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THERMODYNAMIC AND SHOCK PROPERTIES OF A SIMULATED JOVIAN ENTRY ATMOSPHERE

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SUMMARY

The thermodynamic properties of the equilibrium plasma behind normal shock waves (incident and reflected) in a 0.70 Ne-.25H_2-.05He mixture were computed for assigned shock velocities from 5 to 15 km/sec and pressures from 0.05 to 1.0 mm Hg. Equilibrium pressure, temperature, enthalpy, entropy, constant-pressure heat capacity, and component mole fractions are tabulated for an initial temperature of 298.15K. The free energy of the mixture was minimized to obtain composition. The Debye-Hückel approximation was used to account for ionization-potential lowering and partition-function cutoff.

INTRODUCTION

Basic data concerning the atmosphere of Jupiter is needed to provide a better understanding of the evolution of our solar system. Because of its low atmospheric temperature (around 100 K) and its great size, it is thought that Jupiter has kept its primordial condition to a great extent.

To obtain these data, the National Academy of Science has highly recommended a Jovian atmospheric probe. Scientific experiments have been proposed for such a probe during the 1977 Grand Tour of the outer planets (ref. 1).

Entry of a probe into the hydrogen-helium Jovian atmosphere would cause shock-ionization of that mixture because of the probe's high entry speed. Actual entry conditions are expected to involve shock velocities as high as 60 km/sec and temperatures as high as 50 000 K.

Survival of the probe requires proper design of a heat shield. This can be facilitated by simulating the expected conditions in the laboratory and subjecting test probes to these conditions. While these conditions cannot be approached in a conventional shock tube using a H_2-He mixture, they can be simulated by raising the mixture's molecular weight and using a reflected shock wave. The molecular weight is raised by "bathing" the H_2-He mixture in neon, for example, which does not react with hydrogen or helium.

Accordingly, calculations were performed for the thermodynamic properties following passage of incident and reflected shocks through a 0.70 Ne-0.25 H_2-0.05 He atmosphere. The calculation included the Coulombic contribution to the equilibrium thermodynamic properties and the extrapolation of atomic energy levels up to the lowered ionization potential. These properties are used together with the appropriate conservation equations to obtain properties behind the incident and reflected shock waves.

The properties assigned to the cold gas ahead of the shock (condition 1) are: T_1 = 298.15 K, P_1 = 1.0, 0.8, 0.4, 0.2, 0.1, and 0.05 mm Hg and u_1 = 15, 12, 10, 8, 6.5, and 5 km/sec. (Symbols are defined in the symbol list.) These properties permit calculation of initial values of Mach number, H/RT, S/R, M, C_p/R, γ_s, γ, and sonic velocity.

Conditions behind the incident and reflected shock fronts are designated condition 2 and condition 5 respectively.

The properties from the incident shock calculation are: u_2, P/P_o, T, H/RT, S/R, M, $(\partial \ln V/\partial \ln P)_T$, $(\partial \ln V/\partial \ln T)_p$, C_p/R, γ_s, γ, sonic velocity; the Coulombic parameters: ionization potential lowering, Debye length, DEBN/BETN (ratio of principal quantum numbers for Debye and Bethe cutoffs); number of charged particles in the Debye sphere, Coulombic compressibility; ratios across the incident shock: P_2/P_1, T_2/T_1, M_2/M_1, ρ_2/ρ_1; $v_2 = u_1 - u_2$, mole fractions and total particle density; the negative excess thermodynamic properties: $-(H/RT)_{Coulombic}$ and $-(S/R)_{Coulombic}$.

Similar properties are calculated for the reflected shock wave. In this case the ratios are from condition 5 to condition 2 and, instead of v_2, the velocity $u_5 + v_2$ is given.

