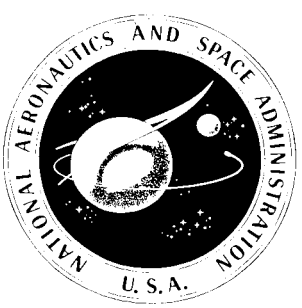
NASA SP-3069

THERMODYNAMIC PROPERTIES AND THEORETICAL ROCKET PERFORMANCE OF HYDROGEN

TO 100000 K and 1.01325×10^8 N/m^2

PATCH



NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

NASA SP-3069

THERMODYNAMIC PROPERTIES AND THEORETICAL ROCKET PERFORMANCE OF HYDROGEN TO 100000 K and 1.01325×10^8 N/m^2

R. W. Patch

NASA Lewis Research Center

Prepared by Lewis Research Center

Scientific and Technical Information Office 1971
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
Washington, D.C.

For sale by the National Technical Information Service, Springfield, Virginia 22151 – Price $3.00

CONTENTS

THERMODYNAMIC PROPERTIES AND THEORETICAL ROCKET PERFORMANCE OF HYDROGEN TO 100 000 K AND 1.01325×10^8 N/m^2

by R. W. Patch

Lewis Research Center

SUMMARY

The composition and thermodynamic properties were calculated for 100 to 110 000 K (180° to 198 000° R) and 1.01325×10^2 to 1.01325×10^8 N/m^2 (0.001 to 1000 atm) for chemical equilibrium in the Debye-Hückel and ideal-gas approximations. Quantities obtained were the concentrations of hydrogen atoms (H), protons (H^+), free electrons (e^-), hydrogen molecules (H_2), negative hydrogen ions (H^-), hydrogen diatomic molecular ions (H_2^+), and hydrogen triatomic molecular ions (H_3^+), and the enthalpy, entropy, average molecular weight, specific heat at constant pressure, density, and isentropic exponent. Electronically excited states of H and H_2 were included.

Choked, isentropic, one-dimensional nozzle flow with shifting chemical equilibrium was calculated to the Debye-Hückel and ideal-gas approximations for stagnation temperatures from 2500 to 100 000 K (4500° to 180 000° R) and stagnation pressures from 1.01325×10^5 to 1.01325×10^8 N/m^2 (1 to 1000 atm). The mass flow per unit throat area and the sonic flow factor were obtained. The pressure ratio, temperature, velocity, and ideal and vacuum specific impulses at the throat and for pressure ratios as low as 10^{-6} downstream were found.

For high temperatures at pressures approaching 1.01325×10^8 N/m^2 (1000 atm), the ideal-gas approximation was found to be inadequate for calculations of composition, precise thermodynamic properties, and precise nozzle flow. For such calculations, the Debye-Hückel approximation is recommended. The greatest discrepancy in nozzle flow occurred in the exit temperature, which was as much as 21 percent higher when the Debye-Hückel approximation was used.

INTRODUCTION

The need for reliable values for thermodynamic properties for high-temperature hydrogen gas occurs in gaseous-core nuclear rockets (refs. 1 to 3), arcjets, and in high-speed entry into the atmospheres of Jupiter, Saturn, Uranus, and Neptune. Calculated performance of high-temperature hydrogen as a propellant depends on the values of thermodynamic properties and is needed for gaseous-core nuclear rockets.

A prerequisite to interpreting the thermodynamic properties of hydrogen is the distinction between the ortho and para forms of the hydrogen molecule H_2. Ortho and para refer to H_2 states with triplet and singlet nuclear spin states, respectively. Ortho states only occur with odd values of total angular momentum quantum number, whereas para states only occur with even values of total angular momentum quantum number. It is this fact, coupled with the difference in nuclear spin statistical weights, that effects the thermodynamic properties (refs. 4 and 5). In the absence of paramagnetic catalysts or hydrogen atoms H, there is very slow equilibration between ortho and para hydrogen; therefore, in many low-temperature problems they may be considered as separate substances. At temperatures of several thousand degrees K, the ortho-para ratio rapidly attains an equilibrium value of 3:1 due to the action of catalysts or H atoms. Hydrogen with this ortho-para ratio is called "normal" hydrogen. At lower temperatures, the equilibrium ortho-para ratio is less than 3:1. Hydrogen with the equilibrium ortho-para ratio for its temperature is said to be "spin equilibrated." For engineering purposes, the difference between the thermodynamic properties of normal and spin-equilibrated hydrogen is negligible above room temperature.

There are many previous calculations of the thermodynamic properties of hydrogen. Calculations with a maximum temperature of 5000 K (9000° R) or less include those of Woolley, Scott, and Brickwedde (ref. 4), Hilsenrath, et al. (ref. 6), King (ref. 7), Roder, Weber, and Goodwin (ref. 8), Svehla (ref. 9), Farmer (ref. 10), and Johnson (ref. 11). Other investigators have calculated thermodynamic properties for chemical equilibrium at higher temperatures. Rosenbaum and Levitt (ref. 12) considered spinless H_2, H, positive hydrogen atomic ions H^+, and free electrons e^- for temperatures from 300 to 100 000 K (540° to $180\ 000^{\circ}$ R) and pressures from 1.01325 to 1.01325×10^7 N/m^2 (0.00001 to 100 atm) and included a covolume correction. McGee and Heller (ref. 13) considered H, H^+, and e^- for temperatures from 2000 to 50 000 K (3600° to $90\ 000^{\circ}$ R) and pressures from 1.01325×10^1 to 1.01325×10^7 N/m^2 (0.0001 to 100 atm) and included Debye-Hückel corrections to the thermodynamic properties. These corrections account for the coulomb interactions between charged particles treated as point charges. McChesney (ref. 14) pointed out that McGee and Heller (ref. 13) were inconsistent because they used the Inglis-Teller cutoff. Krascella (ref. 15) included normal H_2, H, H^+, and e^- in some thermodynamic functions for temperatures from 1667 to 111 111 K (3001° to $200\ 000^{\circ}$ R) and pressures from 1.01325×10^5 to 1.01325×10^8 N/m^2

(1 to 1000 atm). He included lowering of the ionization potential according to Ecker and Weizel (ref. 16) in the composition used to get the thermodynamic functions. However, Ecker and Weizel's work was later retracted (ref. 17). Kubin and Presley (ref. 18) calculated ideal-gas thermodynamic functions including spinless H_2, H, H^+, and e^- for temperatures from 300 to 20 000 K (540° to 36 000° R) and pressures from 1.01325×10^1 to 1.01325×10^8 N/m^2 (0.0001 to 1000 atm); for their calculations they assumed H_2 to be a rigid rotor harmonic oscillator. Roback (ref. 19) computed some ideal-gas thermodynamic functions including normal H_2, H, e, H^+, and the negative hydrogen ion H^- for temperatures from 300 to 111 111 K (540° to 200 000° R) and pressures from 1.01325×10^{-1} to 1.01325×10^8 N/m^2 (0.000001 to 1000 atm). Thus, previous to this report there was no complete published set of hydrogen thermodynamic properties (from an engineering viewpoint) for temperatures above 20 000 K (36 000° R) and no reliable Debye-Hückel calculations for hydrogen at any temperature.

There are three previous calculations of choked nozzle flow of hydrogen. King (ref. 7) assumed chemical equilibrium of H_2 and H during isentropic expansion from stagnation temperatures of 600 to 5000 K (1080° to 9000° R) and stagnation pressures of 1.01325×10^3 to 1.01325×10^7 N/m^2 (0.01 to 100 atm). Roback (ref. 19) did equilibrium-flow and frozen-flow calculations including H_2, H, e^-, H^-, and H^+ for isentropic expansion from stagnation temperatures of 2778 to 111 111 K (5000° to 200 000° R) and stagnation pressures of 1.01325×10^5 to 2.0265×10^8 N/m^2 (1 to 2000 atm). Johnson (ref. 11) did real-gas calculations for stagnation temperatures of 97 to 389 K (175° to 700° R) and stagnation pressures of 0 to 1.01325×10^7 N/m^2 (100 atm).

The present work was based on the Debye-Hückel and ideal-gas approximations and had three purposes: (1) to provide a complete set of more refined compositions and thermodynamic functions for spin-equilibrated hydrogen in chemical equilibrium up to 110 000 K (198 000° R); (2) to provide more-accurate rocket-design and performance data for hydrogen in chemical equilibrium at high temperatures; and (3) to determine the magnitude of the Debye-Hückel effect on thermodynamic properties and rocket-design and performance data. For compositions and thermodynamic functions, the scope of the present work was 100 to 110 000 K (180° to 198 000° R) and 1.01325×10^2 to 1.01325×10^8 N/m^2 (0.001 to 1000 atm), and no deuterium or tritium were included. For rocket performance, the scope was stagnation temperatures of 2500 to 100 000 K (4500° to 180 000° R), stagnation pressures of 1.01325×10^5 to 1.01325×10^8 N/m^2 (1 to 1000 atm), and nozzle pressure ratios from critical down to 10^{-6}. (Nozzle pressure ratio is defined as exit static pressure divided by stagnation pressure.) This report thus supplements the reports of King (ref. 7) and Johnson (ref. 11).

ANALYSIS

Thermodynamic Properties

The thermodynamic properties were based largely on compositions calculated by Patch (ref. 20). In that work, the species H, H^+, e^-, H_2, H^-, H_2^+, and H_3^+ were included for conditions where each was important.

The first six species are well known, but H_3^+ has not previously been included in calculations of thermodynamic properties. It has been observed experimentally for more than 44 years (refs. 21 to 24), but no optical spectrum has been detected. Thus, there was no reliable partition function or dissociation energy before the ab initio calculations of Conroy (ref. 25) and Patch and McBride (refs. 26 and 27). Their H_3^+ partition function was estimated to be accurate to within 20 percent from 298 to 8000 K (536° to 14 400° R) and within a factor of 2 from 8000 to 15 000 K (14 400° to 27 000° R). The H_3^+ ion is not important above 15 000 K (27 000° R). Since references 26 and 27 were written, Leventhal and Friedman (ref. 28) have experimentally determined the dissociation energy of D_3^+. Allowing for differences in vibrational zero point energies of H_3^+ and D_3^+ and also H_2 and D_2, their results agree within the experimental error with the dissociation energy of H_3^+ calculated by Patch and McBride (refs. 26 and 27) and used by Patch (ref. 20) to calculate composition.

Such a wide range of temperatures was included in reference 20 that Patch had to use different approximations for different temperature ranges, being careful that the results matched at the beginnings and ends of the ranges. Above 2000 K (3600° R) there was appreciable ionization, so the generally accepted Debye-Hückel approximation for charged-particle interactions was used. Other interactions between particles were neglected because these are less important at high temperatures. Above 1300 K (2340° R), electronically excited states of H and H_2 were included, necessitating some sort of cutoff. Cox (ref. 29) pointed out that for high degrees of ionization the perturbation of the energy levels is due principally to Coulomb forces, so that one method of cutoff should be used, whereas for low degrees of ionization the perturbation of the energy levels is due principally to neutral particles, so that another method of cutoff should be used. Hence, the cutoff was calculated by the Debye-Hückel method (ref. 30) and a modified Bethe method (ref. 31), and the method which cut off the most states was used. The ground electronic states of H_2 and H_2^+ were assumed to be spin-equilibrated for all temperatures.

Inclusion of the nuclear spin degeneracy in the partition function of H_2 has caused problems in the past (ref. 4) because the resulting entropies and free energies cannot be used directly to calculate chemical equilibria. This is due to the customary neglect of nuclear spin and inclusion of symmetry numbers for other components of a chemical reaction. This inconsistency was eliminated in reference 20 by including symmetry

numbers for H_2 and H_2^+ and weighting ortho states with a factor of 3/2 and para states with a factor of 1/2.

Certain modifications to the method in reference 20 were necessary to extend the temperature and pressure ranges. For temperatures below 298 K (536° R), it was assumed that the only species was H_2. The high-temperature method of reference 20 had a convergence limit because of the small concentrations of H_2 and/or H_3^+ at very high temperatures. In this report, the temperature limit of convergence was approximated by 7989 $\log_{10} p$ - 6323 (with p in N/m^2 and the limit in degrees K). For higher temperatures, equilibrium was calculated for this report by a major-minor Debye-Hückel iteration scheme. The major species were taken to be H, H^+, and e^-, while the minor species were H^- and H_2^+. For pressures below 1.01325×10^5 N/m^2 (1 atm), it was necessary to include additional excited electronic states with principal quantum numbers as high as 65.

The thermodynamic properties for a given pressure and temperature may be calculated from the composition, the partition functions and their derivatives, and two derivatives of the density. The enthalpy, entropy, specific heat at constant pressure, and isentropic exponent were desired. The following paragraphs give the derivations.

As pointed out in reference 20, the Helmholtz free energy, pressure, and Gibbs free energy are each the sum of an ideal gas contribution based on the system volume and number of each kind of particle present and an "excess" contribution due to the Coulomb interactions according to the Debye-Hückel theory. Consider a system of volume V containing the seven chemical species in thermodynamic equilibrium. From reference 20, the excess Helmholtz free energy is

$$\mathcal{A}_{ex} = - \frac{kTV\kappa^3}{12\pi} \tag{1}$$

(Symbols are defined in the appendix.) The reciprocal Debye length is given in SI units by

$$\kappa = \left(\frac{e^2}{\epsilon_0 kTV} \sum_{i=1}^{7} z_i^2 N_i \right)^{1/2} \tag{2}$$

The excess pressure is (ref. 20)

$$p_{ex} = - \frac{kT\kappa^3}{24\pi} \tag{3}$$

The excess Gibbs free energy is then (ref. 20)

$$G_{ex} = -\frac{kTV\kappa^3}{8\pi} \tag{4}$$

The excess internal energy was found from equations (1) and (2) and a thermodynamic identity (ref. 5).

$$E_{ex} = -T^2\left(\frac{\partial \frac{\mathscr{A}_{ex}}{T}}{\partial T}\right)_{V, N_i} = -\frac{kTV\kappa^3}{8\pi} \tag{5}$$

The excess enthalpy was found from equations (3) and (5).

$$H_{ex} = E_{ex} + p_{ex}V = -\frac{kTV\kappa^3}{6\pi} \tag{6}$$

All the excess thermodynamic functions are negative, so the term "excess" is somewhat of a misnomer.

The enthalpy and specific heat were found from the ideal internal energy, ideal pressure, and excess enthalpy. The ideal internal energy of the system with n_i moles of each species i is (ref. 5)

$$E_{id} = \frac{3}{2}nRT + RT^2\sum_{i=1}^{7} n_i\left(\frac{\partial \ln q_i}{\partial T}\right)_V \tag{7}$$

where all partition functions q_i are referenced to the same energy, just as in reference 20. The enthalpy of the system is

$$H = E_{id} + p_{id}V + H_{ex} \tag{8}$$

From equations (6) to (8) and the perfect gas law,

$$H = \frac{5}{2} nRT + RT^2 \sum_{i=1}^{7} n_i \left(\frac{\partial \ln q_i}{\partial T} \right)_V - \frac{kTV\kappa^3}{6\pi} \tag{9}$$

Thus, the enthalpy per unit mass is

$$h = \frac{5}{2} \frac{nRT}{\rho V} + \frac{RT^2}{\rho V} \sum_{i=1}^{7} n_i \left(\frac{\partial \ln q_i}{\partial T} \right)_V - \frac{kT\kappa^3}{6\pi\rho} \tag{10}$$

which is the desired result. In evaluating the seven partial derivatives in equation (10), no simplifying assumptions were made except to neglect the variation of the H and H_2 cutoffs with temperature. The specific heat at constant pressure was found by numerical differentiation.

$$c_p = \left(\frac{\partial h}{\partial T} \right)_p \tag{11}$$

In carrying out the differentiation, the equilibrium, of course, shifted when the temperature was changed.

The entropy was found from the enthalpy and the Gibbs free energy. The Gibbs free energy per unit mass is (ref. 20)

$$g = - \frac{RT}{\rho V} \sum_{i=1}^{7} n_i \ln \frac{V q_i}{\Lambda_i N_o n_i} - \frac{kT\kappa^3}{8\pi\rho} \tag{12}$$

where

$$\Lambda_i \equiv \left(\frac{2\pi\hbar^2}{m_i kT} \right)^{3/2} \qquad i = 1, 2, \ldots, 7 \tag{13}$$

The entropy per unit mass is then

$$s = \frac{h - g}{T} \tag{14}$$

The isentropic exponent is useful in calculating sonic velocity, which for low-frequency sound waves is given by

$$a = \sqrt{\left(\frac{\partial p}{\partial \rho}\right)_s} \tag{15}$$

The isentropic exponent γ is defined by

$$\gamma \equiv \left(\frac{\partial \ln p}{\partial \ln \rho}\right)_s = \frac{\rho}{p}\left(\frac{\partial p}{\partial \rho}\right)_s \tag{16}$$

so

$$a = \sqrt{\frac{\gamma p}{\rho}} \tag{17}$$

Use of the Bridgman table (ref. 32) gives

$$\gamma = \frac{\rho}{p} \frac{c_p}{c_p\left(\frac{\partial \rho}{\partial p}\right)_T - \frac{T}{\rho^2}\left(\frac{\partial \rho}{\partial T}\right)_p^2} \tag{18}$$

which, due to Debye-Hückel effects, cannot be reduced to a simpler form such as given by King (ref. 7). The two partial derivatives in equation (18) were determined numerically. In carrying out the differentiation, the equilibrium, of course, shifted when the temperature or pressure was changed.

To calculate the thermodynamic properties h, c_p, s, and γ for a given temperature and pressure, it was thus necessary to do five equilibrium calculations (one at the specified temperature and pressure, and four at other, slightly different, temperatures and pressures) because of the numerically determined partial derivatives in equations (11) and (18).

Rocket Performance

High-performance rockets always utilize choked nozzles (nozzles with sonic flow at the throat). In evaluating nozzle flow in this report, isentropic, choked, one-dimensional flow with shifting chemical equilibrium was assumed, just as in references 7 and 19. (Shifting chemical equilibrium means chemical equilibrium for the local temperature and pressure.) All necessary quantities were derived from the momentum, energy, and continuity equations. The stagnation conditions (essentially the chamber conditions) were specified.

Conditions at the throat were found by simultaneous solution of the equations

$$h_t = h^* + \frac{1}{2}\frac{\gamma^* p^*}{\rho^*} \tag{19}$$

and

$$s_t = s^* \tag{20}$$

where subscript t indicates stagnation conditions and superscript $*$ indicates throat. The mass flow rate per unit throat area is

$$\frac{\dot{W}}{A^*} = \sqrt{\gamma^* p^* \rho^*} \tag{21}$$

This quantity has a strong dependence on stagnation temperature T_t and stagnation pressure p_t (which are essentially the same as chamber temperature and chamber pressure, respectively). When presenting tables which are to be interpolated to find $\dot{W}/A^*$, a quantity with less T_t and p_t dependence, which can hence be interpolated more accurately than $\dot{W}/A^*$, is the sonic flow factor ψ.

$$\psi \equiv \frac{\dot{W}\sqrt{T_t}}{A^* p_t} \tag{22}$$

The throat velocity is given by

$$v^* = \sqrt{\frac{\gamma^* p^*}{\rho^*}} \tag{23}$$

At any point in the nozzle, the velocity is

$$v = \sqrt{2(h_t - h)} \tag{24}$$

The Mach number is

$$M = v\sqrt{\frac{\rho}{\gamma p}} \tag{25}$$

The area ratio is

$$\frac{A}{A^*} = \frac{\rho^*}{\rho}\frac{v^*}{v} \tag{26}$$

Two kinds of specific impulse are usually given. The ideal specific impulse $I_{sp,\,i}$ is the specific impulse for the case where the ambient pressure is the same as the exit pressure.

$$I_{sp,\,i} = \frac{v_e}{B} \tag{27}$$

where subscript e indicates nozzle exit, and B is a conversion factor numerically equal to the standard acceleration of gravity. The vacuum specific impulse $I_{sp,\,v}$ is the specific impulse when the nozzle exhausts to a perfect vacuum.

$$I_{sp,\,v} = I_{sp,\,i} + \frac{p_e}{B}\frac{A_e}{A^*}\frac{A^*}{\dot{W}} \tag{28}$$

Most other common rocket performance parameters can be derived from those already given.

RESULTS AND DISCUSSION

In this section, numerical results from the Debye-Hückel approximation are presented, their limitations and accuracy are discussed, and they are compared with the results of ideal-gas calculations and with the results of the calculations of other investigators, both for thermodynamic properties and for rocket performance.

Thermodynamic Properties

Values for concentrations and properties. - Numerical results for the dimensionless concentrations $n_i N_o/VL_o$ of the species H, H^+, e^-, H_2, H^-, H_2^+, and H_3^+ in spin-equilibrated hydrogen in chemical equilibrium in the Debye-Hückel approximation are given in table I for pressures from 1.01325×10^2 to 1.01325×10^8 N/m^2 (0.001 to 1000 atm) and temperatures from 100 to 110 000 K (180° to 198 000° R). The dimensionless concentration of each species may also be thought of as the ratio of the number density of the species to the Loschmidt number L_o, where L_o equals 2.68699×10^{25} particles per cubic meter. Graphs of number densities were given in reference 20 for pressures of 1.01325×10^5 and 1.01325×10^8 N/m^2 (1 and 1000 atm). Below 7000 K (12 600° R), H_3^+ is the principal positive ion at a pressure of 1.01325×10^8 N/m^2 (1000 atm) although it was neglected by all previous investigators. Its inclusion greatly increases the concentrations of e^- and H^- at this pressure (ref. 20). However, at lower pressures it is less important.

Values for the thermodynamic properties in spin-equilibrated hydrogen in chemical equilibrium in the Debye-Hückel approximation (eqs. (10) to (14) and (18)) are given in table II for pressures from 1.01325×10^2 to 1.01325×10^8 N/m^2 (0.001 to 1000 atm) and temperatures from 100 to 110 000 K (180° to 198 000° R). Slight irregularities in c_p and γ at the higher temperatures are due to the Debye-Hückel gradual cutoff equations used for H (ref. 20). The reference energies for all partition functions are e^- and the ground state of H, so the reference for enthalpy is the H atom at a temperature of 0 K. This makes many of the enthalpy values negative. To change the reference to liquid parahydrogen at 20.268 K (36.482° R) and 1.01325×10^5 N/m^2 (1 atm), add 214 586 J/g (92 288 Btu/lb) to the tabulated enthalpy values (refs. 4 and 8). The other tabulated thermodynamic properties are independent of the reference energy.

The thermodynamic properties are plotted in figures 1 to 6. In all of these figures, the effects of the dissociation of H_2 and the subsequent ionization of H are apparent as the temperature increases. It is also apparent that these two processes occur at higher temperatures as the pressure is increased.

Accuracy and limitations. - The composition and thermodynamic properties were evaluated to four significant figures or better, based on the equations in reference 20 and this report. However, the interactions between neutral particles and between neutral and charged particles were neglected, resulting in appreciable errors at high density. These errors were evaluated for H_2 and H concentrations by using the equations and virial coefficients of Fisher (ref. 33). The errors in h, s, c_p, ρ, and $\gamma - 1$ were estimated from Johnson's program (ref. 11). For all conditions, the error in $\gamma - 1$ was larger than in the other thermodynamic properties. Conditions where the error in $\gamma - 1$, H concentration, or H_2 concentration exceeded 20 percent were eliminated from tables I and II and figures 1 to 6.

There is a limit to the charged-particle density at which the Debye-Hückel theory is accurate. The theory is believed valid provided the equivalent concentration does not exceed the critical equivalent concentration (refs. 34, 35, and 20). However, as the equivalent concentration approaches the critical equivalent concentration, the accuracy can be expected to decrease (ref. 36). For the conditions in this report, the equivalent concentration never exceeded 0.6 of the critical equivalent concentration.

Estimated error in the H_3^+ partition function had no significant effect on the thermodynamic properties.

Comparisons. - To facilitate an understanding of the Debye-Hückel results, calculations of the composition and thermodynamic properties were repeated with all Debye-Hückel terms omitted but using the same cutoff methods. This gave ideal-gas results. A composition comparison was given in figure 4 of reference 20. At a pressure of 1.01325×10^8 N/m^2 (1000 atm), the Debye-Hückel approximation gave free-electron concentrations as much as 44 percent higher than those given by the ideal-gas approximation. The differences for other species were smaller.

For the thermodynamic properties, the two sets of results are plotted in figures 7 to 12 and are labeled "this report." In the following paragraphs, these two sets of results are discussed and compared with the results of other investigations.

Because of different enthalpy references used by various investigators, some standard had to be devised for comparison of enthalpies. The standard chosen was the enthalpy difference between the given temperature and 298 K (536° R). Such enthalpy differences for two pressures are given in figures 7 and 8 for the two approximations of this report and for the results of four other investigators.

In figure 7 it can be seen that the ideal-gas enthalpy differences of Svehla (ref. 9), Roback (ref. 19), and this report are all in excellent agreement. Including Debye-Hückel effects did not cause the enthalpy difference to deviate appreciably from the ideal-gas calculations, even at 1.01325×10^8 N/m^2 (1000 atm), where such deviation should be largest. This is surprising, considering the large concentration deviations. The explanation is that increased ionization due to Debye-Hückel effects increases the first and second terms in equation (10) but makes the third term more negative, so the changes in the terms roughly cancel. On the other hand, Krascella (ref. 15) gets much higher enthalpy differences from 15 000 to 40 000 K (27 000° to 72 000° R) than any other investigator. This is because his enthalpy equation contains charged-particle interactions only indirectly, through changes in composition, and hence the cancellation mentioned previously does not take place. Anyhow, the theory of Ecker and Weizel (ref. 16) used by Krascella was incorrect (ref. 17).

In figure 8, all calculations are in good agreement because at the low pressure of 1.01325×10^5 N/m^2 (1 atm) the interactions between charged particles have a relatively small effect.

A comparison of entropies calculated by various investigators and those calculated for this report is made in figures 9 and 10 for different pressures. The previous comments on enthalpies also apply to entropies, since a similar cancellation of Debye-Hückel effects takes place.

Specific heats at constant pressure by the two methods of this report are given in figure 11 for a pressure of 1.01325×10^8 N/m^2 (1000 atm). Including Debye-Hückel effects shifted the second peak to lower temperatures because ionization occurs at lower temperatures. The difference between the two methods varied from +14.9 to -13.6 percent.

A comparison of constant-pressure specific heats at 1.01325×10^5 N/m^2 (1 atm) showed that the values from King (ref. 7), Svehla (ref. 9), and this report (ideal gas and Debye-Hückel) for 600 to 5000 K (1080° to 9000° R) were too close together to separate graphically.

Isentropic exponents by the two methods of this report are given in figure 12 for 1.01325×10^8 N/m^2 (1000 atm). The temperatures of the extrema were shifted just as for specific heat at constant pressure. The difference between the two methods varied from -0.051 to +0.030.

A comparison of isentropic exponents at 1.01325×10^5 N/m^2 (1 atm) showed that the values from King (ref. 7), Svehla (ref. 9), and this report (ideal gas and Debye-Hückel) for 600 to 5000 K (1080° to 9000° R) were too close together to separate graphically.

Rocket Performance

Numerical results. - Nozzle flow was calculated from equations (19) to (28) for stagnation pressures of 1.01325×10^5, 1.01325×10^6, 1.01325×10^7, 2.0265×10^7, 5.06625×10^7, and 1.01325×10^8 N/m^2 (1, 10, 100, 200, 500, and 1000 atm), stagnation temperatures from 2500 to 100 000 K (4500° to 180 000° R), and static- to stagnation-pressure ratios of 10^{-1}, 10^{-2}, 10^{-3}, 10^{-4}, 3×10^{-5}, 10^{-5}, 3×10^{-6}, and 10^{-6}. There were two restrictions to the calculations: (1) no calculations were made for static pressures below 1.01325×10^2 N/m^2 (0.001 atm), and (2) no calculations were made for static temperatures below 298.15 K (536.67° R). Both restrictions were due to the spin-equilibrated thermodynamic properties (table II and unpublished tables for intermediate pressures) used. During nozzle expansion from temperatures of 2500 K (4500° R) or higher, nuclear spin of H_2 is not equilibrated after most of the H atoms have recombined. This effect is insignificant until the temperature drops below roughly 298 K (536° R). Below 298 K (536° R), thermodynamic properties for normal H_2 must be used instead of properties for spin-equilibrated H_2 if accurate results are desired for nozzle flow.

Nozzle flow results are given in table III. The line labeled "chamber" gives stagnation conditions. Lines labeled "downstream" are for downstream of the throat. Vacuum specific impulse from table III is plotted in figure 13 for a pressure ratio of 10^{-4}. For this pressure ratio, the ideal specific impulse was at least 97 percent of the vacuum specific impulse for all conditions in table III. Both specific impulses increased monotonically with stagnation temperature.

Accuracy and limitations. - Nozzle flow was calculated by interpolation and inverse interpolation of thermodynamic property tables, so the results are only accurate to ±1 in the third significant digit. In addition, shifting chemical equilibrium was assumed. This is undoubtedly a good assumption for stagnation conditions where there is negligible dissociation and also for high stagnation pressures combined with high exit pressure ratios. However, the validity of shifting chemical equilibrium for other conditions depends on the nozzle length and is beyond the scope of this report.

Comparisons. - Table III agrees with the ideal-gas calculations of King (ref. 7) and the ideal-gas, shifting-equilibrium flow calculations of Roback (ref. 19) to within ±1 in the third significant digit for stagnation temperatures up to 6000 K (10 800° R). For higher stagnation temperatures, there is reasonable agreement with Roback's shifting-equilibrium flow calculations. For comparison, Roback (ref. 19) also gives frozen-flow calculations. Frozen flow gives lower specific impulse than shifting-equilibrium flow.

The effects of the Debye-Hückel approximation compared with the ideal-gas approximation for nozzle flow were evaluated by means of the two sets of thermodynamic properties (this report) described earlier and are presented in figures 14 to 16 for a stagnation pressure of 1.01325×10^8 N/m^2 (1000 atm).

Figures 14 and 15 are for an exit pressure ratio of 10^{-3} and show effects on six parameters. Using the Debye-Hückel approximation gave exit temperature as much as 21 percent higher, exit Mach number as much as 10 percent lower, nozzle area ratio as much as 17 percent higher, exit velocity as much as 3.4 percent higher, ideal specific impulse as much as 3.4 percent higher, and vacuum specific impulse as much as 3.5 percent higher than these quantities according to the ideal-gas approximation. The measurably higher Debye-Hückel exit temperature suggests the use of a choked converging-diverging nozzle to test the validity of the Debye-Hückel approximation for high charged-particle densities.

Figure 16 shows that the Debye-Hückel approximation gave mass rates of flow per unit nozzle throat area of from 1.5 percent lower to 2.1 percent higher than for the ideal-gas approximation.

SUMMARY OF RESULTS

The composition and thermodynamic properties of hydrogen were calculated for 100 to 110 000 K (180° to 198 000° R) and 1.01325×10^2 to 1.01325×10^8 N/m^2 (0.001 to 1000 atm). At a pressure of 1.01325×10^8 N/m^2 (1000 atm), the Debye-Hückel approximation gave free-electron concentrations as much as 44 percent higher than given by the ideal-gas approximation. The differences for other species were smaller.

The differences between enthalpies and entropies calculated by the Debye-Hückel and ideal-gas approximations were slight. However, the specific heats differed by -13.6 to +14.9 percent at 1.01325×10^8 N/m^2 (1000 atm). The isentropic exponents differed by -0.051 to +0.030 at the same pressure.

Choked, isentropic, one-dimensional nozzle flow with shifting chemical equilibrium was calculated to the Debye-Hückel and ideal-gas approximations for stagnation temperatures from 2500 to 100 000 K (4500° to 180 000° R) and stagnation pressures from 1.01325×10^5 to 1.01325×10^8 N/m^2 (1 to 1000 atm). For a stagnation pressure of 1.01325×10^8 N/m^2 (1000 atm) and an exit pressure ratio of 10^{-3}, the Debye-Hückel approximation gave exit temperatures as much as 21 percent higher, exit Mach numbers as much as 10 percent lower, nozzle area ratios as much as 17 percent higher, exit velocities as much as 3.4 percent higher, ideal specific impulses as much as 3.4 percent higher, and vacuum specific impulses as much as 3.5 percent higher than these quantities according to the ideal-gas approximation. For the same stagnation pressure, the Debye-Hückel approximation gave mass rates of flow of from 1.5 percent lower to 2.1 percent higher than for the ideal-gas approximation.

CONCLUSIONS

An analytic investigation was made of the composition, thermodynamic properties, and nozzle flow of spin-equilibrated hydrogen gas in chemical equilibrium in the Debye-Hückel and ideal-gas approximations. The following conclusions are based on the results of this investigation:

1. For hydrogen at temperatures from about 10 000 to 100 000 K (18 000° to 180 000° R) at pressures approaching 1.01325×10^8 N/m^2 (1000 atm), the ideal-gas approximation is inadequate even for crude (±40 percent) calculations of composition. For thermodynamic properties and nozzle flow, the Debye-Hückel approximation is necessary for precise calculations, but the ideal-gas approximation suffices for crude calculations.

2. The Debye-Hückel approximation gave nozzle exit temperatures as much as 21 percent higher than those obtained with the ideal-gas approximation for the same

stagnation conditions, which suggests the use of a choked converging-diverging nozzle to test the validity of the Debye-Hückel approximation for high charged-particle densities.

Lewis Research Center,
National Aeronautics and Space Administration,
Cleveland, Ohio, June 16, 1971,
122-28.

APPENDIX - SYMBOLS

A	cross-sectional area of nozzle
$\mathscr{A}$	Helmholtz free energy of system referenced to H atoms at 0 K
a	sonic velocity
B	conversion factor numerically equal to the standard acceleration of gravity
c_p	specific heat at constant pressure per unit mass
E	internal energy of system referenced to H atoms at 0 K
e	charge of electron
G	Gibbs free energy of system referenced to H atoms at 0 K
g	Gibbs free energy per unit mass referenced to H atoms at 0 K
H	enthalpy of system referenced to H atoms at 0 K
h	enthalpy per unit mass referenced to H atoms at 0 K
$\hbar$	Planck constant divided by 2π
$I_{sp,i}$	ideal specific impulse
$I_{sp,v}$	vacuum specific impulse
k	Boltzmann constant
L_o	Loschmidt number
M	Mach number
m_i	mass of species i
N_i	number of particles of species i
N_o	Avogadro's number
n	moles of all species
n_i	moles of species i
p	pressure
q_i	ideal-gas internal partition function of species i relative to internal energy of e^- and ground electronic state of H
R	universal gas constant
s	entropy per unit mass
T	absolute temperature
V	volume of system

v velocity of gas relative to nozzle

$\dot{W}$ mass rate of flow

z_i net number of elementary charges e on species i (1, 0, or -1)

γ isentropic exponent

ϵ_o electric permittivity of free space

κ reciprocal Debye length

Λ_i characteristic volume for translation for species i

ρ density

ψ sonic flow factor

Subscripts:

DH Debye-Hückel approximation

e nozzle exit

ex excess

id ideal-gas approximation

t stagnation

1 hydrogen atom H

2 proton, H^+

3 free electron, e^-

4 hydrogen molecule, H_2

5 negative hydrogen ion, H^-

6 hydrogen diatomic molecular ion, H_2^+

7 hydrogen triatomic molecular ion, H_3^+

298 temperature of 298 K (536^o R)

Superscript:

* nozzle throat

REFERENCES

1. Rom, Frank E.: Nuclear-Rocket Propulsion. NASA TM X-1685, 1968.

2. Ragsdale, Robert G.: High-Specific-Impulse Gas-Core Reactors. NASA TM X-2243, 1971.

3. Clement, J. D.; and Williams, J. R.: Gas-Core Reactor Technology. Reactor Tech., vol. 13, no. 3, Summer 1970, pp. 226-251.

4. Woolley, Harold W.; Scott, Russell B.; and Brickwedde, F. G.: Complication of Thermal Properties of Hydrogen in Its Various Isotopic and Ortho-Para Modifications. J. Res. Nat. Bur. Std., vol. 41, no. 5, Nov. 1948, pp. 379-475.

5. Davidson, Norman: Statistical Mechanics. McGraw-Hill Book Co., Inc., 1962, pp. 50-138.

6. Hilsenrath, Joseph; Beckett, Charles W.; Benedict, William S.; Fano, Lilla; Hoge, Harold J.; Masi, Joseph F.; Nuttall, Ralph L.; Touloukian, Yerman S.; and Woolley, Harold W.: Tables of Thermal Properties of Gases. Circ. 564, National Bureau of Standards, 1955.

7. King, Charles R.: Compilation of Thermodynamic Properties, Transport Properties, and Theoretical Rocket Performance of Gaseous Hydrogen. NASA TN D-275, 1960.

8. Roder, H. M.; Weber, L. A.; and Goodwin, R. D.: Thermodynamic and Related Properties of Parahydrogen from the Triple Point to 100 K at Pressures to 340 atm. Rep. 7987, National Bureau of Standards, Nov. 1963.

9. Svehla, Roger A.: Thermodynamic and Transport Properties for the Hydrogen-Oxygen System. NASA SP-3011, 1964.

10. Farmer, Otis A.: Thermodynamic-Transport and Related Properties of Para-Hydrogen from 36° to 5000° R at Pressures to 5000 psia. Rep. LA-3405-MS, Los Alamos Scientific Lab., Oct. 1965.

11. Johnson, Robert C.: Real-Gas Effects in Critical-Flow-Through Nozzles and Tabulated Thermodynamic Properties. NASA TN D-2565, 1965.

12. Rosenbaum, Burt M.; and Levitt, Leo: Thermodynamic Properties of Hydrogen from Room Temperature to 100 000° K. NASA TN D-1107, 1962.

13. McGee, Henry A., Jr.; and Heller, Gerhard: Plasma Thermodynamics 1: Properties of Hydrogen, Helium, and Lithium as Pure Elemental Plasmas. ARS J., vol. 32, no. 2, Feb. 1962, pp. 203-215.

14. McChesney, Malcolm: Debye-Hückel Plasma Corrections. AIAA J., vol. 1, no. 7, July 1963, pp. 1666-1668.

15. Krascella, N. L.: Tables of the Composition, Opacity, and Thermodynamic Properties of Hydrogen at High Temperatures. NASA SP-3005, 1963.

16. Ecker, G.; and Weizel, W.: Zustandssumme und effektive Ionisierungsspannung eines Atoms im Inneren des Plasmas. Ann. d. Physik (Leipzig), vol. 17, no. 2-3, Feb. 1, 1956, pp. 126-140.

17. Ecker, G.; and Kröll, W.: Lowering of the Ionization Energy for a Plasma in Thermodynamic Equilibrium. Phys. Fluids, vol. 6, no. 1, Jan. 1963, pp. 62-69.

18. Kubin, Robert F.; and Presley, Leroy L.: Thermodynamic Properties and Mollier Chart for Hydrogen from 300° to $20\,000^{\circ}$ K. NASA SP-3002, 1964.

19. Roback, R.: Theoretical Performance of Rocket Engines Using Gaseous Hydrogen in the Ideal State at Stagnation Temperatures Up to $200\,000^{\circ}$ R. Rep. E-910093-30, United Aircraft Research Lab., Oct. 1966.

20. Patch, R. W.: Components of a Hydrogen Plasma Including Minor Species. NASA TN D-4993, 1969.

21. Dorsch, Karl E.; and Kallmann, Hartmut: Über die Ionisationsvorgänge im Wasserstoff, Stickstoff und Argon. Z. Physik, vol. 44, no. 8, Aug. 1927, pp. 565-574.

22. Brasefield, Charles J.: Triatomic Hydrogen as an Emitter of the Secondary Spectrum. Phys. Rev., vol. 31, no. 1, Jan. 1928, pp. 52-58.

23. Dorsch, K. E.; and Kallmann, H.: Über die Bildung von Wasserstoffatomen durch Stoss langsamer Elektronen. Z. Physik, vol. 53, no. 1-2, Feb. 1929, pp. 80-91.

24. Smyth, H. D.: Products and Processes of Ionization by Low Speed Electrons. Rev. Mod. Phys., vol. 3, no. 3, July 1931, pp. 347-391.

25. Conroy, Harold: Molecular Schrödinger Equation. IV. Results for One- and Two-Electron Systems. J. Chem. Phys., vol. 41, no. 5, Sept. 1, 1964, pp. 1341-1351.

26. Patch, R. W.; and McBride, Bonnie J.: Partition Functions and Thermodynamic Properties to High Temperatures for H_3^+ and H_2^+. NASA TN D-4523, 1968.

27. Patch, R. W.: Partition Functions of the Ground Electronic States of H_3^+ and H_2^+. J. Chem. Phys., vol. 49, no. 2, July 15, 1968, pp. 961-962.

28. Leventhal, J. J.; and Friedman, L.: Experimental Determination of D_3^+ Dissociation Energy. J. Chem. Phys., vol. 49, no. 4, Aug. 15, 1968, pp. 1974-1975.

29. Cox, Arthur N.: Stellar Absorption Coefficients and Opacities. Stellar Structure. Lawrence H. Aller and Dean B. McLaughlin, eds., Univ. of Chicago Press, 1965, pp. 195-267.

30. Cooper, J.: Plasma Spectroscopy. Reports on Progress in Physics, vol. XXIX, Part I, 1966, pp. 35-130.

31. Bond, John W., Jr.: Structure of a Shock Front in Argon. Phys. Rev., vol. 105, no. 6, Mar. 15, 1957, pp. 1683-1694.

32. Lewis, Gilbert Newton; and Randall, Merle: Thermodynamics. Revised by Kenneth S. Pitzer and Leo Brewer. Second ed., McGraw-Hill Book Co., Inc., 1961, pp. 665-668.

33. Fisher, B. B.: Calculations of the Thermal Properties of Hydrogen. Rep. LA-3364, Los Alamos Scientific Lab., Apr. 20, 1966.

34. Berlin, T. H.; and Montroll, E. W.: On the Free Energy of a Mixture of Ions: An Extension of Kramer's Theory. J. Chem. Phys., vol. 20, no. 1, Jan. 1952, pp. 75-84.

35. Griem, Hans R.: High-Density Corrections in Plasma Spectroscopy. Phys. Rev., vol. 128, no. 3, Nov. 1, 1962, pp. 997-1003.

36. Cambel, Ali Bulent; Duclos, Donald P.; and Anderson, Thomas P.: Real Gases. Academic Press, 1963, pp. 59-89.

TABLE I. - CONCENTRATIONS OF SPECIES IN SPIN-EQUILIBRATED HYDROGEN IN CHEMICAL EQUILIBRIUM IN DEBYE-HÜCKEL APPROXIMATION

[E-02, E-03, E+02, E+03, etc., after numbers signify that numbers are to be multiplied by 10^{-2}, 10^{-3}, 10^{2}, 10^{3}, etc.]

(a) Pressure, 1.01325×10^{2} N/m^2 (0.001 atm)

Temperature, T		Species						
K	°R	H	H^+	e^-	H_2	H^-	H_2^+	H_3^+
		Dimensionless concentration, $n_i N_o / V L_o$						
100.00	180.00				2.732E-03			
150.00	270.00				1.821E-03			
200.00	360.00				1.366E-03			
250.00	450.00				1.093E-03			
298.15	536.67	7.095E-38			9.162E-04			
400.00	720.00	2.882E-28			6.829E-04			
500.00	900.00	1.201E-22			5.463E-04			
600.00	1080.00	6.645E-19			4.553E-04			
700.00	1260.00	3.114E-16			3.902E-04			
800.00	1440.00	3.120E-14			3.414E-04			
900.00	1620.00	1.119E-12			3.035E-04			
1000.00	1800.00	1.955E-11			2.732E-04			
1100.00	1980.00	2.024E-10			2.483E-04			
1200.00	2160.00	1.416E-09			2.276E-04			
1300.00	2340.00	7.325E-09			2.101E-04			
1400.00	2520.00	2.990E-08		1.436E-24	1.951E-04	1.347E-30		1.436E-24
1500.00	2700.00	1.010E-07		3.213E-23	1.820E-04	6.033E-29		3.213E-23
1600.00	2880.00	2.922E-07		4.873E-22	1.704E-04	1.655E-27		4.873E-22
1700.00	3060.00	7.443E-07		5.364E-21	1.599E-04	3.057E-26		5.364E-21
1800.00	3240.00	1.703E-06		4.512E-20	1.500E-04	4.031E-25		4.512E-20
1900.00	3420.00	3.550E-06		3.018E-19	1.402E-04	3.991E-24		3.018E-19
2000.00	3600.00	6.822E-06	1.792E-21	1.654E-18	1.298E-04	3.079E-23	8.652E-24	1.652E-18
2100.00	3780.00	1.216E-05	3.207E-20	7.588E-18	1.179E-04	1.891E-22	1.330E-22	7.555E-18
2200.00	3960.00	2.017E-05	4.445E-19	2.964E-17	1.040E-04	9.414E-22	1.577E-21	2.919E-17
2300.00	4140.00	3.111E-05	4.911E-18	1.001E-16	8.765E-05	3.843E-21	1.471E-20	9.513E-17
2400.00	4320.00	4.451E-05	4.365E-17	2.994E-16	6.930E-05	1.313E-20	1.077E-19	2.557E-16
2500.00	4500.00	5.881E-05	3.035E-16	8.394E-16	5.045E-05	3.940E-20	5.966E-19	5.353E-16
2600.00	4680.00	7.164E-05	1.567E-15	2.381E-15	3.341E-05	1.118E-19	2.355E-18	8.117E-16
2700.00	4860.00	8.095E-05	6.063E-15	6.965E-15	2.022E-05	3.076E-19	6.699E-18	8.963E-16
2800.00	5040.00	8.611E-05	1.916E-14	1.997E-14	1.144E-05	7.891E-19	1.512E-17	7.987E-16
2900.00	5220.00	8.793E-05	5.329E-14	5.395E-14	6.263E-06	1.850E-18	2.969E-17	6.366E-16
3000.00	5400.00	8.764E-05	1.357E-13	1.363E-13	3.411E-06	3.993E-18	5.347E-17	4.834E-16
3100.00	5580.00	8.623E-05	3.227E-13	3.232E-13	1.883E-06	8.057E-18	9.081E-17	3.615E-16
3200.00	5760.00	8.430E-05	7.242E-13	7.246E-13	1.063E-06	1.539E-17	1.477E-16	2.706E-16
3400.00	6120.00	7.997E-05	3.149E-12	3.149E-12	3.671E-07	4.915E-17	3.542E-16	1.562E-16
3600.00	6480.00	7.573E-05	1.161E-11	1.161E-11	1.408E-07	1.361E-16	7.668E-16	9.481E-17
3800.00	6840.00	7.182E-05	3.732E-11	3.732E-11	5.929E-08	3.356E-16	1.529E-15	6.048E-17
4000.00	7200.00	6.826E-05	1.068E-10	1.068E-10	2.710E-08	7.511E-16	2.847E-15	4.035E-17
4200.00	7560.00	6.502E-05	2.766E-10	2.766E-10	1.330E-08	1.548E-15	5.001E-15	2.799E-17
4400.00	7920.00	6.207E-05	6.573E-10	6.573E-10	6.946E-09	2.973E-15	8.353E-15	2.010E-17
4600.00	8280.00	5.937E-05	1.449E-09	1.449E-09	3.828E-09	5.371E-15	1.335E-14	1.487E-17
4800.00	8640.00	5.690E-05	2.994E-09	2.994E-09	2.212E-09	9.197E-15	2.055E-14	1.130E-17
5000.00	9000.00	5.462E-05	5.837E-09	5.837E-09	1.333E-09	1.503E-14	3.055E-14	8.787E-18
5200.00	9360.00	5.251E-05	1.082E-08	1.082E-08	8.335E-10	2.356E-14	4.408E-14	6.977E-18
5400.00	9720.00	5.054E-05	1.915E-08	1.915E-08	5.387E-10	3.560E-14	6.190E-14	5.641E-18
5600.00	10080.00	4.871E-05	3.256E-08	3.256E-08	3.585E-10	5.207E-14	8.482E-14	4.636E-18
5800.00	10440.00	4.699E-05	5.337E-08	5.337E-08	2.449E-10	7.392E-14	1.137E-13	3.864E-18
6000.00	10800.00	4.536E-05	8.465E-08	8.465E-08	1.712E-10	1.022E-13	1.492E-13	3.262E-18
6300.00	11340.00	4.304E-05	1.600E-07	1.600E-07	1.039E-10	1.587E-13	2.168E-13	2.577E-18
6600.00	11880.00	4.082E-05	2.852E-07	2.852E-07	6.540E-11	2.345E-13	3.028E-13	2.073E-18

TABLE I. - Continued. CONCENTRATIONS OF SPECIES IN SPIN-EQUILIBRATED HYDROGEN IN CHEMICAL EQUILIBRIUM IN DEBYE-HÜCKEL APPROXIMATION

[E-02, E-03, E+02, E+03, etc., after numbers signify that numbers are to be multiplied by 10^{-2}, 10^{-3}, 10^{2}, 10^{3}, etc.]

(a) Concluded. Pressure, 1.01325×10^{2} N/m^2 (0.001 atm)

Temperature, T		Species						
K	^{o}R	H	H^+	e^-	H_2	H^-	H_2^+	H_3^+
		Dimensionless concentration, $n_i N_o/VL_o$						
7000.00	12600.00	3.788E-05	5.687E-07	5.687E-07	3.685E-11	3.677E-13	4.462E-13	1.574E-18
7300.00	13140.00	3.561E-05	9.045E-07	9.045E-07	2.447E-11	4.897E-13	5.718E-13	1.282E-18
7600.00	13680.00	3.318E-05	1.379E-06	1.379E-06	1.636E-11	6.241E-13	7.050E-13	1.033E-18
8000.00	14400.00	2.960E-05	2.275E-06	2.275E-06	9.493E-12	8.016E-13	8.728E-13	7.485E-19
8300.00	14940.00	2.658E-05	3.166E-06	3.166E-06	6.175E-12	9.106E-13	9.687E-13	5.622E-19
8600.00	15480.00	2.329E-05	4.241E-06	4.241E-06	3.884E-12	9.755E-13	1.017E-12	3.996E-19
9000.00	16200.00	1.857E-05	5.893E-06	5.893E-06	1.938E-12	9.641E-13	9.829E-13	2.260E-19
9300.00	16740.00	1.499E-05	7.198E-06	7.198E-06	1.067E-12	8.757E-13	8.801E-13	1.325E-19
9600.00	17280.00	1.158E-05	8.445E-06	8.445E-06	5.446E-13	7.340E-13	7.286E-13	6.993E-20
10000.00	18000.00	7.664E-06	9.835E-06	9.835E-06		5.119E-13	5.010E-13	
10500.00	18900.00	4.168E-06	1.093E-05	1.093E-05		2.747E-13	2.650E-13	
11000.00	19800.00	2.134E-06	1.136E-05	1.136E-05		1.302E-13	1.242E-13	
11500.00	20700.00	1.081E-06	1.134E-05	1.134E-05		5.874E-14	5.553E-14	
12000.00	21600.00	5.608E-07	1.111E-05	1.111E-05		2.654E-14	2.491E-14	
12500.00	22500.00	3.035E-07	1.078E-05	1.078E-05		1.232E-14	1.150E-14	
13000.00	23400.00	1.730E-07	1.043E-05	1.043E-05		5.929E-15	5.510E-15	
13500.00	24300.00	1.043E-07	1.007E-05	1.007E-05		2.968E-15	2.748E-15	
14000.00	25200.00	6.670E-08	9.727E-06	9.727E-06		1.543E-15	1.425E-15	
15000.00	27000.00	3.228E-08	9.093E-06	9.093E-06		4.635E-16	4.266E-16	
16000.00	28800.00	1.901E-08	8.530E-06	8.530E-06		1.574E-15	1.447E-16	
17000.00	30600.00	1.292E-08	8.030E-06	8.030E-06		5.933E-17	5.451E-17	
18000.00	32400.00	9.653E-09	7.585E-06	7.585E-06		2.443E-17	2.246E-17	
19000.00	34200.00	7.646E-09	7.187E-06	7.187E-06		1.085E-17	9.987E-18	
20000.00	36000.00	6.280E-09	6.827E-06	6.827E-06		5.145E-18	4.743E-18	
21000.00	37800.00	5.283E-09	6.503E-06	6.503E-06		2.582E-18	2.384E-18	
22000.00	39600.00	4.518E-09	6.207E-06	6.207E-06		1.362E-18	1.260E-18	
23000.00	41400.00	3.908E-09	5.937E-06	5.937E-06		7.501E-19	6.956E-19	
24000.00	43200.00	3.414E-09	5.690E-06	5.690E-06		4.296E-19	3.992E-19	
25000.00	45000.00	3.004E-09	5.462E-06	5.462E-06		2.547E-19	2.372E-19	
26000.00	46800.00	2.660E-09	5.252E-06	5.252E-06		1.558E-19	1.454E-19	
27000.00	48600.00	2.369E-09	5.058E-06	5.058E-06		9.796E-20	9.162E-20	
28000.00	50400.00	2.119E-09	4.877E-06	4.877E-06		6.317E-20	5.921E-20	
29000.00	52200.00	1.904E-09	4.709E-06	4.709E-06		4.168E-20	3.914E-20	
30000.00	54000.00	1.718E-09	4.552E-06	4.552E-06		2.808E-20	2.642E-20	
32000.00	57600.00	1.413E-09	4.268E-06	4.268E-06		1.347E-20	1.272E-20	
34000.00	61200.00	1.175E-09	4.017E-06	4.017E-06		6.892E-21	6.533E-21	
36000.00	64800.00	9.899E-10	3.794E-06	3.794E-06		3.725E-21	3.543E-21	
38000.00	68400.00	8.409E-10	3.594E-06	3.594E-06		2.110E-21	2.014E-21	
40000.00	72000.00	7.207E-10	3.414E-06	3.414E-06		1.246E-21	1.192E-21	
43000.00	77400.00	5.795E-10	3.176E-06	3.176E-06		6.035E-22	5.799E-22	
46000.00	82800.00	4.733E-10	2.969E-06	2.969E-06		3.127E-22	3.016E-22	
50000.00	90000.00	3.684E-10	2.731E-06	2.731E-06		1.419E-22	1.374E-22	
55000.00	99000.00	2.766E-10	2.483E-06	2.483E-06		5.915E-23	5.757E-23	
60000.00	108000.00	2.130E-10	2.276E-06	2.276E-06		2.726E-23	2.664E-23	
65000.00	117000.00	1.675E-10	2.101E-06	2.101E-06		1.362E-23	1.336E-23	
70000.00	126000.00	1.341E-10	1.951E-06	1.951E-06		7.258E-24	7.151E-24	
80000.00	144000.00	8.977E-11	1.707E-06	1.707E-06		2.422E-24	2.395E-24	
90000.00	162000.00	6.303E-11	1.517E-06	1.517E-06		9.477E-25	9.412E-25	
100000.00	180000.00	4.594E-11	1.366E-06	1.365E-06		4.185E-25	4.170E-25	
110000.00	198000.00	3.451E-11	1.242E-06	1.242E-06		2.030E-25	2.029E-25	

TABLE I. - Continued. CONCENTRATIONS OF SPECIES IN SPIN-EQUILIBRATED HYDROGEN IN CHEMICAL EQUILIBRIUM IN DEBYE-HÜCKEL APPROXIMATION

[E-02, E-03, E+02, E+03, etc., after numbers signify that numbers are to be multiplied by 10^{-2}, 10^{-3}, 10^{2}, 10^{3}, etc.]

(b) Pressure, 3.03975×10^{2} N/m^2 (0.003 atm)

Temperature, T		Species						
K	^{o}R	H	H^+	e^-	H_2	H^-	H_2^+	H_3^+
		Dimensionless concentration, $n_i N_o / V L_o$						
100.00	180.00				8.195E-03			
150.00	270.00				5.463E-03			
200.00	360.00				4.097E-03			
250.00	450.00				3.278E-03			
298.15	536.67	1.229E-37			2.748E-03			
400.00	720.00	4.991E-28			2.049E-03			
500.00	900.00	2.081E-22			1.639E-03			
600.00	1080.00	1.151E-18			1.366E-03			
700.00	1260.00	5.393E-16			1.171E-03			
800.00	1440.00	5.405E-14			1.024E-03			
900.00	1620.00	1.938E-12			9.105E-04			
1000.00	1800.00	3.385E-11			8.195E-04			
1100.00	1980.00	3.505E-10			7.450E-04			
1200.00	2160.00	2.452E-09			6.829E-04			
1300.00	2340.00	1.269E-08			6.303E-04			
1400.00	2520.00	5.180E-08		3.274E-24	5.853E-04	5.348E-30		3.274E-24
1500.00	2700.00	1.749E-07		7.325E-23	5.461E-04	2.385E-28		7.325E-23
1600.00	2880.00	5.064E-07		1.111E-21	5.116E-04	6.559E-27		1.111E-21
1700.00	3060.00	1.290E-06		1.224E-20	4.807E-04	1.211E-25		1.225E-20
1800.00	3240.00	2.956E-06		1.032E-19	4.523E-04	1.603E-24		1.032E-19
1900.00	3420.00	6.182E-06		6.934E-19	4.251E-04	1.597E-23		6.934E-19
2000.00	3600.00	1.194E-05	1.355E-21	3.830E-18	3.978E-04	1.248E-22	1.145E-23	3.829E-18
2100.00	3780.00	2.150E-05	2.416E-20	1.782E-17	3.687E-04	7.853E-22	1.771E-22	1.779E-17
2200.00	3960.00	3.626E-05	3.332E-19	7.109E-17	3.362E-04	4.060E-21	2.126E-21	7.076E-17
2300.00	4140.00	5.745E-05	3.679E-18	2.466E-16	2.988E-04	1.749E-20	2.034E-20	2.429E-16
2400.00	4320.00	8.553E-05	3.331E-17	7.539E-16	2.559E-04	6.352E-20	1.580E-19	7.205E-16
2500.00	4500.00	1.195E-04	2.499E-16	2.071E-15	2.083E-04	1.975E-19	9.983E-19	1.820E-15
2600.00	4680.00	1.562E-04	1.532E-15	5.311E-15	1.589E-04	5.441E-19	5.022E-18	3.774E-15
2700.00	4860.00	1.910E-04	7.388E-15	1.348E-14	1.125E-04	1.405E-18	1.926E-17	6.079E-15
2800.00	5040.00	2.188E-04	2.765E-14	3.515E-14	7.387E-05	3.529E-18	5.547E-17	7.443E-15
2900.00	5220.00	2.370E-04	8.439E-14	9.184E-14	4.552E-05	8.489E-18	1.268E-16	7.329E-15
3000.00	5400.00	2.462E-04	2.247E-13	2.312E-13	2.693E-05	1.904E-17	2.487E-16	6.317E-15
3100.00	5580.00	2.487E-04	5.457E-13	5.512E-13	1.566E-05	3.963E-17	4.428E-16	5.083E-15
3200.00	5760.00	2.470E-04	1.238E-12	1.242E-12	9.125E-06	7.728E-17	7.395E-16	3.969E-15
3400.00	6120.00	2.378E-04	5.428E-12	5.432E-12	3.245E-06	2.520E-16	1.816E-15	2.380E-15
3600.00	6480.00	2.264E-04	2.007E-11	2.008E-11	1.257E-06	7.033E-16	3.962E-15	1.464E-15
3800.00	6840.00	2.151E-04	6.459E-11	6.460E-11	5.318E-07	1.740E-15	7.925E-15	9.390E-16
4000.00	7200.00	2.046E-04	1.849E-10	1.849E-10	2.435E-07	3.899E-15	1.478E-14	6.277E-16
4200.00	7560.00	1.950E-04	4.790E-10	4.790E-10	1.196E-07	8.041E-15	2.597E-14	4.359E-16
4400.00	7920.00	1.862E-04	1.138E-09	1.138E-09	6.249E-08	1.545E-14	4.339E-14	3.132E-16
4600.00	8280.00	1.781E-04	2.510E-09	2.511E-09	3.444E-08	2.791E-14	6.938E-14	2.318E-16
4800.00	8640.00	1.707E-04	5.186E-09	5.186E-09	1.991E-08	4.779E-14	1.068E-13	1.761E-16
5000.00	9000.00	1.639E-04	1.011E-08	1.011E-08	1.200E-08	7.810E-14	1.588E-13	1.370E-16
5200.00	9360.00	1.575E-04	1.874E-08	1.874E-08	7.504E-09	1.225E-13	2.291E-13	1.088E-16
5400.00	9720.00	1.517E-04	3.318E-08	3.318E-08	4.851E-09	1.851E-13	3.218E-13	8.801E-17
5600.00	10080.00	1.462E-04	5.641E-08	5.641E-08	3.230E-09	2.708E-13	4.411E-13	7.238E-17
5800.00	10440.00	1.411E-04	9.250E-08	9.250E-08	2.208E-09	3.847E-13	5.915E-13	6.039E-17
6000.00	10800.00	1.363E-04	1.468E-07	1.468E-07	1.545E-09	5.322E-13	7.774E-13	5.105E-17
6300.00	11340.00	1.295E-04	2.777E-07	2.777E-07	9.406E-10	8.284E-13	1.132E-12	4.050E-17
6600.00	11880.00	1.232E-04	4.955E-07	4.955E-07	5.956E-10	1.229E-12	1.588E-12	3.280E-17

TABLE I. - Continued. CONCENTRATIONS OF SPECIES IN SPIN-EQUILIBRATED HYDROGEN IN CHEMICAL EQUILIBRIUM IN DEBYE-HÜCKEL APPROXIMATION

[E-02, E-03, E+02, E+03, etc., after numbers signify that numbers are to be multiplied by 10^{-2}, 10^{-3}, 10^{2}, 10^{3}, etc.]

(b) Concluded. Pressure, 3.03975×10^{2} N/m^2 (0.003 atm)

Temperature, T		Species						
K	°R	H	H^+	e^-	H_2	H^-	H_2^+	H_3^+
		Dimensionless concentration, $n_i N_o / V L_o$						
7000.00	12600.00	1.151E-04	9.916E-07	9.916E-07	3.401E-10	1.947E-12	2.363E-12	2.533E-17
7300.00	13140.00	1.091E-04	1.584E-06	1.584E-06	2.297E-10	2.627E-12	3.067E-12	2.105E-17
7600.00	13680.00	1.030E-04	2.430E-06	2.430E-06	1.575E-10	3.413E-12	3.855E-12	1.754E-17
8000.00	14400.00	9.431E-05	4.064E-06	4.064E-06	9.640E-11	4.563E-12	4.968E-12	1.358E-17
8300.00	14940.00	8.725E-05	5.741E-06	5.741E-06	6.654E-11	5.420E-12	5.766E-12	1.099E-17
8600.00	15480.00	7.960E-05	7.848E-06	7.848E-06	4.539E-11	6.172E-12	6.436E-12	8.644E-18
9000.00	16200.00	6.843E-05	1.132E-05	1.132E-05	2.630E-11	6.826E-12	6.959E-12	5.897E-18
9300.00	16740.00	5.944E-05	1.435E-05	1.435E-05	1.678E-11	6.928E-12	6.963E-12	4.158E-18
9600.00	17280.00	5.019E-05	1.761E-05	1.761E-05	1.023E-11	6.638E-12	6.589E-12	2.743E-18
10000.00	18000.00	3.808E-05	2.196E-05	2.196E-05	4.857E-12	5.688E-12	5.567E-12	1.395E-18
10500.00	18900.00	2.471E-05	2.670E-05	2.670E-05	1.644E-12	3.989E-12	3.849E-12	4.841E-19
11000.00	19800.00	1.470E-05	2.994E-05	2.994E-05	4.772E-13	2.377E-12	2.268E-12	1.353E-19
11500.00	20700.00	8.242E-06	3.155E-05	3.155E-05	1.257E-13	1.259E-12	1.191E-12	3.257E-20
12000.00	21600.00	4.526E-06	3.192E-05	3.192E-05	3.231E-14	6.277E-13	5.892E-13	7.372E-21
12500.00	22500.00	2.509E-06	3.156E-05	3.156E-05	8.621E-15	3.080E-13	2.875E-13	1.682E-21
13000.00	23400.00	1.433E-06	3.084E-05	3.084E-05	2.481E-15	1.530E-13	1.421E-13	4.034E-22
13500.00	24300.00	8.514E-07	2.996E-05	2.996E-05	7.861E-16	7.790E-14	7.215E-14	1.035E-22
14000.00	25200.00	5.298E-07	2.903E-05	2.903E-05		4.091E-14	3.779E-14	
15000.00	27000.00	2.372E-07	2.722E-05	2.722E-05		1.240E-14	1.142E-14	
16000.00	28800.00	1.278E-07	2.556E-05	2.556E-05		4.228E-15	3.886E-15	
17000.00	30600.00	8.045E-08	2.408E-05	2.408E-05		1.596E-15	1.467E-15	
18000.00	32400.00	5.676E-08	2.275E-05	2.275E-05		6.579E-16	6.049E-16	
19000.00	34200.00	4.321E-08	2.155E-05	2.155E-05		2.924E-16	2.691E-16	
20000.00	36000.00	3.460E-08	2.048E-05	2.048E-05		1.387E-16	1.278E-16	
21000.00	37800.00	2.862E-08	1.950E-05	1.950E-05		6.960E-17	6.428E-17	
22000.00	39600.00	2.419E-08	1.862E-05	1.862E-05		3.671E-17	3.397E-17	
23000.00	41400.00	2.078E-08	1.781E-05	1.781E-05		2.023E-17	1.876E-17	
24000.00	43200.00	1.806E-08	1.707E-05	1.707E-05		1.159E-17	1.077E-17	
25000.00	45000.00	1.583E-08	1.639E-05	1.639E-05		6.871E-18	6.399E-18	
26000.00	46800.00	1.398E-08	1.576E-05	1.576E-05		4.202E-18	3.922E-18	
27000.00	48600.00	1.242E-08	1.517E-05	1.517E-05		2.643E-18	2.472E-18	
28000.00	50400.00	1.110E-08	1.463E-05	1.463E-05		1.704E-18	1.597E-18	
29000.00	52200.00	9.962E-09	1.413E-05	1.413E-05		1.125E-18	1.056E-18	
30000.00	54000.00	8.976E-09	1.366E-05	1.366E-05		7.576E-19	7.129E-19	
32000.00	57600.00	7.375E-09	1.280E-05	1.280E-05		3.635E-19	3.434E-19	
34000.00	61200.00	6.134E-09	1.205E-05	1.205E-05		1.860E-19	1.763E-19	
36000.00	64800.00	5.160E-09	1.138E-05	1.138E-05		1.005E-19	9.561E-20	
38000.00	68400.00	4.383E-09	1.078E-05	1.078E-05		5.695E-20	5.435E-20	
40000.00	72000.00	3.753E-09	1.024E-05	1.024E-05		3.362E-20	3.218E-20	
43000.00	77400.00	3.019E-09	9.528E-06	9.528E-06		1.629E-20	1.565E-20	
46000.00	82800.00	2.463E-09	8.907E-06	8.907E-06		8.441E-21	8.141E-21	
50000.00	90000.00	1.917E-09	8.194E-06	8.194E-06		3.830E-21	3.710E-21	
55000.00	99000.00	1.439E-09	7.449E-06	7.449E-06		1.597E-21	1.554E-21	
60000.00	108000.00	1.108E-09	6.829E-06	6.829E-06		7.359E-22	7.192E-22	
65000.00	117000.00	8.712E-10	6.303E-06	6.303E-06		3.676E-22	3.606E-22	
70000.00	126000.00	6.971E-10	5.853E-06	5.853E-06		1.962E-22	1.930E-22	
80000.00	144000.00	4.668E-10	5.121E-06	5.121E-06		6.539E-23	6.467E-23	
90000.00	162000.00	3.277E-10	4.552E-06	4.552E-06		2.559E-23	2.541E-23	
100000.00	180000.00	2.388E-10	4.097E-06	4.097E-06		1.130E-23	1.126E-23	
110000.00	198000.00	1.794E-10	3.725E-06	3.725E-06		5.481E-24	5.477E-24	

TABLE I. - Continued. CONCENTRATIONS OF SPECIES IN SPIN-EQUILIBRATED HYDROGEN IN CHEMICAL EQUILIBRIUM IN DEBYE-HÜCKEL APPROXIMATION

[E-02, E-03, E+02, E+03, etc., after numbers signify that numbers are to be multiplied by 10^{-2}, 10^{-3}, 10^{2}, 10^{3}, etc.]

(c) Pressure, 1.01325×10^{3} N/m^2 (0.01 atm)

Temperature, T		Species						
K	^{o}R	H	H^+	e^-	H_2	H^-	H_2^+	H_3^+
		Dimensionless concentration, n_iN_o/VL_o						
100.00	180.00				2.732E-02			
150.00	270.00				1.821E-02			
200.00	360.00				1.366E-02			
250.00	450.00				1.093E-02			
298.15	536.67	2.244E-37			9.162E-03			
400.00	720.00	9.113E-28			6.829E-03			
500.00	900.00	3.799E-22			5.463E-03			
600.00	1080.00	2.101E-18			4.553E-03			
700.00	1260.00	9.846E-16			3.902E-03			
800.00	1440.00	9.868E-14			3.414E-03			
900.00	1620.00	3.538E-12			3.035E-03			
1000.00	1800.00	6.181E-11			2.732E-03			
1100.00	1980.00	6.400E-10			2.483E-03			
1200.00	2160.00	4.477E-09			2.276E-03			
1300.00	2340.00	2.316E-08			2.101E-03			
1400.00	2520.00	9.457E-08		8.077E-24	1.951E-03	2.416E-29		8.077E-24
1500.00	2700.00	3.194E-07		1.807E-22	1.821E-03	1.078E-27		1.807E-22
1600.00	2880.00	9.247E-07		2.743E-21	1.706E-03	2.958E-26		2.743E-21
1700.00	3060.00	2.358E-06		3.023E-20	1.604E-03	5.464E-25		3.024E-20
1800.00	3240.00	5.405E-06		2.552E-19	1.512E-03	7.245E-24		2.552E-19
1900.00	3420.00	1.132E-05		1.719E-18	1.426E-03	7.257E-23		1.719E-18
2000.00	3600.00	2.195E-05	9.994E-22	9.542E-18	1.344E-03	5.717E-22	1.553E-23	9.541E-18
2100.00	3780.00	3.975E-05	1.777E-20	4.479E-17	1.261E-03	3.650E-21	2.410E-22	4.477E-17
2200.00	3960.00	6.775E-05	2.442E-19	1.813E-16	1.174E-03	1.934E-20	2.910E-21	1.810E-16
2300.00	4140.00	1.091E-04	2.684E-18	6.422E-16	1.078E-03	8.653E-20	2.819E-20	6.395E-15
2400.00	4320.00	1.666E-04	2.426E-17	2.017E-15	9.715E-04	3.310E-19	2.242E-19	1.992E-15
2500.00	4500.00	2.415E-04	1.844E-16	5.673E-15	8.511E-04	1.094E-18	1.489E-18	5.488E-15
2600.00	4680.00	3.322E-04	1.193E-15	1.449E-14	7.184E-04	3.157E-18	8.319E-18	1.329E-14
2700.00	4860.00	4.330E-04	6.569E-15	3.439E-14	5.786E-04	8.124E-18	3.883E-17	2.779E-14
2800.00	5040.00	5.346E-04	3.016E-14	7.874E-14	4.410E-04	1.932E-17	1.478E-16	4.845E-14
2900.00	5220.00	6.252E-04	1.128E-13	1.813E-13	3.167E-04	4.420E-17	4.468E-16	6.812E-14
3000.00	5400.00	6.956E-04	3.458E-13	4.244E-13	2.149E-04	9.872E-17	1.081E-15	7.760E-14
3100.00	5580.00	7.418E-04	9.093E-13	9.867E-13	1.393E-04	2.116E-16	2.201E-15	7.537E-14
3200.00	5760.00	7.658E-04	2.149E-12	2.219E-12	8.776E-05	4.280E-16	3.982E-15	6.628E-14
3400.00	6120.00	7.694E-04	9.741E-12	9.795E-12	3.398E-05	1.471E-15	1.054E-14	4.472E-14
3600.00	6480.00	7.451E-04	3.640E-11	3.645E-11	1.362E-05	4.202E-15	2.365E-14	2.877E-14
3800.00	6840.00	7.130E-04	1.176E-10	1.176E-10	5.842E-06	1.050E-14	4.781E-14	1.878E-14
4000.00	7200.00	6.802E-04	3.371E-10	3.372E-10	2.691E-06	2.353E-14	8.955E-14	1.265E-14
4200.00	7560.00	6.490E-04	8.738E-10	8.739E-10	1.325E-06	4.883E-14	1.577E-13	8.812E-15
4400.00	7920.00	6.201E-04	2.078E-09	2.078E-09	6.932E-07	9.390E-14	2.638E-13	6.341E-15
4600.00	8280.00	5.934E-04	4.583E-09	4.583E-09	3.824E-07	1.697E-13	4.220E-13	4.697E-15
4800.00	8640.00	5.688E-04	9.467E-09	9.467E-09	2.211E-07	2.908E-13	6.495E-13	3.571E-15
5000.00	9000.00	5.461E-04	1.846E-08	1.846E-08	1.333E-07	4.753E-13	9.662E-13	2.779E-15
5200.00	9360.00	5.251E-04	3.421E-08	3.421E-08	8.337E-08	7.453E-13	1.394E-12	2.207E-15
5400.00	9720.00	5.057E-04	6.058E-08	6.058E-08	5.391E-08	1.127E-12	1.959E-12	1.785E-15
5600.00	10080.00	4.875E-04	1.030E-07	1.030E-07	3.591E-08	1.649E-12	2.686E-12	1.470E-15
5800.00	10440.00	4.706E-04	1.690E-07	1.690E-07	2.456E-08	2.344E-12	3.604E-12	1.227E-15
6000.00	10800.00	4.547E-04	2.681E-07	2.681E-07	1.720E-08	3.245E-12	4.739E-12	1.038E-15
6300.00	11340.00	4.325E-04	5.076E-07	5.076E-07	1.049E-08	5.058E-12	6.911E-12	8.259E-16
6600.00	11880.00	4.120E-04	9.067E-07	9.067E-07	6.666E-09	7.525E-12	9.718E-12	6.717E-16

TABLE I. - Continued. CONCENTRATIONS OF SPECIES IN SPIN-EQUILIBRATED HYDROGEN IN CHEMICAL EQUILIBRIUM IN DEBYE-HÜCKEL APPROXIMATION

[E-02, E-03, E+02, E+03, etc., after numbers signify that numbers are to be multiplied by 10^{-2}, 10^{-3}, 10^{2}, 10^{3}, etc.]

