Fletscher oven".	Optical pyrometer sighted on specimen.	Observation of specimen suspended in furnace during heating.
	McNally, Peters, and Rihbe [33].	Co_3O_4, SiO_2, and V_2O_3—0.01–0.1% Al_2O_3, MgO, and Fe_2O_3—0.005–0.05% NiO—0.001–0.01% MnO and TiO_2—1–10 ppm.	Induction; graphite tube susceptor.	Optical pyrometer sighted on specimen.	Observation of specimen suspended in furnace during heating.
	v. Wartenberg and Eckhardt [57].	Not stated	Flame; acetylene–O_2	Optical pyrometer sighted on specimen.	Observation of specimen suspended in furnace during heating.
Cs_2O	Rengade [58]	Purified	Flame-heated Al block	Thermocouple	Thermal analysis, cooling curves. Also, observation of specimen during heating.
Cu_2O	Ruer and Nakamoto [59].	Not stated	Resistance; carbon tube heating element.	Pt–PtRh thermocouple immersed in specimen.	Examination of specimen after heating.
	v. Wartenberg, Reusch, and Saran [44].	Pure	Flame; gas-oxygen	Optical pyrometer	Observation of specimen suspended in furnace during heating.
	Roberts and Smyth [60].	0.0083% impurities	Not stated	Pt–PtRh thermocouple	Intersection of pressure-temperature-composition curves.
Dy_2O_3	Wisnyi and Pijanowski [61].	Not stated	Resistance; V-shaped W strip heating element.	Optical pyrometer sighted on specimen.	Observation of specimen during heating. Apparent disappearance of specimen indicated melting.
Er_2O_3					
Eu_2O_3	Wisnyi and Pijanowski [61].	Not stated	Resistance; V-shaped W strip heating element.	Optical pyrometer sighted on specimen.	Observation of specimen during heating. Apparent disappearance of specimen indicated melting.
	Schneider [62]	Ba, Cu, Er, and Si—<0.01%; Cr, Cu, Fe, Mg, and Ni—<0.001%.	Induction; crucible-shaped Ir susceptor.	Optical pyrometer sighted on small hole in crucible lid.	Examination of specimen after heating. Flat button indicated melting.

See footnotes at end of table.

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Calibration Points		Environment	Original Temp. Scale [3]	Melting Points		Comments	Oxide
Materials	Temp.			Original	Int. 1948 [4]		
	°C			°C	°C		
Al_2O_3	2040	Air	(Int. 1927)	2060±25	2053±25	[5]; reduction of specimen probable.	Cr_2O_3—Con.
Al_2O_3	2040	(Air)	(Int. 1927)	2140±25	2133±25	Temperature uniformity between specimen and target area of pyrometer not verified. Bunting in later publication [32] stated 2140 °C value is low because of reduction during calcine.	
Not stated		(Air)	(Int. 1927)	2275±25	2266±25	Temperature uniformity between specimen and target area of pyrometer not verified.	
Pt	(1773)	Air	(Int. 1927)	2275±25	2266±25	(5)	
Al_2O_3	2044	(a) Nitrogen (b) Air	Int. 1948	(a) 2315 (b) 2330	2315 2330	[5]; reduction of specimen is probable.	
Not stated		Air	(Int. 1927)	2435±10	2424±10	[5]; reduction of specimen is probable.	
Not stated		Nitrogen	Not stated	490±10			Cs_2O
Cu Ni Fe	1084 1451 1528	Nitrogen	Not stated	1222	1222		Cu_2O
Not stated		Oxidizing	(Int. 1927)	1230±20	1229±20	(5)	
Quartz transformation Au	Not stated 1062.6	0.6 mm Hg Pressure	Geophysical	1235	1236*		
Al_2O_3	2040	Either helium, hydrogen, or vacuum.	Int. 1948	2340±10	2340±10	[5]; author's stated emissivity of approximately 0.9 to 0.95 is probably overestimated. Reflection error probable.	Dy_2O_3
						No melting point data located in the literature.	Er_2O_3
Al_2O_3	2040	Either helium, hydrogen or vacuum.	Int. 1948	2050±30	2050±30	[5]; author's stated emissivity of approximately 0.9 to 0.95 is probably over estimated. Reflection errors and reduction in vacuum or hydrogen probable.	Eu_2O_3
Au Pt Rh	1063 1769 1960	Air	Int. 1948	2240±10	2240±10*		

Oxide	Reference	Purity [2]	Furnace type	Temperature measurement	Method
FeO	Chipman and Marshall [63].	Fe and C—<0.005%; S <0.004%; Si<0.008%; Mn<0.003%; Cu<0.004 %; Cu<0.004%; P< 0.002%; Ni<0.031%.	Resistance; SiC tube heating element.	Pt-90Pt10Rh thermocouple adjacent to specimen.	Weight loss data; specimen suspended from balance arm. Sudden weight loss indicated melting.
	Hay, Howat, and White [64].	Not stated	Resistance; Mo wire-wound ceramic tube heating element.	Mo-Wthermocouple adjacent to the specimen.	Differential thermal analysis.
	Darken and Gurry [65].	Fe and C—0.012%; Mn<0.01%; P—0.004%; S—0.003%; Cu—0.045%; Si—0.007%; Ni—0.02%; Pb—0.04%.	Resistance; quench type, Pt wire-wound ceramic tube heating element.	Pt-PtRh thermocouple; temperature measured before and after each determination.	Examination of specimen after heating.
	Bowen and Schairer [66]	Not stated	Resistance; quench type, Pt wire-wound ceramic tube heating element.	Pt-90Pt10Rh thermocouple; temperature measured before and after each determination.	Examination with microscope of quenched specimen after heating.
Fe_3O_4	Moruzzi and Shafer [67]	High purity	Resistance; quench type, Pt wire-wound ceramic tube heating element.	Thermocouple adjacent to specimen.	Observation of rod-shaped specimen during heating. Rounded corners indicated melting.
	Darken and Gurry [65]	Not stated	Resistance; quench type, Pt wire-wound ceramic tube heating element.	Pt-PtRh thermocouple; temperature measured before and after each determination.	Examination of specimen after heating. Formation of droplets indicated melting.
	Greig, Posnjak, Merwin, and Sosman [68]	Fe_2O_3—99.7%; FeO—0.03%; SiO_2—0.01%; Na_2O—0.04%; TiO_2—0.01%; MnO—0.01%; P_2O_5—0.005%	Resistance; quench type, Pt wire-wound ceramic tube heating element.	Pt-90Pt10Rh thermocouple adjacent to specimen.	Examination with microscope of quenched specimen after heating.
	v. Wartenberg and Eckhardt [57]	Commercially pure	Flame; acetylene-oxygen.	Optical pyrometer sighted on specimen.	Observation of specimen suspended in furnace during heating.
Ga_2O_3	Hill, Roy, and Osborn [69].	Not stated	Resistance, U-shaped 60 Pt-40Rh strip heating element.	Optical pyrometer	Examination with microscope of specimen after heating.
	v. Wartenberg and Reusch [56].	Not stated	(Flame) "Fletscher Oven".	Optical pyrometer sighted on specimen.	Observation of specimen suspended in furnace during heating.
	Schneider and Waring [70].	99.9%	(a) Induction; crucible-shaped Ir susceptor.	(a) Optical pyrometer sighted on small hole in crucible lid.	(a) and (b) Examination of specimen after heating.
			(b) Resistance; quench type, Pt alloy wire-wound ceramic tube heating element.	(b) 95Pt5Rh-80Pt20Rh thermocouple adjacent to specimen.	
Gd_2O_3	Wisnyi and Pijanowski [61].	Not stated	Resistance; V-shaped W strip heating element.	Optical pyrometer sighted on specimen.	Observation of specimen during heating. Apparent disappearance of specimen indicated melting.