SYMBOLS

BETN	principal quantum number at Bethe cutoff
c	velocity of light
C_p	heat capacity of mixture at constant pressure
C_v	heat capacity of mixture at constant volume
DEBN	principal quantum number at Debye-Hückel cutoff
e	electronic charge
G	Gibbs free energy of mixture
H	enthalpy of mixture
h	Planck's constant
I	ionization potential
k	Boltzmann's constant
M	molecular weight of mixture
N_i	number of particles of species i
n	total number of moles in mixture
n_i	number of moles of species i
P	absolute pressure
R	universal gas constant
S	entropy of mixture
T	absolute temperature
u	velocity in shock-fixed coordinates
V	volume
v	velocity in laboratory coordinates
W_R	reflected shock velocity
W_S	incident shock velocity

Z	Coulomb compressibility
z_i	signed charge number of species i

Greek Symbols

γ	C_p/C_v
γ_S	isentropic exponent; $\gamma_S = -(\partial \ln P/\partial \ln V)_S$
Δ	lowering, as applied to ionization potential
$\mathcal{K}$	reciprocal of Debye length; $\mathcal{K} = 1/\rho_D$
ρ	density of mixture
ρ_D	Debye length

Indices

i,j	dummy index for species

Subscripts

0	property at one atmosphere
1	ahead of incident shock
2	behind incident shock
5	behind reflected shock
R	reflected shock
S	isentropic; incident shock

EQUATIONS DESCRIBING CHEMICAL EQUILIBRIUM

Values of the fundamental constants were obtained from reference 2.

The equilibrium composition of the plasma at an assigned T and P was calculated by minimizing the Gibbs free energy G of a closed, neutral system subject to the conservation of elements and charge. Minimization of G resulted in a system of equations that are non-linear in the number of moles of the constituents. Lagrangian multipliers were used to include the mass balance constraints. Application of the Newton-Raphson method resulted in a set of iteration equations in terms of the Lagrangian multipliers and corrections to the mole numbers. These working equations were taken from reference 3 and programmed for use with a high-speed computer.

The Debye-Hückel corrections (see below) to the Helmholtz free energy, pressure, and thermodynamic functions (H, S and G) and the thermodynamic derivatives $((\partial \ln V/\partial \ln T)_P$, $(\partial \ln V/\partial \ln P)_T$, $(\partial \ln n_i/\partial \ln P)_T$, etc) were taken from reference 4.

Assumptions and Restrictions

1. The species assumed to be present in the simulated Jovian entry atmosphere were: for hydrogen, H, H^+, H_2, H_2^+, H^-; for helium, He, He^+, He^{++}; for neon, Ne, Ne^+, Ne^{++}, Ne^{+++}; and electrons, e^-. Only the ground state was used for H_2; at those conditions where excited H_2 was beginning to comprise a significant proportion of total H_2, total H_2 was unimportant. Excited electronic states of H_2^+ were neglected. The species H_3^+ was not included because its molecular constants are rough estimates (ref. 5) and yield unrealistic heat capacities.

2. Electronically excited states of H, He, He^+, Ne, Ne^+, and Ne^{++} were included. In order to avoid divergence of the partition function, the cutoff of electronic levels was calculated by Griem's extension of the Debye-Hückel electrolytic theory (ref. 6). For small amounts of ionization, the size of the electron's orbit becomes unrealistically large. Therefore, in this instance the Debye-Hückel theory provides a poor criterion for cutoff. For this situation, Bethe's excluded volume criterion was used (ref. 7). In practice, the principal quantum number at each cutoff was calculated: BETN at the Bethe cutoff, and DEBN at the Debye-Huckel cutoff. The ratio DEBN/BETN was used to choose the method that truncated most states. If the ratio exceeded 1, then the Bethe cutoff was used. Otherwise the Debye-Hückel cutoff was used.

The Debye-Hückel method makes no cutoff provision for uninegative ions; thus a fixed number of excited states was used for H^-.

3. The Debye-Hückel theory was also used to account for Coulombic interactions between charged particles (ref. 4). These interactions yield real-gas corrections to the chemical potentials and the equation of state. When the Coulombic interactions became negligible, the plasma was treated as an ideal gas.

4. Shifts of energy levels of excited states relative to ground electronic states were neglected. These shifts are observed to be small (ref. 8).

5. Atomic sublevels for observed principal quantum numbers were interpolated by the "inclusion of predicted levels" technique (ref. 9) and extrapolated by the Rydberg formula (ref. 6) up to the reduced ionization potential.

Electronic Partition Function and Ionization Potential

In the ideal-gas or independent-particle approximation, a bound electron moves under the influence of a single atomic species and has access to an infinite number of energy levels that approach the series limit. If all these levels were used in calculating the electronic partition function, it would diverge.