(c) Concluded. Pressure, 1.01325×10^{3} N/m^2 (0.01 atm)

Temperature, T		Species						
K	°R	H	H^+	e^-	H_2	H^-	H_2^+	H_3^+
		Dimensionless concentration, $n_i N_o/VL_o$						
7000.00	12600.00	3.866E-04	1.818E-06	1.818E-06	3.837E-09	1.200E-11	1.456E-11	5.241E-16
7300.00	13140.00	3.684E-04	2.912E-06	2.912E-06	2.619E-09	1.631E-11	1.904E-11	4.416E-16
7600.00	13680.00	3.504E-04	4.487E-06	4.487E-06	1.825E-09	2.144E-11	2.422E-11	3.750E-16
8000.00	14400.00	3.263E-04	7.566E-06	7.566E-06	1.154E-09	2.939E-11	3.200E-11	3.025E-16
8300.00	14940.00	3.075E-04	1.079E-05	1.079E-05	8.266E-10	3.590E-11	3.819E-11	2.565E-16
8600.00	15480.00	2.878E-04	1.494E-05	1.494E-05	5.932E-10	4.247E-11	4.429E-11	2.151E-16
9000.00	16200.00	2.594E-04	2.208E-05	2.208E-05	3.780E-10	5.046E-11	5.144E-11	1.653E-16
9300.00	16740.00	2.365E-04	2.867E-05	2.867E-05	2.656E-10	5.507E-11	5.535E-11	1.315E-16
9600.00	17280.00	2.121E-04	3.627E-05	3.627E-05	1.828E-10	5.781E-11	5.738E-11	1.010E-16
10000.00	18000.00	1.781E-04	4.762E-05	4.762E-05	1.063E-10	5.772E-11	5.649E-11	6.625E-17
10500.00	18900.00	1.351E-04	6.264E-05	6.264E-05	4.916E-11	5.126E-11	4.946E-11	3.407E-17
11000.00	19800.00	9.542E-05	7.662E-05	7.662E-05	2.011E-11	3.963E-11	3.781E-11	1.470E-17
11500.00	20700.00	6.275E-05	8.758E-05	8.758E-05	7.273E-12	2.680E-11	2.534E-11	5.312E-18
12000.00	21600.00	3.898E-05	9.453E-05	9.453E-05	2.389E-12	1.621E-11	1.522E-11	1.660E-18
12500.00	22500.00	2.344E-05	9.775E-05	9.775E-05	7.468E-13	9.101E-12	8.495E-12	4.741E-19
13000.00	23400.00	1.399E-05	9.826E-05	9.826E-05	2.337E-13	4.924E-12	4.575E-12	1.312E-19
13500.00	24300.00	8.453E-06	9.712E-05	9.712E-05	7.619E-14	2.642E-12	2.447E-12	3.673E-20
14000.00	25200.00	5.242E-06	9.510E-05	9.510E-05	2.652E-14	1.432E-12	1.322E-12	1.069E-20
15000.00	27000.00	2.237E-06	9.007E-05	9.007E-05	4.077E-15	4.476E-13	4.120E-13	1.064E-21
16000.00	28800.00	1.115E-06	8.492E-05	8.492E-05	8.558E-16	1.544E-13	1.419E-13	1.325E-22
17000.00	30600.00	6.451E-07	8.011E-05	8.011E-05	2.310E-16	5.862E-14	5.386E-14	2.025E-23
18000.00	32400.00	4.223E-07	7.574E-05	7.574E-05		2.422E-14	2.227E-14	
19000.00	34200.00	3.037E-07	7.180E-05	7.180E-05		1.078E-14	9.921E-15	
20000.00	36000.00	2.334E-07	6.823E-05	6.823E-05		5.116E-15	4.717E-15	
21000.00	37800.00	1.877E-07	6.499E-05	6.499E-05		2.570E-15	2.373E-15	
22000.00	39600.00	1.555E-07	6.205E-05	6.205E-05		1.356E-15	1.255E-15	
23000.00	41400.00	1.318E-07	5.935E-05	5.935E-05		7.474E-16	6.930E-16	
24000.00	43200.00	1.135E-07	5.688E-05	5.688E-05		4.282E-16	3.979E-16	
25000.00	45000.00	9.883E-08	5.461E-05	5.461E-05		2.540E-16	2.365E-16	
26000.00	46800.00	8.683E-08	5.251E-05	5.251E-05		1.553E-15	1.450E-16	
27000.00	48600.00	7.686E-08	5.057E-05	5.057E-05		9.771E-17	9.138E-17	
28000.00	50400.00	6.850E-08	4.876E-05	4.876E-05		6.302E-17	5.907E-17	
29000.00	52200.00	6.136E-08	4.708E-05	4.708E-05		4.159E-17	3.906E-17	
30000.00	54000.00	5.522E-08	4.552E-05	4.552E-05		2.802E-17	2.637E-17	
32000.00	57600.00	4.522E-08	4.267E-05	4.267E-05		1.345E-17	1.270E-17	
34000.00	61200.00	3.758E-08	4.016E-05	4.016E-05		6.881E-18	6.523E-18	
36000.00	64800.00	3.158E-08	3.793E-05	3.793E-05		3.719E-18	3.538E-18	
38000.00	68400.00	2.679E-08	3.594E-05	3.594E-05		2.108E-18	2.011E-18	
40000.00	72000.00	2.294E-08	3.414E-05	3.414E-05		1.244E-18	1.191E-18	
43000.00	77400.00	1.844E-08	3.176E-05	3.176E-05		6.029E-19	5.794E-19	
46000.00	82800.00	1.503E-08	2.969E-05	2.969E-05		3.124E-19	3.013E-19	
50000.00	90000.00	1.170E-08	2.731E-05	2.731E-05		1.418E-19	1.373E-19	
55000.00	99000.00	8.777E-09	2.483E-05	2.483E-05		5.911E-20	5.753E-20	
60000.00	108000.00	6.757E-09	2.276E-05	2.276E-05		2.725E-20	2.663E-20	
65000.00	117000.00	5.310E-09	2.101E-05	2.101E-05		1.361E-20	1.335E-20	
70000.00	126000.00	4.250E-09	1.951E-05	1.951E-05		7.266E-21	7.148E-21	
80000.00	144000.00	2.845E-09	1.707E-05	1.707E-05		2.421E-21	2.395E-21	
90000.00	162000.00	1.997E-09	1.517E-05	1.517E-05		9.475E-22	9.410E-22	
100000.00	180000.00	1.455E-09	1.366E-05	1.366E-05		4.184E-22	4.170E-22	
110000.00	198000.00	1.093E-09	1.242E-05	1.242E-05		2.030E-22	2.028E-22	

TABLE I. - Continued. CONCENTRATIONS OF SPECIES IN SPIN-EQUILIBRATED HYDROGEN IN CHEMICAL EQUILIBRIUM IN DEBYE-HÜCKEL APPROXIMATION

[E-02, E-03, E+02, E+03, etc., after numbers signify that numbers are to be multiplied by 10^{-2}, 10^{-3}, 10^{2}, 10^{3}, etc.]

(d) Pressure, 3.03975×10^{3} N/m^2 (0.03 atm)

Temperature, T		Species						
K	°R	H	H^+	e^-	H_2	H^-	H_2^+	H_3^+
		Dimensionless concentration, $n_i N_o / V L_o$						
100.00	180.00				8.195E-02			
150.00	270.00				5.463E-02			
200.00	360.00				4.097E-02			
250.00	450.00				3.278E-02			
298.15	536.67	3.886E-37			2.748E-02			
400.00	720.00	1.578E-27			2.049E-02			
500.00	900.00	6.580E-22			1.639E-02			
600.00	1080.00	3.640E-18			1.366E-02			
700.00	1260.00	1.705E-15			1.171E-02			
800.00	1440.00	1.709E-13			1.024E-02			
900.00	1620.00	6.129E-12			9.105E-03			
1000.00	1800.00	1.071E-10			8.195E-03			
1100.00	1980.00	1.108E-09			7.450E-03			
1200.00	2160.00	7.754E-09			6.829E-03			
1300.00	2340.00	4.012E-08			6.303E-03			
1400.00	2520.00	1.638E-07		1.841E-23	5.853E-03	9.558E-29		1.841E-23
1500.00	2700.00	5.532E-07		4.120E-22	5.462E-03	4.252E-27		4.120E-22
1600.00	2880.00	1.602E-06		6.253E-21	5.120E-03	1.168E-25		6.253E-21
1700.00	3060.00	4.085E-06		6.895E-20	4.816E-03	2.160E-24		6.895E-20
1800.00	3240.00	9.369E-06		5.824E-19	4.543E-03	2.866E-23		5.824E-19
1900.00	3420.00	1.965E-05		3.928E-18	4.293E-03	2.878E-22		3.929E-18
2000.00	3600.00	3.816E-05	7.581E-22	2.186E-17	4.059E-03	2.276E-21	2.047E-23	2.186E-17
2100.00	3780.00	6.932E-05	1.346E-20	1.031E-16	3.833E-03	1.465E-20	3.183E-22	1.031E-16
2200.00	3960.00	1.187E-04	1.845E-19	4.204E-16	3.606E-03	7.863E-20	3.855E-21	4.203E-16
2300.00	4140.00	1.929E-04	2.022E-18	1.507E-15	3.370E-03	3.590E-19	3.753E-20	1.505E-15
2400.00	4320.00	2.985E-04	1.821E-17	4.813E-15	3.116E-03	1.415E-18	3.013E-19	4.796E-15
2500.00	4500.00	4.410E-04	1.381E-16	1.383E-14	2.837E-03	4.858E-18	2.036E-18	1.370E-14
2600.00	4680.00	6.232E-04	8.984E-16	3.612E-14	2.529E-03	1.476E-17	1.175E-17	3.522E-14
2700.00	4860.00	8.429E-04	5.081E-15	8.654E-14	2.192E-03	3.979E-17	5.846E-17	8.144E-14
2800.00	5040.00	1.091E-03	2.509E-14	1.931E-13	1.836E-03	9.665E-17	2.509E-16	1.679E-13
2900.00	5220.00	1.350E-03	1.075E-13	4.107E-13	1.476E-03	2.152E-16	9.192E-16	3.025E-13
3000.00	5400.00	1.598E-03	3.924E-13	8.592E-13	1.134E-03	4.591E-16	2.818E-15	4.645E-13
3100.00	5580.00	1.812E-03	1.209E-12	1.813E-12	8.314E-04	9.498E-16	7.148E-15	5.979E-13
3200.00	5760.00	1.975E-03	3.189E-12	3.858E-12	5.844E-04	1.921E-15	1.525E-14	6.551E-13
3400.00	6120.00	2.146E-03	1.601E-11	1.662E-11	2.643E-04	6.960E-15	4.832E-14	5.717E-13
3600.00	6480.00	2.162E-03	6.179E-11	6.229E-11	1.147E-04	2.084E-14	1.165E-13	4.110E-13
3800.00	6840.00	2.105E-03	2.019E-10	2.023E-10	5.095E-05	5.333E-14	2.424E-13	2.811E-13
4000.00	7200.00	2.025E-03	5.814E-10	5.819E-10	2.385E-05	1.214E-13	4.598E-13	1.933E-13
4200.00	7560.00	1.939E-03	1.510E-09	1.511E-09	1.183E-05	2.523E-13	8.144E-13	1.360E-13
4400.00	7920.00	1.856E-03	3.594E-09	3.595E-09	6.211E-06	4.854E-13	1.366E-12	9.829E-14
4600.00	8280.00	1.778E-03	7.932E-09	7.934E-09	3.433E-06	8.803E-13	2.189E-12	7.299E-14
4800.00	8640.00	1.705E-03	1.639E-08	1.639E-08	1.987E-06	1.509E-12	3.371E-12	5.555E-14
5000.00	9000.00	1.639E-03	3.197E-08	3.197E-08	1.198E-06	2.468E-12	5.017E-12	4.327E-14
5200.00	9360.00	1.575E-03	5.925E-08	5.926E-08	7.500E-07	3.872E-12	7.244E-12	3.439E-14
5400.00	9720.00	1.517E-03	1.049E-07	1.049E-07	4.851E-07	5.856E-12	1.018E-11	2.784E-14
5600.00	10080.00	1.463E-03	1.785E-07	1.785E-07	3.232E-07	8.571E-12	1.396E-11	2.292E-14
5800.00	10440.00	1.412E-03	2.927E-07	2.928E-07	2.211E-07	1.219E-11	1.874E-11	1.914E-14
6000.00	10800.00	1.365E-03	4.647E-07	4.647E-07	1.550E-07	1.688E-11	2.465E-11	1.621E-14
6300.00	11340.00	1.299E-03	8.799E-07	8.799E-07	9.460E-08	2.633E-11	3.597E-11	1.291E-14
6600.00	11880.00	1.238E-03	1.573E-06	1.573E-06	6.021E-08	3.923E-11	5.066E-11	1.052E-14

TABLE I. - Continued. CONCENTRATIONS OF SPECIES IN SPIN-EQUILIBRATED HYDROGEN IN CHEMICAL EQUILIBRIUM IN DEBYE-HÜCKEL APPROXIMATION

[E-02, E-03, E+02, E+03, etc., after numbers signify that numbers are to be multiplied by 10^{-2}, 10^{-3}, 10^{2}, 10^{3}, etc.]

(d) Concluded. Pressure, 3.03975×10^{3} N/m^2 (0.03 atm)

Temperature, T		Species						
		H	H^+	e^-	H_2	H^-	H_2^+	H_3^+
K	^{o}R	Dimensionless concentration, $n_i N_o / V L_o$						
7000.00	12600.00	1.164E-03	3.158E-06	3.158E-06	3.481E-08	6.274E-11	7.614E-11	8.255E-15
7300.00	13140.00	1.112E-03	5.064E-06	5.065E-06	2.388E-08	8.566E-11	1.000E-10	7.004E-15
7600.00	13680.00	1.063E-03	7.821E-06	7.821E-06	1.678E-08	1.133E-10	1.280E-10	6.009E-15
8000.00	14400.00	9.979E-04	1.325E-05	1.325E-05	1.079E-08	1.574E-10	1.713E-10	4.954E-15
8300.00	14940.00	9.494E-04	1.898E-05	1.898E-05	7.877E-09	1.950E-10	2.074E-10	4.300E-15
8600.00	15480.00	9.000E-04	2.646E-05	2.646E-05	5.802E-09	2.353E-10	2.453E-10	3.726E-15
9000.00	16200.00	8.315E-04	3.959E-05	3.959E-05	3.884E-09	2.901E-10	2.957E-10	3.045E-15
9300.00	16740.00	7.772E-04	5.208E-05	5.208E-05	2.870E-09	3.288E-10	3.305E-10	2.581E-15
9600.00	17280.00	7.200E-04	6.696E-05	6.696E-05	2.107E-09	3.623E-10	3.596E-10	2.149E-15
10000.00	18000.00	6.391E-04	9.042E-05	9.042E-05	1.369E-09	3.934E-10	3.851E-10	1.621E-15
10500.00	18900.00	5.319E-04	1.246E-04	1.246E-04	7.616E-10	4.018E-10	3.877E-10	1.052E-15
11000.00	19800.00	4.223E-04	1.618E-04	1.618E-04	3.940E-10	3.712E-10	3.541E-10	6.105E-16
11500.00	20700.00	3.177E-04	1.981E-04	1.981E-04	1.864E-10	3.080E-10	2.912E-10	3.102E-16
12000.00	21600.00	2.261E-04	2.292E-04	2.292E-04	8.017E-11	2.294E-10	2.153E-10	1.371E-16
12500.00	22500.00	1.530E-04	2.521E-04	2.521E-04	3.171E-11	1.550E-10	1.446E-10	5.330E-17
13000.00	23400.00	9.995E-05	2.661E-04	2.661E-04	1.184E-11	9.701E-11	9.014E-11	1.880E-17
13500.00	24300.00	6.411E-05	2.723E-04	2.723E-04	4.327E-12	5.779E-11	5.352E-11	6.267E-18
14000.00	25200.00	4.109E-05	2.729E-04	2.729E-04	1.601E-12	3.360E-11	3.103E-11	2.051E-18
15000.00	27000.00	1.769E-05	2.650E-04	2.650E-04	2.497E-13	1.132E-11	1.042E-11	2.314E-19
16000.00	28800.00	8.485E-06	2.524E-04	2.524E-04	4.971E-14	4.033E-12	3.707E-12	3.039E-20
17000.00	30600.00	4.613E-06	2.392E-04	2.392E-04	1.260E-14	1.552E-12	1.426E-12	4.756E-21
18000.00	32400.00	2.824E-06	2.266E-04	2.266E-04	3.891E-15	6.457E-13	5.937E-13	8.781E-22
19000.00	34200.00	1.912E-06	2.150E-04	2.150E-04	1.395E-15	2.884E-13	2.654E-13	1.876E-22
20000.00	36000.00	1.400E-06	2.045E-04	2.045E-04	5.595E-16	1.372E-13	1.265E-13	4.545E-23
21000.00	37800.00	1.085E-06	1.948E-04	1.948E-04	2.445E-16	6.898E-14	6.371E-14	1.229E-23
22000.00	39600.00	8.766E-07	1.860E-04	1.860E-04		3.643E-14	3.371E-14	
23000.00	41400.00	7.285E-07	1.780E-04	1.780E-04		2.009E-14	1.863E-14	
24000.00	43200.00	6.182E-07	1.706E-04	1.706E-04		1.152E-14	1.070E-14	
25000.00	45000.00	5.333E-07	1.638E-04	1.638E-04		6.834E-15	6.364E-15	
26000.00	46800.00	4.653E-07	1.575E-04	1.575E-04		4.182E-15	3.903E-15	
27000.00	48600.00	4.098E-07	1.517E-04	1.517E-04		2.631E-15	2.460E-15	
28000.00	50400.00	3.635E-07	1.463E-04	1.463E-04		1.697E-15	1.591E-15	
29000.00	52200.00	3.244E-07	1.412E-04	1.412E-04		1.120E-15	1.052E-15	
30000.00	54000.00	2.911E-07	1.365E-04	1.365E-04		7.549E-16	7.104E-16	
32000.00	57600.00	2.379E-07	1.280E-04	1.280E-04		3.624E-16	3.423E-16	
34000.00	61200.00	1.971E-07	1.205E-04	1.205E-04		1.855E-16	1.758E-16	
36000.00	64800.00	1.653E-07	1.138E-04	1.138E-04		1.003E-16	9.538E-17	
38000.00	68400.00	1.401E-07	1.078E-04	1.078E-04		5.683E-17	5.423E-17	
40000.00	72000.00	1.199E-07	1.024E-04	1.024E-04		3.356E-17	3.211E-17	
43000.00	77400.00	9.623E-08	9.527E-05	9.527E-05		1.626E-17	1.563E-17	
46000.00	82800.00	7.844E-08	8.906E-05	8.906E-05		8.428E-18	8.129E-18	
50000.00	90000.00	6.100E-08	8.193E-05	8.193E-05		3.825E-18	3.705E-18	
55000.00	99000.00	4.572E-08	7.449E-05	7.449E-05		1.595E-18	1.552E-18	
60000.00	108000.00	3.520E-08	6.828E-05	6.828E-05		7.352E-19	7.185E-19	
65000.00	117000.00	2.765E-08	6.303E-05	6.303E-05		3.674E-19	3.603E-19	
70000.00	126000.00	2.212E-08	5.853E-05	5.853E-05		1.961E-19	1.929E-19	
80000.00	144000.00	1.480E-08	5.121E-05	5.121E-05		6.536E-20	6.464E-20	
90000.00	162000.00	1.039E-08	4.552E-05	4.552E-05		2.558E-20	2.540E-20	
100000.00	180000.00	7.569E-09	4.097E-05	4.097E-05		1.130E-20	1.126E-20	
110000.00	198000.00	5.685E-09	3.725E-05	3.725E-05		5.479E-21	5.476E-21	

TABLE I. - Continued. CONCENTRATIONS OF SPECIES IN SPIN-EQUILIBRATED HYDROGEN IN CHEMICAL EQUILIBRIUM IN DEBYE-HÜCKEL APPROXIMATION

[E-02, E-03, E+02, E+03, etc., after numbers signify that numbers are to be multiplied by 10^{-2}, 10^{-3}, 10^{2}, 10^{3}, etc.]

(e) Pressure, 1.01325×10^{4} N/m^2 (0.1 atm)

Temperature, T		Species						
K	^{o}R	H	H^+	e^-	H_2	H^-	H_2^+	H_3^+
		Dimensionless concentration, n_iN_o/VL_o						
100.00	180.00				2.732E-01			
150.00	270.00				1.821E-01			
200.00	360.00				1.366E-01			
250.00	450.00				1.093E-01			
298.15	536.67	7.095E-37			9.162E-02			
400.00	720.00	2.882E-27			6.829E-02			
500.00	900.00	1.201E-21			5.463E-02			
600.00	1080.00	6.645E-18			4.553E-02			
700.00	1260.00	3.114E-15			3.902E-02			
800.00	1440.00	3.120E-13			3.414E-02			
900.00	1620.00	1.119E-11			3.035E-02			
1000.00	1800.00	1.955E-10			2.732E-02			
1100.00	1980.00	2.024E-09			2.483E-02			
1200.00	2160.00	1.416E-08			2.276E-02			
1300.00	2340.00	7.325E-08			2.101E-02			
1400.00	2520.00	2.991E-07		4.542E-23	1.951E-02	4.303E-28		4.542E-23
1500.00	2700.00	1.010E-06		1.016E-21	1.821E-02	1.915E-26		1.016E-21
1600.00	2880.00	2.925E-06		1.543E-20	1.707E-02	5.264E-25		1.543E-20
1700.00	3060.00	7.459E-06		1.701E-19	1.606E-02	9.729E-24		1.702E-19
1800.00	3240.00	1.711E-05		1.438E-18	1.516E-02	1.293E-22		1.438E-18
1900.00	3420.00	3.591E-05		9.705E-18	1.434E-02	1.300E-21		9.707E-18
2000.00	3600.00	6.981E-05	5.605E-22	5.410E-17	1.359E-02	1.031E-20	2.769E-23	5.411E-17
2100.00	3780.00	1.271E-04	9.944E-21	2.558E-16	1.288E-02	6.654E-20	4.310E-22	2.559E-16
2200.00	3960.00	2.184E-04	1.361E-19	1.048E-15	1.220E-02	3.606E-19	5.229E-21	1.048E-15
2300.00	4140.00	3.567E-04	1.488E-18	3.787E-15	1.152E-02	1.667E-18	5.106E-20	3.787E-15
2400.00	4320.00	5.563E-04	1.336E-17	1.223E-14	1.083E-02	6.700E-18	4.120E-19	1.222E-14
2500.00	4500.00	8.318E-04	1.009E-16	3.570E-14	1.009E-02	2.370E-17	2.806E-18	3.562E-14
2600.00	4680.00	1.195E-03	6.547E-16	9.510E-14	9.310E-03	7.458E-17	1.643E-17	9.450E-14
2700.00	4860.00	1.656E-03	3.708E-15	2.330E-13	8.461E-03	2.104E-16	8.382E-17	2.294E-13
2800.00	5040.00	2.211E-03	1.857E-14	5.289E-13	7.544E-03	5.366E-16	3.765E-16	5.105E-13
2900.00	5220.00	2.848E-03	8.294E-14	1.123E-12	6.571E-03	1.247E-15	1.497E-15	1.040E-12
3000.00	5400.00	3.540E-03	3.310E-13	2.257E-12	5.565E-03	2.671E-15	5.267E-15	1.923E-12
3100.00	5580.00	4.246E-03	1.174E-12	4.374E-12	4.565E-03	5.369E-15	1.627E-14	3.189E-12
3200.00	5760.00	4.918E-03	3.664E-12	8.356E-12	3.618E-03	1.035E-14	4.359E-14	4.659E-12
3400.00	6120.00	5.981E-03	2.403E-11	3.086E-11	2.053E-03	3.602E-14	2.022E-13	6.665E-12
3600.00	6480.00	6.538E-03	1.045E-10	1.114E-10	1.049E-03	1.127E-13	5.959E-13	6.361E-12
3800.00	6840.00	6.675E-03	3.569E-10	3.629E-10	5.122E-04	3.033E-13	1.359E-12	4.995E-12
4000.00	7200.00	6.577E-03	1.046E-09	1.051E-09	2.516E-04	7.124E-13	2.686E-12	3.663E-12
4200.00	7560.00	6.375E-03	2.736E-09	2.742E-09	1.279E-04	1.505E-12	4.851E-12	2.663E-12
4400.00	7920.00	6.140E-03	6.535E-09	6.542E-09	6.796E-05	2.927E-12	8.215E-12	1.955E-12
4600.00	8280.00	5.900E-03	1.445E-08	1.446E-08	3.780E-05	5.324E-12	1.323E-11	1.464E-12
4800.00	8640.00	5.669E-03	2.989E-08	2.990E-08	2.196E-05	9.151E-12	2.043E-11	1.120E-12
5000.00	9000.00	5.450E-03	5.832E-08	5.834E-08	1.327E-05	1.499E-11	3.046E-11	8.741E-13
5200.00	9360.00	5.244E-03	1.081E-07	1.082E-07	8.315E-06	2.353E-11	4.402E-11	6.959E-13
5400.00	9720.00	5.053E-03	1.916E-07	1.916E-07	5.383E-06	3.561E-11	6.190E-11	5.639E-13
5600.00	10080.00	4.873E-03	3.259E-07	3.259E-07	3.588E-06	5.215E-11	8.494E-11	4.645E-13
5800.00	10440.00	4.705E-03	5.346E-07	5.347E-07	2.455E-06	7.417E-11	1.140E-10	3.883E-13
6000.00	10800.00	4.549E-03	8.488E-07	8.488E-07	1.722E-06	1.028E-10	1.501E-10	3.290E-13
6300.00	11340.00	4.331E-03	1.608E-06	1.608E-06	1.052E-06	1.604E-10	2.192E-10	2.623E-13
6600.00	11880.00	4.132E-03	2.875E-06	2.875E-06	6.704E-07	2.393E-10	3.090E-10	2.142E-13

TABLE I. - Continued. CONCENTRATIONS OF SPECIES IN SPIN-EQUILIBRATED HYDROGEN IN CHEMICAL EQUILIBRIUM IN DEBYE-HÜCKEL APPROXIMATION

[E-02, E-03, E+02, E+03, etc., after numbers signify that numbers are to be multiplied by 10^{-2}, 10^{-3}, 10^{2}, 10^{3}, etc.]

(e) Concluded. Pressure, 1.01325×10^{4} N/m^2 (0.1 atm)

Temperature, T		Species						
K	^{o}R	H	H^+	e^-	H_2	H^-	H_2^+	H_3^+
		Dimensionless concentration, $n_i N_o / V L_o$						
7000.00	12600.00	3.890E-03	5.777E-06	5.778E-06	3.886E-07	3.836E-10	4.655E-10	1.686E-13
7300.00	13140.00	3.723E-03	9.276E-06	9.276E-06	2.675E-07	5.251E-10	6.131E-10	1.437E-13
7600.00	13680.00	3.565E-03	1.434E-05	1.434E-05	1.889E-07	6.974E-10	7.878E-10	1.241E-13
8000.00	14400.00	3.366E-03	2.436E-05	2.437E-05	1.228E-07	9.763E-10	1.063E-09	1.037E-13
8300.00	14940.00	3.221E-03	3.503E-05	3.503E-05	9.067E-08	1.221E-09	1.299E-09	9.133E-14
8600.00	15480.00	3.078E-03	4.903E-05	4.903E-05	6.788E-08	1.491E-09	1.555E-09	8.077E-14
9000.00	16200.00	2.887E-03	7.396E-05	7.396E-05	4.684E-08	1.882E-09	1.918E-09	6.861E-14
9300.00	16740.00	2.742E-03	9.809E-05	9.809E-05	3.571E-08	2.184E-09	2.195E-09	6.049E-14
9600.00	17280.00	2.591E-03	1.274E-04	1.274E-04	2.729E-08	2.481E-09	2.463E-09	5.297E-14
10000.00	18000.00	2.382E-03	1.752E-04	1.752E-04	1.902E-08	2.842E-09	2.782E-09	4.366E-14
10500.00	18900.00	2.106E-03	2.490E-04	2.490E-04	1.193E-08	3.179E-09	3.067E-09	3.295E-14
11000.00	19800.00	1.813E-03	3.369E-04	3.369E-04	7.256E-09	3.319E-09	3.167E-09	2.345E-14
11500.00	20700.00	1.511E-03	4.345E-04	4.345E-04	4.211E-09	3.218E-09	3.042E-09	1.544E-14
12000.00	21600.00	1.212E-03	5.347E-04	5.347E-04	2.304E-09	2.881E-09	2.704E-09	9.270E-15
12500.00	22500.00	9.345E-04	6.287E-04	6.287E-04	1.179E-09	2.376E-09	2.217E-09	5.022E-15
13000.00	23400.00	6.920E-04	7.084E-04	7.084E-04	5.644E-10	1.808E-09	1.680E-09	2.454E-15
13500.00	24300.00	4.949E-04	7.682E-04	7.682E-04	2.553E-10	1.281E-09	1.187E-09	1.092E-15
14000.00	25200.00	3.451E-04	8.071E-04	8.071E-04	1.113E-10	8.578E-10	7.923E-10	4.523E-16
15000.00	27000.00	1.627E-04	8.330E-04	8.330E-04	2.062E-11	3.475E-10	3.199E-10	6.934E-17
16000.00	28800.00	7.905E-05	8.175E-04	8.175E-04	4.236E-12	1.355E-10	1.245E-10	1.059E-17
17000.00	30600.00	4.177E-05	7.854E-04	7.854E-04	1.041E-12	5.440E-11	4.999E-11	1.779E-18
18000.00	32400.00	2.425E-05	7.491E-04	7.491E-04	3.062E-13	2.311E-11	2.125E-11	3.403E-19
19000.00	34200.00	1.544E-05	7.133E-04	7.133E-04	1.052E-13	1.044E-11	9.607E-12	7.407E-20
20000.00	36000.00	1.066E-05	6.794E-04	6.794E-04	4.086E-14	4.995E-12	4.605E-12	1.814E-20
21000.00	37800.00	7.870E-06	6.480E-04	6.480E-04	1.745E-14	2.521E-12	2.329E-12	4.936E-21
22000.00	39600.00	6.109E-06	6.191E-04	6.191E-04	8.039E-15	1.335E-12	1.235E-12	1.471E-21
23000.00	41400.00	4.928E-06	5.926E-04	5.926E-04	3.943E-15	7.375E-13	6.838E-13	4.752E-22
24000.00	43200.00	4.092E-06	5.681E-04	5.681E-04	2.036E-15	4.232E-13	3.933E-13	1.645E-22
25000.00	45000.00	3.470E-06	5.455E-04	5.455E-04	1.098E-15	2.513E-13	2.341E-13	6.059E-23
26000.00	46800.00	2.989E-06	5.246E-04	5.246E-04		1.539E-13	1.436E-13	
27000.00	48600.00	2.607E-06	5.053E-04	5.053E-04		9.688E-14	9.061E-14	
28000.00	50400.00	2.295E-06	4.873E-04	4.873E-04		6.253E-14	5.861E-14	
29000.00	52200.00	2.036E-06	4.705E-04	4.705E-04		4.129E-14	3.878E-14	
30000.00	54000.00	1.819E-06	4.549E-04	4.549E-04		2.784E-14	2.619E-14	
32000.00	57600.00	1.477E-06	4.265E-04	4.265E-04		1.337E-14	1.263E-14	
34000.00	61200.00	1.219E-06	4.015E-04	4.015E-04		6.846E-15	6.490E-15	
36000.00	64800.00	1.019E-06	3.792E-04	3.792E-04		3.703E-15	3.522E-15	
38000.00	68400.00	8.615E-07	3.593E-04	3.593E-04		2.099E-15	2.003E-15	
40000.00	72000.00	7.361E-07	3.413E-04	3.413E-04		1.240E-15	1.187E-15	
43000.00	77400.00	5.904E-07	3.175E-04	3.175E-04		6.010E-16	5.776E-16	
46000.00	82800.00	4.807E-07	2.968E-04	2.968E-04		3.116E-16	3.005E-16	
50000.00	90000.00	3.729E-07	2.731E-04	2.731E-04		1.415E-16	1.370E-16	
55000.00	99000.00	2.798E-07	2.483E-04	2.483E-04		5.900E-17	5.743E-17	
60000.00	108000.00	2.150E-07	2.276E-04	2.276E-04		2.720E-17	2.658E-17	
65000.00	117000.00	1.689E-07	2.101E-04	2.101E-04		1.359E-17	1.333E-17	
70000.00	126000.00	1.351E-07	1.951E-04	1.951E-04		7.257E-18	7.140E-18	
80000.00	144000.00	9.029E-08	1.707E-04	1.707E-04		2.419E-18	2.393E-18	
90000.00	162000.00	6.339E-08	1.517E-04	1.517E-04		9.469E-19	9.404E-19	
100000.00	180000.00	4.614E-08	1.366E-04	1.366E-04		4.182E-19	4.167E-19	
110000.00	198000.00	3.466E-08	1.242E-04	1.242E-04		2.029E-19	2.027E-19	

TABLE I. - Continued. CONCENTRATIONS OF SPECIES IN SPIN-EQUILIBRATED HYDROGEN IN CHEMICAL EQUILIBRIUM IN DEBYE-HÜCKEL APPROXIMATION

[E-02, E-03, E+02, E+03, etc., after numbers signify that numbers are to be multiplied by 10^{-2}, 10^{-3}, 10^{2}, 10^{3}, etc.]

(f) Pressure, 3.03975×10^{4} N/m^2 (0.3 atm)

Temperature, T		Species						
K	^{o}R	H	H^+	e^-	H_2	H^-	H_2^+	H_3^+
		Dimensionless concentration, $n_i N_o / V L_o$						
100.00	180.00				8.195E-01			
150.00	270.00				5.463E-01			
200.00	360.00				4.097E-01			
250.00	450.00				3.278E-01			
298.15	536.67	1.229E-36			2.748E-01			
400.00	720.00	4.991E-27			2.049E-01			
500.00	900.00	2.081E-21			1.639E-01			
600.00	1080.00	1.151E-17			1.366E-01			
700.00	1260.00	5.393E-15			1.171E-01			
800.00	1440.00	5.405E-13			1.024E-01			
900.00	1620.00	1.938E-11			9.105E-02			
1000.00	1800.00	3.385E-10			8.195E-02			
1100.00	1980.00	3.505E-09			7.450E-02			
1200.00	2160.00	2.452E-08			6.829E-02			
1300.00	2340.00	1.269E-07			6.303E-02			
1400.00	2520.00	5.180E-07		1.035E-22	5.853E-02	1.698E-27		1.035E-22
1500.00	2700.00	1.750E-06		2.317E-21	5.463E-02	7.561E-26		2.317E-21
1600.00	2880.00	5.066E-06		3.517E-20	5.121E-02	2.079E-24		3.517E-20
1700.00	3060.00	1.292E-05		3.879E-19	4.819E-02	3.844E-23		3.879E-19
1800.00	3240.00	2.965E-05		3.278E-18	4.550E-02	5.107E-22		3.279E-18
1900.00	3420.00	6.222E-05		2.214E-17	4.307E-02	5.138E-21		2.215E-17
2000.00	3600.00	1.210E-04	4.257E-22	1.235E-16	4.085E-02	4.080E-20	3.647E-23	1.236E-16
2100.00	3780.00	2.206E-04	7.548E-21	5.849E-16	3.880E-02	2.644E-19	5.679E-22	5.852E-16
2200.00	3960.00	3.797E-04	1.032E-19	2.403E-15	3.687E-02	1.437E-18	6.896E-21	2.404E-15
2300.00	4140.00	6.217E-04	1.127E-18	8.713E-15	3.501E-02	6.688E-18	6.744E-20	8.719E-15
2400.00	4320.00	9.738E-04	1.010E-17	2.831E-14	3.317E-02	2.715E-17	5.454E-19	2.832E-14
2500.00	4500.00	1.465E-03	7.614E-17	8.335E-14	3.131E-02	9.746E-17	3.729E-18	8.336E-14
2600.00	4680.00	2.125E-03	4.925E-16	2.246E-13	2.939E-02	3.130E-16	2.196E-17	2.244E-13
2700.00	4860.00	2.978E-03	2.781E-15	5.586E-13	2.737E-02	9.077E-16	1.131E-16	5.567E-13
2800.00	5040.00	4.043E-03	1.391E-14	1.291E-12	2.522E-02	2.395E-15	5.157E-16	1.279E-12
2900.00	5220.00	5.321E-03	6.239E-14	2.788E-12	2.294E-02	5.786E-15	2.104E-15	2.730E-12
3000.00	5400.00	6.797E-03	2.530E-13	5.668E-12	2.052E-02	1.288E-14	7.731E-15	5.421E-12
3100.00	5580.00	8.431E-03	9.333E-13	1.093E-11	1.800E-02	2.664E-14	2.568E-14	9.995E-12
3200.00	5760.00	1.016E-02	3.135E-12	2.018E-11	1.545E-02	5.165E-14	7.706E-14	1.702E-11
3400.00	6120.00	1.355E-02	2.626E-11	6.401E-11	1.055E-02	1.693E-13	5.007E-13	3.742E-11
3600.00	6480.00	1.627E-02	1.445E-10	2.005E-10	6.494E-03	5.046E-13	2.050E-12	5.444E-11
3800.00	6840.00	1.789E-02	5.596E-10	6.201E-10	3.677E-03	1.389E-12	5.709E-12	5.624E-11
4000.00	7200.00	1.850E-02	1.730E-09	1.787E-09	1.990E-03	3.406E-12	1.250E-11	4.799E-11
4200.00	7560.00	1.844E-02	4.632E-09	4.686E-09	1.070E-03	7.439E-12	2.375E-11	3.771E-11
4400.00	7920.00	1.804E-02	1.118E-08	1.124E-08	5.865E-04	1.477E-11	4.129E-11	2.887E-11
4600.00	8280.00	1.748E-02	2.485E-08	2.491E-08	3.319E-04	2.718E-11	6.741E-11	2.211E-11
4800.00	8640.00	1.688E-02	5.155E-08	5.162E-08	1.945E-04	4.704E-11	1.049E-10	1.712E-11
5000.00	9000.00	1.627E-02	1.008E-07	1.009E-07	1.183E-04	7.735E-11	1.571E-10	1.346E-11
5200.00	9360.00	1.568E-02	1.870E-07	1.871E-07	7.437E-05	1.218E-10	2.277E-10	1.076E-11
5400.00	9720.00	1.513E-02	3.315E-07	3.317E-07	4.824E-05	1.845E-10	3.207E-10	8.746E-12
5600.00	10080.00	1.460E-02	5.642E-07	5.644E-07	3.220E-05	2.705E-10	4.406E-10	7.218E-12
5800.00	10440.00	1.410E-02	9.259E-07	9.261E-07	2.206E-05	3.850E-10	5.919E-10	6.041E-12
6000.00	10800.00	1.364E-02	1.470E-06	1.471E-06	1.548E-05	5.338E-10	7.796E-10	5.123E-12
6300.00	11340.00	1.299E-02	2.786E-06	2.787E-06	9.465E-06	8.341E-10	1.140E-09	4.090E-12
6600.00	11880.00	1.240E-02	4.985E-06	4.985E-06	6.036E-06	1.245E-09	1.608E-09	3.344E-12

TABLE I. - Continued. CONCENTRATIONS OF SPECIES IN SPIN-EQUILIBRATED HYDROGEN IN CHEMICAL EQUILIBRIUM IN DEBYE-HÜCKEL APPROXIMATION

[E-02, E-03, E+02, E+03, etc., after numbers signify that numbers are to be multiplied by 10^{-2}, 10^{-3}, 10^{2}, 10^{3}, etc.]

(f) Concluded. Pressure, 3.03975×10^{4} N/m^2 (0.3 atm)

Temperature, T		Species						
K	°R	H	H^+	e^-	H_2	H^-	H_2^+	H_3^+
		Dimensionless concentration, $n_i N_o / V L_o$						
7000.00	12600.00	1.168E-02	1.002E-05	1.002E-05	3.505E-06	1.999E-09	2.425E-09	2.639E-12
7300.00	13140.00	1.119E-02	1.610E-05	1.610E-05	2.417E-06	2.740E-09	3.199E-09	2.254E-12
7600.00	13680.00	1.073E-02	2.493E-05	2.493E-05	1.711E-06	3.648E-09	4.120E-09	1.953E-12
8000.00	14400.00	1.016E-02	4.241E-05	4.241E-05	1.118E-06	5.129E-09	5.584E-09	1.644E-12
8300.00	14940.00	9.750E-03	6.108E-05	6.108E-05	8.309E-07	6.443E-09	6.854E-09	1.459E-12
8600.00	15480.00	9.357E-03	8.571E-05	8.571E-05	6.272E-07	7.923E-09	8.262E-09	1.304E-12
9000.00	16200.00	8.846E-03	1.298E-04	1.298E-04	4.396E-07	1.012E-08	1.032E-08	1.130E-12
9300.00	16740.00	8.467E-03	1.729E-04	1.729E-04	3.406E-07	1.189E-08	1.195E-08	1.017E-12
9600.00	17280.00	8.086E-03	2.259E-04	2.259E-04	2.657E-07	1.373E-08	1.363E-08	9.145E-13
10000.00	18000.00	7.571E-03	3.135E-04	3.135E-04	1.921E-07	1.616E-08	1.582E-08	7.891E-13
10500.00	18900.00	6.904E-03	4.530E-04	4.530E-04	1.283E-07	1.896E-08	1.830E-08	6.448E-13
11000.00	19800.00	6.204E-03	6.267E-04	6.267E-04	8.501E-08	2.114E-08	2.017E-08	5.115E-13
11500.00	20700.00	5.473E-03	8.322E-04	8.322E-04	5.526E-08	2.235E-08	2.113E-08	3.889E-13
12000.00	21600.00	4.719E-03	1.063E-03	1.063E-03	3.488E-08	2.232E-08	2.095E-08	2.801E-13
12500.00	22500.00	3.963E-03	1.306E-03	1.306E-03	2.118E-08	2.100E-08	1.960E-08	1.889E-13
13000.00	23400.00	3.233E-03	1.547E-03	1.547E-03	1.229E-08	1.855E-08	1.724E-08	1.183E-13
13500.00	24300.00	2.559E-03	1.769E-03	1.769E-03	6.792E-09	1.540E-08	1.426E-08	6.851E-14
14000.00	25200.00	1.968E-03	1.958E-03	1.958E-03	3.586E-09	1.205E-08	1.113E-08	3.676E-14
15000.00	27000.00	1.084E-03	2.206E-03	2.206E-03	8.934E-10	6.343E-09	5.839E-09	8.722E-15
16000.00	28800.00	5.707E-04	2.291E-03	2.291E-03	2.116E-10	2.934E-09	2.696E-09	1.771E-15
17000.00	30600.00	3.045E-04	2.272E-03	2.272E-03	5.339E-11	1.297E-09	1.192E-09	3.494E-16
18000.00	32400.00	1.716E-04	2.203E-03	2.203E-03	1.537E-11	5.795E-10	5.328E-10	7.274E-17
19000.00	34200.00	1.043E-04	2.115E-03	2.115E-03	5.137E-12	2.687E-10	2.473E-10	1.655E-17
20000.00	36000.00	6.873E-05	2.024E-03	2.024E-03	1.964E-12	1.305E-10	1.203E-10	4.155E-18
21000.00	37800.00	4.879E-05	1.935E-03	1.935E-03	8.377E-13	6.640E-11	6.132E-11	1.147E-18
22000.00	39600.00	3.695E-05	1.851E-03	1.851E-03	3.898E-13	3.533E-11	3.269E-11	3.445E-19
23000.00	41400.00	2.950E-05	1.773E-03	1.773E-03	1.912E-13	1.958E-11	1.815E-11	1.119E-19
24000.00	43200.00	2.389E-05	1.701E-03	1.701E-03	9.773E-14	1.126E-11	1.047E-11	3.892E-20
25000.00	45000.00	1.981E-05	1.634E-03	1.634E-03	5.232E-14	6.702E-12	6.241E-12	1.438E-20
26000.00	46800.00	1.677E-05	1.572E-03	1.572E-03	2.914E-14	4.110E-12	3.836E-12	5.602E-21
27000.00	48600.00	1.442E-05	1.514E-03	1.514E-03	1.681E-14	2.590E-12	2.423E-12	2.279E-21
28000.00	50400.00	1.257E-05	1.461E-03	1.461E-03	1.001E-14	1.673E-12	1.568E-12	9.718E-22
29000.00	52200.00	1.107E-05	1.410E-03	1.410E-03	6.123E-15	1.106E-12	1.039E-12	4.342E-22
30000.00	54000.00	9.831E-06	1.364E-03	1.364E-03		7.460E-13	7.020E-13	
32000.00	57600.00	7.904E-06	1.279E-03	1.279E-03		3.586E-13	3.388E-13	
34000.00	61200.00	6.479E-06	1.204E-03	1.204E-03		1.838E-13	1.743E-13	
36000.00	64800.00	5.392E-06	1.137E-03	1.137E-03		9.948E-14	9.463E-14	
38000.00	68400.00	4.544E-06	1.077E-03	1.077E-03		5.643E-14	5.385E-14	
40000.00	72000.00	3.875E-06	1.024E-03	1.024E-03		3.334E-14	3.191E-14	
43000.00	77400.00	3.101E-06	9.523E-04	9.523E-04		1.617E-14	1.554E-14	
46000.00	82800.00	2.521E-06	8.902E-04	8.902E-04		8.388E-15	8.090E-15	
50000.00	90000.00	1.952E-06	8.191E-04	8.191E-04		3.810E-15	3.691E-15	
55000.00	99000.00	1.462E-06	7.447E-04	7.447E-04		1.590E-15	1.547E-15	
60000.00	108000.00	1.124E-06	6.827E-04	6.827E-04		7.332E-16	7.165E-16	
65000.00	117000.00	8.811E-07	6.302E-04	6.302E-04		3.665E-16	3.594E-16	
70000.00	126000.00	7.043E-07	5.852E-04	5.852E-04		1.957E-16	1.925E-16	
80000.00	144000.00	4.711E-07	5.121E-04	5.121E-04		6.525E-17	6.454E-17	
90000.00	162000.00	3.300E-07	4.552E-04	4.552E-04		2.555E-17	2.537E-17	
100000.00	180000.00	2.405E-07	4.097E-04	4.097E-04		1.128E-17	1.124E-17	
110000.00	198000.00	1.804E-07	3.724E-04	3.724E-04		5.475E-18	5.471E-18	

TABLE I. - Continued. CONCENTRATIONS OF SPECIES IN SPIN-EQUILIBRATED HYDROGEN IN CHEMICAL EQUILIBRIUM IN DEBYE-HÜCKEL APPROXIMATION

[E-02, E-03, E+02, E+03, etc., after numbers signify that numbers are to be multiplied by 10^{-2}, 10^{-3}, 10^{2}, 10^{3}, etc.]

(g) Pressure, 1.01325×10^5 N/m^2 (1 atm)

Temperature, T		Species						
K	°R	H	H^+	e^-	H_2	H^-	H_2^+	H_3^+
		Dimensionless concentration, $n_i N_o / V L_o$						
100.00	180.00				2.732E+00			
150.00	270.00				1.821E+00			
200.00	360.00				1.366E+00			
250.00	450.00				1.093E+00			
298.15	536.67	2.244E-36			9.162E-01			
400.00	720.00	9.113E-27			6.829E-01			
500.00	900.00	3.799E-21			5.463E-01			
600.00	1080.00	2.101E-17			4.553E-01			
700.00	1260.00	9.846E-15			3.902E-01			
800.00	1440.00	9.868E-13			3.414E-01			
900.00	1620.00	3.538E-11			3.035E-01			
1000.00	1800.00	6.181E-10			2.732E-01			
1100.00	1980.00	6.400E-09			2.483E-01			
1200.00	2160.00	4.477E-08			2.276E-01			
1300.00	2340.00	2.316E-07			2.101E-01			
1400.00	2520.00	9.457E-07		2.554E-22	1.951E-01	7.651E-27		2.554E-22
1500.00	2700.00	3.194E-06		5.715E-21	1.821E-01	3.406E-25		5.715E-21
1600.00	2880.00	9.249E-06		8.676E-20	1.707E-01	9.365E-24		8.677E-20
1700.00	3060.00	2.359E-05		9.570E-19	1.607E-01	1.731E-22		9.572E-19
1800.00	3240.00	5.414E-05		8.089E-18	1.517E-01	2.301E-21		8.091E-18
1900.00	3420.00	1.136E-04		5.464E-17	1.436E-01	2.316E-20		5.466E-17
2000.00	3600.00	2.211E-04	3.150E-22	3.050E-16	1.364E-01	1.840E-19	4.930E-23	3.051E-16
2100.00	3780.00	4.032E-04	5.584E-21	1.445E-15	1.297E-01	1.195E-18	7.679E-22	1.447E-15
2200.00	3960.00	6.948E-04	7.634E-20	5.946E-15	1.235E-01	6.507E-18	9.331E-21	5.953E-15
2300.00	4140.00	1.140E-03	8.328E-19	2.162E-14	1.176E-01	3.042E-17	9.134E-20	2.165E-14
2400.00	4320.00	1.790E-03	7.456E-18	7.048E-14	1.120E-01	1.242E-16	7.397E-19	7.059E-14
2500.00	4500.00	2.703E-03	5.610E-17	2.087E-13	1.066E-01	4.501E-16	5.069E-18	2.090E-13
2600.00	4680.00	3.941E-03	3.621E-16	5.666E-13	1.011E-01	1.464E-15	2.995E-17	5.677E-13
2700.00	4860.00	5.566E-03	2.040E-15	1.424E-12	9.560E-02	4.323E-15	1.550E-16	1.426E-12
2800.00	5040.00	7.633E-03	1.017E-14	3.333E-12	8.992E-02	1.167E-14	7.121E-16	3.334E-12
2900.00	5220.00	1.018E-02	4.552E-14	7.314E-12	8.401E-02	2.904E-14	2.938E-15	7.295E-12
3000.00	5400.00	1.324E-02	1.846E-13	1.513E-11	7.781E-02	6.696E-14	1.099E-14	1.500E-11
3100.00	5580.00	1.678E-02	6.849E-13	2.964E-11	7.133E-02	1.438E-13	3.751E-14	2.906E-11
3200.00	5760.00	2.078E-02	2.340E-12	5.528E-11	6.458E-02	2.893E-13	1.176E-13	5.311E-11
3400.00	6120.00	2.970E-02	2.168E-11	1.699E-10	5.064E-02	9.848E-13	9.057E-13	1.483E-10
3600.00	6480.00	3.885E-02	1.479E-10	4.677E-10	3.703E-02	2.812E-12	5.009E-12	3.177E-10
3800.00	6840.00	4.675E-02	7.297E-10	1.243E-09	2.513E-02	7.275E-12	1.946E-11	5.012E-10
4000.00	7200.00	5.235E-02	2.661E-09	3.288E-09	1.594E-02	1.774E-11	5.440E-11	5.912E-10
4200.00	7560.00	5.538E-02	7.756E-09	8.405E-09	9.652E-03	4.008E-11	1.195E-10	5.696E-10
4400.00	7920.00	5.635E-02	1.950E-08	2.013E-08	5.725E-03	8.268E-11	2.250E-10	4.915E-10
4600.00	8280.00	5.598E-02	4.421E-08	4.484E-08	3.403E-03	1.567E-10	3.841E-10	4.033E-10
4800.00	8640.00	5.485E-02	9.269E-08	9.335E-08	2.056E-03	2.765E-10	6.132E-10	3.251E-10
5000.00	9000.00	5.335E-02	1.822E-07	1.830E-07	1.272E-03	4.602E-10	9.319E-10	2.618E-10
5200.00	9360.00	5.172E-02	3.394E-07	3.403E-07	8.087E-04	7.301E-10	1.363E-09	2.124E-10
5400.00	9720.00	5.005E-02	6.030E-07	6.040E-07	5.283E-04	1.112E-09	1.930E-09	1.742E-10
5600.00	10080.00	4.842E-02	1.028E-06	1.029E-06	3.542E-04	1.636E-09	2.661E-09	1.445E-10
5800.00	10440.00	4.685E-02	1.688E-06	1.690E-06	2.434E-04	2.333E-09	3.585E-09	1.215E-10
6000.00	10800.00	4.535E-02	2.683E-06	2.684E-06	1.711E-04	3.240E-09	4.729E-09	1.033E-10
6300.00	11340.00	4.324E-02	5.088E-06	5.090E-06	1.049E-04	5.071E-09	6.925E-09	8.274E-11
6600.00	11880.00	4.130E-02	9.108E-06	9.110E-06	6.597E-05	7.579E-09	9.785E-09	6.779E-11

TABLE I. - Continued. CONCENTRATIONS OF SPECIES IN SPIN-EQUILIBRATED HYDROGEN IN CHEMICAL EQUILIBRIUM IN DEBYE-HÜCKEL APPROXIMATION

[E-02, E-03, E+02, E+03, etc., after numbers signify that numbers are to be multiplied by 10^{-2}, 10^{-3}, 10^{2}, 10^{3}, etc.]

(g) Concluded. Pressure, 1.01325×10^{5} N/m^2 (1 atm)

Temperature, T		Species						
K	^{o}R	H	H^+	e^-	H_2	H^-	H_2^+	H_3^+
		Dimensionless concentration, n_iN_o/VL_o						
7000.00	12600.00	3.895E-02	1.833E-05	1.833E-05	3.895E-02	1.219E-08	1.479E-08	5.363E-11
7300.00	13140.00	3.733E-02	2.947E-05	2.947E-05	2.690E-05	1.673E-08	1.953E-08	4.590E-11
7600.00	13680.00	3.583E-02	4.565E-05	4.566E-05	1.908E-05	2.231E-08	2.520E-08	3.989E-11
8000.00	14400.00	3.398E-02	7.779E-05	7.779E-05	1.251E-05	3.147E-08	3.426E-08	3.373E-11
8300.00	14940.00	3.268E-02	1.122E-04	1.122E-04	9.332E-06	3.966E-08	4.219E-08	3.010E-11
8600.00	15480.00	3.144E-02	1.577E-04	1.577E-04	7.081E-06	4.898E-08	5.107E-08	2.710E-11
9000.00	16200.00	2.987E-02	2.396E-04	2.396E-04	5.012E-06	6.305E-08	6.428E-08	2.378E-11
9300.00	15740.00	2.873E-02	3.201E-04	3.201E-04	3.922E-06	7.470E-08	7.507E-08	2.168E-11
9600.00	17280.00	2.762E-02	4.196E-04	4.196E-04	3.099E-06	8.709E-08	8.645E-08	1.982E-11
10000.00	18000.00	2.615E-02	5.861E-04	5.861E-04	2.291E-06	1.044E-07	1.022E-07	1.760E-11
10500.00	18900.00	2.431E-02	8.558E-04	8.558E-04	1.592E-06	1.262E-07	1.218E-07	1.512E-11
11000.00	19800.00	2.245E-02	1.201E-03	1.201E-03	1.113E-06	1.467E-07	1.399E-07	1.285E-11
11500.00	20700.00	2.053E-02	1.626E-03	1.626E-03	7.776E-07	1.639E-07	1.549E-07	1.070E-11
12000.00	21600.00	1.855E-02	2.127E-03	2.127E-03	5.387E-07	1.759E-07	1.651E-07	8.683E-12
12500.00	22500.00	1.652E-02	2.696E-03	2.696E-03	3.675E-07	1.810E-07	1.689E-07	6.798E-12
13000.00	23400.00	1.446E-02	3.313E-03	3.313E-03	2.453E-07	1.783E-07	1.657E-07	5.101E-12
13500.00	24300.00	1.242E-02	3.954E-03	3.954E-03	1.593E-07	1.679E-07	1.555E-07	3.643E-12
14000.00	25200.00	1.045E-02	4.587E-03	4.587E-03	1.004E-07	1.510E-07	1.394E-07	2.465E-12
15000.00	27000.00	6.937E-03	5.706E-03	5.706E-03	3.602E-08	1.067E-07	9.826E-08	9.550E-13
16000.00	28800.00	4.278E-03	6.473E-03	6.473E-03	1.152E-08	6.426E-08	5.907E-08	3.009E-13
17000.00	30600.00	2.524E-03	6.848E-03	6.848E-03	3.484E-09	3.450E-08	3.171E-08	8.209E-14
18000.00	32400.00	1.479E-03	6.919E-03	6.919E-03	1.071E-09	1.747E-08	1.607E-08	2.106E-14
19000.00	34200.00	8.895E-04	6.807E-03	6.807E-03	3.536E-10	8.735E-09	8.040E-09	5.436E-15
20000.00	36000.00	5.600E-04	6.605E-03	6.605E-03	1.292E-10	4.434E-09	4.087E-09	1.470E-15
21000.00	37800.00	3.727E-04	6.367E-03	6.367E-03	5.224E-11	2.316E-09	2.139E-09	4.241E-16
22000.00	39600.00	2.621E-04	6.120E-03	6.120E-03	2.326E-11	1.253E-09	1.159E-09	1.310E-16
23000.00	41400.00	1.949E-04	5.879E-03	5.879E-03	1.120E-11	7.012E-10	6.502E-10	4.330E-17
24000.00	43200.00	1.517E-04	5.649E-03	5.649E-03	5.768E-12	4.060E-10	3.773E-10	1.522E-17
25000.00	45000.00	1.228E-04	5.432E-03	5.432E-03	3.128E-12	2.425E-10	2.259E-10	5.667E-18
26000.00	46800.00	1.026E-04	5.228E-03	5.228E-03	1.782E-12	1.492E-10	1.392E-10	2.218E-18
27000.00	48600.00	8.812E-05	5.038E-03	5.038E-03	1.053E-12	9.419E-11	8.809E-11	9.058E-19
28000.00	50400.00	7.715E-05	4.861E-03	4.861E-03	6.424E-13	6.094E-11	5.712E-11	3.873E-19
29000.00	52200.00	6.856E-05	4.694E-03	4.694E-03	4.037E-13	4.032E-11	3.787E-11	1.734E-19
30000.00	54000.00	6.173E-05	4.539E-03	4.539E-03	2.602E-13	2.722E-11	2.562E-11	8.089E-20
32000.00	57600.00	5.039E-05	4.257E-03	4.257E-03	1.087E-13	1.311E-11	1.239E-11	1.963E-20
34000.00	61200.00	4.093E-05	4.008E-03	4.008E-03		6.731E-12	6.381E-12	
36000.00	64800.00	3.385E-05	3.787E-03	3.787E-03		3.648E-12	3.470E-12	
38000.00	68400.00	2.841E-05	3.588E-03	3.588E-03		2.072E-12	1.977E-12	
40000.00	72000.00	2.411E-05	3.410E-03	3.410E-03		1.225E-12	1.173E-12	
43000.00	77400.00	1.918E-05	3.173E-03	3.173E-03		5.950E-13	5.717E-13	
46000.00	82800.00	1.553E-05	2.966E-03	2.966E-03		3.089E-13	2.979E-13	
50000.00	90000.00	1.203E-05	2.729E-03	2.729E-03		1.404E-13	1.360E-13	
55000.00	99000.00	8.990E-06	2.482E-03	2.482E-03		5.854E-14	5.708E-14	
60000.00	108000.00	6.891E-06	2.275E-03	2.275E-03		2.706E-14	2.645E-14	
65000.00	117000.00	5.395E-06	2.100E-03	2.100E-03		1.353E-14	1.327E-14	
70000.00	126000.00	4.314E-06	1.950E-03	1.950E-03		7.230E-15	7.113E-15	
80000.00	144000.00	2.882E-06	1.707E-03	1.707E-03		2.412E-15	2.386E-15	
90000.00	162000.00	2.016E-06	1.517E-03	1.517E-03		9.447E-16	9.383E-16	
100000.00	180000.00	1.469E-06	1.365E-03	1.365E-03		4.174E-16	4.160E-16	
110000.00	198000.00	1.103E-06	1.241E-03	1.241E-03		2.026E-16	2.024E-16	

TABLE I. - Continued. CONCENTRATIONS OF SPECIES IN SPIN-EQUILIBRATED HYDROGEN IN CHEMICAL EQUILIBRIUM IN DEBYE-HÜCKEL APPROXIMATION

[E-02, E-03, E+02, E+03, etc., after numbers signify that numbers are to be multiplied by 10^{-2}, 10^{-3}, 10^{2}, 10^{3}, etc.]

(h) Pressure, 3.03975×10^5 N/m^2 (3 atm)

Temperature, T		Species						
K	^{o}R	H	H^+	e^-	H_2	H^-	H_2^+	H_3^+
		Dimensionless concentration, $n_i N_o / V L_o$						
100.00	180.00				8.195E+00			
150.00	270.00				5.463E+00			
200.00	360.00				4.097E+00			
250.00	450.00				3.278E+00			
298.15	536.67	3.886E-36			2.748E+00			
400.00	720.00	1.578E-26			2.049E+00			
500.00	900.00	6.580E-21			1.639E+00			
600.00	1080.00	3.640E-17			1.366E+00			
700.00	1260.00	1.705E-14			1.171E+00			
800.00	1440.00	1.709E-12			1.024E+00			
900.00	1620.00	6.129E-11			9.105E-01			
1000.00	1800.00	1.071E-09			8.195E-01			
1100.00	1980.00	1.108E-08			7.450E-01			
1200.00	2160.00	7.754E-08			6.829E-01			
1300.00	2340.00	4.012E-07			6.303E-01			
1400.00	2520.00	1.638E-06		5.822E-22	5.853E-01	3.023E-26		5.822E-22
1500.00	2700.00	5.533E-06		1.303E-20	5.463E-01	1.345E-24		1.303E-20
1600.00	2880.00	1.602E-05		1.978E-19	5.121E-01	3.698E-23		1.978E-19
1700.00	3060.00	4.086E-05		2.181E-18	4.820E-01	6.836E-22		2.182E-18
1800.00	3240.00	9.377E-05		1.844E-17	4.552E-01	9.085E-21		1.845E-17
1900.00	3420.00	1.969E-04		1.246E-16	4.311E-01	9.146E-20		1.247E-16
2000.00	3600.00	3.832E-04	2.394E-22	6.954E-16	4.093E-01	7.271E-19	6.491E-23	6.961E-16
2100.00	3780.00	6.988E-04	4.243E-21	3.297E-15	3.895E-01	4.723E-18	1.011E-21	3.302E-15
2200.00	3960.00	1.205E-03	5.800E-20	1.357E-14	3.713E-01	2.576E-17	1.229E-20	1.360E-14
2300.00	4140.00	1.978E-03	6.325E-19	4.940E-14	3.543E-01	1.206E-16	1.204E-19	4.952E-14
2400.00	4320.00	3.110E-03	5.659E-18	1.614E-13	3.383E-01	4.943E-16	9.759E-19	1.618E-13
2500.00	4500.00	4.706E-03	4.256E-17	4.790E-13	3.231E-01	1.799E-15	6.695E-18	4.807E-13
2600.00	4680.00	6.882E-03	2.744E-16	1.306E-12	3.083E-01	5.893E-15	3.962E-17	1.311E-12
2700.00	4860.00	9.757E-03	1.543E-15	3.299E-12	2.937E-01	1.756E-14	2.055E-16	3.314E-12
2800.00	5040.00	1.345E-02	7.683E-15	7.777E-12	2.792E-01	4.800E-14	9.475E-16	7.817E-12
2900.00	5220.00	1.807E-02	3.430E-14	1.722E-11	2.645E-01	1.214E-13	3.928E-15	1.731E-11
3000.00	5400.00	2.370E-02	1.388E-13	3.603E-11	2.495E-01	2.855E-13	1.479E-14	3.615E-11
3100.00	5580.00	3.039E-02	5.142E-13	7.150E-11	2.339E-01	6.283E-13	5.100E-14	7.156E-11
3200.00	5760.00	3.816E-02	1.757E-12	1.352E-10	2.179E-01	1.300E-12	1.623E-13	1.345E-10
3400.00	6120.00	5.667E-02	1.654E-11	4.250E-10	1.843E-01	4.700E-12	1.318E-12	4.119E-10
3600.00	6480.00	7.807E-02	1.202E-10	1.157E-09	1.496E-01	1.398E-11	8.180E-12	1.043E-09
3800.00	6840.00	1.002E-01	6.837E-10	2.844E-09	1.154E-01	3.568E-11	3.908E-11	2.157E-09
4000.00	7200.00	1.205E-01	3.028E-09	6.650E-09	8.440E-02	8.255E-11	1.424E-10	3.563E-09
4200.00	7560.00	1.365E-01	1.047E-08	1.535E-08	5.862E-02	1.804E-10	3.973E-10	4.668E-09
4400.00	7920.00	1.472E-01	2.936E-08	3.492E-08	3.905E-02	3.746E-10	8.849E-10	5.049E-09
4600.00	8280.00	1.528E-01	7.076E-08	7.651E-08	2.535E-02	7.295E-10	1.678E-09	4.808E-09
4800.00	8640.00	1.544E-01	1.532E-07	1.590E-07	1.629E-02	1.326E-09	2.854E-09	4.260E-09
5000.00	9000.00	1.534E-01	3.068E-07	3.127E-07	1.051E-02	2.261E-09	4.509E-09	3.642E-09
5200.00	9360.00	1.507E-01	5.773E-07	5.835E-07	6.868E-03	3.648E-09	6.754E-09	3.068E-09
5400.00	9720.00	1.472E-01	1.032E-06	1.039E-06	4.568E-03	5.624E-09	9.714E-09	2.578E-09
5600.00	10080.00	1.432E-01	1.766E-06	1.773E-06	3.099E-03	8.339E-09	1.353E-08	2.174E-09
5800.00	10440.00	1.391E-01	2.909E-06	2.917E-06	2.147E-03	1.196E-08	1.834E-08	1.845E-09
6000.00	10800.00	1.350E-01	4.631E-06	4.640E-06	1.518E-03	1.668E-08	2.431E-08	1.582E-09
6300.00	11340.00	1.291E-01	8.799E-06	8.810E-06	9.349E-04	2.621E-08	3.576E-08	1.276E-09
6600.00	11880.00	1.235E-01	1.577E-05	1.578E-05	5.991E-04	3.927E-08	5.068E-08	1.050E-09

TABLE I. - Continued. CONCENTRATIONS OF SPECIES IN SPIN-EQUILIBRATED HYDROGEN IN CHEMICAL EQUILIBRIUM IN DEBYE-HÜCKEL APPROXIMATION

[E-02, E-03, E+02, E+03, etc., after numbers signify that numbers are to be multiplied by 10^{-2}, 10^{-3}, 10^{2}, 10^{3}, etc.]

(h) Concluded. Pressure, 3.03975×10^{5} N/m^2 (3 atm)

Temperature, T		Species						
K	^{o}R	H	H^+	e^-	H_2	H^-	H_2^+	H_3^+
		Dimensionless concentration, $n_i N_o/VL_o$						
7000.00	12600.00	1.167E-01	3.179E-05	3.180E-05	3.494E-04	6.331E-08	7.679E-08	8.342E-10
7300.00	13140.00	1.119E-01	5.115E-05	5.116E-05	2.417E-04	8.705E-08	1.016E-07	7.159E-10
7600.00	13680.00	1.075E-01	7.930E-05	7.931E-05	1.717E-04	1.153E-07	1.313E-07	5.235E-10
8000.00	14400.00	1.020E-01	1.353E-04	1.353E-04	1.129E-04	1.644E-07	1.789E-07	5.292E-10
8300.00	14940.00	9.826E-02	1.953E-04	1.953E-04	8.438E-05	2.076E-07	2.209E-07	4.739E-10
8600.00	15480.00	9.467E-02	2.748E-04	2.749E-04	6.420E-05	2.571E-07	2.681E-07	4.283E-10
9000.00	16200.00	9.017E-02	4.184E-04	4.185E-04	4.568E-05	3.325E-07	3.390E-07	3.786E-10
9300.00	16740.00	8.697E-02	5.600E-04	5.600E-04	3.593E-05	3.956E-07	3.976E-07	3.476E-10
9600.00	17280.00	8.387E-02	7.358E-04	7.358E-04	2.859E-05	4.638E-07	4.604E-07	3.205E-10
10000.00	18000.00	7.988E-02	1.032E-03	1.032E-03	2.138E-05	5.612E-07	5.493E-07	2.891E-10
10500.00	18900.00	7.503E-02	1.515E-03	1.515E-03	1.515E-05	6.896E-07	6.654E-07	2.549E-10
11000.00	19800.00	7.025E-02	2.144E-03	2.144E-03	1.090E-05	8.194E-07	7.817E-07	2.245E-10
11500.00	20700.00	6.545E-02	2.932E-03	2.932E-03	7.904E-06	9.427E-07	8.913E-07	1.964E-10
12000.00	21600.00	6.061E-02	3.888E-03	3.888E-03	5.750E-06	1.051E-06	9.865E-07	1.695E-10
12500.00	22500.00	5.568E-02	5.011E-03	5.011E-03	4.173E-06	1.135E-06	1.059E-06	1.438E-10
13000.00	23400.00	5.065E-02	6.287E-03	6.287E-03	3.007E-06	1.187E-06	1.103E-06	1.192E-10
13500.00	24300.00	4.557E-02	7.691E-03	7.691E-03	2.142E-06	1.201E-06	1.113E-06	9.590E-11
14000.00	25200.00	4.048E-02	9.183E-03	9.183E-03	1.502E-06	1.176E-06	1.086E-06	7.464E-11
15000.00	27000.00	3.060E-02	1.223E-02	1.223E-02	6.958E-07	1.017E-06	9.360E-07	4.042E-11
16000.00	28800.00	2.179E-02	1.498E-02	1.498E-02	2.945E-07	7.683E-07	7.061E-07	1.858E-11
17000.00	30600.00	1.468E-02	1.706E-02	1.706E-02	1.148E-07	5.134E-07	4.717E-07	7.295E-12
18000.00	32400.00	9.518E-03	1.831E-02	1.831E-02	4.248E-08	3.116E-07	2.864E-07	2.531E-12
19000.00	34200.00	6.075E-03	1.882E-02	1.882E-02	1.559E-08	1.779E-07	1.637E-07	8.152E-13
20000.00	36000.00	3.906E-03	1.880E-02	1.880E-02	5.911E-09	9.876E-08	9.105E-08	2.562E-13
21000.00	37800.00	2.573E-03	1.847E-02	1.847E-02	2.377E-09	5.472E-08	5.054E-08	8.158E-14
22000.00	39600.00	1.754E-03	1.797E-02	1.797E-02	1.028E-09	3.073E-08	2.844E-08	2.687E-14
23000.00	41400.00	1.245E-03	1.739E-02	1.739E-02	4.789E-10	1.763E-08	1.635E-08	9.261E-15
24000.00	43200.00	9.210E-04	1.678E-02	1.678E-02	2.379E-10	1.038E-08	9.644E-09	3.348E-15
25000.00	45000.00	7.072E-04	1.619E-02	1.619E-02	1.257E-10	6.270E-09	5.839E-09	1.271E-15
26000.00	46800.00	5.623E-04	1.562E-02	1.562E-02	6.957E-11	3.886E-09	3.627E-09	5.042E-16
27000.00	48600.00	4.605E-04	1.507E-02	1.507E-02	4.028E-11	2.458E-09	2.308E-09	2.080E-16
28000.00	50400.00	3.873E-04	1.455E-02	1.455E-02	2.426E-11	1.604E-09	1.503E-09	8.958E-17
29000.00	52200.00	3.332E-04	1.406E-02	1.406E-02	1.503E-11	1.064E-09	9.995E-10	4.034E-17
30000.00	54000.00	2.911E-04	1.360E-02	1.360E-02	9.608E-12	7.204E-10	6.779E-10	1.890E-17
32000.00	57600.00	2.321E-04	1.276E-02	1.276E-02	4.185E-12	3.481E-10	3.288E-10	4.615E-18
34000.00	61200.00	1.926E-04	1.202E-02	1.202E-02	1.983E-12	1.790E-10	1.697E-10	1.276E-18
36000.00	64800.00	1.642E-04	1.135E-02	1.135E-02	1.001E-12	9.712E-11	9.238E-11	3.924E-19
38000.00	68400.00	1.425E-04	1.076E-02	1.076E-02		5.520E-11	5.267E-11	
40000.00	72000.00	1.258E-04	1.022E-02	1.022E-02		3.267E-11	3.126E-11	
43000.00	77400.00	1.018E-04	9.508E-03	9.508E-03		1.589E-11	1.527E-11	
46000.00	82800.00	8.236E-05	8.891E-03	8.891E-03		8.260E-12	7.966E-12	
50000.00	90000.00	6.352E-05	8.182E-03	8.182E-03		3.761E-12	3.643E-12	
55000.00	99000.00	4.728E-05	7.441E-03	7.441E-03		1.573E-12	1.531E-12	
60000.00	108000.00	3.614E-05	6.822E-03	6.822E-03		7.267E-13	7.102E-13	
65000.00	117000.00	2.827E-05	6.298E-03	6.298E-03		3.637E-13	3.567E-13	
70000.00	126000.00	2.260E-05	5.849E-03	5.849E-03		1.944E-13	1.913E-13	
80000.00	144000.00	1.508E-05	5.119E-03	5.119E-03		6.493E-14	6.422E-14	
90000.00	162000.00	1.054E-05	4.551E-03	4.551E-03		2.545E-14	2.527E-14	
100000.00	180000.00	7.663E-06	4.096E-03	4.096E-03		1.125E-14	1.121E-14	
110000.00	198000.00	5.754E-06	3.724E-03	3.724E-03		5.461E-15	5.457E-15	

TABLE I. - Continued. CONCENTRATIONS OF SPECIES IN SPIN-EQUILIBRATED HYDROGEN IN CHEMICAL EQUILIBRIUM IN DEBYE-HÜCKEL APPROXIMATION

[E-02, E-03, E+02, E+03, etc., after numbers signify that numbers are to be multiplied by 10^{-2}, 10^{-3}, 10^{2}, 10^{3}, etc.]

(i) Pressure, 1.01325×10^{6} N/m^2 (10 atm)

Temperature, T		Species						
K	^{o}R	H	H^{+}	e^{-}	H_2	H^{-}	H_2^{+}	H_3^{+}
		Dimensionless concentration, n_iN_o/VL_o						
100.00	180.00				2.732E+01			
150.00	270.00				1.821E+01			
200.00	360.00				1.366E+01			
250.00	450.00				1.093E+01			
298.15	536.67	7.095E-36			9.162E+00			
400.00	720.00	2.882E-26			6.829E+00			
500.00	900.00	1.201E-20			5.463E+00			
600.00	1080.00	6.645E-17			4.553E+00			
700.00	1260.00	3.114E-14			3.902E+00			
800.00	1440.00	3.120E-12			3.414E+00			
900.00	1620.00	1.119E-10			3.035E+00			
1000.00	1800.00	1.955E-09			2.732E+00			
1100.00	1980.00	2.024E-08			2.483E+00			
1200.00	2160.00	1.415E-07			2.276E+00			
1300.00	2340.00	7.325E-07			2.101E+00			
1400.00	2520.00	2.991E-06		1.436E-21	1.951E+00	1.361E-25		1.436E-21
1500.00	2700.00	1.010E-05		3.214E-20	1.821E+00	6.059E-24		3.214E-20
1600.00	2880.00	2.925E-05		4.879E-19	1.707E+00	1.655E-22		4.880E-19
1700.00	3060.00	7.461E-05		5.381E-18	1.607E+00	3.079E-21		5.384E-18
1800.00	3240.00	1.712E-04		4.548E-17	1.517E+00	4.092E-20		4.552E-17
1900.00	3420.00	3.595E-04		3.072E-16	1.437E+00	4.119E-19		3.077E-16
2000.00	3600.00	6.997E-04	1.772E-22	1.715E-15	1.365E+00	3.275E-18	8.775E-23	1.719E-15
2100.00	3780.00	1.275E-03	3.141E-21	8.134E-15	1.299E+00	2.128E-17	1.368E-21	8.155E-15
2200.00	3960.00	2.201E-03	4.294E-20	3.349E-14	1.239E+00	1.161E-16	1.663E-20	3.361E-14
2300.00	4140.00	3.616E-03	4.683E-19	1.220E-13	1.184E+00	5.445E-16	1.629E-19	1.225E-13
2400.00	4320.00	5.690E-03	4.189E-18	3.988E-13	1.132E+00	2.235E-15	1.322E-18	4.010E-13
2500.00	4500.00	8.620E-03	3.149E-17	1.186E-12	1.084E+00	8.157E-15	9.075E-18	1.194E-12
2600.00	4680.00	1.263E-02	2.029E-16	3.239E-12	1.038E+00	2.682E-14	5.377E-17	3.266E-12
2700.00	4860.00	1.795E-02	1.141E-15	8.208E-12	9.937E-01	8.036E-14	2.794E-16	8.287E-12
2800.00	5040.00	2.482E-02	5.673E-15	1.944E-11	9.507E-01	2.214E-13	1.291E-15	1.965E-11
2900.00	5220.00	3.349E-02	2.529E-14	4.329E-11	9.084E-01	5.653E-13	5.367E-15	4.383E-11
3000.00	5400.00	4.417E-02	1.022E-13	9.121E-11	8.663E-01	1.347E-12	2.029E-14	9.243E-11
3100.00	5580.00	5.705E-02	3.778E-13	1.826E-10	8.241E-01	3.013E-12	7.033E-14	1.852E-10
3200.00	5760.00	7.225E-02	1.289E-12	3.491E-10	7.813E-01	6.355E-12	2.253E-13	3.539E-10
3400.00	6120.00	1.099E-01	1.212E-11	1.125E-09	6.935E-01	2.413E-11	1.873E-12	1.135E-09
3600.00	6480.00	1.565E-01	8.902E-11	3.134E-09	6.021E-01	7.597E-11	1.216E-11	3.109E-09
3800.00	6840.00	2.103E-01	5.282E-10	7.729E-09	5.085E-01	2.035E-10	6.337E-11	7.341E-09
4000.00	7200.00	2.673E-01	2.580E-09	1.732E-08	4.156E-01	4.771E-10	2.694E-10	1.495E-08
4200.00	7560.00	3.227E-01	1.044E-08	3.640E-08	3.277E-01	1.011E-09	9.370E-10	2.603E-08
4400.00	7920.00	3.717E-01	3.500E-08	7.404E-08	2.491E-01	2.006E-09	2.663E-09	3.838E-08
4600.00	8280.00	4.107E-01	9.801E-08	1.486E-07	1.831E-01	3.808E-09	6.246E-09	4.811E-08
4800.00	8640.00	4.380E-01	2.355E-07	2.937E-07	1.311E-01	6.946E-09	1.244E-08	5.267E-08
5000.00	9000.00	4.541E-01	5.030E-07	5.652E-07	9.216E-02	1.210E-08	2.189E-08	5.235E-08
5200.00	9360.00	4.610E-01	9.841E-07	1.048E-06	6.426E-02	2.005E-08	3.522E-08	4.894E-08
5400.00	9720.00	4.610E-01	1.801E-06	1.867E-06	4.481E-02	3.166E-08	5.311E-08	4.415E-08
5600.00	10080.00	4.563E-01	3.128E-06	3.196E-06	3.146E-02	4.788E-08	7.634E-08	3.909E-08
5800.00	10440.00	4.485E-01	5.202E-06	5.272E-06	2.232E-02	6.972E-08	1.058E-07	3.433E-08
6000.00	10800.00	4.392E-01	8.335E-06	8.409E-06	1.605E-02	9.828E-08	1.423E-07	3.011E-08
6300.00	11340.00	4.235E-01	1.593E-05	1.602E-05	1.005E-02	1.563E-07	2.124E-07	2.495E-08
6600.00	11880.00	4.073E-01	2.867E-05	2.876E-05	6.513E-03	2.350E-07	3.038E-07	2.075E-08

TABLE I. - Continued. CONCENTRATIONS OF SPECIES IN SPIN-EQUILIBRATED HYDROGEN IN CHEMICAL EQUILIBRIUM IN DEBYE-HÜCKEL APPROXIMATION

[E-02, E-03, E+02, E+03, etc., after numbers signify that numbers are to be multiplied by 10^{-2}, 10^{-3}, 10^{2}, 10^{3}, etc.]