See footnotes at end of table.

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Calibration Points		Environment	Original Temp. Scale [3]	Melting Points		Comments	Oxide
Materials	Temp.			Original	Int. 1948 [4]		
	°C			°C	°C		
Cu Ni Pd	Not stated Not stated 1555	Slightly oxidizing	(Int. 1927)	1369	1368		FeO
Not stated		Nitrogen at one atm	(Int. 1927)	1370	1368		
Not stated		Nitrogen at one atm	(Int. 1927)	1371±1	1369±1*		
Li_2SiO_3 Diopside Pd	1201 1391.5 1549.5	Nitrogen—slightly oxidizing.	Geophysical	1380±5	1382±5		
Not stated		Air	(Int. 1948)	1591	1591		Fe_3O_4
Not stated		(a) Oxygen at 1 atm (b) Air at 1 atm (c) Oxygen at 0.0575 atm.	(Int. 1927)	(a) 1583±2 (b) 1594±2 (c) 1597±2	1580±2* 1591±2* 1594±2*		
Au Diopside Pd Pt	1062.6 1391.5 1549.5 1755	Small oxygen pressure	Geophysical	1591±5	1594±5*		
Not stated		Air	(Int. 1927)	1650	1647	(5)	
15% CaO 85% SiO_2	1710	Not stated	Int. 1948	1725±15	1725±15	5; temperature uniformity between specimen and target area of pyrometer not verified.	Ga_2O_3
Not stated		Air	(Int. 1927)	1740±25	1736±25	(5)	
(a) Au Pd Pt Rh (b) Au Pd Pt	1063 1552 1769 1960 1063 1552 1769	(a) and (b) Air	Int. 1948	(a) and (b) 1795±15.	1795±15*		
Al_2O_3	2040	Either helium, hydrogen, or vacuum.	Int. 1948	2330±20	2330±20	5; authors stated emissivity of approximately 0.9 to 0.95 is probably overestimated. Reflection errors probable.	Gd_2O_3

Oxide	Reference	Purity [2]	Furnace type	Temperature measurement	Method
Gd_2O_3—Con.	Curtis and Johnson [71].	Y—0.2%; La<0.05%; Ce—0.5%; Pr<0.1%; Nd—0.5%; Sm—0.5%; Eu—0.5%; Dy—0.5%; Tb—2.0%; Ho<0.5%; Er<0.05%; Yb<0.05%; Lu—0.05%.	Not stated	Optical pyrometer sighted on specimen.	Observation of rod shaped specimen during heating. Definite fluidity of specimen indicated melting.
GeO_2 Quartz type.	Schwarz, Schenk, and Giese [72]	Not stated	Resistance; quench type, Pt wire-wound ceramic tube heating element.	Thermocouple	Examination with microscope of quenched specimen after heating. Disappearance of last crystal indicated melting.
	Laubengayer and Morton [73].	<0.01% impurities	Resistance; quench type, Pt wire-wound ceramic tube heating element.	Pt-PtRh thermocouple adjacent specimen.	Eaxmination with microscope of quenched specimen after heating. Disappearance of last crystal indicated melting.
HfO_2	Clausing [74]	ZrO_2<1%	Resistance; bar-shaped W strip heating element.	Optical pyrometer sighted on small cavity adjacent to specimen cavity.	Observation of specimen during heating. Flowing specimen indicated melting.
	Mark [27]	Fe and Si—0.5-1%; Zr—5%.	Resistance; graphite or metal strip heating element.	Optical pyrometer sighted on specimen.	Observation of specimen during heating.
	Henning [75]	"Pure theoretical"	Resistance; W tube heating element.	Optical pyrometer sighted on specimen.	Observation of specimen during heating.
	Curtis, Doney, and Johnson [76].	Zr-2 ppm; Ti-1000 ppm; Al-600 ppm; Fe-100 ppm; Si—100 ppm.	Flame; oxyacetylene	Optical pyrometer	Not stated
Ho_2O_3					
In_2O_3	Schneider [62]	Al, Ca, Cu, Fe, Mg, Ni, P, and Si, each <0.01%; Er <0.001%; Ag and Mn <0.00001%	Induction; crucible-shaped Ir susceptor.	Optical pyrometer sighted on small hole in crucible lid.	Examination of specimen after heating. Flat button indicated melting.
IrO_2	Cordfunke and Meyer [77].	Not stated	Resistance; "Silibar"	Pt-90Pt10Rh thermocouple	Vapor pressure data
K_2O					
La_2O_3	Ruff [31]	Contained didymium impurities.	Resistance; carbon tube heating element.	Optical pyrometer sighted on specimen.	Observation of specimen during heating.
	Lambertson and Gunzel [30].	99%	Resistance; W heating element.	Optical pyrometer sighted on specimen. Specimen not visible.	Examination of specimen after heating.
	v. Wartenberg and Reusch [56].	100%	(Flame) "Fletscher oven"	Optical pyrometer sighted on specimen.	Observation of specimen during heating.
Li_2O	Chemistry and Physics Handbook [4].	Not stated	Not stated	Not stated	Not stated

See footnotes at end of table.