In a plasma, there is a Coulombic field due to the presence of ions and electrons. This field limits the set of energy levels available to the bound electron. Consequently the partition function terminates at the last level allowed. Also, the ionization potential is lowered and the amount of ionization is increased.

There is no exact procedure for specifying the last level to be permitted. In the present work, the Debye-Hückel approximation is used because it also affords a Coulombic correction to the Helmholtz free energy. This yields a consistent set of corrections to the chemical potentials, thermodynamic functions, and the equation of state.

In the Debye-Hückel cutoff (ref. 6), a level is not counted in the partition function if its energy exceeds the lowered ionization potential given by $I - \Delta I$ where I is the unperturbed ionization potential of the species considered, and ΔI is the lowering defined by

$$\Delta I = (z_i + 1)\kappa e^2/hc \quad (\mathrm{cm}^{-1})$$

Inclusion of Predicted Levels

Under certain conditions, theoretically predicted energy levels which have not been observed for atomic species must be included in the calculation of partition functions. The procedure used to estimate the significant levels depends somewhat on the temperature of the gas mixture.

At temperatures below about 5000 to 6000 K, it generally suffices to note the observed levels for a given principal quantum number and then to interpolate the missing levels. For this purpose, the "fill" method detailed in reference 9 was used.

At the higher temperatures typical of plasmas, quantum numbers for which no levels have been observed are occasionally required. At these higher quantum numbers, the Rydberg formula for hydrogenic levels (ref. 6) is a good approximation:

$$E_{n,y} = I_y - \frac{(z_i + 1)^2}{n^2} I_H$$

where $E_{n,y}$ is the extrapolated energy level of atomic species y for principal quantum number n; I_y is its classical ionization potential; z_i is its charge number. I_H is the ionization potential of the H atom. The Rydberg formula was used for He and the neon species.

For the isoelectronic species H and He^+ the Bohr formula (ref. 10) was used:

$$E_{n,y} = I_y (1 - 1/n^2)$$

As explained below, interpolated levels were used in the first stage of the calculation; in the second stage, the levels were also extrapolated up to the reduced ionization potential.

Accuracy of Composition

The Debye-Hückel approximation can be expected to be valid down to particle densities fulfilling the inequality

$$\frac{\sum_i N_i}{V} \gg \frac{1}{8\pi\rho_D{}^3}$$

where ρ_D is the Debye length and the summation is over charged particles (ref. 6). If V is taken to be the volume of the Debye sphere, i.e.

$$V = (4/3)\pi\rho_D{}^3$$

then the total number of charged particles in the Debye sphere must obey the inequality

$$\sum_i N_i \gg 1/6$$

As $\sum_i N_i$ approaches 1/6, the accuracy can be expected to decrease. For the conditions of this report, $\sum_i N_i$ was never less than 2.67.

Criterion for Using Ideal-Gas Approximation

At temperatures below approximately 4000 K, the degree of ionization was so small that the Coulombic interaction between charged particles could be neglected. A criterion for treating the plasma as an ideal gas was developed by comparing the Debye-Hückel expression for lowering of the ionization potential for a neutral atom: -

$$\Delta I = \mathcal{K} e^2/hc$$

and the definition of inverse Debye length

$$\mathcal{K}^2 = 4\pi e^2 \sum_i N_i z_i^2/kTV$$

where N_i/V is the particle density of the i-th charged species. Eliminating $\mathcal{K}$, one gets a measure of the ionic strength

$$\sum_i N_i z_i^2/V = (hc)^2 kT(\Delta I)^2/\pi e^6$$
$$= 4.4369\times10^8 (\Delta I)^2 T$$

Assuming that the Coulombic interaction becomes negligible when ΔI falls below 0.25 cm^{-1} and that this occurs below approximately 4000 K, then a reasonable lower limit for the ionic strength of the Debye-Hückel gas is:-

$$\sum_i N_i z_i^2/V = 1\times10^{11}$$

When the ionic strength was less than 1×10^{11} particles per cm^3, the plasma was treated as an ideal gas and the following ionization parameters were not computed: Debye length, ratio of principal quantum numbers for Debye cutoff and Bethe cutoff, and number of particles in the Debye sphere. In the output, these three parameters were set equal to 0.- 19 (i.e. $0.\times10^{-19}$) to indicate untouched computer locations.