(i) Concluded. Pressure, 1.01325×10^{6} N/m^2 (10 atm)

Temperature, T		Species						
K	^{o}R	H	H^+	e^-	H_2	H^-	H_2^+	H_3^+
		Dimensionless concentration, $n_i N_o / V L_o$						
7000.00	12600.00	3.863E-01	5.798E-05	5.808E-05	3.831E-03	3.828E-07	4.638E-07	1.669E-08
7300.00	13140.00	3.713E-01	9.347E-05	9.357E-05	2.661E-03	5.283E-07	6.161E-07	1.440E-08
7600.00	13680.00	3.572E-01	1.451E-04	1.452E-04	1.896E-03	7.075E-07	7.987E-07	1.260E-08
8000.00	14400.00	3.397E-01	2.480E-04	2.481E-04	1.251E-03	1.004E-05	1.092E-06	1.075E-08
8300.00	14940.00	3.274E-01	3.586E-04	3.587E-04	9.371E-04	1.271E-05	1.351E-06	9.663E-09
8600.00	15480.00	3.159E-01	5.053E-04	5.054E-04	7.148E-04	1.577E-05	1.645E-06	8.767E-09
9000.00	16200.00	3.015E-01	7.709E-04	7.710E-04	5.105E-04	2.048E-05	2.088E-06	7.795E-09
9300.00	16740.00	2.913E-01	1.034E-03	1.034E-03	4.030E-04	2.445E-05	2.458E-06	7.195E-09
9600.00	17280.00	2.815E-01	1.361E-03	1.361E-03	3.221E-04	2.879E-06	2.858E-06	6.677E-09
10000.00	18000.00	2.691E-01	1.913E-03	1.913E-03	2.427E-04	3.507E-06	3.433E-06	6.086E-09
10500.00	18900.00	2.544E-01	2.823E-03	2.823E-03	1.742E-04	4.357E-05	4.204E-06	5.461E-09
11000.00	19800.00	2.403E-01	4.018E-03	4.018E-03	1.275E-04	5.253E-05	5.011E-06	4.925E-09
11500.00	20700.00	2.265E-01	5.536E-03	5.535E-03	9.467E-05	6.160E-05	5.824E-06	4.442E-09
12000.00	21600.00	2.130E-01	7.409E-03	7.408E-03	7.100E-05	7.039E-05	6.607E-06	3.994E-09
12500.00	22500.00	1.995E-01	9.657E-03	9.656E-03	5.358E-05	7.843E-05	7.321E-06	3.564E-09
13000.00	23400.00	1.860E-01	1.229E-02	1.228E-02	4.053E-05	8.526E-06	7.924E-06	3.147E-09
13500.00	24300.00	1.724E-01	1.528E-02	1.528E-02	3.063E-05	9.046E-05	8.378E-06	2.737E-09
14000.00	25200.00	1.588E-01	1.861E-02	1.861E-02	2.306E-05	9.366E-05	8.652E-06	2.339E-09
15000.00	27000.00	1.314E-01	2.603E-02	2.603E-02	1.277E-05	9.328E-06	8.587E-06	1.599E-09
16000.00	28800.00	1.047E-01	3.389E-02	3.389E-02	6.748E-06	8.421E-06	7.740E-06	9.869E-10
17000.00	30600.00	8.022E-02	4.134E-02	4.134E-02	3.373E-06	6.894E-05	6.335E-06	5.429E-10
18000.00	32400.00	5.910E-02	4.759E-02	4.759E-02	1.594E-06	5.150E-06	4.735E-06	2.660E-10
19000.00	34200.00	4.217E-02	5.214E-02	5.214E-02	7.203E-07	3.556E-05	3.273E-06	1.176E-10
20000.00	36000.00	2.947E-02	5.490E-02	5.490E-02	3.179E-07	2.312E-05	2.132E-06	4.812E-11
21000.00	37800.00	2.044E-02	5.610E-02	5.610E-02	1.405E-07	1.446E-05	1.336E-06	1.875E-11
22000.00	39600.00	1.426E-02	5.615E-02	5.615E-02	6.357E-08	8.874E-07	8.212E-07	7.168E-12
23000.00	41400.00	1.011E-02	5.543E-02	5.543E-02	2.986E-08	5.422E-07	5.028E-07	2.745E-12
24000.00	43200.00	7.326E-03	5.425E-02	5.425E-02	1.467E-08	3.335E-07	3.099E-07	1.070E-12
25000.00	45000.00	5.444E-03	5.282E-02	5.282E-02	7.552E-09	2.079E-07	1.936E-07	4.282E-13
26000.00	46800.00	4.152E-03	5.127E-02	5.127E-02	4.096E-09	1.318E-07	1.230E-07	1.766E-13
27000.00	48600.00	3.260E-03	4.969E-02	4.969E-02	2.321E-09	8.505E-08	7.954E-08	7.488E-14
28000.00	50400.00	2.626E-03	4.813E-02	4.813E-02	1.364E-09	5.591E-08	5.240E-08	3.292E-14
29000.00	52200.00	2.162E-03	4.662E-02	4.662E-02	8.304E-10	3.744E-08	3.516E-08	1.506E-14
30000.00	54000.00	1.818E-03	4.516E-02	4.516E-02	5.220E-10	2.552E-08	2.401E-08	7.143E-15
32000.00	57600.00	1.354E-03	4.245E-02	4.245E-02	2.212E-10	1.245E-08	1.176E-08	1.775E-15
34000.00	61200.00	1.061E-03	4.002E-02	4.002E-02	1.031E-10	6.443E-09	6.108E-09	4.965E-16
36000.00	64800.00	8.711E-04	3.782E-02	3.782E-02	5.128E-11	3.511E-09	3.340E-09	1.539E-16
38000.00	68400.00	7.343E-04	3.584E-02	3.584E-02	2.713E-11	2.002E-09	1.910E-09	5.220E-17
40000.00	72000.00	6.320E-04	3.406E-02	3.406E-02	1.494E-11	1.188E-09	1.137E-09	1.915E-17
43000.00	77400.00	5.199E-04	3.169E-02	3.169E-02		5.788E-10	5.562E-10	
46000.00	82800.00	4.392E-04	2.962E-02	2.962E-02		3.013E-10	2.905E-10	
50000.00	90000.00	3.592E-04	2.725E-02	2.725E-02		1.373E-10	1.330E-10	
55000.00	99000.00	2.905E-04	2.478E-02	2.478E-02		5.751E-11	5.597E-11	
60000.00	108000.00	2.236E-04	2.272E-02	2.272E-02		2.652E-11	2.602E-11	
65000.00	117000.00	1.749E-04	2.098E-02	2.098E-02		1.335E-11	1.309E-11	
70000.00	126000.00	1.393E-04	1.948E-02	1.948E-02		7.144E-12	7.029E-12	
80000.00	144000.00	9.250E-05	1.705E-02	1.705E-02		2.390E-12	2.364E-12	
90000.00	162000.00	6.456E-05	1.516E-02	1.516E-02		9.380E-13	9.316E-13	
100000.00	180000.00	4.702E-05	1.365E-02	1.365E-02		4.150E-13	4.136E-13	
110000.00	198000.00	3.526E-05	1.241E-02	1.241E-02		2.016E-13	2.015E-13	

TABLE I. - Continued. CONCENTRATIONS OF SPECIES IN SPIN-EQUILIBRATED HYDROGEN IN CHEMICAL EQUILIBRIUM IN DEBYE-HÜCKEL APPROXIMATION

[E-02, E-03, E+02, E+03, etc., after numbers signify that numbers are to be multiplied by 10^{-2}, 10^{-3}, 10^{2}, 10^{3}, etc.]

(j) Pressure, 3.03975×10^{6} N/m^2 (30 atm)

Temperature, T		Species						
K	°R	H	H^+	e^-	H_2	H^-	H_2^+	H_3^+
		Dimensionless concentration, $n_i N_o / V L_o$						
150.00	270.00				5.463E+01			
200.00	360.00				4.097E+01			
250.00	450.00				3.278E+01			
298.15	536.67	1.229E-35			2.748E+01			
400.00	720.00	4.991E-26			2.049E+01			
500.00	900.00	2.081E-20			1.639E+01			
600.00	1080.00	1.151E-16			1.366E+01			
700.00	1260.00	5.393E-14			1.171E+01			
800.00	1440.00	5.405E-12			1.024E+01			
900.00	1620.00	1.938E-10			9.105E+00			
1000.00	1800.00	3.385E-09			8.195E+00			
1100.00	1980.00	3.505E-08			7.450E+00			
1200.00	2160.00	2.452E-07			6.829E+00			
1300.00	2340.00	1.269E-06			6.303E+00			
1400.00	2520.00	5.180E-06		3.274E-21	5.853E+00	5.375E-25		3.274E-21
1500.00	2700.00	1.750E-05		7.325E-20	5.463E+00	2.392E-23		7.328E-20
1600.00	2880.00	5.066E-05		1.112E-18	5.122E+00	6.575E-22		1.113E-18
1700.00	3060.00	1.292E-04		1.226E-17	4.820E+00	1.215E-20		1.228E-17
1800.00	3240.00	2.966E-04		1.036E-16	4.552E+00	1.615E-19		1.038E-16
1900.00	3420.00	6.226E-04		7.001E-16	4.312E+00	1.626E-18		7.017E-16
2000.00	3600.00	1.212E-03	1.347E-22	3.908E-15	4.096E+00	1.293E-17	1.156E-22	3.921E-15
2100.00	3780.00	2.211E-03	2.389E-21	1.853E-14	3.900E+00	8.399E-17	1.802E-21	1.861E-14
2200.00	3960.00	3.814E-03	3.266E-20	7.630E-14	3.721E+00	4.584E-16	2.192E-20	7.675E-14
2300.00	4140.00	6.267E-03	3.563E-19	2.778E-13	3.557E+00	2.150E-15	2.149E-19	2.800E-13
2400.00	4320.00	9.865E-03	3.188E-18	9.086E-13	3.405E+00	8.829E-15	1.744E-18	9.174E-13
2500.00	4500.00	1.496E-02	2.397E-17	2.703E-12	3.263E+00	3.226E-14	1.198E-17	2.735E-12
2600.00	4680.00	2.193E-02	1.545E-16	7.390E-12	3.130E+00	1.063E-13	7.107E-17	7.496E-12
2700.00	4860.00	3.120E-02	8.681E-16	1.875E-11	3.004E+00	3.191E-13	3.698E-16	1.907E-11
2800.00	5040.00	4.322E-02	4.317E-15	4.448E-11	2.883E+00	8.823E-13	1.711E-15	4.536E-11
2900.00	5220.00	5.845E-02	1.924E-14	9.933E-11	2.767E+00	2.264E-12	7.127E-15	1.015E-10
3000.00	5400.00	7.731E-02	7.770E-14	2.100E-10	2.654E+00	5.428E-12	2.700E-14	2.153E-10
3100.00	5580.00	1.002E-01	2.870E-13	4.224E-10	2.543E+00	1.224E-11	9.386E-14	4.342E-10
3200.00	5760.00	1.275E-01	9.782E-13	8.118E-10	2.433E+00	2.608E-11	3.018E-13	8.365E-10
3400.00	6120.00	1.964E-01	9.177E-12	2.655E-09	2.214E+00	1.017E-10	2.535E-12	2.745E-09
3600.00	6480.00	2.849E-01	6.737E-11	7.534E-09	1.991E+00	3.321E-10	1.673E-11	7.782E-09
3800.00	6840.00	3.918E-01	4.017E-10	1.894E-08	1.765E+00	9.290E-10	8.978E-11	1.938E-08
4000.00	7200.00	5.137E-01	2.001E-09	4.295E-08	1.535E+00	2.273E-09	4.015E-10	4.282E-08
4200.00	7560.00	6.444E-01	8.491E-09	8.946E-08	1.307E+00	4.963E-09	1.522E-09	8.441E-08
4400.00	7920.00	7.762E-01	3.104E-08	1.745E-07	1.086E+00	9.872E-09	4.932E-09	1.484E-07
4600.00	8280.00	9.006E-01	9.821E-08	3.255E-07	8.808E-01	1.830E-08	1.373E-08	2.319E-07
4800.00	8640.00	1.010E+00	2.700E-07	5.917E-07	6.971E-01	3.227E-08	3.289E-08	3.211E-07
5000.00	9000.00	1.099E+00	6.501E-07	1.060E-06	5.398E-01	5.492E-08	6.847E-08	3.963E-07
5200.00	9360.00	1.165E+00	1.394E-06	1.873E-06	4.106E-01	9.056E-08	1.251E-07	4.431E-07
5400.00	9720.00	1.209E+00	2.722E-06	3.247E-06	3.083E-01	1.444E-07	2.105E-07	4.590E-07
5600.00	10080.00	1.233E+00	4.935E-06	5.489E-06	2.299E-01	2.223E-07	3.256E-07	4.506E-07
5800.00	10440.00	1.242E+00	8.446E-06	9.016E-06	1.710E-01	3.300E-07	4.753E-07	4.270E-07
6000.00	10800.00	1.239E+00	1.379E-05	1.438E-05	1.276E-01	4.737E-07	6.638E-07	3.960E-07
6300.00	11340.00	1.218E+00	2.685E-05	2.745E-05	8.313E-02	7.701E-07	1.029E-06	3.461E-07
6600.00	11880.00	1.186E+00	4.884E-05	4.945E-05	5.525E-02	1.182E-06	1.507E-06	2.999E-07

TABLE I. - Continued. CONCENTRATIONS OF SPECIES IN SPIN-EQUILIBRATED HYDROGEN IN CHEMICAL EQUILIBRIUM IN DEBYE-HÜCKEL APPROXIMATION

[E-02, E-03, E+02, E+03, etc., after numbers signify that numbers are to be multiplied by 10^{-2}, 10^{-3}, 10^{2}, 10^{3}, etc.]

(j) Concluded. Pressure, 3.03975×10^{6} N/m^2 (30 atm)

Temperature, T		Species						
K	^{o}R	H	H^+	e^-	H_2	H^-	H_2^+	H_3^+
		Dimensionless concentration, $n_i N_o / V L_o$						
7000.00	12600.00	1.137E+00	9.962E-05	1.003E-04	3.321E-02	1.946E-06	2.346E-06	2.485E-07
7300.00	13140.00	1.099E+00	1.613E-04	1.619E-04	2.330E-02	2.705E-06	3.146E-06	2.175E-07
7600.00	13680.00	1.061E+00	2.512E-04	2.519E-04	1.673E-02	3.644E-06	4.106E-06	1.924E-07
8000.00	14400.00	1.012E+00	4.307E-04	4.313E-04	1.111E-02	5.198E-06	5.652E-06	1.658E-07
8300.00	14940.00	9.777E-01	6.239E-04	6.244E-04	8.354E-03	6.605E-06	7.021E-06	1.499E-07
8600.00	15480.00	9.447E-01	8.809E-04	8.814E-04	6.393E-03	8.226E-06	8.573E-06	1.367E-07
9000.00	16200.00	9.032E-01	1.347E-03	1.347E-03	4.583E-03	1.072E-05	1.093E-05	1.223E-07
9300.00	16740.00	8.739E-01	1.809E-03	1.809E-03	3.629E-03	1.284E-05	1.291E-05	1.134E-07
9600.00	17280.00	8.460E-01	2.386E-03	2.386E-03	2.908E-03	1.517E-05	1.506E-05	1.057E-07
10000.00	18000.00	8.106E-01	3.363E-03	3.363E-03	2.202E-03	1.857E-05	1.817E-05	9.707E-08
10500.00	18900.00	7.690E-01	4.981E-03	4.980E-03	1.592E-03	2.323E-05	2.242E-05	8.804E-08
11000.00	19800.00	7.298E-01	7.118E-03	7.116E-03	1.176E-03	2.826E-05	2.697E-05	8.050E-08
11500.00	20700.00	6.924E-01	9.854E-03	9.853E-03	8.842E-04	3.352E-05	3.169E-05	7.388E-08
12000.00	21600.00	6.563E-01	1.327E-02	1.326E-02	6.740E-04	3.883E-05	3.646E-05	6.791E-08
12500.00	22500.00	6.211E-01	1.741E-02	1.741E-02	5.191E-04	4.402E-05	4.110E-05	6.230E-08
13000.00	23400.00	5.865E-01	2.233E-02	2.233E-02	4.028E-04	4.889E-05	4.544E-05	5.692E-08
13500.00	24300.00	5.523E-01	2.805E-02	2.805E-02	3.140E-04	5.322E-05	4.929E-05	5.162E-08
14000.00	25200.00	5.182E-01	3.455E-02	3.455E-02	2.454E-04	5.683E-05	5.249E-05	4.637E-08
15000.00	27000.00	4.502E-01	4.971E-02	4.970E-02	1.496E-04	6.118E-05	5.633E-05	3.602E-08
16000.00	28800.00	3.828E-01	6.710E-02	6.709E-02	8.977E-05	6.118E-05	5.624E-05	2.631E-08
17000.00	30600.00	3.175E-01	8.553E-02	8.552E-02	5.241E-05	5.683E-05	5.222E-05	1.783E-08
18000.00	32400.00	2.563E-01	1.035E-01	1.035E-01	2.957E-05	4.912E-05	4.516E-05	1.112E-08
19000.00	34200.00	2.013E-01	1.196E-01	1.196E-01	1.608E-05	3.965E-05	3.649E-05	6.374E-09
20000.00	36000.00	1.544E-01	1.327E-01	1.327E-01	8.453E-06	3.009E-05	2.774E-05	3.371E-09
21000.00	37800.00	1.162E-01	1.422E-01	1.422E-01	4.345E-06	2.169E-05	2.003E-05	1.665E-09
22000.00	39600.00	8.647E-02	1.482E-01	1.482E-01	2.208E-06	1.504E-05	1.392E-05	7.802E-10
23000.00	41400.00	6.407E-02	1.511E-01	1.511E-01	1.124E-06	1.015E-05	9.415E-06	3.533E-10
24000.00	43200.00	4.762E-02	1.516E-01	1.516E-01	5.824E-07	6.755E-06	6.278E-06	1.571E-10
25000.00	45000.00	3.572E-02	1.504E-01	1.504E-01	3.091E-07	4.471E-06	4.164E-06	6.955E-11
26000.00	46800.00	2.721E-02	1.480E-01	1.480E-01	1.688E-07	2.964E-06	2.766E-06	3.095E-11
27000.00	48600.00	2.107E-02	1.449E-01	1.449E-01	9.514E-08	1.979E-06	1.851E-06	1.391E-11
28000.00	50400.00	1.660E-02	1.414E-01	1.414E-01	5.532E-08	1.335E-06	1.252E-06	6.395E-12
29000.00	52200.00	1.332E-02	1.377E-01	1.377E-01	3.331E-08	9.124E-07	8.569E-07	3.028E-12
30000.00	54000.00	1.088E-02	1.339E-01	1.339E-01	2.066E-08	6.314E-07	5.942E-07	1.475E-12
32000.00	57600.00	7.646E-03	1.265E-01	1.265E-01	8.555E-09	3.147E-07	2.973E-07	3.805E-13
34000.00	61200.00	5.667E-03	1.196E-01	1.196E-01	3.855E-09	1.652E-07	1.566E-07	1.091E-13
36000.00	64800.00	4.410E-03	1.133E-01	1.133E-01	1.903E-09	9.086E-08	8.643E-08	3.443E-14
38000.00	68400.00	3.580E-03	1.074E-01	1.074E-01	9.897E-10	5.214E-08	4.976E-08	1.182E-14
40000.00	72000.00	2.977E-03	1.022E-01	1.022E-01	5.449E-10	3.109E-08	2.976E-08	4.375E-15
43000.00	77400.00	2.366E-03	9.507E-02	9.507E-02	2.391E-10	1.523E-08	1.464E-08	1.114E-15
46000.00	82800.00	1.925E-03	8.890E-02	8.890E-02		7.950E-09	7.677E-09	
50000.00	90000.00	1.550E-03	8.179E-02	8.179E-02		3.641E-09	3.527E-09	
55000.00	99000.00	1.225E-03	7.435E-02	7.435E-02		1.530E-09	1.489E-09	
60000.00	108000.00	9.957E-04	6.815E-02	6.815E-02		7.089E-10	6.928E-10	
65000.00	117000.00	8.316E-04	6.290E-02	6.290E-02		3.557E-10	3.489E-10	
70000.00	126000.00	7.061E-04	5.840E-02	5.840E-02		1.905E-10	1.875E-10	
80000.00	144000.00	4.865E-04	5.112E-02	5.112E-02		6.391E-11	6.320E-11	
90000.00	162000.00	3.382E-04	4.546E-02	4.546E-02		2.513E-11	2.496E-11	
100000.00	180000.00	2.450E-04	4.093E-02	4.093E-02		1.114E-11	1.110E-11	
110000.00	198000.00	1.846E-04	3.721E-02	3.721E-02		5.415E-12	5.412E-12	

TABLE I. - Continued. CONCENTRATIONS OF SPECIES IN SPIN-EQUILIBRATED HYDROGEN IN CHEMICAL EQUILIBRIUM IN DEBYE-HÜCKEL APPROXIMATION

[E-02, E-03, E+02, E+03, etc., after numbers signify that numbers are to be multiplied by 10^{-2}, 10^{-3}, 10^{2}, 10^{3}, etc.]

(k) Pressure, 1.01325×10^{7} N/m^2 (100 atm)

Temperature, T		Species						
K	^{o}R	H	H^+	e^-	H_2	H^-	H_2^+	H_3^+
		Dimensionless concentration, $n_i N_o / V L_o$						
400.00	720.00	9.113E-26			6.829E+01			
500.00	900.00	3.799E-20			5.463E+01			
600.00	1080.00	2.101E-16			4.553E+01			
700.00	1260.00	9.846E-14			3.902E+01			
800.00	1440.00	9.868E-12			3.414E+01			
900.00	1620.00	3.538E-10			3.035E+01			
1000.00	1800.00	6.181E-09			2.732E+01			
1100.00	1980.00	6.400E-08			2.483E+01			
1200.00	2160.00	4.477E-07			2.276E+01			
1300.00	2340.00	2.316E-06			2.101E+01			
1400.00	2520.00	9.457E-06		8.076E-21	1.951E+01	2.421E-24		8.078E-21
1500.00	2700.00	3.194E-05		1.807E-19	1.821E+01	1.077E-22		1.809E-19
1600.00	2880.00	9.249E-05		2.742E-18	1.707E+01	2.960E-21		2.745E-18
1700.00	3060.00	2.359E-04		3.024E-17	1.607E+01	5.472E-20		3.030E-17
1800.00	3240.00	5.414E-04		2.555E-16	1.517E+01	7.270E-19		2.563E-16
1900.00	3420.00	1.137E-03		1.726E-15	1.438E+01	7.316E-18		1.733E-15
2000.00	3600.00	2.213E-03	9.984E-23	9.628E-15	1.366E+01	5.815E-17	1.564E-22	9.686E-15
2100.00	3780.00	4.038E-03	1.771E-21	4.564E-14	1.300E+01	3.777E-16	2.439E-21	4.601E-14
2200.00	3960.00	6.965E-03	2.423E-20	1.878E-13	1.241E+01	2.051E-15	2.969E-20	1.899E-13
2300.00	4140.00	1.145E-02	2.644E-19	6.837E-13	1.186E+01	9.662E-15	2.913E-19	6.933E-13
2400.00	4320.00	1.802E-02	2.368E-18	2.235E-12	1.136E+01	3.967E-14	2.366E-18	2.274E-12
2500.00	4500.00	2.733E-02	1.782E-17	6.645E-12	1.090E+01	1.450E-13	1.628E-17	6.790E-12
2600.00	4680.00	4.010E-02	1.149E-16	1.817E-11	1.047E+01	4.777E-13	9.668E-17	1.865E-11
2700.00	4860.00	5.710E-02	6.462E-16	4.610E-11	1.006E+01	1.436E-12	5.037E-16	4.753E-11
2800.00	5040.00	7.918E-02	3.216E-15	1.094E-10	9.676E+00	3.975E-12	2.335E-15	1.134E-10
2900.00	5220.00	1.072E-01	1.434E-14	2.445E-10	9.312E+00	1.022E-11	9.743E-15	2.547E-10
3000.00	5400.00	1.421E-01	5.793E-14	5.176E-10	8.963E+00	2.459E-11	3.699E-14	5.421E-10
3100.00	5580.00	1.846E-01	2.141E-13	1.043E-09	8.627E+00	5.557E-11	1.289E-13	1.099E-09
3200.00	5760.00	2.355E-01	7.296E-13	2.010E-09	8.300E+00	1.193E-10	4.158E-13	2.129E-09
3400.00	6120.00	3.655E-01	6.844E-12	6.628E-09	7.668E+00	4.727E-10	3.519E-12	7.090E-09
3600.00	6480.00	5.361E-01	5.021E-11	1.903E-08	7.051E+00	1.579E-09	2.347E-11	2.054E-08
3800.00	6840.00	7.485E-01	2.994E-10	4.858E-08	6.440E+00	4.552E-09	1.278E-10	5.270E-08
4000.00	7200.00	1.001E+00	1.496E-09	1.121E-07	5.828E+00	1.156E-08	5.848E-10	1.215E-07
4200.00	7560.00	1.288E+00	6.413E-09	2.370E-07	5.215E+00	2.627E-08	2.296E-09	2.545E-07
4400.00	7920.00	1.599E+00	2.402E-08	4.652E-07	4.609E+00	5.421E-08	7.865E-09	4.875E-07
4600.00	8280.00	1.923E+00	7.970E-08	8.583E-07	4.015E+00	1.030E-07	2.378E-08	8.578E-07
4800.00	8640.00	2.245E+00	2.363E-07	1.507E-06	3.445E+00	1.827E-07	6.400E-08	1.389E-06
5000.00	9000.00	2.552E+00	6.299E-07	2.546E-06	2.911E+00	3.056E-07	1.541E-07	2.071E-06
5200.00	9360.00	2.831E+00	1.516E-06	4.199E-06	2.422E+00	4.931E-07	3.332E-07	2.843E-06
5400.00	9720.00	3.070E+00	3.314E-06	6.800E-06	1.988E+00	7.580E-07	6.508E-07	3.603E-06
5600.00	10080.00	3.265E+00	6.631E-06	1.087E-05	1.612E+00	1.155E-06	1.158E-06	4.245E-06
5800.00	10440.00	3.416E+00	1.228E-05	1.715E-05	1.294E+00	1.726E-06	1.900E-06	4.697E-06
6000.00	10800.00	3.521E+00	2.129E-05	2.665E-05	1.032E+00	2.497E-06	2.913E-06	4.943E-06
6300.00	11340.00	3.605E+00	4.407E-05	4.991E-05	7.293E-01	4.145E-06	5.002E-06	4.984E-06
6600.00	11880.00	3.623E+00	8.328E-05	8.938E-05	5.154E-01	6.523E-06	7.849E-06	4.770E-06

TABLE I. - Continued. CONCENTRATIONS OF SPECIES IN SPIN-EQUILIBRATED HYDROGEN IN CHEMICAL EQUILIBRIUM IN DEBYE-HÜCKEL APPROXIMATION

[E-02, E-03, E+02, E+03, etc., after numbers signify that numbers are to be multiplied by 10^{-2}, 10^{-3}, 10^{2}, 10^{3}, etc.]

(k) Concluded. Pressure, 1.01325×10^{7} N/m^2 (100 atm)

Temperature, T		Species						
K	^{o}R	H	H^+	e^-	H_2	H^-	H_2^+	H_3^+
		Dimensionless concentration, $n_i N_o / V L_o$						
7000.00	12600.00	3.574E+00	1.751E-04	1.813E-04	3.280F-01	1.106E-05	1.296E-05	4.313E-06
7300.00	13140.00	3.504E+00	2.874E-04	2.936E-04	2.370E-01	1.564E-05	1.788E-05	3.945E-06
7600.00	13680.00	3.419E+00	4.521F-04	4.582E-04	1.737E-01	2.136E-05	2.382E-05	3.598E-06
8000.00	14400.00	3.295E+00	7.823E-04	7.879E-04	1.177E-01	3.091E-05	3.341E-05	3.190E-06
8300.00	14940.00	3.199E+00	1.139E-03	1.144E-03	8.945E-02	3.960E-05	4.193E-05	2.929E-06
8600.00	15480.00	3.104E+00	1.614E-03	1.619E-03	6.901E-02	4.965E-05	5.163E-05	2.704E-06
9000.00	16200.00	2.980E+00	2.480E-03	2.484E-03	4.989E-02	6.522E-05	6.639E-05	2.451E-06
9300.00	16740.00	2.891E+00	3.341E-03	3.343E-03	3.970E-02	7.851E-05	7.885E-05	2.291E-06
9600.00	17280.00	2.805E+00	4.418E-03	4.420E-03	3.196E-02	9.316E-05	9.245E-05	2.152E-06
10000.00	18000.00	2.695E+00	6.251E-03	6.250E-03	2.434E-02	1.147E-04	1.123F-04	1.994E-05
10500.00	18900.00	2.565E+00	9.299E-03	9.296E-03	1.772E-02	1.447E-04	1.396E-04	1.829E-06
11000.00	19800.00	2.444E+00	1.335E-02	1.334E-02	1.319E-02	1.774E-04	1.694E-04	1.693E-06
11500.00	20700.00	2.329E+00	1.857E-02	1.856E-02	1.000E-02	2.124E-04	2.009E-04	1.575E-06
12000.00	21600.00	2.220E+00	2.514E-02	2.512E-02	7.709E-03	2.488E-04	2.337E-04	1.472E-06
12500.00	22500.00	2.115E+00	3.319E-02	3.317E-02	6.017E-03	2.857E-04	2.668E-04	1.378E-06
13000.00	23400.00	2.014E+00	4.286E-02	4.284E-02	4.746E-03	3.221E-04	2.995E-04	1.288E-06
13500.00	24300.00	1.915E+00	5.425E-02	5.422E-02	3.775E-03	3.570E-04	3.308E-04	1.202E-06
14000.00	25200.00	1.819E+00	6.740E-02	6.737E-02	3.021E-03	3.893E-04	3.598E-04	1.116E-06
15000.00	27000.00	1.630E+00	9.900E-02	9.897E-02	1.958E-03	4.420E-04	4.070E-04	9.444E-07
16000.00	28800.00	1.445E+00	1.371E-01	1.371E-01	1.276E-03	4.734E-04	4.352E-04	7.710E-07
17000.00	30600.00	1.265E+00	1.804E-01	1.804E-01	8.273E-04	4.796E-04	4.407E-04	6.021E-07
18000.00	32400.00	1.089E+00	2.267E-01	2.267E-01	5.296F-04	4.604E-04	4.233E-04	4.463E-07
19000.00	34200.00	9.223E-01	2.733E-01	2.732E-01	3.326E-04	4.192E-04	3.859E-04	3.119E-07
20000.00	36000.00	7.676E-01	3.174E-01	3.173E-01	2.051E-04	3.633E-04	3.349E-04	2.054E-07
21000.00	37800.00	6.284E-01	3.565E-01	3.565E-01	1.238E-04	3.007E-04	2.778E-04	1.277E-07
22000.00	39600.00	5.071E-01	3.890E-01	3.890E-01	7.337E-05	2.390E-04	2.212E-04	7.505E-08
23000.00	41400.00	4.045E-01	4.140E-01	4.140F-01	4.291E-05	1.835E-04	1.702E-04	4.211E-08
24000.00	43200.00	3.201E-01	4.314E-01	4.314E-01	2.491E-05	1.370E-04	1.273E-04	2.270E-08
25000.00	45000.00	2.524E-01	4.420E-01	4.420E-01	1.446E-05	1.002E-04	9.333E-05	1.189E-08
26000.00	46800.00	1.991E-01	4.468E-01	4.468E-01	8.436E-06	7.231E-05	6.748E-05	6.101E-09
27000.00	48600.00	1.576E-01	4.469E-01	4.469E-01	4.980E-06	5.177E-05	4.842E-05	3.085E-09
28000.00	50400.00	1.255E-01	4.436E-01	4.436E-01	2.984E-06	3.697E-05	3.465E-05	1.562E-09
29000.00	52200.00	1.008E-01	4.379E-01	4.379E-01	1.820E-06	2.644E-05	2.483E-05	7.993E-10
30000.00	54000.00	8.175E-02	4.304E-01	4.304E-01	1.131E-06	1.898E-05	1.787E-05	4.148E-10
32000.00	57600.00	5.549E-02	4.127E-01	4.127E-01	4.692E-07	9.991E-06	9.438E-06	1.175E-10
34000.00	61200.00	3.965E-02	3.935E-01	3.935E-01	2.111E-07	5.428E-06	5.146E-06	3.584E-11
36000.00	64800.00	2.960E-02	3.745E-01	3.745E-01	1.015E-07	3.058E-06	2.909E-06	1.179E-11
38000.00	68400.00	2.286E-02	3.565E-01	3.565E-01	5.212E-08	1.786E-06	1.704E-06	4.175E-12
40000.00	72000.00	1.831E-02	3.396E-01	3.396E-01	2.831E-08	1.078E-06	1.031E-06	1.581E-12
43000.00	77400.00	1.375E-02	3.167E-01	3.167E-01	1.219E-08	5.349E-07	5.140E-07	4.125E-13
46000.00	82800.00	1.073E-02	2.964E-01	2.964E-01	5.695E-09	2.821E-07	2.721E-07	1.214E-13
50000.00	90000.00	8.228E-03	2.728E-01	2.728E-01		1.301E-07	1.261E-07	
55000.00	99000.00	6.240E-03	2.480E-01	2.480E-01		5.506E-08	5.358E-08	
60000.00	108000.00	4.970E-03	2.273E-01	2.273E-01		2.564E-08	2.505E-08	
65000.00	117000.00	4.029E-03	2.098E-01	2.098E-01		1.291E-08	1.266E-08	
70000.00	126000.00	3.401E-03	1.948E-01	1.948E-01		6.933E-09	6.821E-09	
80000.00	144000.00	2.507E-03	1.704E-01	1.704E-01		2.331E-09	2.306E-09	
90000.00	162000.00	1.934E-03	1.514E-01	1.514E-01		9.180E-10	9.117E-10	
100000.00	180000.00	1.515E-03	1.363E-01	1.363E-01		4.074E-10	4.059E-10	
110000.00	198000.00	1.135E-03	1.239E-01	1.239E-01		1.985E-10	1.984E-10	

TABLE I. - Continued. CONCENTRATIONS OF SPECIES IN SPIN-EQUILIBRATED HYDROGEN IN CHEMICAL EQUILIBRIUM IN DEBYE-HÜCKEL APPROXIMATION

[E-02, E-03, E+02, E+03, etc., after numbers signify that numbers are to be multiplied by 10^{-2}, 10^{-3}, 10^{2}, 10^{3}, etc.]

(*l*) Pressure, 3.03975×10^{7} N/m^2 (300 atm)

Temperature, T		Species						
K	^{o}R	H	H^+	e^-	H_2	H^-	H_2^+	H_3^+
		Dimensionless concentration, $n_i N_o / V L_o$						
1100.00	1980.00	1.108E-07			7.450E+01			
1200.00	2160.00	7.754E-07			6.829E+01			
1300.00	2340.00	4.012E-06			6.303E+01			
1400.00	2520.00	1.638E-05		1.841E-20	5.853E+01	9.558E-24		1.842E-20
1500.00	2700.00	5.533E-05		4.118E-19	5.463E+01	4.253E-22		4.122E-19
1600.00	2880.00	1.602E-04		6.249E-18	5.122E+01	1.168E-20		6.261E-18
1700.00	3060.00	4.086E-04		6.889E-17	4.820E+01	2.159E-19		6.910E-17
1800.00	3240.00	9.378E-04		5.819E-16	4.552E+01	2.867E-18		5.847E-16
1900.00	3420.00	1.969E-03		3.927E-15	4.313E+01	2.884E-17		3.956E-15
2000.00	3600.00	3.833E-03	7.603E-23	2.190E-14	4.097E+01	2.291E-16	2.063E-22	2.213E-14
2100.00	3780.00	6.994E-03	1.350E-21	1.037E-13	3.901E+01	1.487E-15	3.220E-21	1.052E-13
2200.00	3960.00	1.207E-02	1.848E-20	4.265E-13	3.724E+01	8.107E-15	3.923E-20	4.345E-13
2300.00	4140.00	1.983E-02	2.019E-19	1.551E-12	3.561E+01	3.797E-14	3.854E-19	1.589E-12
2400.00	4320.00	3.123E-02	1.811E-18	5.065E-12	3.411E+01	1.558E-13	3.135E-18	5.220E-12
2500.00	4500.00	4.737E-02	1.364E-17	1.504E-11	3.273E+01	5.687E-13	2.160E-17	1.561E-11
2600.00	4680.00	6.950E-02	8.809E-17	4.108E-11	3.145E+01	1.872E-12	1.285E-16	4.295E-11
2700.00	4860.00	9.902E-02	4.961E-16	1.041E-10	3.025E+01	5.624E-12	6.706E-16	1.097E-10
2800.00	5040.00	1.374E-01	2.473E-15	2.469E-10	2.913E+01	1.556E-11	3.115E-15	2.624E-10
2900.00	5220.00	1.861E-01	1.104E-14	5.513E-10	2.807E+01	4.002E-11	1.303E-14	5.913E-10
3000.00	5400.00	2.469E-01	4.468E-14	1.166E-09	2.707E+01	9.629E-11	4.958E-14	1.263E-09
3100.00	5580.00	3.211E-01	1.653E-13	2.350E-09	2.611E+01	2.182E-10	1.732E-13	2.568E-09
3200.00	5760.00	4.104E-01	5.643E-13	4.530E-09	2.520E+01	4.683E-10	5.603E-13	4.997E-09
3400.00	6120.00	6.393E-01	5.305E-12	1.496E-08	2.346E+01	1.866E-09	4.771E-12	1.682E-08
3600.00	6480.00	9.430E-01	3.899E-11	4.313E-08	2.182E+01	6.294E-09	3.206E-11	4.936E-08
3800.00	6840.00	1.327E+00	2.329E-10	1.108E-07	2.024E+01	1.841E-08	1.763E-10	1.289E-07
4000.00	7200.00	1.793E+00	1.165E-09	2.580E-07	1.869E+01	4.766E-08	8.159E-10	3.037E-07
4200.00	7560.00	2.336E+00	5.008E-09	5.517E-07	1.717E+01	1.110E-07	3.254E-09	6.544E-07
4400.00	7920.00	2.949E+00	1.886E-08	1.096E-06	1.568E+01	2.355E-07	1.138E-08	1.301E-06
4600.00	8280.00	3.616E+00	6.319E-08	2.043E-06	1.420E+01	4.610E-07	3.546E-08	2.405E-06
4800.00	8640.00	4.320E+00	1.909E-07	3.604E-06	1.275E+01	8.406E-07	9.948E-08	4.154E-06
5000.00	9000.00	5.040E+00	5.251E-07	6.068E-06	1.135E+01	1.442E-06	2.536E-07	6.731E-06
5200.00	9360.00	5.753E+00	1.325E-06	9.830E-06	1.001E+01	2.346E-06	5.916E-07	1.025E-05
5400.00	9720.00	6.437E+00	3.084E-06	1.543E-05	8.738E+00	3.655E-06	1.270E-06	1.474E-05
5600.00	10080.00	7.074E+00	6.653E-06	2.365E-05	7.559E+00	5.493E-06	2.517E-06	1.998E-05
5800.00	10440.00	7.645E+00	1.336E-05	3.559E-05	6.483E+00	8.020E-06	4.630E-06	2.561E-05
6000.00	10800.00	8.142E+00	2.510E-05	5.278E-05	5.516E+00	1.143E-05	7.944E-06	3.116E-05
6300.00	11340.00	8.732E+00	5.778E-05	9.322E-05	4.275E+00	1.875E-05	1.588E-05	3.831E-05
6600.00	11880.00	9.139E+00	1.186E-04	1.604E-04	3.278E+00	2.953E-05	2.818E-05	4.320E-05

TABLE I. - Continued. CONCENTRATIONS OF SPECIES IN SPIN-EQUILIBRATED HYDROGEN IN CHEMICAL EQUILIBRIUM IN DEBYE-HÜCKEL APPROXIMATION

[E-02, E-03, E+02, E+03, etc., after numbers signify that numbers are to be multiplied by 10^{-2}, 10^{-3}, 10^{2}, 10^{3}, etc.]

(l) Concluded. Pressure, 3.03975×10^{7} N/m^2 (300 atm)

Temperature, T		Species						
K	^{o}R	H	H^+	e^-	H_2	H^-	H_2^+	H_3^+
		Dimensionless concentration, $n_i N_o/VL_o$						
7000.00	12600.00	9.425E+00	2.688E-04	3.165E-04	2.281E+00	5.090E-05	5.248E-05	4.606E-05
7300.00	13140.00	9.487E+00	4.582E-04	5.081E-04	1.737E+00	7.329E-05	7.716E-05	4.609E-05
7600.00	13680.00	9.453E+00	7.399E-04	7.907E-04	1.328E+00	1.019E-04	1.077E-04	4.499E-05
8000.00	14400.00	9.302E+00	1.311E-03	1.361E-03	9.378E-01	1.508E-04	1.581E-04	4.262E-05
8300.00	14940.00	9.139E+00	1.933E-03	1.981E-03	7.299E-01	1.959E-04	2.034E-04	4.058E-05
8600.00	15480.00	8.949E+00	2.768E-03	2.813E-03	5.736E-01	2.487E-04	2.551E-04	3.853E-05
9000.00	16200.00	8.673E+00	4.293E-03	4.333E-03	4.226E-01	3.311E-04	3.345E-04	3.594E-05
9300.00	15740.00	8.459E+00	5.818E-03	5.852E-03	3.400E-01	4.021E-04	4.018E-04	3.415E-05
9600.00	17280.00	8.244E+00	7.733E-03	7.760E-03	2.762E-01	4.809E-04	4.756E-04	3.255E-05
10000.00	18000.00	7.960E+00	1.100E-02	1.102E-02	2.123E-01	5.975E-04	5.840E-04	3.063E-05
10500.00	18900.00	7.615E+00	1.648E-02	1.648E-02	1.561E-01	7.611E-04	7.343E-04	2.855E-05
11000.00	19800.00	7.285E+00	2.379E-02	2.377E-02	1.172E-01	9.424E-04	8.996E-04	2.681E-05
11500.00	20700.00	6.970E+00	3.328E-02	3.324E-02	8.961E-02	1.139E-03	1.078E-03	2.529E-05
12000.00	21600.00	6.671E+00	4.529E-02	4.523E-02	6.962E-02	1.346E-03	1.265E-03	2.396E-05
12500.00	22500.00	6.384E+00	6.013E-02	6.006E-02	5.483E-02	1.552E-03	1.459E-03	2.275E-05
13000.00	23400.00	6.109E+00	7.811E-02	7.801E-02	4.368E-02	1.780E-03	1.656E-03	2.162E-05
13500.00	24300.00	5.844E+00	9.947E-02	9.934E-02	3.514E-02	1.997E-03	1.852E-03	2.054E-05
14000.00	25200.00	5.588E+00	1.244E-01	1.243E-01	2.850E-02	2.207E-03	2.041E-03	1.947E-05
15000.00	27000.00	5.094E+00	1.854E-01	1.853E-01	1.910E-02	2.588E-03	2.385E-03	1.731E-05
16000.00	28800.00	4.620E+00	2.613E-01	2.611E-01	1.301E-02	2.886E-03	2.654E-03	1.505E-05
17000.00	30600.00	4.160E+00	3.507E-01	3.505E-01	8.923E-03	3.073E-03	2.826E-03	1.273E-05
18000.00	32400.00	3.714E+00	4.510E-01	4.508E-01	6.123E-03	3.133E-03	2.882E-03	1.040E-05
19000.00	34200.00	3.282E+00	5.582E-01	5.580E-01	4.185E-03	3.054E-03	2.822E-03	8.165E-06
20000.00	36000.00	2.869E+00	6.676E-01	6.674E-01	2.835E-03	2.881E-03	2.656E-03	6.143E-06
21000.00	37800.00	2.480E+00	7.742E-01	7.740E-01	1.902E-03	2.608E-03	2.410E-03	4.424E-06
22000.00	39600.00	2.121E+00	8.733E-01	8.732E-01	1.262E-03	2.282E-03	2.112E-03	3.048E-06
23000.00	41400.00	1.796E+00	9.614E-01	9.612E-01	8.282E-04	1.935E-03	1.794E-03	2.015E-06
24000.00	43200.00	1.507E+00	1.036E+00	1.036E+00	5.383E-04	1.595E-03	1.483E-03	1.282E-06
25000.00	45000.00	1.255E+00	1.095E+00	1.095E+00	3.473E-04	1.285E-03	1.196E-03	7.884E-07
26000.00	46800.00	1.042E+00	1.140E+00	1.140E+00	2.231E-04	1.014E-03	9.466E-04	4.705E-07
27000.00	48600.00	8.610E-01	1.171E+00	1.171E+00	1.431E-04	7.885E-04	7.375E-04	2.732E-07
28000.00	50400.00	7.110E-01	1.189E+00	1.189E+00	9.202E-05	6.051E-04	5.681E-04	1.566E-07
29000.00	52200.00	5.878E-01	1.197E+00	1.197E+00	5.944E-05	4.623E-04	4.341E-04	8.941E-08
30000.00	54000.00	4.872E-01	1.196E+00	1.196E+00	3.868E-05	3.510E-04	3.303E-04	5.102E-08
32000.00	57600.00	3.390E-01	1.177E+00	1.177E+00	1.686E-05	2.018E-04	1.906E-04	1.693E-08
34000.00	61200.00	2.414E-01	1.142E+00	1.142E+00	7.701E-06	1.171E-04	1.110E-04	5.743E-09
36000.00	64800.00	1.765E-01	1.100E+00	1.100E+00	3.728E-06	6.913E-05	6.576E-05	2.053E-09
38000.00	68400.00	1.340E-01	1.054E+00	1.054E+00	1.909E-06	4.159E-05	3.978E-05	7.695E-10
40000.00	72000.00	1.045E-01	1.010E+00	1.010E+00	1.024E-06	2.578E-05	2.467E-05	3.044E-10
43000.00	77400.00	7.509E-02	9.458E-01	9.458E-01	4.364E-07	1.314E-05	1.262E-05	8.332E-11
46000.00	82800.00	5.678E-02	8.874E-01	8.874E-01	2.072E-07	7.050E-06	6.800E-06	2.531E-11
50000.00	90000.00	4.148E-02	8.183E-01	8.183E-01	8.329E-08	3.306E-06	3.202E-06	5.966E-12
55000.00	99000.00	2.962E-02	7.449E-01	7.449E-01		1.418E-06	1.380E-06	
60000.00	108000.00	2.272E-02	6.829E-01	6.829E-01		6.662E-07	6.511E-07	
65000.00	117000.00	1.816E-02	6.302E-01	6.302E-01		3.375E-07	3.310E-07	
70000.00	126000.00	1.495E-02	5.850E-01	5.850E-01		1.821E-07	1.792E-07	
80000.00	144000.00	1.060E-02	5.116E-01	5.116E-01		6.165E-08	6.097E-08	
90000.00	162000.00	8.095E-03	4.546E-01	4.546E-01		2.437E-08	2.420E-08	
100000.00	180000.00	6.401E-03	4.090E-01	4.090E-01		1.084E-08	1.080E-08	
110000.00	198000.00	5.131E-03	3.718E-01	3.718E-01		5.290E-09	5.287E-09	

TABLE I. - Continued. CONCENTRATIONS OF SPECIES IN SPIN-EQUILIBRATED HYDROGEN IN CHEMICAL EQUILIBRIUM IN DEBYE-HÜCKEL APPROXIMATION

[E-02, E-03, E+02, E+03, etc., after numbers signify that numbers are to be multiplied by 10^{-2}, 10^{-3}, 10^{2}, 10^{3}, etc.]

(m) Pressure, 1.01325×10^{8} N/m^2 (1000 atm)

Temperature, T		Species						
K	°R	H	H^+	e^-	H_2	H^-	H_2^+	H_3^+
		Dimensionless concentration, n_iN_o/VL_o						
3200.00	5760.00	7.520E-01	4.329E-13	1.082E-08	8.461E+01	2.051E-09	7.877E-13	1.287E-08
3400.00	6120.00	1.174E+00	4.094E-12	3.564E-08	7.916E+01	8.166E-09	6.763E-12	4.379E-08
3600.00	6480.00	1.738E+00	3.025E-11	1.026E-07	7.414E+01	2.759E-08	4.585E-11	1.301E-07
3800.00	6840.00	2.458E+00	1.815E-10	2.638E-07	6.942E+01	8.116E-08	2.545E-10	3.445E-07
4000.00	7200.00	3.341E+00	9.122E-10	6.159E-07	6.495E+01	2.121E-07	1.190E-09	8.259E-07
4200.00	7560.00	4.390E+00	3.935E-09	1.324E-06	6.065E+01	5.004E-07	4.804E-09	1.816E-06
4400.00	7920.00	5.597E+00	1.487E-08	2.650E-06	5.648E+01	1.081E-06	1.705E-08	3.699E-06
4600.00	8280.00	6.949E+00	5.009E-08	4.983E-06	5.243E+01	2.161E-06	5.401E-08	7.040E-06
4800.00	8640.00	8.424E+00	1.524E-07	8.875E-06	4.848E+01	4.036E-06	1.548E-07	1.260E-05
5000.00	9000.00	9.995E+00	4.234E-07	1.507E-05	4.464E+01	7.101E-06	4.056E-07	2.134E-05
5200.00	9360.00	1.163E+01	1.085E-06	2.456E-05	4.090E+01	1.185E-05	9.796E-07	3.434E-05
5400.00	9720.00	1.330E+01	2.584E-06	3.860E-05	3.729E+01	1.888E-05	2.198E-06	5.269E-05
5600.00	10080.00	1.496E+01	5.756E-06	5.880E-05	3.382E+01	2.888E-05	4.606E-06	7.732E-05
5800.00	10440.00	1.659E+01	1.206E-05	8.723E-05	3.051E+01	4.254E-05	9.063E-06	1.088E-04
6000.00	10800.00	1.814E+01	2.384E-05	1.265E-04	2.738E+01	6.108E-05	1.681E-05	1.470E-04
6300.00	11340.00	2.028E+01	6.008E-05	2.136E-04	2.307E+01	9.981E-05	3.836E-05	2.150E-04
6600.00	11880.00	2.214E+01	1.359E-04	3.491E-04	1.925E+01	1.557E-04	7.826E-05	2.906E-04
7000.00	12600.00	2.410E+01	3.482E-04	6.462E-04	1.492E+01	2.658E-04	1.738E-04	3.901E-04
7300.00	13140.00	2.518E+01	6.414E-04	9.998E-04	1.224E+01	3.828E-04	2.867E-04	4.545E-04
7600.00	13680.00	2.594E+01	1.104E-03	1.515E-03	9.998E+00	5.359E-04	4.412E-04	5.055E-04
8000.00	14400.00	2.652E+01	2.089E-03	2.553E-03	7.621E+00	8.051E-04	7.182E-04	5.519E-04
8300.00	14940.00	2.668E+01	3.196E-03	3.686E-03	6.221E+00	1.054E-03	9.816E-04	5.718E-04
8600.00	15480.00	2.665E+01	4.711E-03	5.213E-03	5.091E+00	1.373E-03	1.294E-03	5.820E-04
9000.00	16200.00	2.641E+01	7.528E-03	8.030E-03	3.919E+00	1.869E-03	1.786E-03	5.843E-04
9300.00	16740.00	2.611E+01	1.038E-02	1.087E-02	3.238E+00	2.304E-03	2.212E-03	5.804E-04
9600.00	17280.00	2.573E+01	1.399E-02	1.445E-02	2.690E+00	2.795E-03	2.686E-03	5.735E-04
10000.00	18000.00	2.515E+01	2.021E-02	2.063E-02	2.120E+00	3.534E-03	3.389E-03	5.615E-04
10500.00	18900.00	2.435E+01	3.073E-02	3.106E-02	1.596E+00	4.588E-03	4.379E-03	5.445E-04
11000.00	19800.00	2.351E+01	4.492E-02	4.515E-02	1.221E+00	5.778E-03	5.484E-03	5.275E-04
11500.00	20700.00	2.267E+01	6.351E-02	6.362E-02	9.481E-01	7.088E-03	6.689E-03	5.107E-04
12000.00	21600.00	2.184E+01	8.725E-02	8.722E-02	7.462E-01	8.500E-03	7.981E-03	4.948E-04
12500.00	22500.00	2.102E+01	1.169E-01	1.167E-01	5.946E-01	9.993E-03	9.341E-03	4.795E-04

TABLE I. - Concluded. CONCENTRATIONS OF SPECIES IN SPIN-EQUILIBRATED HYDROGEN IN CHEMICAL EQUILIBRIUM IN DEBYE-HÜCKEL APPROXIMATION

[E-02, E-03, E+02, E+03, etc., after numbers signify that numbers are to be multiplied by 10^{-2}, 10^{-3}, 10^{2}, 10^{3}, etc.]

(m) Concluded. Pressure, 1.01325×10^{8} N/m^2 (1000 atm)

Temperature, T		Species						
K	^{o}R	H	H^+	e^-	H_2	H^-	H_2^+	H_3^+
		Dimensionless concentration, n_iN_o/VL_o						
13000.00	23400.00	2.023E+01	1.531E-01	1.527E-01	4.790E-01	1.154E-02	1.075E-02	4.648E-04
13500.00	24300.00	1.946E+01	1.965E-01	1.960E-01	3.896E-01	1.312E-02	1.218E-02	4.501E-04
14000.00	25200.00	1.872E+01	2.477E-01	2.471E-01	3.197E-01	1.471E-02	1.362E-02	4.353E-04
15000.00	27000.00	1.729E+01	3.754E-01	3.744E-01	2.197E-01	1.776E-02	1.639E-02	4.040E-04
16000.00	28800.00	1.592E+01	5.380E-01	5.367E-01	1.543E-01	2.047E-02	1.886E-02	3.692E-04
17000.00	30600.00	1.462E+01	7.353E-01	7.338E-01	1.100E-01	2.265E-02	2.086E-02	3.309E-04
18000.00	32400.00	1.335E+01	9.641E-01	9.625E-01	7.912E-02	2.414E-02	2.223E-02	2.895E-04
19000.00	34200.00	1.215E+01	1.219E+00	1.217E+00	5.716E-02	2.485E-02	2.290E-02	2.463E-04
20000.00	36000.00	1.098E+01	1.491E+00	1.490E+00	4.136E-02	2.475E-02	2.285E-02	2.034E-04
21000.00	37800.00	9.855E+00	1.773E+00	1.771E+00	2.988E-02	2.393E-02	2.212E-02	1.629E-04
22000.00	39600.00	8.788E+00	2.053E+00	2.051E+00	2.153E-02	2.250E-02	2.083E-02	1.262E-04
23000.00	41400.00	7.786E+00	2.322E+00	2.321E+00	1.544E-02	2.060E-02	1.911E-02	9.471E-05
24000.00	43200.00	6.855E+00	2.572E+00	2.570E+00	1.101E-02	1.840E-02	1.711E-02	6.879E-05
25000.00	45000.00	6.001E+00	2.796E+00	2.795E+00	7.830E-03	1.610E-02	1.500E-02	4.853E-05
26000.00	46800.00	5.227E+00	2.991E+00	2.990E+00	5.544E-03	1.382E-02	1.290E-02	3.329E-05
27000.00	48600.00	4.533E+00	3.154E+00	3.154E+00	3.913E-03	1.167E-02	1.091E-02	2.221E-05
28000.00	50400.00	3.918E+00	3.286E+00	3.285E+00	2.756E-03	9.715E-03	9.107E-03	1.455E-05
29000.00	52200.00	3.379E+00	3.386E+00	3.386E+00	1.939E-03	7.997E-03	7.511E-03	9.460E-06
30000.00	54000.00	2.909E+00	3.458E+00	3.458E+00	1.365E-03	6.522E-03	6.138E-03	6.095E-06
32000.00	57600.00	2.155E+00	3.529E+00	3.529E+00	6.803E-04	4.256E-03	4.020E-03	2.495E-06
34000.00	61200.00	1.603E+00	3.525E+00	3.525E+00	3.449E-04	2.739E-03	2.596E-03	1.018E-06
36000.00	64800.00	1.205E+00	3.470E+00	3.470E+00	1.795E-04	1.757E-03	1.671E-03	4.202E-07
38000.00	68400.00	9.231E-01	3.380E+00	3.380E+00	9.629E-05	1.130E-03	1.078E-03	1.764E-07
40000.00	72000.00	7.194E-01	3.273E+00	3.273E+00	5.331E-05	7.349E-04	7.033E-04	7.629E-08
43000.00	77400.00	5.108E-01	3.102E+00	3.102E+00	2.325E-05	3.960E-04	3.805E-04	2.308E-08
46000.00	82800.00	3.756E-01	2.932E+00	2.932E+00	1.083E-05	2.213E-04	2.134E-04	7.549E-09
50000.00	90000.00	2.640E-01	2.718E+00	2.718E+00	4.378E-06	1.076E-04	1.043E-04	1.904E-09
55000.00	99000.00	1.825E-01	2.482E+00	2.482E+00	1.578E-06	4.754E-05	4.627E-05	4.023E-10
60000.00	108000.00	1.326E-01	2.279E+00	2.279E+00		2.281E-05	2.229E-05	
65000.00	117000.00	9.996E-02	2.106E+00	2.106E+00		1.174E-05	1.151E-05	
70000.00	126000.00	8.004E-02	1.955E+00	1.955E+00		6.393E-06	6.290E-06	
80000.00	144000.00	5.507E-02	1.709E+00	1.709E+00		2.193E-06	2.169E-06	
90000.00	162000.00	4.099E-02	1.517E+00	1.517E+00		8.741E-07	8.681E-07	
100000.00	180000.00	3.112E-02	1.365E+00	1.365E+00		3.914E-07	3.901E-07	
110000.00	198000.00	2.493E-02	1.240E+00	1.240E+00		1.917E-07	1.916E-07	

TABLE II. - THERMODYNAMIC PROPERTIES OF SPIN-EQUILIBRATED HYDROGEN IN CHEMICAL EQUILIBRIUM IN DEBYE-HÜCKEL APPROXIMATION

[E-02, E-03, E+02, E+03, etc., after numbers signify that numbers are to be multiplied by 10^{-2}, 10^{-3}, 10^{2}, 10^{3}, etc.]

(a) Pressure, 1.01325×10^{2} N/m^2 (0.001 atm)

Temperature, T		Enthalpy, h		Entropy, s		Average molecular weight, g/g-mole or lb/lb-mole	Specific heat, c_p		Density, ρ		Isentropic exponent, γ
K	^{o}R	J/g	Btu/lb	J/(g)(K)	Btu/(lb)(^{o}R)		J/(g)(K)	Btu/(lb)(^{o}R)	g/m^3	lb/ft^3	
100.00	180.0	-2.1284E+05	-9.1537E+04	78.41	18.734	2.0156	13.967	3.337	2.456E-01	1.534E-05	1.419
150.00	270.0	-2.1217E+05	-9.1250E+04	83.84	20.031	2.0156	13.174	3.148	1.638E-01	1.022E-05	1.456
200.00	360.0	-2.1150E+05	-9.0963E+04	87.68	20.949	2.0156	13.619	3.254	1.228E-01	7.668E-06	1.434
250.00	450.0	-2.1081E+05	-9.0665E+04	90.77	21.687	2.0156	14.064	3.360	9.826E-02	6.134E-06	1.415
298.15	536.7	-2.1013E+05	-9.0371E+04	93.27	22.285	2.0156	14.299	3.417	8.239E-02	5.143E-06	1.405
400.00	720.0	-2.0866E+05	-8.9739E+04	97.50	23.296	2.0156	14.479	3.460	6.141E-02	3.834E-06	1.398
500.00	900.0	-2.0721E+05	-8.9116E+04	100.74	24.070	2.0156	14.519	3.469	4.913E-02	3.067E-06	1.397
600.00	1080.0	-2.0576E+05	-8.8491E+04	103.39	24.703	2.0156	14.550	3.476	4.094E-02	2.556E-06	1.396
700.00	1260.0	-2.0430E+05	-8.7864E+04	105.63	25.239	2.0156	14.607	3.490	3.509E-02	2.191E-06	1.394
800.00	1440.0	-2.0283E+05	-8.7234E+04	107.59	25.707	2.0156	14.696	3.511	3.071E-02	1.917E-06	1.390
900.00	1620.0	-2.0136E+05	-8.6599E+04	109.33	26.122	2.0156	14.825	3.542	2.729E-02	1.704E-06	1.386
1000.00	1800.0	-1.9987E+05	-8.5958E+04	110.90	26.497	2.0156	14.985	3.580	2.456E-02	1.534E-06	1.380
1100.00	1980.0	-1.9835E+05	-8.5310E+04	112.34	26.840	2.0156	15.173	3.625	2.233E-02	1.394E-06	1.373
1200.00	2160.0	-1.9683E+05	-8.4653E+04	113.66	27.158	2.0156	15.389	3.677	2.047E-02	1.278E-06	1.366
1300.00	2340.0	-1.9528E+05	-8.3986E+04	114.91	27.455	2.0156	15.650	3.739	1.890E-02	1.180E-06	1.358
1400.00	2520.0	-1.9370E+05	-8.3305E+04	116.08	27.735	2.0155	16.042	3.833	1.754E-02	1.095E-06	1.347
1500.00	2700.0	-1.9205E+05	-8.2601E+04	117.21	28.005	2.0151	16.769	4.007	1.637E-02	1.022E-06	1.330
1600.00	2880.0	-1.9032E+05	-8.1852E+04	118.33	28.273	2.0139	18.265	4.364	1.534E-02	9.576E-07	1.302
1700.00	3060.0	-1.8835E+05	-8.1008E+04	119.52	28.557	2.0110	21.335	5.098	1.442E-02	9.000E-07	1.261
1800.00	3240.0	-1.8595E+05	-7.9976E+04	120.89	28.885	2.0043	27.284	6.519	1.357E-02	8.472E-07	1.214
1900.00	3420.0	-1.8274E+05	-7.8592E+04	122.63	29.300	1.9908	38.075	9.097	1.277E-02	7.971E-07	1.171
2000.00	3600.0	-1.7809E+05	-7.6593E+04	125.01	29.868	1.9653	56.409	13.478	1.198E-02	7.476E-07	1.139
2100.00	3780.0	-1.7109E+05	-7.3583E+04	128.42	30.683	1.9214	85.692	20.475	1.115E-02	6.961E-07	1.120
2200.00	3960.0	-1.6046E+05	-6.9012E+04	133.35	31.862	1.8520	129.611	30.968	1.026E-02	6.404E-07	1.109
2300.00	4140.0	-1.4460E+05	-6.2189E+04	140.40	33.545	1.7516	190.541	45.526	9.281E-03	5.794E-07	1.105
2400.00	4320.0	-1.2189E+05	-5.2421E+04	150.05	35.852	1.6215	265.115	63.344	8.234E-03	5.140E-07	1.104
2500.00	4500.0	-9.1672E+04	-3.9426E+04	162.37	38.796	1.4732	336.108	80.307	7.181E-03	4.483E-07	1.106
2600.00	4680.0	-5.5925E+04	-2.4052E+04	176.39	42.145	1.3284	359.350	88.249	5.226E-03	3.887E-07	1.111
2700.00	4860.0	-2.0018E+04	-8.6093E+03	189.95	45.384	1.2392	337.733	80.695	5.458E-03	3.407E-07	1.119
2800.00	5040.0	9.9771E+03	4.2909E+03	200.86	47.992	1.1261	257.735	61.581	4.901E-03	3.060E-07	1.131
2900.00	5220.0	3.1412E+04	1.3509E+04	208.39	49.791	1.0748	173.352	41.422	4.517E-03	2.820E-07	1.151
3000.00	5400.0	4.5408E+04	1.9529E+04	213.14	50.927	1.0456	110.895	26.496	4.247E-03	2.652E-07	1.182
3100.00	5580.0	5.4386E+04	2.3390E+04	216.09	51.631	1.0294	72.110	17.229	4.047E-03	2.526E-07	1.229
3200.00	5760.0	6.0378E+04	2.5967E+04	218.00	52.086	1.0204	49.856	11.912	3.886E-03	2.426E-07	1.293
3400.00	5120.0	6.8041E+04	2.9263E+04	220.32	52.642	1.0124	30.460	7.278	3.629E-03	2.265E-07	1.441
3600.00	5480.0	7.3399E+04	3.1567E+04	221.86	53.008	1.0097	24.236	5.791	3.418E-03	2.134E-07	1.556
3800.00	5840.0	7.7995E+04	3.3544E+04	223.10	53.305	1.0087	22.079	5.275	3.235E-03	2.019E-07	1.617
4000.00	7200.0	8.2317E+04	3.5403E+04	224.21	53.570	1.0082	21.268	5.082	3.072E-03	1.918E-07	1.644
4200.00	7560.0	8.6534E+04	3.7216E+04	225.24	53.816	1.0080	20.949	5.005	2.925E-03	1.826E-07	1.655
4400.00	7920.0	9.0713E+04	3.9012E+04	226.21	54.048	1.0079	20.837	4.979	2.792E-03	1.743E-07	1.659

4600.00	8280.0	9.4875E+04	4.0804E+04	227.13	54.269	1.0079	20.839	4.979	2.670E-03	1.667E-07	1.658
4800.00	8640.0	9.9052E+04	4.2600E+04	228.02	54.482	1.0078	20.940	5.003	2.559E-03	1.597E-07	1.653
5000.00	9000.0	1.0325E+05	4.4410E+04	228.88	54.687	1.0077	21.163	5.057	2.456E-03	1.533E-07	1.643
5200.00	9360.0	1.0753E+05	4.6246E+04	229.72	54.887	1.0076	21.560	5.151	2.362E-03	1.474E-07	1.627
5400.00	9720.0	1.1190E+05	4.8126E+04	230.54	55.084	1.0075	22.214	5.308	2.274E-03	1.419E-07	1.602
5600.00	10080.0	1.1644E+05	5.0078E+04	231.37	55.281	1.0072	23.238	5.552	2.192E-03	1.368E-07	1.568
5800.00	10440.0	1.2123E+05	5.2139E+04	232.21	55.482	1.0067	24.783	5.921	2.115E-03	1.321E-07	1.524
6000.00	10800.0	1.2640E+05	5.4361E+04	233.09	55.691	1.0060	27.041	6.461	2.043E-03	1.276E-07	1.473
6300.00	11340.0	1.3524E+05	5.8161E+04	234.52	56.034	1.0041	32.301	7.718	1.942E-03	1.213E-07	1.391
6600.00	11880.0	1.4610E+05	6.2833E+04	236.20	56.436	1.0009	40.737	9.733	1.848E-03	1.154E-07	1.315
7000.00	12600.0	1.6575E+05	7.1289E+04	239.09	57.126	0.9931	59.202	14.145	1.729E-03	1.079E-07	1.235
7300.00	13140.0	1.8653E+05	8.0224E+04	241.99	57.820	0.9835	80.563	19.249	1.642E-03	1.025E-07	1.195
7600.00	13680.0	2.1495E+05	9.2444E+04	245.80	58.730	0.9692	110.445	26.389	1.554E-03	9.702E-08	1.167
8000.00	14400.0	2.6973E+05	1.1600E+05	252.82	60.406	0.9407	166.952	39.890	1.433E-03	8.947E-08	1.145
8300.00	14940.0	3.2803E+05	1.4108E+05	259.97	62.114	0.9109	223.950	53.509	1.338E-03	8.350E-08	1.135
8600.00	15480.0	4.0543E+05	1.7435E+05	269.11	64.300	0.8733	293.865	70.213	1.238E-03	7.727E-08	1.130
9000.00	16200.0	5.4417E+05	2.3403E+05	284.87	68.064	0.8122	401.727	95.985	1.100E-03	6.868E-08	1.127
9300.00	16740.0	6.7692E+05	2.9113E+05	299.37	71.529	0.7509	481.721	115.098	9.976E-04	6.228E-08	1.127
9600.00	17280.0	8.3131E+05	3.5753E+05	315.71	75.432	0.7089	542.660	129.658	9.004E-04	5.621E-08	1.129
10000.00	18000.0	1.0551E+06	4.5376E+05	338.54	80.888	0.6452	561.926	134.261	7.868E-04	4.912E-08	1.134
10500.00	18900.0	1.3177E+06	5.6672E+05	364.19	87.016	0.5846	470.399	112.393	6.790E-04	4.239E-08	1.146
11000.00	19800.0	1.5160E+06	6.5199E+05	382.66	91.430	0.5472	321.929	76.919	6.067E-04	3.788E-08	1.167
11500.00	20700.0	1.6446E+06	7.0731E+05	394.12	94.167	0.5268	200.626	47.936	5.587E-04	3.488E-08	1.204
12000.00	21600.0	1.7247E+06	7.4173E+05	400.94	95.798	0.5163	126.636	30.257	5.247E-04	3.276E-08	1.261
12500.00	22500.0	1.7769E+06	7.6421E+05	405.22	96.818	0.5109	86.663	20.706	4.985E-04	3.112E-08	1.337
13000.00	23400.0	1.8145E+06	7.8036E+05	408.16	97.523	0.5081	65.826	15.728	4.766E-04	2.975E-08	1.421
13500.00	24300.0	1.8444E+06	7.9322E+05	410.42	98.063	0.5065	54.927	13.124	4.575E-04	2.856E-08	1.497
14000.00	25200.0	1.8702E+06	8.0434E+05	412.30	98.512	0.5056	49.102	11.732	4.404E-04	2.749E-08	1.555
15000.00	27000.0	1.9164E+06	8.2418E+05	415.49	99.273	0.5048	44.097	10.536	4.103E-04	2.562E-08	1.622
16000.00	28800.0	1.9595E+06	8.4272E+05	418.27	99.938	0.5045	42.414	10.134	3.844E-04	2.400E-08	1.649
17000.00	30600.0	2.0015E+06	8.6080E+05	420.82	100.548	0.5043	41.784	9.983	3.617E-04	2.258E-08	1.659
18000.00	32400.0	2.0432E+06	8.7871E+05	423.20	101.116	0.5042	41.523	9.921	3.415E-04	2.132E-08	1.663
19000.00	34200.0	2.0846E+06	8.9654E+05	425.44	101.652	0.5042	41.404	9.893	3.235E-04	2.019E-08	1.665
20000.00	36000.0	2.1260E+06	9.1433E+05	427.57	102.159	0.5041	41.347	9.879	3.073E-04	1.918E-08	1.666
21000.00	37800.0	2.1673E+06	9.3211E+05	429.58	102.641	0.5041	41.316	9.872	2.926E-04	1.827E-08	1.666
22000.00	39600.0	2.2086E+06	9.4987E+05	431.51	103.100	0.5041	41.299	9.868	2.793E-04	1.744E-08	1.667
23000.00	41400.0	2.2499E+06	9.6763E+05	433.34	103.539	0.5041	41.289	9.865	2.671E-04	1.668E-08	1.667
24000.00	43200.0	2.2912E+06	9.8539E+05	435.10	103.958	0.5041	41.281	9.863	2.560E-04	1.598E-08	1.667
25000.00	45000.0	2.3325E+06	1.0031E+06	436.78	104.361	0.5041	41.276	9.862	2.458E-04	1.534E-08	1.667
26000.00	46800.0	2.3738E+06	1.0209E+06	438.40	104.748	0.5040	41.273	9.861	2.363E-04	1.475E-08	1.667
27000.00	48600.0	2.4150E+06	1.0386E+06	439.96	105.120	0.5040	41.270	9.861	2.275E-04	1.420E-08	1.667
28000.00	50400.0	2.4563E+06	1.0564E+06	441.46	105.479	0.5040	41.268	9.860	2.194E-04	1.370E-08	1.667
29000.00	52200.0	2.4976E+06	1.0741E+06	442.91	105.825	0.5040	41.267	9.860	2.118E-04	1.322E-08	1.667
30000.00	54000.0	2.5388E+06	1.0919E+06	444.31	106.159	0.5040	41.265	9.859	2.048E-04	1.278E-08	1.667
32000.00	57600.0	2.6214E+06	1.1274E+06	446.97	106.795	0.5040	41.263	9.859	1.920E-04	1.198E-08	1.667
34000.00	61200.0	2.7039E+06	1.1629E+06	449.47	107.393	0.5040	41.261	9.859	1.807E-04	1.128E-08	1.667
36000.00	64800.0	2.7864E+06	1.1984E+06	451.83	107.957	0.5040	41.260	9.858	1.706E-04	1.065E-08	1.667
38000.00	68400.0	2.8689E+06	1.2339E+06	454.06	108.490	0.5040	41.259	9.858	1.616E-04	1.009E-08	1.667
40000.00	72000.0	2.9514E+06	1.2693E+06	456.18	108.995	0.5040	41.257	9.858	1.536E-04	9.586E-09	1.667
43000.00	77400.0	3.0752E+06	1.3226E+06	459.16	109.708	0.5040	41.257	9.857	1.428E-04	8.917E-09	1.667
46000.00	82800.0	3.1990E+06	1.3758E+06	461.94	110.373	0.5040	41.256	9.857	1.335E-04	8.335E-09	1.667
50000.00	90000.0	3.3643E+06	1.4468E+06	465.38	111.195	0.5039	41.254	9.857	1.228E-04	7.668E-09	1.667
55000.00	99000.0	3.5703E+06	1.5355E+06	469.32	112.134	0.5039	41.253	9.857	1.117E-04	6.971E-09	1.667
60000.00	108000.0	3.7765E+06	1.6242E+06	472.91	112.992	0.5039	41.252	9.856	1.024E-04	6.390E-09	1.667
65000.00	117000.0	3.9828E+06	1.7129E+06	476.21	113.781	0.5039	41.252	9.856	9.448E-05	5.899E-09	1.667
70000.00	126000.0	4.1890E+06	1.8016E+06	479.27	114.511	0.5039	41.252	9.855	8.774E-05	5.477E-09	1.667
80000.00	144000.0	4.6016E+06	1.9790E+06	484.77	115.827	0.5039	41.251	9.856	7.677E-05	4.792E-09	1.667
90000.00	162000.0	5.0141E+06	2.1564E+06	489.63	116.988	0.5039	41.250	9.856	6.824E-05	4.260E-09	1.667
100000.00	180000.0	5.4266E+06	2.3338E+06	493.98	118.027	0.5039	41.250	9.856	6.141E-05	3.834E-09	1.667
110000.00	198000.0	5.8391E+06	2.5112E+06	497.91	118.966	0.5039	41.250	9.855	5.583E-05	3.485E-09	1.667

TABLE II. - Continued. THERMODYNAMIC PROPERTIES OF SPIN-EQUILIBRATED HYDROGEN IN CHEMICAL EQUILIBRIUM IN DEBYE-HÜCKEL APPROXIMATION

[E-02, E-03, E+02, E+03, etc., after numbers signify that numbers are to be multiplied by 10^{-2}, 10^{-3}, 10^{2}, 10^{3}, etc.]