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Calibration Points		Environment	Original Temp. Scale [3]	Melting Points		Comments	Oxide
Materials	Temp.			Original	Int. 1948 [4]		
	°C			°C	°C		
Not stated		Air	(Int. 1948)	2350±50	2350±50	[5]; authors stated an attempt was made to correct for nonblackbody conditions.	Gd_2O_3—Con.
Na_2SO_4 K_2SO_4 Li_2SiO_3	884.7 1069.1 1201.8	Air	(Geophysical)	1115±3	1115±3*		GeO_2 Quartz type.
Not stated		(Air)	(Int. 1927)	1116±4	1116±4*		
Not stated		Hydrogen	(Int. 1927)	2774±25	2758±25	[5]; temperature uniformity between specimen and target area of pyrometer not verified.	HfO_2
Not stated		Neutral	(Int. 1948)	2770	2770	[5]; reflection errors probable.	
Not stated		Nitrogen or hydrogen	Not stated	2812±25		[5]; melting point determind for impure HfO_2 sample and extrapolated to 100% es	
Not stated		Not stated	(Int. 1948)	2900±25	2900±25		
						No melting point data located in the literature.	Ho_1O_3
Au Pt Rh	1063 1769 1960	Air	Int. 1948	1910±10	1910±10		In_2O_3
Not stated		Oxygen at 1 atm	Int. 1948	1100 dissociates	1100		IrO_2
						No melting point data located in the literature. Because of the reactivity of K_2O, it is unlikely that a melting point can be determined.	K_2O
Pt	1755	Not stated	C_2=1.46 cm deg	1840	1859	[5]; reaction between specimen and ZrO_2 support probable.	La_2O_3
Pt	(1769)	Helium	(Int. 1948)	2210±20	2210±20		
Pt	(1773)	Air	(Int. 1927)	2315	2307	([5])	
Not stated		Not stated	Not stated	>1700		Survey, not original data. Because of the reactivity of Li_2O it is unlikely that a melting point can be determined.	Li_2O

TABLE 1[1]

Oxide	Reference	Purity [2]	Furnace type	Temperature measurement	Method
Lu_2O_3					
MgO	Ruff [31]	Contained: H_2CO_3, H_2O, Fe_2O_3, $Si(OH)_4$ and NaCl.	Resistance; carbon tube heating element.	Optical pyrometer sighted on specimen.	Observation of specimen during heating.
	Kelley [1]	Not stated	Not stated	Not stated	Not stated
	McNally, Peters, and Ribbe [33].	Co_3O_4 and WO_3—0.01-0.1%; SiO_2 and Fe_2O_3—0.005-0.05%; Al_2O_3 and Cr_2O_3—0.001-0.01%; B_2O_3, V_2O_3, TiO_2, and CuO—5-50 ppm; MnO and Ag_2O—1-10 ppm.	Induction; graphite tube susceptor.	Optical pyrometer sighted on small hollow graphite cylinder adjacent to specimen.	Observation of specimen during heating.
	Kanolt [37]	CaO—none. Al_2O_3—0.0002%. Fe—0.0005%. CO_2—0.130%. Cl—0.275%. SO_3—0.001%. HNO_3—none.	Resistance; graphite tube heating element.	Optical pyrometer sighted on blackbody cavity immersed in specimen.	Thermal analysis; heating curves.
MnO	Tiede and Birnbrauer [23].	Not stated	Arc	Optical pyrometer sighted on specimen.	Observation of specimen during heating.
	White, Howat and Hay [78].	Not stated	Resistance; Mo wire-wound ceramic tube heating element.	Mo-W thermocouple adjacent to the specimen.	Differential thermal analysis.
Mn_3O_4	v. Wartenberg and Prophet [53].	Not stated	Flame; oxyhydrogen or gas-air.	Optical pyrometer	Not stated
	Van Hook and Keith [79].	Not stated	Resistance; quench type, Pt wire-wound ceramic tube heating element.	Pt-90Pt10Rh thermocouple adjacent to specimen.	Examination with microscope of quenched specimen after heating.
	Ranganathan, Mackean and Muan [80].	Reagent grade	Resistance; Mo wire-wound ceramic tube heating element.	Pt-90Pt10Rh thermocouple adjacent to specimen.	Examination with X-rays and microscope of quenched specimen after heating.
	v. Wartenberg, Reusch and Saran [44].	Commercially pure	Flame; oil-oxygen	Optical pyrometer	Observation of specimen suspended in furnace during heating.
	v. Wartenberg and Gurr [52].	Pure	Not stated	Optical pyrometer	Not stated
MoO_3	Carnelley [81]	Not stated	Flame; "Bunsen lamp"	Mercury thermometer	Not stated
	Groschuff [82]	Not stated	Not stated	Not stated	Thermal analysis; heating and cooling curves.
	v. Jaeger and Germs [83].	Purified	Resistance; nichrome wire heating element.	Thermocouple immersed in specimen.	Thermal analysis, heating curves.
	Hoermann [84]	Not stated	Resistance; Pt wire heating element.	Pt-PtRh thermocouple immersed in specimen.	Observation of specimen during heating.

See footnotes at end of table.

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Calibration Points		Environment	Original Temp. Scale [3]	Melting Points		Comments	Oxide
Materials	Temp.			Original	Int. 1948 [4]		
	°C			°C	°C		
						No melting point data located in the literature.	Lu_2O_3
Pt	1755	(a) Nitrogen at 10–30 mm Hg. (b) Nitrogen at 1 atm (c) Nitrogen at 10–30 mm Hg. (d) Nitrogen at 1 atm (e) Nitrogen at 10–30 mm Hg.	C_2=1.46 cm deg.	(a) 2120 (b) 2250–2280 (c) 2450 (d) 2500 (e) 2550	2150 2285–2316 2494 2546 2599	[5]; various melting points obtained using different shaped specimens and graphite supports. Reaction with graphite and partial reduction of MgO occurred.	MgO
Not stated		Not stated	Not stated	2642		Survey; not original data.	
Al_2O_3	2044	Nitrogen	Int. 1948	2825±20	2825±20	Temperature uniformity between specimen and target area of pyrometer not verified.	
Sb Cu-Ag eutectic. Ag Cu Diopside Pt	630 779 960.5 1083 1391 1755	Carbon monoxide and nitrogen at atmospheric pressure.	([6])	2800	2852*		
Not stated		Vacuum	Not stated	1650		([5])	MnO
Fe transformation. Fe	1400 1530	Not stated	(Int. 1927)	1785	1781		
Not stated		Air	(Int. 1927)	1560	1557		Mn_3O_4
$CaSiO_3$	1544	Air	(Geophysical)	1562	1564*		
$CaSiO_3$ $90SiO_2$:10CaO Pt	1546 1707 1769	Air	Int. 1948	1567±5	1567±5*		
Not stated		Air	(Int. 1927)	1590±20	1587±20	([5])	
Not stated		Air	(Int. 1927)	1705	1701		
Not stated		Not stated	Not stated	759			MoO_3
Not stated		Air	Not stated	791			
Not stated		Oxidizing	Not stated	795			
Not stated		Not stated	(Int. 1927)	795			

