Thermal Conductivity of the Elements

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This is the abridged version of a comprehensive volume on the thermal conductivity of the elements. It contains recommended reference values resulting from critical evaluation, analysis, and synthesis of all the available data. It also gives estimated values for those elements for which no thermal conductivity data are available. Thus, the work provides recommended or estimated thermal conductivity values for all the elements over the full temperature ranges where experimental data are available or reliable extrapolations or estimations can be made. The results on each element are presented in both graphical and tabular forms. Summary graphs arranged by group in the periodic table are also given.

Key words: Conductivity: critically evaluated data; data compilation; elements: reference data; thermal conductivity; transport properties.

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Thermal Conductivity of the Elements

1. Introduction

The purpose of this work is to present and discuss the available data and information on the thermal conductivity of each element of the periodic table, to critically evaluate, analyze, and synthesize the data, and to make recommendations for the most probable values of its thermal conductivity over a wide temperature range.

The work is published in two companion versions: a comprehensive volume [1],[1] which is to be published as a supplement to the *Journal of Physical and Chemical Reference Data*, and this abridged version. In addition to the recommended and estimated thermal conductivity values for the elements, the comprehensive volume presents the original data, specimen characterization, and measurement information for the 5200 sets of raw data which were extracted from the primary literature. It contains also a detailed discussion for every element, reviewing the individual pieces of available data and information together with the considerations involved in arriving at the final assessment and recommendations and the theoretical guidelines or semi-empirical correlations on which the critical evaluation, analysis, and synthesis are based. The complete bibliographic citations for the 1630 references are also included. This abridged version of the comprehensive volume is designed for the practical user of data and contains only the recommended and estimated thermal conductivity values.

The thermal conductivity values given cover the widest possible temperature ranges and are for the purest form of each element for which measurements have been made. In the one instance of iron, values for Armco iron, a form of lower purity much used as a thermal conductivity reference material, have also been included.

Experimental thermal conductivity data are available in the world literature for 82 elements and estimated values for four other elements. The elements for which experimental data are lacking comprise all elements having an atomic number above 94 and twelve others: namely, actinium, astatine, barium, calcium, europium, francium, polonium, promethium, protactinium, radium, radon, and strontium. For all these elements estimated values have been included in this work at least for normal temperature.

The original papers upon which this work is based were retrieved through a continuing, comprehensive monitoring of the world literature carried out by the Thermophysical Properties Research Center (TPRC). The cut-off date for literature inclusion in this work was January 1971. The authors are keenly aware of the possibility of omissions or errors which may be encountered in a work of this scope. It is hoped that these faults will not be judged too harshly and that we will receive the benefit of suggestions regarding references omitted, improvements in presentation, and, most important, any inadvertent errors.

Inherent in the character of this work is the fact that we have drawn most heavily upon the scientific literature and feel a debt of gratitude to the authors whose results have been used. While their often discordant results have caused as much difficulty in reconciling their findings, we consider this to be our challenge and our contribution to the negative entropy of information as an effort is made to create from the randomly distributed data a more orderly state.

[1] Numbers in brackets refer to literature references in Section 5.

2. General Procedures for the Evaluation, Correlation, and Estimation of Thermal Conductivity

In this section it is proposed to outline some of the methods of treatment that have been employed and which are common to many of the elements and to group together some of the resulting thermal conductivity values with a view to revealing any general trends which might be of assistance in the prediction of values for other elements or in data extrapolation.

2.1. Theoretical background

In metals the principal carriers of heat are electrons and lattice waves, and it is commonly assumed that the total thermal conductivity

$$k = k_e + k_g \tag{1}$$

where k_e and k_g are the thermal conductivity components due to the transport of heat respectively by the electrons and by the phonons or lattice waves. In a very pure metal, k_g is extremely small compared with k_e and in the majority of cases it can practically be neglected.

The electronic component is given by

$$k_e = W_e^{-1} = (W_0 + W_i)^{-1} \tag{2}$$

where W_e is the electronic thermal resistivity, W_0 is the residual electronic thermal resistivity due to scattering of electrons by static imperfections, and W_i the intrinsic electronic thermal resistivity due to electron-phonon interactions.

The electrical resistivity is likewise composed of a residual and an intrinsic component

$$\rho = \rho_0 + \rho_i \, .$$

The residual thermal and electrical resistivities are related by the Wiedemann-Franz-Lorenz law

$$\frac{\rho_0}{W_o T} = L_0$$

hence

$$W_0=(\rho_0/L_0)T^{-1}=\frac{\beta}{T} \tag{3}$$

where $\beta=\rho_0/L_0$, L_0 is the theoretical Lorenz number (L_0=2.443×$10^{-8}V^2K^{-2}$) and T the absolute temperature. The intrinsic thermal and electrical resistivities are related by the Wiedemann-Franz-Lorenz law only in the high-temperature limit, while at lower temperatures

$$\frac{\rho_i}{W_iT}=L_i$$

is generally less than L_0. In the limit of low temperatures

$$L_i=\delta(T/\theta)^2$$

where θ is the Debye temperature and the coefficient δ depends on the topology of the Fermi surface.

The derivation of theoretical expressions for W_i and ρ_i involves the solution of the Bloch integral equation [2] which is very complicated. Explicit expressions have been obtained only for the very simplest model, first by Wilson [3] and later by several others [4–13]. The general form of their results is the same. In the low-temperature limit

$$\rho_i\propto T^5$$

$$W_i\propto T^2 \tag{4}$$

and

$$L_i=\rho_i/W_iT=7.8N_a^{-2/3}(T/\theta)^2$$

where N_a is the number of conduction electrons per atom. From equations (2–4), the low-temperature electronic thermal resistivity can therefore be written in the form

$$W_e=\alpha T^2+\beta/T.$$

Thus

$$k_e=\frac{1}{\alpha T^2+\beta/T}. \tag{5}$$

Equation (5) has been extensively compared with low-temperature experimental data for high-purity metals whose k_g is negligibly small, and disagreements have been found [14–16] in that the power of T for most metals is not 2 but greater and the coefficient α is not a constant for a metal. Considering the temperature dependence of the coefficient α and the interaction between intrinsic and residual thermal resistivities, Cezairliyan [14] and Cezairliyan and Touloukian [15, 16] have modified equation (5) to become

$$k_e=\frac{1}{\alpha' T^n+\beta/T} \tag{6}$$

or, assuming k_g being negligible, simply

$$k=\frac{1}{\alpha' T^n+\beta/T} \tag{7}$$

where

$$\alpha'=\alpha''\left(\frac{\beta}{n\alpha''}\right)^{(m-n)/(m+1)} \tag{8}$$

and α'', m, and n are constants for a metal. The value of n lies between 2 and 3 for most metals.

At low temperatures the thermal conductivity of a metal has a maximum value k_m at a corresponding temperature T_m. The purer the sample, the higher is the maximum conductivity and the lower is the temperature at which the maximum occurs. Physically, the constant m in equation (8) is the absolute value of the slope of the straight line (in a logarithmic plot) passing through the maxima of the thermal conductivity curves of different samples of different purity and imperfection, hence different ρ_0 and β.

Figure 1, reproduced from Cezairliyan's treatise shows how, by plotting a reduced thermal conductivity k/k_m (denoted by k^*) against the corresponding reduced temperature T/T_m (denoted by T^*), the data then (1962) available for 22 metals (some 1000 data points for 83 samples) were found to approximate to a single curve

$$k^*=\left[\frac{1}{3}(T^*)^2+\frac{2}{3T^*}\right]^{-1}. \tag{9}$$

The standard deviation of points from this curve was calculated as 0.032.

In this work for most of the metallic elements whose k is negligibly small, equations (7) and (8) have been used to fit experimental data for deriving recommended thermal conductivity values at temperatures below about 1.5 T_m. For a number of metallic elements the values of the constants m, n, and α'' to be used in equations (7) and (8) for low-temperature thermal conductivity calculations are given in table 1.

In equations (7) and (8), the only parameter is β, and each low-temperature thermal conductivity curve is uniquely determined by its value. An experimental value of β is obtainable by fitting equations (7) and (8) to the measured thermal conductivity data at temperatures below T_m. Using equations (7) and (8) and the constants for each of the metallic elements given in table 1, the low-temperature thermal conductivity of a particular sample can be calculated when the appropriate value of β is used. Different values of β give a family of thermal conductivity curves for each metallic element and a family of recommended curves could have been generated in this way for each metallic element.

In this work, at low temperatures only one recommended curve for one particular sample has been generated and this usually relates to the lowest value of β for the purest sample for which a thermal conductivity measurement has been made. For generating other curves for other samples equations (7) and (8) and the recommended constants of table 1 may be used. It often happens that electrical resistivity investigations

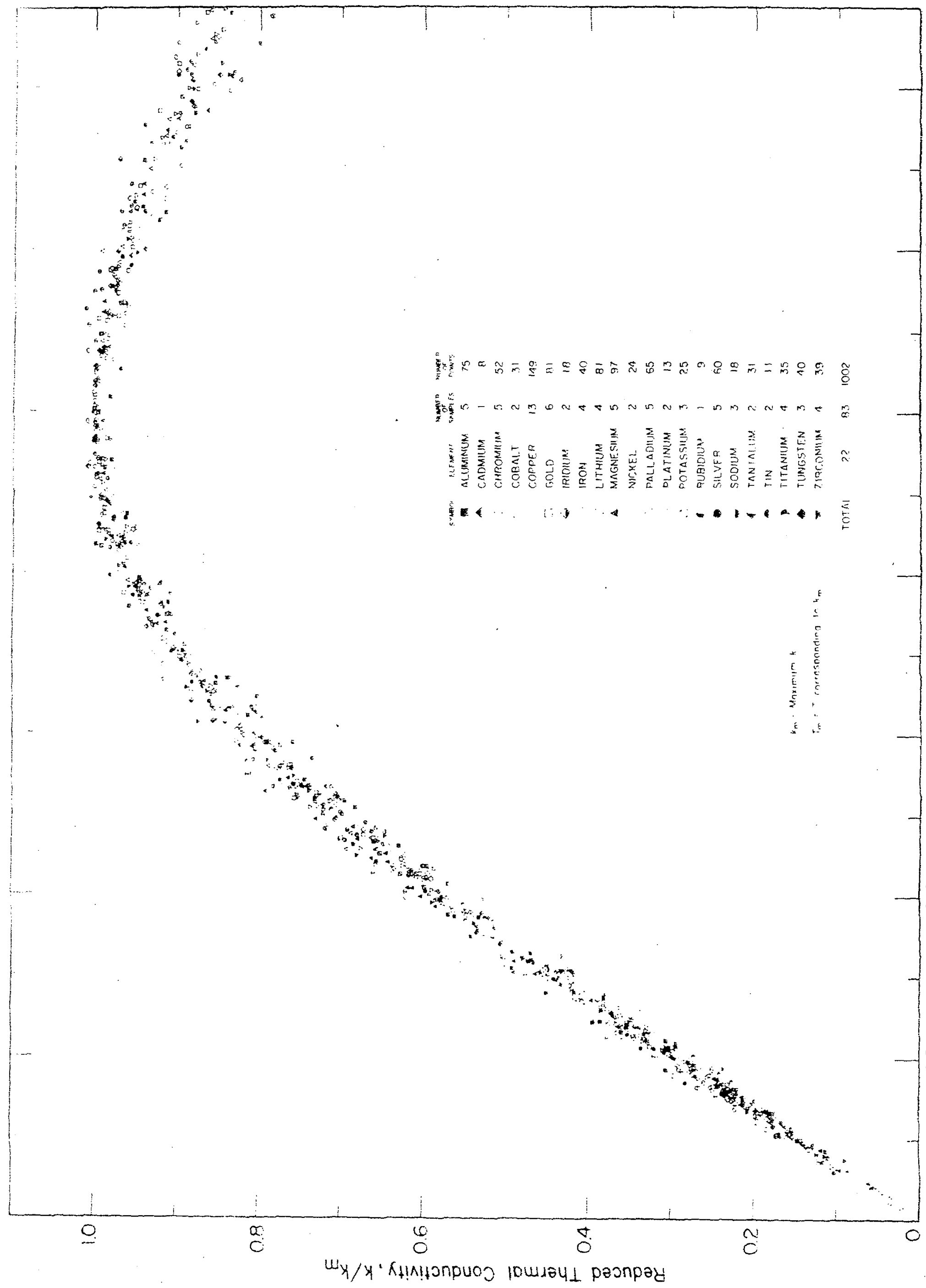


FIGURE 1. REDUCED THERMAL CONDUCTIVITY AS A FUNCTION OF REDUCED TEMPERATURE FOR TWENTY-TWO METALS AT CRYOGENIC TEMPERATURES

TABLE 1. CONSTANTS FOR LOW-TEMPERATURE THERMAL CONDUCTIVITY CALCULATIONS USING EQUATIONS (7) AND (8)

Element	m	n	$\alpha'' \times 10^4$
Aluminum	2.62	2.00	0.0479
Cadmium			
(// to c-axis)	5.00	4.50	0.0468
(⊥ to c-axis)	5.00	4.50	0.0468
(polycrystalline)	5.00	4.50	0.0468
Chromium	2.20	2.00	0.592
Cobalt	2.20	2.10	0.540
Copper	2.63	2.21	0.0423
Gallium			
(// to a-axis)	2.78	2.00	2.04
(// to b-axis)	2.78	2.00	0.806
(// to c-axis)	2.78	2.00	6.57
Gold	2.46	2.00	0.460
Indium	3.00	2.00	3.50
Iridium	4.40	3.00	0.000272
Iron	2.20	2.00	0.517
Lead	3.50	3.00	4.12
Lithium	2.25	2.00	0.774
Magnesium	2.10	2.00	0.627
Molybdenum	3.20	2.60	0.00967
Nickel	2.60	2.00	0.192
Niobium	2.00	2.00	6.21
Osmium	5.80	3.00	0.00000379
Palladium	2.40	2.00	1.54
Potassium	2.10	2.00	18.0
Rhenium	3.30	2.20	0.0656
Rhodium	3.00	2.80	0.0132
Ruthenium	5.80	2.60	0.00000321
Silver	2.75	2.20	0.0730
Sodium	2.13	2.00	2.89
Tantalum	2.54	2.00	1.39
Thallium	2.80	2.00	26.2
Thorium	2.80	2.79	1.75
Titanium	2.90	2.30	0.188
Tungsten	2.80	2.40	0.0539
Zinc	3.40	3.00	0.0750
Zirconium	2.40	2.00	3.99

have included purer samples yielding much lower values for β, but to use these values seems unwise at present as some doubt exists as to the validity of this simple treatment for samples of much greater purity, especially for transition metals. There is some evidence [17–19] that electron-electron scattering may become important for exceedingly high-purity samples and necessitate one additional term γT such that

$$k=[\alpha T^{n}+\beta T^{-1}+\gamma T]^{-1}\cdot \tag{10}$$

Also, for many of the elements available data are insufficient to determine the constants m, n, and α'' of equation (8).

A further complication may arise with metallic samples of very high purity in that boundary scattering can become important and render the thermal conductivity at very low temperatures dependent on the size of sample or on that of the individual crystallites of which it is composed. Since the late 1930's, see for instance the work of Casimir [20], size dependence has been known for the thermal conductivity of nonmetallic crystals but measurements by Olsen and Wyder [21] and by Boughton and Yaqub [22] have more recently directed attention to the influence of crystal size on the electronic thermal conductivity of a metal of sufficiently high physical and chemical purity. Isotopic content is another factor that has been shown to influence the thermal conductivity at low temperatures. See for instance the work on an isotopically enriched germanium by Geballe and Hull [23], on tellurium by Oskotskii et al. [24], and on solid helium by Berman et al. [25] (see also [26]).

As the temperature rises from the liquid-helium temperature region, the value of the Lorenz function falls quite appreciably to a minimum, but near the Debye temperature it again tends asymptotically towards the theoretical value (see, e.g. Wilson [27], Makinson [4]). For some metals including the transition metals definitely higher values of the Lorenz function may be attained, but the excess seldom exceeds about 30 percent. It follows that in the region from about normal to high temperatures the Lorenz function is generally reasonably close to the theoretical value, and for a particular metal follows a fairly predictable departure curve. Thermal conductivity values can then be calculated from the derived, assumed, or experimentally determined Lorenz function values as a function of temperature and from the measured electrical resistivity data. Considerable use of the Lorenz relationship has therefore been made, both when analyzing thermal conductivity data in the above-normal temperature region and when attempting to make estimations or extrapolations in this range.

For elements such as gallium and yttrium, whose transport properties are strongly anisotropic, uncertainties are associated with the derivation of values from single crystal data that would apply to a polycrystalline sample.

Consider an orthorhombic crystal, such as that of gallium, for which k_a, k_b, and k_c are the thermal conductivity values for the three main crystal axes a, b, and c, and k_p is the thermal conductivity of the polycrystal. By considering the conductivities to be additive, Voigt [28] showed that

$$k_p=\frac{1}{3}\,(k_a+k_b+k_c)\,. \tag{11}$$

If however the thermal resistivities are considered to be additive, which Hall, Legvold, and Spedding [29] regarded to be preferable in the case of rods of yttrium, then

$$\frac{1}{k_p}=\frac{1}{3}\left(\frac{1}{k_a}+\frac{1}{k_b}+\frac{1}{k_c}\right) \tag{12}$$

or

$$k_p=\frac{3k_ak_bk_c}{k_ak_b+k_ak_c+k_bk_c}\,\cdot \tag{13}$$

For gallium at 300 K, $k_a=0.406$, $k_b=0.883$, and $k_c=0.159$ W cm^{-1} K^{-1}. Hence the values of k_p according to equations (11) and (12) are respectively 0.483 and 0.304 W cm^{-1} K^{-1}, and differ by some ± 25 percent from the mean value of 0.393 W cm^{-1} K^{-1}. A more recent treatment, in which Hashin and Shtrikman [30] used a variational method, shows that for the case where $k_c<k_a<k_b$

$$\frac{k_b(4k_b^2+8k_bk_a+8k_ck_b+7k_ak_c)}{16k_b^2+5k_bk_a+5k_ck_b+k_ak_c}$$

$$>k_p>\quad\frac{k_c(4k_c^2+8k_ck_a+8k_ck_b+7k_ak_b)}{16k_c^2+5k_ck_a+5k_ck_b+k_ak_b} \tag{14}$$

which leads to extreme values of 0.444 and 0.377 W cm^{-1} K^{-1} for k_p in the case of gallium at 300 K. The treatment embraces a narrower ($\pm 8\%$) range of values and gives a mean of 0.410 W cm^{-1} K^{-1} which happens to be only about 1 percent greater than k_a. In this instance the value of k_a has been taken as representing approximately the thermal conductivity of polycrystalline gallium, but it is clear that more attention could well be devoted both experimentally and theoretically to this problem. Electrical conductivity would behave similarly and this property is likely to be measurable with greater accuracy, although high accuracy would not be so necessary with the large differences indicated for gallium. A practical difficulty could however arise in this instance from the ease with which gallium solidifies in the single crystal form, and the difficulty experienced so far in preparing truly polycrystalline samples of this metal.

In this work, the mean of the values given by equations (10) and (11) has been adopted as the value for a polycrystalline sample of an element of large anisotropy.

In connection with the thermal conductivity of molten metals, reference will frequently be made to estimated values that are due to Grosse [31, 32]. These values have been derived from the melting to the critical point using the equation $k=L_0\sigma T$ with derived values for the electrical conductivity, σ, and usually assuming the theoretical Lorenz number, L_0, to hold throughout the range. To derive an expression for the electrical conductivity, Grosse has proposed an equation of the form of a simple equilateral hyperbola [33]

$$(\sigma'+b)\ (T'+b)=a \tag{15}$$

where the reduced electrical conductivity $\sigma'=\sigma_T/\sigma_f$, the reduced temperature $T'=(T-T_f)/(T_c-T_f)$, σ_f is the electrical conductivity of the molten metal at the melting point, and σ_T is the electrical conductivity at a temperature T between T_f, the melting point, and T_c, the critical temperature. The quantities a and b are constants. At T_c both σ and k are assumed to be zero.

Since these predictions were made, increasing uncertainty has developed as to the Lorenz function of molten metals and its variation with temperature. Previous work, for instance of Powell [34], had indicated the Lorenz function to approximate to the theoretical value, as was assumed by Grosse [31, 32], but according to the work of Filippov [35] on tin and lead and some other recent measurements [36, 37] the Lorenz function continues to decrease with increase in temperature to values that are well below L_0. This uncertainty needs resolving and, pending confirmation and theoretical support for the lower values, values closer to those of Grosse have provisionally been adopted in the present work.

2.2. Data Evaluation

The data analysis and synthesis employed in this work have included critical evaluation of the validity and accuracy of available data and related information, resolution and reconciliation of disagreement in conflicting data, correlation of data in terms of various parameters (sometimes in reduced forms using the principle of corresponding states), curve fitting with theoretical or empirical equations, and comparison of resulting data with theoretical predictions or with results derived from semi-theoretical relationships or from generalized empirical correlations. Besides critical evaluation and analysis of the existing data, thermodynamic, kinetic, or statistical mechanical principles and semiempirical techniques have been employed to fill gaps and to extrapolate existing data so that the resulting recommended values are internally consistent and cover as wide a range of the controlling parameters as possible.

In the critical evaluation of the validity and uncertainty of a particular set of data, say, the thermal conductivity of a solid substance, the temperature dependence of the thermal conductivity has been examined and any unusual dependence or anomal carefully investigated, the experimental techniqu reviewed to see whether the actual boundary condition in the experiment agree with those assumed in the theory, and the author's estimations of uncertainties checked to ensure that all the possible sources of errors have been considered. For a steady-state absolute measurement of the thermal conductivity of a solid specimen, for example, the sources of errors may include the uncertainty in the measurements of specimen dimensions and of the distances between points of temperature measurements; the uncertainty due to the effect of thermal expansion; the uncertainty in determining the power input to the specimen heater; the uncertainty in determining the heat gains or losses to or from the specimen due to direct radiation interchange or to conduction through the surrounding insulation, along the electric leads, and along the thermocouple wires and the ceramic insulating tubings or beads; the uncertainty in temperature measurements due to poor thermocouple calibration, poor thermocouple contact, poor sensitivity of the measuring circuits, and temperature drift; the uncertainty due to thermal contact resistance; the uncertainty for measurements at elevated temperatures due to thermocouple contamination, specimen oxidation, or reaction of specimen with apparatus components; etc. In a comparative measurement, additional uncertainties may come from the conductivity mismatch between the specimen and the reference sample(s), from the additional interfacial thermal contact resistance, and from the additional uncertainty in the conductivity of the reference sample (especially, if the conductivity values of the "reference" sample are blindly taken from a handbook). For a nonsteady-state measurement, large uncertainty may result if the density and specific heat values are taken from the literature and not directly measured on the specimen for which the thermal diffusivity data are obtained. The abovementioned and other possible sources of errors have been carefully considered in this work.

Many authors have included detailed error estimates in their published papers, and from these it is possible to evaluate the uncertainty for a particular method. However, experience has shown that the uncertainty estimates of most authors are unreliable. In many cases the difference between the results of two sets of data is much larger than that given by the sum of their stated uncertainties. Cases even occur where measurements reported to be accurate to within 1 or 2 percent differ from each other by more than 100 percent. In these cases either the actual error must greatly exceed its estimated value, or the author was unaware of the additional sources of error, or there must be essential unrecorded sample differences.

Besides evaluating and analyzing individual data sets, correlation of data in terms of various relevant parameters is a valuable technique that is frequently used in data analysis. These parameters may include purity, composition, residual electrical resistivity or electrical resistivity ratio (if a metal), density or porosity, hardness, crystal axis orientation, degree of cold working, degree of heat treatment, etc. Applying the principle of corresponding states, reduced property values may be correlated with reduced temperature and other reduced parameters. Certain properties of the elements may also be correlated with the atomic numbers of the elements in the periodic system. Examples are critical temperatures, critical pressures, critical volumes, and atomic volumes at 0 K. Wherever appropriate, such correlation techniques have been applied to the thermal conductivity of the elements in the present work.

Several properties of the same material can also be cross-correlated. For example, thermal conductivity, specific heat, and density can be correlated with thermal diffusivity, and viscosity and specific heat of a gas can be correlated with thermal conductivity through the Chapman-Enskog theory or through the experimental Prandtl number. For a fluid, the property of the saturated liquid may also be correlated with that of the saturated vapor.

For meaningful data correlation, the information on specimen characterization is very important, especially for solid specimens. A full description of a solid specimen should include, whenever applicable, the following: purity or chemical composition, carrier concentration; type of crystal, crystal axis orientation for a single crystal; microstructure, grain size, preferred grain orientation, pore size and shape and orientation, inhomogeneity and additional phases for a polycrystalline specimen; specimen shape and dimensions, method and procedure of fabrication; thermal history and cold work history, heat treatment, mechanical, irradiative, and other treatments; manufacturer and supplier, stock number, and catalog number; test environment, degree of vacuum or pressure, heat flow direction, strength and orientation of an applied magnetic field; pertinent physical properties such as density, porosity, hardness, electrical resistivity (residual, ratio, and temperature variations), Lorenz function, transition temperature, etc.; and reference material and its property values for a comparative method of measurement. Data (no matter how accurate) on poorly characterized materials can hardly be analyzed or used for data correlation. It has been found in this and other studies that the specimen purity or composition reported by the author is often unreliable. This is because in many cases the stated purity or composition is the result of ladle analysis which the author obtained from the company who supplied the specimen and it can at best represent only the nominal purity or composition. In other cases there is a strong tendency for only certain elements to be covered by a chemical analysis, which could miss other quite important constituents.

Besides specimen characterization, a full description of experimental details should, of course, be given by the author in order that his data can be meaningfully evaluated and fully utilized. Sometimes, as an initial method of evaluating the quality of a paper, consideration has been given to the amount of experimental details reported in the paper. Lack of experimental details has led to the results being given less weight.

In estimating the degree of uncertainty of our recommended values for the various ranges of temperature, it is apparent from the above discussion that only for the few much studied materials has it been possible to place close error limits that can be considered reliable. For the less well studied materials, wider limits of uncertainty are generally given; these are based on other factors and considerations such as general knowledge of the worker, the accuracy of measurements of other materials using the same or similar apparatus, etc. The estimated uncertainty also takes into consideration behavior of the material itself. For a well-behaved material narrower limits are given when the temperature dependence is predictable from theoretical considerations or from empirical correlations. For an ill-behaved material or a material with phase or magnetic transformation, such as the rare earths, the estimated uncertainties are greater. For the recommended values of the thermal conductivity of fluids, the uncertainty estimation is based on the degree of agreement of our values with those proposed by other experimental or analysis specialists, coupled with a more personal opinion of the experimental accuracy of the existing measurement techniques. Finally, the scatter around the recommended value of those experimental points considered reliable has been included in the uncertainty estimates.

2.3 Summary Graphs

With a view to bringing out any similarities or differences between the proposed values for the elements of a particular group of the periodic table, these values for all the elements of each group have been plotted in figures 2 to 13, which show some of the generalizations for the property of thermal conductivity that were mentioned at the beginning of this section. These figures may prove helpful when making estimations to temperatures not covered in the sections which follow. In figure 14 the thermal conductivity of each element at 300 K is plotted against the atomic number of the element. A fairly definite pattern can be traced, and this has been of assistance in deriving estimated values for certain elements for which no information is available. These include actinium, francium, and the trans-plutonium elements. Estimated values for barium, calcium, europium, polonium, protactinium, and strontium have also been based on electrical resistivity data, and those for radon are based mainly on a generalized correlation by Owens and Thodos [38]. The value for radium comes from collected data by Samsonov [39], and is attributed to Chirkin [40], but no details are given.

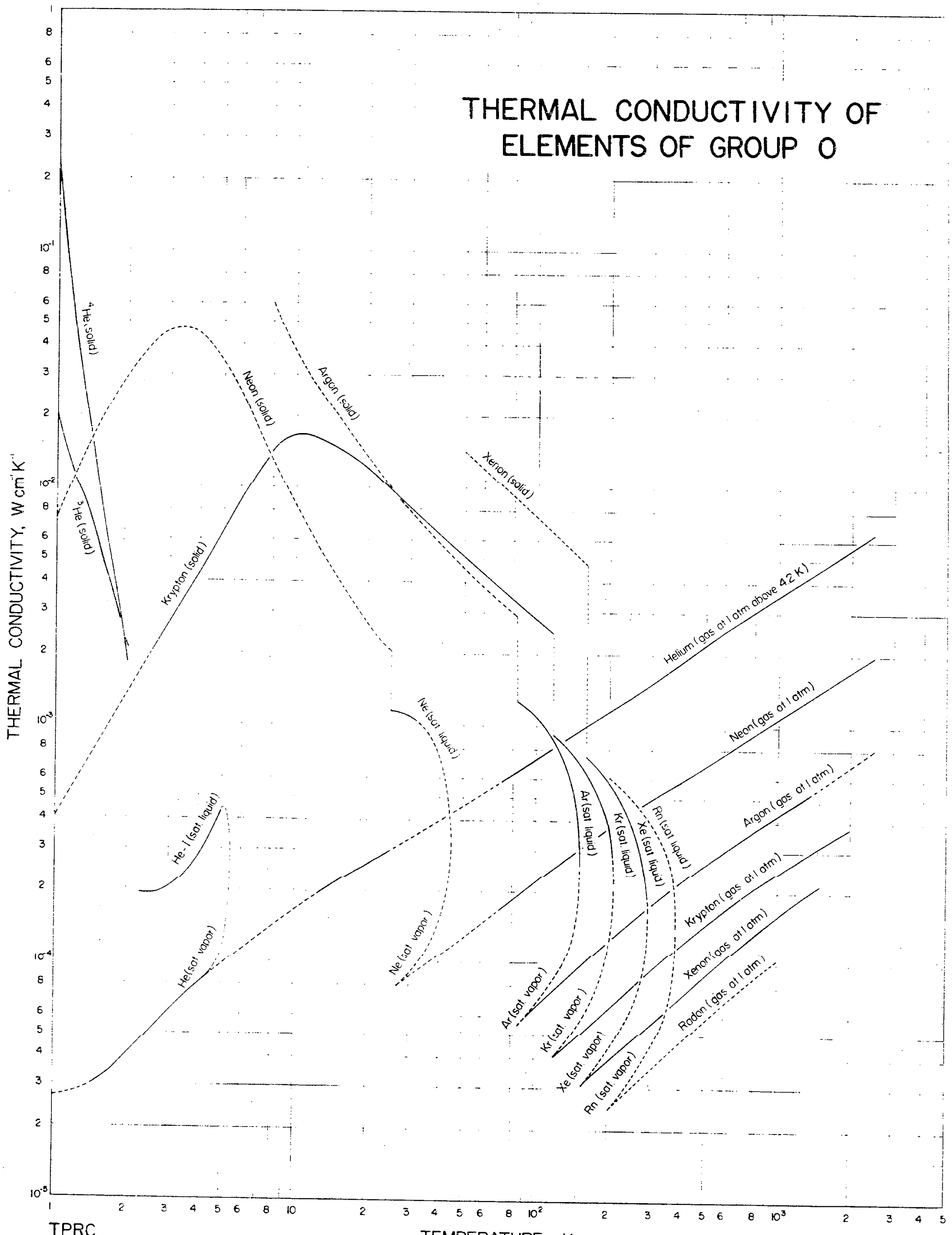
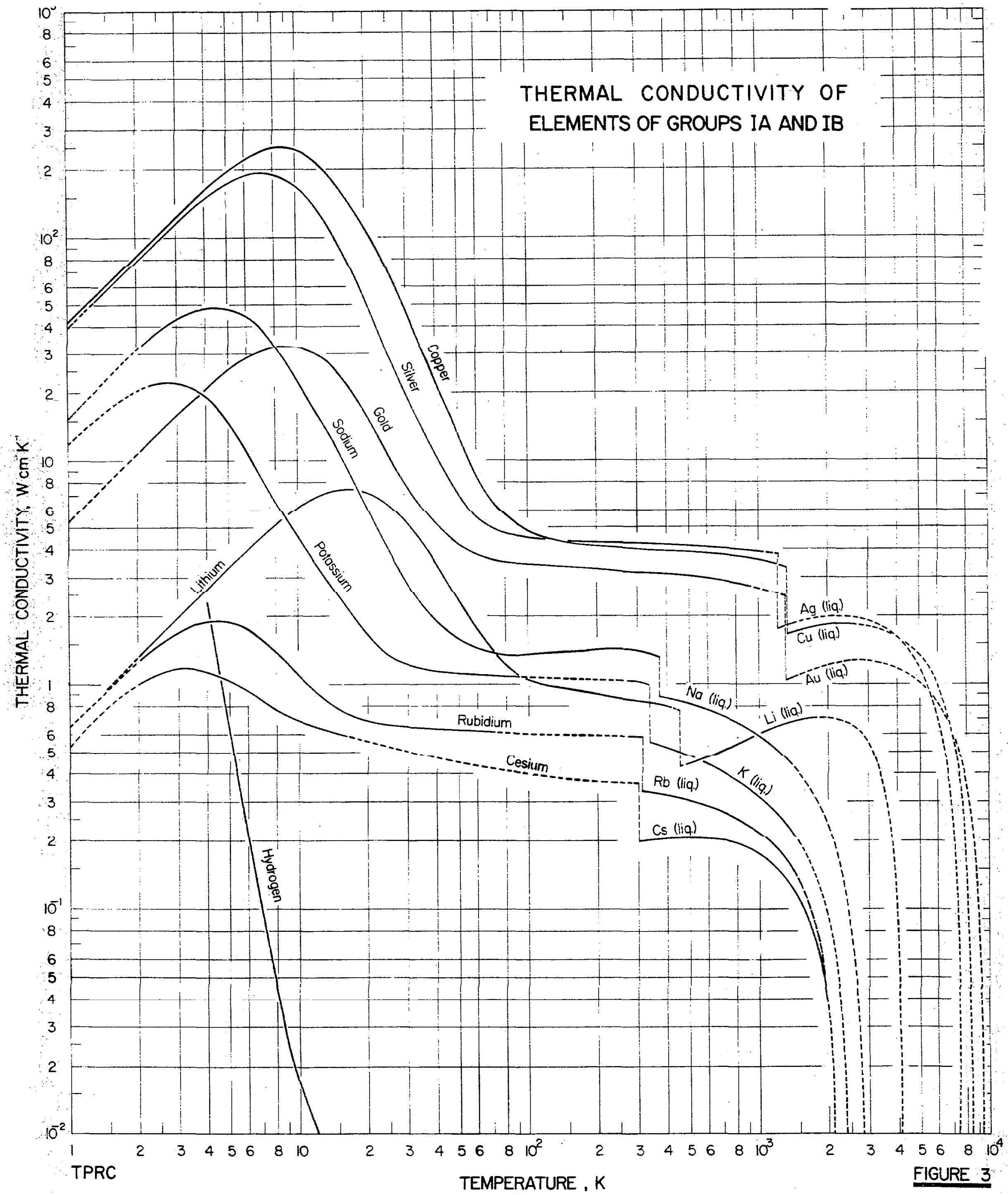
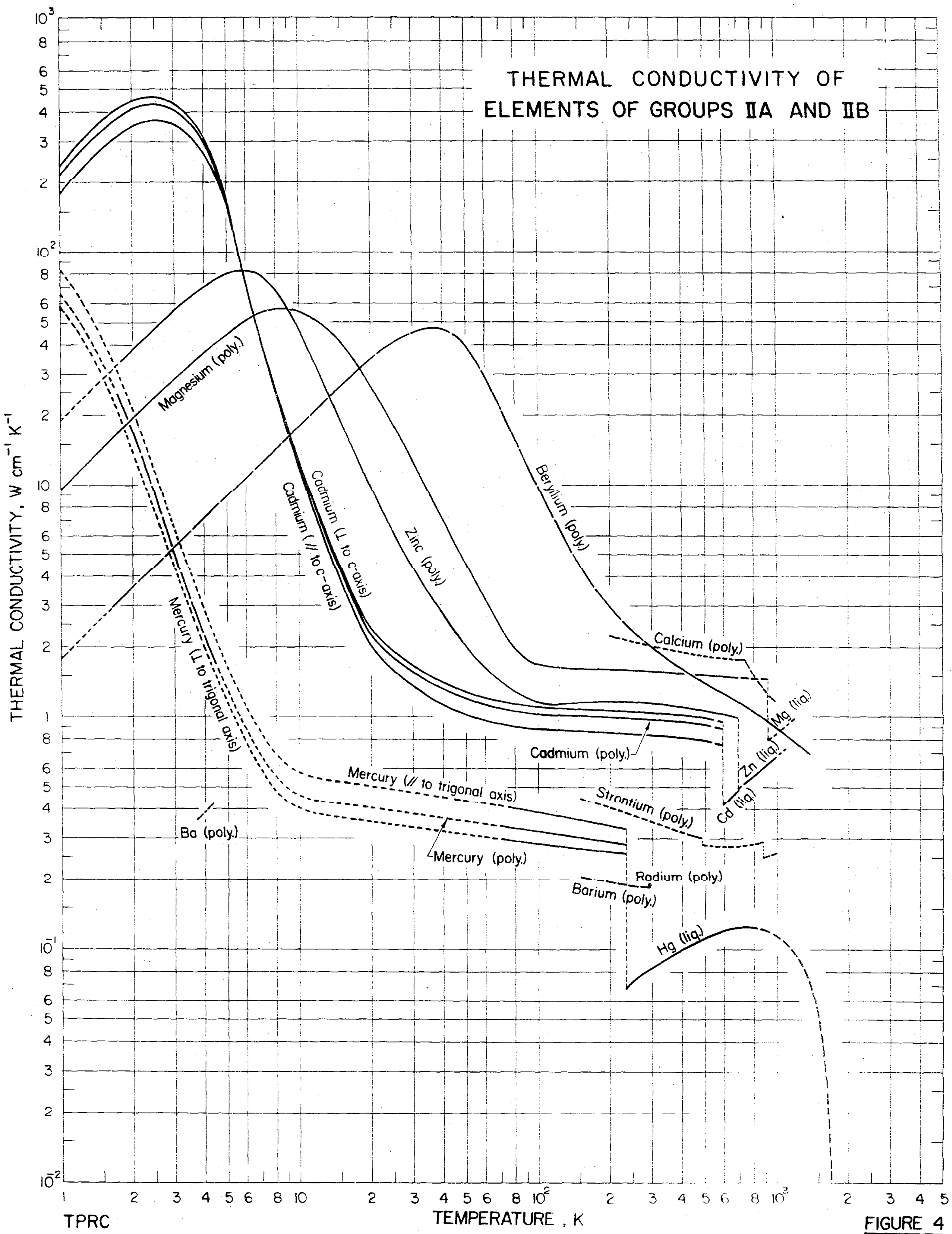

THERMAL CONDUCTIVITY OF ELEMENTS OF GROUP O
THERMAL CONDUCTIVITY, W cm⁻¹ K⁻¹
TEMPERATURE, K
⁴He (solid)
³He (solid)
Neon (solid)
Argon (solid)
Krypton (solid)
Xenon (solid)
Helium (gas at 1 atm above 4.2 K)
Neon (gas at 1 atm)
Argon (gas at 1 atm)
Krypton (gas at 1 atm)
Xenon (gas at 1 atm)
Radon (gas at 1 atm)
He-I (sat. liquid)
He (sat. vapor)
Ne (sat. liquid)
Ne (sat. vapor)
Ar (sat. liquid)
Ar (sat. vapor)
Kr (sat. liquid)
Kr (sat. vapor)
Xe (sat. liquid)
Xe (sat. vapor)
Rn (sat. liquid)
Rn (sat. vapor)
TPRC

FIGURE 2



THERMAL CONDUCTIVITY OF ELEMENTS OF GROUPS IA AND IB
THERMAL CONDUCTIVITY, W cm⁻¹ K⁻¹
TEMPERATURE, K
Copper
Silver
Gold
Sodium
Potassium
Lithium
Rubidium
Cesium
Hydrogen
Ag (liq.)
Cu (liq.)
Au (liq.)
Na (liq.)
Li (liq.)
K (liq.)
Rb (liq.)
Cs (liq.)
TPRC

FIGURE 3


THERMAL CONDUCTIVITY OF
ELEMENTS OF GROUPS IIA AND IIB
THERMAL CONDUCTIVITY, W cm⁻¹ K⁻¹
TEMPERATURE, K
Magnesium (poly.)
Cadmium (⊥ to c-axis)
Cadmium (// to c-axis)
Zinc (poly.)
Beryllium (poly.)
Calcium (poly.)
Mg (liq.)
Zn (liq.)
Cd (liq.)
Cadmium (poly.)
Mercury (⊥ to trigonal axis)
Mercury (// to trigonal axis)
Mercury (poly.)
Strontium (poly.)
Ba (poly.)
Radium (poly.)
Barium (poly.)
Hg (liq.)
TPRC
FIGURE 4

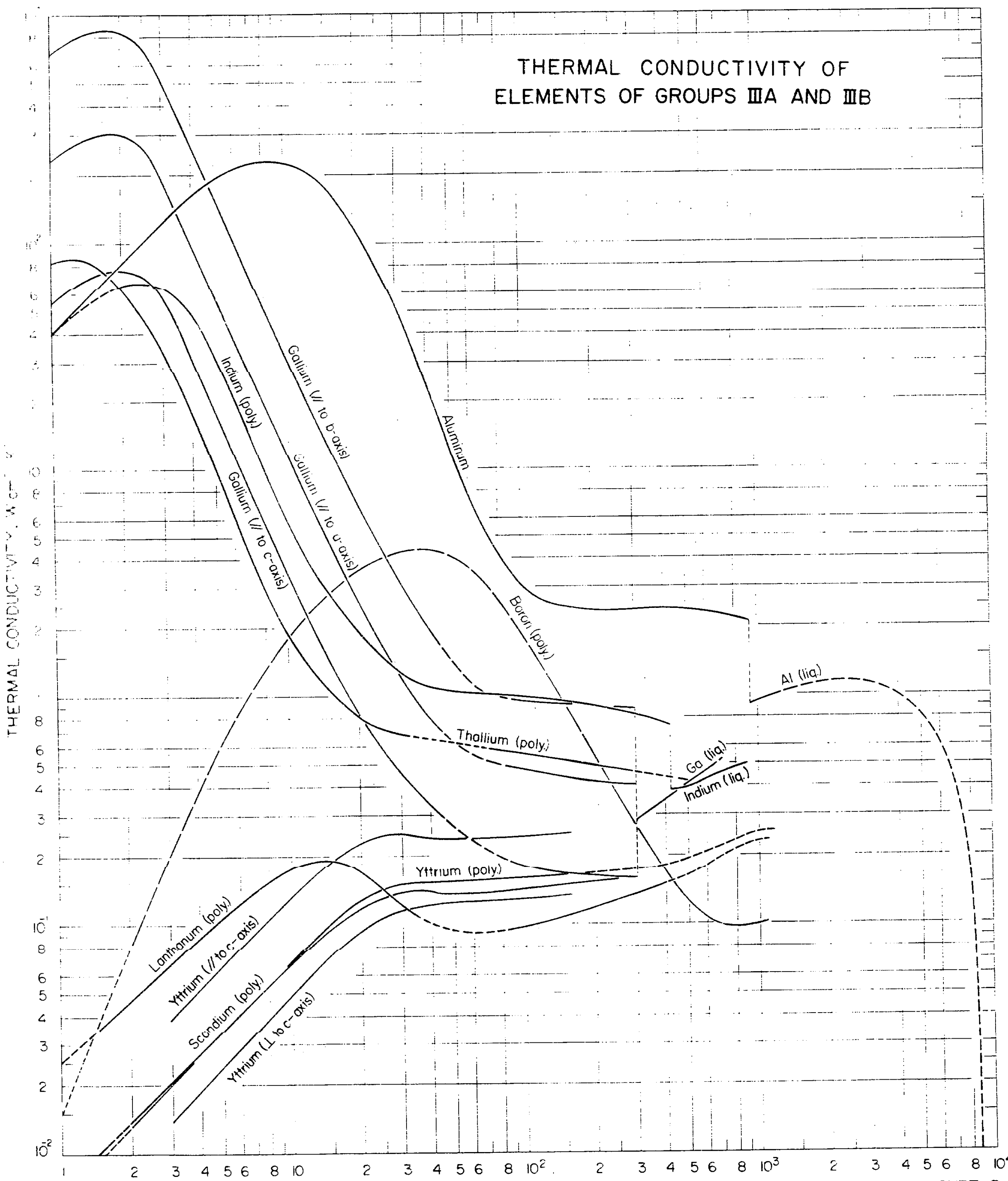

THERMAL CONDUCTIVITY OF
ELEMENTS OF GROUPS IIIA AND IIIB
Aluminum
Gallium (// to b-axis)
Gallium (// to a-axis)
Gallium (// to c-axis)
Indium (poly.)
Boron (poly.)
Thallium (poly.)
Al (liq.)
Ga (liq.)
Indium (liq.)
Yttrium (poly.)
Lanthanum (poly.)
Yttrium (// to c-axis)
Scandium (poly.)
Yttrium (⊥ to c-axis)
8
6
5
4
3
2
10^{-1}
10^{-2}
1 2 3 4 5 6 8 10 2 3 4 5 6 8 10^2 2 3 4 5 6 8 10^3 2 3 4 5 6 8 10^4
TPRC
TEMPERATURE, K

FIGURE 5

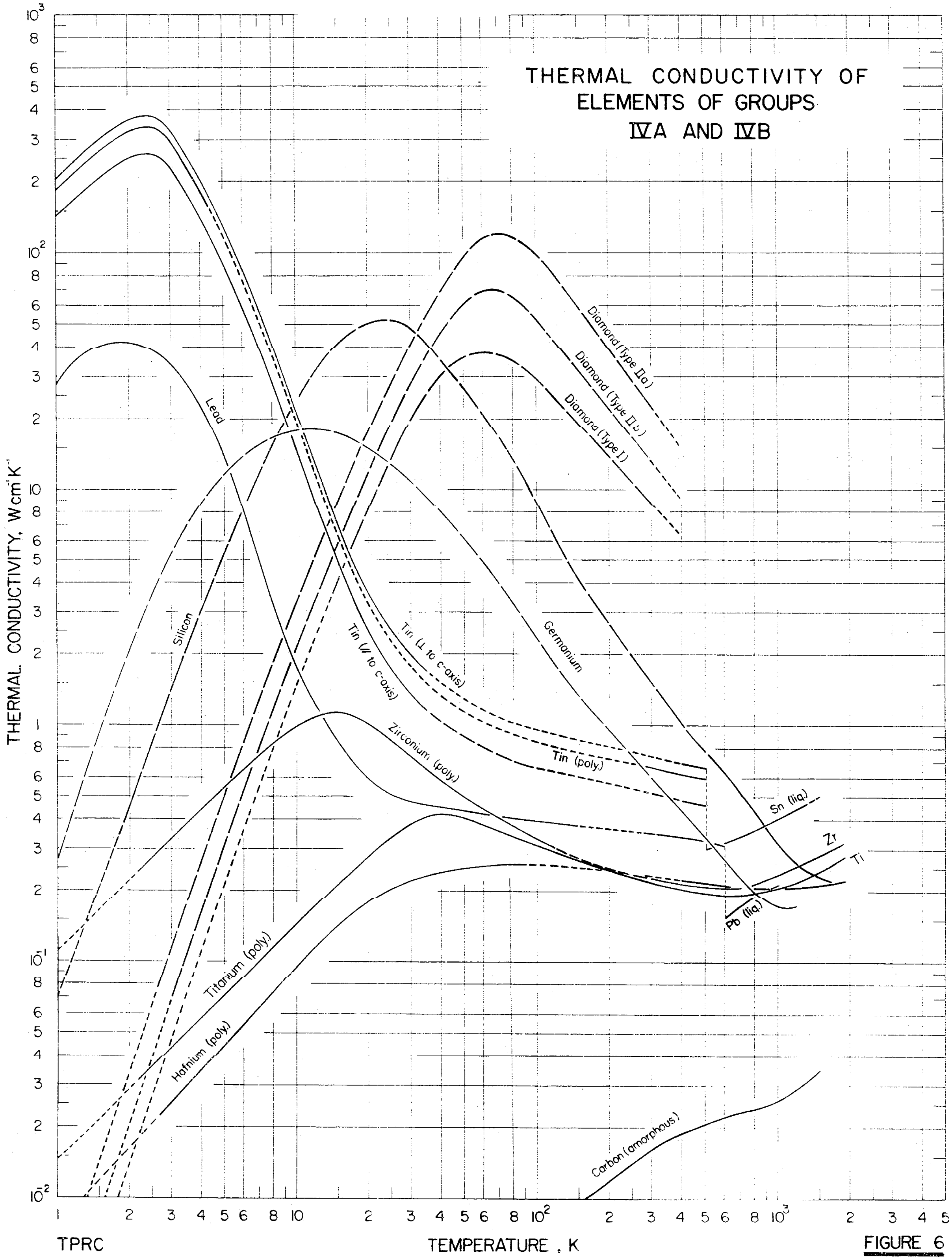
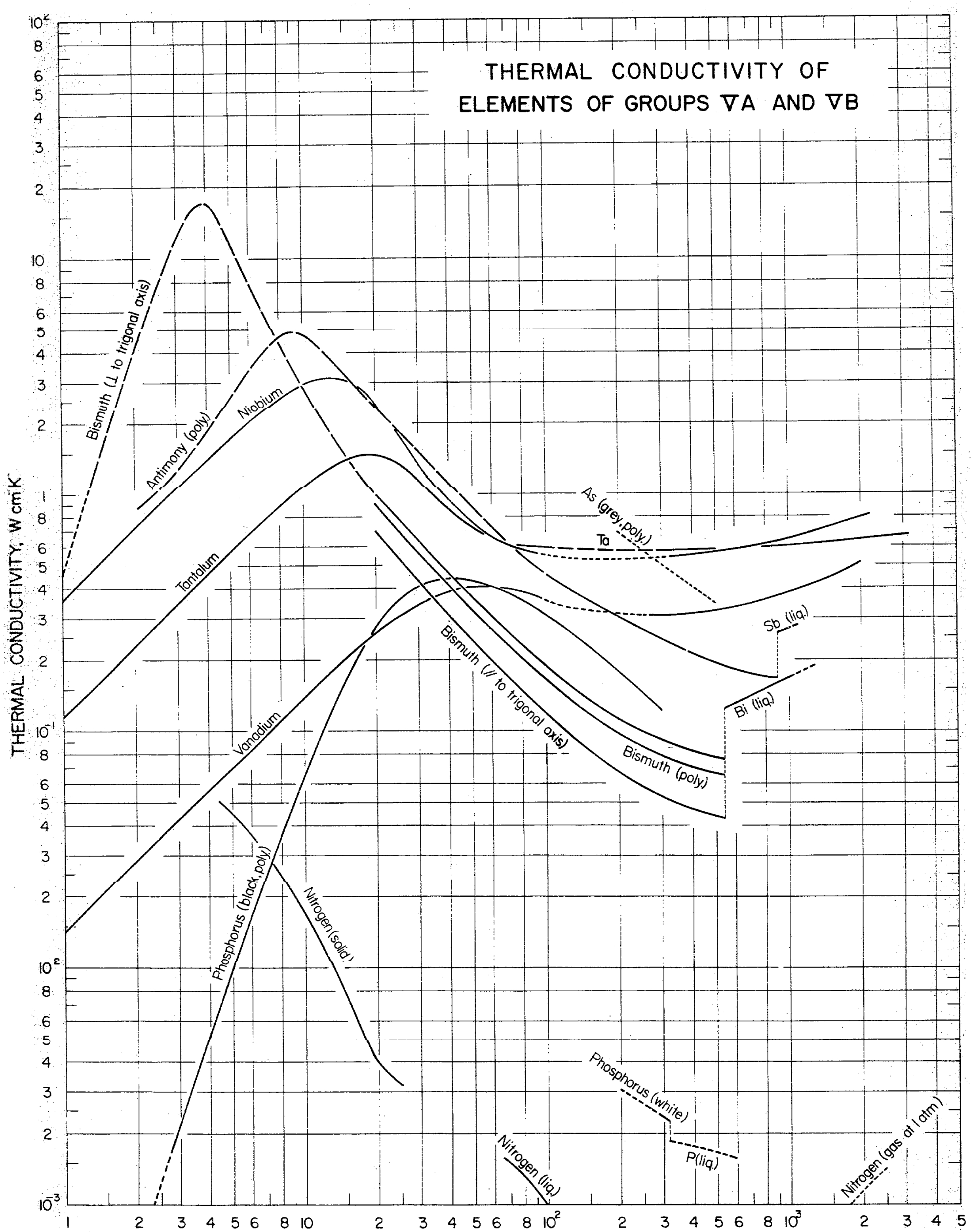
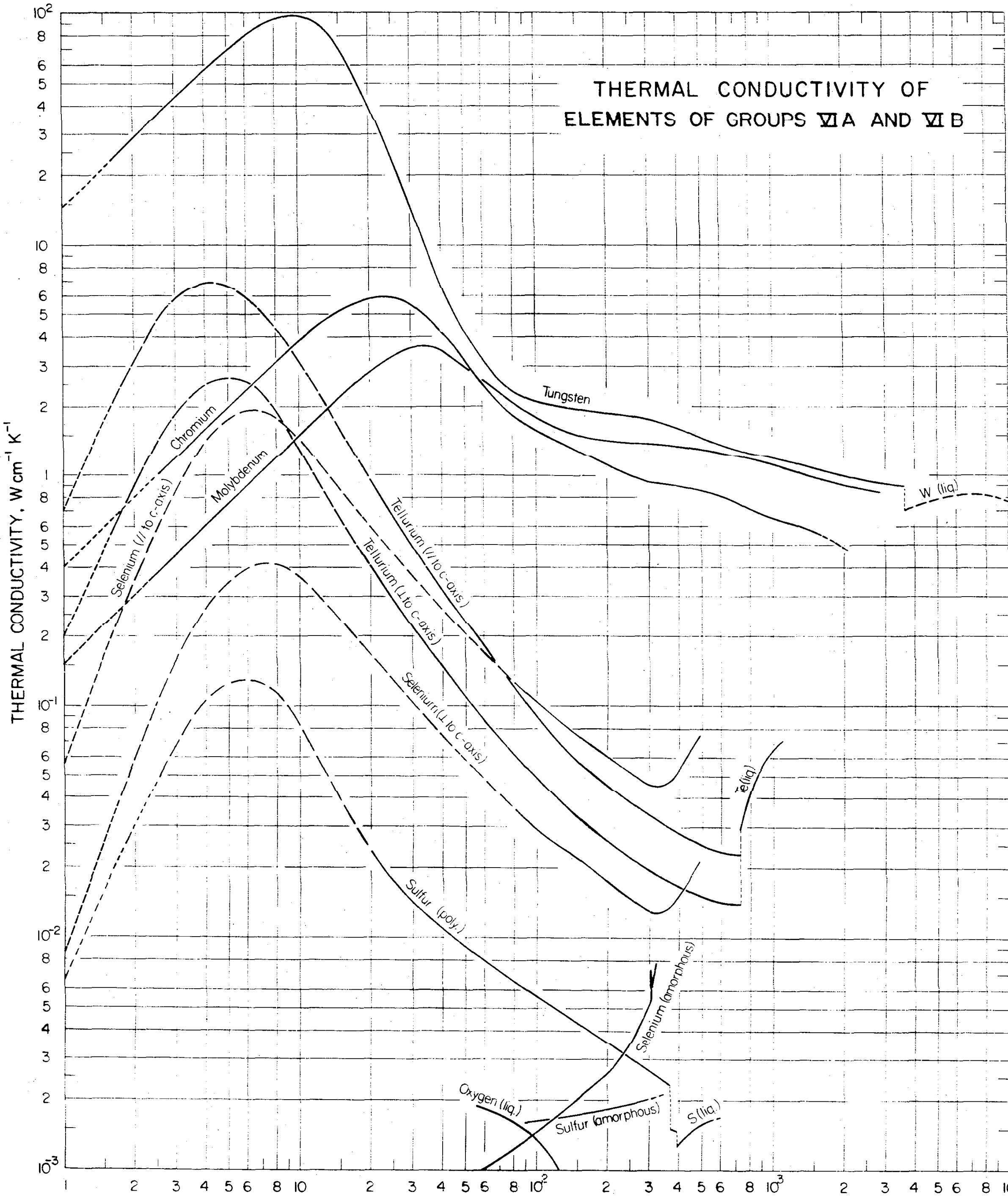

THERMAL CONDUCTIVITY OF
ELEMENTS OF GROUPS
IVA AND IVB
THERMAL CONDUCTIVITY, W cm⁻¹ K⁻¹
TEMPERATURE, K
Diamond (Type IIa)
Diamond (Type IIb)
Diamond (Type I)
Lead
Silicon
Germanium
Tin (⊥ to c-axis)
Tin (// to c-axis)
Tin (poly.)
Zirconium (poly.)
Titanium (poly.)
Hafnium (poly.)
Carbon (amorphous)
Sn (liq.)
Pb (liq.)
Zr
Ti
TPRC

FIGURE 6



TPRC

FIGURE 7


THERMAL CONDUCTIVITY OF
ELEMENTS OF GROUPS VIA AND VIB
THERMAL CONDUCTIVITY, W cm^{-1} K^{-1}
TEMPERATURE, K
Tungsten
W (liq.)
Chromium
Molybdenum
Selenium (// to c-axis)
Tellurium (// to c-axis)
Tellurium (⊥ to c-axis)
Selenium (⊥ to c-axis)
Te (liq.)
Sulfur (poly.)
Selenium (amorphous)
Oxygen (liq.)
Sulfur (amorphous)
S (liq.)
TPRC
FIGURE 8

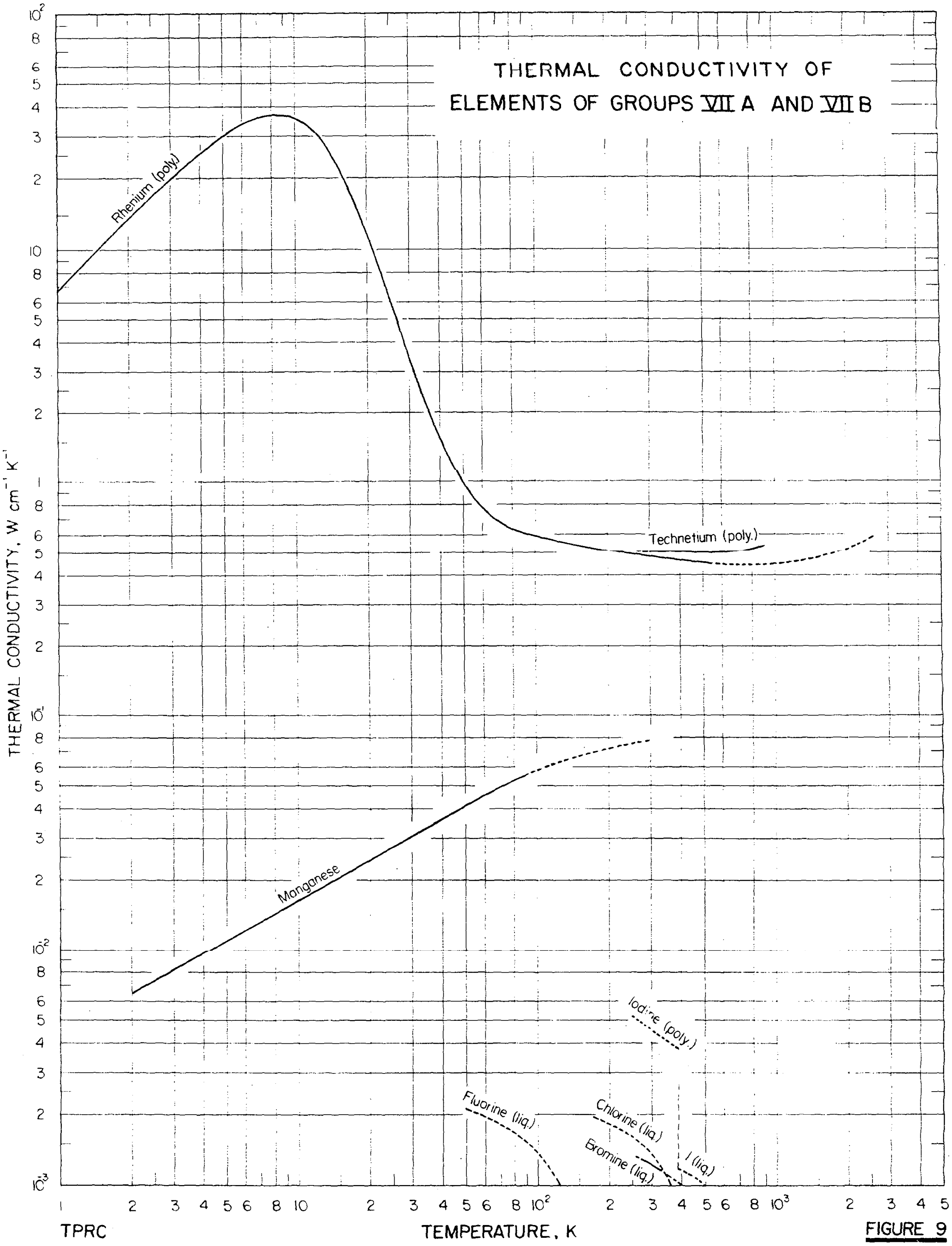

THERMAL CONDUCTIVITY OF
ELEMENTS OF GROUPS VII A AND VII B
Rhenium (poly.)
Technetium (poly.)
Manganese
Iodine (poly.)
Fluorine (liq.)
Chlorine (liq.)
Bromine (liq.)
I (liq.)
THERMAL CONDUCTIVITY, W cm⁻¹ K⁻¹
TEMPERATURE, K
TPRC

FIGURE 9

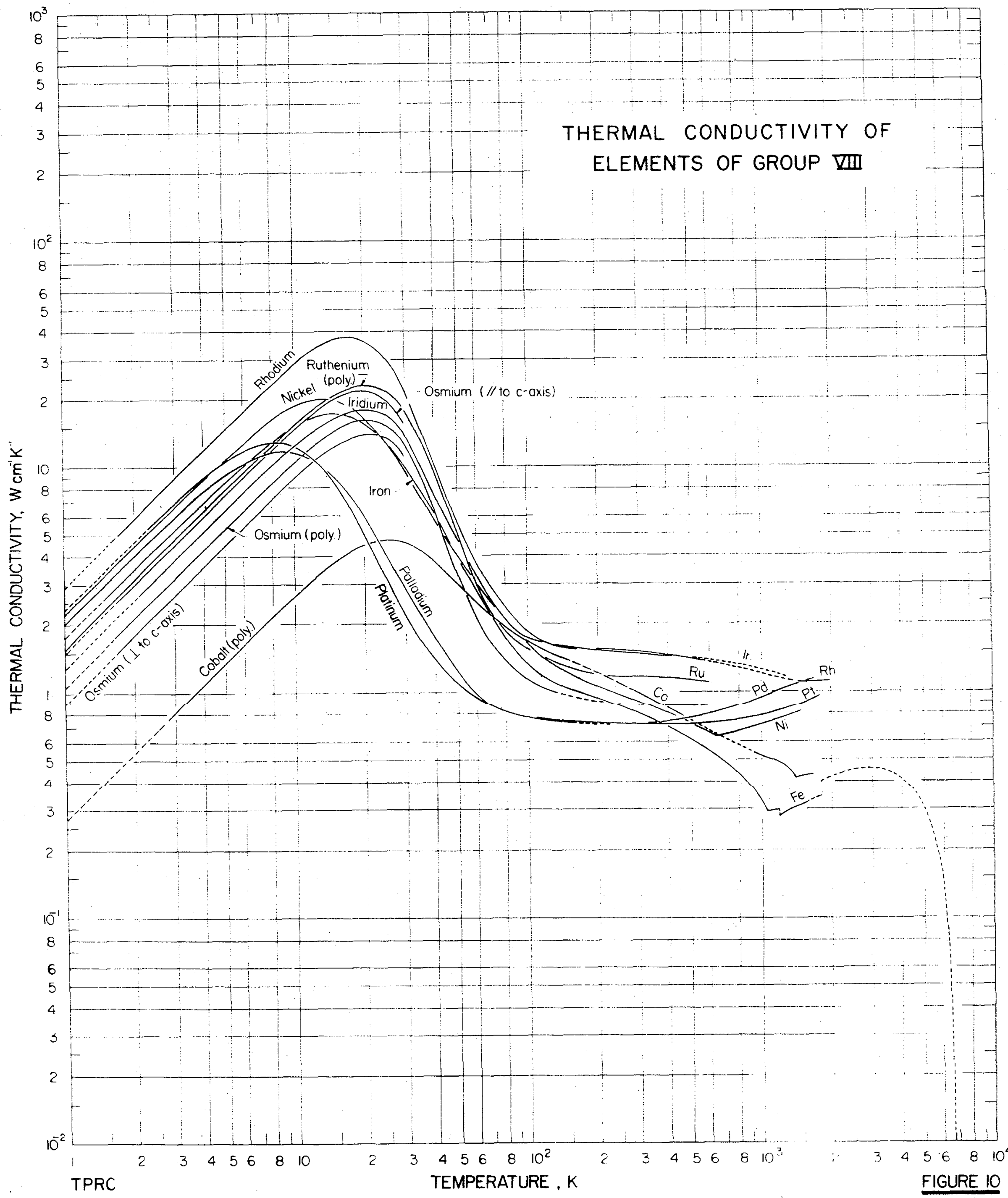

THERMAL CONDUCTIVITY OF
ELEMENTS OF GROUP VIII
THERMAL CONDUCTIVITY, W cm⁻¹ K⁻¹
TEMPERATURE , K
Rhodium
Ruthenium
(poly.)
Nickel
Iridium
Osmium (// to c-axis)
Iron
Osmium (poly.)
Osmium (⊥ to c-axis)
Cobalt (poly.)
Platinum
Palladium
Ir
Ru
Rh
Pd
Pt
Co
Ni
Fe
TPRC

FIGURE 10

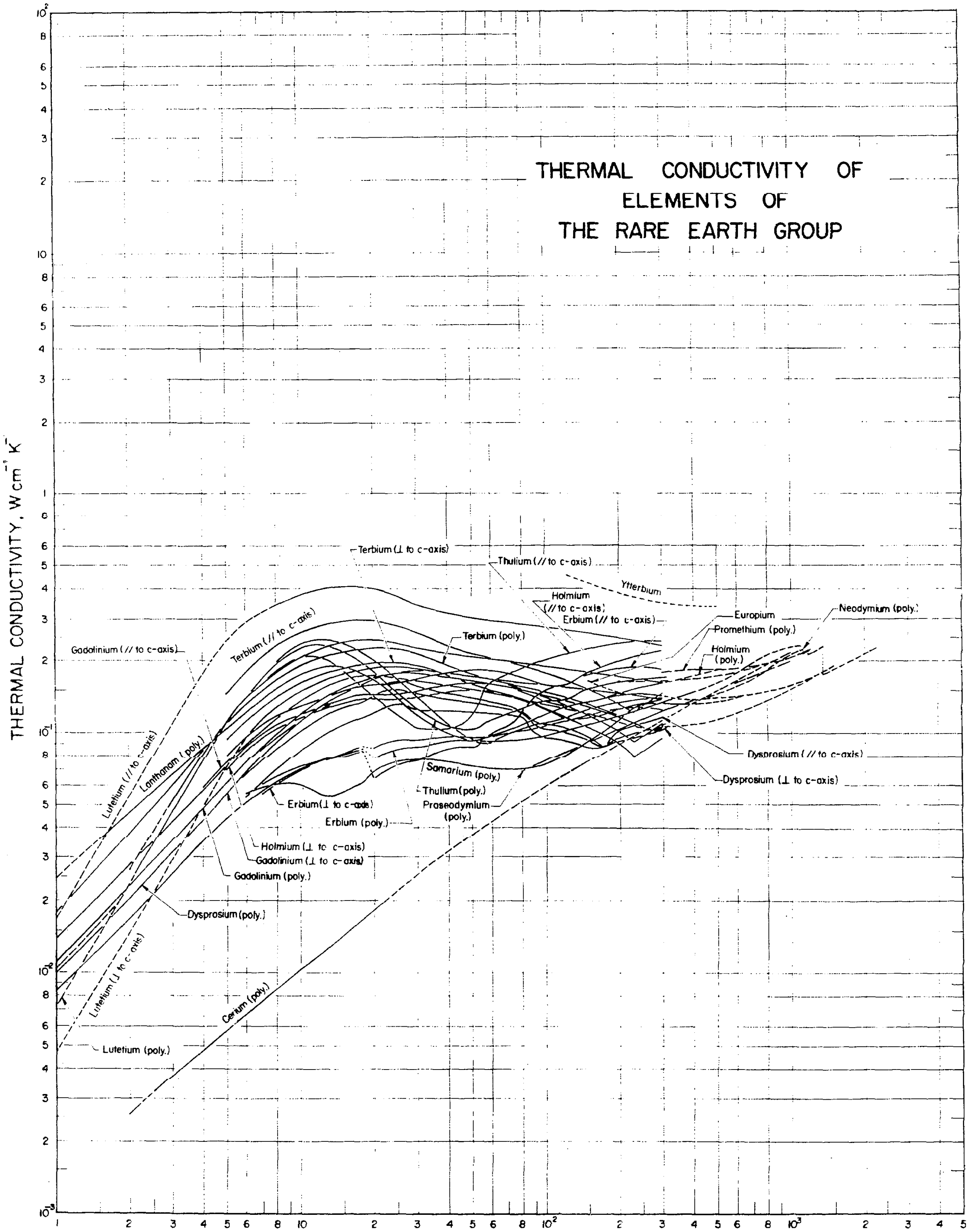
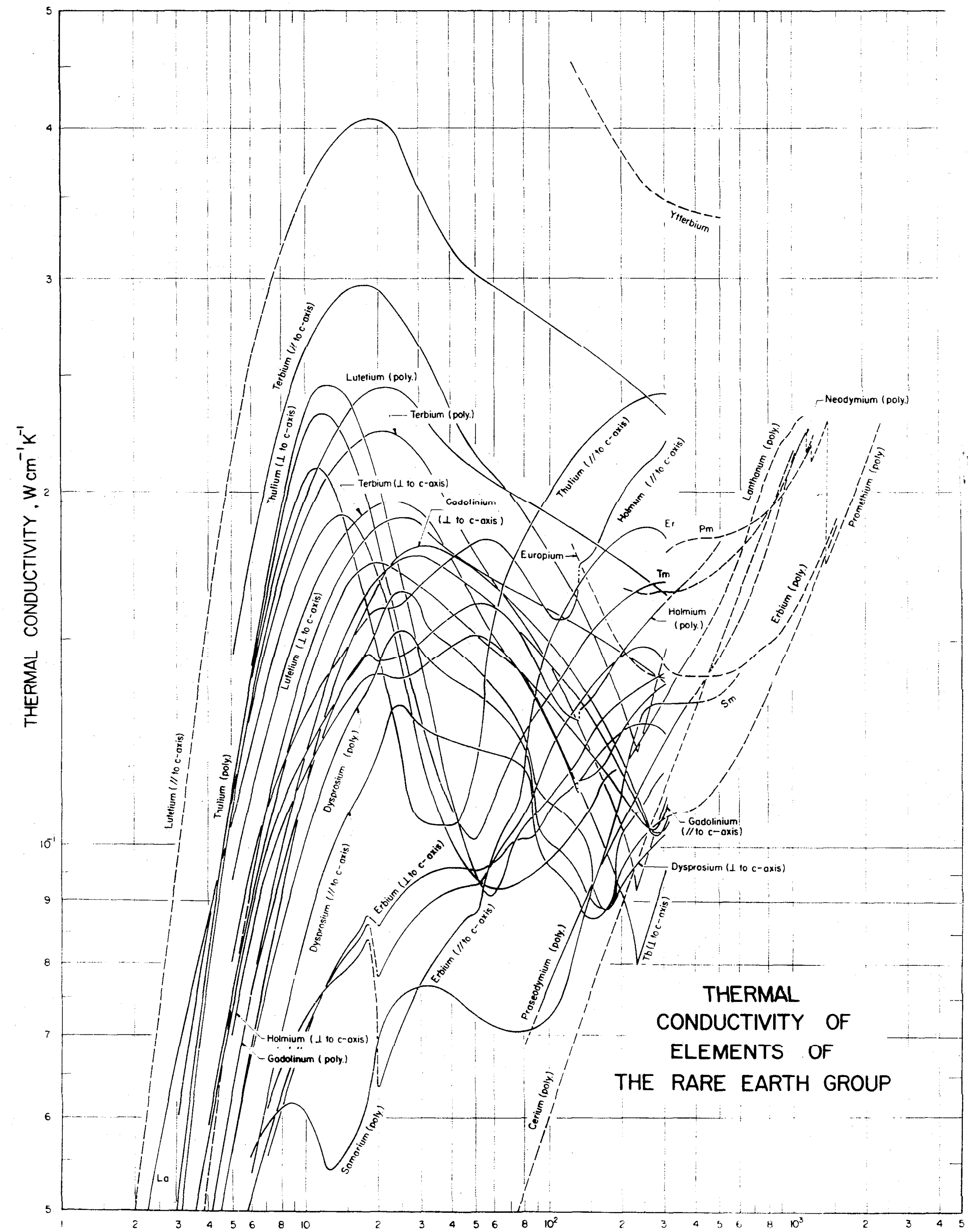

THERMAL CONDUCTIVITY OF
ELEMENTS OF
THE RARE EARTH GROUP
THERMAL CONDUCTIVITY, W cm⁻¹ K⁻¹
TEMPERATURE, K
TPRC
Terbium (⊥ to c-axis)
Thulium (// to c-axis)
Ytterbium
Holmium (// to c-axis)
Erbium (// to c-axis)
Europium
Promethium (poly.)
Neodymium (poly.)
Holmium (poly.)
Terbium (poly.)
Terbium (// to c-axis)
Gadolinium (// to c-axis)
Lutetium (// to c-axis)
Lanthanum (poly.)
Samarium (poly.)
Thulium (poly.)
Praseodymium (poly.)
Erbium (⊥ to c-axis)
Erbium (poly.)
Holmium (⊥ to c-axis)
Gadolinium (⊥ to c-axis)
Gadolinium (poly.)
Dysprosium (poly.)
Dysprosium (// to c-axis)
Dysprosium (⊥ to c-axis)
Lutetium (⊥ to c-axis)
Lutetium (poly.)
Cerium (poly.)

