The Calculated Thermodynamic Properties of Superfluid Helium-4

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Comprehensive tables of the primary thermodynamic properties of superfluid helium-4, such as the specific heat and entropy, are presented as computed from the Landau quasiparticle model, with the aid of inelastic neutron scattering data. The neutron data are represented by continuous functions of temperature, pressure, and wave number and certain excitation properties such as number density, normal and superfluid densities are calculated directly from it. A discussion of the methods used in our computations is included, and comparisons of computed and experimental results are made where applicable. Certain inadequacies of present theoretical methods to describe the thermodynamic properties are reported, and the use of an effective spectrum is introduced to offset some of these difficulties. Considerable experimental effort is also needed to improve the present situation.

Key words: Computed thermodynamic properties; entropy; equation of state; excitation spectrum; helium-4; normal fluid helium-4; phonons; rotons; specific heat; superfluid helium-4.

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Nomenclature

Symbol or expression	Physical quantity	Unit symbol or value
m	Helium-4 mass	6.646×10^{-24} g
k	Boltzmann's constant	1.38054×10^{-23} J·K^{-1}
h, ($\hbar$)	Planck's constant, ($\div 2\pi$)	6.6256×10^{-34} J·s (1.0545×10^{-34} J·s)
P	Pressure	atm (1 atm = 1.01325 ·10^5 N·m^{-2})
V	Molar volume	cm^3·mol^{-1}
T	Temperature	K
PVT	Pressure-Volume-Temperature, the equation of state	
SVP	Saturated vapor pressure	
$T_\lambda(P)$	The temperature at which liquid helium-4 becomes a superfluid for a given pressure	K
helium I (He I)	The non-superfluid state of liquid helium-4, $T > T_\lambda$	
helium II (He II)	The superfluid state of liquid helium-4, $T < T_\lambda$	
ρ	Density	g·cm^{-3}
ρ_n	Density of the normal component	g·cm^{-3}
ρ_s	Density of the superfluid component	g·cm^{-3}
ϵ/k	Energy of an excitation $\div k$	K
$\omega=\epsilon/\hbar$	Frequency of an excitation	rad·s^{-1}
p	Excitation momentum	g·cm·s^{-1}

Nomenclature — Continued

Symbol or expression	Physical quantity	Unit symbol or value
$q=p/\hbar$	Wave number of excitation	Å^{-1} ($1\ \text{Å}^{-1}=10^{10}\text{m}^{-1}$)
p_0	Momentum at the roton minimum	$\text{g}\cdot\text{cm}\cdot\text{s}^{-1}$
p_c	Momentum at which $d\epsilon/dp=u_1$	$\text{g}\cdot\text{cm}\cdot\text{s}^{-1}$
$n(p)$	Distribution of excitations as a function of momentum	cm^{-3}
Δ	Roton energy	K
Δ_t	"Thermal" roton energy	K
μ	Roton effective mass	m
μ_t	"Thermal" roton effective mass	m
Γ/k	Half width of scattered neutron distribution ÷ k	K
$S(q, \omega)$	Dynamic structure factor	
S	Entropy	$\text{J}\cdot\text{g}^{-1}\cdot\text{K}^{-1}$
u_1, u_2, u_4	Velocity of first, second, fourth sound	$\text{m}\cdot\text{s}^{-1}$
u_I, u_{II}	Velocity of first, second sound, uncorrected	$\text{m}\cdot\text{s}^{-1}$
ϵ_{max}/k	Energy of maxon peak ÷ k	K
N_r	Roton number density	cm^{-3}
N_p	Phonon number density	cm^{-3}
a_n	Coefficients of excitation energy series	$\text{K}\cdot\text{Å}^n$
α_P	Coefficient of thermal expansion	K^{-1}
κ_T	Isothermal compressibility	$\text{cm}^2\cdot\text{dyne}^{-1}$
U_G	Grüneisen constant	
L	Latent heat	$\text{J}\cdot\text{g}^{-1}$
F	Helmholtz free energy	$\text{J}\cdot\text{g}^{-1}$
Φ	Gibbs free energy	$\text{J}\cdot\text{g}^{-1}$
W	Enthalpy	$\text{J}\cdot\text{g}^{-1}$
C_P	Specific heat at constant pressure	$\text{J}\cdot\text{g}^{-1}\cdot\text{K}^{-1}$
C_V	Specific heat at constant volume	$\text{J}\cdot\text{g}^{-1}\cdot\text{K}^{-1}$
$\gamma=C_P/C_V$	Ratio of specific heats	
$V_0, L_0, F_0, \Phi_0, W_0$, etc.	Ground state ($T=0$) values of quantities	
V_E, F_E, Φ_E, W_E, etc.	Finite temperature values of quantities due to excitations only	

1. Introduction

Liquid helium is a rewarding subject for the study of thermodynamic properties, especially because helium II, the lower temperature phase, exhibits the property of superfluidity. The hydrodynamics of this phase are extraordinary: both normal viscous behavior and superflow may be exhibited in closely related experiments. Phenomenologically, one speaks of a "two-fluid" behavior in which the fluid (of density ρ) [1] acts dynamically as if a fraction of effective density ρ_n flows as a normal fluid, and a fraction of effective density $\rho_s=\rho-\rho_n$ flows as an inviscid fluid. This two-fluid motion of helium II leads to some very unusual results, such as the wave-like rather than diffusive propagation of temperature fluctuations (called second sound). Furthermore, the thermodynamic properties are deeply related to the hydrodynamic: for example, the Gibbs free energy is related to the square of the relative velocity between the two fluids. We shall be concerned principally with the static properties of helium II in which all net flow velocities are zero.

On a deeper level, one has the Landau picture [1] [2] in which the entire fluid is superfluid at absolute zero. As the temperature [3] is raised, the heat content is described entirely in terms of "elementary excitations" of the superfluid. At low temperatures these are "phonons", at higher temperatures more complex excitations called "rotons" are excited.

The energy $\epsilon\,(=\hbar\omega)$ and momentum $p\,(=\hbar q)$ of the elementary excitations in superfluid helium may be represented by the excitation spectrum (dispersion curve) first proposed by Landau [1] which is shown schematically in figure 1. We will refer again to this

[1] All symbols used in this paper are defined in the section labeled Nomenclature.

[2] Figures in brackets indicate literature references in section 7.

[3] Experiments at liquid helium temperatures almost invariably use the 1958 vapor pressure scale [12]. Caution should be used with earlier data.

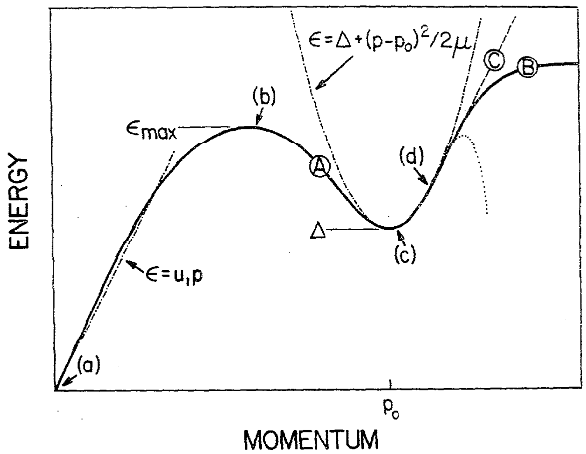

FIGURE 1. A schematic diagram of the excitation spectrum for helium II. Details and labels are discussed in the text.

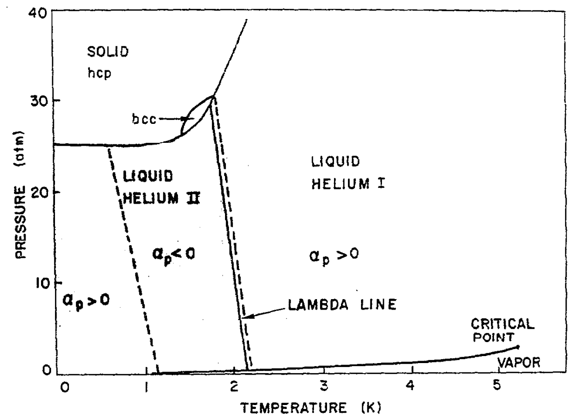

FIGURE 2. A schematic phase diagram for helium-4. The pressure of the liquid-gas transition line has been exaggerated. The hexagonal close-packed and body centered cubic (bcc) phases of the solid are shown, as are the loci of zero thermal expansion (dashed lines).

figure in subsequent sections. In recent years many of the features, and in some cases the entire dispersion curve, have been measured by inelastic thermal neutron scattering techniques for different pressures and temperatures. (See for example references [2–10].) Landau has put forth a simple but elegant theory which allows one to calculate the thermodynamic properties of He II at low temperatures from the excitation spectrum.

The purpose of this paper is to give an account of the equilibrium thermodynamic properties of He II and related quantities such as the velocities of first, second, and fourth sounds and properties of the excitations themselves. These quantities are used in a wide variety of contexts, both experimental and theoretical; and it is often important that the data for different properties be thermodynamically consistent. The ideal solution to this problem would be a critical compilation of experimental properties over the entire $T-P$ plane for He II, and some day this will undoubtedly be possible. At the time this project was begun (1972), the tables in the appendices of the books by Wilks [11] and Donnelly [12] were the most complete available, and far from adequate for the task undertaken here.

Another promising avenue is the use of Landau's theory mentioned above. The thermodynamic properties along the vapor pressure curve have been extracted from neutron scattering measurements with reasonable success by Bendt, Cowan, and Yarnell [10]. We have, then, the possibility that direct thermodynamic measurements can be supplemented by the increasing body of neutron data indicated by the references cited. In particular, we were greatly encouraged by the appearance in 1972 of the landmark study of neutron scattering from rotons by Dietrich, Graf, Huang, and Passell at Brookhaven National Laboratory [3].

The superfluid region of the helium $P-T$ phase diagram is shown schematically as the shaded portion of figure 2. It is to this area that our analysis and subsequent tabulations apply. For all pressures in this shaded region, there is a temperature $T_\lambda(P)$ above which the superfluid properties cease to exist, and one has a classical liquid phase (called helium I). The line which separates these two regions is called the lambda-line, in recognition of the characteristic anomaly in the specific heat observed along this line. In this paper, we do not treat the thermodynamic properties in the immediate vicinity of this line. Such a treatment has, however, been undertaken in an earlier volume of this Journal, by McCarty [13], who has reported on the thermodynamic properties of helium I; and IUPAC Helium-4 tables by Angus, de Reuck, and McCarty [14] are in the process of completion at the time of writing of the present article.

The results described here are the result of a lengthy series of investigations by our research group at the University of Oregon. The first product of our analysis of the Brookhaven data was a report on the Landau parameters [15]. An early attempt at approximating the dispersion curve in a piecewise fashion was reported at LT13 [16]. This proved to be imprecise and was succeeded by the series representation used in this paper [17]. The results of these investigations were summarized in the Ph. D. thesis of J. S. Brooks, which appeared in 1973 [18]. We issued the Tables from that thesis in the form of a University of Oregon Technical Report in December 1973 [19], requesting contributions from other laboratories. We were gratified to receive a number of suggestions, corrections, and reports of new experimental work. In particular, the thesis of Van Degrift on the expansion coefficient [20], and a systematic study of first, second, and fourth sound by Maynard and Rudnick, began at UCLA, have been extremely useful, as has some independent work on dispersion curves by Dr. Maynard [21]. Since this work was submitted, the UCLA measurements have been completed and sent for publication as shown in [21].

The problem of the proper treatment of the statistical mechanics of interacting Bose excitations has taken considerable effort. Much confusion about the effects of temperature-dependent levels and thermal expansion has been removed with the recent appearance of papers by Goodstein, Brooks, Donnelly, and Roberts [22], Roberts and Donnelly [23, 24]. In particular, the latter authors have developed the set of expressions displayed in table I which allow the calculation of the equilibrium properties of He II when the energy levels of excitations are known from experiment. This is the basis of the present calculated tables, which represent a considerable advance in accuracy over the calculations in our earlier work [18, 19]. For example, the need for an empirical equation of state is eliminated altogether.

The computations reported here have been carried out by James Gibbons on a Hewlett-Packard 2100 A computer.

2. Theoretical Background

Although several authors have discussed the Landau spectrum and theory in detail (see, for example, Wilks [11], Donnelly [12], Keller [25], Khalatnikov [26]) we present here a brief description for completeness. Landau's theory for superfluid helium is based on the assumption that the thermal excitations in the liquid can be described as constituting a weakly interacting gas with the energy spectrum given as the solid line in figure 1. It is also assumed that these excitations obey Bose statistics, and therefore the number density of excitations of a particular momentum, $n(p)$ is given by

$$n(p)=\frac{1}{h^3}\left[e^{\epsilon(p)/kT}-1\right]^{-1}. \quad (1)$$

From this expression, we see that the low-lying regions of the energy spectrum will contribute predominantly to the thermodynamic properties, and referring to figure 1 we find that there are two such regions on interest. The first is for small momenta, where the spectrum is approximately linear, and is called the phonon branch. The other is the energy minimum about momentum p_0, which is nearly parabolic and is called the roton branch, or roton minimum. Here the energy is much higher, but the density of states is also very large.

The experimentally observed values of the minimum roton energy Δ are large enough that the Boltzmann distribution is an adequate approximation to eq (1). As a rough guide to thinking of the thermodynamics of helium II, it is sufficient to recognize that below 1 K, the phonon excitations are the more numerous and dominate the thermal properties, whereas at higher temperatures the number of rotons increases exponentially with temperature, and rotons become predominant thermodynamically above 1 K.

If one knows the dispersion curve of the excitations, it is straightforward to construct a partition function and proceed by standard statistical mechanical methods to compute the entire set of equilibrium properties of the liquid. As we shall see, this ideal is far from realizable today.

At very low temperatures, when the liquid is relatively free of excitations, inelastically scattered neutrons are observed to form a very sharp spectrum, limited only by the instrumental resolution of the analyzing spectrometer. The location of this spectral line is taken as a measure of the transfer of energy from the incoming neutron beam to single phonons in the liquid, for a given momentum transfer p set by the spectrometer. The result of many such measurements is an excitation spectrum such as is shown in figure 3. It appears theoretically reasonable, and experimentally fairly certain, that the observed excitation spectrum can be identified with the dispersion curve of the elementary excitations in the fluid at low temperatures.

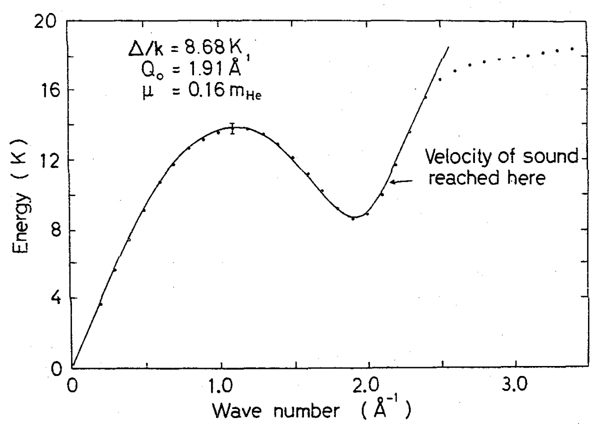

FIGURE 3. The experimentally determined excitation spectrum at 1.1 K, SVP. The dots are the neutron scattering data of Cowley and Woods [2]; the solid line is eqs (20) and (14). The error bar is the smallest experimental error, and is not to be associated with any one data point.

At higher temperatures, however, Yarnell et al. [9], and Henshaw and Woods [5] observed that the widths of the scattered spectra increase rapidly with temperatures. For rotons (at (c) in fig. 1) the linewidths, as measured by the half-width at half maximum Γ, approach the magnitude of the energy itself as T approaches T_λ (i.e., $\Gamma \rightarrow \sim \Delta$ as $T \rightarrow T_\lambda$). This means, among other things, that the lifetimes of the excitations are decreasing rapidly with increasing temperature. Furthermore, the roton energy Δ is observed to decrease with increasing T and increasing P.

The scattered neutron intensity is proportional to the dynamic structure factor $S(q, \omega)$ which is in turn related to density-density correlations in the fluid. The unfolding of the experimental scattered neutron spectra in terms of assumed forms for $S(q, \omega)$ has been discussed in detail by Dietrich et al. [3]. To the best of our knowledge at the time of writing, no one has been able to make a rigorous connection between $S(q, \omega)$ at finite temperatures and the energies which enter the thermodynamic calculations. Dietrich et al. [3] have included the linewidth Γ in their thermodynamic calculations in an ad hoc way; perhaps a complete theory will require considerable information on the observed line shape.

If one were to brush aside the considerations of the last paragraph and try to work with the unfolded dispersion curve $\epsilon(q)$, one would still have the problem of treating the statistical mechanics of interacting Bose excitations whose interactions are manifested by an observed dependence of $\epsilon(q)$ on T and P. Bendt, Cowan, and Yarnell [10] argue that when $\epsilon(q)$ is a function of T alone, the entropy should be given by

$$S=\frac{V}{2\pi^2}\int_0^\infty\left[k\ln(1+n)+\frac{n\epsilon}{T}\right]q^2dq, \tag{2}$$

where n is the Bose distribution function (1). Roberts and Donnelly [23] have presented arguments to show that even at arbitrary T and P, (1) and (2) are still valid provided $\epsilon(q)$ is available from experiment. They have presented a way in which all the thermodynamic properties may be consistently deduced from experimental dispersion curves [24]. We show in table I the expressions which they have derived for the quantities of interest in the present study. In table I we have omitted the subscripts on α_P and κ_T for clarity.

TABLE I. Expressions for thermodynamic quantities

S	$\frac{Vk}{2\pi^2}\int_0^\infty\left[\frac{n\epsilon}{kT}+\ln(1+n)\right]q^2dq$
V	$V_0(P)-\frac{1}{2\pi^2}\int_0^T\frac{VdT}{T}\int_0^\infty\epsilon\left[\left(\frac{\partial n}{\partial P}\right)_{T,q}+\frac{\kappa q}{3}\left(\frac{\partial n}{\partial q}\right)_{P,T}\right]q^2dq$
α_P	$-\frac{1}{2\pi^2T}\int_0^\infty\epsilon\left[\left(\frac{\partial n}{\partial P}\right)_{T,q}+\frac{\kappa q}{3}\left(\frac{\partial n}{\partial q}\right)_{P,T}\right]q^2dq$
F	$F_0(V)+\frac{V}{2\pi^2}\int_0^T\frac{dT}{T}\int_0^\infty\frac{\epsilon}{3}\left(\frac{\partial n}{\partial q}\right)_{V,T}q^3dq$
Φ	$\Phi_0(P)+\frac{1}{2\pi^2}\int_0^T\frac{VdT}{T}\int_0^\infty\frac{\epsilon}{3}\left(\frac{\partial n}{\partial q}\right)_{P,T}q^3dq$
W	$\Phi_0(P)+\frac{1}{2\pi^2}\int_0^T VdT\int_0^\infty\epsilon\left[\left(\frac{\partial n}{\partial T}\right)_{P,q}-\frac{\alpha q}{3}\left(\frac{\partial n}{\partial q}\right)_{P,T}\right]q^2dq$
C_P	$\frac{V}{2\pi^2}\int_0^\infty\epsilon\left[\left(\frac{\partial n}{\partial T}\right)_{P,q}-\frac{\alpha q}{3}\left(\frac{\partial n}{\partial q}\right)_{P,T}\right]q^2dq$
C_V	$\frac{V}{2\pi^2}\int_0^\infty\epsilon\left(\frac{\partial n}{\partial T}\right)_{V,q}q^2dq$

3. Experimental Data Used in the Analysis

In this section the experimental data underlying the Landau theory is discussed.

3.1. Data Obtained by the Inelastic Scattering of Thermal Neutrons from Helium II

The energies and line widths of the elementary excitations of helium II are obtained from examination of inelastically scattered thermal neutrons. The techniques are discussed in detail, for example, in a recent review article by Woods and Cowley [8]. We shall use the measured energy spectrum, following Bendt, Cowan, and Yarnell [10], as the basis for our computations of the thermodynamic properties of helium II from the Landau theory. A completely determined experimental excitation spectrum is shown in figure 3 for $T=1.1$ K, at the SVP. The shape of this spectrum is a complicated function of pressure and temperature, and to use the Landau theory one must first know the detailed spectrum for every value of P and T. A complete set of data for a single pressure and temperature such as is shown in figure 3 is a major experimental undertaking. Hence it is necessary to find a method of estimating the energy spectrum for general P and T accurate enough that derivatives such as appear in table I may be accurately determined. In the sections below, we discuss the salient features of the excitation spectrum obtained from various kinds of experiments, and in section 3.1.e we describe a method of representing the spectrum as a power series in momentum, with pressure- and temperature-dependent coefficients.

3.1.a. The Phonon Branch

For momentum p decreasing to zero, the phonon branch of the energy spectrum approaches linearity, in accordance with theoretical predictions (cf. Feenberg [27]). Here we take the energy spectrum, as indicated at (a) in figure 1, to be

$$\lim_{p\to 0}\epsilon(p)=u_1p, \tag{3}$$

where u_1 is the velocity of ultrasonic (first) sound, a temperature- and pressure-dependent quantity which may be determined experimentally either from the slope of the excitation spectrum in the zero momentum limit, or more conveniently from experimental first sound data (see section 4.2.a).

The first non-linear terms correcting eq. (3) for small, but non-zero, momenta have been the subject of much controversy in the literature in recent years (see Svensson, Woods, and Martel [7], and references therein). These terms may affect the behavior of, for example, the specific heat at temperatures below 0.45 K, as suggested by Phillips, Waterfield, and Hoffer [28]. We will return to this question in section 3.1.e.

3.1.b. The Maxon Branch

The elementary excitations which have energies at or near the first energy maximum, (b) in figure 1, have come to be called "maxons". This part of the spectrum has been measured at 1.1 K, at the vapor pressure as indicated in figure 3, and the peak position has been determined for various pressures at 1.18 K by Graf, Minkiewicz, Møller, and Passell [6] Measurements have also been made by Henshaw and Woods at the vapor pressure and 25.3 atm [4]. From the existing data on the maxon part of the spectrum, we conclude that the peak energy is density dependent only, since no shift in the peak position in momentum space has been observed. Very little data exists on the temperature dependence of the maxon peak. Figure 1 of Bendt, Cowan, and Yarnell [10] and figure 20 of Cowley and Woods [2] suggest it decreases slowly with temperature. Because the maxon energies are relatively high, their contribution to the thermal properties is very small, and the details of this part of the spectrum are not critical to the computations in this paper.

We represent the density dependence of the maxon energy by the expression

$$\epsilon_{\max}(0, \rho_0)/k = E_0 + E_1\rho_0 + E_2\rho_0^2 + E_3\rho_0^3, \qquad (4a)$$

where ρ_0 is the density at $T=0$ and the coefficients E_n are

$E_0 = -216.5672$ (K)

$E_1 = 3998.6005$ $(\mathrm{K \cdot g^{-1} \cdot cm^3})$

$E_2 = -23028.6027$ $(\mathrm{K \cdot g^{-2} \cdot cm^6})$

$E_3 = 44199.7232$ $(\mathrm{K \cdot g^{-3} \cdot cm^9})$

Equation 4a is a fit to the neutron data of Cowley and Woods [2] and Graf et al. [6] and is plotted with the data in figure 4. The rather slow temperature dependence of the peak is represented by

$$\epsilon_{\max}(T, \rho) = \epsilon_{\max}(0, \rho_0)\,(1 - 0.452 \times 10^{-3} T^7). \qquad (4b)$$

Values of $\epsilon_{\max}(T, P)$ are given in table 21, the conversion to pressure being obtained from the equation of state.

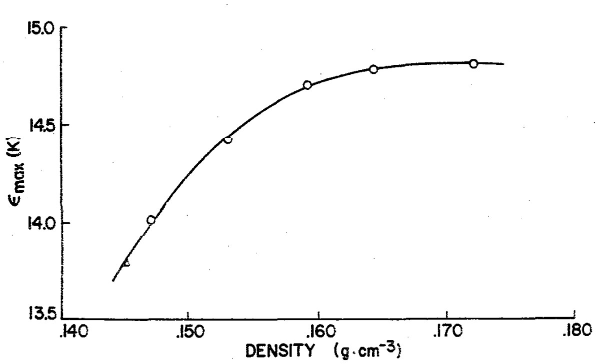

FIGURE 4. The density dependence of the maxon peak. Triangle, Cowley, and Woods [2]: circles, Graf et al. [6]: solid line, eq (4).

3.1.c. The Roton Minimum

The region of the spectrum denoted (c) in figure 1 is called the "roton minimum" and can be very well represented by Landau's parabolic expression

$$\epsilon_{\mathrm{roton}} = \Delta + (p - p_0)^2/2\mu, \qquad (5)$$

where Δ is the minimum roton energy, or energy gap, p_0 is the roton momentum at minimum energy, and μ is the effective mass of excitation near p_0. These three quantities which describe the roton minimum are called the "Landau parameters", and have the typical values at 1.1 K, SVP of $\Delta/k = 8.68$ K, $p_0/\hbar = 1.91\,\text{Å}^{-1}$, and $\mu = 0.16\,m$. The temperature, pressure, and density dependence of these parameters are best known from the experimental work of Dietrich et al. [3], who find that Δ and μ decrease with increasing temperature and/or pressure, but that p_0 is a function of density only:

$$p_0/\hbar = 3.64\,\rho^{1/3}\,\text{Å}^{-1}. \qquad (6)$$

Values of eq (6) are given in table 24.

Donnelly [15] has provided simple relations for the density dependence of Δ and μ at $T=0$, and also for the relation between Δ and μ at finite temperatures:

$$\Delta(\rho, 0)/k = (16.99 - 57.31\rho)\ (\mathrm{K}), \qquad (7)$$

$$\mu(\rho, 0) = (0.32 - 1.103\rho)\,(m), \qquad (8)$$

and

$$\frac{\mu(\rho, T)}{\mu(\rho, 0)} = \frac{\Delta(\rho, T)}{\Delta(\rho, 0)}. \qquad (9)$$

An expression which describes the temperature and density dependence of $\Delta(\rho,T)/k$ has been given by Brooks and Donnelly [16]:

$$\frac{\Delta(\rho,T)}{k} = \frac{\Delta(\rho,0)}{k} - \frac{\rho_n}{\rho}T\left(1 - \frac{aN_r}{T}\right), \qquad (10)$$

where ρ_n is the normal fluid density and N_r is the roton number density (both quantities will be discussed in section 4). Here, $a = 8.75 \times 10^{-23}\mathrm{cm^3 \cdot K}$. Equation (10) gives a good qualitative description of the data of Dietrich et al. [3] to within 20% for Δ[and μ through eq (9)] below the lambda point. These expressions are discussed in detail by Brooks [18].

Recently, motivated by (10), we have performed a least squares fit on the data for Δ and μ, using expressions of the form

$$\Delta(\rho,T)/k = \Delta_1 + \Delta_2\rho + \Delta_3 e^t T/\rho + \Delta_4 e^{2t}\rho + (\Delta_5 + \Delta_6\rho + \Delta_7\rho^2)e^{3t}\ (\mathrm{K}) \qquad (11)$$

and

$$\mu(\rho,T) = U_1 + U_2 e^t T + U_3\rho + U_4 e^t T/\rho + (U_5 + U_6\rho)e^{3t}\ (m), \qquad (12)$$

Here, $t \equiv -\Delta(\rho, 0)/kT$, and the coefficients of eqs (11) and (12) are:

$\Delta_1 = 17.41647$ (K)

$\Delta_2 = -60.48823$ $(\mathrm{K \cdot g^{-1} \cdot cm^3})$

$\Delta_3 = -0.5307478$ $(\mathrm{g \cdot cm^{-3}})$

$\Delta_4 = 1.817261 \times 10^4$ $(\mathrm{K \cdot g^{-1} \cdot cm^3})$

$\Delta_5 = -1.351398 \times 10^7$ (K)

$\Delta_6 = 1.621499 \times 10^8$ $(\mathrm{K \cdot g^{-1} \cdot cm^3})$

$\Delta_7 = -5.062661 \times 10^8$ $(\mathrm{K \cdot g^{-2} \cdot cm^6})$

and

$U_1 = 0.3420601$ (m)

$U_2 = 1.239037$ $(m \cdot \mathrm{K^{-1}})$

$U_3 = -1.238153$ $(m \cdot \mathrm{g^{-1} \cdot cm^3})$

$U_4 = -0.2234561$ $(m \cdot \mathrm{K^{-1} \cdot g \cdot cm^{-3}})$

$U_5 = -13429.95$ (m)

$U_6 = 632197.06$ $(m \cdot \mathrm{g^{-1} \cdot cm^3})$

The experimental roton energy gap and effective mass are shown in figures 5 and 6 with the results of eqs (11) and (12) respectively. Although eqs (11) and (12) suggest an expansion in terms of the roton number density, no particular theoretical significance can be attached to the terms in these equations.

We will see in section 3.1.f below that the experimental values of Δ and μ described in this section will have to be adjusted slightly to obtain the accurate thermodynamic information from the Landau theory.

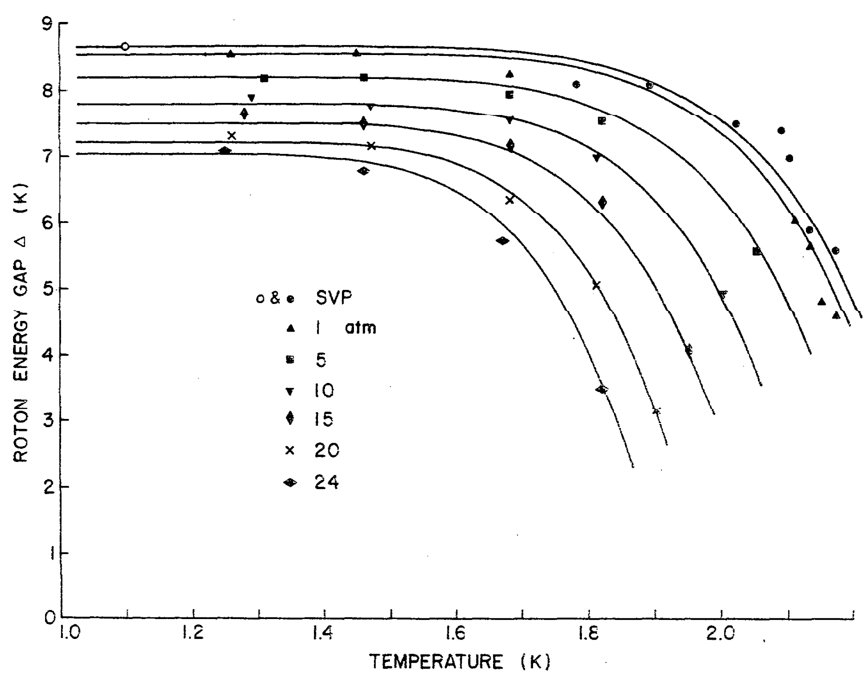

FIGURE 5. Least squares fit of eq (11) to the experimental roton energy gap Δ. Data at SVP, Henshaw and Woods [5] (solid circles), Cowley and Woods [2] (open circle); data at higher pressures, Dietrich et al. [3].

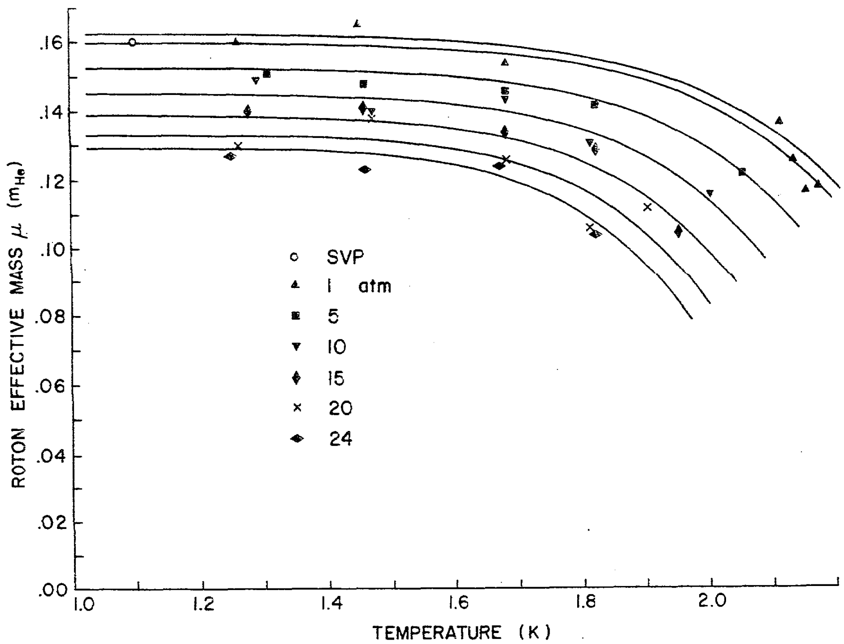

FIGURE 6. Least squares fit of eq (12) to the experimental roton effective mass μ. Data point at SVP, Cowley and Woods [2]: data at higher pressures, Dietrich et al. [3].

3.1.d. The Shoulder Beyond the Roton Minimum

Recent neutron scattering experimental results (Graf, Minkiewicz, Møller, and Passell [6] indicate that for momenta larger than $p_0/\hbar$ the slope of the spectrum approaches the velocity of sound at a momentum $p_c/\hbar$ ($\simeq 2.15$ Å^{-1}), as shown at point (d) in figure 1 and by the arrow in figure 3. The spectrum then bends over and approaches twice the roton energy (curve B in figure 1), finally terminating at a momentum p'. The experimental spectrum in figure 3 also has this qualitative feature. This behavior for large momenta was predicted by Pitaevskii [29] to be

$$\epsilon_P(p) = 2\Delta - \alpha \exp[-a/(p'-p)], \qquad (13)$$

where α and a are constants to be determined. Neutron measurements have not yet been made over a sufficient range to provide information for the dependence of eq (13), and in particular α and a, on temperature and pressure. Fortunately, like the maxon peak, this region of the spectrum has little thermodynamic content, and it is sufficient for our purposes to locate the momentum p_c to the right of p_0 at which $d\epsilon/dp$ from eq (5) reaches the slope of the velocity of first sound u_1, and to represent the dispersion curve as a straight line of slope u_1 above p_c, terminating at $p/\hbar = 3.0$Å^{-1}. This is curve C in figure 1, which is given by

$$\epsilon(p) = u_1\ (p - p_c) + \epsilon(p_c) \qquad p \geq p_c, \qquad (14)$$

where

$$p_c = \mu u_1 + p_0. \qquad (15)$$

This approximation is also indicated in figure 3 as the straight line above $p_c/\hbar \simeq 2.15$Å^{-1}.

3.1.e. A Polynomial Representation for the Excitation Spectrum

We may summarize the behavior of the excitation spectrum described in the previous sections in the following way:

The excitation spectrum starts out at zero momentum and energy with the slope u_1. Hence

$$\epsilon(0) = 0; \qquad \epsilon'(0) = u_1, \qquad (16)$$

at point (a) of figure 1. Here $\epsilon'(p) = d\epsilon(p)/dp$. For momentum increasing from zero, the spectrum attains its first maximum at 1.1Å^{-1}, and

$$\epsilon(1.1\text{Å}^{-1}) = \epsilon_{max}; \qquad \epsilon'(1.1\text{Å}^{-1}) = 0, \qquad (17)$$

at point (b) in figure 1. Continuing down to the roton minimum, we find that the parabolic representation near p_0 provides us with the relations

$$\epsilon(p_0) = \Delta; \qquad \epsilon'(p_0) = 0; \qquad \epsilon''(p_0) = 1/\mu, \quad (18)$$

at point (c) of figure 1. Beyond the roton minimum, for momentum p_c where the slope approaches the velocity at sound, we finally have

$$\epsilon'(p_c) = u_1 \qquad (19)$$

at point (d) in figure 1.

Clearly, eqs (16) through (19) represent the most important features of the excitation spectrum. We have discovered, partially guided by theoretical considerations (see Feenberg [27]), that a polynomial in momentum without a quadratic term

$$\epsilon(p)/k = u_1 p + a_3 p^3 + a_4 p^4 + a_5 p^5 + a_6 p^6 + a_7 p^7 + a_8 p^8, \tag{20}$$

is an excellent representation for the excitation spectrum in the momentum interval $0 \leq p \leq p_c$, and that by using eq (14) for the interval $p_c/\hbar \leq p/\hbar \leq 3.0$ Å^{-1}, one has a continuous expression for the spectrum which may be used to great advantage in the computation of thermodynamic properties based upon the Landau theory. Note that if eq (20) is continued above p_c, it diverges negatively, as indicated by the dotted line in figure 1. Hence care must be used to apply eq (14) above p_c.

The coefficients a_n of eq (20) may be obtained for any temperature and pressure by applying the conditions imposed by eqs (16) through (19), which in turn will depend on T and P. Since there is no constant term, and the first coefficient must be u_1, the problem of determining the coefficients a_n is reduced to solving six equations with six unknowns, at any temperature and pressure.

The degree to which eqs (20) and (14) fit the neutron scattering data is shown as the solid line in figure 3 at 1.1 K, SVP, and again by the solid lines in figure 7 at

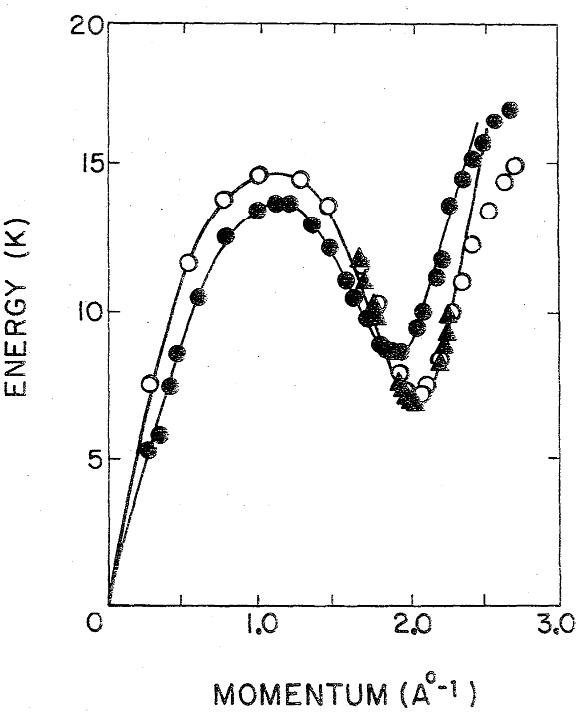

FIGURE 7. The excitation spectrum at two pressures at 1.1 K. Dots, SVP, open circles, 25.3 atm, Henshaw and Woods [4]: triangles, 1.25 K, 24.26 atm, Dietrich et al. [3]: solid lines, eqs (20) and (14).

1.1 K, at SVP, and at 25.3 atm. The experimental values were used in eqs (16) through (19) to obtain these plots. One can appreciate from figure 7 how the spectrum changes with pressure.