Oxide	Reference	Purity [2]	Furnace type	Temperature measurement	Method
MoO_3—Con.	Rieck [85]	Purified	Flame; gas-air	Pt-PtRh thermocouple immersed in specimen.	(Thermal analysis)
	Cosgrove and Snyder [86].	Trace—heavy and alkali metals.	Resistance; nichrome wire-wound ceramic tube heating element.	Pt-PtRh thermocouple	Thermal analysis, cooling curves.
Na_2O					
Nb_2O_5	Brauer [87]	TiO_2—0.28%	"Tammann oven"	Optical pyrometer sighted on specimen.	Observation of specimen during heating. Flowing specimen indicated melting.
	Shafer and Roy [88]	Ta_2O_5<0.2%	Resistance; Pt wire-wound ceramic tube heating element.	Thermocouple	Not stated
	Ihrahim, Bright, and Rowland [89].	99+%	Resistance; Pt wire-wound tube heating element.	Pt-90Pt10Rh thermocouple	Observation of cone shaped specimen during heating. Complete slumping indicated melting.
	Roth and Waring [90]	Si <0.01%; Ca and Mg <0.001%; As, Cu, and Ta perhaps present.	Resistance; quench type Pt alloy wire-wound ceramic tube heating element.	Pt-90Pt10Rh thermocouple adjacent to the specimen.	Examination of quenched specimen after heating.
	Reisman and Holtzberg [91].	Ta_2O_3<0.2%	Resistance; Pt wire-wound ceramic tube heating element.	Pt-90Pt10Rh thermocouple immersed in specimen.	Differential thermal analysis.
	Roth and Waring [92]	99.7+%	Resistance; quench type, Pt alloy wire-wound ceramic tube heating element.	Pt-90Pt10Rh thermocouple adjacent to specimen.	Examination of quenched specimen after heating.
	Holtzberg, Reisman, Berry, and Berkenblit [93].	Ta<0.2%	Resistance; kanthal wire heating element.	Pt-90Pt10Rh thermocouple immersed in specimen.	Differential thermal analysis.
	Diamond and Schneider [28].	99.7+%	Solar	Optical pyrometer sighted on specimen.	Observation of bar-shaped specimen during cooling.
	Roth and Coughanour [94].	99.7+%	Resistance; Pt alloy heating element.	Pt-90Pt10Rh thermocouple	Examination of pyramid-shaped specimen after heating.
	Orr [95]	Si<0.03%; Mg<0.05%; Ti<0.01%	Not stated	Thermocouple	Not stated
	Ruff [31]	Ta_2O_5—1-2%	Resistance; carbon tube heating element.	Optical pyrometer sighted on specimen.	Observation of specimen during heating.
Nd_2O_3	Lambertson and Gunzel [30].	99%	Resistance; W heating element.	Optical pyrometer sighted on specimen. Specimen not visible.	Examination of specimen after heating.
NiO	Merica and Waltenberg [96],	Not stated	Not stated	Optical pyrometer	Not stated
	v. Wartenberg and Prophet [53].	99.9%	Flame; oxyhydrogen or gas-air.	Optical pyrometer	Not stated
	v. Wartenberg and Gurr [52].	Pure	Not stated	Optical pyrometer	Not stated

See footnotes at end of table.

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Calibration Points		Environment	Original Temp. Scale [3]	Melting Points		Comments	Oxide
Materials	Temp.			Original	Int. 1948 [4]		
	°C			°C	°C		
NaCl	Not stated	Air	(Int. 1927)	795±2	795±2		MoO_3—Con.
Sn, Pb, Al, Cu, Ag, Si.	Not stated	Nitrogen at 1 atmo	Int. 1948	795.36	795.36*		
Steam	Not stated						
						No melting point data located in the literature. Because of the reactivity of Na_2O, it is unlikely that a melting point can be determined.	Na_2O
Not stated		Oxygen	(Int. 1927)	1460±5	1458±5	[5]	Nb_2O_5
Not Stated		Not Stated	(Int. 1948)	1465±5	1465±5		
Au Pd Pseudowollastonite.	Not stated Not stated Not stated	Air	Int. 1948	1479	1479	Authors stated that recorded temperatures may be as much as 20 °C low.	
Au	1063	Air	Int. 1948	1485±5	1485±5*		
K_2CO_3 NaCl	Not stated Not stated	Oxygen plus air	(Int. 1948)	1486±5	1486±5*		
Au Barium disilicate.	1063 1420	Air	Int. 1948	1487	1487		
$KNbO_3$ Transformations.	215 425	(Air)	(Int.1948)	1491±2	1491±2*		
None		Air	Int. 1948	1496	1496	[5]; emissivity stated by authors to be about unity.	
Not stated		Air	Int. 1948	1500 ± 10	1500 ± 10		
Au	(1063)	Not stated	(Int. 1948)	1512	1512		
Pt	1755	Not stated	C_2-1.46 cm deg	1520	1530	[5]; reaction between specimen and Mgo support probable.	
Pt	(1769)	Helium	(Int. 1948)	2272 ± 20	2272 ± 20		Nd_2O_3
Not stated		(a) Vacuum (b) Air	Not stated	(a) 1552 (b) 1660			NiO
Not stated		Air	(Int. 1927)	1990	1984	[5]	
Not stated		Air	(Int. 1927)	2090	2083	[5]; authors stated this melting point to be in error. See preceding reference [53] for corrected value.	