FIGURE 11a



THERMAL CONDUCTIVITY OF ELEMENTS OF THE RARE EARTH GROUP

FIGURE 11b

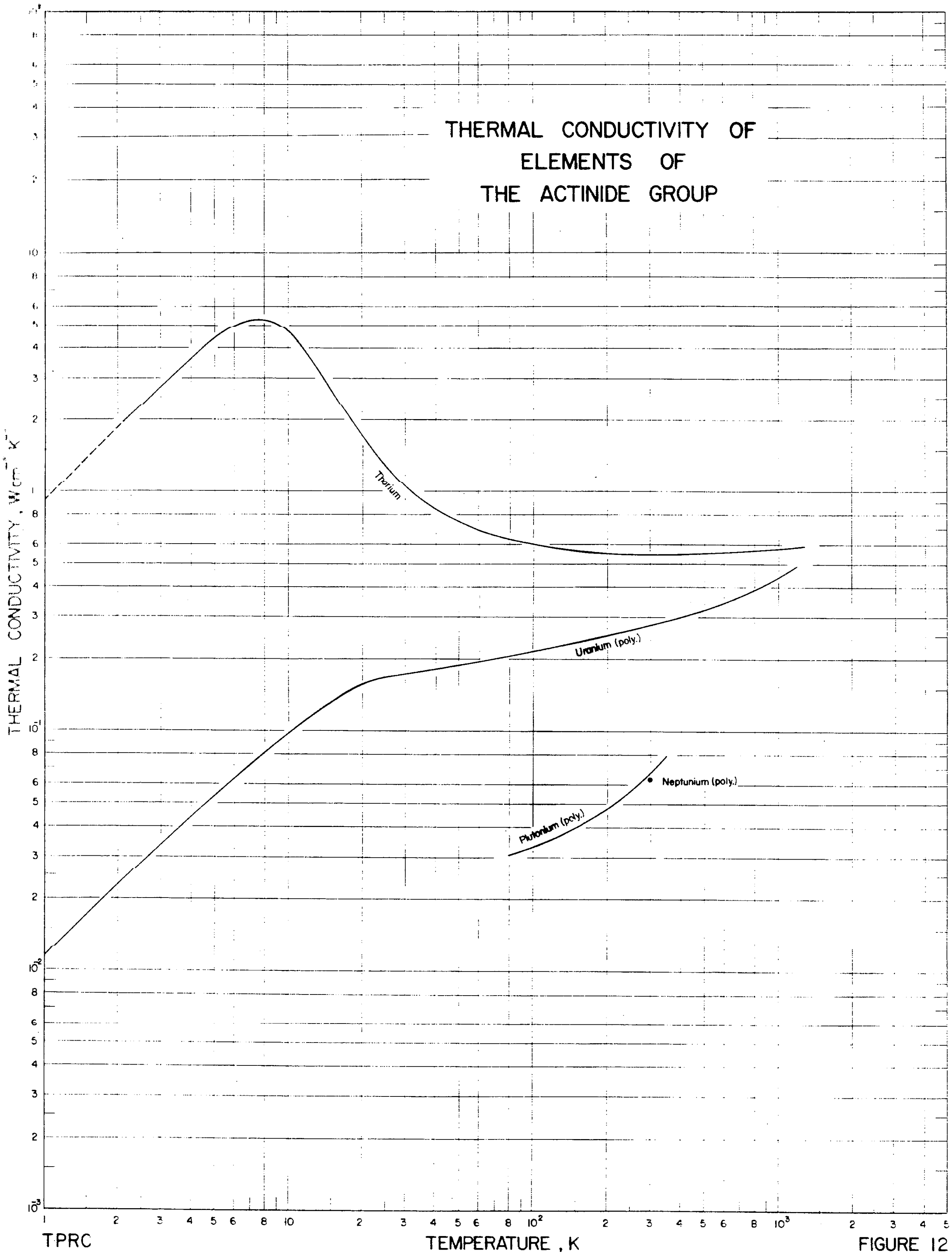

THERMAL CONDUCTIVITY OF
ELEMENTS OF
THE ACTINIDE GROUP
Thorium
Uranium (poly.)
Neptunium (poly.)
Plutonium (poly.)
THERMAL CONDUCTIVITY, W cm⁻¹ K⁻¹
TEMPERATURE, K
TPRC

FIGURE 12

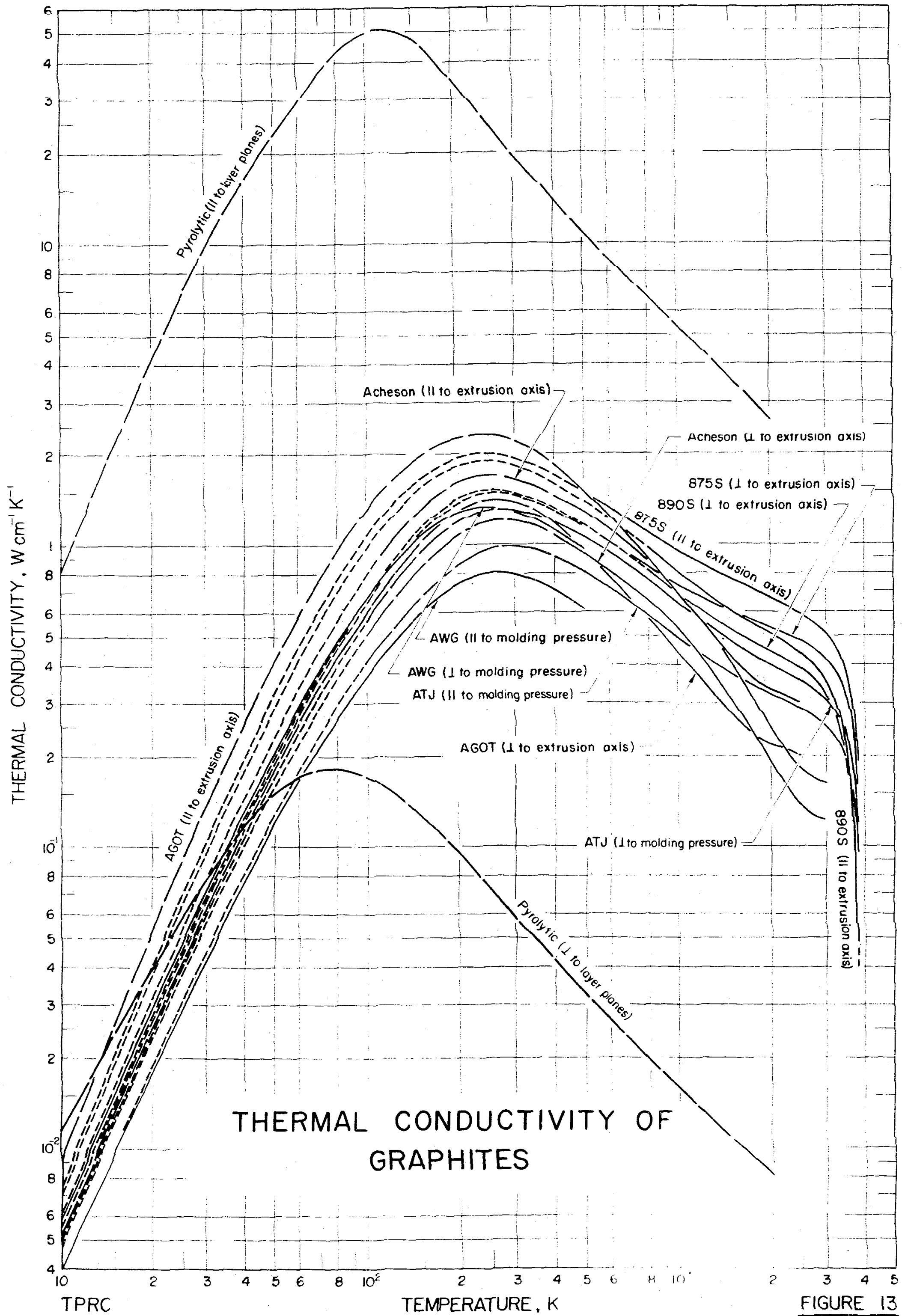

Pyrolytic (II to layer planes)
Acheson (II to extrusion axis)
Acheson (⊥ to extrusion axis)
875S (⊥ to extrusion axis)
890S (⊥ to extrusion axis)
875S (II to extrusion axis)
AWG (II to molding pressure)
AWG (⊥ to molding pressure)
ATJ (II to molding pressure)
AGOT (⊥ to extrusion axis)
AGOT (II to extrusion axis)
ATJ (⊥ to molding pressure)
890S (II to extrusion axis)
Pyrolytic (⊥ to layer planes)
THERMAL CONDUCTIVITY OF GRAPHITES
THERMAL CONDUCTIVITY, W cm⁻¹ K⁻¹
TEMPERATURE, K
TPRC

FIGURE 13

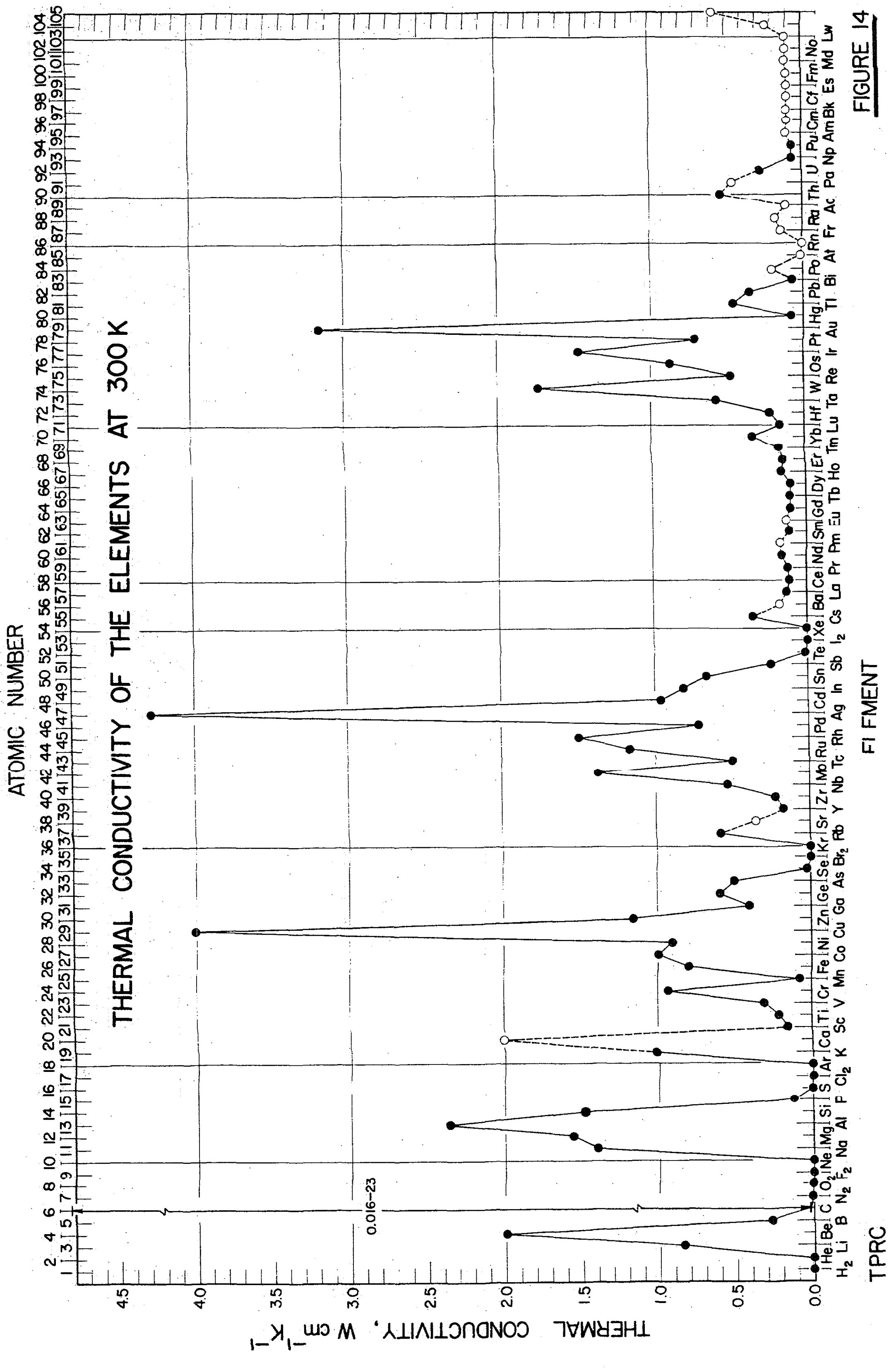

THERMAL CONDUCTIVITY OF THE ELEMENTS AT 300 K
ATOMIC NUMBER
ELEMENT
THERMAL CONDUCTIVITY, W cm^{-1}K^{-1}
0.016–23
TPRC

FIGURE 14

3. Specific Considerations Concerning the Body of Data

This compilation consists of graphs and tables of thermal conductivity as a function of temperature. The conventions used in this presentation and special comments on the interpretation and use of the data are given below.

The thermal conductivities of the elements are presented alphabetically by the names of the elements, but it should be noted that where information is given for different forms of a particular element, these follow that element. Thus, entries for amorphous carbon, diamond, and for several types of graphite come in the entry for carbon, and those for deuterium and tritium are found after the entry for hydrogen. For the nonmetallic elements which are liquid or gaseous at normal temperature and pressure (N.T.P.), and for iodine, thermal conductivity values are given mostly for the solid, saturated liquid, saturated vapor, and gas. For the other elements, values are given only for the solid state or solid and liquid states.

In the figures, solid curves represent recommended or provisional values. Accompanying sections of short-dashed lines represent values in the temperature range where experimental data are not available. In some instances, notably for semimetals and nonmetals at low temperatures, where the specimen cannot be uniquely characterized to correspond exactly with the thermal conductivity values, a curve considered as typical is composed of longer-dashed lines. For all the elements, logarithmic plotting of thermal conductivity against temperature is adopted.

In the figures, the melting point (M.P.), phase transition point (T.P.), superconducting transition point (T.P. (s.c.)), critical temperature (C.T.), Curie temperature, Néel temperature, etc. of the elements have been indicated. The inclusion of these transition points is intended to caution the reader of the existence of such transitions so that one must be extremely cautious in attempting the extrapolate the thermal conductivity values across any such transition temperature, since at such temperature the thermal conductivity generally exhibits sharp discontinuities. No attempt has been made to critically evaluate these transition temperatures, and they should not be considered as recommended values. Some of the given values, however, are the defining fixed points or secondary reference points of the International Practical Temperature Scale of 1968 (IPTS–68) such as the indicated melting points of gold, silver, tin, zinc, aluminum, antimony, bismuth, cadmium, cobalt, copper, indium, iridium, lead, mercury, nickel, palladium, platinum, rhodium, and tungsten, and boiling point of mercury.

The compiled 5200 sets of original thermal conductivity data which are presented in the comprehensive volume [1] were published over a period of 110 years from 1861 to 1970. It is realized that many different temperature scales were used for these data. However, in thermal conductivity measurements, the thermal conductivity values are determined by the measured differences in temperature and not by the absolute magnitude of temperature. Furthermore the thermal conductivity is only a weak function of temperature and the effect of using different temperature scales on the reported thermal conductivity values is practically negligible. Consequently, no attempt has been made to convert the original data to a common scale. For the recommended values, the temperatures are based on the IPTS–68.

In the Thirteenth General Conference of Weights and Measures held in October 1967 in Paris, the unit "watt per metre-kelvin" (symbol: $W\ m^{-1}K^{-1}$) was adopted as the SI unit for thermal conductivity. In this work, the unit "$W\ cm^{-1}K^{-1}$" is used which is a slight modification of the SI unit. Table 2 gives conversion factors which may be used to convert the thermal conductivity values in $W\ cm^{-1}\ K^{-1}$ presented in this work to values in the SI unit or to any of the several other units listed.

In the tables of recommended, provisional, or typical thermal conductivities, the values are presented with uniform but step-increasing increments in temperature as the temperature increases. For those elements which are solid at NTP and for mercury, the values are presented such that temperatures with uniform increments in both kelvin and Celsius are accommodated. In other words, those values given for temperatures 123.2 K, 173.2 K, 223.2 K, 273.2 K, 323.2 K, . . . are for −150 °C, −100 °C, −50 °C, 0 °C, 50 °C, ... The ".2" has been dropped for temperatures above 3000 K.

In the tables the third and occasionally the fourth significant figures are given for the thermal conductivity values, but this is only for internal comparison and for tabular smoothness and should not be considered indicative of the degree of accuracy. The accuracy of the recommended or provisional values for each element in different temperature ranges is given in the REMARKS. The thermal conductivity is zero at absolute zero temperature, i.e. at the point ($T=0$, $k=0$). This is a theoretical consequence based upon the premise that the specific heat is zero at absolute zero temperature according to the third law of thermodynamics.

For a solid element at moderate and high temperatures the true thermal conductivity values for different well-annealed high-purity (99.99+%) samples at any given temperature should be close, and therefore a set of recommended thermal conductivity values can be given for a well-annealed high-purity element. At low temperatures, however, the thermal conductivity values for different samples with small differences in purity and/or imperfection differ greatly, and a set of recommended or provisional values applies only to a sample of a particular purity and imperfection. Ideally the low-temperature thermal conductivity of a solid element should be represented by a family (or families, for a non-cubic

TABLE 2. Conversion factors for units of thermal conductivity

MULTIPLY ↓ by appropriate factor to OBTAIN →	$Btu_{IT}\ h^{-1}\ ft^{-1}\ F^{-1}$	Btu_{IT} in. $h^{-1}\ ft^{-2}\ F^{-1}$	$Btu_{th}\ h^{-1}\ ft^{-1}\ F^{-1}$	Btu_{th} in. $h^{-1}\ ft^{-2}\ F^{-1}$	$cal_{IT}\ s^{-1}\ cm^{-1}\ C^{-1}$	$cal_{th}\ s^{-1}\ cm^{-1}\ C^{-1}$	$kcal_{th}\ h^{-1}\ m^{-1}\ C^{-1}$	$J\ s^{-1}\ cm^{-1}\ K^{-1}$	$W\ cm^{-1}\ K^{-1}$	$W\ m^{-1}\ K^{-1}$	$mW\ cm^{-1}\ K^{-1}$
$Btu_{IT}\ h^{-1}\ ft^{-1}\ F^{-1}$	1	12	1.00067	12.0080	4.13379×10^{-3}	4.13656×10^{-3}	1.48916	1.73073×10^{-2}	1.73073×10^{-2}	1.73073	17.3073
Btu_{IT} in. $h^{-1}\ ft^{-2}\ F^{-1}$	8.33333×10^{-2}	1	8.33891×10^{-2}	1.00067	3.44482×10^{-4}	3.44713×10^{-4}	0.124097	1.44228×10^{-3}	1.44228×10^{-3}	0.144228	1.44228
$Btu_{th}\ h^{-1}\ ft^{-1}\ F^{-1}$	0.999331	11.9920	1	12	4.13102×10^{-3}	4.13379×10^{-3}	1.48816	1.72958×10^{-2}	1.72958×10^{-2}	1.72958	17.2958
Btu_{th} in. $h^{-1}\ ft^{-2}\ F^{-1}$	8.32776×10^{-2}	0.999331	8.33333×10^{-2}	1	3.44252×10^{-4}	3.44482×10^{-4}	0.124014	1.44131×10^{-3}	1.44131×10^{-3}	0.144131	1.44131
$cal_{IT}\ s^{-1}\ cm^{-1}\ C^{-1}$	2.41909×10^{2}	2.90291×10^{3}	2.42071×10^{2}	2.90485×10^{3}	1	1.00067	3.60241×10^{2}	4.1868	4.1868	4.1868×10^{2}	4.1868×10^{-3}
$cal_{th}\ s^{-1}\ cm^{-1}\ C^{-1}$	2.41747×10^{2}	2.90096×10^{3}	2.41909×10^{2}	2.90291×10^{3}	0.999331	1	3.6×10^{2}	4.184	4.184	4.184×10^{2}	4.184×10^{-3}
$kcal_{th}\ h^{-1}\ m^{-1}\ C^{-1}$	0.671520	8.05824	0.671969	8.06363	2.77592×10^{-3}	2.77778×10^{-3}	1	1.16222×10^{-2}	1.16222×10^{-2}	1.16222	11.6222
$J\ s^{-1}\ cm^{-1}\ K^{-1}$	57.7789	6.93347×10^{2}	57.8176	6.93811×10^{2}	0.238846	0.239006	86.0421	1	1	1×10^{2}	1×10^{3}
$W\ cm^{-1}\ K^{-1}$	57.7789	6.93347×10^{2}	57.8176	6.93811×10^{2}	0.238846	0.239006	86.0421	1	1	1×10^{2}	1×10^{3}
$W\ m^{-1}\ K^{-1}$	0.577789	6.93347	0.578176	6.93811	2.38846×10^{-3}	2.39006×10^{-3}	0.860421	1×10^{-2}	1×10^{-2}	1	10
$mW\ cm^{-1}\ K^{-1}$	5.77789×10^{-2}	0.693347	5.78176×10^{-2}	0.693811	2.38846×10^{-4}	2.39006×10^{-4}	8.60421×10^{-2}	1×10^{-3}	1×10^{-3}	0.1	1

crystal) of curves, each of which is recommended for a sample of a particular purity and imperfection, and hence having a particular residual electrical resistivity for a metal. In this work, such a family of recommended curves for specimens of different hypothetical impurities and imperfections has not been generated. Instead, a single, well defined curve is drawn to link with the recommended curve for moderate and high temperatures so as to complete the functions for the full range of temperature. The recommended low-temperature values in the table, which are for the purest form of each element for which measurements have been made, are of course only applicable to that particular characterized sample whose residual electrical resistivity has clearly been specified in the REMARKS. Consequently, this recommended curve should not be interpreted as a unique function for the low temperature region but it is only applicable to a sample of specified conditions. For samples having different impurities and imperfections, i.e., having different residual electrical resistivities for a metallic element, the reader may similarly derive low-temperature thermal conductivity curves following the same guidelines and procedures as used in this work.

As mentioned before, the residual electrical resistivity ρ_0 is used for the characterization of a metallic sample to correspond with the recommended low-temperature thermal conductivity values. At temperatures around 4 K or below, $\rho_0 \gg \rho_i$, and hence ρ_0 may be written as

$$\rho_0 = \frac{L_0 T}{k_e} \,. \tag{16}$$

It is ρ_0 which is determined experimentally as the residual electrical resistivity resulting from electron-defect scattering. If however ρ_0 is calculated from an equation similar to (16) but using a measured value of the thermal conductivity, this value is k and not k_e. Denoting the value so calculated by ρ_0', then

$$\rho_0' = \frac{L_0 T}{k} = \frac{L_0 T}{k_e + k_g} = \frac{\rho_0}{1 + k_g/k_e} \,. \tag{17}$$

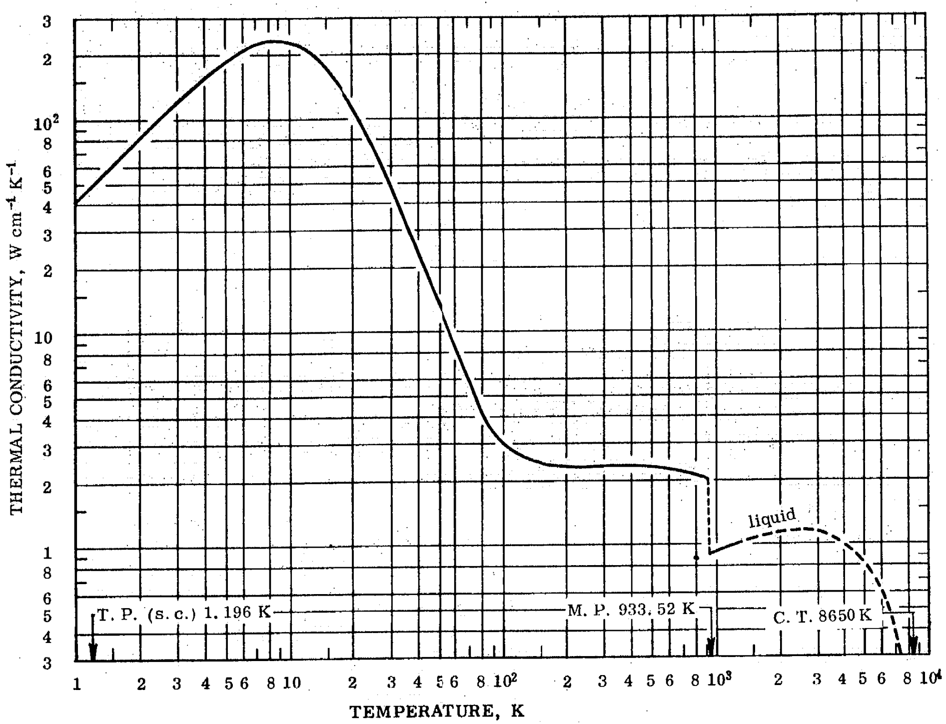
It can be seen from equation (17) that if $k_g \geq 0$ then $\rho_0' \leq \rho_0$. This is usually true, and the experimental ρ_0 is then the value given to correspond with the recommended k values.

It happens occasionally, however, that $\rho_0' > \rho_0$ implying that $k_g < 0$. As negative values for k_g seem impossible, the measured ρ_0 is concluded to be in error and in this case, the calculated value ρ_0' has been given as corresponding with the recommended k values.

Regarding those elements which are liquid or gaseous at N.T.P., the provision of recommended values of the thermal conductivity at the critical point takes no account of anomalies in the immediate vicinity of this point. While evidence seems to be accumulating that a rapid increase in thermal conductivity to very large, if not infinite, values does occur in the immediate vicinity of the critical point, the temperature span of any such departure is very short, and in the preparation of the present tables this factor has been disregarded. The values recommended here for the critical point are thus obtained through arbitrary extrapolations of the saturated liquid and vapor curves with no considerations being given to such anomalies. This approach was considered justified by the very meager and indefinite investigations which have been concerned with such an effect. The present approach has been taken so that interpolation of the recommended critical-point values with those tabulated for lower temperatures will enable intermediate temperature values to be obtained which will be accurate except for the small temperature region where anomalies may occur. Furthermore, the values at the critical point are needed for data correlation using the principle of the corresponding states. Likewise, the error estimates refer to possible errors in estimating such values. Should recent studies on anomalies prove to be confirmed, the present values might be regarded as "pseudo-critical" values of thermal conductivities. While the merit of our present approach could be questioned by some, it might be added that the above defined "critical" thermal conductivities have been found to give consistent values when comparing "critical" thermal conductivities of families of substances. At the present time, similar treatments of "true" critical values present serious difficulties.

The recommended values for the various gases, which cover very wide ranges of temperature, are only for a pressure of one atmosphere. The pressure dependence of thermal conductivity is not yet included in this work.

THERMAL CONDUCTIVITY OF ALUMINUM



RECOMMENDED VALUES†

[Temperature, T, K; Thermal Conductivity, k, W cm^{-1} K^{-1}]

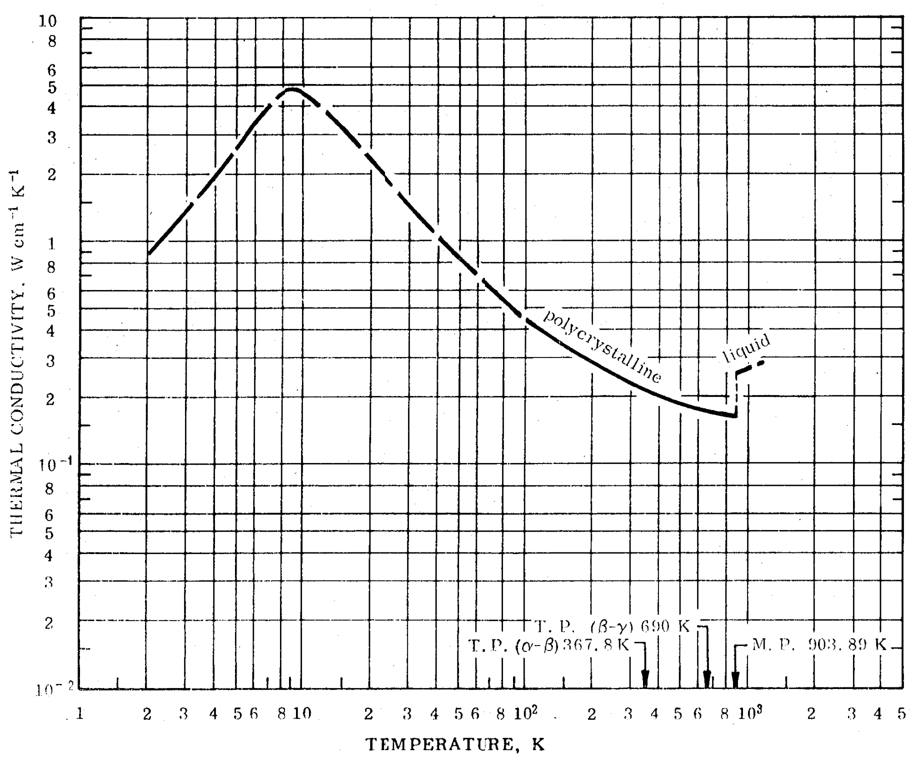
SOLID				LIQUID			
T	k	T	k	T	k	T	k
0	0	60	8.50	933.52	0.907*	2673.2	1.15*
1	41.1	70	5.85	973.2	0.921	2800	1.14*
2	81.8	80	4.32	1000	0.930	2873.2	1.13*
3	121	90	3.42	1073.2	0.955	3000	1.13*
4	157	100	3.02	1100	0.964	3073	1.12*
5	188	123.2	2.62	1173.2	0.986	3200	1.11*
6	213	150	2.48	1200	0.994	3273	1.10*
7	229	173.2	2.41	1273.2	1.01	3400	1.09*
8	237	200	2.37	1300	1.02*	3473	1.07*
9	239	223.2	2.35	1373.2	1.04*	3600	1.05*
10	235	250	2.35	1400	1.05*	3673	1.05*
11	226	273.2	2.36	1473.2	1.07*	3800	1.03*
12	214	298.2	2.37	1500	1.07*	3873	1.02*
13	201	300	2.37	1573.2	1.08*	4000	0.997*
14	189	323.2	2.39	1600	1.09*	4073	0.986*
15	176	350	2.40	1673.2	1.10*	4273	0.952*
16	163	373.2	2.40	1700	1.11*	4500	0.912*
18	138	400	2.40	1773.2	1.11*	4773	0.861*
20	117	473.2	2.37	1800	1.12*	5000	0.818*
25	75.2	500	2.36	1873.2	1.13*	5273	0.764*
30	49.5	573.2	2.33	1900	1.13*	5500	0.719*
35	33.8	600	2.31	1973.2	1.14*	5773	0.662*
40	24.0	673.2	2.26	2000	1.14*	6000	0.614*
45	17.7	700	2.25	2073.2	1.14*	6273	0.555*
50	13.5	773.2	2.19	2173.2	1.15*	6500	0.505*
		800	2.18	2200	1.15*	6773	0.444*
		873.2	2.12	2273.2	1.15*	7000	0.392*
		900	2.10	2400	1.15*	7273	0.329*
		933.52	2.08	2473.2	1.15*	7500	0.275*
				2600	1.15*	7773	0.210*
						8000	0.156*
						8273	0.0915*
						8500	0.0365*

* Estimated or extrapolated.
† Values above 1273 K are provisional.

REMARKS

The recommended values are for well-annealed high-purity aluminum and are thought to be accurate to within ±5% of the true values at temperatures below room temperature and ±2 to ±3% above. For molten aluminum near the melting point the values are probably good to within ±8%. The thermal conductivity at temperatures near and below the corresponding temperature, T_m, of the conductivity maximum is highly sensitive to small physical and chemical variations among different specimens, and the conductivity values below 150 K are applicable only to a specimen having residual electrical resistivity $\rho_0 = 0.000594$ μΩ cm. Values at temperatures below about 1.5 T_m are calculated to fit the experimental data by using eq. (7) and using the constants m, n, α'' as given in Table 1 and $\beta = 0.0243$. The values for molten aluminum above 1273 K are provisional values.

THERMAL CONDUCTIVITY OF ANTIMONY



REMARKS

The values above 100 K are provisional for well-annealed high-purity antimony and are considered accurate to within ± 15% of the true values at moderate temperatures and ± 25% near the melting point and above. The thermal conductivity at temperatures near and below the corresponding temperature of the conductivity maximum is highly sensitive to small physical and chemical variations among different specimens, and the conductivity values below 100 K only represent a typical curve serving to indicate the general trend of the low-temperature behavior of the thermal conductivity.

PROVISIONAL VALUES †

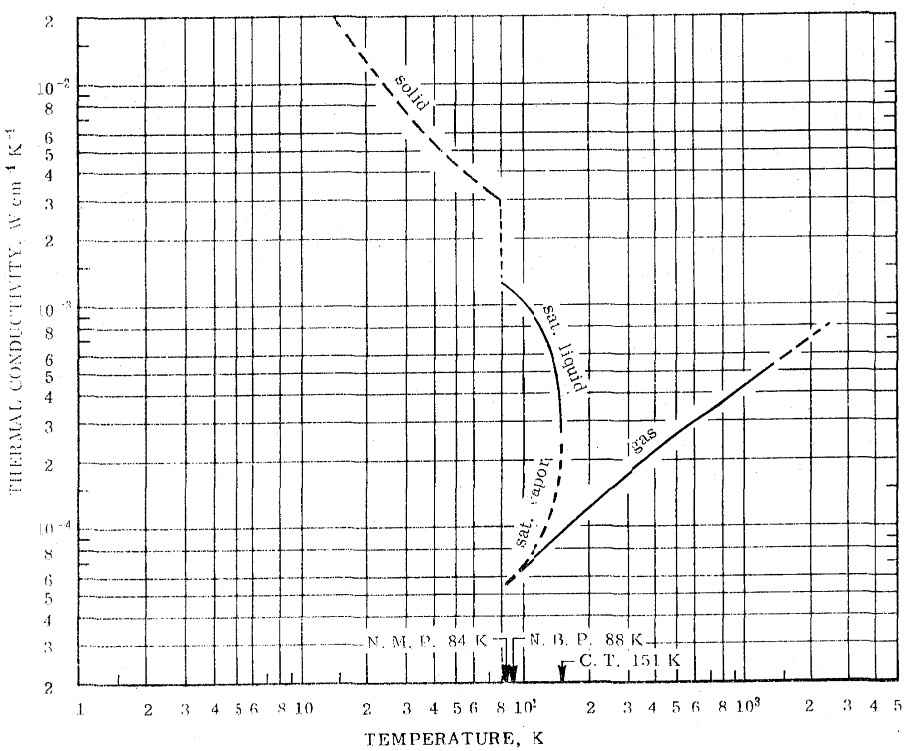
[Temperature, T, K; Thermal Conductivity, k, W cm^{-1} K^{-1}]

SOLID Polycrystalline				LIQUID	
T	k	T	k	T	k
2	0.87	173.2	0.326	903.89	0.259
3	1.27	200	0.302	973.2	0.267
4	1.86	223.2	0.283	1000	0.270
5	2.58	250	0.267	1073.2	0.277*
6	3.34	273.2	0.255	1100	0.280*
7	4.06	298.2	0.244		
8	4.63	300	0.243		
9	4.89	323.2	0.235		
10	4.80	350	0.226		
11	4.50	373.2	0.219		
12	4.07	400	0.213		
13	3.79	473.2	0.199		
14	3.51	500	0.195		
15	3.25	573.2	0.186		
16	3.04	600	0.183		
18	2.67	673.2	0.176		
20	2.38	700	0.174		
25	1.87	773.2	0.170		
30	1.54	800	0.168		
35	1.30	850	0.167		
40	1.13	873.2	0.167		
45	0.994	900	0.167		
50	0.883	903.89	0.167		
60	0.725				
70	0.620				
80	0.550				
90	0.500				
100	0.464				
123.2	0.405				
150	0.356				

* Extrapolated

† Values below 100 K are merely typical values.

THERMAL CONDUCTIVITY OF ARGON



RECOMMENDED VALUES

[Temperature, T, K; Thermal Conductivity, k, W cm^{-1} K^{-1}]

SOLID		SATURATED LIQUID		SATURATED VAPOR	
T	k x 10^3	T	k x 10^3	T	k x 10^3
		84	1.270*		
		85	1.258	85	0.055*
8	60*	90	1.201	90	0.059*
9	46*	95	1.142	95	0.064*
10	37*	100	1.082	100	0.068*
12	27*	105	1.021	105	0.072*
14	22*	110	0.963	110	0.077*
16	18*	115	0.903	115	0.082*
18	16*	120	0.842	120	0.088*
20	13.6*	125	0.780	125	0.095*
25	9.9*	130	0.718	130	0.103*
30	7.8*	135	0.655	135	0.109*
35	6.5*	140	0.592	140	0.120*
40	5.6*	145	0.518	145	0.140*
45	5.1*	150	0.404	150	0.19*
50	4.6*	151	0.25†	151	0.25*†
60	3.8*				
70	3.3*				
80	3.0*				

REMARKS

Values for the solid are of only moderate accuracy, due to structural variations produced by impurities. From 8 to 20 K the uncertainty may be as much as 50%, the uncertainty gradually decreasing to 10% at the highest temperatures tabulated. Saturated liquid values below 140 K should be accurate to a few percent. At higher temperatures the uncertainty increases to as much as 25% at the critical point. Saturated vapor values should have a similar uncertainty below 125 K and at the critical point. At intermediate temperatures the uncertainty is somewhat larger. The gas values should be accurate to within 1% from 100 to 500 K, 5% below 100 K and from 500 to 1500 K and 10% above 1500 K.

*Estimated or extrapolated, hence provisional.

†Pseudo-critical value.

THERMAL CONDUCTIVITY OF ARGON (continued)

RECOMMENDED VALUES

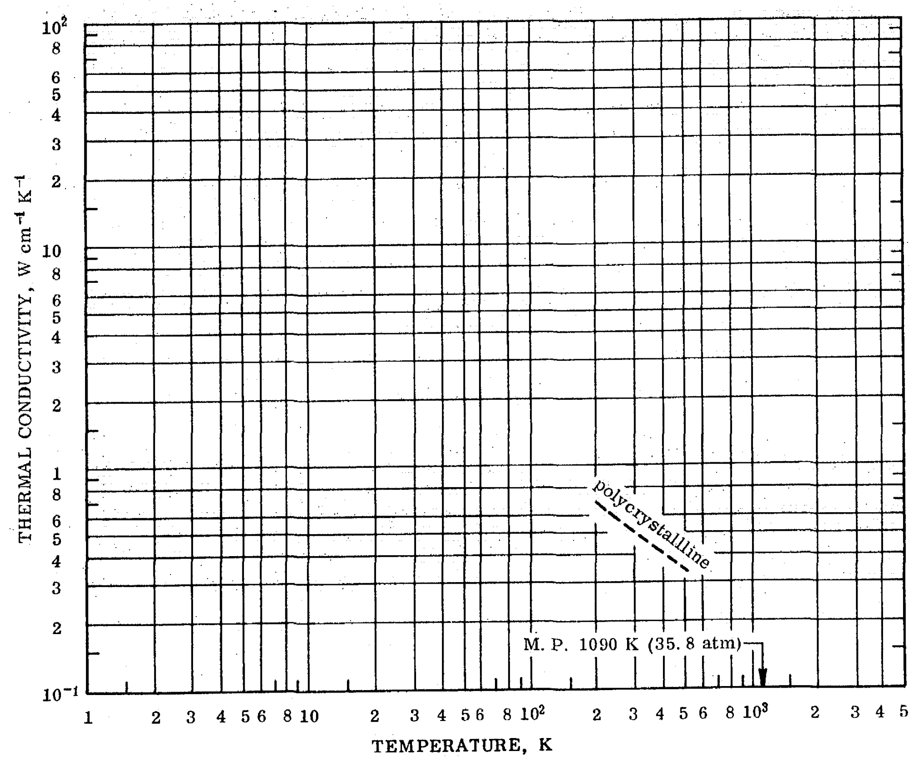
GAS

(At 1 atm)

T	k x 10^3	T	k x 10^3	T	k x 10^3	T	k x 10^3
		400	0.2233	750	0.353	1500	0.561*
		410	0.2276	760	0.356	1550	0.575*
		420	0.2318	770	0.359	1600	0.588*
88	0.0574*	430	0.2359	780	0.362	1650	0.602*
90	0.0587	440	0.2400	790	0.366	1700	0.615*
100	0.0652	450	0.2441	800	0.369	1750	0.628*
110	0.0716	460	0.2481	810	0.372	1800	0.641*
120	0.0779	470	0.2520	820	0.375	1850	0.654*
130	0.0839	480	0.2559	830	0.378	1900	0.667*
140	0.0898	490	0.2599	840	0.381	1950	0.680*
150	0.0957	500	0.2638	850	0.384	2000	0.692*
160	0.1016	510	0.268	860	0.387	2100	0.717*
170	0.1074	520	0.272	870	0.390	2200	0.741*
180	0.1131	530	0.276	880	0.393	2300	0.766*
190	0.1188	540	0.280	890	0.396	2400	0.790*
200	0.1244	550	0.283	900	0.398	2500	0.815*
210	0.1300	560	0.287	910	0.401		
220	0.1355	570	0.290	920	0.404		
230	0.1409	580	0.294	930	0.407		
240	0.1462	590	0.297	940	0.410		
250	0.1515	600	0.301	950	0.413		
260	0.1567	610	0.305	960	0.416		
270	0.1619	630	0.308	970	0.418		
280	0.1671	630	0.311	980	0.421		
290	0.1722	640	0.315	990	0.424		
300	0.1772	650	0.319	1000	0.427		
310	0.1822	660	0.322	1050	0.441		
320	0.1871	670	0.326	1100	0.454		
330	0.1919	680	0.329	1150	0.468		
340	0.1966	690	0.333	1200	0.481		
350	0.2013	700	0.336	1250	0.495		
360	0.2059	710	0.339	1300	0.508		
370	0.2103	720	0.343	1350	0.521		
380	0.2147	730	0.346	1400	0.535*		
390	0.2190	740	0.349	1450	0.548*		

*Estimated or extrapolated.

THERMAL CONDUCTIVITY OF ARSENIC



REMARKS

The provisional values are for well-annealed high-purity polycrystalline grey arsenic and should be good to within ±15%.

PROVISIONAL VALUES

[Temperature, T, K; Thermal Conductivity, k, W cm^{-1} K^{-1}]

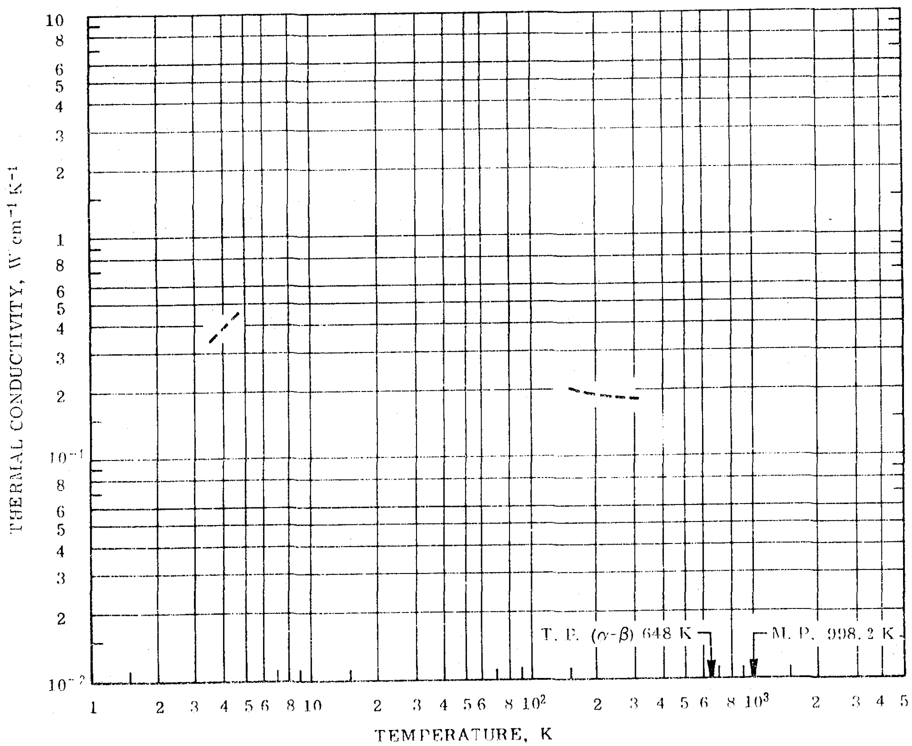
SOLID

Gray, polycrystalline

T	k
200	0.690*
223.2	0.633*
250	0.578*
273.2	0.539*
293.2	0.510
298.2	0.502*
300	0.500*
323.2	0.474*
350	0.446*
373.2	0.427*
400	0.406*
473.2	0.360*
500	0.348*

*Extrapolated or estimated.

THERMAL CONDUCTIVITY OF BARIUM



REMARKS

The provisional values are for well-annealed high-purity barium and should be good to ±20%. The value at 4 K is applicable only to barium having residual electrical resistivity ρ_0 0.25 $\mu\Omega$ cm.

PROVISIONAL VALUES

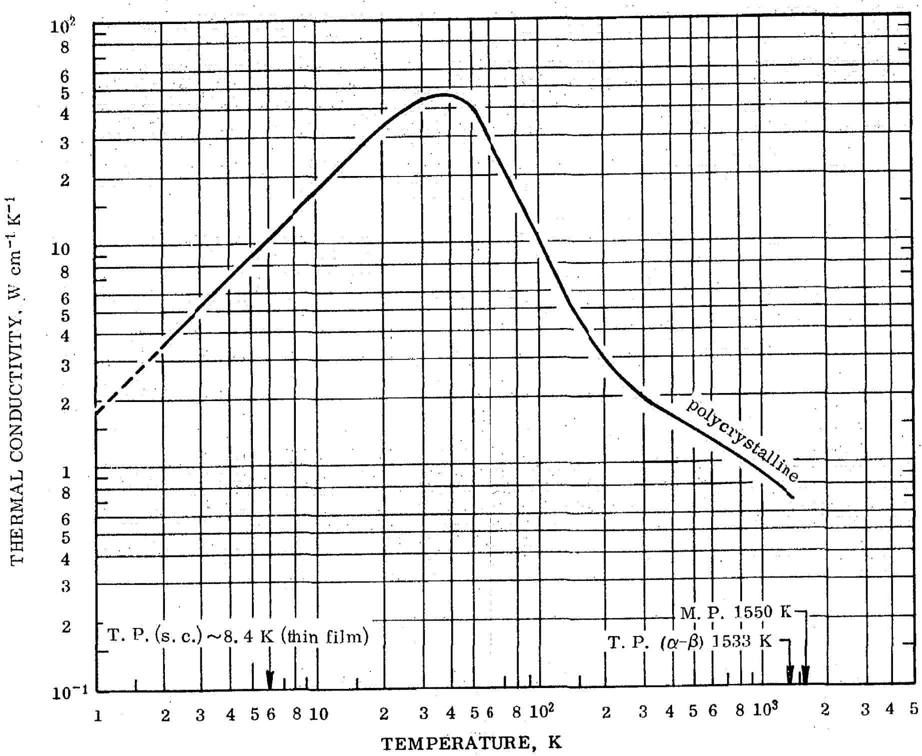
[Temperature, T, K; Thermal Conductivity, k, W cm^{-1} K^{-1}]

SOLID

T	k
4	0.39*
150	0.205*
173.2	0.199*
200	0.194*
223.2	0.190*
250	0.186*
273.2	0.185*
295	0.184*

* Estimated.

THERMAL CONDUCTIVITY OF BERYLLIUM



RECOMMENDED VALUES †

[Temperature, T, K; Thermal Conductivity, k, W cm^{-1} K^{-1}]

SOLID

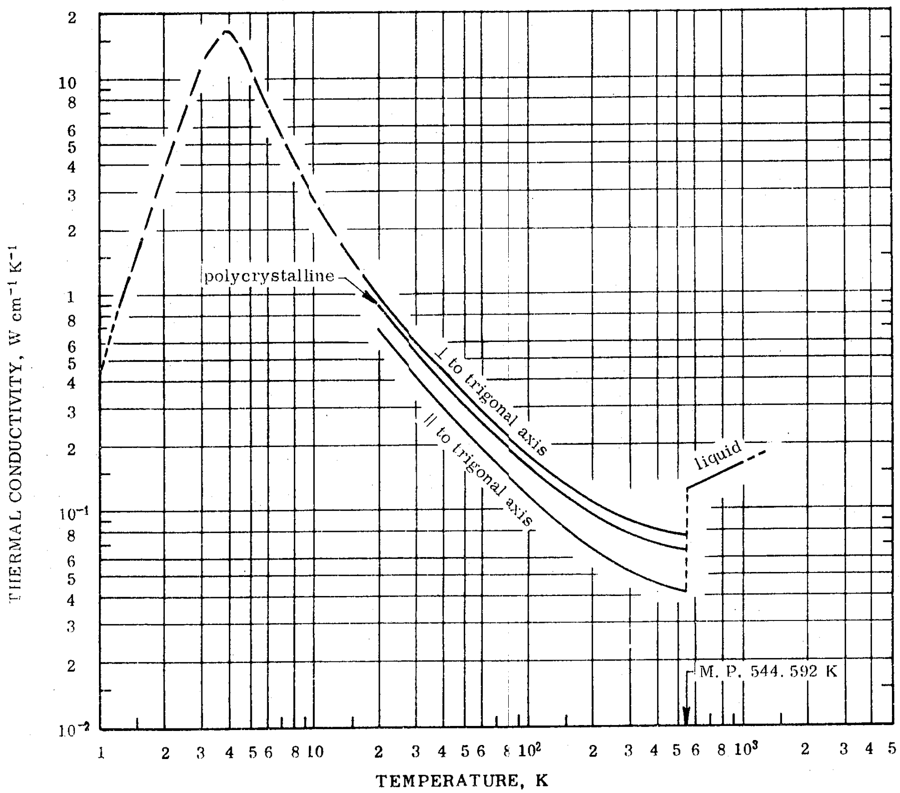
T	k	T	k
0	0	250	2.36
1	1.81*	273.2	2.18
2	3.62	298.2	2.01
3	5.42	300	2.00
4	7.23	323.2	1.88
5	9.04	350	1.78
6	10.8	373.2	1.68
7	12.6	400	1.61
8	14.4	473.2	1.44
9	16.2	500	1.39
10	18.0	573.2	1.29
11	19.8	600	1.26
12	21.6	673.2	1.18
13	23.3	700	1.15
14	25.1	773.2	1.09
15	26.8	800	1.06
16	28.4	873.2	1.00
18	31.7	900	0.982
20	34.8	973.2	0.927
25	41.2	1000	0.908
30	45.6	1073.2	0.858
35	47.2	1100	0.842
40	46.2	1173.2	0.802
45	44.2	1200	0.787
50	40.0	1273.2	0.751
60	29.8	1300	0.738
70	21.7	1373.2	0.705
80	16.2	1400	0.694
90	12.5		
100	9.90		
123.2	6.54		
150	4.51		
173.2	3.64		
200	3.01		
223.2	2.66		

REMARKS

The recommended values (above 290 K) are for well annealed high-purity beryllium and their uncertainty is thought to be of the order of ±10%. The thermal conductivity at temperatures near and below the corresponding temperature, T_m, of the conductivity maximum is highly sensitive to small physical and chemical variations among different specimens, and the conductivity values below 290 K, which are provisional, are only applicable to beryllium having residual electrical resistivity $\rho_0 = 0.0135$ μΩ cm. Values at temperatures below about 1.5 T_m are calculated to fit the experimental data by using equation (7) and using $n = 2.80$, $\alpha' = 2.56 \times 10^{-7}$, and $\beta = 0.553$.

* Extrapolated.
† Values below 290 K are provisional.

THERMAL CONDUCTIVITY OF BISMUTH



REMARKS

The values are for well-annealed high-purity bismuth. The probable uncertainty of the recommended values (those above 20 K) is of the order of ±5 to ±10% for the solid state at room temperature and above, increasing to ±15 to ±20% for the molten state. The thermal conductivity at temperatures near and below the corresponding temperature of the conductivity maximum is highly sensitive to small physical and chemical variations among different specimens, and the conductivity values below 20 K only represent a typical curve serving to indicate the general trend of the low-temperature behavior of the thermal conductivity.

RECOMMENDED VALUES

[Temperature, T, K; Thermal Conductivity, k, W cm^{-1} K^{-1}]

SOLID

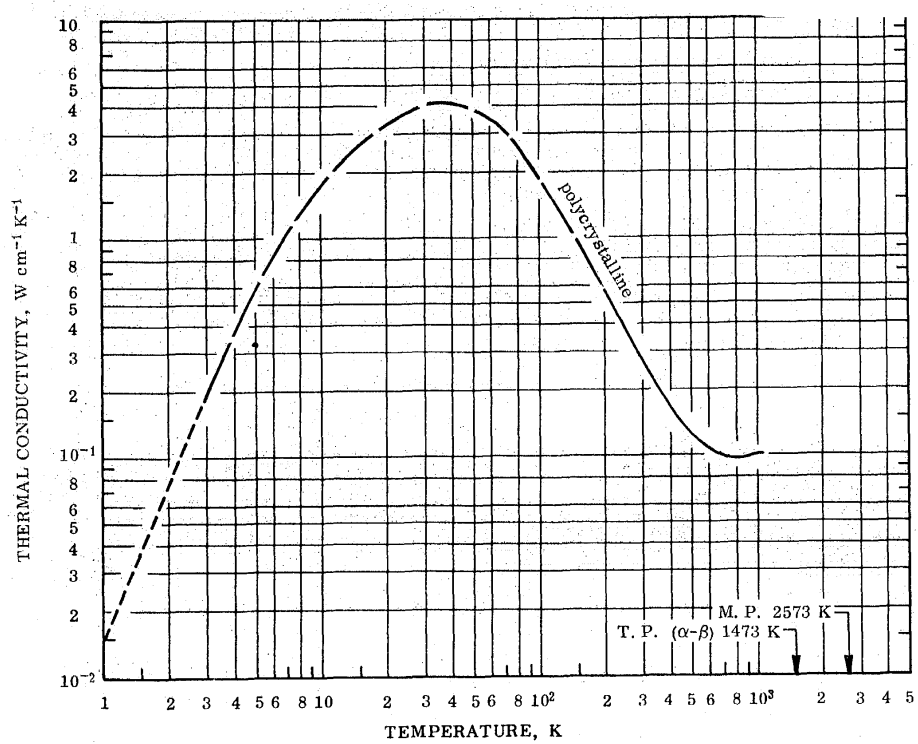
T	// to trigonal axis k	⊥ to trigonal axis k	Poly-crystalline k
0		0	
1		0.452*	
2		3.94	
3		11.8	
4		17.1	
5		11.9	
6		7.98	
7		5.77	
8		4.40	
9		3.50	
10		2.88	
11		2.45	
12		2.11	
13		1.85	
14		1.65	
15		1.48	
16		1.36	
18		1.15	
20	0.700	1.00	0.900
25	0.538	0.780	0.695
30	0.434	0.635	0.568
35	0.364	0.536	0.478
40	0.311	0.465	0.414
45	0.272	0.410	0.365
50	0.243	0.367	0.326
60	0.199	0.303	0.268
70	0.168	0.260	0.231
80	0.148	0.230	0.203
90	0.131	0.206	0.182
100	0.119	0.188	0.165
123.2	0.0994	0.159	0.138
150	0.0826	0.136	0.118
173.2	0.0739	0.123	0.107
200	0.0667	0.112	0.0969
223.2	0.0612	0.105	0.0904
250	0.0581	0.0995	0.0857
273.2	0.0554	0.0953	0.0822
298.2	0.0530	0.0919	0.0792
300	0.0528	0.0915	0.0786
323.2	0.0510	0.0890	0.0766
350	0.0491	0.0860	0.0737
373.2	0.0481	0.0844	0.0722
400	0.0469	0.0822	0.0704
473.2	0.0446	0.0784	0.0669
500	0.0438	0.0775	0.0663
544.592	0.0429	0.0761	0.0650

LIQUID

T	k
544.592	0.124
573.2	0.128
600	0.131
673.2	0.138
700	0.141
773.2	0.148
800	0.150
873.2	0.157
900	0.159
973.2	0.166
1000	0.168
1073.2	0.172*
1100	0.175*
1173.2	0.179*
1200	0.182*
1273.2	0.185*
1300	0.188*

*Extrapolated.

THERMAL CONDUCTIVITY OF BOR(



REMARKS

The values are for well-annealed high-purity boron. The recommended values (those above 200 K) are probably accurate to within ±10 to ±15%. The thermal conductivity at temperatures near and below the corresponding temperature of the conductivity maximum is highly sensitive to small physical and chemical variations among different specimens, and the conductivity values below 200 K only represent a typical curve serving to indicate the general trend of the low-temperature behavior of the thermal conductivity.