For example, for an initial pressure of 0.8 mm Hg and an incident shock velocity of 5 km/sec, T_2 = 3680 K and ΔI = 0.2 cm^{-1}. Therefore

$$\frac{\sum_i N_i z_i^2}{V} = 4.4369\times10^8 (0.2)^2 (3680)$$
$$= 0.65\times10^{11}$$

Since $\sum_i N_i z_i^2/V$ was less than 1×10^{11}, the gas was considered to be ideal.

OVER-ALL ITERATION PROCEDURE FOR COMPOSITION

The system of equations resulting from minimization of G can not be solved for composition in closed form for two reasons:

(1) The system is non-linear in composition; that is, there are terms that contain $\ln(n_j/n)$

(2) The electronic partition function of an atomic species with highly excited states depends on the ionic density, which in turn depends on the electronic partition function.

The over-all iteration is accomplished in two stages.

In the first stage, the mixture is initially assumed to consist of equimolar proportions of all species considered. Corrections to these mole numbers and the Lagrangian multipliers are found, assuming that each atomic species has a fixed number of energy levels. These are the observed levels (ref. 11) plus those filled in by the method of reference 9. In this stage, the classical or isolated-atom ionization potential, I, is used. Iteration is terminated when successive estimates of mole numbers agree to five significant figures.

For the second stage, mole numbers from the first stage are used as estimates for a real-gas composition (Debye approximation). These mole numbers are used to calculate an initial estimate of ionization-potential lowering, ΔI (ref. 6). When mole numbers have converged for the initial ΔI, a new value for this quantity is calculated. Thus, iterations are performed, not only on the mole numbers, but also on ΔI.

The following flow diagram summarizes the over-all iteration procedure:-

Assume equimolar composition

$\Delta I = 0$ (ideal gas)

Sum electronic levels:

if $\Delta I \leq 0.25\text{cm}^{-1}$, sum over fixed number of levels

if $\Delta I > 0.25\text{cm}^{-1}$, sum up to $(I - \Delta I)$

if $\Delta I = 0$, sum only once

Corrections to mole numbers

NO — New mole numbers within tolerance?

YES

Correction to ΔI

NO — New ΔI within tolerance?

YES

Calculate thermodynamic properties

INCIDENT AND REFLECTED SHOCKS

Calculation of the conditions behind a shock front involves the laws of conservation of mass flow rate (continuity), momentum, and energy. Application of the Newton-Raphson method to these equations results in a set of iteration equations. In reference 12, the independent variables chosen were the logarithm of temperature ratio and the logarithm of pressure ratio across the shock. For use with plasmas, these equations were modified to include the effect of Coulomb compressibility, Z.

Nomenclature for Shock Parameters

The shock parameters listed in Table I are u_1, u_2, $v_2 = u_1 - u_2$, and $u_5 + v_2$.

In order to define these parameters, it will be convenient to refer to Figure 1. The nomenclature is that of reference 13.

Actual Velocities

Actual velocities are velocities in laboratory-fixed coordinates.

The initial test gas is assumed to be at rest. Therefore, the quantity v_1, the actual velocity of the gas ahead of the incident shock, is zero.

The quantity v_2 is the actual velocity of the shocked gas behind the incident shock and also the actual velocity of the shocked gas ahead of the reflected shock.

The quantity v_5 is the actual velocity of the shocked gas behind the reflected shock. This velocity is assumed to be zero.

The incident shock velocity is W_S. The reflected shock velocity is W_R.

Relative Velocities

Relative velocities are velocities relative to the pertinent shock front, i.e. in shock-fixed coordinates.