TABLE 1[1]

Oxide	Reference	Purity [2]	Furnace type	Temperature measurement	Method
OsO_4 yellow-type	v. Wartenberg [97]	Not stated	Resistance	Thermocouple adjacent to specimen.	Observation of specimen during heating. Also from intersection of vapor pressure curves.
	Chemistry and Physics Handbook [4].	Not stated	Not stated	Not stated	Not stated
	Kelley [1]	Not stated	Not stated	Not stated	Not stated
P_2O_5	Hoeflake and Scheffer [98].	Purified	Resistance; "oven"	Pt-PtRh thermocouple	Observation of specimen during heating. Also from vapor pressure data.
PbO yellow type.	Balladen [47]	Not stated	Resistance	Pt-PtRh thermocouple immersed in specimen.	Thermal analysis, cooling curves.
	Hilpert and Weiller [99].	Not stated	Resistance	Pt-PtRh thermocouple immersed in specimen.	Thermal analysis
	v. Jaeger and Germs [83].	(a) 99.2% (b) Not stated (c) Not stated	Resistance; nichrome heating element.	Thermocouple immersed in specimen.	Thermal analysis.
	Schenck and Rasshach [100].	Pure	Resistance	Pt-PtRh thermocouple	Thermal analysis, cooling curves.
	Geller, Creamer, and Bunting [101].	0.02% total impurities	Not stated	Pt-PtRh thermocouple	Differential thermal analysis
	Krakau [102]	0.1-0.2% impurities	Not stated	Pt-PtRh thermocouple	Thermal analysis, cooling curves.
	Kroll [103]	Not stated	Resistance; Pt heating element.	Thermocouple immersed in specimen.	Thermal analysis, cooling curves; also observation of specimen.
	Cooper, Shaw, and Loomis [104].	Pure	Resistance	Pt-PtRh thermocouple	(Thermal analysis.)
PdO_2					
Pr_6O_{11}					
PtO_2	Chemistry and Physics Handbook [4].	Not stated	Not stated	Not stated	Not stated
Rb_2O					
Re_2O_7	Kelley [1]	Not stated	Not stated	Not stated	Not stated
Rh_2O_3					

See footnotes at end of table.

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Calibration Points		Environment	Original Temp. Scale [3]	Melting Points		Comments	Oxide
Materials	Temp.			Original	Int. 1948 [4]		
	°C			°C	°C		
Not stated		About 11 mm Hg	Not stated	40.1		Crystal form not indicated. The reported melting point is probably determined from mixture of both the white and yellow types.	OsO_4 yellow type
Not stated		Not stated	Not stated	41		Survey, not original data	
Not stated		Not stated	Not stated	56		Survey, not original data	
Naphthaline Benzophenone. Sulphur Sb	218 306 444.5 630	4600 mm Hg	Not stated	569 Triple point.	569		P_2O_5.
Not stated		Not stated	Not stated	870			PbO yellow type.
Not stated		Air	Not stated	876			
Not stated		Oxidizing	Not stated	(a) 877 (b) 879 (c) 879			
Not stated		Air	Not stated	879			
K_2SO_4 Transformation. KCl_4 K_2SO_4	583±1 770.3 1069.1	Air	Int. 1927	886	886*		
Not stated		Air	(Int. 1927)	886	886		
Not stated		Air	Not stated	888			
Not stated		(Air)	Not stated	888			
						No melting point data located in the literature. The oxide probably dissociates to the metal before melting.	PdO_2
						No melting point data located in the literature.	Pr_6O_{11}
Not stated		Not stated	Not stated	450		Survey; not original data. The oxide probably dissociates to the metal before melting.	PtO_2
						No melting point data located in the literature.	Rb_2O
Not stated		Not stated	Not stated	296		Survey, not original data	Re_2O_7
						No melting point data located in the literature. The oxide probably dissociates to the metal before melting.	Rh_2O_3

TABLE 1[1]

Oxide	Reference	Purity [2]	Furnace type	Temperature measurement	Method
RuO_4					
Sb_2O_3 orthorombic type	Hincke [105]	Not stated	Not stated	Not stated	Calculated from vapor pressure data.
Sc_2O_3	Schneider and Waring [70].	99.9%	Induction; crucible shaped Ir susceptor.	Optical pyrometer sighted on small hole in crucible lid.	Examination of specimen after heating.
SeO_2	Chemistry and Physics Handbook [4].	Not stated	Not stated	Not stated	Not stated
SiO_2 cristobalite type	Wietzel [106]	Not stated	Resistance; Ir heating element.	Optical pyrometer sighted on Pt blacked with Fe_3O.	Examination of specimen after heating. First glass formation indicated melting.
	Endell and Rieke [107]	99.9%	Resistance; Ir heating element.	Ir-IrRh thermocouple adjacent to specimen.	Examination of specimen after heating.
	White, Howat, and Hay [78]	Not stated	Resistance; Mo wire-wound ceramic tube heating element.	Mo-W thermocouple	Observation of specimen during heating.
	Ferguson and Merwin [108]	Not stated	Resistance; quench type, Pt alloy wire-wound ceramic tube heating element.	Pt-90Pt10Rh thermocouple. Temperature measured before and after each determination.	Examination with microscope of quenched specimen after heating. Last trace of crystals indicated melting.
	Greig [109]	Very pure	Resistance; quench type, Pt alloy wire-wound ceramic tube heating element.	Pt-90Pt10Rh thermocouple adjacent to the specimen.	Examination with microscope of quenched specimen after heating. Last trace of crystals indicated melting.
	Zhirnova [110]	Not stated	Flame; acetylene-O_2	Optical pyrometer sighted on specimen.	Observation of cone shaped specimen during heating. Slumping of the cone indicated melting.
	Ruff and Lauschke [25]	Not stated	Resistance; graphite tube heating element.	Optical pyrometer sighted on specimen.	Observation of specimen during heating.
Sm_2O_3	Wisnyi and Pijanowski [61]	Not stated	Resistance; V-shaped W strip heating element.	Optical pyrometer sighted on specimen.	Observation of specimen during heating. Apparent disappearance of specimen indicated melting.
	Curtis and Johnson [71]	Y<0.05%; La<0.05%; Pr<0.2%; Nd<0.05%; Ho<0.02%; Er<0.05%; Eu—0.4%; Gd—0.03%; Tb<0.01%; Dy—0.02%; Yb<0.05%.	Not stated	Optical pyrometer sighted on specimen.	Observation of rod shaped specimen during heating. Definite fluidity of specimen indicated melting.
SnO_2	Ruff [31]	Not stated	Resistance, carbon tube heating element.	Optical pyrometer sighted on specimen.	Observation of specimen during heating.
	Barczak and Insley [111].	Not stated	Not stated	Not stated	Differential thermal analysis. Also examination of specimen after heating.