(b) Pressure, 3.03975×10^{2} N/m^2 (0.003 atm)

Temperature, T		Enthalpy, h		Entropy, s		Average molecular weight, g/g-mole or lb/lb-mole	Specific heat, c_p		Density, ρ		Isentropic exponent, γ
K	^{o}R	J/g	Btu/lb	J/(g)(K)	Btu/(lb)(^{o}R)		J/(g)(K)	Btu/(lb)(^{o}R)	g/m^3	lb/ft^3	
100.00	180.0	-2.1284E+05	-9.1537E+04	73.88	17.652	2.0156	13.956	3.334	7.369E-01	4.601E-05	1.420
150.00	270.0	-2.1217E+05	-9.1250E+04	79.30	18.948	2.0156	13.170	3.147	4.913E-01	3.067E-05	1.456
200.00	360.0	-2.1150E+05	-9.0963E+04	83.15	19.866	2.0156	13.614	3.253	3.685E-01	2.300E-05	1.435
250.00	450.0	-2.1081E+05	-9.0665E+04	86.24	20.605	2.0156	14.062	3.360	2.948E-01	1.840E-05	1.415
298.15	536.7	-2.1013E+05	-9.0371E+04	88.74	21.202	2.0156	14.303	3.417	2.472E-01	1.543E-05	1.405
400.00	720.0	-2.0866E+05	-8.9739E+04	92.97	22.214	2.0156	14.479	3.460	1.842E-01	1.150E-05	1.398
500.00	900.0	-2.0721E+05	-8.9116E+04	96.21	22.987	2.0156	14.516	3.468	1.474E-01	9.201E-06	1.397
600.00	1080.0	-2.0575E+05	-8.8491E+04	98.86	23.620	2.0156	14.546	3.475	1.228E-01	7.668E-06	1.396
700.00	1260.0	-2.0430E+05	-8.7864E+04	101.10	24.157	2.0156	14.606	3.490	1.053E-01	5.572E-06	1.394
800.00	1440.0	-2.0283E+05	-8.7234E+04	103.06	24.624	2.0156	14.697	3.512	9.212E-02	5.751E-06	1.390
900.00	1620.0	-2.0136E+05	-8.6599E+04	104.80	25.039	2.0156	14.826	3.542	8.188E-02	5.112E-06	1.385
1000.00	1800.0	-1.9987E+05	-8.5958E+04	106.37	25.414	2.0156	14.986	3.581	7.369E-02	4.601E-06	1.380
1100.00	1980.0	-1.9836E+05	-8.5310E+04	107.80	25.758	2.0156	15.172	3.625	6.699E-02	4.182E-06	1.373
1200.00	2160.0	-1.9683E+05	-8.4653E+04	109.13	26.075	2.0156	15.383	3.675	6.141E-02	3.834E-06	1.366
1300.00	2340.0	-1.9528E+05	-8.3986E+04	110.37	26.372	2.0156	15.624	3.733	5.669E-02	3.539E-06	1.359
1400.00	2520.0	-1.9371E+05	-8.3308E+04	111.54	26.651	2.0156	15.942	3.809	5.264E-02	3.286E-06	1.350
1500.00	2700.0	-1.9209E+05	-8.2612E+04	112.66	26.917	2.0153	16.454	3.931	4.912E-02	3.067E-06	1.337
1600.00	2880.0	-1.9040E+05	-8.1886E+04	113.75	27.178	2.0147	17.407	4.159	4.604E-02	2.874E-06	1.317
1700.00	3060.0	-1.8859E+05	-8.1102E+04	114.85	27.442	2.0130	19.266	4.603	4.329E-02	2.703E-06	1.287
1800.00	3240.0	-1.8649E+05	-8.0206E+04	116.04	27.726	2.0091	22.785	5.444	4.081E-02	2.548E-06	1.247
1900.00	3420.0	-1.8393E+05	-7.9103E+04	117.43	28.057	2.0012	29.096	6.952	3.851E-02	2.404E-06	1.205
2000.00	3600.0	-1.8053E+05	-7.7641E+04	119.17	28.473	1.9863	39.771	9.502	3.631E-02	2.267E-06	1.168
2100.00	3780.0	-1.7576E+05	-7.5590E+04	121.49	29.028	1.9601	56.830	13.578	3.413E-02	2.130E-06	1.141
2200.00	3960.0	-1.6887E+05	-7.2627E+04	124.69	29.793	1.9175	82.669	19.752	3.187E-02	1.989E-06	1.124
2300.00	4140.0	-1.5885E+05	-6.8319E+04	129.14	30.855	1.8532	119.714	28.603	2.946E-02	1.839E-06	1.115
2400.00	4320.0	-1.4450E+05	-6.2147E+04	135.24	32.313	1.7632	169.384	40.471	2.686E-02	1.677E-06	1.110
2500.00	4500.0	-1.2462E+05	-5.3595E+04	143.35	34.250	1.6483	229.579	54.853	2.410E-02	1.505E-06	1.109
2600.00	4680.0	-9.8559E+04	-4.2388E+04	153.56	36.690	1.5160	290.218	69.342	2.132E-02	1.331E-06	1.111
2700.00	4860.0	-6.7251E+04	-2.8923E+04	165.37	39.512	1.3815	330.339	78.928	1.871E-02	1.168E-06	1.115
2800.00	5040.0	-3.3958E+04	-1.4605E+04	177.48	42.405	1.2622	327.096	78.153	1.648E-02	1.029E-06	1.122
2900.00	5220.0	-3.3869E+03	-1.4566E+03	188.21	44.970	1.1702	278.144	66.457	1.475E-02	9.210E-07	1.131
3000.00	5400.0	2.0961E+04	9.0147E+03	196.47	46.943	1.1072	207.882	49.669	1.349E-02	8.423E-07	1.145
3100.00	5580.0	3.8413E+04	1.6519E+04	202.20	48.312	1.0675	143.601	34.311	1.259E-02	7.860E-07	1.167
3200.00	5760.0	5.0280E+04	2.1624E+04	205.97	49.213	1.0437	96.913	23.156	1.192E-02	7.444E-07	1.200
3400.00	5120.0	6.4044E+04	2.7544E+04	210.16	50.213	1.0214	48.595	11.611	1.098E-02	6.857E-07	1.303
3600.00	5480.0	7.1730E+04	3.0849E+04	212.36	50.739	1.0134	31.222	7.460	1.029E-02	6.425E-07	1.435
3800.00	5840.0	7.7244E+04	3.3221E+04	213.85	51.096	1.0103	24.936	5.958	9.720E-03	6.068E-07	1.542
4000.00	7200.0	8.1953E+04	3.5246E+04	215.06	51.385	1.0090	22.520	5.381	9.223E-03	5.758E-07	1.605
4200.00	7560.0	8.6344E+04	3.7134E+04	216.13	51.641	1.0084	21.528	5.144	8.778E-03	5.480E-07	1.636
4400.00	7920.0	9.0601E+04	3.8965E+04	217.12	51.877	1.0082	21.105	5.043	8.377E-03	5.230E-07	1.650

4600.00	8280.0	9.4802E+04	4.0772E+04	218.06	52.100	1.0080	20.938	5.003	8.012E-03	5.001E-07	1.655
4800.00	8640.0	9.8985E+04	4.2571E+04	218.95	52.313	1.0079	20.912	4.996	7.677E-03	4.793E-07	1.655
5000.00	9000.0	1.0317E+05	4.4373E+04	219.80	52.517	1.0078	20.996	5.017	7.369E-03	4.601E-07	1.651
5200.00	9360.0	1.0739E+05	4.6187E+04	220.63	52.715	1.0078	21.201	5.066	7.085E-03	4.423E-07	1.642
5400.00	9720.0	1.1167E+05	4.8025E+04	221.43	52.908	1.0076	21.565	5.153	6.822E-03	4.259E-07	1.627
5600.00	10080.0	1.1603E+05	4.9903E+04	222.23	53.097	1.0075	22.148	5.292	6.577E-03	4.106E-07	1.605
5800.00	10440.0	1.2054E+05	5.1843E+04	223.02	53.286	1.0072	23.035	5.504	6.349E-03	3.963E-07	1.575
6000.00	10800.0	1.2527E+05	5.3877E+04	223.82	53.478	1.0068	24.336	5.815	6.135E-03	3.830E-07	1.537
6300.00	11340.0	1.3299E+05	5.7197E+04	225.08	53.778	1.0057	27.372	6.540	5.836E-03	3.643E-07	1.468
6600.00	11880.0	1.4188E+05	6.1019E+04	226.45	54.107	1.0038	32.243	7.704	5.561E-03	3.471E-07	1.394
7000.00	12600.0	1.5672E+05	6.7403E+04	228.63	54.628	0.9993	42.914	10.253	5.219E-03	3.258E-07	1.304
7300.00	13140.0	1.7134E+05	7.3690E+04	230.68	55.116	0.9936	55.271	13.206	4.976E-03	3.107E-07	1.250
7600.00	13680.0	1.9038E+05	8.1878E+04	233.23	55.726	0.9851	72.599	17.346	4.739E-03	2.959E-07	1.210
8000.00	14400.0	2.2560E+05	9.7026E+04	237.74	56.803	0.9678	105.607	25.233	4.423E-03	2.761E-07	1.175
8300.00	14940.0	2.6215E+05	1.1274E+05	242.22	57.874	0.9492	139.466	33.323	4.182E-03	2.611E-07	1.158
8600.00	15480.0	3.1018E+05	1.3340E+05	247.90	59.231	0.9248	182.365	43.573	3.932E-03	2.455E-07	1.147
9000.00	16200.0	3.9697E+05	1.7073E+05	257.75	61.585	0.8825	254.316	60.764	3.586E-03	2.239E-07	1.138
9300.00	16740.0	4.8263E+05	2.0757E+05	267.11	63.821	0.8437	317.826	75.939	3.318E-03	2.072E-07	1.135
9600.00	17280.0	5.8805E+05	2.5290E+05	278.26	66.485	0.8000	385.020	91.993	3.049E-03	1.903E-07	1.134
10000.00	18000.0	7.5889E+05	3.2638E+05	295.69	70.649	0.7379	465.647	111.257	2.700E-03	1.685E-07	1.135
10500.00	18900.0	1.0068E+06	4.3301E+05	319.87	76.427	0.6633	511.943	122.319	2.312E-03	1.443E-07	1.139
11000.00	19800.0	1.2548E+06	5.3966E+05	342.95	81.942	0.6032	464.617	111.011	2.007E-03	1.253E-07	1.149
11500.00	20700.0	1.4605E+06	6.2814E+05	361.26	86.317	0.5621	353.031	84.350	1.789E-03	1.117E-07	1.166
12000.00	21600.0	1.6078E+06	6.9149E+05	373.82	89.317	0.5373	240.058	57.357	1.639E-03	1.023E-07	1.193
12500.00	22500.0	1.7060E+06	7.3372E+05	381.85	91.235	0.5232	158.583	37.890	1.532E-03	9.564E-08	1.235
13000.00	23400.0	1.7717E+06	7.6197E+05	387.01	92.468	0.5154	108.620	25.953	1.451E-03	9.058E-08	1.293
13500.00	24300.0	1.8182E+06	7.8196E+05	390.52	93.307	0.5110	79.999	19.114	1.385E-03	8.648E-08	1.364
14000.00	25200.0	1.8538E+06	7.9726E+05	393.11	93.926	0.5085	63.905	15.269	1.329E-03	8.297E-08	1.437
15000.00	27000.0	1.9092E+06	8.2111E+05	396.94	94.842	0.5061	49.574	11.845	1.235E-03	7.707E-08	1.553
16000.00	28800.0	1.9559E+06	8.4119E+05	399.96	95.562	0.5052	44.644	10.667	1.155E-03	7.212E-08	1.616
17000.00	30600.0	1.9995E+06	8.5993E+05	402.60	96.194	0.5048	42.780	10.222	1.086E-03	6.781E-08	1.644
18000.00	32400.0	2.0418E+06	8.7814E+05	405.02	96.772	0.5045	42.011	10.038	1.025E-03	6.401E-08	1.656
19000.00	34200.0	2.0836E+06	8.9612E+05	407.28	97.312	0.5044	41.665	9.955	9.711E-04	6.063E-08	1.662
20000.00	36000.0	2.1252E+06	9.1400E+05	409.41	97.822	0.5043	41.497	9.915	9.224E-04	5.758E-08	1.664
21000.00	37800.0	2.1667E+06	9.3183E+05	411.44	98.305	0.5043	41.410	9.894	8.783E-04	5.483E-08	1.666
22000.00	39600.0	2.2080E+06	9.4963E+05	413.36	98.765	0.5042	41.362	9.883	8.383E-04	5.233E-08	1.666
23000.00	41400.0	2.2494E+06	9.6741E+05	415.20	99.204	0.5042	41.334	9.875	8.018E-04	5.005E-08	1.667
24000.00	43200.0	2.2907E+06	9.8518E+05	416.96	99.625	0.5042	41.315	9.871	7.683E-04	4.796E-08	1.667
25000.00	45000.0	2.3320E+06	1.0029E+06	418.65	100.028	0.5042	41.305	9.869	7.375E-04	4.604E-08	1.667
26000.00	46800.0	2.3733E+06	1.0207E+06	420.27	100.415	0.5041	41.295	9.867	7.091E-04	4.427E-08	1.667
27000.00	48600.0	2.4146E+06	1.0385E+06	421.83	100.787	0.5041	41.289	9.865	6.828E-04	4.263E-08	1.667
28000.00	50400.0	2.4559E+06	1.0562E+06	423.33	101.146	0.5041	41.285	9.864	6.584E-04	4.110E-08	1.667
29000.00	52200.0	2.4972E+06	1.0740E+06	424.78	101.492	0.5041	41.282	9.863	6.357E-04	3.968E-08	1.667
30000.00	54000.0	2.5385E+06	1.0917E+06	426.18	101.826	0.5041	41.279	9.863	6.144E-04	3.836E-08	1.667
32000.00	57600.0	2.6210E+06	1.1272E+06	428.84	102.463	0.5041	41.274	9.862	5.760E-04	3.596E-08	1.667
34000.00	61200.0	2.7036E+06	1.1627E+06	431.34	103.061	0.5040	41.270	9.861	5.421E-04	3.384E-08	1.667
36000.00	64800.0	2.7861E+06	1.1982E+06	433.70	103.624	0.5040	41.268	9.860	5.120E-04	3.196E-08	1.667
38000.00	68400.0	2.8685E+06	1.2337E+06	435.93	104.158	0.5040	41.266	9.860	4.850E-04	3.028E-08	1.667
40000.00	72000.0	2.9512E+06	1.2692E+06	438.05	104.663	0.5040	41.264	9.859	4.607E-04	2.876E-08	1.667
43000.00	77400.0	3.0750E+06	1.3225E+06	441.03	105.376	0.5040	41.262	9.859	4.286E-04	2.675E-08	1.667
46000.00	82800.0	3.1987E+06	1.3757E+06	443.82	106.041	0.5040	41.260	9.858	4.006E-04	2.501E-08	1.667
50000.00	90000.0	3.3638E+06	1.4467E+06	447.26	106.863	0.5040	41.258	9.858	3.685E-04	2.301E-08	1.667
55000.00	99000.0	3.5701E+06	1.5354E+06	451.19	107.803	0.5040	41.256	9.857	3.350E-04	2.091E-08	1.667
60000.00	108000.0	3.7764E+06	1.6241E+06	454.78	108.661	0.5040	41.256	9.857	3.071E-04	1.917E-08	1.667
65000.00	117000.0	3.9826E+06	1.7128E+06	458.08	109.450	0.5039	41.254	9.857	2.835E-04	1.770E-08	1.667
70000.00	126000.0	4.1889E+06	1.8015E+06	461.14	110.180	0.5039	41.254	9.857	2.632E-04	1.643E-08	1.667
80000.00	144000.0	4.6014E+06	1.9790E+06	466.65	111.496	0.5039	41.252	9.856	2.303E-04	1.438E-08	1.667
90000.00	162000.0	5.0139E+06	2.1564E+06	471.51	112.657	0.5039	41.252	9.856	2.047E-04	1.278E-08	1.667
100000.00	180000.0	5.4265E+06	2.3338E+06	475.85	113.696	0.5039	41.251	9.856	1.842E-04	1.150E-08	1.667
110000.00	198000.0	5.8390E+06	2.5112E+06	479.78	114.635	0.5039	41.250	9.856	1.675E-04	1.046E-08	1.667

TABLE II. - Continued. THERMODYNAMIC PROPERTIES OF SPIN-EQUILIBRATED HYDROGEN IN CHEMICAL EQUILIBRIUM IN DEBYE-HÜCKEL APPROXIMATION

[E-02, E-03, E+02, E+03, etc., after numbers signify that numbers are to be multiplied by 10^{-2}, 10^{-3}, 10^{2}, 10^{3}, etc.]

(c) Pressure, 1.01325×10^{3} N/m^2 (0.01 atm)

Temperature, T		Enthalpy, h		Entropy, s		Average molecular weight, g/g-mole or lb/lb-mole	Specific heat, c_p		Density, ρ		Isentropic exponent, γ
K	^{o}R	J/g	Btu/lb	J/(g)(K)	Btu/(lb)(^{o}R)		J/(g)(K)	Btu/(lb)(^{o}R)	g/m^3	lb/ft^3	
100.00	180.0	-2.1284E+05	-9.1537E+04	68.91	16.465	2.0156	13.967	3.337	2.456E+00	1.534E-04	1.419
150.00	270.0	-2.1217E+05	-9.1250E+04	74.34	17.762	2.0156	13.174	3.148	1.638E+00	1.022E-04	1.456
200.00	360.0	-2.1150E+05	-9.0963E+04	78.18	18.680	2.0155	13.617	3.253	1.228E+00	7.668E-05	1.435
250.00	450.0	-2.1081E+05	-9.0665E+04	81.27	19.418	2.0156	14.067	3.361	9.826E-01	6.134E-05	1.415
298.15	536.7	-2.1013E+05	-9.0371E+04	83.77	20.015	2.0156	14.301	3.417	8.239E-01	5.143E-05	1.405
400.00	720.0	-2.0865E+05	-8.9739E+04	88.01	21.027	2.0156	14.478	3.459	6.141E-01	3.834E-05	1.398
500.00	900.0	-2.0721E+05	-8.9116E+04	91.24	21.800	2.0156	14.517	3.468	4.913E-01	3.067E-05	1.397
600.00	1080.0	-2.0575E+05	-8.8491E+04	93.89	22.433	2.0156	14.548	3.476	4.094E-01	2.556E-05	1.396
700.00	1260.0	-2.0430E+05	-8.7864E+04	96.14	22.970	2.0156	14.606	3.490	3.509E-01	2.191E-05	1.394
800.00	1440.0	-2.0283E+05	-8.7234E+04	98.09	23.437	2.0156	14.697	3.512	3.071E-01	1.917E-05	1.390
900.00	1620.0	-2.0135E+05	-8.6599E+04	99.83	23.853	2.0156	14.826	3.542	2.729E-01	1.704E-05	1.385
1000.00	1800.0	-1.9987E+05	-8.5958E+04	101.40	24.228	2.0156	14.984	3.580	2.456E-01	1.534E-05	1.380
1100.00	1980.0	-1.9835E+05	-8.5310E+04	102.84	24.571	2.0156	15.171	3.625	2.233E-01	1.394E-05	1.373
1200.00	2160.0	-1.9683E+05	-8.4653E+04	104.17	24.889	2.0156	15.380	3.675	2.047E-01	1.278E-05	1.366
1300.00	2340.0	-1.9528E+05	-8.3987E+04	105.41	25.185	2.0156	15.609	3.729	1.890E-01	1.180E-05	1.359
1400.00	2520.0	-1.9371E+05	-8.3310E+04	106.57	25.463	2.0156	15.881	3.794	1.755E-01	1.095E-05	1.351
1500.00	2700.0	-1.9210E+05	-8.2619E+04	107.68	25.728	2.0155	16.259	3.885	1.637E-01	1.022E-05	1.341
1600.00	2880.0	-1.9045E+05	-8.1908E+04	108.75	25.983	2.0151	16.878	4.033	1.535E-01	9.582E-06	1.327
1700.00	3060.0	-1.8871E+05	-8.1161E+04	109.80	26.235	2.0142	17.988	4.298	1.444E-01	9.014E-06	1.306
1800.00	3240.0	-1.8682E+05	-8.0348E+04	110.88	26.493	2.0121	20.004	4.780	1.362E-01	8.504E-06	1.277
1900.00	3420.0	-1.8466E+05	-7.9418E+04	112.05	26.772	2.0077	23.548	5.626	1.288E-01	8.039E-06	1.241
2000.00	3600.0	-1.8203E+05	-7.8288E+04	113.39	27.093	1.9994	29.478	7.043	1.218E-01	7.606E-06	1.204
2100.00	3780.0	-1.7865E+05	-7.6832E+04	115.04	27.488	1.9848	38.914	9.298	1.152E-01	7.191E-06	1.172
2200.00	3960.0	-1.7409E+05	-7.4871E+04	117.16	27.994	1.9607	53.221	12.716	1.086E-01	6.780E-06	1.148
2300.00	4140.0	-1.6779E+05	-7.2163E+04	119.95	28.662	1.9230	73.936	17.666	1.019E-01	6.361E-06	1.132
2400.00	4320.0	-1.5904E+05	-6.8398E+04	123.68	29.551	1.8681	102.573	24.508	9.486E-02	5.922E-06	1.123
2500.00	4500.0	-1.4698E+05	-6.3212E+04	128.60	30.726	1.7929	140.103	33.475	8.740E-02	5.456E-06	1.118
2600.00	4680.0	-1.3074E+05	-5.6228E+04	134.96	32.246	1.6970	185.808	44.395	7.954E-02	4.966E-06	1.116
2700.00	4860.0	-1.0969E+05	-4.7173E+04	142.90	34.143	1.5842	235.244	56.207	7.151E-02	4.464E-06	1.117
2800.00	5040.0	-8.3905E+04	-3.6085E+04	152.27	36.382	1.4634	278.071	66.440	6.369E-02	3.976E-06	1.120
2900.00	5220.0	-5.4797E+04	-2.3567E+04	162.48	38.822	1.3467	299.166	71.480	5.659E-02	3.533E-06	1.125
3000.00	5400.0	-2.5191E+04	-1.0834E+04	172.52	41.221	1.2457	287.125	68.603	5.060E-02	3.159E-06	1.131
3100.00	5580.0	1.6173E+03	6.9558E+02	181.32	43.322	1.1672	245.202	58.586	4.589E-02	2.865E-06	1.141
3200.00	5760.0	2.3413E+04	1.0069E+04	188.24	44.976	1.1114	190.124	45.427	4.233E-02	2.642E-06	1.155
3400.00	5120.0	5.1555E+04	2.2172E+04	196.80	47.021	1.0505	99.020	23.659	3.765E-02	2.351E-06	1.204
3600.00	6480.0	6.6164E+04	2.8456E+04	200.99	48.022	1.0259	53.405	12.760	3.473E-02	2.168E-06	1.290
3800.00	5840.0	7.4673E+04	3.2115E+04	203.29	48.572	1.0160	34.510	8.246	3.258E-02	2.034E-06	1.403
4000.00	7200.0	8.0694E+04	3.4705E+04	204.84	48.942	1.0118	26.821	6.408	3.083E-02	1.924E-06	1.507
4200.00	7560.0	8.5689E+04	3.6853E+04	206.06	49.233	1.0099	23.567	5.631	2.930E-02	1.829E-06	1.578
4400.00	7920.0	9.0238E+04	3.8809E+04	207.11	49.486	1.0090	22.117	5.284	2.795E-02	1.745E-06	1.618

4600.00	8280.0	9.4586E+04	4.0679E+04	208.08	49.717	1.0085	21.447	5.124	2.672E-02	1.668E-06	1.639
4800.00	8640.0	9.8841E+04	4.2509E+04	208.99	49.933	1.0082	21.143	5.052	2.560E-02	1.598E-06	1.649
5000.00	9000.0	1.0306E+05	4.4322E+04	209.85	50.139	1.0080	21.038	5.027	2.457E-02	1.534E-06	1.651
5200.00	9360.0	1.0726E+05	4.6132E+04	210.67	50.336	1.0079	21.067	5.034	2.362E-02	1.475E-06	1.649
5400.00	9720.0	1.1149E+05	4.7950E+04	211.47	50.526	1.0078	21.218	5.070	2.274E-02	1.420E-06	1.642
5600.00	10080.0	1.1576E+05	4.9786E+04	212.25	50.712	1.0077	21.510	5.139	2.193E-02	1.369E-06	1.630
5800.00	10440.0	1.2011E+05	5.1655E+04	213.01	50.894	1.0075	21.979	5.251	2.117E-02	1.322E-06	1.612
6000.00	10800.0	1.2457E+05	5.3574E+04	213.76	51.075	1.0073	22.681	5.419	2.046E-02	1.277E-06	1.587
6300.00	11340.0	1.3160E+05	5.6598E+04	214.91	51.348	1.0067	24.335	5.814	1.947E-02	1.216E-06	1.538
6600.00	11880.0	1.3927E+05	5.9897E+04	216.10	51.632	1.0056	27.000	6.451	1.857E-02	1.159E-06	1.477
7000.00	12600.0	1.5114E+05	6.5000E+04	217.84	52.049	1.0031	32.846	7.848	1.746E-02	1.090E-06	1.389
7300.00	13140.0	1.6195E+05	6.9649E+04	219.35	52.410	1.0000	39.623	9.457	1.669E-02	1.042E-06	1.328
7600.00	13680.0	1.7518E+05	7.5342E+04	221.13	52.834	0.9953	49.137	11.740	1.596E-02	9.963E-07	1.277
8000.00	14400.0	1.9824E+05	8.5257E+04	224.08	53.539	0.9855	67.310	16.082	1.501E-02	9.373E-07	1.225
8300.00	14940.0	2.2112E+05	9.5099E+04	226.89	54.210	0.9748	86.065	20.564	1.431E-02	8.936E-07	1.197
8600.00	15480.0	2.5040E+05	1.0769E+05	230.35	55.037	0.9604	110.105	26.307	1.361E-02	8.498E-07	1.177
9000.00	16200.0	3.0237E+05	1.3004E+05	236.25	56.447	0.9345	151.616	36.226	1.266E-02	7.902E-07	1.160
9300.00	16740.0	3.5351E+05	1.5203E+05	241.83	57.781	0.9095	190.435	45.501	1.192E-02	7.443E-07	1.152
9600.00	17280.0	4.1727E+05	1.7946E+05	248.58	59.393	0.8794	235.691	56.314	1.117E-02	6.973E-07	1.147
10000.00	18000.0	5.2494E+05	2.2576E+05	259.56	62.016	0.8323	303.709	72.566	1.015E-02	6.336E-07	1.143
10500.00	18900.0	6.9861E+05	3.0045E+05	276.49	66.061	0.7554	389.305	93.017	8.893E-03	5.552E-07	1.142
11000.00	19800.0	9.0984E+05	3.9130E+05	296.13	70.755	0.6973	448.232	107.097	7.736E-03	4.829E-07	1.145
11500.00	20700.0	1.1370E+06	4.8902E+05	316.33	75.581	0.6368	449.338	107.361	6.760E-03	4.220E-07	1.152
12000.00	21600.0	1.3437E+06	5.8003E+05	334.35	79.888	0.5901	388.698	92.872	6.003E-03	3.748E-07	1.164
12500.00	22500.0	1.5207E+06	6.5402E+05	348.42	83.247	0.5579	297.877	71.172	5.449E-03	3.402E-07	1.182
13000.00	23400.0	1.6477E+06	7.0862E+05	358.39	85.630	0.5374	212.965	50.884	5.047E-03	3.151E-07	1.209
13500.00	24300.0	1.7374E+06	7.4723E+05	365.17	87.251	0.5249	150.058	35.853	4.747E-03	2.964E-07	1.249
14000.00	25200.0	1.8013E+06	7.7471E+05	369.82	88.363	0.5174	108.747	25.983	4.512E-03	2.817E-07	1.300
15000.00	27000.0	1.8861E+06	8.1116E+05	375.69	89.764	0.5101	57.486	16.124	4.151E-03	2.591E-07	1.423
16000.00	28800.0	1.9447E+06	8.3636E+05	379.48	90.669	0.5072	52.129	12.455	3.868E-03	2.415E-07	1.531
17000.00	30600.0	1.9934E+06	8.5730E+05	382.43	91.375	0.5056	46.151	11.027	3.631E-03	2.267E-07	1.598
18000.00	32400.0	2.0381E+06	8.7654E+05	384.99	91.986	0.5053	43.649	10.429	3.425E-03	2.138E-07	1.633
19000.00	34200.0	2.0811E+06	8.9504E+05	387.32	92.542	0.5050	42.522	10.160	3.242E-03	2.024E-07	1.650
20000.00	36000.0	2.1233E+06	9.1319E+05	389.48	93.060	0.5048	41.979	10.030	3.078E-03	1.922E-07	1.658
21000.00	37800.0	2.1652E+06	9.3118E+05	391.52	93.547	0.5046	41.701	9.964	2.931E-03	1.830E-07	1.662
22000.00	39600.0	2.2069E+06	9.4908E+05	393.46	94.010	0.5045	41.548	9.927	2.797E-03	1.746E-07	1.665
23000.00	41400.0	2.2483E+06	9.6693E+05	395.31	94.451	0.5045	41.460	9.906	2.675E-03	1.670E-07	1.666
24000.00	43200.0	2.2897E+06	9.8475E+05	397.07	94.872	0.5044	41.408	9.894	2.563E-03	1.600E-07	1.666
25000.00	45000.0	2.3311E+06	1.0026E+06	398.76	95.276	0.5044	41.374	9.886	2.460E-03	1.536E-07	1.667
26000.00	46800.0	2.3725E+06	1.0203E+06	400.38	95.664	0.5043	41.351	9.880	2.365E-03	1.477E-07	1.667
27000.00	48600.0	2.4138E+06	1.0381E+06	401.94	96.037	0.5043	41.334	9.876	2.277E-03	1.422E-07	1.667
28000.00	50400.0	2.4551E+06	1.0559E+06	403.45	96.396	0.5043	41.323	9.873	2.196E-03	1.371E-07	1.667
29000.00	52200.0	2.4965E+06	1.0737E+06	404.90	96.742	0.5042	41.315	9.871	2.120E-03	1.323E-07	1.667
30000.00	54000.0	2.5378E+06	1.0914E+06	406.30	97.077	0.5042	41.308	9.870	2.049E-03	1.279E-07	1.667
32000.00	57600.0	2.6204E+06	1.1270E+06	408.96	97.714	0.5042	41.298	9.867	1.921E-03	1.199E-07	1.667
34000.00	61200.0	2.7030E+06	1.1625E+06	411.47	98.312	0.5041	41.290	9.866	1.808E-03	1.128E-07	1.667
36000.00	64800.0	2.7855E+06	1.1980E+06	413.83	98.876	0.5041	41.286	9.864	1.707E-03	1.066E-07	1.667
38000.00	68400.0	2.8681E+06	1.2335E+06	416.06	99.409	0.5041	41.282	9.864	1.617E-03	1.010E-07	1.667
40000.00	72000.0	2.9507E+06	1.2690E+06	418.18	99.915	0.5041	41.277	9.862	1.536E-03	9.590E-08	1.667
43000.00	77400.0	3.0745E+06	1.3223E+06	421.16	100.629	0.5041	41.273	9.861	1.429E-03	8.920E-08	1.667
46000.00	82800.0	3.1983E+06	1.3755E+06	423.95	101.294	0.5040	41.271	9.861	1.336E-03	8.338E-08	1.667
50000.00	90000.0	3.3634E+06	1.4465E+06	427.39	102.116	0.5040	41.266	9.860	1.229E-03	7.670E-08	1.667
55000.00	99000.0	3.5697E+06	1.5352E+06	431.32	103.056	0.5040	41.263	9.859	1.117E-03	6.973E-08	1.667
60000.00	108000.0	3.7760E+06	1.6240E+06	434.91	103.914	0.5040	41.261	9.859	1.024E-03	6.391E-08	1.667
65000.00	117000.0	3.9823E+06	1.7127E+06	438.21	104.703	0.5040	41.259	9.858	9.450E-04	5.899E-08	1.667
70000.00	126000.0	4.1886E+06	1.8014E+06	441.27	105.433	0.5040	41.257	9.858	8.775E-04	5.478E-08	1.667
80000.00	144000.0	4.6012E+06	1.9789E+06	446.78	106.749	0.5040	41.256	9.857	7.677E-04	4.793E-08	1.667
90000.00	162000.0	5.0137E+06	2.1563E+06	451.64	107.911	0.5039	41.254	9.857	6.824E-04	4.260E-08	1.667
100000.00	180000.0	5.4263E+06	2.3337E+06	455.99	108.949	0.5039	41.253	9.857	6.142E-04	3.834E-08	1.667
110000.00	198000.0	5.8389E+06	2.5111E+06	459.92	109.888	0.5039	41.252	9.856	5.583E-04	3.486E-08	1.667

TABLE II. - Continued. THERMODYNAMIC PROPERTIES OF SPIN-EQUILIBRATED HYDROGEN IN CHEMICAL EQUILIBRIUM IN DEBYE-HÜCKEL APPROXIMATION

[E-02, E-03, E+02, E+03, etc., after numbers signify that numbers are to be multiplied by 10^{-2}, 10^{-3}, 10^{2}, 10^{3}, etc.]

(d) Pressure, 3.03975×10^{3} N/m^2 (0.03 atm)

Temperature, T		Enthalpy, h		Entropy, s		Average molecular weight, g/g-mole or lb/lb-mole	Specific heat, c_p		Density, ρ		Isentropic exponent, γ
K	^{o}R	J/g	Btu/lb	J/(g)(K)	Btu/(lb)(^{o}R)		J/(g)(K)	Btu/(lb)(^{o}R)	g/m^3	lb/ft^3	
100.00	180.0	-2.1284E+05	-9.1537E+04	64.38	15.382	2.0156	13.961	3.336	7.369E+00	4.601E-04	1.419
150.00	270.0	-2.1217E+05	-9.1250E+04	69.81	16.679	2.0156	13.174	3.148	4.913E+00	3.067E-04	1.456
200.00	360.0	-2.1150E+05	-9.0963E+04	73.65	17.597	2.0156	13.614	3.253	3.685E+00	2.300E-04	1.435
250.00	450.0	-2.1081E+05	-9.0669E+04	76.74	18.335	2.0156	14.060	3.359	2.948E+00	1.840E-04	1.415
298.15	536.7	-2.1013E+05	-9.0371E+04	79.24	18.933	2.0156	14.299	3.417	2.472E+00	1.543E-04	1.405
400.00	720.0	-2.0866E+05	-8.9739E+04	83.47	19.944	2.0156	14.478	3.459	1.842E+00	1.150E-04	1.398
500.00	900.0	-2.0721E+05	-8.9116E+04	86.71	20.717	2.0156	14.517	3.468	1.474E+00	9.201E-05	1.397
600.00	1080.0	-2.0576E+05	-8.8491E+04	89.36	21.350	2.0156	14.548	3.476	1.228E+00	7.668E-05	1.396
700.00	1260.0	-2.0430E+05	-8.7864E+04	91.60	21.887	2.0156	14.604	3.489	1.053E+00	6.572E-05	1.394
800.00	1440.0	-2.0283E+05	-8.7234E+04	93.56	22.355	2.0156	14.695	3.511	9.212E-01	5.751E-05	1.390
900.00	1620.0	-2.0136E+05	-8.6599E+04	95.30	22.770	2.0156	14.825	3.542	8.188E-01	5.112E-05	1.386
1000.00	1800.0	-1.9987E+05	-8.5958E+04	96.87	23.145	2.0156	14.984	3.580	7.369E-01	4.601E-05	1.380
1100.00	1980.0	-1.9835E+05	-8.5310E+04	98.31	23.488	2.0156	15.172	3.625	6.699E-01	4.182E-05	1.373
1200.00	2160.0	-1.9683E+05	-8.4653E+04	99.63	23.806	2.0156	15.378	3.674	6.141E-01	3.834E-05	1.367
1300.00	2340.0	-1.9528E+05	-8.3987E+04	100.87	24.102	2.0156	15.600	3.727	5.669E-01	3.539E-05	1.359
1400.00	2520.0	-1.9371E+05	-8.3311E+04	102.04	24.380	2.0155	15.849	3.787	5.264E-01	3.286E-05	1.352
1500.00	2700.0	-1.9211E+05	-8.2623E+04	103.14	24.644	2.0155	16.160	3.861	4.913E-01	3.067E-05	1.344
1600.00	2880.0	-1.9048E+05	-8.1919E+04	104.20	24.896	2.0153	16.606	3.968	4.605E-01	2.875E-05	1.333
1700.00	3060.0	-1.8878E+05	-8.1190E+04	105.23	25.142	2.0148	17.335	4.142	4.333E-01	2.705E-05	1.318
1800.00	3240.0	-1.8699E+05	-8.0421E+04	106.25	25.386	2.0136	18.582	4.440	4.090E-01	2.553E-05	1.296
1900.00	3420.0	-1.8504E+05	-7.9580E+04	107.31	25.639	2.0111	20.707	4.948	3.870E-01	2.416E-05	1.269
2000.00	3600.0	-1.8280E+05	-7.8620E+04	108.45	25.912	2.0063	24.207	5.784	3.668E-01	2.290E-05	1.237
2100.00	3780.0	-1.8013E+05	-7.7468E+04	109.75	26.224	1.9977	29.730	7.103	3.478E-01	2.171E-05	1.205
2200.00	3960.0	-1.7675E+05	-7.6022E+04	111.32	26.597	1.9835	38.072	9.097	3.296E-01	2.058E-05	1.177
2300.00	4140.0	-1.7239E+05	-7.4140E+04	113.26	27.061	1.9611	50.157	11.984	3.117E-01	1.946E-05	1.155
2400.00	4320.0	-1.6653E+05	-7.1640E+04	115.73	27.652	1.9276	66.984	15.005	2.936E-01	1.833E-05	1.140
2500.00	4500.0	-1.5880E+05	-6.8297E+04	118.90	28.409	1.8801	89.507	21.386	2.749E-01	1.716E-05	1.130
2600.00	4680.0	-1.4846E+05	-6.3850E+04	122.95	29.377	1.8164	118.364	28.281	2.554E-01	1.594E-05	1.125
2700.00	4860.0	-1.3492E+05	-5.8027E+04	128.06	30.597	1.7358	153.334	36.636	2.350E-01	1.467E-05	1.123
2800.00	5040.0	-1.1765E+05	-5.0601E+04	134.33	32.097	1.6401	192.388	45.968	2.141E-01	1.337E-05	1.123
2900.00	5220.0	-9.6473E+04	-4.1491E+04	141.76	33.872	1.5342	230.502	55.074	1.934E-01	1.207E-05	1.125
3000.00	5400.0	-7.1865E+04	-3.0908E+04	150.10	35.864	1.4261	259.218	61.935	1.738E-01	1.085E-05	1.129
3100.00	5580.0	-4.5265E+04	-1.9467E+04	158.82	37.948	1.3248	268.964	64.264	1.562E-01	9.754E-06	1.134
3200.00	5760.0	-1.8883E+04	-8.1211E+03	167.20	39.950	1.2378	254.682	60.851	1.414E-01	8.829E-06	1.141
3400.00	6120.0	2.4903E+04	1.0710E+04	180.50	43.127	1.1184	177.141	42.324	1.203E-01	7.507E-06	1.165
3600.00	6480.0	5.2272E+04	2.2481E+04	188.34	45.000	1.0586	101.546	24.262	1.075E-01	6.711E-06	1.208
3800.00	6840.0	6.7782E+04	2.9151E+04	192.54	46.005	1.0315	58.576	13.996	9.926E-02	6.196E-06	1.280
4000.00	7200.0	7.7212E+04	3.3207E+04	194.97	46.584	1.0196	38.366	9.167	9.319E-02	5.818E-06	1.376
4200.00	7560.0	8.3851E+04	3.6062E+04	196.59	46.971	1.0139	29.219	6.981	8.826E-02	5.510E-06	1.472
4400.00	7920.0	8.9220E+04	3.8371E+04	197.84	47.269	1.0112	24.995	5.972	8.402E-02	5.245E-06	1.548

4600.00	8280.0	9.3992E+04	4.0424E+04	198.90	47.523	1.0098	22.970	5.488	8.026E-02	5.010E-06	1.596
4800.00	8640.0	9.8474E+04	4.2351E+04	199.85	47.751	1.0090	21.967	5.249	7.685E-02	4.798E-06	1.624
5000.00	9000.0	1.0281E+05	4.4217E+04	200.74	47.962	1.0085	21.469	5.130	7.375E-02	4.604E-06	1.639
5200.00	9360.0	1.0708E+05	4.6052E+04	201.57	48.162	1.0083	21.245	5.076	7.089E-02	4.426E-06	1.645
5400.00	9720.0	1.1132E+05	4.7877E+04	202.38	48.354	1.0081	21.195	5.064	6.825E-02	4.261E-06	1.645
5600.00	10080.0	1.1557E+05	4.9703E+04	203.15	48.538	1.0079	21.282	5.085	6.580E-02	4.108E-06	1.641
5800.00	10440.0	1.1984E+05	5.1542E+04	203.90	48.717	1.0078	21.503	5.138	6.353E-02	3.966E-06	1.631
6000.00	10800.0	1.2418E+05	5.3406E+04	204.63	48.893	1.0076	21.878	5.227	6.140E-02	3.833E-06	1.617
6300.00	11340.0	1.3087E+05	5.6283E+04	205.72	49.153	1.0072	22.806	5.449	5.845E-02	3.649E-06	1.584
6600.00	11880.0	1.3792E+05	5.9317E+04	206.81	49.414	1.0066	24.331	5.813	5.576E-02	3.481E-06	1.540
7000.00	12600.0	1.4827E+05	6.3766E+04	208.33	49.778	1.0051	27.699	6.618	5.250E-02	3.277E-06	1.466
7300.00	13140.0	1.5713E+05	6.7577E+04	209.57	50.074	1.0033	31.613	7.553	5.025E-02	3.137E-06	1.407
7600.00	13680.0	1.6739E+05	7.1992E+04	210.95	50.403	1.0005	37.113	8.867	4.813E-02	3.005E-06	1.351
8000.00	14400.0	1.8421E+05	7.9223E+04	213.10	50.917	0.9948	47.633	11.381	4.547E-02	2.838E-06	1.287
8300.00	14940.0	2.0005E+05	8.6039E+04	215.05	51.382	0.9885	58.513	13.980	4.354E-02	2.718E-06	1.249
8600.00	15480.0	2.1962E+05	9.4455E+04	217.36	51.935	0.9799	72.507	17.324	4.166E-02	2.601E-06	1.220
9000.00	16200.0	2.5327E+05	1.0892E+05	221.18	52.847	0.9640	96.884	23.149	3.917E-02	2.445E-06	1.192
9300.00	16740.0	2.8570E+05	1.2287E+05	224.72	53.694	0.9483	120.063	28.687	3.729E-02	2.328E-06	1.178
9600.00	17280.0	3.2576E+05	1.4010E+05	228.96	54.706	0.9288	147.836	35.322	3.539E-02	2.209E-06	1.167
10000.00	18000.0	3.9349E+05	1.6923E+05	235.87	56.356	0.8967	192.155	45.912	3.280E-02	2.048E-06	1.158
10500.00	18900.0	5.0555E+05	2.1742E+05	246.79	58.966	0.8470	257.596	61.548	2.952E-02	1.843E-06	1.152
11000.00	19800.0	6.5181E+05	2.8033E+05	260.39	62.214	0.7892	327.073	78.148	2.627E-02	1.640E-06	1.150
11500.00	20700.0	8.3073E+05	3.5728E+05	276.28	66.013	0.7282	384.959	91.979	2.319E-02	1.448E-06	1.152
12000.00	21600.0	1.0313E+06	4.4356E+05	293.36	70.092	0.6703	410.523	98.087	2.047E-02	1.278E-06	1.156
12500.00	22500.0	1.2335E+06	5.3053E+05	309.87	74.039	0.6213	390.812	93.377	1.822E-02	1.137E-06	1.165
13000.00	23400.0	1.4158E+06	6.0891E+05	324.18	77.457	0.5836	333.595	79.706	1.646E-02	1.027E-06	1.177
13500.00	24300.0	1.5649E+06	6.7298E+05	335.44	80.146	0.5570	261.904	62.577	1.513E-02	9.443E-07	1.196
14000.00	25200.0	1.6788E+06	7.2202E+05	343.74	82.130	0.5392	196.311	46.905	1.412E-02	8.815E-07	1.223
15000.00	27000.0	1.8272E+06	7.8582E+05	354.01	84.584	0.5202	110.504	26.403	1.271E-02	7.935E-07	1.303
16000.00	28800.0	1.9155E+06	8.2382E+05	359.73	85.950	0.5122	71.663	17.123	1.173E-02	7.324E-07	1.409
17000.00	30600.0	1.9778E+06	8.5061E+05	363.51	86.854	0.5087	55.235	13.197	1.096E-02	6.844E-07	1.509
18000.00	32400.0	2.0290E+06	8.7263E+05	366.44	87.554	0.5070	48.111	11.495	1.032E-02	6.441E-07	1.578
19000.00	34200.0	2.0753E+06	8.9253E+05	368.95	88.152	0.5061	44.850	10.716	9.756E-03	6.090E-07	1.619
20000.00	36000.0	2.1193E+06	9.1144E+05	371.20	88.692	0.5056	43.273	10.339	9.257E-03	5.779E-07	1.641
21000.00	37800.0	2.1621E+06	9.2986E+05	373.29	89.191	0.5053	42.463	10.146	8.809E-03	5.499E-07	1.653
22000.00	39600.0	2.2043E+06	9.4802E+05	375.26	89.661	0.5051	42.024	10.041	8.404E-03	5.247E-07	1.659
23000.00	41400.0	2.2452E+06	9.6603E+05	377.12	90.106	0.5049	41.775	9.981	8.036E-03	5.016E-07	1.663
24000.00	43200.0	2.2879E+06	9.8397E+05	378.90	90.530	0.5048	41.624	9.945	7.698E-03	4.806E-07	1.665
25000.00	45000.0	2.3295E+06	1.0018E+06	380.59	90.936	0.5047	41.531	9.923	7.388E-03	4.612E-07	1.666
26000.00	45800.0	2.3710E+06	1.0197E+06	382.22	91.325	0.5047	41.471	9.909	7.103E-03	4.434E-07	1.666
27000.00	48600.0	2.4124E+06	1.0375E+06	383.79	91.698	0.5046	41.430	9.899	6.838E-03	4.269E-07	1.667
28000.00	50400.0	2.4538E+06	1.0553E+06	385.29	92.058	0.5045	41.400	9.892	5.593E-03	4.116E-07	1.667
29000.00	52200.0	2.4952E+06	1.0731E+06	386.75	92.405	0.5045	41.380	9.887	6.365E-03	3.973E-07	1.667
30000.00	54000.0	2.5365E+06	1.0909E+06	388.15	92.741	0.5045	41.363	9.883	6.152E-03	3.840E-07	1.667
32000.00	57600.0	2.6193E+06	1.1265E+06	390.82	93.378	0.5044	41.340	9.877	5.766E-03	3.600E-07	1.667
34000.00	61200.0	2.7020E+06	1.1620E+06	393.32	93.977	0.5043	41.325	9.874	5.426E-03	3.387E-07	1.667
36000.00	64800.0	2.7846E+06	1.1976E+06	395.69	94.542	0.5043	41.315	9.871	5.124E-03	3.199E-07	1.667
38000.00	68400.0	2.8672E+06	1.2331E+06	397.92	95.075	0.5042	41.306	9.869	4.853E-03	3.030E-07	1.667
40000.00	72000.0	2.9498E+06	1.2686E+06	400.04	95.582	0.5042	41.301	9.868	4.610E-03	2.878E-07	1.667
43000.00	77400.0	3.0737E+06	1.3219E+06	403.03	96.295	0.5042	41.292	9.866	4.288E-03	2.677E-07	1.667
46000.00	82800.0	3.1976E+06	1.3752E+06	405.81	96.961	0.5041	41.287	9.865	4.008E-03	2.502E-07	1.667
50000.00	90000.0	3.3627E+06	1.4462E+06	409.25	97.783	0.5041	41.281	9.863	3.687E-03	2.302E-07	1.667
55000.00	99000.0	3.5691E+06	1.5350E+06	413.19	98.723	0.5041	41.274	9.862	3.351E-03	2.092E-07	1.667
60000.00	108000.0	3.7755E+06	1.6237E+06	416.78	99.581	0.5040	41.270	9.861	3.072E-03	1.918E-07	1.667
65000.00	117000.0	3.9818E+06	1.7125E+06	420.08	100.371	0.5040	41.267	9.860	2.835E-03	1.770E-07	1.667
70000.00	125000.0	4.1881E+06	1.8012E+06	423.14	101.101	0.5040	41.265	9.859	2.633E-03	1.644E-07	1.667
80000.00	144000.0	4.6008E+06	1.9787E+06	428.65	102.418	0.5040	41.261	9.858	2.303E-03	1.438E-07	1.667
90000.00	162000.0	5.0134E+06	2.1561E+06	433.51	103.579	0.5040	41.258	9.858	2.047E-03	1.278E-07	1.667
100000.00	180000.0	5.4259E+06	2.3336E+06	437.86	104.618	0.5040	41.256	9.857	1.843E-03	1.150E-07	1.667
110000.00	198000.0	5.8385E+06	2.5110E+06	441.79	105.557	0.5040	41.254	9.857	1.675E-03	1.046E-07	1.667

TABLE II. - Continued. THERMODYNAMIC PROPERTIES OF SPIN-EQUILIBRATED HYDROGEN IN CHEMICAL EQUILIBRIUM

IN DEBYE-HUCKEL APPROXIMATION

[E-02, E-03, E+02, E+03, etc., after numbers signify that numbers are to be multiplied by 10^{-2}, 10^{-3}, 10^{2}, 10^{3}, etc.]

(e) Pressure, 1.01325×10^{4} N/m^2 (0.1 atm)

Temperature, T		Enthalpy, h		Entropy, s		Average molecular weight, g/g-mole or lb/lb-mole	Specific heat, c_p		Density, ρ		Isentropic exponent, γ
K	^{o}R	J/g	Btu/lb	J/(g)(K)	Btu/(lb)(^{o}R)		J/(g)(K)	Btu/(lb)(^{o}R)	g/m^3	lb/ft^3	
100.00	180.0	-2.1284E+05	-9.1537E+04	59.41	14.196	2.0155	13.961	3.336	2.456E+01	1.534E-03	1.419
150.00	270.0	-2.1217E+05	-9.1250E+04	64.84	15.492	2.0156	13.167	3.146	1.638E+01	1.022E-03	1.456
200.00	360.0	-2.1150E+05	-9.0963E+04	68.68	16.410	2.0156	13.614	3.253	1.228E+01	7.668E-04	1.435
250.00	450.0	-2.1081E+05	-9.0665E+04	71.77	17.149	2.0156	14.064	3.360	9.826E+00	6.134E-04	1.415
298.15	536.7	-2.1013E+05	-9.0371E+04	74.27	17.746	2.0156	14.331	3.417	8.239E+00	5.143E-04	1.405
400.00	720.0	-2.0866E+05	-8.9739E+04	78.51	18.758	2.0156	14.478	3.459	6.141E+00	3.834E-04	1.398
500.00	900.0	-2.0721E+05	-8.9116E+04	81.74	19.531	2.0156	14.520	3.469	4.913E+00	3.067E-04	1.397
600.00	1080.0	-2.0575E+05	-8.8491E+04	84.39	20.164	2.0156	14.546	3.476	4.094E+00	2.556E-04	1.396
700.00	1260.0	-2.0433E+05	-8.7864E+04	86.64	20.701	2.0156	14.607	3.490	3.509E+00	2.191E-04	1.394
800.00	1440.0	-2.0283E+05	-8.7234E+04	88.59	21.168	2.0156	14.696	3.511	3.071E+00	1.917E-04	1.390
900.00	1620.0	-2.0135E+05	-8.6599E+04	90.33	21.583	2.0156	14.827	3.543	2.729E+00	1.704E-04	1.385
1000.00	1800.0	-1.9987E+05	-8.5958E+04	91.90	21.958	2.0156	14.985	3.580	2.456E+00	1.534E-04	1.380
1100.00	1980.0	-1.9835E+05	-8.5310E+04	93.34	22.302	2.0156	15.171	3.625	2.233E+00	1.394E-04	1.373
1200.00	2160.0	-1.9683E+05	-8.4653E+04	94.67	22.619	2.0156	15.378	3.674	2.047E+00	1.278E-04	1.367
1300.00	2340.0	-1.9528E+05	-8.3987E+04	95.91	22.915	2.0156	15.594	3.726	1.890E+00	1.180E-04	1.360
1400.00	2520.0	-1.9371E+05	-8.3311E+04	97.07	23.193	2.0156	15.831	3.782	1.755E+00	1.095E-04	1.353
1500.00	2700.0	-1.9212E+05	-8.2625E+04	98.17	23.457	2.0156	16.098	3.845	1.638E+00	1.022E-04	1.345
1600.00	2880.0	-1.9049E+05	-8.1926E+04	99.22	23.707	2.0155	16.438	3.928	1.535E+00	9.584E-05	1.336
1700.00	3060.0	-1.8882E+05	-8.1209E+04	100.23	23.949	2.0152	16.930	4.045	1.445E+00	9.019E-05	1.325
1800.00	3240.0	-1.8710E+05	-8.0465E+04	101.22	24.185	2.0145	17.702	4.230	1.364E+00	8.515E-05	1.310
1900.00	3420.0	-1.8527E+05	-7.9679E+04	102.21	24.421	2.0131	18.952	4.528	1.291E+00	8.061E-05	1.291
2000.00	3600.0	-1.8328E+05	-7.8825E+04	103.23	24.664	2.0105	20.950	5.006	1.225E+00	7.648E-05	1.266
2100.00	3780.0	-1.8104E+05	-7.7862E+04	104.32	24.925	2.0058	24.054	5.747	1.164E+00	7.267E-05	1.238
2200.00	3950.0	-1.7842E+05	-7.6734E+04	105.54	25.216	1.9979	28.699	6.857	1.107E+00	6.909E-05	1.211
2300.00	4140.0	-1.7523E+05	-7.5364E+04	106.95	25.554	1.9854	35.399	8.458	1.052E+00	6.567E-05	1.186
2400.00	4320.0	-1.7125E+05	-7.3651E+04	108.65	25.959	1.9664	44.727	10.687	9.985E-01	6.233E-05	1.166
2500.00	4500.0	-1.6618E+05	-7.1470E+04	110.71	26.453	1.9389	57.282	13.685	9.452E-01	5.901E-05	1.151
2600.00	4680.0	-1.5967E+05	-6.8670E+04	113.27	27.063	1.9009	73.635	17.594	8.910E-01	5.562E-05	1.141
2700.00	4860.0	-1.5131E+05	-6.5076E+04	116.42	27.816	1.8507	94.212	22.510	8.353E-01	5.215E-05	1.135
2800.00	5040.0	-1.4068E+05	-6.0504E+04	120.28	28.739	1.7872	119.088	28.454	7.779E-01	4.856E-05	1.131
2900.00	5220.0	-1.2737E+05	-5.4779E+04	124.95	29.854	1.7109	147.635	35.275	7.190E-01	4.488E-05	1.130
3000.00	5400.0	-1.1109E+05	-4.7778E+04	130.46	31.172	1.6238	178.006	42.531	6.596E-01	4.118E-05	1.131
3100.00	5580.0	-9.1826E+04	-3.9492E+04	136.78	32.681	1.5300	206.651	49.375	6.015E-01	3.755E-05	1.134
3200.00	5760.0	-6.9992E+04	-3.0102E+04	143.71	34.337	1.4350	228.366	54.564	5.465E-01	3.412E-05	1.137
3400.00	6120.0	-2.3011E+04	-9.8967E+03	157.95	37.739	1.2654	230.893	55.168	4.536E-01	2.831E-05	1.150
3600.00	6480.0	1.8585E+04	7.9930E+03	169.85	40.583	1.1472	178.904	42.746	3.883E-01	2.424E-05	1.170
3800.00	6840.0	4.7851E+04	2.0579E+04	177.78	42.477	1.0796	115.583	27.616	3.462E-01	2.162E-05	1.203
4000.00	7200.0	6.6172E+04	2.8459E+04	182.49	43.602	1.0450	71.445	17.070	3.184E-01	1.988E-05	1.257
4200.00	7560.0	7.7753E+04	3.3440E+04	185.32	44.278	1.0277	47.013	11.233	2.982E-01	1.862E-05	1.331
4400.00	7920.0	8.5764E+04	3.6885E+04	187.18	44.724	1.0189	34.511	8.245	2.822E-01	1.762E-05	1.416

4600.00	8280.0	9.1962E+04	3.9551E+04	188.56	45.053	1.0142	28.170	6.731	2.687E-01	1.677E-05	1.494
4800.00	8640.0	9.7233E+04	4.1818E+04	189.68	45.321	1.0117	24.891	5.947	2.569E-01	1.604E-05	1.554
5000.00	9000.0	1.0202E+05	4.3876E+04	190.66	45.555	1.0103	23.153	5.532	2.462E-01	1.537E-05	1.594
5200.00	9360.0	1.0655E+05	4.5823E+04	191.55	45.767	1.0094	22.215	5.308	2.366E-01	1.477E-05	1.618
5400.00	9720.0	1.1093E+05	4.7710E+04	192.38	45.965	1.0089	21.719	5.189	2.277E-01	1.421E-05	1.632
5600.00	10080.0	1.1525E+05	4.9567E+04	193.16	46.152	1.0085	21.488	5.134	2.195E-01	1.370E-05	1.638
5800.00	10440.0	1.1954E+05	5.1412E+04	193.91	46.332	1.0082	21.439	5.123	2.118E-01	1.323E-05	1.637
6000.00	10800.0	1.2384E+05	5.3259E+04	194.64	46.506	1.0080	21.537	5.146	2.047E-01	1.278E-05	1.632
6300.00	11340.0	1.3035E+05	5.6061E+04	195.70	46.759	1.0077	21.952	5.245	1.949E-01	1.217E-05	1.615
6600.00	11880.0	1.3704E+05	5.8940E+04	196.74	47.007	1.0073	22.736	5.432	1.860E-01	1.161E-05	1.588
7000.00	12600.0	1.4647E+05	6.2992E+04	198.13	47.338	1.0064	24.548	5.865	1.752E-01	1.094E-05	1.536
7300.00	13140.0	1.5413E+05	6.6289E+04	199.20	47.594	1.0054	26.681	6.375	1.678E-01	1.048E-05	1.488
7600.00	13680.0	1.6256E+05	6.9915E+04	200.33	47.865	1.0039	29.691	7.094	1.610E-01	1.005E-05	1.436
8000.00	14400.0	1.7552E+05	7.5487E+04	201.99	48.261	1.0007	35.462	8.473	1.524E-01	9.517E-06	1.369
8300.00	14940.0	1.8702E+05	8.0431E+04	203.40	48.598	0.9971	41.442	9.902	1.464E-01	9.140E-06	1.324
8600.00	15480.0	2.0056E+05	8.6255E+04	205.00	48.981	0.9923	49.147	11.743	1.406E-01	8.779E-06	1.285
9000.00	16200.0	2.2278E+05	9.5811E+04	207.52	49.584	0.9833	62.617	14.961	1.332E-01	8.313E-06	1.244
9300.00	16740.0	2.4363E+05	1.0469E+05	209.78	50.123	0.9742	75.507	18.041	1.277E-01	7.971E-06	1.221
9600.00	17280.0	2.6835E+05	1.1541E+05	212.42	50.753	0.9627	91.107	21.768	1.223E-01	7.632E-06	1.203
10000.00	18000.0	3.0970E+05	1.3319E+05	216.63	51.760	0.9432	116.539	27.845	1.150E-01	7.180E-06	1.186
10500.00	18900.0	3.7752E+05	1.6236E+05	223.24	53.340	0.9114	155.209	37.323	1.059E-01	6.610E-06	1.172
11000.00	19800.0	4.6729E+05	2.0097E+05	231.59	55.333	0.8713	204.091	48.764	9.665E-02	6.034E-06	1.164
11500.00	20700.0	5.8251E+05	2.5052E+05	241.82	57.779	0.8238	257.242	61.463	8.746E-02	5.460E-06	1.161
12000.00	21600.0	7.2429E+05	3.1150E+05	253.88	60.661	0.7717	308.826	73.788	7.856E-02	4.904E-06	1.160
12500.00	22500.0	8.8923E+05	3.8246E+05	267.35	63.878	0.7188	348.017	83.152	7.029E-02	4.388E-06	1.162
13000.00	23400.0	1.0683E+06	4.5944E+05	281.39	67.233	0.6693	363.157	85.769	6.297E-02	3.931E-06	1.167
13500.00	24300.0	1.2474E+06	5.3647E+05	294.91	70.464	0.6257	348.221	83.201	5.580E-02	3.546E-06	1.174
14000.00	25200.0	1.4122E+06	6.0737E+05	306.91	73.331	0.5927	307.814	73.546	5.181E-02	3.234E-06	1.188
15000.00	27000.0	1.6678E+06	7.1726E+05	324.59	77.553	0.5487	203.308	48.577	4.477E-02	2.795E-06	1.226
16000.00	28800.0	1.8285E+06	7.8640E+05	334.99	80.040	0.5272	124.998	29.866	4.031E-02	2.517E-06	1.289
17000.00	30600.0	1.9300E+06	8.3003E+05	341.16	81.514	0.5170	82.747	19.771	3.720E-02	2.322E-06	1.374
18000.00	32400.0	2.0013E+06	8.6070E+05	345.25	82.491	0.5119	62.349	14.897	3.478E-02	2.171E-06	1.466
19000.00	34200.0	2.0581E+06	8.8514E+05	348.33	83.226	0.5093	52.443	12.530	3.277E-02	2.045E-06	1.540
20000.00	36000.0	2.1078E+06	9.0651E+05	350.88	83.835	0.5078	47.507	11.351	3.103E-02	1.937E-06	1.591
21000.00	37800.0	2.1539E+06	9.2633E+05	353.13	84.373	0.5070	44.942	10.738	2.949E-02	1.841E-06	1.622
22000.00	39600.0	2.1981E+06	9.4533E+05	355.18	84.865	0.5064	43.548	10.405	2.811E-02	1.755E-06	1.641
23000.00	41400.0	2.2412E+06	9.6387E+05	357.10	85.323	0.5060	42.751	10.215	2.687E-02	1.677E-06	1.652
24000.00	43200.0	2.2837E+06	9.8215E+05	358.91	85.755	0.5057	42.282	10.103	2.573E-02	1.606E-06	1.658
25000.00	45000.0	2.3258E+06	1.0003E+06	360.63	86.166	0.5055	41.994	10.034	2.469E-02	1.541E-06	1.662
26000.00	46800.0	2.3677E+06	1.0183E+06	362.28	86.559	0.5053	41.809	9.989	2.373E-02	1.481E-06	1.664
27000.00	48600.0	2.4094E+06	1.0362E+06	363.85	86.936	0.5052	41.687	9.960	2.284E-02	1.426E-06	1.666
28000.00	50400.0	2.4511E+06	1.0541E+06	365.37	87.298	0.5051	41.603	9.940	2.201E-02	1.374E-06	1.666
29000.00	52200.0	2.4926E+06	1.0720E+06	366.83	87.647	0.5050	41.544	9.926	2.125E-02	1.327E-06	1.667
30000.00	54000.0	2.5342E+06	1.0899E+06	368.24	87.983	0.5049	41.496	9.915	2.054E-02	1.282E-06	1.667
32000.00	57600.0	2.6171E+06	1.1255E+06	370.91	88.623	0.5048	41.439	9.901	1.924E-02	1.201E-06	1.668
34000.00	61200.0	2.6999E+06	1.1612E+06	373.43	89.223	0.5047	41.404	9.893	1.811E-02	1.130E-06	1.668
36000.00	64800.0	2.7827E+06	1.1968E+06	375.79	89.788	0.5046	41.378	9.887	1.710E-02	1.067E-06	1.668
38000.00	68400.0	2.8655E+06	1.2324E+06	378.03	90.323	0.5045	41.361	9.882	1.619E-02	1.011E-06	1.668
40000.00	72000.0	2.9482E+06	1.2679E+06	380.15	90.830	0.5045	41.346	9.879	1.538E-02	9.601E-07	1.668
43000.00	77400.0	3.0722E+06	1.3213E+06	383.14	91.544	0.5044	41.331	9.875	1.430E-02	8.929E-07	1.667
46000.00	82800.0	3.1962E+06	1.3746E+06	385.93	92.210	0.5043	41.320	9.873	1.337E-02	8.345E-07	1.667
50000.00	90000.0	3.3614E+06	1.4457E+06	389.37	93.033	0.5043	41.307	9.870	1.230E-02	7.676E-07	1.667
55000.00	99000.0	3.5679E+06	1.5345E+06	393.31	93.974	0.5042	41.297	9.867	1.118E-02	6.977E-07	1.667
60000.00	108000.0	3.7744E+06	1.6233E+06	396.90	94.833	0.5042	41.289	9.865	1.024E-02	6.395E-07	1.667
65000.00	117000.0	3.9809E+06	1.7121E+06	400.21	95.622	0.5041	41.282	9.864	9.454E-03	5.902E-07	1.667
70000.00	126000.0	4.1872E+06	1.8008E+06	403.27	96.353	0.5041	41.278	9.863	8.778E-03	5.480E-07	1.667
80000.00	144000.0	4.6000E+06	1.9783E+06	408.78	97.670	0.5040	41.271	9.861	7.680E-03	4.794E-07	1.667
90000.00	162000.0	5.0125E+06	2.1558E+06	413.64	98.832	0.5040	41.266	9.860	6.826E-03	4.261E-07	1.667
100000.00	180000.0	5.4253E+06	2.3333E+06	417.99	99.870	0.5040	41.263	9.859	5.143E-03	3.835E-07	1.667
110000.00	198000.0	5.8379E+06	2.5107E+06	421.92	100.810	0.5040	41.260	9.858	5.584E-03	3.486E-07	1.667

TABLE II. - Continued. THERMODYNAMIC PROPERTIES OF SPIN-EQUILIBRATED HYDROGEN IN CHEMICAL EQUILIBRIUM IN DEBYE-HÜCKEL APPROXIMATION

[E-02, E-03, E+02, E+03, etc., after numbers signify that numbers are to be multiplied by 10^{-2}, 10^{-3}, 10^{2}, 10^{3}, etc.]

(f) Pressure, 3.03975×10^{4} N/m^2 (0.3 atm)

Temperature, T		Enthalpy, h		Entropy, s		Average molecular weight, g/g-mole or lb/lb-mole	Specific heat, c_p		Density, ρ		Isentropic exponent, γ
K	^{o}R	J/g	Btu/lb	J/(g)(K)	Btu/(lb)(^{o}R)		J/(g)(K)	Btu/(lb)(^{o}R)	g/m^3	lb/ft^3	
100.00	180.0	-2.1284E+05	-9.1537E+04	54.88	13.113	2.0156	13.956	3.334	7.369E+01	4.601E-03	1.420
150.00	270.0	-2.1217E+05	-9.1250E+04	60.31	14.410	2.0156	13.170	3.147	4.913E+01	3.067E-03	1.456
200.00	360.0	-2.1150E+05	-9.0963E+04	64.15	15.328	2.0156	13.617	3.253	3.685E+01	2.300E-03	1.435
250.00	450.0	-2.1081E+05	-9.0665E+04	67.24	16.066	2.0156	14.064	3.360	2.948E+01	1.840E-03	1.415
298.15	536.7	-2.1013E+05	-9.0371E+04	69.74	16.663	2.0156	14.305	3.418	2.472E+01	1.543E-03	1.405
400.00	720.0	-2.0865E+05	-8.9739E+04	73.98	17.675	2.0156	14.479	3.460	1.842E+01	1.150E-03	1.398
500.00	900.0	-2.0721E+05	-8.9116E+04	77.21	18.448	2.0156	14.518	3.469	1.474E+01	9.201E-04	1.397
600.00	1080.0	-2.0576E+05	-8.8491E+04	79.86	19.081	2.0156	14.548	3.476	1.228E+01	7.668E-04	1.396
700.00	1260.0	-2.0430E+05	-8.7864E+04	82.11	19.618	2.0155	14.506	3.490	1.053E+01	6.572E-04	1.394
800.00	1440.0	-2.0283E+05	-8.7234E+04	84.06	20.085	2.0155	14.696	3.511	9.212E+00	5.751E-04	1.390
900.00	1620.0	-2.0136E+05	-8.6599E+04	85.80	20.501	2.0156	14.824	3.542	8.188E+00	5.112E-04	1.386
1000.00	1800.0	-1.9987E+05	-8.5958E+04	87.37	20.876	2.0156	14.986	3.581	7.369E+00	4.601E-04	1.380
1100.00	1980.0	-1.9835E+05	-8.5310E+04	88.81	21.219	2.0156	15.171	3.625	6.699E+00	4.182E-04	1.373
1200.00	2160.0	-1.9683E+05	-8.4653E+04	90.14	21.536	2.0156	15.375	3.674	6.141E+00	3.834E-04	1.367
1300.00	2340.0	-1.9528E+05	-8.3987E+04	91.38	21.833	2.0156	15.592	3.725	5.669E+00	3.539E-04	1.360
1400.00	2520.0	-1.9371E+05	-8.3312E+04	92.54	22.111	2.0156	15.820	3.780	5.264E+00	3.286E-04	1.353
1500.00	2700.0	-1.9212E+05	-8.2626E+04	93.64	22.373	2.0156	16.056	3.839	4.913E+00	3.067E-04	1.346
1600.00	2880.0	-1.9050E+05	-8.1929E+04	94.69	22.623	2.0156	16.353	3.907	4.606E+00	2.875E-04	1.338
1700.00	3060.0	-1.8885E+05	-8.1218E+04	95.69	22.863	2.0154	16.723	3.996	4.334E+00	2.706E-04	1.329
1800.00	3240.0	-1.8715E+05	-8.0488E+04	96.66	23.094	2.0150	17.253	4.122	4.093E+00	2.555E-04	1.318
1900.00	3420.0	-1.8539E+05	-7.9730E+04	97.61	23.322	2.0142	18.054	4.314	3.876E+00	2.420E-04	1.304
2000.00	3600.0	-1.8352E+05	-7.8929E+04	98.56	23.550	2.0127	19.284	4.607	3.679E+00	2.297E-04	1.286
2100.00	3780.0	-1.8151E+05	-7.8063E+04	99.55	23.785	2.0100	21.148	5.053	3.499E+00	2.185E-04	1.264
2200.00	3960.0	-1.7927E+05	-7.7098E+04	100.59	24.034	2.0054	23.898	5.710	3.333E+00	2.080E-04	1.240
2300.00	4140.0	-1.7669E+05	-7.5990E+04	101.74	24.308	1.9981	27.834	6.650	3.176E+00	1.983E-04	1.216
2400.00	4320.0	-1.7365E+05	-7.4682E+04	103.03	24.617	1.9869	33.289	7.954	3.027E+00	1.890E-04	1.195
2500.00	4500.0	-1.6997E+05	-7.3100E+04	104.53	24.975	1.9706	40.522	9.705	2.882E+00	1.799E-04	1.176
2600.00	4680.0	-1.6545E+05	-7.1156E+04	106.30	25.399	1.9477	50.202	11.995	2.739E+00	1.710E-04	1.162
2700.00	4860.0	-1.5984E+05	-6.8745E+04	108.42	25.904	1.9167	62.370	14.902	2.595E+00	1.620E-04	1.152
2800.00	5040.0	-1.5289E+05	-6.5750E+04	110.95	26.508	1.8764	77.396	18.492	2.450E+00	1.530E-04	1.145
2900.00	5220.0	-1.4425E+05	-6.2045E+04	113.97	27.230	1.8259	95.394	22.793	2.302E+00	1.437E-04	1.141
3000.00	5400.0	-1.3371E+05	-5.7505E+04	117.54	28.085	1.7649	116.174	27.757	2.151E+00	1.343E-04	1.139
3100.00	5580.0	-1.2095E+05	-5.2022E+04	121.72	29.083	1.6942	139.047	33.223	1.998E+00	1.247E-04	1.139
3200.00	5760.0	-1.0588E+05	-4.5534E+04	126.51	30.227	1.6158	162.578	38.845	1.845E+00	1.152E-04	1.140
3400.00	5120.0	-6.9155E+04	-2.9742E+04	137.63	32.884	1.4488	201.371	48.114	1.558E+00	9.726E-05	1.146
3600.00	5480.0	-2.7472E+04	-1.1815E+04	149.54	35.729	1.2954	208.510	49.819	1.316E+00	8.213E-05	1.158
3800.00	5840.0	1.1528E+04	4.9578E+03	160.09	38.250	1.1797	175.082	42.072	1.135E+00	7.086E-05	1.175
4000.00	7200.0	4.1825E+04	1.7988E+04	167.87	40.109	1.1057	126.573	30.244	1.011E+00	6.309E-05	1.202
4200.00	7560.0	6.2715E+04	2.6972E+04	172.98	41.329	1.0631	84.688	20.235	9.254E-01	5.777E-05	1.243
4400.00	7920.0	7.6696E+04	3.2985E+04	176.23	42.107	1.0396	57.433	13.723	8.638E-01	5.393E-05	1.299

4600.00	8280.0	8.6451E+04	3.7181E+04	178.40	42.626	1.0266	41.624	9.945	8.159E-01	5.094E-05	1.368
4800.00	8640.0	9.3807E+04	4.0344E+04	179.97	43.000	1.0193	32.797	7.836	7.764E-01	4.847E-05	1.440
5000.00	9000.0	9.9827E+04	4.2933E+04	181.20	43.294	1.0151	27.874	6.660	7.422E-01	4.634E-05	1.504
5200.00	9360.0	1.0510E+05	4.5200E+04	182.23	43.541	1.0126	25.089	5.995	7.119E-01	4.444E-05	1.554
5400.00	9720.0	1.0994E+05	4.7283E+04	183.15	43.759	1.0110	23.490	5.613	6.845E-01	4.273E-05	1.588
5600.00	10080.0	1.1454E+05	4.9260E+04	183.98	43.959	1.0100	22.569	5.392	6.594E-01	4.117E-05	1.611
5800.00	10440.0	1.1899E+05	5.1177E+04	184.76	44.146	1.0093	22.055	5.270	6.362E-01	3.972E-05	1.623
6000.00	10800.0	1.2338E+05	5.3061E+04	185.51	44.324	1.0089	21.804	5.210	6.147E-01	3.838E-05	1.629
6300.00	11340.0	1.2990E+05	5.5869E+04	186.57	44.577	1.0083	21.772	5.202	5.852E-01	3.653E-05	1.626
6600.00	11880.0	1.3647E+05	5.8694E+04	187.59	44.821	1.0079	22.077	5.275	5.583E-01	3.486E-05	1.613
7000.00	12600.0	1.4547E+05	6.2564E+04	188.91	45.137	1.0073	23.020	5.500	5.261E-01	3.284E-05	1.580
7300.00	13140.0	1.5254E+05	6.5605E+04	189.90	45.373	1.0066	24.211	5.785	5.041E-01	3.147E-05	1.546
7600.00	13680.0	1.6005E+05	6.8834E+04	190.91	45.614	1.0057	25.927	6.195	4.838E-01	3.020E-05	1.505
8000.00	14400.0	1.7104E+05	7.3561E+04	192.32	45.950	1.0038	29.249	6.988	4.587E-01	2.864E-05	1.445
8300.00	14940.0	1.8031E+05	7.7547E+04	193.45	46.222	1.0017	32.705	7.814	4.412E-01	2.755E-05	1.400
8600.00	15480.0	1.9075E+05	8.2043E+04	194.69	46.518	0.9988	37.168	8.880	4.247E-01	2.651E-05	1.357
9000.00	16200.0	2.0712E+05	8.9077E+04	196.55	46.961	0.9935	44.987	10.749	4.036E-01	2.520E-05	1.308
9300.00	16740.0	2.2170E+05	9.5349E+04	198.14	47.342	0.9881	52.490	12.541	3.885E-01	2.425E-05	1.277
9600.00	17280.0	2.3877E+05	1.0269E+05	199.95	47.773	0.9812	61.601	14.718	3.738E-01	2.333E-05	1.252
10000.00	18000.0	2.6629E+05	1.1453E+05	202.75	48.444	0.9693	76.557	18.292	3.545E-01	2.213E-05	1.226
10500.00	18900.0	3.1025E+05	1.3343E+05	207.04	49.468	0.9494	100.277	23.959	3.308E-01	2.065E-05	1.202
11000.00	19800.0	3.6757E+05	1.5808E+05	212.37	50.741	0.9232	129.989	31.058	3.072E-01	1.918E-05	1.187
11500.00	20700.0	4.4122E+05	1.8976E+05	218.91	52.304	0.8903	165.552	39.555	2.835E-01	1.770E-05	1.177
12000.00	21600.0	5.3389E+05	2.2961E+05	226.79	54.187	0.8514	205.675	49.142	2.600E-01	1.623E-05	1.172
12500.00	22500.0	6.4717E+05	2.7833E+05	236.03	56.396	0.8077	247.327	59.094	2.369E-01	1.479E-05	1.169
13000.00	23400.0	7.8061E+05	3.3572E+05	246.50	58.896	0.7614	285.287	68.164	2.150E-01	1.342E-05	1.169
13500.00	24300.0	9.3069E+05	4.0027E+05	257.83	61.602	0.7154	312.673	74.707	1.946E-01	1.215E-05	1.171
14000.00	25200.0	1.0901E+06	4.6882E+05	269.42	64.372	0.6724	321.996	76.935	1.765E-01	1.102E-05	1.179
15000.00	27000.0	1.3998E+06	6.0203E+05	290.80	69.481	0.6033	285.881	68.305	1.479E-01	9.236E-06	1.197
16000.00	28800.0	1.6477E+06	7.0866E+05	306.83	73.311	0.5597	208.018	49.702	1.287E-01	8.034E-06	1.229
17000.00	30600.0	1.8194E+06	7.8247E+05	317.26	75.803	0.5356	139.194	33.258	1.159E-01	7.234E-06	1.279
18000.00	32400.0	1.9348E+06	8.3209E+05	323.87	77.383	0.5228	95.547	22.829	1.068E-01	6.666E-06	1.347
19000.00	34200.0	2.0169E+06	8.6742E+05	328.33	78.448	0.5160	71.256	17.025	9.981E-02	6.231E-06	1.425
20000.00	36000.0	2.0813E+06	8.9497E+05	331.62	79.235	0.5123	58.241	13.916	9.409E-02	5.874E-06	1.497
21000.00	37800.0	2.1353E+06	9.1836E+05	334.29	79.871	0.5102	51.194	12.232	8.920E-02	5.569E-06	1.554
22000.00	39600.0	2.1844E+06	9.3947E+05	336.58	80.418	0.5089	47.303	11.302	8.490E-02	5.300E-06	1.595
23000.00	41400.0	2.2305E+06	9.5930E+05	338.63	80.910	0.5081	45.111	10.779	8.105E-02	5.060E-06	1.621
24000.00	43200.0	2.2751E+06	9.7846E+05	340.53	81.363	0.5074	43.970	10.506	7.755E-02	4.841E-06	1.640
25000.00	45000.0	2.3185E+06	9.9718E+05	342.31	81.788	0.5070	43.156	10.311	7.436E-02	4.642E-06	1.650
26000.00	46800.0	2.3615E+06	1.0156E+06	343.99	82.190	0.5066	42.639	10.188	7.143E-02	4.459E-06	1.656
27000.00	48600.0	2.4039E+06	1.0339E+06	345.60	82.574	0.5063	42.299	10.107	6.874E-02	4.291E-06	1.661
28000.00	50400.0	2.4461E+06	1.0520E+06	347.13	82.940	0.5061	42.061	10.050	6.624E-02	4.135E-06	1.664
29000.00	52200.0	2.4881E+06	1.0701E+06	348.61	83.293	0.5059	41.902	10.012	6.392E-02	3.990E-06	1.665
30000.00	54000.0	2.5299E+06	1.0881E+06	350.02	83.632	0.5057	41.788	9.984	6.176E-02	3.856E-06	1.666
32000.00	57600.0	2.6134E+06	1.1239E+06	352.72	84.275	0.5055	41.641	9.949	5.786E-02	3.612E-06	1.667
34000.00	61200.0	2.6965E+06	1.1597E+06	355.24	84.878	0.5053	41.555	9.929	5.442E-02	3.397E-06	1.668
36000.00	64800.0	2.7796E+06	1.1954E+06	357.62	85.445	0.5051	41.499	9.915	5.137E-02	3.207E-06	1.668
38000.00	68400.0	2.8625E+06	1.2311E+06	359.86	85.981	0.5050	41.455	9.905	4.865E-02	3.037E-06	1.668
40000.00	72000.0	2.9454E+06	1.2668E+06	361.99	86.490	0.5049	41.428	9.898	4.620E-02	2.884E-06	1.668
43000.00	77400.0	3.0697E+06	1.3202E+06	364.98	87.205	0.5047	41.398	9.891	4.296E-02	2.682E-06	1.668
46000.00	82800.0	3.1938E+06	1.3736E+06	367.77	87.872	0.5046	41.375	9.885	4.014E-02	2.506E-06	1.668
50000.00	90000.0	3.3593E+06	1.4447E+06	371.22	88.697	0.5045	41.354	9.881	3.692E-02	2.305E-06	1.668
55000.00	99000.0	3.5660E+06	1.5336E+06	375.16	89.638	0.5044	41.334	9.876	3.355E-02	2.095E-06	1.668
60000.00	108000.0	3.7728E+06	1.6225E+06	378.76	90.498	0.5043	41.319	9.872	3.075E-02	1.919E-06	1.667
65000.00	117000.0	3.9792E+06	1.7114E+06	382.07	91.288	0.5043	41.309	9.870	2.838E-02	1.771E-06	1.667
70000.00	126000.0	4.1857E+06	1.8002E+06	385.13	92.019	0.5042	41.300	9.868	2.635E-02	1.645E-06	1.667
80000.00	144000.0	4.5985E+06	1.9778E+06	390.64	93.337	0.5041	41.287	9.865	2.305E-02	1.439E-06	1.667
90000.00	162000.0	5.0115E+06	2.1553E+06	395.51	94.499	0.5041	41.279	9.863	2.048E-02	1.279E-06	1.667
100000.00	180000.0	5.4242E+06	2.3328E+06	399.86	95.538	0.5041	41.273	9.861	1.843E-02	1.151E-06	1.667
110000.00	198000.0	5.8370E+06	2.5103E+06	403.79	96.478	0.5040	41.269	9.860	1.676E-02	1.046E-06	1.667

TABLE II. - Continued. THERMODYNAMIC PROPERTIES OF SPIN-EQUILIBRATED HYDROGEN IN CHEMICAL EQUILIBRIUM IN DEBYE-HÜCKEL APPROXIMATION

[E-02, E-03, E+02, E+03, etc., after numbers signify that numbers are to be multiplied by 10^{-2}, 10^{-3}, 10^{2}, 10^{3}, etc.]