As mentioned in section 3.1.a, a controversy surrounds the exact form that eq (20) should have for small momenta. We make here several comments concerning our choice of eq (20). First, we found that a series with no quadratic term was by far the best fit to the neutron data. A detailed comparison of several series is given by Brooks [18]. Secondly, one can see by inspection of the results of such calculations that the coefficient of the first nonlinear term a_3 changes sign upon increasing pressure. We find this to be consistent with the results of Phillips et al. [28] (see Brooks and Donnelly [17]). Finally, the form of eq (20) has prompted us to make some calculations concerning the low temperature behavior of the second sound velocity (Brooks and Donnelly [30]). The second sound velocity is quite sensitive to the leading terms in (20) and a careful measurement would serve as a check on the form we have chosen [30].

3.1.f. The Effective Sharp Spectrum for Thermodynamics

If we use the neutron model dispersion curves described in the previous section to compute, say, the entropy from table I, we discover that the agreement with the calorimetrically determined entropy is quite good at low temperatures for all pressures. At higher temperatures, however, the calculated entropy lies markedly higher. For example, at the vapor pressure, the calculated entropy exceeds the experimental by 17% at ~2.1 K; at 15 atmospheres the calculated entropy is 11% high at ~1.9 K, and at 20 atmospheres it is 23% high at ~1.8 K. This same trend may be seen in figure 17 of Dietrich et al. [3] who, however, made a correction to the formula for S by an additional integration over the linewidth. The departures between calculated and measured entropy occur at about the same value of $(T_\lambda - T)$ at all pressures, and correspond to the temperatures at which the linewidths of the scattered neutron distributions start to grow rapidly. The resulting problem in interpretation has been referred to in section 2 above.

Following Brooks [18] we have investigated the idea of constructing an effective dispersion spectrum, which represents the energies which yield thermodynamic results in accord with experiment. This is done by noting that the only constraint among eqs (16)–(19) which can be varied at all readily within experimental uncertainty is the exact value of Δ in (18) [and also of μ since it is computed from eq (9)]. We therefore allow Δ to float, retaining all other constraints as before, and produce a dispersion curve identical with the neutron data except for the precise value of Δ, computing μ from eq (9). This spectrum assumes there is some effective sharp frequency (that is, $\Gamma \rightarrow 0$) for each value of q; since there is but one adjustment, the resulting effective spectrum is unique. An extensive numerical investigation has demonstrated the great utility of such a spectrum.

We find:

(1) The effective spectrum is capable of yielding accurate thermodynamic results over all pressures and temperatures up to $\sim (T_\lambda - 0.1\ \text{K})$. All quantities calculated from table I and this spectrum appear to be in reasonable agreement with experiment.

(2) The effective spectrum is consistent with the observed functional form of the spectrum determined by neutron scattering. It coincides with the neutron spectrum within experimental error at low temperatures, and at high temperatures the difference between the observed and effective values of Δ is such that $(\Delta_{\text{effective}} - \Delta_{\text{neutron}}) < \Gamma$.

(3) Because the effective spectrum is unique, the exact value of Δ can be chosen by reference to more than one thermodynamic quantity. We have used entropy, expansion coefficient, and normal fluid density.

(4) The points listed above allow one to guess that the effective spectrum is probably a reasonable representation of the energies of elementary excitations of helium II.

3.2. The Thermodynamic Data

In order to use the formulas provided by the Landau theory, we need an equation of state to relate the pressure, volume (or density), and temperature, and from which we may obtain the velocity of first sound. Likewise, to test the results of our computations, we need calorimetric data, primarily entropy and specific heat. We now discuss these experimental data.

3.2.a. The Equation of State

Many of the parameters of the excitation spectrum depend on the density, and terms in the density, or molar volume, appear in expressions of the Landau theory (table I). It is therefore imperative to have a suitable equation of state or "*PVT*" relation. Our relationship is based upon the work of Abraham, Eckstein, Ketterson, Kuchnir, and Roach [31], who showed that as $T \to 0$, the equation of state can be written

$$P = A_0(\rho - \rho_0) + A_1(\rho - \rho_0)^2 + A_2(\rho - \rho_0)^3, \quad (21)$$

where ρ_0 is the density at $P = 0$, $T = 0$; $A_0 = 560$ atm g^{-1}cm^3, $A_1 = 1.097 \times 10^4$ atm g^{-2}cm^6, and $A_2 = 7.33 \times 10^4$ atm g^{-3}cm^9. The "ground state" molar volume, $V_0(P) \equiv V(0, P)$ is calculated from eq. (21) by a root-searching technique.

Before the methods which led to the expressions in table I were developed, an empirical equation of state generalizing (21) was developed by Brooks [18]. This empirical equation of state was based on (21) and the data of Boghosian and Meyer [32], Elwell and Meyer [33], and Kerr and Taylor [34]. It was sufficiently accurate to give a good account of the density and isothermal compressibility, but was not sufficiently accurate to calculate the expansion coefficient.

Since this work was begun, a thesis has appeared by Craig Van Degrift [20] which employs the dielectric method for determining the density and expansion coefficient at the vapor pressure. Dr. Van Degrift has kindly supplied to us a table of data corrected to zero pressure. We have abstracted some of his data in table II. His complete results are in the process of preparation for publication. We should like to encourage the acquisition of data of comparable accuracy at a series of higher pressures.

TABLE II. Density differences and expansion coefficients corrected to $P = 0$ as determined by Van Degrift [20]. $\rho_0 = 0.145119$ g/cm³

T	$(\rho - \rho_0)/\rho_0 \times 10^6$	$\alpha_P(K^{-1}) \times 10^6$
0.30	−2.255	29.49
0.35	−4.122	45.96
0.40	−6.931	67.28
0.45	−10.94	93.93
0.50	−16.42	126.3
0.55	−23.67	164.5
0.60	−32.95	207.7
0.65	−44.49	254.2
0.70	−58.37	300.5
0.75	−74.46	342.1
0.80	−92.40	373.3
0.85	−111.5	387.9
0.90	−130.8	380.2
0.95	−149.1	345.4
1.00	−164.8	279.8
1.05	−176.5	181.0
1.10	−182.4	47.48
1.15	−180.6	−122.3
1.20	−169.5	−330.4
1.25	−146.9	−580.2
1.30	−110.7	−876.4
1.35	−58.43	−1223.0
1.40	12.50	−1622.0
1.45	104.5	−2062.0
1.50	218.9	−2511.0
1.55	356.7	−3045.0
1.60	524.0	−3652.0
1.65	722.8	−4304.0
1.70	955.7	−5015.0
1.75	1226.0	−5806.0
1.80	1539.0	−6699.0
1.85	1899.0	−7724.0
1.90	2315.0	−8922.0
1.95	2797.0	−10360.0
2.00	3360.0	−12140.0
2.05	4025.0	−14480.0
2.10	4833.0	−17990.0
2.15	5896.0	−25880.0

3.2.b. The Calorimetric Data

The most fundamental calorimetric property directly accessible experimentally is the entropy S, which can be measured in an unusual way by employing the thermomechanical effect. The entropy is calculated from the relation

$$S=\frac{1}{\rho}\frac{\Delta P}{\Delta T}, \tag{22}$$

where ΔP and ΔT are the differences in pressure and temperature between two chambers of helium II connected by a superleak. This relation, which is a direct result of the two fluid nature of superfluid helium, is discussed in the standard references [11, 12, 25, 26].

The specific heat C may be obtained by conventional calorimetric methods, and the entropy may be computed from the results by the relation

$$S=\int_0^T \frac{C}{T}\,dT. \tag{23}$$

The entropy is available from the thermomechanical effect data of Van den Meijdenberg, Taconis, and De Bruyn Ouboter [35] in the temperature range $1.15 \leqslant T \leqslant 2.05$ K and pressure range $0 \leqslant P \leqslant 25$ atm. The specific heat capacity measurements of Wiebes [36] cover the same range of pressure, but the temperature range $0.3 \leqslant T \leqslant 1.65$ K. We have used these two sets of data in our analysis, since they cover nearly the entire superfluid phase, and are in reasonable mutual agreement.

The specific heat has also been measured by Phillips, Waterfield, and Hoffer [28]. Through the kindness of Professor Phillips and Dr. Hoffer we have had access to some of their original calorimetric measurements, which are in satisfactory agreement with those of Wiebes (see, for example, Brooks and Donnelly [17], figure 2). The publication of the final data from these experiments is still awaited.

4. Computational Methods and Comparison of Computed Values With Experiment

In this section we discuss the way in which each of the tabulated properties given in Appendix A is obtained, and describe to what degree of accuracy the computed values agree with the corresponding experimental data. Direct references are made to the tables.

4.1. Generation of the Effective Spectrum

We discussed in section 3.1.f above, the concept of an effective sharp spectrum for thermodynamics. It differs from the spectrum of section 3.1.e. only in allowing the value of $\epsilon(p_0)=\Delta$ to float, its exact value being chosen by comparison of the calculated quantities with experiment. In the original tables computed by Brooks [18], the procedure was to adjust Δ and thus the effective mass through eq (9), so that the calculated entropy agrees with the experimental entropy at all temperatures and pressures at which the roton part of the spectrum contributes significantly. This method had the disadvantage that even with quite accurate values of S, the expansion coefficient calculated from $(\partial S/\partial P)_T$ could be quite poor. Dr. Jay Maynard of UCLA drew our attention to the fact that the normal fluid density (cf. section 4.4.b.) is weighted heavily toward higher momenta, and hence is also a useful measure of the effective roton gap. We decided, therefore, that for the generation of the effective spectrum for this work, we would endeavor to employ a method which would incorporate all available thermodynamic evidence: from entropy, expansion coefficient, and normal fluid density.

James Gibbons undertook the job of computing the effective spectrum. This proved to be an arduous task because of the great sensitivity of the thermodynamics to minor changes of the spectrum in the vicinity of the roton minimum. The first step was a weighted fit to experimental values of S and α, making use of the Maxwell relations $(\partial V/\partial T)_P=-(\partial S/\partial P)_T$. This produced a set of polynomials in the pressure at 0.1 K temperature intervals. Since the tables are tabulated in 0.05 K intervals, this data was interpolated by a second degree polynomial in temperature fitted to three local points to find the best fit to data at 0.05 K intervals. A new set of polynomials in pressure were then generated from $T=1$ K to $T=2.2$ K in 0.05 K intervals. Special care had to be taken near the lambda line because of the existence of large high-order derivatives. An iterative root-searching method was then used to find what one could call $\Delta(S,\alpha)$ from eq (2), in all cases calculating μ from eq (9).

The second step was to interpolate the experimental data on ρ_n/ρ, which also exists chiefly on 0.1 K increments, by a procedure analogous to that used for S and α. The end result of a similar root search was a set of values named $\Delta(\rho_n/\rho)$, at 0.05 K intervals.

The third step was to adjust the values of Δ at zero pressure to the compromise $[\Delta(\rho_n/\rho)+\Delta(S,\ \alpha)]/2$, retaining the curvature of the polynomials determined in the first step at higher pressures. The result of this step might be called $\Delta(S,\alpha,\rho_n/\rho)$.

The fourth and final step was a smoothing operation on the energy data of step three by means of a power series in N_r, the roton number density. This step was essential to encourage the monotonic behavior of the values of Δ as T is reduced below 1 K. Once the smoothed table of Δ was available, μ was calculated by eq (9). We have named these final values of Δ the "thermal" roton gap Δ_t, and the corresponding thermal effective masses μ_t. They are listed in tables 22 and 23. Having obtained Δ_t and μ_t, the effective spectrum (20) is computed by the methods described in section 3.1.e. In eqs (16) and (19), the isothermal velocity of sound was used, eq (24) below. The errors resulting from this approximation are negligible. Attempts to use eq (25) for u_1 led to severe problems in numerical instability.

It is interesting to note that the differences between the neutron roton energy gap and the thermal roton gap Δ_t are not random but systematic. We find that, in general, Δ_t lies above Δ at higher temperatures and pressures. The two agree within experimental uncertainties at low temperatures. The differences $(\Delta_t - \Delta) \ll \Gamma$ except at temperatures near the lambda line. Γ may be calculated from the expression of Roberts and Donnelly [37]:

$$\Gamma/k = 0.65 \times 10^{-33} N_r / (\mu^{1/2} \rho^{2/9} T^{1/6}) \text{ K}.$$

At the vapor pressure, the neutron determinations of Yarnell et al. [9] give $\Delta/k = 8.65 \pm 0.04$ K at 1.1 K, while Cowley and Woods [2] obtained $\Delta/k = 8.67 \pm 0.04$ K at the same temperature, and Dietrich et al. [3] find $\Delta/k = 8.54$ K at $T = 1.26$ K, $P = 1$ atm, which extrapolated to zero pressure gives $\Delta/k = 8.64$ K. There is a completely independent way of finding Δ. It is known that Raman scattering from liquid helium at low temperatures gives a peak at 16.97 ± 0.03 K. This peak has been identified by Greytak and his collaborators as a loosely bound state of two rotons [38]. An exact quantum mechanical solution to one model for this state by Roberts and Pardee [39] gives the binding energy of the rotons as 0.290 K. Thus the roton energy should be $(16.97 + 0.290)/2 = 8.63 \pm 0.015$ K, in good agreement with the neutron measurements. We find $\Delta_t = 8.622$ K at 1.1 K, $P = 0$, in satisfactory agreement with all methods.

4.2. The Equation of State

The integral expression for V in table I is, in contrast to our earlier empirical equation of state [18, 19], completely consistent with the expressions for α_P and κ_T. By making use of the empirical equation of state [19], the equation of state for our tables 1 and 2 was obtained in a single iteration. One can also start from absolute zero data for V and κ_T and iterate to find substantially the same results. As we mentioned in section 3.2.a above, $V_0(P)$ comes from eq (21).

The low temperature behavior of the molar volume is shown in figure 8, plotted in the form $V_E(T, P) = V(T, P) - V(0, P)$ vs. temperature for 2.5 atmosphere increments in pressure. A nonlinear scale has been deliberately chosen to emphasize the characteristic maximum in the molar volume near 1 K. We show in figure 9 the entire temperature and pressure range of V, plotted with the data of Boghosian and Meyer [32], and Elwell and Meyer [33]. The deviations of our equation of state from the experimental data used in our analysis varies across the $P-T$ plane. If we define a fractional deviation for the molar volume $\Delta V = (V_{\text{calculated}} - V_{\text{measured}})/V_{\text{measured}}$, we can get a rough idea of the variations by averaging ΔV over temperature at each pressure and denoting the result by $\overline{\Delta V}$ expressed in percent. The results are given in tabular form below, separated to display positive and negative deviations at six pressures, and we see that the temperature-averaged deviations are at most +0.42%–0% from the data.

P (atm)	0	5	10	15	20	25
$\pm(\overline{\Delta V})$%	0.01	0.17	0.19	0.29	0.39	0.42
$-(\overline{\Delta V}$(%	0	0	0	0	0	0

4.2.a. The Velocity of Sound

There are several other quantities which may be calculated from the equation of state, such as the isothermal velocity of sound:

$$u_{1,T}^2 = \left(\frac{\partial P}{\partial \rho}\right)_T = (\rho \kappa_T)^{-1}, \tag{24}$$

where κ_T is defined in (26) below. A first order correction for thermal expansion using computed values of $\gamma = C_P/C_V$ (discussed in section 4.3.e.) gives

$$u_1^2 = \left(\frac{\partial P}{\partial \rho}\right)_S = \frac{\gamma}{\rho \kappa_T}.$$

The actual expression used for the calculations reported here carries a higher order correction for thermal expansion [40, 41]

$$u_1^2 = u_1^2 + \frac{\gamma - 1}{\gamma} \frac{u_1^2 u_{II}^2}{u_1^2 - u_{II}^2}, \tag{25}$$

where u_{II} is defined in section 4.4.c. below. The corrected velocity of first sound u_1 is given in table 3 and illustrated in figure 10. At $T = 0$ K, the deviations from the data of Abraham et al. [31] are less than 0.09%. At higher temperatures, (>1 K), the deviations $\Delta u_1 = (u_{1\,\text{calc}} - u_{1\,\text{meas}})/u_{1\,\text{meas}}$ from some preliminary data of Maynard and Rudnick [21] are as follows:

P (atm)	0	5	10	15	20	25
$+(\overline{\Delta u_1})$%	0.8	0.3	0.5	0.8	1.0	0.5
$-(\overline{\Delta u_1})$%	0	0	0	0	0	1.2

Below 1.6 K, the deviations are much less than 1%. Only the highest few temperatures depart significantly from the data.

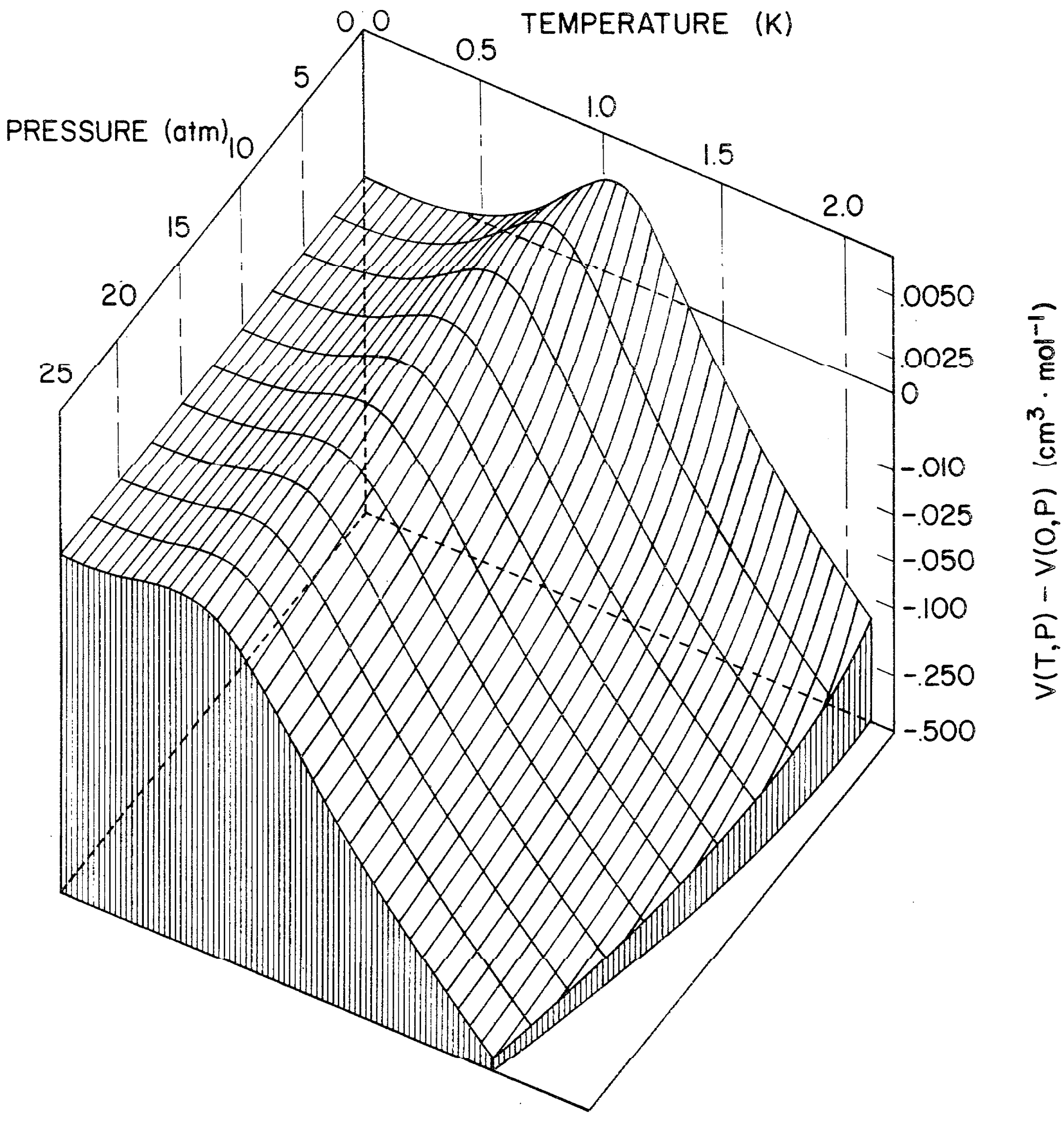

FIGURE 8. The relative change in molar volume given by the expression in table I. The nonlinear scale is chosen to emphasize the locus of maximum molar volume, or zero thermal expansion.

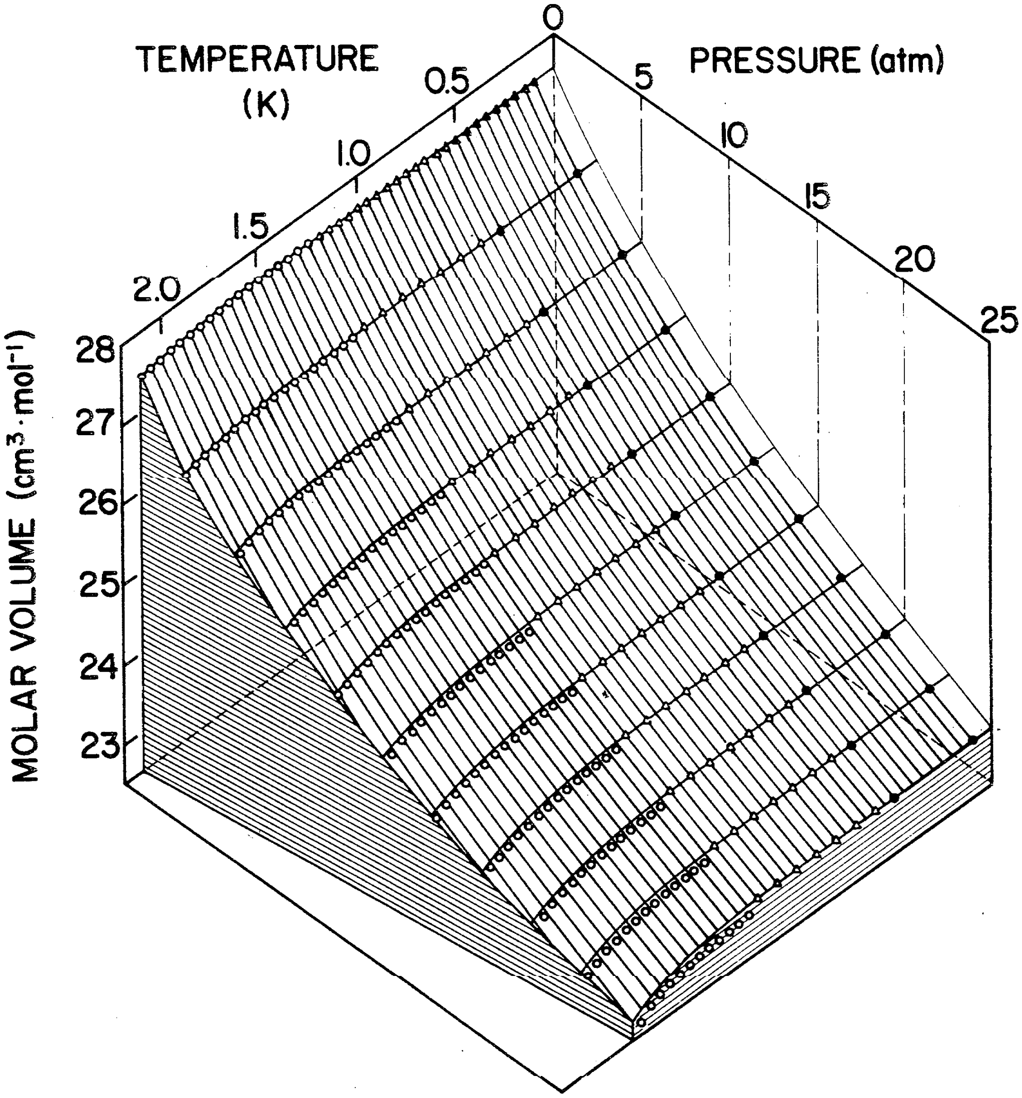

FIGURE 9. The P–V–T surface of helium II. Solid lines come from the expression in table I; open circles, Elwell and Meyer [33]; open triangles, Boghosian and Meyer [32]; solid circles, Abraham et al. [31]; solid triangles, Kerr and Taylor [34]. The deviation between calculation and the data may be seen as a difference perpendicular to the P–T plane. The experimental data have been numerically interpolated to 5 atm intervals in pressure.

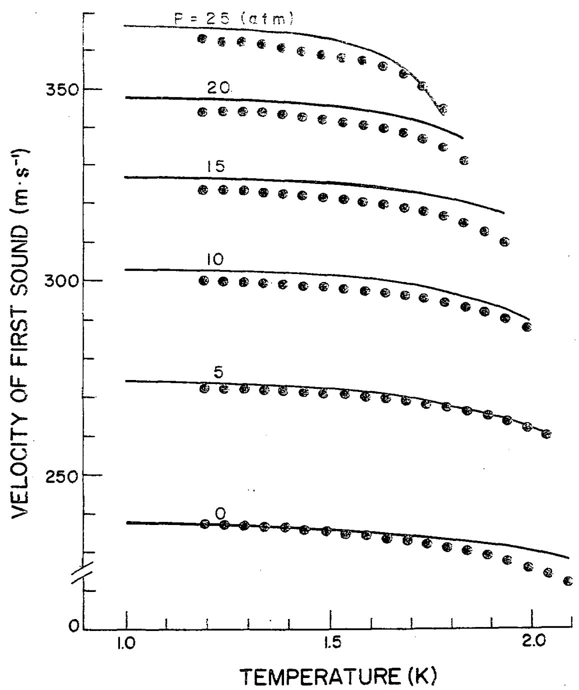

FIGURE 10. The velocity of first sound as a function of temperature for different pressures calculated from eq (25). Data points from Heiserman et al. [21].

4.2.b. The Isothermal Compressibility

The isothermal compressibility, which is defined as

$$\kappa_T = -\frac{1}{V}\left(\frac{\partial V}{\partial P}\right)_T, \tag{26}$$

is obtained by noting that $V(T, P) = V(O, P) + \delta V(T, P)$ from table I. The derivative $(\partial V/\partial P)$ is calculated separately for the two terms, resulting in more reliable results than differentiating the total molar volume directly. The results are in table 4.

The first term $\kappa_T(0)$ can be compared directly with the data of table V of Boghosian and Meyer [32]. The deviations $\Delta\kappa \equiv (\kappa_{\text{calc}} - \kappa_{\text{meas}})/\kappa_{\text{meas}}$ range from $+4.1\%$ to -5.0%. However, we believe that our data, derived from the later measurements of Abraham et al. [31], are considerably more reliable. Since the contribution from the temperature dependent part of V is so small, the the deviations quoted are the dominant ones at all temperatures up to 1.25 K, the highest reported by Boghosian and Meyer [32].

Elwell and Meyer [33] report measurements of κ_T in the range above 1.2 K. Comparing with their tables IV and V, we find the pressure averaged deviations $\Delta\kappa$ to be $+0, -2.4\%$ at 1.3 K; and $+0, -2.0\%$ at 1.8 K.

Our computed values of the compressibility are not sufficiently accurate near the lambda line to exhibit the peak structure observed by Grilly [42].

4.2.c. The Grüneisen Constant

Another quantity which appears in expressions for the ultrasonic attenuation and dispersion in helium II is the Grüneisen constant, defined as

$$U_G \equiv \left(\frac{\rho}{u_1}\right)\left(\frac{\partial u_1}{\partial \rho}\right)_T. \tag{27}$$

It is listed in table III below; the values at $T = 0$ K are in agreement with the $T = 0.1$ K data of Abraham et al. [31] at all pressures, to within $\pm 0.25\%$.

TABLE III. The Grüneisen constant U_G

T(K)	P(atm)					
	0	5	10	15	20	25
0.0	2.843	2.608	2.460	2.356	2.276	2.212
0.5	2.842	2.608	2.460	2.356	2.275	2.213
1.0	2.842	2.624	2.466	2.339	2.270	2.194

4.2.d. The Coefficient of Thermal Expansion

The thermal expansion coefficient is a temperature derivative of the equation of state:

$$\alpha_P \equiv \frac{1}{V}\left(\frac{\partial V}{\partial T}\right)_P. \tag{28}$$

It is, however, directly calculated from the integral expression of Roberts and Donnelly given in table I.

We experienced great difficulty with α_P because it is a very small quantity which passes through zero near 1 K. Our calculations, listed in table 5 and illustrated in figure 11, are sufficiently accurate to give a good account of the locus of zero expansion indicated by the dashed line in figure 2. We have also managed to keep the deviations from growing rapidly above 1.6 K as they did in our earlier work [18, 19]. The temperature-averaged deviations $\Delta\alpha_P = (\alpha_{P\text{calculated}} - \alpha_{P\text{ measured}})/\alpha_{P\text{measured}}$ follow:

P(atm)	0	5	10	15	20	25
$+(\overline{\Delta\alpha_P})\%$	14	16	34	0.8	1.1	1.6
$-(\overline{\Delta\alpha_P})\%$	16	3.2	8	9	10	11

Except for the vapor pressure, where the systematic work of Van Degrift exists, the experimental situation on α_P is quite unsatisfactory and the data often in mutual conflict. A systematic study over the entire T–P plane would be of great benefit in reducing the deviations listed above.

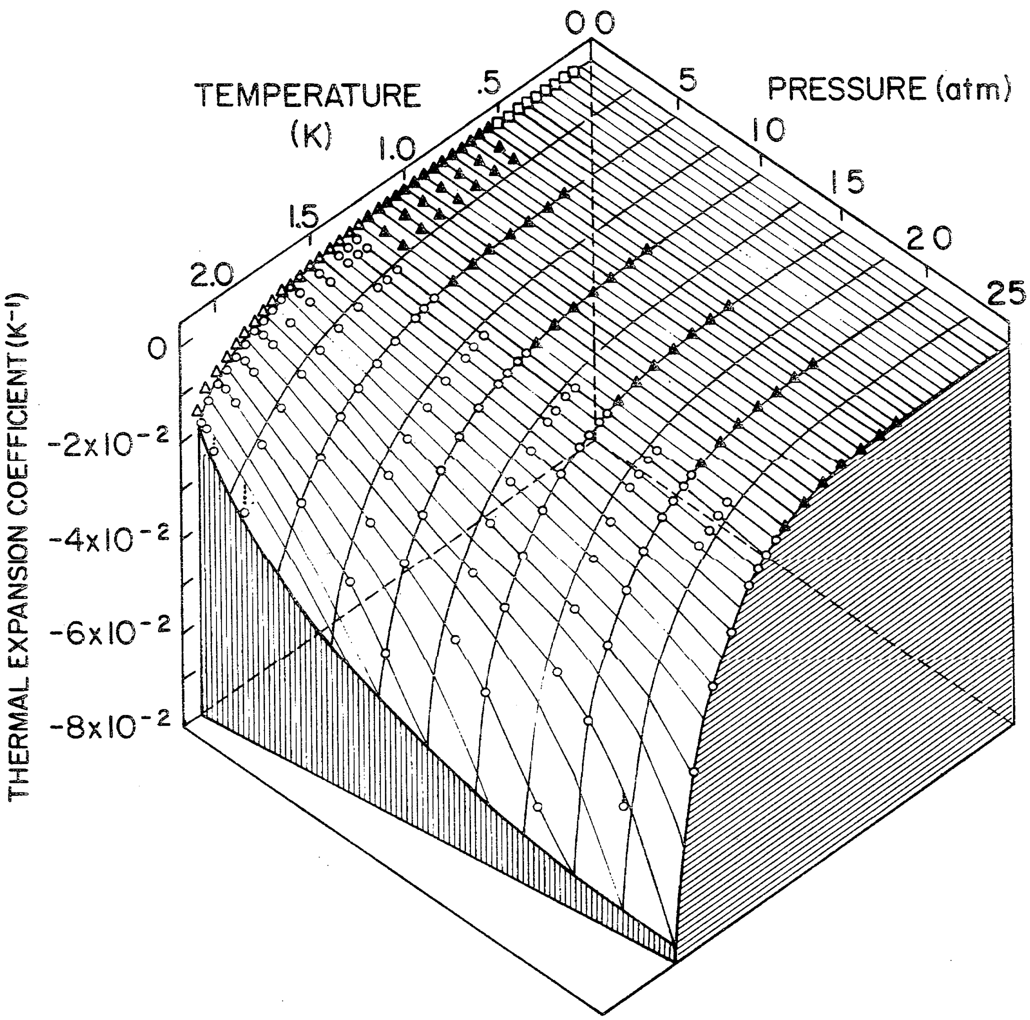

FIGURE 11. The thermal expansion coefficient as a function of pressure and temperature. The solid lines are calculated from the expression in table I; circles, Elwell and Meyer [33]; solid triangles, Boghosian and Meyer [32]; open triangles, Van DeGrift [20]; open diamonds, Kerr and Taylor [34].

4.3. The Fundamental Thermodynamic Functions

In this section we describe our use of the Landau theory and the effective spectrum to compute the thermodynamic properties of helium II.

4.3.a. The Entropy

The entropy is the fundamental quantity used to find the effective spectrum. Deviations, then, reflect imperfections in the data itself as well as the effective spectrum. The temperature averaged deviations $\Delta S=(S_{calc}-S_{meas})/S_{meas}$ are as follows:

P(atm)	0	5	10	15	20	25
$+(\overline{\Delta S})$%	0.7	1.5	1.2	0.5	0.6	0.2
$-(\overline{\Delta S})$%	3.9	2.6	2.4	2.5	2.8	2.0

The entropy is listed in table 9 and plotted in figure 12.

4.3.b. The Helmholtz Free Energy

Table I shows that the Helmholtz free energy F consists of a ground state part $F_0(V)$ and an excitation part F_E given by the double integral over the spectrum. $F_0(V)$ can be determined by integrating the expression $dF_0=-PdV$. The results give F_0 at $T=0$ K to within an additive constant $L_0[L_0=F(0,0)=\Phi(0,0)]$ where L_0 is the latent heat of vaporization extrapolated to zero temperature, and is approximately $14.6 \mathrm{J\cdot g^{-1}}$ (from Keesom [43]). L is a measure of the energy required to separate the atoms of the liquid to infinity.

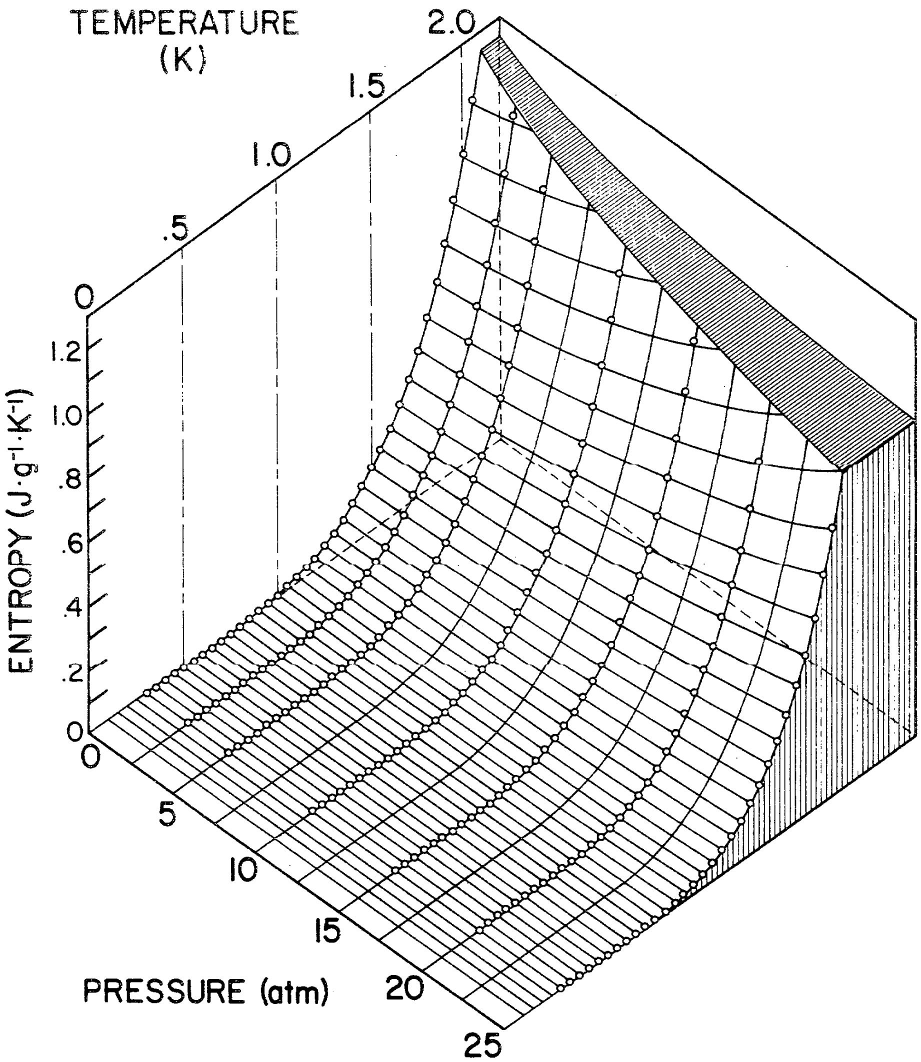

FIGURE 12. The entropy of helium II as a function of pressure and temperature calculated from equation (2). The data for $0.3 \leq T \leq 1.6$ K is from Wiebes [36], and for $1.6 \leq T \leq 2.05$ K is from Van der Meijdenberg et al. [35].

TABLE IV. The ground state Helmholtz free energy $\Delta F_0(P) = [F(0, P) - F(0, 0)]$ J·g^{-1}

P (atm)	0	2.5	5	7.5	10	12.5
$F_0(V)$ (J·g^{-1})	0	0.023254	0.082368	0.16671	0.26980	0.38737
P (atm)		15	17.5	20	22.5	25
$F_0(V)$ (J·g^{-1})		0.51645	0.65490	0.80111	0.95385	1.1122

The Helmholtz free energy is not a directly accessible quantity, and no comparison with experimental data can be readily made. However, table IV comes from the equation of state of Abraham et al. [31] and should be quite accurate. The excitation free energy is tabulated in table 6 and plotted in figure 13. The derivative $(\partial n/\partial q)$ in the expression for F in table I is taken at constant volume. We approximated it by constant pressure. In order to check the accuracy of our calculation, we computed $-(\partial F/\partial T)$ at constant pressure and compared it to S. Except at the highest temperatures and pressures, the error in our procedure is generally less than 1% and never more than 2.2%.

4.3.c. The Gibbs Free Energy

The Gibbs free energy Φ has a ground state part $\Phi_0(P)$ and an excitation part $\Phi_E(P, T)$ given by the double integral in table I. $\Phi_0(P)$ can be determined by integrating the expression $d\Phi = VdP$. The results determine Φ_0 at $T=0$ K to within an additive constant L_0 as described in section 4.3.b. above.