See footnotes at end of table.

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Calibration Points		Environment	Original Temp. Scale [3]	Melting Points		Comments	Oxide
Materials	Temp.			Original	Int. 1948 [4]		
	°C			°C	°C		
						No melting point data located in the literature.	RuO_4
Not stated		8.5 mm Hg	(Int. 1927)	655	655		Sb_2O_3 orthorhombic type
Au Pd Pt Rh	1063 1552 1769 1960	Air	Int. 1948	<2405	<2405		Sc_2O_3
Not stated		Not stated	Not stated	240-250		Survey, not original data. The oxide is extremely volatile.	SeO_2
Pd	1556	Air	(C_2=1.437 cm deg).	1696±10	1691±10		SiO_2 cristobalite type
An Pd Pt	1063 1549 1755	Nitrogen	(Geophysical)	1685	1692		
Fe transformation. Fe	1400 1530	Not stated	(Int. 1927)	1705	1701		
Pd	1549.5	Air	Geophysical	1710±10	1720±10		
Ice Au Pd Pt	0 1062.6 1549.5 1755	Air	Geophysical	1713±5	1723±5*		
Pt Al_2O_3 CaO	1755 2050 2570	Air	(C_2=1.457 cm deg).	1715±20	1728±20	(5)	
An CaF_2	1062.4 1398	17.0 mm Hg	(C_2=1.437 cm deg.)	1850	1850	5; reaction between specimen and graphite support probable.	
Al_2O_3	2040	Either helium, hydrogen, or vacuum	Int. 1948	2300±50	2300±50	5; authors' stated emissivity of approximately 0.9 to 0.95 is probably overestimated. Reflection errors probable.	Sm_2O_3
Not given		Air	(Int. 1948)	2350±50	2350±50	5; authors' stated an attempt was made to correct for nonblackbody conditions.	
Pt	1755	Not stated	C_2=1.46 cm deg.	(a) 1385 (b) 1625	1391 1637	5 reaction between specimen and (a) MgO or (b) ZrO_2 supports probable.	SnO_2
Not stated		Not stated	(Int. 1948)	1630±5	1630±5	Possible reaction of SnO_2 with Pt container probable.	

Oxide	Reference	Purity [2]	Furnace type	Temperature measurement	Method
SrO	Schumacher [43]	C. P. grade	Resistance; boat-shaped W strip heating element.	Optical pyrometer sighted on W strip adjacent to specimen; spectral emissivity equals 0.431.	Observation of specimen during heating.
Ta_2O_5 alpha type	Reisman, Holtzberg, Berkenblit, and Berry [112].	TiO_2<0.001%	Resistance, U-shaped Rh or Pt alloy strip heating element.	Optical pyrometer sighted on specimen.	Observation of specimen during heating.
	Ruff [31]	Nb_2O_5—7.1%	Resistance; carbon tube heating element.	Optical pyrometer sighted on specimen.	Observation of specimen during heating.
Tb_4O_7					
TeO_2	Kracek [3]	Not stated	Not stated	Not stated	Not stated
ThO_2	Tiede and Birnbrauer [23].	Commercially pure	Arc	Optical pyrometer sighted on specimen.	Observation of specimen during heating.
	Ruff [31]	Pure	Resistance; carbon tube heating element.	Optical pyrometer sighted on specimen.	Observation of specimen during heating.
	Trombe [2]	Not stated	Not stated	Not stated	Not stated
	Ruff, Ebert, and Woitinek [113].	"Pure"	Flame; oxyacetylene	Optical pyrometer	Not stated
	Lambertson and Gunzel [30].	99.7%	Resistance; W heating element.	Optical pyrometer sighted on specimen. Specimen not visible.	Examination of specimen after heating.
TiO_2	Statton [114]	Reagent grade	Resistance; Mo strip heating element.	Optical pyrometer sighted on Mo strip adjacent to specimen. Corrected for spectral emissivity of Mo.	Observation of specimen during heating.
	v. Wartenberg and Prophet [53].	Not stated	Flame; oxyhydrogen or gas-air.	Optical pyrometer	Not stated
	Sigurdson and Cole [115].	Not stated	Resistance; Pt strip heating element.	Optical pyrometer sighted on Pt strip adjacent to specimen. Corrected for spectral emissivity of Pt.	Observation of specimen during heating.
	Rase and Roy [116]	Not stated	Resistance; U-shaped Pt alloy heating element.	Optical pyrometer sighted on Pt alloy strip.	Observation of specimen during heating.
	Coughanour and De Prosse [117].	99.9%	Resistance; ThO_2 heating element.	Optical pyrometer sighted on specimen.	Observation of pyramid-shaped specimen during heating.
	St. Pierre [118]	Si—0.04%; Mg—0.02%; Ca—0.01%.	Induction; carbon tube susceptor.	Optical pyrometer sighted on specimen.	Observation of specimen during heating.
	Diamond and Schneider [28].	About 99.9%	Solar	Optical pyrometer sighted on specimen.	Observation of bar-shaped specimen during cooling.

See footnotes at end of table.