(g) Pressure, 1.01325×10^{5} N/m^2 (1 atm)

Temperature, T		Enthalpy, h		Entropy, s		Average molecular weight, g/g-mole or lb/lb-mole	Specific heat, c_p		Density, ρ		Isentropic exponent, γ
K	^{o}R	J/g	Btu/lb	J/(g)(K)	Btu/(lb)(^{o}R)		J/(g)(K)	Btu/(lb)(^{o}R)	g/m^3	lb/ft^3	
100.00	180.0	-2.1284E+05	-9.1537E+04	49.92	11.926	2.0156	13.961	3.336	2.456E+02	1.534E-02	1.419
150.00	270.0	-2.1217E+05	-9.1250E+04	55.34	13.223	2.0156	13.170	3.147	1.638E+02	1.022E-02	1.456
200.00	360.0	-2.1150E+05	-9.0963E+04	59.19	14.141	2.0156	13.617	3.253	1.228E+02	7.668E-03	1.435
250.00	450.0	-2.1081E+05	-9.0665E+04	62.27	14.879	2.0156	14.064	3.360	9.826E+01	6.134E-03	1.415
298.15	536.7	-2.1013E+05	-9.0371E+04	64.77	15.477	2.0156	14.303	3.417	8.239E+01	5.143E-03	1.405
400.00	720.0	-2.0865E+05	-8.9739E+04	69.01	16.488	2.0156	14.478	3.459	5.141E+01	3.834E-03	1.398
500.00	900.0	-2.0721E+05	-8.9116E+04	72.24	17.262	2.0156	14.518	3.469	4.913E+01	3.067E-03	1.397
600.00	1080.0	-2.0576E+05	-8.8491E+04	74.89	17.895	2.0156	14.547	3.476	4.094E+01	2.556E-03	1.396
700.00	1260.0	-2.0430E+05	-8.7864E+04	77.14	18.431	2.0156	14.606	3.490	3.509E+01	2.191E-03	1.394
800.00	1440.0	-2.0283E+05	-8.7234E+04	79.10	18.899	2.0156	14.697	3.512	3.071E+01	1.917E-03	1.390
900.00	1620.0	-2.0136E+05	-8.6599E+04	80.83	19.314	2.0156	14.824	3.542	2.729E+01	1.704E-03	1.386
1000.00	1800.0	-1.9987E+05	-8.5958E+04	82.40	19.689	2.0156	14.984	3.580	2.456E+01	1.534E-03	1.380
1100.00	1980.0	-1.9835E+05	-8.5310E+04	83.84	20.032	2.0155	15.172	3.625	2.233E+01	1.394E-03	1.373
1200.00	2160.0	-1.9683E+05	-8.4653E+04	85.17	20.350	2.0156	15.375	3.674	2.047E+01	1.278E-03	1.367
1300.00	2340.0	-1.9529E+05	-8.3987E+04	86.41	20.646	2.0156	15.589	3.725	1.890E+01	1.180E-03	1.360
1400.00	2520.0	-1.9371E+05	-8.3312E+04	87.57	20.924	2.0156	15.814	3.778	1.755E+01	1.095E-03	1.353
1500.00	2700.0	-1.9212E+05	-8.2627E+04	88.67	21.186	2.0156	16.047	3.834	1.638E+01	1.022E-03	1.346
1600.00	2880.0	-1.9050E+05	-8.1931E+04	89.72	21.436	2.0156	16.300	3.895	1.535E+01	9.584E-04	1.339
1700.00	3060.0	-1.8886E+05	-8.1224E+04	90.71	21.674	2.0155	16.595	3.965	1.445E+01	9.020E-04	1.332
1800.00	3240.0	-1.8718E+05	-8.0503E+04	91.67	21.903	2.0153	16.975	4.056	1.364E+01	8.518E-04	1.323
1900.00	3420.0	-1.8546E+05	-7.9762E+04	92.60	22.126	2.0149	17.500	4.181	1.292E+01	8.068E-04	1.313
2000.00	3600.0	-1.8367E+05	-7.8994E+04	93.52	22.344	2.0140	18.253	4.361	1.227E+01	7.661E-04	1.300
2100.00	3780.0	-1.8180E+05	-7.8187E+04	94.43	22.563	2.0125	19.352	4.624	1.168E+01	7.291E-04	1.284
2200.00	3960.0	-1.7979E+05	-7.7323E+04	95.37	22.786	2.0100	20.932	5.001	1.113E+01	6.951E-04	1.266
2300.00	4140.0	-1.7759E+05	-7.6377E+04	96.34	23.020	2.0060	23.157	5.533	1.063E+01	6.635E-04	1.246
2400.00	4320.0	-1.7513E+05	-7.5319E+04	97.39	23.270	1.9998	26.213	6.263	1.015E+01	6.339E-04	1.226
2500.00	4500.0	-1.7231E+05	-7.4108E+04	98.54	23.544	1.9907	30.298	7.239	9.704E+00	6.058E-04	1.207
2600.00	4680.0	-1.6903E+05	-7.2695E+04	99.83	23.852	1.9778	35.621	8.511	9.271E+00	5.787E-04	1.191
2700.00	4860.0	-1.6514E+05	-7.1023E+04	101.29	24.202	1.9602	42.340	10.128	8.848E+00	5.523E-04	1.177
2800.00	5040.0	-1.6050E+05	-6.9025E+04	102.98	24.606	1.9358	50.795	12.137	8.430E+00	5.263E-04	1.166
2900.00	5220.0	-1.5492E+05	-6.6628E+04	104.94	25.073	1.9067	61.001	14.575	8.013E+00	5.002E-04	1.158
3000.00	5400.0	-1.4823E+05	-6.3751E+04	107.20	25.614	1.8691	73.135	17.457	7.593E+00	4.740E-04	1.153
3100.00	5580.0	-1.4024E+05	-6.0313E+04	109.82	26.240	1.8237	87.101	20.811	7.169E+00	4.476E-04	1.150
3200.00	5760.0	-1.3075E+05	-5.6235E+04	112.83	26.960	1.7704	102.812	24.565	6.742E+00	4.209E-04	1.148
3400.00	6120.0	-1.0678E+05	-4.5922E+04	120.09	28.694	1.6431	137.287	32.802	5.889E+00	3.677E-04	1.149
3600.00	6480.0	-7.6043E+04	-3.2704E+04	128.87	30.790	1.4997	168.504	40.261	5.077E+00	3.169E-04	1.155
3800.00	6840.0	-4.0471E+04	-1.7406E+04	138.48	33.087	1.3501	183.375	43.814	4.362E+00	2.723E-04	1.165
4000.00	7200.0	-4.4383E+03	-1.9088E+03	147.72	35.295	1.2431	172.608	41.241	3.787E+00	2.364E-04	1.179
4200.00	7560.0	2.7199E+04	1.1698E+04	155.45	37.141	1.1574	141.596	33.832	3.358E+00	2.097E-04	1.199
4400.00	7920.0	5.1883E+04	2.2316E+04	161.20	38.515	1.1008	105.687	25.252	3.049E+00	1.903E-04	1.227

4600.00	8280.0	6.9914E+04	3.0068E+04	165.21	39.473	1.0556	76.081	18.178	2.823E+00	1.762E-04	1.266
4800.00	8640.0	8.2934E+04	3.5668E+04	167.98	40.136	1.0442	55.563	13.276	2.651E+00	1.655E-04	1.315
5000.00	9000.0	9.2635E+04	3.9841E+04	169.96	40.609	1.0313	42.493	10.153	2.514E+00	1.569E-04	1.372
5200.00	9360.0	1.0026E+05	4.3121E+04	171.46	40.967	1.0233	34.447	8.230	2.398E+00	1.497E-04	1.432
5400.00	9720.0	1.0662E+05	4.5855E+04	172.66	41.254	1.0183	29.528	7.055	2.298E+00	1.435E-04	1.487
5600.00	10080.0	1.1220E+05	4.8255E+04	173.67	41.496	1.0151	26.507	6.333	2.209E+00	1.379E-04	1.533
5800.00	10440.0	1.1730E+05	5.0448E+04	174.57	41.710	1.0130	24.637	5.887	2.129E+00	1.329E-04	1.567
6000.00	10800.0	1.2210E+05	5.2513E+04	175.38	41.905	1.0116	23.481	5.610	2.055E+00	1.283E-04	1.591
6300.00	11340.0	1.2899E+05	5.5475E+04	176.50	42.172	1.0101	22.551	5.388	1.954E+00	1.220E-04	1.611
6600.00	11880.0	1.3569E+05	5.8358E+04	177.54	42.421	1.0092	22.215	5.308	1.864E+00	1.163E-04	1.617
7000.00	12600.0	1.4459E+05	6.2185E+04	178.85	42.733	1.0084	22.376	5.346	1.756E+00	1.096E-04	1.606
7300.00	13140.0	1.5137E+05	6.5101E+04	179.80	42.960	1.0078	22.884	5.468	1.682E+00	1.050E-04	1.588
7600.00	13680.0	1.5835E+05	6.8104E+04	180.74	43.184	1.0071	23.735	5.671	1.615E+00	1.008E-04	1.562
8000.00	14400.0	1.6817E+05	7.2327E+04	182.00	43.485	1.0059	25.489	6.090	1.532E+00	9.566E-05	1.517
8300.00	14940.0	1.7609E+05	7.5731E+04	182.97	43.717	1.0047	27.359	6.537	1.475E+00	9.209E-05	1.480
8600.00	15480.0	1.8465E+05	7.9412E+04	183.98	43.959	1.0031	29.795	7.119	1.421E+00	8.874E-05	1.440
9000.00	16200.0	1.9738E+05	8.4888E+04	185.43	44.304	1.0000	34.090	8.145	1.354E+00	8.454E-05	1.389
9300.00	16740.0	2.0821E+05	8.9544E+04	186.61	44.587	0.9970	38.226	9.133	1.307E+00	8.157E-05	1.354
9600.00	17280.0	2.2040E+05	9.4791E+04	187.90	44.895	0.9931	43.252	10.337	1.261E+00	7.872E-05	1.322
10000.00	18000.0	2.3931E+05	1.0292E+05	189.83	45.356	0.9863	51.561	12.319	1.202E+00	7.506E-05	1.286
10500.00	18900.0	2.6825E+05	1.1537E+05	192.65	46.030	0.9748	64.821	15.488	1.132E+00	7.067E-05	1.251
11000.00	19800.0	3.0473E+05	1.3106E+05	196.04	46.840	0.9592	81.676	19.515	1.064E+00	6.640E-05	1.226
11500.00	20700.0	3.5058E+05	1.5078E+05	200.11	47.814	0.9390	102.414	24.470	9.964E-01	6.220E-05	1.208
12000.00	21600.0	4.0779E+05	1.7538E+05	204.98	48.976	0.9139	127.070	30.361	9.299E-01	5.805E-05	1.195
12500.00	22500.0	4.7824E+05	2.0568E+05	210.73	50.350	0.8839	155.248	37.093	8.641E-01	5.394E-05	1.187
13000.00	23400.0	5.6345E+05	2.4233E+05	217.41	51.946	0.8495	185.879	44.412	7.993E-01	4.990E-05	1.182
13500.00	24300.0	6.6421E+05	2.8566E+05	225.01	53.762	0.8118	216.985	51.844	7.362E-01	4.596E-05	1.179
14000.00	25200.0	7.7990E+05	3.3541E+05	233.42	55.772	0.7722	244.195	58.346	6.761E-01	4.220E-05	1.182
15000.00	27000.0	1.0447E+06	4.4931E+05	251.67	60.133	0.6944	279.119	66.690	5.685E-01	3.549E-05	1.189
16000.00	28800.0	1.3228E+06	5.6889E+05	269.62	64.420	0.6291	258.860	64.239	4.834E-01	3.018E-05	1.203
17000.00	30600.0	1.5696E+06	6.7505E+05	284.60	67.999	0.5823	220.799	52.756	4.214E-01	2.631E-05	1.227
18000.00	32400.0	1.7618E+06	7.5763E+05	295.59	70.627	0.5526	164.070	39.201	3.775E-01	2.357E-05	1.263
19000.00	34200.0	1.9018E+06	8.1790E+05	303.19	72.441	0.5348	118.811	28.388	3.461E-01	2.160E-05	1.313
20000.00	36000.0	2.0044E+06	8.6205E+05	308.47	73.703	0.5244	88.816	21.221	3.222E-01	2.011E-05	1.373
21000.00	37800.0	2.0832E+06	8.9595E+05	312.33	74.624	0.5182	70.436	16.829	3.030E-01	1.892E-05	1.437
22000.00	39600.0	2.1477E+06	9.2369E+05	315.34	75.344	0.5145	59.513	14.220	2.870E-01	1.792E-05	1.497
23000.00	41400.0	2.2036E+06	9.4773E+05	317.83	75.939	0.5121	52.916	12.643	2.731E-01	1.705E-05	1.546
24000.00	43200.0	2.2544E+06	9.6957E+05	320.00	76.458	0.5106	48.919	11.688	2.603E-01	1.628E-05	1.583
25000.00	45000.0	2.3020E+06	9.9004E+05	321.95	76.924	0.5095	46.480	11.106	2.493E-01	1.559E-05	1.610
26000.00	46800.0	2.3475E+06	1.0097E+06	323.74	77.353	0.5088	44.861	10.719	2.397E-01	1.496E-05	1.628
27000.00	48600.0	2.3920E+06	1.0287E+06	325.42	77.754	0.5083	43.869	10.482	2.305E-01	1.439E-05	1.640
28000.00	50400.0	2.4355E+06	1.0474E+06	327.01	78.133	0.5079	43.166	10.314	2.220E-01	1.386E-05	1.649
29000.00	52200.0	2.4784E+06	1.0659E+06	328.52	78.494	0.5076	42.726	10.209	2.142E-01	1.337E-05	1.655
30000.00	54000.0	2.5209E+06	1.0842E+06	329.97	78.840	0.5073	42.357	10.120	2.069E-01	1.291E-05	1.659
32000.00	57600.0	2.6054E+06	1.1205E+06	332.70	79.493	0.5069	42.166	10.075	1.937E-01	1.209E-05	1.666
34000.00	61200.0	2.6895E+06	1.1567E+06	335.25	80.102	0.5065	41.926	10.017	1.821E-01	1.137E-05	1.668
36000.00	64800.0	2.7732E+06	1.1927E+06	337.65	80.674	0.5062	41.779	9.982	1.718E-01	1.073E-05	1.668
38000.00	68400.0	2.8566E+06	1.2286E+06	339.90	81.214	0.5059	41.682	9.959	1.626E-01	1.015E-05	1.669
40000.00	72000.0	2.9399E+06	1.2644E+06	342.04	81.724	0.5057	41.613	9.943	1.544E-01	9.639E-06	1.669
43000.00	77400.0	3.0645E+06	1.3180E+06	345.05	82.443	0.5054	41.544	9.926	1.435E-01	8.959E-06	1.669
46000.00	82800.0	3.1892E+06	1.3716E+06	347.85	83.113	0.5052	41.495	9.914	1.341E-01	8.370E-06	1.669
50000.00	90000.0	3.3551E+06	1.4429E+06	351.31	83.939	0.5050	41.446	9.903	1.233E-01	7.695E-06	1.669
55000.00	99000.0	3.5622E+06	1.5320E+06	355.26	84.883	0.5048	41.408	9.894	1.120E-01	6.991E-06	1.668
60000.00	108000.0	3.7692E+06	1.6210E+06	358.86	85.744	0.5047	41.381	9.887	1.026E-01	6.405E-06	1.668
65000.00	117000.0	3.9760E+06	1.7100E+06	362.18	86.535	0.5046	41.350	9.882	9.468E-02	5.911E-06	1.668
70000.00	126000.0	4.1829E+06	1.7989E+06	365.24	87.268	0.5045	41.343	9.878	8.789E-02	5.487E-06	1.668
80000.00	144000.0	4.5961E+06	1.9767E+06	370.76	88.586	0.5043	41.320	9.873	7.687E-02	4.799E-06	1.667
90000.00	162000.0	5.0092E+06	2.1543E+06	375.63	89.749	0.5042	41.306	9.869	6.831E-02	4.264E-06	1.667
100000.00	180000.0	5.4222E+06	2.3320E+06	379.98	90.789	0.5042	41.294	9.866	6.147E-02	3.837E-06	1.667
110000.00	198000.0	5.8351E+06	2.5095E+06	383.92	91.729	0.5041	41.286	9.865	5.587E-02	3.488E-06	1.667

TABLE II. - Continued. THERMODYNAMIC PROPERTIES OF SPIN-EQUILIBRATED HYDROGEN IN CHEMICAL EQUILIBRIUM IN DEBYE-HÜCKEL APPROXIMATION

[E-02, E-03, E+02, E+03, etc., after numbers signify that numbers are to be multiplied by 10^{-2}, 10^{-3}, 10^{2}, 10^{3}, etc.]

(h) Pressure, 3.03975×10^5 N/m^2 (3 atm)

Temperature, T		Enthalpy, h		Entropy, s		Average molecular weight, g/g-mole or lb/lb-mole	Specific heat, c_p		Density, ρ		Isentropic exponent, γ
K	^{o}R	J/g	Btu/lb	J/(g)(K)	Btu/(lb)(^{o}R)		J/(g)(K)	Btu/(lb)(^{o}R)	g/m^3	lb/ft^3	
100.00	180.0	-2.1284E+05	-9.1537E+04	45.38	10.844	2.0155	13.967	3.337	7.369E+02	4.601E-02	1.419
150.00	270.0	-2.1217E+05	-9.1250E+04	50.81	12.140	2.0156	13.163	3.145	4.913E+02	3.067E-02	1.456
200.00	360.0	-2.1150E+05	-9.0963E+04	54.65	13.058	2.0156	13.622	3.255	3.685E+02	2.300E-02	1.434
250.00	450.0	-2.1081E+05	-9.0665E+04	57.74	13.797	2.0156	14.060	3.359	2.948E+02	1.840E-02	1.415
298.15	536.7	-2.1013E+05	-9.0371E+04	60.24	14.394	2.0156	14.305	3.418	2.472E+02	1.543E-02	1.405
400.00	720.0	-2.0866E+05	-8.9739E+04	64.48	15.406	2.0156	14.478	3.459	1.842E+02	1.150E-02	1.398
500.00	900.0	-2.0721E+05	-8.9116E+04	67.71	16.179	2.0155	14.517	3.468	1.474E+02	9.201E-03	1.397
600.00	1080.0	-2.0575E+05	-8.8491E+04	70.36	16.812	2.0155	14.548	3.476	1.228E+02	7.668E-03	1.396
700.00	1260.0	-2.0430E+05	-8.7864E+04	72.61	17.349	2.0156	14.605	3.490	1.053E+02	6.572E-03	1.394
800.00	1440.0	-2.0283E+05	-8.7234E+04	74.57	17.816	2.0156	14.697	3.512	9.212E+01	5.751E-03	1.390
900.00	1620.0	-2.0135E+05	-8.6599E+04	76.30	18.231	2.0156	14.825	3.542	8.188E+01	5.112E-03	1.386
1000.00	1800.0	-1.9987E+05	-8.5958E+04	77.87	18.606	2.0156	14.984	3.580	7.369E+01	4.601E-03	1.380
1100.00	1980.0	-1.9836E+05	-8.5310E+04	79.31	18.950	2.0156	15.171	3.625	6.699E+01	4.182E-03	1.373
1200.00	2160.0	-1.9683E+05	-8.4653E+04	80.64	19.267	2.0156	15.375	3.674	6.141E+01	3.834E-03	1.367
1300.00	2340.0	-1.9528E+05	-8.3987E+04	81.88	19.563	2.0156	15.590	3.725	5.669E+01	3.539E-03	1.360
1400.00	2520.0	-1.9371E+05	-8.3312E+04	83.04	19.841	2.0156	15.812	3.778	5.264E+01	3.286E-03	1.353
1500.00	2700.0	-1.9212E+05	-8.2627E+04	84.14	20.104	2.0155	16.038	3.832	4.913E+01	3.067E-03	1.346
1600.00	2880.0	-1.9051E+05	-8.1932E+04	85.18	20.353	2.0156	16.272	3.888	4.606E+01	2.875E-03	1.340
1700.00	3060.0	-1.8887E+05	-8.1227E+04	86.18	20.590	2.0156	16.530	3.950	4.335E+01	2.706E-03	1.333
1800.00	3240.0	-1.8720E+05	-8.0510E+04	87.13	20.818	2.0154	16.833	4.022	4.094E+01	2.556E-03	1.326
1900.00	3420.0	-1.8550E+05	-7.9778E+04	88.05	21.038	2.0152	17.215	4.113	3.878E+01	2.421E-03	1.318
2000.00	3600.0	-1.8375E+05	-7.9027E+04	88.94	21.252	2.0147	17.726	4.235	3.683E+01	2.299E-03	1.308
2100.00	3780.0	-1.8195E+05	-7.8251E+04	89.83	21.462	2.0138	18.433	4.404	3.506E+01	2.189E-03	1.297
2200.00	3960.0	-1.8005E+05	-7.7438E+04	90.70	21.672	2.0124	19.414	4.639	3.344E+01	2.088E-03	1.283
2300.00	4140.0	-1.7805E+05	-7.6575E+04	91.60	21.885	2.0101	20.764	4.961	3.195E+01	1.995E-03	1.268
2400.00	4320.0	-1.7589E+05	-7.5645E+04	92.52	22.105	2.0065	22.591	5.398	3.057E+01	1.908E-03	1.251
2500.00	4500.0	-1.7351E+05	-7.4624E+04	93.49	22.337	2.0012	25.009	5.975	2.927E+01	1.827E-03	1.234
2600.00	4680.0	-1.7086E+05	-7.3484E+04	94.52	22.585	1.9936	28.141	6.724	2.803E+01	1.750E-03	1.218
2700.00	4860.0	-1.6786E+05	-7.2191E+04	95.66	22.856	1.9832	32.110	7.672	2.686E+01	1.677E-03	1.203
2800.00	5040.0	-1.6441E+05	-7.0708E+04	96.91	23.155	1.9693	37.035	8.849	2.571E+01	1.605E-03	1.190
2900.00	5220.0	-1.6041E+05	-6.8990E+04	98.31	23.490	1.9512	43.027	10.280	2.460E+01	1.536E-03	1.180
3000.00	5400.0	-1.5575E+05	-6.6990E+04	99.89	23.866	1.9282	50.177	11.989	2.350E+01	1.467E-03	1.172
3100.00	5580.0	-1.5034E+05	-6.4657E+04	101.67	24.291	1.8998	58.552	13.990	2.241E+01	1.399E-03	1.166
3200.00	5760.0	-1.4401E+05	-6.1936E+04	103.67	24.771	1.8655	68.173	16.289	2.131E+01	1.331E-03	1.161
3400.00	6120.0	-1.2818E+05	-5.5126E+04	108.47	25.916	1.7787	90.883	21.715	1.913E+01	1.194E-03	1.158
3600.00	6480.0	-1.0745E+05	-4.6212E+04	114.38	27.330	1.6700	116.623	27.865	1.696E+01	1.059E-03	1.159
3800.00	6840.0	-8.1604E+04	-3.5096E+04	121.37	28.998	1.5473	141.129	33.720	1.489E+01	9.293E-04	1.164
4000.00	7200.0	-5.1542E+04	-2.2167E+04	129.07	30.839	1.4231	157.480	37.627	1.301E+01	8.120E-04	1.173
4200.00	7560.0	-1.9613E+04	-8.4349E+03	136.86	32.700	1.3106	158.994	37.989	1.141E+01	7.122E-04	1.185
4400.00	7920.0	1.0969E+04	4.7176E+03	143.98	34.400	1.2192	144.467	34.518	1.013E+01	6.324E-04	1.200

4600.00	8280.0	3.7503E+04	1.6129E+04	149.88	35.810	1.1512	119.936	28.656	9.150E+00	5.712E-04	1.221
4800.00	8640.0	5.8852E+04	2.5311E+04	154.42	36.897	1.1040	93.898	22.435	8.409E+00	5.250E-04	1.248
5000.00	9000.0	7.5341E+04	3.2402E+04	157.79	37.702	1.0725	71.908	17.181	7.942E+00	4.896E-04	1.283
5200.00	9360.0	8.7995E+04	3.7845E+04	160.28	38.295	1.0517	55.575	13.279	7.595E+00	4.616E-04	1.325
5400.00	9720.0	9.7906E+04	4.2107E+04	162.15	38.742	1.0382	44.259	10.575	7.329E+00	4.388E-04	1.372
5600.00	10080.0	1.0595E+05	4.5566E+04	163.61	39.092	1.0292	36.678	8.763	6.719E+00	4.195E-04	1.422
5800.00	10440.0	1.1275E+05	4.8490E+04	164.80	39.377	1.0231	31.665	7.566	6.449E+00	4.026E-04	1.469
6000.00	10800.0	1.1873E+05	5.1061E+04	165.82	39.619	1.0190	28.357	6.775	5.209E+00	3.876E-04	1.510
6300.00	11340.0	1.2674E+05	5.4508E+04	167.12	39.931	1.0150	25.376	6.063	5.390E+00	3.677E-04	1.557
6600.00	11880.0	1.3409E+05	5.7669E+04	168.26	40.203	1.0126	23.795	5.685	5.509E+00	3.502E-04	1.587
7000.00	12600.0	1.4339E+05	6.1669E+04	169.63	40.530	1.0106	22.886	5.468	5.278E+00	3.295E-04	1.603
7300.00	13140.0	1.5023E+05	6.4610E+04	170.59	40.759	1.0095	22.764	5.439	5.056E+00	3.156E-04	1.601
7600.00	13680.0	1.5709E+05	6.7559E+04	171.51	40.979	1.0087	22.996	5.494	4.852E+00	3.029E-04	1.590
8000.00	14400.0	1.6643E+05	7.1576E+04	172.71	41.265	1.0076	23.803	5.687	4.605E+00	2.875E-04	1.564
8300.00	14940.0	1.7371E+05	7.4707E+04	173.60	41.478	1.0067	24.791	5.923	4.434E+00	2.768E-04	1.537
8600.00	15480.0	1.8134E+05	7.7989E+04	174.50	41.694	1.0056	26.141	6.246	4.275E+00	2.669E-04	1.506
9000.00	16200.0	1.9225E+05	8.2684E+04	175.74	41.990	1.0037	28.583	6.829	4.078E+00	2.546E-04	1.462
9300.00	16740.0	2.0117E+05	8.6520E+04	176.72	42.223	1.0018	30.965	7.398	3.939E+00	2.459E-04	1.428
9600.00	17280.0	2.1089E+05	9.0698E+04	177.74	42.469	0.9995	33.883	8.096	3.807E+00	2.377E-04	1.395
10000.00	18000.0	2.2537E+05	9.6926E+04	179.22	42.822	0.9954	38.717	9.251	3.640E+00	2.272E-04	1.354
10500.00	18900.0	2.4659E+05	1.0605E+05	181.29	43.316	0.9885	46.480	11.105	3.443E+00	2.150E-04	1.311
11000.00	19800.0	2.7221E+05	1.1707E+05	183.67	43.885	0.9790	56.413	13.479	3.256E+00	2.033E-04	1.276
11500.00	20700.0	3.0343E+05	1.3048E+05	186.44	44.547	0.9665	68.758	16.428	3.076E+00	1.920E-04	1.249
12000.00	21600.0	3.4140E+05	1.4683E+05	189.68	45.320	0.9505	83.688	19.996	2.901E+00	1.811E-04	1.229
12500.00	22500.0	3.8753E+05	1.6667E+05	193.44	46.219	0.9310	101.256	24.193	2.729E+00	1.704E-04	1.215
13000.00	23400.0	4.4307E+05	1.9056E+05	197.80	47.259	0.9077	121.329	28.989	2.561E+00	1.599E-04	1.204
13500.00	24300.0	5.0921E+05	2.1900E+05	202.78	48.452	0.8807	143.492	34.285	2.395E+00	1.495E-04	1.197
14000.00	25200.0	5.8679E+05	2.5236E+05	208.43	49.799	0.8506	166.955	39.891	2.233E+00	1.394E-04	1.192
15000.00	27000.0	7.7564E+05	3.3359E+05	221.43	52.907	0.7840	210.465	50.287	1.926E+00	1.202E-04	1.192
16000.00	28800.0	1.0032E+06	4.3144E+05	236.10	56.412	0.7161	241.007	57.584	1.653E+00	1.032E-04	1.198
17000.00	30600.0	1.2485E+06	5.3698E+05	250.97	59.965	0.6555	244.672	58.460	1.427E+00	8.910E-05	1.209
18000.00	32400.0	1.4829E+06	6.3776E+05	264.37	63.166	0.6079	220.050	52.577	1.251E+00	7.811E-05	1.228
19000.00	34200.0	1.6836E+06	7.2406E+05	275.23	65.761	0.5740	180.165	43.047	1.119E+00	6.988E-05	1.255
20000.00	35000.0	1.8433E+06	7.9277E+05	283.44	67.723	0.5513	140.293	33.520	1.021E+00	6.375E-05	1.292
21000.00	37800.0	1.9670E+06	8.4594E+05	289.49	69.168	0.5367	108.592	25.946	9.461E-01	5.907E-05	1.337
22000.00	39600.0	2.0636E+06	8.8752E+05	294.00	70.245	0.5274	86.225	20.602	8.867E-01	5.535E-05	1.389
23000.00	41400.0	2.1418E+06	9.2115E+05	297.48	71.078	0.5213	71.224	17.018	8.378E-01	5.230E-05	1.443
24000.00	43200.0	2.2079E+06	9.4954E+05	300.30	71.752	0.5174	61.519	14.699	7.961E-01	4.970E-05	1.493
25000.00	45000.0	2.2660E+06	9.7454E+05	302.69	72.321	0.5147	55.147	13.176	7.598E-01	4.743E-05	1.536
26000.00	46800.0	2.3189E+06	9.9731E+05	304.77	72.819	0.5128	51.029	12.193	7.274E-01	4.541E-05	1.570
27000.00	48600.0	2.3685E+06	1.0186E+06	306.65	73.268	0.5115	48.300	11.540	6.982E-01	4.359E-05	1.596
28000.00	50400.0	2.4158E+06	1.0390E+06	308.38	73.680	0.5105	46.348	11.074	6.717E-01	4.193E-05	1.616
29000.00	52200.0	2.4614E+06	1.0586E+06	309.99	74.065	0.5098	45.096	10.775	6.473E-01	4.041E-05	1.630
30000.00	54000.0	2.5061E+06	1.0778E+06	311.50	74.428	0.5093	44.154	10.550	6.247E-01	3.900E-05	1.641
32000.00	57600.0	2.5932E+06	1.1153E+06	314.33	75.103	0.5085	43.101	10.298	5.843E-01	3.648E-05	1.653
34000.00	61200.0	2.6787E+06	1.1520E+06	316.93	75.724	0.5079	42.452	10.143	5.490E-01	3.427E-05	1.660
36000.00	64800.0	2.7632E+06	1.1884E+06	319.35	76.303	0.5075	42.092	10.057	5.178E-01	3.233E-05	1.664
38000.00	68400.0	2.8472E+06	1.2245E+06	321.63	76.848	0.5072	41.919	10.016	4.900E-01	3.059E-05	1.666
40000.00	72000.0	2.9308E+06	1.2605E+06	323.78	77.362	0.5070	41.743	9.974	4.651E-01	2.904E-05	1.667
43000.00	77400.0	3.0562E+06	1.3144E+06	326.81	78.086	0.5066	41.802	9.988	4.321E-01	2.698E-05	1.670
46000.00	82800.0	3.1815E+06	1.3683E+06	329.63	78.759	0.5062	41.701	9.964	4.035E-01	2.519E-05	1.670
50000.00	90000.0	3.3481E+06	1.4399E+06	333.11	79.590	0.5059	41.611	9.942	3.708E-01	2.315E-05	1.670
55000.00	99000.0	3.5560E+06	1.5293E+06	337.07	80.537	0.5055	41.537	9.924	3.367E-01	2.102E-05	1.669
60000.00	108000.0	3.7635E+06	1.6186E+06	340.69	81.400	0.5052	41.485	9.912	3.084E-01	1.925E-05	1.669
65000.00	117000.0	3.9708E+06	1.7078E+06	344.01	82.194	0.5050	41.442	9.902	2.845E-01	1.776E-05	1.669
70000.00	126000.0	4.1780E+06	1.7968E+06	347.08	82.927	0.5049	41.414	9.895	2.640E-01	1.648E-05	1.668
80000.00	144000.0	4.5919E+06	1.9749E+06	352.61	84.249	0.5047	41.375	9.886	2.308E-01	1.441E-05	1.668
90000.00	162000.0	5.0055E+06	2.1527E+06	357.48	85.413	0.5045	41.348	9.879	2.051E-01	1.280E-05	1.668
100000.00	180000.0	5.4189E+06	2.3305E+06	361.84	86.454	0.5044	41.327	9.874	1.845E-01	1.152E-05	1.668
110000.00	198000.0	5.8321E+06	2.5082E+06	365.77	87.395	0.5043	41.313	9.871	1.677E-01	1.047E-05	1.667

TABLE II. - Continued. THERMODYNAMIC PROPERTIES OF SPIN-EQUILIBRATED HYDROGEN IN CHEMICAL EQUILIBRIUM IN DEBYE-HÜCKEL APPROXIMATION

[E-02, E-03, E+02, E+03, etc., after numbers signify that numbers are to be multiplied by 10^{-2}, 10^{-3}, 10^{2}, 10^{3}, etc.]

(i) Pressure, 1.01325×10^{6} N/m^2 (10 atm)

Temperature, T		Enthalpy, h		Entropy, s		Average molecular weight, g/g-mole or lb/lb-mole	Specific heat, c_p		Density, ρ		Isentropic exponent, γ
K	^{o}R	J/g	Btu/lb	J/(g)(K)	Btu/(lb)(^{o}R)		J/(g)(K)	Btu/(lb)(^{o}R)	g/m^3	lb/ft^3	
100.00	180.0	-2.1284E+05	-9.1537E+04	40.42	9.657	2.0156	13.967	3.337	2.456E+03	1.534E-01	1.419
150.00	270.0	-2.1217E+05	-9.1250E+04	45.84	10.954	2.0155	13.174	3.148	1.638E+03	1.022E-01	1.456
200.00	360.0	-2.1150E+05	-9.0963E+04	49.69	11.872	2.0156	13.617	3.253	1.228E+03	7.668E-02	1.435
250.00	450.0	-2.1081E+05	-9.0665E+04	52.78	12.610	2.0156	14.062	3.360	9.826E+02	6.134E-02	1.415
298.15	536.7	-2.1013E+05	-9.0371E+04	55.28	13.207	2.0155	14.299	3.417	8.239E+02	5.143E-02	1.405
400.00	720.0	-2.0866E+05	-8.9739E+04	59.51	14.219	2.0156	14.479	3.460	6.141E+02	3.834E-02	1.398
500.00	900.0	-2.0721E+05	-8.9116E+04	62.75	14.992	2.0156	14.517	3.468	4.913E+02	3.067E-02	1.397
600.00	1080.0	-2.0575E+05	-8.8491E+04	65.40	15.625	2.0155	14.547	3.475	4.094E+02	2.556E-02	1.396
700.00	1260.0	-2.0430E+05	-8.7864E+04	67.64	16.162	2.0156	14.605	3.490	3.509E+02	2.191E-02	1.394
800.00	1440.0	-2.0283E+05	-8.7234E+04	69.60	16.629	2.0156	14.695	3.511	3.071E+02	1.917E-02	1.390
900.00	1620.0	-2.0135E+05	-8.6599E+04	71.34	17.045	2.0156	14.825	3.542	2.729E+02	1.704E-02	1.386
1000.00	1800.0	-1.9987E+05	-8.5958E+04	72.91	17.420	2.0156	14.984	3.580	2.456E+02	1.534E-02	1.380
1100.00	1980.0	-1.9836E+05	-8.5310E+04	74.34	17.763	2.0156	15.171	3.625	2.233E+02	1.394E-02	1.373
1200.00	2160.0	-1.9683E+05	-8.4653E+04	75.67	18.081	2.0156	15.375	3.674	2.047E+02	1.278E-02	1.367
1300.00	2340.0	-1.9529E+05	-8.3987E+04	76.91	18.377	2.0156	15.590	3.725	1.890E+02	1.180E-02	1.360
1400.00	2520.0	-1.9371E+05	-8.3312E+04	78.07	18.655	2.0156	15.810	3.777	1.755E+02	1.095E-02	1.353
1500.00	2700.0	-1.9212E+05	-8.2627E+04	79.17	18.917	2.0156	16.031	3.830	1.638E+02	1.022E-02	1.346
1600.00	2880.0	-1.9051E+05	-8.1933E+04	80.21	19.166	2.0155	16.256	3.884	1.535E+02	9.584E-03	1.340
1700.00	3060.0	-1.8887E+05	-8.1229E+04	81.21	19.403	2.0155	16.490	3.940	1.445E+02	9.020E-03	1.334
1800.00	3240.0	-1.8721E+05	-8.0514E+04	82.16	19.630	2.0155	16.745	4.001	1.365E+02	8.519E-03	1.328
1900.00	3420.0	-1.8552E+05	-7.9788E+04	83.07	19.848	2.0154	17.040	4.071	1.293E+02	8.070E-03	1.321
2000.00	3600.0	-1.8380E+05	-7.9048E+04	83.95	20.059	2.0151	17.401	4.158	1.228E+02	7.666E-03	1.313
2100.00	3780.0	-1.8204E+05	-7.8290E+04	84.81	20.264	2.0147	17.866	4.269	1.169E+02	7.299E-03	1.305
2200.00	3960.0	-1.8022E+05	-7.7509E+04	85.66	20.466	2.0139	18.476	4.414	1.116E+02	6.964E-03	1.295
2300.00	4140.0	-1.7834E+05	-7.6698E+04	86.50	20.666	2.0126	19.285	4.608	1.066E+02	6.657E-03	1.284
2400.00	4320.0	-1.7635E+05	-7.5847E+04	87.34	20.868	2.0106	20.352	4.863	1.021E+02	6.374E-03	1.272
2500.00	4500.0	-1.7425E+05	-7.4943E+04	88.20	21.073	2.0077	21.740	5.194	9.787E+01	5.110E-03	1.258
2600.00	4680.0	-1.7200E+05	-7.3971E+04	89.08	21.284	2.0035	23.516	5.619	9.391E+01	5.863E-03	1.245
2700.00	4860.0	-1.6954E+05	-7.2913E+04	90.01	21.506	1.9978	25.750	6.152	9.017E+01	5.629E-03	1.231
2800.00	5040.0	-1.6683E+05	-7.1749E+04	90.99	21.741	1.9900	28.507	6.811	8.661E+01	5.407E-03	1.218
2900.00	5220.0	-1.6382E+05	-7.0453E+04	92.05	21.994	1.9798	31.851	7.610	8.320E+01	5.194E-03	1.207
3000.00	5400.0	-1.6044E+05	-6.9000E+04	93.20	22.267	1.9668	35.841	8.564	7.990E+01	4.988E-03	1.197
3100.00	5580.0	-1.5662E+05	-6.7360E+04	94.45	22.565	1.9504	40.526	9.683	7.667E+01	4.787E-03	1.188
3200.00	5760.0	-1.5231E+05	-6.5503E+04	95.82	22.893	1.9303	45.943	10.977	7.351E+01	4.589E-03	1.182
3400.00	6120.0	-1.4185E+05	-6.1010E+04	98.98	23.649	1.8778	59.037	14.106	6.731E+01	4.202E-03	1.173
3600.00	6480.0	-1.2850E+05	-5.5265E+04	102.79	24.560	1.8076	74.972	17.913	6.119E+01	3.820E-03	1.169
3800.00	6840.0	-1.1173E+05	-4.8053E+04	107.32	25.642	1.7207	92.953	22.209	5.519E+01	3.445E-03	1.170
4000.00	7200.0	-9.1300E+04	-3.9266E+04	112.56	26.893	1.6212	111.191	26.567	4.939E+01	3.083E-03	1.174
4200.00	7560.0	-6.7433E+04	-2.9001E+04	118.38	28.284	1.5156	126.725	30.279	4.398E+01	2.745E-03	1.181
4400.00	7920.0	-4.1033E+04	-1.7647E+04	124.51	29.750	1.4122	135.920	32.476	3.911E+01	2.442E-03	1.190

4600.00	8280.0	-1.3679E+04	-5.8829E+03	130.59	31.203	1.3186	135.985	32.491	3.494E+01	2.181E-03	1.202
4800.00	8640.0	1.2735E+04	5.4768E+03	136.22	32.546	1.2400	126.751	30.285	3.148E+01	1.965E-03	1.217
5000.00	9000.0	3.6587E+04	1.5735E+04	141.09	33.710	1.1778	111.029	26.528	2.871E+01	1.792E-03	1.235
5200.00	9360.0	5.6992E+04	2.4511E+04	145.09	34.667	1.1311	92.961	22.211	2.651E+01	1.655E-03	1.258
5400.00	9720.0	7.3846E+04	3.1759E+04	148.27	35.427	1.0971	75.955	18.148	2.476E+01	1.546E-03	1.285
5600.00	10080.0	8.7565E+04	3.7660E+04	150.77	36.023	1.0728	61.770	14.759	2.335E+01	1.458E-03	1.318
5800.00	10440.0	9.8769E+04	4.2478E+04	152.74	36.493	1.0556	50.787	12.135	2.218E+01	1.385E-03	1.354
6000.00	10800.0	1.0807E+05	4.6478E+04	154.31	36.870	1.0433	42.647	10.190	2.119E+01	1.323E-03	1.393
6300.00	11340.0	1.1954E+05	5.1410E+04	156.18	37.316	1.0312	34.480	8.238	1.995E+01	1.245E-03	1.451
6600.00	11880.0	1.2908E+05	5.5515E+04	157.66	37.670	1.0235	29.571	7.065	1.890E+01	1.180E-03	1.503
7000.00	12600.0	1.4011E+05	6.0256E+04	159.28	38.058	1.0176	25.977	6.207	1.772E+01	1.106E-03	1.552
7300.00	13140.0	1.4767E+05	6.3509E+04	160.34	38.311	1.0147	24.573	5.871	1.694E+01	1.058E-03	1.575
7600.00	13680.0	1.5492E+05	6.6626E+04	161.32	38.543	1.0127	23.844	5.697	1.624E+01	1.014E-03	1.585
8000.00	14400.0	1.6438E+05	7.0696E+04	162.53	38.833	1.0108	23.586	5.635	1.540E+01	9.613E-04	1.583
8300.00	14940.0	1.7148E+05	7.3749E+04	163.40	39.041	1.0096	23.802	5.687	1.482E+01	9.254E-04	1.573
8600.00	15480.0	1.7869E+05	7.6851E+04	164.25	39.245	1.0085	24.322	5.811	1.429E+01	8.922E-04	1.556
9000.00	16200.0	1.8863E+05	8.1126E+04	165.38	39.515	1.0070	25.475	6.087	1.364E+01	8.513E-04	1.526
9300.00	16740.0	1.9645E+05	8.4489E+04	166.24	39.719	1.0057	26.696	6.379	1.318E+01	8.228E-04	1.499
9600.00	17280.0	2.0468E+05	8.8029E+04	167.11	39.927	1.0042	28.246	6.749	1.275E+01	7.959E-04	1.471
10000.00	18000.0	2.1648E+05	9.3105E+04	168.31	40.215	1.0017	30.870	7.376	1.221E+01	7.622E-04	1.433
10500.00	18900.0	2.3294E+05	1.0018E+05	169.92	40.599	0.9976	35.152	8.399	1.158E+01	7.231E-04	1.387
11000.00	19800.0	2.5185E+05	1.0831E+05	171.68	41.019	0.9921	40.690	9.722	1.100E+01	6.865E-04	1.346
11500.00	20700.0	2.7386E+05	1.1778E+05	173.63	41.486	0.9848	47.629	11.380	1.044E+01	6.520E-04	1.311
12000.00	21600.0	2.9973E+05	1.2891E+05	175.83	42.012	0.9754	55.101	13.404	9.919E+00	6.192E-04	1.282
12500.00	22500.0	3.3024E+05	1.4203E+05	178.32	42.607	0.9637	65.203	15.818	9.412E+00	5.876E-04	1.259
13000.00	23400.0	3.6621E+05	1.5750E+05	181.14	43.281	0.9493	77.982	18.632	8.922E+00	5.570E-04	1.242
13500.00	24300.0	4.0849E+05	1.7568E+05	184.33	44.043	0.9322	91.410	21.841	8.445E+00	5.272E-04	1.228
14000.00	25200.0	4.5788E+05	1.9692E+05	187.92	44.901	0.9123	106.353	25.411	7.978E+00	4.981E-04	1.217
15000.00	27000.0	5.8005E+05	2.4947E+05	196.34	46.911	0.8650	137.959	32.963	7.080E+00	4.420E-04	1.209
16000.00	28800.0	7.3464E+05	3.1595E+05	206.30	49.291	0.8100	170.887	40.830	6.235E+00	3.893E-04	1.205
17000.00	30600.0	9.1973E+05	3.9555E+05	217.50	51.968	0.7522	197.692	47.235	5.467E+00	3.413E-04	1.208
18000.00	32400.0	1.1257E+06	4.8415E+05	229.27	54.779	0.6970	211.635	50.566	4.798E+00	2.995E-04	1.215
19000.00	34200.0	1.3371E+06	5.7506E+05	240.69	57.509	0.6491	208.223	49.751	4.241E+00	2.648E-04	1.229
20000.00	36000.0	1.5370E+06	6.6105E+05	250.95	59.960	0.6106	189.585	45.298	3.794E+00	2.368E-04	1.248
21000.00	37800.0	1.7135E+06	7.3695E+05	259.57	62.020	0.5816	152.659	38.864	3.442E+00	2.149E-04	1.273
22000.00	39600.0	1.8621E+06	8.0085E+05	266.49	63.674	0.5607	134.860	32.222	3.166E+00	1.977E-04	1.306
23000.00	41400.0	1.9845E+06	8.5348E+05	271.95	64.977	0.5460	110.730	26.457	2.947E+00	1.840E-04	1.342
24000.00	43200.0	2.0853E+06	8.9686E+05	276.25	66.005	0.5358	91.859	21.948	2.769E+00	1.728E-04	1.383
25000.00	45000.0	2.1693E+06	9.3321E+05	279.71	66.832	0.5286	77.928	18.619	2.620E+00	1.635E-04	1.426
26000.00	46800.0	2.2425E+06	9.6445E+05	282.57	67.515	0.5235	67.946	16.234	2.492E+00	1.556E-04	1.468
27000.00	48600.0	2.3065E+06	9.9202E+05	285.00	68.095	0.5199	60.713	14.506	2.381E+00	1.486E-04	1.508
28000.00	50400.0	2.3647E+06	1.0170E+06	287.12	68.602	0.5173	55.721	13.313	2.282E+00	1.425E-04	1.542
29000.00	52200.0	2.4185E+06	1.0402E+06	289.02	69.056	0.5153	52.181	12.468	2.193E+00	1.369E-04	1.569
30000.00	54000.0	2.4693E+06	1.0620E+06	290.75	69.459	0.5139	49.544	11.838	2.112E+00	1.319E-04	1.592
32000.00	57600.0	2.5649E+06	1.1031E+06	293.85	70.210	0.5118	46.386	11.083	1.970E+00	1.230E-04	1.623
34000.00	61200.0	2.6558E+06	1.1422E+06	296.62	70.871	0.5105	44.498	10.632	1.847E+00	1.153E-04	1.642
36000.00	64800.0	2.7437E+06	1.1800E+06	299.14	71.474	0.5097	43.530	10.401	1.740E+00	1.086E-04	1.653
38000.00	68400.0	2.8301E+06	1.2171E+06	301.49	72.035	0.5090	42.865	10.242	1.645E+00	1.027E-04	1.659
40000.00	72000.0	2.9154E+06	1.2538E+06	303.69	72.560	0.5085	42.513	10.158	1.560E+00	9.738E-05	1.663
43000.00	77400.0	3.0422E+06	1.3084E+06	306.76	73.294	0.5080	42.087	10.056	1.448E+00	9.041E-05	1.666
46000.00	82800.0	3.1682E+06	1.3626E+06	309.60	73.973	0.5076	41.861	10.002	1.352E+00	8.439E-05	1.668
50000.00	90000.0	3.3354E+06	1.4345E+06	313.10	74.809	0.5072	41.758	9.977	1.242E+00	7.751E-05	1.668
55000.00	99000.0	3.5436E+06	1.5240E+06	317.08	75.750	0.5069	41.562	9.931	1.127E+00	7.036E-05	1.669
60000.00	108000.0	3.7522E+06	1.6137E+06	320.72	76.629	0.5064	41.491	9.961	1.032E+00	6.440E-05	1.671
65000.00	117000.0	3.9605E+06	1.7033E+06	324.05	77.426	0.5060	41.618	9.944	9.512E-01	5.938E-05	1.670
70000.00	125000.0	4.1684E+06	1.7927E+06	327.14	78.163	0.5057	41.562	9.931	8.824E-01	5.509E-05	1.670
80000.00	144000.0	4.5837E+06	1.9713E+06	332.68	79.489	0.5053	41.486	9.912	7.710E-01	4.813E-05	1.669
90000.00	162000.0	4.9982E+06	2.1496E+06	337.57	80.656	0.5050	41.428	9.898	6.847E-01	4.275E-05	1.669
100000.00	180000.0	5.4123E+06	2.3277E+06	341.93	81.699	0.5048	41.394	9.890	6.158E-01	3.845E-05	1.668
110000.00	198000.0	5.8261E+06	2.5057E+06	345.88	82.641	0.5046	41.369	9.884	5.596E-01	3.493E-05	1.668

TABLE II. - Continued. THERMODYNAMIC PROPERTIES OF SPIN-EQUILIBRATED HYDROGEN IN CHEMICAL EQUILIBRIUM IN DEBYE-HÜCKEL APPROXIMATION

[E-02, E-03, E+02, E+03, etc., after numbers signify that numbers are to be multiplied by 10^{-2}, 10^{-3}, 10^{2}, 10^{3}, etc.]

(j) Pressure, 3.03975×10^{6} N/m^2 (30 atm)

Temperature, T		Enthalpy, h		Entropy, s		Average molecular weight, g/g-mole or lb/lb-mole	Specific heat, c_p		Density, ρ		Isentropic exponent, γ
K	^{o}R	J/g	Btu/lb	J/(g)(K)	Btu/(lb)(^{o}R)		J/(g)(K)	Btu/(lb)(^{o}R)	g/m^3	lb/ft^3	
150.00	270.0	-2.1217E+05	-9.1250E+04	41.31	9.871	2.0156	13.174	3.148	4.913E+03	3.067E-01	1.456
200.00	360.0	-2.1150E+05	-9.0963E+04	45.16	10.789	2.0156	13.619	3.254	3.685E+03	2.300E-01	1.434
250.00	450.0	-2.1081E+05	-9.0665E+04	48.25	11.527	2.0156	14.069	3.361	2.948E+03	1.840E-01	1.415
298.15	536.7	-2.1013E+05	-9.0371E+04	50.75	12.125	2.0156	14.305	3.418	2.472E+03	1.543E-01	1.405
400.00	720.0	-2.0865E+05	-8.9739E+04	54.98	13.136	2.0156	14.479	3.460	1.842E+03	1.150E-01	1.398
500.00	900.0	-2.0721E+05	-8.9116E+04	58.22	13.909	2.0156	14.517	3.468	1.474E+03	9.201E-02	1.397
600.00	1080.0	-2.0576E+05	-8.8491E+04	60.86	14.542	2.0156	14.548	3.476	1.228E+03	7.668E-02	1.396
700.00	1260.0	-2.0430E+05	-8.7864E+04	63.11	15.079	2.0155	14.607	3.490	1.053E+03	6.572E-02	1.394
800.00	1440.0	-2.0283E+05	-8.7234E+04	65.07	15.547	2.0155	14.697	3.512	9.212E+02	5.751E-02	1.390
900.00	1620.0	-2.0135E+05	-8.6599E+04	66.81	15.962	2.0156	14.826	3.542	8.188E+02	5.112E-02	1.385
1000.00	1800.0	-1.9987E+05	-8.5958E+04	68.38	16.337	2.0156	14.984	3.580	7.369E+02	4.601E-02	1.380
1100.00	1980.0	-1.9835E+05	-8.5310E+04	69.81	16.680	2.0156	15.171	3.625	6.699E+02	4.182E-02	1.373
1200.00	2160.0	-1.9683E+05	-8.4653E+04	71.14	16.998	2.0156	15.375	3.673	6.141E+02	3.834E-02	1.367
1300.00	2340.0	-1.9529E+05	-8.3987E+04	72.38	17.294	2.0156	15.589	3.725	5.569E+02	3.539E-02	1.360
1400.00	2520.0	-1.9371E+05	-8.3312E+04	73.54	17.572	2.0156	15.808	3.777	5.264E+02	3.286E-02	1.353
1500.00	2700.0	-1.9212E+05	-8.2627E+04	74.64	17.834	2.0156	16.028	3.830	4.913E+02	3.067E-02	1.347
1600.00	2880.0	-1.9051E+05	-8.1933E+04	75.68	18.083	2.0156	16.247	3.882	4.606E+02	2.875E-02	1.340
1700.00	3060.0	-1.8887E+05	-8.1230E+04	76.67	18.320	2.0156	16.469	3.935	4.335E+02	2.706E-02	1.334
1800.00	3240.0	-1.8722E+05	-8.0517E+04	77.62	18.546	2.0156	16.700	3.990	4.094E+02	2.556E-02	1.328
1900.00	3420.0	-1.8553E+05	-7.9793E+04	78.53	18.764	2.0155	16.950	4.050	3.878E+02	2.421E-02	1.322
2000.00	3600.0	-1.8382E+05	-7.9058E+04	79.41	18.973	2.0154	17.234	4.118	3.684E+02	2.300E-02	1.316
2100.00	3780.0	-1.8208E+05	-7.8310E+04	80.26	19.176	2.0151	17.575	4.199	3.508E+02	2.190E-02	1.310
2200.00	3960.0	-1.8031E+05	-7.7545E+04	81.08	19.373	2.0146	17.995	4.300	3.348E+02	2.090E-02	1.302
2300.00	4140.0	-1.7848E+05	-7.6761E+04	81.90	19.567	2.0139	18.528	4.427	3.201E+02	1.998E-02	1.294
2400.00	4320.0	-1.7660E+05	-7.5950E+04	82.70	19.759	2.0127	19.206	4.589	3.066E+02	1.914E-02	1.285
2500.00	4500.0	-1.7463E+05	-7.5106E+04	83.50	19.950	2.0111	20.066	4.794	2.941E+02	1.836E-02	1.274
2600.00	4680.0	-1.7258E+05	-7.4220E+04	84.31	20.143	2.0086	21.149	5.053	2.824E+02	1.763E-02	1.264
2700.00	4860.0	-1.7043E+05	-7.3283E+04	85.13	20.340	2.0053	22.493	5.374	2.715E+02	1.695E-02	1.253
2800.00	5040.0	-1.6807E+05	-7.2281E+04	85.97	20.542	2.0008	24.136	5.767	2.612E+02	1.631E-02	1.241
2900.00	5220.0	-1.6555E+05	-7.1202E+04	86.86	20.752	1.9948	26.119	6.241	2.515E+02	1.570E-02	1.231
3000.00	5400.0	-1.6283E+05	-7.0029E+04	87.78	20.973	1.9871	28.475	6.804	2.422E+02	1.512E-02	1.220
3100.00	5580.0	-1.5985E+05	-6.8747E+04	88.76	21.207	1.9774	31.234	7.463	2.332E+02	1.456E-02	1.211
3200.00	5760.0	-1.5657E+05	-6.7337E+04	89.80	21.455	1.9655	34.423	8.225	2.246E+02	1.402E-02	1.203
3400.00	5120.0	-1.4894E+05	-6.4056E+04	92.11	22.007	1.9335	42.165	10.074	2.079E+02	1.298E-02	1.191
3600.00	5480.0	-1.3958E+05	-6.0030E+04	94.78	22.646	1.8895	51.755	12.366	1.919E+02	1.198E-02	1.184
3800.00	5840.0	-1.2812E+05	-5.5103E+04	97.87	23.385	1.8325	63.065	15.068	1.763E+02	1.101E-02	1.180
4000.00	7200.0	-1.1427E+05	-4.9143E+04	101.43	24.234	1.7529	75.688	18.084	1.611E+02	1.006E-02	1.181
4200.00	7560.0	-9.7814E+04	-4.2067E+04	105.44	25.192	1.6828	88.826	21.223	1.465E+02	9.145E-03	1.184
4400.00	7920.0	-7.8785E+04	-3.3883E+04	109.86	26.249	1.5956	101.208	24.182	1.326E+02	8.277E-03	1.189

4600.00	8280.0	-5.7492E+04	-2.4726E+04	114.59	27.379	1.5061	111.156	26.559	1.197E+02	7.473E-03	1.197
4800.00	8640.0	-3.4601E+04	-1.4881E+04	119.46	28.543	1.4194	116.924	27.937	1.081E+02	6.749E-03	1.206
5000.00	9000.0	-1.1084E+04	-4.7668E+03	124.26	29.690	1.3398	117.303	28.027	9.797E+01	6.116E-03	1.218
5200.00	9350.0	1.1952E+04	5.1404E+03	128.78	30.769	1.2704	112.200	26.808	8.932E+01	5.576E-03	1.232
5400.00	9720.0	3.3505E+04	1.4410E+04	132.85	31.742	1.2125	102.763	24.553	8.210E+01	5.125E-03	1.248
5600.00	10080.0	5.2896E+04	2.2749E+04	136.38	32.584	1.1661	90.902	21.719	7.613E+01	4.753E-03	1.267
5800.00	10440.0	6.9835E+04	3.0034E+04	139.35	33.295	1.1298	78.539	18.765	7.122E+01	4.446E-03	1.289
6000.00	10800.0	8.4373E+04	3.6287E+04	141.81	33.884	1.1020	67.066	16.024	6.715E+01	4.192E-03	1.314
6300.00	11340.0	1.0227E+05	4.3986E+04	144.73	34.580	1.0722	52.962	12.654	6.222E+01	3.884E-03	1.357
6600.00	11880.0	1.1655E+05	5.0125E+04	146.94	35.109	1.0526	42.813	10.229	5.831E+01	3.640E-03	1.404
7000.00	12600.0	1.3179E+05	5.6679E+04	149.19	35.646	1.0363	34.167	8.164	5.413E+01	3.379E-03	1.464
7300.00	13140.0	1.4140E+05	6.0814E+04	150.53	35.967	1.0286	30.206	7.217	5.152E+01	3.216E-03	1.504
7600.00	13680.0	1.5005E+05	6.4534E+04	151.69	36.244	1.0232	27.651	6.607	4.922E+01	3.073E-03	1.534
8000.00	14400.0	1.6067E+05	6.9102E+04	153.06	36.570	1.0183	25.675	6.135	4.654E+01	2.905E-03	1.560
8300.00	14940.0	1.6825E+05	7.2360E+04	153.99	36.792	1.0157	24.917	5.953	4.474E+01	2.793E-03	1.568
8600.00	15480.0	1.7567E+05	7.5550E+04	154.86	37.002	1.0137	24.603	5.878	4.309E+01	2.690E-03	1.568
9000.00	16200.0	1.8551E+05	7.9785E+04	155.98	37.269	1.0114	24.722	5.907	4.109E+01	2.565E-03	1.557
9300.00	16740.0	1.9299E+05	8.3000E+04	156.80	37.464	1.0099	25.154	6.010	3.970E+01	2.479E-03	1.543
9600.00	17280.0	2.0063E+05	8.6287E+04	157.61	37.658	1.0085	25.856	6.178	3.841E+01	2.398E-03	1.524
10000.00	18000.0	2.1123E+05	9.0845E+04	158.69	37.916	1.0064	27.204	6.500	3.680E+01	2.297E-03	1.495
10500.00	18900.0	2.2539E+05	9.6935E+04	160.07	38.246	1.0035	29.572	7.066	3.495E+01	2.182E-03	1.455
11000.00	19800.0	2.4094E+05	1.0362E+05	161.52	38.592	0.9998	32.751	7.825	3.325E+01	2.075E-03	1.414
11500.00	20700.0	2.5829E+05	1.1108E+05	163.06	38.960	0.9952	36.813	8.796	3.166E+01	1.976E-03	1.376
12000.00	21600.0	2.7791E+05	1.1952E+05	164.73	39.359	0.9893	41.833	9.995	3.017E+01	1.884E-03	1.343
12500.00	22500.0	3.0029E+05	1.2915E+05	166.56	39.795	0.9820	47.878	11.440	2.876E+01	1.796E-03	1.313
13000.00	23400.0	3.2597E+05	1.4019E+05	168.57	40.276	0.9729	55.001	13.142	2.742E+01	1.712E-03	1.289
13500.00	24300.0	3.5548E+05	1.5288E+05	170.80	40.808	0.9620	63.227	15.107	2.613E+01	1.631E-03	1.269
14000.00	25200.0	3.8938E+05	1.6746E+05	173.26	41.397	0.9491	72.549	17.334	2.488E+01	1.553E-03	1.253
15000.00	27000.0	4.7239E+05	2.0316E+05	178.98	42.764	0.9171	93.327	22.299	2.250E+01	1.405E-03	1.233
16000.00	28800.0	5.7729E+05	2.4827E+05	185.74	44.378	0.8774	116.726	27.889	2.025E+01	1.264E-03	1.222
17000.00	30600.0	7.0614E+05	3.0369E+05	193.53	46.241	0.8317	140.855	33.655	1.813E+01	1.132E-03	1.217
18000.00	32400.0	8.5804E+05	3.6902E+05	202.20	48.312	0.7829	162.214	38.758	1.619E+01	1.010E-03	1.219
19000.00	34200.0	1.0287E+06	4.4240E+05	211.42	50.514	0.7344	177.750	42.470	1.444E+01	9.013E-04	1.222
20000.00	36000.0	1.2102E+06	5.2049E+05	220.72	52.738	0.6894	183.722	43.897	1.291E+01	8.062E-04	1.232
21000.00	37800.0	1.3927E+06	5.9896E+05	229.63	54.865	0.6502	179.531	42.896	1.162E+01	7.256E-04	1.246
22000.00	39600.0	1.5665E+06	6.7369E+05	237.71	56.797	0.6178	166.841	39.864	1.055E+01	6.588E-04	1.265
23000.00	41400.0	1.7247E+06	7.4175E+05	244.75	58.479	0.5921	149.102	35.625	9.675E+00	6.040E-04	1.287
24000.00	43200.0	1.8642E+06	8.0175E+05	250.70	59.899	0.5723	129.958	31.051	8.959E+00	5.593E-04	1.314
25000.00	45000.0	1.9850E+06	8.5371E+05	255.64	61.080	0.5574	112.010	25.763	8.369E+00	5.225E-04	1.347
26000.00	46800.0	2.0891E+06	8.9847E+05	259.73	62.058	0.5464	96.615	23.084	7.879E+00	4.918E-04	1.380
27000.00	48600.0	2.1792E+06	9.3724E+05	263.15	62.874	0.5381	84.185	20.114	7.463E+00	4.659E-04	1.415
28000.00	50400.0	2.2584E+06	9.7127E+05	266.03	63.564	0.5319	74.492	17.798	7.104E+00	4.435E-04	1.450
29000.00	52200.0	2.3290E+06	1.0016E+06	268.52	64.158	0.5272	67.079	16.027	6.790E+00	4.239E-04	1.483
30000.00	54000.0	2.3931E+06	1.0292E+06	270.71	64.680	0.5236	61.334	14.655	5.511E+00	4.065E-04	1.515
32000.00	57600.0	2.5075E+06	1.0785E+06	274.42	65.568	0.5187	53.869	12.871	6.034E+00	3.767E-04	1.566
34000.00	61200.0	2.6106E+06	1.1228E+06	277.56	66.318	0.5156	49.554	11.840	5.634E+00	3.517E-04	1.601
36000.00	64800.0	2.7068E+06	1.1641E+06	280.32	66.978	0.5135	46.757	11.172	5.291E+00	3.303E-04	1.626
38000.00	68400.0	2.7985E+06	1.2036E+06	282.82	67.575	0.5122	45.212	10.802	4.992E+00	3.116E-04	1.641
40000.00	72000.0	2.8880E+06	1.2420E+06	285.13	68.125	0.5112	44.096	10.536	4.727E+00	2.951E-04	1.652
43000.00	77400.0	3.0188E+06	1.2983E+06	288.30	68.884	0.5101	43.242	10.332	4.381E+00	2.735E-04	1.660
46000.00	82800.0	3.1478E+06	1.3538E+06	291.21	69.579	0.5093	42.700	10.202	4.084E+00	2.550E-04	1.664
50000.00	90000.0	3.3173E+06	1.4267E+06	294.76	70.428	0.5086	42.247	10.094	3.747E+00	2.339E-04	1.667
55000.00	99000.0	3.5277E+06	1.5172E+06	298.79	71.390	0.5080	41.953	10.024	3.398E+00	2.121E-04	1.669
60000.00	108000.0	3.7369E+06	1.6072E+06	302.45	72.264	0.5076	41.730	9.971	3.109E+00	1.941E-04	1.669
65000.00	117000.0	3.9454E+06	1.6968E+06	305.80	73.064	0.5072	41.621	9.944	2.866E+00	1.789E-04	1.670
70000.00	126000.0	4.1535E+06	1.7863E+06	308.89	73.804	0.5069	41.610	9.942	2.658E+00	1.659E-04	1.669
80000.00	144000.0	4.5702E+06	1.9655E+06	314.46	75.135	0.5063	41.668	9.956	2.321E+00	1.449E-04	1.671
90000.00	162000.0	4.9864E+06	2.1445E+06	319.37	76.307	0.5058	41.576	9.934	2.059E+00	1.286E-04	1.670
100000.00	180000.0	5.4017E+06	2.3231E+06	323.75	77.354	0.5054	41.502	9.916	1.851E+00	1.156E-04	1.669
110000.00	198000.0	5.8165E+06	2.5015E+06	327.70	78.299	0.5052	41.459	9.906	1.682E+00	1.050E-04	1.669

TABLE II. - Continued. THERMODYNAMIC PROPERTIES OF SPIN-EQUILIBRATED HYDROGEN IN CHEMICAL EQUILIBRIUM IN DEBYE-HÜCKEL APPROXIMATION

[E-02, E-03, E+02, E+03, etc., after numbers signify that numbers are to be multiplied by 10^{-2}, 10^{-3}, 10^{2}, 10^{3}, etc.]