RECOMMENDED VALUES†

[Temperature, T, K; Thermal Conductivity, k, W cm⁻¹ K⁻¹]

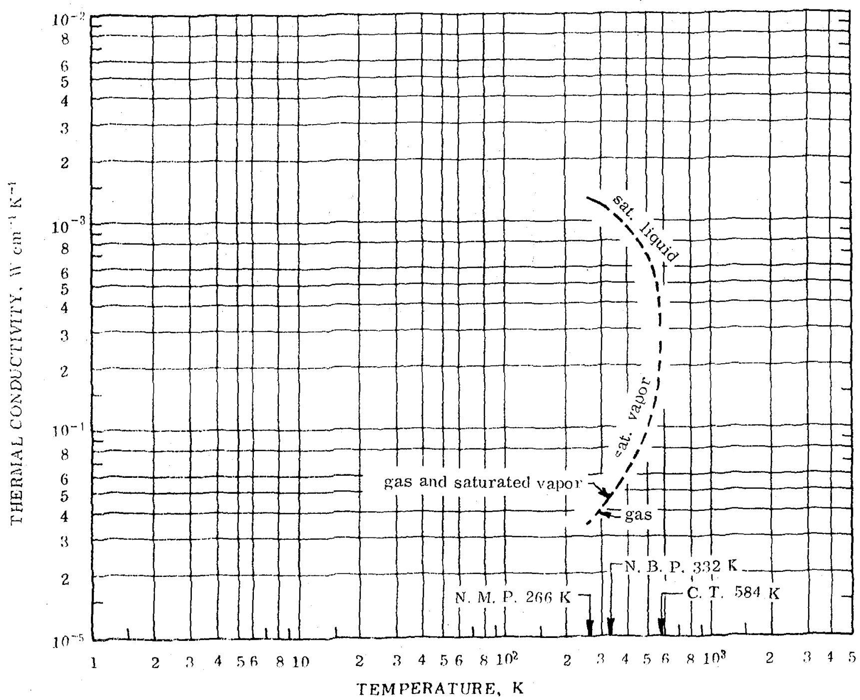
SOLID

Polycrystalline

T	k	T	k
0	0	123.2	1.35
1	0.0150*	150	0.935
2	0.0781*	173.2	0.718
3	0.198	200	0.551
4	0.375	223.2	0.454
5	0.588	250	0.371
6	0.826	273.2	0.318
7	1.07	298.2	0.274
8	1.31	300	0.270
9	1.54	323.2	0.240
10	1.77	350	0.209
11	1.98	373.2	0.188
12	2.19	400	0.168
13	2.39	473.2	0.133
14	2.58	500	0.125
15	2.76	573.2	0.109
16	2.93	600	0.106
18	3.22	673.2	0.0994
20	3.46	700	0.0981
25	3.92	773.2	0.0964
30	4.21	800	0.0960
35	4.30	873.2	0.0966
40	4.28	900	0.0969
45	4.19	973.2	0.0980
50	4.04	1000	0.0985
60	3.63	1073.2	0.100
70	3.10	1100	0.101
80	2.63		
90	2.24		
100	1.90		

* Extrapolated.
† Values below 200 K are merely typical values.

THERMAL CONDUCTIVITY OF BROMINE



RECOMMENDED VALUES

[Temperature, T, K; Thermal Conductivity, k, W cm^{-1} K^{-1}]

SATURATED LIQUID T	SATURATED LIQUID k x 10^3	SATURATED VAPOR T	SATURATED VAPOR k x 10^3	GAS T	GAS k x 10^3
		300	0.047*	250	0.038*
266	1.31*	310	0.049*	260	0.040*
270	1.30*	320	0.051*	270	0.042*
280	1.27	330	0.053*	280	0.044*
290	1.25	340	0.055*	290	0.046*
300	1.22	350	0.057*	300	0.048*
310	1.20	360	0.059*	310	0.049*
320	1.18	370	0.061*	320	0.051*
330	1.16*	380	0.063*	330	0.053*
340	1.14*	390	0.065*	340	0.055*
350	1.11*	400	0.068*	350	0.057*
360	1.09*	410	0.070*		
370	1.06*	420	0.072*		
380	1.04*	430	0.075*		
390	1.02*	440	0.078*		
400	0.99*	450	0.080*		
410	0.97*	460	0.084*		
420	0.94*	470	0.087*		
430	0.92*	480	0.091*		
440	0.89*	490	0.095*		
450	0.87*	500	0.099*		
460	0.84*	510	0.104*		
470	0.82*	520	0.109*		
480	0.79*	530	0.116*		
490	0.76*	540	0.128*		
500	0.73*	550	0.144*		
510	0.70*	560	0.16*		
520	0.66*	570	0.19*		
530	0.63*	580	0.23*		
540	0.59*	584	0.28*†		
550	0.55*				
560	0.50*				
570	0.44*				
580	0.35*				
584	0.28*†				

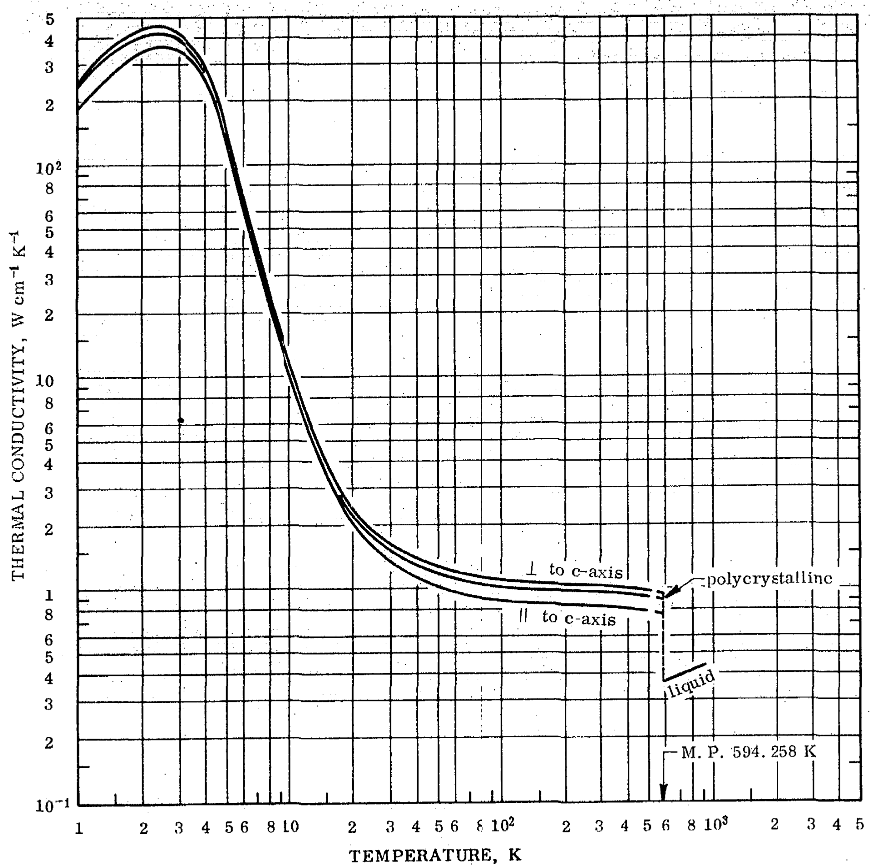
REMARKS

Severe disagreement exists between experimental and estimated values for the liquid above 305 K. No experimental measurements above 325 K were found. An uncertainty of 15% below 500 K and an unknown amount at higher temperatures appears probable. The vapor values are based on a correlation. Uncertainties of 10% below 450 K, 15% from 450 to 550 K and unknown accuracy above 550 K appear probable. The gas values are of uncertain accuracy.

* Estimated or extrapolated, hence provisional.
† Pseudo-critical value.

* Estimated or extrapolated, hence provisional.
† Pseudo-critical value.

THERMAL CONDUCTIVITY OF CADMIUM



REMARKS

The recommended values are for well-annealed high-purity cadmium and are thought to be accurate to within ±20% at low temperatures, ±4% at normal and moderate temperatures, ±6% for the solid and ±12% for the liquid near the melting point. The thermal conductivity at temperatures near and below the corresponding temperature, T_m, of the conductivity maximum is highly sensitive to small physical and chemical variations among different specimens, and the conductivity values below 100 K for $k_{\parallel}$, $k_{\perp}$, and k_{poly} are applicable only to samples having residual electrical resistivities of 0.000134, 0.000103, and 0.000112 μΩ cm, respectively. Values at temperatures below about 1.5 T_m are calculated by equation (7) and using the constants m, n, α'' as given in Table 1 and the parameter β = 0.0055, 0.0042, and 0.0046, respectively, for $k_{\parallel}$, $k_{\perp}$, and k_{poly}.

RECOMMENDED VALUES †

[Temperature, T, K; Thermal Conductivity, k, W cm^{-1} K^{-1}]

SOLID

T	// to c-axis k	⊥ to c-axis k	Poly-crystalline k
0	0	0	0
1	182	239	220
2	343	442	409
3	354	432	406
4	264	314	297
5	157	167	164
6	73.8	76.8	75.8
7	40.0	42.8	41.9
8	24.6	26.2	25.7
9	16.3	17.6	17.2
10	11.5	12.5	12.2
11	8.68	9.50	9.23
12	6.74	7.44	7.21
13	5.44	6.05	5.85
14	4.48	5.01	4.83
15	3.76	4.26	4.09
16	3.23	3.67	3.52
18	2.50	2.88	2.75
20	2.07	2.44	2.32
25	1.59	1.92	1.81
30	1.37	1.67	1.57
35	1.23	1.51	1.42
40	1.13	1.41	1.32
45	1.07	1.34	1.24
50	1.03	1.28	1.20
60	0.970	1.21	1.13
70	0.930	1.16	1.08
80	0.905	1.13	1.06
90	0.892	1.11	1.04
100	0.883	1.10	1.03
123.2	0.872	1.09	1.02
150	0.864	1.08	1.01
173.2	0.856	1.07	1.00
200	0.851	1.06	0.993
223.2	0.846	1.05	0.987

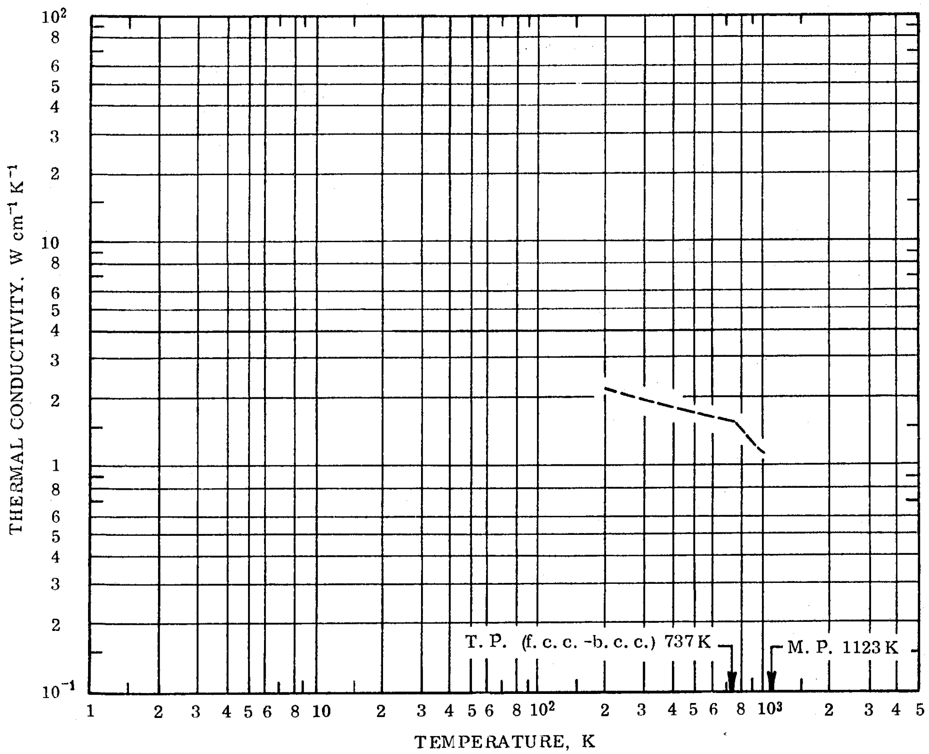
T	// to c-axis k	⊥ to c-axis k	Poly-crystalline k
250	0.840	1.05	0.980
273.2	0.835	1.04	0.975
298.2	0.830	1.04	0.969
300	0.830	1.04	0.968
323.2	0.826	1.03	0.963
350	0.821	1.03	0.958
373.2	0.816	1.02	0.953
400	0.811	1.01	0.947
473.2	0.793	0.990	0.928
500	0.786	0.980	0.920
573.2	0.760	0.951	0.891
594.258	0.751	0.942	0.880

LIQUID

T	k
594.258	0.368
600	0.370
673.2	0.389
700	0.396
773.2	0.414
800	0.420
873.2	0.434
900	0.439

† Values for the liquid state are provisional.

THERMAL CONDUCTIVITY OF CALCIUM



REMARKS

The provisional values are estimates based on the reported electrical resistivity for high-purity calcium and should be good to ± 20%.

PROVISIONAL VALUES

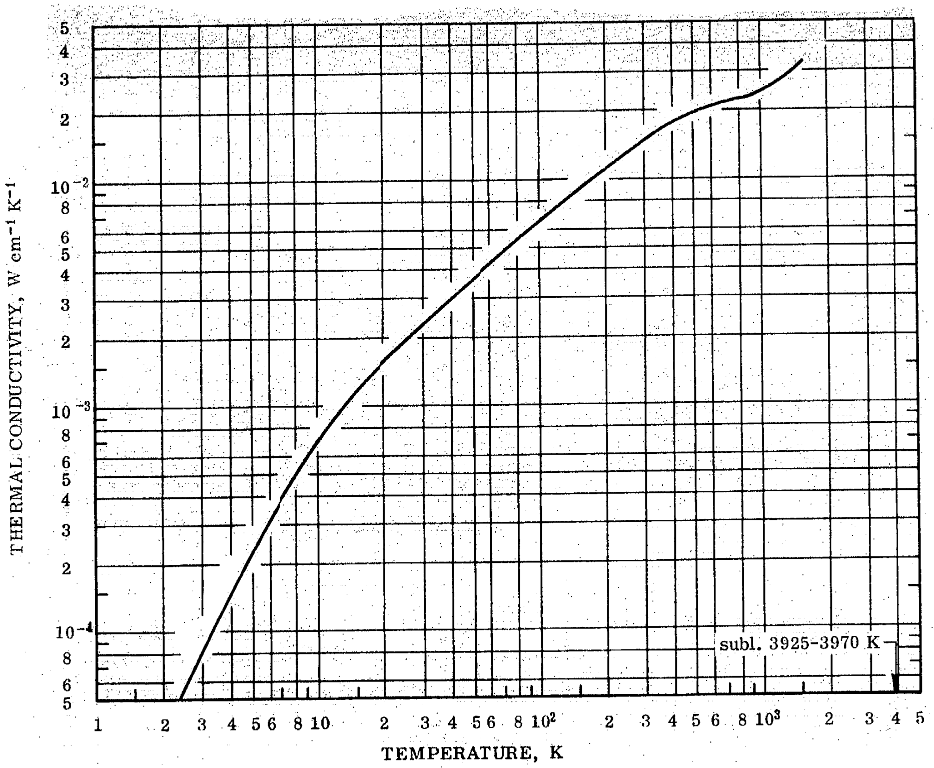
[Temperature, T, K; Thermal Conductivity, k, W cm^{-1} K^{-1}]

SOLID

T	k
200	2.21*
223.2	2.16*
250	2.10*
273.2	2.06*
298.2	2.01*
300	2.01*
323.2	1.98*
350	1.94*
373.2	1.92*
400	1.89*
473.2	1.83*
500	1.82*
573.2	1.79*
600	1.78*
673.2	1.77*
700	1.76*
737	1.76*
773.2	1.63*
800	1.53*
873.2	1.32*
900	1.27*
973.2	1.18*
1000	1.16*

*Estimated, hence provisio

THERMAL CONDUCTIVITY OF CARBON (Amorphous)



REMARK

The recommended values are for high-purity amorphous carbon and are thought to be accurate to within ±10 to 20% above room temperature. Values below room temperature are provisional and their uncertainty is considerably larger.

RECOMMENDED VALUES †

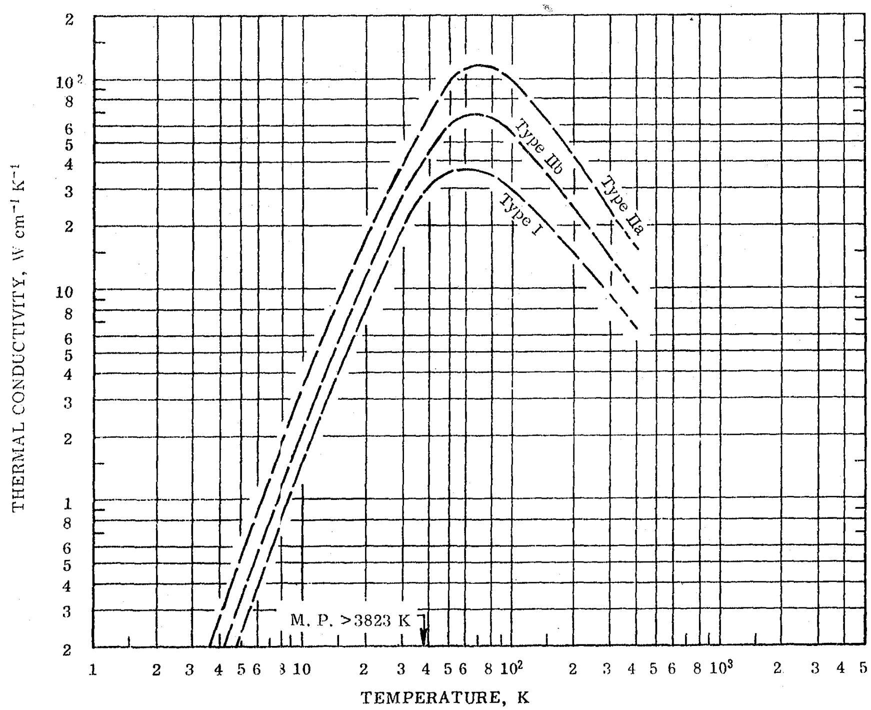
[Temperature, T, K; Thermal Conductivity, k, W cm⁻¹ K⁻¹]

SOLID
Amorphous

T	k	T	k
0	0	250	0.0140
1		273.2	0.0150
2	0.0000361	298.2	0.0159
3	0.0000859	300	0.0160
4	0.000155	323.2	0.0168
5	0.000236	350	0.0176
6	0.000325	373.2	0.0182
7	0.000419	400	0.0187
8	0.000514	473.2	0.0202
9	0.000610	500	0.0206
10	0.000705	573.2	0.0216
11	0.000795	600	0.0219
12	0.000890	673.2	0.0226
13	0.000982	700	0.0229
14	0.00107	773.2	0.0235
15	0.00117	800	0.0237
16	0.00126	873.2	0.0242
18	0.00143	900	0.0244
20	0.00160	973.2	0.0250
25	0.00200	1000	0.0253
30	0.00239	1073.2	0.0262
35	0.00276	1100	0.0267
40	0.00312	1173.2	0.0279
45	0.00345	1200	0.0284
50	0.00377	1273.2	0.0297
60	0.00440	1300	0.0302
70	0.00500	1373.2	0.0318
80	0.00558	1400	0.0324
90	0.00614	1473.2	0.0341
100	0.00668	1500	0.0348
123.2	0.00798		
150	0.00938		
173.2	0.0106		
200	0.0118		
223.2	0.0129		

† Values below room temperature are provisional.

THERMAL CONDUCTIVITY OF DIAMOND



TYPICAL VALUES

[Temperature, T, K; Thermal Conductivity, k, W cm^{-1} K^{-1}]

SOLID

T	Type I k	Type IIa k	Type IIb k	T	Type I k	Type IIa k	Type IIb k
2	0.0138*	0.0331*	0.0200*	40	29.4	65.9	44.0
3	0.0461	0.111	0.0676	45	32.9	79.3	52.3
4	0.108	0.261	0.160	50	35.3	92.1	59.1
5	0.206	0.494	0.307	60	37.4	112	67.5
6	0.344	0.820	0.510	70	36.9	119	69.1
7	0.523	1.24	0.778	80	35.1	117	65.7
8	0.762	1.77	1.12	90	32.7	109	60.0
9	1.05	2.41	1.53	100	30.0	100	54.2
10	1.40	3.17	2.03	123.2	24.2	79.2	41.8
11	1.79	4.00	2.58	150	19.5	60.2	32.5
12	2.24	5.00	3.22	173.2	16.6	49.3	27.0
13	2.76	6.10	3.96	200	14.1	40.3	22.6
14	3.33	7.32	4.77	223.2	12.5	34.7	19.7
15	3.96	8.65	5.66	250	11.0	29.7	17.0
16	4.65	10.0	6.62	273.2	9.94	26.2	15.2
18	6.15	13.2	8.75	298.2	9.00	23.2	13.6
20	7.87	16.8	11.2	300	8.95	23.0	13.5
25	12.9	27.1	18.2	323.2	8.26*	20.7*	12.3*
30	18.8	38.9	26.5	350	7.55*	18.5*	11.1*
35	24.5	51.8	35.0	373.2	7.03*	17.0*	10.2*
				400	6.50*	15.4*	9.32*

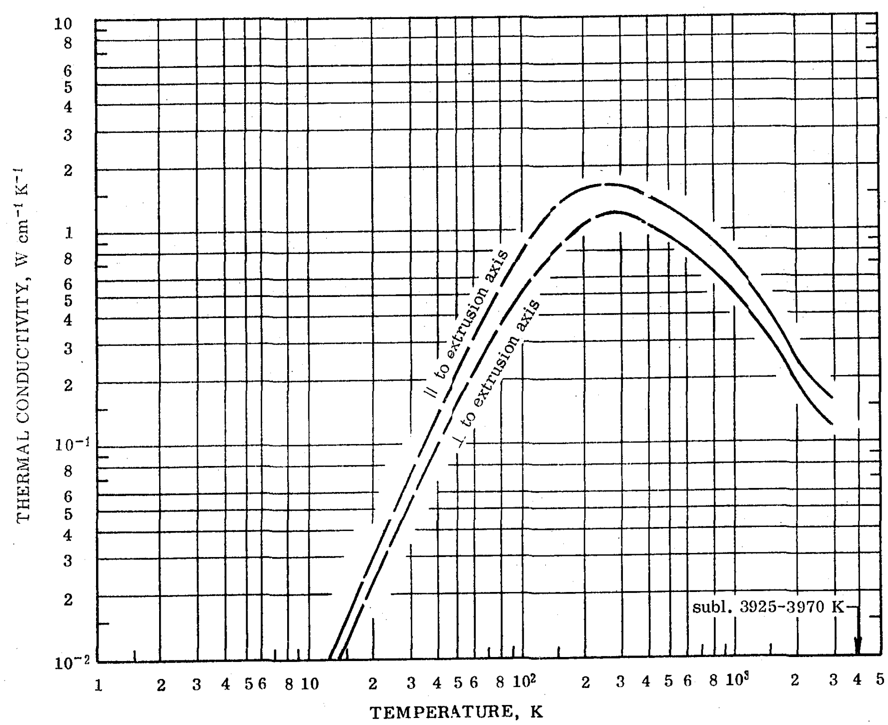
REMARKS

The 3 sets of thermal conductivity values only represent 3 typical curves serving to indicate the general trend of the thermal conductivity of the three types of diamond.

* Extrapolated.

* Extrapolated.

THERMAL CONDUCTIVITY OF ACHESON GRAPHITE



REMARKS

The values above 400 K are recommended values for Acheson graphite and are considered accurate to within ±10 to ±20%. The values below 400 K are merely typical values and represent a typical curve serving only to indicate the general trend of the thermal conductivity of Acheson graphite at moderate and low temperatures, since the thermal conductivity at temperatures near and below the corresponding temperature of the conductivity maximum is highly sensitive to small physical and chemical variations among different specimens.

RECOMMENDED VALUES †

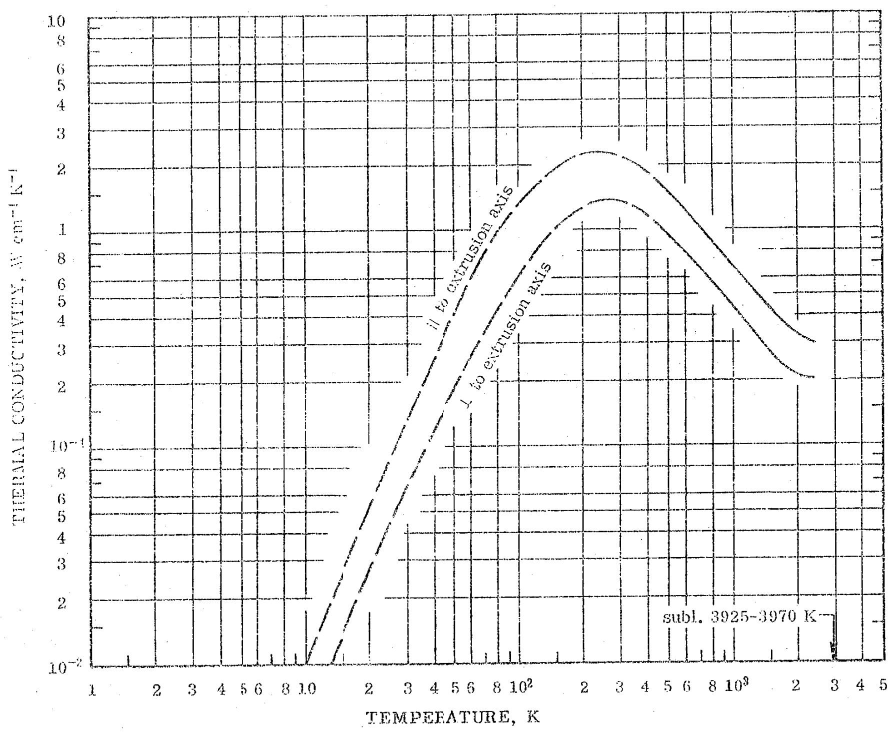
[Temperature, T, K; Thermal Conductivity, k, W cm^{-1} K^{-1}]

SOLID

T	k (// to axis of extrusion)	k (⊥ to axis of extrusion)	T	k (// to axis of extrusion)	k (⊥ to axis of extrusion)
10	0.00606*	0.00470*	1073.2	0.644	0.488
20	0.0320*	0.0235*	1100	0.626	0.474
30	0.0791*	0.0568*	1173.2	0.576	0.436
40	0.148*	0.103*	1200	0.559	0.422
50	0.235*	0.158*	1273.2	0.516	0.389
60	0.337*	0.223*	1300	0.501	0.377
70	0.450*	0.293*	1373.2	0.462	0.348
80	0.571*	0.366*	1400	0.449	0.338
90	0.694*	0.439*	1473.2	0.412	0.312
100	0.814	0.513*	1500	0.401	0.304
123.2	1.07	0.674	1573.2	0.372	0.281
150	1.32	0.844	1600	0.361	0.274
173.2	1.48	0.966	1673.2	0.337	0.255
200	1.62	1.08	1700	0.327	0.248
223.2	1.68	1.16	1773.2	0.308	0.232
250	1.70	1.19	1800	0.296	0.226
273.2	1.69	1.21	1873.2	0.277	0.212
298.2	1.65	1.19	1900	0.269	0.207
300	1.65	1.19	1973.2	0.252	0.195
323.2	1.61	1.18	2000	0.247	0.190
350	1.55	1.14	2073.2	0.233*	0.179
373.2	1.50	1.11	2173.2	0.217*	0.166
400	1.45	1.07	2200	0.213*	0.166
473.2	1.31	0.963	2273.2	0.203*	0.155
500	1.27	0.927	2400	0.191*	0.144
573.2	1.16	0.846	2473.2	0.185*	0.139
600	1.12	0.816	2600	0.176*	0.132
673.2	1.02	0.751	2673.2	0.171*	0.129
700	0.988	0.729	2800	0.166*	0.125
773.2	0.906	0.674	2873.2	0.163*	0.123
800	0.875	0.654	3000	0.161*	0.122
873.2	0.803	0.607			
900	0.778	0.589			
973.2	0.717	0.544			
1000	0.695	0.528			

* Extrapolated.
† Values below 400 K are merely typical values.

THERMAL CONDUCTIVITY OF AGOT GRAPHITE



REMARKS

The values above 400 K are recommenced values for AGOT graphite and are considered accurate to within ±10 to ±20%. The values below 400 K are merely typical values and represent a typical curve serving only to indicate the general trend of the thermal conductivity of AGOT graphite at moderate and low temperatures, since the thermal conductivity at temperatures near and below the corresponding temperature of the conductivity maximum is highly sensitive to small physical and chemical variations among different specimens.

RECOMMENDED VALUES †

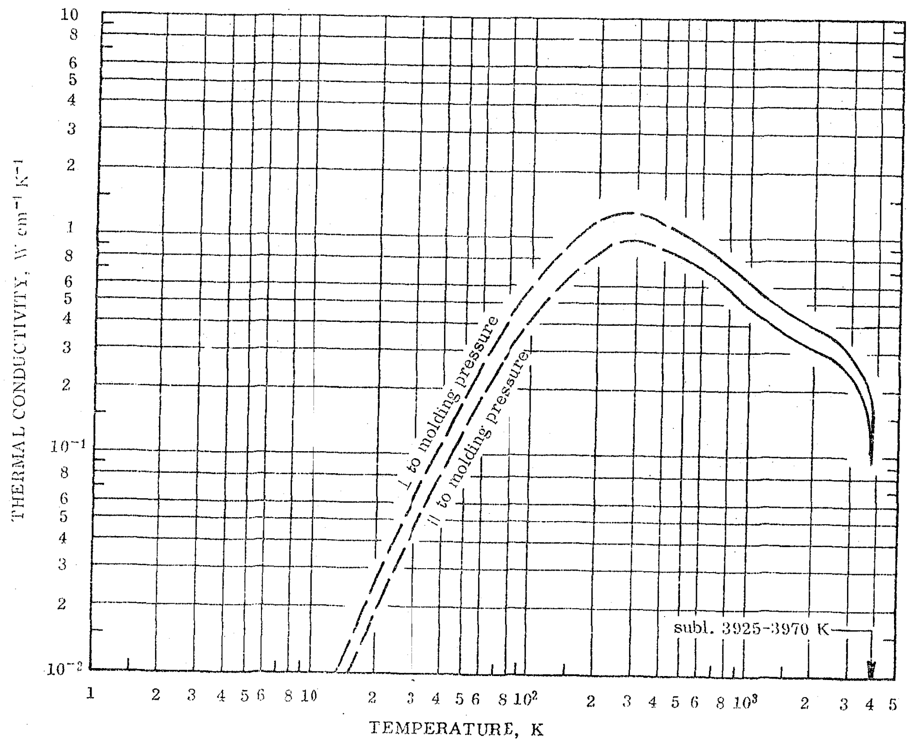
[Temperature, T, K; Thermal Conductivity, k, W cm⁻¹ K⁻¹]

SOLID

T	// to axis of extrusion k	⊥ to axis of extrusion k	T	// to axis of extrusion k	⊥ to axis of extrusion k
10	0.00904	0.00515	1073.2	0.635	0.405
20	0.0531	0.0256	1100	0.618	0.394
30	0.138	0.0628	1173.2	0.573	0.366
40	0.262	0.117	1200	0.558	0.355
50	0.414	0.184	1273.2	0.516	0.330
60	0.587	0.261	1300	0.503	0.323
70	0.776	0.345	1373.2	0.470	0.303
80	0.968	0.434	1400	0.459	0.295
90	1.16	0.523	1473.2	0.431	0.277
100	1.33	0.612	1500	0.421	0.272
123.2	1.67	0.810	1573.2	0.400	0.259
150	1.98	1.02	1600	0.392	0.255
173.2	2.16	1.18	1673.2	0.375	0.245
200	2.28	1.31	1700	0.369	0.242
223.2	2.32	1.38	1773.2	0.356	0.234
250	2.30	1.41	1800	0.352	0.231
273.2	2.28	1.41	1873.2	0.341	0.224
298.2	2.21	1.38	1900	0.340	0.222
300	2.20	1.38	1973.2	0.332	0.218
323.2	2.14	1.34	2000	0.330	0.217
350	2.03	1.27	2073.2	0.324	0.214
373.2	1.95	1.22	2173.2	0.317	0.212
400	1.85	1.16	2200	0.316	0.211
473.2	1.59	0.998	2273.2	0.312	0.209
500	1.50	0.945	2400	0.304	0.204
573.2	1.31	0.820	2473.2	0.297*	0.200*
600	1.24	0.779			
673.2	1.10	0.691			
700	1.05	0.660			
773.2	0.936	0.591			
800	0.898	0.569			
873.2	0.810	0.505			
900	0.780	0.497			
973.2	0.711	0.454			
1000	0.683	0.440			

* Extrapolated.
† Values below 400 K are merely typical values.

* Extrapolated.
† Values below 400 K are merely typical values.



REMARKS

The values above 400 K are recommended values for ATJ graphite and are considered accurate to within ±10 to ±20%. The values below 400 K are merely typical values and represent two typical curves serving only to indicate the general trend of the thermal conductivity of ATJ graphite at moderate and low temperatures, since the thermal conductivity at temperatures near and below the corresponding temperature of the conductivity maximum is highly sensitive to small physical and chemical variations among different specimens.

RECOMMENDED VALUES†

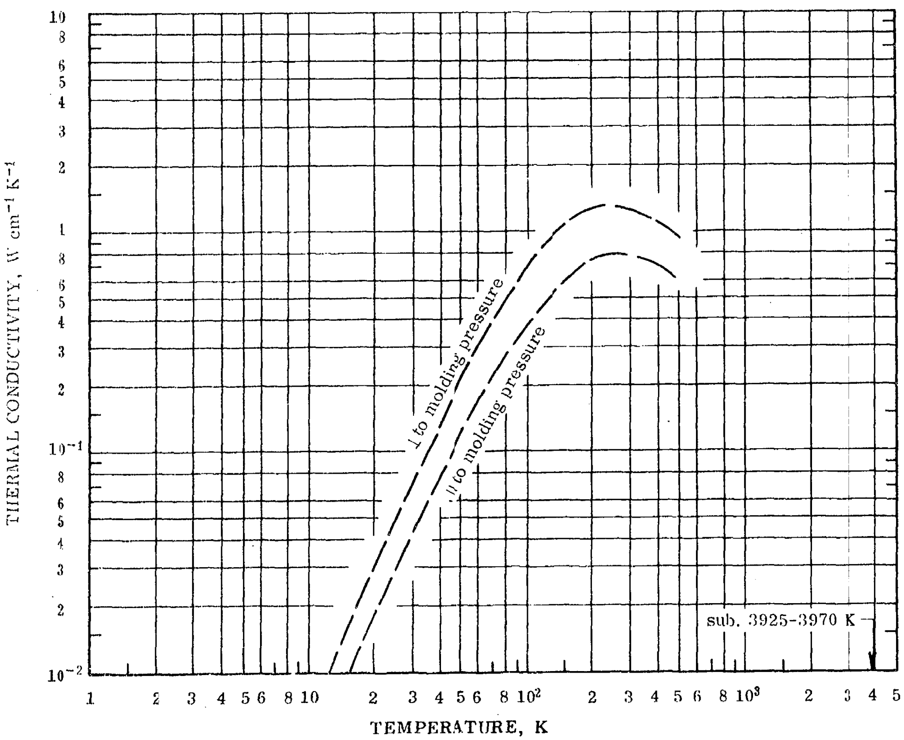
[Temperature, T, K; Thermal Conductivity, k, W cm^{-1} K^{-1}]

SOLID

T	k (// to molding pressure)	k (⊥ to molding pressure)	T	k (// to molding pressure)	k (⊥ to molding pressure)
10	0.00396*	0.00522*	1073.2	0.465	0.607
20	0.0192*	0.0245*	1100	0.458	0.595
30	0.0457*	0.0597*	1173.2	0.437	0.566
40	0.0826*	0.109*	1200	0.430	0.556
50	0.128*	0.171*	1273.2	0.413	0.532
60	0.181*	0.241*	1300	0.407	0.524
70	0.238*	0.319*	1373.2	0.393	0.504
80	0.298*	0.400*	1400	0.389	0.497
90	0.357*	0.488*	1473.2	0.376	0.480
100	0.415	0.571	1500	0.372	0.474
123.2	0.541	0.752	1573.2	0.361	0.460
150	0.673	0.946	1600	0.358	0.455
173.2	0.771	1.08	1673.2	0.349	0.443
200	0.865	1.20	1700	0.346	0.438
223.2	0.922	1.27	1773.2	0.338	0.428
250	0.965	1.30	1800	0.336	0.424
273.2	0.984	1.31	1873.2	0.329	0.414
298.2	0.982	1.29	1900	0.327	0.411
300	0.982	1.29	1973.2	0.321	0.403
323.2	0.972	1.27	2000	0.319	0.400
350	0.952	1.24	2073.2	0.314	0.392
373.2	0.933	1.21	2173.2	0.307	0.383
400	0.907	1.18	2200	0.305	0.380
473.2	0.834	1.08	2273.2	0.301	0.374
500	0.808	1.05	2400	0.293	0.364
573.2	0.742	0.967	2473.2	0.288	0.358
600	0.718	0.938	2600	0.280	0.346
673.2	0.665	0.870	2673.2	0.275	0.340
700	0.645	0.844	2800	0.266	0.328
773.2	0.599	0.785	2873.2	0.260	0.321
800	0.583	0.763	3000	0.250	0.308
873.2	0.546	0.712	3073	0.244*	0.300*
900	0.532	0.693	3200	0.233*	0.283*
973.2	0.501	0.653	3273	0.225*	0.273*
1000	0.491	0.640	3400	0.209*	0.252*
			3600	0.170*	0.204*
			3800	0.095*	0.113*

* Extrapolated.
† Values below 400 K are merely typical values.

THERMAL CONDUCTIVITY OF AWG GRAPHITE



TYPICAL VALUES

[Temperature, T, K; Thermal Conductivity, k, W cm^{-1} K^{-1}]

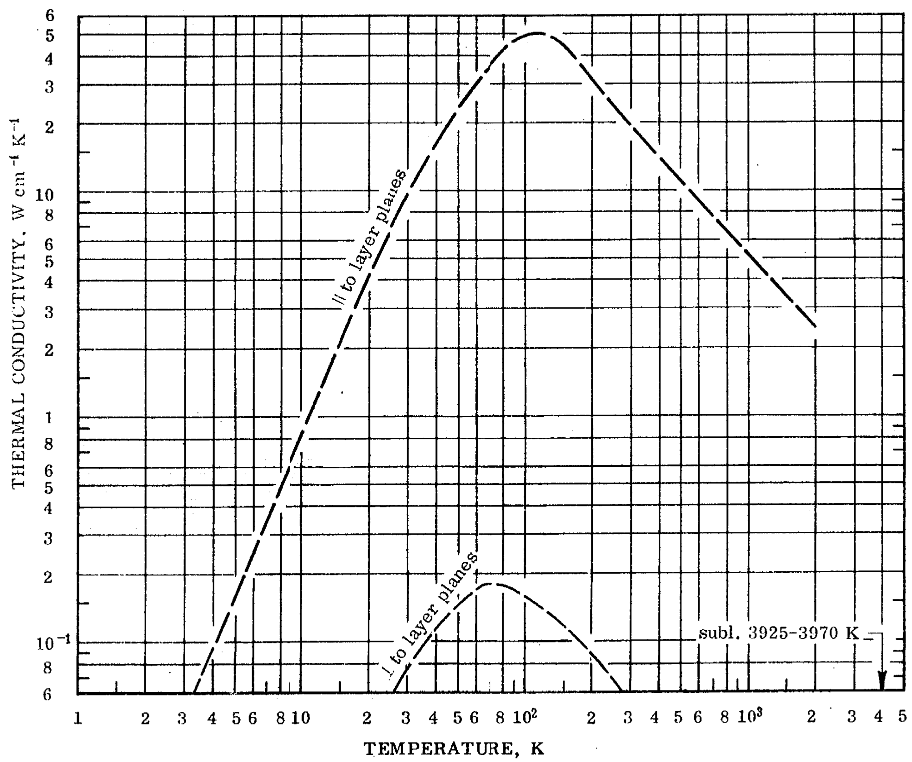
SOLID

T	// to molding pressure k	⊥ to molding pressure k
10	0.00397	0.00583
20	0.0181	0.0298
30	0.0428	0.0730
40	0.0783	0.133
50	0.122	0.209
60	0.168	0.296
70	0.212	0.389
80	0.269	0.483
90	0.327	0.582
100	0.375	0.677
123.2	0.486	0.878
150	0.604	1.08
173.2	0.682	1.20
200	0.748	1.29
223.2	0.785	1.33
250	0.803	1.33
273.2	0.807	1.32
298.2	0.796	1.28
300	0.795	1.28
323.2	0.778	1.24
350	0.754	1.20
373.2	0.733	1.16
400	0.705	1.12
473.2	0.635	1.00
500	0.611	0.965

REMARKS

The values are merely typical values and represent two typical curves serving only to indicate the general trend of the thermal conductivity of AWG graphite.

THERMAL CONDUCTIVITY OF PYROLYTIC GRAPHITE



TYPICAL VALUES

[Temperature, T, K; Thermal Conductivity, k, W cm^{-1} K^{-1}]

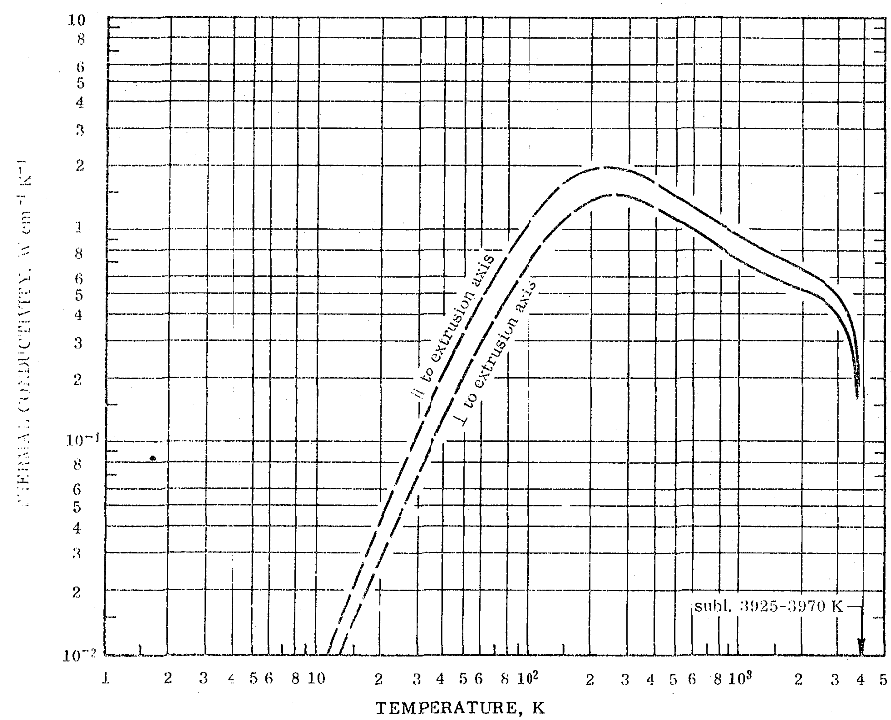
SOLID

T	// to layer planes k	⊥ to layer planes k
0	0	0
10	0.811	0.0116
20	4.20	0.0397
30	9.86	0.0786
40	16.4	0.120
50	23.1	0.152
60	29.8	0.173
70	36.6	0.181
80	42.8	0.181
90	47.5	0.176
100	49.7	0.168
123.2	50.4	0.148
150	45.1	0.125
173.2	38.7	0.108
200	32.3	0.0923
223.2	28.2	0.0814
250	24.4	0.0711
273.2	21.3	0.0636
298.2	19.6	0.0573
300	19.5	0.0570
323.2	17.8	0.0522
350	16.2	0.0477
373.2	15.1	0.0442
400	13.9	0.0409
473.2	11.4	0.0341
500	10.8	0.0322
573.2	9.36	0.0281
600	8.92	0.0268
673.2	7.92	0.0238
700	7.59	0.0229
773.2	6.88	0.0207
800	6.67	0.0201
873.2	6.13	0.0184
900	5.94	0.0178
973.2	5.49	0.0164
1000	5.34	0.0160
1073.2	5.00	0.0148
1100	4.88	0.0145
1173.2	4.57	0.0136
1200	4.48	0.0134
1273.2	4.22	0.0126
1300	4.13	0.0124
1373.2	3.91	0.0118
1400	3.84	0.0116
1473.2	3.64	0.0110
1500	3.57	0.0108
1573.2	3.40	0.0102
1600	3.33	0.0100
1673.2	3.18	0.00962
1700	3.12	0.00947
1773.2	2.97	0.00909
1800	2.93	0.00895
1883.2	2.80	0.00860
1900	2.77	0.00848
1973.2	2.66	0.00817
2000	2.62	0.00807

REMARKS

The values are merely typical values and represent two typical curves serving only to indicate the general trend for the thermal conductivity of pyrolytic graphite.

THERMAL CONDUCTIVITY OF 875S GRAPHITE



REMARKS

The values above 400 K are recommended values for 875S graphite and are considered accurate to within ±10 to ±20%. The values below 400 K are merely typical values and represent a typical curve serving only to indicate the general trend of the thermal conductivity of 875S graphite at moderate and low temperatures, since the thermal conductivity at temperatures near and below the corresponding temperature of the conductivity maximum is highly sensitive to small physical and chemical variations among different specimens.

RECOMMENDED VALUES †

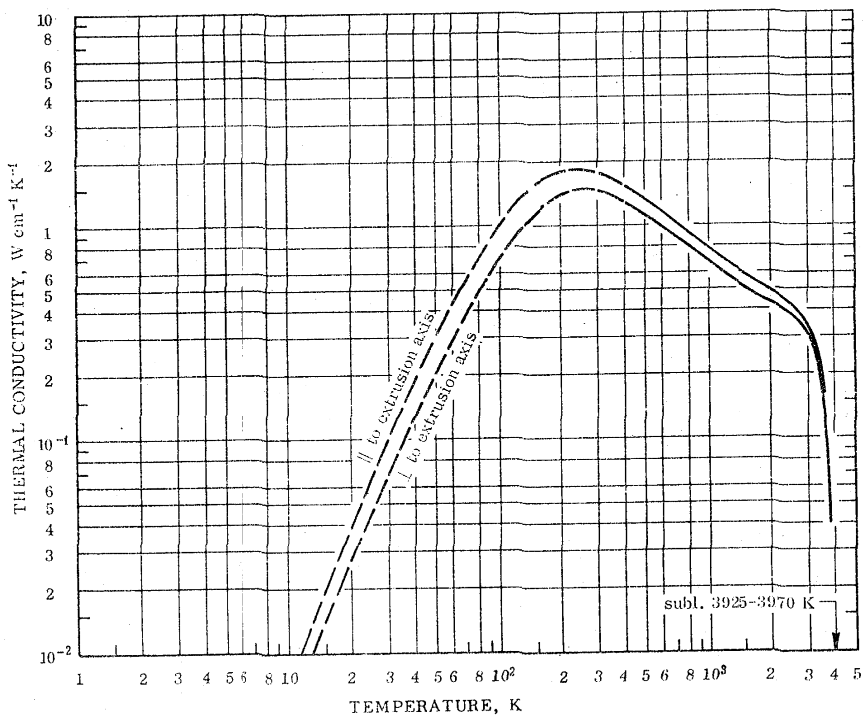
[Temperature, T, K; Thermal Conductivity, k, W cm^{-1} K^{-1}]

SOLID

T	// to axis of extrusion k	⊥ to axis of extrusion k	T	// to axis of extrusion k	⊥ to axis of extrusion k
10	0.00750*	0.00529*	1073.2	0.910	0.706
20	0.0411*	0.0270*	1100	0.898	0.696
30	0.105*	0.0667*	1173.2	0.868	0.673
40	0.199*	0.122*	1200	0.858	0.666
50	0.321*	0.193*	1273.2	0.833	0.646
60	0.465*	0.277*	1300	0.823	0.640
70	0.616*	0.367*	1373.2	0.800	0.623
80	0.772*	0.463*	1400	0.792	0.618
90	0.930*	0.559*	1473.2	0.773	0.603
100	1.09*	0.660*	1500	0.766	0.598
123.2	1.39*	0.880*	1573.2	0.748	0.586
150	1.66*	1.10*	1600	0.742	0.582
173.2	1.82*	1.27*	1673.2	0.725	0.570
200	1.95*	1.39*	1700	0.720	0.567
223.2	1.99*	1.46*	1773.2	0.704	0.556
250	1.99*	1.49*	1800	0.699	0.552
273.2	1.97*	1.49*	1873.2	0.685	0.542
298.2	1.92*	1.46*	1900	0.680	0.540
300	1.92*	1.46*	1973.2	0.667	0.532
323.2	1.87*	1.43*	2000	0.663	0.529
350	1.81*	1.38*	2073.2	0.652	0.522
373.2	1.75*	1.34*	2173.2	0.636	0.512
400	1.69*	1.29*	2200	0.632	0.510
473.2	1.54	1.18	2273.2	0.620	0.502
500	1.49	1.14	2400	0.601	0.490
573.2	1.38	1.04	2473.2	0.590	0.483
600	1.32	1.01	2600	0.571	0.470
673.2	1.22	0.941	2673.2	0.560	0.463
700	1.19	0.918	2800	0.540	0.448
773.2	1.11	0.861	2873.2	0.528	0.439
800	1.09	0.842	3000	0.508	0.421
873.2	1.03	0.795	3073	0.496	0.410
900	1.01	0.781	3200	0.471	0.390
973.2	0.962	0.745	3273	0.454	0.376
1000	0.946	0.734	3400	0.418	0.348
			3600	0.340	0.283
			3800	0.190*	0.160*

* Extrapolated.

† Values below 400 K are merely typical values.



REMARKS

The values above 400 K are recommended values for S90S graphite and are considered accurate to within ±10 to ±20%. The values below 400 K are merely typical values and represent a typical curve serving only to indicate the general trend of the thermal conductivity of S90S graphite at moderate and low temperatures, since the thermal conductivity at temperatures near and below the corresponding temperature of the conductivity maximum is highly sensitive to small physical and chemical variations among different specimens.

RECOMMENDED VALUES †

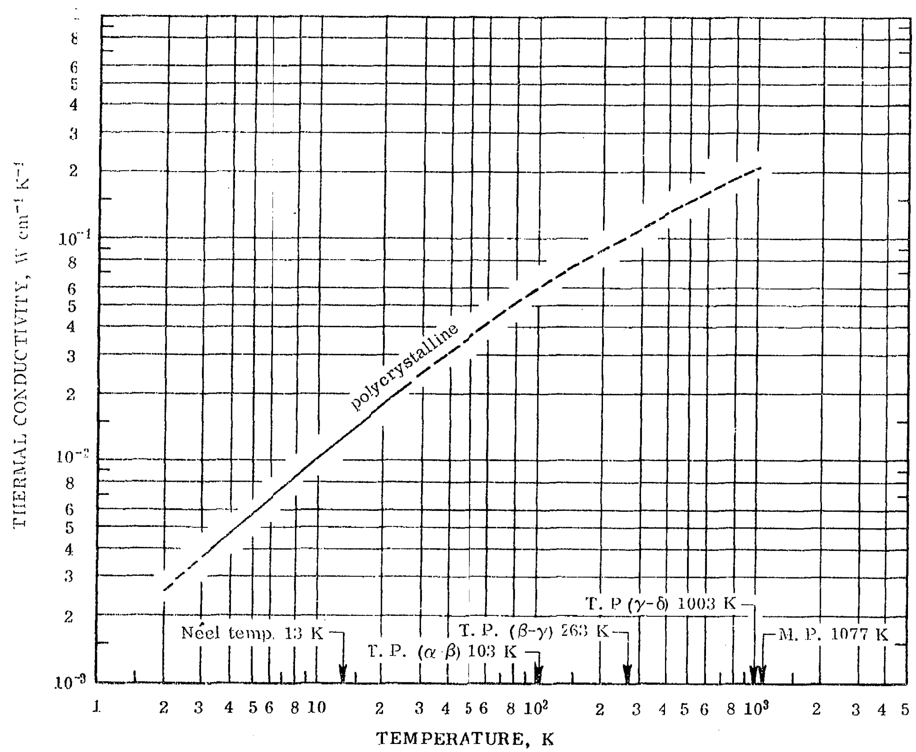
[Temperature, T, K; Thermal Conductivity, k, W $cm^{-1} K^{-1}$]

SOLID

T	// to axis of extrusion k	⊥ to axis of extrusion k	T	// to axis of extrusion k	⊥ to axis of extrusion k
10	0.00700*	0.00542*	1073.2	0.764	0.650
20	0.0381*	0.0278*	1100	0.749	0.638
30	0.0961*	0.0687*	1173.2	0.711	0.609
40	0.182*	0.127*	1200	0.699	0.600
50	0.289*	0.200*	1273.2	0.668	0.577
60	0.419*	0.287*	1300	0.659	0.569
70	0.559*	0.379*	1373.2	0.634	0.550
80	0.702*	0.475*	1400	0.626	0.543
90	0.845*	0.574*	1473.2	0.605	0.526
100	0.984*	0.678*	1500	0.597	0.520
123.2	1.27*	0.908*	1573.2	0.579	0.504
150	1.55*	1.15*	1600	0.573	0.498
173.2	1.71*	1.31*	1673.2	0.559	0.484
200	1.83*	1.43*	1700	0.554	0.479
223.2	1.88*	1.49*	1773.2	0.541	0.468
250	1.89*	1.52*	1800	0.536	0.464
273.2	1.87*	1.51*	1873.2	0.524	0.455
298.2	1.83*	1.48*	1900	0.520	0.452
300	1.82*	1.48*	1973.2	0.508	0.443
323.2	1.77*	1.44*	2000	0.504	0.440
350	1.71*	1.40*	2073.2	0.494	0.432
373.2	1.66*	1.36*	2173.2	0.481	0.422
400	1.59*	1.32*	2200	0.477	0.419
473.2	1.43*	1.20*	2273.2	0.467	0.412
500	1.38*	1.15*	2400	0.450	0.399
573.2	1.25*	1.05*	2473.2	0.440	0.392
600	1.21*	1.01*	2600	0.422	0.377
673.2	1.11*	0.933*	2673.2	0.411	0.369
700	1.08*	0.906*	2800	0.392	0.353
773.2	0.998*	0.843*	2873.2	0.380	0.342
800	0.970*	0.821*	3000	0.358	0.320
873.2	0.902	0.768	3073	0.344	0.307
900	0.880	0.749	3200	0.313	0.282
973.2	0.828	0.703	3273	0.293	0.265
1000	0.810	0.687	3400	0.251	0.232
			3600	0.160	0.150
			3800	0.0430*	0.0400*

* Extrapolated.
† Values below 400 K are merely typical values.

THERMAL CONDUCTIVITY OF CERIUM



REMARKS

Near room temperature the uncertainty of the provisional values is probably of the order of ±20% but it will be greater at lower temperatures on account of the phase changes and the magnetic transformation. The values below 270 K are applicable only to cerium having electrical resistivity ratio $\rho(293\ K)/\rho(20\ K) = 1.93$.

PROVISIONAL VALUES

[Temperature, T, K; Thermal Conductivity, k, W cm^{-1} K^{-1}]

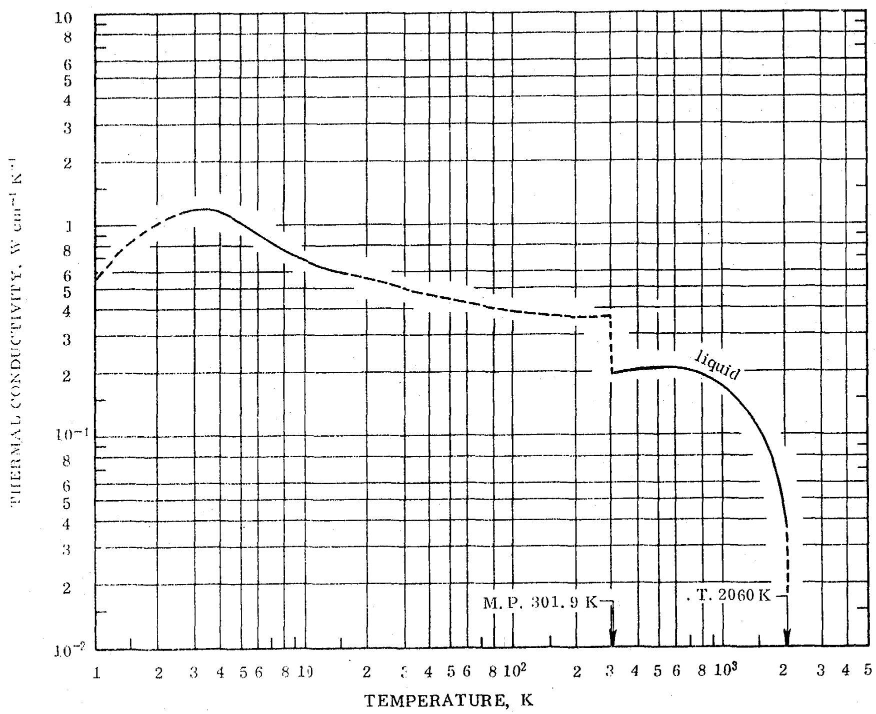
SOLID

Polycrystalline

T	k	T	k
2	0.00260*	80	0.0521*
3	0.00373	90	0.0561*
4	0.00482	100	0.0600*
5	0.00584	123.2	0.0679*
6	0.00683	150	0.0766*
7	0.00776	173.2	0.0828*
8	0.00868	200	0.0900*
9	0.00959	223.2	0.0958*
10	0.0105	250	0.1025*
11	0.0113	273.2	0.108*
12	0.0122	298.2	0.113
13	0.0130	300	0.114
14	0.0138	323.2	0.119*
15	0.0147	350	0.124*
16	0.0155	373.2	0.128*
18	0.0171	400	0.133*
20	0.0186	473.2	0.145*
25	0.0224*	500	0.150*
30	0.0260*	573.2	0.161*
35	0.0293*	600	0.165*
40	0.0323*	673.2	0.176*
45	0.0352*	700	0.180*
50	0.0379*	773.2	0.189*
60	0.0432*	800	0.193*
70	0.0478*	873.2	0.202*
		900	0.206*
		973.2	0.215*
		1000	0.218*

* Extrapolated or interpolated.

THERMAL CONDUCTIVITY OF CESIUM



REMARKS

The recommended values are for high-purity cesium and are thought to be accurate to within ±8% of the true values at temperatures below 15 K and from room temperature to about 1500 K. The thermal conductivity at temperature near and below the corresponding temperature, T_m, of the conductivity maximum is highly sensitive to small physical and chemical variations among different specimens, and the recommended values below 40 K are applicable only to cesium having residual electrical resistivity ρ_0 = 0.0418 $\mu\Omega$ cm. Values at temperatures below about 1.1 T_m are calculated to fit experimental data by using equation (7) and using n = 2.00, α' = 0.0300, and β = 1.71.

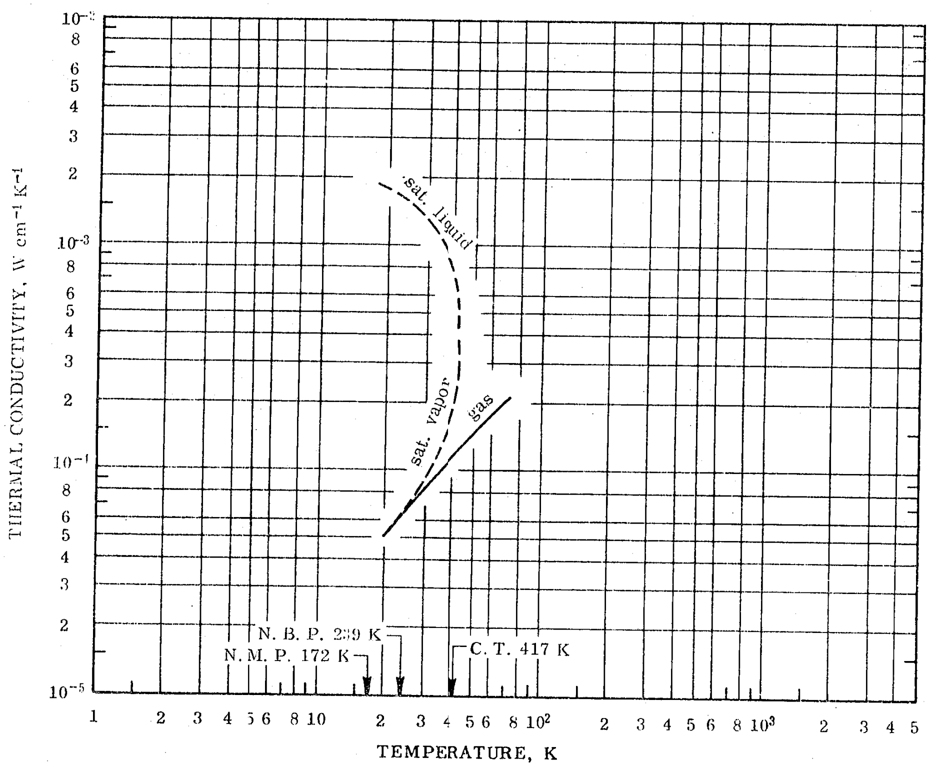
RECOMMENDED VALUES

[Temperature, T, K; Thermal Conductivity, k, W cm^{-1} K^{-1}]

SOLID T	SOLID k	LIQUID T	LIQUID k
0	0	301.9	0.197
1	0.574*	323.2	0.198
2	1.02*	350	0.200
3	1.19	373.2	0.201
4	1.14	400	0.203
5	1.04	473.2	0.205
6	0.935	500	0.205
7	0.837	573.2	0.206
8	0.769	600	0.205
9	0.720	673.2	0.202
10	0.689	700	0.201
11	0.666	773.2	0.196
12	0.647	800	0.194
13	0.630	873.2	0.187
14	0.615	973.2	0.177
15	0.600	1073.2	0.166
16	0.590	1100	0.163
18	0.572*	1173.2	0.153
20	0.554*	1200	0.150
25	0.523*	1273.2	0.140
30	0.500*	1300	0.136
35	0.483*	1373.2	0.126
40	0.470*	1400	0.122
45	0.457*	1473.2	0.112
50	0.447*	1500	0.108
60	0.430*	1573.2	0.098
70	0.420*	1600	0.094
80	0.410*	1673.2	0.084
90	0.402*	1700	0.080
100	0.397*	1773.2	0.070
123.2	0.387*	1800	0.066
150	0.378*	1873.2	0.055
173.2	0.373*	1900	0.051
200	0.368*	1973.2	0.036*
223.2	0.365*	2000	0.029*
250	0.363*		
273.2	0.361*		
298.2	0.359		
300	0.359		
301.9	0.359		

*Extrapolated, interpolated, or estimated, hence provisional.

THERMAL CONDUCTIVITY OF CHLORINE



PROVISIONAL VALUES

[Temperature, T, K; Thermal Conductivity, k, W cm^{-1} K^{-1}]

SATURATED LIQUID		SATURATED VAPOR	
T	k x 10^3	T	k x 10^3
		200	0.054 *
		210	0.058 *
172	1.93 *	220	0.061 *
180	1.89 *	230	0.065 *
190	1.85 *	240	0.068 *
200	1.81 *	250	0.074 *
210	1.76 *	260	0.078 *
220	1.72 *	270	0.082 *
230	1.67 *	280	0.086 *
240	1.63 *	290	0.092 *
250	1.58 *	300	0.097 *
260	1.54 *	310	0.103 *
270	1.49 *	320	0.110 *
280	1.44 *	330	0.117 *
290	1.39 *	340	0.125 *
300	1.34 *	350	0.134 *
310	1.29 *	360	0.144 *
320	1.24 *	370	0.155 *
330	1.18 *	380	0.168 *
340	1.13 *	390	0.185 *
350	1.07 *	400	0.210 *
360	1.01 *	410	0.25 *
370	0.95 *	417	0.40 *†
380	0.88 *		
390	0.80 *		
400	0.72 *		
410	0.62 *		
417	0.40 * †		

REMARKS

The liquid and vapor values are based on a correlation for diatomic substances. No experimental data were located to verify the present estimates, which must be regarded as provisional. The gas values, based on subatmospheric pressure experiments of a single source, should be accurate to 5%.

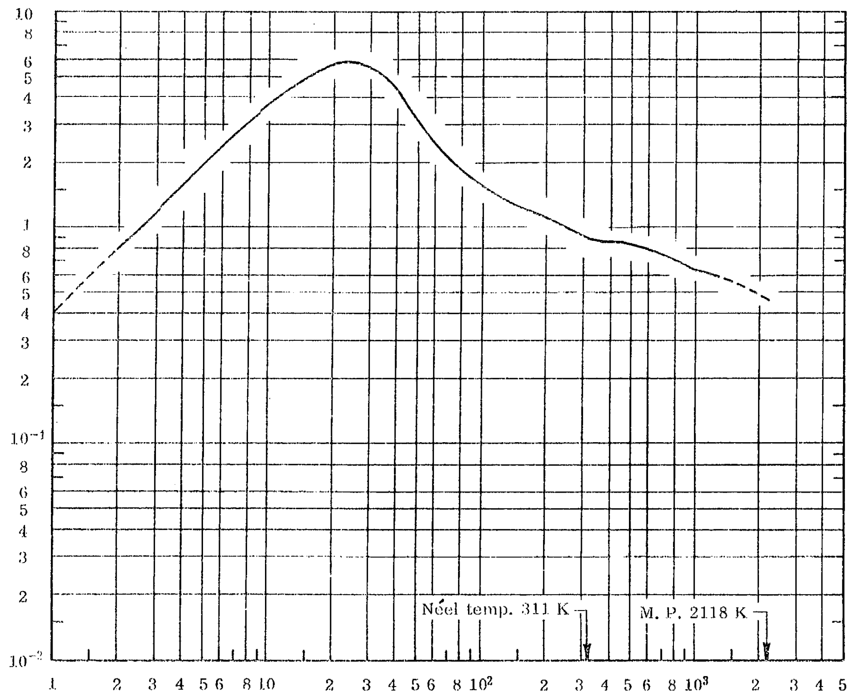
* Estimated, hence provisional.
† Pseudo-critical value.

THERMAL CONDUCTIVITY OF CHLORINE (continued)

RECOMMENDED VALUES
GAS
(At 1 atm)

T	k x 10^3	T	k x 10^3
239	0.068		
240	0.068		
250	0.071	500	0.156
260	0.075	510	0.160
270	0.078	520	0.163
280	0.082	530	0.166
290	0.085	540	0.170
300	0.089	550	0.173
310	0.093	560	0.176
320	0.096	570	0.180
330	0.100	580	0.183
340	0.103	590	0.186
350	0.107	600	0.190
360	0.110	610	0.192
370	0.114	620	0.195
380	0.117	630	0.197
390	0.120	640	0.200
400	0.124	650	0.202
410	0.127	660	0.205
420	0.131	670	0.207
430	0.134	680	0.210
440	0.137	690	0.212
450	0.141	700	0.215
460	0.144		
470	0.147		
480	0.150		
490	0.153		

THERMAL CONDUCTIVITY OF CHROMIUM



REMARKS

The recommended values are for well-annealed high-purity chromium and are thought to be accurate to within ±10% of the true values at temperatures below 150 K and above 700 K, and ±3% from 150 to 700 K except possibly near the Néel temperature. The thermal conductivity at temperatures near and below the corresponding temperature, T_m, of the conductivity maximum is highly sensitive to small physical and chemical variations among different specimens, and the recommended values below 150 K are applicable only to a specimen having residual electrical resistivity $\rho_0 = 0.0608$ μΩ cm. Values at temperatures below about 1.5 T_m are calculated to fit experimental data by using equation (7) and using constants m, n, and α'' as given in Table 1 and β = 2.49.