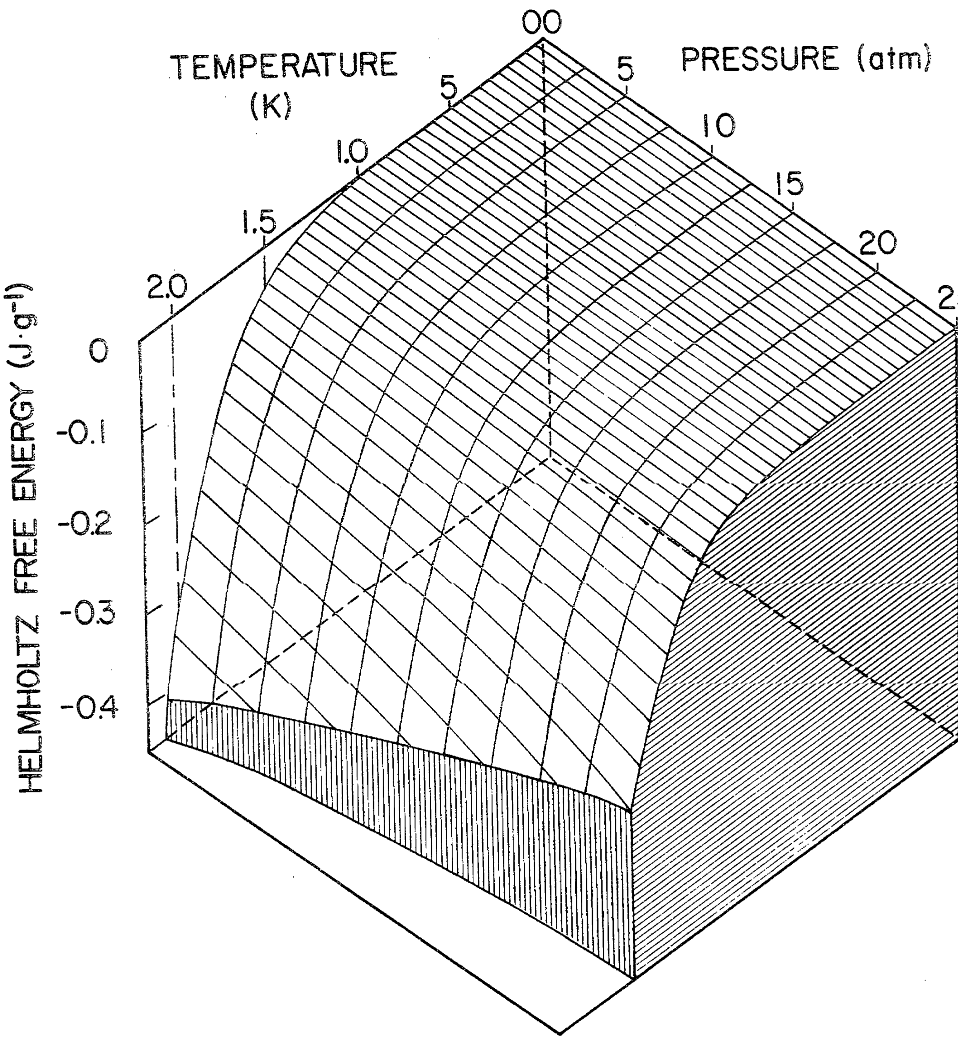

FIGURE 13. The Helmholtz free energy of the excitations as a function of pressure and temperature. The Gibbs free energy has substantially the same appearance.

TABLE V. The ground state Gibbs free energy $\Phi_0(P)=[\Phi(0, P)-\Phi(0, 0)]\mathrm{J}\cdot\mathrm{g}^{-1}$

P(atm)	0	2.5	2	7.5	10	12.5
$\Phi_0(P)\mathrm{J}\cdot\mathrm{g}^{-1}$	0	1.7205	3.3972	5.0373	6.6457	8.2263

P(atm)	15	17.5	20	22.5	25
$\Phi_0(P)\mathrm{J}\cdot\mathrm{g}^{-1}$	9.7821	11.316	12.829	14.323	15.800

The Gibbs free energy is not directly accessible experimentally. The data of table V come from integration of the equation of state of Abraham et al. [31] and hence should be reliable. The excitation part of the Gibbs free energy is tabulated in table 7: the appearance of this energy surface is similar to the Helmholtz energy in figure 13. We have checked the integration by comparing $(\partial\Phi/\partial T)_P$ to S. The differences are less than 0.3% over most of the T–P plane and never exceed 1%.

4.3.d. The Enthalpy

The enthalpy W has a ground state part $W_0(P)$ and an excitation part $W_E(P, T)$ as given by the double integral in table I. The ground state part $W_0(P)=\Phi_0(P)$ is tabulated in table V in section 4.3.c. above. The enthalpy of the excitations is tabulated in table 8 and illustrated in figure 14.

We have cross-checked our tabulations with the equivalent expression $\int_0^T C_P dT$. We find the differences are less than 1.7% at most temperatures and pressures. The enthalpy, then, should have the same basic accuracy as the specific heat, as discussed in section 4.3.e below.

4.3.e. The Specific Heat

The specific heat at constant pressure,

$$C_P=T(\partial S/\partial T)_P, \tag{29}$$

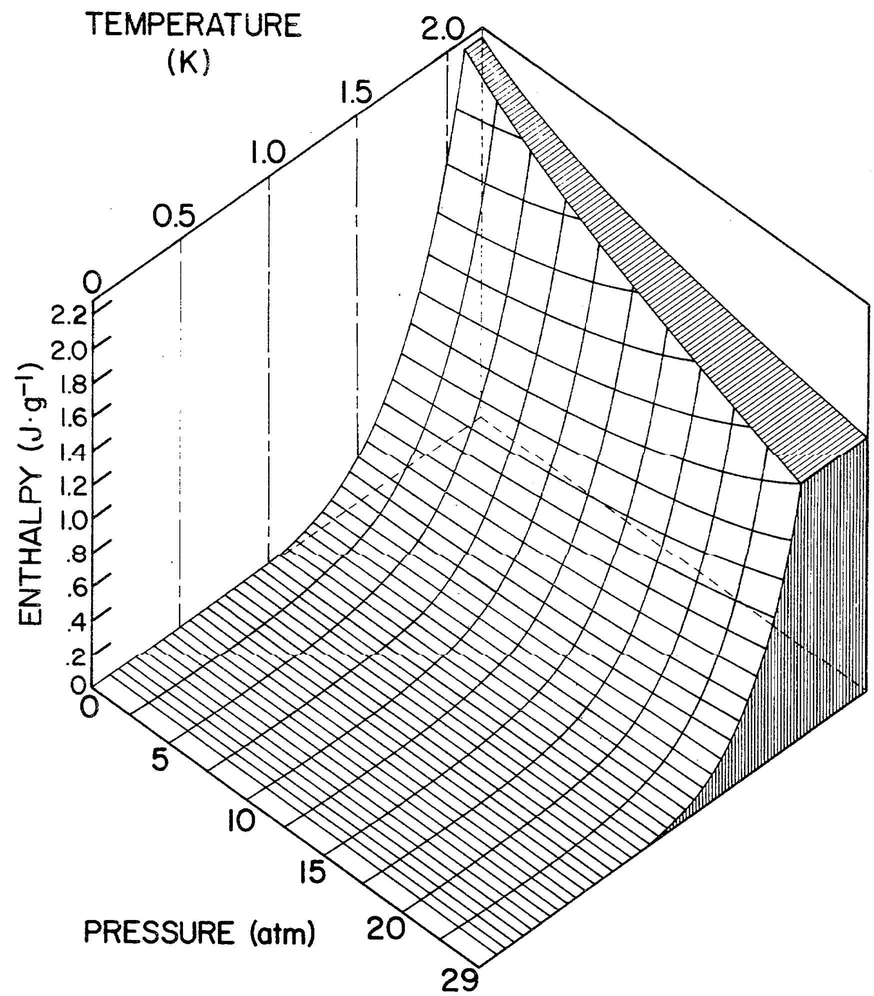

FIGURE 14. The enthalpy of the excitations as a function of pressure and temperature, as calculated from the expression in table I.

is obtained by the integral expression in table I. Below 1 K this worked satisfactorily; above 1 K we experienced difficulty in getting a smooth table. We therefore used (29) directly, selecting five local entropy values, fitting a quadratic function by least squares, and finding $\partial S/\partial T$ from that function. The resulting values are listed in table 10 and plotted in figure 15.

The deviations $\Delta C_P = (C_{P\,\mathrm{calc}} - C_{P\,\mathrm{meas}})/C_{P\,\mathrm{meas}}$ have been compared with the data of Wiebes [36] for $T \leq 1.6$ K.

P(atm)	0	5	10	15	20	25
$+(\overline{\Delta C_P})\%$	2.2	1.5	1.4	0.88	1.0	2.0
$-(\overline{\Delta C_P})\%$	6.5	3.0	2.2	2.3	3.3	2.8

The ratio of specific heats is compiled from

$$\gamma = \frac{C_P}{C_V} = \left[1 - \frac{\alpha_P^2 T}{\rho C_P \kappa_T}\right]^{-1} \tag{30}$$

The term in α_P^2 is subject to an accumulation of errors and is perhaps as much as 50% in error in some regions. Values of γ are tabulated in table 12.

The specific heat at constant volume $C_V = C_P/\gamma$ is listed in table 11. Although γ is quite uncertain, the correction is generally small. Comparing with the data of Wiebes [36], we find the deviations are as follows ($T \leq 1.6$ K):

P(atm)	0	5	10	15	20	25
$+(\overline{\Delta C_V})\%$	2.2	1.6	1.4	1.0	2.2	2.7
$-(\overline{\Delta C_V})\%$	6.5	2.9	2.1	2.3	3.2	2.6

Table I shows an integral expression for C_V. We have used the correction of eq (30) rather than our theoretical expression because the latter involves a derivative at constant volume.

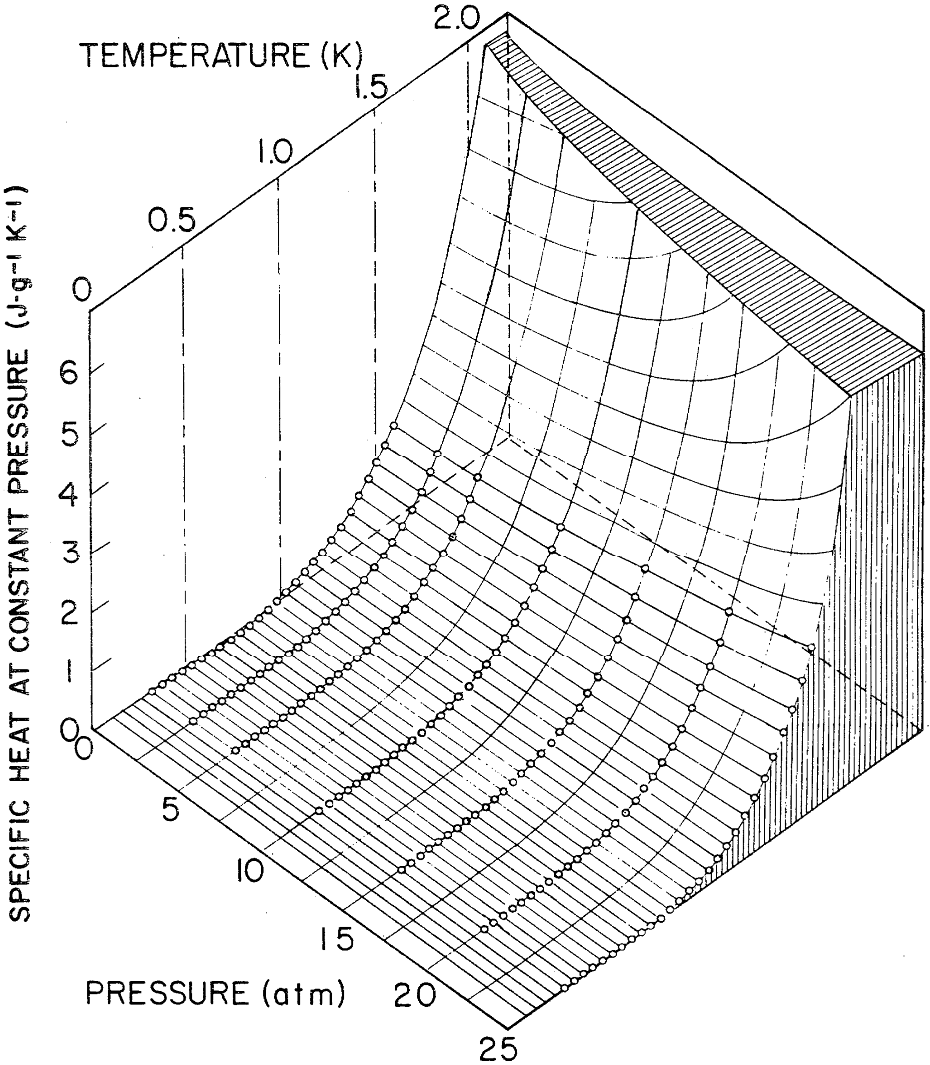

FIGURE 15. The specific heat at constant pressure as a function of pressure and temperature, calculated from the expression in table I. Data, Wiebes, [36].

4.4. Superfluid Properties

4.4.a. The Excitation Number Densities

The density of thermal excitations, calculated by numerical integration, has been separated into a phonon part N_p and a roton part N_r by defining (quite arbitrarily) excitations with wave number less than 1.1 $Å^{-1}$ phonons. For phonons, we have for the number density [from eq (1)]

$$N_p = \int_0^{q_{max}} n(q) d^3q, \tag{31}$$

and for rotons

$$N_r = \int_{q_{max}}^{q_f} n(q) d^3q, \tag{32}$$

where $q_{max}=1.1$ $Å^{-1}$, $q_f=3.0$ $Å^{-1}$. Tabulations of N_p and N_r appear in tables 13 and 14, respectively. No comparison of the results can be made since the number densities are not directly accessible experimentally.

4.4.b. The Normal Fluid and Superfluid Densities

The normal fluid density may be computed from Landau's expression

$$\rho_n = \frac{\hbar^2}{6\pi^2 kT} \int_0^{3Å^{-1}} \frac{\exp[\epsilon(q)/kT]}{[\exp(\epsilon(q)/kT) - 1]^2} q^4 dq, \tag{33}$$

and the computed values appear in table 15. From the equation of state, we may obtain the superfluid density by subtraction of ρ_n,

$$\rho_s = \rho - \rho_n,$$

and one may also obtain the ratios ρ_n/ρ and ρ_s/ρ. The quantities ρ_n/ρ, ρ_s, and ρ_s/ρ appear in tables 16, 17, and 18 respectively, and ρ_n/ρ is plotted in figure 16.

The calculations can be compared with a variety of experiments. At the vapor pressure, the deviations $\Delta\rho_n = (\rho_{n\,calc} - \rho_{n\,meas})/(\rho_{n\,meas})$ from the data of Tough et al. [44] are $\overline{\Delta\rho_n} = -0.78\%, +3.1\%$, with most of the latter error occurring at 2 K and above. Comparing with some unpublished data of Maynard (based on second and fourth sound measurements [21]), one finds the following:

P(atm)	0	5	10	15	20	25
$+(\overline{\Delta\rho_n/\rho})\%$	3.1	2.7	2.5	3.8	3.6	8.0
$-(\overline{\Delta\rho_n/\rho})\%$	0	2.8	4.0	3.5	5.8	5.0

The oscillating disk data of Romer and Duffy [45], principally above 1.6 K, averages about 4–7% low compared to our calculations.

4.4.c. The Velocity of Second Sound

The velocity of second sound, neglecting thermal expansion, is

$$u_{\rm II}^2 = \left(\frac{\rho_s}{\rho_n}\right)\frac{TS^2}{C_V},$$

where $u_{\rm II}$ was used to correct the velocity of first sound in section 4.2.a above. Allowing for thermal expansion, the velocity of second sound is given by [40, 41].

$$u_2^2 = u_{\rm II}^2 - \left(\frac{\gamma-1}{\gamma}\right)\left[\frac{u_{\rm I}^2 u_{\rm II}^2}{u_{\rm I}^2 - u_{\rm II}^2}\right] \tag{34}$$

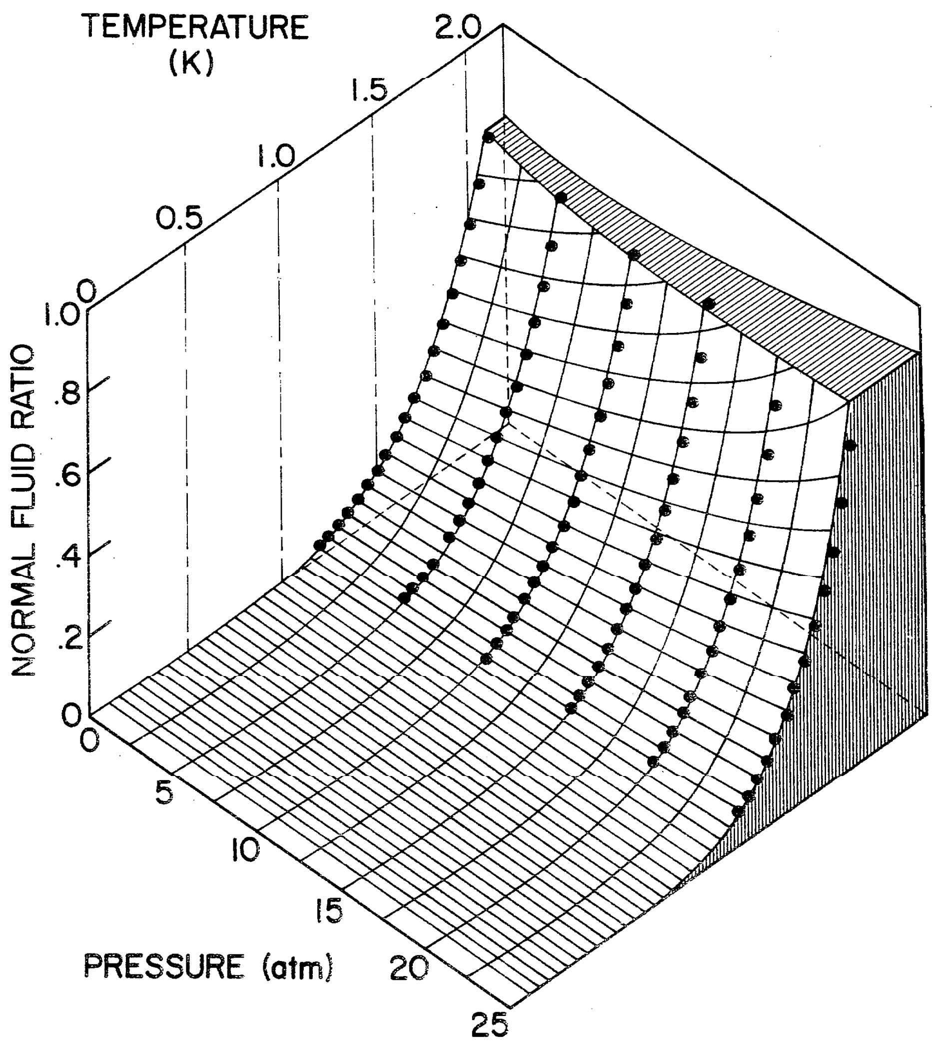

FIGURE 16. The normal fluid fraction as a function of temperature for different pressures calculated from eq (33). The data points are from Maynard [21].

We have used equation (34) to compute u_2, with results given in table 19 and figure 17. The data shown in figure 17 is that of Heiserman et al. [21]. Comparison of our results with the data of [21] is as follows:

P(atm)	0	5	10	15	20	25
$+(\overline{\Delta u_2})\%$	0	0.5	0.1	0.6	0.9	0.8
$-(\overline{\Delta u_2})\%$	2.1	1.7	2.4	4.6	4.2	4.8

Below 0.8 K, the calculated values show marked effects of phonon dispersion, as discussed by Brooks and Donnelly [30].

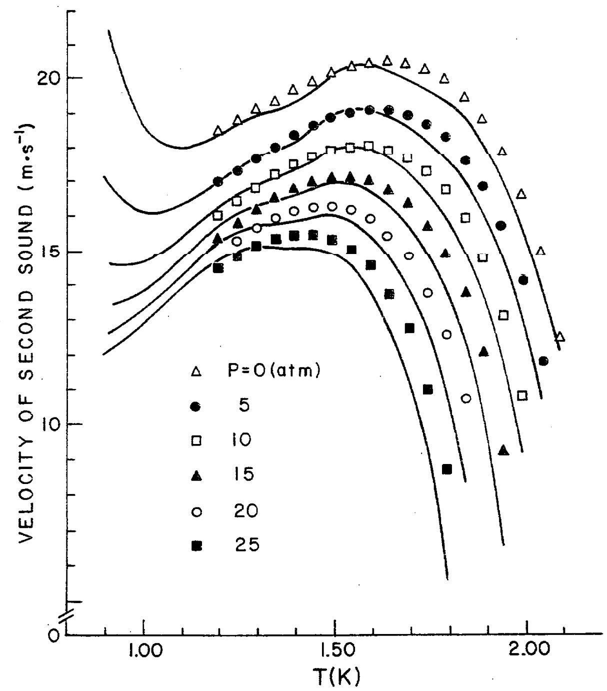

FIGURE 17. The velocity of second sound as a function of temperature, at different pressures. Solid lines, eq (34); data points, from Heiserman et al. [21]. Some of the unevenness of the calculated curves may be the result of numerical problems; note how many derived quantities appear in eq (34).

4.4.d. The Velocity of Fourth Sound

The velocity of fourth sound is, to good approximation [40, 41]

$$u_4^2 = \frac{\rho_s}{\rho} u_{\rm I}^2 + \frac{\rho_n}{\rho} u_{\rm II}^2 \left[1 - \frac{2\alpha_P u_{\rm I}^2}{\gamma S}\right]. \qquad (35)$$

We have used equation (35) to compute u_4, with results given in table 20 and figure 18. The deviations, compared with the data of Heiserman et al. [21] are:

P(atm)	0	5	10	15	20	25
$+(\overline{\Delta u_4})\%$	0.3	0.5	0.9	6.4	1.5	1.4
$-(\overline{\Delta u_4})\%$	0.4	5.3	6.4	0.2	0.5	2.4

5. Conclusions

We have provided tables of the thermodynamic and superfluid properties of helium II computed, when possible, by theoretical methods. Due to inadequacies in the present theory, we were not able to achieve absolute agreement with the experimental data in all cases. The accuracy of our computed values is, however, generally very good, and we hope that the tables will provide a ready reference for theoretical and experimental research in helium II.

Perhaps the most interesting outcome of this research, other than the tables, is the result that there appears to be no theory at present which can accurately relate the energy and momentum of the elementary excitations of helium II, as measured by inelastic neutron scattering, to the thermodynamic properties. The problem may be in part the assumption of zero line width for the spectrum, but other considerations such as the time scale of the neutron probe, and the re-establishment of equilibrium after an excitation is created, may prove important factors. These tables provide a unique opportunity for comparison of the spectrum measured by neutron scattering, and the spectrum which yields the correct thermodynamic properties via the Landau theory, and it is hoped that our analysis will stimulate theoretical interest in this problem.

On the experimental side, we see that there are serious gaps and discrepancies in some of the data which have been considered established for many years. Even the equation of state would benefit from a systematic study over the entire (T, P) plane. An ideal experiment would simultaneously measure the velocities of first, second, and fourth sounds, and the expansion coefficient in one cryostat over all pressures and all temperatures from 0.3 K upward. When such data are available, the present study could be repeated with considerable profit.

6. Acknowledgments

This research was supported by the Air Force Office of Scientific Research under grant AFOSR-76-2880 and by the National Science Foundation under grant DMR-72-3221/A01. This work was begun when the authors were guests at the Niels Bohr Institute, Copenhagen, and we thank Professor Aage Bohr for the hospitality of the Institute. We would also like to thank Mr. James Gibbons for much help in the preparation of the computer results for our initial report, and for the entire task of preparing the present tables using recent data and the

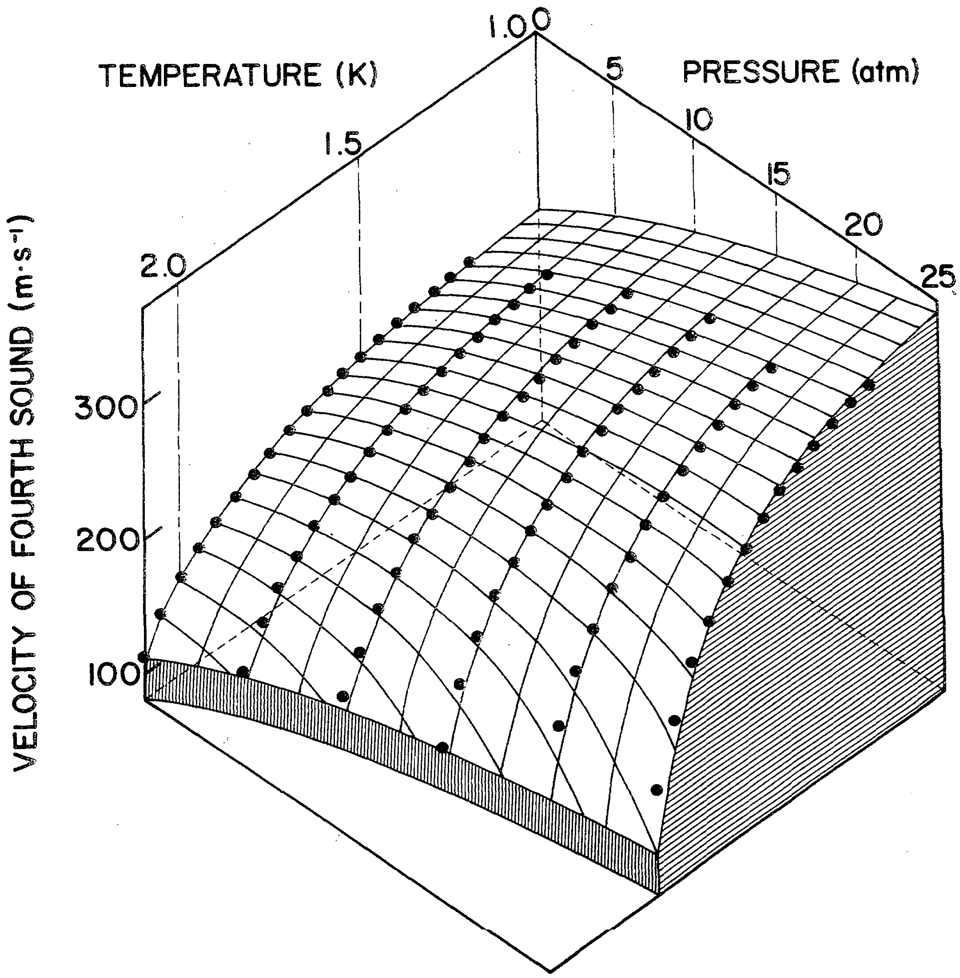

FIGURE 18. The velocity of fourth sound as a function of pressure and temperature calculated from eq (35). The data points are from Heiserman et al. [21].

formulae of table I. We are indebted to Professors D. L. Goodstein, R. P. Feynman, R. M. Mazo, and P. H. Roberts for discussions and collaboration on the theory. Professor I. Rudnick, Dr. Jay Maynard, and Dr. C. Van Degrift have made data available to us in advance of publication. We have appreciated the support and patience of the editors and staff of this Journal in the preparation of the manuscript.

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Appendix A

Tables of the Calculated Properties of Helium II

A short statement concerning the use of these tables is appropriate here. There are seven important points to remember:

(i) As a rule-of-thumb, the tables can be expected to be most accurate below 1.6 K.

(ii) The tables may be less reliable near the lambda-line, and certainly no attempt should be made to use them in scaling relations.

(iii) All numbers are the result of continuous functions, and each number has been given as many figures as space allows to provide a continuous tabulation for numerical analysis. The large number of figures for the power series in table 25 is needed since these coefficients are highly correlated. Similarly, accurate derivatives of thermodynamic variables need many significant figures. In all other cases, the values should be rounded to two or three figures as indicated by the tabulations of average deviations in the relevant sections of the text. The notation .34753+05 indicates that the number 0.34753 is to be multiplied by 10^{+5}, etc.

(iv) The highest temperature for which data is listed in each pressure column is governed by the temperature at which the calculated normal fluid density starts to exceed the total density $\rho_n/\rho=1$ and represents the "lambda-line" of the model calculation.

(v) When unusual accuracy is required, the original data must be consulted. An annotated bibliography is given in Appendix B as an initial guide.

(vi) Data at "$P=0$" are generally measured SVP. The corrections are generally insignificant since SVP at 2.10 K is only 0.04 atm.

(vii) Several units in common use in low temperature physics have S.I. equivalents:

$$1 \text{ atm} = 1.01325 \times 10^5 \text{ Nm}^{-2}$$

$$\text{For } {}^4\text{He: } 1 \text{ mol} = 4.0026 \text{ g}$$

$$1 \text{ Å} = 10^{-10} \text{ m}$$

$$1 \text{ Å}^{-1} = 10^{10} \text{ m}^{-1}$$

TABLE 1. Density (g cm^{-3})

Temp. (K)	Pressure (atm) .00	2.50	5.00	7.50	10.00	12.50	15.00	17.50	20.00	22.50	25.00
.10	.14513E+00	.14925E+00	.15284E+00	.15603E+00	.15892E+00	.16157E+00	.16403E+00	.16633E+00	.16849E+00	.17053E+00	.17246E+00
.15	.14513E+00	.14925E+00	.15284E+00	.15603E+00	.15892E+00	.16157E+00	.16403E+00	.16633E+00	.16849E+00	.17053E+00	.17246E+00
.20	.14513E+00	.14925E+00	.15284E+00	.15603E+00	.15892E+00	.16157E+00	.16403E+00	.16633E+00	.16849E+00	.17053E+00	.17246E+00
.25	.14513E+00	.14925E+00	.15284E+00	.15603E+00	.15892E+00	.16157E+00	.16403E+00	.16633E+00	.16849E+00	.17053E+00	.17246E+00
.30	.14513E+00	.14925E+00	.15284E+00	.15603E+00	.15892E+00	.16157E+00	.16403E+00	.16633E+00	.16849E+00	.17053E+00	.17246E+00
.35	.14513E+00	.14925E+00	.15284E+00	.15603E+00	.15892E+00	.16157E+00	.16403E+00	.16633E+00	.16849E+00	.17053E+00	.17246E+00
.40	.14513E+00	.14925E+00	.15284E+00	.15603E+00	.15892E+00	.16157E+00	.16403E+00	.16633E+00	.16849E+00	.17053E+00	.17246E+00
.45	.14513E+00	.14925E+00	.15283E+00	.15603E+00	.15892E+00	.16157E+00	.16403E+00	.16633E+00	.16849E+00	.17053E+00	.17246E+00
.50	.14513E+00	.14925E+00	.15283E+00	.15603E+00	.15892E+00	.16157E+00	.16403E+00	.16633E+00	.16849E+00	.17053E+00	.17246E+00
.55	.14513E+00	.14925E+00	.15283E+00	.15603E+00	.15892E+00	.16157E+00	.16403E+00	.16633E+00	.16849E+00	.17053E+00	.17246E+00
.60	.14513E+00	.14925E+00	.15283E+00	.15603E+00	.15892E+00	.16157E+00	.16403E+00	.16633E+00	.16849E+00	.17053E+00	.17246E+00
.65	.14512E+00	.14925E+00	.15283E+00	.15603E+00	.15892E+00	.16157E+00	.16403E+00	.16633E+00	.16849E+00	.17053E+00	.17246E+00
.70	.14512E+00	.14925E+00	.15283E+00	.15602E+00	.15892E+00	.16157E+00	.16403E+00	.16633E+00	.16849E+00	.17053E+00	.17246E+00
.75	.14512E+00	.14925E+00	.15283E+00	.15602E+00	.15892E+00	.16157E+00	.16403E+00	.16633E+00	.16849E+00	.17053E+00	.17247E+00
.80	.14512E+00	.14924E+00	.15283E+00	.15602E+00	.15892E+00	.16157E+00	.16403E+00	.16633E+00	.16849E+00	.17053E+00	.17247E+00
.85	.14512E+00	.14924E+00	.15283E+00	.15603E+00	.15892E+00	.16157E+00	.16403E+00	.16633E+00	.16849E+00	.17054E+00	.17247E+00
.90	.14511E+00	.14924E+00	.15283E+00	.15603E+00	.15892E+00	.16158E+00	.16404E+00	.16634E+00	.16850E+00	.17054E+00	.17248E+00
.95	.14511E+00	.14924E+00	.15283E+00	.15603E+00	.15893E+00	.16158E+00	.16404E+00	.16634E+00	.16851E+00	.17055E+00	.17249E+00
1.00	.14511E+00	.14925E+00	.15284E+00	.15604E+00	.15893E+00	.16159E+00	.16405E+00	.16635E+00	.16852E+00	.17056E+00	.17251E+00
1.05	.14511E+00	.14925E+00	.15284E+00	.15604E+00	.15894E+00	.16160E+00	.16406E+00	.16636E+00	.16853E+00	.17058E+00	.17252E+00
1.10	.14510E+00	.14925E+00	.15285E+00	.15605E+00	.15895E+00	.16161E+00	.16408E+00	.16638E+00	.16855E+00	.17060E+00	.17255E+00
1.15	.14510E+00	.14926E+00	.15286E+00	.15607E+00	.15897E+00	.16163E+00	.16410E+00	.16640E+00	.16858E+00	.17063E+00	.17258E+00
1.20	.14511E+00	.14926E+00	.15287E+00	.15608E+00	.15899E+00	.16165E+00	.16412E+00	.16643E+00	.16861E+00	.17066E+00	.17262E+00
1.25	.14511E+00	.14927E+00	.15289E+00	.15610E+00	.15901E+00	.16168E+00	.16415E+00	.16647E+00	.16865E+00	.17071E+00	.17267E+00
1.30	.14511E+00	.14929E+00	.15291E+00	.15612E+00	.15904E+00	.16171E+00	.16419E+00	.16651E+00	.16870E+00	.17077E+00	.17273E+00
1.35	.14512E+00	.14930E+00	.15293E+00	.15615E+00	.15907E+00	.16175E+00	.16423E+00	.16656E+00	.16876E+00	.17083E+00	.17282E+00
1.40	.14513E+00	.14932E+00	.15296E+00	.15619E+00	.15911E+00	.16180E+00	.16429E+00	.16663E+00	.16883E+00	.17092E+00	.17291E+00
1.45	.14514E+00	.14934E+00	.15299E+00	.15623E+00	.15916E+00	.16185E+00	.16436E+00	.16670E+00	.16892E+00	.17102E+00	.17303E+00
1.50	.14516E+00	.14937E+00	.15303E+00	.15628E+00	.15922E+00	.16192E+00	.16444E+00	.16680E+00	.16903E+00	.17114E+00	.17317E+00
1.55	.14518E+00	.14941E+00	.15308E+00	.15634E+00	.15929E+00	.16201E+00	.16453E+00	.16691E+00	.16916E+00	.17129E+00	.17335E+00
1.60	.14520E+00	.14944E+00	.15313E+00	.15641E+00	.15938E+00	.16211E+00	.16465E+00	.16704E+00	.16931E+00	.17146E+00	.17356E+00
1.65	.14523E+00	.14949E+00	.15319E+00	.15649E+00	.15948E+00	.16223E+00	.16478E+00	.16719E+00	.16949E+00	.17168E+00	.17382E+00
1.70	.14526E+00	.14954E+00	.15327E+00	.15659E+00	.15960E+00	.16237E+00	.16495E+00	.16738E+00	.16971E+00	.17193E+00	.17413E+00
1.75	.14530E+00	.14960E+00	.15335E+00	.15670E+00	.15974E+00	.16254E+00	.16514E+00	.16760E+00	.16997E+00	.17225E+00	.17457E+00
1.80	.14535E+00	.14967E+00	.15345E+00	.15684E+00	.15991E+00	.16274E+00	.16536E+00	.16786E+00	.17028E+00	.17263E+00	.17512E+00
1.85	.14540E+00	.14975E+00	.15357E+00	.15699E+00	.16011E+00	.16297E+00	.16564E+00	.16818E+00	.17070E+00	.17317E+00	
1.90	.14546E+00	.14984E+00	.15370E+00	.15717E+00	.16032E+00	.16323E+00	.16596E+00	.16860E+00			
1.95	.14553E+00	.14996E+00	.15387E+00	.15738E+00	.16059E+00	.16357E+00	.16641E+00				
2.00	.14561E+00	.15009E+00	.15405E+00	.15762E+00	.16091E+00						
2.05	.14570E+00	.15024E+00	.15427E+00								
2.10	.14582E+00	.15041E+00									

TABLE 2. Molar volume (cm³ mol⁻¹)