(k) Pressure, 1.01325×10^{7} N/m^2 (100 atm)

Temperature, T		Enthalpy, h		Entropy, s		Average molecular weight, g/g-mole or lb/lb-mole	Specific heat, c_p		Density, ρ		Isentropic exponent, γ
K	^{o}R	J/g	Btu/lb	J/(g)(K)	Btu/(lb)(^{o}R)		J/(g)(K)	Btu/(lb)(^{o}R)	g/m^3	lb/ft^3	
400.00	720.0	-2.0865E+05	-8.9739E+04	50.01	11.950	2.0155	14.478	3.459	5.141E+03	3.834E-01	1.398
500.00	900.0	-2.0721E+05	-8.9116E+04	53.25	12.723	2.0155	14.516	3.458	4.913E+03	3.067E-01	1.397
600.00	1080.0	-2.0575E+05	-8.8491E+04	55.90	13.356	2.0156	14.545	3.476	4.094E+03	2.556E-01	1.396
700.00	1260.0	-2.0430E+05	-8.7864E+04	58.15	13.893	2.0156	14.607	3.490	3.509E+03	2.191E-01	1.394
800.00	1440.0	-2.0283E+05	-8.7234E+04	60.10	14.360	2.0156	14.696	3.511	3.071E+03	1.917E-01	1.390
900.00	1620.0	-2.0136E+05	-8.6599E+04	61.84	14.775	2.0156	14.825	3.542	2.729E+03	1.704E-01	1.386
1000.00	1800.0	-1.9987E+05	-8.5958E+04	63.41	15.150	2.0156	14.984	3.580	2.456E+03	1.534E-01	1.380
1100.00	1980.0	-1.9835E+05	-8.5310E+04	64.85	15.494	2.0156	15.171	3.625	2.233E+03	1.394E-01	1.373
1200.00	2160.0	-1.9683E+05	-8.4653E+04	66.17	15.811	2.0156	15.376	3.674	2.047E+03	1.278E-01	1.367
1300.00	2340.0	-1.9528E+05	-8.3987E+04	67.41	16.107	2.0156	15.589	3.725	1.890E+03	1.180E-01	1.360
1400.00	2520.0	-1.9371E+05	-8.3312E+04	68.58	16.385	2.0156	15.808	3.777	1.755E+03	1.095E-01	1.353
1500.00	2700.0	-1.9212E+05	-8.2628E+04	69.68	16.648	2.0156	16.026	3.829	1.638E+03	1.022E-01	1.347
1600.00	2880.0	-1.9051E+05	-8.1934E+04	70.72	16.896	2.0156	16.242	3.881	1.535E+03	9.584E-02	1.340
1700.00	3060.0	-1.8887E+05	-8.1231E+04	71.71	17.133	2.0155	16.456	3.932	1.445E+03	9.021E-02	1.335
1800.00	3240.0	-1.8722E+05	-8.0518E+04	72.65	17.359	2.0155	16.672	3.983	1.365E+03	8.519E-02	1.329
1900.00	3420.0	-1.8554E+05	-7.9796E+04	73.56	17.576	2.0156	16.895	4.037	1.293E+03	8.071E-02	1.323
2000.00	3600.0	-1.8384E+05	-7.9065E+04	74.43	17.785	2.0155	17.131	4.093	1.228E+03	7.667E-02	1.318
2100.00	3780.0	-1.8211E+05	-7.8322E+04	75.28	17.986	2.0153	17.395	4.156	1.170E+03	7.301E-02	1.312
2200.00	3960.0	-1.8035E+05	-7.7568E+04	76.09	18.181	2.0151	17.699	4.229	1.116E+03	6.969E-02	1.307
2300.00	4140.0	-1.7857E+05	-7.6799E+04	76.89	18.371	2.0147	18.060	4.315	1.068E+03	6.664E-02	1.300
2400.00	4320.0	-1.7674E+05	-7.6013E+04	77.66	18.556	2.0141	18.498	4.420	1.023E+03	6.385E-02	1.293
2500.00	4500.0	-1.7487E+05	-7.5207E+04	78.43	18.739	2.0131	19.033	4.548	9.813E+02	6.126E-02	1.286
2600.00	4680.0	-1.7293E+05	-7.4375E+04	79.19	18.921	2.0118	19.686	4.704	9.430E+02	5.887E-02	1.278
2700.00	4860.0	-1.7093E+05	-7.3511E+04	79.95	19.102	2.0100	20.480	4.893	9.072E+02	5.664E-02	1.270
2800.00	5040.0	-1.6883E+05	-7.2611E+04	80.71	19.283	2.0075	21.436	5.122	8.737E+02	5.455E-02	1.261
2900.00	5220.0	-1.6663E+05	-7.1665E+04	81.48	19.468	2.0042	22.575	5.394	8.422E+02	5.258E-02	1.252
3000.00	5400.0	-1.6431E+05	-7.0666E+04	82.27	19.656	1.9999	23.917	5.715	8.124E+02	5.072E-02	1.243
3100.00	5580.0	-1.6184E+05	-6.9605E+04	83.08	19.849	1.9945	25.480	6.088	7.841E+02	4.895E-02	1.235
3200.00	5760.0	-1.5921E+05	-6.8471E+04	83.91	20.049	1.9878	27.279	6.518	7.570E+02	4.726E-02	1.227
3400.00	6120.0	-1.5333E+05	-6.5945E+04	85.69	20.474	1.9698	31.631	7.558	7.060E+02	4.408E-02	1.214
3600.00	6480.0	-1.4648E+05	-6.2999E+04	87.65	20.942	1.9444	37.032	8.848	6.582E+02	4.109E-02	1.204
3800.00	6840.0	-1.3845E+05	-5.9544E+04	89.82	21.460	1.9107	43.484	10.390	6.128E+02	3.825E-02	1.197
4000.00	7200.0	-1.2903E+05	-5.5491E+04	92.23	22.037	1.8679	50.904	12.163	5.691E+02	3.553E-02	1.194
4200.00	7560.0	-1.1803E+05	-5.0764E+04	94.91	22.678	1.8161	59.117	14.125	5.270E+02	3.290E-02	1.193
4400.00	7920.0	-1.0535E+05	-4.5307E+04	97.86	23.382	1.7561	67.818	16.204	4.864E+02	3.036E-02	1.195

4600.00	3280.0	-9.0905E+04	-3.9096E+04	101.07	24.149	1.6893	76.552	18.291	4.475E+02	2.794E-02	1.198
4800.00	3640.0	-7.4763E+04	-3.2154E+04	104.50	24.969	1.6180	84.712	20.240	4.108E+02	2.564E-02	1.204
5000.00	9000.0	-5.7107E+04	-2.4560E+04	108.11	25.830	1.5448	91.573	21.880	3.765E+02	2.351E-02	1.211
5200.00	9360.0	-3.8270E+04	-1.6459E+04	111.80	26.713	1.4726	96.395	23.032	3.451E+02	2.154E-02	1.220
5400.00	9720.0	-1.8725E+04	-8.0530E+03	115.49	27.594	1.4039	98.586	23.555	3.168E+02	1.978E-02	1.230
5600.00	10080.0	9.6983E+02	4.1710E+02	119.07	28.449	1.3408	97.870	23.384	2.918E+02	1.822E-02	1.242
5800.00	10440.0	2.0239E+04	8.7043E+03	122.45	29.257	1.2847	94.393	22.553	2.699E+02	1.685E-02	1.256
6000.00	10800.0	3.8579E+04	1.6592E+04	125.56	30.000	1.2362	88.692	21.191	2.511E+02	1.567E-02	1.271
6300.00	11340.0	6.3582E+04	2.7345E+04	129.63	30.972	1.1773	77.686	18.562	2.277E+02	1.422E-02	1.297
6600.00	11880.0	8.5131E+04	3.6613E+04	132.97	31.771	1.1333	66.049	15.781	2.093E+02	1.306E-02	1.327
7000.00	12600.0	1.0873E+05	4.6764E+04	136.45	32.602	1.0925	52.500	12.544	1.902E+02	1.187E-02	1.371
7300.00	13140.0	1.2325E+05	5.3008E+04	138.48	33.087	1.0716	44.635	10.665	1.789E+02	1.117E-02	1.407
7600.00	13680.0	1.3571E+05	5.8364E+04	140.15	33.487	1.0564	38.687	9.244	1.694E+02	1.058E-02	1.442
8000.00	14400.0	1.5000E+05	6.4511E+04	141.99	33.925	1.0423	33.175	7.927	1.588E+02	9.913E-03	1.484
8300.00	14940.0	1.5951E+05	6.8602E+04	143.15	34.204	1.0349	30.408	7.266	1.520E+02	9.486E-03	1.510
8600.00	15480.0	1.6833E+05	7.2394E+04	144.20	34.453	1.0292	28.497	6.809	1.459E+02	9.105E-03	1.530
9000.00	16200.0	1.7939E+05	7.7148E+04	145.45	34.754	1.0235	26.926	6.434	1.386E+02	8.653E-03	1.544
9300.00	16740.0	1.8735E+05	8.0577E+04	146.33	34.962	1.0203	26.300	6.284	1.337E+02	8.347E-03	1.548
9600.00	17280.0	1.9520E+05	8.3950E+04	147.16	35.160	1.0176	26.042	6.222	1.292E+02	8.065E-03	1.545
10000.00	18000.0	2.0562E+05	8.8434E+04	148.22	35.414	1.0145	26.172	6.253	1.237E+02	7.720E-03	1.534
10500.00	18900.0	2.1888E+05	9.4137E+04	149.51	35.723	1.0111	26.982	6.447	1.174E+02	7.328E-03	1.510
11000.00	19800.0	2.3271E+05	1.0008E+05	150.80	36.031	1.0078	28.440	6.795	1.117E+02	6.973E-03	1.480
11500.00	20700.0	2.4743E+05	1.0641E+05	152.11	36.343	1.0043	30.527	7.294	1.065E+02	6.647E-03	1.447
12000.00	21600.0	2.6335E+05	1.1326E+05	153.46	36.667	1.0002	33.247	7.944	1.017E+02	6.347E-03	1.413
12500.00	22500.0	2.8079E+05	1.2076E+05	154.89	37.007	0.9954	36.625	8.751	9.717E+01	6.066E-03	1.381
13000.00	23400.0	3.0008E+05	1.2906E+05	156.40	37.369	0.9897	40.679	9.720	9.294E+01	5.802E-03	1.352
13500.00	24300.0	3.2158E+05	1.3830E+05	158.02	37.755	0.9829	45.430	10.855	8.894E+01	5.553E-03	1.326
14000.00	25200.0	3.4563E+05	1.4865E+05	159.77	38.174	0.9749	50.884	12.158	8.514E+01	5.315E-03	1.304
15000.00	27000.0	4.0278E+05	1.7323E+05	163.71	39.115	0.9547	63.866	15.260	7.799E+01	4.869E-03	1.269
16000.00	28800.0	4.7361E+05	2.0369E+05	168.27	40.206	0.9286	77.951	18.625	7.135E+01	4.454E-03	1.251
17000.00	30600.0	5.5964E+05	2.4069E+05	173.48	41.449	0.8969	94.192	22.505	6.512E+01	4.065E-03	1.239
18000.00	32400.0	6.6210E+05	2.8475E+05	179.32	42.845	0.8605	110.850	26.486	5.928E+01	3.701E-03	1.233
19000.00	34200.0	7.8141E+05	3.3607E+05	185.76	44.384	0.8210	127.140	30.378	5.384E+01	3.361E-03	1.229
20000.00	36000.0	9.1557E+05	3.9376E+05	192.63	46.026	0.7803	140.627	33.600	4.885E+01	3.050E-03	1.232
21000.00	37800.0	1.0614E+06	4.5647E+05	199.74	47.724	0.7404	150.197	35.887	4.434E+01	2.768E-03	1.238
22000.00	39600.0	1.2143E+06	5.2223E+05	206.85	49.423	0.7031	154.753	36.975	4.033E+01	2.518E-03	1.248
23000.00	41400.0	1.3691E+06	5.8880E+05	213.73	51.066	0.6696	153.932	35.779	3.683E+01	2.299E-03	1.261
24000.00	43200.0	1.5205E+06	6.5394E+05	220.18	52.607	0.6405	148.255	35.423	3.381E+01	2.111E-03	1.277
25000.00	45000.0	1.6644E+06	7.1580E+05	226.05	54.011	0.6160	138.956	33.201	3.124E+01	1.950E-03	1.296
26000.00	46800.0	1.7978E+06	7.7317E+05	231.29	55.262	0.5959	127.590	30.485	2.905E+01	1.814E-03	1.317
27000.00	48600.0	1.9193E+06	8.2547E+05	235.89	56.360	0.5795	115.608	27.622	2.719E+01	1.697E-03	1.341
28000.00	50400.0	2.0291E+06	8.7268E+05	239.89	57.316	0.5664	104.090	24.870	2.560E+01	1.598E-03	1.367
29000.00	52200.0	2.1279E+06	9.1516E+05	243.36	58.147	0.5560	93.691	22.386	2.423E+01	1.512E-03	1.394
30000.00	54000.0	2.2170E+06	9.5347E+05	246.39	58.870	0.5477	84.693	20.236	2.303E+01	1.438E-03	1.422
32000.00	57600.0	2.3717E+06	1.0200E+06	251.40	60.068	0.5357	70.887	16.937	2.106E+01	1.314E-03	1.477
34000.00	61200.0	2.5031E+06	1.0765E+06	255.41	61.025	0.5281	61.351	14.659	1.948E+01	1.216E-03	1.528
36000.00	64800.0	2.6193E+06	1.1265E+06	258.75	61.824	0.5231	55.330	13.220	1.817E+01	1.134E-03	1.567
38000.00	68400.0	2.7258E+06	1.1723E+06	261.65	62.516	0.5196	51.408	12.283	1.706E+01	1.065E-03	1.597
40000.00	72000.0	2.8255E+06	1.2152E+06	264.23	63.132	0.5171	48.626	11.618	1.609E+01	1.005E-03	1.619
43000.00	77400.0	2.9675E+06	1.2763E+06	267.67	63.955	0.5146	46.236	11.047	1.486E+01	9.275E-04	1.640
46000.00	82800.0	3.1040E+06	1.3350E+06	270.76	64.692	0.5129	44.842	10.714	1.381E+01	8.621E-04	1.652
50000.00	90000.0	3.2803E+06	1.4108E+06	274.46	65.576	0.5114	43.524	10.399	1.264E+01	7.889E-04	1.662
55000.00	99000.0	3.4960E+06	1.5036E+06	278.59	66.564	0.5102	42.724	10.208	1.143E+01	7.138E-04	1.667
60000.00	108000.0	3.7088E+06	1.5951E+06	282.32	67.454	0.5094	42.409	10.133	1.045E+01	6.521E-04	1.668
65000.00	117000.0	3.9202E+06	1.6860E+06	285.71	68.266	0.5087	42.015	10.039	9.516E+00	6.003E-04	1.670
70000.00	126000.0	4.1300E+06	1.7762E+06	288.84	69.013	0.5083	41.938	10.020	8.911E+00	5.563E-04	1.670
80000.00	144000.0	4.5482E+06	1.9561E+06	294.45	70.353	0.5076	41.752	9.976	7.774E+00	4.853E-04	1.670
90000.00	162000.0	4.9647E+06	2.1352E+06	299.37	71.529	0.5071	41.597	9.939	6.896E+00	4.305E-04	1.670
100000.00	180000.0	5.3807E+06	2.3141E+06	303.77	72.580	0.5067	41.719	9.968	6.196E+00	3.868E-04	1.672
110000.00	198000.0	5.7975E+06	2.4933E+06	307.74	73.530	0.5062	41.637	9.948	5.624E+00	3.511E-04	1.671

TABLE II. - Continued. THERMODYNAMIC PROPERTIES OF SPIN-EQUILIBRATED HYDROGEN IN CHEMICAL EQUILIBRIUM IN DEBYE-HÜCKEL APPROXIMATION

[E-02, E-03, E+02, E+03, etc., after numbers signify that numbers are to be multiplied by 10^{-2}, 10^{-3}, 10^{2}, 10^{3}, etc.]

(*l*) Pressure, 3.03975×10^{7} N/m^2 (300 atm)

Temperature, T		Enthalpy, h		Entropy, s		Average molecular weight, g/g-mole or lb/lb-mole	Specific heat, c_p		Density, ρ		Isentropic exponent, γ
K	^{o}R	J/g	Btu/lb	J/(g)(K)	Btu/(lb)(^{o}R)		J/(g)(K)	Btu/(lb)(^{o}R)	g/m^3	lb/ft^3	
1100.00	1980.0	-1.9836E+05	-8.5310E+04	60.31	14.411	2.0156	15.171	3.625	5.699E+03	4.182E-01	1.373
1200.00	2160.0	-1.9683E+05	-8.4653E+04	61.64	14.728	2.0156	15.375	3.674	5.141E+03	3.834E-01	1.367
1300.00	2340.0	-1.9528E+05	-8.3987E+04	62.88	15.024	2.0156	15.589	3.725	5.669E+03	3.539E-01	1.360
1400.00	2520.0	-1.9371E+05	-8.3312E+04	64.05	15.302	2.0156	15.806	3.777	5.264E+03	3.286E-01	1.353
1500.00	2700.0	-1.9212E+05	-8.2628E+04	65.14	15.565	2.0156	16.026	3.829	4.913E+03	3.067E-01	1.347
1600.00	2880.0	-1.9051E+05	-8.1934E+04	66.18	15.814	2.0156	16.239	3.880	4.606E+03	2.875E-01	1.341
1700.00	3060.0	-1.8888E+05	-8.1231E+04	67.18	16.050	2.0156	16.450	3.930	4.335E+03	2.706E-01	1.335
1800.00	3240.0	-1.8722E+05	-8.0519E+04	68.12	16.276	2.0156	16.657	3.980	4.094E+03	2.556E-01	1.329
1900.00	3420.0	-1.8554E+05	-7.9798E+04	69.03	16.493	2.0156	16.865	4.030	3.878E+03	2.421E-01	1.324
2000.00	3600.0	-1.8385E+05	-7.9068E+04	69.90	16.701	2.0156	17.078	4.081	3.684E+03	2.300E-01	1.319
2100.00	3780.0	-1.8213E+05	-7.8329E+04	70.74	16.901	2.0155	17.304	4.134	3.509E+03	2.191E-01	1.314
2200.00	3960.0	-1.8039E+05	-7.7579E+04	71.55	17.095	2.0153	17.547	4.193	3.349E+03	2.091E-01	1.309
2300.00	4140.0	-1.7862E+05	-7.6819E+04	72.33	17.283	2.0151	17.821	4.258	3.203E+03	2.000E-01	1.304
2400.00	4320.0	-1.7682E+05	-7.6046E+04	73.10	17.465	2.0147	18.135	4.333	3.069E+03	1.916E-01	1.298
2500.00	4500.0	-1.7499E+05	-7.5258E+04	73.85	17.644	2.0142	18.503	4.421	2.946E+03	1.839E-01	1.292
2600.00	4680.0	-1.7312E+05	-7.4453E+04	74.58	17.819	2.0134	18.937	4.525	2.831E+03	1.767E-01	1.286
2700.00	4860.0	-1.7120E+05	-7.3628E+04	75.30	17.992	2.0124	19.449	4.647	2.725E+03	1.701E-01	1.280
2800.00	5040.0	-1.6922E+05	-7.2779E+04	76.02	18.164	2.0109	20.053	4.791	2.626E+03	1.639E-01	1.273
2900.00	5220.0	-1.6718E+05	-7.1902E+04	76.74	18.335	2.0090	20.761	4.960	2.533E+03	1.581E-01	1.266
3000.00	5400.0	-1.6507E+05	-7.0992E+04	77.45	18.506	2.0065	21.584	5.157	2.445E+03	1.527E-01	1.259
3100.00	5580.0	-1.6285E+05	-7.0044E+04	78.18	18.679	2.0034	22.533	5.384	2.363E+03	1.475E-01	1.253
3200.00	5760.0	-1.6055E+05	-6.9052E+04	78.91	18.854	1.9995	23.618	5.643	2.284E+03	1.426E-01	1.246
3400.00	6120.0	-1.5558E+05	-6.6912E+04	80.42	19.214	1.9889	26.220	6.265	2.139E+03	1.335E-01	1.233
3600.00	6480.0	-1.5003E+05	-6.4523E+04	82.00	19.593	1.9739	29.433	7.032	2.005E+03	1.251E-01	1.223
3800.00	6840.0	-1.4377E+05	-6.1831E+04	83.69	19.997	1.9535	33.266	7.948	1.880E+03	1.173E-01	1.214
4000.00	7200.0	-1.3668E+05	-5.8783E+04	85.51	20.431	1.9275	37.701	9.008	1.762E+03	1.100E-01	1.209
4200.00	7560.0	-1.2865E+05	-5.5330E+04	87.47	20.899	1.8950	42.683	10.198	1.650E+03	1.030E-01	1.205
4400.00	7920.0	-1.1959E+05	-5.1427E+04	89.58	21.403	1.8551	48.120	11.497	1.542E+03	9.628E-02	1.204
4600.00	8280.0	-1.0938E+05	-4.7042E+04	91.84	21.944	1.8111	53.877	12.873	1.439E+03	8.986E-02	1.205
4800.00	8640.0	-9.8018E+04	-4.2155E+04	94.26	22.522	1.7606	59.770	14.281	1.341E+03	8.372E-02	1.208
5000.00	9000.0	-8.5480E+04	-3.6763E+04	96.82	23.133	1.7057	65.567	15.666	1.247E+03	7.786E-02	1.212
5200.00	9360.0	-7.1815E+04	-3.0886E+04	99.50	23.773	1.6477	70.992	16.962	1.159E+03	7.232E-02	1.217
5400.00	9720.0	-5.7129E+04	-2.4570E+04	102.27	24.435	1.5881	75.735	18.095	1.075E+03	6.712E-02	1.224

5600.00	10080.0	-4.1587E+04	-1.7886E+04	105.09	25.110	1.5285	79.488	18.992	9.979E+02	6.230E-02	1.232
5800.00	10440.0	-2.5417E+04	-1.0931E+04	107.93	25.788	1.4703	81.984	19.588	9.268E+02	5.786E-02	1.242
6000.00	10800.0	-8.8899E+03	-3.8233E+03	110.73	26.458	1.4149	83.037	19.840	8.621E+02	5.382E-02	1.252
6300.00	11340.0	1.5921E+04	6.8474E+03	114.77	27.422	1.3391	81.822	19.550	7.771E+02	4.851E-02	1.270
6600.00	11880.0	3.9905E+04	1.7162E+04	118.49	28.310	1.2739	77.634	18.549	7.057E+02	4.405E-02	1.290
7000.00	12600.0	6.9318E+04	2.9812E+04	122.82	29.345	1.2042	69.040	16.496	6.289E+02	3.926E-02	1.320
7300.00	13140.0	8.8939E+04	3.8251E+04	125.56	30.001	1.1537	61.748	14.754	5.828E+02	3.639E-02	1.345
7600.00	13680.0	1.0639E+05	4.5757E+04	127.91	30.561	1.1319	54.707	13.071	5.445E+02	3.399E-02	1.371
8000.00	14400.0	1.2659E+05	5.4443E+04	130.50	31.180	1.1000	46.550	11.125	5.027E+02	3.138E-02	1.408
8300.00	14940.0	1.3979E+05	6.0121E+04	132.12	31.567	1.0822	41.616	9.943	4.767E+02	2.976E-02	1.435
8600.00	15480.0	1.5166E+05	6.5224E+04	133.52	31.903	1.0682	37.653	8.996	4.541E+02	2.835E-02	1.460
9000.00	16200.0	1.6588E+05	7.1342E+04	135.14	32.289	1.0542	33.703	8.053	4.282E+02	2.673E-02	1.489
9300.00	16740.0	1.7565E+05	7.5546E+04	136.21	32.545	1.0461	31.570	7.543	4.113E+02	2.567E-02	1.506
9600.00	17280.0	1.8489E+05	7.9513E+04	137.19	32.778	1.0395	30.011	7.170	3.959E+02	2.472E-02	1.518
10000.00	18000.0	1.9659E+05	8.4548E+04	138.38	33.064	1.0327	28.651	6.846	3.776E+02	2.357E-02	1.526
10500.00	18900.0	2.1068E+05	9.0609E+04	139.76	33.392	1.0260	27.862	6.657	3.573E+02	2.230E-02	1.525
11000.00	19800.0	2.2458E+05	9.6588E+04	141.05	33.701	1.0206	27.865	6.658	3.393E+02	2.118E-02	1.513
11500.00	20700.0	2.3865E+05	1.0264E+05	142.30	34.000	1.0160	28.523	6.815	3.231E+02	2.017E-02	1.492
12000.00	21600.0	2.5320E+05	1.0890E+05	143.54	34.296	1.0116	29.755	7.109	3.084E+02	1.925E-02	1.467
12500.00	22500.0	2.6850E+05	1.1547E+05	144.79	34.594	1.0073	31.519	7.531	2.949E+02	1.841E-02	1.438
13000.00	23400.0	2.8481E+05	1.2249E+05	146.07	34.900	1.0026	33.796	8.075	2.824E+02	1.763E-02	1.410
13500.00	24300.0	3.0238E+05	1.3005E+05	147.39	35.217	0.9975	36.576	8.739	2.707E+02	1.690E-02	1.382
14000.00	25200.0	3.2145E+05	1.3825E+05	148.78	35.548	0.9917	39.853	9.522	2.597E+02	1.621E-02	1.357
15000.00	27000.0	3.6515E+05	1.5705E+05	151.79	36.268	0.9778	47.859	11.435	2.395E+02	1.495E-02	1.314
16000.00	28800.0	4.1767E+05	1.7963E+05	155.18	37.077	0.9599	56.910	13.598	2.210E+02	1.380E-02	1.286
17000.00	30600.0	4.7969E+05	2.0630E+05	158.93	37.973	0.9378	67.405	16.105	2.040E+02	1.274E-02	1.266
18000.00	32400.0	5.5275E+05	2.3773E+05	163.10	38.969	0.9116	78.742	18.814	1.882E+02	1.175E-02	1.253
19000.00	34200.0	6.3725E+05	2.7407E+05	167.65	40.058	0.8818	90.237	21.560	1.734E+02	1.083E-02	1.246
20000.00	36000.0	7.3361E+05	3.1551E+05	172.59	41.237	0.8495	102.190	24.415	1.595E+02	9.966E-03	1.240
21000.00	37800.0	8.4108E+05	3.6173E+05	177.82	42.488	0.8156	112.508	26.882	1.468E+02	9.167E-03	1.241
22000.00	39600.0	9.5804E+05	4.1203E+05	183.26	43.786	0.7815	121.055	28.926	1.351E+02	8.431E-03	1.245
23000.00	41400.0	1.0824E+06	4.6553E+05	188.78	45.105	0.7483	127.283	30.412	1.243E+02	7.760E-03	1.252
24000.00	43200.0	1.2117E+06	5.2112E+05	194.28	46.420	0.7170	130.773	31.246	1.146E+02	7.155E-03	1.261
25000.00	45000.0	1.3433E+06	5.7760E+05	199.64	47.700	0.6883	131.421	31.401	1.059E+02	6.613E-03	1.273
26000.00	45800.0	1.4736E+06	6.3378E+05	204.76	48.924	0.6625	129.397	30.917	9.825E+01	6.133E-03	1.288
27000.00	48600.0	1.6011E+06	6.8858E+05	209.57	50.074	0.6399	125.133	29.898	9.147E+01	5.710E-03	1.304
28000.00	50400.0	1.7234E+06	7.4118E+05	214.03	51.138	0.6203	119.220	28.485	8.553E+01	5.339E-03	1.322
29000.00	52200.0	1.8392E+06	7.9099E+05	218.10	52.110	0.6036	112.300	26.832	8.032E+01	5.014E-03	1.342
30000.00	54000.0	1.9478E+06	8.3771E+05	221.79	52.991	0.5894	104.959	25.078	7.575E+01	4.729E-03	1.363
32000.00	57600.0	2.1433E+06	9.2178E+05	228.11	54.503	0.5675	90.750	21.683	6.818E+01	4.256E-03	1.407
34000.00	61200.0	2.3123E+06	9.9448E+05	233.25	55.731	0.5522	78.747	18.815	5.221E+01	3.884E-03	1.452
36000.00	64800.0	2.4600E+06	1.0580E+06	237.49	56.744	0.5414	69.105	15.511	5.740E+01	3.583E-03	1.499
38000.00	68400.0	2.5909E+06	1.1143E+06	241.06	57.596	0.5341	62.146	14.849	5.344E+01	3.336E-03	1.536
40000.00	72000.0	2.7099E+06	1.1655E+06	244.13	58.331	0.5287	57.140	13.652	5.010E+01	3.127E-03	1.567
43000.00	77400.0	2.8732E+06	1.2357E+06	248.10	59.278	0.5232	52.150	12.460	4.591E+01	2.866E-03	1.602
46000.00	82800.0	3.0243E+06	1.3007E+06	251.52	60.096	0.5195	48.828	11.667	4.296E+01	2.650E-03	1.627
50000.00	90000.0	3.2143E+06	1.3824E+06	255.51	61.050	0.5164	46.407	11.088	3.866E+01	2.413E-03	1.646
55000.00	99000.0	3.4418E+06	1.4802E+06	259.88	62.092	0.5137	44.752	10.693	3.483E+01	2.174E-03	1.658
60000.00	108000.0	3.6619E+06	1.5749E+06	263.73	63.014	0.5122	43.506	10.395	3.173E+01	1.981E-03	1.666
65000.00	117000.0	3.8782E+06	1.6679E+06	267.22	63.847	0.5111	43.037	10.283	2.915E+01	1.820E-03	1.668
70000.00	126000.0	4.0920E+06	1.7599E+06	270.41	64.609	0.5103	42.562	10.169	2.698E+01	1.684E-03	1.670
80000.00	144000.0	4.5163E+06	1.9422E+06	276.10	65.969	0.5091	42.260	10.097	2.348E+01	1.466E-03	1.670
90000.00	162000.0	4.9363E+06	2.1228E+06	281.07	67.157	0.5084	41.912	10.014	2.080E+01	1.299E-03	1.670
100000.00	180000.0	5.3541E+06	2.3027E+06	285.50	68.214	0.5078	41.743	9.974	1.868E+01	1.166E-03	1.670
110000.00	198000.0	5.7714E+06	2.4821E+06	289.49	69.168	0.5074	41.718	9.968	1.695E+01	1.058E-03	1.669

TABLE II. - Concluded. THERMODYNAMIC PROPERTIES OF SPIN-EQUILIBRATED HYDROGEN IN CHEMICAL EQUILIBRIUM IN DEBYE-HÜCKEL APPROXIMATION

[E-02, E-03, E+02, E+03, etc., after numbers signify that numbers are to be multiplied by 10^{-2}, 10^{-3}, 10^{2}, 10^{3}, etc.]

(m) Pressure, 1.01325×10^{8} N/m^2 (1000 atm)

Temperature, T		Enthalpy, h		Entropy, s		Average molecular weight, g/g-mole or lb/lb-mole	Specific heat, c_p		Density, ρ		Isentropic exponent, γ
K	^{o}R	J/g	Btu/lb	J/(g)(K)	Btu/(lb)(^{o}R)		J/(g)(K)	Btu/(lb)(^{o}R)	g/m^3	lb/ft^3	
3200.00	5760.0	-1.6139E+05	-6.9410E+04	73.65	17.598	2.0068	21.355	5.102	7.643E+03	4.771E-01	1.261
3400.00	6120.0	-1.5697E+05	-6.7511E+04	74.99	17.918	2.0009	22.874	5.465	7.172E+03	4.477E-01	1.250
3600.00	6480.0	-1.5222E+05	-6.5466E+04	76.35	18.242	1.9926	24.725	5.908	6.745E+03	4.211E-01	1.241
3800.00	6840.0	-1.4705E+05	-6.3247E+04	77.74	18.575	1.9812	26.917	6.431	6.354E+03	3.967E-01	1.233
4000.00	7200.0	-1.4143E+05	-6.0826E+04	79.19	18.920	1.9663	29.444	7.035	5.991E+03	3.740E-01	1.226
4200.00	7560.0	-1.3526E+05	-5.8173E+04	80.69	19.280	1.9476	32.287	7.714	5.651E+03	3.528E-01	1.221
4400.00	7920.0	-1.2850E+05	-5.5263E+04	82.26	19.655	1.9248	35.413	8.461	5.331E+03	3.328E-01	1.218
4600.00	8280.0	-1.2108E+05	-5.2074E+04	83.91	20.049	1.8977	38.773	9.264	5.028E+03	3.139E-01	1.216
4800.00	8640.0	-1.1298E+05	-4.8588E+04	85.64	20.461	1.8665	42.311	10.109	4.739E+03	2.958E-01	1.216
5000.00	9000.0	-1.0415E+05	-4.4792E+04	87.44	20.891	1.8313	45.955	10.980	4.463E+03	2.786E-01	1.218
5200.00	9360.0	-9.4592E+04	-4.0682E+04	89.31	21.339	1.7925	49.622	11.856	4.201E+03	2.623E-01	1.220
5400.00	9720.0	-8.4305E+04	-3.6258E+04	91.25	21.803	1.7507	53.221	12.716	3.951E+03	2.467E-01	1.224
5600.00	10080.0	-7.3315E+04	-3.1531E+04	93.25	22.280	1.7065	56.646	13.535	3.714E+03	2.318E-01	1.229
5800.00	10440.0	-6.1665E+04	-2.6521E+04	95.29	22.768	1.6607	59.793	14.286	3.489E+03	2.178E-01	1.235
6000.00	10800.0	-4.9423E+04	-2.1256E+04	97.37	23.264	1.6141	62.553	14.946	3.278E+03	2.047E-01	1.242
6300.00	11340.0	-3.0146E+04	-1.2965E+04	100.50	24.013	1.5441	65.752	15.710	2.987E+03	1.865E-01	1.254
6600.00	11880.0	-1.0108E+04	-4.3471E+03	103.61	24.755	1.4765	67.594	16.150	2.726E+03	1.702E-01	1.267
7000.00	12600.0	1.7047E+04	7.3316E+03	107.60	25.710	1.3931	67.739	16.185	2.425E+03	1.514E-01	1.288
7300.00	13140.0	3.7171E+04	1.5986E+04	110.42	26.383	1.3374	66.203	15.818	2.233E+03	1.394E-01	1.306
7600.00	13680.0	5.6655E+04	2.4366E+04	113.03	27.008	1.2882	63.523	15.178	2.066E+03	1.290E-01	1.324
8000.00	14400.0	8.1146E+04	3.4899E+04	116.18	27.758	1.2327	58.765	14.041	1.878E+03	1.172E-01	1.350
8300.00	14940.0	9.8181E+04	4.2225E+04	118.27	28.258	1.1983	54.779	13.089	1.759E+03	1.098E-01	1.371
8600.00	15480.0	1.1401E+05	4.9034E+04	120.14	28.706	1.1693	50.778	12.132	1.657E+03	1.034E-01	1.392
9000.00	16200.0	1.3331E+05	5.7333E+04	122.34	29.230	1.1378	45.796	10.942	1.541E+03	9.618E-02	1.419
9300.00	16740.0	1.4654E+05	6.3024E+04	123.78	29.575	1.1187	42.492	10.153	1.466E+03	9.152E-02	1.438
9600.00	17280.0	1.5885E+05	6.8316E+04	125.08	29.887	1.1027	39.623	9.457	1.400E+03	8.740E-02	1.455
10000.00	18000.0	1.7404E+05	7.4852E+04	126.64	30.257	1.0854	36.489	8.718	1.323E+03	8.259E-02	1.475
10500.00	18900.0	1.9152E+05	8.2369E+04	128.34	30.665	1.0687	33.607	8.030	1.241E+03	7.744E-02	1.493
11000.00	19800.0	2.0782E+05	8.9377E+04	129.86	31.027	1.0558	31.719	7.579	1.170E+03	7.304E-02	1.502
11500.00	20700.0	2.2338E+05	9.6071E+04	131.24	31.358	1.0457	30.665	7.327	1.109E+03	6.920E-02	1.501
12000.00	21600.0	2.3860E+05	1.0261E+05	132.54	31.667	1.0374	30.301	7.240	1.054E+03	6.581E-02	1.492
12500.00	22500.0	2.5379E+05	1.0914E+05	133.78	31.963	1.0303	30.529	7.294	1.005E+03	6.276E-02	1.476

13000.00	23400.0	2.6921E+05	1.1578E+05	134.99	32.253	1.0240	31.271	7.472	9.612E+02	6.000E-02	1.456
13500.00	24300.0	2.8513E+05	1.2263E+05	136.19	32.540	1.0181	32.473	7.759	9.207E+02	5.748E-02	1.433
14000.00	25200.0	3.0175E+05	1.2978E+05	137.40	32.829	1.0123	34.099	8.147	8.834E+02	5.515E-02	1.409
15000.00	27000.0	3.3793E+05	1.4534E+05	139.89	33.425	1.0003	38.504	9.200	8.162E+02	5.095E-02	1.363
16000.00	28800.0	3.7922E+05	1.6309E+05	142.56	34.061	0.9866	44.237	10.570	7.568E+02	4.725E-02	1.324
17000.00	30600.0	4.2623E+05	1.8331E+05	145.40	34.741	0.9705	50.246	12.005	7.033E+02	4.391E-02	1.300
18000.00	32400.0	4.7993E+05	2.0640E+05	148.46	35.472	0.9516	57.233	13.675	6.544E+02	4.086E-02	1.280
19000.00	34200.0	5.4092E+05	2.3264E+05	151.75	36.258	0.9299	64.808	15.485	6.094E+02	3.804E-02	1.266
20000.00	36000.0	6.0951E+05	2.6213E+05	155.26	37.097	0.9056	72.367	17.291	5.676E+02	3.543E-02	1.257
21000.00	37800.0	6.8559E+05	2.9486E+05	158.96	37.982	0.8793	79.753	19.055	5.286E+02	3.300E-02	1.253
22000.00	39600.0	7.6887E+05	3.3067E+05	162.83	38.905	0.8516	86.714	20.719	4.923E+02	3.073E-02	1.253
23000.00	41400.0	8.5923E+05	3.6953E+05	166.84	39.863	0.8233	93.754	22.403	4.586E+02	2.863E-02	1.251
24000.00	43200.0	9.5579E+05	4.1106E+05	170.94	40.843	0.7951	99.168	23.694	4.273E+02	2.667E-02	1.255
25000.00	45000.0	1.0572E+06	4.5467E+05	175.08	41.832	0.7676	103.416	24.709	3.984E+02	2.487E-02	1.262
26000.00	46800.0	1.1622E+06	4.9983E+05	179.19	42.815	0.7414	106.396	25.421	3.718E+02	2.321E-02	1.272
27000.00	48600.0	1.2695E+06	5.4600E+05	183.24	43.783	0.7168	108.070	25.821	3.475E+02	2.170E-02	1.283
28000.00	50400.0	1.3779E+06	5.9261E+05	187.18	44.724	0.6940	108.464	25.916	3.254E+02	2.032E-02	1.296
29000.00	52200.0	1.4861E+06	6.3913E+05	190.98	45.631	0.6732	107.682	25.729	3.054E+02	1.906E-02	1.310
30000.00	54000.0	1.5929E+06	6.8508E+05	194.61	46.497	0.6544	105.879	25.298	2.873E+02	1.793E-02	1.325
32000.00	57600.0	1.7992E+06	7.7380E+05	201.27	48.090	0.6227	99.995	23.892	2.562E+02	1.599E-02	1.359
34000.00	61200.0	1.9918E+06	8.5663E+05	207.12	49.487	0.5979	92.437	22.086	2.310E+02	1.442E-02	1.394
36000.00	64800.0	2.1689E+06	9.3273E+05	212.19	50.699	0.5789	84.445	20.177	2.104E+02	1.314E-02	1.436
38000.00	68400.0	2.3299E+06	1.0020E+06	216.58	51.747	0.5648	76.876	18.368	1.936E+02	1.209E-02	1.471
40000.00	72000.0	2.4773E+06	1.0653E+06	220.37	52.654	0.5540	70.375	16.815	1.796E+02	1.121E-02	1.503
43000.00	77400.0	2.6761E+06	1.1509E+06	225.21	53.810	0.5424	62.771	14.998	1.625E+02	1.014E-02	1.545
46000.00	82800.0	2.8559E+06	1.2282E+06	229.28	54.783	0.5343	57.360	13.705	1.487E+02	9.285E-03	1.580
50000.00	90000.0	3.0743E+06	1.3222E+06	233.88	55.881	0.5273	52.288	12.493	1.341E+02	8.372E-03	1.614
55000.00	99000.0	3.3259E+06	1.4304E+06	238.72	57.038	0.5218	48.708	11.638	1.198E+02	7.479E-03	1.639
60000.00	108000.0	3.5638E+06	1.5327E+06	242.89	58.035	0.5182	45.626	11.140	1.085E+02	6.770E-03	1.653
65000.00	117000.0	3.7935E+06	1.6315E+06	246.59	58.919	0.5156	45.339	10.833	9.918E+01	6.192E-03	1.660
70000.00	126000.0	4.0162E+06	1.7273E+06	249.92	59.714	0.5140	44.034	10.521	9.149E+01	5.712E-03	1.667
80000.00	144000.0	4.4521E+06	1.9147E+06	255.79	61.115	0.5119	43.232	10.330	7.932E+01	4.952E-03	1.670
90000.00	162000.0	4.8801E+06	2.0988E+06	260.86	62.328	0.5106	42.611	10.181	7.008E+01	4.375E-03	1.671
100000.00	180000.0	5.3050E+06	2.2816E+06	265.36	63.403	0.5096	42.384	10.127	6.278E+01	3.919E-03	1.670
110000.00	198000.0	5.7263E+06	2.4627E+06	269.40	64.368	0.5089	41.974	10.029	5.689E+01	3.552E-03	1.671

TABLE III. - CHOKED NOZZLE FLOW OF HYDROGEN IN CHEMICAL EQUILIBRIUM

IN DEBYE-HÜCKEL APPROXIMATION

[E-02, E-03, E+02, E+03, etc., after numbers signify that numbers are to be multiplied by 10^{-2}, 10^{-3}, 10^{2}, 10^{3}, etc.]

(a) Stagnation pressure, 1.01325×10^5 N/m^2 (1 atm)

Location	Pressure ratio, p/p_t	Temperature, T		Velocity, v		Mach number, M	Area ratio, A/A^*	Specific impulse, sec	
		K	^{o}R	m/sec	ft/sec			Ideal, $I_{sp,i}$	Vacuum, $I_{sp,v}$
Stagnation temperature, T_t: 2500 K; 4500^{o} R Sonic flow factor, ψ: 1.01E-02 (kg)(K$^{1/2}$)/(sec)(N); 2.81E+02 (lb)(^{o}R$^{1/2}$)/(sec)(ft^2)(atm) Mass flow per unit throat area, $\dot{W}/A^*$: 2.05E+01 kg/(sec)(m^2); 4.20E+00 lb/(sec)(ft^2)									
CHAMBER	1.	2500.	4500.	0	0	0	INFINITY		
THROAT	5.56E-01	2263.	4073.	3.41E+03	1.12E+04	1.00	1.00E+00	348.	628.
DOWNSTREAM	1.00E-01	1535.	2762.	6.20E+03	2.04E+04	2.13	2.06E+00	633.	737.
DOWNSTREAM	1.00E-02	825.	1485.	7.77E+03	2.55E+04	3.57	8.86E+00	792.	837.
DOWNSTREAM	1.00E-03	430.	773.	8.48E+03	2.78E+04	5.38	4.23E+01	864.	886.
Stagnation temperature, T_t: 3500 K; 6300^{o} R Sonic flow factor, ψ: 8.78E-03 (kg)(K$^{1/2}$)/(sec)(N); 2.44E+02 (lb)(^{o}R$^{1/2}$)/(sec)(ft^2)(atm) Mass flow per unit throat area, $\dot{W}/A^*$: 1.50E+01 kg/(sec)(m^2); 3.08E+00 lb/(sec)(ft^2)									
CHAMBER	1.	3500.	6300.	0	0	0	INFINITY		
THROAT	5.76E-01	3334.	6002.	4.44E+03	1.46E+04	1.00	1.00E+00	453.	849.
DOWNSTREAM	1.00E-01	2888.	5198.	8.60E+03	2.82E+04	2.17	2.41E+00	877.	1043.
DOWNSTREAM	1.00E-02	2415.	4347.	1.14E+04	3.75E+04	3.28	1.40E+01	1166.	1262.
DOWNSTREAM	1.00E-03	1975.	3556.	1.32E+04	4.34E+04	4.28	9.35E+01	1347.	1412.
Stagnation temperature, T_t: 5000 K; 9000^{o} R Sonic flow factor, ψ: 7.44E-03 (kg)(K$^{1/2}$)/(sec)(N); 2.07E+02 (lb)(^{o}R$^{1/2}$)/(sec)(ft^2)(atm) Mass flow per unit throat area, $\dot{W}/A^*$: 1.07E+01 kg/(sec)(m^2); 2.18E+00 lb/(sec)(ft^2)									
CHAMBER	1.	5000.	9000.	0	0	0	INFINITY		
THROAT	5.53E-01	4450.	8010.	6.66E+03	2.19E+04	1.00	1.00E+00	679.	1215.
DOWNSTREAM	1.00E-01	3602.	6484.	1.21E+04	3.98E+04	2.20	2.27E+00	1238.	1457.
DOWNSTREAM	1.00E-02	2974.	5353.	1.58E+04	5.20E+04	3.38	1.29E+01	1615.	1741.
DOWNSTREAM	1.00E-03	2555.	4598.	1.82E+04	5.96E+04	4.42	8.84E+01	1853.	1939.

Stagnation temperature, T_t: 6000 K; 10 800° R
Sonic flow factor, ψ: 7.72E-03 (kg)($K^{1/2}$)/(sec)(N); 2.15E+02 (lb)($^oR^{1/2}$)/(sec)(ft^2)(atm)
Mass flow per unit throat area, $\dot{W}/A^*$: 1.01E+01 kg/(sec)(m^2); 2.07E+00 lb/(sec)(ft^2)

CHAMBER	1.	6000.	10800.	0	0	0	INFINITY		
THROAT	5.30E-01	4903.	8825.	7.50E+03	2.46E+04	1.00	1.00E+00	755.	1306.
DOWNSTREAM	1.00E-01	3729.	6713.	1.29E+04	4.23E+04	2.23	2.18E+00	1316.	1539.
DOWNSTREAM	1.00E-02	3031.	5455.	1.67E+04	5.46E+04	3.44	1.24E+01	1698.	1825.
DOWNSTREAM	1.00E-03	2593.	4667.	1.90E+04	6.24E+04	4.49	8.45E+01	1938.	2025.

Stagnation temperature, T_t: 7000 K; 12 600° R
Sonic flow factor, ψ: 7.90E-03 (kg)($K^{1/2}$)/(sec)(N); 2.20E+02 (lb)($^oR^{1/2}$)/(sec)(ft^2)(atm)
Mass flow per unit throat area, $\dot{W}/A^*$: 9.56E+00 kg/(sec)(m^2); 1.96E+00 lb/(sec)(ft^2)

CHAMBER	1.	7000.	12600.	0	0	0	INFINITY		
THROAT	5.05E-01	5442.	9796.	8.34E+03	2.74E+04	1.00	1.00E+00	850.	1397.
DOWNSTREAM	1.00E-01	3837.	6907.	1.36E+04	4.47E+04	2.27	2.06E+00	1388.	1611.
DOWNSTREAM	1.00E-02	3070.	5526.	1.74E+04	5.69E+04	3.51	1.17E+01	1770.	1896.
DOWNSTREAM	1.00E-03	2617.	4711.	1.97E+04	6.46E+04	4.58	7.98E+01	2009.	2095.

Stagnation temperature, T_t: 8000 K; 14 400° R
Sonic flow factor, ψ: 7.87E-03 (kg)($K^{1/2}$)/(sec)(N); 2.19E+02 (lb)($^oR^{1/2}$)/(sec)(ft^2)(atm)
Mass flow per unit throat area, $\dot{W}/A^*$: 8.92E+00 kg/(sec)(m^2); 1.83E+00 lb/(sec)(ft^2)

CHAMBER	1.	8000.	14400.	0	0	0	INFINITY		
THROAT	4.93E-01	5178.	11120.	9.08E+03	2.98E+04	1.00	1.00E+00	926.	1498.
DOWNSTREAM	1.00E-01	3974.	7152.	1.44E+04	4.73E+04	2.30	1.92E+00	1470.	1693.
DOWNSTREAM	1.00E-02	3109.	5596.	1.81E+04	5.95E+04	3.60	1.08E+01	1849.	1974.
DOWNSTREAM	1.00E-03	2640.	4752.	2.05E+04	6.71E+04	4.58	7.39E+01	2087.	2172.

Stagnation temperature, T_t: 10 000 K; 18 000° R
Sonic flow factor, ψ: 7.34E-03 (kg)($K^{1/2}$)/(sec)(N); 2.04E+02 (lb)($^oR^{1/2}$)/(sec)(ft^2)(atm)
Mass flow per unit throat area, $\dot{W}/A^*$: 7.43E+00 kg/(sec)(m^2); 1.52E+00 lb/(sec)(ft^2)

CHAMBER	1.	10000.	18000.	0	0	0	INFINITY		
THROAT	5.28E-01	8653.	15576.	1.00E+04	3.28E+04	1.00	1.00E+00	1020.	1753.
DOWNSTREAM	1.00E-01	4828.	8691.	1.68E+04	5.52E+04	2.14	1.73E+00	1715.	1955.
DOWNSTREAM	1.00E-02	3228.	5811.	2.05E+04	6.74E+04	3.86	8.72E+00	2094.	2215.
DOWNSTREAM	1.00E-03	2699.	4858.	2.28E+04	7.48E+04	5.00	5.97E+01	2324.	2407.

Stagnation temperature, T_t: 12 000 K; 21 600° R
Sonic flow factor, ψ: 6.80E-03 (kg)($K^{1/2}$)/(sec)(N); 1.89E+02 (lb)($^oR^{1/2}$)/(sec)(ft^2)(atm)
Mass flow per unit throat area, $\dot{W}/A^*$: 6.29+00 kg/(sec)(m^2); 1.29E+00 lb/(sec)(ft^2)

CHAMBER	1.	12000.	21600.	0	0	0	INFINITY		
THROAT	5.65E-01	11174.	20113.	1.09E+04	3.58E+04	1.00	1.00E+00	1112.	2039.
DOWNSTREAM	1.00E-01	8596.	15474.	2.04E+04	6.68E+04	2.12	2.20E+00	2077.	2437.
DOWNSTREAM	1.00E-02	4022.	7239.	2.56E+04	8.38E+04	3.61	8.03E+00	2606.	2738.
DOWNSTREAM	1.00E-03	2850.	5129.	2.78E+04	9.12E+04	5.60	4.83E+01	2834.	2913.

TABLE III. - Continued. CHOKED NOZZLE FLOW OF HYDROGEN IN CHEMICAL EQUILIBRIUM IN DEBYE-HÜCKEL APPROXIMATION

[E-02, E-03, E+02, E+03, etc., after numbers signify that numbers are to be multiplied by 10^{-2}, 10^{-3}, 10^{2}, 10^{3}, etc.]

(a) Concluded. Stagnation pressure, 1.01325×10^5 N/m^2 (1 atm)

Location	Pressure ratio, p/p_t	Temperature, T		Velocity, v		Mach number, M	Area ratio, A/A^*	Specific impulse, sec	
		K	^{o}R	m/sec	ft/sec			Ideal, $I_{sp,i}$	Vacuum, $I_{sp,v}$
Stagnation temperature, T_t: 14 000 K; 25 200^{o} R Sonic flow factor, ψ: 6.24E-03 (kg)(K$^{1/2}$)/(sec)(N); 1.74E+02 (lb)(^{o}R$^{1/2}$)/(sec)(ft^2)(atm) Mass flow per unit throat area, $\dot{W}/A^*$: 5.34E+00 kg/(sec)(m^2); 1.09E+00 lb/(sec)(ft^2)									
CHAMBER	1.	14000.	25200.	0	0	0	INFINITY		
THROAT	5.70E-01	13200.	23759.	1.27E+04	4.17E+04	1.00	1.00E+00	1296.	2400.
DOWNSTREAM	1.00E-01	11097.	19974.	2.42E+04	7.93E+04	2.17	2.33E+00	2456.	2916.
DOWNSTREAM	1.00E-02	8822.	15880.	3.17E+04	1.04E+05	3.34	1.29E+01	3233.	3482.
DOWNSTREAM	1.00E-03	6074.	10934.	3.61E+04	1.18E+05	4.23	7.33E+01	3681.	3823.
Stagnation temperature, T_t: 16 000 K; 28 800^{o} R Sonic flow factor, ψ: 5.68E-03 (kg)(K$^{1/2}$)/(sec)(N); 1.58E+02 (lb)(^{o}R$^{1/2}$)/(sec)(ft^2)(atm) Mass flow per unit throat area, $\dot{W}/A^*$: 4.55E+00 kg/(sec)(m^2); 9.31E-01 lb/(sec)(ft^2)									
CHAMBER	1.	15000.	28800.	0	0	0	INFINITY		
THROAT	5.68E-01	14997.	26994.	1.51E+04	4.94E+04	1.00	1.00E+00	1536.	2827.
DOWNSTREAM	1.00E-01	12581.	22646.	2.85E+04	9.34E+04	2.18	2.31E+00	2902.	3428.
DOWNSTREAM	1.00E-02	10308.	18554.	3.73E+04	1.22E+05	3.35	1.30E+01	3803.	4099.
DOWNSTREAM	1.00E-03	8615.	15506.	4.27E+04	1.40E+05	4.43	8.63E+01	4357.	4554.
Stagnation temperature, T_t: 18 000 K; 32 400^{o} R Sonic flow factor, ψ: 5.39E-03 (kg)(K$^{1/2}$)/(sec)(N); 1.50E+02 (lb)(^{o}R$^{1/2}$)/(sec)(ft^2)(atm) Mass flow per unit throat area, $\dot{W}/A^*$: 4.07E+00 kg/(sec)(m^2); 8.34E-01 lb/(sec)(ft^2)									
CHAMBER	1.	19000.	32400.	0	0	0	INFINITY		
THROAT	5.61E-01	15534.	29761.	1.71E+04	5.63E+04	1.00	1.00E+00	1749.	3172.
DOWNSTREAM	1.00E-01	13527.	24348.	3.18E+04	1.04E+05	2.19	2.27E+00	3241.	3816.
DOWNSTREAM	1.00E-02	10987.	19776.	4.14E+04	1.36E+05	3.39	1.27E+01	4223.	4545.
DOWNSTREAM	1.00E-03	9226.	16606.	4.73E+04	1.55E+05	4.48	8.42E+01	4826.	5039.

Stagnation temperature, T_t: 25 000 K; 45 000° R
Sonic flow factor, ψ: 5.54E-03 (kg)($K^{1/2}$)/(sec)(N); 1.54E+02 (lb)($^{\circ}R^{1/2}$)/(sec)(ft^2)(atm)
Mass flow per unit throat area, $\dot{W}/A^*$: 3.55E+00 kg/(sec)(m^2); 7.27E-01 lb/(sec)(ft^2)

CHAMBER	1.	25000.	45000.	0	0	0	INFINITY		
THROAT	5.23E-01	20189.	36340.	2.17E+04	7.11E+04	1.00	1.00E+00	2211.	3733.
DOWNSTREAM	1.00E-01	14818.	26673.	3.67E+04	1.20E+05	2.24	2.11E+00	3743.	4357.
DOWNSTREAM	1.00E-02	11647.	20965.	4.69E+04	1.54E+05	3.50	1.16E+01	4783.	5121.
DOWNSTREAM	1.00E-03	9709.	17477.	5.31E+04	1.74E+05	4.62	7.71E+01	5416.	5640.

Stagnation temperature, T_t: 35 000 K; 63 000° R
Sonic flow factor, ψ: 5.67E-03 (kg)($K^{1/2}$)/(sec)(N); 1.58E+02 (lb)($^{\circ}R^{1/2}$)/(sec)(ft^2)(atm)
Mass flow per unit throat area, $\dot{W}/A^*$: 3.07E+00 kg/(sec)(m^2); 6.29E-01 lb/(sec)(ft^2)

CHAMBER	1.	35000.	63000.	0	0	0	INFINITY		
THROAT	4.90E-01	26412.	47541.	2.67E+04	8.76E+04	1.00	1.00E+00	2722.	4370.
DOWNSTREAM	1.00E-01	16197.	29155.	4.19E+04	1.38E+05	2.30	1.85E+00	4276.	4898.
DOWNSTREAM	1.00E-02	12067.	21720.	5.21E+04	1.71E+05	3.59	9.96E+00	5313.	5648.
DOWNSTREAM	1.00E-03	9963.	17934.	5.83E+04	1.91E+05	4.85	6.62E+01	5941.	6163.

Stagnation temperature, T_t: 50 000 K; 90 000° R
Sonic flow factor, ψ: 5.67E-03 (kg)($K^{1/2}$)/(sec)(N); 1.58E+02 (lb)($^{\circ}R^{1/2}$)/(sec)(ft^2)(atm)
Mass flow per unit throat area, $\dot{W}/A^*$: 2.57E+00 kg/(sec)(m^2); 5.26E-01 lb/(sec)(ft^2)

CHAMBER	1.	50000.	90000.	0	0	0	INFINITY		
THROAT	4.87E-01	37533.	67559.	3.21E+04	1.05E+05	1.00	1.00E+00	3271.	5231.
DOWNSTREAM	1.00E-01	20184.	36332.	4.98E+04	1.63E+05	2.17	1.68E+00	5075.	5751.
DOWNSTREAM	1.00E-02	12628.	22730.	6.00E+04	1.97E+05	3.99	8.03E+00	6115.	6438.
DOWNSTREAM	1.00E-03	10236.	18425.	6.59E+04	2.16E+05	5.25	5.33E+01	6719.	6933.

Stagnation temperature, T_t: 75 000 K; 135 000° R
Sonic flow factor, ψ: 5.66E-03 (kg)($K^{1/2}$)/(sec)(N); 1.58E+02 (lb)($^{\circ}R^{1/2}$)/(sec)(ft^2)(atm)
Mass flow per unit throat area, $\dot{W}/A^*$: 2.10E+00 kg/(sec)(m^2); 4.29E-01 lb/(sec)(ft^2)

CHAMBER	1.	75000.	135000.	0	0	0	INFINITY		
THROAT	4.87E-01	56278.	101301.	3.93E+04	1.29E+05	1.00	1.00E+00	4009.	6413.
DOWNSTREAM	1.00E-01	29898.	53816.	6.10E+04	2.00E+05	2.13	1.67E+00	6219.	7041.
DOWNSTREAM	1.00E-02	13792.	24826.	7.23E+04	2.37E+05	4.31	6.30E+00	7370.	7681.
DOWNSTREAM	1.00E-03	10591.	19064.	7.79E+04	2.55E+05	5.88	4.06E+01	7939.	8139.

Stagnation temperature, T_t: 100 000 K; 180 000° R
Sonic flow factor, ψ: 5.66E-03 (kg)($K^{1/2}$)/(sec)(N); 1.58E+02 (lb)($^{\circ}R^{1/2}$)/(sec)(ft^2)(atm)
Mass flow per unit throat area, $\dot{W}/A^*$: 1.81E+00 kg/(sec)(m^2); 3.71E-01 lb/(sec)(ft^2)

CHAMBER	1.	100000.	180000.	0	0	0	INFINITY		
THROAT	4.87E-01	75031.	135056.	4.54E+04	1.49E+05	1.00	1.00E+00	4630.	7407.
DOWNSTREAM	1.00E-01	39836.	71704.	7.04E+04	2.31E+05	2.13	1.67E+00	7183.	8133.
DOWNSTREAM	1.00E-02	15156.	29081.	8.33E+04	2.73E+05	4.12	5.69E+00	8494.	8818.
DOWNSTREAM	1.00E-03	10914.	19645.	8.87E+04	2.91E+05	6.42	3.31E+01	9047.	9236.

TABLE III. - Continued. CHOKED NOZZLE FLOW OF HYDROGEN IN CHEMICAL EQUILIBRIUM IN DEBYE-HÜCKEL APPROXIMATION

[E-02, E-03, E+02, E+03, etc., after numbers signify that numbers are to be multiplied by 10^{-2}, 10^{-3}, 10^{2}, 10^{3}, etc.]

(b) Stagnation pressure, 1.01325×10^6 N/m^2 (10 atm)

Location	Pressure ratio, p/p_t	Temperature, T		Velocity, v		Mach number, M	Area ratio, A/A^*	Specific impulse, sec	
		K	$^\circ$R	m/sec	ft/sec			Ideal, $I_{sp,i}$	Vacuum, $I_{sp,v}$
Stagnation temperature, T_t: 2500 K; 4500° R Sonic flow factor, ψ: 1.03E-02 (kg)($K^{1/2}$)/(sec)(N); 2.87E+02 (lb)($^\circ R^{1/2}$)/(sec)(ft^2)(atm) Mass flow per unit throat area, $\dot{W}/A^*$: 2.09E+02 kg/(sec)(m^2); 4.28E+01 lb/(sec)(ft^2)									
CHAMBER	1.	2500.	4500.	0	0	0	INFINITY		
THROAT	5.47E-01	2202.	3963.	3.42E+03	1.12E+04	1.00	1.00E+00	349.	620.
DOWNSTREAM	1.00E-01	1456.	2621.	6.09E+03	2.00E+04	2.14	2.03E+00	621.	722.
DOWNSTREAM	1.00E-02	779.	1401.	7.60E+03	2.49E+04	3.60	8.70E+00	775.	818.
DOWNSTREAM	1.00E-03	405.	730.	8.29E+03	2.72E+04	5.42	4.15E+01	845.	866.
Stagnation temperature, T_t: 3500 K; 6300° R Sonic flow factor, ψ: 9.57E-03 (kg)($K^{1/2}$)/(sec)(N); 2.66E+02 (lb)($^\circ R^{1/2}$)/(sec)(ft^2)(atm) Mass flow per unit throat area, $\dot{W}/A^*$: 1.64E+02 kg/(sec)(m^2); 3.36E+01 lb/(sec)(ft^2)									
CHAMBER	1.	3500.	6300.	0	0	0	INFINITY		
THROAT	5.71E-01	3286.	5914.	4.12E+03	1.35E+04	1.00	1.00E+00	420.	780.
DOWNSTREAM	1.00E-01	2668.	4802.	7.86E+03	2.58E+04	2.15	2.32E+00	802.	948.
DOWNSTREAM	1.00E-02	1757.	3163.	1.02E+04	3.35E+04	3.31	1.15E+01	1043.	1115.
DOWNSTREAM	1.00E-03	961.	1729.	1.14E+04	3.74E+04	4.87	5.63E+01	1162.	1197.
DOWNSTREAM	1.00E-04	502.	904.	1.20E+04	3.93E+04	7.04	2.80E+02	1220.	1238.
Stagnation temperature, T_t: 5000 K; 9000° R Sonic flow factor, ψ: 7.77E-03 (kg)($K^{1/2}$)/(sec)(N); 2.16E+02 (lb)($^\circ R^{1/2}$)/(sec)(ft^2)(atm) Mass flow per unit throat area, $\dot{W}/A^*$: 1.11E+02 kg/(sec)(m^2); 2.28E+01 lb/(sec)(ft^2)									
CHAMBER	1.	5000.	9000.	0	0	0	INFINITY		
THROAT	5.62E-01	4642.	8356.	6.21E+03	2.04E+04	1.00	1.00E+00	633.	1155.
DOWNSTREAM	1.00E-01	3854.	6938.	1.16E+04	3.80E+04	2.18	2.29E+00	1181.	1394.
DOWNSTREAM	1.00E-02	3163.	5693.	1.52E+04	4.97E+04	3.36	1.30E+01	1546.	1666.
DOWNSTREAM	1.00E-03	2679.	4822.	1.74E+04	5.70E+04	4.42	8.75E+01	1773.	1854.
DOWNSTREAM	1.00E-04	2308.	4155.	1.90E+04	6.22E+04	5.43	6.39E+02	1933.	1992.

Stagnation temperature, T_t: 6000 K; 10 800° R
Sonic flow factor, ψ: 7.55E-03 (kg)($K^{1/2}$)/(sec)(N); 2.10E+02 (lb)($^oR^{1/2}$)/(sec)(ft^2)(atm)
Mass flow per unit throat area, $\dot{W}/A^*$: 9.87E+01 kg/(sec)(m^2); 2.02E+01 lb/(sec)(ft^2)

CHAMBER	1.	6000.	10800.	0	0	0	INFINITY		
THROAT	5.47E-01	5287.	9517.	7.30E+03	2.40E+04	1.00	1.00E+00	745.	1317.
DOWNSTREAM	1.00E-01	4167.	7501.	1.31E+04	4.29E+04	2.20	2.21E+00	1334.	1565.
DOWNSTREAM	1.00E-02	3347.	6025.	1.69E+04	5.55E+04	3.43	1.23E+01	1726.	1855.
DOWNSTREAM	1.00E-03	2820.	5077.	1.93E+04	6.33E+04	4.52	8.23E+01	1968.	2054.
DOWNSTREAM	1.00E-04	2437.	4386.	2.10E+04	6.88E+04	5.55	6.01E+02	2137.	2200.

Stagnation temperature, T_t: 7000 K; 12 600° R
Sonic flow factor, ψ: 7.71E-03 (kg)($K^{1/2}$)/(sec)(N); 2.15E+02 (lb)($^oR^{1/2}$)/(sec)(ft^2)(atm)
Mass flow per unit throat area, $\dot{W}/A^*$: 9.34E+01 kg/(sec)(m^2); 1.91E+01 lb/(sec)(ft^2)

CHAMBER	1.	7000.	12600.	0	0	0	INFINITY		
THROAT	5.29E-01	5787.	10417.	8.09E+03	2.66E+04	1.00	1.00E+00	825.	1411.
DOWNSTREAM	1.00E-01	4326.	7787.	1.39E+04	4.56E+04	2.22	2.13E+00	1417.	1653.
DOWNSTREAM	1.00E-02	3420.	6156.	1.78E+04	5.84E+04	3.48	1.18E+01	1816.	1946.
DOWNSTREAM	1.00E-03	2869.	5164.	2.02E+04	6.63E+04	4.59	7.87E+01	2060.	2147.
DOWNSTREAM	1.00E-04	2476.	4458.	2.19E+04	7.18E+04	5.63	5.75E+02	2232.	2295.

Stagnation temperature, T_t: 8000 K; 14 400° R
Sonic flow factor, ψ: 7.84E-03 (kg)($K^{1/2}$)/(sec)(N); 2.18E+02 (lb)($^oR^{1/2}$)/(sec)(ft^2)(atm)
Mass flow per unit throat area, $\dot{W}/A^*$: 8.89E+01 kg/(sec)(m^2); 1.82E+01 lb/(sec)(ft^2)

CHAMBER	1.	8000.	14400.	0	0	0	INFINITY		
THROAT	5.11E-01	6330.	11393.	8.86E+03	2.91E+04	1.00	1.00E+00	903.	1497.
DOWNSTREAM	1.00E-01	4459.	8026.	1.46E+04	4.79E+04	2.25	2.05E+00	1489.	1727.
DOWNSTREAM	1.00E-02	3471.	6247.	1.85E+04	6.08E+04	3.54	1.12E+01	1889.	2020.
DOWNSTREAM	1.00E-03	2900.	5221.	2.09E+04	6.87E+04	4.66	7.50E+01	2134.	2222.
DOWNSTREAM	1.00E-04	2501.	4502.	2.26E+04	7.42E+04	5.72	5.48E+02	2306.	2370.

Stagnation temperature, T_t: 10 000 K; 18 000° R
Sonic flow factor, ψ: 7.72E-03 (kg)($K^{1/2}$)/(sec)(N); 2.15E+02 (lb)($^oR^{1/2}$)/(sec)(ft^2)(atm)
Mass flow per unit throat area, $\dot{W}/A^*$: 7.83E+01 kg/(sec)(m^2); 1.60E+01 lb/(sec)(ft^2)

CHAMBER	1.	10000.	18000.	0	0	0	INFINITY		
THROAT	4.98E-01	7960.	14329.	1.02E+04	3.34E+04	1.00	1.00E+00	1037.	1695.
DOWNSTREAM	1.00E-01	4829.	8693.	1.62E+04	5.33E+04	2.28	1.83E+00	1657.	1898.
DOWNSTREAM	1.00E-02	3570.	6427.	2.02E+04	6.62E+04	3.69	9.79E+00	2057.	2186.
DOWNSTREAM	1.00E-03	2957.	5323.	2.25E+04	7.40E+04	4.86	6.55E+01	2299.	2386.
DOWNSTREAM	1.00E-04	2543.	4577.	2.42E+04	7.94E+04	5.94	4.79E+02	2469.	2532.

Stagnation temperature, T_t: 12 000 K; 21 600° R
Sonic flow factor, ψ: 7.26E-03 (kg)($K^{1/2}$)/(sec)(N); 2.02E+02 (lb)($^oR^{1/2}$)/(sec)(ft^2)(atm)
Mass flow per unit throat area, $\dot{W}/A^*$: 6.71E+01 kg/(sec)(m^2); 1.37E+01 lb/(sec)(ft^2)

CHAMBER	1.	12000.	21600.	0	0	0	INFINITY		
THROAT	5.37E-01	10535.	18963.	1.09E+04	3.57E+04	1.00	1.00E+00	1110.	1936.
DOWNSTREAM	1.00E-01	6117.	11010.	1.87E+04	6.14E+04	2.08	1.78E+00	1907.	2182.
DOWNSTREAM	1.00E-02	3742.	6735.	2.28E+04	7.47E+04	3.91	8.26E+00	2322.	2449.
DOWNSTREAM	1.00E-03	3036.	5464.	2.51E+04	8.23E+04	5.17	5.48E+01	2559.	2644.
DOWNSTREAM	1.00E-04	2596.	4673.	2.67E+04	8.77E+04	6.30	4.01E+02	2725.	2787.

TABLE III. - Continued. CHOKED NOZZLE FLOW OF HYDROGEN IN CHEMICAL EQUILIBRIUM IN DEBYE-HÜCKEL APPROXIMATION

[E-02, E-03, E+02, E+03, etc., after numbers signify that numbers are to be multiplied by 10^{-2}, 10^{-3}, 10^{2}, 10^{3}, etc.]

(b) Concluded. Stagnation pressure, 1.01325×10^{6} N/m^2 (10 atm)

Location	Pressure ratio, p/p_t	Temperature, T		Velocity, v		Mach number, M	Area ratio, A/A^*	Specific impulse, sec	
		K	^{o}R	m/sec	ft/sec			Ideal, $I_{sp,i}$	Vacuum, $I_{sp,v}$
Stagnation temperature, T_t: 14 000 K; 25 200^{o} R Sonic flow factor, ψ: 6.86E-03 (kg)(K$^{1/2}$)/(sec)(N); 1.91E+02 (lb)(^{o}R$^{1/2}$)/(sec)(ft^2)(atm) Mass flow per unit throat area, $\dot{W}/A^*$: 5.87E+01 kg/(sec)(m^2); 1.20E+01 lb/(sec)(ft^2)									
CHAMBER	1.	14000.	25200.	0	0	0	INFINITY		
THROAT	5.60E-01	12896.	23213.	1.18E+04	3.88E+04	1.00	1.00E+00	1206.	2191.
DOWNSTREAM	1.00E-01	9605.	17289.	2.18E+04	7.15E+04	2.11	2.14E+00	2221.	2598.
DOWNSTREAM	1.00E-02	4501.	8102.	2.72E+04	8.91E+04	3.71	7.86E+00	2770.	2908.
DOWNSTREAM	1.00E-03	3195.	5751.	2.95E+04	9.68E+04	5.62	4.68E+01	3009.	3092.
DOWNSTREAM	1.00E-04	2684.	4831.	3.11E+04	1.02E+05	6.89	3.39E+02	3170.	3230.
Stagnation temperature, T_t: 16 000 K; 28 800^{o} R Sonic flow factor, ψ: 6.46E-03 (kg)(K$^{1/2}$)/(sec)(N); 1.80E+02 (lb)(^{o}R$^{1/2}$)/(sec)(ft^2)(atm) Mass flow per unit throat area, $\dot{W}/A^*$: 5.17E+01 kg/(sec)(m^2); 1.06E+01 lb/(sec)(ft^2)									
CHAMBER	1.	16000.	28800.	0	0	0	INFINITY		
THROAT	5.66E-01	14915.	26847.	1.33E+04	4.36E+04	1.00	1.00E+00	1356.	2487.
DOWNSTREAM	1.00E-01	12122.	21819.	2.49E+04	8.18E+04	2.17	2.27E+00	2543.	2996.
DOWNSTREAM	1.00E-02	8815.	15868.	3.23E+04	1.06E+05	3.34	1.17E+01	3297.	3531.
DOWNSTREAM	1.00E-03	4244.	7638.	3.60E+04	1.18E+05	4.83	4.96E+01	3671.	3770.
DOWNSTREAM	1.00E-04	2868.	5162.	3.77E+04	1.24E+05	7.53	2.97E+02	3841.	3900.
Stagnation temperature, T_t: 18 000 K; 32 400^{o} R Sonic flow factor, ψ: 6.03E-03 (kg)(K$^{1/2}$)/(sec)(N); 1.68E+02 (lb)(^{o}R$^{1/2}$)/(sec)(ft^2)(atm) Mass flow per unit throat area, $\dot{W}/A^*$: 4.55E+01 kg/(sec)(m^2); 9.33E+00 lb/(sec)(ft^2)									
CHAMBER	1.	18000.	32400.	0	0	0	INFINITY		
THROAT	5.66E-01	16757.	30165.	1.52E+04	4.97E+04	1.00	1.00E+00	1546.	2830.
DOWNSTREAM	1.00E-01	13758.	24764.	2.84E+04	9.32E+04	2.18	2.27E+00	2897.	3413.
DOWNSTREAM	1.00E-02	10872.	19569.	3.70E+04	1.21E+05	3.39	1.24E+01	3771.	4053.
DOWNSTREAM	1.00E-03	8513.	15323.	4.21E+04	1.38E+05	4.52	7.84E+01	4289.	4467.
DOWNSTREAM	1.00E-04	5091.	9165.	4.52E+04	1.48E+05	5.45	4.18E+02	4607.	4702.

Stagnation temperature, T_t: 25 000 K; 45 000° R
Sonic flow factor, ψ: 5.48E-03 (kg)($K^{1/2}$)/(sec)(N); 1.53E+02 (lb)($^{\circ}R^{1/2}$)/(sec)(ft^2)(atm)
Mass flow per unit throat area, $\dot{W}/A^*$: 3.51E+01 kg/(sec)(m^2); 7.19E+00 lb/(sec)(ft^2)

CHAMBER	1.	25000.	45000.	0	0	0	INFINITY		
THROAT	5.44E-01	21738.	39128.	2.09E+04	6.85E+04	1.00	1.00E+00	2128.	3727.
DOWNSTREAM	1.00E-01	16646.	29963.	3.69E+04	1.21E+05	2.21	2.15E+00	3767.	4401.
DOWNSTREAM	1.00E-02	12940.	23292.	4.74E+04	1.56E+05	3.48	1.16E+01	4833.	5175.
DOWNSTREAM	1.00E-03	10585.	19053.	5.36E+04	1.76E+05	4.64	7.54E+01	5457.	5689.
DOWNSTREAM	1.00E-04	8880.	15984.	5.78E+04	1.90E+05	5.78	5.32E+02	5896.	6053.

Stagnation temperature, T_t: 35 000 K; 63 000° R
Sonic flow factor, ψ: 5.66E-03 (kg)($K^{1/2}$)/(sec)(N); 1.57E+02 (lb)($^{\circ}R^{1/2}$)/(sec)(ft^2)(atm)
Mass flow per unit throat area, $\dot{W}/A^*$: 3.06E+01 kg/(sec)(m^2); 6.27E+00 lb/(sec)(ft^2)

CHAMBER	1.	35000.	63000.	0	0	0	INFINITY		
THROAT	5.04E-01	27208.	48975.	2.61E+04	8.57E+04	1.00	1.00E+00	2665.	4365.
DOWNSTREAM	1.00E-01	18267.	32881.	4.23E+04	1.39E+05	2.26	1.96E+00	4318.	4981.
DOWNSTREAM	1.00E-02	13618.	24513.	5.31E+04	1.74E+05	3.63	1.04E+01	5419.	5769.
DOWNSTREAM	1.00E-03	11043.	19878.	5.95E+04	1.95E+05	4.83	6.74E+01	6068.	6295.
DOWNSTREAM	1.00E-04	9271.	16689.	6.38E+04	2.09E+05	5.99	4.77E+02	6508.	6669.

Stagnation temperature, T_t: 50 000 K; 90 000° R
Sonic flow factor, ψ: 5.69E-03 (kg)($K^{1/2}$)/(sec)(N); 1.58E+02 (lb)($^{\circ}R^{1/2}$)/(sec)(ft^2)(atm)
Mass flow per unit throat area, $\dot{W}/A^*$: 2.58E+01 kg/(sec)(m^2); 5.28E+00 lb/(sec)(ft^2)

CHAMBER	1.	50000.	90000.	0	0	0	INFINITY		
THROAT	4.88E-01	37621.	67718.	3.19E+04	1.05E+05	1.00	1.00E+00	3256.	5212.
DOWNSTREAM	1.00E-01	21236.	38224.	4.97E+04	1.63E+05	2.24	1.73E+00	5070.	5765.
DOWNSTREAM	1.00E-02	14302.	25744.	6.06E+04	1.99E+05	3.86	8.62E+00	6179.	6524.
DOWNSTREAM	1.00E-03	11418.	20552.	6.69E+04	2.19E+05	5.15	5.58E+01	6818.	7042.
DOWNSTREAM	1.00E-04	9554.	17196.	7.11E+04	2.33E+05	6.36	3.96E+02	7252.	7411.