RECOMMENDED VALUES

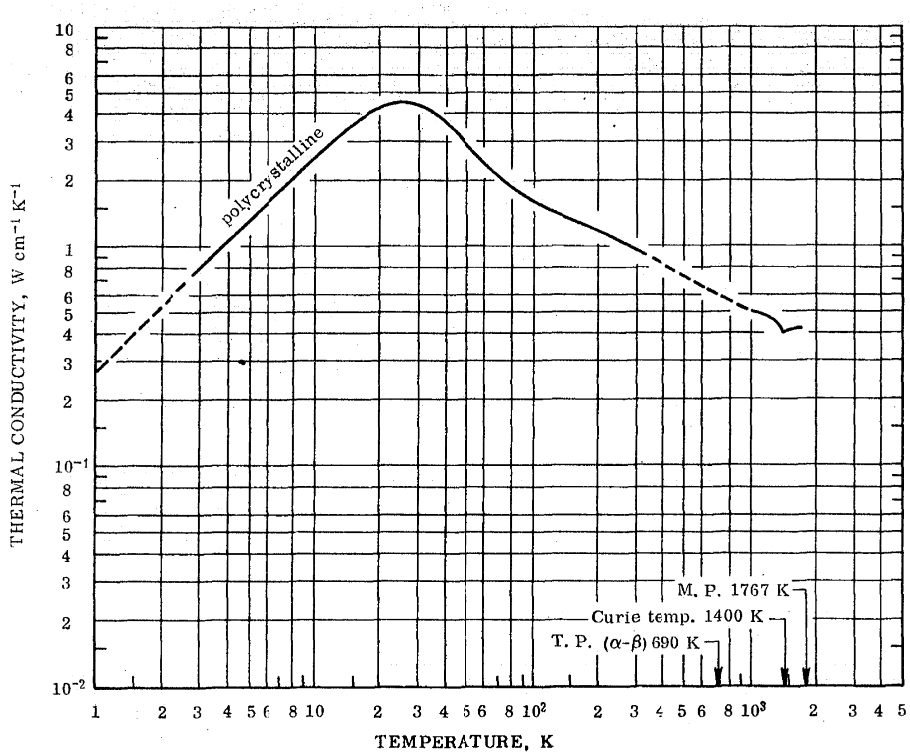
[Temperature, T, K; Thermal Conductivity, k, W cm^{-1} K^{-1}]

SOLID

Polycrystalline T	Polycrystalline k	Polycrystalline T	Polycrystalline k
0	0	350	0.929
1	0.402*	373.2	0.921
2	0.803	400	0.909
3	1.20	473.2	0.874
4	1.60	500	0.860
5	2.00	573.2	0.822
6	2.39	600	0.807
7	2.27	673.2	0.769
8	3.14	700	0.756
9	3.50	773.2	0.726
10	3.85	800	0.713
11	4.17	873.2	0.688
12	4.48	900	0.678
13	4.76	973.2	0.660
14	5.01	1000	0.654
15	5.24	1073.2	0.640
16	5.44	1100	0.636
18	5.74	1173.2	0.624
20	5.93	1200	0.619
25	5.93	1273.2	0.608
30	5.49	1300	0.604
35	4.88	1373.2	0.592
40	4.25	1400	0.588
45	3.67	1473.2	0.576
50	3.17	1500	0.572
60	2.48	1573.2	0.561
70	2.07	1600	0.556
80	1.84	1673.2	0.546*
90	1.69	1700	0.542*
100	1.59	1773.2	0.530*
123.2	1.43	1800	0.526*
150	1.29	1873.2	0.514*
173.2	1.20	1900	0.510*
200	1.11	1973.2	0.498*
223.2	1.06	2000	0.494*
250	1.00	2073.2	0.482*
273.2	0.965	2100	0.478*
298.2	0.939	2118	0.475*
300	0.937		
323.2	0.933		

*Extrapolated.

THERMAL CONDUCTIVITY OF COBALT



RECOMMENDED VALUES

[Temperature, T, K; Thermal Conductivity, k, W cm^{-1} K^{-1}]

SOLID

Polycrystalline

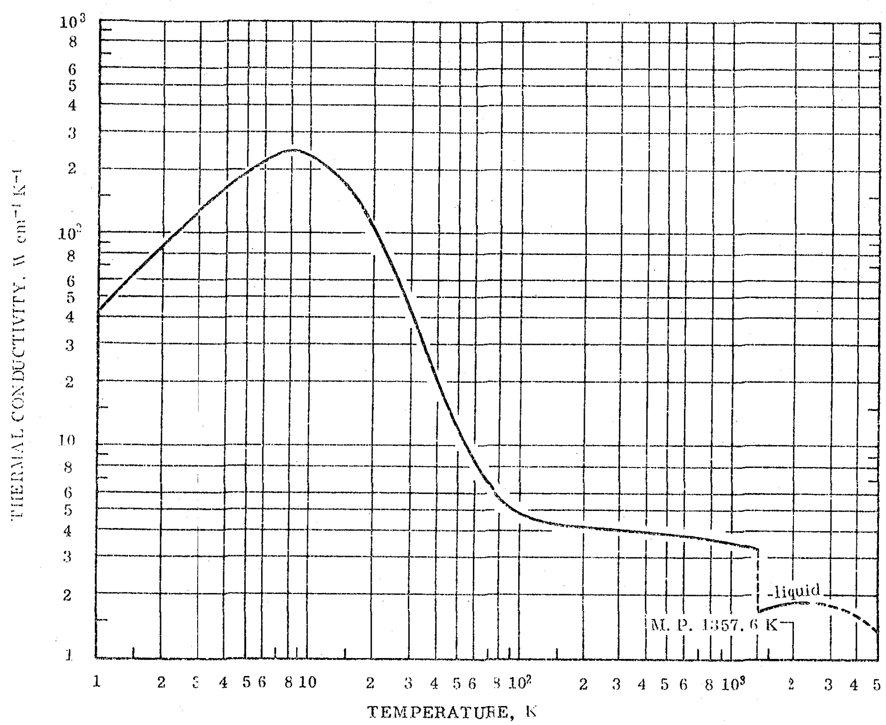
T	k	T	k
0	0	250	1.10
1	0.270*	273.2	1.05
2	0.539*	298.2	1.00
3	0.808	300	1.00
4	1.08	323.2	0.963
5	1.34	350	0.922
6	1.61	373.2	0.890
7	1.87	400	0.854
8	2.13	473.2	0.771*
9	2.38	500	0.747*
10	2.63	573.2	0.692*
11	2.87	600	0.674*
12	3.10	673.2	0.633*
13	3.31	700	0.621*
14	3.52	773.2	0.592*
15	3.71	800	0.582*
16	3.89	873.2	0.556*
18	4.19	900	0.548*
20	4.43	973.2	0.527
25	4.70	1000	0.521
30	4.58	1073.2	0.509
35	4.24	1100	0.505
40	3.78	1173.2	0.495
45	3.34	1200	0.493
50	2.99	1273.2	0.482
60	2.49	1300	0.472
70	2.17	1373.2	0.425
80	1.94	1400	0.417
90	1.78	1473.2	0.424
100	1.67	1500	0.425
123.2	1.53	1573.2	0.428
150	1.38	1600	0.429
173.2	1.30	1673.2	0.430
200	1.22	1700	0.430
223.2	1.16	1767	0.431*

*Extrapolated or interpolated.

REMARKS

The recommended values are for well-annealed high-purity cobalt and are considered accurate to within ±5% of the true values near room temperature, ±10% at low temperatures and up to 1000 K, and ±20% from 1000 K to the melting point. The thermal conductivity at temperatures near and below the corresponding temperature, T_m, of the conductivity maximum is highly sensitive to small physical and chemical variations among different specimens, and the recommended values below 200 K are applicable only to a specimen having residual electrical resistivity $\rho_0 = 0.09075$ μΩ cm. Values at temperatures below about 1.5 T_m are calculated to fit experimental data by using equation (7) and using constants m, n, and α'' as given in Table 1 and $\beta = 3.71$.

THERMAL CONDUCTIVITY OF COPPER



RECOMMENDED VALUES†

[Temperature, T, K; Thermal Conductivity, k, W cm⁻¹ K⁻¹]

SOLID				LIQUID			
T	k	T	k	T	k	T	k
0	0	123.2	4.47	1357.6	1.66	3473	1.73*
1	42.2	150	4.29	1373.2	1.66	3600	1.70*
2	84.0	173.2	4.20	1400	1.67	3673	1.69*
3	125	200	4.13	1473.2	1.70	3800	1.66*
4	162	223.2	4.09	1500	1.71	3873	1.65*
5	195	250	4.06	1573.2	1.73	4000	1.61*
6	222	273.2	4.03	1600	1.74	4073	1.60*
7	239	298.2	4.01	1673.2	1.76	4273	1.54*
8	248	300	4.01	1700	1.77	4500	1.48*
9	249	323.2	3.99	1773.2	1.79	4773	1.40*
10	243	350	3.96	1800	1.79	5000	1.33*
11	232	373.2	3.95	1873.2	1.80	5273	1.24*
12	218	400	3.93	1900	1.81	5500	1.17*
13	202	473.2	3.88	1973.2	1.82	5773	1.07*
14	186	500	3.86	2000	1.82	6000	0.989*
15	171	573.2	3.81	2073.2	1.83	6273	0.889*
16	157	600	3.79	2173.2	1.84	6500	0.804*
18	131	673.2	3.74	2200	1.84	6773	0.698*
20	108	700	3.73	2273.2	1.84	7000	0.611*
25	68.3	773.2	3.68	2400	1.84	7273	0.503*
30	44.5	800	3.66	2473.2	1.84	7500	0.414*
35	30.4	873.2	3.61	2600	1.84*	7773	0.305*
40	21.7	900	3.59	2673.2	1.84*	8000	0.212*
45	16.2	973.2	3.54	2800	1.83*	8273	0.097*
50	12.5	1000	3.52	2873.2	1.82*	C.T.=8500	0.036*
60	8.29	1073.2	3.47	3000	1.80*		
70	6.47	1100	3.46	3073	1.79*		
80	5.57	1173.2	3.41	3200	1.78*		
90	5.08	1200	3.39	3273	1.76*		
100	4.82	1273.2	3.34	3400	1.74*		
		1300	3.32				
		1357.6	3.28				

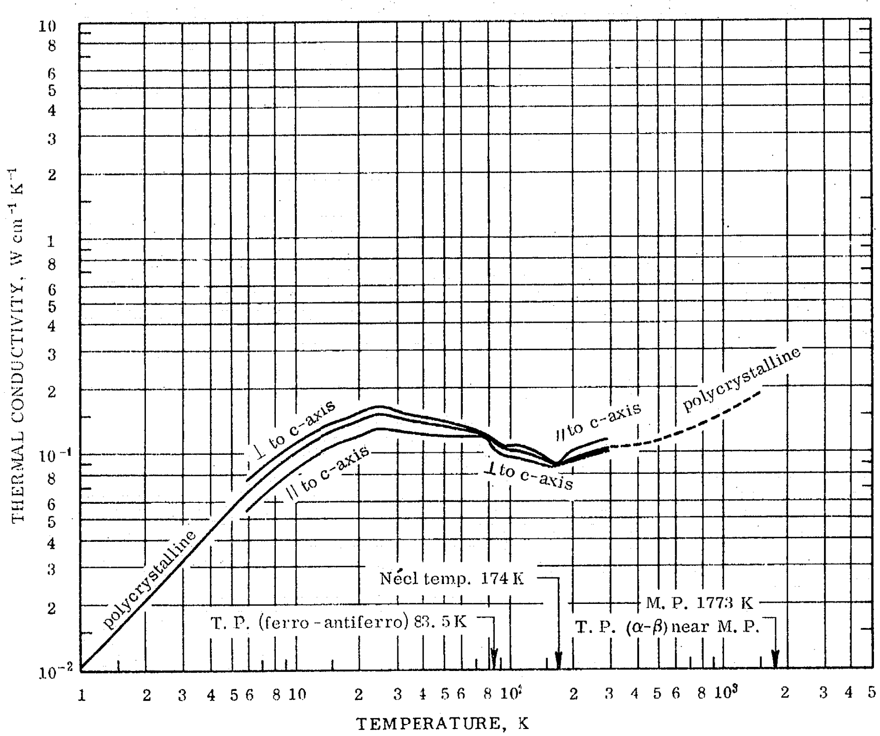
* Extrapolated or estimated.

† Values above 2000 K are provisional.

REMARKS

The recommended values are for well-annealed high-purity copper and are considered accurate to within ±2% of the true values near room temperature and ±4% at low and high temperatures. The values for molten copper up to about 2000 K should be good to ±15%. The thermal conductivity at temperatures near and below the corresponding temperature, T_m, of the conductivity maximum is highly sensitive to small physical and chemical variations among different specimens, and the recommended values below 100 K are applicable only to a specimen having residual electrical resistivity ρ_0 = 0.000579 $\mu\Omega$ cm. Values at temperatures below about 1.5 T_m are calculated to fit experimental data by using equation (7) and using constants m, n, and α'' as listed in Table 1 and β = 0.0237.

THERMAL CONDUCTIVITY OF DYSPROSIUM



REMARKS

The provisional values are for well-annealed high-purity dysprosium and are considered accurate to within ±15% of the true values at temperatures from 200 to 300 K and ±15 to ±25% above 300 K. At temperatures below 200 K the values are highly conditioned by purity and imperfection, and the values for $k_{\parallel}$, $k_{\perp}$, and k_{poly} are applicable only to samples having residual electrical resistivities of 5.77, 4.59, and 4.93 μΩ cm, respectively. Reliable uncertainty limits for the values below 200 K can hardly be given.

PROVISIONAL VALUES

[Temperature, T, K; Thermal Conductivity, k, W cm^{-1} K^{-1}]

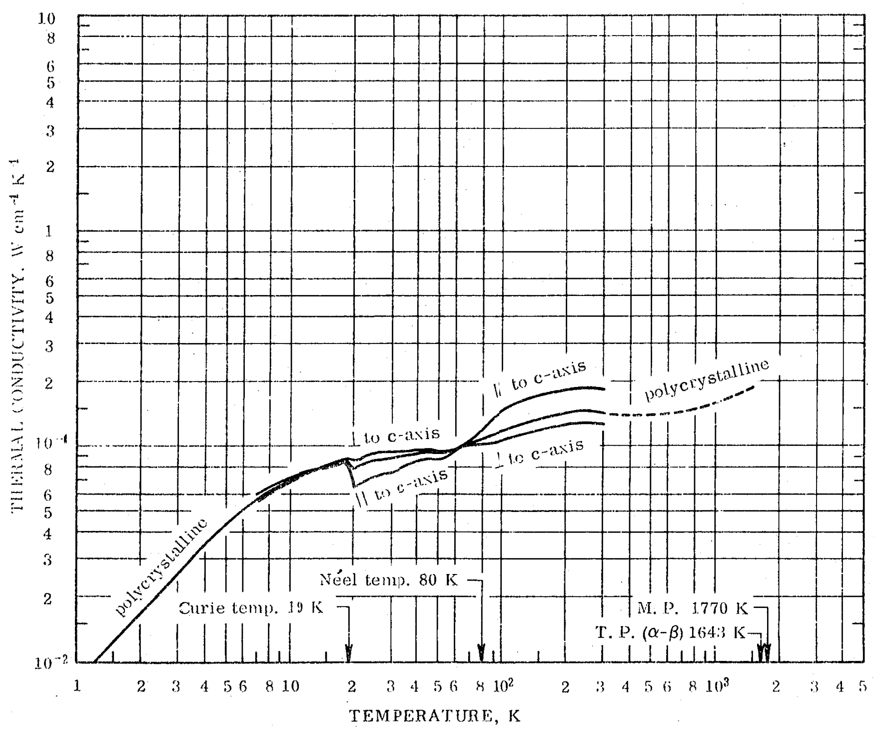
SOLID

T	// to c-axis k	⊥ to c-axis k	Poly-crystalline k
1			0.0102
2			0.0208
3			0.0324
4			0.0442
5			0.0561
6	0.0539	0.0757	0.0676
7	0.0626	0.0865	0.0776
8	0.0704	0.0964	0.0868
9	0.0778	0.106	0.0953
10	0.0844	0.113	0.102
11	0.0901	0.120	0.109
12	0.0956	0.126	0.115
13	0.100	0.131	0.120
14	0.104	0.136	0.124
15	0.108	0.139	0.128
16	0.111	0.142	0.131
18	0.116	0.148	0.136
20	0.121	0.156	0.143
25	0.132	0.165	0.153
30	0.127	0.158	0.147
35	0.125	0.151	0.142
40	0.124	0.148	0.139
45	0.123	0.145	0.137
50	0.123	0.142	0.135
60	0.121	0.136	0.131
70	0.120	0.131	0.127
80	0.117	0.124	0.122
90	0.101	0.113	0.105
100	0.0969	0.110	0.101
123.2	0.0929	0.106	0.0971
150	0.0874	0.0968	0.0904
173.2	0.0887	0.0887	0.0887
200	0.103	0.0931	0.0963
223.2	0.107	0.0960	0.0995

T	// to c-axis k	⊥ to c-axis k	Poly-crystalline k
250	0.111	0.0987	0.103
273.2	0.114	0.101	0.105
298.2	0.117	0.103	0.107
300	0.117	0.103	0.107
323.2			0.108*
350			0.108*
373.2			0.108*
400			0.109*
473.2			0.113*
500			0.115*
573.2			0.119*
600			0.121*
673.2			0.127*
700			0.129*
773.2			0.135*
800			0.137*
873.2			0.143*
900			0.145*
973.2			0.150*
1000			0.152*
1073.2			0.158*
1100			0.160*
1173.2			0.165*
1200			0.167*
1273.2			0.172*
1300			0.174*
1373.2			0.180*
1400			0.182*
1473.2			0.187*
1500			0.189*

*Extrapolated or estimated.

THERMAL CONDUCTIVITY OF ERBIUM



REMARKS

The provisional values are for well-annealed high-purity erbium and are thought to be accurate to within ± 15% at temperatures from 200 to 300 K and ± 20% above 300 K. At temperatures below 200 K the values are very uncertain.

PROVISIONAL VALUES

[Temperature, T, K; Thermal Conductivity, k, W cm^{-1} K^{-1}]

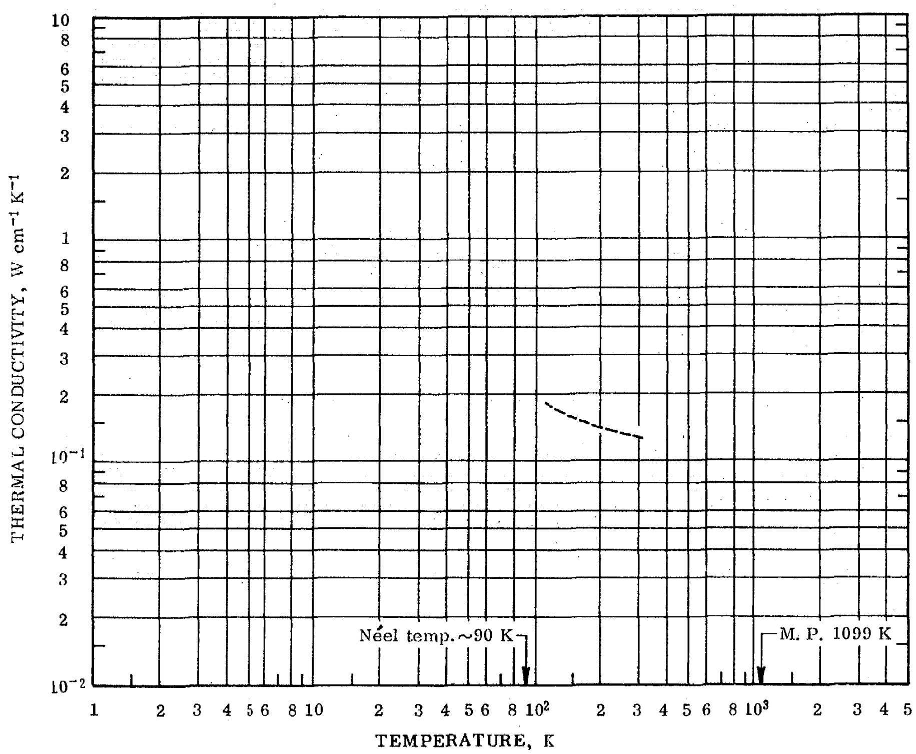
SOLID

T	// to c-axis k	⊥ to c-axis k	Poly-crystalline k
0	0	0	0
1			0.00856
2			0.0171
3			0.0261
4			0.0356
5			0.0442
6			0.0515
7	0.0612	0.0558	0.0576
8	0.0660	0.0612	0.0628
9	0.0696	0.0658	0.0672
10	0.0722	0.0698	0.0706
11	0.0743	0.0731	0.0735
12	0.0760	0.0761	0.0762
13	0.0774	0.0788	0.0783
14	0.0787	0.0810	0.0802
15	0.0797	0.0830	0.0819
16	0.0809	0.0845	0.0833
18	0.0840	0.0880	0.0867
20	0.0639	0.0863	0.0782
25	0.0729	0.0934	0.0866
30	0.0762	0.0938	0.0875
35	0.0820	0.0955	0.0908
40	0.0858	0.0963	0.0926
45	0.0876	0.0966	0.0935
50	0.0874	0.0957	0.0929
60	0.0992	0.0974	0.0980
70	0.107	0.101	0.103
80	0.121	0.102	0.108
90	0.139	0.104	0.115
100	0.150	0.108	0.122
123.2	0.163	0.113	0.130
150	0.174	0.119	0.137
173.2	0.180	0.123	0.142
200	0.185	0.126	0.146
223.2	0.187	0.128	0.148

T	// to c-axis k	⊥ to c-axis k	Poly-crystalline k
250	0.188	0.128	0.148
273.2	0.187	0.127	0.147
298.2	0.184	0.126	0.145
300	0.184	0.126	0.143
323.2			0.144*
350			0.140*
373.2			0.140*
400			0.140*
473.2			0.140*
500			0.141*
573.2			0.142*
600			0.143*
673.2			0.145*
700			0.146*
773.2			0.149*
800			0.150*
873.2			0.153*
900			0.154*
973.2			0.158*
1000			0.159*
1073.2			0.163*
1100			0.165*
1173.2			0.169*
1200			0.171*
1273.2			0.176*
1300			0.178*
1373.2			0.183*
1400			0.185*
1473.2			0.190*
1500			0.191*

* Extrapolated or estimated.

THERMAL CONDUCTIVITY OF EUROPIUM



PROVISIONAL VALUES

[Temperature, T, K; Thermal Conductivity, k, W cm^{-1} K^{-1}]

SOLID

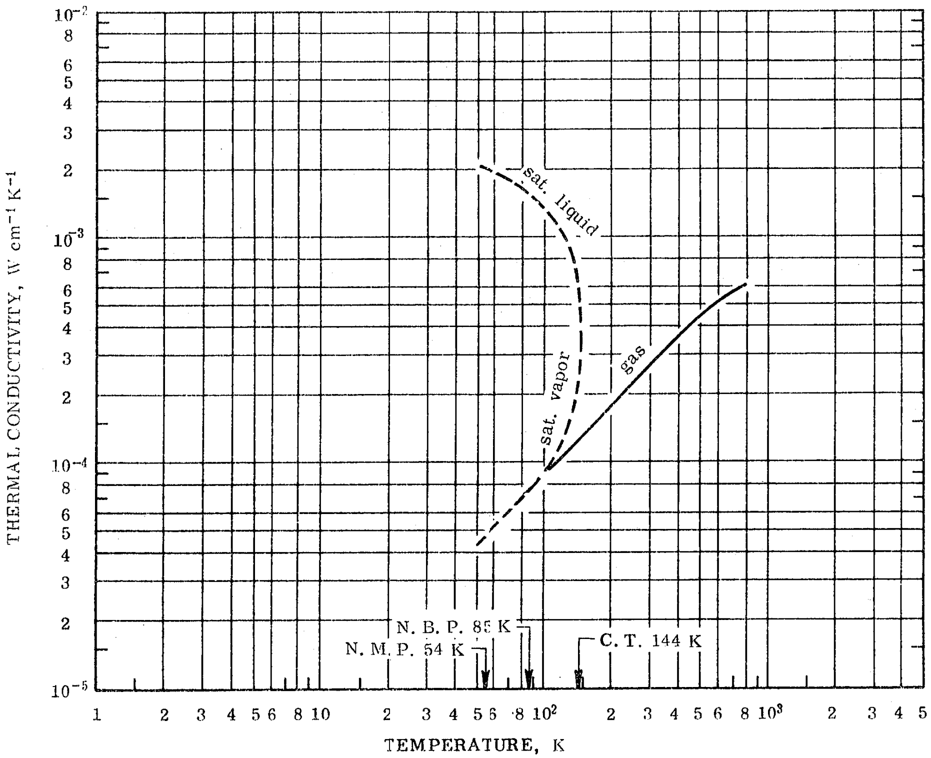
T	k
123.2	0.182*
150	0.165*
173.2	0.156*
200	0.148*
223.2	0.144*
250	0.141*
273.2	0.140*
298.2	0.139*
300	0.139*

REMARKS

The provisional values are for high-purity europium and are probably good to within ±20%.

* Estimated.

THERMAL CONDUCTIVITY OF FLUORINE



RECOMMENDED VALUES

[Temperature, T, K; Thermal Conductivity, k, W cm^{-1} K^{-1}]

SATURATED LIQUID

T	k x 10^3
	2.04 *
60	1.95 *
70	1.80 *
80	1.65 *
90	1.50 *
100	1.35 *
110	1.21 *
120	1.06 *
130	0.90 *
140	0.66 *
144	0.40 * †

SATURATED VAPOR

T	k x 10^3
50	0.044 *
60	0.053 *
70	0.062 *
80	0.071 *
90	0.081 *
100	0.092 *
110	0.105 *
120	0.125 *
130	0.16 *
140	0.22 *
144	0.40 * †

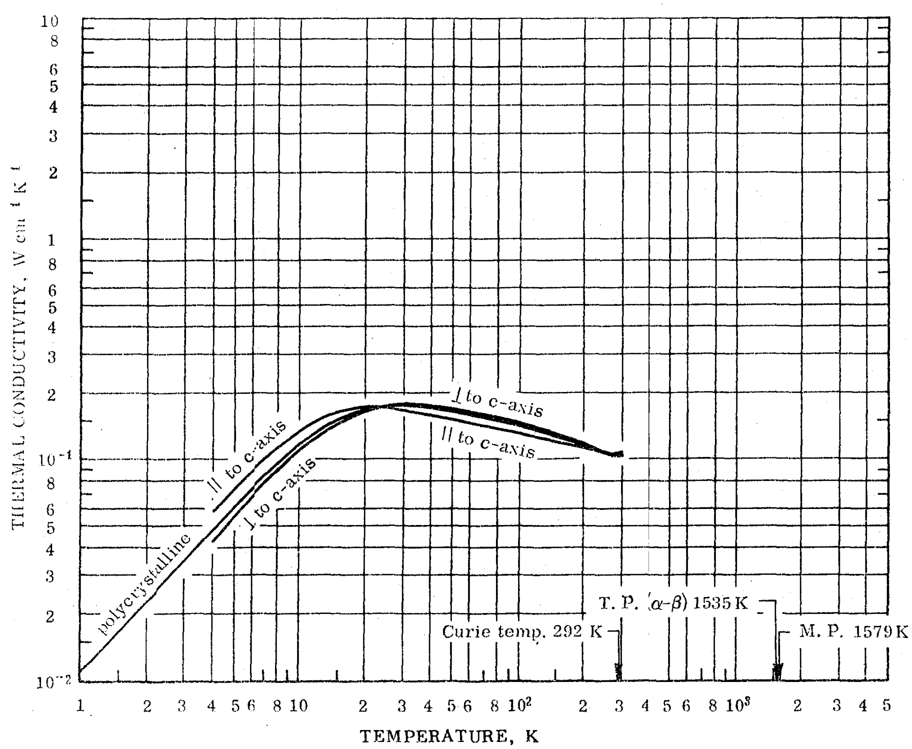
GAS (At 1 atm)

T	k x 10^3	T	k x 10^3
85	0.076 *		
90	0.081		
100	0.090	450	0.413
110	0.100	460	0.421
120	0.109	470	0.430
130	0.118	480	0.438
140	0.128	490	0.446
150	0.137	500	0.455
160	0.146	510	0.463
170	0.156	520	0.471
180	0.165	530	0.479
190	0.174	540	0.486
200	0.184	550	0.493
210	0.193	560	0.500
220	0.202	570	0.507
230	0.212	580	0.514
240	0.221	590	0.520
250	0.231	600	0.527
260	0.241	610	0.534
270	0.251	620	0.541
280	0.260	630	0.547
290	0.269	640	0.552
300	0.279	650	0.557
310	0.288	660	0.563
320	0.298	670	0.568
330	0.307	680	0.573
340	0.316	690	0.579
350	0.326	700	0.583
360	0.335	710	0.588
370	0.344	720	0.592
380	0.354	730	0.596
390	0.363	740	0.599
400	0.371	750	0.603
410	0.378	760	0.607
420	0.388	770	0.610
430	0.397	780	0.613
440	0.405	790	0.616
		800	0.618

REMARKS

The values for the liquid and vapor states are based on a correlation for diatomic substances. No experimental data were located. They should be accurate to 10% below 125 K and uncertain at higher temperatures. The gas values, based on subatmospheric pressure studies, are more probably accurate to within a 10% uncertainty for most, if not all, of the entire temperature range tabulated.

* Estimated or extrapolated, hence provisional.
† Pseudo-critical value.



REMARKS

The provisional values are for well-annealed high-purity gadolinium and are thought to be accurate to within ±10% at temperatures above 100 K. At temperatures below 100 K the values for $k_{//}$, $k_{\perp}$, and k_{poly} are applicable only to samples having residual electrical resistivity ρ_0 = 2.62, 4.43, and 3.71 μΩ cm. These values are very uncertain.

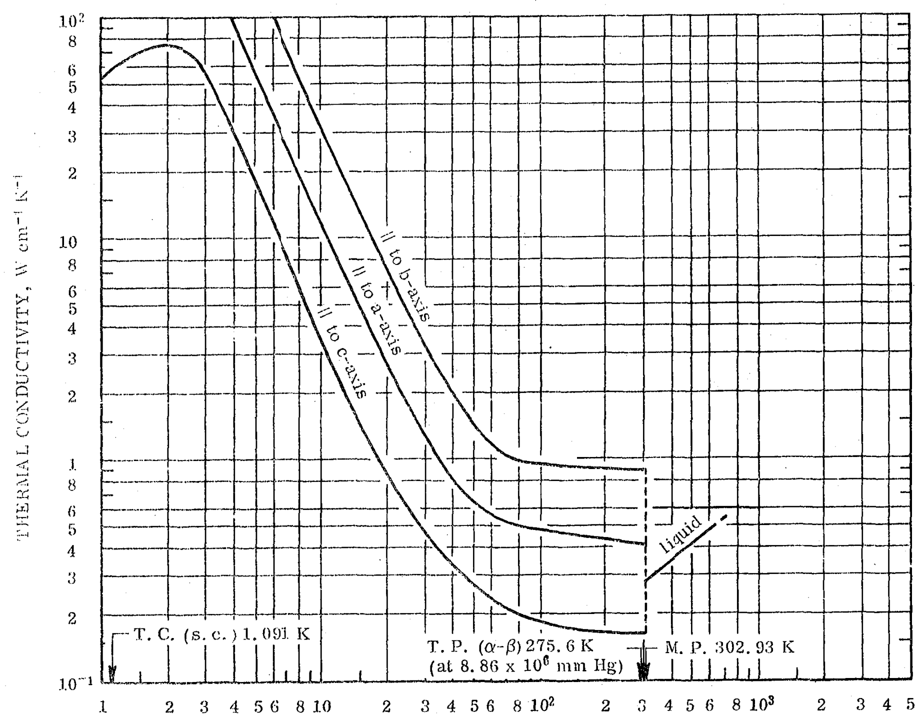
PROVISIONAL VALUES

[Temperature, T, K; Thermal Conductivity: k, W cm^{-1} K^{-1}]

SOLID

T	// to c-axis k	⊥ to c-axis k	Poly-crystalline k
0			0
1			0.0113
2			0.0231
3			0.0357
4	0.0594	0.0442	0.0488
5	0.0754	0.0563	0.0621
6	0.0902	0.0686	0.0752
7	0.104	0.0803	0.0875
8	0.116	0.0918	0.0994
9	0.127	0.103	0.110
10	0.137	0.113	0.121
11	0.145	0.123	0.130
12	0.152	0.130	0.137
13	0.158	0.136	0.143
14	0.164	0.142	0.149
15	0.168	0.147	0.154
16	0.170	0.152	0.158
18	0.174	0.161	0.165
20	0.175	0.168	0.170
25	0.171	0.179	0.176
30	0.166	0.182	0.177
35	0.162	0.180	0.174
40	0.158	0.178	0.171
45	0.155	0.175	0.168
50	0.152	0.172	0.165
60	0.147	0.167	0.160
70	0.143	0.162	0.155
80	0.139	0.157	0.151
90	0.136	0.153	0.147
100	0.133	0.149	0.143
123.2	0.127	0.141	0.136
150	0.121	0.133	0.129
173.2	0.117	0.127	0.123
200	0.112	0.119	0.117
223.2	0.108	0.113	0.111
250	0.105	0.107	0.106
273.2	0.104	0.103	0.103
298.2	0.108	0.103	0.105
300	0.108	0.104	0.105
310	0.110	0.106	0.107

THERMAL CONDUCTIVITY OF GALLIUM



REMARKS

The recommended values are for high-purity gallium and are considered accurate to within ±20% of the true values at temperatures below 10 K due to additional uncertainty in the location of the maxima, ±10% from 10 K to 100 K, and ±5% from 100 K to the melting point. For liquid gallium the uncertainty of the values is probably ±10% near the melting point and increase to ±20% at the highest temperatures. The thermal conductivity at temperatures near and below the corresponding temperature, T_m, of the conductivity maximum is highly sensitive to small physical and chemical variations among different specimens, and the recommended values below 60 K for k_a, k_b, and k_c are applicable only to specimens having residual electrical resistivities of 0.000100, 0.0000342, and 0.000425 μΩ cm, respectively. Values at temperatures below about 1.5 T_m are calculated to fit experimental data by using equation (7) and using the constants m, n, and α'' given in Table 1 for gallium and β = 0.00409, 0.00140, and 0.0174 for k_a, k_b, and k_c, respectively. The values for k_a are also good for polycrystalline gallium.

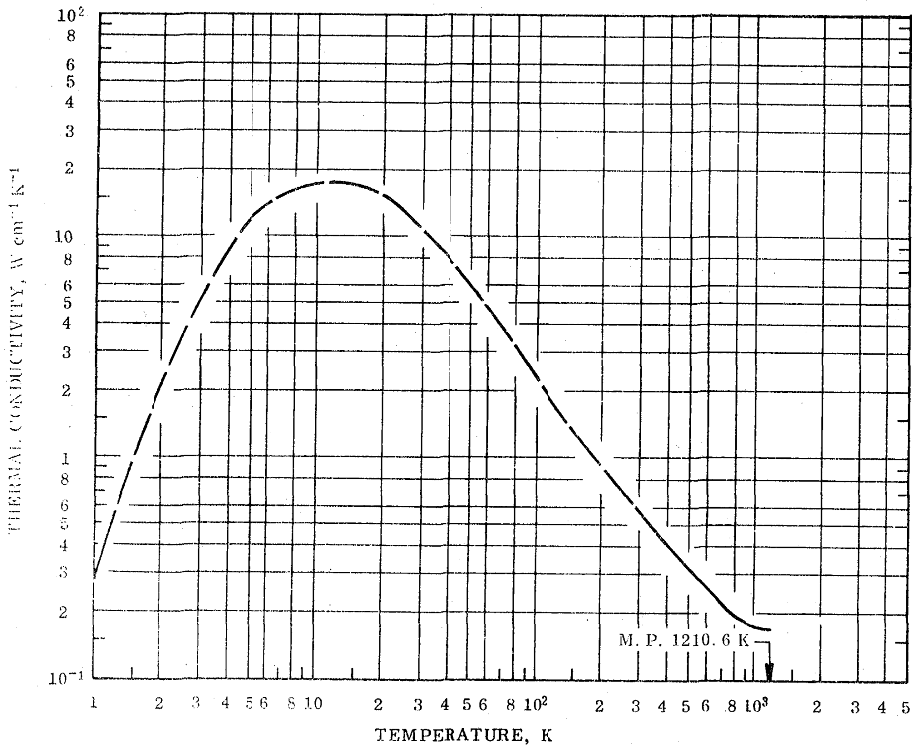
RECOMMENDED VALUES †

[Temperature, T, K; Thermal Conductivity, W cm⁻¹ K⁻¹]

	SOLID			LIQUID	
	// to a-axis ‡	// to b-axis	// to c-axis		
T	k	k	k	T	k
0	0	0	0	302.93	0.281
1	226	657	54.1	323.2	0.294
2	298	832	76.0	373.2	0.328
3	194	524	58.2	400	0.345
4	99.3	272	31.1	473.2	0.389
5	59.2	163	18.2	500	0.406
6	38.8	107	11.8	573.2	0.447
7	27.2	74.0	8.15	600	0.462
8	19.9	54.2	5.93	673.2	0.503*
9	15.2	41.4	4.47	700	0.519*
10	11.9	32.5	3.49		
15	4.48	13.2	1.44		
20	2.65	17.3	0.835		
25	1.71	4.54	0.588		
30	1.23	3.22	0.462		
35	0.952	2.46	0.385		
40	0.795	1.98	0.333		
50	0.634	1.42	0.269		
60	0.555	1.15	0.233		
70	0.516	1.02	0.210		
80	0.494	0.983	0.196		
90	0.483	0.960	0.187		
100	0.474	0.951	0.181		
123.2	0.457	0.933	0.172		
150	0.443	0.918	0.167		
173.2	0.433	0.906	0.165		
200	0.424	0.896	0.163		
223.2	0.418	0.890	0.162		
250	0.414	0.885	0.160		
273.2	0.410	0.884	0.160		
298.2	0.408	0.883	0.159		
300	0.406	0.883	0.159		
302.93	0.406	0.883	0.159		

* Extrapolated.
† Values above 500 K are provisional.
‡ The values for k_a are also good for polycrystalline gallium.

THERMAL CONDUCTIVITY OF GERMANIUM



REMARKS

The values are for well-annealed high-purity germanium. The recommended values (those above 290 K) are considered accurate to within ±10% of the true values. The thermal conductivity at temperatures near and below the corresponding temperature of the conductivity maximum is highly sensitive to small physical and chemical variations among different specimens and the conductivity values below 290 K are only typical values representing a typical curve to indicate the general trend of the low-temperature behavior of the thermal conductivity.

RECOMMENDED VALUES †

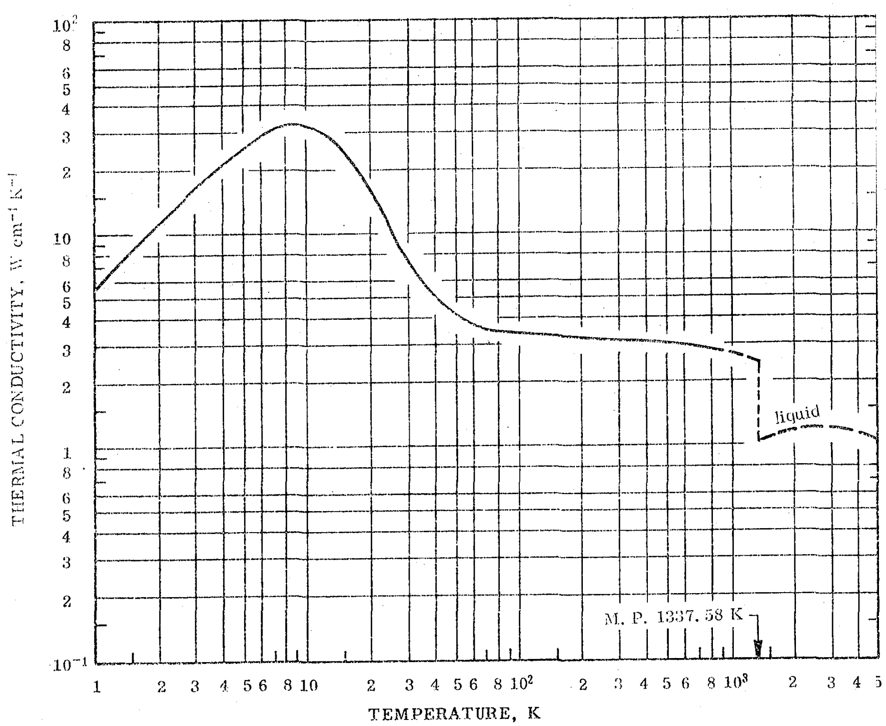
[Temperature, T, K; Thermal Conductivity, k, W cm^{-1} K^{-1}]

SOLID

T	k	T	k
0	0	123.2	1.68
1	0.274	150	1.32
2	2.06	173.2	1.13
3	5.35	200	0.968
4	8.77	223.2	0.859
5	11.6	250	0.749
6	13.9	273.2	0.667
7	15.5	298.2	0.602
8	16.6	300	0.599
9	17.3	323.2	0.548
10	17.7	350	0.495
11	17.9	373.2	0.465
12	18.0	400	0.432
13	17.9	473.2	0.359
14	17.7	500	0.338
15	17.3	573.2	0.288
16	16.9	600	0.273
18	15.9	673.2	0.237
20	14.9	700	0.227
25	12.7	773.2	0.204
30	10.8	800	0.198
35	9.20	873.2	0.185
40	7.98	900	0.182
45	6.95	973.2	0.176
50	6.15	1000	0.174
60	4.87	1073.2	0.171
70	3.93	1100	0.170
80	3.25	1173.2	0.172
90	2.70	1200	0.174
100	2.32		

† Values below 290 K are merely typical values.

THERMAL CONDUCTIVITY OF GOLD



REMARKS

The recommended values are for well-annealed high-purity gold and are considered accurate to within ±2% of the true values near room temperature, and ±5% below 80 K and at 1200 K. The thermal conductivity at temperatures near and below the corresponding temperature, T_m, of the conductivity maximum is highly sensitive to small physical and chemical variations among different specimens, and the recommended values below 80 K are applicable only to a specimen having residual electrical resistivity ρ_0 = 0.00550 $\mu\Omega$ cm. Values at temperatures below about 1.5 T_m are calculated to fit experimental data by using equation (7) and using the constants m, r, and α'' given in Table 1 for gold and β = 0.225. No experimental data are available for molten gold. The values given here are estimated and are provisional values. They are probably good to ±20% from melting point to 2000 K.

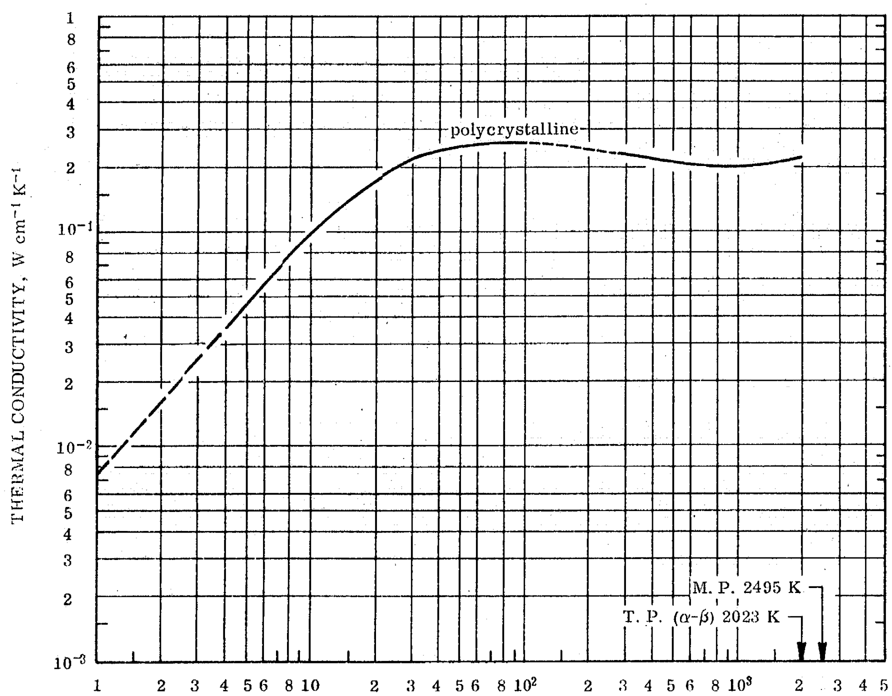
RECOMMENDED VALUES †

[Temperature, T, K; Thermal Conductivity, k, W cm⁻¹ K⁻¹]

SOLID				LIQUID			
T	k	T	k	T	k	T	k
0	0	123.2	3.26	1337.58	1.04*	3300	1.21*
1	5.46	150	3.25	1373.2	1.06*	3573	1.21*
2	10.9	173.2	3.24	1400	1.06*	3800	1.19*
3	16.1	200	3.23	1473.2	1.09*	3873	1.18*
4	20.9	223.2	3.22	1500	1.08*	4000	1.17*
5	25.2	250	3.21	1573.2	1.10*	4073	1.17*
6	28.5	273.2	3.19	1673.2	1.14*	4273	1.14*
7	30.9	298.2	3.18	1700	1.13*	4500	1.11*
8	32.3	300	3.17	1773.2	1.15*	4773	1.06*
9	32.7	323.2	3.16	1800	1.16*	5000	1.02*
10	32.4	350	3.14	1873.2	1.17*	5273	0.974*
11	31.5	373.2	3.13	1900	1.17*	5500	0.933*
12	30.0	400	3.11	1973.2	1.18*	5773	0.884*
13	28.4	473.2	3.06	2000	1.19*	6000	0.839*
14	26.6	500	3.04	2073.2	1.20*	6273	0.781*
15	24.6	573.2	2.99	2173.2	1.21*	6500	0.731*
16	22.7	600	2.98	2200	1.22*	6773	0.761*
18	18.9	673.2	2.93	2273.2	1.22*	7000	0.620*
20	15.8	700	2.91	2400	1.23*	7273	0.557*
25	10.3	773.2	2.86	2473.2	1.24*	7500	0.504*
30	7.55	800	2.84	2600	1.25*	7773	0.439*
35	6.00	873.2	2.79	2673.2	1.25*	8000	0.384*
40	5.15	900	2.77	2800	1.25*	8273	0.346*
45	4.59	973.2	2.72	2873.2	1.25*	8500	0.259*
50	4.21	1000	2.70	3000	1.25*	8773	0.189*
60	3.74	1073.2	2.64	3073	1.24*	9000	0.131*
70	3.48	1100	2.62	3200	1.24*	9273	0.0601*
80	3.32	1173.2	2.57	3273	1.23*		
90	3.28	1200	2.55	3400	1.23*		
100	3.27	1273.2	2.49*	3473	1.22*		
		1300	2.47*				
		1337.58	2.44*				

* Extrapolated or estimated.
† Values for molten gold are merely provisional values.

THERMAL CONDUCTIVITY OF HAFNIUM



REMARKS

The recommended values above 150 K are for well-annealed high-purity polycrystalline hafnium and are considered accurate to within ±10% of the true values at temperatures below 900 K and ±20% above 900 K. Values below 150 K are applicable only to a sample having residual electrical resistivity $\rho_0 = 4.23\ \mu\Omega$ cm and electrical resistivity ratio $\rho(295\ K)/\rho_0 = 8.58$.

RECOMMENDED VALUES

[Temperature, T, K; Thermal Conductivity, k, W cm^{-1} K^{-1}]

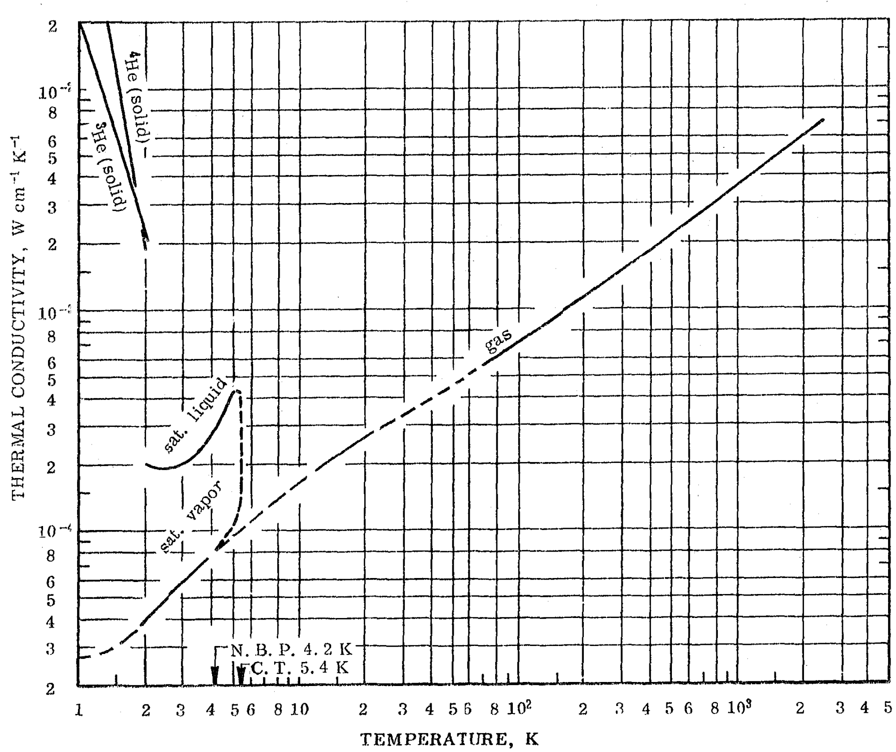
SOLID

Polycrystalline

T	k	T	k
0	0	350	0.226
1	0.00764*	373.2	0.224
2	0.0163*	400	0.223
3	0.0255	473.2	0.219
4	0.0349	500	0.217
5	0.0445	573.2	0.214
6	0.0544	600	0.213
7	0.0645	673.2	0.211
8	0.0746	700	0.210
9	0.0848	773.2	0.209
10	0.0952	800	0.208
11	0.106	873.2	0.207
12	0.116	900	0.207
13	0.126	973.2	0.207
14	0.135	1000	0.207
15	0.144	1073.2	0.207
16	0.152	1100	0.207
18	0.167	1173.2	0.208
20	0.180	1200	0.208
25	0.205	1273.2	0.209
30	0.222	1300	0.209
35	0.233	1373.2	0.211
40	0.241	1400	0.211
45	0.247	1473.2	0.212
50	0.251	1500	0.213
60	0.256	1573.2	0.215
70	0.259	1600	0.215
80	0.260	1673.2	0.217
90	0.260	1700	0.218
100	0.260*	1773.2	0.220
123.2	0.256*	1800	0.220
150	0.251*	1873.2	0.222
173.2	0.248*	1900	0.223
200	0.244*	1973.2	0.225*
223.2	0.240*	2000	0.226*
250	0.236*		
273.2	0.233*		
298.2	0.230		
300	0.230		
323.2	0.228		

*Extrapolated or interpolated.

THERMAL CONDUCTIVITY OF HELIUM



REMARKS

Values of the thermal conductivity of the solid presented here are offered as order of magnitude values. Detailed specification of the sample size, orientation, density, etc. will be needed for a more accurate recommendation. The liquid values should be accurate to within 2%. Due to the lack of any experimental values for the gas from 4 to 14 K and from 21 to 73 K, the recommended values below 100 K may be uncertain to 5%. From 100 to 700 K the accuracy should be 2%, from 700 to 1500 K 5%, and above 1500 K 10%.

RECOMMENDED VALUES

[Temperature, T, K; Thermal Conductivity, k, W cm^{-1} K^{-1}]

SOLID

T	k(^{3}He)	k(^{4}He)
0.6	0.250	
0.7	0.104	
0.8	0.055	
0.9	0.033	0.650
1.0	0.020	0.245
1.1	0.0144	0.097
1.2	0.0108	0.045
1.3	0.0089	0.027
1.4	0.0073	0.016
1.5	0.0057	0.0105
1.6	0.0046	0.0069
1.7	0.0038	0.0049
1.8	0.0030	0.0034
1.9	0.0025	0.0025
2.0	0.0021	0.0018

SATURATED LIQUID -- He-I

T	k x 10^3
2.5	0.191
3.0	0.203
3.5	0.232
4.0	0.281
4.5	0.348
5.0	0.434

THERMAL CONDUCTIVITY OF HELIUM (continued)

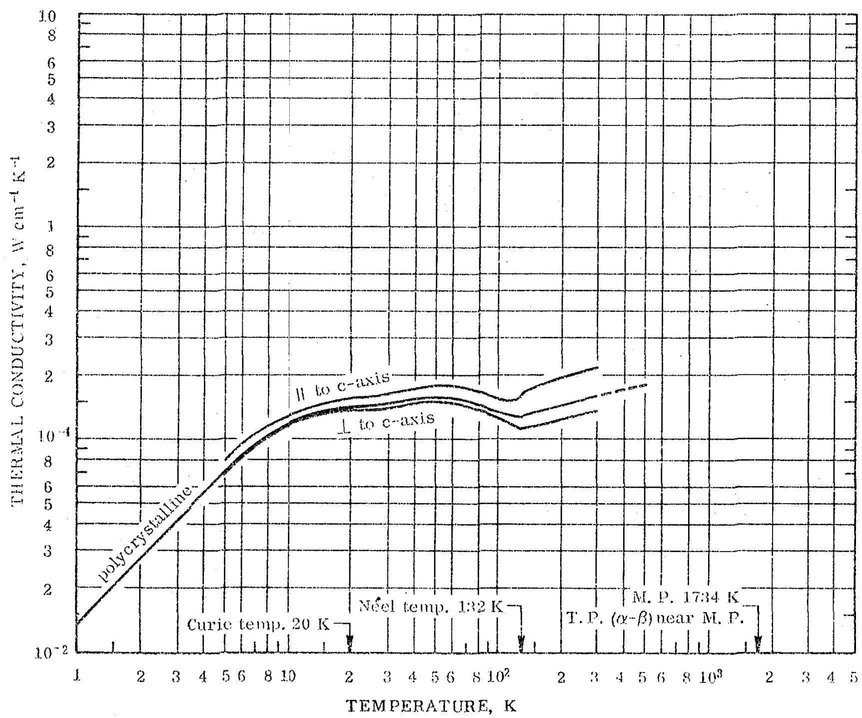
RECOMMENDED VALUES

GAS
(At 1 atm above 4.2 K)

T	k x 10^3	T	k x 10^3	T	k x 10^3	T	k x 10^3
0.08	0.00044*	50	0.4623*	450	2.038	850	3.20
0.09	0.00053*	60	0.521*	460	2.071	860	3.23
0.10	0.00064*	70	0.578*	470	2.104	870	3.25
0.15	0.00130*	80	0.631	480	2.136	880	3.28
0.20	0.00231*	90	0.679	490	2.169	890	3.30
0.25	0.0039*	100	0.730	500	2.202	900	3.32
0.30	0.0062*	110	0.776	510	2.234	910	3.35
0.35	0.0089*	120	0.819	520	2.266	920	3.37
0.40	0.0120*	130	0.863	530	2.297	930	3.40
0.45	0.0154*	140	0.907	540	2.329	940	3.43
0.5	0.0187*	150	0.950	550	2.361	950	3.45
0.6	0.0231*	160	0.992	560	2.392	960	3.47
0.7	0.0252*	170	1.033	570	2.423	970	3.50
0.8	0.0262*	180	1.072	580	2.453	980	3.52
0.9	0.0266*	190	1.112	590	2.484	990	3.54
1.0	0.0269*	200	1.151	600	2.515	1000	3.57
1.25	0.0281*	210	1.190	610	2.55	1050	3.69
1.5	0.0306*	220	1.228	620	2.58	1100	3.80
2.0	0.0393	230	1.266	630	2.60	1150	3.91
2.5	0.0502	240	1.304	640	2.63	1200	4.03
3.0	0.0607	250	1.338	650	2.66	1250	4.14
3.5	0.0710	260	1.374	660	2.69	1300	4.25
4.0	0.0803	270	1.411	670	2.72	1350	4.36
4.5	0.0879*	280	1.447	680	2.75	1400	4.47
5.0	0.0962*	290	1.484	690	2.78	1450	4.57
6	0.1113*	300	1.520	700	2.81	1500	4.68
7	0.1247*	310	1.555	710	2.83	1550	4.78
8	0.1393*	320	1.591	720	2.86	1600	4.88
9	0.1523*	330	1.626	730	2.89	1650	4.98
10	0.1640*	340	1.662	740	2.91	1700	5.08
12	0.1866*	350	1.697	750	2.94	1750	5.18
14	0.2067	360	1.732	760	2.97	1800	5.28
16	0.2259	370	1.766	770	3.00	1850	5.38
18	0.2435	380	1.801	780	3.02	1900	5.47
20	0.2582	390	1.835	790	3.05	1950	5.57
25	0.2962*	400	1.870	800	3.08	2000	5.66
30	0.3330*	410	1.904	810	3.10	2100	5.85
35	0.3669*	420	1.937	820	3.13	2200	6.03
40	0.4000*	430	1.971	830	3.15	2300	6.22
45	0.4314*	440	2.004	840	3.18	2400	6.40
						2500	6.57

* Estimated or extrapolated.

THERMAL CONDUCTIVITY OF HOLMIUM



REMARKS

The provisional values are for well-annealed high-purity holmium and are thought to be accurate to within ±20% at temperatures above 150 K. Values below 150 K for $k_{\parallel}$, $k_{\perp}$, and k_{poly} are applicable only to specimens having residual electrical resistivities of 3.21, 2.82, and 2.67 μΩ cm, respectively. These values are very uncertain.

PROVISIONAL VALUES

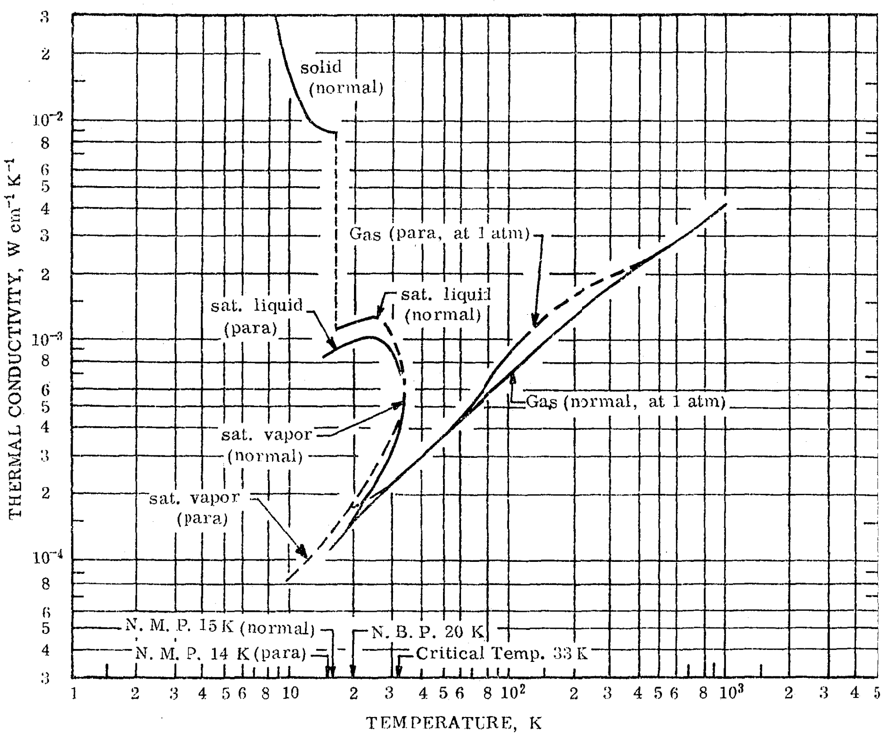
[Temperature, T, K; Thermal Conductivity, k, W cm⁻¹ K⁻¹]

SOLID

T	∥ to c-axis k	⊥ to c-axis k	Poly-crystalline k	T	∥ to c-axis k	⊥ to c-axis k	Poly-crystalline k
0			0	60	0.182	0.149	0.160
1			0.0140	70	0.176	0.144	0.156
2			0.0282	80	0.170	0.139	0.149
3			0.0428	90	0.163	0.133	0.142
4			0.0580	100	0.158	0.127	0.136
5	0.0803	0.0701	0.0733	123.2	0.159	0.116	0.129
6	0.0962	0.0846	0.0883	132	0.166	0.113	0.128
7	0.109	0.0967	0.101	132	0.169	0.115	0.131
8	0.118	0.105	0.109	150	0.179	0.116	0.135
9	0.124	0.112	0.116	173.2	0.190	0.120	0.140
10	0.130	0.117	0.121	200	0.200	0.126	0.147
11	0.135	0.121	0.125	223.2	0.207	0.130	0.152
12	0.139	0.125	0.129	250	0.212	0.134	0.156
13	0.142	0.128	0.132	273.2	0.215	0.136	0.159
14	0.146	0.131	0.136	298.2	0.222	0.138	0.162
15	0.149	0.134	0.138	300	0.222	0.138	0.162
16	0.152	0.136	0.141	323.2			0.165*
18	0.157	0.140	0.146	350			0.167*
20	0.160	0.140	0.144	373.2			0.170*
25	0.161	0.139	0.146	400			0.173*
30	0.168	0.142	0.150	473.2			0.180*
35	0.173	0.146	0.154	500			0.183*
40	0.177	0.149	0.158				
45	0.180	0.150	0.160				
50	0.182	0.152	0.161				

*Extrapolated or estimated.

THERMAL CONDUCTIVITY OF HYDROGEN



RECOMMENDED VALUES

[Temperature, T, K; Thermal Conductivity, k, W cm^{-1} K^{-1}]

SOLID (normal-Hydrogen)		SATURATED LIQUID (normal-Hydrogen)		SATURATED VAPOR (normal-Hydrogen)	
T	k	T	k x 10^3	T	k x 10^3
4	2.30				
5	0.550	15	1.022	15	0.117 *
6	0.190	16	1.055	16	0.126 *
7	0.083	17	1.088	17	0.134 *
8	0.043	18	1.121	18	0.142 *
9	0.023	19	1.153	19	0.150 *
10	0.0158	20	1.184	20	0.159 *
11	0.0125	21	1.213	21	0.169 *
12	0.0100	22	1.238	22	0.180 *
13	0.0095	23	1.258	23	0.192 *
14	0.0090	24	1.272	24	0.205 *
15	0.0090	25	1.269	25	0.22 *
16	0.0089	26	1.251 *	26	0.23 *
17	0.0089	27	1.217 *	27	0.25 *
		28	1.168 *	28	0.27 *
		29	1.117 *	29	0.29 *
		30	1.06 *	30	0.31 *
		31	1.00 *	31	0.35 *
		32	0.91 *	32	0.40 *
		33	0.60 *†	33	0.60 *†

REMARKS

No overlap between two different experimental studies for the solid occurs. While the values from 5 to 10 K appear accurate to within 5%, from 10 to 17 K to within 15% and at 4 K to within 25%, confirmatory measurements are very desirable. The liquid values below 25 K are probably accurate to about 3%. However, an error of 100% at the critical point could occur. The saturated vapor values should have similar uncertainties. The gas values should be accurate to within 2% from 100 to 400 K and 5% for other tabulated temperatures.

The para form uncertainties for the liquid may be accurate to within 2%, although a 5% uncertainty for both liquid and vapor forms is not ruled out. The gas values between 100 and 400 K should check to within 3% and other table entries to within 5%.

* Estimated or extrapolated, hence provisional.
† Pseudo-critical value.

THERMAL CONDUCTIVITY OF HYDROGEN (continued)

RECOMMENDED VALUES

GAS (normal-Hydrogen, at 1 atm)

T	k x 10^3	T	k x 10^3	T	k x 10^3
20	0.159				
25	0.193	350	2.033	700	3.25
30	0.227	360	2.069	710	3.29
35	0.261	370	2.106	720	3.32
40	0.294	380	2.142	730	3.36
45	0.328	390	2.177	740	3.39
50	0.361	400	2.212	750	3.43
60	0.426	410	2.248	760	3.46
70	0.489	420	2.283	770	3.50
80	0.552	430	2.318	780	3.53
90	0.614	440	2.354	790	3.56
100	0.676	450	2.389	800	3.60
110	0.738	460	2.424	810	3.63
120	0.801	470	2.459	820	3.67
130	0.864	480	2.494	830	3.70
140	0.926	490	2.529	840	3.74
150	0.986	500	2.564	850	3.77
160	1.046	510	2.60	860	3.80
170	1.105	520	2.64	870	3.84
180	1.164	530	2.67	880	3.87
190	1.222	540	2.70	890	3.91
200	1.280	550	2.74	900	3.94
210	1.338	560	2.77	910	3.97
220	1.395	570	2.80	920	4.01
230	1.451	580	2.84	930	4.04
240	1.506	590	2.88	940	4.08
250	1.560	600	2.91	950	4.11
260	1.613	610	2.95	960	4.14
270	1.665	620	2.98	970	4.18
280	1.717	630	3.01	980	4.21
290	1.767	640	3.05	990	4.25
300	1.815	650	3.08	1000	4.28
310	1.863	660	3.12		
320	1.910	670	3.15		
330	1.954	680	3.19		
340	1.994	690	3.22		

RECOMMENDED VALUES

SATURATED LIQUID (para-Hydrogen)		SATURATED VAPOR (para-Hydrogen)	
T	k x 10^3	T	k x 10^3
14†	0.824		
15	0.855	10	0.081*
16	0.885	11	0.089*
17	0.910	12	0.096*
18	0.933	13	0.103*
19	0.954	14	0.111*
20	0.972	15	0.118*
21	0.988	16	0.128*
22	0.999	17	0.137*
23	1.007	18	0.147*
24	1.006	19	0.157*
25	0.998	20	0.168*
26	0.975	21	0.181*
27	0.947	22	0.194*
28	0.910	23	0.209*
29	0.870	24	0.224*
30	0.826	25	0.242*
31	0.74*	26	0.260*
32	0.58*†	27	0.280*
		28	0.304*
		29	0.332*
		30	0.363*
		31	0.45*
		32	0.58*†

* Estimated or extrapolated, hence provisional.
† Pseudo-critical value.