Temp. (K)	Pressure (atm) .00	2.50	5.00	7.50	10.00	12.50	15.00	17.50	20.00	22.50	25.00
.10	.27579E+02	.26818E+02	.26189E+02	.25653E+02	.25186E+02	.24773E+02	.24401E+02	.24064E+02	.23756E+02	.23472E+02	.23208E+02
.15	.27579E+02	.26818E+02	.26189E+02	.25653E+02	.25186E+02	.24773E+02	.24401E+02	.24064E+02	.23756E+02	.23472E+02	.23208E+02
.20	.27579E+02	.26818E+02	.26189E+02	.25653E+02	.25186E+02	.24773E+02	.24401E+02	.24064E+02	.23756E+02	.23472E+02	.23208E+02
.25	.27579E+02	.26818E+02	.26189E+02	.25653E+02	.25186E+02	.24773E+02	.24401E+02	.24064E+02	.23756E+02	.23472E+02	.23208E+02
.30	.27579E+02	.26818E+02	.26189E+02	.25653E+02	.25186E+02	.24773E+02	.24401E+02	.24064E+02	.23756E+02	.23472E+02	.23208E+02
.35	.27580E+02	.26818E+02	.26189E+02	.25653E+02	.25186E+02	.24773E+02	.24401E+02	.24064E+02	.23756E+02	.23472E+02	.23208E+02
.40	.27580E+02	.26818E+02	.26189E+02	.25653E+02	.25186E+02	.24773E+02	.24401E+02	.24064E+02	.23756E+02	.23472E+02	.23208E+02
.45	.27580E+02	.26818E+02	.26189E+02	.25653E+02	.25186E+02	.24773E+02	.24401E+02	.24064E+02	.23756E+02	.23472E+02	.23208E+02
.50	.27580E+02	.26818E+02	.26189E+02	.25653E+02	.25186E+02	.24773E+02	.24401E+02	.24064E+02	.23756E+02	.23472E+02	.23208E+02
.55	.27580E+02	.26818E+02	.26189E+02	.25653E+02	.25187E+02	.24773E+02	.24401E+02	.24064E+02	.23756E+02	.23472E+02	.23208E+02
.60	.27580E+02	.26818E+02	.26189E+02	.25653E+02	.25187E+02	.24773E+02	.24401E+02	.24064E+02	.23756E+02	.23472E+02	.23208E+02
.65	.27580E+02	.26818E+02	.26189E+02	.25654E+02	.25187E+02	.24773E+02	.24401E+02	.24064E+02	.23756E+02	.23472E+02	.23208E+02
.70	.27581E+02	.26819E+02	.26190E+02	.25654E+02	.25187E+02	.24773E+02	.24401E+02	.24064E+02	.23756E+02	.23472E+02	.23208E+02
.75	.27581E+02	.26819E+02	.26190E+02	.25654E+02	.25187E+02	.24773E+02	.24401E+02	.24064E+02	.23756E+02	.23472E+02	.23208E+02
.80	.27582E+02	.26819E+02	.26190E+02	.25654E+02	.25187E+02	.24773E+02	.24401E+02	.24064E+02	.23756E+02	.23471E+02	.23208E+02
.85	.27582E+02	.26819E+02	.26190E+02	.25654E+02	.25186E+02	.24773E+02	.24401E+02	.24064E+02	.23755E+02	.23471E+02	.23207E+02
.90	.27583E+02	.26819E+02	.26190E+02	.25653E+02	.25186E+02	.24772E+02	.24400E+02	.24063E+02	.23754E+02	.23470E+02	.23206E+02
.95	.27583E+02	.26819E+02	.26189E+02	.25653E+02	.25185E+02	.24771E+02	.24400E+02	.24062E+02	.23753E+02	.23469E+02	.23205E+02
1.00	.27583E+02	.26819E+02	.26189E+02	.25652E+02	.25184E+02	.24770E+02	.24398E+02	.24061E+02	.23752E+02	.23467E+02	.23203E+02
1.05	.27584E+02	.26818E+02	.26188E+02	.25651E+02	.25183E+02	.24769E+02	.24397E+02	.24059E+02	.23750E+02	.23465E+02	.23200E+02
1.10	.27584E+02	.26818E+02	.26186E+02	.25649E+02	.25181E+02	.24767E+02	.24395E+02	.24057E+02	.23747E+02	.23462E+02	.23197E+02
1.15	.27584E+02	.26817E+02	.26185E+02	.25647E+02	.25179E+02	.24764E+02	.24392E+02	.24054E+02	.23744E+02	.23458E+02	.23192E+02
1.20	.27584E+02	.26816E+02	.26183E+02	.25644E+02	.25176E+02	.24761E+02	.24388E+02	.24050E+02	.23739E+02	.23453E+02	.23187E+02
1.25	.27584E+02	.26814E+02	.26180E+02	.25641E+02	.25172E+02	.24757E+02	.24384E+02	.24045E+02	.23734E+02	.23447E+02	.23180E+02
1.30	.27583E+02	.26812E+02	.26177E+02	.25637E+02	.25168E+02	.24752E+02	.24378E+02	.24038E+02	.23727E+02	.23439E+02	.23172E+02
1.35	.27582E+02	.26809E+02	.26173E+02	.25633E+02	.25162E+02	.24746E+02	.24371E+02	.24031E+02	.23718E+02	.23430E+02	.23161E+02
1.40	.27580E+02	.26805E+02	.26168E+02	.25627E+02	.25156E+02	.24739E+02	.24363E+02	.24021E+02	.23708E+02	.23418E+02	.23149E+02
1.45	.27578E+02	.26801E+02	.26163E+02	.25620E+02	.25148E+02	.24730E+02	.24353E+02	.24010E+02	.23695E+02	.23405E+02	.23133E+02
1.50	.27574E+02	.26796E+02	.26156E+02	.25612E+02	.25139E+02	.24719E+02	.24341E+02	.23997E+02	.23680E+02	.23388E+02	.23114E+02
1.55	.27571E+02	.26790E+02	.26148E+02	.25602E+02	.25127E+02	.24706E+02	.24327E+02	.23981E+02	.23662E+02	.23367E+02	.23090E+02
1.60	.27566E+02	.26783E+02	.26139E+02	.25591E+02	.25114E+02	.24691E+02	.24310E+02	.23962E+02	.23641E+02	.23344E+02	.23062E+02
1.65	.27561E+02	.26775E+02	.26128E+02	.25577E+02	.25098E+02	.24673E+02	.24290E+02	.23940E+02	.23616E+02	.23315E+02	.23027E+02
1.70	.27555E+02	.26765E+02	.26115E+02	.25561E+02	.25079E+02	.24652E+02	.24266E+02	.23913E+02	.23585E+02	.23280E+02	.22986E+02
1.75	.27547E+02	.26755E+02	.26100E+02	.25543E+02	.25056E+02	.24626E+02	.24238E+02	.23882E+02	.23549E+02	.23237E+02	.22929E+02
1.80	.27539E+02	.26744E+02	.26084E+02	.25521E+02	.25030E+02	.24596E+02	.24205E+02	.23845E+02	.23506E+02	.23186E+02	.22857E+02
1.85	.27528E+02	.26729E+02	.26064E+02	.25495E+02	.24999E+02	.24561E+02	.24165E+02	.23799E+02	.23449E+02	.23114E+02	
1.90	.27516E+02	.26713E+02	.26041E+02	.25467E+02	.24966E+02	.24521E+02	.24118E+02	.23741E+02			
1.95	.27503E+02	.26691E+02	.26014E+02	.25433E+02	.24924E+02	.24470E+02	.24053E+02				
2.00	.27488E+02	.26669E+02	.25982E+02	.25394E+02	.24874E+02						
2.05	.27471E+02	.26641E+02	.25946E+02								
2.10	.27449E+02	.26612E+02									

TABLE 3. First sound velocity (m s^{-1})

Temp. (K)	Pressure (atm)										
	.00	2.50	5.00	7.50	10.00	12.50	15.00	17.50	20.00	22.50	25.00
.10	.23821E+03	.25746E+03	.27422E+03	.28916E+03	.30271E+03	.31515E+03	.32669E+03	.33747E+03	.34760E+03	.35718E+03	.36627E+03
.15	.23821E+03	.25746E+03	.27422E+03	.28916E+03	.30271E+03	.31515E+03	.32669E+03	.33747E+03	.34760E+03	.35718E+03	.36627E+03
.20	.23821E+03	.25746E+03	.27422E+03	.28916E+03	.30271E+03	.31515E+03	.32669E+03	.33747E+03	.34760E+03	.35718E+03	.36627E+03
.25	.23821E+03	.25746E+03	.27422E+03	.28916E+03	.30271E+03	.31515E+03	.32669E+03	.33747E+03	.34760E+03	.35718E+03	.36627E+03
.30	.23821E+03	.25746E+03	.27422E+03	.28916E+03	.30271E+03	.31515E+03	.32669E+03	.33747E+03	.34760E+03	.35718E+03	.36627E+03
.35	.23821E+03	.25746E+03	.27422E+03	.28916E+03	.30271E+03	.31515E+03	.32669E+03	.33747E+03	.34760E+03	.35718E+03	.36627E+03
.40	.23821E+03	.25746E+03	.27422E+03	.28916E+03	.30271E+03	.31515E+03	.32669E+03	.33747E+03	.34760E+03	.35718E+03	.36627E+03
.45	.23821E+03	.25746E+03	.27422E+03	.28916E+03	.30271E+03	.31515E+03	.32669E+03	.33747E+03	.34760E+03	.35718E+03	.36627E+03
.50	.23821E+03	.25746E+03	.27422E+03	.28916E+03	.30271E+03	.31515E+03	.32669E+03	.33746E+03	.34760E+03	.35717E+03	.36627E+03
.55	.23821E+03	.25746E+03	.27422E+03	.28916E+03	.30271E+03	.31515E+03	.32668E+03	.33746E+03	.34759E+03	.35717E+03	.36627E+03
.60	.23820E+03	.25745E+03	.27421E+03	.28915E+03	.30270E+03	.31514E+03	.32668E+03	.33745E+03	.34759E+03	.35716E+03	.36626E+03
.65	.23819E+03	.25744E+03	.27420E+03	.28914E+03	.30269E+03	.31513E+03	.32667E+03	.33745E+03	.34758E+03	.35716E+03	.36625E+03
.70	.23817E+03	.25742E+03	.27418E+03	.28912E+03	.30268E+03	.31512E+03	.32666E+03	.33744E+03	.34757E+03	.35715E+03	.36624E+03
.75	.23815E+03	.25739E+03	.27416E+03	.28911E+03	.30266E+03	.31511E+03	.32665E+03	.33742E+03	.34756E+03	.35713E+03	.36622E+03
.80	.23812E+03	.25736E+03	.27413E+03	.28909E+03	.30265E+03	.31510E+03	.32663E+03	.33741E+03	.34753E+03	.35711E+03	.36621E+03
.85	.23806E+03	.25731E+03	.27410E+03	.28907E+03	.30264E+03	.31509E+03	.32662E+03	.33738E+03	.34751E+03	.35709E+03	.36617E+03
.90	.23798E+03	.25725E+03	.27406E+03	.28905E+03	.30263E+03	.31508E+03	.32660E+03	.33735E+03	.34748E+03	.35706E+03	.36611E+03
.95	.23787E+03	.25718E+03	.27402E+03	.28903E+03	.30262E+03	.31508E+03	.32658E+03	.33731E+03	.34744E+03	.35702E+03	.36604E+03
1.00	.23775E+03	.25708E+03	.27396E+03	.28900E+03	.30261E+03	.31507E+03	.32656E+03	.33726E+03	.34737E+03	.35695E+03	.36601E+03
1.05	.23758E+03	.25696E+03	.27388E+03	.28896E+03	.30260E+03	.31506E+03	.32652E+03	.33720E+03	.34731E+03	.35689E+03	.36586E+03
1.10	.23743E+03	.25681E+03	.27378E+03	.28890E+03	.30256E+03	.31504E+03	.32649E+03	.33712E+03	.34725E+03	.35688E+03	.36562E+03
1.15	.23720E+03	.25668E+03	.27366E+03	.28881E+03	.30251E+03	.31500E+03	.32645E+03	.33705E+03	.34714E+03	.35674E+03	.36551E+03
1.20	.23705E+03	.25649E+03	.27350E+03	.28868E+03	.30242E+03	.31494E+03	.32638E+03	.33697E+03	.34707E+03	.35670E+03	.36518E+03
1.25	.23680E+03	.25633E+03	.27335E+03	.28851E+03	.30225E+03	.31476E+03	.32620E+03	.33684E+03	.34696E+03	.35652E+03	.36493E+03
1.30	.23658E+03	.25608E+03	.27316E+03	.28838E+03	.30212E+03	.31461E+03	.32597E+03	.33652E+03	.34674E+03	.35651E+03	.36526E+03
1.35	.23638E+03	.25588E+03	.27293E+03	.28814E+03	.30189E+03	.31438E+03	.32575E+03	.33625E+03	.34636E+03	.35600E+03	.36408E+03
1.40	.23600E+03	.25563E+03	.27273E+03	.28797E+03	.30170E+03	.31413E+03	.32543E+03	.33585E+03	.34600E+03	.35582E+03	.36411E+03
1.45	.23572E+03	.25530E+03	.27240E+03	.28766E+03	.30141E+03	.31386E+03	.32518E+03	.33561E+03	.34578E+03	.35554E+03	.36360E+03
1.50	.23542E+03	.25496E+03	.27207E+03	.28737E+03	.30110E+03	.31351E+03	.32473E+03	.33501E+03	.34545E+03	.35567E+03	.36325E+03
1.55	.23509E+03	.25452E+03	.27163E+03	.28693E+03	.30071E+03	.31315E+03	.32431E+03	.33435E+03	.34450E+03	.35458E+03	.36162E+03
1.60	.23489E+03	.25398E+03	.27108E+03	.28647E+03	.30029E+03	.31273E+03	.32383E+03	.33365E+03	.34378E+03	.35387E+03	.35977E+03
1.65	.23443E+03	.25351E+03	.27044E+03	.28575E+03	.29970E+03	.31227E+03	.32344E+03	.33317E+03	.34303E+03	.35274E+03	.35587E+03
1.70	.23391E+03	.25288E+03	.26974E+03	.28500E+03	.29898E+03	.31167E+03	.32279E+03	.33231E+03	.34229E+03	.35220E+03	.35484E+03
1.75	.23361E+03	.25216E+03	.26869E+03	.28392E+03	.29817E+03	.31109E+03	.32204E+03	.33074E+03	.34002E+03	.34957E+03	.34988E+03
1.80	.23347E+03	.25126E+03	.26746E+03	.28258E+03	.29710E+03	.31061E+03	.32178E+03	.32993E+03	.33901E+03	.34820E+03	.34266E+03
1.85	.23303E+03	.25049E+03	.26634E+03	.28112E+03	.29536E+03	.30887E+03	.32015E+03	.32750E+03	.33652E+03	.34586E+03	
1.90	.23271E+03	.24913E+03	.26506E+03	.27998E+03	.29410E+03	.30749E+03	.31380E+03	.32582E+03			
1.95	.23118E+03	.24813E+03	.26385E+03	.27836E+03	.29219E+03	.30559E+03	.31589E+03				
2.00	.23065E+03	.24598E+03	.26208E+03	.27656E+03	.28984E+03						
2.05	.22871E+03	.24474E+03	.26010E+03								
2.10	.22793E+03	.24309E+03									

TABLE 4. Isothermal compressibility (cm² dyn⁻¹) (1 cm² dyn⁻¹ = 10 m² N⁻¹)

Temp. (K)	Pressure (atm) .00	2.50	5.00	7.50	10.00	12.50	15.00	17.50	20.00	22.50	25.00
.10	.12143E−07	.10108E−07	.87012E−08	.76651E−08	.68670E−08	.62315E−08	.57122E−08	.52792E−08	.49121E−08	.45966E−08	.43221E−08
.15	.12143E−07	.10108E−07	.87012E−08	.76651E−08	.68670E−08	.62315E−08	.57122E−08	.52792E−08	.49121E−08	.45966E−08	.43221E−08
.20	.12143E−07	.10108E−07	.87012E−08	.76651E−08	.68670E−08	.62315E−08	.57122E−08	.52792E−08	.49121E−08	.45966E−08	.43221E−08
.25	.12143E−07	.10108E−07	.87013E−08	.76652E−08	.68670E−08	.62315E−08	.57122E−08	.52792E−08	.49121E−08	.45966E−08	.43221E−08
.30	.12143E−07	.10108E−07	.87013E−08	.76652E−08	.68671E−08	.62315E−08	.57122E−08	.52793E−08	.49122E−08	.45966E−08	.43221E−08
.35	.12144E−07	.10108E−07	.87014E−08	.76653E−08	.68671E−08	.62315E−08	.57123E−08	.52793E−08	.49122E−08	.45966E−08	.43221E−08
.40	.12144E−07	.10108E−07	.87016E−08	.76654E−08	.68672E−08	.62316E−08	.57123E−08	.52793E−08	.49122E−08	.45966E−08	.43221E−08
.45	.12145E−07	.10109E−07	.87018E−08	.76655E−08	.68673E−08	.62316E−08	.57124E−08	.52793E−08	.49122E−08	.45967E−08	.43222E−08
.50	.12145E−07	.10109E−07	.87021E−08	.76657E−08	.68674E−08	.62317E−08	.57124E−08	.52794E−08	.49123E−08	.45967E−08	.43222E−08
.55	.12146E−07	.10110E−07	.87024E−08	.76659E−08	.68676E−08	.62319E−08	.57125E−08	.52795E−08	.49124E−08	.45968E−08	.43223E−08
.60	.12147E−07	.10110E−07	.87029E−08	.76663E−08	.68678E−08	.62321E−08	.57127E−08	.52796E−08	.49125E−08	.45970E−08	.43224E−08
.65	.12149E−07	.10111E−07	.87036E−08	.76667E−08	.68682E−08	.62323E−08	.57129E−08	.52799E−08	.49128E−08	.45972E−08	.43227E−08
.70	.12151E−07	.10113E−07	.87044E−08	.76673E−08	.68686E−08	.62327E−08	.57133E−08	.52803E−08	.49132E−08	.45976E−08	.43232E−08
.75	.12153E−07	.10114E−07	.87056E−08	.76681E−08	.68692E−08	.62332E−08	.57138E−08	.52808E−08	.49138E−08	.45984E−08	.43241E−08
.80	.12156E−07	.10117E−07	.87071E−08	.76691E−08	.68699E−08	.62338E−08	.57145E−08	.52817E−08	.49149E−08	.45995E−08	.43251E−08
.85	.12162E−07	.10120E−07	.87091E−08	.76704E−08	.68708E−08	.62346E−08	.57155E−08	.52831E−08	.49163E−08	.46010E−08	.43274E−08
.90	.12169E−07	.10125E−07	.87118E−08	.76720E−08	.68719E−08	.62356E−08	.57169E−08	.52850E−08	.49183E−08	.46031E−08	.43304E−08
.95	.12181E−07	.10130E−07	.87150E−08	.76740E−08	.68733E−08	.62369E−08	.57187E−08	.52874E−08	.49212E−08	.46061E−08	.43338E−08
1.00	.12193E−07	.10139E−07	.87196E−08	.76765E−08	.68749E−08	.62386E−08	.57210E−08	.52906E−08	.49250E−08	.46100E−08	.43374E−08
1.05	.12210E−07	.10148E−07	.87252E−08	.76797E−08	.68771E−08	.62407E−08	.57239E−08	.52949E−08	.49292E−08	.46140E−08	.43448E−08
1.10	.12225E−07	.10160E−07	.87325E−08	.76841E−08	.68803E−08	.62435E−08	.57277E−08	.53003E−08	.49341E−08	.46186E−08	.43543E−08
1.15	.12249E−07	.10171E−07	.87405E−08	.76903E−08	.68847E−08	.62478E−08	.57326E−08	.53060E−08	.49411E−08	.46263E−08	.43631E−08
1.20	.12264E−07	.10187E−07	.87518E−08	.76985E−08	.68912E−08	.62533E−08	.57387E−08	.53134E−08	.49483E−08	.46340E−08	.43785E−08
1.25	.12290E−07	.10200E−07	.87625E−08	.77079E−08	.68990E−08	.62614E−08	.57482E−08	.53230E−08	.49594E−08	.46466E−08	.43882E−08
1.30	.12313E−07	.10219E−07	.87749E−08	.77173E−08	.69090E−08	.62724E−08	.57609E−08	.53380E−08	.49722E−08	.46567E−08	.44007E−08
1.35	.12335E−07	.10237E−07	.87919E−08	.77323E−08	.69215E−08	.62843E−08	.57734E−08	.53526E−08	.49905E−08	.46782E−08	.44329E−08
1.40	.12374E−07	.10258E−07	.88069E−08	.77448E−08	.69351E−08	.63007E−08	.57921E−08	.53734E−08	.50100E−08	.46938E−08	.44445E−08
1.45	.12404E−07	.10285E−07	.88299E−08	.77651E−08	.69537E−08	.63189E−08	.58106E−08	.53949E−08	.50349E−08	.47215E−08	.44871E−08
1.50	.12436E−07	.10314E−07	.88535E−08	.77854E−08	.69756E−08	.63429E−08	.58337E−08	.54291E−08	.50646E−08	.47460E−08	.45319E−08
1.55	.12471E−07	.10349E−07	.88859E−08	.78159E−08	.70030E−08	.63683E−08	.58657E−08	.54621E−08	.51051E−08	.47941E−08	.46081E−08
1.60	.12492E−07	.10394E−07	.89247E−08	.78479E−08	.70335E−08	.63991E−08	.58992E−08	.55027E−08	.51488E−08	.48425E−08	.47050E−08
1.65	.12540E−07	.10435E−07	.89707E−08	.78940E−08	.70738E−08	.64352E−08	.59339E−08	.55482E−08	.52065E−08	.49143E−08	.48411E−08
1.70	.12597E−07	.10487E−07	.90205E−08	.79450E−08	.71232E−08	.64818E−08	.59864E−08	.56087E−08	.52730E−08	.49911E−08	.49837E−08
1.75	.12626E−07	.10540E−07	.90908E−08	.80166E−08	.71849E−08	.65327E−08	.60354E−08	.56785E−08	.53696E−08	.51215E−08	.52959E−08
1.80	.12641E−07	.10620E−07	.91803E−08	.81043E−08	.72576E−08	.65854E−08	.60897E−08	.57691E−08	.54986E−08	.53021E−08	.57486E−08
1.85	.12690E−07	.10691E−07	.92707E−08	.81977E−08	.73439E−08	.66673E−08	.61859E−08	.59250E−08	.57100E−08	.55689E−08	
1.90	.12720E−07	.10819E−07	.93726E−08	.82808E−08	.74357E−08	.67849E−08	.63471E−08	.61711E−08			
1.95	.12890E−07	.10908E−07	.94707E−08	.84000E−08	.75874E−08	.69843E−08	.66173E−08				
2.00	.12943E−07	.11100E−07	.96099E−08	.85478E−08	.78040E−08						
2.05	.13169E−07	.11218E−07	.97637E−08								
2.10	.13267E−07	.11360E−07									

TABLE 5. Thermal expansion coefficient (K⁻¹)

Temp. (K)	Pressure (atm) .00	2.50	5.00	7.50	10.00	12.50	15.00	17.50	20.00	22.50	25.00
.10	.1138E−05	.7258E−06	.5025E−06	.3682E−06	.2813E−06	.2219E−06	.1795E−06	.1482E−06	.1244E−06	.1054E−06	.9090E−07
.15	.3761E−05	.2419E−05	.1683E−05	.1237E−05	.9469E−06	.7478E−06	.6054E−06	.5001E−06	.4201E−06	.3559E−06	.3071E−06
.20	.8682E−05	.5644E−05	.3952E−05	.2916E−05	.2237E−05	.1770E−05	.1434E−05	.1185E−05	.9964E−06	.8445E−06	.7290E−06
.25	.1646E−04	.1082E−04	.7632E−05	.5657E−05	.4353E−05	.3449E−05	.2799E−05	.2316E−05	.1948E−05	.1652E−05	.1426E−05
.30	.2750E−04	.1833E−04	.1303E−04	.9703E−05	.7491E−05	.5948E−05	.4834E−05	.4004E−05	.3370E−05	.2859E−05	.2470E−05
.35	.4219E−04	.2847E−04	.2041E−04	.1528E−04	.1184E−04	.9424E−05	.7669E−05	.6358E−05	.5353E−05	.4541E−05	.3919E−05
.40	.6075E−04	.4153E−04	.3002E−04	.2260E−04	.1757E−04	.1401E−04	.1140E−04	.9444E−05	.7931E−05	.6694E−05	.5732E−05
.45	.8335E−04	.5770E−04	.4201E−04	.3176E−04	.2471E−04	.1968E−04	.1596E−04	.1312E−04	.1086E−04	.8978E−05	.7407E−05
.50	.1101E−03	.7691E−04	.5623E−04	.4248E−04	.3290E−04	.2596E−04	.2075E−04	.1660E−04	.1314E−04	.1012E−04	.7271E−05
.55	.1408E−03	.9866E−04	.7131E−04	.5365E−04	.4083E−04	.3141E−04	.2403E−04	.1781E−04	.1232E−04	.7153E−05	.1361E−05
.60	.1749E−03	.1214E−03	.8655E−04	.6270E−04	.4572E−04	.3287E−04	.2249E−04	.1297E−04	.3806E−05	−.5229E−05	−.1709E−04
.65	.2112E−03	.1422E−03	.9653E−04	.6493E−04	.4249E−04	.2554E−04	.1069E−04	−.4306E−05	−.1998E−04	−.3601E−04	−.5501E−04
.70	.2497E−03	.1561E−03	.9537E−04	.5402E−04	.2419E−04	.1493E−05	−.1924E−04	−.4238E−04	−.6654E−04	−.9307E−04	−.1279E−03
.75	.2818E−03	.1599E−03	.7569E−04	.2037E−04	−.1767E−04	−.4729E−04	−.7539E−04	−.1098E−03	−.1496E−03	−.1965E−03	−.2399E−03
.80	.3233E−03	.1370E−03	.2509E−04	−.4430E−04	−.9283E−04	−.1319E−03	−.1694E−03	−.2190E−03	−.2785E−03	−.3412E−03	−.4180E−03
.85	.3450E−03	.9061E−04	−.6036E−04	−.1533E−03	−.2133E−03	−.2590E−03	−.3084E−03	−.3799E−03	−.4664E−03	−.5494E−03	−.6761E−03
.90	.3598E−03	−.2966E−05	−.1943E−03	−.3099E−03	−.3864E−03	−.4410E−03	−.5061E−03	−.6013E−03	−.7212E−03	−.8463E−03	−.1005E−02
.95	.3497E−03	−.1128E−03	−.3747E−03	−.5261E−03	−.6157E−03	−.6856E−03	−.7746E−03	−.8950E−03	−.1056E−02	−.1234E−02	−.1389E−02
1.00	.3294E−03	−.2673E−03	−.6053E−03	−.7986E−03	−.9087E−03	−.9983E−03	−.1112E−02	−.1268E−02	−.1474E−02	−.1679E−02	−.1922E−02
1.05	.2495E−03	−.4329E−03	−.8585E−03	−.1105E−02	−.1259E−02	−.1392E−02	−.1517E−02	−.1730E−02	−.1993E−02	−.2176E−02	−.2588E−02
1.10	.1225E−03	−.6585E−03	−.1126E−02	−.1446E−02	−.1668E−02	−.1839E−02	−.2038E−02	−.2287E−02	−.2588E−02	−.2908E−02	−.3292E−02
1.15	.4805E−05	−.8227E−03	−.1404E−02	−.1833E−02	−.2150E−02	−.2405E−02	−.2657E−02	−.2953E−02	−.3309E−02	−.3656E−02	−.4233E−02
1.20	−.2215E−03	−.1086E−02	−.1738E−02	−.2261E−02	−.2684E−02	−.3020E−02	−.3370E−02	−.3768E−02	−.4192E−02	−.4716E−02	−.5387E−02
1.25	−.4523E−03	−.1510E−02	−.2174E−02	−.2649E−02	−.3080E−02	−.3548E−02	−.4096E−02	−.4733E−02	−.5367E−02	−.5922E−02	−.6283E−02
1.30	−.7342E−03	−.1715E−02	−.2578E−02	−.3289E−02	−.3903E−02	−.4480E−02	−.5054E−02	−.5721E−02	−.6516E−02	−.7377E−02	−.8599E−02
1.35	−.1117E−02	−.2387E−02	−.3272E−02	−.4011E−02	−.4662E−02	−.5330E−02	−.6107E−02	−.6942E−02	−.7910E−02	−.8883E−02	−.9883E−02
1.40	−.1387E−02	−.2930E−02	−.4017E−02	−.4904E−02	−.5710E−02	−.6548E−02	−.7456E−02	−.8410E−02	−.9511E−02	−.1067E−01	−.1187E−01
1.45	−.1994E−02	−.3458E−02	−.4748E−02	−.5843E−02	−.6839E−02	−.7914E−02	−.9020E−02	−.1032E−01	−.1181E−01	−.1316E−01	−.1520E−01
1.50	−.2417E−02	−.4111E−02	−.5605E−02	−.6933E−02	−.8210E−02	−.9478E−02	−.1079E−01	−.1237E−01	−.1424E−01	−.1618E−01	−.1885E−01
1.55	−.2937E−02	−.4713E−02	−.6618E−02	−.8284E−02	−.9789E−02	−.1122E−01	−.1267E−01	−.1433E−01	−.1636E−01	−.1886E−01	−.2267E−01
1.60	−.3579E−02	−.5508E−02	−.7717E−02	−.9809E−02	−.1167E−01	−.1340E−01	−.1510E−01	−.1699E−01	−.1948E−01	−.2258E−01	−.2800E−01
1.65	−.3965E−02	−.6625E−02	−.9036E−02	−.1146E−01	−.1389E−01	−.1605E−01	−.1819E−01	−.2062E−01	−.2357E−01	−.2728E−01	−.3294E−01
1.70	−.5155E−02	−.7651E−02	−.1048E−01	−.1351E−01	−.1647E−01	−.1917E−01	−.2176E−01	−.2468E−01	−.2861E−01	−.3375E−01	−.4315E−01
1.75	−.5524E−02	−.7739E−02	−.1172E−01	−.1591E−01	−.1977E−01	−.2270E−01	−.2504E−01	−.2796E−01	−.3297E−01	−.4060E−01	−.5743E−01
1.80	−.6582E−02	−.9490E−02	−.1368E−01	−.1847E−01	−.2307E−01	−.2681E−01	−.3012E−01	−.3466E−01	−.4242E−01	−.5375E−01	−.7711E−01
1.85	−.7929E−02	−.1150E−01	−.1651E−01	−.2106E−01	−.2530E−01	−.2986E−01	−.3533E−01	−.4306E−01	−.5537E−01	−.7240E−01	
1.90	−.8732E−02	−.1440E−01	−.1943E−01	−.2440E−01	−.2978E−01	−.3664E−01	−.4585E−01	−.5877E−01			
1.95	−.1031E−01	−.1659E−01	−.2270E−01	−.2871E−01	−.3652E−01	−.4745E−01	−.6173E−01				
2.00	−.1128E−01	−.1897E−01	−.2610E−01	−.3420E−01	−.4564E−01						
2.05	−.1416E−01	−.2186E−01	−.2949E−01								
2.10	−.1770E−01	−.2344E−01									

TABLE 6. Helmholtz free energy of excitations (J g^{-1})

Temp. (K)	Pressure (atm) .00	2.50	5.00	7.50	10.00	12.50	15.00	17.50	20.00	22.50	25.00
.10	-.1395E-05	-.1079E-05	-.8744E-06	-.7314E-06	-.6264E-06	-.5463E-06	-.4832E-06	-.4324E-06	-.3907E-06	-.3558E-06	-.3263E-06
.15	-.2092E-05	-.1619E-05	-.1312E-05	-.1097E-05	-.9396E-06	-.8194E-06	-.7248E-06	-.6486E-06	-.5860E-06	-.5337E-06	-.4894E-06
.20	-.3957E-05	-.3067E-05	-.2487E-05	-.2082E-05	-.1784E-05	-.1556E-05	-.1376E-05	-.1232E-05	-.1113E-05	-.1014E-05	-.9295E-06
.25	-.7859E-05	-.6110E-05	-.4963E-05	-.4158E-05	-.3564E-05	-.3110E-05	-.2752E-05	-.2464E-05	-.2226E-05	-.2028E-05	-.1860E-05
.30	-.1489E-04	-.1162E-04	-.9460E-05	-.7935E-05	-.6807E-05	-.5942E-05	-.5260E-05	-.4709E-05	-.4256E-05	-.3877E-05	-.3556E-05
.35	-.2637E-04	-.2066E-04	-.1686E-04	-.1416E-04	-.1216E-04	-.1062E-04	-.9402E-05	-.8420E-05	-.7611E-05	-.6935E-05	-.6361E-05
.40	-.4382E-04	-.3447E-04	-.2819E-04	-.2371E-04	-.2038E-04	-.1781E-04	-.1578E-04	-.1414E-04	-.1279E-04	-.1165E-04	-.1070E-04
.45	-.6897E-04	-.5449E-04	-.4468E-04	-.3765E-04	-.3239E-04	-.2834E-04	-.2513E-04	-.2254E-04	-.2041E-04	-.1864E-04	-.1714E-04
.50	-.1038E-03	-.8236E-04	-.6774E-04	-.5721E-04	-.4933E-04	-.4325E-04	-.3845E-04	-.3459E-04	-.3144E-04	-.2885E-04	-.2671E-04
.55	-.1505E-03	-.1201E-03	-.9915E-04	-.8407E-04	-.7279E-04	-.6413E-04	-.5733E-04	-.5194E-04	-.4763E-04	-.4421E-04	-.4156E-04
.60	-.2120E-03	-.1702E-03	-.1414E-03	-.1207E-03	-.1054E-03	-.9372E-04	-.8473E-04	-.7780E-04	-.7256E-04	-.6873E-04	-.6627E-04
.65	-.2922E-03	-.2365E-03	-.1984E-03	-.1714E-03	-.1517E-03	-.1371E-03	-.1262E-03	-.1184E-03	-.1132E-03	-.1103E-03	-.1098E-03
.70	-.3967E-03	-.3249E-03	-.2766E-03	-.2431E-03	-.2196E-03	-.2030E-03	-.1917E-03	-.1847E-03	-.1818E-03	-.1828E-03	-.1880E-03
.75	-.5345E-03	-.4446E-03	-.3860E-03	-.3475E-03	-.3221E-03	-.3063E-03	-.2974E-03	-.2950E-03	-.2987E-03	-.3089E-03	-.3263E-03
.80	-.7188E-03	-.6098E-03	-.5429E-03	-.5027E-03	-.4797E-03	-.4695E-03	-.4683E-03	-.4767E-03	-.4942E-03	-.5226E-03	-.5618E-03
.85	-.9697E-03	-.8414E-03	-.7706E-03	-.7350E-03	-.7218E-03	-.7253E-03	-.7406E-03	-.7694E-03	-.8117E-03	-.8703E-03	-.9461E-03
.90	-.1315E-02	-.1170E-02	-.1102E-02	-.1081E-02	-.1090E-02	-.1118E-02	-.1162E-02	-.1225E-02	-.1308E-02	-.1415E-02	-.1548E-02
.95	-.1793E-02	-.1636E-02	-.1583E-02	-.1591E-02	-.1635E-02	-.1707E-02	-.1797E-02	-.1912E-02	-.2055E-02	-.2235E-02	-.2449E-02
1.00	-.2458E-02	-.2294E-02	-.2270E-02	-.2325E-02	-.2428E-02	-.2561E-02	-.2720E-02	-.2912E-02	-.3144E-02	-.3425E-02	-.3755E-02
1.05	-.3375E-02	-.3216E-02	-.3238E-02	-.3364E-02	-.3549E-02	-.3771E-02	-.4028E-02	-.4326E-02	-.4679E-02	-.5098E-02	-.5584E-02
1.10	-.4634E-02	-.4491E-02	-.4579E-02	-.4798E-02	-.5093E-02	-.5436E-02	-.5825E-02	-.6266E-02	-.6784E-02	-.7384E-02	-.8076E-02
1.15	-.6335E-02	-.6224E-02	-.6398E-02	-.6736E-02	-.7176E-02	-.7678E-02	-.8241E-02	-.8873E-02	-.9595E-02	-.1043E-01	-.1139E-01
1.20	-.8599E-02	-.8535E-02	-.8813E-02	-.9301E-02	-.9922E-02	-.1063E-01	-.1141E-01	-.1229E-01	-.1328E-01	-.1442E-01	-.1570E-01
1.25	-.1155E-01	-.1156E-01	-.1198E-01	-.1265E-01	-.1349E-01	-.1443E-01	-.1550E-01	-.1668E-01	-.1801E-01	-.1953E-01	-.2122E-01
1.30	-.1534E-01	-.1545E-01	-.1604E-01	-.1693E-01	-.1802E-01	-.1927E-01	-.2066E-01	-.2221E-01	-.2397E-01	-.2597E-01	-.2817E-01
1.35	-.2013E-01	-.2037E-01	-.2116E-01	-.2232E-01	-.2374E-01	-.2536E-01	-.2716E-01	-.2918E-01	-.3144E-01	-.3401E-01	-.3689E-01
1.40	-.2610E-01	-.2651E-01	-.2758E-01	-.2908E-01	-.3088E-01	-.3294E-01	-.3523E-01	-.3779E-01	-.4068E-01	-.4395E-01	-.4756E-01
1.45	-.3353E-01	-.3415E-01	-.3553E-01	-.3745E-01	-.3972E-01	-.4232E-01	-.4523E-01	-.4848E-01	-.5211E-01	-.5622E-01	-.6081E-01
1.50	-.4265E-01	-.4355E-01	-.4534E-01	-.4772E-01	-.5056E-01	-.5379E-01	-.5742E-01	-.6148E-01	-.6606E-01	-.7122E-01	-.7697E-01
1.55	-.5364E-01	-.5488E-01	-.5711E-01	-.6006E-01	-.6359E-01	-.6760E-01	-.7212E-01	-.7715E-01	-.8280E-01	-.8919E-01	-.9642E-01
1.60	-.6674E-01	-.6836E-01	-.7113E-01	-.7476E-01	-.7910E-01	-.8404E-01	-.8954E-01	-.9570E-01	-.1027E+00	-.1105E+00	-.1194E+00
1.65	-.8220E-01	-.8427E-01	-.8765E-01	-.9208E-01	-.9740E-01	-.1035E+00	-.1102E+00	-.1177E+00	-.1262E+00	-.1358E+00	-.1469E+00
1.70	-.1005E+00	-.1030E+00	-.1072E+00	-.1126E+00	-.1190E+00	-.1264E+00	-.1346E+00	-.1438E+00	-.1541E+00	-.1659E+00	-.1795E+00
1.75	-.1219E+00	-.1251E+00	-.1301E+00	-.1366E+00	-.1444E+00	-.1533E+00	-.1633E+00	-.1745E+00	-.1870E+00	-.2014E+00	-.2184E+00
1.80	-.1471E+00	-.1509E+00	-.1568E+00	-.1646E+00	-.1740E+00	-.1849E+00	-.1969E+00	-.2103E+00	-.2254E+00	-.2430E+00	-.2643E+00
1.85	-.1762E+00	-.1810E+00	-.1880E+00	-.1973E+00	-.2086E+00	-.2216E+00	-.2361E+00	-.2523E+00	-.2708E+00	-.2927E+00	
1.90	-.2100E+00	-.2157E+00	-.2241E+00	-.2353E+00	-.2486E+00	-.2640E+00	-.2814E+00	-.3010E+00			
1.95	-.2486E+00	-.2557E+00	-.2657E+00	-.2789E+00	-.2948E+00	-.3133E+00	-.3346E+00				
2.00	-.2930E+00	-.3015E+00	-.3134E+00	-.3291E+00	-.3479E+00						
2.05	-.3440E+00	-.3542E+00	-.3684E+00								
2.10	-.4023E+00	-.4145E+00									

TABLE 7. Gibbs free energy of excitations (J g^{-1})