Stagnation temperature, T_t: 75 000 K; 135 000° R
Sonic flow factor, ψ: 5.68E-03 (kg)($K^{1/2}$)/(sec)(N); 1.58E+02 (lb)($^{\circ}R^{1/2}$)/(sec)(ft^2)(atm)
Mass flow per unit throat area, $\dot{W}/A^*$: 2.10E+01 kg/(sec)(m^2); 4.30E+00 lb/(sec)(ft^2)

CHAMBER	1.	75000.	135000.	0	0	0	INFINITY		
THROAT	4.87E-01	55306.	101352.	3.93E+04	1.29E+05	1.00	1.00E+00	4004.	6402.
DOWNSTREAM	1.00E-01	30025.	54045.	6.09E+04	2.00E+05	2.14	1.67E+00	6210.	7030.
DOWNSTREAM	1.00E-02	15454.	27817.	7.25E+04	2.38E+05	4.20	6.81E+00	7390.	7725.
DOWNSTREAM	1.00E-03	11871.	21367.	7.85E+04	2.57E+05	5.69	4.33E+01	8002.	8215.
DOWNSTREAM	1.00E-04	9850.	17729.	8.25E+04	2.71E+05	7.01	3.08E+02	8416.	8567.

Stagnation temperature, T_t: 100 000 K; 180 000° R
Sonic flow factor, ψ: 5.67E-03 (kg)($K^{1/2}$)/(sec)(N); 1.58E+02 (lb)($^{\circ}R^{1/2}$)/(sec)(ft^2)(atm)
Mass flow per unit throat area, $\dot{W}/A^*$: 1.82E+01 kg/(sec)(m^2); 3.72E+00 lb/(sec)(ft^2)

CHAMBER	1.	100000.	180000.	0	0	0	INFINITY		
THROAT	4.87E-01	75049.	135088.	4.54E+04	1.49E+05	1.00	1.00E+00	4627.	7400.
DOWNSTREAM	1.00E-01	39897.	71814.	7.04E+04	2.31E+05	2.13	1.67E+00	7177.	8125.
DOWNSTREAM	1.00E-02	17162.	30892.	8.33E+04	2.73E+05	4.26	5.93E+00	8494.	8831.
DOWNSTREAM	1.00E-03	12252.	22053.	8.91E+04	2.92E+05	6.18	3.57E+01	9088.	9292.
DOWNSTREAM	1.00E-04	10061.	18110.	9.30E+04	3.05E+05	7.62	2.53E+02	9482.	9626.

TABLE III. - Continued. CHOKED NOZZLE FLOW OF HYDROGEN IN CHEMICAL EQUILIBRIUM IN DEBYE-HÜCKEL APPROXIMATION

[E-02, E-03, E+02, E+03, etc., after numbers signify that numbers are to be multiplied by 10^{-2}, 10^{-3}, 10^{2}, 10^{3}, etc.]

(c) Stagnation pressure, 1.01325×10^{7} (100 atm)

Location	Pressure ratio, p/p_t	Temperature, T		Velocity, v		Mach number, M	Area ratio, A/A^*	Specific impulse, sec	
		K	^{o}R	m/sec	ft/sec			Ideal, $I_{sp,i}$	Vacuum, $I_{sp,v}$
Stagnation temperature, T_t: 2500 K; 4500^{o} R Sonic flow factor, ψ: 1.04E-02 (kg)($K^{1/2}$)/(sec)(N); 2.89E+02 (lb)($^{o}R^{1/2}$)/(sec)(ft^2)(atm) Mass flow per unit throat area, $\dot{W}/A^*$: 2.10E+03 kg/(sec)(m^2); 4.31E+02 lb/(sec)(ft^2)									
CHAMBER	1.	2500.	4500.	0	0	0	INFINITY		
THROAT	5.44E-01	2178.	3920.	3.43E+03	1.12E+04	1.00	1.00E+00	349.	617.
DOWNSTREAM	1.00E-01	1432.	2577.	6.05E+03	1.99E+04	2.14	2.02E+00	618.	717.
DOWNSTREAM	1.00E-02	764.	1376.	7.55E+03	2.48E+04	3.60	8.57E+00	770.	812.
DOWNSTREAM	1.00E-03	398.	716.	8.22E+03	2.70E+04	5.43	4.14E+01	839.	859.
Stagnation temperature, T_t: 3500 K; 6300^{o} R Sonic flow factor, ψ: 9.99E-03 (kg)($K^{1/2}$)/(sec)(N); 2.78E+02 (lb)($^{o}R^{1/2}$)/(sec)(ft^2)(atm) Mass flow per unit throat area, $\dot{W}/A^*$: 1.71E+03 kg/(sec)(m^2); 3.50E+02 lb/(sec)(ft^2)									
CHAMBER	1.	3500.	6300.	0	0	0	INFINITY		
THROAT	5.61E-01	3197.	5755.	4.04E+03	1.33E+04	1.00	1.00E+00	412.	751.
DOWNSTREAM	1.00E-01	2318.	4172.	7.48E+03	2.45E+04	2.13	2.16E+00	762.	893.
DOWNSTREAM	1.00E-02	1320.	2375.	9.48E+03	3.11E+04	3.49	9.70E+00	957.	1025.
DOWNSTREAM	1.00E-03	700.	1260.	1.04E+04	3.42E+04	5.19	4.68E+01	1052.	1090.
DOWNSTREAM	1.00E-04	364.	655.	1.09E+04	3.57E+04	7.50	2.33E+02	1109.	1123.
Stagnation temperature, T_t: 5000 K; 9000^{o} R Sonic flow factor, ψ: 8.85E-03 (kg)($K^{1/2}$)/(sec)(N); 2.46E+02 (lb)($^{o}R^{1/2}$)/(sec)(ft^2)(atm) Mass flow per unit throat area, $\dot{W}/A^*$: 1.27E+03 kg/(sec)(m^2); 2.60E+02 lb/(sec)(ft^2)									
CHAMBER	1.	5000.	9000.	0	0	0	INFINITY		
THROAT	5.65E-01	4657.	8382.	5.41E+03	1.78E+04	1.00	1.00E+00	552.	1012.
DOWNSTREAM	1.00E-01	3832.	6897.	1.02E+04	3.33E+04	2.17	2.30E+00	1036.	1224.
DOWNSTREAM	1.00E-02	3036.	5465.	1.33E+04	4.36E+04	3.36	1.28E+01	1355.	1460.
DOWNSTREAM	1.00E-03	2370.	4266.	1.52E+04	4.98E+04	4.44	8.23E+01	1549.	1616.
DOWNSTREAM	1.00E-04	1540.	2771.	1.64E+04	5.38E+04	5.63	4.85E+02	1672.	1711.
DOWNSTREAM	3.00E-05	1122.	2020.	1.68E+04	5.51E+04	6.66	1.15E+03	1712.	1740.
DOWNSTREAM	1.00E-05	829.	1491.	1.70E+04	5.59E+04	7.82	2.51E+03	1738.	1759.

Stagnation temperature, T_t: 6000 K; 10 800^{o} R
Sonic flow factor, ψ: 8.04E-03 (kg)($K^{1/2}$)/(sec)(N); 2.24E+02 (lb)($^{o}R^{1/2}$)/(sec)(ft^2)(atm)
Mass flow per unit throat area, $\dot{W}/A^*$: 1.05E+03 kg/(sec)(m^2); 2.15E+02 lb/(sec)(ft^2)

CHAMBER	1.	6000.	10800.	0	0	0	INFINITY		
THROAT	5.57E-01	5496.	9893.	6.67E+03	2.19E+04	1.00	1.00E+00	680.	1228.
DOWNSTREAM	1.00E-01	4434.	7981.	1.22E+04	4.02E+04	2.18	2.24E+00	1249.	1469.
DOWNSTREAM	1.00E-02	3528.	6350.	1.59E+04	5.22E+04	3.41	1.23E+01	1621.	1743.
DOWNSTREAM	1.00E-03	2912.	5241.	1.81E+04	5.95E+04	4.52	8.15E+01	1848.	1928.
DOWNSTREAM	1.00E-04	2442.	4395.	1.97E+04	6.45E+04	5.59	5.83E+02	2004.	2061.
DOWNSTREAM	3.00E-05	2222.	4000.	2.03E+04	6.65E+04	6.15	1.65E+03	2057.	2116.
DOWNSTREAM	1.00E-05	2019.	3634.	2.08E+04	6.81E+04	6.65	4.28E+03	2117.	2159.

Stagnation temperature, T_t: 7000 K; 12 600^{o} R
Sonic flow factor, ψ: 7.72E-03 (kg)($K^{1/2}$)/(sec)(N); 2.15E+02 (lb)($^{o}R^{1/2}$)/(sec)(ft^2)(atm)
Mass flow per unit throat area, $\dot{W}/A^*$: 9.35E+02 kg/(sec)(m^2); 1.91E+02 lb/(sec)(ft^2)

CHAMBER	1.	7000.	12600.	0	0	0	INFINITY		
THROAT	5.45E-01	6198.	11156.	7.74E+03	2.54E+04	1.00	1.00E+00	789.	1391.
DOWNSTREAM	1.00E-01	4809.	8656.	1.38E+04	4.52E+04	2.20	2.17E+00	1405.	1644.
DOWNSTREAM	1.00E-02	3758.	6764.	1.77E+04	5.81E+04	3.46	1.17E+01	1806.	1936.
DOWNSTREAM	1.00E-03	3095.	5571.	2.01E+04	6.59E+04	4.61	7.70E+01	2048.	2133.
DOWNSTREAM	1.00E-04	2620.	4717.	2.17E+04	7.12E+04	5.70	5.53E+02	2213.	2275.
DOWNSTREAM	3.00E-05	2417.	4350.	2.24E+04	7.34E+04	6.26	1.58E+03	2282.	2334.
DOWNSTREAM	1.00E-05	2248.	4047.	2.29E+04	7.51E+04	6.77	4.17E+03	2335.	2382.

Stagnation temperature, T_t: 8000 K; 14 400^{o} R
Sonic flow factor, ψ: 7.72E-03 (kg)($K^{1/2}$)/(sec)(N); 2.15E+02 (lb)($^{o}R^{1/2}$)/(sec)(ft^2)(atm)
Mass flow per unit throat area, $\dot{W}/A^*$: 8.74E+02 kg/(sec)(m^2); 1.79E+02 lb/(sec)(ft^2)

CHAMBER	1.	8000.	14400.	0	0	0	INFINITY		
THROAT	5.32E-01	6781.	12205.	8.55E+03	2.80E+04	1.00	1.00E+00	872.	1501.
DOWNSTREAM	1.00E-01	5041.	9075.	1.48E+04	4.84E+04	2.21	2.10E+00	1505.	1753.
DOWNSTREAM	1.00E-02	3873.	6972.	1.88E+04	6.17E+04	3.51	1.12E+01	1919.	2051.
DOWNSTREAM	1.00E-03	3176.	5716.	2.12E+04	6.97E+04	4.68	7.36E+01	2155.	2252.
DOWNSTREAM	1.00E-04	2689.	4841.	2.29E+04	7.51E+04	5.79	5.28E+02	2335.	2397.
DOWNSTREAM	3.00E-05	2485.	4473.	2.36E+04	7.74E+04	6.36	1.51E+03	2404.	2458.
DOWNSTREAM	1.00E-05	2319.	4173.	2.41E+04	7.91E+04	6.87	3.99E+03	2460.	2507.

Stagnation temperature, T_t: 10 000 K; 18 000^{o} R
Sonic flow factor, ψ: 7.83E-03 (kg)($K^{1/2}$)/(sec)(N); 2.18E+02 (lb)($^{o}R^{1/2}$)/(sec)(ft^2)(atm)
Mass flow per unit throat area, $\dot{W}/A^*$: 7.93E+02 kg/(sec)(m^2); 1.62E+02 lb/(sec)(ft^2)

CHAMBER	1.	10000.	18000.	0	0	0	INFINITY		
THROAT	5.09E-01	7969.	14345.	9.93E+03	3.26E+04	1.00	1.00E+00	1013.	1676.
DOWNSTREAM	1.00E-01	5396.	9713.	1.63E+04	5.33E+04	2.24	1.97E+00	1657.	1914.
DOWNSTREAM	1.00E-02	4012.	7221.	2.04E+04	6.69E+04	3.62	1.03E+01	2080.	2215.
DOWNSTREAM	1.00E-03	3262.	5872.	2.28E+04	7.50E+04	4.82	6.74E+01	2330.	2418.
DOWNSTREAM	1.00E-04	2758.	4965.	2.45E+04	8.05E+04	5.95	4.83E+02	2501.	2564.
DOWNSTREAM	3.00E-05	2550.	4590.	2.52E+04	8.27E+04	6.54	1.39E+03	2571.	2626.
DOWNSTREAM	1.00E-05	2383.	4289.	2.58E+04	8.45E+04	7.07	3.66E+03	2627.	2675.

Stagnation temperature, T_t: 12 000 K; 21 600^{o} R
Sonic flow factor, ψ: 7.66E-03 (kg)($K^{1/2}$)/(sec)(N); 2.13E+02 (lb)($^{o}R^{1/2}$)/(sec)(ft^2)(atm)
Mass flow per unit throat area, $\dot{W}/A^*$: 7.08E+02 kg/(sec)(m^2); 1.45E+02 lb/(sec)(ft^2)

CHAMBER	1.	12000.	21600.	0	0	0	INFINITY		
THROAT	5.05E-01	9732.	17518.	1.11E+04	3.63E+04	1.00	1.00E+00	1129.	1866.
DOWNSTREAM	1.00E-01	5887.	10596.	1.79E+04	5.88E+04	2.24	1.82E+00	1825.	2092.
DOWNSTREAM	1.00E-02	4144.	7459.	2.21E+04	7.25E+04	3.74	9.24E+00	2255.	2389.
DOWNSTREAM	1.00E-03	3335.	6004.	2.46E+04	8.06E+04	5.00	6.00E+01	2534.	2591.
DOWNSTREAM	1.00E-04	2812.	5061.	2.62E+04	8.60E+04	6.17	4.30E+02	2674.	2737.
DOWNSTREAM	3.00E-05	2599.	4678.	2.69E+04	8.83E+04	6.75	1.23E+03	2744.	2798.
DOWNSTREAM	1.00E-05	2430.	4373.	2.75E+04	9.01E+04	7.30	3.26E+03	2800.	2848.

TABLE III. - Continued. CHOKED NOZZLE FLOW OF HYDROGEN IN CHEMICAL EQUILIBRIUM IN DEBYE-HÜCKEL APPROXIMATION

[E-02, E-03, E+02, E+03, etc., after numbers signify that numbers are to be multiplied by 10^{-2}, 10^{-3}, 10^{2}, 10^{3}, etc.]

(c) Concluded. Stagnation pressure, 1.01325×10^{7} (100 atm)

Location	Pressure ratio, p/p_t	Temperature, T		Velocity, v		Mach number, M	Area ratio, A/A^*	Specific impulse, sec	
		K	^{o}R	m/sec	ft/sec			Ideal, $I_{sp,i}$	Vacuum, $I_{sp,v}$
Stagnation temperature, T_t: 14 000 K; 25 200^{o} R Sonic flow factor, ψ: 7.31E-03 (kg)$(K^{1/2})$/(sec)(N); 2.03E+02 (lb)$(^{o}R^{1/2})$/(sec)(ft^2)(atm) Mass flow per unit throat area, W/A^*: 6.26E+02 kg/(sec)(m^2); 1.28E+02 lb/(sec)(ft^2)									
CHAMBER	1.	14000.	25200.	0	0	0	INFINITY	1202.	2082.
THROAT	5.33E-01	12159.	21886.	1.18E+04	3.87E+04	1.00	1.00E+00	2050.	2346.
DOWNSTREAM	1.00E-01	7134.	12841.	2.01E+04	6.60E+04	2.10	1.79E+00	2498.	2633.
DOWNSTREAM	1.00E-02	4344.	7819.	2.45E+04	8.04E+04	3.90	8.17E+00	2745.	2832.
DOWNSTREAM	1.00E-03	3428.	6170.	2.69E+04	8.83E+04	5.25	5.25E+01	2914.	2976.
DOWNSTREAM	1.00E-04	2874.	5173.	2.86E+04	9.37E+04	6.47	3.75E+02	2983.	3036.
DOWNSTREAM	3.00E-05	2654.	4776.	2.93E+04	9.60E+04	7.09	1.08E+03	3038.	3085.
DOWNSTREAM	1.00E-05	2480.	4464.	2.98E+04	9.77E+04	7.65	2.84E+03		
Stagnation temperature, T_t: 16 000 K; 28 800^{o} R Sonic flow factor, ψ: 7.01E-03 (kg)$(K^{1/2})$/(sec)(N); 1.95E+02 (lb)$(^{o}R^{1/2})$/(sec)(ft^2)(atm) Mass flow per unit throat area, W/A^*: 5.62E+02 kg/(sec)(m^2); 1.15E+02 lb/(sec)(ft^2)									
CHAMBER	1.	16000.	28800.	0	0	0	INFINITY	1284.	2302.
THROAT	5.53E-01	14474.	26052.	1.26E+04	4.13E+04	1.00	1.00E+00	2314.	2687.
DOWNSTREAM	1.00E-01	9987.	17977.	2.27E+04	7.45E+04	2.08	2.02E+00	2845.	2986.
DOWNSTREAM	1.00E-02	4826.	8686.	2.79E+04	9.15E+04	3.91	7.65E+00	3095.	3181.
DOWNSTREAM	1.00E-03	3570.	6426.	3.04E+04	9.96E+04	5.56	4.65E+01	3261.	3322.
DOWNSTREAM	1.00E-04	2957.	5322.	3.20E+04	1.05E+05	6.89	3.31E+02	3329.	3382.
DOWNSTREAM	3.00E-05	2724.	4903.	3.26E+04	1.07E+05	7.55	9.48E+02	3383.	3429.
DOWNSTREAM	1.00E-05	2543.	4577.	3.32E+04	1.09E+05	8.14	2.50E+03		
Stagnation temperature, T_t: 18 000 K; 32 400^{o} R Sonic flow factor, ψ: 6.74E-03 (kg)$(K^{1/2})$/(sec)(N); 1.88E+02 (lb)$(^{o}R^{1/2})$/(sec)(ft^2)(atm) Mass flow per unit throat area, W/A^*: 5.09E+02 kg/(sec)(m^2); 1.04E+02 lb/(sec)(ft^2)									
CHAMBER	1.	18000.	32400.	0	0	0	INFINITY	1399.	2536.
THROAT	5.60E-01	16519.	29733.	1.37E+04	4.50E+04	1.00	1.00E+00	2577.	3020.
DOWNSTREAM	1.00E-01	12684.	22832.	2.53E+04	8.29E+04	2.16	2.18E+00	3270.	3458.
DOWNSTREAM	1.00E-02	7148.	12866.	3.21E+04	1.05E+05	3.30	9.24E+00	3557.	3645.
DOWNSTREAM	1.00E-03	3855.	6938.	3.49E+04	1.14E+05	5.77	4.32E+01	3723.	3784.
DOWNSTREAM	1.00E-04	3076.	5536.	3.65E+04	1.20E+05	7.36	2.97E+02	3790.	3842.
DOWNSTREAM	3.00E-05	2816.	5069.	3.72E+04	1.22E+05	8.09	8.47E+02	3844.	3889.
DOWNSTREAM	1.00E-05	2621.	4717.	3.77E+04	1.24E+05	8.73	2.23E+03		

Stagnation temperature, T_t: 25 000 K; 45 000° R
Sonic flow factor, ψ: 5.86E-03 (kg)($K^{1/2}$)/(sec)(N); 1.63E+02 (lb)($^oR^{1/2}$)/(sec)(ft^2)(atm)
Mass flow per unit throat area, $\dot{W}/A^*$: 3.75E+02 kg/(sec)(m^2); 7.69E+01 lb/(sec)(ft^2)

CHAMBER	1.	25000.	45000.	0	0	0	INFINITY		
THROAT	5.56E-01	22627.	40729.	1.90E+04	6.23E+04	1.00	1.00E+00	1935.	3464.
DOWNSTREAM	1.00E-01	17727.	31908.	3.45E+04	1.13E+05	2.20	2.19E+00	3521.	4123.
DOWNSTREAM	1.00E-02	13564.	24415.	4.44E+04	1.46E+05	3.47	1.16E+01	4529.	4848.
DOWNSTREAM	1.00E-03	10681.	19226.	5.01E+04	1.65E+05	4.67	7.30E+01	5113.	5314.
DOWNSTREAM	1.00E-04	8217.	14791.	5.39E+04	1.77E+05	5.87	4.80E+02	5492.	5624.
DOWNSTREAM	3.00E-05	6516.	11729.	5.52E+04	1.81E+05	6.32	1.21E+03	5632.	5731.
DOWNSTREAM	1.00E-05	4367.	7860.	5.61E+04	1.84E+05	7.26	2.38E+03	5722.	5787.

Stagnation temperature, T_t: 35 000 K; 63 000° R
Sonic flow factor, ψ: 5.65E-03 (kg)($K^{1/2}$)/(sec)(N); 1.57E+02 (lb)($^oR^{1/2}$)/(sec)(ft^2)(atm)
Mass flow per unit throat area, $\dot{W}/A^*$: 3.06E+02 kg/(sec)(m^2); 6.27E+01 lb/(sec)(ft^2)

CHAMBER	1.	35000.	63000.	0	0	0	INFINITY		
THROAT	5.25E-01	28976.	52157.	2.50E+04	8.21E+04	1.00	1.00E+00	2553.	4327.
DOWNSTREAM	1.00E-01	20699.	37257.	4.24E+04	1.39E+05	2.23	2.04E+00	4325.	5014.
DOWNSTREAM	1.00E-02	15296.	27532.	5.36E+04	1.76E+05	3.59	1.06E+01	5463.	5819.
DOWNSTREAM	1.00E-03	12125.	21825.	6.00E+04	1.97E+05	4.84	6.67E+01	6117.	6342.
DOWNSTREAM	1.00E-04	9919.	17854.	6.42E+04	2.11E+05	6.07	4.60E+02	6548.	6703.
DOWNSTREAM	3.00E-05	8979.	16161.	6.59E+04	2.16E+05	6.73	1.29E+03	6720.	6850.
DOWNSTREAM	1.00E-05	8191.	14744.	6.72E+04	2.20E+05	7.33	3.32E+03	6853.	6965.

Stagnation temperature, T_t: 50 000 K; 90 000° R
Sonic flow factor, ψ: 5.72E-03 (kg)($K^{1/2}$)/(sec)(N); 1.59E+02 (lb)($^oR^{1/2}$)/(sec)(ft^2)(atm)
Mass flow per unit throat area, $\dot{W}/A^*$: 2.59E+02 kg/(sec)(m^2); 5.31E+01 lb/(sec)(ft^2)

CHAMBER	1.	50000.	90000.	0	0	0	INFINITY		
THROAT	4.94E-01	38228.	68811.	3.15E+04	1.03E+05	1.00	1.00E+00	3207.	5178.
DOWNSTREAM	1.00E-01	23555.	42399.	4.97E+04	1.63E+05	2.26	1.83E+00	5073.	5803.
DOWNSTREAM	1.00E-02	15298.	29337.	6.13E+04	2.01E+05	3.77	9.13E+00	6252.	6616.
DOWNSTREAM	1.00E-03	12753.	22955.	6.78E+04	2.23E+05	5.09	5.75E+01	6918.	7147.
DOWNSTREAM	1.00E-04	10444.	18800.	7.22E+04	2.37E+05	6.37	3.98E+02	7357.	7516.
DOWNSTREAM	3.00E-05	9503.	17105.	7.39E+04	2.42E+05	7.05	1.12E+03	7533.	7667.
DOWNSTREAM	1.00E-05	8748.	15746.	7.52E+04	2.47E+05	7.66	2.90E+03	7670.	7785.

Stagnation temperature, T_t: 75 000 K; 135 000° R
Sonic flow factor, ψ: 5.70E-03 (kg)($K^{1/2}$)/(sec)(N); 1.59E+02 (lb)($^oR^{1/2}$)/(sec)(ft^2)(atm)
Mass flow per unit throat area, $\dot{W}/A^*$: 2.11E+02 kg/(sec)(m^2); 4.32E+01 lb/(sec)(ft^2)

CHAMBER	1.	75000.	135000.	0	0	0	INFINITY		
THROAT	4.88E-01	55406.	101531.	3.91E+04	1.28E+05	1.00	1.00E+00	3985.	6373.
DOWNSTREAM	1.00E-01	30610.	55099.	6.07E+04	1.99E+05	2.16	1.68E+00	6186.	7010.
DOWNSTREAM	1.00E-02	17610.	31698.	7.27E+04	2.39E+05	4.06	7.38E+00	7418.	7780.
DOWNSTREAM	1.00E-03	13379.	24082.	7.92E+04	2.60E+05	5.54	4.58E+01	8074.	8298.
DOWNSTREAM	1.00E-04	10891.	19604.	8.34E+04	2.74E+05	6.92	3.17E+02	8504.	8659.
DOWNSTREAM	3.00E-05	9914.	17845.	8.51E+04	2.79E+05	7.63	8.94E+02	8676.	8808.
DOWNSTREAM	1.00E-05	9147.	16465.	8.64E+04	2.83E+05	8.28	2.33E+03	8811.	8925.

Stagnation temperature, T_t: 100 000 K; 180 000° R
Sonic flow factor, ψ: 5.69E-03 (kg)($K^{1/2}$)/(sec)(N); 1.58E+02 (lb)($^oR^{1/2}$)/(sec)(ft^2)(atm)
Mass flow per unit throat area, $\dot{W}/A^*$: 1.82E+02 kg/(sec)(m^2); 3.73+01 lb/(sec)(ft^2)

CHAMBER	1.	100000.	180000.	0	0	0	INFINITY		
THROAT	4.87E-01	75106.	135190.	4.52E+04	1.48E+05	1.00	1.00E+00	4614.	7377.
DOWNSTREAM	1.00E-01	40076.	72137.	7.02E+04	2.30E+05	2.13	1.67E+00	7156.	8101.
DOWNSTREAM	1.00E-02	19094.	34369.	8.33E+04	2.73E+05	4.22	6.37E+00	8492.	8853.
DOWNSTREAM	1.00E-03	13861.	24951.	8.96E+04	2.94E+05	5.96	3.83E+01	9135.	9352.
DOWNSTREAM	1.00E-04	11187.	20136.	9.37E+04	3.07E+05	7.45	2.65E+02	9551.	9701.
DOWNSTREAM	3.00E-05	10169.	18305.	9.53E+04	3.13E+05	8.21	7.47E+02	9717.	9844.
DOWNSTREAM	1.00E-05	9383.	16890.	9.66E+04	3.17E+05	8.90	1.95E+03	9847.	9958.

TABLE III. - Continued. CHOKED NOZZLE FLOW OF HYDROGEN IN CHEMICAL EQUILIBRIUM IN DEBYE-HÜCKEL APPROXIMATION

[E-02, E-03, E+02, E+03, etc., after numbers signify that numbers are to be multiplied by 10^{-2}, 10^{-3}, 10^{2}, 10^{3}, etc.]

(d) Stagnation pressure, 2.02650E×10^{7} N/m^{2} (200 atm)

Location	Pressure ratio, p/p_t	Temperature, T		Velocity, v		Mach number, M	Area ratio, A/A^*	Specific impulse, sec	
		K	^{o}R	m/sec	ft/sec			Ideal, $I_{sp,i}$	Vacuum, $I_{sp,v}$
Stagnation temperature, T_t: 2500 K; 4500^{o} R Sonic flow factor, ψ: 1.04E-02 (kg)(K$^{1/2}$)/(sec)(N); 2.89E+02 (lb)(^{o}R$^{1/2}$)/(sec)(ft^{2})(atm) Mass flow per unit throat area, $\dot{W}/A^*$: 4.21E+03 kg/(sec)(m^{2}); 8.62E+02 lb/(sec)(ft^{2})									
CHAMBER	1.	2500.	4500.	0	0	0	INFINITY		
THROAT	5.44E-01	2174.	3913.	3.43E+03	1.12E+04	1.00	1.00E+00	349.	616.
DOWNSTREAM	1.00E-01	1428.	2571.	6.05E+03	1.99E+04	2.14	2.02E+00	617.	716.
DOWNSTREAM	1.00E-02	763.	1373.	7.54E+03	2.47E+04	3.60	8.67E+00	759.	811.
DOWNSTREAM	1.00E-03	397.	714.	8.22E+03	2.70E+04	5.43	4.14E+01	838.	858.
Stagnation temperature, T_t: 3500 K; 6300^{o} R Sonic flow factor, ψ: 1.01E-02 (kg)(K$^{1/2}$)/(sec)(N); 2.80E+02 (lb)(^{o}R$^{1/2}$)/(sec)(ft^{2})(atm) Mass flow per unit throat area, $\dot{W}/A^*$: 3.45E+03 kg/(sec)(m^{2}); 7.07E+02 lb/(sec)(ft^{2})									
CHAMBER	1.	3500.	6300.	0	0	0	INFINITY		
THROAT	5.58E-01	3170.	5707.	4.04E+03	1.32E+04	1.00	1.00E+00	412.	746.
DOWNSTREAM	1.00E-01	2246.	4044.	7.40E+03	2.43E+04	2.14	2.13E+00	755.	883.
DOWNSTREAM	1.00E-02	1267.	2281.	9.36E+03	3.07E+04	3.51	9.51E+00	954.	1011.
DOWNSTREAM	1.00E-03	671.	1207.	1.03E+04	3.37E+04	5.23	4.59E+01	1047.	1074.
DOWNSTREAM	1.00E-04	348.	627.	1.07E+04	3.51E+04	7.55	2.28E+02	1092.	1106.
Stagnation temperature, T_t: 5000 K; 9000^{o} R Sonic flow factor, ψ: 9.15E-03 (kg)(K$^{1/2}$)/(sec)(N); 2.55E+02 (lb)(^{o}R$^{1/2}$)/(sec)(ft^{2})(atm) Mass flow per unit throat area, $\dot{W}/A^*$: 2.62E+03 kg/(sec)(m^{2}); 5.37E+02 lb/(sec)(ft^{2})									
CHAMBER	1.	5000.	9000.	0	0	0	INFINITY		
THROAT	5.65E-01	4644.	8359.	5.24E+03	1.72E+04	1.00	1.00E+00	534.	979.
DOWNSTREAM	1.00E-01	3777.	6798.	9.82E+03	3.22E+04	2.17	2.29E+00	1002.	1182.
DOWNSTREAM	1.00E-02	2900.	5220.	1.28E+04	4.21E+04	3.36	1.26E+01	1308.	1407.
DOWNSTREAM	1.00E-03	2035.	3662.	1.46E+04	4.78E+04	4.46	7.47E+01	1487.	1545.
DOWNSTREAM	1.00E-04	1148.	2066.	1.56E+04	5.11E+04	5.11	3.94E+02	1587.	1618.
DOWNSTREAM	3.00E-05	824.	1482.	1.59E+04	5.21E+04	7.31	9.23E+02	1619.	1641.
DOWNSTREAM	1.00E-05	604.	1087.	1.61E+04	5.27E+04	8.62	2.01E+03	1639.	1655.

Stagnation temperature, T_t: 6000 K; 10 800^{o} R

Sonic flow factor, ψ: 8.36E-03 (kg)($K^{1/2}$)/(sec)(N); 2.33E+02 (lb)($^{o}R^{1/2}$)/(sec)(ft^2)(atm)

Mass flow per unit throat area, $\dot{W}/A^*$: 2.19E+03 kg/(sec)(m^2); 4.48E+02 lb/(sec)(ft^2)

CHAMBER	1.	6000.	10800.	0	0	0	INFINITY		
THROAT	5.59E-01	5511.	9920.	6.39E+03	2.10E+04	1.00	1.00E+00	652.	1179.
DOWNSTREAM	1.00E-01	4445.	8001.	1.18E+04	3.88E+04	2.18	2.24E+00	1200.	1413.
DOWNSTREAM	1.00E-02	3510.	6319.	1.53E+04	5.02E+04	3.40	1.23E+01	1559.	1676.
DOWNSTREAM	1.00E-03	2856.	5141.	1.74E+04	5.72E+04	4.52	8.10E+01	1777.	1853.
DOWNSTREAM	1.00E-04	2316.	4169.	1.89E+04	6.19E+04	5.61	5.66E+02	1925.	1978.
DOWNSTREAM	3.00E-05	2013.	3623.	1.94E+04	6.38E+04	6.17	1.55E+03	1983.	2027.
DOWNSTREAM	1.00E-05	1650.	2971.	1.99E+04	6.52E+04	6.69	3.70E+03	2027.	2062.

Stagnation temperature, T_t: 7000 K; 12 600^{o} R

Sonic flow factor, ψ: 7.88E-03 (kg)($K^{1/2}$)/(sec)(N); 2.20E+02 (lb)($^{o}R^{1/2}$)/(sec)(ft^2)(atm)

Mass flow per unit throat area, $\dot{W}/A^*$: 1.91E+03 kg (sec)(m^2); 3.91E+02 lb/(sec)(ft^2)

CHAMBER	1.	7000.	12600.	0	0	0	INFINITY		
THROAT	5.49E-01	5271.	11287.	7.51E+03	2.46E+04	1.00	1.00E+00	766.	1359.
DOWNSTREAM	1.00E-01	4902.	8824.	1.35E+04	4.42E+04	2.19	2.18E+00	1374.	1610.
DOWNSTREAM	1.00E-02	3817.	6875.	1.73E+04	5.69E+04	3.45	1.18E+01	1759.	1896.
DOWNSTREAM	1.00E-03	3124.	5623.	1.97E+04	6.45E+04	4.60	7.69E+01	2005.	2089.
DOWNSTREAM	1.00E-04	2619.	4715.	2.13E+04	6.97E+04	5.71	5.48E+02	2167.	2227.
DOWNSTREAM	3.00E-05	2398.	4316.	2.19E+04	7.19E+04	6.28	1.56E+03	2233.	2284.
DOWNSTREAM	1.00E-05	2209.	3975.	2.24E+04	7.35E+04	6.80	4.08E+03	2285.	2329.

Stagnation temperature, T_t: 8000 K; 14 400^{o} R

Sonic flow factor, ψ: 7.76E-03 (kg)($K^{1/2}$)/(sec)(N); 2.16E+02 (lb)($^{o}R^{1/2}$)/(sec)(ft^2)(atm)

Mass flow per unit throat area, $\dot{W}$ A^*: 1.76E+03 kg/(sec)(m^2); 3.60E+02 lb/(sec)(ft^2)

CHAMBER	1.	8000.	14400.	0	0	0	INFINITY		
THROAT	5.37E-01	5914.	12443.	8.40E+03	2.76E+04	1.00	1.00E+00	857.	1488.
DOWNSTREAM	1.00E-01	5201.	9362.	1.47E+04	4.81E+04	2.20	2.11E+00	1495.	1743.
DOWNSTREAM	1.00E-02	3942.	7158.	1.87E+04	6.14E+04	3.51	1.13E+01	1908.	2040.
DOWNSTREAM	1.00E-03	3244.	5840.	2.11E+04	6.93E+04	4.68	7.32E+01	2153.	2239.
DOWNSTREAM	1.00E-04	2729.	4911.	2.28E+04	7.47E+04	5.81	5.22E+02	2320.	2382.
DOWNSTREAM	3.00E-05	2510.	4519.	2.34E+04	7.69E+04	6.39	1.49E+03	2389.	2441.
DOWNSTREAM	1.00E-05	2331.	4197.	2.40E+04	7.86E+04	6.91	3.92E+03	2443.	2489.

Stagnation temperature, T_t: 10 000 K; 18 000^{o} R

Sonic flow factor, ψ: 7.82E-03 (kg)($K^{1/2}$)/(sec)(N); 2.18E+02 (lb)($^{o}R^{1/2}$)/(sec)(ft^2)(atm)

Mass flow per unit throat area, $\dot{W}$ A^*: 1.58E+03 kg (sec)(m^2); 3.24E+02 lb/(sec)(ft^2)

CHAMBER	1.	10000.	18000.	0	0	0	INFINITY		
THROAT	5.15E-01	8042.	14565.	9.82E+03	3.22E+04	1.00	1.00E+00	1001.	1672.
DOWNSTREAM	1.00E-01	5606.	10071.	1.63E+04	5.34E+04	2.23	1.99E+00	1660.	1920.
DOWNSTREAM	1.00E-02	4156.	7492.	2.05E+04	6.72E+04	3.60	1.04E+01	2087.	2223.
DOWNSTREAM	1.00E-03	3358.	6044.	2.29E+04	7.52E+04	4.82	6.73E+01	2338.	2426.
DOWNSTREAM	1.00E-04	2822.	5079.	2.46E+04	8.07E+04	5.98	4.80E+02	2509.	2571.
DOWNSTREAM	3.00E-05	2600.	4681.	2.53E+04	8.30E+04	6.57	1.37E+03	2578.	2632.
DOWNSTREAM	1.00E-05	2423.	4361.	2.58E+04	8.47E+04	7.11	3.61E+03	2633.	2681.

Stagnation temperature, T_t: 12 000 K; 21 600^{o} R

Sonic flow factor, ψ: 7.73E-03 (kg)($K^{1/2}$) (sec)(N); 2.15E+02 (lb)($^{o}R^{1/2}$) (sec)(ft^2)(atm)

Mass flow per unit throat area, $\dot{W}$ A^*: 1.43E+03 kg (sec)(m^2); 2.93E+02 lb/(sec)(ft^2)

CHAMBER	1.	12000.	21600.	0	0	0	INFINITY		
THROAT	5.04E-01	9637.	17347.	1.10E+04	3.62E+04	1.00	1.00E+00	1125.	1853.
DOWNSTREAM	1.00E-01	6051.	10892.	1.78E+04	5.85E+04	2.24	1.86E+00	1818.	2087.
DOWNSTREAM	1.00E-02	4295.	7730.	2.21E+04	7.25E+04	3.71	9.45E+00	2253.	2390.
DOWNSTREAM	1.00E-03	3438.	6188.	2.46E+04	8.06E+04	4.98	6.09E+01	2505.	2593.
DOWNSTREAM	1.00E-04	2881.	5187.	2.62E+04	8.61E+04	6.17	4.33E+02	2675.	2738.
DOWNSTREAM	3.00E-05	2656.	4780.	2.69E+04	8.83E+04	6.77	1.24E+03	2745.	2799.
DOWNSTREAM	1.00E-05	2476.	4457.	2.75E+04	9.01E+04	7.32	3.27E+03	2801.	2848.

TABLE III. - Continued. CHOKED NOZZLE FLOW OF HYDROGEN IN CHEMICAL EQUILIBRIUM IN DEBYE-HÜCKEL APPROXIMATION

[E-02, E-03, E+02, E+03, etc., after numbers signify that numbers are to be multiplied by 10^{-2}, 10^{-3}, 10^{2}, 10^{3}, etc.]

(d) Concluded. Stagnation pressure, 2.02650E+10^{7} N/m^2 (200 atm)

Location	Pressure ratio, p/p_t	Temperature, T		Velocity, v		Mach number, M	Area ratio, A/A^*	Specific impulse, sec	
		K	^{o}R	m/sec	ft/sec			Ideal, $I_{sp,i}$	Vacuum, $I_{sp,v}$
Stagnation temperature, T_t: 14 000 K; 25 200^{o} R Sonic flow factor, ψ: 7.43E-03 (kg)($K^{1/2}$)/(sec)(N); 2.07E+02 (lb)($^{o}R^{1/2}$)/(sec)(ft^2)(atm) Mass flow per unit throat area, $\dot{W}/A^*$: 1.27E+03 kg/(sec)(m^2); 2.61E+02 lb/(sec)(ft^2)									
CHAMBER	1.	14000.	25200.	0	0	0	INFINITY		
THROAT	5.23E-01	11882.	21388.	1.18E+04	3.89E+04	1.00	1.00E+00	1208.	2056.
DOWNSTREAM	1.00E-01	5938.	12488.	1.98E+04	6.49E+04	2.15	1.78E+00	2016.	2305.
DOWNSTREAM	1.00E-02	4473.	8051.	2.42E+04	7.93E+04	3.85	8.44E+00	2455.	2602.
DOWNSTREAM	1.00E-03	3526.	6347.	2.66E+04	8.74E+04	5.18	5.39E+01	2716.	2803.
DOWNSTREAM	1.00E-04	2943.	5297.	2.83E+04	9.28E+04	6.42	3.33E+02	2885.	2948.
DOWNSTREAM	3.00E-05	2711.	4879.	2.90E+04	9.51E+04	7.05	1.10E+03	2955.	3008.
DOWNSTREAM	1.00E-05	2528.	4550.	2.95E+04	9.68E+04	7.61	2.89E+03	3010.	3056.
Stagnation temperature, T_t: 16 000 K; 28 800^{o} R Sonic flow factor, ψ: 7.14E-03 (kg)($K^{1/2}$)/(sec)(N); 1.99E+02 (lb)($^{o}R^{1/2}$)/(sec)(ft^2)(atm) Mass flow per unit throat area, $\dot{W}/A^*$: 1.14E+03 kg/(sec)(m^2); 2.34E+02 lb/(sec)(ft^2)									
CHAMBER	1.	16000.	28800.	0	0	0	INFINITY		
THROAT	5.44E-01	14255.	25659.	1.26E+04	4.12E+04	1.00	1.00E+00	1281.	2267.
DOWNSTREAM	1.00E-01	9111.	16399.	2.22E+04	7.27E+04	2.06	1.91E+00	2259.	2605.
DOWNSTREAM	1.00E-02	4798.	8636.	2.70E+04	8.87E+04	3.95	7.74E+00	2757.	2897.
DOWNSTREAM	1.00E-03	3647.	6565.	2.95E+04	9.68E+04	5.45	4.81E+01	3009.	3096.
DOWNSTREAM	1.00E-04	3019.	5434.	3.12E+04	1.02E+05	6.75	3.40E+02	3177.	3238.
DOWNSTREAM	3.00E-05	2776.	4997.	3.18E+04	1.04E+05	7.42	9.71E+02	3245.	3298.
DOWNSTREAM	1.00E-05	2587.	4656.	3.24E+04	1.06E+05	8.02	2.55E+03	3299.	3346.
Stagnation temperature, T_t: 18 000 K; 32 400^{o} R Sonic flow factor, ψ: 6.90E-03 (kg)($K^{1/2}$)/(sec)(N); 1.92E+02 (lb)($^{o}R^{1/2}$)/(sec)(ft^2)(atm) Mass flow per unit throat area, $\dot{W}/A^*$: 1.04E+03 kg/(sec)(m^2); 2.13E+02 lb/(sec)(ft^2)									
CHAMBER	1.	18000.	32400.	0	0	0	INFINITY		
THROAT	5.57E-01	16372.	29469.	1.35E+04	4.43E+04	1.00	1.00E+00	1378.	2482.
DOWNSTREAM	1.00E-01	11998.	21596.	2.46E+04	8.07E+04	2.13	2.11E+00	2509.	2928.
DOWNSTREAM	1.00E-02	5846.	10522.	3.07E+04	1.01E+05	3.51	8.00E+00	3130.	3289.
DOWNSTREAM	1.00E-03	3841.	6914.	3.33E+04	1.09E+05	5.72	4.41E+01	3395.	3482.
DOWNSTREAM	1.00E-04	3118.	5612.	3.49E+04	1.15E+05	7.18	3.07E+02	3562.	3622.
DOWNSTREAM	3.00E-05	2856.	5142.	3.56E+04	1.17E+05	7.89	8.73E+02	3629.	3681.
DOWNSTREAM	1.00E-05	2657.	4783.	3.61E+04	1.18E+05	8.52	2.30E+03	3683.	3728.

Stagnation temperature, T_t: 25 000 K; 45 000° R

Sonic flow factor, ψ: 6.08E-03 (kg)($K^{1/2}$)/(sec)(N); 1.69E+02 (lb)($^{\circ}R^{1/2}$)/(sec)(ft^2)(atm)

Mass flow per unit throat area, $\dot{W}/A^*$: 7.79E+02 kg/(sec)(m^2); 1.60E+02 lb/(sec)(ft^2)

CHAMBER	1.	25000.	45000.	0	0	0	INFINITY		
THROAT	5.58E-01	22701.	40861.	1.82E+04	5.98E+04	1.00	1.00E+00	1859.	3339.
DOWNSTREAM	1.00E-01	17758.	31964.	3.33E+04	1.09E+05	2.19	2.19E+00	3396.	3977.
DOWNSTREAM	1.00E-02	13401.	24121.	4.28E+04	1.40E+05	3.46	1.15E+01	4366.	4671.
DOWNSTREAM	1.00E-03	10159.	18286.	4.82E+04	1.58E+05	4.68	7.05E+01	4919.	5106.
DOWNSTREAM	1.00E-04	6278.	11301.	5.15E+04	1.69E+05	5.72	3.87E+02	5254.	5356.
DOWNSTREAM	3.00E-05	3972.	7149.	5.25E+04	1.72E+05	7.41	7.98E+02	5352.	5415.
DOWNSTREAM	1.00E-05	3135.	5642.	5.31E+04	1.74E+05	9.70	1.81E+03	5412.	5460.

Stagnation temperature, T_t: 35 000 K; 63 000° R

Sonic flow factor, ψ: 5.70E-03 (kg)($K^{1/2}$)/(sec)(N); 1.59E+02 (lb)($^{\circ}R^{1/2}$)/(sec)(ft^2)(atm)

Mass flow per unit throat area, $\dot{W}/A^*$: 6.17E+02 kg/(sec)(m^2); 1.26E+02 lb/(sec)(ft^2)

CHAMBER	1.	35000.	63000.	0	0	0	INFINITY		
THROAT	5.31E-01	29533.	53160.	2.45E+04	8.05E+04	1.00	1.00E+00	2501.	4281.
DOWNSTREAM	1.00E-01	21366.	38459.	4.21E+04	1.38E+05	2.22	2.05E+00	4290.	4978.
DOWNSTREAM	1.00E-02	15738.	28328.	5.32E+04	1.75E+05	3.58	1.06E+01	5426.	5780.
DOWNSTREAM	1.00E-03	12371.	22268.	5.96E+04	1.95E+05	4.84	6.64E+01	6074.	6297.
DOWNSTREAM	1.00E-04	9997.	17994.	6.37E+04	2.09E+05	6.10	4.53E+02	6498.	6650.
DOWNSTREAM	3.00E-05	8958.	16125.	6.54E+04	2.14E+05	6.77	1.26E+03	6665.	6791.
DOWNSTREAM	1.00E-05	8049.	14488.	6.66E+04	2.19E+05	7.40	3.20E+03	6793.	6900.

Stagnation temperature, T_t: 50 000 K; 90 000° R

Sonic flow factor, ψ: 5.73E-03 (kg)($K^{1/2}$)/(sec)(N); 1.60E+02 (lb)($^{\circ}R^{1/2}$)/(sec)(ft^2)(atm)

Mass flow per unit throat area, $\dot{W}/A^*$: 5.19E+02 kg/(sec)(m^2); 1.06E+02 lb/(sec)(ft^2)

CHAMBER	1.	50000.	90000.	0	0	0	INFINITY		
THROAT	4.98E-01	38627.	69528.	3.12E+04	1.02E+05	1.00	1.00E+00	3178.	5159.
DOWNSTREAM	1.00E-01	24437.	43987.	4.97E+04	1.63E+05	2.25	1.86E+00	5069.	5809.
DOWNSTREAM	1.00E-02	16943.	30498.	6.14E+04	2.02E+05	3.75	9.25E+00	6264.	6632.
DOWNSTREAM	1.00E-03	13165.	23696.	6.80E+04	2.23E+05	5.08	5.77E+01	6935.	7165.
DOWNSTREAM	1.00E-04	10696.	19253.	7.23E+04	2.37E+05	6.39	3.96E+02	7374.	7531.
DOWNSTREAM	3.00E-05	9685.	17434.	7.40E+04	2.43E+05	7.07	1.11E+03	7547.	7680.
DOWNSTREAM	1.00E-05	8870.	15966.	7.53E+04	2.47E+05	7.71	2.86E+03	7682.	7796.

Stagnation temperature, T_t: 75 000 K; 135 000° R

Sonic flow factor, ψ: 5.71E-03 (kg)($K^{1/2}$)/(sec)(N); 1.59E+02 (lb)($^{\circ}R^{1/2}$)/(sec)(ft^2)(atm)

Mass flow per unit throat area, $\dot{W}/A^*$: 4.23E+02 kg/(sec)(m^2); 8.66E+01 lb/(sec)(ft^2)

CHAMBER	1.	75000.	135000.	0	0	0	INFINITY		
THROAT	4.88E-01	55481.	101665.	3.90E+04	1.28E+05	1.00	1.00E+00	3975.	6359.
DOWNSTREAM	1.00E-01	31051.	55892.	6.06E+04	1.99E+05	2.18	1.69E+00	6177.	7004.
DOWNSTREAM	1.00E-02	18353.	33035.	7.28E+04	2.39E+05	4.02	7.54E+00	7428.	7797.
DOWNSTREAM	1.00E-03	13875.	24976.	7.94E+04	2.60E+05	5.50	4.64E+01	8095.	8322.
DOWNSTREAM	1.00E-04	11220.	20195.	8.36E+04	2.74E+05	5.90	3.19E+02	8528.	8684.
DOWNSTREAM	3.00E-05	10175.	18316.	8.53E+04	2.80E+05	7.63	8.95E+02	8701.	8832.
DOWNSTREAM	1.00E-05	9357.	16843.	8.66E+04	2.84E+05	8.30	2.32E+03	8835.	8949.

Stagnation temperature, T_t: 100 000 K; 180 000° R

Sonic flow factor, ψ: 5.70E-03 (kg)($K^{1/2}$)/(sec)(N); 1.59E+02 (lb)($^{\circ}R^{1/2}$)/(sec)(ft^2)(atm)

Mass flow per unit throat area, $\dot{W}/A^*$: 3.65E+02 kg/(sec)(m^2); 7.49E+01 lb/(sec)(ft^2)

CHAMBER	1.	100000.	180000.	0	0	0	INFINITY		
THROAT	4.88E-01	75196.	135354.	4.52E+04	1.48E+05	1.00	1.00E+00	4609.	7370.
DOWNSTREAM	1.00E-01	40210.	72378.	7.01E+04	2.30E+05	2.14	1.67E+00	7152.	8097.
DOWNSTREAM	1.00E-02	19838.	35709.	8.33E+04	2.73E+05	4.20	6.52E+00	8499.	8867.
DOWNSTREAM	1.00E-03	14404.	25928.	8.98E+04	2.95E+05	5.90	3.91E+01	9154.	9375.
DOWNSTREAM	1.00E-04	11552.	20794.	9.39E+04	3.08E+05	7.41	2.68E+02	9575.	9728.
DOWNSTREAM	3.00E-05	10468.	18842.	9.56E+04	3.13E+05	8.18	7.53E+02	9744.	9871.
DOWNSTREAM	1.00E-05	9630.	17334.	9.68E+04	3.18E+05	8.89	1.95E+03	9874.	9985.

TABLE III. - Continued. CHOKED NOZZLE FLOW OF HYDROGEN IN CHEMICAL EQUILIBRIUM IN DEBYE-HÜCKEL APPROXIMATION

[E-02, E-03, E+02, E+03, etc., after numbers signify that numbers are to be multiplied by 10^{-2}, 10^{-3}, 10^{2}, 10^{3}, etc.]

(e) Stagnation pressure, 5.06625E×10^{7} N/m^{2} (500 atm)

Location	Pressure ratio, p/p_t	Temperature, T		Velocity, v		Mach number, M	Area ratio, A/A^*	Specific impulse, sec	
		K	^{o}R	m/sec	ft/sec			Idea., $I_{sp,i}$	Vacuum, $I_{sp,v}$
Stagnation temperature, T_t: 2500 K; 4500^{o} R Sonic flow factor, ψ: 1.04E-02 (kg)(K$^{1/2}$)/(sec)(N); 2.89E+02 (lb)(^{o}R$^{1/2}$)/(sec)(ft^{2})(atm) Mass flow per unit throat area, $\dot{W}/A^*$: 1.05E+04 kg/(sec)(m^{2}); 2.16E+03 lb/(sec)(ft^{2})									
CHAMBER	1.	2500.	4500.	0	0	0	INFINITY		
THROAT	5.44E-01	2171.	3908.	3.43E+03	1.12E+04	1.00	1.00E+00	349.	616.
DOWNSTREAM	1.00E-01	1426.	2566.	6.05E+03	1.98E+04	2.15	2.02E+00	617.	716.
DOWNSTREAM	1.00E-02	761.	1370.	7.53E+03	2.47E+04	3.61	8.66E+00	768.	811.
DOWNSTREAM	1.00E-03	396.	713.	8.21E+03	2.69E+04	5.43	4.14E+01	837.	857.
Stagnation temperature, T_t: 3500 K; 6300^{o} R Sonic flow factor, ψ: 1.02E-02 (kg)(K$^{1/2}$)/(sec)(N); 2.83E+02 (lb)(^{o}R$^{1/2}$)/(sec)(ft^{2})(atm) Mass flow per unit throat area, $\dot{W}/A^*$: 8.70E+03 kg/(sec)(m^{2}); 1.78E+03 lb/(sec)(ft^{2})									
CHAMBER	1.	3500.	6300.	0	0	0	INFINITY		
THROAT	5.55E-01	3139.	5651.	4.04E+03	1.32E+04	1.00	1.00E+00	412.	741.
DOWNSTREAM	1.00E-01	2181.	3926.	7.34E+03	2.41E+04	2.14	2.11E+00	748.	873.
DOWNSTREAM	1.00E-02	1222.	2199.	9.24E+03	3.03E+04	3.52	9.36E+00	943.	998.
DOWNSTREAM	1.00E-03	645.	1161.	1.01E+04	3.32E+04	5.25	4.51E+01	1033.	1060.
DOWNSTREAM	1.00E-04	335.	603.	1.06E+04	3.47E+04	7.59	2.25E+02	1078.	1091.
Stagnation temperature, T_t: 5000 K; 9000^{o} R Sonic flow factor, ψ: 9.48E-03 (kg)(K$^{1/2}$)/(sec)(N); 2.64E+02 (lb)(^{o}R$^{1/2}$)/(sec)(ft^{2})(atm) Mass flow per unit throat area, $\dot{W}/A^*$: 6.79E+03 kg/(sec)(m^{2}); 1.39E+03 lb/(sec)(ft^{2})									
CHAMBER	1.	5000.	9000.	0	0	0	INFINITY		
THROAT	5.64E-01	4618.	8313.	5.07E+03	1.66E+04	1.00	1.00E+00	517.	946.
DOWNSTREAM	1.00E-01	3674.	6613.	9.48E+03	3.11E+04	2.17	2.27E+00	956.	1139.
DOWNSTREAM	1.00E-02	2635.	4742.	1.23E+04	4.04E+04	3.36	1.19E+01	1255.	1346.
DOWNSTREAM	1.00E-03	1595.	2872.	1.38E+04	4.54E+04	4.66	6.37E+01	1412.	1460.
DOWNSTREAM	1.00E-04	861.	1549.	1.46E+04	4.80E+04	6.60	3.25E+02	1493.	1518.
DOWNSTREAM	3.00E-05	613.	1103.	1.49E+04	4.89E+04	7.93	7.58E+02	1518.	1536.
DOWNSTREAM	1.00E-05	449.	808.	1.50E+04	4.94E+04	9.35	1.65E+03	1535.	1547.
DOWNSTREAM	3.00E-06	318.	573.	1.52E+04	4.98E+04	11.18	3.86E+03	1547.	1556.

Stagnation temperature, T_t: 6000 K; 10 800° R
Sonic flow factor, ψ: 8.81E-03 (kg)($K^{1/2}$)/(sec)(N); 2.45E+02 (lb)($^oR^{1/2}$)/(sec)(ft^2)(atm)
Mass flow per unit throat area, $\dot{W}/A^*$: 5.76E+03 kg/(sec)(m^2); 1.18E+03 lb/(sec)(ft^2)

CHAMBER	1.	5000.	10800.	0	0	0	INFINITY		
THROAT	5.59E-01	5512.	9922.	6.04E+03	1.98E+04	1.00	1.00E+00	616.	1117.
DOWNSTREAM	1.00E-01	4416.	7949.	1.12E+04	3.66E+04	2.18	2.25E+00	1138.	1340.
DOWNSTREAM	1.00E-02	3423.	6161.	1.45E+04	4.76E+04	3.40	1.23E+01	1479.	1589.
DOWNSTREAM	1.00E-03	2668.	4802.	1.65E+04	5.41E+04	4.53	7.86E+01	1682.	1753.
DOWNSTREAM	1.00E-04	1851.	3332.	1.78E+04	5.83E+04	5.66	4.89E+02	1813.	1857.
DOWNSTREAM	3.00E-05	1376.	2477.	1.82E+04	5.98E+04	6.57	1.18E+03	1858.	1890.
DOWNSTREAM	1.00E-05	1025.	1845.	1.85E+04	6.08E+04	7.67	2.63E+03	1888.	1912.
DOWNSTREAM	3.00E-06	733.	1319.	1.87E+04	6.15E+04	9.14	6.11E+03	1912.	1928.

Stagnation temperature, T_t: 7000 K; 12 600° R
Sonic flow factor, ψ: 8.24E-03 (kg)($K^{1/2}$)/(sec)(N); 2.29E+02 (lb)($^oR^{1/2}$)/(sec)(ft^2)(atm)
Mass flow per unit throat area, $\dot{W}/A^*$: 4.99E+03 kg/(sec)(m^2); 1.02E+03 lb/(sec)(ft^2)

CHAMBER	1.	7000.	12600.	0	0	0	INFINITY		
THROAT	5.51E-01	6325.	11384.	7.12E+03	2.34E+04	1.00	1.00E+00	726.	1297.
DOWNSTREAM	1.00E-01	4966.	8939.	1.29E+04	4.23E+04	2.19	2.19E+00	1314.	1541.
DOWNSTREAM	1.00E-02	3843.	6917.	1.66E+04	5.45E+04	3.44	1.18E+01	1694.	1817.
DOWNSTREAM	1.00E-03	3100.	5581.	1.88E+04	6.18E+04	4.60	7.68E+01	1921.	2000.
DOWNSTREAM	1.00E-04	2533.	4560.	2.03E+04	6.67E+04	5.72	5.39E+02	2075.	2130.
DOWNSTREAM	3.00E-05	2256.	4062.	2.09E+04	6.87E+04	6.31	1.50E+03	2136.	2183.
DOWNSTREAM	1.00E-05	1973.	3551.	2.14E+04	7.02E+04	6.84	3.78E+03	2183.	2222.
DOWNSTREAM	3.00E-06	1562.	2811.	2.18E+04	7.16E+04	7.48	9.70E+03	2225.	2255.

Stagnation temperature, T_t: 8000 K; 14 400° R
Sonic flow factor, ψ: 7.94E-03 (kg)($K^{1/2}$)/(sec)(N); 2.21E+02 (lb)($^oR^{1/2}$)/(sec)(ft^2)(atm)
Mass flow per unit throat area, $\dot{W}/A^*$: 4.50E+03 kg/(sec)(m^2); 9.21E+02 lb/(sec)(ft^2)

CHAMBER	1.	8000.	14400.	0	0	0	INFINITY		
THROAT	5.42E-01	7045.	12682.	8.10E+03	2.66E+04	1.00	1.00E+00	826.	1449.
DOWNSTREAM	1.00E-01	5364.	9654.	1.43E+04	4.69E+04	2.20	2.13E+00	1458.	1703.
DOWNSTREAM	1.00E-02	4089.	7359.	1.83E+04	6.00E+04	3.49	1.13E+01	1865.	1995.
DOWNSTREAM	1.00E-03	3300.	5939.	2.06E+04	6.77E+04	4.68	7.31E+01	2105.	2189.
DOWNSTREAM	1.00E-04	2740.	4932.	2.22E+04	7.30E+04	5.82	5.17E+02	2268.	2327.
DOWNSTREAM	3.00E-05	2498.	4496.	2.29E+04	7.51E+04	6.42	1.47E+03	2334.	2384.
DOWNSTREAM	1.00E-05	2291.	4124.	2.34E+04	7.67E+04	6.96	3.82E+03	2385.	2429.
DOWNSTREAM	3.00E-06	2066.	3718.	2.39E+04	7.83E+04	7.56	1.09E+04	2434.	2472.

Stagnation temperature, T_t: 10 000 K; 18 000° R
Sonic flow factor, ψ: 7.83E-03 (kg)($K^{1/2}$)/(sec)(N); 2.18E+02 (lb)($^oR^{1/2}$)/(sec)(ft^2)(atm)
Mass flow per unit throat area, $\dot{W}/A^*$: 3.97E+03 kg/(sec)(m^2); 8.13E+02 lb/(sec)(ft^2)

CHAMBER	1.	10000.	18000.	0	0	0	INFINITY		
THROAT	5.22E-01	8295.	14931.	9.63E+03	3.16E+04	1.00	1.00E+00	982.	1662.
DOWNSTREAM	1.00E-01	5884.	10592.	1.62E+04	5.32E+04	2.22	2.02E+00	1554.	1917.
DOWNSTREAM	1.00E-02	4343.	7818.	2.05E+04	6.71E+04	3.59	1.05E+01	2096.	2222.
DOWNSTREAM	1.00E-03	3477.	6258.	2.29E+04	7.52E+04	4.83	6.70E+01	2336.	2423.
DOWNSTREAM	1.00E-04	2895.	5211.	2.46E+04	8.06E+04	5.00	4.74E+02	2505.	2566.
DOWNSTREAM	3.00E-05	2654.	4777.	2.52E+04	8.28E+04	6.61	1.35E+03	2573.	2626.
DOWNSTREAM	1.00E-05	2460.	4427.	2.58E+04	8.45E+04	7.15	3.54E+03	2627.	2673.
DOWNSTREAM	3.00E-06	2266.	4078.	2.63E+04	8.62E+04	7.77	1.03E+04	2679.	2719.

Stagnation temperature, T_t: 12 000 K; 21 600° R
Sonic flow factor, ψ: 7.80E-03 (kg)($K^{1/2}$)/(sec)(N); 2.17E+02 (lb)($^oR^{1/2}$)/(sec)(ft^2)(atm)
Mass flow per unit throat area, $\dot{W}/A^*$: 3.61E+03 kg/(sec)(m^2); 7.39E+02 lb/(sec)(ft^2)

CHAMBER	1.	12000.	21600.	0	0	0	INFINITY		
THROAT	5.08E-01	9663.	17394.	1.09E+04	3.57E+04	1.00	1.00E+00	1110.	1838.
DOWNSTREAM	1.00E-01	6327.	11389.	1.78E+04	5.83E+04	2.23	1.91E+00	1811.	2085.
DOWNSTREAM	1.00E-02	4506.	8110.	2.21E+04	7.25E+04	3.68	9.66E+00	2253.	2392.
DOWNSTREAM	1.00E-03	3576.	6436.	2.46E+04	8.07E+04	4.96	6.16E+01	2507.	2595.
DOWNSTREAM	1.00E-04	2972.	5349.	2.63E+04	8.61E+04	6.18	4.34E+02	2677.	2740.
DOWNSTREAM	3.00E-05	2727.	4909.	2.69E+04	8.84E+04	6.80	1.24E+03	2747.	2800.
DOWNSTREAM	1.00E-05	2532.	4558.	2.75E+04	9.01E+04	7.36	3.25E+03	2801.	2848.
DOWNSTREAM	3.00E-06	2342.	4215.	2.80E+04	9.18E+04	7.97	9.44E+03	2854.	2894.

TABLE III. - Continued. CHOKED NOZZLE FLOW OF HYDROGEN IN CHEMICAL EQUILIBRIUM IN DEBYE-HÜCKEL APPROXIMATION

[E-02, E-03, E+02, E+03, etc., after numbers signify that numbers are to be multiplied by 10^{-2}, 10^{-3}, 10^{2}, 10^{3}, etc.]

(e) Concluded. Stagnation pressure, $5.06625E{\times}10^{7}$ N/m^2 (500 atm)

Location	Pressure ratio, p/p_t	Temperature, T		Velocity, v		Mach number, M	Area ratio, A/A^*	Specific impulse, sec	
		K	^{o}R	m/sec	ft/sec			Ideal, $I_{sp,i}$	Vacuum, $I_{sp,v}$
Stagnation temperature, T_t: 14 000 K; 25 200^{o} R Sonic flow factor, ψ: 7.59E-03 (kg)(K$^{1/2}$)/(sec)(N); 2.11E+02 (lb)(^{o}R$^{1/2}$)/(sec)(ft^2)(atm) Mass flow per unit throat area, $\dot{W}/A^*$: 3.25E+03 kg/(sec)(m^2); 6.65E+02 lb/(sec)(ft^2)									
CHAMBER	1.	14000.	25200.	0	0	0	INFINITY		
THROAT	5.13E-01	11577.	20838.	1.19E+04	3.89E+04	1.00	1.00E+00	1210.	2026.
DOWNSTREAM	1.00E-01	6975.	12554.	1.95E+04	6.39E+04	2.21	1.81E+00	1985.	2273.
DOWNSTREAM	1.00E-02	4676.	8417.	2.39E+04	7.85E+04	3.79	8.77E+00	2439.	2579.
DOWNSTREAM	1.00E-03	3667.	6600.	2.64E+04	8.67E+04	5.13	5.55E+01	2694.	2782.
DOWNSTREAM	1.00E-04	3038.	5468.	2.81E+04	9.22E+04	6.38	3.91E+02	2854.	2927.
DOWNSTREAM	3.00E-05	2787.	5017.	2.88E+04	9.44E+04	7.02	1.11E+03	2934.	2987.
DOWNSTREAM	1.00E-05	2590.	4662.	2.93E+04	9.61E+04	7.60	2.92E+03	2988.	3035.
DOWNSTREAM	3.00E-06	2399.	4318.	2.98E+04	9.78E+04	8.23	8.51E+03	3041.	3081.
Stagnation temperature, T_t: 16 000 K; 28 800^{o} R Sonic flow factor, ψ: 7.30E-03 (kg)(K$^{1/2}$)/(sec)(N); 2.03E+02 (lb)(^{o}R$^{1/2}$)/(sec)(ft^2)(atm) Mass flow per unit throat area, $\dot{W}/A^*$: 2.92E+03 kg/(sec)(m^2); 5.99E+02 lb/(sec)(ft^2)									
CHAMBER	1.	16000.	28800.	0	0	0	INFINITY		
THROAT	5.35E-01	13922.	25059.	1.26E+04	4.12E+04	1.00	1.00E+00	1281.	2227.
DOWNSTREAM	1.00E-01	8356.	15041.	2.16E+04	7.07E+04	2.10	1.82E+00	2138.	2520.
DOWNSTREAM	1.00E-02	4922.	8860.	2.63E+04	8.62E+04	3.90	8.01E+00	2679.	2820.
DOWNSTREAM	1.00E-03	3776.	6797.	2.88E+04	9.44E+04	5.34	4.99E+01	2935.	3023.
DOWNSTREAM	1.00E-04	3110.	5599.	3.04E+04	9.99E+04	6.66	3.50E+02	3104.	3166.
DOWNSTREAM	3.00E-05	2851.	5132.	3.11E+04	1.02E+05	7.32	9.96E+02	3173.	3226.
DOWNSTREAM	1.00E-05	2649.	4768.	3.16E+04	1.04E+05	7.92	2.62E+03	3227.	3273.
DOWNSTREAM	3.00E-06	2456.	4421.	3.22E+04	1.06E+05	8.57	7.62E+03	3279.	3320.
Stagnation temperature, T_t: 18 000 K; 32 400^{o} R Sonic flow factor, ψ: 7.08E-03 (kg)(K$^{1/2}$)/(sec)(N); 1.97E+02 (lb)(^{o}R$^{1/2}$)/(sec)(ft^2)(atm) Mass flow per unit throat area, $\dot{W}/A^*$: 2.67E+03 kg/(sec)(m^2); 5.48E+02 lb/(sec)(ft^2)									
CHAMBER	1.	18000.	32400.	0	0	0	INFINITY		
THROAT	5.50E-01	15121.	29018.	1.33E+04	4.38E+04	1.00	1.00E+00	1351.	2424.
DOWNSTREAM	1.00E-01	10863.	19554.	2.38E+04	7.82E+04	2.08	1.99E+00	2430.	2815.
DOWNSTREAM	1.00E-02	5392.	9706.	2.92E+04	9.59E+04	3.90	7.66E+00	2982.	3130.
DOWNSTREAM	1.00E-03	3923.	7061.	3.18E+04	1.04E+05	5.58	4.57E+01	3242.	3330.
DOWNSTREAM	1.00E-04	3196.	5753.	3.34E+04	1.10E+05	6.99	3.18E+02	3411.	3472.
DOWNSTREAM	3.00E-05	2924.	5263.	3.41E+04	1.12E+05	7.69	9.02E+02	3479.	3531.
DOWNSTREAM	1.00E-05	2714.	4885.	3.46E+04	1.14E+05	8.32	2.37E+03	3533.	3579.
DOWNSTREAM	3.00E-06	2516.	4528.	3.52E+04	1.15E+05	9.00	6.90E+03	3584.	3624.

Stagnation temperature, T_t: 25 000 K; 45 000° R
Sonic flow factor, ψ: 6.38E-03 (kg)($K^{1/2}$)/(sec)(N); 1.78E+02 (lb)($^{\circ}R^{1/2}$)/(sec)(ft^2)(atm)
Mass flow per unit throat area, $\dot{W}/A^*$: 2.04E+03 kg/(sec)(m^2); 4.18E+02 lb/(sec)(ft^2)

CHAMBER	1.	25000.	45000.	0	0	0	INFINITY		
THROAT	5.59E-01	22702.	40864.	1.73E+04	5.68E+04	1.00	1.00E+00	1757.	3181.
DOWNSTREAM	1.00E-01	17583.	31650.	3.17E+04	1.04E+05	2.19	2.19E+00	3234.	3787.
DOWNSTREAM	1.00E-02	12775.	22995.	4.07E+04	1.33E+05	3.46	1.12E+01	4147.	4431.
DOWNSTREAM	1.00E-03	8183.	14729.	4.55E+04	1.49E+05	4.59	6.01E+01	4640.	4792.
DOWNSTREAM	1.00E-04	3897.	7014.	4.78E+04	1.57E+05	7.57	2.64E+02	4873.	4940.
DOWNSTREAM	3.00E-05	3334.	6000.	4.85E+04	1.59E+05	8.89	7.05E+02	4945.	4999.
DOWNSTREAM	1.00E-05	3021.	5438.	4.90E+04	1.61E+05	9.79	1.81E+03	4999.	5045.
DOWNSTREAM	3.00E-06	2763.	4974.	4.95E+04	1.62E+05	10.69	5.19E+03	5050.	5090.

Stagnation temperature, T_t: 35 000 K; 63 000° R
Sonic flow factor, ψ: 5.83E-03 (kg)($K^{1/2}$)/(sec)(N); 1.62E+02 (lb)($^{\circ}R^{1/2}$)/(sec)(ft^2)(atm)
Mass flow per unit throat area, $\dot{W}/A^*$: 1.58E+03 kg/(sec)(m^2); 3.23E+02 lb/(sec)(ft^2)

CHAMBER	1.	35000.	63000.	0	0	0	INFINITY		
THROAT	5.38E-01	30123.	54222.	2.37E+04	7.76E+04	1.00	1.00E+00	2413.	4173.
DOWNSTREAM	1.00E-01	22073.	39731.	4.11E+04	1.35E+05	2.22	2.07E+00	4195.	4873.
DOWNSTREAM	1.00E-02	16171.	29108.	5.21E+04	1.71E+05	3.56	1.06E+01	5314.	5663.
DOWNSTREAM	1.00E-03	12527.	22548.	5.83E+04	1.91E+05	4.84	6.59E+01	5948.	6164.
DOWNSTREAM	1.00E-04	9845.	17721.	6.23E+04	2.04E+05	6.14	4.40E+02	6355.	6499.
DOWNSTREAM	3.00E-05	8548.	15386.	6.39E+04	2.10E+05	6.83	1.19E+03	6512.	6629.
DOWNSTREAM	1.00E-05	7127.	12828.	6.50E+04	2.13E+05	7.35	2.84E+03	6627.	6720.
DOWNSTREAM	3.00E-06	4812.	8662.	6.59E+04	2.16E+05	8.11	6.25E+03	6721.	6782.

Stagnation temperature, T_t: 50 000 K; 90 000° R
Sonic flow factor, ψ: 5.77E-03 (kg)($K^{1/2}$)/(sec)(N); 1.61E+02 (lb)($^{\circ}R^{1/2}$)/(sec)(ft^2)(atm)
Mass flow per unit throat area, $\dot{W}/A^*$: 1.31E+03 kg/(sec)(m^2); 2.68E+02 lb/(sec)(ft^2)

CHAMBER	1.	50000.	90000.	0	0	0	INFINITY		
THROAT	5.05E-01	39372.	70870.	3.06E+04	1.01E+05	1.00	1.00E+00	3125.	5120.
DOWNSTREAM	1.00E-01	25654.	46177.	4.95E+04	1.62E+05	2.25	1.89E+00	5050.	5799.
DOWNSTREAM	1.00E-02	17793.	32027.	6.14E+04	2.01E+05	3.72	9.38E+00	6260.	6631.
DOWNSTREAM	1.00E-03	13684.	24631.	6.80E+04	2.23E+05	5.08	5.79E+01	6933.	7162.
DOWNSTREAM	1.00E-04	10981.	19765.	7.23E+04	2.37E+05	6.41	3.93E+02	7368.	7523.
DOWNSTREAM	3.00E-05	9861.	17750.	7.39E+04	2.43E+05	7.12	1.09E+03	7538.	7668.
DOWNSTREAM	1.00E-05	8941.	16094.	7.52E+04	2.47E+05	7.78	2.79E+03	7670.	7780.
DOWNSTREAM	3.00E-06	7978.	14361.	7.64E+04	2.51E+05	8.52	7.83E+03	7792.	7885.

Stagnation temperature, T_t: 75 000 K; 135 000° R
Sonic flow factor, ψ: 5.74E-03 (kg)($K^{1/2}$)/(sec)(N); 1.60E+02 (lb)($^{\circ}R^{1/2}$)/(sec)(ft^2)(atm)
Mass flow per unit throat area, $\dot{W}/A^*$: 1.06E+03 kg/(sec)(m^2); 2.17E+02 lb/(sec)(ft^2)

CHAMBER	1.	75000.	135000.	0	0	0	INFINITY		
THROAT	4.88E-01	55684.	102030.	3.88E+04	1.27E+05	1.00	1.00E+00	3956.	6334.
DOWNSTREAM	1.00E-01	31903.	57425.	6.04E+04	1.98E+05	2.20	1.71E+00	6160.	6994.
DOWNSTREAM	1.00E-02	19397.	34915.	7.29E+04	2.39E+05	3.97	7.74E+00	7436.	7813.
DOWNSTREAM	1.00E-03	14552.	26193.	7.95E+04	2.61E+05	5.46	4.72E+01	8115.	8345.
DOWNSTREAM	1.00E-04	11651.	20971.	8.33E+04	2.75E+05	6.89	3.20E+02	8552.	8708.
DOWNSTREAM	3.00E-05	10509.	18916.	8.56E+04	2.81E+05	7.64	8.94E+02	8724.	8855.
DOWNSTREAM	1.00E-05	9611.	17300.	8.69E+04	2.85E+05	8.33	2.31E+03	8857.	8969.
DOWNSTREAM	3.00E-06	8739.	15731.	8.81E+04	2.89E+05	9.09	6.56E+03	8982.	9078.

Stagnation temperature, T_t: 100 000 K; 180 000° R
Sonic flow factor, ψ: 5.72E-03 (kg)($K^{1/2}$)/(sec)(N); 1.59E+02 (lb)($^{\circ}R^{1/2}$)/(sec)(ft^2)(atm)
Mass flow per unit throat area, $\dot{W}/A^*$: 9.17E+02 kg/(sec)(m^2); 1.88E+02 lb/(sec)(ft^2)

CHAMBER	1.	100000.	180000.	0	0	0	INFINITY		
THROAT	4.89E-01	75305.	135549.	4.51E+04	1.48E+05	1.00	1.00E+00	4599.	7353.
DOWNSTREAM	1.00E-01	40536.	72965.	7.00E+04	2.30E+05	2.15	1.67E+00	7137.	8081.
DOWNSTREAM	1.00E-02	20926.	37667.	8.34E+04	2.73E+05	4.15	6.73E+00	8500.	8879.
DOWNSTREAM	1.00E-03	15160.	27287.	9.00E+04	2.95E+05	5.84	4.00E+01	9173.	9398.
DOWNSTREAM	1.00E-04	12049.	21688.	9.42E+04	3.09E+05	7.37	2.71E+02	9601.	9754.
DOWNSTREAM	3.00E-05	10866.	19559.	9.58E+04	3.14E+05	8.16	7.58E+02	9770.	9898.
DOWNSTREAM	1.00E-05	9951.	17912.	9.71E+04	3.19E+05	8.89	1.96E+03	9901.	10011.
DOWNSTREAM	3.00E-06	9081.	16346.	9.83E+04	3.23E+05	9.69	5.59E+03	10024.	10118.