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Calibration Points		Environment	Original Temp. Scale [3]	Melting Points		Comments	Oxide
Materials	Temp.			Original	Int. 1948 [4]		
	°C			°C	°C		
Not stated		Hydrogen at 0.2 atm	C_2=1.433 cm deg.	2430	2420	[5]; temperature uniformity between specimen and target area of pyrometer not verified; reflection errors probable.	**SrO**
Diopside 15% CaO: 85% SiO_2	1392 1712	(Air)	Int. 1948	1872±10	1872±10	(5)	**Ta_2O_5 alpha type.**
Pt	1755	Nitrogen at reduced pressure.	C_2=1.46 cm deg	1875	1895	[5]; reaction between specimen and ZrO_2 support probable.	
						No melting point data located in the literature.	**Tb_4O_7**
Not stated		Not stated	Not stated	732.6		Survey; not original data. This oxide is very volatile and has a tendency to sublime rather than to melt.	**TeO_2**
Not stated		Vacuum	Not stated	2000		(5)	**ThO_2**
Pt	1755	Nitrogen at reduced pressure.	C_2=1.46 cm deg	2425 2440 2470	2468 2483 2515	[5]; reaction between specimen and ceramic supports probable.	
Not stated		Not stated	Not stated	3000		Survey, not original data	
Not stated		Not stated	(Int. 1927)	3050±50	3030±50	Melting point extrapolated from liquidus curves of the ZrO_2–ThO_2 system.	
Pt	(1769)	Helium	(Int. 1948)	3220±50	3220±50*		
Pd Pt	1555 1774	Vacuum	(Int. 1927)	1720	1716	[5]; temperature uniformity between specimen and target area of pyrometer not verified. Reduction of TiO_2 very probable.	**TiO_2**
Not stated		Air	(Int. 1927)	1825	1820	[5]; partial reduction of TiO_2 probably occurred.	
Au $Na_2Ti_3O_7$ BaF_2 $CaMgSi_2O_6$ $MgTi_2O_3$	1063 1128 1280 1391 1660	Oxidizing	(Int. 1948)	1825	1825	(5)	
Diopside Pseudo-wollastonite. 15% CaO: 85% SiO_2.	1391.5 1544 1698	(Air)	(Geophysical)	1830		(5)	
Pt	1769	Air	Int. 1948	1839±10	1839±10	(5)	
Not stated		Air	(Int. 1948)	1840±10	1840±10	(5)	
None		Air	Int. 1948	1840	1840	[5]; emissivity stated by authors to be about unity.	

TABLE 1 [1]

Oxide	Reference	Purity [2]	Furnace type	Temperature measurement	Method
TiO_2—Con.	v. Wartenberg and Gurr [52].	Not stated	Not stated	Optical pyrometer	Not stated
	Lang, Fillmore, and Maxwell [119].	99.9%	Resistance; ThO_2 heating elements.	Optical pyrometer sighted on specimen.	Observation of pyramid-shaped specimen during heating.
	v. Wartenberg and Eckhardt [57].	Pure; SiO_2 free	Flame; acetylene-O_2	Optical pyrometer sighted on specimen.	Observation of specimen suspended in furnace during heating.
	Brauer and Littke [120].	>99.8%	Solar	Radiation pyrometer sighted on specimen.	Observation of specimen during heating.
Tl_2O_3	Duncan [121]	Not stated	Not stated	Pt-90Pt10Rh thermocouple immersed in specimen.	Thermal analysis, cooling curves.
Tm_2O_3					
UO_2	Ruff and Goecke [34]	Not stated	Resistance; graphite tube heating element.	Optical pyrometer sighted on specimen.	Observation of cone-shaped specimen during heating.
	Wisnyi and Pijanowski [61].	Not stated	Resistance; V-shaped W strip heating element.	Optical pyrometer sighted on specimen.	Observation of specimen during heating. Apparent disappearance of specimen indicated melting.
	Ehlert and Margrave [122].	Not stated	Induction; graphite susceptor.	Optical pyrometer sighted on specimen. Correction made for spectral emissivity.	Observation of specimen during heating.
	Lambertson and Gunzel [30].	Very pure	Resistance; W heating element.	Optical pyrometer sighted on specimen. Specimen not visible.	Examination of specimen during heating.
V_2O_5	Kracek [3]	Not stated	Not stated	Not stated	Not stated
	Carnelley [81]	Not stated	Flame; "bunsen lamp"	Mercury thermometer	Not stated
	Cook [123]	Purified	Not stated	Thermocouple	Heat content curves
	Illarionov, Ozeron, and Kil'disheva [124].	Not stated	Not stated	Pt-PtRh thermocouple	Differential thermal analysis
	Holtzberg, Reisman, Berry, and Berkenblit [125].	99.94%	Not stated	Pt-90Pt10Rh thermocouple immersed in specimen.	Thermal analysis
	McDaniel [126]	99.5%	Resistance; Pt alloy wire-wound ceramic tube heating element.	Pt-90Pt10Rh thermocouple immersed in specimen.	Thermal analysis; electrical conductance versus temperature curves.
	Burdese [127]	Not stated	Not stated	Not stated	Examination with microscope of specimen after heating.
	Chemistry and Physics Handbook [4].	Not stated	Not stated	Not stated	Not stated
WO_3	v. Jaeger and Germs [83].	Fe-0.05%	Resistance; nichrome wire heating element.	Thermocouple immersed in specimen.	Thermal analysis, heating curves.

See footnotes at end of table.

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Calibration Points		Environment	Original Temp. Scale [3]	Melting Points		Comments	Oxide
Materials	Temp.			Original	Int. 1948 [4]		
	°C			°C	°C		
Not stated		Air	(Int. 1927)	1850	1845		TiO_2—Con.
Not stated		Air	Int. 1948	1845	1845	(5)	
Not stated		Air	(Int. 1927)	1855	1850	(5)	
CaF_2 NiO Cr_2O_3 Al_2O_3	Not stated Not stated Not stated Not stated	(a) Oxygen at 300 torr. Argon at 460 torr. (b) Oxygen at 500 torr. Argon at 260 torr. (c) Oxygen at 600 torr. Argon at 160 torr. (d) Oxygen at 760 torr. (e) Oxygen at 1140 torr.	(Int. 1948)	(a) 1840±15 (b) 1860±15 (c) 1870±15 (d) 1870±15 (e) 1870±15	1840±15 1860±15 1870±15 1870±15 1870±15	(5)	
Not stated		Oxygen at 1 atm	(Int. 1927)	717±5	717±5		Tl_2O_3
						No melting point data located in the literature.	Tm_2O_3
Au Pt	1071 1757	Nitrogen	(C_2=1.48 cm deg).	2176	2208	5; reaction between specimen and uranium carbide support probable.	UO_2
Al_2O_3	2040	Either helium, hydrogen, or vacuum.	Int. 1948	2760±30	2760±30	5; author's stated emissivity of 0.9 to 0.95 probably overestimated. Reflection errors probable.	
Not stated		Vacuum	(Int. 1948)	2860±45	2860±45		
Pt	(1769)	Helium	(Int. 1948)	2878±22	2878±22*		
Not stated		Not stated	Not stated	656		Survey; not original data	V_2O_5
Not stated		Not stated	Not stated	658			
Au Pd	(1063) (1555)	Not stated	(Int. 1927)	670	670		
Not stated		Not stated	(Int. 1948)	672	672		
NaCl K_2SO_4	800.4 1069	Air + Oxygen	Int. 1948	674±5	674±5*		
NaCl	800	Air	Int. 1948	675±3	675±3*		
Not stated		Carbon dioxide	(Int. 1948)	685±5	685±5		
Not stated		Not stated	Not stated	690		Survey, not original data	
Not stated		Oxidizing	Not stated	1473±1			WO_3