THERMAL CONDUCTIVITY OF HYDROGEN (continued)

RECOMMENDED VALUES

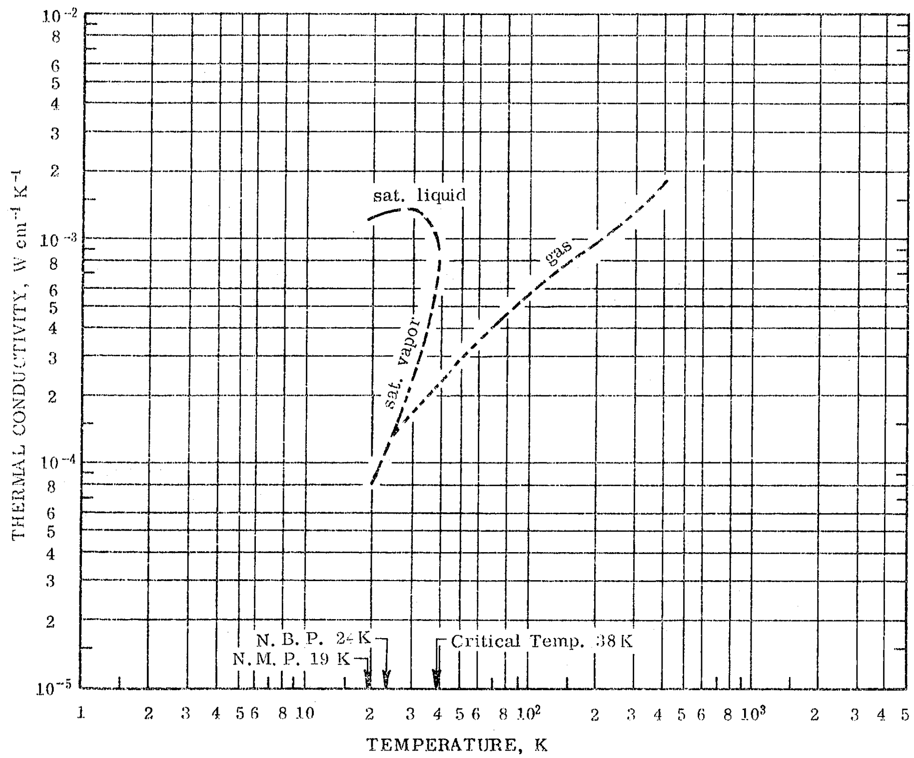
GAS

(para-Hydrogen, at 1 atm)

T	k x 10^3	T	k x 10^3	T	k x 10^3
20	0.168				
25	0.198	300	1.880 *	650	3.08 *
30	0.229	310	1.920 *	660	3.12 *
35	0.261	320	1.958 *	670	3.15 *
40	0.294	330	1.994 *	680	3.19 *
45	0.328	340	2.028 *	690	3.22 *
50	0.363	350	2.061 *	700	3.25 *
60	0.434	360	2.093 *	710	3.29 *
70	0.513	370	2.126 *	720	3.32 *
80	0.601	380	2.159 *	730	3.36 *
90	0.696	390	2.191 *	740	3.39 *
100	0.797	400	2.223 *	750	3.43 *
110	0.899	410	2.258 *	760	3.46 *
120	1.000	420	2.292 *	770	3.50 *
130	1.093 *	430	2.326 *	780	3.53 *
140	1.177 *	440	2.361 *	790	3.56 *
150	1.251 *	450	2.395 *	800	3.60 *
160	1.316 *	560	2.429 *	810	3.63 *
170	1.372 *	470	2.463 *	820	3.67 *
180	1.426 *	480	2.497 *	830	3.70 *
190	1.470 *	490	2.532 *	840	3.74 *
200	1.512 *	500	2.565 *	850	3.77 *
210	1.551 *	510	2.60 *	860	3.80 *
220	1.588 *	520	2.64 *	870	3.84 *
230	1.624 *	530	2.67 *	880	3.87 *
240	1.660 *	540	2.70 *	890	3.91 *
250	1.696 *	550	2.74 *	900	3.94 *
260	1.732 *	560	2.77 *	910	3.97 *
270	1.768 *	570	2.80 *	920	4.01 *
280	1.806 *	580	2.84 *	930	4.04 *
290	1.843 *	590	2.88 *	940	4.08 *
		600	2.91 *	950	4.11 *
		610	2.95 *	960	4.14 *
		620	2.98 *	970	4.18 *
		630	3.01 *	980	4.21 *
		640	3.05 *	990	4.25 *
				1000	4.28 *

* Estimated or extrapolated, hence provisional.

THERMAL CONDUCTIVITY OF DEUTERIUM (Hydrogen Isotope)



RECOMMENDED VALUES

[Temperature, T, K; Thermal Conductivity, k, W cm^{-1} K^{-1}]

SATURATED LIQUID		SATURATED VAPOR	
T	k x 10^3	T	k x 10^3
19	1.24*		
20	1.26	20	0.084*
21	1.28	21	0.096*
22	1.30	22	0.109*
23	1.33	23	0.123*
24	1.34	24	0.138*
25	1.36*	25	0.155*
26	1.37*	26	0.174*
27	1.38*	27	0.193*
28	1.38*	28	0.215*
29	1.38*	29	0.238*
30	1.37*	30	0.26*
31	1.35*	31	0.29*
32	1.32*	32	0.32*
33	1.29*	33	0.36*
34	1.25*	34	0.40*
35	1.21*	35	0.45*
36	1.15*	36	0.51*
37	1.07*	37	0.58*
38	0.83*†	38	0.83*†

REMARKS

The liquid state apparently exhibits a maximum in conductivity at about 28 K. While some earlier tabulations neglected this, the present values are thought accurate to within 5% below 30 K and 10% from 30 to 35 K, with an unknown uncertainty at higher temperatures. The vapor values are provisional. The gas values are based on a set of measurements from 15 to 25 K, from 65 to 89 K and measurements at the ice point. Between 20 and 280 K they may be accurate to within 5%.

* Estimated or extrapolated, hence provisional.
† Pseudo-critical value.

* Estimated or extrapolated, hence provisional.
† Pseudo-critical value.

THERMAL CONDUCTIVITY OF DEUTERIUM (Hydrogen Isotope) (continued)

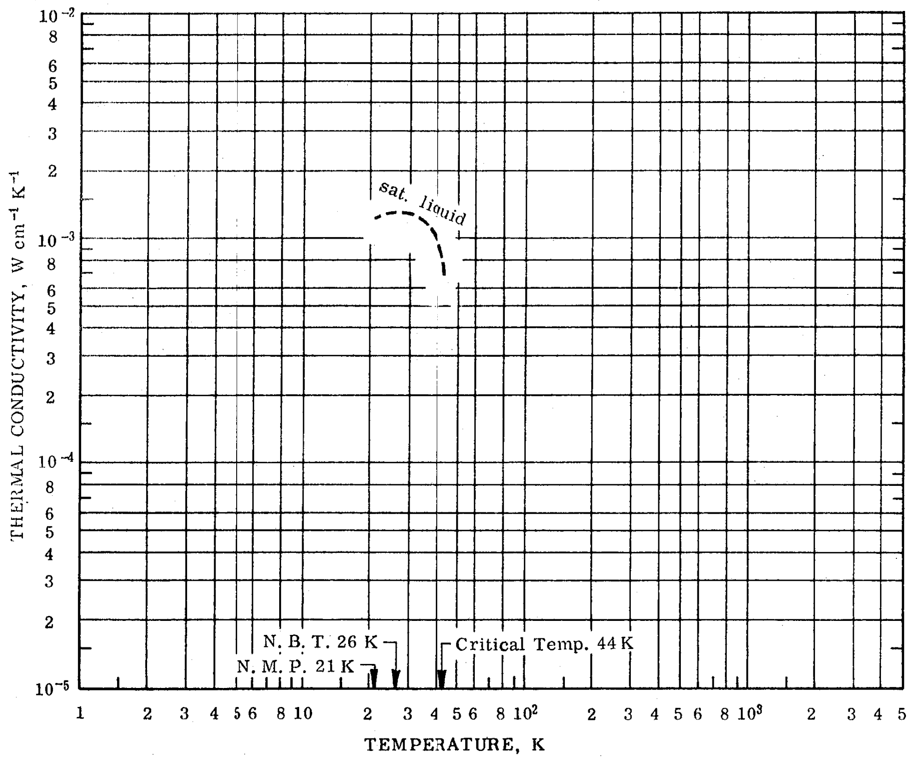
RECOMMENDED VALUES

GAS
(At 1 atm)

T	k x 10^3	T	k x 10^3
24	0.135		
25	0.139	200	1.014*
30	0.175	210	1.056*
35	0.206	220	1.097*
40	0.236	230	1.138*
45	0.268	240	1.178*
50	0.299	250	1.217*
60	0.360	260	1.256*
70	0.421	270	1.294*
80	0.475	280	1.331*
90	0.527	290	1.369*
100	0.577*	300	1.406*
110	0.625*	310	1.44*
120	0.672*	320	1.48*
130	0.718*	330	1.51*
140	0.762*	340	1.55*
150	0.806*	350	1.59*
160	0.848*	360	1.62*
170	0.890*	370	1.66*
180	0.931*	380	1.69*
190	0.973*	390	1.73*
		400	1.76*

* Estimated or extrapolated, hence provisional.

THERMAL CONDUCTIVITY OF TRITIUM (Hydrogen Isotope)



PROVISIONAL VALUES

[Temperature, T, K; Thermal Conductivity, k, W cm^{-1} K^{-1}]

SATURATED LIQUID

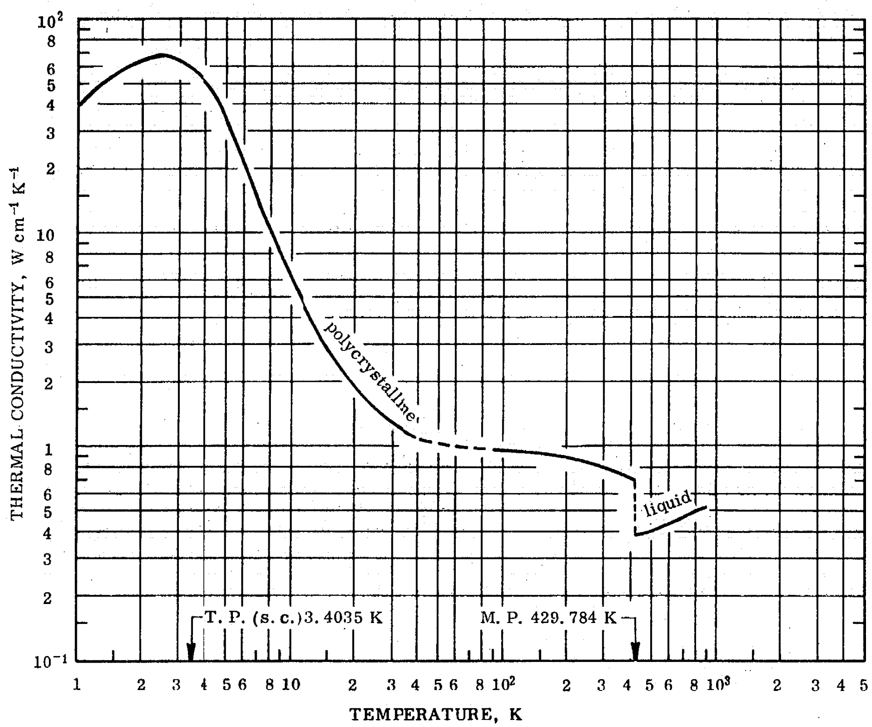
T	k x 10^3
21	1.25*
22	1.28*
24	1.32*
26	1.36*
28	1.37*
30	1.34*
32	1.30*
34	1.25*
36	1.18*
38	1.10*
40	1.00*
42	0.89*
44	0.68*†

REMARKS

The liquid values presented here are based on a correlation which, while apparently reasonable, lacks experimental substantiation. No error estimate is offered.

* Estimated or extrapolated.
† Pseudo-critical value.

THERMAL CONDUCTIVITY OF INDIUM



REMARKS

The recommended values are for well-annealed high-purity polycrystalline indium and are considered accurate to within ±15% of the true values at temperatures below 100 K and ±5% above. For liquid indium the values are probably good to ±15%. The thermal conductivity at temperatures near and below the corresponding temperature, T_m, of the conductivity maximum is highly sensitive to small physical and chemical variations among different specimens, and the recommended values below 60 K are applicable only to a specimen having residual electrical resistivity $\rho_0 = 0.000587\ \mu\Omega$ cm. Values at temperatures below about 1.5 T_m are calculated to fit experimental data by using equation (7) and using the constants m, n, and α'' given in Table 1 for indium and $\beta = 0.0240$.

RECOMMENDED VALUES †

[Temperature, T, K; Thermal Conductivity, k, W cm^{-1} K^{-1}]

SOLID

T	k (Polycrystalline)	T	k (Polycrystalline)
0	0	60	1.02*
1	40.2*	70	1.00*
2	64.9	80	0.992*
3	64.0	90	0.983
4	49.6	100	0.976
5	32.4	123.2	0.958
6	20.7	150	0.939
7	14.1	173.2	0.920
8	10.1	200	0.897
9	7.47	223.2	0.878
10	5.88	250	0.856
11	4.86	273.2	0.837
12	4.12	298.2	0.818
13	3.59	300	0.816
14	3.18	323.2	0.798
15	2.86	350	0.778
16	2.61	373.2	0.762
18	2.22	400	0.745
20	1.94	429.784	0.729*
25	1.51		
30	1.28		
35	1.15*		
40	1.09*		
45	1.06*		
50	1.04*		

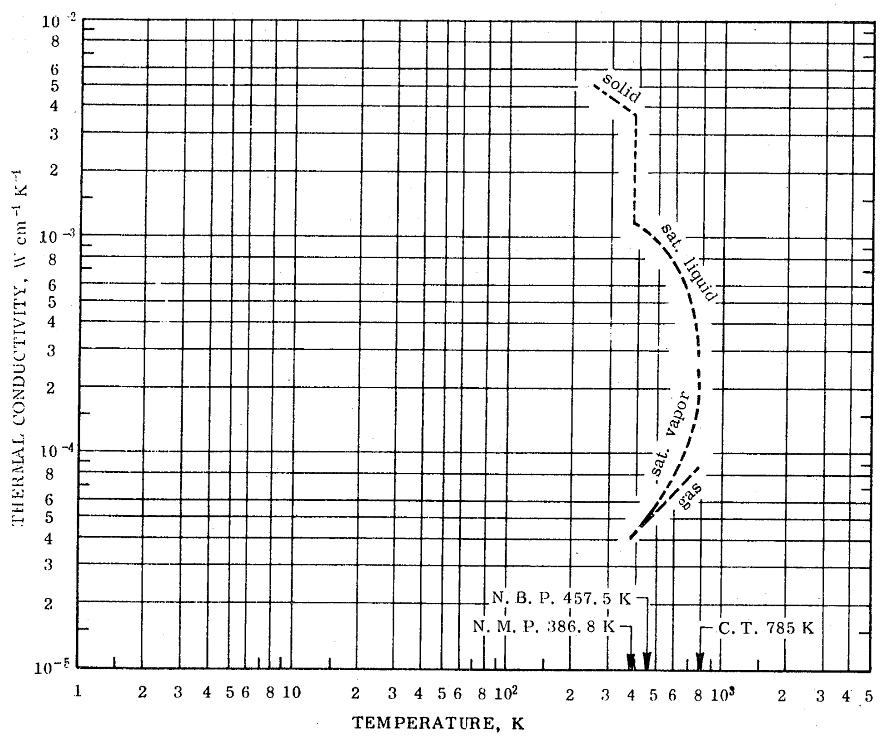
LIQUID

T	k
429.784	0.382
473.2	0.387
500	0.394
573.2	0.417
600	0.425
673.2	0.446
700	0.453
773.2	0.472
800	0.479
873.2	0.492
900	0.494

* Extrapolated or interpolated.

† Values for the liquid state are provisional.

THERMAL CONDUCTIVITY OF IODINE



RECOMMENDED VALUES

[Temperature, T, K; Thermal Conductivity, k, W cm^{-1} K^{-1}]

SOLID

T	k x 10^3
250	5.12*
273.2	4.81*
275	4.79*
300	4.49
325	4.24
350	4.01*
375	3.83*
386.8‡	3.75*

SATURATED LIQUID

T	k x 10^3
386.8‡	1.16*
400	1.14*
425	1.11*
450	1.07*
475	1.03*
500	0.99*
525	0.95*
550	0.90*
575	0.86*
600	0.82*
625	0.77*
650	0.71*
675	0.65*
700	0.58*
725	0.51*
750	0.43*
775	0.32*
785	0.26*†

SATURATED VAPOR

T	k x 10^3
350	0.038*
375	0.041*
400	0.044*
425	0.047*
450	0.050*
475	0.053*
500	0.056*
525	0.060*
550	0.064*
575	0.069*
600	0.074*
625	0.079*
650	0.085*
675	0.093*
700	0.104*
725	0.119*
750	0.143*
775	0.186*
785	0.26*†

GAS
(At 1 atm)

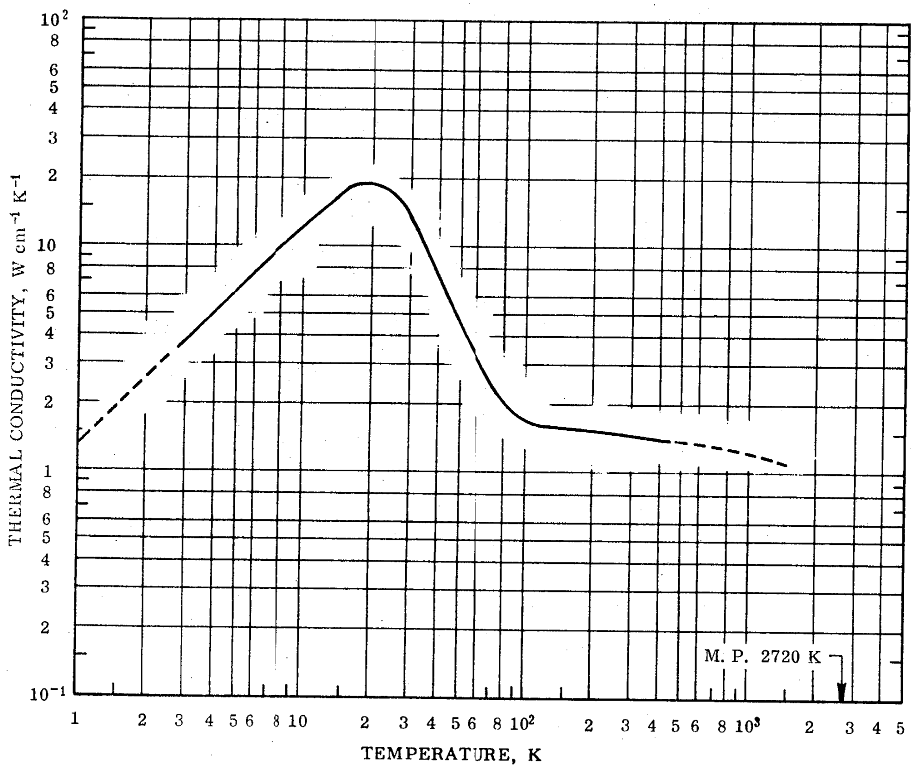
T	k x 10^3	T	k x 10^3
457.5	0.051		
475	0.052	600	0.065
500	0.055	625	0.068
525	0.058	650	0.071
550	0.060	675	0.073
575	0.063	700	0.076
		725	0.079*
		750	0.082*
		775	0.084*
		800	0.087*

REMARKS

Few experimental values exist for any phase for this element. The few that are available enable an estimate to be made, that the recommended values for the solid are accurate to within 10% from 300 to 330 K and for the gas to within 25%. All other values are considered provisional.

* Estimated or extrapolated, hence provisional.
† Pseudo-critical value.
‡ Normal melting point.

THERMAL CONDUCTIVITY OF IRIDIUM



REMARKS

The recommended values are for well-annealed high-purity iridium and are considered accurate to within ±5% of the true values at temperatures below 500 K and ±10% above. The thermal conductivity at temperatures near and below the corresponding temperature, T_m, of the conductivity maximum is highly sensitive to small physical and chemical variations among different specimens, and the recommended values below 150 K are applicable only to a specimen having residual electrical resistivity $\rho_0 = 0.0191$ μΩ cm. Values at temperatures below about 1.5 T_m are calculated to fit experimental data by using equation (7) and using the constants m, n, and α'' given in Table 1 for iridium and $\beta = 0.781$.

RECOMMENDED VALUES

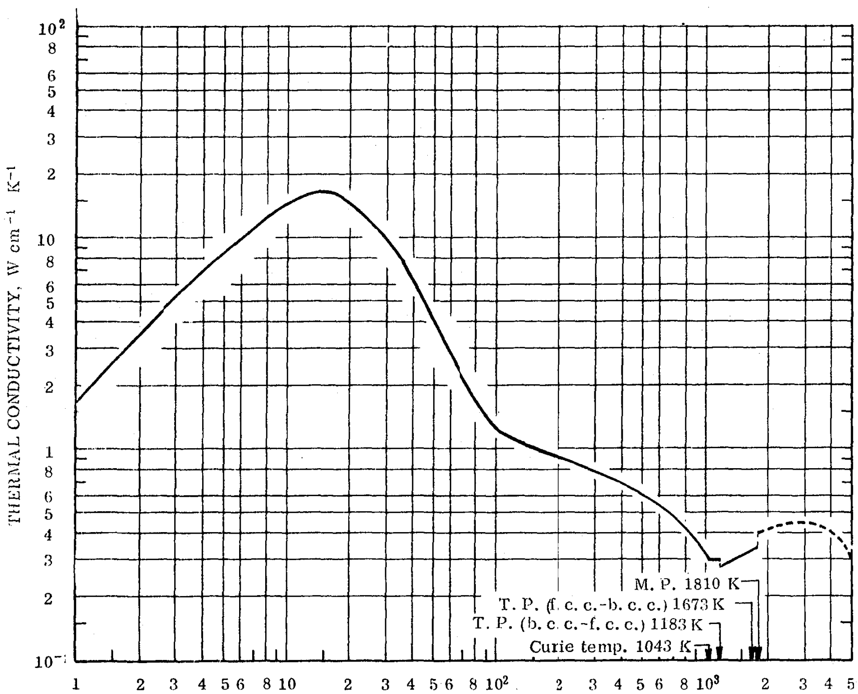
[Temperature, T, K; Thermal Conductivity, k, W cm^{-1} K^{-1}]

SOLID

T	k	T	k
0	0	250	1.50
1	1.30*	273.2	1.48
2	2.60	298.2	1.47
3	3.90	300	1.47
4	5.19	323.2	1.47
5	6.48	350	1.46
6	7.77	373.2	1.45
7	9.04	400	1.44
8	10.3	473.2	1.42
9	11.5	500	1.41*
10	12.7	573.2	1.39*
11	13.8	600	1.38*
12	14.9	673.2	1.36*
13	15.9	700	1.35*
14	16.7	773.2	1.33*
15	17.5	800	1.32*
16	18.1	873.2	1.30*
18	18.9	900	1.29*
20	19.0	973.2	1.27*
25	17.2	1000	1.26*
30	13.7	1073.2	1.24*
35	10.1	1100	1.23*
40	7.50	1173.2	1.21*
45	5.89	1200	1.20*
50	4.72	1273.2	1.18*
60	3.31	1300	1.17*
70	2.54	1373.2	1.15*
80	2.09	1400	1.14*
90	1.84	1473.2	1.12*
100	1.72	1500	1.11*
123.2	1.65		
150	1.59		
173.2	1.56		
200	1.53		
223.2	1.51		

*Extrapolated.

THERMAL CONDUCTIVITY OF IRON



RECOMMENDED VALUES †

[Temperature, T, K; Thermal Conductivity, k, W cm^{-1} K^{-1}]

SOLID				LIQUID	
T	k	T	k	T	k
0	0	250	0.865	1810	0.403*
1	1.71*	273.2	0.835	1873.2	0.413*
2	3.42	298.2	0.804	1900	0.415*
3	5.11	300	0.802	1973.2	0.423*
4	6.77	323.2	0.774	2000	0.426*
5	8.39	350	0.744	2073.2	0.432*
6	9.93	373.2	0.720	2173.2	0.439*
7	11.4	400	0.695	2200	0.441*
8	12.7	473.2	0.634	2273.2	0.446*
9	13.9	500	0.613	2400	0.450*
10	14.8	573.2	0.564	2473.2	0.452*
11	15.6	600	0.547	2600	0.455*
12	16.3	673.2	0.504	2673.2	0.456*
13	16.7	700	0.488	2800	0.458*
14	16.9	773.2	0.448	2873.2	0.459*
15	17.0	800	0.433	3000	0.458*
16	16.9	873.2	0.394	3073	0.458*
18	16.3	900	0.380	3200	0.456*
20	15.4	973.2	0.340	3273	0.454*
25	12.7	1000	0.323	3400	0.451*
30	10.0	1043	0.295	3600	0.442*
35	7.88	1073.2	0.298	3800	0.430*
40	6.23	1100	0.298	4000	0.415*
45	4.99	1173.2	0.300	4500	0.368*
50	4.05	1183	0.300	5000	0.308*
60	2.85	1183	0.280	5500	0.233*
70	2.16	1200	0.283	6000	0.147*
80	1.75	1273.2	0.296	6500	0.051*
90	1.50	1300	0.300		
100	1.34	1373.2	0.309		
123.2	1.15	1400	0.312		
150	1.04	1473.2	0.319		
173.2	0.991	1500	0.329		
200	0.940	1573.2	0.327		
223.2	0.904	1600	0.330		
		1673.2	0.335*		
		1700	0.338*		
		1773.2	0.343*		
		1800	0.345*		
		1810	0.346*		

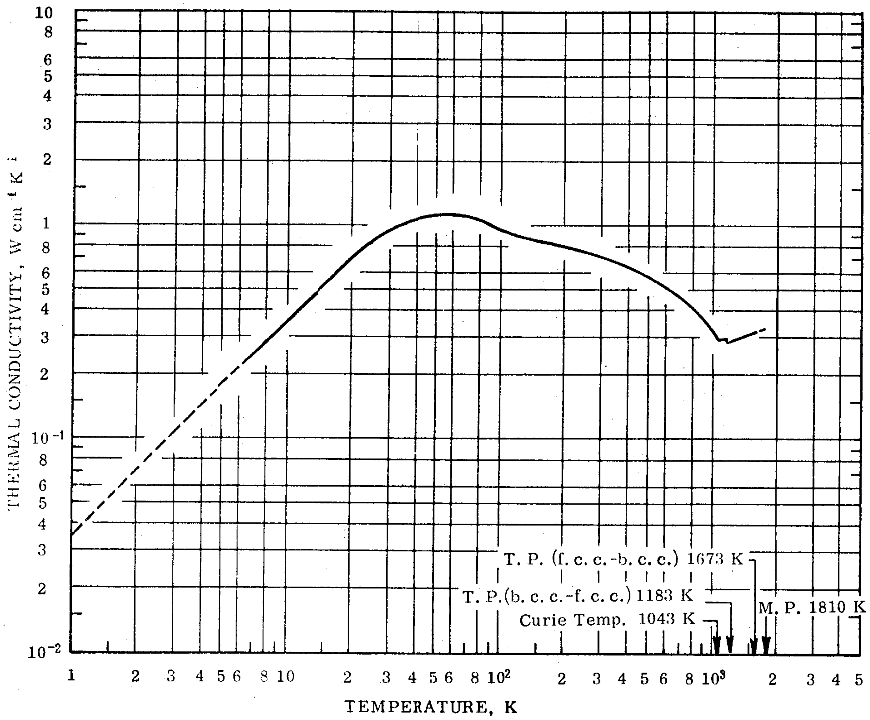
* Extrapolated or estimated.
† Values for molten iron are provisional.

REMARKS

The recommended values are for well-annealed high-purity iron and are considered accurate to within ±5% of the true values at temperatures below 100 K, ±3% from 100 K to room temperature, ±2% from room temperature to about 1000 K, the uncertainty probably increasing to about ±8% at 1600 K and ±15% at the melting point. Reliable estimation of the uncertainty of the provisional values for molten iron can hardly be given. The thermal conductivity at temperatures near and below the corresponding temperature, T_m, of the conductivity maximum is highly sensitive to small physical and chemical variations among different specimens, and the recommended values below 200 K are applicable only to a specimen having residual electrical resistivity $\rho_0 = 0.0143$ μΩ cm.

Values at temperatures below about 1.5 T_m are calculated to fit experimental data by using equation (7) and using the constants m, n, and α'' given in Table 1 for iron and the parameter $\beta = 0.585$.

THERMAL CONDUCTIVITY OF ARMCO IRON



REMARKS

The recommended values are for well-annealed Armco iron and are considered accurate to within ±5% of the true values at temperatures below 100 K, ±3% from 100 K to room temperature, ±2% from room temperature to about 1000 K, the uncertainty probably increasing to about ±8% at 1600 K and ±15% at the melting point. The thermal conductivity at temperatures near and below the corresponding temperature of the conductivity maximum is highly sensitive to small physical and chemical variations among different specimens, and the recommended values below 200 K are applicable only to a specimen having residual electrical resistivity $\rho_0 = 0.690\ \mu\Omega$ cm. For other specimens having different residual electrical resistivities, thermal conductivity values may be derived from measured electrical resistivity data and values of the Lorenz function given in the table.

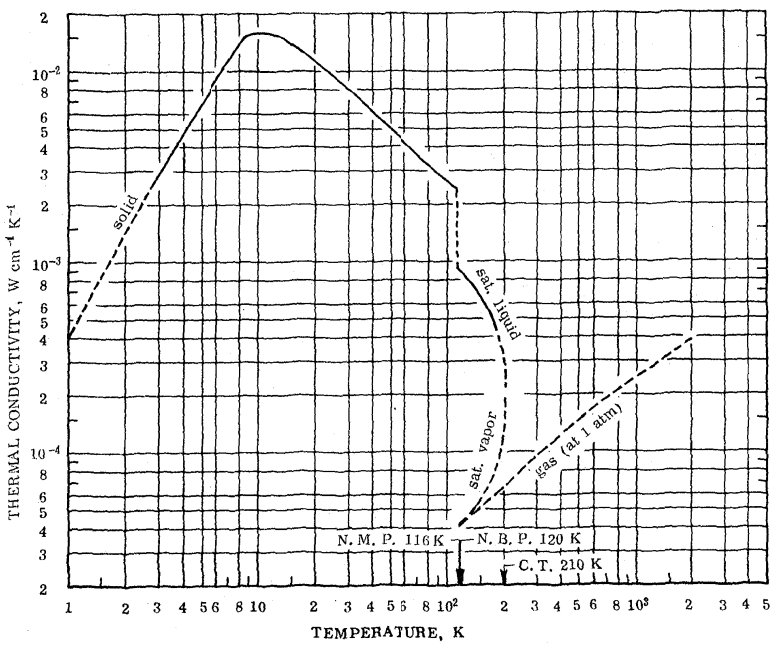
RECOMMENDED VALUES

[Temperature, T, K; Thermal Conductivity, k, W cm^{-1} K^{-1}; Lorenz Function, L, 10^{-8} V^2 K^{-2}]

Thermal Conductivity				Lorenz Function	
T	k	T	k	T	L
0	0	250	0.765	6	2.505
1	0.0358*	273.2	0.747	7	2.523
2	0.0718*	298.2	0.728	8	2.531
3	0.108*	300	0.727	9	2.533
4	0.144*	323.2	0.710	10	2.532
5	0.180*	350	0.691	12	2.529
6	0.217	373.2	0.676	14	2.528
7	0.253	400	0.657	16	2.528
8	0.290	473.2	0.610	18	2.527
9	0.326	500	0.593	20	2.521
10	0.362	573.2	0.547	25	2.477
11	0.398	600	0.531	30	2.395
12	0.434	673.2	0.488	35	2.292
13	0.470	700	0.473	40	2.188
14	0.505	773.2	0.435	45	2.096
15	0.541	800	0.422	50	2.021
16	0.575	873.2	0.386	55	1.965
18	0.644	900	0.372	60	1.927
20	0.712	973.2	0.336	65	1.905
25	0.858	1000	0.323	70	1.895
30	0.982	1059	0.293	75	1.895
35	1.07	1073.2	0.293	80	1.903
40	1.13	1100	0.294	85	1.917
45	1.15	1173.2	0.296	90	1.935
50	1.15	1183	0.296	95	1.956
60	1.13	1183	0.285	100	1.980
70	1.09	1200	0.287	110	2.034
80	1.05	1273.2	0.294	120	2.091
90	1.00	1300	0.296	130	2.150
100	0.956	1373.2	0.303	140	2.209
123.2	0.896	1400	0.306	150	2.266
150	0.855	1473.2	0.312	160	2.320
173.2	0.831	1500	0.314	170	2.371
200	0.806	1573.2	0.320	180	2.418
223.2	0.786	1600	0.322*	190	2.461
		1673.2	0.328*	200	2.499
		1700	0.330*		
		1773.2	0.336*		
		1800	0.338*		

*Extrapolated.

THERMAL CONDUCTIVITY OF KRYPTON



REMARKS

Serious differences exist in measurements for the solid, possibly produced by varying impurity contents. These produce an uncertainty of possibly 40% above 25 K. No reliable estimate at lower temperatures is felt possible. The saturated liquid values below 190 K should be accurate to within 2%, the uncertainty steadily increasing to possibly 20% at the critical point. For the vapor a 3% uncertainty below 150 K is considered to increase to 20% at the critical point. The gas values are considered accurate to within 2% below 600 K, 5% from 600 to 1500 K, and possibly within 10% at 2000 K.

RECOMMENDED VALUES

[Temperature, T, K; Thermal Conductivity, k, W cm^{-1} K^{-1}]

SOLID

T	k x 10^3
1	0.4*
1.5	0.8*
2	1.3*
2.5	2.0*
3	2.7
3.5	3.5
4	4.4
4.5	5.4
5	6.5
6	8.9
7	10.7
8	14.4
9	16
10	17
12	16
14	15
16	14
18	13
20	12
25	9.8
30	8.3
35	7.1
40	6.2
45	5.6
50	5.1
60	4.3
70	3.8
80	3.4
90	3.1
100	2.8
110	2.6
116‡	2.5

SATURATED LIQUID

T	k x 10^3
116‡	0.931
120	0.905
125	0.872
130	0.839
135	0.806
140	0.773
145	0.740
150	0.708
155	0.675
160	0.642
165	0.609
170	0.576
175	0.543
180	0.510
185	0.477
190	0.444
195	0.408
200	0.366
205	0.31*
210	0.21*†

SATURATED VAPOR

T	k x 10^3
120	0.0406*
125	0.0429*
130	0.0452*
135	0.0476*
140	0.0501*
145	0.0527*
150	0.0554*
155	0.059*
160	0.062*
165	0.065*
170	0.070*
175	0.074*
180	0.079*
185	0.085*
190	0.093*
195	0.101*
200	0.112*
205	0.135*
210	0.21*†

* Estimated or extrapolated.
† Pseudo-critical value.
‡ Normal boiling point.

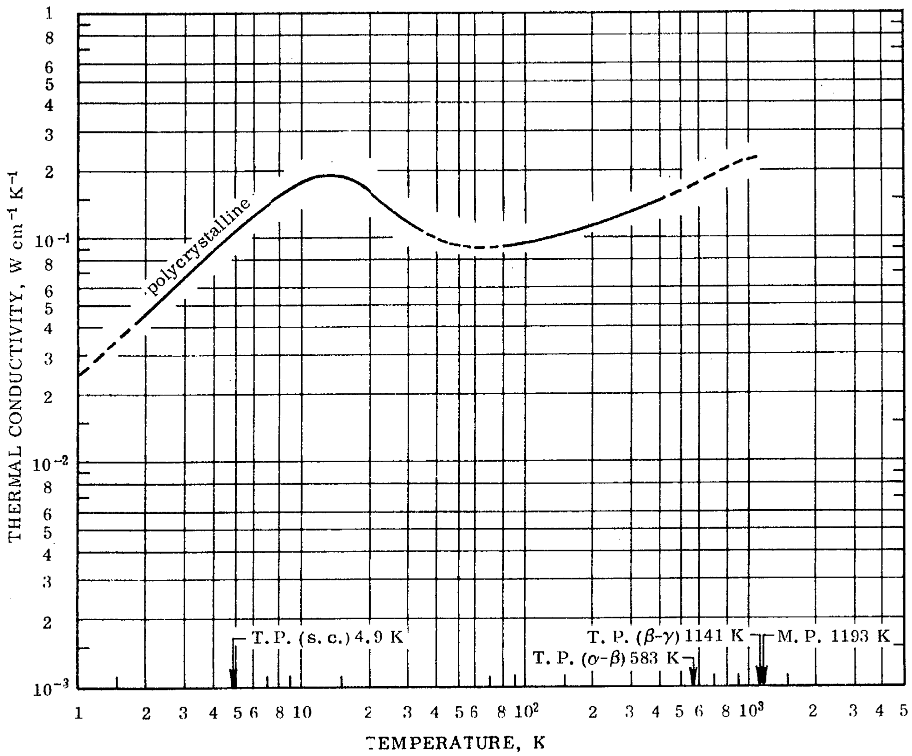
THERMAL CONDUCTIVITY OF KRYPTON (continued)

RECOMMENDED VALUES

GAS
(AT 1 atm)

T	k x 10^3	T	k x 10^3	T	k x 10^3
		500	0.147	900	0.227
		510	0.149	910	0.228
120	0.0405	520	0.151	920	0.230
130	0.0437	530	0.154	930	0.231
140	0.0469	540	0.156	940	0.233
150	0.0501	550	0.158	950	0.235
160	0.0533	560	0.160	960	0.237
170	0.0562	570	0.162	970	0.239
180	0.0593	580	0.165	980	0.240
190	0.0623	590	0.167	990	0.242
200	0.0653	600	0.169	1000	0.244
210	0.0683	610	0.171	1050	0.252
220	0.0713	620	0.173	1100	0.260
230	0.0742	630	0.176	1150	0.268
240	0.0772	640	0.178	1200	0.276
250	0.0802	650	0.180	1250	0.284
260	0.0830	660	0.182	1300	0.291
270	0.0860	670	0.184	1350	0.299
280	0.0891	680	0.186	1400	0.306
290	0.0920	690	0.188	1450	0.313
300	0.0949	700	0.190	1500	0.320
310	0.0978	710	0.192	1550	0.327
320	0.1007	720	0.194	1600	0.334
330	0.1035	730	0.196	1650	0.341
340	0.1063	740	0.198	1700	0.347
350	0.1090	750	0.200	1750	0.353
360	0.1118	760	0.201	1800	0.359
370	0.1145	770	0.203	1850	0.365
380	0.1173	780	0.205	1900	0.371
390	0.1199	790	0.207	1950	0.377
400	0.1226	800	0.209	2000	0.382
410	0.1252	810	0.211		
420	0.1278	820	0.212		
430	0.1302	830	0.214		
440	0.1329	840	0.216		
450	0.1355	850	0.218		
460	0.1380	860	0.220		
470	0.1405	870	0.221		
480	0.1430	880	0.223		
490	0.1450	890	0.225		

THERMAL CONDUCTIVITY OF LANTHANUM



REMARKS

The values are for well-annealed high-purity lanthanum. Above 80 K the values are recommended values and are considered accurate to within ±5% of the true values at temperatures within ±100 K of room temperature and ±10 to ±15% at other temperatures. The provisional values above 10K are very uncertain, and those below 10K should be good to ±15%. The thermal conductivity at temperatures near and below the corresponding temperature of the conductivity maximum is highly sensitive to small physical and chemical variations among different specimens, and the values below 50 K are applicable only to lanthanum having residual electrical resistivity $\rho_0 = 1.29\ \mu\Omega$ cm.

RECOMMENDED VALUES †

[Temperature, T, K; Thermal Conductivity, k, W cm^{-1} K^{-1}]

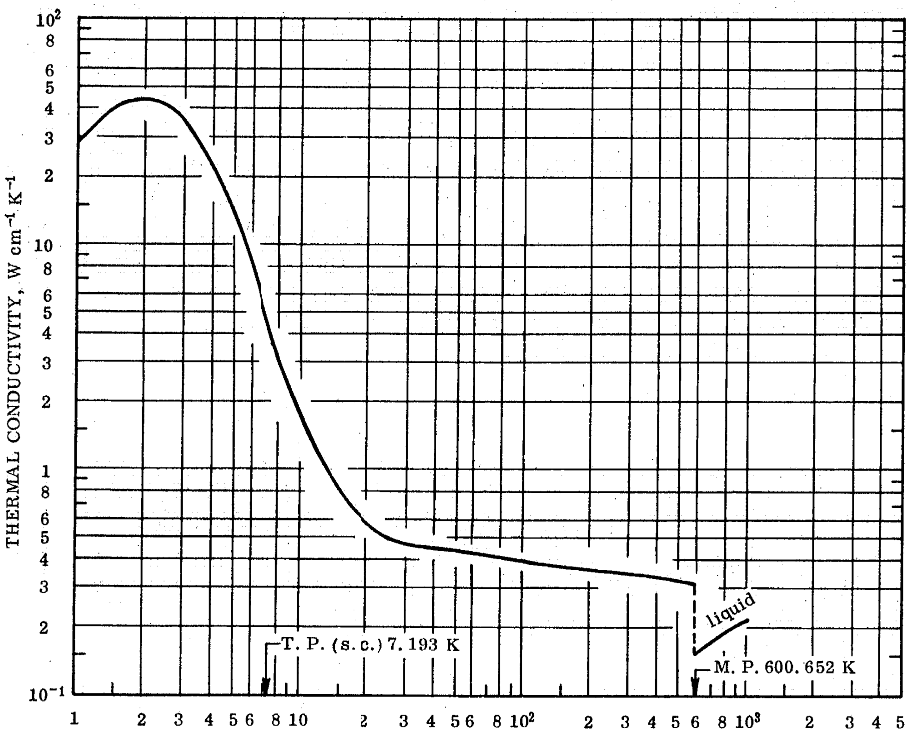
SOLID

Polycrystalline

T	k	T	k
0	0	123.2	0.103
1	0.0250*	150	0.109
2	0.0468	173.2	0.116
3	0.0674	200	0.118
4	0.0875	223.2	0.122
5	0.107	250	0.127
6	0.124	273.2	0.131
7	0.140	298.2	0.134
8	0.154	300	0.135
9	0.166	323.2	0.138
10	0.176	350	0.142
11	0.183	373.2	0.145
12	0.188	400	0.149
13	0.191	473.2	0.158*
14	0.192	500	0.162*
15	0.191	573.2	0.175*
16	0.188	600	0.179*
18	0.179	673.2	0.192*
20	0.168	700	0.196*
25	0.141	773.2	0.207*
30	0.121	800	0.211*
35	0.108	873.2	0.219*
40	0.101	900	0.222*
45	0.0969*	973.2	0.227*
50	0.0943*	1000	0.229*
60	0.0927*	1073.2	0.232*
70	0.0929*	1100	0.232*
80	0.0941*		
90	0.0958		
100	0.0978		

* Extrapolated or interpolated.
† Values below 80 K are provisional.

THERMAL CONDUCTIVITY OF LEAD



REMARKS

The recommended values are for well-annealed high-purity lead and are considered accurate to within ±3% of the true values at moderate temperatures, ±5% at high temperatures, and ±10% at low temperatures and for molten lead within about 200 K of the melting point. The thermal conductivity at temperatures near and below the corresponding temperature, T_m, of the conductivity maximum is highly sensitive to small physical and chemical variations among different specimens, and the recommended values below 30 K are applicable only to lead in the normal state having residual electrical resistivity $\rho_0 = 0.000862\ \mu\Omega$ cm. Values at temperatures below about 1.5 T_m are calculated by using equation (7) and using the constants m, n, and α'' given for lead in Table 1 and the parameter $\beta = 0.0353$.

RECOMMENDED VALUES †

[Temperature, T, K; Thermal Conductivity, k, W cm^{-1} K^{-1}]

SOLID

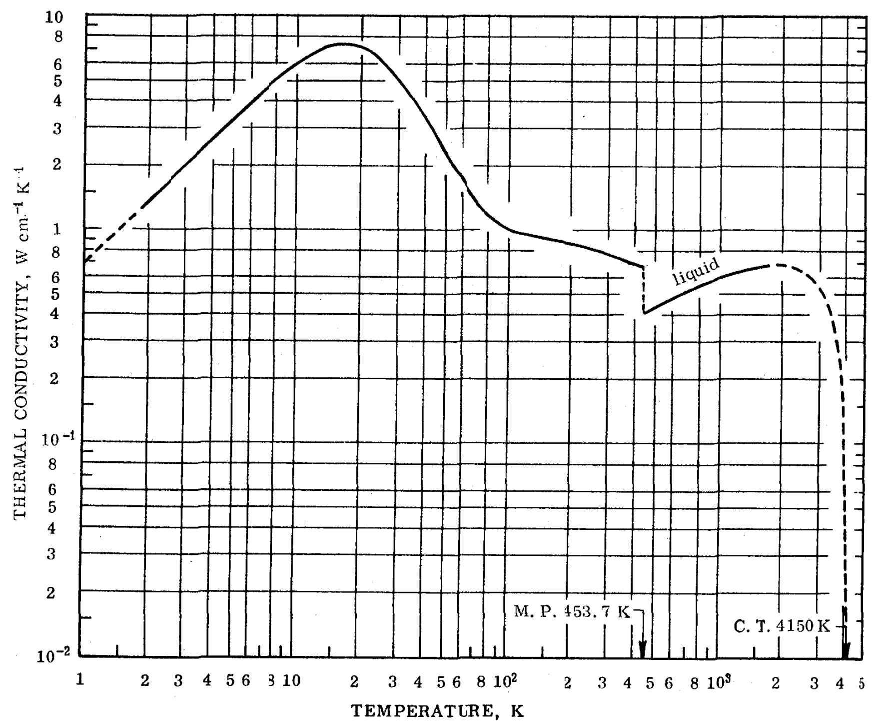
T	k	T	k
0	0	60	0.425
1	27.9	70	0.416
2	44.6	80	0.409
3	35.8	90	0.403
4	22.2	100	0.397
5	13.8	123.2	0.389
6	8.10	150	0.379
7	4.86	173.2	0.372
8	3.20	200	0.367
9	2.30	223.2	0.365
10	1.78	250	0.360
11	1.46	273.2	0.356
12	1.23	298.2	0.353
13	1.07	300	0.353
14	0.944	323.2	0.350
15	0.845	350	0.347
16	0.772	373.2	0.344
18	0.661	400	0.340
20	0.591	473.2	0.330
25	0.507	500	0.328
30	0.477	573.2	0.318
35	0.462	600	0.314
40	0.451	600.652	0.314
45	0.442		
50	0.436		

LIQUID

T	k
600.652	0.155
673.2	0.170
700	0.175
773.2	0.187
800	0.192
873.2	0.201
900	0.205
973.2	0.212
1000	0.215

† Values above 800 K are provisional.

THERMAL CONDUCTIVITY OF LITHIUM



RECOMMENDED VALUES †

[Temperature, T, K; Thermal Conductivity, k, W cm^{-1} K^{-1}]

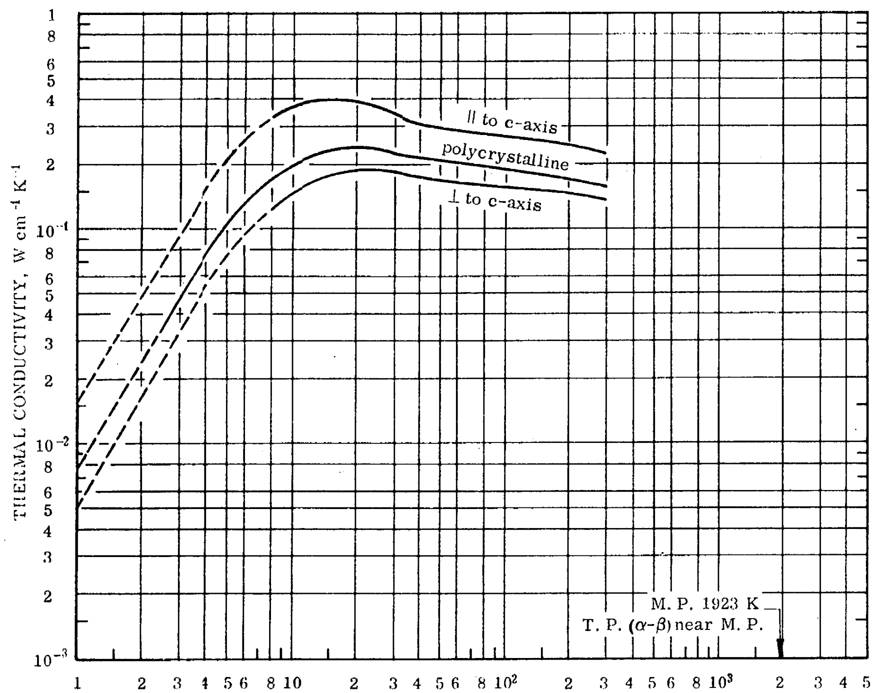
SOLID				LIQUID			
T	k	T	k	T	k	T	k
0	0	60	1.75	453.7	0.428*	1900	0.707*
1	0.658*	70	1.40	473.2	0.434	1973.2	0.706*
2	1.32	80	1.20	500	0.443	2000	0.705*
3	1.97	90	1.10	573.2	0.467	2073.2	0.703*
4	2.62	100	1.04	600	0.476	2173.2	0.698*
5	3.29	123.2	0.986	673.2	0.500	2200	0.696*
6	3.86	150	0.949	700	0.509	2273.2	0.690*
7	4.56	173.2	0.925	773.2	0.533	2400	0.676*
8	5.15	200	0.901	800	0.541	2473.2	0.666*
9	5.67	223.2	0.887	873.2	0.564	2600	0.645*
10	6.13	250	0.871	900	0.572	2673.2	0.630*
11	6.51	273.2	0.859	973.2	0.593	2800	0.602*
12	6.82	298.2	0.848	1000	0.600	2873.2	0.581*
13	7.09	300	0.847	1073.2	0.619	3000	0.543*
14	7.25	323.2	0.839	1100	0.625	3073	0.516*
15	7.38	350	0.828	1173.2	0.641	3200	0.467*
16	7.40	373.2	0.818	1200	0.647	3273	0.437*
18	7.39	400	0.804	1273.2	0.661	3400	0.383*
20	7.20	453.7	0.772*	1300	0.665	3473	0.351*
25	6.30			1373.2	0.676	3600	0.293*
30	5.20			1400	0.680	3673	0.257*
35	4.22			1473.2	0.688	3800	0.193*
40	3.43			1500	0.691	3873	0.155*
45	2.81			1573.2	0.697	4000	0.086*
50	2.35			1600	0.699	4073	0.045*
				1673.2	0.703	C.T. = 4150	0.002*
				1700	0.704		
				1773.2	0.706		
				1800	0.707*		
				1873.2	0.707*		

* Extrapolated or estimated.
† Values above 1800 K are provisional.

REMARKS

The recommended values are for well-annealed high-purity lithium and are considered accurate to within about ±5% for the solid state and for molten lithium to about 700 K. The uncertainty increases to about ±10% by 1600 K and continues to increase at higher temperatures. The thermal conductivity at temperatures near and below the corresponding temperature, T_m, of the conductivity maximum is highly sensitive to small physical and chemical variations among different specimens, and the recommended values below 150 K are applicable only to lithium having residual electrical resistivity $\rho_0 = 0.0372$ μΩ cm. Values at temperatures below about 1.5 T_m are calculated to fit experimental data by using equation (7) and using the constants m, n, and α'' given for lithium in Table 1 and the parameter $\beta = 1.52$.

THERMAL CONDUCTIVITY OF LUTETIUM



REMARKS

The provisional values are for well-annealed high-purity lutetium and are considered accurate to within ±20% of the true values at temperatures from 10 to 100 K and ±15% above 100 K. The values below 10 K are very uncertain.

At temperatures below 100 K the values for $k_{\parallel}$, $k_{\perp}$, and k_{poly} are applicable only to samples having residual electrical resistivities of 0.76, 2.65, and 1.45 $\mu\Omega$ cm, respectively.

PROVISIONAL VALUES

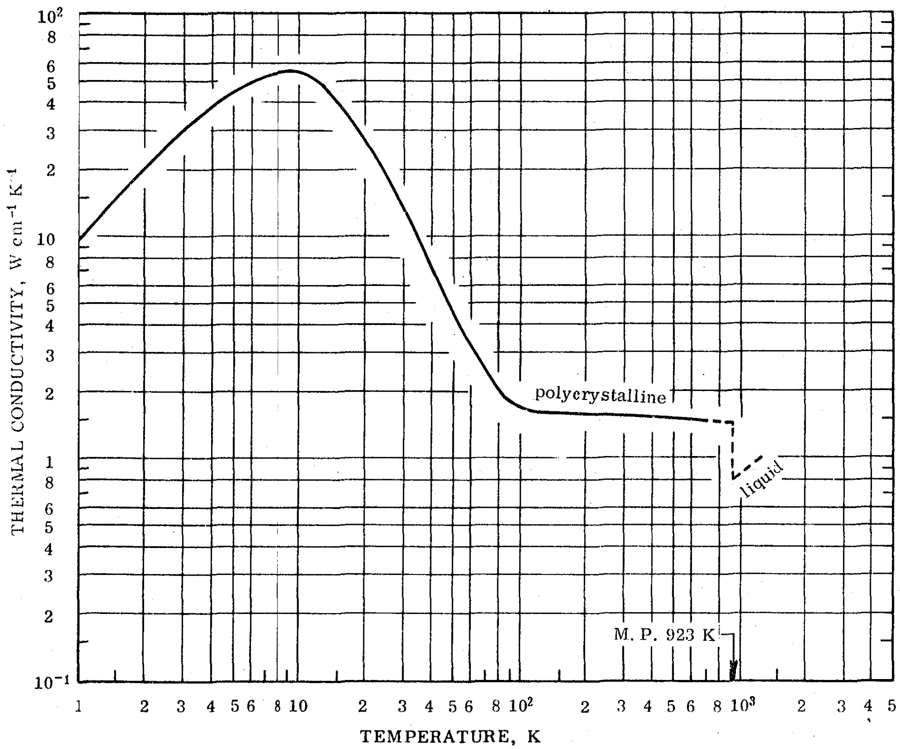
[Temperature, T, K; Thermal Conductivity, k, W cm^{-1} K^{-1}]

SOLID

T	// to c-axis k	⊥ to c-axis k	Polycrystalline k
0	0	0	0
1	0.0155*	0.00510*	0.00757*
2	0.0496*	0.0165*	0.0244*
3	0.0984*	0.0328	0.0484
4	0.160*	0.0532	0.0786
5	0.217*	0.0742	0.108
6	0.262*	0.0934	0.134
7	0.295*	0.110	0.155
8	0.322	0.124	0.173
9	0.343	0.136	0.188
10	0.359	0.145	0.199
11	0.372	0.153	0.208
12	0.383	0.160	0.216
13	0.391	0.166	0.223
14	0.397	0.171	0.229
15	0.402	0.175	0.233
16	0.406	0.179	0.237
18	0.408	0.185	0.243
20	0.406	0.188	0.245
25	0.384	0.191	0.242
30	0.353	0.188	0.233
35	0.330	0.182	0.223
40	0.317	0.178	0.216
45	0.308	0.175	0.212
50	0.303	0.173	0.209
60	0.296	0.169	0.204
70	0.290	0.166	0.200
80	0.285	0.163	0.197
90	0.280	0.161	0.194
100	0.277	0.160	0.192
123.2	0.267	0.155	0.186
150	0.260	0.152	0.182
173.2	0.255	0.149	0.179
200	0.249	0.146	0.175
223.2	0.245	0.144	0.173
250	0.240	0.142	0.170
273.2	0.236	0.140	0.167
298.2	0.232	0.138	0.164
300	0.232	0.138	0.164

*Extrapolated.

THERMAL CONDUCTIVITY OF MAGNESIUM



REMARKS

The recommended values are for well-annealed high-purity magnesium and are considered accurate to within ±3% of the true values at moderate temperatures, ±10% for low temperatures and as the melting point is approached, and ±15% for the liquid state within some 200 K of the melting point. The thermal conductivity at temperatures near and below the corresponding temperature, T_m, of the conductivity maximum is highly sensitive to small physical and chemical variations among different specimens, and the recommended values below 100 K are applicable only to magnesium having residual electrical resistivity $\rho_0 = 0.00261$ $\mu\Omega$ cm. Values at temperatures below about 1.5 T_m are calculated to fit experimental data by using equation (7) and using the constants m, n, and α'' given for magnesium in Table 1 and the parameter $\beta = 0.101$.

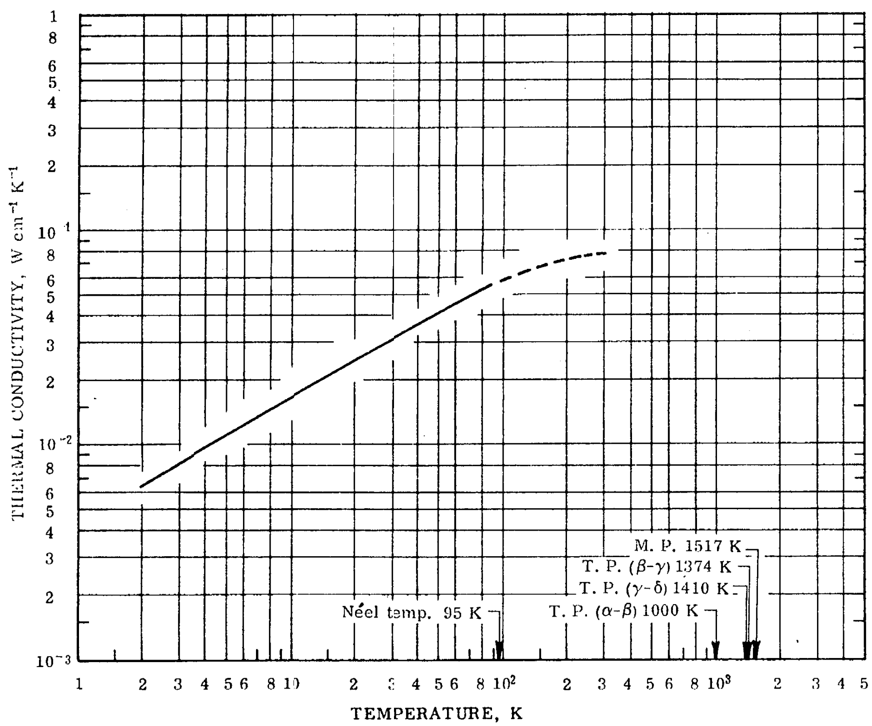
RECOMMENDED VALUES †

[Temperature, T, K; Thermal Conductivity, k, W cm^{-1} K^{-1}]

SOLID				LIQUID	
Polycrystalline					
T	k	T	k	T	k
0	0	123.2	1.63	923.2	0.790*
1	9.86	150	1.61	973.2	0.826*
2	19.6	173.2	1.60	1000	0.844*
3	29.0	200	1.59	1073.2	0.893*
4	37.6	250	1.57	1100	0.911*
5	45.0	273.2	1.57	1173.2	0.961*
6	50.8	298.2	1.56	1200	0.978*
7	54.7	300	1.56		
8	56.7	323.2	1.55		
9	57.0	350	1.55		
10	55.8	373.2	1.54		
11	53.7	400	1.53		
12	50.9	473.2	1.52		
13	47.8	500	1.51		
14	44.4	573.2	1.50		
15	41.1	600	1.49		
16	37.9	673.2	1.48		
18	32.2	700	1.47		
20	27.2	773.2	1.46*		
25	18.3	800	1.46*		
30	12.9	873.2	1.45*		
35	9.45	900	1.45*		
40	7.19	923.2	1.45*		
45	5.70				
50	4.65				
60	3.27				
70	2.49				
80	2.02				
90	1.78				
100	1.69				

* Extrapolated or estimated.
† Values for molten magnesium are provisional.

THERMAL CONDUCTIVITY OF MANGANESE



REMARKS

The values around room temperature are for well-annealed high-purity manganese and are considered accurate to within ± 20%. The accuracy may be slightly better around room temperature. Values below room temperature are applicable only to manganese of 99.99% pure having residual electrical resistivity ρ_0 = 11.3 μΩ cm.

PROVISIONAL VALUES

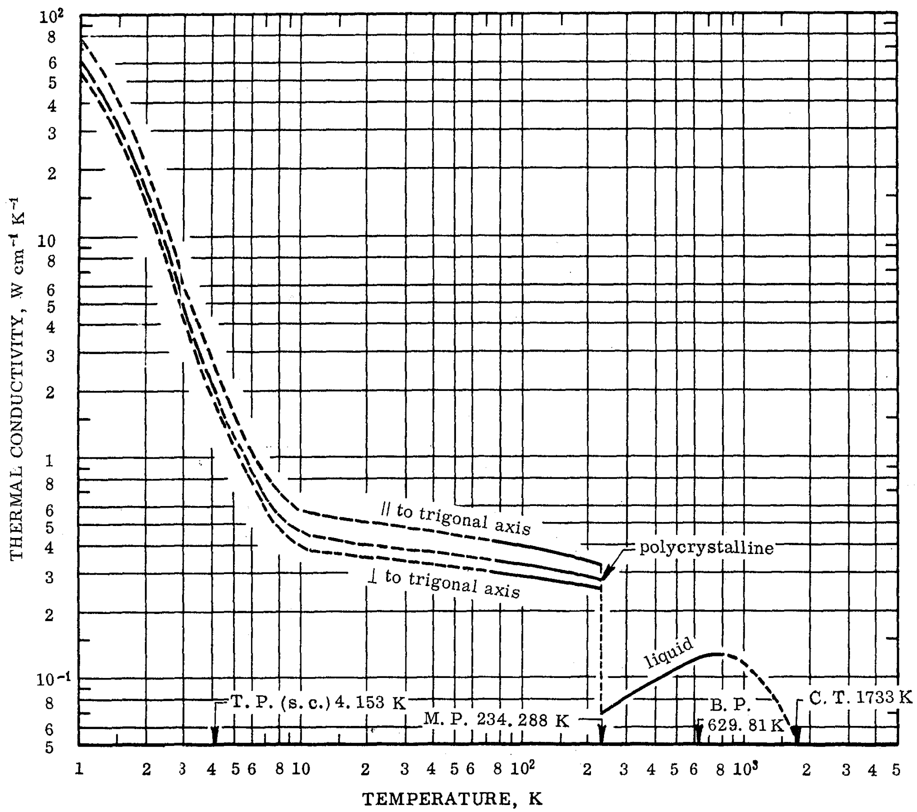
[Temperature, T, K; Thermal Conductivity, k, W cm^{-1} K^{-1}]

SOLID

T	k
2	0.00645*
3	0.00813
4	0.00956
5	0.0109
6	0.0121
7	0.0132
8	0.0143
9	0.0153
10	0.0163
11	0.0172
12	0.0180
13	0.0188
14	0.0196
15	0.0205
16	0.0213
18	0.0227
20	0.0241
25	0.0274
30	0.0304
35	0.0332
40	0.0358
45	0.0382
50	0.0406
60	0.0450
70	0.0491
80	0.0526
90	0.0555
100	0.0579*
123.2	0.0624*
150	0.0663*
173.2	0.0691*
200	0.0717*
223.2	0.0735*
250	0.0754*
273.2	0.0768*
298.2	0.0781
300	0.0782*

*Extrapolated or interpolated.

THERMAL CONDUCTIVITY OF MERCURY



REMARKS

The values for the solid state above 80 K and for the liquid state are recommended values for high-purity mercury and are considered accurate to within ±10% of the true values at temperature from 80 K to the melting point and ±5% from the melting point to 700 K. The uncertainty increases above 700 K and up to ±20% at the highest temperature. The values below 80 K are merely typical values and represent typical curves serving to indicate the general trend of the thermal conductivity of mercury at low temperatures.