The quantity u_1 is the relative velocity with which the initial gas flows towards the resting incident shock. Thus

$$u_1 = W_S - v_1 = W_S$$

The quantity u_2 is the relative velocity with which the shocked gas flows away from the resting incident shock. Thus

$$u_2 = W_S - v_2 = u_1 - v_2$$

and therefore

$$v_2 = u_1 - u_2$$

The quantity u_5 is the relative velocity with which the shocked gas moves away from the resting reflected shock. Thus

$$u_5 = W_R - v_5 = W_R$$

The quantity, u_2^*, is the relative velocity with which the gas moves toward the resting reflected shock. Thus

$$u_2^* = W_R + v_2 = u_5 + v_2$$

ATOMIC AND MOLECULAR CONSTANTS

Values for the observed energy levels, statistical weights, and ionization potentials of H, He, He^+, Ne, Ne^+, Ne^{++} and Ne^{+++} were taken from reference 11.

The levels of H^- were taken to be the same as those for the isoelectronic species He.

The dissociation energies of H_2 and H_2^+ and the electron affinity of H were obtained from reference 14. This publication was also the source for the equations for the partition functions of H_2 and H_2^+.

SUMMARY OF RESULTS

The shock relations and associated equations for chemical equilibrium were solved for six entry velocities (u_1 = 15, 12, 10, 8, 6.5 and 5 km/sec) at six ambient pressures for a simulated Jovian entry atmosphere consisting of 70 percent Ne, 25 percent H_2 and 5 percent He by volume.

The resulting thermodynamic and shock (incident and reflected) properties are presented in Table I. Temperatures and pressures are plotted in Figure 2.

Subtables (a), (b), (c), (d), (e), and (f) of Table I give the properties respectively for initial pressures P_1 = 1.0, 0.8, 0.4, 0.2, 0.1, and 0.05 mm Hg. These pressures are actually listed in dimensionless form P_1/P_o where P_o = 760 mm Hg(1 atmosphere).

Each subtable consists of three parts: properties of the unshocked gas; properties associated with the incident shock; and properties associated with the reflected shock.

The properties given for the unshocked or initial gas are: P/P_o, T, H/RT, S/R, M, C_p/R, γ_s, sonic velocity, Mach number, and u_1.

The properties associated with the incident shock are: u_2, P/P_o, T, H/RT, S/R, M, $(\partial \ln V/\partial \ln P)_T$, $(\partial \ln V/\partial \ln T)_p$, C_p/R, γ_s, γ , sonic velocity; the Coulombic parameters: ionization potential lowering, Debye length, ratio of Debye principal quantum number to Bethe principal quantum number, number of charged particles in the Debye sphere, and Coulomb compressibility; additional incident-shock properties: P_2/P_1, T_2/T_1, M_2/M_1, ρ_2/ρ_1, $v_2 = u_1 - u_2$; mole fractions; total particle density; and negative excess thermodynamic properties:

$-(H/RT)_{Coulombic}$ and $-(S/R)_{Coulombic}$.

Similar properties are calculated for the reflected shock wave. In this case the ratios are from condition 5 to condition 2 and, instead of v_2, the velocity $u_5 + v_2$ is given.

Figure 2(a) gives the temperature and pressure behind the incident shock and Figure 2(b) gives these variables behind the reflected shock. For the conditions of this report, the final temperature increases more rapidly with shock velocity than with initial pressure.

The only shock data available in the literature for the Jovian atmosphere are given in reference 15 for a .50 H_2 - .50 He mixture. However, instead of the Debye approximation used in this report, reference 15 used the ideal-gas approximation.

For purposes of comparison, Figure 3 presents two sets of ideal-gas data for this mixture: one calculated by the present author and the other by reference 15. The figure presents theoretical density ratio and temperature for equilibrium states behind incident shocks. There are significant temperature differences between the two calculations: approximately 1000 K at u_1 = 42 672 m/sec (140 000 fps) and approximately 3000 K at u_1 = 57912 m/sec (190 000 fps).

The key to the discrepancies is the following statement in reference 15: "Since molecular hydrogen is completely dissociated at the temperatures and densities of interest, the only process involving hydrogen is the ionization of atomic hydrogen." This assumption leads to the following errors: (1) Violation of energy conservation since the dissociation energy of diatomic hydrogen is neglected. (2) Wrong values for molecular weight and thermodynamic properties of the initial mixture.