Temp. (K)	Pressure (atm) .00	2.50	5.00	7.50	10.00	12.50	15.00	17.50	20.00	22.50	25.00
.10	−.1395E−05	−.1079E−05	−.8744E−06	−.7314E−06	−.6264E−06	−.5463E−06	−.4832E−06	−.4324E−06	−.3907E−06	−.3558E−06	−.3263E−06
.15	−.2092E−05	−.1619E−05	−.1312E−05	−.1097E−05	−.9396E−06	−.8194E−06	−.7243E−06	−.6486E−06	−.5860E−06	−.5337E−06	−.4894E−06
.20	−.3957E−05	−.3067E−05	−.2487E−05	−.2082E−05	−.1784E−05	−.1556E−05	−.1376E−05	−.1232E−05	−.1113E−05	−.1014E−05	−.9295E−06
.25	−.7859E−05	−.6110E−05	−.4963E−05	−.4158E−05	−.3564E−05	−.3110E−05	−.2752E−05	−.2464E−05	−.2226E−05	−.2028E−05	−.1860E−05
.30	−.1489E−04	−.1162E−04	−.9460E−05	−.7935E−05	−.6807E−05	−.5942E−05	−.5260E−05	−.4709E−05	−.4256E−05	−.3877E−05	−.3556E−05
.35	−.2637E−04	−.2066E−04	−.1686E−04	−.1416E−04	−.1216E−04	−.1062E−04	−.9402E−05	−.8420E−05	−.7611E−05	−.6935E−05	−.6361E−05
.40	−.4382E−04	−.3448E−04	−.2819E−04	−.2372E−04	−.2038E−04	−.1781E−04	−.1573E−04	−.1414E−04	−.1279E−04	−.1165E−04	−.1070E−04
.45	−.6897E−04	−.5449E−04	−.4468E−04	−.3765E−04	−.3239E−04	−.2834E−04	−.2513E−04	−.2254E−04	−.2041E−04	−.1864E−04	−.1714E−04
.50	−.1038E−03	−.8237E−04	−.6774E−04	−.5721E−04	−.4933E−04	−.4325E−04	−.3845E−04	−.3459E−04	−.3144E−04	−.2885E−04	−.2671E−04
.55	−.1505E−03	−.1201E−03	−.9916E−04	−.8407E−04	−.7279E−04	−.6413E−04	−.5734E−04	−.5194E−04	−.4763E−04	−.4421E−04	−.4156E−04
.60	−.2120E−03	−.1702E−03	−.1414E−03	−.1207E−03	−.1054E−03	−.9373E−04	−.8474E−04	−.7781E−04	−.7256E−04	−.6873E−04	−.6627E−04
.65	−.2922E−03	−.2366E−03	−.1985E−03	−.1714E−03	−.1517E−03	−.1371E−03	−.1262E−03	−.1184E−03	−.1132E−03	−.1103E−03	−.1098E−03
.70	−.3968E−03	−.3249E−03	−.2766E−03	−.2431E−03	−.2196E−03	−.2031E−03	−.1917E−03	−.1847E−03	−.1818E−03	−.1829E−03	−.1880E−03
.75	−.5345E−03	−.4446E−03	−.3861E−03	−.3475E−03	−.3222E−03	−.3064E−03	−.2974E−03	−.2950E−03	−.2987E−03	−.3089E−03	−.3263E−03
.80	−.7188E−03	−.6099E−03	−.5429E−03	−.5028E−03	−.4797E−03	−.4696E−03	−.4683E−03	−.4767E−03	−.4942E−03	−.5226E−03	−.5617E−03
.85	−.9698E−03	−.8415E−03	−.7707E−03	−.7351E−03	−.7219E−03	−.7254E−03	−.7405E−03	−.7694E−03	−.8117E−03	−.8702E−03	−.9460E−03
.90	−.1315E−02	−.1170E−02	−.1103E−02	−.1081E−02	−.1090E−02	−.1118E−02	−.1162E−02	−.1224E−02	−.1307E−02	−.1414E−02	−.1547E−02
.95	−.1793E−02	−.1636E−02	−.1583E−02	−.1591E−02	−.1635E−02	−.1706E−02	−.1796E−02	−.1911E−02	−.2055E−02	−.2234E−02	−.2448E−02
1.00	−.2458E−02	−.2295E−02	−.2270E−02	−.2325E−02	−.2428E−02	−.2561E−02	−.2719E−02	−.2911E−02	−.3143E−02	−.3424E−02	−.3753E−02
1.05	−.3376E−02	−.3217E−02	−.3238E−02	−.3364E−02	−.3548E−02	−.3770E−02	−.4027E−02	−.4325E−02	−.4677E−02	−.5095E−02	−.5580E−02
1.10	−.4634E−02	−.4491E−02	−.4579E−02	−.4797E−02	−.5092E−02	−.5434E−02	−.5823E−02	−.6263E−02	−.6780E−02	−.7379E−02	−.8069E−02
1.15	−.6336E−02	−.6224E−02	−.6397E−02	−.6735E−02	−.7174E−02	−.7674E−02	−.8236E−02	−.8867E−02	−.9587E−02	−.1042E−01	−.1137E−01
1.20	−.8601E−02	−.8535E−02	−.8812E−02	−.9298E−02	−.9918E−02	−.1062E−01	−.1140E−01	−.1228E−01	−.1327E−01	−.1440E−01	−.1568E−01
1.25	−.1155E−01	−.1156E−01	−.1198E−01	−.1264E−01	−.1348E−01	−.1442E−01	−.1543E−01	−.1666E−01	−.1799E−01	−.1950E−01	−.2119E−01
1.30	−.1535E−01	−.1545E−01	−.1604E−01	−.1692E−01	−.1801E−01	−.1925E−01	−.2063E−01	−.2218E−01	−.2393E−01	−.2592E−01	−.2811E−01
1.35	−.2013E−01	−.2036E−01	−.2115E−01	−.2230E−01	−.2372E−01	−.2532E−01	−.2712E−01	−.2912E−01	−.3138E−01	−.3393E−01	−.3680E−01
1.40	−.2610E−01	−.2651E−01	−.2757E−01	−.2906E−01	−.3084E−01	−.3288E−01	−.3516E−01	−.3771E−01	−.4058E−01	−.4383E−01	−.4742E−01
1.45	−.3353E−01	−.3414E−01	−.3551E−01	−.3740E−01	−.3966E−01	−.4223E−01	−.4512E−01	−.4835E−01	−.5196E−01	−.5603E−01	−.6059E−01
1.50	−.4264E−01	−.4353E−01	−.4529E−01	−.4766E−01	−.5046E−01	−.5366E−01	−.5726E−01	−.6128E−01	−.6582E−01	−.7094E−01	−.7664E−01
1.55	−.5364E−01	−.5485E−01	−.5704E−01	−.5995E−01	−.6344E−01	−.6741E−01	−.7187E−01	−.7686E−01	−.8245E−01	−.8878E−01	−.9594E−01
1.60	−.6673E−01	−.6831E−01	−.7102E−01	−.7460E−01	−.7888E−01	−.8375E−01	−.8919E−01	−.9527E−01	−.1021E+00	−.1099E+00	−.1187E+00
1.65	−.8218E−01	−.8419E−01	−.8749E−01	−.9184E−01	−.9708E−01	−.1030E+00	−.1097E+00	−.1171E+00	−.1255E+00	−.1350E+00	−.1459E+00
1.70	−.1004E+00	−.1029E+00	−.1069E+00	−.1122E+00	−.1185E+00	−.1258E+00	−.1333E+00	−.1429E+00	−.1531E+00	−.1646E+00	−.1780E+00
1.75	−.1219E+00	−.1249E+00	−.1298E+00	−.1361E+00	−.1437E+00	−.1525E+00	−.1623E+00	−.1732E+00	−.1856E+00	−.1997E+00	−.2164E+00
1.80	−.1470E+00	−.1507E+00	−.1564E+00	−.1639E+00	−.1731E+00	−.1837E+00	−.1954E+00	−.2085E+00	−.2234E+00	−.2406E+00	−.2615E+00
1.85	−.1761E+00	−.1806E+00	−.1873E+00	−.1963E+00	−.2073E+00	−.2199E+00	−.2341E+00	−.2499E+00	−.2680E+00	−.2893E+00	
1.90	−.2097E+00	−.2152E+00	−.2232E+00	−.2339E+00	−.2468E+00	−.2617E+00	−.2785E+00	−.2977E+00			
1.95	−.2483E+00	−.2549E+00	−.2644E+00	−.2771E+00	−.2923E+00	−.3102E+00	−.3303E+00				
2.00	−.2925E+00	−.3004E+00	−.3116E+00	−.3265E+00	−.3446E+00						
2.05	−.3434E+00	−.3527E+00	−.3660E+00								
2.10	−.4014E+00	−.4124E+00									

TABLE 8. Enthalpy of excitations (J g⁻¹)

Temp. (K)	Pressure (atm) .00	2.50	5.00	7.50	10.00	12.50	15.00	17.50	20.00	22.50	25.00
.10	.4174E-05	.3236E-05	.2618E-05	.2190E-05	.1874E-05	.1633E-05	.1443E-05	.1290E-05	.1164E-05	.1058E-05	.9670E-06
.15	.6261E-05	.4855E-05	.3927E-05	.3285E-05	.2811E-05	.2449E-05	.2165E-05	.1936E-05	.1746E-05	.1587E-05	.1450E-05
.20	.1181E-04	.9183E-05	.7449E-05	.6238E-05	.5343E-05	.4660E-05	.4122E-05	.3687E-05	.3328E-05	.3028E-05	.2771E-05
.25	.2337E-04	.1826E-04	.1486E-04	.1247E-04	.1069E-04	.9335E-05	.8262E-05	.7395E-05	.6680E-05	.6082E-05	.5573E-05
.30	.4412E-04	.3467E-04	.2832E-04	.2381E-04	.2045E-04	.1786E-04	.1582E-04	.1417E-04	.1280E-04	.1166E-04	.1069E-04
.35	.7787E-04	.6155E-04	.5046E-04	.4250E-04	.3655E-04	.3196E-04	.2832E-04	.2537E-04	.2294E-04	.2090E-04	.1916E-04
.40	.1290E-03	.1026E-03	.8440E-04	.7126E-04	.6138E-04	.5373E-04	.4766E-04	.4275E-04	.3869E-04	.3531E-04	.3246E-04
.45	.2025E-03	.1621E-03	.1339E-03	.1134E-03	.9799E-04	.8604E-04	.7658E-04	.6897E-04	.6277E-04	.5772E-04	.5359E-04
.50	.3046E-03	.2455E-03	.2041E-03	.1739E-03	.1513E-03	.1339E-03	.1203E-03	.1097E-03	.1014E-03	.9515E-04	.9067E-04
.55	.4436E-03	.3610E-03	.3032E-03	.2616E-03	.2309E-03	.2080E-03	.1909E-03	.1784E-03	.1700E-03	.1652E-03	.1643E-03
.60	.6331E-03	.5226E-03	.4470E-03	.3943E-03	.3572E-03	.3315E-03	.3144E-03	.3047E-03	.3022E-03	.3067E-03	.3191E-03
.65	.8974E-03	.7563E-03	.6648E-03	.6060E-03	.5696E-03	.5493E-03	.5414E-03	.5459E-03	.5626E-03	.5926E-03	.6374E-03
.70	.1278E-02	.1108E-02	.1009E-02	.9573E-03	.9368E-03	.9396E-03	.9594E-03	.9994E-03	.1059E-02	.1143E-02	.1253E-02
.75	.1844E-02	.1652E-02	.1565E-02	.1546E-02	.1569E-02	.1625E-02	.1703E-02	.1813E-02	.1954E-02	.2138E-02	.2364E-02
.80	.2705E-02	.2501E-02	.2461E-02	.2516E-02	.2626E-02	.2781E-02	.2966E-02	.3195E-02	.3477E-02	.3823E-02	.4238E-02
.85	.4008E-02	.3824E-02	.3877E-02	.4065E-02	.4329E-02	.4645E-02	.5001E-02	.5418E-02	.5919E-02	.6513E-02	.7218E-02
.90	.5966E-02	.5841E-02	.6059E-02	.6455E-02	.6953E-02	.7514E-02	.8128E-02	.8828E-02	.9641E-02	.1060E-01	.1171E-01
.95	.8873E-02	.8855E-02	.9306E-02	.1001E-01	.1084E-01	.1175E-01	.1273E-01	.1383E-01	.1507E-01	.1653E-01	.1817E-01
1.00	.1311E-01	.1324E-01	.1401E-01	.1512E-01	.1639E-01	.1776E-01	.1924E-01	.2086E-01	.2270E-01	.2480E-01	.2715E-01
1.05	.1916E-01	.1952E-01	.2066E-01	.2225E-01	.2406E-01	.2603E-01	.2815E-01	.3044E-01	.3306E-01	.3595E-01	.3921E-01
1.10	.2754E-01	.2820E-01	.2977E-01	.3188E-01	.3436E-01	.3706E-01	.3999E-01	.4318E-01	.4671E-01	.5065E-01	.5504E-01
1.15	.3883E-01	.3979E-01	.4179E-01	.4452E-01	.4779E-01	.5144E-01	.5541E-01	.5971E-01	.6442E-01	.6962E-01	.7548E-01
1.20	.5344E-01	.5490E-01	.5751E-01	.6097E-01	.6511E-01	.6979E-01	.7491E-01	.8062E-01	.8684E-01	.9371E-01	.1014E+00
1.25	.7210E-01	.7424E-01	.7768E-01	.8197E-01	.8694E-01	.9259E-01	.9898E-01	.1062E+00	.1144E+00	.1235E+00	.1331E+00
1.30	.9543E-01	.9819E-01	.1024E+00	.1078E+00	.1142E+00	.1215E+00	.1297E+00	.1389E+00	.1492E+00	.1607E+00	.1738E+00
1.35	.1240E+00	.1279E+00	.1335E+00	.1404E+00	.1485E+00	.1575E+00	.1678E+00	.1792E+00	.1921E+00	.2064E+00	.2223E+00
1.40	.1602E+00	.1651E+00	.1723E+00	.1811E+00	.1912E+00	.2027E+00	.2157E+00	.2301E+00	.2462E+00	.2641E+00	.2838E+00
1.45	.2054E+00	.2118E+00	.2205E+00	.2312E+00	.2438E+00	.2581E+00	.2743E+00	.2924E+00	.3131E+00	.3361E+00	.3619E+00
1.50	.2584E+00	.2661E+00	.2767E+00	.2898E+00	.3053E+00	.3230E+00	.3430E+00	.3654E+00	.3908E+00	.4196E+00	.4527E+00
1.55	.3185E+00	.3278E+00	.3406E+00	.3567E+00	.3758E+00	.3976E+00	.4218E+00	.4488E+00	.4789E+00	.5134E+00	.5543E+00
1.60	.3882E+00	.3993E+00	.4145E+00	.4341E+00	.4575E+00	.4843E+00	.5142E+00	.5473E+00	.5842E+00	.6267E+00	.6779E+00
1.65	.4715E+00	.4849E+00	.5034E+00	.5268E+00	.5553E+00	.5884E+00	.6254E+00	.6669E+00	.7132E+00	.7663E+00	.8293E+00
1.70	.5721E+00	.5883E+00	.6100E+00	.6382E+00	.6731E+00	.7138E+00	.7594E+00	.8100E+00	.8670E+00	.9339E+00	.1018E+01
1.75	.6917E+00	.7090E+00	.7331E+00	.7667E+00	.8094E+00	.8597E+00	.9146E+00	.9744E+00	.1042E+01	.1124E+01	.1238E+01
1.80	.8276E+00	.8490E+00	.8785E+00	.9185E+00	.9694E+00	.1029E+01	.1096E+01	.1171E+01	.1258E+01	.1370E+01	.1525E+01
1.85	.9832E+00	.1010E+01	.1048E+01	.1096E+01	.1154E+01	.1222E+01	.1301E+01	.1395E+01	.1511E+01	.1665E+01	
1.90	.1161E+01	.1194E+01	.1240E+01	.1298E+01	.1368E+01	.1451E+01	.1555E+01	.1684E+01			
1.95	.1363E+01	.1402E+01	.1458E+01	.1528E+01	.1613E+01	.1723E+01	.1865E+01				
2.00	.1603E+01	.1654E+01	.1719E+01	.1803E+01	.1911E+01						
2.05	.1891E+01	.1945E+01	.2020E+01								
2.10	.2197E+01	.2262E+01									

TABLE 9. Entropy (J g^{-1} K^{-1})

Temp. (K)	Pressure (atm) .00	2.50	5.00	7.50	10.00	12.50	15.00	17.50	20.00	22.50	25.00
.10	.68889E-05	.53212E-05	.43073E-05	.36013E-05	.30835E-05	.26885E-05	.23779E-05	.21278E-05	.19223E-05	.17507E-05	.16053E-05
.15	.23112E-04	.17910E-04	.14522E-04	.12153E-04	.10411E-04	.90809E-05	.80538E-05	.71898E-05	.64961E-05	.59167E-05	.54258E-05
.20	.54383E-04	.42309E-04	.34379E-04	.28808E-04	.24697E-04	.21551E-04	.19072E-04	.17072E-04	.15427E-04	.14052E-04	.12887E-04
.25	.10534E-03	.82321E-04	.67062E-04	.56275E-04	.48288E-04	.42161E-04	.37325E-04	.33419E-04	.30205E-04	.27517E-04	.25238E-04
.30	.18041E-03	.14169E-03	.11574E-03	.97286E-04	.83563E-04	.73007E-04	.64662E-04	.57914E-04	.52355E-04	.47703E-04	.43757E-04
.35	.28386E-03	.22408E-03	.18360E-03	.15460E-03	.13295E-03	.11624E-03	.10301E-03	.92302E-04	.83472E-04	.76082E-04	.69818E-04
.40	.41983E-03	.33319E-03	.27388E-03	.23111E-03	.19903E-03	.17422E-03	.15455E-03	.13862E-03	.12552E-03	.11458E-03	.10537E-03
.45	.59254E-03	.47292E-03	.39022E-03	.33023E-03	.28510E-03	.25019E-03	.22257E-03	.20032E-03	.18222E-03	.16740E-03	.15522E-03
.50	.80709E-03	.64828E-03	.53774E-03	.45745E-03	.39716E-03	.35081E-03	.31462E-03	.28606E-03	.26359E-03	.24614E-03	.23324E-03
.55	.10714E-02	.86783E-03	.72633E-03	.62421E-03	.54858E-03	.49184E-03	.44872E-03	.41671E-03	.39395E-03	.37942E-03	.37333E-03
.60	.14005E-02	.11486E-02	.97586E-03	.85450E-03	.76775E-03	.70618E-03	.66321E-03	.63604E-03	.62338E-03	.62473E-03	.64195E-03
.65	.18226E-02	.15219E-02	.13238E-02	.11926E-02	.11070E-02	.10538E-02	.10254E-02	.10205E-02	.10386E-02	.10811E-02	.11493E-02
.70	.23865E-02	.20413E-02	.18328E-02	.17118E-02	.16495E-02	.16304E-02	.16430E-02	.16908E-02	.17725E-02	.18928E-02	.20589E-02
.75	.31649E-02	.27906E-02	.25972E-02	.25218E-02	.25192E-02	.25729E-02	.26656E-02	.28086E-02	.30018E-02	.32620E-02	.35866E-02
.80	.42735E-02	.38840E-02	.37520E-02	.37708E-02	.38804E-02	.40606E-02	.42917E-02	.45890E-02	.49635E-02	.54308E-02	.59979E-02
.85	.58517E-02	.54850E-02	.54647E-02	.56441E-02	.59400E-02	.63147E-02	.67525E-02	.72765E-02	.79173E-02	.86838E-02	.96015E-02
.90	.80843E-02	.77855E-02	.79541E-02	.83705E-02	.89332E-02	.95887E-02	.10319E-01	.11166E-01	.12162E-01	.13343E-01	.14726E-01
.95	.11230E-01	.11042E-01	.11460E-01	.12207E-01	.13127E-01	.14156E-01	.15283E-01	.16562E-01	.18024E-01	.19748E-01	.21696E-01
1.00	.15562E-01	.15531E-01	.16276E-01	.17438E-01	.18815E-01	.20318E-01	.21955E-01	.23770E-01	.25837E-01	.28212E-01	.30896E-01
1.05	.21457E-01	.21648E-01	.22755E-01	.24383E-01	.26280E-01	.28378E-01	.30639E-01	.33093E-01	.35933E-01	.39080E-01	.42648E-01
1.10	.29233E-01	.29716E-01	.31223E-01	.33340E-01	.35858E-01	.38625E-01	.41629E-01	.44939E-01	.48610E-01	.52737E-01	.57356E-01
1.15	.39275E-01	.40009E-01	.41895E-01	.44562E-01	.47776E-01	.51374E-01	.55305E-01	.59588E-01	.64319E-01	.69555E-01	.75456E-01
1.20	.51689E-01	.52846E-01	.55231E-01	.58523E-01	.62507E-01	.67028E-01	.71957E-01	.77447E-01	.83426E-01	.90091E-01	.97621E-01
1.25	.66910E-01	.68645E-01	.71759E-01	.75720E-01	.80318E-01	.85539E-01	.91459E-01	.98205E-01	.10584E+00	.11425E+00	.12317E+00
1.30	.85256E-01	.87415E-01	.91048E-01	.95878E-01	.10165E+00	.10827E+00	.11567E+00	.12389E+00	.13311E+00	.14350E+00	.15539E+00
1.35	.10675E+00	.10981E+00	.11456E+00	.12053E+00	.12752E+00	.13536E+00	.14424E+00	.15420E+00	.16537E+00	.17790E+00	.19172E+00
1.40	.13301E+00	.13679E+00	.14263E+00	.14995E+00	.15848E+00	.16811E+00	.17897E+00	.19108E+00	.20455E+00	.21959E+00	.23620E+00
1.45	.16481E+00	.16958E+00	.17651E+00	.18521E+00	.19538E+00	.20696E+00	.22013E+00	.23477E+00	.25150E+00	.27013E+00	.29107E+00
1.50	.20076E+00	.20644E+00	.21462E+00	.22489E+00	.23703E+00	.25096E+00	.26664E+00	.28423E+00	.30423E+00	.32689E+00	.35275E+00
1.55	.24020E+00	.24688E+00	.25645E+00	.26869E+00	.28315E+00	.29972E+00	.31816E+00	.33871E+00	.36168E+00	.38791E+00	.41876E+00
1.60	.28431E+00	.29219E+00	.30331E+00	.31767E+00	.33491E+00	.35460E+00	.37664E+00	.40100E+00	.42826E+00	.45963E+00	.49733E+00
1.65	.33558E+00	.34472E+00	.35780E+00	.37452E+00	.39481E+00	.41841E+00	.44473E+00	.47423E+00	.50720E+00	.54494E+00	.58951E+00
1.70	.39554E+00	.40654E+00	.42166E+00	.44122E+00	.46522E+00	.49321E+00	.52474E+00	.55989E+00	.59956E+00	.64589E+00	.70314E+00
1.75	.46502E+00	.47641E+00	.49270E+00	.51527E+00	.54382E+00	.57730E+00	.61399E+00	.65402E+00	.69906E+00	.75398E+00	.82798E+00
1.80	.54155E+00	.55525E+00	.57448E+00	.60062E+00	.63384E+00	.67304E+00	.71670E+00	.76541E+00	.82223E+00	.89379E+00	.99186E+00
1.85	.62676E+00	.64369E+00	.66728E+00	.69801E+00	.73486E+00	.77786E+00	.82766E+00	.88645E+00	.95862E+00	.10529E+01	
1.90	.72189E+00	.74187E+00	.77007E+00	.80561E+00	.84859E+00	.89991E+00	.96275E+00	.10406E+01			
1.95	.82613E+00	.84953E+00	.88240E+00	.92403E+00	.97517E+00	.10400E+01	.11228E+01				
2.00	.95098E+00	.97708E+00	.10145E+01	.10630E+01	.11252E+01						
2.05	.10920E+01	.11224E+01	.11643E+01								
2.10	.12394E+01	.12737E+01									

TABLE 10. Specific heat at constant pressure (J g^{-1} K^{-1})

Temp. (K)	Pressure (atm) .00	2.50	5.00	7.50	10.00	12.50	15.00	17.50	20.00	22.50	25.00
.10	.20597E−04	.15930E−04	.12912E−04	.10798E−04	.92471E−05	.80639E−05	.71329E−05	.63825E−05	.57664E−05	.52515E−05	.48151E−05
.15	.68827E−04	.53569E−04	.43498E−04	.36449E−04	.31241E−04	.27256E−04	.24116E−04	.21583E−04	.19494E−04	.17747E−04	.16263E−04
.20	.16143E−03	.12631E−03	.10296E−03	.86430E−04	.74178E−04	.64773E−04	.57348E−04	.51350E−04	.46413E−04	.42283E−04	.38781E−04
.25	.31144E−03	.24535E−03	.20076E−03	.16891E−03	.14516E−03	.12687E−03	.11239E−03	.10068E−03	.91019E−04	.82932E−04	.76069E−04
.30	.53136E−03	.42160E−03	.34640E−03	.29216E−03	.25148E−03	.22000E−03	.19501E−03	.17475E−03	.15803E−03	.14400E−03	.13208E−03
.35	.83310E−03	.66583E−03	.54949E−03	.46471E−03	.40071E−03	.35099E−03	.31141E−03	.27928E−03	.25274E−03	.23051E−03	.21171E−03
.40	.12285E−02	.98942E−03	.82064E−03	.69655E−03	.60240E−03	.52919E−03	.47098E−03	.42402E−03	.38582E−03	.35472E−03	.32915E−03
.45	.17329E−02	.14078E−02	.11761E−02	.10059E−02	.87707E−03	.77784E−03	.70119E−03	.64131E−03	.59557E−03	.56183E−03	.53960E−03
.50	.23752E−02	.19532E−02	.16558E−02	.14404E−02	.12826E−02	.11677E−02	.10838E−02	.10281E−02	.99666E−03	.98835E−03	.10069E−02
.55	.32242E−02	.27072E−02	.23571E−02	.21212E−02	.19642E−02	.18694E−02	.18204E−02	.18147E−02	.18535E−02	.19388E−02	.20859E−02
.60	.44304E−02	.38399E−02	.34844E−02	.32930E−02	.32150E−02	.32157E−02	.32847E−02	.34256E−02	.36485E−02	.39671E−02	.43823E−02
.65	.62771E−02	.56538E−02	.53997E−02	.53745E−02	.55072E−02	.57552E−02	.60901E−02	.65498E−02	.71343E−02	.78674E−02	.87990E−02
.70	.91759E−02	.86499E−02	.86468E−02	.90032E−02	.95489E−02	.10265E−01	.11075E−01	.12077E−01	.13259E−01	.14748E−01	.16499E−01
.75	.13833E−01	.13474E−01	.14016E−01	.15026E−01	.16267E−01	.17726E−01	.19328E−01	.21162E−01	.23312E−01	.25876E−01	.28825E−01
.80	.21063E−01	.21080E−01	.22425E−01	.24426E−01	.26777E−01	.29302E−01	.32026E−01	.35025E−01	.38580E−01	.42565E−01	.47270E−01
.85	.31764E−01	.32527E−01	.35068E−01	.38410E−01	.42238E−01	.46242E−01	.50433E−01	.55051E−01	.60302E−01	.66319E−01	.73260E−01
.90	.47605E−01	.49215E−01	.53157E−01	.58252E−01	.63842E−01	.69707E−01	.75875E−01	.82655E−01	.89970E−01	.98593E−01	.10779E+00
.95	.70011E−01	.72512E−01	.78033E−01	.85181E−01	.92970E−01	.10097E+00	.10956E+00	.11877E+00	.12886E+00	.14021E+00	.15250E+00
1.00	.10505E+00	.10894E+00	.11567E+00	.12423E+00	.13401E+00	.14459E+00	.15595E+00	.16816E+00	.18161E+00	.19624E+00	.21243E+00
1.05	.14650E+00	.15146E+00	.15922E+00	.16929E+00	.18132E+00	.19477E+00	.20941E+00	.22517E+00	.24227E+00	.26070E+00	.28137E+00
1.10	.19817E+00	.20459E+00	.21352E+00	.22518E+00	.23954E+00	.25613E+00	.27428E+00	.29448E+00	.31585E+00	.33932E+00	.36578E+00
1.15	.26074E+00	.26939E+00	.28064E+00	.29408E+00	.30987E+00	.32827E+00	.34953E+00	.37429E+00	.40165E+00	.43169E+00	.46300E+00
1.20	.33524E+00	.34568E+00	.35884E+00	.37496E+00	.39393E+00	.41632E+00	.44217E+00	.47164E+00	.50524E+00	.54295E+00	.58506E+00
1.25	.42129E+00	.43542E+00	.45289E+00	.47325E+00	.49659E+00	.52307E+00	.55397E+00	.58914E+00	.62947E+00	.67528E+00	.72575E+00
1.30	.52646E+00	.54351E+00	.56578E+00	.59192E+00	.62176E+00	.65517E+00	.69371E+00	.73647E+00	.78460E+00	.83890E+00	.89883E+00
1.35	.65761E+00	.67836E+00	.70490E+00	.73720E+00	.77472E+00	.81724E+00	.86570E+00	.91888E+00	.97941E+00	.10472E+01	.11248E+01
1.40	.80938E+00	.83389E+00	.86541E+00	.90353E+00	.94808E+00	.99947E+00	.10579E+01	.11235E+01	.11994E+01	.12852E+01	.13833E+01
1.45	.97047E+00	.99701E+00	.10317E+01	.10766E+01	.11305E+01	.11935E+01	.12629E+01	.13403E+01	.14276E+01	.15292E+01	.16548E+01
1.50	.11339E+01	.11643E+01	.12038E+01	.12567E+01	.13219E+01	.13972E+01	.14801E+01	.15713E+01	.16728E+01	.17935E+01	.19498E+01
1.55	.13177E+01	.13516E+01	.13988E+01	.14612E+01	.15398E+01	.16322E+01	.17334E+01	.18465E+01	.19697E+01	.21151E+01	.22983E+01
1.60	.15517E+01	.15936E+01	.16493E+01	.17230E+01	.18176E+01	.19301E+01	.20568E+01	.21978E+01	.23556E+01	.25439E+01	.27886E+01
1.65	.18508E+01	.18922E+01	.19498E+01	.20351E+01	.21504E+01	.22894E+01	.24412E+01	.26053E+01	.27920E+01	.30307E+01	.33800E+01
1.70	.21893E+01	.22365E+01	.23026E+01	.24026E+01	.25393E+01	.27055E+01	.28878E+01	.30891E+01	.33312E+01	.36629E+01	.41734E+01
1.75	.25493E+01	.26132E+01	.27012E+01	.28223E+01	.29704E+01	.31455E+01	.33524E+01	.36048E+01	.39392E+01	.44235E+01	.51414E+01
1.80	.29321E+01	.30166E+01	.31371E+01	.32816E+01	.34480E+01	.36502E+01	.39229E+01	.42982E+01	.48294E+01	.55658E+01	.65587E+01
1.85	.33395E+01	.34515E+01	.36075E+01	.37832E+01	.39865E+01	.42632E+01	.46753E+01	.52718E+01	.61137E+01	.72245E+01	
1.90	.38692E+01	.39880E+01	.41612E+01	.43727E+01	.46478E+01	.50610E+01	.56810E+01	.65809E+01			
1.95	.45223E+01	.46510E+01	.48294E+01	.50766E+01	.54595E+01	.60556E+01	.69572E+01				
2.00	.52035E+01	.53463E+01	.55206E+01	.58063E+01	.63029E+01						
2.05	.59223E+01	.61268E+01	.63100E+01								
2.10	.66768E+01	.68762E+01									

TABLE 11. Specific heat at constant volume (J g^{-1} K^{-1})

Temp. (K)	Pressure (atm) .00	2.50	5.00	7.50	10.00	12.50	15.00	17.50	20.00	22.50	25.00
.10	.20597E-04	.15930E-04	.12912E-04	.10798E-04	.92471E-05	.80639E-05	.71329E-05	.63825E-05	.57664E-05	.52515E-05	.48151E-05
.15	.68827E-04	.53569E-04	.43498E-04	.36449E-04	.31241E-04	.27256E-04	.24115E-04	.21583E-04	.19494E-04	.17747E-04	.16263E-04
.20	.16143E-03	.12631E-03	.10296E-03	.86429E-04	.74178E-04	.64773E-04	.57343E-04	.51350E-04	.46413E-04	.42283E-04	.38781E-04
.25	.31144E-03	.24535E-03	.20075E-03	.16891E-03	.14516E-03	.12687E-03	.11239E-03	.10068E-03	.91019E-04	.82932E-04	.76069E-04
.30	.53134E-03	.42159E-03	.34639E-03	.29216E-03	.25148E-03	.22000E-03	.19501E-03	.17475E-03	.15802E-03	.14400E-03	.13208E-03
.35	.83306E-03	.66581E-03	.54918E-03	.46471E-03	.40070E-03	.35098E-03	.31140E-03	.27928E-03	.25274E-03	.23051E-03	.21171E-03
.40	.12284E-02	.98937E-03	.82061E-03	.69653E-03	.60239E-03	.52919E-03	.47097E-03	.42401E-03	.38581E-03	.35472E-03	.32915E-03
.45	.17327E-02	.14077E-02	.11760E-02	.10058E-02	.87705E-03	.77782E-03	.70113E-03	.64130E-03	.59556E-03	.56182E-03	.53959E-03
.50	.23749E-02	.19530E-02	.16557E-02	.14403E-02	.12825E-02	.11677E-02	.10833E-02	.10280E-02	.99665E-03	.98834E-03	.10069E-02
.55	.32236E-02	.27068E-02	.23569E-02	.21210E-02	.19642E-02	.18694E-02	.18204E-02	.18147E-02	.18535E-02	.19388E-02	.20859E-02
.60	.44293E-02	.38393E-02	.34840E-02	.32928E-02	.32148E-02	.32156E-02	.32847E-02	.34256E-02	.36485E-02	.39671E-02	.43823E-02
.65	.62754E-02	.56529E-02	.53993E-02	.53742E-02	.55071E-02	.57552E-02	.60901E-02	.65498E-02	.71342E-02	.78673E-02	.87987E-02
.70	.91734E-02	.86487E-02	.86463E-02	.90030E-02	.95489E-02	.10265E-01	.11075E-01	.12077E-01	.13259E-01	.14747E-01	.16498E-01
.75	.13830E-01	.13472E-01	.14016E-01	.15026E-01	.16267E-01	.17726E-01	.19323E-01	.21161E-01	.23310E-01	.25873E-01	.28820E-01
.80	.21058E-01	.21079E-01	.22425E-01	.24426E-01	.26776E-01	.29301E-01	.32021E-01	.35021E-01	.38572E-01	.42554E-01	.47252E-01
.85	.31759E-01	.32527E-01	.35068E-01	.38408E-01	.42234E-01	.46237E-01	.50424E-01	.55037E-01	.60280E-01	.66287E-01	.73208E-01
.90	.47598E-01	.49215E-01	.53154E-01	.58245E-01	.63830E-01	.69690E-01	.75851E-01	.82618E-01	.89913E-01	.98511E-01	.10767E+00
.95	.70005E-01	.72512E-01	.78023E-01	.85160E-01	.92937E-01	.10092E+00	.10950E+00	.11869E+00	.12873E+00	.14003E+00	.15225E+00
1.00	.10504E+00	.10893E+00	.11564E+00	.12418E+00	.13393E+00	.14449E+00	.15582E+00	.16797E+00	.18135E+00	.19588E+00	.21193E+00
1.05	.14650E+00	.15145E+00	.15916E+00	.16919E+00	.18117E+00	.19456E+00	.20915E+00	.22482E+00	.24177E+00	.26007E+00	.28043E+00
1.10	.19816E+00	.20456E+00	.21312E+00	.22498E+00	.23926E+00	.25576E+00	.27380E+00	.29383E+00	.31497E+00	.33814E+00	.36419E+00
1.15	.26074E+00	.26933E+00	.28047E+00	.29375E+00	.30938E+00	.32762E+00	.34867E+00	.37315E+00	.40014E+00	.42974E+00	.46027E+00
1.20	.33523E+00	.34559E+00	.35856E+00	.37445E+00	.39314E+00	.41524E+00	.44072E+00	.46971E+00	.50271E+00	.53958E+00	.58045E+00
1.25	.42128E+00	.43523E+00	.45245E+00	.47252E+00	.49550E+00	.52151E+00	.55174E+00	.58598E+00	.62517E+00	.66976E+00	.71924E+00
1.30	.52642E+00	.54326E+00	.56513E+00	.59076E+00	.61995E+00	.65259E+00	.69020E+00	.73168E+00	.77802E+00	.83001E+00	.88619E+00
1.35	.65752E+00	.67786E+00	.70383E+00	.73540E+00	.77206E+00	.81347E+00	.86039E+00	.91158E+00	.96938E+00	.10339E+01	.11076E+01
1.40	.80923E+00	.83311E+00	.86374E+00	.90075E+00	.94394E+00	.99358E+00	.10497E+01	.11124E+01	.11844E+01	.12653E+01	.13577E+01
1.45	.97015E+00	.99588E+00	.10293E+01	.10725E+01	.11243E+01	.11846E+01	.12505E+01	.13231E+01	.14038E+01	.14981E+01	.16116E+01
1.50	.11334E+01	.11626E+01	.12003E+01	.12508E+01	.13128E+01	.13841E+01	.14619E+01	.15459E+01	.16373E+01	.17451E+01	.18818E+01
1.55	.13169E+01	.13493E+01	.13938E+01	.14525E+01	.15265E+01	.16132E+01	.17076E+01	.18116E+01	.19216E+01	.20479E+01	.21986E+01
1.60	.15506E+01	.15905E+01	.16423E+01	.17105E+01	.17982E+01	.19024E+01	.20192E+01	.21475E+01	.22859E+01	.24456E+01	.26350E+01
1.65	.18494E+01	.18876E+01	.19400E+01	.20176E+01	.21222E+01	.22487E+01	.23854E+01	.25297E+01	.26880E+01	.28851E+01	.31672E+01
1.70	.21868E+01	.22301E+01	.22891E+01	.23776E+01	.24987E+01	.26461E+01	.28063E+01	.29789E+01	.31757E+01	.34372E+01	.38086E+01
1.75	.25464E+01	.26066E+01	.26840E+01	.27871E+01	.29109E+01	.30605E+01	.32422E+01	.34611E+01	.37308E+01	.40964E+01	.45170E+01
1.80	.29278E+01	.30064E+01	.31132E+01	.32333E+01	.33655E+01	.35295E+01	.37607E+01	.40750E+01	.44834E+01	.49978E+01	.54955E+01
1.85	.33332E+01	.34363E+01	.35720E+01	.37195E+01	.38858E+01	.41114E+01	.44494E+01	.49275E+01	.55318E+01	.62190E+01	
1.90	.38614E+01	.39637E+01	.41114E+01	.42858E+01	.45065E+01	.48307E+01	.53017E+01	.59501E+01			
1.95	.45113E+01	.46182E+01	.47604E+01	.49550E+01	.52460E+01	.56713E+01	.62825E+01				
2.00	.51900E+01	.53031E+01	.54286E+01	.56327E+01	.59711E+01						
2.05	.59009E+01	.60686E+01	.61916E+01								
2.10	.66428E+01	.68086E+01									

TABLE 12. Ratio of specific heats (C_P/C_V)