RECOMMENDED VALUES †

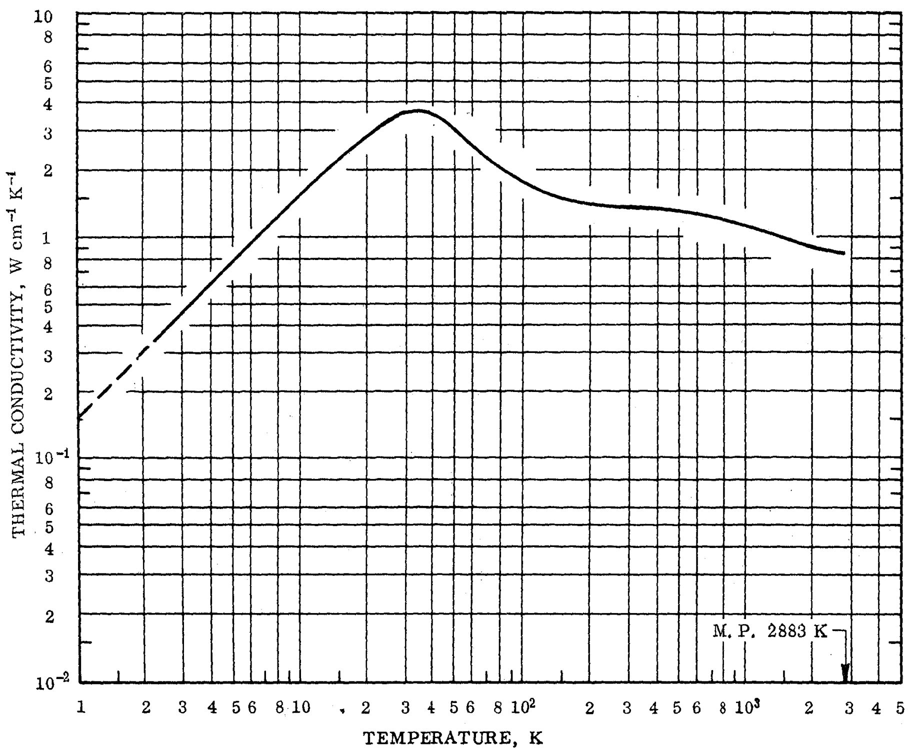
[Temperature, T, K; Thermal Conductivity, k, W cm^{-1} K^{-1}]

SOLID				LIQUID	
	// to trigonal axis	⊥ to trigonal axis	Polycrystalline		
T	k	k	k	T	k
0	0	0	0	234.288	0.0697
1	82.4*	57.2*	65.6*	250	0.0732
2	21.5*	14.9*	17.1	273.2	0.0782
3	6.34*	4.40*	5.05	298.2	0.0830
4	2.84*	1.97*	2.26	300	0.0834
5	1.66*	1.15*	1.32*	323.2	0.0874
6	1.11*	0.770*	0.883*	350	0.0915
7	0.834*	0.581*	0.665*	373.2	0.0947
8	0.691*	0.481*	0.551*	400	0.0984
9	0.615*	0.429*	0.491*	473.2	0.107
10	0.576*	0.400*	0.459*	500	0.110
11	0.559*	0.387*	0.444*	573.2	0.117
12	0.547*	0.382*	0.437*	600	0.120
13	0.538*	0.377*	0.431*	673.2	0.126
14	0.532*	0.373*	0.426*	700	0.127
15	0.527*	0.369*	0.422*	770	0.1283
16	0.522*	0.366*	0.418*	773.2	0.128
18	0.512*	0.360*	0.411*	800	0.128
20	0.504*	0.354*	0.404*	873.2	0.126
25	0.488*	0.343*	0.391*	900	0.124*
30	0.474*	0.334*	0.381*	973.2	0.119*
35	0.462*	0.327*	0.372*	1000	0.117*
40	0.452*	0.320*	0.364*	1073.2	0.111*
45	0.444*	0.315*	0.358*	1100	0.108*
50	0.437*	0.311*	0.353*	1173.2	0.101*
60	0.424*	0.304*	0.344*	1200	0.0984*
70	0.413*	0.297*	0.336*	1273.2	0.0904*
80	0.404	0.293	0.330*	1300	0.0872*
90	0.396	0.288	0.324	1373.2	0.0773*
100	0.390	0.285	0.320	1400	0.0732*
123.2	0.374	0.279	0.311	1473.2	0.0610*
150	0.360	0.271	0.301	1500	0.0559*
173.2	0.349	0.268	0.295	1573.2	0.0407*
200	0.340	0.264	0.289	1600	0.0345*
223.2	0.332	0.260	0.284	1673.2	0.0164*
234.288			0.283	1700	0.0094*
				C. T. = 1733	0.00045*

* Extrapolated or estimated.

† Values below 80 K are merely typical values. and those above 1000 K are provisional.

THERMAL CONDUCTIVITY OF MOLYBDENUM



RECOMMENDED VALUES

[Temperature, T, K; Thermal Conductivity, k, W cm^{-1} K^{-1}]

SOLID

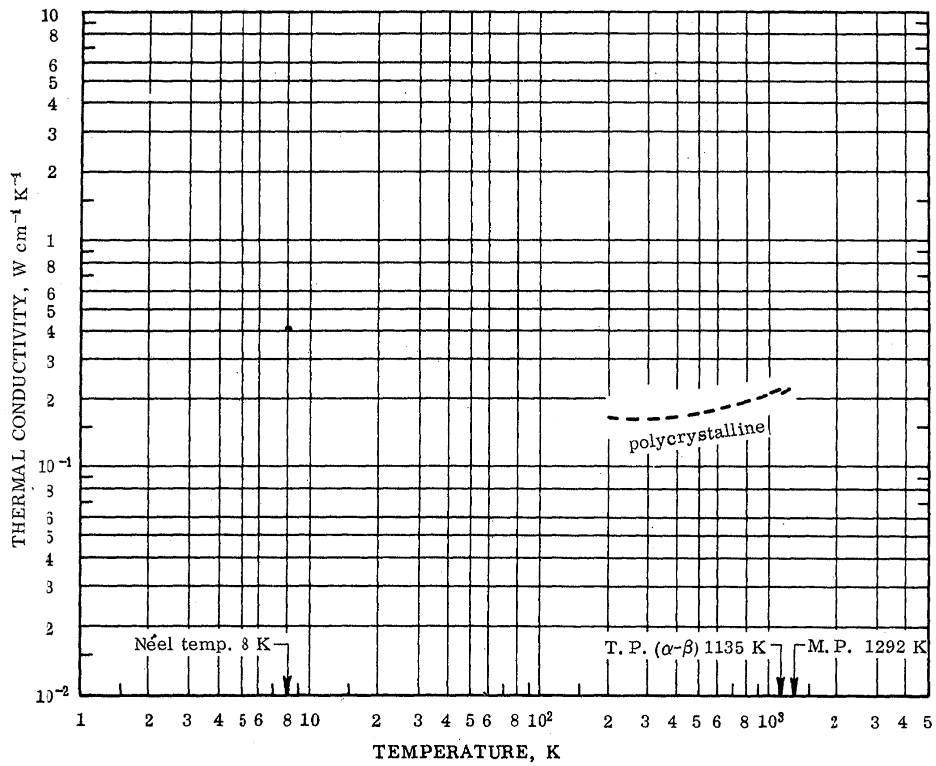
T	k	T	k	T	k
0	0	123.2	1.60	1300	1.03
1	0.152*	150	1.49	1373.2	1.01
2	0.304*	173.2	1.45	1400	1.00
3	0.456	200	1.43	1473.2	0.985
4	0.608	223.2	1.42	1500	0.980
5	0.760	250	1.40	1573.2	0.966
6	0.911	273.2	1.39	1600	0.960
7	1.06	298.2	1.38	1673.2	0.948
8	1.21	300	1.38	1700	0.944
9	1.36	323.2	1.38	1773.2	0.933
10	1.51	350	1.36	1800	0.929
11	1.66	373.2	1.35	1873.2	0.918
12	1.81	400	1.34	1900	0.915
13	1.95	473.2	1.32	1973.2	0.906
14	2.09	500	1.30	2000	0.903
15	2.23	573.2	1.27	2073.2	0.894
16	2.37	600	1.26	2173.2	0.885
18	2.63	673.2	1.23	2200	0.882
20	2.87	700	1.22	2273.2	0.876
25	3.36	773.2	1.19	2400	0.866
30	3.64	800	1.18	2473.2	0.861
35	3.70	873.2	1.16	2600	0.852
40	3.55	900	1.15	2673.2	0.848
45	3.28	973.2	1.13	2800	0.840
50	3.02	1000	1.12		
60	2.62	1073.2	1.09		
70	2.32	1100	1.08		
80	2.09	1173.2	1.06		
90	1.93	1200	1.05		
100	1.79	1273.2	1.03		

*Extrapolated.

REMARKS

The recommended values are for well-annealed high-purity molybdenum and are considered accurate to within ±10% of the true values at low temperatures, ±4% at moderate temperatures, and within ±15% as the melting point is approached. The thermal conductivity at temperatures near and below the corresponding temperature, T_m, of the conductivity maximum is highly sensitive to small physical and chemical variations among different specimens, and the recommended values below room temperature are applicable only to molybdenum having residual electrical resistivity $\rho_0 = 0.167$ $\mu\Omega$ cm. Values at temperatures below about 1.5 T_m are calculated to fit experimental data by using equation (7) and using the constants m, n, and α'' given for molybdenum in Table 1 and the parameter $\beta = 6.58$.

THERMAL CONDUCTIVITY OF NEODYMIUM



PROVISIONAL VALUES

[Temperature, T, K; Thermal Conductivity, k, W cm^{-1} K^{-1}]

SOLID

Polycrystalline

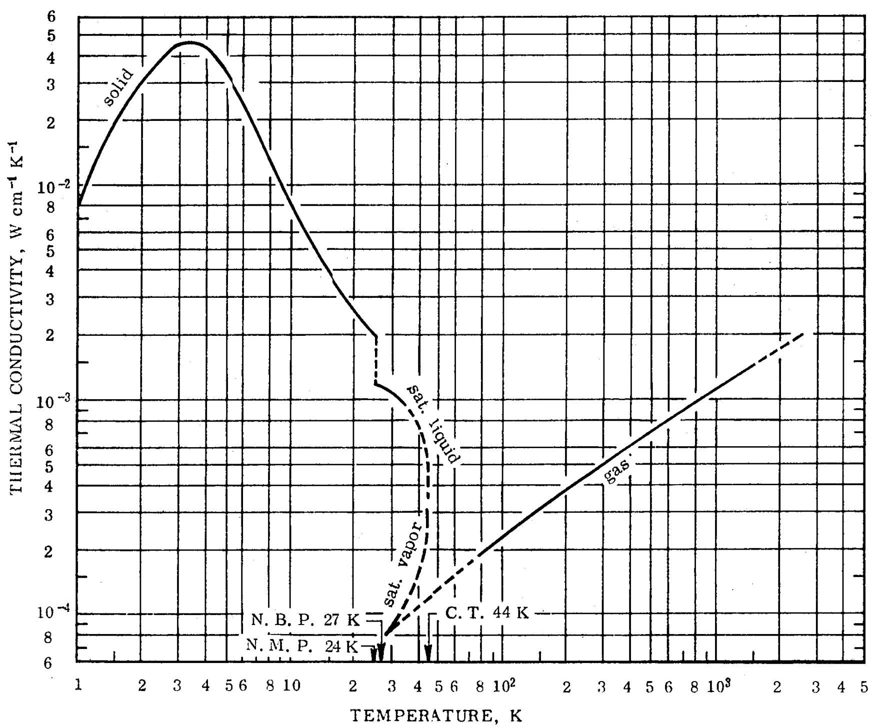
T	k
200	0.166*
223.2	0.165*
250	0.164*
273.2	0.165*
298.2	0.165*
300	0.165
323.2	0.165*
350	0.166*
373.2	0.167*
400	0.168*
473.2	0.171*
500	0.173*
573.2	0.178*
600	0.179*
673.2	0.185*
700	0.187*
773.2	0.192*
800	0.195*
873.2	0.201*
900	0.203*
973.2	0.212*
1000	0.215*
1073.2	0.222*
1100	0.224*
1120	0.225*
1140	0.217*
1173.2	0.220*
1200	0.224*

REMARKS

The provisional values are for high-purity polycrystalline neodymium and are considered accurate to within ±15% of the true values near room temperature. The uncertainty increases to ± 30% at the highest temperatures.

*Extrapolated.

THERMAL CONDUCTIVITY OF NEON



REMARKS

The paucity of experimental data for the solid restricts the error estimate to that the recommended values are probably accurate to within 20% above 5 K. Severe disagreement exists between some measurements and correlations for the liquid phase, resulting in a probable uncertainty of 20% below 35 K and as much as 40% at the critical point. Similar uncertainties are probable for the vapor. The gas values should be accurate to within 2% up to 400 K, 4% at 1000 K, and 10% at 2500 K.

RECOMMENDED VALUES

[Temperature, T, K; Thermal Conductivity, k, W cm^{-1} K^{-1}]

SOLID		SATURATED LIQUID		SATURATED VAPOR	
T	k x 10^3	T	k x 10^3	T	k x 10^3
		24	1.17		
1.0	7.3*	26	1.15		
1.5	18.5*	27	1.13	27	0.079*
2.0	29.5*	28	1.12	28	0.082*
2.5	39.8*	29	1.10	29	0.085*
3.0	45.7*	30	1.08	30	0.089*
3.5	47.1*	31	1.06	31	0.093*
4.0	44.0*	32	1.04*	32	0.097*
4.5	39.3*	33	1.02*	33	0.102*
5	33.6*	34	0.99*	34	0.107*
6	24.5*	35	0.96*	35	0.112*
7	17.0*	36	0.92*	36	0.118*
8	13.0*	37	0.88*	37	0.124*
9	10.2*	38	0.84*	38	0.131*
10	8.4*	39	0.79*	39	0.138*
12	6.0*	40	0.73*	40	0.147*
14	4.5*	41	0.67*	41	0.16*
16	3.7*	42	0.61*	42	0.17*
18	3.1*	43	0.54*	43	0.19*
20	2.7*	44	0.33*†	44	0.33*†
22	2.3*				
24	2.1*				

* Estimated or extrapolated, hence provisional.
† Pseudo-critical value.

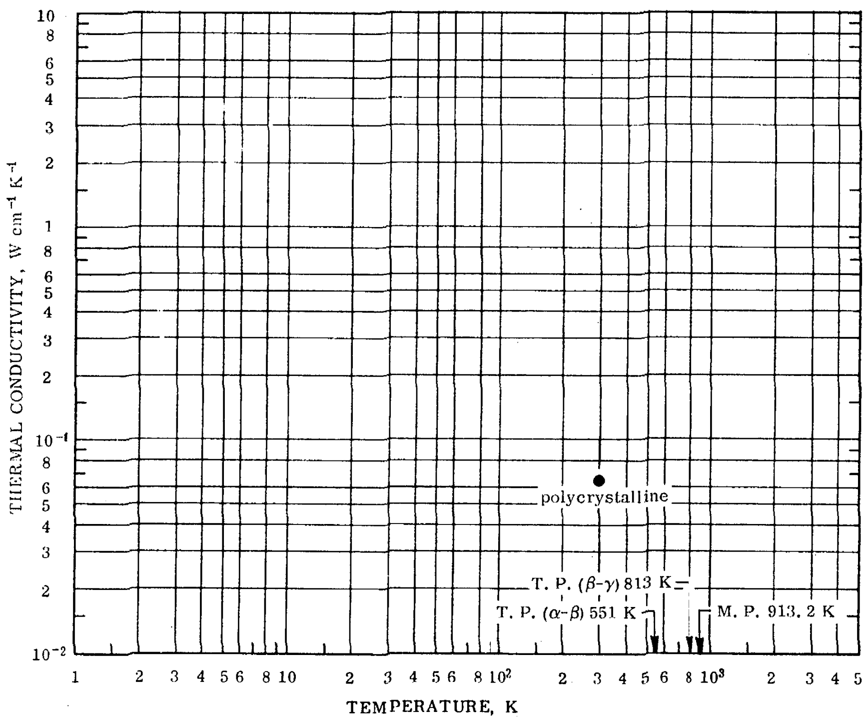
THERMAL CONDUCTIVITY OF NEON (continued)

RECOMMENDED VALUES
GAS
(At 1 atm)

T	k x 10^3	T	k x 10^3	T	k x 10^3	T	k x 10^3
27*	0.079*	350	0.544	650	0.815	950	1.054
30	0.086*	360	0.553	660	0.824	960	1.061
35	0.097*	370	0.563	670	0.833	970	1.069
40	0.107*	380	0.572	680	0.842	980	1.076
45	0.117*	390	0.581	690	0.851	990	1.084
50	0.128*	400	0.590	700	0.861	1000	1.091
60	0.148*	410	0.600	710	0.870	1050	1.129
70	0.168*	420	0.609	720	0.879	1100	1.166
80	0.186	430	0.618	730	0.888	1150	1.202
90	0.204	440	0.628	740	0.897	1200	1.238
100	0.222	450	0.637	750	0.906	1250	1.273
110	0.239	460	0.647	760	0.914	1300	1.307
120	0.256	470	0.656	770	0.922	1350	1.340
130	0.272	480	0.666	780	0.929	1400	1.372
140	0.288	490	0.675	790	0.937	1450	1.404
150	0.303	500	0.685	800	0.945	1500	1.435
160	0.318	510	0.693	810	0.952	1550	1.467*
170	0.333	520	0.702	820	0.960	1600	1.499*
180	0.347	530	0.710	830	0.967	1650	1.530*
190	0.361	540	0.719	840	0.975	1700	1.561*
200	0.375	550	0.727	850	0.982	1750	1.590*
210	0.388	560	0.736	860	0.989	1800	1.618*
220	0.401	570	0.744	870	0.996	1850	1.648*
230	0.414	580	0.753	880	1.003	1900	1.673*
240	0.426	590	0.762	890	1.010	1950	1.700*
250	0.438	600	0.771	900	1.017	2000	1.727*
260	0.449	610	0.780	910	1.024	2100	1.79*
270	0.461	620	0.789	920	1.032	2200	1.84*
280	0.472	630	0.797	930	1.039	2300	1.90*
290	0.483	640	0.806	940	1.047	2400	1.95*
300	0.493					2500	2.00*
310	0.504						
320	0.514						
330	0.524						
340	0.534						

* Estimated or extrapolated.

THERMAL CONDUCTIVITY OF NEPTUNIUM



PROVISIONAL VALUES

[Temperature, T, K; Thermal Conductivity, k, W cm^{-1} K^{-1}]

SOLID

Polycrystalline

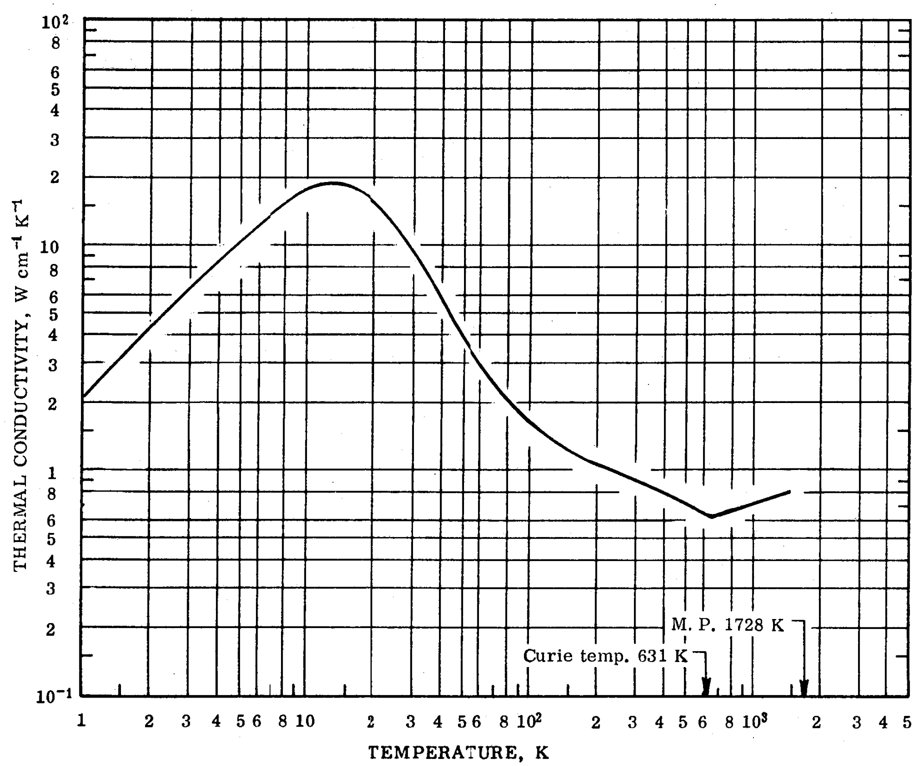
T	k
300	0.063*

REMARKS

The provisional value is for high-purity polycrystalline neptunium and is probably good to within ±20%.

*Estimated.

THERMAL CONDUCTIVITY OF NICKEL



REMARKS

The recommended values are for well-annealed high-purity nickel and are considered accurate to within ±10% of the true values. The thermal conductivity at temperatures near and below the corresponding temperature, T_m, of the conductivity maximum is highly sensitive to small physical and chemical variations among different specimens, and the recommended values below room temperature are applicably only to nickel having residual electrical resistivity $\rho_0 = 0.0112\ \mu\Omega$ cm. Values at temperatures below about 1.5 T_m are calculated to fit experimental data by using equation (7) and using the constants m, n, and α'' given by nickel in Table 1 and the parameter $\beta = 0.460$.

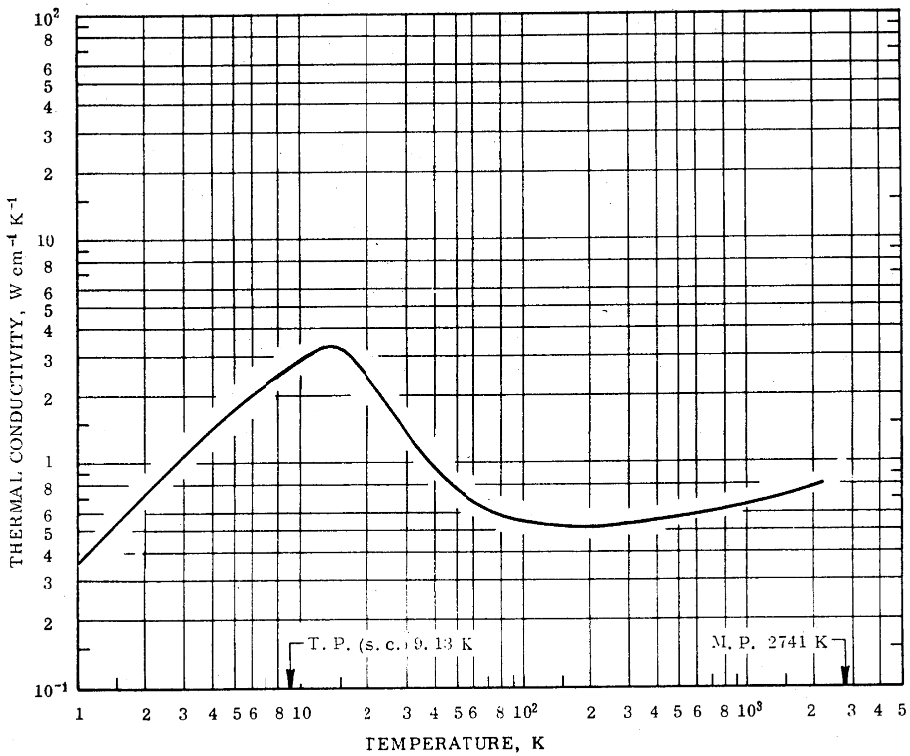
RECOMMENDED VALUES

[Temperature, T, K; Thermal Conductivity, k, W cm⁻¹ K⁻¹]

SOLID

T	k	T	k
0	0	250	0.975
1	2.17	273.2	0.941
2	4.34	298.2	0.909
3	6.49	300	0.907
4	8.59	323.2	0.880
5	10.6	350	0.850
6	12.5	373.2	0.827
7	14.2	400	0.802
8	15.8	473.2	0.741
9	17.1	500	0.722
10	18.1	573.2	0.673
11	18.9	600	0.656
12	19.4	630	0.639
13	19.7	673.2	0.648
14	19.7	700	0.654
15	19.5	773.2	0.670
16	19.1	800	0.676
18	18.1	873.2	0.693
20	16.5	900	0.697
25	12.6	973.2	0.712
30	9.56	1000	0.718
35	7.36	1073.2	0.734
40	5.82	1100	0.740
45	4.75	1173.2	0.756
50	4.00	1200	0.762
60	3.08	1273.2	0.777
70	2.50	1300	0.783
80	2.10	1373.2	0.798
90	1.83	1400	0.804
100	1.64	1473.2	0.820
123.2	1.37	1500	0.826
150	1.22		
173.2	1.13		
200	1.07		
223.2	1.02		

THERMAL CONDUCTIVITY OF NIOBIUM



REMARKS

The recommended values are for well-annealed high-purity niobium and are considered accurate to within ±5 to ±10% of the true values at moderate temperatures and ±15% at low and high temperatures. The thermal conductivity at temperatures near and below the corresponding temperature, T_m, of the conductivity maximum is highly sensitive to small physical and chemical variations among different specimens, and the recommended values below 150 K are applicable only to niobium having residual electrical resistivity $\rho_0 = 0.0679\ \mu\Omega$ cm. Values at temperatures below about 1.5 T_m are calculated to fit experimental data by using equation (7) and using the constants m, n, and α'' given for niobium in Table 1 and the parameter $\beta = 2.78$.

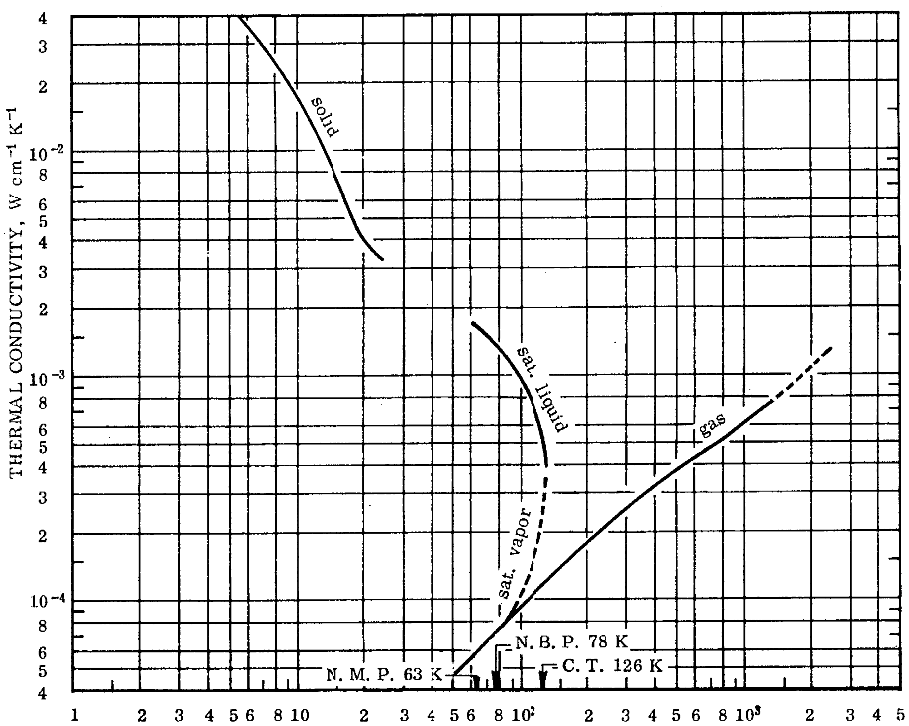
RECOMMENDED VALUES

[Temperature, T, K; Thermal Conductivity, k, W cm^{-1} K^{-1}]

SOLID

T	k	T	k
0	0	350	0.544
1	0.360	373.2	0.548
2	0.718	400	0.552
3	1.07	473.2	0.563
4	1.42	500	0.567
5	1.75	573.2	0.578
6	2.06	600	0.582
7	2.34	673.2	0.594
8	2.58	700	0.598
9	2.78	773.2	0.609
10	2.94	800	0.613
11	3.05	873.2	0.625
12	3.11	900	0.629
13	3.14	973.2	0.640
14	3.12	1000	0.644
15	3.08	1073.2	0.656
16	3.01	1100	0.659
18	2.81	1173.2	0.671
20	2.49	1200	0.675
25	1.82	1273.2	0.686
30	1.39	1300	0.690
35	1.12	1373.2	0.701
40	0.953	1400	0.705
45	0.838	1473.2	0.717
50	0.758	1500	0.721
60	0.661	1573.2	0.732
70	0.612	1600	0.736
80	0.584	1673.2	0.747
90	0.566	1700	0.751
100	0.552	1773.2	0.761
123.2	0.537	1800	0.765
150	0.530	1873.2	0.775
173.2	0.527	1900	0.778
200	0.526	1973.2	0.787
223.2	0.527	2000	0.791
250	0.530	2073.2	0.801
273.2	0.533	2173.2	0.812
298.2	0.537	2200	0.815
300	0.537		
323.2	0.540		

THERMAL CONDUCTIVITY OF NITROGEN



RECOMMENDED VALUES

[Temperature, T, K; Thermal Conductivity, k, W cm^{-1} K^{-1}]

SOLID T	SOLID $k \times 10^3$	SATURATED LIQUID T	SATURATED LIQUID $k \times 10^3$	SATURATED VAPOR T	SATURATED VAPOR $k \times 10^3$
4	56				
5	45			60	0.056*
6	37			65	0.061*
7	30	63	1.64	70	0.066*
8	25	65	1.60	75	0.071*
9	20	70	1.51	80	0.077*
10	17	75	1.413	85	0.084*
11	14	80	1.322	90	0.091*
12	12	85	1.231	95	0.100*
13	10	90	1.142	100	0.111*
14	9.2	95	1.053	105	0.123*
15	7.6	100	0.966	110	0.138*
16	6.5	105	0.880	115	0.160*
17	5.6	110	0.795	120	0.195*
18	4.9	115	0.710	125	0.265*
19	4.5	120	0.628	126	0.37*†
20	4.0	125	0.520*		
21	3.8	126	0.37*†		
22	3.6				
23	3.5				
24	3.3				
25	3.2				

REMARKS

The values recommended here for the solid must be regarded as tentative below 12 K as the experimental evidence was insufficient to determine if a maximum in conductivity occurred below or above 4 K. From 12 to 25 K an uncertainty of 10% appears probable. The liquid values should be accurate to a few percent below 120 K, the uncertainty then increasing to 5% at 125 K and higher near the critical point. For the vapor, a similar increase occurs from a few percent below 90 K to 10% at 100 K, etc. The gas values should be accurate to 2% below 350 K, 5% from 350 to 1200 K, and 10% at higher temperatures.

* Estimated or extrapolated.
† Pseudo-critical value.

THERMAL CONDUCTIVITY OF NITROGEN (continued)

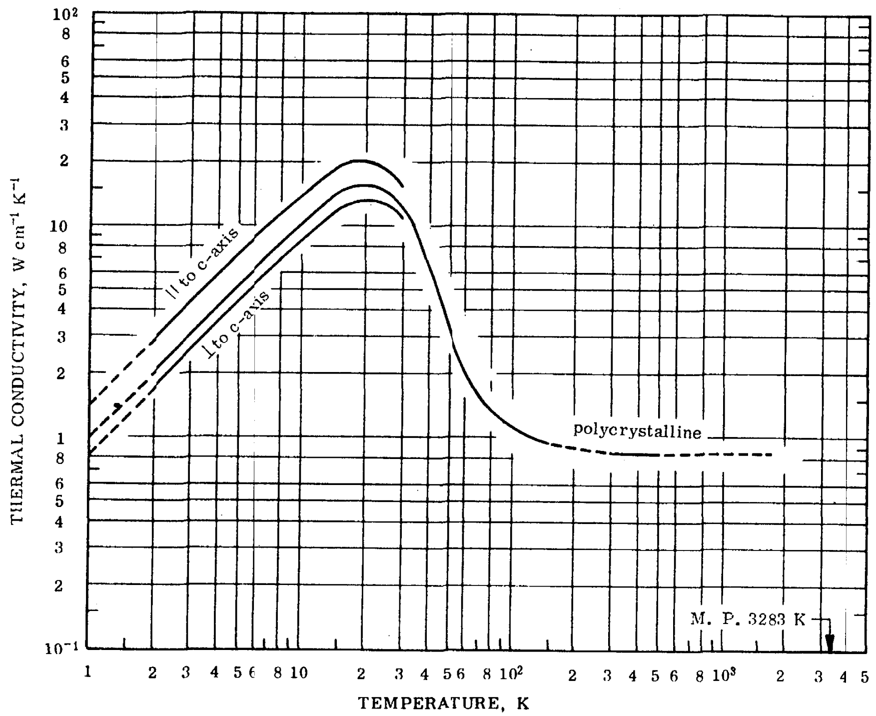
RECOMMENDED VALUES

GAS
(At 1 atm)

T	k x 10^3	T	k x 10^3	T	k x 10^3
		450	0.3564	850	0.564
		460	0.3626	860	0.569
78	0.0745	470	0.3688	870	0.574
80	0.0762	480	0.3749	880	0.578
90	0.0852	490	0.3808	890	0.583
100	0.0941	500	0.3864	900	0.587
110	0.1030	510	0.392	910	0.592
120	0.1119	520	0.398	920	0.596
130	0.1208	530	0.403	930	0.600
140	0.1296	540	0.408	940	0.605
150	0.1385	550	0.414	950	0.609
160	0.1474	560	0.420	960	0.613
170	0.1562	570	0.425	970	0.618
180	0.1651	580	0.431	980	0.622
190	0.1739	590	0.436	990	0.626
200	0.1826	600	0.441	1000	0.631
210	0.1908	610	0.446	1050	0.651
220	0.1989	620	0.452	1100	0.672
230	0.2067	630	0.457	1150	0.693
240	0.2145	640	0.462	1200	0.713
250	0.2222	650	0.467	1250	0.733
260	0.2298	660	0.472	1300	0.754
270	0.2374	670	0.478	1350	0.775
280	0.2449	680	0.483	1400	0.797
290	0.2524	690	0.488	1450	0.819
300	0.2598	700	0.493	1500	0.842
310	0.2671	710	0.498	1550	0.867*
320	0.2741	720	0.503	1600	0.893*
330	0.2808	730	0.508	1650	0.921*
340	0.2874	740	0.513	1700	0.950*
350	0.2939	750	0.517	1750	0.981*
360	0.3002	760	0.522	1800	1.013*
370	0.3065	770	0.526	1850	1.046*
380	0.3127	780	0.531	1900	1.080*
390	0.3189	790	0.536	1950	1.113*
400	0.3252	800	0.541	2000	1.146*
410	0.3314	810	0.546	2100	1.207*
420	0.3376	820	0.551	2200	1.263*
430	0.3438	830	0.555	2300	1.314*
440	0.3501	840	0.559	2400	1.361*
				2500	1.406*

* Estimated or extrapolated.

THERMAL CONDUCTIVITY OF OSMIUM



REMARKS

The recommended values are for well-annealed high-purity polycrystalline osmium and are considered accurate to within ± 10% of the true values at temperatures below 300 K, ± 5% from 300 to 500 K, and ± 10% above 500 K. The thermal conductivity at temperatures near and below the corresponding temperature, T_m, of the conductivity maximum is highly sensitive to small physical and chemical variations among different specimens, and the conductivity values below 150 K for $k_{\parallel}$, $k_{\perp}$, and k_{poly} are applicable only to osmium having residual electrical resistivities of 0.0167, 0.0278, and 0.0234 μΩ cm respectively. Values at temperatures below about 1.5 T_m are calculated to fit experimental data by using equation (7) and using the constants m, n, and α'' given in Table 1 and the parameter β = 0.682, 1.137, and 0.957, respectively, for $k_{\parallel}$, $k_{\perp}$, and k_{poly}.

RECOMMENDED VALUES

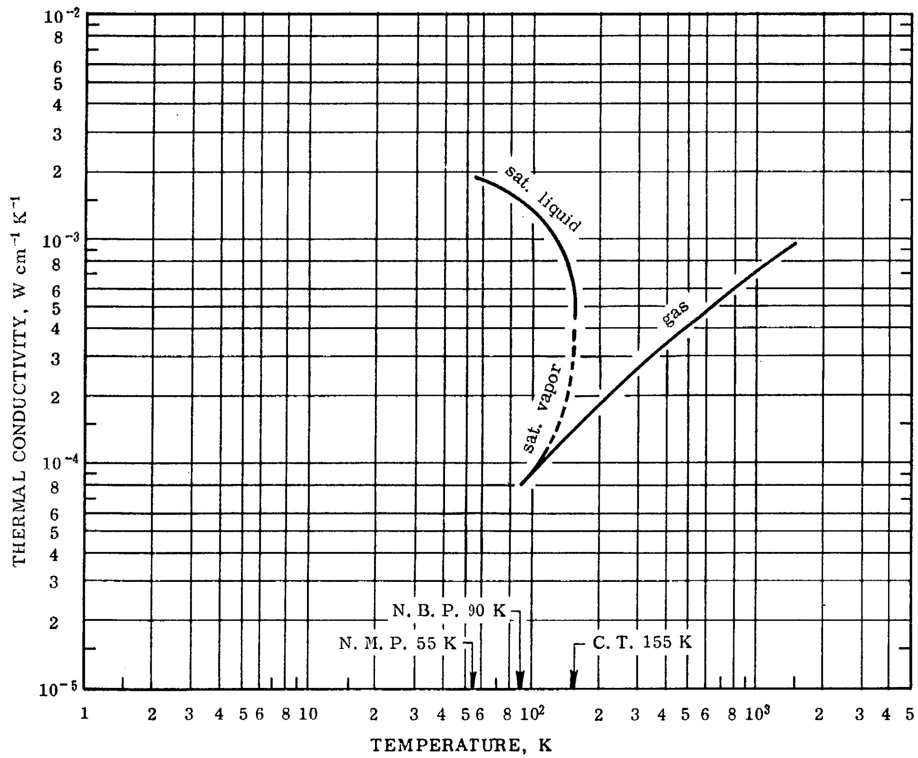
[Temperature, T, K; Thermal Conductivity, k, W cm^{-1} K^{-1}]

SOLID

T	// to c-axis k	⊥ to c-axis k	polycrystalline k	T	polycrystalline k
0	0	0	0	250	0.886*
1	1.47*	0.88*	1.05*	273.2	0.880*
2	2.93	1.76	2.09	298.2	0.876*
3	4.40	2.64	3.14	300	0.876*
4	5.86	3.52	4.18	323.2	0.874
5	7.32	4.39	5.22	350	0.870
6	8.77	5.27	6.26	373.2	0.870
7	10.2	6.13	7.28	400	0.869
8	11.6	6.99	8.29	473.2	0.869
9	13.0	7.83	9.29	500	0.869
10	14.3	8.65	10.2	573.2	0.869*
11	15.6	9.44	11.2	600	0.869*
12	16.8	10.2	12.1	673.2	0.869*
13	17.9	10.9	12.9	700	0.869*
14	18.9	11.6	13.7	773.2	0.869*
15	19.7	12.2	14.3	800	0.869*
16	20.4	12.7	14.9	873.2	0.869*
18	21.3	13.4	15.7	900	0.869*
20	21.5	13.8	16.0	973.2	0.869*
25	19.4	13.2	15.0	1000	0.869*
30	15.4	11.1	12.4	1073.2	0.869*
35			9.17	1100	0.869*
40			6.38	1173.2	0.869*
45			4.58	1200	0.869*
50			3.42	1273.2	0.869*
60			2.18	1300	0.869*
70			1.65	1373.2	0.869*
80			1.39	1400	0.869*
90			1.24	1473.2	0.869*
100			1.14	1500	0.869*
123.2			1.02	1573.2	0.869*
150			0.962*	1600	0.869*
173.2			0.932*	1673.2	0.869*
200			0.908*		
223.2			0.896*		

* Extrapolated or interpolated.

THERMAL CONDUCTIVITY OF OXYGEN



REMARKS

The liquid values recommended here should be accurate to within 2% below 150 K and within 15% at the critical point. The vapor uncertainties are assessed as being a few percent below 100 K, increasing to about 10% at 125 K, etc. The gas values are considered to be well within a few percent below 600 K, 4% from 600 to 900 K, and probably within 6% at the higher temperatures.

RECOMMENDED VALUES

[Temperature, T, K; Thermal Conductivity, k, W cm^{-1} K^{-1}]

SATURATED LIQUID		SATURATED VAPOR	
T	k x 10^3	T	k x 10^3
55	1.90		
60	1.85		
65	1.80	90	0.081*
70	1.74	95	0.087*
75	1.682	100	0.093*
80	1.623	105	0.100*
85	1.563	110	0.108*
90	1.501	115	0.116*
95	1.437	120	0.124*
100	1.372	125	0.135*
105	1.306	130	0.15*
110	1.237	135	0.16*
115	1.168	140	0.18*
120	1.096	145	0.21*
125	1.023	150	0.25*
130	0.949	155	0.41*†
135	0.873		
140	0.796		
145	0.712		
150	0.610		
155	0.41*†		

* Estimated or extrapolated.
† Pseudo-critical value.

THERMAL CONDUCTIVITY OF OXYGEN (continued)

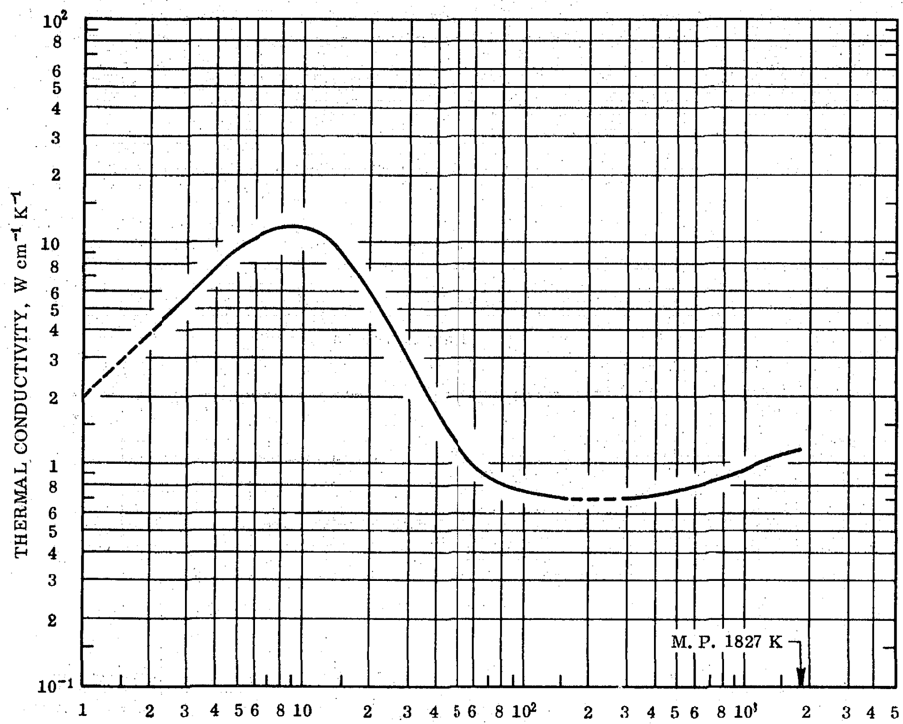
RECOMMENDED VALUES

GAS

(At 1 atm)

T	k x 10^3	T	k x 10^3	T	k x 10^3	T	k x 10^3
90	0.0813						
100	0.0905	450	0.377	800	0.603	1150	0.796
110	0.0998	460	0.384	810	0.609	1160	0.801
120	0.1092	470	0.391	820	0.615	1170	0.806
130	0.1187	480	0.398	830	0.620	1180	0.811
140	0.1281	490	0.405	840	0.626	1190	0.816
150	0.1376	500	0.412	850	0.632	1200	0.821
160	0.1466	510	0.419	860	0.638	1210	0.826
170	0.1556	520	0.426	870	0.644	1220	0.831
180	0.1646	530	0.433	880	0.650	1230	0.836
190	0.1735	540	0.440	890	0.655	1240	0.841
200	0.1824	550	0.447	900	0.661	1250	0.846
210	0.1911	560	0.453	910	0.667	1260	0.851
220	0.1997	570	0.460	920	0.672	1270	0.856
230	0.2083	580	0.467	930	0.678	1280	0.861
240	0.2168	590	0.474	940	0.684	1290	0.866
250	0.2254	600	0.480	950	0.689	1300	0.871
260	0.2339	610	0.487	960	0.695	1310	0.876
270	0.2424	620	0.493	970	0.701	1320	0.881
280	0.2509	630	0.500	980	0.706	1330	0.886
290	0.2592	640	0.506	990	0.712	1340	0.891
300	0.2674	650	0.513	1000	0.717	1350	0.896
310	0.2753	660	0.519	1010	0.723	1360	0.901
320	0.2831	670	0.525	1020	0.728	1370	0.906
330	0.2907	680	0.532	1030	0.734	1380	0.911
340	0.2982	690	0.538	1040	0.739	1390	0.916
350	0.3056	700	0.544	1050	0.745	1400	0.921
360	0.3130	710	0.550	1060	0.750	1410	0.926
370	0.3204	720	0.556	1070	0.755	1420	0.931
380	0.3276	730	0.562	1080	0.760	1430	0.936
390	0.3348	740	0.568	1090	0.765	1440	0.941
400	0.342	750	0.574	1100	0.771	1450	0.946
410	0.349	760	0.579	1110	0.776	1460	0.951
420	0.356	770	0.585	1120	0.781	1470	0.956
430	0.363	780	0.591	1130	0.786	1480	0.960
440	0.370	790	0.597	1140	0.791	1490	0.965
						1500	0.970

THERMAL CONDUCTIVITY OF PALLADIUM



REMARKS

The recommended values are for well-annealed high-purity palladium and are considered accurate to within ±5% of the true values at temperatures from room temperature to about 1000 K and ±10% below room temperature and above 1000 K. The thermal conductivity at temperatures near and below the corresponding temperature, T_m, of the conductivity maximum is highly sensitive to small physical and chemical variations among different specimens, and the recommended values below 150 K are applicable only to palladium having residual electrical resistivity $\rho_0 = 0.0123\ \mu\Omega$ cm. Values at temperatures below about 1.5 T_m are calculated to fit experimental data by using equation (7) and using the constants m, n, and α'' given for palladium in Table 1 and the parameter $\beta = 0.502$.

RECOMMENDED VALUES

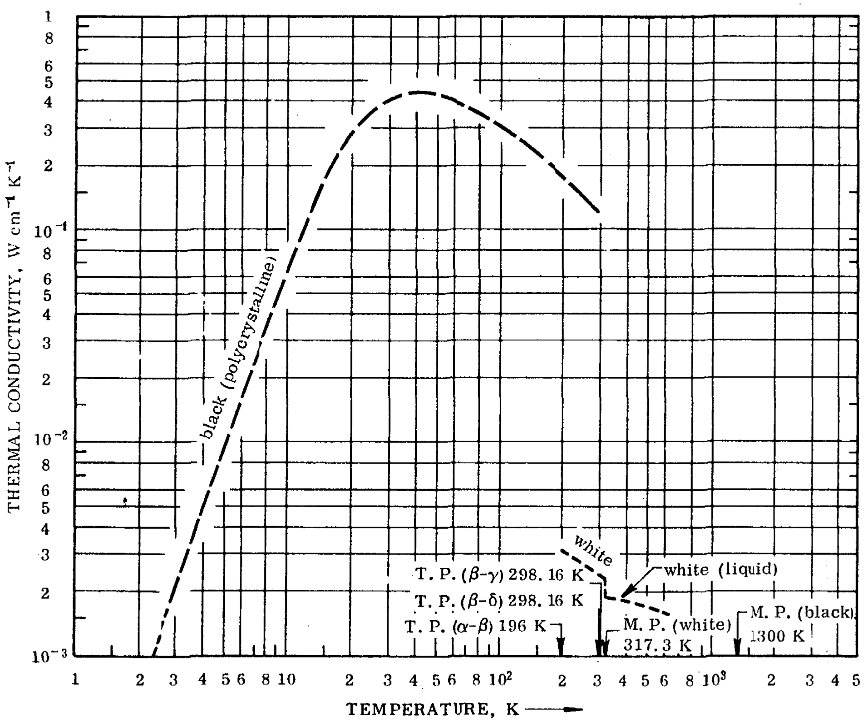
[Temperature, T, K; Thermal Conductivity, k, W cm^{-1} K^{-1}]

SOLID

T	k	T	k
0	0	250	0.715*
1	1.99*	273.2	0.716*
2	3.96*	298.2	0.718
3	5.86	300	0.718
4	7.61	323.2	0.721
5	9.13	350	0.726
6	10.3	373.2	0.730
7	11.1	400	0.736
8	11.6	473.2	0.755
9	11.7	500	0.763
10	11.5	573.2	0.787
11	11.2	600	0.797
12	10.7	673.2	0.823
13	10.1	700	0.833
14	9.49	773.2	0.860
15	8.88	800	0.869
16	8.28	873.2	0.896
18	7.08	900	0.906
20	5.98	973.2	0.932
25	4.04	1000	0.942
30	2.85	1073.2	0.971
35	2.15	1100	0.981
40	1.73	1173.2	1.01
45	1.44	1200	1.02
50	1.24	1273.2	1.04
60	0.983	1300	1.05
70	0.868	1373.2	1.07
80	0.811	1400	1.07
90	0.783	1473.2	1.09
100	0.765	1500	1.10
123.2	0.742	1573.2	1.11
150	0.727	1600	1.12
173.2	0.720*	1673.2	1.13
200	0.716*	1700	1.14
223.2	0.715*	1773.2	1.15*
		1800	1.15*

*Extrapolated or interpolated.

THERMAL CONDUCTIVITY OF PHOSPHORUS



REMARKS

The values for white phosphorus are recommended values for high-purity white phosphorus and are considered accurate to within ± 10% of the true values at temperatures around the melting point. The values for polycrystalline black phosphorus are merely typical values and represent a typical curve serving to indicate the general trend of the thermal conductivity of black phosphorus at moderate and low temperatures.

RECOMMENDED VALUES †

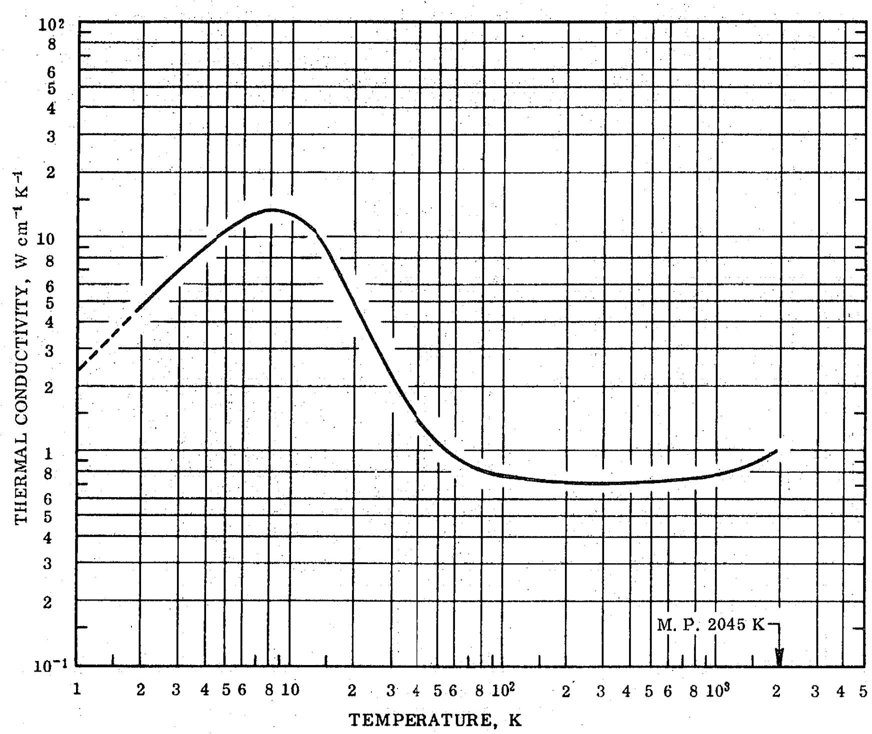
[Temperature, T, K; Thermal Conductivity, k, W cm^{-1} K^{-1}]

SOLID				LIQUID	
Black, polycrystalline		White		White	
T	k	T	k	T	k
0	0	200	0. 00308*	317. 3	0. 00187
1	0. 0000796*	223. 2	0. 00287*	323. 2	0. 00187
2	0. 000645*	250	0. 00265*	350	0. 00183*
3	0. 00220	273. 2	0. 00250*	373. 2	0. 00181*
4	0. 00511	298. 2	0. 00236*	400	0. 00178*
5	0. 00998	300	0. 00235	473. 2	0. 00170*
6	0. 0167	317. 3	0. 00226*	500	0. 00167*
7	0. 0255			573. 2	0. 00160*
8	0. 0367			600	0. 00157*
9	0. 0497				
10	0. 0653				
11	0. 0822				
12	0. 101				
13	0. 122				
14	0. 144				
15	0. 165				
16	0. 187				
18	0. 230				
20	0. 272				
25	0. 357				
30	0. 401				
35	0. 425				
40	0. 435				
45	0. 434				
50	0. 427				
60	0. 402				
70	0. 377				
80	0. 352				
90	0. 328				
100	0. 307				
123. 2	0. 266				
150	0. 227				
173. 2	0. 201				
200	0. 177				
223. 2	0. 160				
250	0. 144				
273. 2	0. 132				
298. 2	0. 121				
300	0. 121				

* Extrapolated.

† Values for polycrystalline black phosphorus are merely typical values and those for white phosphorus below 273 K and above 400 K are provisional.

THERMAL CONDUCTIVITY OF PLATINUM



REMARKS

The recommended values are for well-annealed high-purity platinum and are considered accurate to within ±3% of the true values near room temperature, ±6% at about 100 K and 1200 K, and ±10% below 100 K and at 2000 K. The thermal conductivity at temperatures near and below the corresponding temperature, T_m, of the conductivity maximum is highly sensitive to small physical and chemical variations among different specimens, and the recommended values below 200 K are applicable only to platinum having residual electrical resistivity $\rho_0 = 0.0106\ \mu\Omega$ cm. Values at temperatures below about 1.5 T_m are calculated to fit experimental data by using equation (7) and using n = 2.10, $\alpha' = 0.000301$, and the parameter $\beta = 0.433$.

RECOMMENDED VALUES

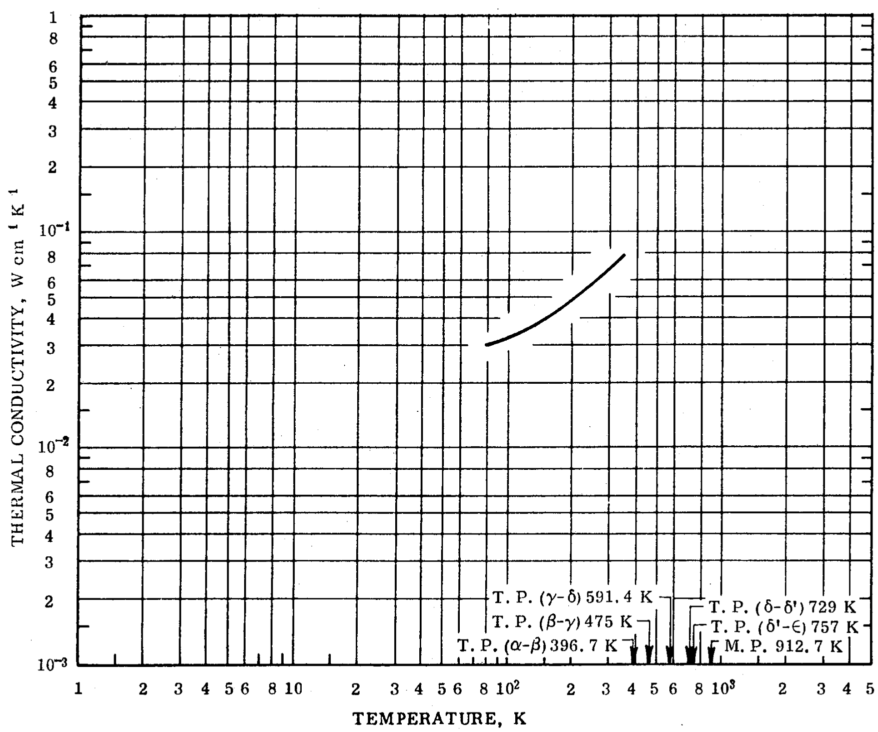
[Temperature, T, K; Thermal Conductivity, k, W cm^{-1} K^{-1}]

SOLID

T	k	T	k
0	0	350	0.717
1	2.31	373.2	0.717
2	4.60	400	0.718
3	6.79	473.2	0.722
4	8.8	500	0.723
5	10.5	573.2	0.729
6	11.8	600	0.732
7	12.6	673.2	0.740
8	12.9	700	0.743
9	12.8	773.2	0.752
10	12.3	800	0.756
11	11.7	873.2	0.767
12	10.9	900	0.771
13	10.1	973.2	0.783
14	9.30	1000	0.787
15	8.41	1073.2	0.800
16	7.59	1100	0.806
18	6.12	1173.2	0.820
20	4.95	1200	0.826
25	3.13	1273.2	0.842
30	2.15	1300	0.848
35	1.68	1373.2	0.863
40	1.39	1400	0.871
45	1.22	1473.2	0.889
50	1.09	1500	0.895
60	0.947	1573.2	0.913
70	0.862	1600	0.919
80	0.815	1673.2	0.936
90	0.789	1700	0.942
100	0.775	1773.2	0.957
123.2	0.755	1800	0.961
150	0.740	1873.2	0.974
173.2	0.732	1900	0.978
200	0.726	1973.2	0.990
223.2	0.721	2000	0.994*
250	0.718	2045	1.004*
273.2	0.717		
298.2	0.716		
300	0.716		
323.2	0.716		

*Extrapolated.

THERMAL CONDUCTIVITY OF PLUTONIUM



PROVISIONAL VALUES

[Temperature, T, K; Thermal Conductivity, k, W cm^{-1} K^{-1}]

SOLID

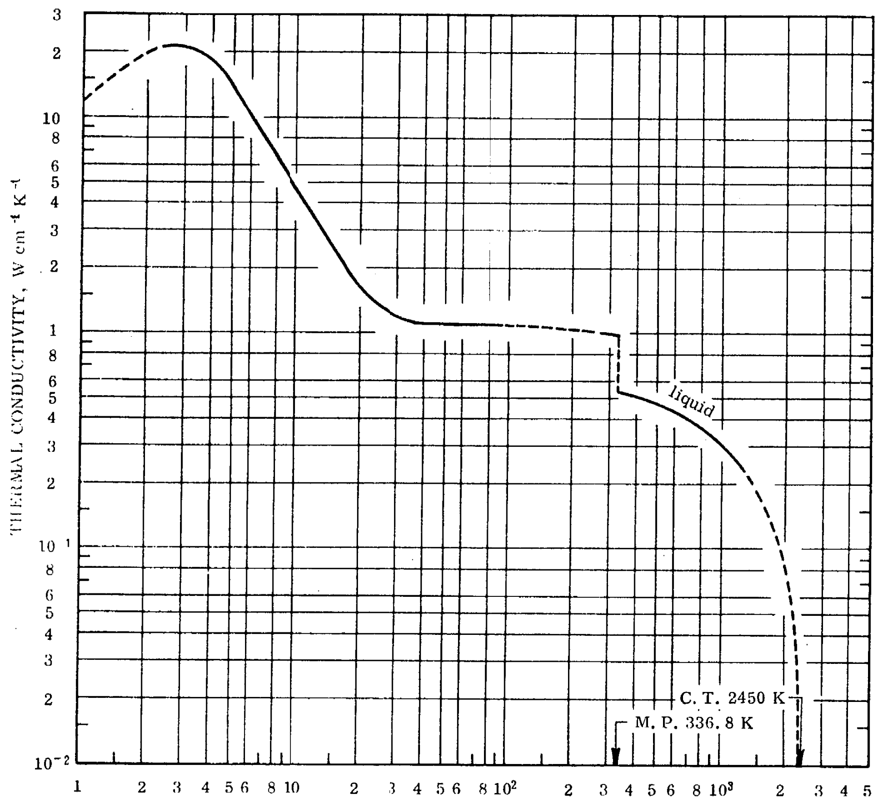
Polycrystalline

T	k
80	0.0306
90	0.0318
100	0.0332
123.2	0.0361
150	0.0399
173.2	0.0432
200	0.0476
223.2	0.0516
250	0.0568
273.2	0.0616
298.2	0.0670
300	0.0674
323.2	0.0726
350	0.0790

REMARKS

The provisional values are for well-annealed high-purity polycrystalline plutonium. The uncertainty of the values is of the order of ±25%.

THERMAL CONDUCTIVITY OF POTASSIUM



REMARKS

The recommended values are for high-purity potassium and are considered accurate to within ±10% of the true values for the solid state, ±5% for the liquid state below 1000 K, and ±10% from 1000 to 1500 K. The uncertainty increases at higher temperatures. The thermal conductivity at temperatures near and below the corresponding temperature, T_m, of the conductivity maximum is highly sensitive to small physical and chemical variations among different specimens, and the recommended values below 50 K are applicable only to potassium having residual electrical resistivity $\rho_0 = 0.00220\ \mu\Omega$ cm. Values at temperatures below about 1.5 T_m are calculated to fit experimental data by using equation (7) and using the constants m, n, and α'' given for potassium in Table 1 and the parameter $\beta = 0.0820$.

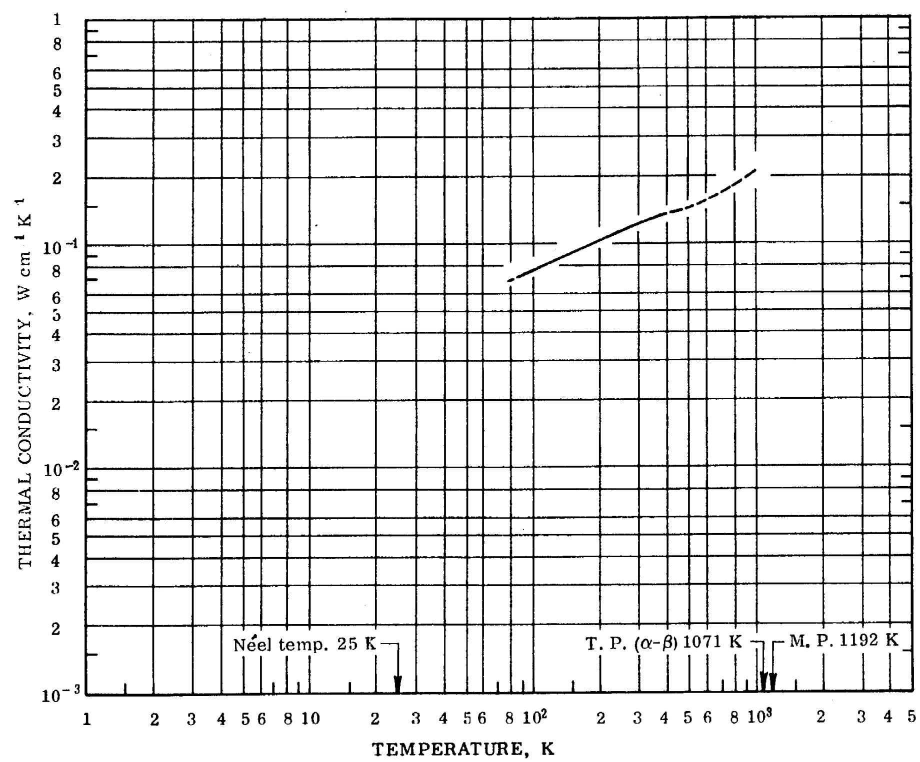
RECOMMENDED VALUES †

[Temperature, T, K; Thermal Conductivity, k, W cm^{-1} K^{-1}]

SOLID				LIQUID			
T	k	T	k	T	k	T	k
0	0	60	1.10	336.8	0.548	1500	0.192*
1	11.9*	70	1.09	350	0.542	1573.2	0.176*
2	20.4*	80	1.08	373.2	0.532	1600	0.170*
3	22.1	90	1.075	400	0.520	1673.2	0.155*
4	19.1	100	1.070*	473.2	0.490	1700	0.149*
5	14.4	123.2	1.058*	500	0.479	1773.2	0.134*
6	10.8	150	1.050*	573.2	0.449	1800	0.128*
7	8.33	173.2	1.046*	600	0.439	1873.2	0.113*
8	6.62	200	1.043*	673.2	0.413	1900	0.108*
9	5.42	223.2	1.042*	700	0.404	1973.2	0.0932*
10	4.58	250	1.040*	773.2	0.380	2000	0.0880*
11	3.97	273.2	1.036*	800	0.371	2073.2	0.0737*
12	3.47	298.2	1.025	873.2	0.348	2100	0.0680*
13	3.06	300	1.024	900	0.340	2173.2	0.0541
14	2.74	323.2	1.003	973.2	0.320	2200	0.0490*
15	2.48	336.8	0.985	1000	0.313	2273.2	0.0346*
16	2.26			1073.2	0.294	2300	0.0290*
18	1.91			1100	0.287	2373.2	0.0151*
20	1.67			1173.2	0.269	2400	0.0100*
25	1.33			1200	0.263	2423.2	0.0053*
30	1.23			1273.2	0.245	C.T.= 2450	0.0008*
35	1.18			1300	0.239		
40	1.15			1373.2	0.222		
45	1.13			1400	0.215		
50	1.12			1473.2	0.199		

* Extrapolated, interpolated, or estimated.
† Values above 1500 K are provisional.

THERMAL CONDUCTIVITY OF PRASEODYMIUM



RECOMMENDED VALUES

[Temperature, T, K; Thermal Conductivity, k, W cm^{-1} K^{-1}]

SOLID

Polycrystalline

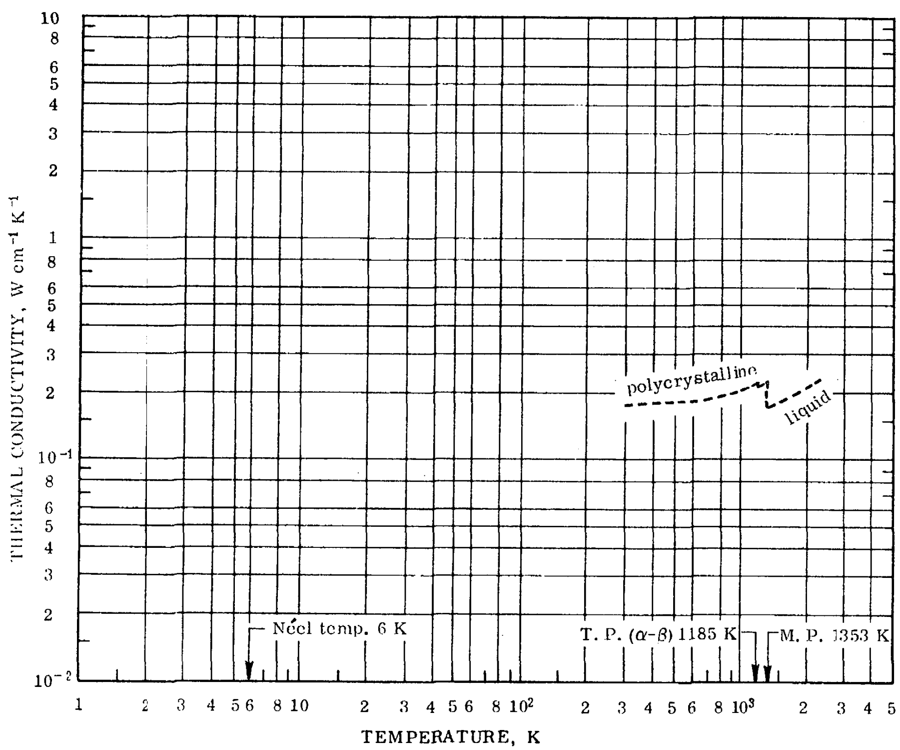
T	k
80	0.0692*
90	0.0732
100	0.0769
123.2	0.0844
150	0.0926
173.2	0.0987
200	0.105
223.2	0.110
250	0.116
273.2	0.120
298.2	0.125
300	0.125
323.2	0.128
350	0.131
373.2	0.134
400	0.136*
473.2	0.144*
500	0.147*
573.2	0.154*
600	0.157*
673.2	0.166*
700	0.169*
773.2	0.180*
800	0.184*
873.2	0.195*
900	0.200*
973.2	0.212*
1000	0.216*

REMARKS

The recommended values are for well-annealed high-purity polycrystalline praseodymium and are thought to be accurate to within ±5% of the true values near room temperature and ±10 to ±15% at other temperatures.