TABLE 1[1]

Oxide	Reference	Purity [2]	Furnace type	Temperature measurement	Method
WO_3—Con.	Hoerman [84]	Not stated	Resistance; Pt wire heating element.	Pt-PtRh thermocouple immersed in specimen.	Observation of specimen during heating.
Y_2O_3	Ruff and Lausche [25]	Commercially pure	Resistance; graphite tube heating element.	Optical pyrometer sighted on specimen.	Observation of specimen during heating.
	Ruff [31]	Traces of impurities	Resistance; carbon tube heating element.	Optical pyrometer sighted on specimen.	Observation of specimen during heating.
Yb_2O_3					
ZnO	Bunting [128]	>99.9%	Induction, button-shaped Ir-Pt susceptor.	Optical pyrometer sighted on small cavity adjacent to specimen cavity.	Examination of specimen after heating.
ZrO_2	Tiede and Birnbrauer [23].	Very pure	Arc	Optical pyrometer sighted on specimen.	Observation of specimen during heating.
	Ruff and Lauschke [25].	SiO_2—0.95% Fe_2O_3—0.27%	Resistance; graphite tube heating element.	Optical pyrometer sighted on specimen.	Observation of specimen during heating.
	Ruff [31]	93%	Resistance; graphite tube heating element.	Optical pyrometer sighted on specimen.	Observation of specimen during heating.
	Clausing [74]	HfO_2<1%	Resistance; bar-shaped W strip heating element.	Optical pyrometer sighted on small cavity adjacent to the specimen cavity.	Observation of specimen during heating. Flowing specimen indicated melting.
	Podszus [129]	Pure	Arc, carbon electrodes	Optical pyrometer sighted on specimen.	Observation of specimen during heating.
	Henning [75]	Pure	Resistance; W tube heating element.	Optical pyrometer sighted on specimen.	Observation of specimen during heating.
	Mark [27]	Not stated	Resistance; graphite or metal heating element.	Optical pyrometer sighted on specimen.	Observation of specimen during heating.
	Trombe [2]	Not stated	Not stated	Not stated	Not stated
	Lambertson and Gunzel [30].	HfO_2—2.03% Others—0.03%	Resistance, W heating element.	Optical pyrometer sighted on specimen. Specimen not visible.	Examination of specimen after heating.
	Zhirnova [110]	Not stated	Flame; acetylene-O_2	Optical pyrometer sighted on specimen.	Observation of cone shaped specimen during heating. Slumping of the cone indicated melting.
	Curtis, Doney, and Johnson [76].	Hf—80 ppm Ti—60 ppm Al—150 ppm Fe—600 ppm Si—200 ppm	Flame; oxyacetylene	Optical pyrometer	Not stated

[1] All phrases, numbers, words, etc., enclosed in parentheses indicate that these items are not directly expressed in the quoted reference. However, based on information contained in the published report, the enclosed items can be reasonably assumed to be valid.

[2] Purities are listed as quoted in the reference. No attempt has been made to convert them to a common basis.

[3] Int. 1927—The International Temperature Scale (of 1927) [19].
Int. 1948—The International Practical Temperature Scale of 1948 [10].
Geophysical—Geophysical Temperature Scale [18].
C_2—second radiation constant. This constant is required in the definition of the temperature scale. See text for more complete description of appropriate equations.

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Calibration Points		Environment	Original Temp. Scale [3]	Melting Points		Comments	Oxide
Materials	Temp.			Original	Int. 1948 [4]		
	°C			°C	°C		
Not stated		Not stated	(Int. 1927)	1473	1471		WO_3—Con.
Au CaF_2	1062.4 1398	Air at 21.5 mm Hg	C_2=1.437 cm deg.	2410	2410	[5]; reaction between specimen and graphite support probable.	Y_2O_3
Pt	1755	Nitrogen at 15 mm Hg	C_2=1.46 cm deg	2415	2458	[5]; reaction between specimen and ZrO_2 support probable.	
						No melting point data located in literature.	Yb_2O_3
Not stated		Air	(Int. 1927)	1975±25	1969±25	Temperature uniformity between specimen cavity and target area of pyrometer not verified.	ZnO
Not stated		Vacuum	Not stated	2430		([5])	ZrO_2
Au CaF_2	1062.4 1398	(a) Hydrogen at 760 mm Hg. (b) Air at 8.22 mm Hg	C_2=1.437 cm deg.	(a) 2519 (b) 2563±10	2519 2563±10	[5]; reaction between specimen and graphite support probable.	
Pt	1755	Nitrogen	C_2=1.46 cm deg.	2585	2636	([5])	
Not stated		Hydrogen	(Int. 1927)	2677±25	2663±5	([5])	
Pt	Not stated	Air	Not stated	(a) 2677 (b) 2727		([5])	
Not stated		Hydrogen and nitrogen.	Not stated	2687		([5])	
Not stated		Neutral	(Int. 1948)	2690	2690	([5])	
Not stated		Not stated	Not stated	2700		Survey; not original data	
Pt	(1769)	Helium	(Int. 1948)	2710±15	2710±15		
Pt Al_2O_3 CaO	1755 2050 2570	Air	(C_2=1.457 cm deg.).	2715	2765	([5])	
Not stated		Not stated	(Int. 1948)	2850±25	2850±25	([5])	

[4] (A) The melting points marked with an asterisk are considered to be the better values of those listed. The values so designated do not necessarily represent the true melting points, but merely highlight those values believed to be more reliable.

(B) See text for method of conversion to values based on International Practical Temperature Scale of 1948. No entry in this column indicates insufficient data in original paper to permit conversion of melting point to 1948 basis.

[5] A close enough approach to blackbody conditions to facilitate accurate temperature measurement probably has not been obtained. As a general guideline, it should be noted that if an object in an enclosure is distinguishable from its surroundings, blackbody conditions probably have not been realized.

[6] Kanolt did not specifically employ Wien's equation in the measurement of high temperatures. A complete discussion of the method of conversion to temperatures on the 1948 scale is given elsewhere [130].

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