TABLE III. - Continued. CHOKED NOZZLE FLOW OF HYDROGEN IN CHEMICAL EQUILIBRIUM IN DEBYE-HÜCKEL APPROXIMATION

[E-02, E-03, E+02, E+03, etc., after numbers signify that numbers are to be multiplied by 10^{-2}, 10^{-3}, 10^{2}, 10^{3}, etc.]

(f) Stagnation pressure, 1.01325×10^{8} N/m^2 (1000 atm)

Location	Pressure ratio, p/p_t	Temperature, T		Velocity, v		Mach number, M	Area ratio, A/A^*	Specific impulse, sec	
		K	^{o}R	m/sec	ft/sec			Ideal, $I_{sp,i}$	Vacuum, $I_{sp,v}$
Stagnation temperature, T_t: 3500 K; 6300^{o} R Sonic flow factor, ψ: 1.02E-02 (kg)(K$^{1/2}$)/(sec)(N); 2.84E+02 (lb)(^{o}R$^{1/2}$)/(sec)(ft^2)(atm) Mass flow per unit throat area, $\dot{W}/A^*$: 1.75E+04 kg/(sec)(m^2); 3.58E+03 lb/(sec)(ft^2)									
CHAMBER	1.	3500.	6300.	0	0	0	INFINITY	411.	738.
THROAT	5.53E-01	3121.	5617.	4.04E+03	1.32E+04	1.00	1.00E+00	744.	868.
DOWNSTREAM	1.00E-01	2148.	3866.	7.30E+03	2.39E+04	2.14	2.09E+00	937.	992.
DOWNSTREAM	1.00E-02	1200.	2159.	9.19E+03	3.01E+04	3.53	9.29E+00	1026.	1053.
DOWNSTREAM	1.00E-03	633.	1139.	1.01E+04	3.30E+04	5.27	4.47E+01	1070.	1083.
DOWNSTREAM	1.00E-04	329.	591.	1.05E+04	3.44E+04	7.61	2.23E+02		
Stagnation temperature, T_t: 5000 K; 9000^{o} R Sonic flow factor, ψ: 9.66E-03 (kg)(K$^{1/2}$)/(sec)(N); 2.69E+02 (lb)(^{o}R$^{1/2}$)/(sec)(ft^2)(atm) Mass flow per unit throat area, $\dot{W}/A^*$: 1.38E+04 kg/(sec)(m^2); 2.84E+03 lb/(sec)(ft^2)									
CHAMBER	1.	5000.	9000.	0	0	0	INFINITY	508.	928.
THROAT	5.63E-01	4595.	8271.	4.98E+03	1.63E+04	1.00	1.00E+00	947.	1114.
DOWNSTREAM	1.00E-01	3579.	6443.	9.28E+03	3.05E+04	2.15	2.25E+00	1223.	1308.
DOWNSTREAM	1.00E-02	2412.	4341.	1.20E+04	3.94E+04	3.37	1.14E+01	1366.	1410.
DOWNSTREAM	1.00E-03	1388.	2498.	1.34E+04	4.40E+04	4.81	5.84E+01	1439.	1461.
DOWNSTREAM	1.00E-04	739.	1331.	1.41E+04	4.63E+04	6.85	2.95E+02	1461.	1477.
DOWNSTREAM	3.00E-05	526.	946.	1.43E+04	4.70E+04	8.23	6.89E+02	1476.	1487.
DOWNSTREAM	1.00E-05	385.	692.	1.45E+04	4.75E+04	9.72	1.50E+03		
Stagnation temperature, T_t: 6000 K; 10 800^{o} R Sonic flow factor, ψ: 9.12E-03 (kg)(K$^{1/2}$)/(sec)(N); 2.54E+02 (lb)(^{o}R$^{1/2}$)/(sec)(ft^2)(atm) Mass flow per unit throat area, $\dot{W}/A^*$: 1.19E+04 kg/(sec)(m^2); 2.44E+03 lb/(sec)(ft^2)									
CHAMBER	1.	6000.	10800.	0	0	0	INFINITY	594.	1079.
THROAT	5.60E-01	5502.	9904.	5.83E+03	1.91E+04	1.00	1.00E+00	1099.	1294.
DOWNSTREAM	1.00E-01	4368.	7862.	1.08E+04	3.54E+04	2.18	2.25E+00	1426.	1531.
DOWNSTREAM	1.00E-02	3303.	5945.	1.40E+04	4.59E+04	3.40	1.21E+01	1617.	1681.
DOWNSTREAM	1.00E-03	2398.	4316.	1.59E+04	5.20E+04	4.54	7.40E+01	1730.	1765.
DOWNSTREAM	1.00E-04	1426.	2568.	1.70E+04	5.57E+04	6.02	4.09E+02	1766.	1791.
DOWNSTREAM	3.00E-05	1034.	1861.	1.73E+04	5.68E+04	7.14	9.67E+02	1789.	1808.
DOWNSTREAM	1.00E-05	761.	1371.	1.75E+04	5.76E+04	8.39	2.11E+03	1808.	1821.
DOWNSTREAM	3.00E-06	542.	975.	1.77E+04	5.82E+04	10.04	4.95E+03	1820.	1829.
DOWNSTREAM	1.00E-06	396.	713.	1.78E+04	5.86E+04	11.81	1.08E+04		
Stagnation temperature, T_t: 7000 K; 12 600^{o} R Sonic flow factor, ψ: 8.57E-03 (kg)(K$^{1/2}$)/(sec)(N); 2.39E+02 (lb)(^{o}R$^{1/2}$)/(sec)(ft^2)(atm) Mass flow per unit throat area, $\dot{W}/A^*$: 1.04E+04 kg/(sec)(m^2); 2.13E+03 lb/(sec)(ft^2)									
CHAMBER	1.	7000.	12600.	0	0	0	INFINITY	695.	1245.
THROAT	5.53E-01	5341.	11414.	6.81E+03	2.24E+04	1.00	1.00E+00	1263.	1482.
DOWNSTREAM	1.00E-01	4972.	8950.	1.24E+04	4.06E+04	2.18	2.20E+00	1630.	1748.
DOWNSTREAM	1.00E-02	3811.	6861.	1.60E+04	5.24E+04	3.44	1.18E+01	1847.	1923.
DOWNSTREAM	1.00E-03	3016.	5429.	1.81E+04	5.94E+04	4.60	7.62E+01	1992.	2043.
DOWNSTREAM	1.00E-04	2341.	4213.	1.95E+04	6.41E+04	5.74	5.16E+02	2067.	2088.
DOWNSTREAM	3.00E-05	1927.	3469.	2.01E+04	6.59E+04	6.33	1.36E+03	2086.	2117.
DOWNSTREAM	1.00E-05	1493.	2687.	2.05E+04	6.71E+04	7.12	3.09E+03	2118.	2140.
DOWNSTREAM	3.00E-06	1086.	1954.	2.08E+04	6.81E+04	8.37	7.37E+03	2138.	2154.
DOWNSTREAM	1.00E-06	801.	1441.	2.10E+04	6.88E+04	9.79	1.61E+04		

Stagnation temperature, T_t: 8000 K; 14 400° R

Sonic flow factor, ψ: 8.18E-03 (kg)($K^{1/2}$)/(sec)(N); 2.28E+02 (lb)($^{\circ}R^{1/2}$)/(sec)(ft^2)(atm)

Mass flow per unit throat area, $\dot{W}/A^*$: 9.27E+03 kg/(sec)(m^2); 1.90E+03 lb/(sec)(ft^2)

CHAMBER	1.	8000.	14400.	0	0	0	INFINITY		
THROAT	5.45E-01	7107.	12793.	7.80E+03	2.56E+04	1.00	1.00E+00	795.	1402.
DOWNSTREAM	1.00E-01	5438.	9788.	1.39E+04	4.55E+04	2.19	2.14E+00	1414.	1653.
DOWNSTREAM	1.00E-02	4126.	7427.	1.78E+04	5.83E+04	3.48	1.14E+01	1811.	1938.
DOWNSTREAM	1.00E-03	3298.	5936.	2.01E+04	6.58E+04	4.57	7.31E+01	2045.	2126.
DOWNSTREAM	1.00E-04	2693.	4847.	2.16E+04	7.08E+04	5.83	5.12E+02	2202.	2259.
DOWNSTREAM	3.00E-05	2416.	4348.	2.22E+04	7.29E+04	6.44	1.44E+03	2265.	2313.
DOWNSTREAM	1.00E-05	2157.	3882.	2.27E+04	7.44E+04	6.99	3.67E+03	2314.	2354.
DOWNSTREAM	3.00E-06	1811.	3259.	2.31E+04	7.59E+04	7.58	9.88E+03	2358.	2391.
DOWNSTREAM	1.00E-06	1409.	2535.	2.34E+04	7.69E+04	8.38	2.27E+04	2390.	2415.

Stagnation temperature, T_t: 10 000 K; 18 000° R

Sonic flow factor, ψ: 7.90E-03 (kg)($K^{1/2}$)/(sec)(N); 2.20E+02 (lb)($^{\circ}R^{1/2}$)/(sec)(ft^2)(atm)

Mass flow per unit throat area, $\dot{W}/A^*$: 8.01E+03 kg/(sec)(m^2); 1.64E+03 lb/(sec)(ft^2)

CHAMBER	1.	10000.	18000.	0	0	0	INFINITY		
THROAT	5.27E-01	8443.	15197.	9.43E+03	3.09E+04	1.00	1.00E+00	961.	1641.
DOWNSTREAM	1.00E-01	6074.	10934.	1.61E+04	5.27E+04	2.21	2.04E+00	1638.	1901.
DOWNSTREAM	1.00E-02	4469.	8044.	2.03E+04	6.65E+04	3.58	1.05E+01	2068.	2204.
DOWNSTREAM	1.00E-03	3551.	6393.	2.27E+04	7.45E+04	4.82	6.69E+01	2317.	2403.
DOWNSTREAM	1.00E-04	2932.	5278.	2.44E+04	7.99E+04	6.02	4.70E+02	2483.	2544.
DOWNSTREAM	3.00E-05	2674.	4814.	2.50E+04	8.21E+04	6.64	1.33E+03	2550.	2602.
DOWNSTREAM	1.00E-05	2463.	4434.	2.55E+04	8.38E+04	7.20	3.48E+03	2603.	2648.
DOWNSTREAM	3.00E-06	2248.	4046.	2.60E+04	8.54E+04	7.82	1.00E+04	2654.	2692.
DOWNSTREAM	1.00E-06	2053.	3695.	2.64E+04	8.67E+04	8.40	2.63E+04	2693.	2727.

Stagnation temperature, T_t: 12 000 K; 21 600° R

Sonic flow factor, ψ: 7.84E-03 (kg)($K^{1/2}$)/(sec)(N); 2.18E+02 (lb)($^{\circ}R^{1/2}$)/(sec)(ft^2)(atm)

Mass flow per unit throat area, $\dot{W}/A^*$: 7.26E+03 kg/(sec)(m^2); 1.49E+03 lb/(sec)(ft^2)

CHAMBER	1.	12000.	21600.	0	0	0	INFINITY		
THROAT	5.13E-01	9760.	17568.	1.07E+04	3.52E+04	1.00	1.00E+00	1094.	1824.
DOWNSTREAM	1.00E-01	6557.	11803.	1.77E+04	5.80E+04	2.22	1.94E+00	1803.	2079.
DOWNSTREAM	1.00E-02	4667.	8400.	2.21E+04	7.24E+04	3.66	9.76E+00	2249.	2388.
DOWNSTREAM	1.00E-03	3677.	6618.	2.45E+04	8.05E+04	4.96	6.17E+01	2503.	2591.
DOWNSTREAM	1.00E-04	3034.	5461.	2.62E+04	8.60E+04	6.19	4.33E+02	2672.	2734.
DOWNSTREAM	3.00E-05	2773.	4992.	2.69E+04	8.82E+04	6.82	1.23E+03	2741.	2793.
DOWNSTREAM	1.00E-05	2565.	4616.	2.74E+04	8.99E+04	7.40	3.21E+03	2795.	2841.
DOWNSTREAM	3.00E-06	2359.	4247.	2.79E+04	9.16E+04	8.03	9.31E+03	2846.	2886.
DOWNSTREAM	1.00E-06	2186.	3935.	2.83E+04	9.29E+04	8.60	2.47E+04	2887.	2922.

Stagnation temperature, T_t: 14 000 K; 25 200° R

Sonic flow factor, ψ: 7.68E-03 (kg)($K^{1/2}$)/(sec)(N); 2.14E+02 (lb)($^{\circ}R^{1/2}$)/(sec)(ft^2)(atm)

Mass flow per unit throat area, $\dot{W}/A^*$: 6.58E+03 kg/(sec)(m^2); 1.35E+03 lb/(sec)(ft^2)

CHAMBER	1.	14000.	25200.	0	0	0	INFINITY		
THROAT	5.10E-01	11459.	20626.	1.18E+04	3.87E+04	1.00	1.00E+00	1204.	2006.
DOWNSTREAM	1.00E-01	7133.	12839.	1.93E+04	6.33E+04	2.21	1.94E+00	1968.	2258.
DOWNSTREAM	1.00E-02	4846.	8722.	2.38E+04	7.81E+04	3.76	8.98E+00	2427.	2568.
DOWNSTREAM	1.00E-03	3778.	6800.	2.63E+04	8.63E+04	5.10	5.54E+01	2634.	2772.
DOWNSTREAM	1.00E-04	3109.	5597.	2.80E+04	9.18E+04	6.38	3.94E+02	2854.	2916.
DOWNSTREAM	3.00E-05	2843.	5117.	2.87E+04	9.40E+04	7.03	1.12E+03	2923.	2975.
DOWNSTREAM	1.00E-05	2633.	4739.	2.92E+04	9.58E+04	7.61	2.93E+03	2977.	3023.
DOWNSTREAM	3.00E-06	2429.	4373.	2.97E+04	9.74E+04	8.26	8.50E+03	3029.	3069.
DOWNSTREAM	1.00E-06	2261.	4071.	3.01E+04	9.88E+04	8.84	2.26E+04	3070.	3105.

TABLE III. - Concluded. CHOKED NOZZLE FLOW OF HYDROGEN IN CHEMICAL EQUILIBRIUM IN DEBYE-HÜCKEL APPROXIMATION

[E-02, E-03, E+02, E+03, etc., after numbers signify that numbers are to be multiplied by 10^{-2}, 10^{-3}, 10^{2}, 10^{3}, etc.]

(f) Concluded. Stagnation pressure, 1.01325×10^{8} N/m^2 (1000 atm)

Location	Pressure ratio, p/p_t	Temperature, T		Velocity, v		Mach number, M	Area ratio, A/A^*	Specific impulse, sec	
		K	^{o}R	m/sec	ft/sec			Ideal, $I_{sp,i}$	Vacuum, $I_{sp,v}$
Stagnation temperature, T_t: 16 000 K; 28 800^{o} R Sonic flow factor, ψ: 7.42E-03 (kg)(K$^{1/2}$)/(sec)(N); 2.07E+02 (lb)(^{o}R$^{1/2}$)/(sec)(ft^2)(atm) Mass flow per unit throat area, $\dot{W}/A^*$: 5.95E+03 kg/(sec)(m^2); 1.22E+03 lb/(sec)(ft^2)									
CHAMBER	1.	16000.	28800.	0	0	0	INFINITY		
THROAT	5.27E-01	13665.	24598.	1.26E+04	4.13E+04	1.00	1.00E+00	1283.	2198.
DOWNSTREAM	1.00E-01	8141.	14655.	2.12E+04	6.95E+04	2.15	1.80E+00	2161.	2475.
DOWNSTREAM	1.00E-02	5069.	9123.	2.59E+04	8.50E+04	3.85	8.23E+00	2640.	2783.
DOWNSTREAM	1.00E-03	3886.	6994.	2.84E+04	9.33E+04	5.28	5.10E+01	2899.	2987.
DOWNSTREAM	1.00E-04	3184.	5731.	3.01E+04	9.87E+04	6.61	3.56E+02	3069.	3131.
DOWNSTREAM	3.00E-05	2910.	5238.	3.08E+04	1.01E+05	7.28	1.01E+03	3138.	3190.
DOWNSTREAM	1.00E-05	2696.	4853.	3.13E+04	1.03E+05	7.89	2.54E+03	3192.	3238.
DOWNSTREAM	3.00E-06	2491.	4484.	3.18E+04	1.04E+05	8.55	7.68E+03	3243.	3283.
DOWNSTREAM	1.00E-06	2325.	4185.	3.22E+04	1.06E+05	9.15	2.05E+04	3285.	3320.
Stagnation temperature, T_t: 18 000 K; 32 400^{o} R Sonic flow factor, ψ: 7.21E-03 (kg)(K$^{1/2}$)/(sec)(N); 2.01E+02 (lb)(^{o}R$^{1/2}$)/(sec)(ft^2)(atm) Mass flow per unit throat area, $\dot{W}/A^*$: 5.44E+03 kg/(sec)(m^2); 1.11E+03 lb/(sec)(ft^2)									
CHAMBER	1.	18000.	32400.	0	0	0	INFINITY		
THROAT	5.45E-01	15906.	28630.	1.33E+04	4.35E+04	1.00	1.00E+00	1353.	2388.
DOWNSTREAM	1.00E-01	10093.	18168.	2.33E+04	7.65E+04	2.07	1.91E+00	2378.	2740.
DOWNSTREAM	1.00E-02	5414.	9745.	2.85E+04	9.34E+04	3.91	7.76E+00	2902.	3050.
DOWNSTREAM	1.00E-03	4017.	7231.	3.10E+04	1.02E+05	5.49	4.68E+01	3164.	3253.
DOWNSTREAM	1.00E-04	3266.	5879.	3.27E+04	1.07E+05	6.89	3.24E+02	3334.	3396.
DOWNSTREAM	3.00E-05	2981.	5366.	3.34E+04	1.09E+05	7.59	9.19E+02	3403.	3455.
DOWNSTREAM	1.00E-05	2761.	4969.	3.39E+04	1.11E+05	8.22	2.41E+03	3456.	3502.
DOWNSTREAM	3.00E-06	2552.	4594.	3.44E+04	1.13E+05	8.91	6.99E+03	3508.	3547.
DOWNSTREAM	1.00E-06	2385.	4294.	3.48E+04	1.14E+05	9.53	1.85E+04	3549.	3584.
Stagnation temperature, T_t: 25 000 K; 45 000^{o} R Sonic flow factor, ψ: 6.59E-03 (kg)(K$^{1/2}$)/(sec)(N); 1.84E+02 (lb)(^{o}R$^{1/2}$)/(sec)(ft^2)(atm) Mass flow per unit throat area, $\dot{W}/A^*$: 4.23E+03 kg/(sec)(m^2); 8.65E+02 lb/(sec)(ft^2)									
CHAMBER	1.	25000.	45000.	0	0	0	INFINITY		
THROAT	5.59E-01	22641.	40754.	1.68E+04	5.50E+04	1.00	1.00E+00	1710.	3077.
DOWNSTREAM	1.00E-01	17285.	31112.	3.07E+04	1.01E+05	2.18	2.17E+00	3127.	3658.
DOWNSTREAM	1.00E-02	11835.	21304.	3.92E+04	1.28E+05	3.44	1.07E+01	3992.	4254.
DOWNSTREAM	1.00E-03	5923.	10661.	4.33E+04	1.42E+05	4.93	4.69E+01	4414.	4529.
DOWNSTREAM	1.00E-04	3721.	6698.	4.52E+04	1.48E+05	7.82	2.59E+02	4605.	4668.
DOWNSTREAM	3.00E-05	3309.	5956.	4.58E+04	1.50E+05	8.79	7.17E+02	4674.	4726.
DOWNSTREAM	1.00E-05	3027.	5449.	4.64E+04	1.52E+05	9.59	1.85E+03	4727.	4773.
DOWNSTREAM	3.00E-06	2780.	5003.	4.69E+04	1.54E+05	10.44	5.34E+03	4778.	4817.
DOWNSTREAM	1.00E-06	2591.	4663.	4.73E+04	1.55E+05	11.19	1.42E+04	4819.	4853.

Stagnation temperature, T_t: 35 000 K; 63 000° R
Sonic flow factor, ψ: 6.00E-03 (kg)($K^{1/2}$)/(sec)(N); 1.67E+02 (lb)($^{\circ}R^{1/2}$)/(sec)(ft^2)(atm)
Mass flow per unit throat area, $\dot{W}/A^*$: 3.25E+03 kg/(sec)(m^2); 6.65E+02 lb/(sec)(ft^2)

CHAMBER	1.	35000.	63000.	0	0	0	INFINITY		
THROAT	5.42E-01	30434.	54782.	2.29E+04	7.50E+04	1.00	1.00E+00	2332.	4057.
DOWNSTREAM	1.00E-01	22415.	40347.	4.01E+04	1.32E+05	2.22	2.09E+00	4088.	4752.
DOWNSTREAM	1.00E-02	15316.	29370.	5.08E+04	1.67E+05	3.55	1.07E+01	5183.	5523.
DOWNSTREAM	1.00E-03	12420.	22356.	5.69E+04	1.87E+05	4.85	6.53E+01	5798.	6005.
DOWNSTREAM	1.00E-04	9296.	16732.	6.06E+04	1.99E+05	6.16	4.19E+02	6184.	6318.
DOWNSTREAM	3.00E-05	7339.	13211.	6.20E+04	2.04E+05	6.72	1.05E+03	6325.	6425.
DOWNSTREAM	1.00E-05	4976.	8957.	6.29E+04	2.06E+05	7.64	2.09E+03	6415.	6483.
DOWNSTREAM	3.00E-06	3371.	6069.	6.36E+04	2.09E+05	10.71	4.61E+03	6481.	6525.
DOWNSTREAM	1.00E-06	2924.	5263.	6.40E+04	2.10E+05	12.46	1.14E+04	6524.	6561.

Stagnation temperature, T_t: 50 000 K; 90 000° R
Sonic flow factor, ψ: 5.82E-03 (kg)($K^{1/2}$)/(sec)(N); 1.62E+02 (lb)($^{\circ}R^{1/2}$)/(sec)(ft^2)(atm)
Mass flow per unit throat area, $\dot{W}/A^*$: 2.64E+03 kg/(sec)(m^2); 5.40E+02 lb/(sec)(ft^2)

CHAMBER	1.	50000.	90000.	0	0	0	INFINITY		
THROAT	5.10E-01	39986.	71975.	3.01E+04	9.88E+04	1.00	1.00E+00	3070.	5068.
DOWNSTREAM	1.00E-01	25547.	47785.	4.92E+04	1.61E+05	2.24	1.91E+00	5013.	5764.
DOWNSTREAM	1.00E-02	18396.	33112.	6.11E+04	2.00E+05	3.71	9.45E+00	6227.	6598.
DOWNSTREAM	1.00E-03	14026.	25247.	6.76E+04	2.22E+05	5.07	5.79E+01	6898.	7125.
DOWNSTREAM	1.00E-04	11120.	20017.	7.19E+04	2.36E+05	6.43	3.88E+02	7327.	7480.
DOWNSTREAM	3.00E-05	9894.	17809.	7.35E+04	2.41E+05	7.16	1.07E+03	7494.	7620.
DOWNSTREAM	1.00E-05	8853.	15935.	7.47E+04	2.45E+05	7.85	2.71E+03	7621.	7728.
DOWNSTREAM	3.00E-06	7667.	13800.	7.59E+04	2.49E+05	8.59	7.41E+03	7738.	7825.
DOWNSTREAM	1.00E-06	6171.	11108.	7.67E+04	2.52E+05	8.99	1.73E+04	7823.	7891.

Stagnation temperature, T_t: 75 000 K; 135 000° R
Sonic flow factor, ψ: 5.76E-03 (kg)($K^{1/2}$)/(sec)(N); 1.60E+02 (lb)($^{\circ}R^{1/2}$)/(sec)(ft^2)(atm)
Mass flow per unit throat area, $\dot{W}/A^*$: 2.13E+03 kg/(sec)(m^2); 4.37E+02 lb/(sec)(ft^2)

CHAMBER	1.	75000.	135000.	0	0	0	INFINITY		
THROAT	4.90E-01	56941.	102494.	3.86E+04	1.27E+05	1.00	1.00E+00	3932.	6305.
DOWNSTREAM	1.00E-01	32734.	58922.	6.02E+04	1.98E+05	2.21	1.73E+00	6141.	6980.
DOWNSTREAM	1.00E-02	20218.	36392.	7.29E+04	2.39E+05	3.94	7.88E+00	7435.	7817.
DOWNSTREAM	1.00E-03	15070.	27125.	7.96E+04	2.61E+05	5.44	4.76E+01	8121.	8352.
DOWNSTREAM	1.00E-04	11964.	21536.	8.39E+04	2.75E+05	6.89	3.21E+02	8558.	8714.
DOWNSTREAM	3.00E-05	10739.	19330.	8.56E+04	2.81E+05	7.65	8.91E+02	8729.	8859.
DOWNSTREAM	1.00E-05	9770.	17586.	8.69E+04	2.85E+05	8.36	2.28E+03	8861.	8972.
DOWNSTREAM	3.00E-06	8820.	15876.	8.81E+04	2.89E+05	9.15	6.46E+03	8984.	9078.
DOWNSTREAM	1.00E-06	8007.	14413.	8.90E+04	2.92E+05	9.89	1.67E+04	9080.	9161.

Stagnation temperature, T_t: 100 000 K; 180 000° R
Sonic flow factor, ψ: 5.73E-03 (kg)($K^{1/2}$)/(sec)(N); 1.59E+02 (lb)($^{\circ}R^{1/2}$)/(sec)(ft^2)(atm)
Mass flow per unit throat area, $\dot{W}/A^*$: 1.83E+03 kg/(sec)(m^2); 3.76E+02 lb/(sec)(ft^2)

CHAMBER	1.	100000.	180000.	0	0	0	INFINITY		
THROAT	4.87E-01	75314.	135565.	4.50E+04	1.48E+05	1.00	1.00E+00	4585.	7329.
DOWNSTREAM	1.00E-01	40947.	73704.	6.98E+04	2.29E+05	2.15	1.68E+00	7114.	8059.
DOWNSTREAM	1.00E-02	21820.	39276.	8.33E+04	2.73E+05	4.11	6.85E+00	8492.	8878.
DOWNSTREAM	1.00E-03	15752.	28354.	9.00E+04	2.95E+05	5.79	4.06E+01	9177.	9406.
DOWNSTREAM	1.00E-04	12428.	22371.	9.42E+04	3.09E+05	7.34	2.73E+02	9610.	9763.
DOWNSTREAM	3.00E-05	11163.	20093.	9.59E+04	3.15E+05	8.15	7.58E+02	9779.	9907.
DOWNSTREAM	1.00E-05	10182.	18328.	9.72E+04	3.19E+05	8.89	1.95E+03	9909.	10019.
DOWNSTREAM	3.00E-06	9248.	16646.	9.84E+04	3.23E+05	9.71	5.54E+03	10031.	10125.
DOWNSTREAM	1.00E-06	8485.	15274.	9.93E+04	3.26E+05	10.48	1.45E+04	10127.	10209.

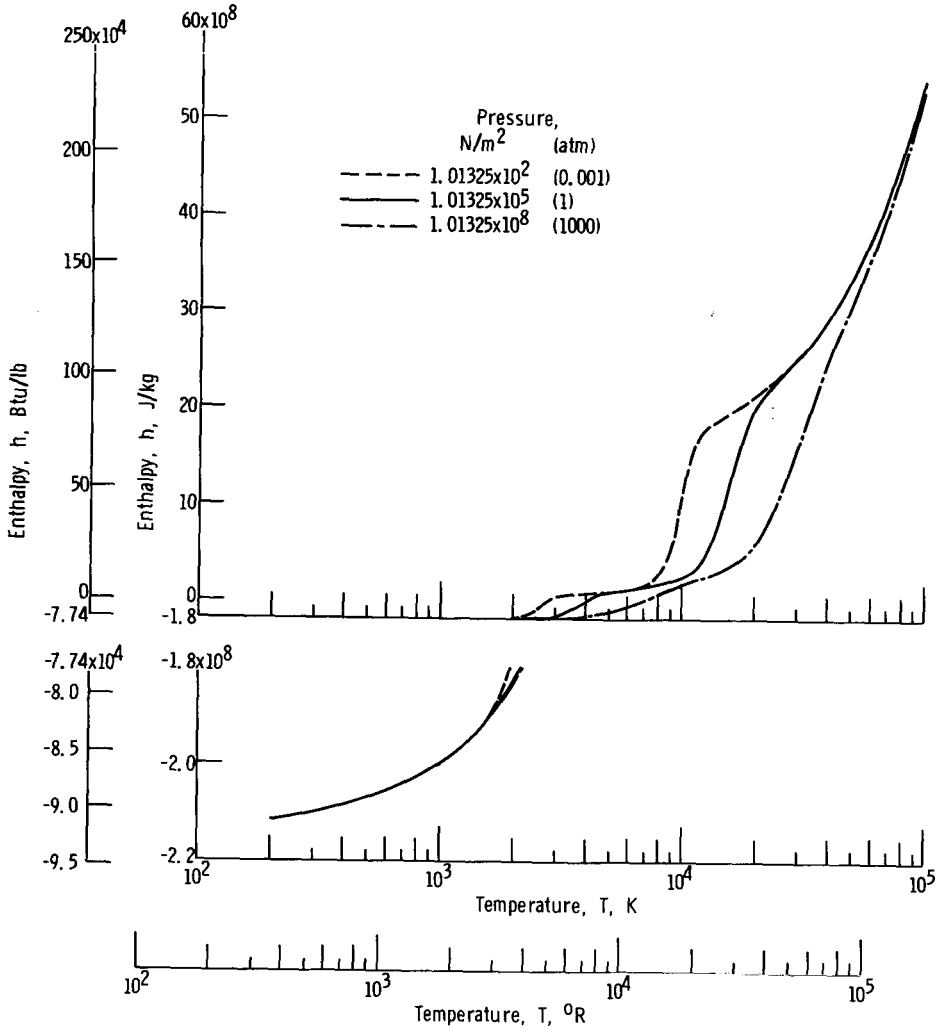


Figure 1. - Enthalpy of spin-equilibrated hydrogen in chemical equilibrium in Debye-Hückel approximation.

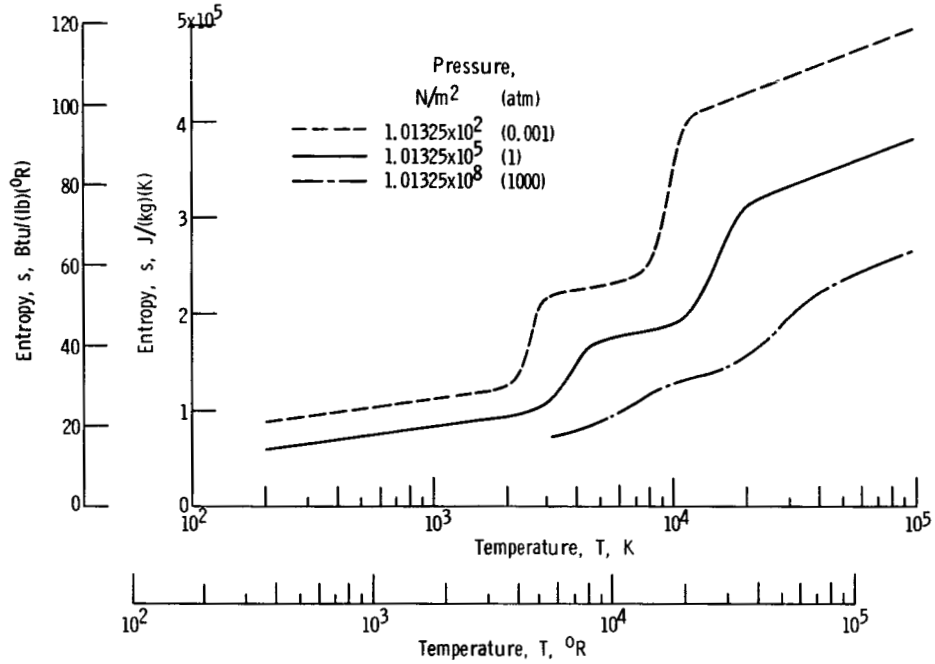


Figure 2. - Entropy of spin-equilibrated hydrogen in chemical equilibrium in Debye-Hückel approximation.

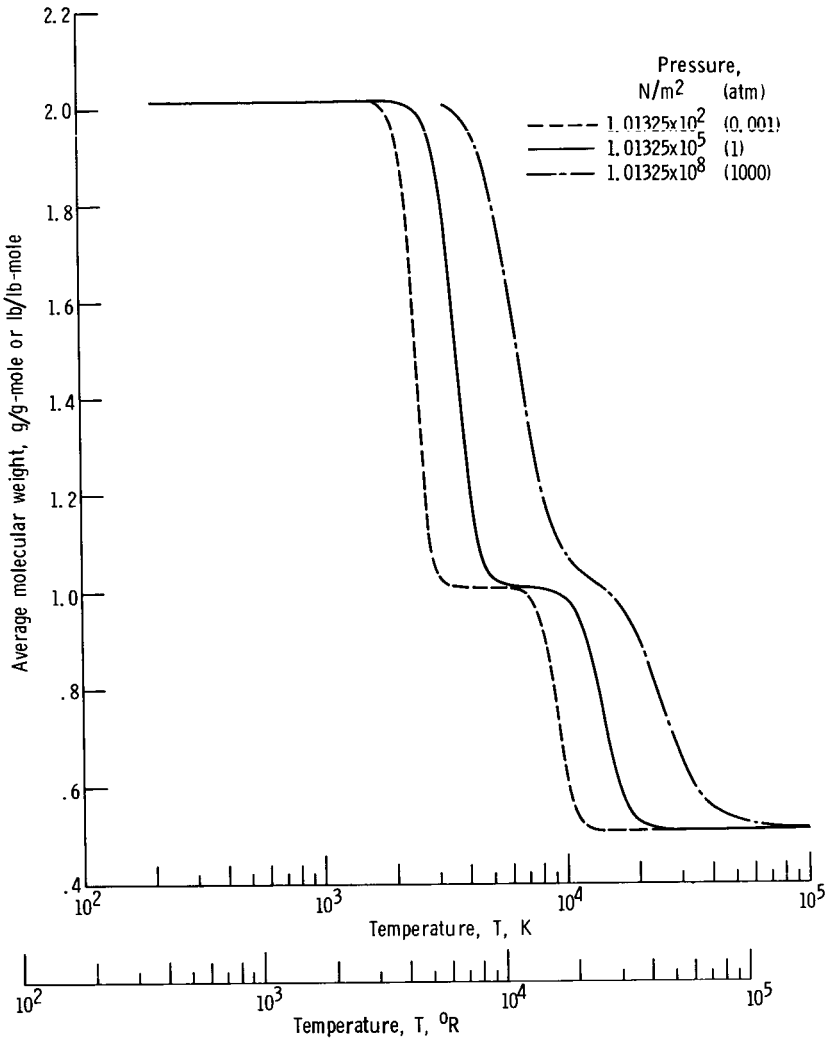


Figure 3. - Average molecular weight of spin-equilibrated hydrogen in chemical equilibrium in Debye-Hückel approximation.

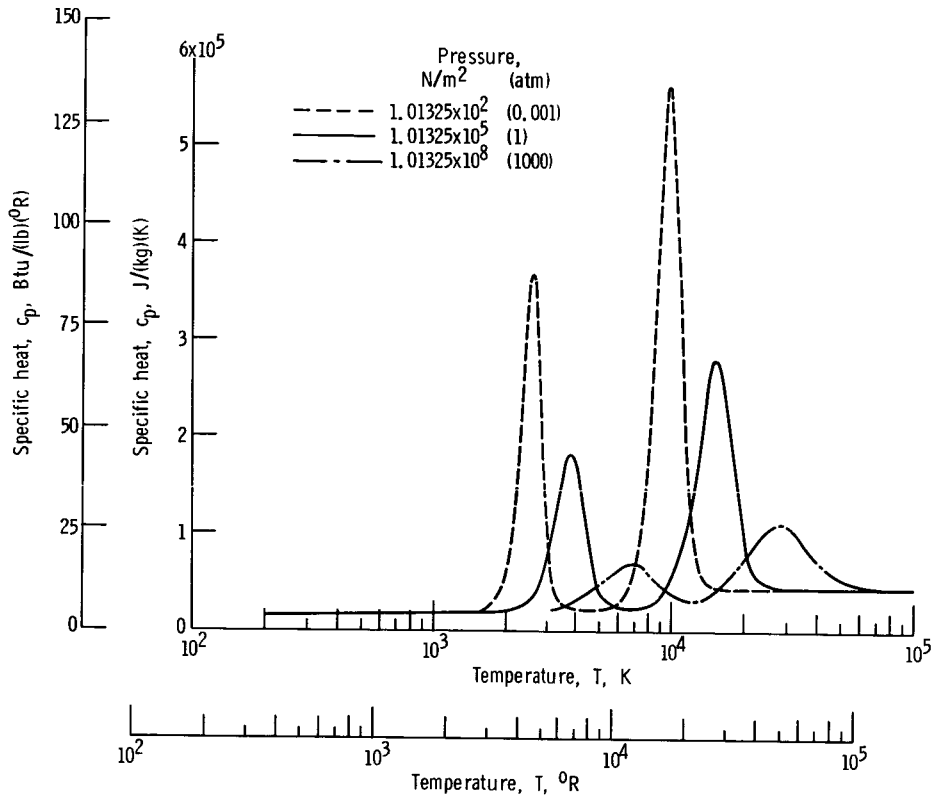


Figure 4. - Specific heat at constant pressure of spin-equilibrated hydrogen in chemical equilibrium in Debye-Hückel approximation.

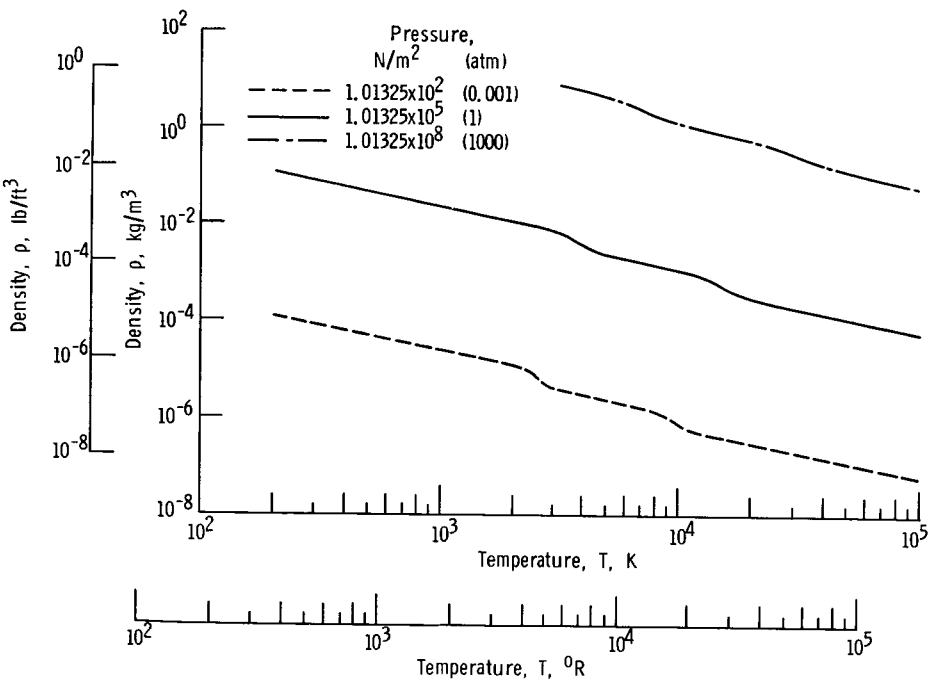


Figure 5. - Density of spin-equilibrated hydrogen in chemical equilibrium in Debye-Hückel approximation.

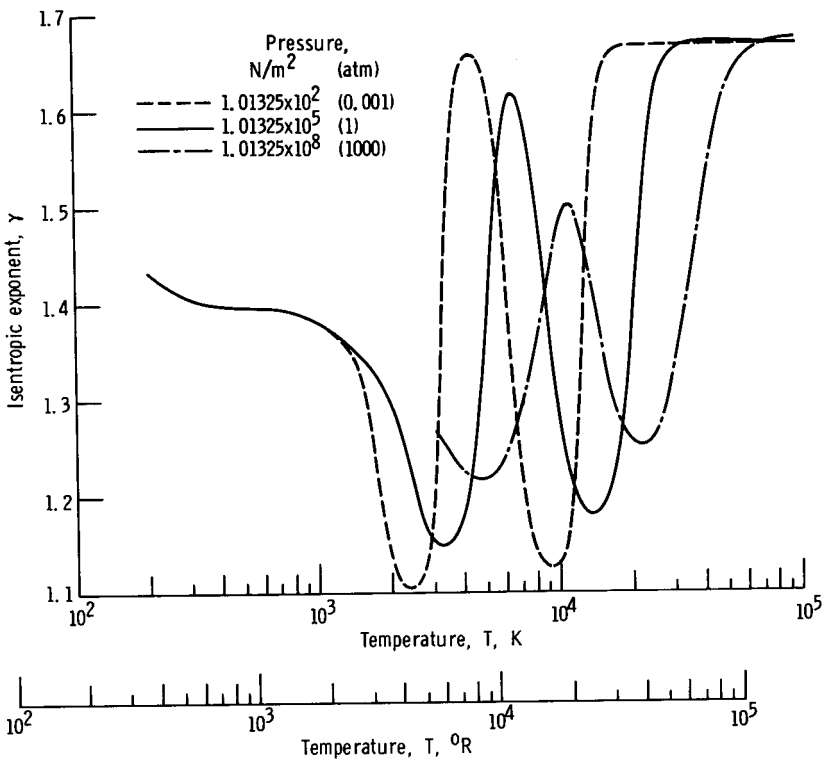


Figure 6. - Isentropic exponent of spin-equilibrated hydrogen in chemical equilibrium in Debye-Hückel approximation.

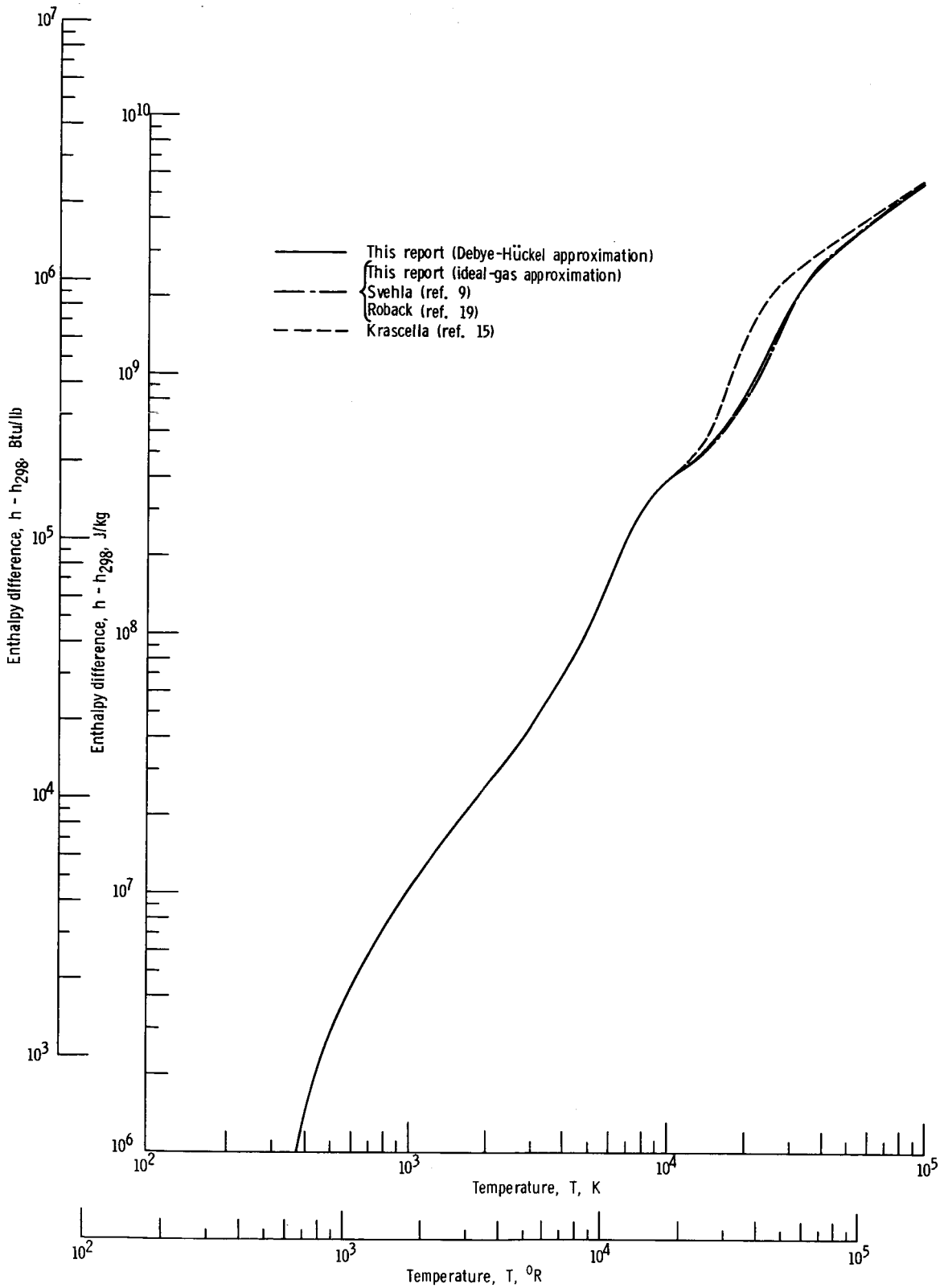


Figure 7. - Comparison of enthalpy differences of hydrogen in chemical equilibrium according to the Debye-Hückel and ideal-gas approximations of this report and the results of three other investigators for a pressure of 1.01325×10^8 N/m^2 (1000 atm).

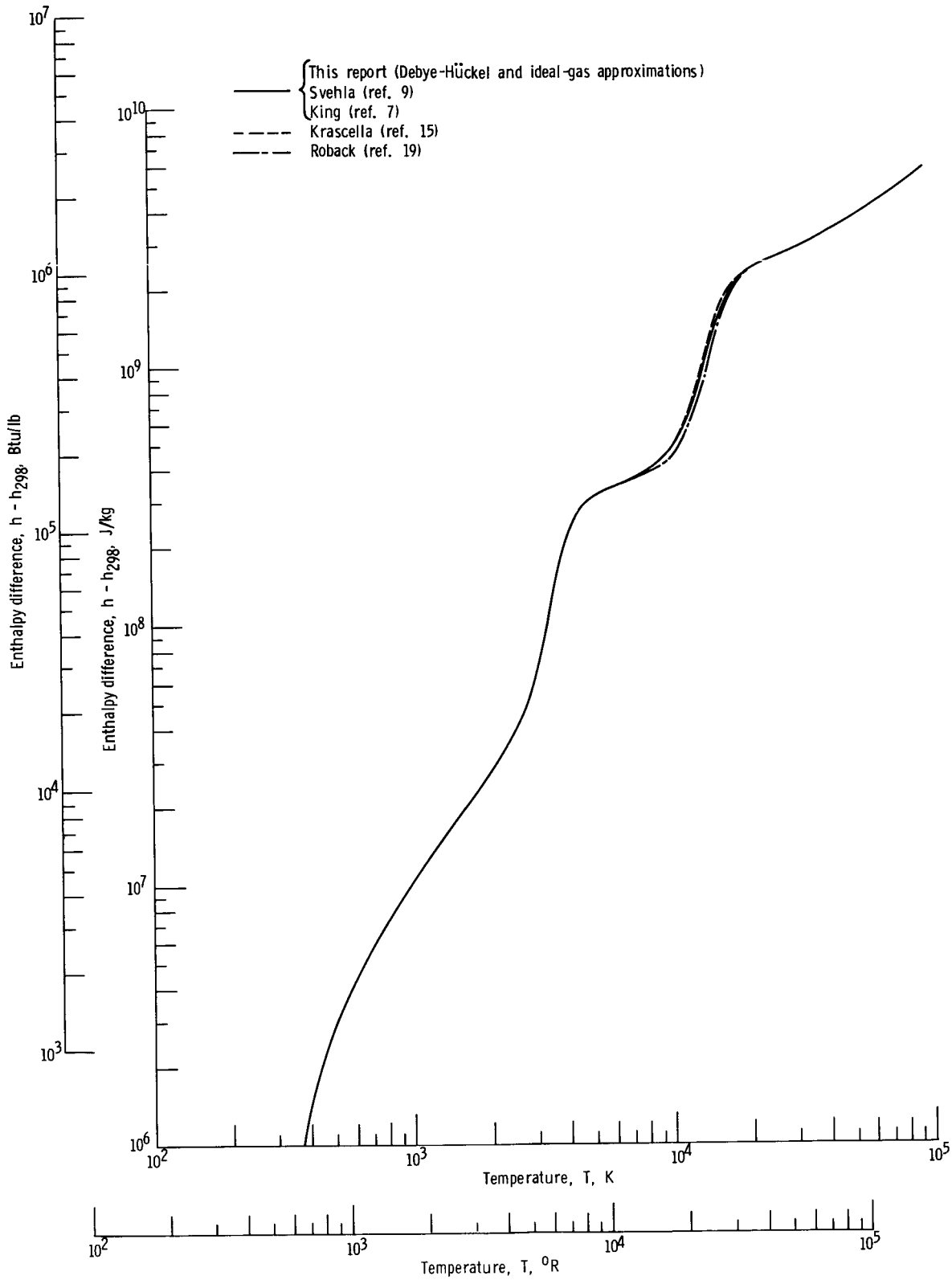


Figure 8. - Comparison of enthalpy differences of hydrogen in chemical equilibrium according to the Debye-Hückel and ideal-gas approximations of this report and the results of four other investigators for a pressure of 1.01325×10^5 N/m^2 (1 atm).

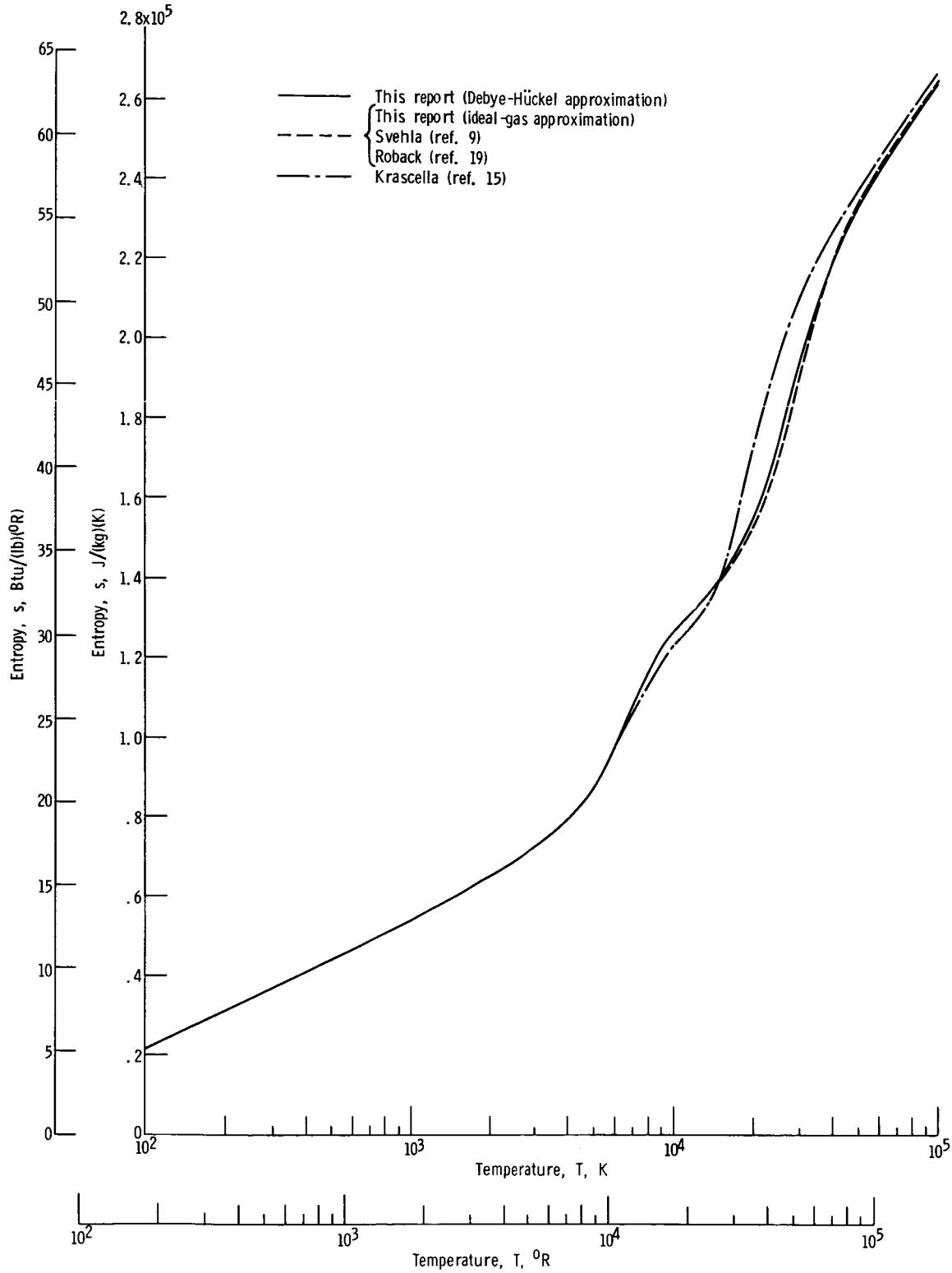


Figure 9. - Comparison of entropy of hydrogen in chemical equilibrium according to the Debye-Hückel and ideal-gas approximations of this report and the results of three other investigators for a pressure of 1.01325×10^8 N/m^2 (1000 atm).

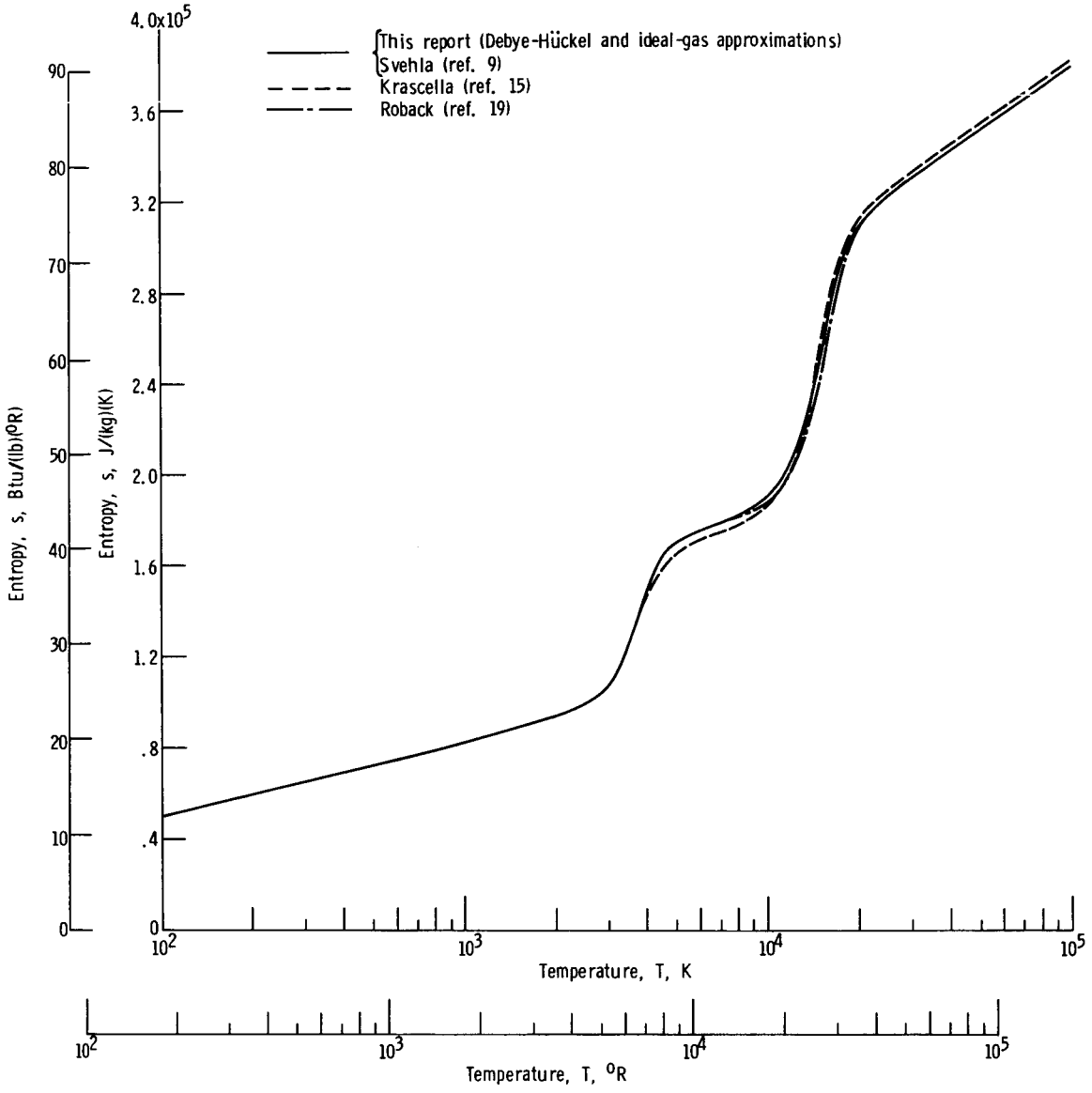


Figure 10. - Comparison of entropy of hydrogen in chemical equilibrium according to the Debye-Hückel and ideal-gas approximations of this report and the results of three other investigators for a pressure of 1.01325×10^5 N/m^2 (1 atm).

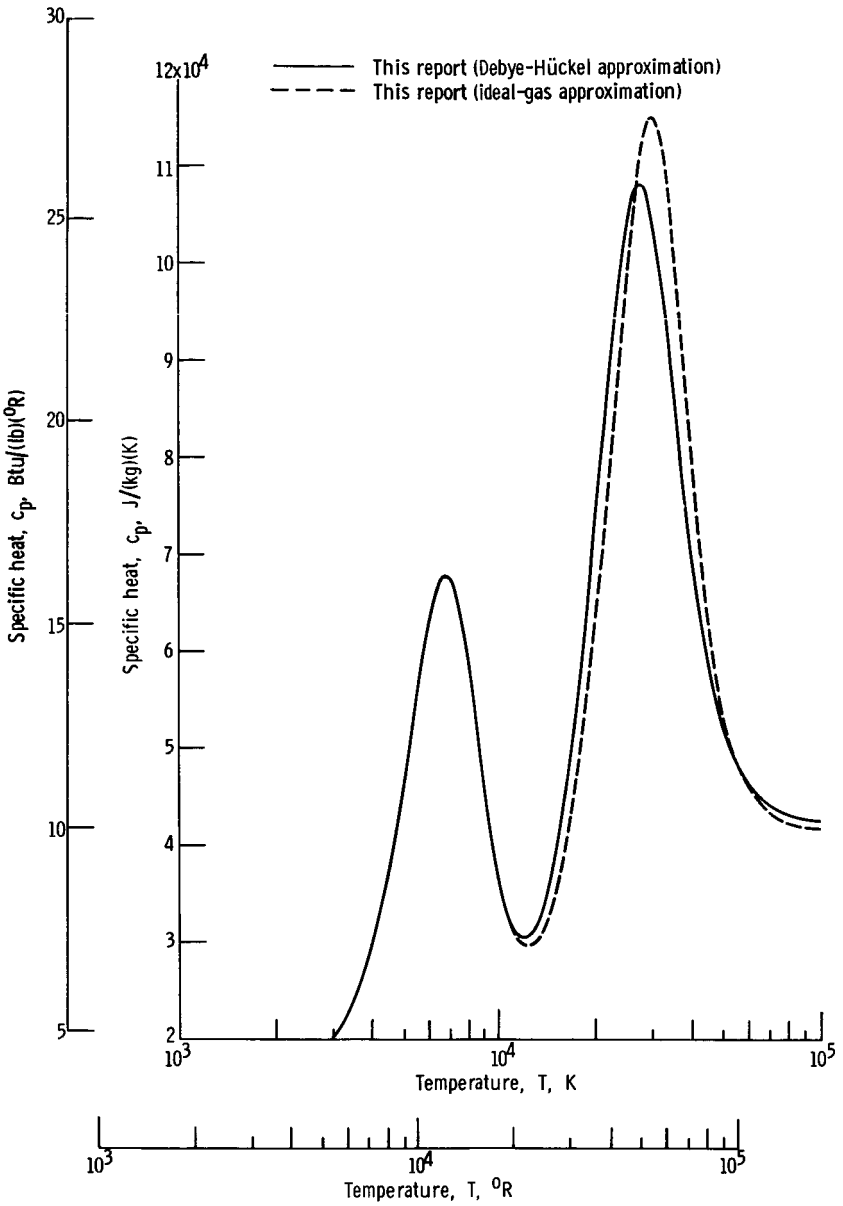


Figure 11. - Comparison of specific heat at constant pressure according to the Debye-Hückel and ideal-gas approximations of this report. Pressure, $1.01325x10^8$ N/m^2 (1000 atm).

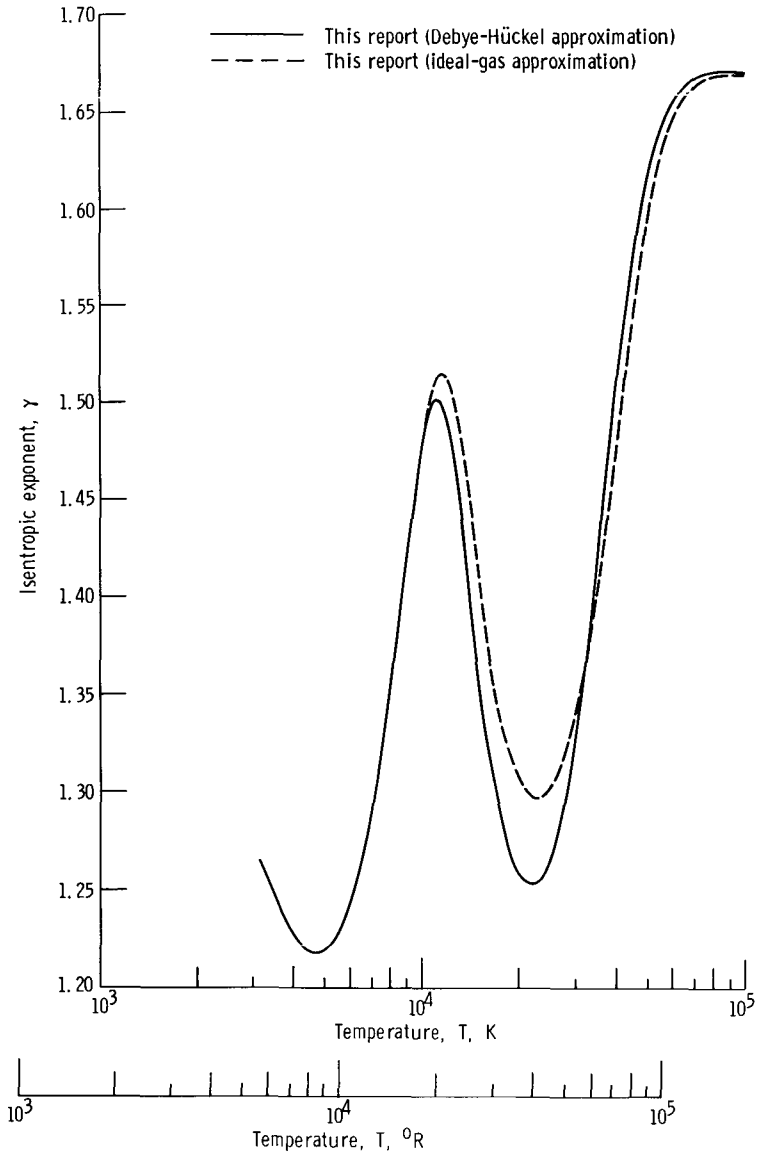


Figure 12. - Comparison of isentropic exponent according to the Debye-Hückel and ideal-gas approximations of this report. Pressure, 1.01325×10^8 N/m^2 (1000 atm).

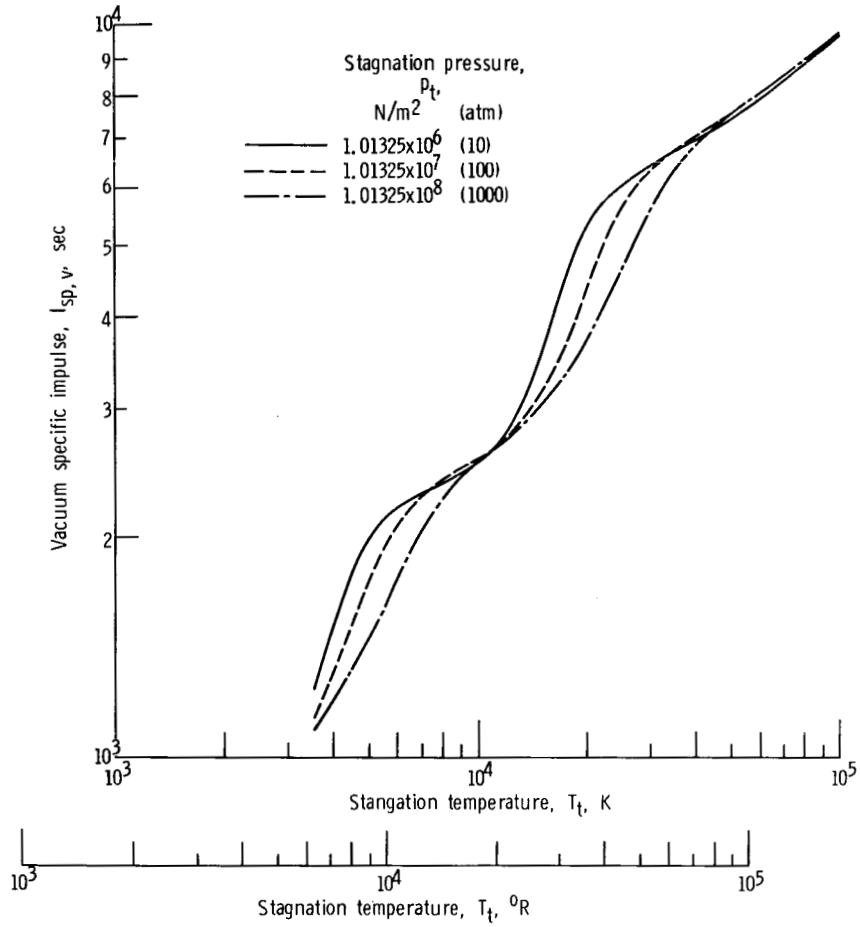


Figure 13. - Vacuum specific impulse for choked nozzle flow with shifting chemical equilibrium in Debye-Hückel approximation. Ratio of nozzle-exit pressure to stagnation pressure of 10^{-4}

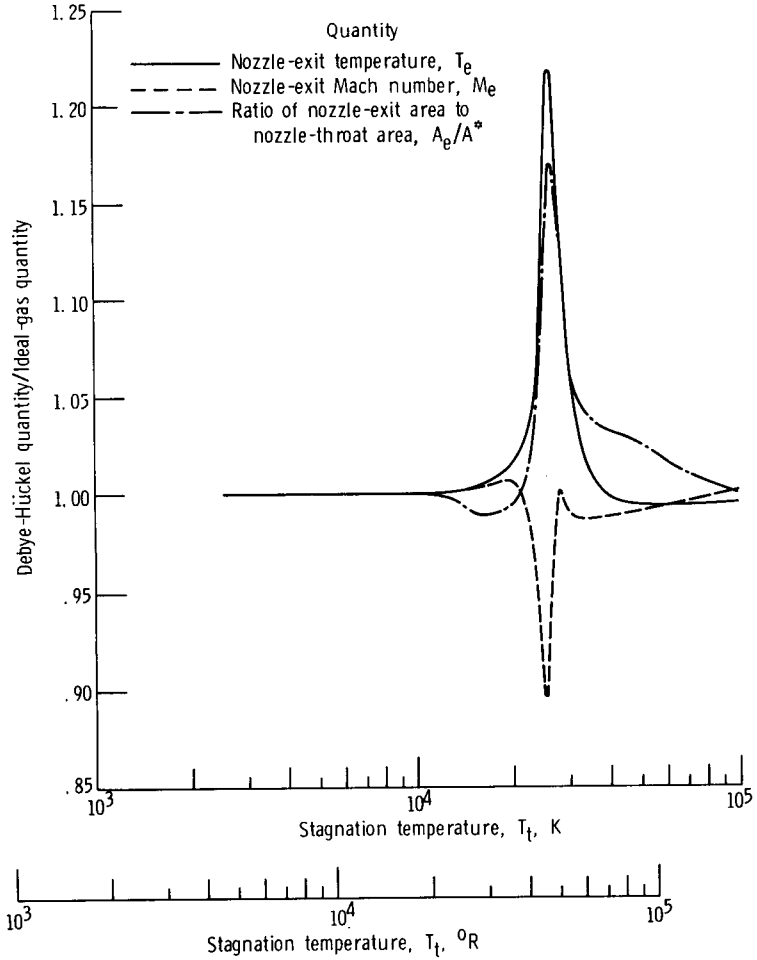


Figure 14. - Ratio of nozzle-exit quantities calculated by two approximations with shifting chemical equilibrium at a stagnation pressure of 1.01325×10^8 N/m^2 (1000 atm). Ratio of nozzle-exit pressure to stagnation pressure of 10^{-3}.

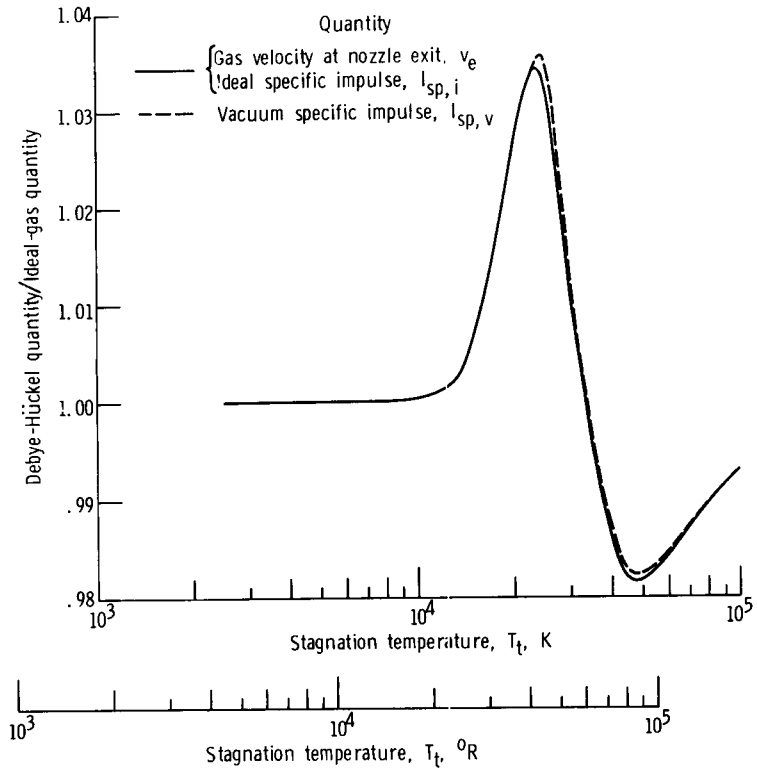


Figure 15. - Ratio of nozzle-exit quantities calculated by two approximations with shifting chemical equilibrium at a stagnation pressure of 1.01325×10^8 N/m^2 (1000 atm). Ratio of nozzle-exit pressure to stagnation pressure of 10^{-3}.

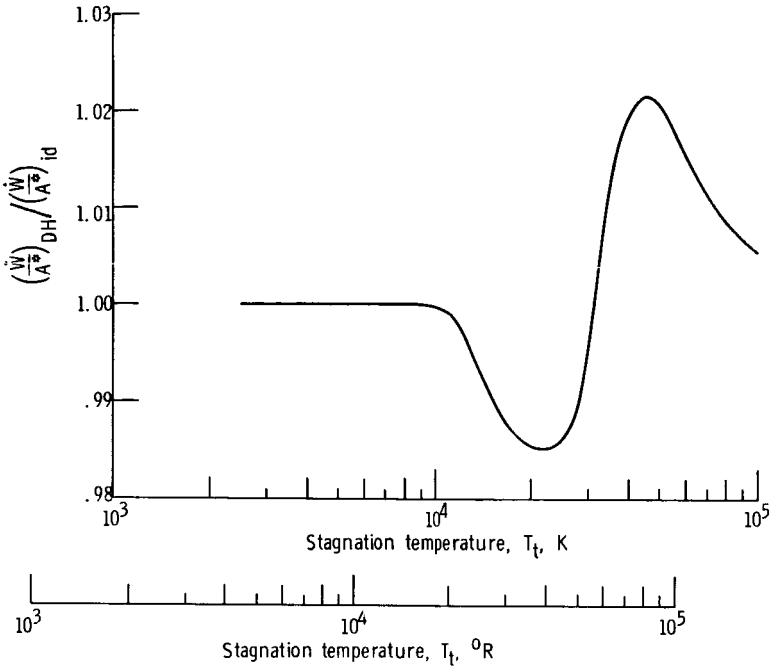


Figure 16. - Ratio of mass flows per unit throat area according to the Debye-Hückel and ideal-gas approximations with shifting chemical equilibrium at a stagnation pressure of 1.01325×10^8 N/m^2 (1000 atm). Choked flow assumed.

NATIONAL AERONAUTICS AND SPACE ADMISTRATION
WASHINGTON, D.C. 20546

OFFICIAL BUSINESS
PENALTY FOR PRIVATE USE $300

FIRST CLASS MAIL

POSTAGE AND FEES PAID
NATIONAL AERONAUTICS AND
SPACE ADMINISTRATION

U.S.MAIL

POSTMASTER: If Undeliverable (Section 158 Postal Manual) Do Not Return

"The aeronautical and space activities of the United States shall be conducted so as to contribute . . . to the expansion of human knowledge of phenomena in the atmosphere and space. The Administration shall provide for the widest practicable and appropriate dissemination of information concerning its activities and the results thereof."

—NATIONAL AERONAUTICS AND SPACE ACT OF 1958

NASA SCIENTIFIC AND TECHNICAL PUBLICATIONS

TECHNICAL REPORTS: Scientific and technical information considered important, complete, and a lasting contribution to existing knowledge.

TECHNICAL NOTES: Information less broad in scope but nevertheless of importance as a contribution to existing knowledge.

TECHNICAL MEMORANDUMS: Information receiving limited distribution because of preliminary data, security classification, or other reasons.

CONTRACTOR REPORTS: Scientific and technical information generated under a NASA contract or grant and considered an important contribution to existing knowledge.

TECHNICAL TRANSLATIONS: Information published in a foreign language considered to merit NASA distribution in English.

SPECIAL PUBLICATIONS: Information derived from or of value to NASA activities. Publications include conference proceedings, monographs, data compilations, handbooks, sourcebooks, and special bibliographies.

TECHNOLOGY UTILIZATION PUBLICATIONS: Information on technology used by NASA that may be of particular interest in commercial and other non-aerospace applications. Publications include Tech Briefs, Technology Utilization Reports and Technology Surveys.

Details on the availability of these publications may be obtained from:

SCIENTIFIC AND TECHNICAL INFORMATION OFFICE

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Washington, D.C. 20546