*Extrapolated.

THERMAL CONDUCTIVITY OF PROMETHIUM



PROVISIONAL VALUES

[Temperature, T, K; Thermal Conductivity, k, W cm^{-1} K^{-1}]

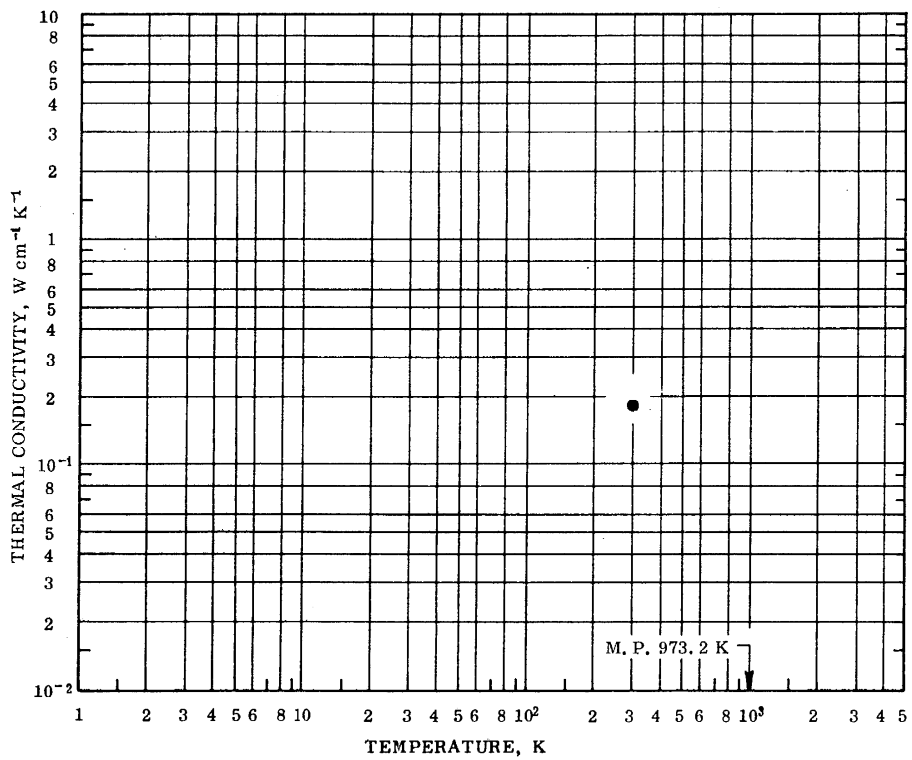
SOLID Polycrystalline T	k	LIQUID T	k
300	0.179*	1353	0.175*
323.2	0.181*	1373.2	0.177*
350	0.182*	1400	0.178*
373.2	0.184*	1473.2	0.182*
400	0.184*	1500	0.184*
473.2	0.185*	1573.2	0.188*
500	0.185*	1600	0.190*
573.2	0.186*	1673.2	0.194*
600	0.187*	1700	0.196*
673.2	0.190*	1773.2	0.200*
700	0.191*	1800	0.202*
773.2	0.194*	1873.2	0.206*
800	0.195*	1900	0.208*
873.2	0.198*	1973.2	0.212*
900	0.201*	2000	0.214*
973.2	0.205*	2073.2	0.212*
1000	0.207*	2173.2	0.225*
1073.2	0.213*	2200	0.226*
1100	0.215*	2253	0.229*
1173.2	0.221*		
1135	0.222*		
1135	0.213*		
1200	0.214*		
1273.2	0.220*		
1300	0.223*		
1353	0.230*		

REMARKS

The provisional values are for high-purity promethium and those for solid promethium are for polycrystalline samples. They are probably accurate to within ±25% for solid and ±40% for molten promethium.

*Estimated.

THERMAL CONDUCTIVITY OF RADIUM



PROVISIONAL VALUES

[Temperature, T, K; Thermal Conductivity, k, W cm^{-1} K^{-1}]

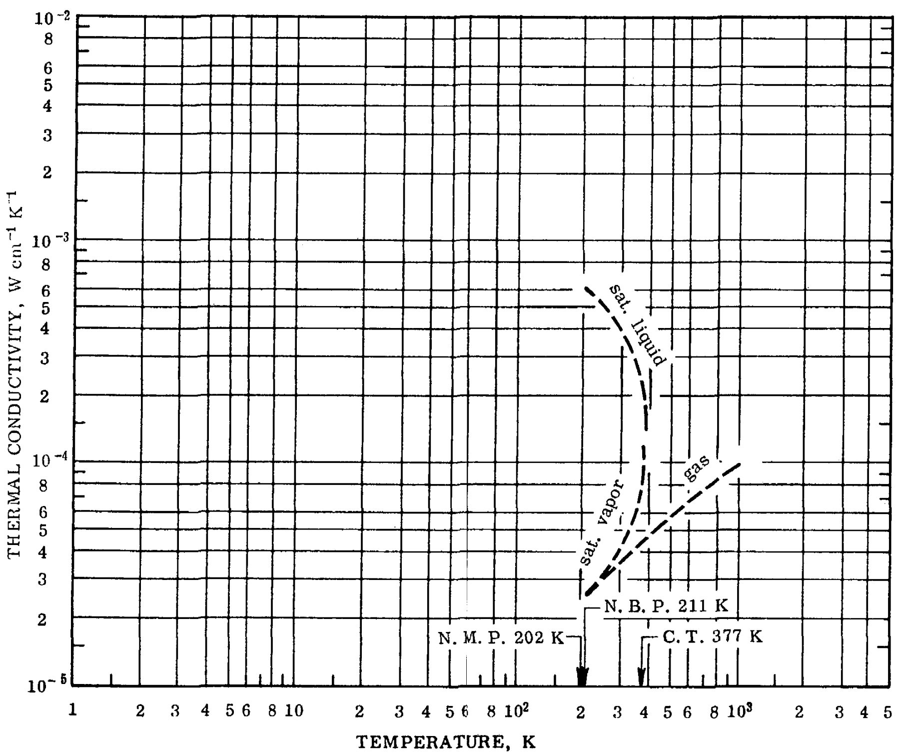
SOLID

T	k
293.2	0.186

REMARKS

This thermal conductivity value is provisional and its uncertainty may be as much as ±50%.

THERMAL CONDUCTIVITY OF RADON



REMARKS

Values for the liquid and vapor were based on a generalized correlation together with estimated critical parameters and are thus considered tentative. The gas values, while likewise lacking experimental corroboration, could possibly be accurate to within 5% below 500 K and 10% at higher temperatures.

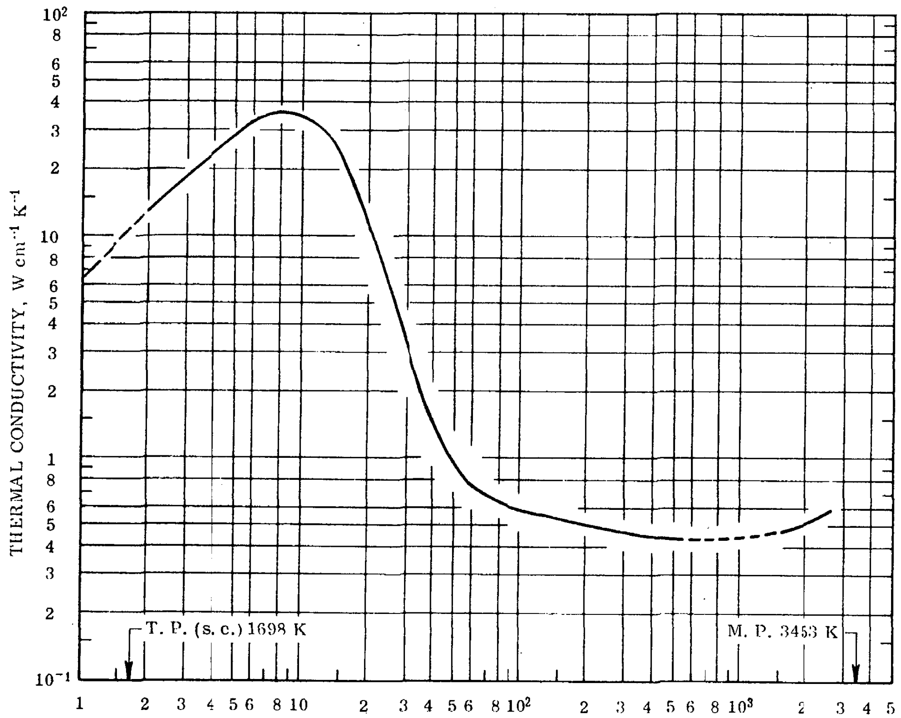
PROVISIONAL VALUES

[Temperature, T, K; Thermal Conductivity, k, W cm^{-1} K^{-1}]

SATURATED LIQUID		SATURATED VAPOR		GAS (At 1 atm)	
T	k x 10^3	T	k x 10^3	T	k x 10^3
				211	0.0256 *
				220	0.0266 *
				230	0.0279 *
				240	0.0291 *
202	0.604 *			250	0.0303 *
210	0.586 *	211	0.026 *	260	0.0315 *
220	0.562 *	220	0.028 *	270	0.0327 *
230	0.540 *	230	0.030 *	280	0.0339 *
240	0.518 *	240	0.032 *	290	0.0351 *
250	0.498 *	250	0.034 *	300	0.0364 *
260	0.477 *	260	0.035 *	310	0.0376 *
270	0.456 *	270	0.038 *	320	0.0387 *
280	0.437 *	280	0.040 *	330	0.0398 *
290	0.417 *	290	0.042 *	340	0.0410 *
300	0.396 *	300	0.045 *	350	0.0422 *
310	0.375 *	310	0.047 *	360	0.0433 *
320	0.353 *	320	0.051 *	370	0.0445 *
330	0.330 *	330	0.055 *	380	0.0457 *
340	0.305 *	340	0.060 *	390	0.0468 *
350	0.278 *	350	0.065 *	400	0.0480 *
360	0.249 *	360	0.073 *	410	0.0490 *
370	0.213 *	370	0.089 *	420	0.0501 *
377	0.138 * †	377	0.138 * †	430	0.0512 *
				440	0.0523 *
				450	0.0534 *
				460	0.0544 *
				470	0.0555 *
				480	0.0566 *
				490	0.0576 *
				500	0.0586 *
				550	0.0643 *
				600	0.0690 *
				650	0.0740 *
				700	0.0789 *
				750	0.0832 *
				800	0.0874 *
				850	0.0915 *
				900	0.0964 *
				950	0.0997 *
				1000	0.1042 *

* Estimated or extrapolated.
† Pseudo-critical value.

THERMAL CONDUCTIVITY OF RHENIUM



REMARKS

The recommended values are for well-annealed high-purity polycrystalline rhenium and are considered accurate to within ±10% of the true values at temperatures below 100 K, ±5% from 100 to 500 K, and ±15% above 500 K. The thermal conductivity at temperatures near and below the corresponding temperature, T_m, of the conductivity maximum is highly sensitive to small physical and chemical variations among different specimens, and the recommended values below 100 K are applicable only to rhenium having residual electrical resistivity ρ_0 = 0.00366 $\mu\Omega$ cm. Values at temperatures below about 1.5 T_m are calculated to fit experimental data by using equation (10) and using the values n = 2.2, α = 0.0000648, β = 0.150, and γ = 0.000282. However, for specimens of lower purity (higher ρ_0), equation (7) and the constants given in Table 1 should be used.

RECOMMENDED VALUES

[Temperature, T, K; Thermal Conductivity, k, W cm^{-1} K^{-1}]

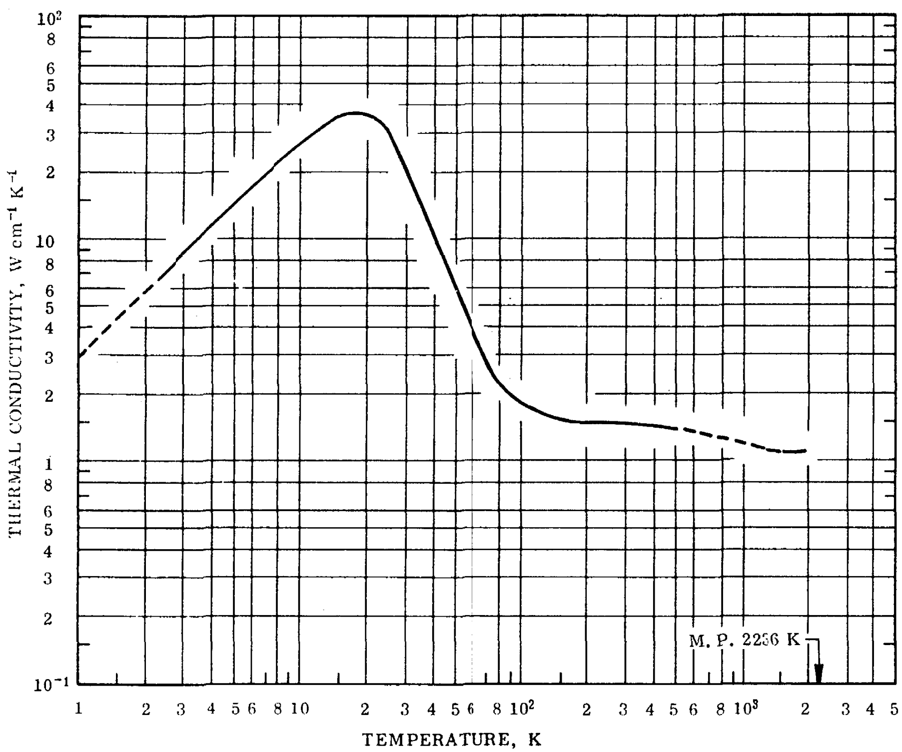
SOLID

Polycrystalline

T	k	T	k
0	0	350	0.470
1	6.65*	373.2	0.466
2	13.2*	400	0.461
3	19.4	473.2	0.451
4	25.0	500	0.449
5	29.7	573.2	0.444*
6	33.3	600	0.442*
7	35.6	673.2	0.441*
8	36.6	700	0.440*
9	36.6	773.2	0.440*
10	35.6	800	0.441*
11	34.0	873.2	0.442*
12	31.7	900	0.443*
13	28.9	973.2	0.445*
14	26.0	1000	0.446*
15	23.1	1073.2	0.450*
16	20.3	1100	0.451*
18	15.4	1173.2	0.455*
20	11.6	1200	0.457*
25	6.02	1273.2	0.462*
30	3.39	1300	0.464*
35	2.19	1373.2	0.469*
40	1.56	1400	0.471*
45	1.21	1473.2	0.476*
50	0.986	1500	0.478*
60	0.774	1573.2	0.483
70	0.678	1600	0.485
80	0.629	1673.2	0.490
90	0.606	1700	0.492
100	0.589	1773.2	0.498
123.2	0.561	1800	0.500
150	0.538	1873.2	0.507
173.2	0.524	1900	0.509
200	0.510	1973.2	0.516
223.2	0.501	2000	0.519
250	0.492	2073.2	0.526
273.2	0.486	2173.2	0.536
298.2	0.480	2200	0.539
300	0.479	2273.2	0.547
323.2	0.475	2400	0.563
		2473.2	0.573
		2600	0.592

*Extrapolated or interpolated.

THERMAL CONDUCTIVITY OF RHODIUM



RECOMMENDED VALUES

[Temperature, T, K; Thermal Conductivity, k, W cm^{-1} K^{-1}]

SOLID

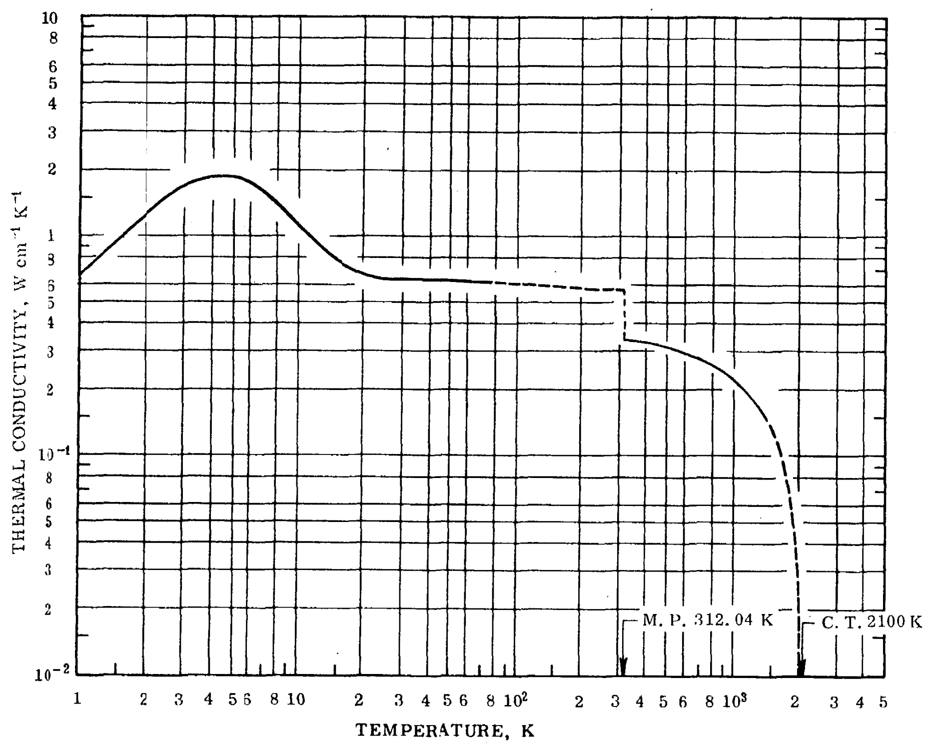
T	k	T	k
0	0	250	1.52
1	2.91*	273.2	1.51
2	5.81	298.2	1.50
3	8.69	300	1.50
4	11.6	323.2	1.49
5	14.5	350	1.48
6	17.3	373.2	1.47
7	20.1	400	1.46
8	22.8	473.2	1.42
9	25.4	500	1.41
10	27.8	573.2	1.37
11	29.9	600	1.36*
12	32.1	673.2	1.32*
13	33.8	700	1.31*
14	35.3	773.2	1.28*
15	36.3	800	1.27*
16	37.0	873.2	1.25*
18	37.3	900	1.24*
20	36.4	973.2	1.21*
25	30.5	1000	1.21*
30	21.6	1073.2	1.19*
35	14.5	1100	1.18*
40	10.2	1173.2	1.17*
45	7.47	1200	1.16*
50	5.70	1273.2	1.15*
60	3.78	1300	1.14*
70	2.89	1373.2	1.13*
80	2.38	1400	1.12*
90	2.06	1473.2	1.11*
100	1.86	1500	1.10
123.2	1.63	1573.2	1.10
150	1.58	1600	1.10
173.2	1.56	1673.2	1.10
200	1.54	1700	1.10
223.2	1.53	1773.2	1.10
		1800	1.10
		1873.2	1.11
		1900	1.11
		1973.2	1.12
		2000	1.12

* Extrapolated or interpolated.

REMARKS

The recommended values are for well-annealed high-purity rhodium and are considered accurate to within ±5% of the true values at moderate temperatures and ±10% at low and high temperatures. The thermal conductivity at temperatures near and below the corresponding temperature, T_m, of the conductivity maximum is highly sensitive to small physical and chemical variations among different specimens, and the recommended values below 150 K are applicable only to rhodium having residual electrical resistivity $\rho_0 = 0.00840$ μΩ cm. Values at temperatures below about 1.5 T_m are calculated to fit experimental data by using equation (7) and using the constants m, n, and α' given for rhodium in Table 1 and the parameter $\beta = 0.344$.

THERMAL CONDUCTIVITY OF RUBIDIUM



RECOMMENDED VALUES †

[Temperature, T, K; Thermal Conductivity, k, W cm^{-1} K^{-1}]

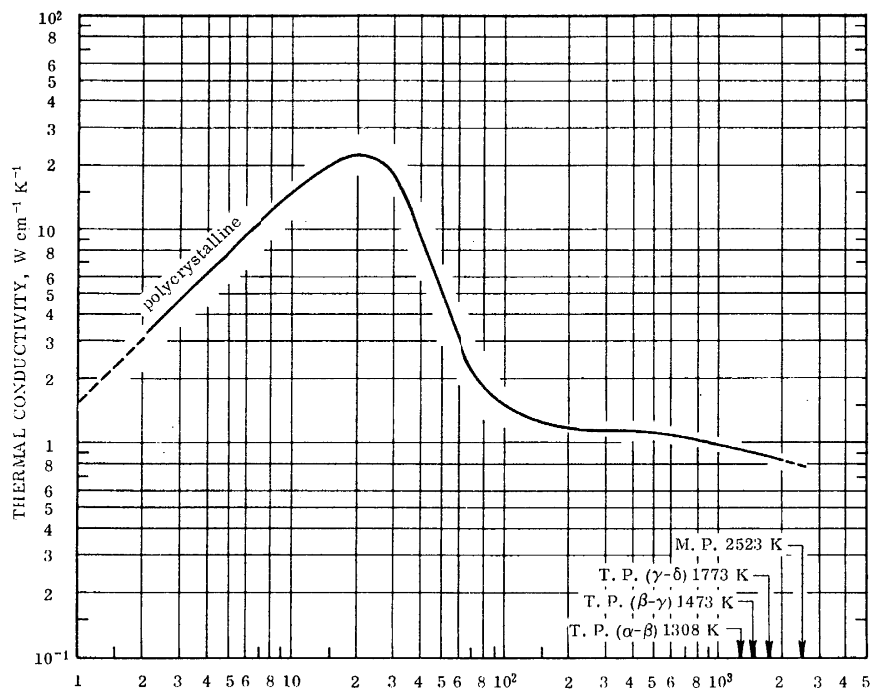
SOLID T	SOLID k	LIQUID T	LIQUID k
0	0	312.04	0.333
1	0.663*	323.2	0.331
2	1.27	350	0.325
3	1.71	373.2	0.321
4	1.91	400	0.318
5	1.88	473.2	0.306
6	1.73	500	0.302
7	1.56	573.2	0.289
8	1.38	600	0.285
9	1.22	673.2	0.273
10	1.09	700	0.268
11	0.991	773.2	0.256
12	0.919	800	0.251
13	0.859	873.2	0.239
14	0.810	900	0.234
15	0.772	973.2	0.222
16	0.746	1000	0.218
18	0.710	1073.2	0.205
20	0.685	1100	0.201
25	0.657	1173.2	0.188
30	0.647	1200	0.184
35	0.640	1273.2	0.172
40	0.635	1300	0.167
45	0.630	1373.2	0.155*
50	0.627	1400	0.150*
60	0.620	1473.2	0.137*
70	0.615	1500	0.132*
80	0.611*	1573.2	0.118*
90	0.607*	1600	0.113*
100	0.603*	1673.2	0.0987*
123.2	0.599*	1700	0.0933*
150	0.594*	1773.2	0.0787*
173.2	0.592*	1800	0.0730*
200	0.589*	1873.2	0.0580*
223.2	0.587*	1900	0.0516*
250	0.586*	1973.2	0.0339*
273.2	0.583*	2000	0.0272*
298.2	0.582	2073.2	0.0079*
300	0.582		
312.04	0.581		

* Extrapolated, interpolated, or estimated.
† Values above 1300 K are provisional.

REMARKS

The recommended values are for high-purity rubidium and are considered accurate to within ±10% of the true values at temperatures below 1000 K. The uncertainty increases at higher temperatures. The thermal conductivity at temperatures near and below the corresponding temperature, T_m, of the conductivity maximum is highly sensitive to small physical and chemical variations among different specimens, and the recommended values below 40 K are applicable only to rubidium having residual electrical resistivity $\rho_0 = 0.0384$ $\mu\Omega$ cm. Values at temperatures below about 1.5 T_m are calculated to fit experimental data by using equation (7) and using n = 2.00, $\alpha' = 0.00930$, and the parameter $\beta = 1.50$.

THERMAL CONDUCTIVITY OF RUTHENIUM



REMARKS

The recommended values are for well-annealed high-purity polycrystalline ruthenium and are considered accurate to within ±5% of the true values at temperatures below 500 K and ±15% at the highest temperatures. The thermal conductivity at temperatures near and below the corresponding temperature, T_m, of the conductivity maximum is highly sensitive to small physical and chemical variations among different specimens, and the conductivity values below 250 K are applicable only to ruthenium having residual electrical resistivity $\rho_0 = 0.0158$ $\mu\Omega$ cm. Values at temperatures below about 1.5 T_m are calculated to fit experimental data by using equation (7) and using the constants m, n, and α'' given for ruthenium in Table 1 and the parameter β = 0.647.

RECOMMENDED VALUES

[Temperature, T, K; Thermal Conductivity, k, W cm^{-1} K^{-1}]

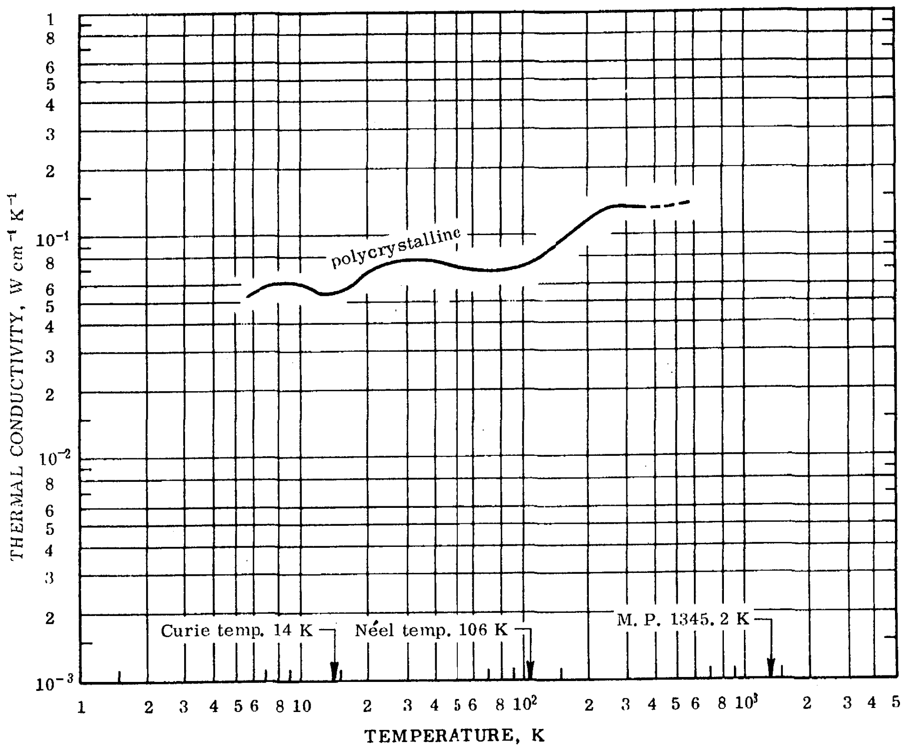
SOLID

Polycrystalline

T	k	T	k
0	0	350	1.15
1	1.55*	373.2	1.15
2	3.09*	400	1.14
3	4.64	473.2	1.12
4	6.18	500	1.11
5	7.71	573.2	1.08
6	9.23	600	1.08
7	10.7	673.2	1.06
8	12.2	700	1.05
9	13.6	773.2	1.03
10	15.0	800	1.02
11	16.3	873.2	1.01
12	17.5	900	0.997
13	18.7	973.2	0.982
14	19.7	1000	0.976
15	20.5	1073.2	0.962
16	21.3	1100	0.957
18	22.3	1173.2	0.944
20	22.6	1200	0.939
25	21.3	1273.2	0.928
30	17.8	1300	0.923
35	13.3	1373.2	0.913
40	9.53	1400	0.909
45	6.88	1473.2	0.899
50	5.10	1500	0.895
60	3.10	1573.2	0.885
70	2.26	1600	0.882
80	1.86	1673.2	0.873
90	1.65	1700	0.870
100	1.54	1773.2	0.862
123.2	1.38	1800	0.859
150	1.28	1873.2	0.851
173.2	1.23	1900	0.848
200	1.18	1973.2	0.841
223.2	1.17	2000	0.838
250	1.17	2073.2	0.831*
273.2	1.17	2173.2	0.822*
298.2	1.17	2200	0.820*
300	1.17	2273.2	0.813*
323.2	1.16	2400	0.803*
		2473.2	0.798*
		2500	0.796*

* Extrapolated.

THERMAL CONDUCTIVITY OF SAMARIUM



PROVISIONAL VALUES

[Temperature, T, K; Thermal Conductivity, k, W cm^{-1} K^{-1}]

SOLID

Polycrystalline

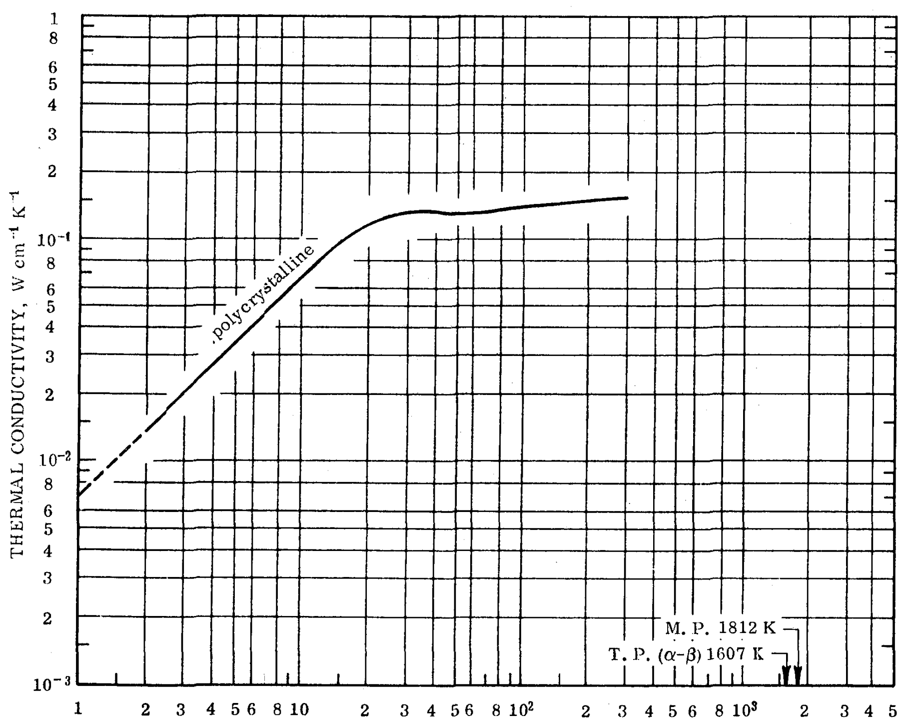
T	k	T	k
6	0.0555	100	0.0735
7	0.0591	123.2	0.0820
8	0.0611	150	0.0924
9	0.0618	173.2	0.101
10	0.0607	200	0.113
11	0.0586	220	0.123
12	0.0557	223.2	0.124
13	0.0542	250	0.132
14	0.0551	273.2	0.133
15	0.0566	298.2	0.133
16	0.0580	300	0.133
17	0.0598	323.2	0.133
18	0.0623	350	0.133
19	0.0659	373.2	0.133
20	0.0692	400	0.133
25	0.0754	473.2	0.134*
30	0.0770	500	0.135*
35	0.0768	573.2	0.139*
40	0.0754	600	0.141*
45	0.0742		
50	0.0732		
60	0.0714		
70	0.0708		
80	0.0709		
90	0.0714		

REMARKS

The provisional values are for well-annealed high-purity polycrystalline samarium and are thought to be accurate to within ±15% of the true values near room temperature, ±20% at higher temperatures, and ± 25% at lower temperatures. Values below room temperature are applicable only to samarium having electrical resistivity ρ_0 = 6.73 μΩ cm at 4.2 K.

*Extrapolated.

THERMAL CONDUCTIVITY OF SCANDIUM



REMARKS

The recommended values are for well-annealed high-purity polycrystalline scandium and are considered accurate to within ±5% of the true values near room temperature and ±15% below 200 K. The values below 200 K are applicable only to scandium having residual electrical resistivity $\rho_0 = 10.6\ \mu\Omega$ cm.

RECOMMENDED VALUES

[Temperature, T, K; Thermal Conductivity, k, W cm^{-1} K^{-1}]

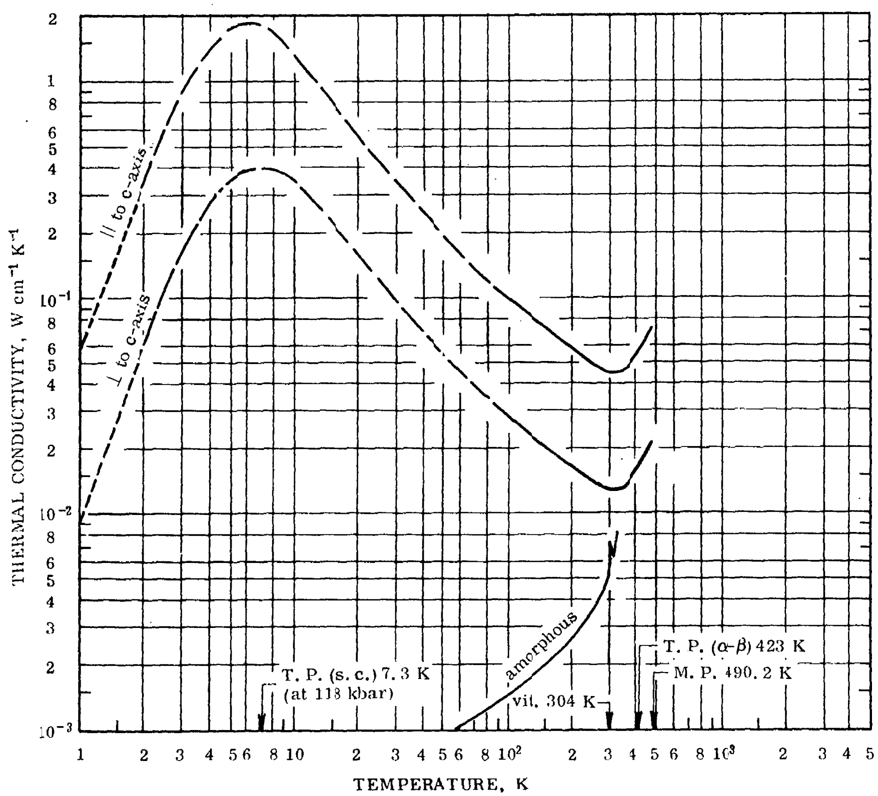
SOLID

Polycrystalline

T	k
0	0
1	0.00706*
2	0.0140
3	0.0208
4	0.0276
5	0.0344
6	0.0412
7	0.0479
8	0.0545
9	0.0612
10	0.0678
11	0.0738
12	0.0797
13	0.0855
14	0.0910
15	0.0960
16	0.101
18	0.109
20	0.117
25	0.130
30	0.137
35	0.138
40	0.138
45	0.136
50	0.135
60	0.136
70	0.138
80	0.139
90	0.141
100	0.143
123.2	0.146
150	0.149
173.2	0.151
200	0.153
223.2	0.154
250	0.156
273.2	0.157
298.2	0.158
300	0.158

* Extrapolated.

THERMAL CONDUCTIVITY OF SELENIUM



REMARKS

The values are for high-purity selenium. Those for selenium single crystal at temperatures above 80 K are recommended values and are thought to be accurate to within ± 10 to ± 20%. The values below 80 K are merely typical values and represent a typical curve serving only to indicate the general trend of the thermal conductivity of selenium single crystal at low temperatures. The values for amorphous selenium are recommended values and are considered accurate to within ± 10% except for those values around the vitrification temperature, which are provisional and their uncertainty may be as much as ± 25%.

RECOMMENDED VALUES †

[Temperature, T, K; Thermal Conductivity, k, W cm^{-1} K^{-1}]

SOLID

T	// to c-axis k	⊥ to c-axis k
0	0	0
1	0.0563*	0.00865*
2	0.353	0.0600
3	0.855	0.160
4	1.41	0.268
5	1.75	0.348
6	1.92	0.395
7	1.90	0.410
8	1.78	0.407
9	1.61	0.390
10	1.42	0.359
11	1.26	0.329
12	1.12	0.301
13	1.01	0.276
14	0.919	0.253
15	0.844	0.234
16	0.778	0.217
18	0.672	0.189
20	0.588	0.166
25	0.448	0.127
30	0.362	0.103
35	0.303	0.0866
40	0.260	0.0743
45	0.228	0.0651
50	0.203	0.0580
60	0.168	0.0480
70	0.144	0.0411
80	0.126	0.0360
90	0.112	0.0320
100	0.103	0.0294
123.2	0.0880	0.0253
150	0.0762	0.0218
173.2	0.0681	0.0195
200	0.0608	0.0174
223.2	0.0555	0.0161
250	0.0513	0.0147
273.2	0.0481	0.0137
298.2	0.0452	0.0131
300	0.0452	0.0130
323.2	0.0448	0.0127
350	0.0461	0.0132
373.2	0.0483	0.0139
400	0.0538	0.0154
473.2	0.0696	0.0198
490.2	0.0747	0.0213

* Extrapolated.
† Values below 80 K are merely typical values.

THERMA

THERMAL CONDUCTIVITY OF SELENIUM (continued)

RECOMMENDED VALUES †

SOLID

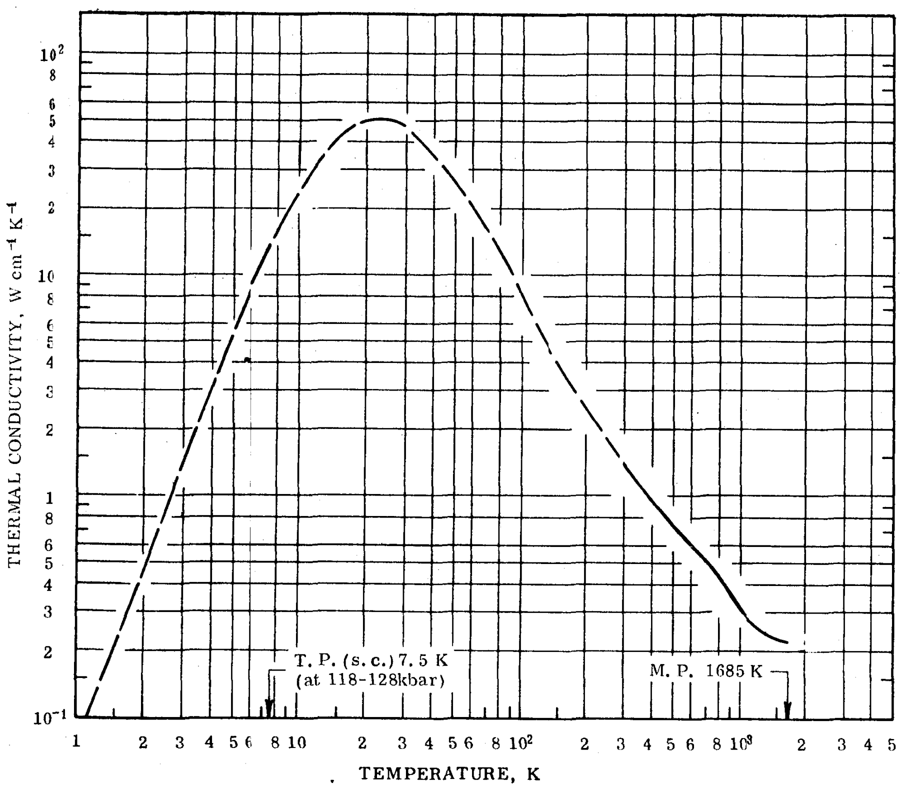
Amorphous

T	k	T	k
0	0	250	0.00360
1	0.000130*	273.2	0.00428
2	0.000236	290	0.00484
3	0.000290	295	0.00504
4	0.000323	298.2	0.00519
5	0.000342	299.2	0.00524
6	0.000358	300	0.00528
7	0.000374	300.2	0.00529
8	0.000390	301	0.00533
9	0.000405	301.2	0.00534
10	0.000420	302	0.00538
11	0.000435	302.2	0.00539
12	0.000450	303	0.00544
13	0.000465	303.2	0.00545
14	0.000480	303.5	0.00547
15	0.000494	304	0.00732
16	0.000508	304.5	0.00681
18	0.000532	304.7	0.00671
20	0.000560	305	0.00657
25	0.000619	305.2	0.00650
30	0.000675	305.5	0.00640
35	0.000730	305.7	0.00635
40	0.000788	306	0.00627
45	0.000843	306.2	0.00623
50	0.000900	306.5	0.00619
60	0.00102	306.7	0.00619
70	0.00113	307	0.00619
80	0.00125	307.2	0.00621
90	0.00136	307.5	0.00625
100	0.00148	308	0.00631
123.2	0.00173	309	0.00644
150	0.00204	310	0.00656
173.2	0.00230	313.2	0.00696
200	0.00263	320	0.00782
223.2	0.00299	323.2	0.00818

* Extrapolated.

† Values at temperatures from 301 to 309 K are provisional.

THERMAL CONDUCTIVITY OF SILICON



REMARKS

The values are for high-purity silicon. Those at temperatures 300 K and above are recommended values and are considered accurate to within ±5% of the true values at temperatures from 300 to 1000 K and ±10% at the highest temperatures. The values below 300 K are merely typical values and represent a typical curve serving to indicate the general trend of the thermal conductivity of silicon at moderate and low temperatures.

RECOMMENDED VALUES †

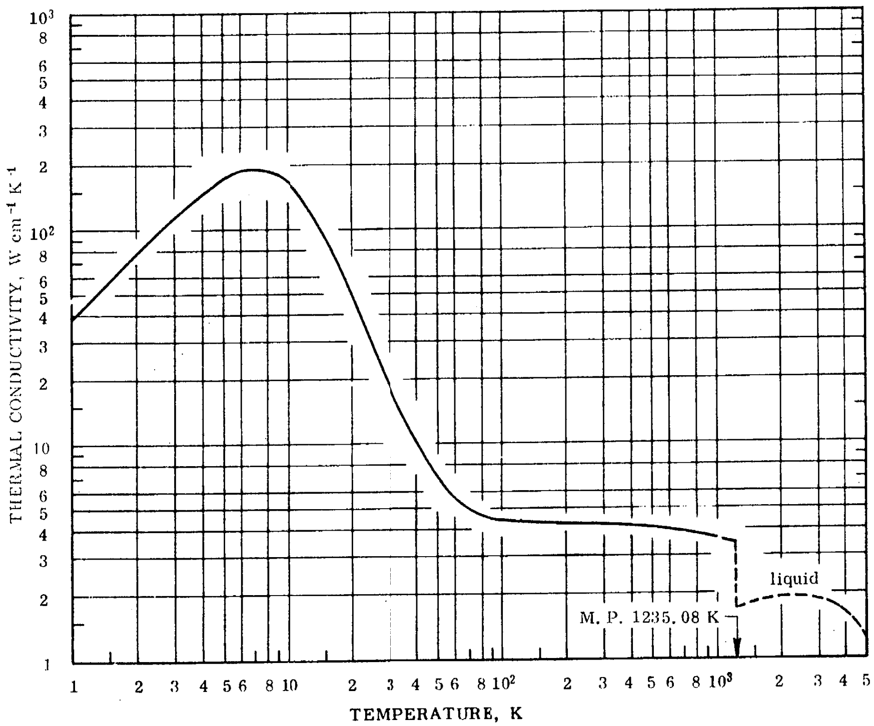
[Temperature, T, K; Thermal Conductivity, k, W cm^{-1} K^{-1}]

SOLID

T	k	T	k
0	0	250	1.91
1	0.0693*	273.2	1.68
2	0.454	298.2	1.49
3	1.38	300	1.48
4	2.97	323.2	1.33
5	5.27	350	1.19
6	8.23	373.2	1.08
7	11.7	400	0.989
8	15.5	473.2	0.814
9	19.5	500	0.762
10	23.3	573.2	0.651
11	27.0	600	0.619
12	30.9	673.2	0.536
13	34.8	700	0.508
14	38.4	773.2	0.442
15	41.6	800	0.422
16	44.1	873.2	0.374
18	47.7	900	0.359
20	49.8	973.2	0.323
25	51.3	1000	0.312
30	48.1	1073.2	0.286
35	41.3	1100	0.279
40	35.3	1173.2	0.262
45	30.6	1200	0.257
50	26.8	1273.2	0.247
60	21.1	1300	0.244
70	16.8	1373.2	0.237
80	13.4	1400	0.235
90	10.8	1473.2	0.229
100	8.84	1500	0.227
123.2	5.99	1573.2	0.223
150	4.09	1600	0.221
173.2	3.30	1673.2	0.220
200	2.64	1685	0.220
223.2	2.25		

* Extrapolated.
† Values below 300 K are merely typical values.

THERMAL CONDUCTIVITY OF SILVER



RECOMMENDED VALUES†

[Temperature, T, K; Thermal Conductivity, k, W cm^{-1} K^{-1}]

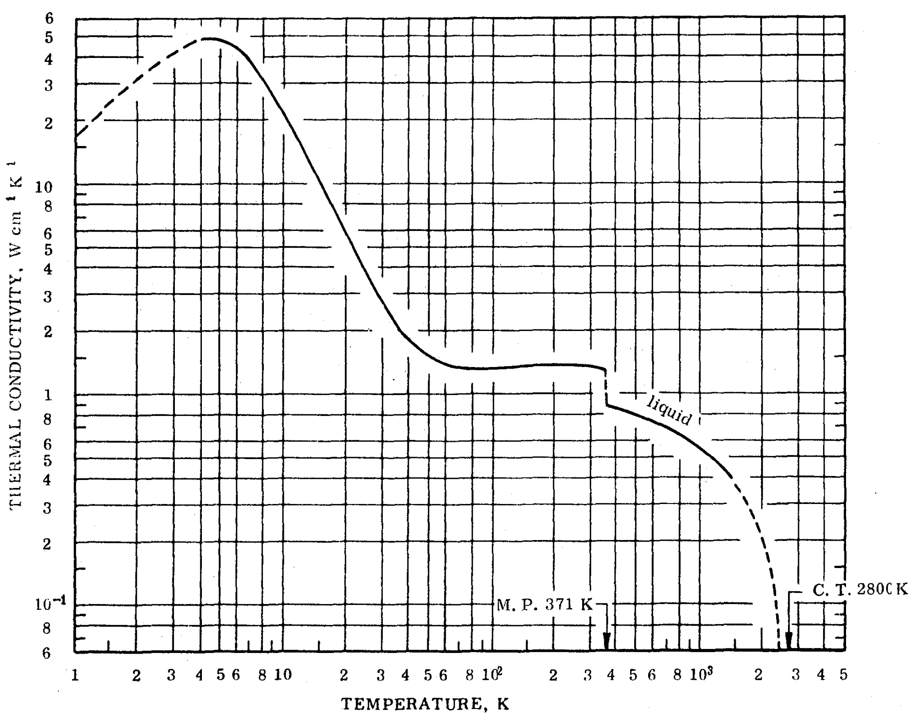
SOLID				LIQUID			
T	k	T	k	T	k	T	k
0	0	123.2	4.38	1235.08	1.75*	3273	1.85*
1	39.4	150	4.32	1273.2	1.77*	3400	1.82*
2	78.3	173.2	4.31	1300	1.78*	3473	1.79*
3	115	200	4.30	1373.2	1.82*	3600	1.76*
4	147	223.2	4.30	1400	1.83*	3673	1.74*
5	172	250	4.29	1473.2	1.86*	3800	1.70*
6	187	273.2	4.29	1500	1.87*	3873	1.68*
7	193	298.2	4.29	1573.2	1.89*	4000	1.63*
8	190	300	4.29	1600	1.90*	4073	1.61*
9	181	323.2	4.28	1673.2	1.92*	4273	1.54*
10	168	350	4.27	1700	1.93*	4500	1.45*
11	154	373.2	4.26	1773.2	1.94*	4773	1.33*
12	139	400	4.25	1800	1.95*	5000	1.23*
13	124	473.2	4.20	1873.2	1.96*	5273	1.11*
14	109	500	4.19	1900	1.96*	5500	1.01*
15	96	573.2	4.14	1973.2	1.97*	5773	0.875*
16	85	600	4.12	2000	1.97*	6000	0.764*
18	66	673.2	4.07	2073.2	1.98*	6273	0.628*
20	51	700	4.04	2173.2	1.98*	6500	0.514*
25	29.5	773.2	3.99	2200	1.98*	6773	0.373*
30	19.3	800	3.96	2273.2	1.99*	7000	0.251*
35	13.7	873.2	3.90	2400	1.98*	7273	0.104*
40	10.5	900	3.88	2473.2	1.98*		
45	8.4	973.2	3.82	2600	1.97*		
50	7.0	1000	3.79	2673.2	1.96*		
60	5.5	1073.2	3.73*	2800	1.95*		
70	4.97	1100	3.70*	2873.2	1.94*		
80	4.71	1173.2	3.63*	3000	1.91*		
90	4.60	1200	3.61*	3073	1.90*		
100	4.50	1235.08	3.58*	3200	1.87*		

REMARKS

The recommended values are for well-annealed high-purity silver and are considered accurate to within ±2% of the true values near room temperature and ±5% below 100 K and above 1000 K. The thermal conductivity at temperatures near and below the corresponding temperature, T_m, of the conductivity maximum is highly sensitive to small physical and chemical variations among different specimens, and the recommended values below 150 K are applicable only to silver having residual electrical resistivity $\rho_0 = 0.000621$ μΩ cm. Values at temperatures below about 1.5 T_m are calculated by using equation (7) and using the constants m, n, and α'' given for silver in Table 1 and the parameter $\beta = 0.0254$. No experimental data are available for molten silver and the values given here are estimated and are provisional values. They are probably good to ±20% from melting point to 2000 K.

* Extrapolated or estimated.
† Values for molten silver are provisional.

THERMAL CONDUCTIVITY OF SODIUM



REMARKS

The recommended values are for high-purity sodium and are considered accurate to within ±6% of the true values at temperatures below 60 K, ±10% from 60 K to the melting point, ±5% for the liquid state below 1000 K, and ±10% from 1000 to 1600 K. The thermal conductivity at temperatures near and below the corresponding temperature, T_m, of the conductivity maximum is highly sensitive to small physical and chemical variations among different specimens, and the recommended values below 80 K are applicable only to sodium having residual electrical resistivity $\rho_0 = 0.00147\ \mu\Omega$ cm. Values at temperatures below about 1.5 T_m are calculated to fit experimental data by using equation (7) and using the constants m, n, and α'' given for sodium in Table 1 and the parameter $\beta = 0.0600$.

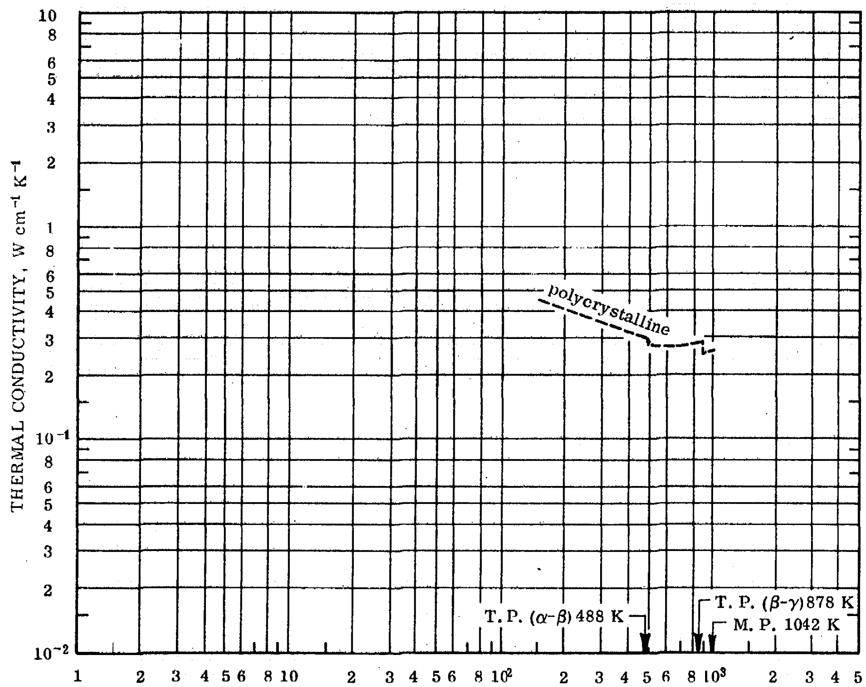
RECOMMENDED VALUES†

[Temperature, T, K; Thermal Conductivity, k, W cm^{-1} K^{-1}]

SOLID T	SOLID k	LIQUID T	LIQUID k	LIQUID T	LIQUID k
0	0	371	0.883	1800	0.292*
1	16.6*	373.2	0.882	1873.2	0.269*
2	31.8*	400	0.868	1900	0.260*
3	43.2	473.2	0.827	1973.2	0.238*
4	48.5	500	0.815	2000	0.229*
5	48.2	573.2	0.778	2073.2	0.207*
6	44.2	600	0.764	2173.2	0.177*
7	38.4	673.2	0.728	2200	0.170*
8	31.7	700	0.715	2273.2	0.148*
9	26.3	773.2	0.681	2400	0.112*
10	22.0	800	0.668	2473.2	0.087*
11	18.8	873.2	0.638	2600	0.056*
12	16.1	900	0.625	2673.2	0.033*
13	14.0	973.2	0.596	C. T. = 2800	0.0013*
14	12.2	1000	0.583		
15	10.7	1073.2	0.553		
16	9.40	1100	0.543		
18	7.48	1173.2	0.513		
20	6.09	1200	0.503		
25	3.94	1273.2	0.476		
30	2.83	1300	0.465		
35	2.22	1373.2	0.438		
40	1.89	1400	0.428*		
45	1.71	1473.2	0.402*		
50	1.58	1500	0.393*		
60	1.45	1573.2	0.367*		
70	1.38	1600	0.358*		
80	1.35	1673.2	0.334*		
90	1.36	1700	0.325*		
100	1.36	1773.2	0.301*		
123.2	1.38				
150	1.40				
173.2	1.41				
200	1.42				
223.2	1.42				
250	1.43				
273.2	1.42				
298.2	1.42				
300	1.41				
323.2	1.39				
350	1.35				
371	1.32				

* Extrapolated or estimated.
† Values above 1600 K are provisional.

THERMAL CONDUCTIVITY OF STRONTIUM



PROVISIONAL VALUES

[Temperature, T, K; Thermal Conductivity, k, W cm^{-1} K^{-1}]

SOLID

Polycrystalline

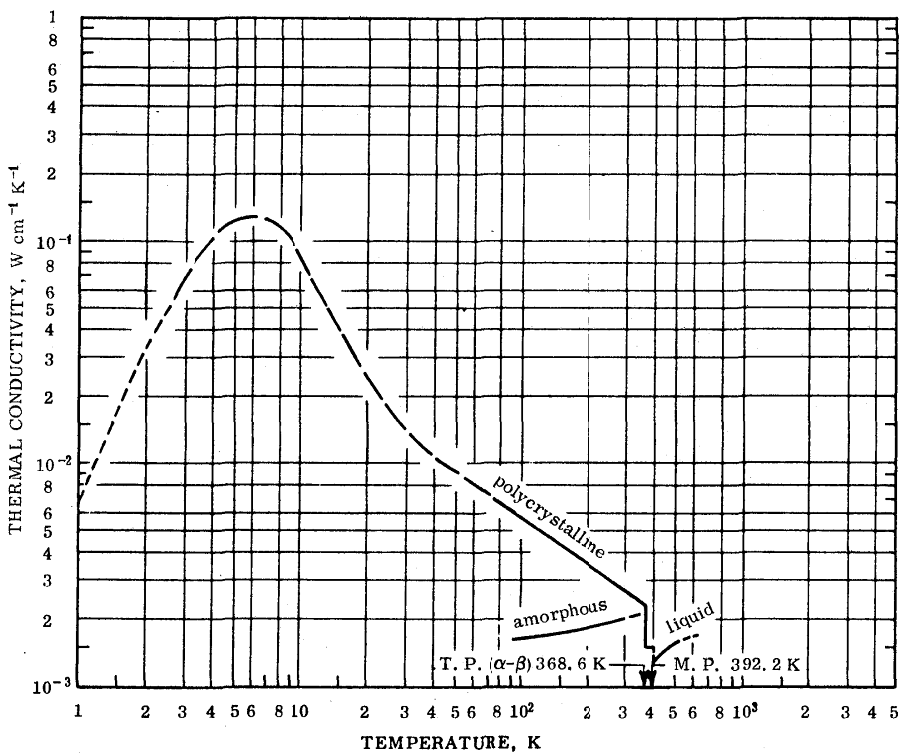
T	k
150	0.446*
173.2	0.424*
200	0.405*
223.2	0.390*
250	0.375*
273.2	0.364*
298.2	0.354*
300	0.353*
323.2	0.344*
350	0.333*
373.2	0.325*
400	0.317*
473.2	0.301*
488	).300*
488	0.281*
500	0.280*
573.2	0.277*
600	0.276*
673.2	0.277*
700	0.278*
773.2	0.282*
800	0.284*
873.2	0.289*
878	0.290*
878	0.248*
900	0.250*
973.2	0.257*
1000	0.260*

REMARKS

The provisional values are for high-purity strontium and are probably good to ± 20% below 450 K. The uncertainty increases above 500 K due to the effect of the phase transformations. No values appear to have been reported for the thermal conductivity of strontium, and these provisional values are derived from electrical resistivity data.

*Estimated.

THERMAL CONDUCTIVITY OF SULFUR



RECOMMENDED VALUES†

[Temperature, T, K; Thermal Conductivity, k, W cm^{-1} K^{-1}]

SOLID

Polycrystalline

T	k	T	k
0	0	60	0.00799
1	0.00662*	70	0.00717
2	0.0320*	80	0.00654
3	0.0694	90	0.00602
4	0.106	100	0.00562
5	0.124	123.2	0.00490
6	0.128	150	0.00430
7	0.123	173.2	0.00389
8	0.112	200	0.00355
9	0.0970	223.2	0.00330
10	0.0817	250	0.00305
11	0.0688	273.2	0.00287
12	0.0581	298.2	0.00270
13	0.0499	300	0.00269
14	0.0435	323.2	0.00256
15	0.0384	350	0.00242
16	0.0343	368.6	0.00233
18	0.0280	368.6	0.00154
20	0.0235	373.2	0.00154
25	0.0169	392.2	0.00150
30	0.0140		
35	0.0122		
40	0.0109		
45	0.00993		
50	0.00917		

Amorphous

T	k
90	0.00163
100	0.00165
123.2	0.00169
150	0.00175
173.2	0.00180
200	0.00185
223.2	0.00190
250	0.00195
273.2	0.00200
298.2	0.00205
300	0.00206
323.2	0.00210*
350	0.00216*

LIQUID

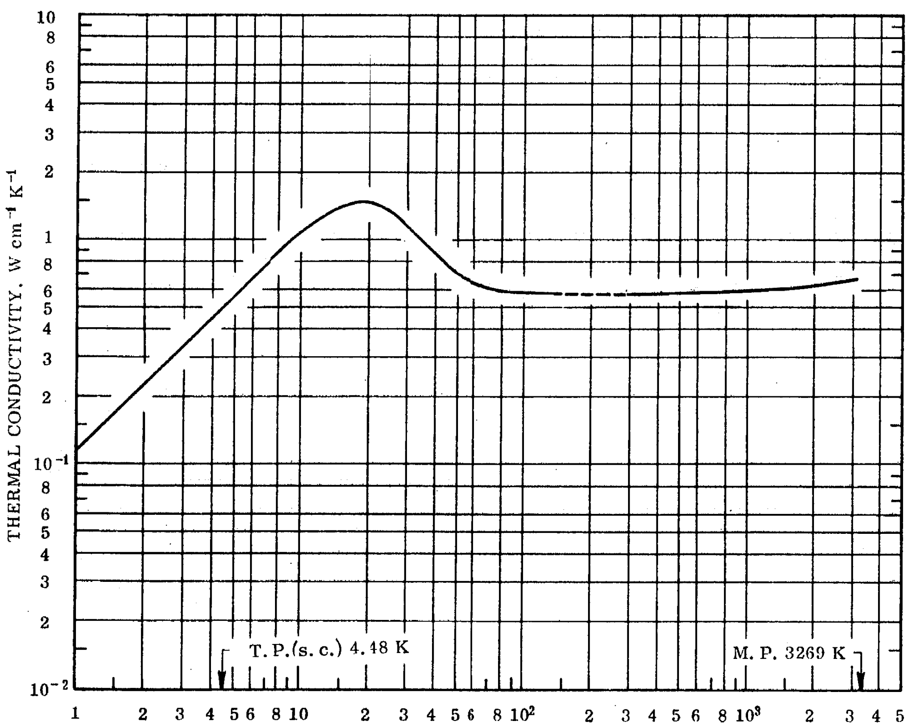
T	k
392.2	0.00129
400	0.00132
473.2	0.00153
500	0.00160
573.2	0.00169
600	0.00170*

REMARKS

The values are for high-purity sulfur. Those for polycrystalline sulfur at temperatures above 70 K are recommended values and are considered accurate to within ±10% of the true values from 70 K to room temperature and ±5% from room temperature to the melting point. The values below 70 K are merely typical values and represent a typical curve serving to indicate the general trend of the thermal conductivity of sulfur at low temperatures. The values for amorphous sulfur are recommended values and are probably good to ±15%. The recommended values for liquid sulfur are considered accurate to within ±5%.

* Extrapolated.
† Values below 70 K are merely typical values.

THERMAL CONDUCTIVITY OF TANTALUM



RECOMMENDED VALUES

[Temperature, T, K; Thermal Conductivity, k, W cm^{-1} K^{-1}]

SOLID

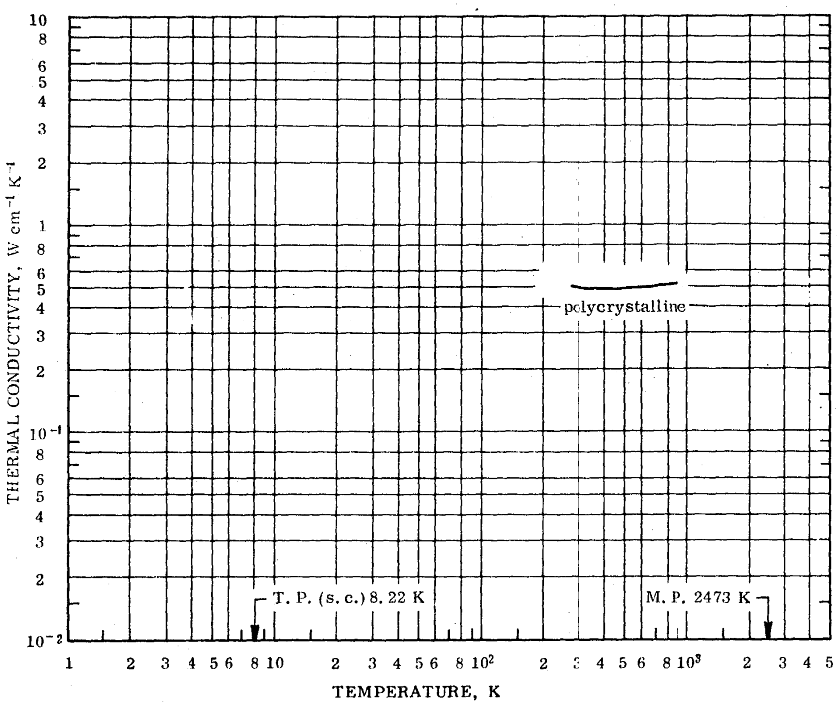
T	k	T	k	T	k
0	0	123.2	0.586*	1300	0.614
1	0.115	150	0.580*	1373.2	0.617
2	0.230	173.2	0.578*	1400	0.618
3	0.344	200	0.575*	1473.2	0.622
4	0.458	223.2	0.574*	1500	0.622
5	0.569	250	0.574*	1573.2	0.625
6	0.678	273.2	0.574	1600	0.626
7	0.784	298.2	0.575	1673.2	0.629
8	0.884	300	0.575	1700	0.630
9	0.979	323.2	0.576	1773.2	0.633
10	1.07	350	0.576	1800	0.634
11	1.15	373.2	0.577	1873.2	0.637
12	1.22	400	0.578	1900	0.638
13	1.28	473.2	0.582	1973.2	0.640
14	1.33	500	0.582	2000	0.641
15	1.37	573.2	0.585	2073.2	0.644
16	1.40	600	0.586	2173.2	0.647
18	1.43	673.2	0.588	2200	0.648
20	1.42	700	0.590	2273.2	0.650
25	1.30	773.2	0.593	2400	0.654
30	1.15	800	0.594	2473.2	0.656
35	0.99	873.2	0.597	2600	0.659
40	0.87	900	0.598	2673.2	0.661
45	0.78	973.2	0.602	2800	0.664
50	0.72	1000	0.602	2873.2	0.665
60	0.651	1073.2	0.605	3000	0.666
70	0.616	1100	0.606	3073	0.666
80	0.603	1173.2	0.609	3200	0.666
90	0.596	1200	0.610		
100	0.592	1273.2	0.613		

* Interpolated.