Temp. (K)	Pressure (atm) .00	2.50	5.00	7.50	10.00	12.50	15.00	17.50	20.00	22.50	25.00
.10	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01
.15	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01
.20	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01
.25	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01
.30	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01
.35	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01
.40	.10001E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01
.45	.10001E+01	.10001E+01	.10001E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01
.50	.10001E+01	.10001E+01	.10001E+01	.10001E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01
.55	.10002E+01	.10001E+01	.10001E+01	.10001E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01
.60	.10002E+01	.10002E+01	.10001E+01	.10001E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01
.65	.10003E+01	.10002E+01	.10001E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01
.70	.10003E+01	.10001E+01	.10001E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10001E+01	.10001E+01
.75	.10002E+01	.10001E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10001E+01	.10001E+01	.10002E+01
.80	.10002E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10001E+01	.10001E+01	.10002E+01	.10003E+01	.10004E+01
.85	.10002E+01	.10000E+01	.10000E+01	.10000E+01	.10001E+01	.10001E+01	.10002E+01	.10003E+01	.10004E+01	.10005E+01	.10007E+01
.90	.10001E+01	.10000E+01	.10000E+01	.10001E+01	.10002E+01	.10002E+01	.10003E+01	.10004E+01	.10006E+01	.10008E+01	.10011E+01
.95	.10001E+01	.10000E+01	.10001E+01	.10003E+01	.10004E+01	.10004E+01	.10006E+01	.10007E+01	.10010E+01	.10013E+01	.10016E+01
1.00	.10001E+01	.10000E+01	.10002E+01	.10004E+01	.10006E+01	.10007E+01	.10008E+01	.10011E+01	.10014E+01	.10018E+01	.10023E+01
1.05	.10000E+01	.10001E+01	.10004E+01	.10006E+01	.10008E+01	.10010E+01	.10012E+01	.10016E+01	.10021E+01	.10024E+01	.10033E+01
1.10	.10000E+01	.10002E+01	.10005E+01	.10009E+01	.10012E+01	.10014E+01	.10018E+01	.10022E+01	.10028E+01	.10035E+01	.10044E+01
1.15	.10000E+01	.10002E+01	.10006E+01	.10011E+01	.10016E+01	.10020E+01	.10025E+01	.10030E+01	.10038E+01	.10045E+01	.10059E+01
1.20	.10000E+01	.10003E+01	.10008E+01	.10014E+01	.10020E+01	.10026E+01	.10033E+01	.10041E+01	.10050E+01	.10063E+01	.10079E+01
1.25	.10000E+01	.10004E+01	.10010E+01	.10015E+01	.10022E+01	.10030E+01	.10040E+01	.10054E+01	.10069E+01	.10083E+01	.10091E+01
1.30	.10001E+01	.10005E+01	.10011E+01	.10020E+01	.10029E+01	.10039E+01	.10051E+01	.10065E+01	.10085E+01	.10107E+01	.10143E+01
1.35	.10001E+01	.10007E+01	.10015E+01	.10024E+01	.10035E+01	.10046E+01	.10062E+01	.10080E+01	.10103E+01	.10129E+01	.10155E+01
1.40	.10002E+01	.10009E+01	.10019E+01	.10031E+01	.10044E+01	.10059E+01	.10078E+01	.10099E+01	.10126E+01	.10157E+01	.10189E+01
1.45	.10003E+01	.10011E+01	.10024E+01	.10038E+01	.10055E+01	.10075E+01	.10099E+01	.10130E+01	.10170E+01	.10208E+01	.10268E+01
1.50	.10004E+01	.10014E+01	.10029E+01	.10047E+01	.10069E+01	.10095E+01	.10124E+01	.10164E+01	.10217E+01	.10277E+01	.10361E+01
1.55	.10006E+01	.10017E+01	.10036E+01	.10060E+01	.10087E+01	.10117E+01	.10151E+01	.10193E+01	.10250E+01	.10328E+01	.10454E+01
1.60	.10007E+01	.10020E+01	.10042E+01	.10073E+01	.10108E+01	.10145E+01	.10186E+01	.10234E+01	.10305E+01	.10402E+01	.10583E+01
1.65	.10008E+01	.10025E+01	.10051E+01	.10087E+01	.10133E+01	.10181E+01	.10234E+01	.10299E+01	.10387E+01	.10504E+01	.10672E+01
1.70	.10011E+01	.10028E+01	.10059E+01	.10105E+01	.10162E+01	.10224E+01	.10290E+01	.10370E+01	.10490E+01	.10656E+01	.10958E+01
1.75	.10011E+01	.10026E+01	.10064E+01	.10127E+01	.10205E+01	.10277E+01	.10340E+01	.10415E+01	.10559E+01	.10798E+01	.11382E+01
1.80	.10014E+01	.10034E+01	.10077E+01	.10149E+01	.10245E+01	.10342E+01	.10431E+01	.10548E+01	.10772E+01	.11137E+01	.11935E+01
1.85	.10019E+01	.10044E+01	.10099E+01	.10171E+01	.10259E+01	.10369E+01	.10508E+01	.10699E+01	.11052E+01	.11617E+01	
1.90	.10020E+01	.10061E+01	.10121E+01	.10203E+01	.10314E+01	.10477E+01	.10715E+01	.11060E+01			
1.95	.10024E+01	.10071E+01	.10145E+01	.10245E+01	.10407E+01	.10678E+01	.11074E+01				
2.00	.10026E+01	.10081E+01	.10169E+01	.10308E+01	.10556E+01						
2.05	.10036E+01	.10096E+01	.10191E+01								
2.10	.10051E+01	.10099E+01									

TABLE 13. Phonon number density (cm^{-3})

Temp. (K)	Pressure (atm) .00	2.50	5.00	7.50	10.00	12.50	15.00	17.50	20.00	22.50	25.00
.10	.20148E+17	.15987E+17	.13244E+17	.11301E+17	.98534E+16	.87335E+16	.78416E+16	.71146E+16	.65106E+16	.60010E+16	.55652E+16
.15	.67739E+17	.53861E+17	.44667E+17	.38138E+17	.33264E+17	.29490E+17	.26483E+17	.24030E+17	.21992E+17	.20271E+17	.18800E+17
.20	.15979E+18	.12738E+18	.10579E+18	.90395E+17	.78882E+17	.69953E+17	.62831E+17	.57019E+17	.52188E+17	.48108E+17	.44618E+17
.25	.31034E+18	.24815E+18	.20642E+18	.17656E+18	.15416E+18	.13676E+18	.12287E+18	.11152E+18	.10208E+18	.94110E+17	.87288E+17
.30	.53296E+18	.42760E+18	.35636E+18	.30513E+18	.26660E+18	.23661E+18	.21263E+18	.19304E+18	.17672E+18	.16294E+18	.15114E+18
.35	.84081E+18	.67700E+18	.56537E+18	.48468E+18	.42379E+18	.37631E+18	.33828E+18	.30717E+18	.28126E+18	.25935E+18	.24058E+18
.40	.12466E+19	.10075E+19	.84324E+18	.72385E+18	.63343E+18	.56276E+18	.50608E+18	.45966E+18	.42095E+18	.38821E+18	.36014E+18
.45	.17628E+19	.14303E+19	.11998E+19	.10314E+19	.90338E+18	.80305E+18	.72245E+18	.65636E+18	.60121E+18	.55452E+18	.51448E+18
.50	.24018E+19	.19564E+19	.16451E+19	.14163E+19	.12417E+19	.11045E+19	.99404E+18	.90336E+18	.82764E+18	.76348E+18	.70842E+18
.55	.31754E+19	.25970E+19	.21892E+19	.18876E+19	.16566E+19	.14745E+19	.13277E+19	.12070E+19	.11061E+19	.10205E+19	.94699E+18
.60	.40958E+19	.33634E+19	.28425E+19	.24549E+19	.21567E+19	.19210E+19	.17306E+19	.15738E+19	.14426E+19	.13312E+19	.12355E+19
.65	.51751E+19	.42673E+19	.36157E+19	.31280E+19	.27510E+19	.24523E+19	.22103E+19	.20108E+19	.18436E+19	.17016E+19	.15794E+19
.70	.64261E+19	.53205E+19	.45201E+19	.39171E+19	.34490E+19	.30768E+19	.27749E+19	.25254E+19	.23161E+19	.21381E+19	.19849E+19
.75	.78612E+19	.65358E+19	.55672E+19	.48332E+19	.42607E+19	.38042E+19	.34329E+19	.31256E+19	.28674E+19	.26476E+19	.24582E+19
.80	.94952E+19	.79260E+19	.67702E+19	.58879E+19	.51970E+19	.46442E+19	.41935E+19	.38199E+19	.35056E+19	.32376E+19	.30066E+19
.85	.11342E+20	.95061E+19	.81415E+19	.70938E+19	.62696E+19	.56079E+19	.50671E+19	.46179E+19	.42394E+19	.39165E+19	.36377E+19
.90	.13419E+20	.11291E+20	.96969E+19	.84647E+19	.74913E+19	.67069E+19	.60646E+19	.55300E+19	.50789E+19	.46934E+19	.43602E+19
.95	.15743E+20	.13300E+20	.11452E+20	.10016E+20	.88760E+19	.79550E+19	.71987E+19	.65681E+19	.60350E+19	.55790E+19	.51842E+19
1.00	.18341E+20	.15552E+20	.13425E+20	.11764E+20	.10440E+20	.93667E+19	.84833E+19	.77453E+19	.71203E+19	.65849E+19	.61207E+19
1.05	.21234E+20	.18070E+20	.15637E+20	.13727E+20	.12200E+20	.10959E+20	.99341E+19	.90765E+19	.83490E+19	.77247E+19	.71830E+19
1.10	.24448E+20	.20879E+20	.18109E+20	.15926E+20	.14176E+20	.12749E+20	.11569E+20	.10579E+20	.97372E+19	.90139E+19	.83853E+19
1.15	.28009E+20	.23999E+20	.20864E+20	.18384E+20	.16389E+20	.14760E+20	.13408E+20	.12271E+20	.11304E+20	.10470E+20	.97448E+19
1.20	.31934E+20	.27459E+20	.23931E+20	.21127E+20	.18866E+20	.17014E+20	.15473E+20	.14176E+20	.13069E+20	.12114E+20	.11281E+20
1.25	.36255E+20	.31289E+20	.27342E+20	.24185E+20	.21631E+20	.19536E+20	.17791E+20	.16318E+20	.15057E+20	.13968E+20	.13016E+20
1.30	.41026E+20	.35519E+20	.31116E+20	.27585E+20	.24719E+20	.22360E+20	.20389E+20	.18723E+20	.17293E+20	.16056E+20	.14971E+20
1.35	.46251E+20	.40196E+20	.35312E+20	.31372E+20	.28164E+20	.25516E+20	.23300E+20	.21421E+20	.19808E+20	.18406E+20	.17177E+20
1.40	.52041E+20	.45375E+20	.39964E+20	.35583E+20	.32005E+20	.29043E+20	.26559E+20	.24446E+20	.22632E+20	.21049E+20	.19661E+20
1.45	.58432E+20	.51110E+20	.45130E+20	.40266E+20	.36284E+20	.32979E+20	.30204E+20	.27837E+20	.25797E+20	.24015E+20	.22445E+20
1.50	.65428E+20	.57404E+20	.50818E+20	.45448E+20	.41037E+20	.37367E+20	.34273E+20	.31633E+20	.29348E+20	.27351E+20	.25579E+20
1.55	.73026E+20	.64297E+20	.57078E+20	.51175E+20	.46309E+20	.42250E+20	.38816E+20	.35881E+20	.33333E+20	.31102E+20	.29111E+20
1.60	.81322E+20	.71851E+20	.63977E+20	.57512E+20	.52163E+20	.47684E+20	.43887E+20	.40626E+20	.37793E+20	.35297E+20	.33063E+20
1.65	.90455E+20	.80183E+20	.71610E+20	.64534E+20	.58663E+20	.53726E+20	.49538E+20	.45921E+20	.42772E+20	.39982E+20	.37474E+20
1.70	.10053E+21	.89391E+20	.80046E+20	.72320E+20	.65879E+20	.60458E+20	.55831E+20	.51828E+20	.48324E+20	.45197E+20	.42345E+20
1.75	.11159E+21	.99502E+20	.89345E+20	.80920E+20	.73886E+20	.67931E+20	.62840E+20	.58415E+20	.54527E+20	.51040E+20	.47796E+20
1.80	.12362E+21	.11062E+21	.99617E+20	.90450E+20	.82770E+20	.76243E+20	.70626E+20	.65724E+20	.61387E+20	.57423E+20	.53652E+20
1.85	.13680E+21	.12284E+21	.11097E+21	.10099E+21	.92624E+20	.85471E+20	.79313E+20	.73893E+20	.69015E+20	.64478E+20	
1.90	.15122E+21	.13628E+21	.12347E+21	.11268E+21	.10357E+21	.95740E+20	.88937E+20	.82856E+20			
1.95	.16704E+21	.15105E+21	.13729E+21	.12567E+21	.11574E+21	.10716E+21	.99557E+20				
2.00	.18452E+21	.16744E+21	.15269E+21	.14006E+21	.12929E+21						
2.05	.20389E+21	.18564E+21	.16976E+21								
2.10	.22513E+21	.20581E+21									

TABLE 14. Roton number density (cm^{-3})

Temp. (K)	Pressure (atm) .00	2.50	5.00	7.50	10.00	12.50	15.00	17.50	20.00	22.50	25.00
.10	.25396E−14	.29891E−14	.90537E−14	.49107E−13	.25799E−12	.11777E−11	.45392E−11	.16808E−10	.61165E−10	.22282E−09	.84183E−09
.15	.12490E−02	.31626E−02	.11525E−01	.41287E−01	.12801E+00	.35257E+00	.86994E+00	.20769E+01	.48902E+01	.11644E+02	.28084E+02
.20	.29191E+04	.58882E+04	.15524E+05	.40309E+05	.94703E+05	.20190E+06	.39665E+06	.76259E+06	.14574E+07	.27769E+07	.53816E+07
.25	.19943E+08	.34950E+08	.75923E+08	.16261E+09	.32148E+09	.58949E+09	.10147E+10	.17089E+10	.28613E+10	.48170E+10	.81674E+10
.30	.72613E+10	.11657E+11	.22187E+11	.41921E+11	.73857E+11	.12257E+12	.19299E+12	.29834E+12	.45741E+12	.70384E+12	.10960E+13
.35	.49805E+12	.74631E+12	.12952E+13	.22398E+13	.36469E+13	.56224E+13	.82872E+13	.12040E+14	.17364E+14	.25126E+14	.36700E+14
.40	.11963E+14	.17060E+14	.27756E+14	.44677E+14	.68271E+14	.10013E+15	.14038E+15	.19465E+15	.26806E+15	.37103E+15	.51508E+15
.45	.14310E+15	.19635E+15	.30210E+15	.46157E+15	.67367E+15	.94422E+15	.12767E+16	.17050E+16	.22706E+16	.30290E+16	.40551E+16
.50	.10496E+16	.13949E+16	.20550E+16	.30076E+16	.42265E+16	.57303E+16	.75258E+16	.97504E+16	.12624E+17	.16362E+17	.21283E+17
.55	.53761E+16	.69608E+16	.98981E+16	.14005E+17	.19079E+17	.25163E+17	.32159E+17	.40798E+17	.51567E+17	.65160E+17	.82940E+17
.60	.21095E+17	.26747E+17	.36886E+17	.50740E+17	.67293E+17	.86638E+17	.10873E+18	.13504E+18	.16722E+18	.20725E+18	.25881E+18
.65	.67172E+17	.83714E+17	.11260E+18	.15101E+18	.19645E+18	.24773E+18	.30525E+18	.37292E+18	.45456E+18	.55497E+18	.67892E+18
.70	.18249E+18	.22330E+18	.29434E+18	.38604E+18	.49229E+18	.61182E+18	.74261E+18	.89530E+18	.10747E+19	.12911E+19	.15573E+19
.75	.43328E+18	.52553E+18	.67821E+18	.87423E+18	.10956E+19	.13419E+19	.16070E+19	.19126E+19	.22666E+19	.26963E+19	.32067E+19
.80	.93329E+18	.11116E+19	.14149E+19	.17921E+19	.22120E+19	.26737E+19	.31695E+19	.37291E+19	.43772E+19	.51441E+19	.60508E+19
.85	.18364E+19	.21681E+19	.27116E+19	.33810E+19	.41244E+19	.49236E+19	.57771E+19	.67287E+19	.78316E+19	.91144E+19	.10629E+20
.90	.33614E+19	.39375E+19	.48574E+19	.59633E+19	.71857E+19	.84895E+19	.98726E+19	.11407E+20	.13160E+20	.15199E+20	.17575E+20
.95	.58313E+19	.67617E+19	.82011E+19	.99335E+19	.11828E+20	.13838E+20	.15976E+20	.18336E+20	.20989E+20	.24079E+20	.27586E+20
1.00	.96233E+19	.11047E+20	.13196E+20	.15764E+20	.18567E+20	.21527E+20	.24686E+20	.28138E+20	.32024E+20	.36471E+20	.41522E+20
1.05	.15278E+20	.17393E+20	.20421E+20	.24021E+20	.27949E+20	.32162E+20	.36651E+20	.41493E+20	.47033E+20	.53194E+20	.60220E+20
1.10	.23329E+20	.26364E+20	.30477E+20	.35294E+20	.40646E+20	.46387E+20	.52553E+20	.59303E+20	.66785E+20	.75216E+20	.84728E+20
1.15	.34436E+20	.38520E+20	.43855E+20	.50152E+20	.57221E+20	.64931E+20	.73273E+20	.82351E+20	.92383E+20	.10356E+21	.11625E+21
1.20	.48941E+20	.54508E+20	.61441E+20	.69537E+20	.78666E+20	.88721E+20	.99604E+20	.11166E+21	.12487E+21	.13967E+21	.15654E+21
1.25	.67553E+20	.75179E+20	.84305E+20	.94527E+20	.10571E+21	.11799E+21	.13165E+21	.14706E+21	.16449E+21	.18387E+21	.20482E+21
1.30	.91255E+20	.10081E+21	.11208E+21	.12500E+21	.13944E+21	.15548E+21	.17314E+21	.19272E+21	.21470E+21	.23964E+21	.26841E+21
1.35	.12006E+21	.13269E+21	.14742E+21	.16389E+21	.18206E+21	.20194E+21	.22406E+21	.24875E+21	.27651E+21	.30785E+21	.34293E+21
1.40	.15583E+21	.17275E+21	.19136E+21	.21218E+21	.23518E+21	.26045E+21	.28857E+21	.31983E+21	.35470E+21	.39403E+21	.43805E+21
1.45	.20336E+21	.22358E+21	.24665E+21	.27250E+21	.30110E+21	.33274E+21	.36816E+21	.40755E+21	.45251E+21	.50318E+21	.56089E+21
1.50	.25783E+21	.28277E+21	.31107E+21	.34284E+21	.37819E+21	.41765E+21	.46153E+21	.51064E+21	.56665E+21	.63067E+21	.70481E+21
1.55	.31940E+21	.34969E+21	.38401E+21	.42295E+21	.46648E+21	.51498E+21	.56857E+21	.62828E+21	.69539E+21	.77274E+21	.86460E+21
1.60	.39045E+21	.42706E+21	.46834E+21	.51549E+21	.56882E+21	.62834E+21	.69446E+21	.76786E+21	.85056E+21	.94654E+21	.10631E+22
1.65	.47590E+21	.51988E+21	.56988E+21	.62674E+21	.69164E+21	.76516E+21	.84682E+21	.93873E+21	.10424E+22	.11626E+22	.13066E+22
1.70	.57947E+21	.63326E+21	.69337E+21	.76226E+21	.84168E+21	.93195E+21	.10333E+22	.11470E+22	.12768E+22	.14303E+22	.16226E+22
1.75	.70382E+21	.76574E+21	.83526E+21	.91784E+21	.10151E+22	.11266E+22	.12494E+22	.13849E+22	.15394E+22	.17289E+22	.19864E+22
1.80	.84507E+21	.92026E+21	.10046E+22	.11039E+22	.12214E+22	.13569E+22	.15085E+22	.16794E+22	.18809E+22	.21374E+22	.24945E+22
1.85	.10072E+22	.10994E+22	.12037E+22	.13242E+22	.14616E+22	.16185E+22	.17989E+22	.20126E+22	.22768E+22	.26272E+22	
1.90	.11939E+22	.13047E+22	.14315E+22	.15763E+22	.17424E+22	.19359E+22	.21698E+22	.24603E+22			
1.95	.14044E+22	.15365E+22	.16886E+22	.18632E+22	.20668E+22	.23163E+22	.26315E+22				
2.00	.16662E+22	.18222E+22	.20028E+22	.22139E+22	.24688E+22						
2.05	.19722E+22	.21591E+22	.23728E+22								
2.10	.22995E+22	.25191E+22									

TABLE 15. Normal fluid density (g cm^{-3})

Temp. (K)	Pressure (atm) .00	2.50	5.00	7.50	10.00	12.50	15.00	17.50	20.00	22.50	25.00
.10	.17497E-08	.11945E-08	.87476E-09	.67253E-09	.53584E-09	.43875E-09	.36709E-09	.31254E-09	.26997E-09	.23603E-09	.20850E-09
.15	.87412E-08	.60088E-08	.44157E-08	.34006E-08	.27113E-08	.22201E-08	.18567E-08	.15796E-08	.13631E-08	.11903E-08	.10500E-08
.20	.27191E-07	.18853E-07	.13920E-07	.10750E-07	.85847E-08	.70367E-08	.58890E-08	.50125E-08	.43267E-08	.37789E-08	.33338E-08
.25	.65232E-07	.45661E-07	.33900E-07	.26262E-07	.21014E-07	.17247E-07	.14447E-07	.12304E-07	.10625E-07	.92839E-08	.81937E-08
.30	.13280E-06	.93920E-07	.70145E-07	.54547E-07	.43758E-07	.35988E-07	.30206E-07	.25791E-07	.22355E-07	.19648E-07	.17517E-07
.35	.24164E-06	.17281E-06	.13010E-06	.10191E-06	.82488E-07	.68707E-07	.58770E-07	.51672E-07	.46848E-07	.44101E-07	.43556E-07
.40	.40748E-06	.29650E-06	.22814E-06	.18479E-06	.15749E-06	.14161E-06	.13420E-06	.13497E-06	.14415E-06	.16392E-06	.19704E-06
.45	.66794E-06	.50857E-06	.42237E-06	.38448E-06	.38156E-06	.40756E-06	.45896E-06	.54128E-06	.66308E-06	.83716E-06	.10821E-05
.50	.11607E-05	.98361E-06	.95820E-06	.10472E-05	.12284E-05	.14956E-05	.18453E-05	.23035E-05	.29171E-05	.37337E-05	.48261E-05
.55	.23363E-05	.22929E-05	.26222E-05	.32542E-05	.41316E-05	.52506E-05	.65878E-05	.82820E-05	.10432E-04	.13182E-04	.16812E-04
.60	.53746E-05	.59092E-05	.73762E-05	.96145E-05	.12434E-04	.15840E-04	.19821E-04	.24639E-04	.30604E-04	.38083E-04	.47788E-04
.65	.12758E-04	.14874E-04	.19169E-04	.25196E-04	.32554E-04	.41051E-04	.50747E-04	.62294E-04	.76359E-04	.93772E-04	.11542E-03
.70	.29073E-04	.34585E-04	.44851E-04	.58536E-04	.74759E-04	.93340E-04	.11399E-03	.13834E-03	.16718E-03	.20217E-03	.24549E-03
.75	.61233E-04	.73621E-04	.94708E-04	.12239E-03	.15425E-03	.19026E-03	.22955E-03	.27525E-03	.32858E-03	.39369E-03	.47146E-03
.80	.12033E-03	.14354E-03	.18344E-03	.23383E-03	.29087E-03	.35454E-03	.42376E-03	.50253E-03	.59442E-03	.70371E-03	.83354E-03
.85	.21939E-03	.26101E-03	.32899E-03	.41381E-03	.50938E-03	.61356E-03	.72620E-03	.85279E-03	.10005E-02	.11732E-02	.13777E-02
.90	.37579E-03	.44501E-03	.55459E-03	.68775E-03	.83697E-03	.99826E-03	.11714E-02	.13650E-02	.15873E-02	.18472E-02	.21514E-02
.95	.61393E-03	.72125E-03	.88514E-03	.10839E-02	.13042E-02	.15407E-02	.17951E-02	.20781E-02	.23981E-02	.27723E-02	.31990E-02
1.00	.95892E-03	.11168E-02	.13510E-02	.16328E-02	.19438E-02	.22763E-02	.26347E-02	.30292E-02	.34758E-02	.39892E-02	.45751E-02
1.05	.14462E-02	.16719E-02	.19893E-02	.23683E-02	.27859E-02	.32386E-02	.37252E-02	.42544E-02	.48623E-02	.55423E-02	.63205E-02
1.10	.21043E-02	.24167E-02	.28327E-02	.33206E-02	.38673E-02	.44589E-02	.50994E-02	.58055E-02	.65919E-02	.74822E-02	.84911E-02
1.15	.29681E-02	.33756E-02	.38975E-02	.45133E-02	.52081E-02	.59704E-02	.68023E-02	.77128E-02	.87252E-02	.98577E-02	.11148E-01
1.20	.40407E-02	.45767E-02	.52329E-02	.59978E-02	.63628E-02	.78211E-02	.88647E-02	.10027E-01	.11308E-01	.12749E-01	.14396E-01
1.25	.53610E-02	.60598E-02	.68948E-02	.78296E-02	.83569E-02	.99896E-02	.11254E-01	.12684E-01	.14308E-01	.16122E-01	.18095E-01
1.30	.69538E-02	.78160E-02	.88172E-02	.99606E-02	.11240E-01	.12664E-01	.14241E-01	.15994E-01	.17971E-01	.20222E-01	.22824E-01
1.35	.88131E-02	.99110E-02	.11174E-01	.12583E-01	.14142E-01	.15852E-01	.17761E-01	.19898E-01	.22310E-01	.25042E-01	.28112E-01
1.40	.11109E-01	.12452E-01	.13998E-01	.15724E-01	.17631E-01	.19736E-01	.22080E-01	.24698E-01	.27633E-01	.30951E-01	.34682E-01
1.45	.13921E-01	.15576E-01	.17438E-01	.19518E-01	.21820E-01	.24374E-01	.27237E-01	.30433E-01	.34091E-01	.38226E-01	.42958E-01
1.50	.17079E-01	.19062E-01	.21286E-01	.23766E-01	.26531E-01	.29616E-01	.33057E-01	.36921E-01	.41340E-01	.46409E-01	.52295E-01
1.55	.20500E-01	.22842E-01	.25461E-01	.28416E-01	.31714E-01	.35398E-01	.39478E-01	.44046E-01	.49195E-01	.55148E-01	.62226E-01
1.60	.24307E-01	.27061E-01	.30126E-01	.33603E-01	.37530E-01	.41919E-01	.46810E-01	.52264E-01	.58433E-01	.65614E-01	.74342E-01
1.65	.28776E-01	.31999E-01	.35610E-01	.39689E-01	.44338E-01	.49607E-01	.55483E-01	.62117E-01	.69644E-01	.78395E-01	.88917E-01
1.70	.34071E-01	.37902E-01	.42140E-01	.46959E-01	.52496E-01	.58799E-01	.65898E-01	.73907E-01	.83087E-01	.93976E-01	.10766E+00
1.75	.40292E-01	.44624E-01	.49428E-01	.55068E-01	.61671E-01	.69252E-01	.77654E-01	.86994E-01	.97683E-01	.11082E+00	.12869E+00
1.80	.47147E-01	.52273E-01	.57957E-01	.64577E-01	.72376E-01	.81380E-01	.91507E-01	.10300E+00	.11660E+00	.13396E+00	.15821E+00
1.85	.54815E-01	.60936E-01	.67771E-01	.75629E-01	.84572E-01	.94804E-01	.10663E+00	.12067E+00	.13809E+00	.16129E+00	
1.90	.63446E-01	.70632E-01	.78754E-01	.87984E-01	.98573E-01	.11093E+00	.12589E+00	.14454E+00			
1.95	.72933E-01	.81325E-01	.90857E-01	.10175E+00	.11446E+00	.13002E+00	.14971E+00				
2.00	.84682E-01	.94402E-01	.10553E+00	.11847E+00	.13405E+00						
2.05	.98195E-01	.10964E+00	.12260E+00								
2.10	.11222E+00	.12547E+00									

TABLE 16. Normal fluid ratio

Temp. (K)	Pressure (atm) .00	2.50	5.00	7.50	10.00	12.50	15.00	17.50	20.00	22.50	25.00
.10	.12056E−07	.80033E−08	.57235E−08	.43103E−08	.33718E−08	.27155E−08	.22379E−08	.18791E−08	.16023E−08	.13841E−08	.12089E−08
.15	.60230E−07	.40259E−07	.28892E−07	.21795E−07	.17061E−07	.13740E−07	.11319E−07	.94970E−08	.80900E−08	.69800E−08	.60880E−08
.20	.18736E−06	.12632E−06	.91080E−07	.68896E−07	.54019E−07	.43552E−07	.35901E−07	.30136E−07	.25680E−07	.22160E−07	.19331E−07
.25	.44947E−06	.30593E−06	.22181E−06	.16832E−06	.13223E−06	.10675E−06	.88073E−07	.73974E−07	.63064E−07	.54443E−07	.47510E−07
.30	.91502E−06	.62928E−06	.45896E−06	.34961E−06	.27535E−06	.22274E−06	.18415E−06	.15506E−06	.13268E−06	.11522E−06	.10157E−06
.35	.16650E−05	.11579E−05	.85123E−06	.65317E−06	.51907E−06	.42525E−06	.35829E−06	.31067E−06	.27806E−06	.25862E−06	.25256E−06
.40	.28077E−05	.19866E−05	.14927E−05	.11844E−05	.99105E−06	.87647E−06	.81818E−06	.81146E−06	.85558E−06	.96126E−06	.11425E−05
.45	.46024E−05	.34076E−05	.27637E−05	.24643E−05	.24011E−05	.25226E−05	.27981E−05	.32544E−05	.39356E−05	.49094E−05	.62743E−05
.50	.79980E−05	.65906E−05	.62699E−05	.67121E−05	.77304E−05	.92572E−05	.11250E−04	.13850E−04	.17314E−04	.21896E−04	.27984E−04
.55	.16099E−04	.15364E−04	.17158E−04	.20858E−04	.26000E−04	.32499E−04	.40164E−04	.49796E−04	.61921E−04	.77306E−04	.97486E−04
.60	.37035E−04	.39595E−04	.48267E−04	.61627E−04	.78250E−04	.98046E−04	.12084E−03	.14814E−03	.18165E−03	.22333E−03	.27709E−03
.65	.87917E−04	.99668E−04	.12543E−03	.16150E−03	.20487E−03	.25409E−03	.30939E−03	.37454E−03	.45321E−03	.54990E−03	.66921E−03
.70	.20034E−03	.23175E−03	.29350E−03	.37521E−03	.47047E−03	.57774E−03	.69495E−03	.83175E−03	.99226E−03	.11855E−02	.14233E−02
.75	.42196E−03	.49333E−03	.61975E−03	.78453E−03	.97070E−03	.11776E−02	.13994E−02	.16548E−02	.19501E−02	.23085E−02	.27334E−02
.80	.82922E−03	.96188E−03	.12004E−02	.14988E−02	.18304E−02	.21943E−02	.25833E−02	.30211E−02	.35276E−02	.41261E−02	.48323E−02
.85	.15119E−02	.17490E−02	.21528E−02	.26524E−02	.32054E−02	.37973E−02	.44268E−02	.51264E−02	.59368E−02	.68779E−02	.79862E−02
.90	.25897E−02	.29821E−02	.36291E−02	.44081E−02	.52665E−02	.61778E−02	.71398E−02	.82044E−02	.94178E−02	.10828E−01	.12469E−01
.95	.42309E−02	.48331E−02	.57920E−02	.69466E−02	.82057E−02	.95339E−02	.10940E−01	.12490E−01	.14227E−01	.16248E−01	.18537E−01
1.00	.66085E−02	.74837E−02	.88402E−02	.10464E−01	.12229E−01	.14084E−01	.16055E−01	.18202E−01	.20616E−01	.23376E−01	.26506E−01
1.05	.99664E−02	.11203E−01	.13016E−01	.15177E−01	.17525E−01	.20035E−01	.22697E−01	.25559E−01	.28833E−01	.32469E−01	.36608E−01
1.10	.14502E−01	.16193E−01	.18532E−01	.21276E−01	.24324E−01	.27579E−01	.31062E−01	.34869E−01	.39079E−01	.43820E−01	.49163E−01
1.15	.20455E−01	.22617E−01	.25497E−01	.28914E−01	.32750E−01	.36919E−01	.41424E−01	.46310E−01	.51708E−01	.57711E−01	.64524E−01
1.20	.27846E−01	.30663E−01	.34228E−01	.38417E−01	.43146E−01	.48350E−01	.53966E−01	.60184E−01	.66985E−01	.74601E−01	.83280E−01
1.25	.36943E−01	.40595E−01	.45091E−01	.50139E−01	.55667E−01	.61734E−01	.68482E−01	.76098E−01	.84718E−01	.94295E−01	.10462E+00
1.30	.47917E−01	.52354E−01	.57652E−01	.63769E−01	.70619E−01	.78231E−01	.86619E−01	.95909E−01	.10635E+00	.11820E+00	.13188E+00
1.35	.60726E−01	.66378E−01	.73046E−01	.80534E−01	.88818E−01	.97874E−01	.10797E+00	.11924E+00	.13194E+00	.14627E+00	.16230E+00
1.40	.76541E−01	.83380E−01	.91479E−01	.10059E+00	.11068E+00	.12179E+00	.13415E+00	.14791E+00	.16329E+00	.18063E+00	.20006E+00
1.45	.95903E−01	.10428E+00	.11392E+00	.12481E+00	.13690E+00	.15031E+00	.16536E+00	.18210E+00	.20127E+00	.22288E+00	.24755E+00
1.50	.11765E+00	.12758E+00	.13901E+00	.15190E+00	.16635E+00	.18251E+00	.20052E+00	.22072E+00	.24383E+00	.27030E+00	.30101E+00
1.55	.14120E+00	.15284E+00	.16620E+00	.18151E+00	.19870E+00	.21795E+00	.23923E+00	.26303E+00	.28982E+00	.32079E+00	.35769E+00
1.60	.16739E+00	.18100E+00	.19655E+00	.21449E+00	.23494E+00	.25785E+00	.28335E+00	.31172E+00	.34378E+00	.38112E+00	.42668E+00
1.65	.19813E+00	.21395E+00	.23218E+00	.25314E+00	.27730E+00	.30479E+00	.33542E+00	.36997E+00	.40911E+00	.45462E+00	.50945E+00
1.70	.23454E+00	.25330E+00	.27457E+00	.29923E+00	.32795E+00	.36080E+00	.39780E+00	.43948E+00	.48722E+00	.54395E+00	.61559E+00
1.75	.27728E+00	.29806E+00	.32180E+00	.35054E+00	.38477E+00	.42431E+00	.46799E+00	.51636E+00	.57167E+00	.64009E+00	.73419E+00
1.80	.32436E+00	.34894E+00	.37697E+00	.41058E+00	.45091E+00	.49778E+00	.55042E+00	.61005E+00	.68084E+00	.77182E+00	.90026E+00
1.85	.37699E+00	.40648E+00	.44034E+00	.48018E+00	.52601E+00	.57877E+00	.63997E+00	.71302E+00	.80422E+00	.92673E+00	
1.90	.43617E+00	.47078E+00	.51109E+00	.55774E+00	.61192E+00	.67572E+00	.75368E+00	.85172E+00			
1.95	.50116E+00	.54155E+00	.58881E+00	.64384E+00	.70897E+00	.78996E+00	.89376E+00				
2.00	.58158E+00	.62796E+00	.68281E+00	.74811E+00	.82823E+00						
2.05	.67397E+00	.72845E+00	.79181E+00								
2.10	.76967E+00	.83239E+00									

TABLE 17. Superfluid density (g cm^{-3})