REMARKS

The recommended values are for well-annealed high-purity tantalum and are considered accurate to within ±5% of the true values at moderate temperatures and ±10% at low and high temperatures. The thermal conductivity at temperatures near and below the corresponding temperature, T_m, of the conductivity maximum is highly sensitive to small physical and chemical variations among different specimens, and the recommended values below 100 K are applicable only to tantalum having residual electrical resistivity $\rho_0 = 0.214$ $\mu\Omega$ cm. Values at temperatures below about 1.5 T_m are calculated to fit experimental data by using equation (7) and using the constants m, n, and α'' given for tantalum in Table 1 and the parameter $\beta = 8.70$.

THERMAL CONDUCTIVITY OF TECHNETIUM



RECOMMENDED VALUES

[Temperature, T, K; Thermal Conductivity, k, W cm^{-1} K^{-1}]

SOLID

Polycrystalline

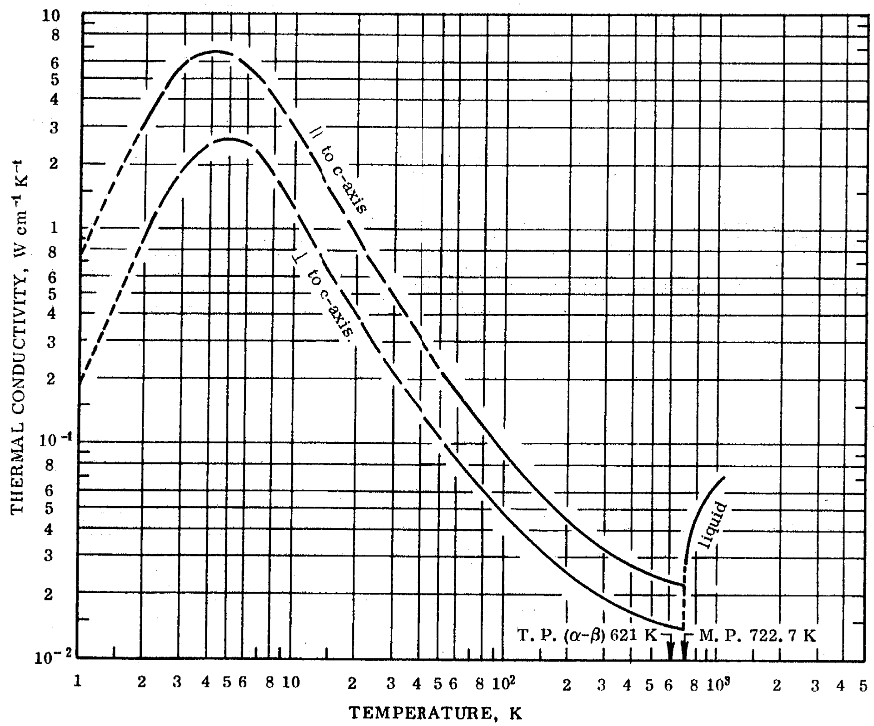
T	k
273.2	0.509*
298.2	0.506
300	0.506
323.2	0.504
350	0.502
373.2	0.501
400	0.500
473.2	0.498
500	0.498
573.2	0.499
600	0.499
673.2	0.504
700	0.507
773.2	0.515
800	0.519
873.2	0.530*
900	0.534*

REMARKS

The recommended values are for well-annealed high-purity polycrystalline technetium and are thought to be accurate to within ±10% near room temperature and ±20% at the highest temperatures.

*Extrapolated.

THERMAL CONDUCTIVITY OF TELLURIUM



REMARKS

The values are for well-annealed high-purity tellurium. Those at temperatures above 50 K are recommended values and are considered accurate to within ±10 to ±15% of the true values for the solid and ±10 to ±20% for the liquid. The values below 50 K are merely typical values and represent two typical curves serving to indicate the general trend of the thermal conductivity of tellurium at low temperatures.

RECOMMENDED VALUES†

[Temperature, T, K; Thermal Conductivity, k, W cm^{-1} K^{-1}]

SOLID

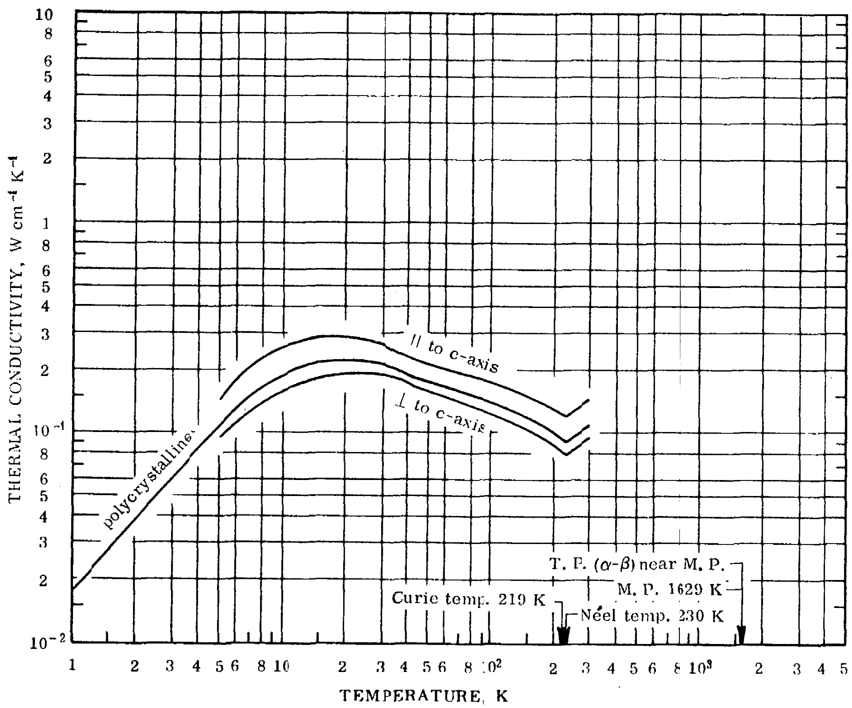
T	// to c-axis k	⊥ to c-axis k	T	// to c-axis k	⊥ to c-axis k
0	0	0	60	0.180	0.0870
1	0.710*	0.198*	70	0.146	0.0723
2	3.14	0.906	80	0.122	0.0618
3	5.75	1.87	90	0.104	0.0542
4	6.72	2.50	100	0.0912	0.0484
5	6.59	2.67	123.2	0.0716	0.0396
6	5.92	2.56	150	0.0585	0.0328
7	5.04	2.28	173.2	0.0513	0.0291
8	4.33	1.91	200	0.0455	0.0259
9	3.66	1.57	223.2	0.0417	0.0239
10	3.09	1.30	250	0.0383	0.0221
11	2.67	1.10	273.2	0.0360	0.0208
12	2.31	0.943	298.2	0.0338	0.0197
13	2.01	0.823	300	0.0337	0.0196
14	1.77	0.728	323.2	0.0320	0.0188
15	1.57	0.649	350	0.0304	0.0180
16	1.40	0.583	373.2	0.0292	0.0173
18	1.14	0.482	400	0.0280	0.0168
20	0.950	0.407	473.2	0.0256	0.0156
25	0.660	0.289	500	0.0250	0.0152
30	0.494	0.221	573.2	0.0236	0.0146
35	0.391	0.178	600	0.0234	0.0144
40	0.321	0.148	673.2	0.0230	0.0141
45	0.271	0.127	700	0.0229	0.0141
50	0.233	0.110	722.7	0.0229	0.0140

LIQUID

T	k
722.7	0.0290
773.2	0.0381
800	0.0424
873.2	0.0522
900	0.0554
973.2	0.0630
1000	0.0651
1073.2	0.0696
1100	0.0709*

* Extrapolated.
† Values below 50 K are merely typical values.

THERMAL CONDUCTIVITY OF TERBIUM



PROVISIONAL VALUES

[Temperature, T, K; Thermal Conductivity, k, W cm^{-1} K^{-1}]

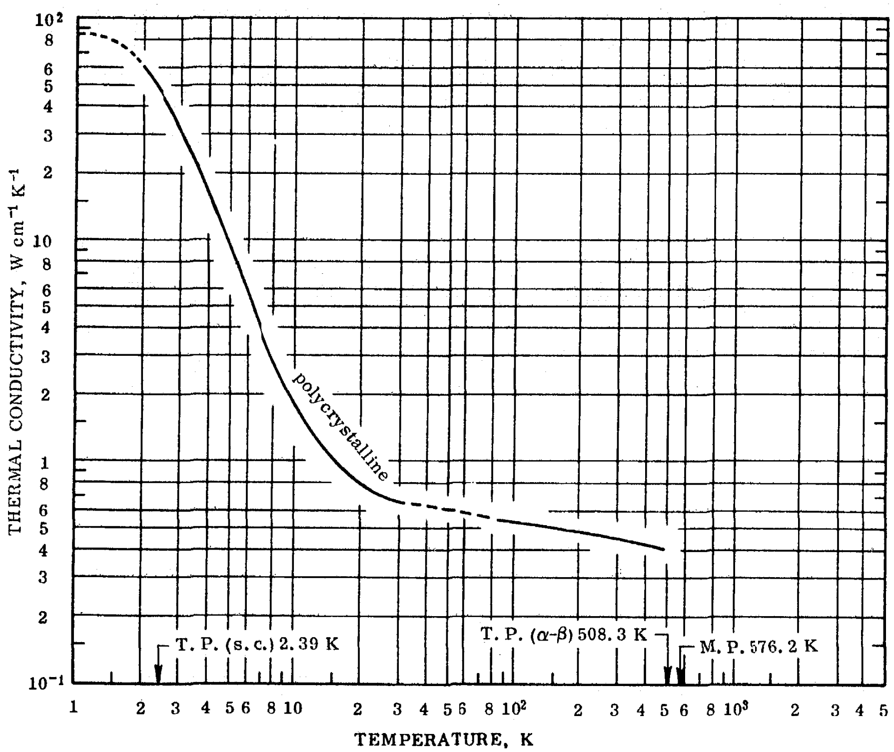
SOLID

T	// to c-axis k	⊥ to c-axis k	Poly-crystalline k	T	// to c-axis k	⊥ to c-axis k	Poly-crystalline k
0	0	0	0	30	0.262	0.192	0.213
1			0.0180	35	0.245	0.184	0.202
2			0.0383	40	0.231	0.174	0.191
3			0.0602	45	0.221	0.166	0.183
4			0.0842	50	0.214	0.160	0.176
5	0.146	0.0939	0.109	60	0.205	0.151	0.168
6	0.179	0.112	0.131	70	0.198	0.144	0.160
7	0.208	0.127	0.150	80	0.190	0.138	0.153
8	0.231	0.140	0.166	90	0.183	0.132	0.147
9	0.249	0.151	0.179	100	0.177	0.127	0.142
10	0.263	0.160	0.189	123.2	0.164	0.117	0.131
11	0.273	0.168	0.198	150	0.152	0.106	0.120
12	0.281	0.173	0.204	173.2	0.143	0.0988	0.112
13	0.288	0.178	0.209	200	0.132	0.0902	0.103
14	0.292	0.182	0.213	223.2	0.124	0.0828	0.0948
15	0.295	0.186	0.217	230	0.122	0.0800	0.0922
16	0.296	0.189	0.220	250	0.131	0.0846	0.0980
18	0.296	0.193	0.223	273.2	0.138	0.0900	0.104
20	0.294	0.196	0.225	298.2	0.147	0.0956	0.111
25	0.279	0.196	0.221	300	0.148	0.0959	0.111

REMARKS

The provisional values are for well-annealed high-purity terbium and are considered accurate to within ±15% of the true values near room temperature and ±20% down to 50 K. The values below 50 K are very uncertain. The values below 150 K for $k_{//}$, $k_{\perp}$, and k_{poly} are applicable only to samples having residual electrical resistivities of 1.87, 2.37, and 2.19 μΩ cm, respectively.

THERMAL CONDUCTIVITY OF THALLIUM



RECOMMENDED VALUES †

[Temperature, T, K; Thermal Conductivity, k, W cm^{-1} K^{-1}]

SOLID

Polycrystalline

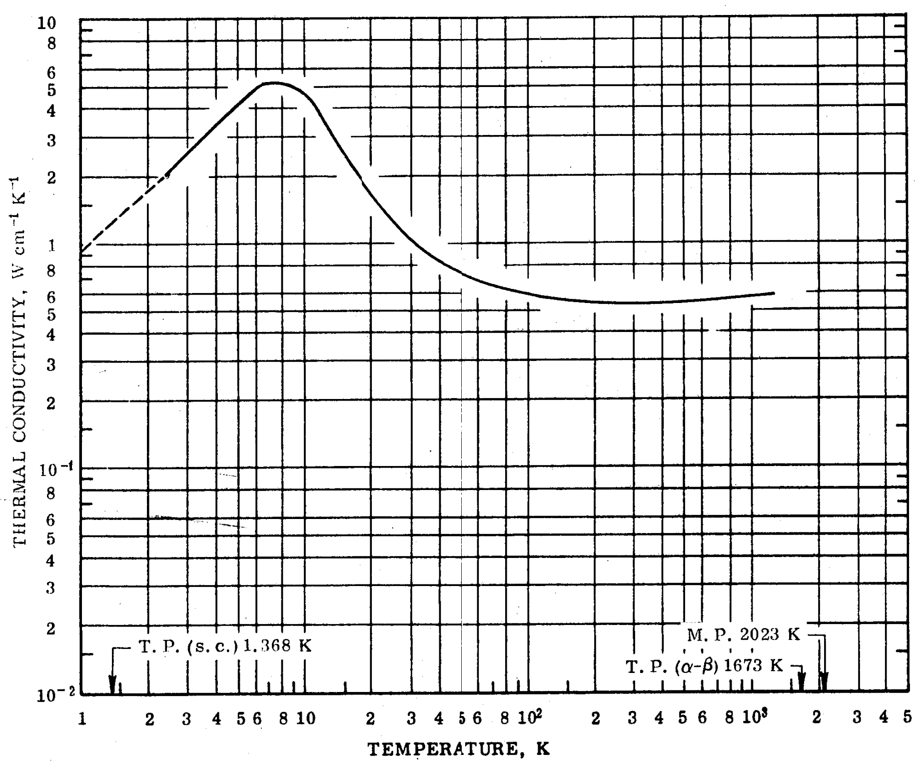
T	k	T	k
0	0	60	0.607*
1	82.7*	70	0.590*
2	63.4*	80	0.578
3	33.2	90	0.567
4	17.6	100	0.556
5	10.2	123.2	0.538
6	6.19	150	0.519
7	4.04	173.2	0.506
8	2.95	200	0.494
9	2.30	223.2	0.485
10	1.87	250	0.476
11	1.60	273.2	0.469
12	1.40	298.2	0.461
13	1.27	300	0.461
14	1.16	323.2	0.455
15	1.07	373.2	0.443
16	1.00	400	0.438
18	0.889	473.2	0.425
20	0.811	500	0.421*
25	0.718		
30	0.682		
35	0.665*		
40	0.650*		
45	0.637*		
50	0.626*		

REMARKS

The values are for well-annealed high-purity polycrystalline thallium. Those at temperatures above 30 K are recommended values and are considered accurate to within ±15% of the true values from 30 to 100 K and ±10% above 100 K. The values below 30 K are provisional and furthermore they are applicable only to a sample having residual electrical resistivity ρ_0 = 0.000240 μΩcm. These provisional values are probably good to within ±20%. Values at temperatures below about 1.5 T_m are calculated by using equation (7) and using the constants m, n, and α'' given for thallium in Table 1 and the parameter β = 0.00982.

* Extrapolated or interpolated.
† Values below 30 K are provisional.

THERMAL CONDUCTIVITY OF THORIUM



REMARKS

The provisional values are for well-annealed high-purity thorium and their uncertainty is probably of the order of ±15% below 100K, ±20% from 100 to 500K, and ±25% above 500K. The thermal conductivity at temperatures near and below the corresponding temperature, T_m, of the conductivity maximum ishighly sensitive to small physical and chemical variations among different specimens, and the values below 150K are applicable only to thorium having residual electrical resistivity ρ_0 = 0.0268 $\mu\Omega$ cm. Values at temperatures below about 1.5 T_m are calculated to fit experimental data by using equation (7) and using the constants m, n, and α'' given for thorium in Table 1 and the parameter β = 1.07.

PROVISIONAL VALUES

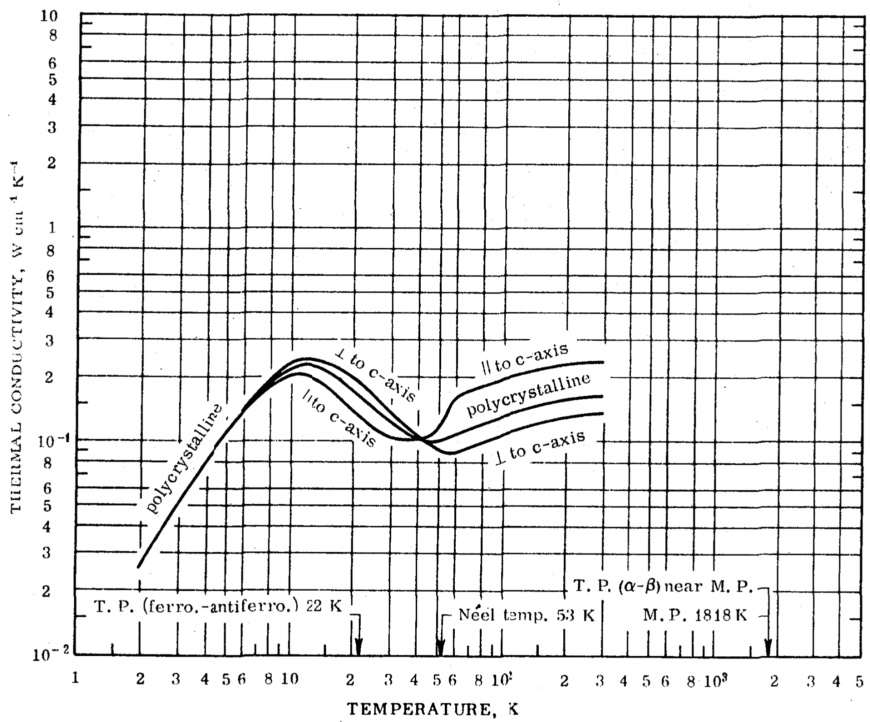
[Temperature, T, K; Thermal Conductivity, k, W cm^{-1} K^{-1}]

SOLID

T	k	T	k
0	0	123.2	0.578
1	0.938*	150	0.563
2	1.87	173.2	0.554
3	2.78	200	0.546
4	3.64	223.2	0.543
5	4.37	250	0.541
6	4.91	273.2	0.540
7	5.20	298.2	0.540
8	5.23	300	0.540
9	5.02	323.2	0.541
10	4.66	350	0.542
11	4.20	373.2	0.543
12	3.72	400	0.545
13	3.30	473.2	0.549
14	2.96	500	0.551
15	2.66	573.2	0.556
16	2.41	600	0.558
18	2.01	673.2	0.563
20	1.70	700	0.564
25	1.26	773.2	0.568
30	1.04	800	0.569
35	0.917	873.2	0.572
40	0.841	900	0.573
45	0.788	973.2	0.577
50	0.747	1000	0.578
60	0.690	1073.2	0.581
70	0.655	1100	0.583
80	0.630	1173.2	0.586
90	0.612	1200	0.587
100	0.598	1273.2	0.589
		1300	0.590

*Extrapolated.

THERMAL CONDUCTIVITY OF THULIUM



PROVISIONAL VALUES

[Temperature, T, K; Thermal Conductivity, k, W cm^{-1} K^{-1}]

SOLID

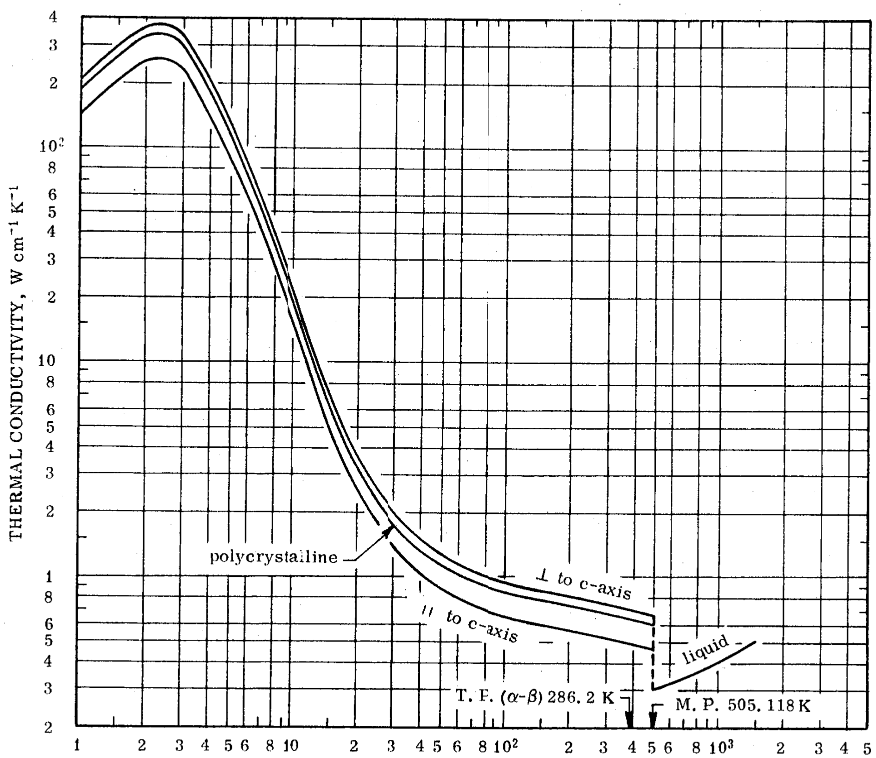
T	// to c-axis k	⊥ to c-axis k	Poly-crystalline k	T	// to c-axis k	⊥ to c-axis k	Poly-crystalline k
2			0.0269*	40	0.105	0.110	0.108
3			0.0517	42.4	0.106	0.106	0.106
4			0.0815	45	0.109	0.102	0.104
5			0.113	50	0.119	0.0948	0.102
6	0.139	0.142	0.141	55	0.141	0.0912	0.106
7	0.162	0.170	0.167	58	0.160	0.0911	0.110
8	0.180	0.197	0.191	60	0.164	0.0920	0.112
9	0.196	0.221	0.212	70	0.175	0.0997	0.120
10	0.207	0.236	0.226	80	0.185	0.105	0.127
11	0.210	0.244	0.232	90	0.193	0.108	0.131
12	0.207	0.246	0.232	100	0.200	0.111	0.135
13	0.202	0.245	0.230	123.2	0.214	0.117	0.144
14	0.193	0.243	0.225	150	0.224	0.126	0.153
15	0.183	0.238	0.218	173.2	0.230	0.130	0.158
16	0.173	0.232	0.211	200	0.235	0.134	0.162
18	0.158	0.218	0.196	223.2	0.238	0.136	0.164
20	0.144	0.202	0.180	250	0.241	0.138	0.167
25	0.120	0.167	0.150	273.2	0.242	0.140	0.168
30	0.106	0.141	0.128	298.2	0.242	0.141	0.169
35	0.105	0.123	0.117	300	0.242	0.141	0.169

REMARKS

The provisional values are for well-annealed high-purity thulium and are considered accurate to within ±15% of the true values at temperatures above 150K. The values below 150K are very uncertain. Values below 100K for $k_{//}$, $k_{\perp}$, and k_{poly} are applicable only to samples having residual electrical resistivities of 3.5, 1.7, and .18 μΩ cm respectively.

*Extrapolated.

THERMAL CONDUCTIVITY OF TIN



REMARKS

The recommended values are for well-annealed high-purity tin. The values for polycrystalline tin are thought to be accurate to within ±3% of the true values at moderate temperatures, ±5% at high temperatures, and ±15% at low temperatures. Those for $k_{//}$ and $k_{\perp}$ of tin single crystal should be accurate to within ±6% at moderate temperatures, ±10 % at high temperatures, and ±15% at low temperatures. For molten tin the values are probably good to ±5% near the melting point, but an increasing uncertainty remains to be resolved at higher temperatures. At temperatures below 100 K the values for $k_{//}$, $k_{\perp}$, and k_{poly} are applicable only to samples having ρ_o = 0.000170, 0.000118, and 0.000132 μΩ cm, respectively. Values for $k_{//}$ and $k_{\perp}$ at temperatures below about 1.5 T_m are calculated by using equation (7) and using n = 2.6, α' = 0.0000861 and 0.0000588, and β = 0.00696 and 0.00484, respectively.

RECOMMENDED VALUES †

[Temperature, T, K; Thermal Conductivity, k, W cm⁻¹ K⁻¹]

SOLID

T	// to c-axis k	⊥ to c-axis k	Poly-crystalline k
0	0	0	0
1	142	204	183
2	250	360	323
3	230	331	297
4	140	202	181
5	90	130	117
6	59	85.0	76
7	40	58.0	52
8	28	40.0	36
9	20.1	29.0	26
10	14.9	21.5	19.3
11	11.4	16.5	14.8
12	9.0	12.9	11.6
13	7.2	10.4	9.3
14	5.9	8.5	7.6
15	4.9	7.0	6.3
16	4.1	5.9	5.3
18	3.1	4.5	4.0
20	2.5	3.6	3.2
25	1.72	2.5	2.24
30	1.36	2.0	1.79
35	1.16	1.67	1.50
40	1.04	1.50	1.33
45	0.950	1.37	1.23
50	0.886	1.28	1.15

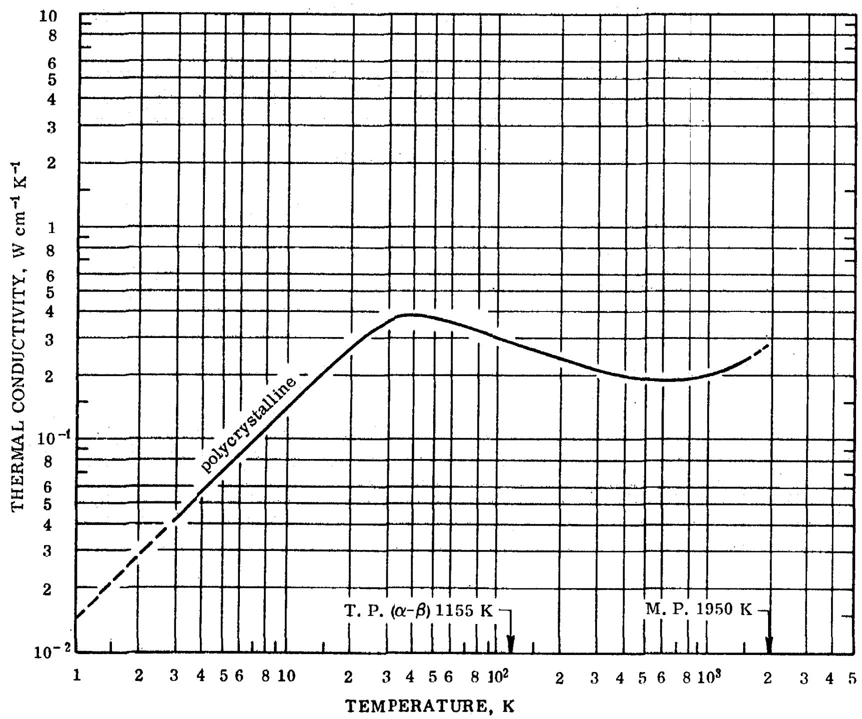
T	// to c-axis k	⊥ to c-axis k	Poly-crystalline k
60	0.797	1.16	1.04
70	0.740	1.07	0.960
80	0.705	1.02	0.915
90	0.679	0.980	0.880
100	0.660	0.950	0.853
123.2	0.630	0.906	0.814
150	0.602	0.867	0.779
173.2	0.585	0.842	0.757
200	0.567	0.816	0.733
223.2	0.553	0.796	0.715
250	0.538	0.775	0.696
273.2	0.527	0.759	0.682
298.2	0.516	0.743	0.668
300	0.515	0.742	0.666
323.2	0.506	0.729	0.655
350	0.496	0.715	0.642
373.2	0.489	0.704	0.632
400	0.481	0.693	0.622
473.2	0.466	0.670	0.602
500	0.461	0.664	0.596
505.118	0.460	0.662	0.595

LIQUID

T	k	T	k
505.118	0.303	1000	0.405
573.2	0.317	1073.2	0.420
600	0.323	1100	0.425
673.2	0.338	1173.2	0.440
700	0.344	1200	0.446
773.2	0.358	1273.2	0.460
800	0.364	1300	0.466
873.2	0.378	1373.2	0.481
900	0.384	1400	0.487
973.2	0.399	1473.2	0.501
		1500	0.507

† Values above 873 K are provisional.

THERMAL CONDUCTIVITY OF TITANIUM



REMARKS

The recommended values are for well-annealed high-purity polycrystalline titanium and are considered accurate to within ±10% of the true values at moderate temperatures and ±15% at low and high temperatures. The thermal conductivity at temperatures near and below the corresponding temperature, T_m, of the conductivity maximum is highly sensitive to small physical and chemical variations among different specimens, and the recommended values below room temperature are applicable only to titanium having residual electrical resistivity ρ_0 = 1.90 $\mu\Omega$ cm. Values at temperatures below about 1.5 T_m are calculated to fit experimental data by using equation (7) and using the constants m, n, and α'' as listed in Table 1 and the parameter β = 69.5.

RECOMMENDED VALUES

[Temperature, T, K; Thermal Conductivity, k, W cm^{-1} K^{-1}]

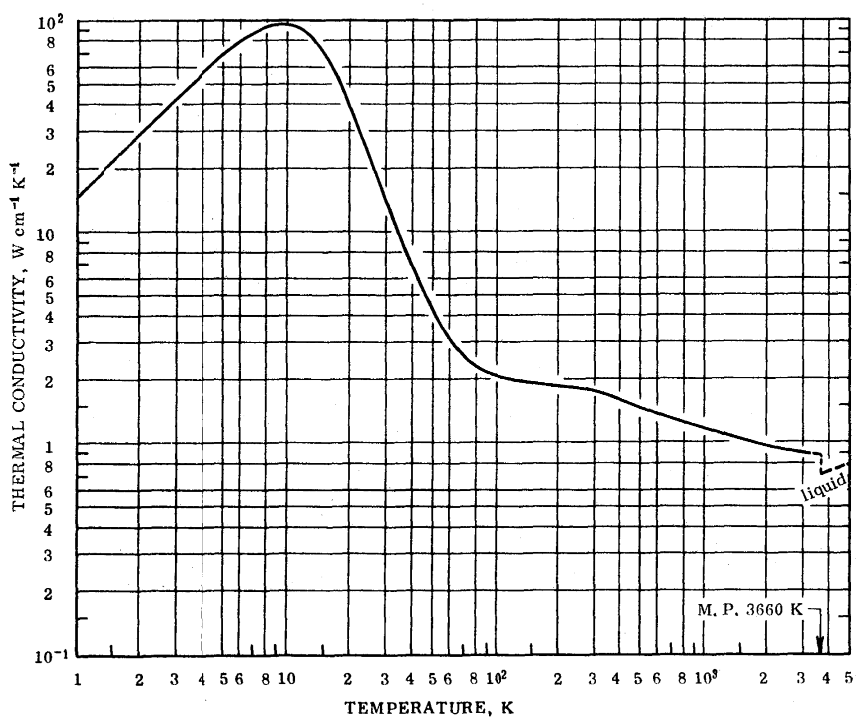
SOLID

Polycrystalline

T	k	T	k
0	0	250	0.229
1	0.0144*	273.2	0.224
2	0.0288*	298.2	0.219
3	0.0432	300	0.219
4	0.0575	323.2	0.215
5	0.0719	350	0.210
6	0.0863	373.2	0.207
7	0.101	400	0.204
8	0.115	473.2	0.198
9	0.129	500	0.197
10	0.143	573.2	0.194
11	0.157	600	0.194
12	0.171	673.2	0.194
13	0.185	700	0.194
14	0.199	773.2	0.196
15	0.212	800	0.197
16	0.225	873.2	0.200
18	0.250	900	0.202
20	0.275	973.2	0.205
25	0.327	1000	0.207
30	0.365	1073.2	0.211
35	0.386	1100	0.213
40	0.390	1173.2	0.218
45	0.385	1200	0.220
50	0.374	1273.2	0.225
60	0.355	1300	0.228
70	0.340	1373.2	0.234
80	0.326	1400	0.236
90	0.315	1473.2	0.242
100	0.305	1500	0.245
123.2	0.286	1573.2	0.251
150	0.270	1600	0.253
173.2	0.257	1673.2	0.259*
200	0.245	1700	0.262*
223.2	0.237	1773.2	0.268*
		1800	0.270*
		1873.2	0.277*
		1900	0.279*
		1950	0.283*

*Extrapolated.

THERMAL CONDUCTIVITY OF TUNGSTEN



REMARKS

The recommended values are for well-annealed high-purity tungsten and are considered accurate to within ±3% of the true values at temperatures from 300 to 1500 K, ±5% from 100 to 300 K and 1500 to 3000 K, and ±10% below 100 K and above 3000K. The provisional values for molten tungsten are estimated and very uncertain. The thermal conductivity at temperatures near and below the corresponding temperature, T_m, of the conductivity maximum is highly sensitive to small physical and chemical variations among different specimens, and the conductivity values below 200 K are applicable only to tungsten having residual electrical resistivity $\rho_0 = 0.00170\ \mu\Omega$ cm. Values at temperatures below about 1.5 T_m are calculated by using equation (7) and using the constants m, n, and α'' as listed in Table 1 and the parameter $\beta = 0.0696$.

RECOMMENDED VALUES

[Temperature, T, K; Thermal Conductivity, k, W cm^{-1} K^{-1}]

SOLID

T	k	T	k	T	k
0	0	123.2	1.98	1300	1.10
1	14.4	150	1.92	1373.2	1.08
2	28.7	173.2	1.88	1400	1.08
3	42.8	200	1.85	1473.2	1.06
4	56.3	223.2	1.82	1500	1.06
5	68.7	250	1.80	1573.2	1.04
6	79.5	273.2	1.77	1600	1.04
7	88.0	298.2	1.73	1673.2	1.03
8	93.8	300	1.74	1700	1.02
9	96.8	323.2	1.71	1773.2	1.01
10	97.1	350	1.67	1800	1.01
11	95.0	373.2	1.63	1873.2	0.997
12	91.1	400	1.59	1900	0.994
13	86.0	473.2	1.50	1973.2	0.984
14	79.4	500	1.46	2000	0.980
15	72.0	573.2	1.39	2073.2	0.971
16	64.5	600	1.37	2173.2	0.960
18	51.2	673.2	1.32	2200	0.957
20	40.5	700	1.30	2273.2	0.950
25	23.2	773.2	1.27	2400	0.937
30	14.4	800	1.25	2473.2	0.931
35	9.61	873.2	1.22	2600	0.920
40	6.92	900	1.21	2673.2	0.914
45	5.27	973.2	1.19	2800	0.906
50	4.27	1000	1.18	2873.2	0.902
60	3.14	1073.2	1.16	3000	0.895
70	2.58	1100	1.15	3073	0.892
80	2.29	1173.2	1.13	3200	0.887
90	2.17	1200	1.12	3273	0.885
100	2.08	1273.2	1.11	3400	0.882
				3600	0.878*
				3660	0.877*

*Extrapolated.

THERMAL CONDUCTIVITY OF TUNGSTEN (continued)

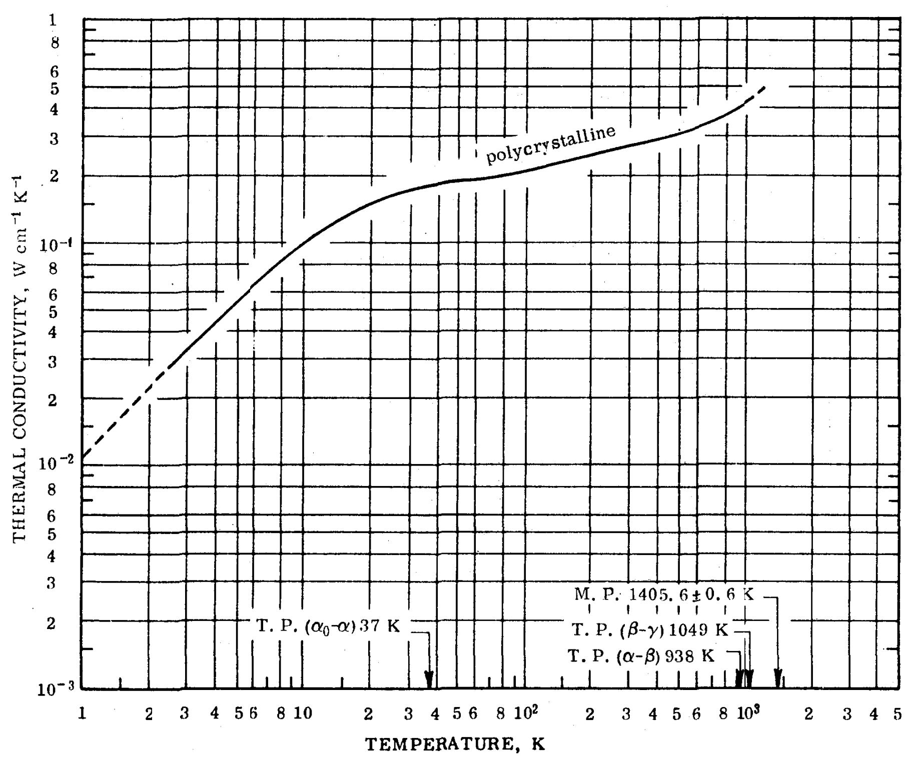
PROVISIONAL VALUES

LIQUID

T	k	T	k
3660	0.705*	11000	0.732*
3673	0.704*	11273	0.721*
3800	0.723*	12000	0.693*
3873	0.721*	12273	0.681*
4000	0.730*	13000	0.646*
4073	0.735*	13273	0.632*
4273	0.748*	14000	0.594*
4500	0.761*	14273	0.579*
4773	0.780*	15000	0.538*
5000	0.785*	15273	0.521*
5273	0.795*	16000	0.478*
5500	0.801*	16273	0.461*
5773	0.809*	17000	0.416*
6000	0.811*	17273	0.398*
6273	0.817*	18000	0.352*
6773	0.818*	18273	0.334*
7000	0.819*	19000	0.286*
7273	0.819*	19273	0.267*
7500	0.819*	20000	0.217*
7773	0.818*	20273	0.198*
8000	0.816*	21000	0.146*
8273	0.813*	21273	0.127*
8500	0.810*	22000	0.0736*
8773	0.805*	22273	0.054*
9000	0.799*		
9273	0.791*		
9500	0.784*		
9773	0.776*		
10000	0.768*		
10273	0.758*		

* Estimated.

THERMAL CONDUCTIVITY OF URANIUM



REMARKS

The recommended values are for well-annealed high-purity polycrystalline uranium and are considered accurate to within ±10% of the true values at temperatures from 300 to 900 K and ±15 to ±20% at other temperatures. The values below room temperature are applicable only to uranium having residual electrical resistivity $\rho_0 = 2.14\ \mu\Omega$ cm.

RECOMMENDED VALUES

[Temperature, T, K; Thermal Conductivity, k, W cm^{-1} K^{-1}]

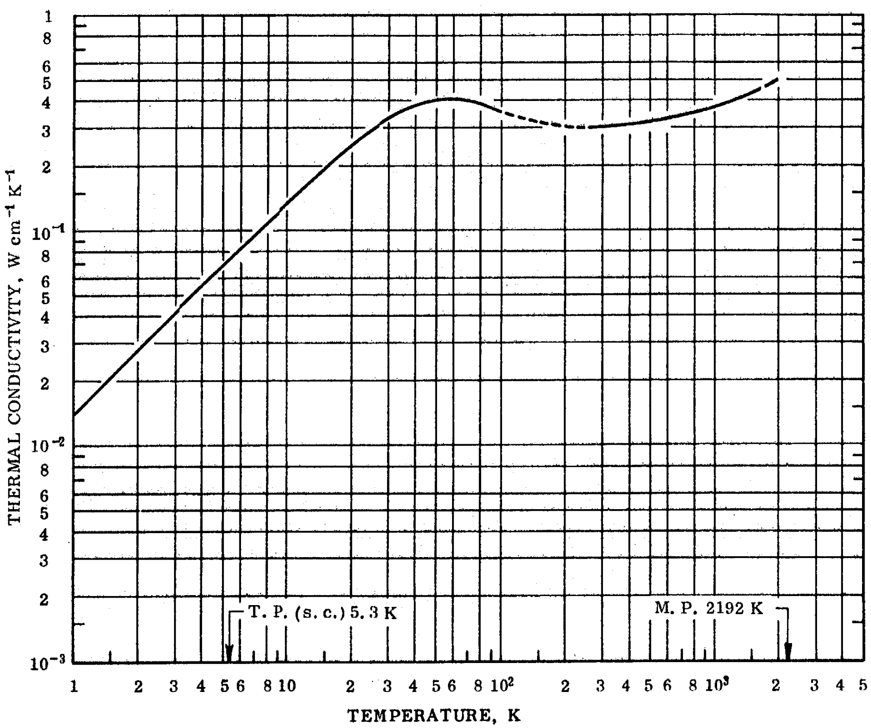
SOLID

Polycrystalline

T	k	T	k
0	0	123.2	0.226
1	0.0114*	150	0.236
2	0.0228*	173.2	0.243
3	0.0338	200	0.251
4	0.0442	223.2	0.257
5	0.0541	250	0.264
6	0.0638	273.2	0.270
7	0.0731	298.2	0.275
8	0.0818	300	0.276
9	0.0898	323.2	0.281
10	0.0980	350	0.286
11	0.106	373.2	0.291
12	0.113	400	0.296
13	0.120	473.2	0.311
14	0.126	500	0.317
15	0.132	573.2	0.334
16	0.138	600	0.340
18	0.149	673.2	0.357
20	0.158	700	0.364
25	0.167	773.2	0.381
30	0.173	800	0.388
35	0.178	873.2	0.405
40	0.182	900	0.413
45	0.186	973.2	0.431
50	0.189	1000	0.439
60	0.196	1073.2	0.456
70	0.202	1100	0.463
80	0.208	1173.2	0.483
90	0.212	1200	0.490*
100	0.217		

*Extrapolated.

THERMAL CONDUCTIVITY OF VANADIUM



REMARKS

The recommended values are for well-annealed high-purity vanadium and are considered accurate to within ±10% of the true values at room temperature and above and ±15% below 30 K. Values between 30 K and room temperature are conjectured and very uncertain. The values below 200 K are applicable only to vanadium having residual electrical resistivity $\rho_0 = 1.72\ \mu\Omega$ cm.

RECOMMENDED VALUES

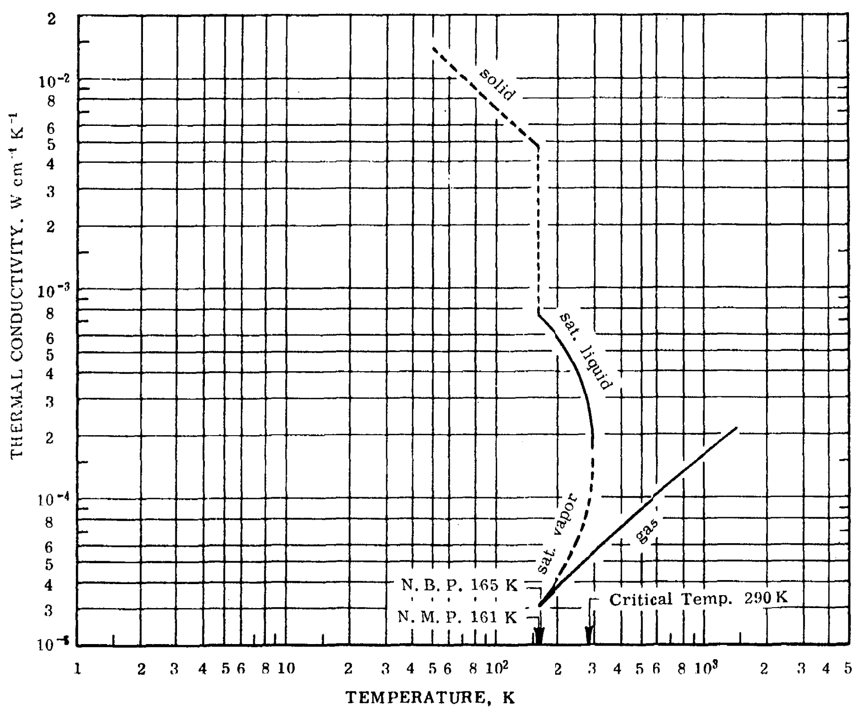
[Temperature, T, K; Thermal Conductivity, k, W cm^{-1} K^{-1}]

SOLID

T	k	T	k
0	0	350	0.309
1	0.0142	373.2	0.310
2	0.0282	400	0.313
3	0.0422	473.2	0.319
4	0.0561	500	0.322
5	0.0697	573.2	0.330
6	0.0835	600	0.333
7	0.0971	673.2	0.342
8	0.111	700	0.345
9	0.125	773.2	0.354
10	0.138	800	0.357
11	0.151	[illegible]	0.366
12	0.165	900	0.369
13	0.177	973.2	0.379
14	0.190	1000	0.382
15	0.202	1073.2	0.392
16	0.214	1100	0.395
18	0.237	1173.2	0.405
20	0.258	1200	0.408
25	0.305	1273.2	0.417
30	0.342	1300	0.421
35	0.369	1373.2	0.430
40	0.389	1400	0.434
45	0.401	1473.2	0.443
50	0.405	1500	0.446
60	0.406	1573.2	0.455
70	0.402	1600	0.459
80	0.390	1673.2	0.468
90	0.373	1700	0.472
100	0.358*	1773.2	0.481
123.2	0.336*	1800	0.484
150	0.324*	1873.2	0.494
173.2	0.318*	1900	0.497*
200	0.313*	1973.2	0.506*
223.2	0.310*	2000	0.509*
250	0.308*		
273.2	0.307*		
298.2	0.307		
300	0.307		
323.2	0.308		

*Extrapolated or interpolated.

THERMAL CONDUCTIVITY OF XENON



RECOMMENDED VALUES

[Temperature, T, K; Thermal Conductivity, k, W cm^{-1} K^{-1}]

SOLID		SATURATED LIQUID		SATURATED VAPOR	
T	k x 10^3	T	k x 10^3	T	k x 10^3
50	14.4*				
60	12.0*	161	0.74	165	0.032*
70	10.5*	170	0.70	170	0.034*
80	9.2*	180	0.66	180	0.037*
90	8.2*	190	0.62	190	0.041*
100	7.5*	200	0.58	200	0.044*
110	6.8*	210	0.54	210	0.048*
120	6.3*	220	0.50	220	0.051*
130	5.8*	230	0.46	230	0.055*
140	5.4*	240	0.42	240	0.060*
150	5.1*	250	0.38	250	0.066*
160	4.8*	260	0.34	260	0.073*
161	4.8*	270	0.31	270	0.084*
		280	0.27	280	0.098*
		290	0.16*†	290	0.16*†

REMARKS

Difficulties in sample characterization limit the accuracy of the recommended values to possibly within 20% for the solid material. The liquid values should be reliable to within 5% except possibly in the immediate vicinity of the critical point. The vapor values are felt to have a similar accuracy below 250 K. The gas values should be accurate to a few percent below 500 K, the uncertainty then increasing to at least 5% at 1000 K and 10% at 1500 K.

* Estimated or extrapolated, hence provisional.
† Pseudo-critical value.

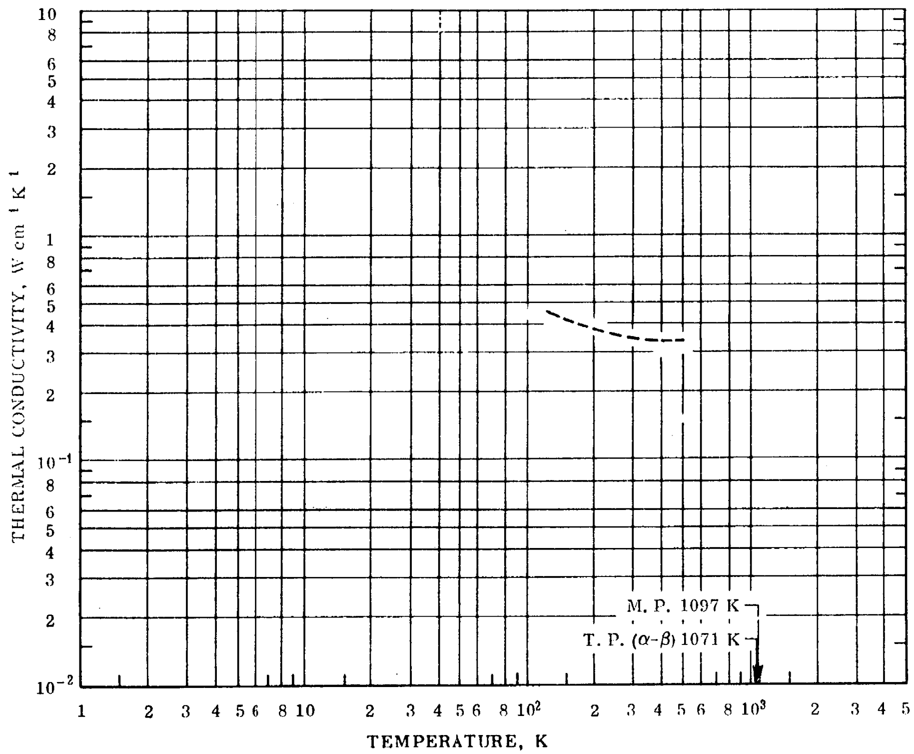
THERMAL CONDUCTIVITY OF XENON (continued)

RECOMMENDED VALUES

GAS
(At 1 atm)

T	k x 10^3	T	k x 10^3	T	k x 10^3
		500	0.0905	850	0.142
165	0.0325	510	0.0920	860	0.143
170	0.0334	520	0.0935	870	0.145
180	0.0352	530	0.0950	880	0.146
190	0.0370	540	0.0965	890	0.147
200	0.0388	550	0.0980	900	0.149
210	0.0406	560	0.0995	910	0.150
220	0.0424	570	0.1010	920	0.151
230	0.0442	580	0.1025	930	0.152
240	0.0460	590	0.1040	940	0.154
250	0.0478	600	0.1055	950	0.155
260	0.0496	610	0.1070	960	0.156
270	0.0514	620	0.1085	970	0.157
280	0.0532	630	0.1100	980	0.159
290	0.0550	640	0.1115	990	0.160
300	0.0569	650	0.1130	1000	0.161
310	0.0587	660	0.1145	1050	0.167
320	0.0605	670	0.1160	1100	0.173
330	0.0623	680	0.1175	1150	0.179
340	0.0641	690	0.1190	1200	0.185
350	0.0659	700	0.1205	1250	0.190
360	0.0677	710	0.1220	1300	0.196
370	0.0695	720	0.1234	1350	0.202
380	0.0713	730	0.1249	1400	0.208
390	0.0731	740	0.1263	1450	0.213
400	0.0745	750	0.1278	1500	0.219
410	0.0761	760	0.129		
420	0.0777	770	0.131		
430	0.0793	780	0.132		
440	0.0809	790	0.134		
450	0.0825	800	0.135		
460	0.0841	810	0.136		
470	0.0857	820	0.138		
480	0.0873	830	0.139		
490	0.0889	840	0.140		

THERMAL CONDUCTIVITY OF YTTERBIUM



REMARKS

The provisional values are for high-purity ytterbium and are probably good to ±20% near room temperature and ±30% at extreme temperatures.

PROVISIONAL VALUES

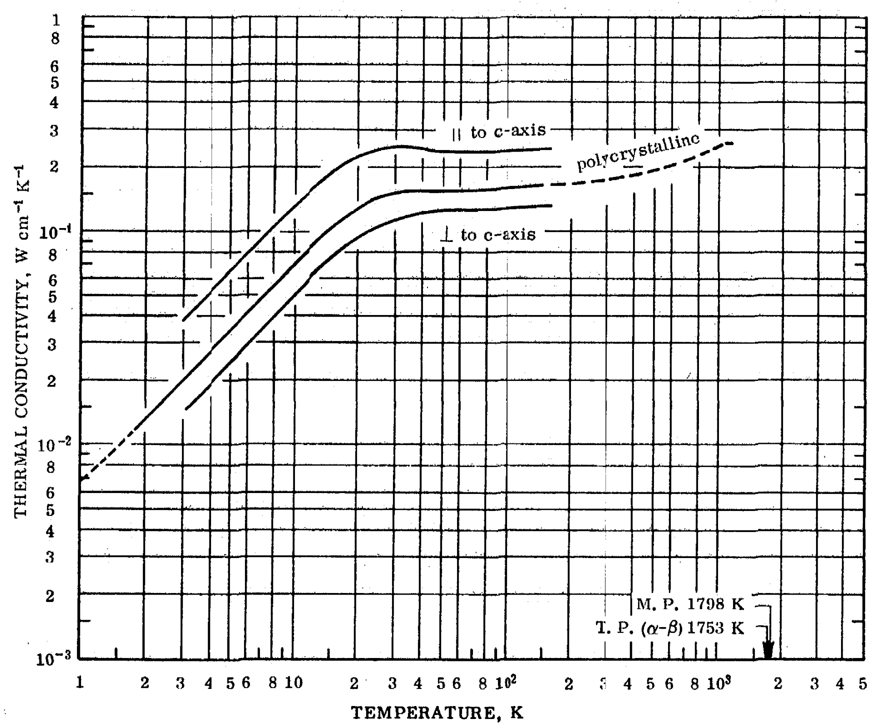
[Temperature, T, K; Thermal Conductivity, k, W cm^{-1} K^{-1}]

SOLID

T	k
123.2	0.456*
150	0.423*
173.2	0.402*
200	0.384*
223.2	0.372*
250	0.361*
273.2	0.354*
298.2	0.349*
300	0.349*
323.2	0.347*
350	0.345*
373.2	0.343*
400	0.341*
473.2	0.338*
500	0.337*

* Estimated.

THERMAL CONDUCTIVITY OF YTTRIUM



REMARKS

The provisional values are for well-annealed high-purity yttrium and are probably good to ±10% near room temperature and ±15 to ± 20% at other temperatures. The values below 100 K for $k_{//}$, $k_{\perp}$, and k_{poly} are applicable only to yttrium having residual electrical resistivity ρ_0 = 2.30, 8.70, and 5.54 $\mu\Omega$ cm, respectively.

PROVISIONAL VALUES

[Temperature, T, K; Thermal Conductivity, k, W cm^{-1} K^{-1}]

SOLID

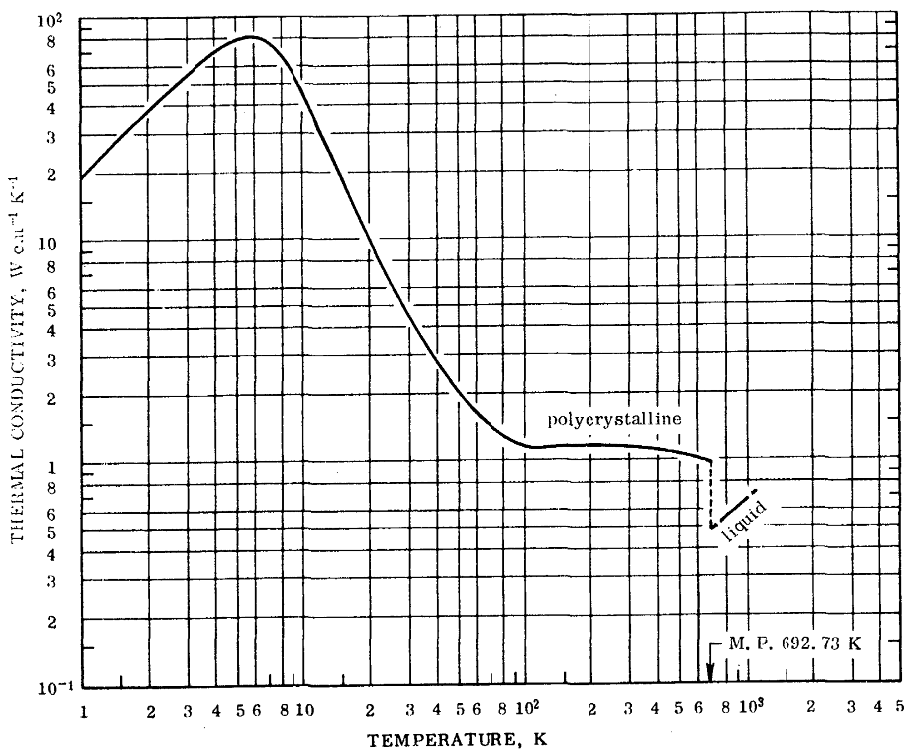
T	// to c-axis k	⊥ to c-axis k
3	0.0389	0.0138
4	0.0526	0.0189
5	0.0662	0.0240
6	0.0795	0.0292
7	0.0927	0.0343
8	0.106	0.0395
9	0.119	0.0445
10	0.132	0.0497
11	0.144	0.0545
12	0.156	0.0594
13	0.167	0.0646
14	0.178	0.0695
15	0.188	0.0742
16	0.198	0.0787
18	0.214	0.0870
20	0.228	0.0943
25	0.245	0.107
30	0.248	0.115
35	0.244	0.118
40	0.238	0.121
45	0.236	0.122
50	0.236	0.124
60	0.236	0.125
70	0.237	0.126
80	0.238	0.127
90	0.240	0.128
100	0.241	0.128
123.2	0.245	0.130
150	0.247	0.133
160	0.248	0.133

Polycrystalline

T	k	T	k
0	0	123.2	0.161
1	0.00648*	150	0.164
2	0.0133	173.2	0.165*
3	0.0199	200	0.166*
4	0.0271	223.2	0.168*
5	0.0343	250	0.169*
6	0.0415	273.2	0.170*
7	0.0486	298.2	0.172*
8	0.0558	300	0.172*
9	0.0628	323.2	0.173*
10	0.0699	350	0.175*
11	0.0765	373.2	0.177*
12	0.0832	400	0.180*
13	0.0900	473.2	0.188*
14	0.0964	500	0.192*
15	0.102	573.2	0.201*
16	0.106	600	0.205*
18	0.119	673.2	0.213*
20	0.128	700	0.217*
25	0.142	773.2	0.226*
30	0.150	800	0.230*
35	0.151	873.2	0.239*
40	0.152	900	0.242*
45	0.153	973.2	0.249*
50	0.154	1000	0.250*
60	0.155	1073.2	0.254*
70	0.156	1100	0.255*
80	0.157	1173.2	0.255*
90	0.158		
100	0.159		

*Extrapolated or estimated.

THERMAL CONDUCTIVITY OF ZINC



REMARKS

The recommended values are for well-annealed high-purity polycrystalline zinc and are considered accurate to within ±3% of the true values at moderate temperatures, ±5% at high temperatures, ±10% from 20 to 100 K, and ±15% below 20 K. The thermal conductivity at temperatures near and below the corresponding temperature, T_m, of the conductivity maximum is highly sensitive to small physical and chemical variations among different specimens, and the recommended values below 150 K are applicable only to zinc having residual electrical resistivity $\rho_0 = 0.00128\ \mu\Omega$ cm. Values at temperatures below about 1.5 T_m are calculated by using equation (7) and the constants m, n, and α'' as listed in Table 1 and the parameter $\beta = 0.0525$. Values for molten zinc are provisional and they are probably good to ±15%.

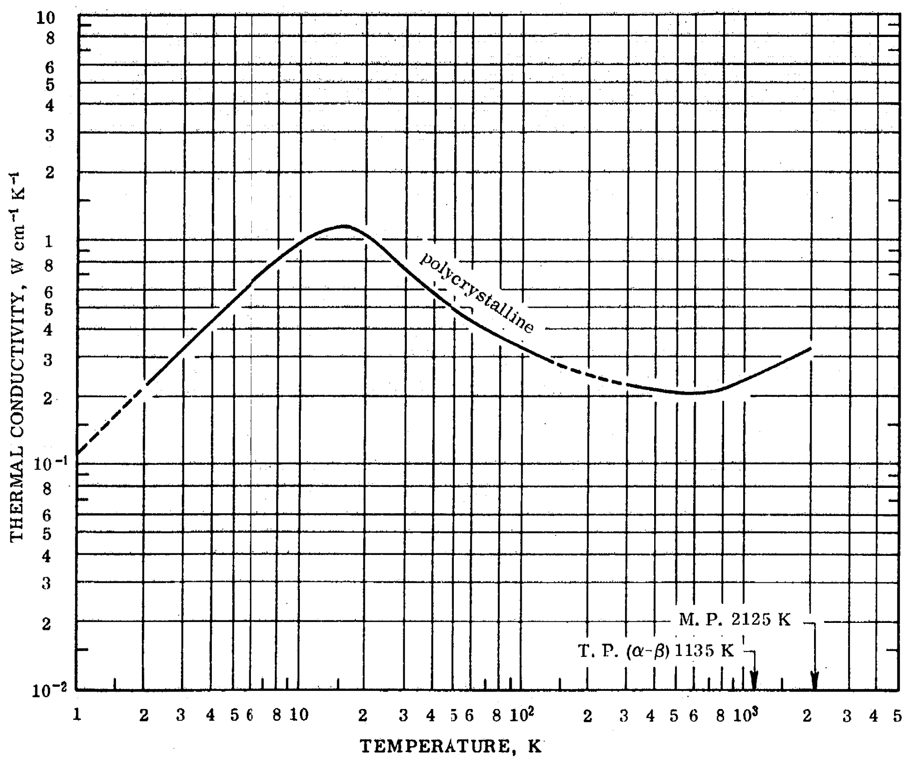
RECOMMENDED VALUES †

[Temperature, T, K; Thermal Conductivity, k, W cm^{-1} K^{-1}]

SOLID Polycrystalline T	k	T	k	LIQUID T	k
0	0	60	1.65	692.73	0.495*
1	19.0	70	1.43	700	0.499*
2	37.9	80	1.30	773.2	0.542
3	55.8	90	1.22	800	0.557
4	70.9	100	1.17	873.2	0.599
5	80.7	123.2	1.16	900	0.615
6	83.1	150	1.17	973.2	0.657
7	78.7	173.2	1.17	1000	0.673
8	69.7	200	1.18	1073.2	0.715*
9	58.0	223.2	1.18	1100	0.730*
10	47.3	250	1.18		
11	38.8	273.2	1.17		
12	31.9	298.2	1.16		
13	26.5	300	1.16		
14	22.4	323.2	1.15		
15	19.2	350	1.14		
16	16.6	373.2	1.12		
18	12.7	400	1.11		
20	9.98	473.2	1.08		
25	6.26	500	1.07		
30	4.42	573.2	1.04		
35	3.42	600	1.03		
40	2.80	673.2	1.00		
45	2.36	692.73	0.993		
50	2.05				

* Extrapolated.
† Values for molten zinc are provisional.

THERMAL CONDUCTIVITY OF ZIRCONIUM



REMARKS

The recommended values are for well-annealed high-purity polycrystalline zirconium and are considered accurate to within ±10% of the true values at temperatures below 800 K, the uncertainity increasing to ±20 to ±25% as the melting point is approached. The thermal conductivity at temperatures near and below the corresponding temperature, T_m, of the conductivity maximum is highly sensitive to small physical and chemical variations among different specimens, and the recommended values below room temperature are applicable only to zirconium having residual electrical resistivity $\rho_0 = 0.218\ \mu\Omega$ cm. Values at temperatures below about 1.5 T_m are calculated to fit experimental data by using equation (7) and using the constants m, n, and α'' as listed in Table 1 and the parameter $\beta = 8.93$.

RECOMMENDED VALUES

[Temperature, T, K; Thermal Conductivity, k, W cm^{-1} K^{-1}]

SOLID

Polycrystalline

T	k	T	k
0	0	373.2	0.218
1	0.112*	400	0.216
2	0.224*	473.2	0.211
3	0.335	500	0.210
4	0.444	573.2	0.207
5	0.551	600	0.207
6	0.653	673.2	0.208
7	0.750	700	0.209
8	0.839	773.2	0.213
9	0.918	800	0.216
10	0.988	873.2	0.223
11	1.05	900	0.226
12	1.09	973.2	0.234
13	1.13	1000	0.237
14	1.15	1073.2	0.246
15	1.16	1100	0.249
16	1.16	1173.2	0.257
18	1.13	1200	0.260
20	1.08	1273.2	0.267
25	0.906	1300	0.270
30	0.761	1373.2	0.277
35	0.663	1400	0.279
40	0.590	1473.2	0.286
45	0.538	1500	0.288
50	0.497	1573.2	0.295
60	0.442	1600	0.297
70	0.402	1673.2	0.303
80	0.374	1700	0.306
90	0.350	1773.2	0.312
100	0.332	1800	0.314
123.2	0.302	1873.2	0.320
150	0.278*	1900	0.322
173.2	0.265*	1973.2	0.328
200	0.252*	2000	0.330
223.2	0.245*		
250	0.237*		
273.2	0.232*		
300	0.227		
323.2	0.224		
350	0.221		

*Extrapolated or interpolated.

THERMAL CONDUCTIVITY OF ACTINIUM, AMERICIUM, ASTATINE, BERKELIUM, CALIFORNIUM, CURIUM, EINSTEINIUM, FERMIUM, FRANCIUM, LAWRENCIUM, MENDELEVIUM, NOBELIUM, POLONIUM, PROTACTINIUM, ELEMENT 104, ELEMENT 105, ELEMENT 106, AND ELEMENT 118

No information is available in the literature for the thermal conductivity of these elements. Very rough estimations of their thermal conductivity values at 300 K have been made and they are given below. For details of the estimations, the reader is referred to the comprehensive volume [1]. The values are very uncertain and are probably good to ±50%.

	Thermal Conductivity at 300 K ($W\ cm^{-1}\ K^{-1}$)
Actinium	0.12
Americium	0.1
Astatine	0.017
Berkelium	0.1
Californium	0.1
Curium	0.1
Einsteinium	0.1
Fermium	0.1
Francium	0.15
Lawrencium	0.1
Mendelevium	0.1
Nobelium	0.1
Polonium	0.20
Protactinium	0.47
Element 104	0.23
Element 105	0.58
Element 106	1.9
Element 118	2.3×10^{-5} (in the gaseous state; N.B.P. 262.5 K)

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