Temp. (K)	Pressure (atm) .00	2.50	5.00	7.50	10.00	12.50	15.00	17.50	20.00	22.50	25.00
.10	.14513E+00	.14925E+00	.15284E+00	.15603E+00	.15892E+00	.16157E+00	.16403E+00	.16633E+00	.16849E+00	.17053E+00	.17246E+00
.15	.14513E+00	.14925E+00	.15284E+00	.15603E+00	.15892E+00	.16157E+00	.16403E+00	.16633E+00	.16849E+00	.17053E+00	.17246E+00
.20	.14513E+00	.14925E+00	.15284E+00	.15603E+00	.15892E+00	.16157E+00	.16403E+00	.16633E+00	.16849E+00	.17053E+00	.17246E+00
.25	.14513E+00	.14925E+00	.15283E+00	.15603E+00	.15892E+00	.16157E+00	.16403E+00	.16633E+00	.16849E+00	.17053E+00	.17246E+00
.30	.14513E+00	.14925E+00	.15283E+00	.15602E+00	.15892E+00	.16157E+00	.16403E+00	.16633E+00	.16849E+00	.17053E+00	.17246E+00
.35	.14513E+00	.14925E+00	.15283E+00	.15602E+00	.15891E+00	.16157E+00	.16403E+00	.16632E+00	.16848E+00	.17052E+00	.17246E+00
.40	.14513E+00	.14925E+00	.15283E+00	.15602E+00	.15891E+00	.16157E+00	.16403E+00	.16632E+00	.16848E+00	.17052E+00	.17246E+00
.45	.14513E+00	.14925E+00	.15283E+00	.15602E+00	.15891E+00	.16156E+00	.16402E+00	.16632E+00	.16848E+00	.17052E+00	.17246E+00
.50	.14512E+00	.14924E+00	.15282E+00	.15602E+00	.15891E+00	.16156E+00	.16402E+00	.16632E+00	.16848E+00	.17052E+00	.17245E+00
.55	.14512E+00	.14924E+00	.15282E+00	.15601E+00	.15890E+00	.16156E+00	.16402E+00	.16631E+00	.16847E+00	.17051E+00	.17244E+00
.60	.14512E+00	.14923E+00	.15281E+00	.15600E+00	.15889E+00	.16154E+00	.16400E+00	.16630E+00	.16845E+00	.17048E+00	.17241E+00
.65	.14511E+00	.14922E+00	.15280E+00	.15599E+00	.15887E+00	.16152E+00	.16397E+00	.16626E+00	.16841E+00	.17043E+00	.17235E+00
.70	.14509E+00	.14920E+00	.15277E+00	.15595E+00	.15883E+00	.16147E+00	.16391E+00	.16619E+00	.16832E+00	.17033E+00	.17223E+00
.75	.14505E+00	.14916E+00	.15272E+00	.15589E+00	.15875E+00	.16137E+00	.16380E+00	.16606E+00	.16817E+00	.17015E+00	.17201E+00
.80	.14499E+00	.14909E+00	.15263E+00	.15578E+00	.15862E+00	.16122E+00	.16361E+00	.16584E+00	.16791E+00	.16985E+00	.17166E+00
.85	.14489E+00	.14897E+00	.15249E+00	.15560E+00	.15841E+00	.16096E+00	.16332E+00	.16550E+00	.16752E+00	.16940E+00	.17114E+00
.90	.14473E+00	.14878E+00	.15226E+00	.15533E+00	.15809E+00	.16059E+00	.16289E+00	.16500E+00	.16695E+00	.16874E+00	.17039E+00
.95	.14449E+00	.14851E+00	.15194E+00	.15494E+00	.15763E+00	.16006E+00	.16228E+00	.16431E+00	.16617E+00	.16785E+00	.16937E+00
1.00	.14415E+00	.14811E+00	.15148E+00	.15441E+00	.15701E+00	.15935E+00	.16147E+00	.16339E+00	.16512E+00	.16666E+00	.16803E+00
1.05	.14366E+00	.14756E+00	.15085E+00	.15368E+00	.15618E+00	.15841E+00	.16041E+00	.16220E+00	.16377E+00	.16516E+00	.16633E+00
1.10	.14300E+00	.14682E+00	.15002E+00	.15275E+00	.15513E+00	.15722E+00	.15907E+00	.16069E+00	.16209E+00	.16327E+00	.16422E+00
1.15	.14214E+00	.14587E+00	.14897E+00	.15158E+00	.15382E+00	.15575E+00	.15741E+00	.15883E+00	.16001E+00	.16096E+00	.16163E+00
1.20	.14107E+00	.14468E+00	.14765E+00	.15012E+00	.15220E+00	.15394E+00	.15540E+00	.15658E+00	.15750E+00	.15814E+00	.15847E+00
1.25	.13975E+00	.14321E+00	.14601E+00	.14833E+00	.15025E+00	.15183E+00	.15308E+00	.15400E+00	.15458E+00	.15486E+00	.15486E+00
1.30	.13817E+00	.14148E+00	.14412E+00	.14624E+00	.14792E+00	.14922E+00	.15017E+00	.15077E+00	.15101E+00	.15086E+00	.15025E+00
1.35	.13632E+00	.13940E+00	.14180E+00	.14367E+00	.14508E+00	.14611E+00	.14673E+00	.14697E+00	.14679E+00	.14616E+00	.14509E+00
1.40	.13403E+00	.13689E+00	.13902E+00	.14058E+00	.14167E+00	.14231E+00	.14252E+00	.14229E+00	.14159E+00	.14039E+00	.13868E+00
1.45	.13123E+00	.13379E+00	.13563E+00	.13686E+00	.13757E+00	.13778E+00	.13748E+00	.13669E+00	.13528E+00	.13328E+00	.13057E+00
1.50	.12809E+00	.13035E+00	.13184E+00	.13269E+00	.13296E+00	.13266E+00	.13180E+00	.13035E+00	.12821E+00	.12529E+00	.12144E+00
1.55	.12469E+00	.12661E+00	.12774E+00	.12814E+00	.12789E+00	.12701E+00	.12554E+00	.12341E+00	.12055E+00	.11676E+00	.11174E+00
1.60	.12090E+00	.12244E+00	.12315E+00	.12306E+00	.12221E+00	.12065E+00	.11839E+00	.11540E+00	.11154E+00	.10655E+00	.99891E−01
1.65	.11646E+00	.11756E+00	.11776E+00	.11710E+00	.11556E+00	.11315E+00	.10993E+00	.10578E+00	.10059E+00	.94047E−01	.85620E−01
1.70	.11120E+00	.11173E+00	.11134E+00	.10997E+00	.10758E+00	.10417E+00	.99757E−01	.94261E−01	.87445E−01	.78789E−01	.67228E−01
1.75	.10502E+00	.10509E+00	.10417E+00	.10203E+00	.98607E−01	.93958E−01	.88278E−01	.81483E−01	.73189E−01	.62313E−01	.46593E−01
1.80	.98205E−01	.97531E−01	.95785E−01	.92706E−01	.88137E−01	.82107E−01	.74742E−01	.65837E−01	.54659E−01	.39602E−01	.17528E−01
1.85	.90588E−01	.88974E−01	.86133E−01	.81871E−01	.76209E−01	.69000E−01	.59985E−01	.48568E−01	.33617E−01	.12751E−01	
1.90	.82016E−01	.79401E−01	.75336E−01	.69766E−01	.62516E−01	.53236E−01	.41142E−01	.25164E−01			
1.95	.72596E−01	.68847E−01	.63448E−01	.56286E−01	.46985E−01	.34569E−01	.17795E−01				
2.00	.60925E−01	.55930E−01	.49022E−01	.39891E−01	.27802E−01						
2.05	.47502E−01	.40873E−01	.32235E−01								
2.10	.33582E−01	.25265E−01									

TABLE 18. Superfluid ratio

Temp. (K)	Pressure (atm) .00	2.50	5.00	7.50	10.00	12.50	15.00	17.50	20.00	22.50	25.00
.10	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01
.15	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01
.20	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01
.25	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01
.30	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01
.35	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01
.40	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01
.45	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.10000E+01	.99999E+00
.50	.99999E+00	.99999E+00	.99999E+00	.99999E+00	.99999E+00	.99999E+00	.99999E+00	.99999E+00	.99998E+00	.99998E+00	.99997E+00
.55	.99998E+00	.99998E+00	.99998E+00	.99998E+00	.99997E+00	.99997E+00	.99996E+00	.99995E+00	.99994E+00	.99992E+00	.99990E+00
.60	.99996E+00	.99996E+00	.99995E+00	.99994E+00	.99992E+00	.99990E+00	.99988E+00	.99985E+00	.99982E+00	.99978E+00	.99972E+00
.65	.99991E+00	.99990E+00	.99987E+00	.99984E+00	.99980E+00	.99975E+00	.99969E+00	.99963E+00	.99955E+00	.99945E+00	.99933E+00
.70	.99980E+00	.99977E+00	.99971E+00	.99962E+00	.99953E+00	.99942E+00	.99931E+00	.99917E+00	.99901E+00	.99881E+00	.99858E+00
.75	.99958E+00	.99951E+00	.99938E+00	.99922E+00	.99903E+00	.99882E+00	.99860E+00	.99835E+00	.99805E+00	.99769E+00	.99727E+00
.80	.99917E+00	.99904E+00	.99880E+00	.99850E+00	.99817E+00	.99781E+00	.99742E+00	.99698E+00	.99647E+00	.99587E+00	.99517E+00
.85	.99849E+00	.99825E+00	.99785E+00	.99735E+00	.99679E+00	.99620E+00	.99557E+00	.99487E+00	.99406E+00	.99312E+00	.99201E+00
.90	.99741E+00	.99702E+00	.99637E+00	.99559E+00	.99473E+00	.99382E+00	.99286E+00	.99180E+00	.99058E+00	.98917E+00	.98753E+00
.95	.99577E+00	.99517E+00	.99421E+00	.99305E+00	.99179E+00	.99047E+00	.98906E+00	.98751E+00	.98577E+00	.98375E+00	.98146E+00
1.00	.99339E+00	.99252E+00	.99116E+00	.98954E+00	.98777E+00	.98592E+00	.98395E+00	.98180E+00	.97938E+00	.97662E+00	.97349E+00
1.05	.99003E+00	.98880E+00	.98698E+00	.98482E+00	.98248E+00	.97996E+00	.97730E+00	.97444E+00	.97117E+00	.96753E+00	.96339E+00
1.10	.98550E+00	.98381E+00	.98147E+00	.97872E+00	.97568E+00	.97242E+00	.96894E+00	.96513E+00	.96092E+00	.95618E+00	.95084E+00
1.15	.97955E+00	.97738E+00	.97450E+00	.97109E+00	.96725E+00	.96308E+00	.95858E+00	.95369E+00	.94829E+00	.94229E+00	.93548E+00
1.20	.97215E+00	.96934E+00	.96577E+00	.96158E+00	.95685E+00	.95165E+00	.94603E+00	.93982E+00	.93301E+00	.92540E+00	.91672E+00
1.25	.96306E+00	.95940E+00	.95491E+00	.94986E+00	.94433E+00	.93827E+00	.93152E+00	.92390E+00	.91528E+00	.90570E+00	.89538E+00
1.30	.95208E+00	.94765E+00	.94235E+00	.93623E+00	.92938E+00	.92177E+00	.91338E+00	.90409E+00	.89365E+00	.88180E+00	.86812E+00
1.35	.93927E+00	.93362E+00	.92695E+00	.91947E+00	.91118E+00	.90213E+00	.89203E+00	.88076E+00	.86806E+00	.85373E+00	.83770E+00
1.40	.92346E+00	.91662E+00	.90852E+00	.89941E+00	.88932E+00	.87821E+00	.86585E+00	.85209E+00	.83671E+00	.81937E+00	.79994E+00
1.45	.90410E+00	.89572E+00	.88608E+00	.87519E+00	.86310E+00	.84969E+00	.83464E+00	.81790E+00	.79873E+00	.77712E+00	.75245E+00
1.50	.88235E+00	.87242E+00	.86099E+00	.84810E+00	.83365E+00	.81749E+00	.79948E+00	.77928E+00	.75617E+00	.72970E+00	.69899E+00
1.55	.85880E+00	.84716E+00	.83380E+00	.81849E+00	.80130E+00	.78205E+00	.76077E+00	.73697E+00	.71018E+00	.67921E+00	.64231E+00
1.60	.83261E+00	.81900E+00	.80345E+00	.78551E+00	.76506E+00	.74215E+00	.71665E+00	.68828E+00	.65622E+00	.61888E+00	.57332E+00
1.65	.80187E+00	.78605E+00	.76782E+00	.74686E+00	.72270E+00	.69521E+00	.66458E+00	.63003E+00	.59089E+00	.54538E+00	.49055E+00
1.70	.76546E+00	.74670E+00	.72543E+00	.70077E+00	.67205E+00	.63920E+00	.60220E+00	.56052E+00	.51278E+00	.45605E+00	.38441E+00
1.75	.72272E+00	.70194E+00	.67820E+00	.64946E+00	.61523E+00	.57569E+00	.53201E+00	.48364E+00	.42833E+00	.35991E+00	.26581E+00
1.80	.67564E+00	.65106E+00	.62303E+00	.58942E+00	.54909E+00	.50222E+00	.44958E+00	.38995E+00	.31916E+00	.22818E+00	.99739E−01
1.85	.62301E+00	.59352E+00	.55966E+00	.51982E+00	.47399E+00	.42123E+00	.36003E+00	.28698E+00	.19578E+00	.73265E−01	
1.90	.56383E+00	.52922E+00	.48891E+00	.44226E+00	.38808E+00	.32428E+00	.24632E+00	.14828E+00			
1.95	.49884E+00	.45845E+00	.41119E+00	.35616E+00	.29103E+00	.21004E+00	.10624E+00				
2.00	.41842E+00	.37204E+00	.31719E+00	.25189E+00	.17177E+00						
2.05	.32603E+00	.27155E+00	.20819E+00								
2.10	.23033E+00	.16761E+00									

TABLE 19. Velocity of second sound (m s⁻¹)

Temp. (K)	Pressure (atm) .00	2.50	5.00	7.50	10.00	12.50	15.00	17.50	20.00	22.50	25.00
.10	.13824E+03	.14903E+03	.15845E+03	.16693E+03	.17463E+03	.18168E+03	.18821E+03	.19429E+03	.19998E+03	.20534E+03	.21041E+03
.15	.13903E+03	.14936E+03	.15865E+03	.16700E+03	.17466E+03	.18174E+03	.18832E+03	.19450E+03	.20034E+03	.20589E+03	.21119E+03
.20	.13985E+03	.14980E+03	.15877E+03	.16695E+03	.17448E+03	.18146E+03	.18797E+03	.19408E+03	.19984E+03	.20530E+03	.21050E+03
.25	.14077E+03	.15024E+03	.15890E+03	.16688E+03	.17427E+03	.18114E+03	.18758E+03	.19362E+03	.19934E+03	.20476E+03	.20991E+03
.30	.14171E+03	.15067E+03	.15899E+03	.16673E+03	.17393E+03	.18064E+03	.18689E+03	.19270E+03	.19804E+03	.20284E+03	.20692E+03
.35	.14259E+03	.15098E+03	.15882E+03	.16601E+03	.17246E+03	.17801E+03	.18245E+03	.18538E+03	.18628E+03	.18435E+03	.17863E+03
.40	.14296E+03	.15030E+03	.15650E+03	.16092E+03	.16291E+03	.16179E+03	.15746E+03	.14946E+03	.13817E+03	.12410E+03	.10867E+03
.45	.14074E+03	.14484E+03	.14519E+03	.14070E+03	.13179E+03	.11982E+03	.10659E+03	.93018E+02	.79840E+02	.67614E+02	.56589E+02
.50	.13093E+03	.12776E+03	.11801E+03	.10403E+03	.89188E+02	.75449E+02	.63712E+02	.53606E+02	.44868E+02	.37413E+02	.31069E+02
.55	.11028E+03	.99793E+02	.84701E+02	.69596E+02	.56929E+02	.46796E+02	.38917E+02	.32509E+02	.27271E+02	.22983E+02	.19415E+02
.60	.84688E+02	.72151E+02	.58286E+02	.46462E+02	.37493E+02	.30805E+02	.25783E+02	.21869E+02	.18755E+02	.16256E+02	.14268E+02
.65	.62548E+02	.51687E+02	.41006E+02	.32634E+02	.26568E+02	.22213E+02	.19041E+02	.16608E+02	.14723E+02	.13248E+02	.12071E+02
.70	.46564E+02	.38141E+02	.30434E+02	.24637E+02	.20586E+02	.17708E+02	.15663E+02	.14108E+02	.12923E+02	.11970E+02	.11233E+02
.75	.35867E+02	.29636E+02	.24126E+02	.20107E+02	.17353E+02	.15413E+02	.14026E+02	.12987E+02	.12181E+02	.11545E+02	.11050E+02
.80	.28910E+02	.24385E+02	.20442E+02	.17614E+02	.15663E+02	.14308E+02	.13328E+02	.12599E+02	.12013E+02	.11567E+02	.11198E+02
.85	.24600E+02	.21183E+02	.18317E+02	.16281E+02	.14860E+02	.13867E+02	.13146E+02	.12596E+02	.12163E+02	.11813E+02	.11527E+02
.90	.21815E+02	.19251E+02	.17149E+02	.15636E+02	.14577E+02	.13819E+02	.13253E+02	.12810E+02	.12475E+02	.12185E+02	.11975E+02
.95	.20068E+02	.18136E+02	.16566E+02	.15413E+02	.14589E+02	.13996E+02	.13551E+02	.13171E+02	.12882E+02	.12648E+02	.12460E+02
1.00	.18616E+02	.17136E+02	.16024E+02	.15214E+02	.14608E+02	.14137E+02	.13763E+02	.13462E+02	.13214E+02	.13017E+02	.12847E+02
1.05	.18105E+02	.16934E+02	.16091E+02	.15469E+02	.14974E+02	.14572E+02	.14236E+02	.13953E+02	.13729E+02	.13539E+02	.13365E+02
1.10	.17954E+02	.16984E+02	.16309E+02	.15805E+02	.15390E+02	.15031E+02	.14724E+02	.14450E+02	.14225E+02	.14026E+02	.13832E+02
1.15	.18050E+02	.17185E+02	.16580E+02	.16149E+02	.15817E+02	.15530E+02	.15260E+02	.14989E+02	.14739E+02	.14506E+02	.14319E+02
1.20	.18273E+02	.17506E+02	.16966E+02	.16563E+02	.16247E+02	.15965E+02	.15695E+02	.15437E+02	.15174E+02	.14917E+02	.14668E+02
1.25	.18609E+02	.17880E+02	.17349E+02	.16938E+02	.16597E+02	.16302E+02	.16023E+02	.15762E+02	.15503E+02	.15234E+02	.14954E+02
1.30	.18884E+02	.18189E+02	.17645E+02	.17216E+02	.16863E+02	.16556E+02	.16260E+02	.15981E+02	.15706E+02	.15429E+02	.15162E+02
1.35	.19022E+02	.18371E+02	.17860E+02	.17428E+02	.17050E+02	.16703E+02	.16372E+02	.16063E+02	.15748E+02	.15432E+02	.15089E+02
1.40	.19215E+02	.18583E+02	.18079E+02	.17649E+02	.17262E+02	.16895E+02	.16541E+02	.16190E+02	.15819E+02	.15436E+02	.15025E+02
1.45	.19560E+02	.18954E+02	.18455E+02	.17998E+02	.17569E+02	.17151E+02	.16757E+02	.16365E+02	.15967E+02	.15532E+02	.15021E+02
1.50	.19997E+02	.19377E+02	.18855E+02	.18359E+02	.17874E+02	.17402E+02	.16949E+02	.16501E+02	.16043E+02	.15532E+02	.14909E+02
1.55	.20318E+02	.19683E+02	.19120E+02	.18582E+02	.18040E+02	.17496E+02	.16965E+02	.16426E+02	.15882E+02	.15280E+02	.14572E+02
1.60	.20361E+02	.19694E+02	.19100E+02	.18525E+02	.17931E+02	.17321E+02	.16706E+02	.16077E+02	.15421E+02	.14688E+02	.13808E+02
1.65	.20157E+02	.19511E+02	.18927E+02	.18317E+02	.17655E+02	.16964E+02	.16274E+02	.15573E+02	.14818E+02	.13926E+02	.12781E+02
1.70	.19912E+02	.19244E+02	.18623E+02	.17960E+02	.17231E+02	.16455E+02	.15664E+02	.14833E+02	.13894E+02	.12740E+02	.11214E+02
1.75	.19670E+02	.18919E+02	.18205E+02	.17464E+02	.16690E+02	.15860E+02	.14957E+02	.13946E+02	.12753E+02	.11245E+02	.91909E+01
1.80	.19365E+02	.18527E+02	.17690E+02	.16854E+02	.15981E+02	.15012E+02	.13874E+02	.12523E+02	.10868E+02	.87391E+01	.54691E+01
1.85	.18964E+02	.18007E+02	.17035E+02	.16059E+02	.15027E+02	.13823E+02	.12348E+02	.10535E+02	.82274E+01	.47375E+01	
1.90	.18188E+02	.17168E+02	.16094E+02	.14953E+02	.13663E+02	.12079E+02	.10065E+02	.73777E+01			
1.95	.17115E+02	.16005E+02	.14817E+02	.13469E+02	.11807E+02	.96227E+01	.64804E+01				
2.00	.15814E+02	.14546E+02	.13160E+02	.11447E+02	.91281E+01						
2.05	.14131E+02	.12535E+02	.10760E+02								
2.10	.12024E+02	.99886E+01									

TABLE 20. Velocity of fourth sound (m s⁻¹)

Temp. (K)	Pressure (atm) .00	2.50	5.00	7.50	10.00	12.50	15.00	17.50	20.00	22.50	25.00
.10	.23821E+03	.25746E+03	.27422E+03	.28916E+03	.30271E+03	.31515E+03	.32669E+03	.33747E+03	.34760E+03	.35718E+03	.36627E+03
.15	.23821E+03	.25746E+03	.27422E+03	.28916E+03	.30271E+03	.31515E+03	.32669E+03	.33747E+03	.34760E+03	.35718E+03	.36627E+03
.20	.23821E+03	.25746E+03	.27422E+03	.28916E+03	.30271E+03	.31515E+03	.32669E+03	.33747E+03	.34760E+03	.35718E+03	.36627E+03
.25	.23821E+03	.25746E+03	.27422E+03	.28916E+03	.30271E+03	.31515E+03	.32669E+03	.33747E+03	.34760E+03	.35718E+03	.36627E+03
.30	.23821E+03	.25746E+03	.27422E+03	.28916E+03	.30271E+03	.31515E+03	.32669E+03	.33747E+03	.34760E+03	.35718E+03	.36627E+03
.35	.23821E+03	.25746E+03	.27422E+03	.28916E+03	.30271E+03	.31515E+03	.32669E+03	.33747E+03	.34760E+03	.35718E+03	.36627E+03
.40	.23821E+03	.25746E+03	.27422E+03	.28916E+03	.30271E+03	.31515E+03	.32669E+03	.33747E+03	.34760E+03	.35718E+03	.36627E+03
.45	.23820E+03	.25746E+03	.27422E+03	.28916E+03	.30271E+03	.31515E+03	.32669E+03	.33746E+03	.34760E+03	.35717E+03	.36627E+03
.50	.23820E+03	.25745E+03	.27421E+03	.28916E+03	.30271E+03	.31515E+03	.32668E+03	.33746E+03	.34759E+03	.35717E+03	.36626E+03
.55	.23820E+03	.25745E+03	.27421E+03	.28915E+03	.30270E+03	.31514E+03	.32667E+03	.33745E+03	.34758E+03	.35716E+03	.36625E+03
.60	.23819E+03	.25744E+03	.27420E+03	.28914E+03	.30269E+03	.31512E+03	.32666E+03	.33743E+03	.34756E+03	.35712E+03	.36621E+03
.65	.23817E+03	.25742E+03	.27418E+03	.28911E+03	.30266E+03	.31509E+03	.32662E+03	.33738E+03	.34750E+03	.35706E+03	.36613E+03
.70	.23814E+03	.25738E+03	.27414E+03	.28907E+03	.30261E+03	.31503E+03	.32655E+03	.33730E+03	.34740E+03	.35694E+03	.36598E+03
.75	.23809E+03	.25733E+03	.27407E+03	.28899E+03	.30252E+03	.31493E+03	.32642E+03	.33715E+03	.34722E+03	.35673E+03	.36573E+03
.80	.23801E+03	.25723E+03	.27397E+03	.28888E+03	.30238E+03	.31476E+03	.32622E+03	.33690E+03	.34693E+03	.35639E+03	.36534E+03
.85	.23787E+03	.25708E+03	.27381E+03	.28869E+03	.30216E+03	.31450E+03	.32591E+03	.33653E+03	.34650E+03	.35588E+03	.36473E+03
.90	.23766E+03	.25687E+03	.27357E+03	.28843E+03	.30185E+03	.31413E+03	.32545E+03	.33599E+03	.34587E+03	.35516E+03	.36387E+03
.95	.23735E+03	.25657E+03	.27324E+03	.28805E+03	.30140E+03	.31360E+03	.32483E+03	.33524E+03	.34501E+03	.35417E+03	.36271E+03
1.00	.23695E+03	.25613E+03	.27277E+03	.28752E+03	.30080E+03	.31289E+03	.32398E+03	.33424E+03	.34384E+03	.35285E+03	.36123E+03
1.05	.23639E+03	.25554E+03	.27214E+03	.28682E+03	.30000E+03	.31196E+03	.32288E+03	.33296E+03	.34238E+03	.35118E+03	.35925E+03
1.10	.23571E+03	.25476E+03	.27129E+03	.28589E+03	.29895E+03	.31077E+03	.32150E+03	.33132E+03	.34056E+03	.34916E+03	.35673E+03
1.15	.23478E+03	.25381E+03	.27023E+03	.28471E+03	.29765E+03	.30928E+03	.31978E+03	.32935E+03	.33827E+03	.34655E+03	.35381E+03
1.20	.23376E+03	.25259E+03	.26888E+03	.28322E+03	.29599E+03	.30743E+03	.31768E+03	.32693E+03	.33555E+03	.34349E+03	.35004E+03
1.25	.23244E+03	.25117E+03	.26725E+03	.28136E+03	.29393E+03	.30514E+03	.31513E+03	.32412E+03	.33234E+03	.33975E+03	.34581E+03
1.30	.23092E+03	.24942E+03	.26534E+03	.27926E+03	.29153E+03	.30238E+03	.31191E+03	.32041E+03	.32829E+03	.33537E+03	.34102E+03
1.35	.22919E+03	.24742E+03	.26300E+03	.27658E+03	.28852E+03	.29900E+03	.30813E+03	.31611E+03	.32333E+03	.32966E+03	.33403E+03
1.40	.22692E+03	.24497E+03	.26025E+03	.27347E+03	.28495E+03	.29489E+03	.30341E+03	.31070E+03	.31727E+03	.32296E+03	.32664E+03
1.45	.22433E+03	.24191E+03	.25679E+03	.26957E+03	.28057E+03	.28996E+03	.29783E+03	.30438E+03	.31003E+03	.31456E+03	.31670E+03
1.50	.22138E+03	.23850E+03	.25293E+03	.26523E+03	.27562E+03	.28427E+03	.29129E+03	.29682E+03	.30166E+03	.30526E+03	.30534E+03
1.55	.21818E+03	.23470E+03	.24862E+03	.26032E+03	.27005E+03	.27792E+03	.28400E+03	.28831E+03	.29178E+03	.29390E+03	.29177E+03
1.60	.21472E+03	.23037E+03	.24368E+03	.25477E+03	.26369E+03	.27061E+03	.27548E+03	.27831E+03	.28020E+03	.28033E+03	.27470E+03
1.65	.21037E+03	.22539E+03	.23779E+03	.24798E+03	.25601E+03	.26179E+03	.26527E+03	.26624E+03	.26570E+03	.26275E+03	.25174E+03
1.70	.20520E+03	.21925E+03	.23069E+03	.23978E+03	.24654E+03	.25084E+03	.25235E+03	.25085E+03	.24742E+03	.24040E+03	.22284E+03
1.75	.19923E+03	.21204E+03	.22234E+03	.23020E+03	.23557E+03	.23796E+03	.23698E+03	.23225E+03	.22499E+03	.21241E+03	.18340E+03
1.80	.19265E+03	.20367E+03	.21233E+03	.21852E+03	.22208E+03	.22231E+03	.21811E+03	.20852E+03	.19419E+03	.16904E+03	.11055E+03
1.85	.18482E+03	.19408E+03	.20069E+03	.20443E+03	.20538E+03	.20274E+03	.19455E+03	.17799E+03	.15145E+03	.95511E+02	
1.90	.17570E+03	.18254E+03	.18695E+03	.18810E+03	.18540E+03	.17753E+03	.16077E+03	.12785E+03			
1.95	.16433E+03	.16940E+03	.17093E+03	.16815E+03	.15993E+03	.14252E+03	.10545E+03				
2.00	.15030E+03	.15150E+03	.14941E+03	.14087E+03	.12235E+03						
2.05	.13180E+03	.12902E+03	.12037E+03								
2.10	.11065E+03	.10084E+03									

TABLE 21. Energy of maxon peak (K)

Temp. (K)	Pressure (atm)										
	.00	2.50	5.00	7.50	10.00	12.50	15.00	17.50	20.00	22.50	25.00
.10	.13816E+02	.14197E+02	.14438E+02	.14592E+02	.14691E+02	.14752E+02	.14789E+02	.14809E+02	.14819E+02	.14822E+02	.14822E+02
.15	.13816E+02	.14197E+02	.14438E+02	.14592E+02	.14691E+02	.14752E+02	.14789E+02	.14809E+02	.14819E+02	.14822E+02	.14822E+02
.20	.13816E+02	.14197E+02	.14438E+02	.14592E+02	.14691E+02	.14752E+02	.14789E+02	.14809E+02	.14819E+02	.14822E+02	.14822E+02
.25	.13816E+02	.14197E+02	.14438E+02	.14592E+02	.14691E+02	.14752E+02	.14789E+02	.14809E+02	.14819E+02	.14822E+02	.14822E+02
.30	.13816E+02	.14197E+02	.14438E+02	.14592E+02	.14691E+02	.14752E+02	.14789E+02	.14809E+02	.14819E+02	.14822E+02	.14822E+02
.35	.13816E+02	.14197E+02	.14438E+02	.14592E+02	.14691E+02	.14752E+02	.14789E+02	.14809E+02	.14819E+02	.14822E+02	.14822E+02
.40	.13816E+02	.14197E+02	.14438E+02	.14592E+02	.14691E+02	.14752E+02	.14789E+02	.14809E+02	.14819E+02	.14822E+02	.14822E+02
.45	.13816E+02	.14197E+02	.14438E+02	.14592E+02	.14691E+02	.14752E+02	.14789E+02	.14809E+02	.14819E+02	.14822E+02	.14822E+02
.50	.13816E+02	.14197E+02	.14438E+02	.14592E+02	.14691E+02	.14752E+02	.14789E+02	.14809E+02	.14819E+02	.14822E+02	.14822E+02
.55	.13816E+02	.14197E+02	.14438E+02	.14592E+02	.14691E+02	.14752E+02	.14789E+02	.14809E+02	.14819E+02	.14822E+02	.14822E+02
.60	.13816E+02	.14197E+02	.14437E+02	.14592E+02	.14690E+02	.14752E+02	.14789E+02	.14809E+02	.14819E+02	.14822E+02	.14821E+02
.65	.13816E+02	.14196E+02	.14437E+02	.14592E+02	.14690E+02	.14752E+02	.14789E+02	.14809E+02	.14818E+02	.14822E+02	.14821E+02
.70	.13815E+02	.14196E+02	.14437E+02	.14592E+02	.14690E+02	.14752E+02	.14788E+02	.14809E+02	.14818E+02	.14821E+02	.14821E+02
.75	.13815E+02	.14196E+02	.14437E+02	.14591E+02	.14690E+02	.14751E+02	.14788E+02	.14808E+02	.14818E+02	.14821E+02	.14821E+02
.80	.13815E+02	.14195E+02	.14436E+02	.14591E+02	.14689E+02	.14751E+02	.14787E+02	.14808E+02	.14817E+02	.14821E+02	.14820E+02
.85	.13814E+02	.14195E+02	.14436E+02	.14590E+02	.14689E+02	.14750E+02	.14787E+02	.14807E+02	.14817E+02	.14820E+02	.14820E+02
.90	.13813E+02	.14194E+02	.14434E+02	.14589E+02	.14687E+02	.14749E+02	.14786E+02	.14806E+02	.14816E+02	.14819E+02	.14818E+02
.95	.13812E+02	.14192E+02	.14433E+02	.14587E+02	.14686E+02	.14748E+02	.14784E+02	.14804E+02	.14814E+02	.14817E+02	.14817E+02
1.00	.13810E+02	.14190E+02	.14431E+02	.14585E+02	.14684E+02	.14745E+02	.14782E+02	.14802E+02	.14812E+02	.14815E+02	.14815E+02
1.05	.13807E+02	.14188E+02	.14428E+02	.14583E+02	.14681E+02	.14743E+02	.14779E+02	.14800E+02	.14809E+02	.14812E+02	.14812E+02
1.10	.13804E+02	.14184E+02	.14425E+02	.14579E+02	.14678E+02	.14739E+02	.14776E+02	.14796E+02	.14806E+02	.14809E+02	.14809E+02
1.15	.13799E+02	.14180E+02	.14420E+02	.14575E+02	.14673E+02	.14734E+02	.14771E+02	.14791E+02	.14801E+02	.14804E+02	.14804E+02
1.20	.13794E+02	.14174E+02	.14414E+02	.14568E+02	.14667E+02	.14728E+02	.14765E+02	.14785E+02	.14795E+02	.14798E+02	.14798E+02
1.25	.13786E+02	.14166E+02	.14406E+02	.14561E+02	.14659E+02	.14720E+02	.14757E+02	.14777E+02	.14787E+02	.14790E+02	.14790E+02
1.30	.13777E+02	.14156E+02	.14397E+02	.14551E+02	.14649E+02	.14710E+02	.14747E+02	.14767E+02	.14777E+02	.14780E+02	.14780E+02
1.35	.13765E+02	.14144E+02	.14384E+02	.14538E+02	.14636E+02	.14698E+02	.14734E+02	.14754E+02	.14764E+02	.14767E+02	.14767E+02
1.40	.13750E+02	.14129E+02	.14369E+02	.14523E+02	.14621E+02	.14682E+02	.14718E+02	.14739E+02	.14748E+02	.14751E+02	.14751E+02
1.45	.13732E+02	.14110E+02	.14350E+02	.14503E+02	.14601E+02	.14662E+02	.14699E+02	.14719E-02	.14728E+02	.14732E+02	.14731E+02
1.50	.13709E+02	.14087E+02	.14326E+02	.14479E+02	.14577E+02	.14638E+02	.14675E+02	.14695E+02	.14704E+02	.14707E+02	.14707E+02
1.55	.13682E+02	.14059E+02	.14297E+02	.14450E+02	.14548E+02	.14609E+02	.14645E+02	.14665E-02	.14675E+02	.14678E+02	.14678E+02
1.60	.13648E+02	.14024E+02	.14262E+02	.14415E+02	.14512E+02	.14573E+02	.14609E+02	.14629E+02	.14639E+02	.14642E+02	.14642E+02
1.65	.13608E+02	.13983E+02	.14220E+02	.14372E+02	.14469E+02	.14530E+02	.14566E+02	.14586E-02	.14596E+02	.14599E+02	.14599E+02
1.70	.13560E+02	.13933E+02	.14170E+02	.14321E+02	.14418E+02	.14478E+02	.14514E+02	.14534E-02	.14544E+02	.14547E+02	.14547E+02
1.75	.13502E+02	.13874E+02	.14109E+02	.14260E+02	.14357E+02	.14417E+02	.14453E+02	.14473E-02	.14482E+02	.14485E+02	.14485E+02
1.80	.13433E+02	.13804E+02	.14038E+02	.14188E+02	.14284E+02	.14344E+02	.14379E+02	.14399E-02	.14409E+02	.14412E+02	.14411E+02
1.85	.13353E+02	.13721E+02	.13953E+02	.14103E+02	.14198E+02	.14257E+02	.14293E+02	.14313E-02	.14322E+02	.14325E+02	
1.90	.13258E+02	.13623E+02	.13854E+02	.14002E+02	.14097E+02	.14156E+02	.14191E+02	.14211E-02			
1.95	.13146E+02	.13508E+02	.13738E+02	.13885E+02	.13978E+02	.14037E+02	.14072E+02				
2.00	.13016E+02	.13375E+02	.13602E+02	.13748E+02	.13840E+02						
2.05	.12865E+02	.13220E+02	.13444E+02								
2.10	.12691E+02	.13041E+02									

TABLE 22. Thermal roton energy gap (K)

Temp. (K)	Pressure (atm) .00	2.50	5.00	7.50	10.00	12.50	15.00	17.50	20.00	22.50	25.00
.10	.87117E+01	.85726E+01	.83799E+01	.81893E+01	.80193E+01	.78676E+01	.77323E+01	.76020E+01	.74729E+01	.73429E+01	.72102E+01
.15	.87117E+01	.85726E+01	.83799E+01	.81893E+01	.80193E+01	.78676E+01	.77323E+01	.76020E+01	.74729E+01	.73429E+01	.72102E+01
.20	.87117E+01	.85726E+01	.83799E+01	.81893E+01	.80193E+01	.78676E+01	.77323E+01	.76020E+01	.74729E+01	.73429E+01	.72102E+01
.25	.87117E+01	.85726E+01	.83799E+01	.81893E+01	.80193E+01	.78676E+01	.77323E+01	.76020E+01	.74729E+01	.73429E+01	.72102E+01
.30	.87117E+01	.85726E+01	.83799E+01	.81893E+01	.80193E+01	.78676E+01	.77323E+01	.76020E+01	.74729E+01	.73429E+01	.72102E+01
.35	.87117E+01	.85726E+01	.83799E+01	.81893E+01	.80193E+01	.78676E+01	.77323E+01	.76020E+01	.74729E+01	.73429E+01	.72102E+01
.40	.87117E+01	.85726E+01	.83799E+01	.81893E+01	.80193E+01	.78676E+01	.77323E+01	.76020E+01	.74729E+01	.73429E+01	.72102E+01
.45	.87117E+01	.85726E+01	.83799E+01	.81893E+01	.80193E+01	.78676E+01	.77323E+01	.76020E+01	.74729E+01	.73429E+01	.72102E+01
.50	.87117E+01	.85726E+01	.83799E+01	.81893E+01	.80193E+01	.78676E+01	.77323E+01	.76020E+01	.74729E+01	.73429E+01	.72102E+01
.55	.87117E+01	.85725E+01	.83799E+01	.81893E+01	.80193E+01	.78676E+01	.77323E+01	.76020E+01	.74729E+01	.73429E+01	.72101E+01
.60	.87116E+01	.85725E+01	.83799E+01	.81893E+01	.80193E+01	.78676E+01	.77323E+01	.76020E+01	.74729E+01	.73429E+01	.72101E+01
.65	.87114E+01	.85723E+01	.83798E+01	.81892E+01	.80193E+01	.78676E+01	.77323E+01	.76020E+01	.74729E+01	.73428E+01	.72101E+01
.70	.87109E+01	.85718E+01	.83795E+01	.81891E+01	.80192E+01	.78676E+01	.77323E+01	.76019E+01	.74728E+01	.73428E+01	.72100E+01
.75	.87098E+01	.85708E+01	.83789E+01	.81889E+01	.80192E+01	.78676E+01	.77323E+01	.76019E+01	.74727E+01	.73426E+01	.72099E+01
.80	.87077E+01	.85689E+01	.83777E+01	.81884E+01	.80190E+01	.78676E+01	.77322E+01	.76018E+01	.74725E+01	.73424E+01	.72096E+01
.85	.87039E+01	.85653E+01	.83757E+01	.81875E+01	.80188E+01	.78677E+01	.77321E+01	.76016E+01	.74721E+01	.73419E+01	.72091E+01
.90	.86976E+01	.85595E+01	.83722E+01	.81861E+01	.80184E+01	.78677E+01	.77319E+01	.76012E+01	.74715E+01	.73412E+01	.72083E+01
.95	.86877E+01	.85503E+01	.83667E+01	.81838E+01	.80177E+01	.78678E+01	.77316E+01	.76007E+01	.74705E+01	.73400E+01	.72070E+01
1.00	.86729E+01	.85366E+01	.83586E+01	.81804E+01	.80168E+01	.78680E+01	.77312E+01	.75999E+01	.74691E+01	.73382E+01	.72051E+01
1.05	.86494E+01	.85148E+01	.83457E+01	.81751E+01	.80154E+01	.78685E+01	.77308E+01	.75991E+01	.74672E+01	.73361E+01	.72030E+01
1.10	.86218E+01	.84893E+01	.83305E+01	.81686E+01	.80135E+01	.78686E+01	.77298E+01	.75973E+01	.74640E+01	.73321E+01	.71985E+01
1.15	.85950E+01	.84673E+01	.83186E+01	.81647E+01	.80131E+01	.78673E+01	.77284E+01	.75912E+01	.74586E+01	.73243E+01	.71891E+01
1.20	.85738E+01	.84464E+01	.83030E+01	.81557E+01	.80075E+01	.78641E+01	.77232E+01	.75860E+01	.74502E+01	.73123E+01	.71722E+01
1.25	.85557E+01	.84234E+01	.82823E+01	.81392E+01	.80009E+01	.78640E+01	.77262E+01	.75868E+01	.74437E+01	.73020E+01	.71634E+01
1.30	.85370E+01	.84088E+01	.82719E+01	.81310E+01	.79892E+01	.78476E+01	.77065E+01	.75661E+01	.74221E+01	.72771E+01	.71241E+01
1.35	.85255E+01	.83901E+01	.82482E+01	.81056E+01	.79646E+01	.78242E+01	.76835E+01	.75385E+01	.73944E+01	.72441E+01	.70942E+01
1.40	.84966E+01	.83598E+01	.82167E+01	.80719E+01	.79279E+01	.77845E+01	.76391E+01	.74925E+01	.73454E+01	.71929E+01	.70399E+01
1.45	.84504E+01	.83111E+01	.81684E+01	.80243E+01	.78790E+01	.77330E+01	.75848E+01	.74337E+01	.72785E+01	.71182E+01	.69550E+01
1.50	.84160E+01	.82737E+01	.81307E+01	.79832E+01	.78365E+01	.76867E+01	.75333E+01	.73777E+01	.72175E+01	.70513E+01	.68762E+01
1.55	.83956E+01	.82501E+01	.81035E+01	.79541E+01	.78005E+01	.76457E+01	.74887E+01	.73306E+01	.71677E+01	.69982E+01	.68140E+01
1.60	.83759E+01	.82274E+01	.80782E+01	.79235E+01	.77641E+01	.76020E+01	.74387E+01	.72725E+01	.71025E+01	.69240E+01	.67276E+01
1.65	.83428E+01	.81909E+01	.80370E+01	.78778E+01	.77126E+01	.75419E+01	.73699E+01	.71922E+01	.70129E+01	.68244E+01	.66191E+01
1.70	.82894E+01	.81317E+01	.79752E+01	.78114E+01	.76384E+01	.74616E+01	.72799E+01	.70952E+01	.69050E+01	.66995E+01	.64689E+01
1.75	.82227E+01	.80682E+01	.79131E+01	.77439E+01	.75630E+01	.73744E+01	.71877E+01	.69996E+01	.68051E+01	.65885E+01	.63261E+01
1.80	.81594E+01	.79973E+01	.78352E+01	.76617E+01	.74730E+01	.72769E+01	.70777E+01	.68746E+01	.66589E+01	.64105E+01	.61073E+01
1.85	.80920E+01	.79210E+01	.77472E+01	.75648E+01	.73766E+01	.71792E+01	.69765E+01	.67559E+01	.65108E+01	.62240E+01	
1.90	.80215E+01	.78419E+01	.76574E+01	.74669E+01	.72696E+01	.70607E+01	.68320E+01	.65780E+01			
1.95	.79480E+01	.77614E+01	.75687E+01	.73688E+01	.71573E+01	.69217E+01	.66558E+01				
2.00	.78425E+01	.76502E+01	.74512E+01	.72422E+01	.70120E+01						
2.05	.77268E+01	.75260E+01	.73215E+01								
2.10	.76284E+01	.74221E+01									

TABLE 23. Thermal roton effective mass (m)

Temp. (K)	Pressure (atm) .00	2.50	5.00	7.50	10.00	12.50	15.00	17.50	20.00	22.50	25.00
.10	.16079E+00	.15803E+00	.15432E+00	.15066E+00	.14739E+00	.14447E+00	.14186E+00	.13935E+00	.13687E+00	.13438E+00	.13185E+00
.15	.16079E+00	.15803E+00	.15432E+00	.15066E+00	.14739E+00	.14447E+00	.14186E+00	.13935E+00	.13687E+00	.13438E+00	.13185E+00
.20	.16079E+00	.15803E+00	.15432E+00	.15066E+00	.14739E+00	.14447E+00	.14186E+00	.13935E+00	.13687E+00	.13438E+00	.13185E+00
.25	.16079E+00	.15803E+00	.15432E+00	.15066E+00	.14739E+00	.14447E+00	.14186E+00	.13935E+00	.13687E+00	.13438E+00	.13185E+00
.30	.16079E+00	.15803E+00	.15432E+00	.15066E+00	.14739E+00	.14447E+00	.14186E+00	.13935E+00	.13687E+00	.13438E+00	.13185E+00
.35	.16079E+00	.15803E+00	.15432E+00	.15066E+00	.14739E+00	.14447E+00	.14186E+00	.13935E+00	.13687E+00	.13438E+00	.13185E+00
.40	.16079E+00	.15803E+00	.15432E+00	.15066E+00	.14739E+00	.14447E+00	.14186E+00	.13935E+00	.13687E+00	.13438E+00	.13185E+00
.45	.16079E+00	.15803E+00	.15432E+00	.15066E+00	.14739E+00	.14447E+00	.14186E+00	.13935E+00	.13687E+00	.13438E+00	.13185E+00
.50	.16079E+00	.15803E+00	.15432E+00	.15066E+00	.14739E+00	.14447E+00	.14186E+00	.13935E+00	.13687E+00	.13438E+00	.13185E+00
.55	.16079E+00	.15803E+00	.15432E+00	.15066E+00	.14739E+00	.14447E+00	.14186E+00	.13935E+00	.13687E+00	.13438E+00	.13185E+00
.60	.16079E+00	.15803E+00	.15432E+00	.15066E+00	.14739E+00	.14447E+00	.14186E+00	.13935E+00	.13687E+00	.13438E+00	.13185E+00
.65	.16078E+00	.15803E+00	.15431E+00	.15065E+00	.14739E+00	.14447E+00	.14186E+00	.13935E+00	.13687E+00	.13438E+00	.13185E+00
.70	.16077E+00	.15802E+00	.15431E+00	.15065E+00	.14739E+00	.14447E+00	.14186E+00	.13935E+00	.13687E+00	.13438E+00	.13185E+00
.75	.16075E+00	.15800E+00	.15430E+00	.15065E+00	.14739E+00	.14447E+00	.14186E+00	.13935E+00	.13687E+00	.13438E+00	.13184E+00
.80	.16071E+00	.15797E+00	.15428E+00	.15064E+00	.14738E+00	.14447E+00	.14186E+00	.13935E+00	.13686E+00	.13437E+00	.13184E+00
.85	.16064E+00	.15790E+00	.15424E+00	.15062E+00	.14738E+00	.14447E+00	.14186E+00	.13934E+00	.13686E+00	.13436E+00	.13183E+00
.90	.16053E+00	.15779E+00	.15418E+00	.15060E+00	.14737E+00	.14447E+00	.14185E+00	.13934E+00	.13685E+00	.13435E+00	.13181E+00
.95	.16035E+00	.15763E+00	.15407E+00	.15055E+00	.14736E+00	.14447E+00	.14185E+00	.13933E+00	.13683E+00	.13433E+00	.13179E+00
1.00	.16007E+00	.15737E+00	.15392E+00	.15049E+00	.14734E+00	.14448E+00	.14184E+00	.13931E+00	.13680E+00	.13430E+00	.13176E+00
1.05	.15964E+00	.15697E+00	.15369E+00	.15039E+00	.14732E+00	.14449E+00	.14183E+00	.13930E+00	.13677E+00	.13426E+00	.13172E+00
1.10	.15913E+00	.15650E+00	.15341E+00	.15028E+00	.14728E+00	.14449E+00	.14181E+00	.13926E+00	.13671E+00	.13418E+00	.13163E+00
1.15	.15864E+00	.15609E+00	.15319E+00	.15020E+00	.14727E+00	.14446E+00	.14179E+00	.13915E+00	.13661E+00	.13404E+00	.13146E+00
1.20	.15824E+00	.15571E+00	.15290E+00	.15004E+00	.14717E+00	.14440E+00	.14169E+00	.13906E+00	.13646E+00	.13382E+00	.13115E+00
1.25	.15791E+00	.15529E+00	.15252E+00	.14973E+00	.14705E+00	.14440E+00	.14175E+00	.13907E+00	.13634E+00	.13363E+00	.13099E+00
1.30	.15756E+00	.15502E+00	.15233E+00	.14958E+00	.14683E+00	.14410E+00	.14139E+00	.13869E+00	.13594E+00	.13318E+00	.13027E+00
1.35	.15735E+00	.15467E+00	.15189E+00	.14912E+00	.14638E+00	.14367E+00	.14096E+00	.13819E+00	.13543E+00	.13257E+00	.12973E+00
1.40	.15682E+00	.15411E+00	.15131E+00	.14850E+00	.14571E+00	.14294E+00	.14015E+00	.13734E+00	.13454E+00	.13164E+00	.12873E+00
1.45	.15597E+00	.15322E+00	.15042E+00	.14762E+00	.14481E+00	.14200E+00	.13915E+00	.13627E+00	.13331E+00	.13027E+00	.12718E+00
1.50	.15533E+00	.15253E+00	.14973E+00	.14686E+00	.14403E+00	.14115E+00	.13821E+00	.13524E+00	.13219E+00	.12904E+00	.12574E+00
1.55	.15495E+00	.15209E+00	.14923E+00	.14633E+00	.14337E+00	.14039E+00	.13739E+00	.13438E+00	.13128E+00	.12807E+00	.12460E+00
1.60	.15459E+00	.15167E+00	.14876E+00	.14577E+00	.14270E+00	.13959E+00	.13647E+00	.13331E+00	.13009E+00	.12672E+00	.12302E+00
1.65	.15398E+00	.15100E+00	.14800E+00	.14493E+00	.14175E+00	.13849E+00	.13521E+00	.13184E+00	.12845E+00	.12489E+00	.12104E+00
1.70	.15299E+00	.14991E+00	.14686E+00	.14370E+00	.14039E+00	.13701E+00	.13356E+00	.13006E+00	.12647E+00	.12261E+00	.11829E+00
1.75	.15176E+00	.14874E+00	.14572E+00	.14246E+00	.13900E+00	.13541E+00	.13187E+00	.12831E+00	.12464E+00	.12057E+00	.11568E+00
1.80	.15059E+00	.14743E+00	.14429E+00	.14095E+00	.13735E+00	.13362E+00	.12985E+00	.12602E+00	.12196E+00	.11732E+00	.11168E+00
1.85	.14935E+00	.14602E+00	.14267E+00	.13917E+00	.13558E+00	.13183E+00	.12799E+00	.12384E+00	.11925E+00	.11390E+00	
1.90	.14805E+00	.14456E+00	.14101E+00	.13737E+00	.13361E+00	.12965E+00	.12534E+00	.12058E+00			
1.95	.14669E+00	.14308E+00	.13938E+00	.13556E+00	.13154E+00	.12710E+00	.12211E+00				
2.00	.14475E+00	.14103E+00	.13722E+00	.13323E+00	.12888E+00						
2.05	.14261E+00	.13874E+00	.13483E+00								
2.10	.14079E+00	.13683E+00									

TABLE 24. Wave number of roton minimum (Å^{-1}) (1 Å^{-1} = 10^{10} m^{-1})

Temp. (K)	Pressure (atm)										
	.00	2.50	5.00	7.50	10.00	12.50	15.00	17.50	20.00	22.50	25.00
.10	.19129E+01	.19308E+01	.19462E+01	.19596E+01	.19716E+01	.19826E+01	.19926E+01	.20018E+01	.20104E+01	.20185E+01	.20261E+01
.15	.19129E+01	.19308E+01	.19461E+01	.19596E+01	.19716E+01	.19826E+01	.19926E+01	.20018E+01	.20104E+01	.20185E+01	.20261E+01
.20	.19129E+01	.19308E+01	.19461E+01	.19596E+01	.19716E+01	.19825E+01	.19926E+01	.20018E+01	.20104E+01	.20185E+01	.20261E+01
.25	.19129E+01	.19308E+01	.19461E+01	.19596E+01	.19716E+01	.19825E+01	.19926E+01	.20018E+01	.20104E+01	.20185E+01	.20261E+01
.30	.19129E+01	.19308E+01	.19461E+01	.19596E+01	.19716E+01	.19825E+01	.19925E+01	.20018E+01	.20104E+01	.20185E+01	.20261E+01
.35	.19129E+01	.19308E+01	.19461E+01	.19596E+01	.19716E+01	.19825E+01	.19925E+01	.20018E+01	.20104E+01	.20185E+01	.20261E+01
.40	.19129E+01	.19308E+01	.19461E+01	.19596E+01	.19716E+01	.19825E+01	.19925E+01	.20018E+01	.20104E+01	.20185E+01	.20261E+01
.45	.19129E+01	.19308E+01	.19461E+01	.19596E+01	.19716E+01	.19825E+01	.19925E+01	.20018E+01	.20104E+01	.20185E+01	.20261E+01
.50	.19129E+01	.19308E+01	.19461E+01	.19596E+01	.19716E+01	.19825E+01	.19925E+01	.20018E+01	.20104E+01	.20185E+01	.20261E+01
.55	.19128E+01	.19308E+01	.19461E+01	.19596E+01	.19716E+01	.19825E+01	.19925E+01	.20018E+01	.20104E+01	.20185E+01	.20261E+01
.60	.19128E+01	.19308E+01	.19461E+01	.19595E+01	.19716E+01	.19825E+01	.19925E+01	.20018E+01	.20104E+01	.20185E+01	.20261E+01
.65	.19128E+01	.19308E+01	.19461E+01	.19595E+01	.19716E+01	.19825E+01	.19925E+01	.20018E+01	.20104E+01	.20185E+01	.20261E+01
.70	.19128E+01	.19307E+01	.19461E+01	.19595E+01	.19716E+01	.19825E+01	.19925E+01	.20018E+01	.20104E+01	.20185E+01	.20262E+01
.75	.19128E+01	.19307E+01	.19461E+01	.19595E+01	.19716E+01	.19825E+01	.19925E+01	.20018E+01	.20105E+01	.20186E+01	.20262E+01
.80	.19128E+01	.19307E+01	.19461E+01	.19595E+01	.19716E+01	.19825E+01	.19926E+01	.20019E+01	.20105E+01	.20186E+01	.20263E+01
.85	.19128E+01	.19307E+01	.19461E+01	.19595E+01	.19716E+01	.19826E+01	.19926E+01	.20019E+01	.20106E+01	.20187E+01	.20263E+01
.90	.19128E+01	.19307E+01	.19461E+01	.19596E+01	.19717E+01	.19826E+01	.19927E+01	.20020E+01	.20106E+01	.20188E+01	.20264E+01
.95	.19128E+01	.19307E+01	.19461E+01	.19596E+01	.19717E+01	.19827E+01	.19927E+01	.20021E+01	.20107E+01	.20189E+01	.20265E+01
1.00	.19128E+01	.19307E+01	.19461E+01	.19596E+01	.19718E+01	.19828E+01	.19928E+01	.20022E+01	.20109E+01	.20190E+01	.20267E+01
1.05	.19128E+01	.19307E+01	.19462E+01	.19597E+01	.19718E+01	.19829E+01	.19930E+01	.20023E+01	.20110E+01	.20192E+01	.20269E+01
1.10	.19128E+01	.19308E+01	.19462E+01	.19598E+01	.19719E+01	.19830E+01	.19931E+01	.20025E+01	.20112E+01	.20194E+01	.20271E+01
1.15	.19128E+01	.19308E+01	.19463E+01	.19599E+01	.19721E+01	.19831E+01	.19933E+01	.20027E+01	.20114E+01	.20196E+01	.20274E+01
1.20	.19128E+01	.19309E+01	.19464E+01	.19600E+01	.19722E+01	.19833E+01	.19935E+01	.20029E+01	.20117E+01	.20199E+01	.20277E+01
1.25	.19128E+01	.19309E+01	.19465E+01	.19601E+01	.19724E+01	.19835E+01	.19938E+01	.20032E+01	.20120E+01	.20203E+01	.20281E+01
1.30	.19128E+01	.19310E+01	.19466E+01	.19603E+01	.19726E+01	.19838E+01	.19941E+01	.20036E+01	.20124E+01	.20207E+01	.20285E+01
1.35	.19129E+01	.19311E+01	.19467E+01	.19605E+01	.19729E+01	.19841E+01	.19944E+01	.20040E+01	.20129E+01	.20212E+01	.20290E+01
1.40	.19129E+01	.19312E+01	.19469E+01	.19608E+01	.19732E+01	.19845E+01	.19949E+01	.20044E+01	.20134E+01	.20217E+01	.20296E+01
1.45	.19130E+01	.19313E+01	.19471E+01	.19611E+01	.19736E+01	.19849E+01	.19953E+01	.20050E+01	.20140E+01	.20224E+01	.20303E+01
1.50	.19130E+01	.19315E+01	.19474E+01	.19614E+01	.19740E+01	.19854E+01	.19959E+01	.20056E+01	.20146E+01	.20231E+01	.20311E+01
1.55	.19131E+01	.19317E+01	.19477E+01	.19618E+01	.19745E+01	.19860E+01	.19965E+01	.20063E+01	.20154E+01	.20240E+01	.20320E+01
1.60	.19132E+01	.19319E+01	.19480E+01	.19623E+01	.19750E+01	.19866E+01	.19973E+01	.20071E+01	.20163E+01	.20249E+01	.20330E+01
1.65	.19134E+01	.19322E+01	.19484E+01	.19628E+01	.19757E+01	.19874E+01	.19981E+01	.20081E+01	.20174E+01	.20260E+01	.20342E+01
1.70	.19135E+01	.19325E+01	.19489E+01	.19634E+01	.19764E+01	.19882E+01	.19991E+01	.20092E+01	.20185E+01	.20273E+01	.20356E+01
1.75	.19137E+01	.19328E+01	.19494E+01	.19641E+01	.19772E+01	.19892E+01	.20002E+01	.20104E+01	.20199E+01	.20288E+01	.20371E+01
1.80	.19139E+01	.19332E+01	.19500E+01	.19648E+01	.19782E+01	.19903E+01	.20015E+01	.20118E+01	.20214E+01	.20304E+01	.20389E+01
1.85	.19141E+01	.19337E+01	.19507E+01	.19658E+01	.19793E+01	.19916E+01	.20029E+01	.20134E+01	.20232E+01	.20323E+01	
1.90	.19143E+01	.19342E+01	.19515E+01	.19668E+01	.19806E+01	.19931E+01	.20046E+01	.20153E+01			
1.95	.19146E+01	.19348E+01	.19524E+01	.19680E+01	.19820E+01	.19948E+01	.20065E+01				
2.00	.19150E+01	.19355E+01	.19534E+01	.19693E+01	.19837E+01						
2.05	.19154E+01	.19363E+01	.19546E+01								
2.10	.19158E+01	.19372E+01									

TABLE 25. Coefficients u_1 and a_n of the MDC series (K Å^n)(1 Å$=10^{-10}$m)

T (K)	P (atm)	u_1	a_3	a_4	a_5	a_6	a_7	a_8
.20	.00	18.196846	45.108719	−163.085876	211.667572	−136.115967	43.272781	−5.389564
.20	2.50	19.667023	26.523594	−112.360092	152.520172	−100.990311	32.799019	−4.142713
.20	5.00	20.946884	13.519928	−79.787628	116.719101	−80.569763	26.869144	−3.448239
.20	7.50	22.088062	3.969789	−58.034119	94.421631	−68.426041	23.433270	−3.050060
.20	10.00	23.122910	−3.381524	−42.918419	80.189056	−61.114006	21.424671	−2.818585
.20	12.50	24.073158	−9.328510	−31.882721	70.802612	−56.660950	20.251656	−2.684020
.20	15.00	24.954227	−14.386789	−23.284580	64.210098	−53.816437	19.541046	−2.602543
.20	17.50	25.777447	−18.847580	−16.243782	59.369171	−51.980667	19.123726	−2.555310
.20	20.00	26.551479	−22.856491	−10.320194	55.749977	−50.841278	18.909050	−2.531901
.20	22.50	27.283047	−26.474239	−5.339409	53.146721	−50.278160	18.862236	−2.528291
.20	25.00	27.977539	−29.764984	−1.116019	51.340134	−50.162460	18.945549	−2.540059
.40	.00	18.202255	45.046959	−162.938599	211.512787	−136.031036	43.248993	−5.386869
.40	2.50	19.670414	26.481247	−112.258484	152.414948	−100.934372	32.784042	−4.141109
.40	5.00	20.948875	13.491226	−79.717514	116.646820	−80.532272	26.859520	−3.447267
.40	7.50	22.089031	3.967130	−58.038261	94.437393	−68.441177	23.439346	−3.050950
.40	10.00	23.123085	−3.362782	−42.983986	80.277740	−61.172585	21.443634	−2.820991
.40	12.50	24.072704	−9.336058	−31.856209	70.769669	−56.641846	20.246380	−2.683459
.40	15.00	24.953247	−14.393038	−23.257160	64.172882	−53.793556	19.534393	−2.601797
.40	17.50	25.776039	−18.855232	−16.207016	59.316772	−51.946960	19.113453	−2.554100
.40	20.00	26.549694	−22.835377	−10.372450	55.807526	−50.874641	18.918961	−2.533086
.40	22.50	27.280945	−26.463436	−5.355791	53.157700	−50.282394	18.863247	−2.528409
.40	25.00	27.975163	−29.745289	−1.158225	51.381783	−50.184845	18.951885	−2.540795
.60	.00	18.210155	44.947212	−162.696777	211.257385	−135.891357	43.210213	−5.382538
.60	2.50	19.673195	26.448883	−112.187561	152.349792	−100.905060	32.777870	−4.140655
.60	5.00	20.948116	13.472624	−79.654282	116.567139	−80.484283	26.845539	−3.445675
.60	7.50	22.085663	3.966507	−58.007721	94.383545	−68.403625	23.427425	−3.049511
.60	10.00	23.117702	−3.337157	−43.018486	80.294022	−61.174126	21.442753	−2.820804
.60	12.50	24.065712	−9.266668	−32.015945	70.934006	−56.731209	20.271423	−2.686308
.60	15.00	24.944935	−14.323412	−23.403755	64.311218	−53.862968	19.552479	−2.603728
.60	17.50	25.766621	−18.758907	−16.428543	59.542412	−52.067474	19.146423	−2.557751
.60	20.00	26.539330	−22.741051	−10.577082	56.004501	−50.974304	18.944862	−2.535820
.60	22.50	27.269764	−26.344913	−5.630239	53.437424	−50.431076	18.903553	−2.532817
.60	25.00	27.963257	−29.653122	−1.339696	51.538643	−50.255287	18.967911	−2.542256
.80	.00	18.214394	44.885498	−162.573425	211.165649	−135.866547	43.211037	−5.383513
.80	2.50	19.667351	26.488655	−112.289688	152.477020	−100.990265	32.806671	−4.144476
.80	5.00	20.935299	13.580513	−79.899826	116.821625	−80.625046	26.885708	−3.450315
.80	7.50	22.067688	4.161252	−58.476311	94.878967	−68.675858	23.503426	−3.058043
.80	10.00	23.095741	−3.094258	−43.598465	80.898880	−61.500557	21.532032	−2.830614
.80	12.50	24.040565	−8.995251	−32.653259	71.587036	−57.077126	20.364201	−2.696301
.80	15.00	24.917152	−14.022804	−24.107124	65.028442	−54.240601	19.653042	−2.614472
.80	17.50	25.736622	−18.448452	−17.139606	60.252594	−52.433647	19.241837	−2.567715
.80	20.00	26.507439	−22.400311	−11.365572	56.798393	−51.386284	19.052788	−2.547145
.80	22.50	27.236233	−25.995335	−6.429257	54.231972	−50.838043	19.008675	−2.543683
.80	25.00	27.928276	−29.267151	−2.238814	52.446419	−50.726234	19.090992	−2.555119
1.00	.00	18.204235	44.652832	−161.936188	210.556702	−135.624695	43.178589	−5.384238
1.00	2.50	19.639828	26.539146	−112.374146	152.640625	−101.164108	32.884987	−4.156837
1.00	5.00	20.895721	13.968925	−80.890884	117.962906	−81.314407	27.096333	−3.475906
1.00	7.50	22.019199	4.711472	−59.847031	96.367493	−69.508804	23.738297	−3.084483
1.00	10.00	23.040333	−2.439907	−45.208374	82.606598	−62.427147	21.784409	−2.858028
1.00	12.50	23.979599	−8.277168	−34.398270	73.409180	−58.047661	20.623207	−2.723837
1.00	15.00	24.851604	−13.248381	−25.989033	66.995193	−55.289787	19.933578	−2.644359
1.00	17.50	25.667217	−17.631157	−19.118877	62.314148	−53.529625	19.533794	−2.598693
1.00	20.00	26.434711	−21.556465	−13.397085	58.904289	−52.501068	19.348454	−2.578362
1.00	22.50	27.160610	−25.133644	−8.485947	56.346336	−51.947769	19.300289	−2.574163
1.00	25.00	27.850113	−28.360394	−4.412244	54.687294	−51.904831	19.401215	−2.587592

TABLE 25. Coefficients u_1 and a_n of the MDC series (K Å^n)(1 Å = 10^{-10}m)—Continued

T (K)	P (atm)	u_1	a_3	a_4	a_5	a_6	a_7	a_8
1.20	.00	18.164108	44.275581	−160.940887	209.781281	−135.492432	43.245468	−5.404290
1.20	2.50	19.572063	26.758766	−112.963913	153.591400	−101.961929	33.197128	−4.202121
1.20	5.00	20.808731	14.826330	−83.174515	120.683197	−82.995148	27.616653	−3.539522
1.20	7.50	21.917927	5.987774	−63.197815	100.143555	−71.676208	24.360001	−3.155261
1.20	10.00	22.927975	−.953682	−49.053604	86.835022	−64.781586	22.437943	−2.930016
1.20	12.50	23.858326	−6.700869	−38.413834	77.752090	−60.422890	21.270164	−2.793734
1.20	15.00	24.722965	−11.594639	−30.183372	71.519653	−57.760544	20.605816	−2.716905
1.20	17.50	25.532345	−15.921318	−23.439617	66.968201	−56.070633	20.225227	−2.673302
1.20	20.00	26.294491	−19.785034	−17.865482	63.712936	−55.125114	20.062019	−2.655275
1.20	22.50	27.015709	−23.259411	−13.246851	61.503365	−54.780006	20.075176	−2.658149
1.20	25.00	27.701077	−26.405735	−9.396870	60.106216	−54.890816	20.220387	−2.676547
1.40	.00	18.072956	45.500061	−164.784180	214.792206	−138.740295	44.278648	−5.532924
1.40	2.50	19.438976	28.420647	−117.804657	159.588531	−105.707138	34.354279	−4.342721
1.40	5.00	20.646286	16.919952	−89.076736	127.769882	−87.295731	28.911419	−3.693208
1.40	7.50	21.733669	8.454481	−70.038254	108.202164	−76.472626	25.777176	−3.320523
1.40	10.00	22.726757	1.779231	−56.529221	95.506714	69.860260	23.914516	3.099521
1.40	12.50	23.643452	−3.734785	−46.470146	87.017044	−65.798294	22.817932	−2.969692
1.40	15.00	24.496807	−8.445623	−38.698273	81.261871	−63.381508	22.214680	−2.898664
1.40	17.50	25.296650	−12.555998	−32.553452	77.396759	−62.083504	21.944016	−2.867117
1.40	20.00	26.050594	−16.232990	−27.498936	74.739670	−61.480286	21.876575	−2.859508
1.40	22.50	26.764648	−19.447979	−23.649632	73.455765	−61.685036	22.049335	−2.880445
1.40	25.00	27.443665	−22.335537	−20.564976	72.970154	−62.329536	22.346832	−2.915753
1.60	.00	17.902641	48.812119	−175.371002	228.404266	−147.344147	46.941986	−5.856093
1.60	2.50	19.206341	32.339539	−129.711182	174.417542	−114.864029	37.134735	−4.674360
1.60	5.00	20.369839	21.354656	−102.164581	143.726654	−96.977600	31.805569	−4.033397
1.60	7.50	21.424599	13.275105	−84.012787	125.009552	−86.552719	28.757961	−3.667232
1.60	10.00	22.392326	6.959643	−71.399368	113.254333	−80.433380	27.021046	−3.458503
1.60	12.50	23.288635	1.812648	−62.317459	105.852966	−76.976807	26.089340	−3.346109
1.60	15.00	24.125160	−2.519477	−55.587433	101.279404	−75.224640	25.668606	−3.294540
1.60	17.50	24.910809	−6.211314	−50.637695	98.803894	−74.724228	25.621296	−3.287316
1.60	20.00	25.652557	−9.388725	−47.062798	97.911530	−75.156067	25.849960	−3.312699
1.60	22.50	26.355961	−12.038965	−44.917770	98.682465	−76.574875	26.371922	−3.372718
1.60	25.00	27.025574	−14.073032	−44.509460	101.518951	−79.234451	27.264038	−3.476307
1.80	.00	17.614632	55.727371	−197.996429	257.666931	−165.818451	52.637192	−6.543551
1.80	2.50	18.825653	40.186943	−154.354584	205.484100	−134.100006	42.966637	−5.367590
1.80	5.00	19.923534	29.928108	−128.418213	176.256683	−116.839203	37.751259	−4.731647
1.80	7.50	20.929398	22.472076	−111.735825	158.975952	−107.096619	34.853951	−4.376947
1.80	10.00	21.859222	16.755856	−100.653961	148.854645	−101.841476	33.337959	−4.189687
1.80	12.50	22.725193	12.282404	−93.426895	143.557465	−99.566986	32.729744	−4.111550
1.80	15.00	23.536781	8.741184	−88.975906	141.647369	−99.348129	32.739151	−4.106864
1.80	17.50	24.301491	5.986689	−86.808777	142.483459	−100.781143	33.241653	−4.160482
1.80	20.00	25.025322	3.967886	−86.760010	145.855957	−103.735855	34.196609	−4.267243
1.80	22.50	25.713169	3.099761	−90.202667	153.533234	−109.319916	35.940804	−4.466936
1.80	25.00	26.369068	4.027386	−99.219772	168.126648	−119.121857	38.942955	−4.813305
2.00	.00	17.152634	70.090286	−245.461426	318.905151	−204.214142	64.376389	−7.948897
2.00	2.50	18.221794	55.730057	−204.122437	268.480164	−173.024445	54.714104	−6.756611
2.00	5.00	19.218197	46.419075	−180.144836	240.874268	−156.345490	49.558441	−6.114318
2.00	7.50	20.148487	40.057701	−166.143066	226.299347	−147.931000	46.966454	−5.784702
2.00	10.00	21.020050	35.440361	−157.926758	219.237213	−144.272736	45.848648	−5.634654

Appendix B

Selected Helium Data: A Reference Guide

This appendix is intended to aid the reader in locating original, published experimental data on helium-4. Reference to data not listed herein, such as viscosity, latent heat or vaporization, ion mobilities, etc., may be found in one or more of the general books on helium: Keller [25], Donnelly [12], Wilks [11], and Keesom [43].

Quantity	Symbol	Experimental method	Temperature range (K)	Pressure range (atm)	Comments	Authors
Density or molar volume	ρ or V	Pycnometric	$0.5 \leq T \leq 2.8$	SVP	Detailed measurements near T_λ	Kerr & Taylor [34]
" " "	"	Dielectric constant	$0 < T \leq 4.4$	SVP	" " " "	Van Degrift [20]
" " "	"	" "	$T = 0.05$	$0 \leq P \leq 22$	Also data on ^3He-^4He mixtures	Watson, Reppy, & Richardson [47]
" " "	"	Ultrasonic	$T \simeq 0.5$	$0 \leq P \leq 23$	Integration of $u_1^2 = \left(\frac{\partial P}{\partial \rho}\right)_T$	Abraham, Eckstein, Ketterson, Kuchnir, & Roach [31]
" " "	"	"	$T < 0.1$	$0 \leq P \leq 24$	" " "	Abraham, Eckstein, Ketterson, Kuchnir, & Roach [31]
" " "	"	Dielectric constant	$0.5 \leq T \leq 1.4$	$0 < P \leq 24.5$		Boghosian & Meyer [32]
" " "	"	" "	$1.25 \leq T \leq 4.2$	$0.5 \leq P \leq 28$	Data also near T_λ, P_λ	Elwell & Meyer [33]
" " "	"	P–V–T measurement	$0.3 \leq T \leq 2.0$	$25 \leq P \leq 37$	Data around melting curve	Grilly [48]
First sound velocity	u_1	Ultrasonic	$0.1 \leq T \leq 1.7$	SVP		Whitney & Chase [49]
" " "	"	"	$T \simeq 0.5$	$0 \leq P \leq 23$		Abraham et al. [31]
" " "	"	"	$T < 0.1$	$0 < P \leq 24$		Abraham et al. [31]
" " "	"	"	$1.0 \leq T \leq 2.1$	$0 \leq P \leq 25$		Atkins & Stasior [50]
" " "	"	"	$1.0 \leq T \leq 4.2$	$1 \leq P \leq 150$	Also data on ^3He-^4He mixtures	Vignos & Fairbank [51]
" " "	"	"	$1.8 \leq T \leq 2.5$	SVP	Data around T_λ	Barmatz & Rudnick [52]
" " "	"	"	$1.2 \leq T < T_\lambda$	$0 \leq P \leq 25$	0.2% precision	Heiserman et al. [21]
Compressibility	κ_T	Indirect	$0.85 \leq T \leq T_\lambda$	SVP	Calculated from u_1 and other data	Atkins & Edwards [53]
"	"	Dielectric constant	$0 \leq T \leq 1.25$	$0 \leq P \leq 24$		Boghosian & Meyer [32]
"	"	" "	$1.3 \leq T \leq 4.0$	$1 \leq P \leq 25$		Elwell & Meyer [33]
"	"	P–V–T measurement	$0.3 \leq T \leq 2.0$	$25 \leq P \leq 35$	Data around melting curve	Grilly [48]
"	"	" "	$1.6 \leq T \leq 2.5$	$1 \leq P < 45$		Grilly [42]
"	"	" "	Near T_λ	Near P_λ		Kierstead [54]
Thermal expansion	α_P	Pycnometric	$0.85 \leq T \leq T_\lambda$	SVP		Atkins & Edwards [53]
" "	"	"	$0.5 \leq T \leq 2.8$	SVP		Kerr & Taylor [34]
" "	"	Dielectric constant	$0.85 \leq T \leq T_\lambda$	SVP		Harris-Lowe & Smee [55]
" "	"	" "	$0 < T \leq 4.4$	SVP		Van Degrift [20]
" "	"	Adiabatic compression and expansion	$0.5 \leq T \leq 1.5$	$3 \leq P \leq 24$		Mills & Sydoriak [56]

Quantity	Symbol	Experimental method	Temperature range (K)	Pressure range (atm)	Comments	Authors
" "	"	Dielectric constant	$0.6 \leq T \leq 1.4$	$0 \leq P \leq 25$		Boghosian & Meyer [32]
" "	"	" "	$1.25 \leq T \leq 4.0$	$0.5 \leq P \leq 28$		Elwell & Meyer [33]
" "	"	Indirect	$0.3 \leq T \leq 1.6$	$0 \leq P \leq 25$	From analysis of entropy	Wiebes [36]
" "	"	P-V-T measurement	$0.3 \leq T \leq 2.0$	$25 \leq P \leq 35$		Grilly [48]
" "	"	" "	Near T_λ	$0 \leq P \leq 25$		Mueller, Pobell, & Ahlers [57]
" "	"	" "	Near T_λ	Near P_λ		Kierstead [58]
Entropy & heat capacity	S, C	Calorimeter	$0.6 \leq T \leq 2.2$	SVP		Kramers, Wasscher, & Gorter [59]
" " "	"	"	$1.0 \leq T \leq 2.0$	$0 < P < 25$	Data ≈ 10% high	Hercus & Wilks [60]
" "	"	"	$1.5 \leq T \leq 2.8$	$0 < P < 25$		Lounasmaa & Kojo [61]
" " "	S only	Thermomechanical effect	$1.15 \leq T \leq 2.0$	$0 \leq P \leq 25$		Van den Meijdenberg, Taconis, & De Bruyn Ouboter [35]
" " "	S, C	Calorimeter	$0.3 \leq T \leq 1.6$	$0 \leq P \leq 25$		Wiebes [36]
" " "	C only	"	$0.3 \leq T < 0.9$	$0 \leq P < 20$		Phillips, Waterfield, & Hoffer [28]
" " "	C only	"	$1.3 \leq T \leq 2.5$	SVP	Porous media	Scott, Guyon, & Rudnick [62]
" " "	C only	"	Near T_λ	SVP; $0 < P < 26$		Ahlers [63] & [64]
Normal fluid density	ρ_n	Oscillating disks	$1.2 \leq T \leq T_\lambda$	SVP		Dash & Taylor [65].
" " "	"	Wire viscometer	$1.1 \leq T \leq 2.18$	SVP		Tough, McCormick, & Dash [44].
" " "	"	Oscillating disks	$1.45 \leq T \leq T_\lambda$	$5 \leq P \leq 25$		Romer & Duffy [45].
Superfluid density	ρ_s	Persistent current	$1.25 \leq T < T_\lambda$	SVP		Clow & Reppy [66].
" "	"	Fourth sound resonance	$1.1 \leq T \leq T_\lambda$	SVP	Porous media	Scott, Guyon, & Rudnick [62].
" "	"	Second sound resonance	$T \geq 1.6$	$0 \leq P < 30$	Calculated from second sound data, emphasis near λ transition.	Greywall & Ahlers [67].
Second sound velocity	u_2	Heat pulse	$0.015 \leq T \leq 1.0$	SVP		De Klerk, Hudson, & Pellam [68].
" " "	"	Second sound resonance	$0.5 < T < 1.7$	SVP		Peshkov [69].
" " "	"	Heat pulse	$0.95 \leq T < T_\lambda$	SVP $\leq P \leq 25$		Maurer & Herlin [46].
" " "	"	Second sound resonance	$T \geq 1.6$	$0 \leq P < 30$	Emphasis near λ transition	Greywall & Ahlers [67].
" " "	"	" " "	$1.2 \leq T < T_\lambda$	$0 \leq P \leq 25$	0.2% precision	Heiserman et al. [21]
Fourth sound velocity	u_4	Fourth sound resonance	$1.2 \leq T < T_\lambda$	$0 \leq P \leq 25$	0.2% precision	Heiserman et al. [21]
Energy spectrum	$\epsilon(p)$	Inelastic neutron scattering	$T = 1.1$	SVP	$0.55 \leq p/\hbar \leq 2.36$ Å^{-1}	Yarnell, Arnold, Bendt, & Kerr [9].
" "	"	" " "	$T = 1.6, 1.8$	SVP	Roton minimum	" " " "
" "	"	" " "	$T = 1.1$	SVP	$0.25 \leq p/\hbar \leq 2.6$ Å^{-1}	Henshaw & Woods [4].
" "	"	" " "	$T = 1.1$	$P = 25.3$	"	" "
" "	"	" " "	$T = 1.12$	SVP	$0.25 \leq p/\hbar \leq 2.6$ Å^{-1}	Henshaw & Woods [5].
" "	"	" " "	$1.1 \leq T \leq 4.21$	SVP	Roton minimum	" "
" "	"	" " "	$T = 1.1, 2.1$	SVP	$0.20 \leq p/\hbar \leq 3.6$ Å^{-1}	Cowley & Woods [2].
" "	"	" " "	$T = 1.1, 2.3, 4.2$	SVP	$0 < p/\hbar < 0.5$ Å^{-1}	" "
" "	"	" " "	$T = 1.2$	$P = 24$	$0.2 \leq p/\hbar \leq 0.7$ Å^{-1}	Svensson, Woods, & Martel [7].
" "	"	" " "	$1.26 \leq T \leq 4.37$	$1.0 \leq P \leq 24.5$	$1.5 < p/\hbar < 2.3$ Å^{-1}	Dietrich, Graf, Huang, & Passell [3].