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TABLE I. THERMODYNAMIC PROPERTIES FOR EQUILIBRIUM STATES BEHIND INCIDENT AND REFLECTED SHOCKS THROUGH A 0.70 Ne - 0.25 H_2 - 0.05 He MIXTURE

(a) P_1 = 1.0 MM Hg

INITIAL GAS (1)

P/PO	1.3158-3	M, MOL WT	14.83221
T, DEG K	298	CP/R	2.7423
H/RT	0.0000	GAMMA (S)	1.5740
S/R	24.3736	SON VEL,M/SEC	512.9

MACH NO.	29.2460	23.3968	19.4973	15.5979	12.6733	9.7487
U1, M/SEC	15000.00	12000.00	10000.00	8000.00	6500.00	5000.00
SHOCKED GAS (2)--INCIDENT						
U2, M/SEC	1325.45	1246.82	1196.78	1153.54	981.75	567.90
P/P0	1.6162 0	1.0172 0	6.9438-1	4.3253-1	2.8370-1	1.7578-1
T, DEG K	17937	15255	13227	10856	7753	3714
H/RT	6.1119	5.2842	4.6596	3.9541	3.7927	4.8655
S/R	23.1336	24.4023	25.4351	26.3203	26.1919	25.1200
M, MOL WT	8.16578	9.41016	10.39774	11.38889	11.84361	12.17626
(DLV/DLP)T	-1.12023	-1.09115	-1.06843	-1.02463	-1.00109	-1.02067
(DLV/DLT)P	2.2599	1.9275	1.7440	1.3269	1.0216	1.3093
CP/R	21.8686	16.3416	13.8949	8.2656	2.9990	7.1863
GAMMA (S)	1.1278	1.1577	1.1771	1.2321	1.5313	1.2786
GAMMA	1.2634	1.2632	1.2577	1.2624	1.5329	1.3050
SON VEL,M/SEC	4538.4	3950.2	3528.5	3124.8	2886.9	1800.7

COULOMBIC PARAMETERS

IP LOWER,CM-1	809.7	614.5	452.3	247.7	60.9	0.3
DEBYE LNG,CM	1.434 -6	1.890 -6	2.568 -6	4.689 -6	1.908 -5	0. -19
DEBN/BETN	8.272 -1	8.429 -1	8.662 -1	9.268 -1	1.107 0	0. -19

NUMBER OF CHARGED PARTICLES IN DEBYE SPHERE

	5.129 0	5.735 0	6.750 0	1.016 1	2.947 1	0. -19
COUL COMPRESS	0.99325	0.99600	0.99797	0.99956	0.99999	1.00000

P2/P1	1228.297	773.083	527.729	328.721	215.615	133.594
T2/T1	60.160	51.166	44.365	36.411	26.005	12.457
M2/M1	0.5505	0.6344	0.7010	0.7678	0.7985	0.8209
RHO2/RHO1	11.3169	9.6245	8.3557	6.9352	6.6208	8.8044
V2=U1-U2,M/SEC	13674.55	10753.18	8803.22	6846.46	5518.25	4432.10

MOLE FRACTIONS

E	3.1182-1	2.0695-1	1.2372-1	4.0193-2	1.8889-3	1.4100-8
H2	2.6489-8	1.9630-7	8.1846-7	2.9957-6	2.0696-5	2.6167-2
H2+	4.737 -7	1.049 -6	1.319 -6	8.041 -7	1.079 -7	4.434-11
H	5.3881-2	1.2809-1	2.2958-1	3.4387-1	3.9732-1	3.5813-1
H+	2.2139-1	1.8913-1	1.2092-1	4.0047-2	1.8887-3	1.4064-8
H-	7.255 -7	1.247 -6	1.455 -6	8.429 -7	9.700 -8	8.933-12
HE	2.7128-2	3.1677-2	3.5046-2	3.8392-2	3.9925-2	4.1047-2
HE+	3.992 -4	4.526 -5	4.852 -6	1.419 -7	5.521-11	7.900-24
HE++	5.757-15	2.138-18	6.899-22	1.800-27	0. 0	0. 0
NE	2.9535-1	4.2633-1	4.8792-1	5.3735-1	5.5895-1	5.7465-1
NE+	9.003 -2	1.777 -2	2.795 -3	1.459 -4	2.021 -7	3.828-18
NE++	2.628 -8	7.578-11	1.672-13	9.851-18	4.373-27	0. 0
NE+++	6.989-22	2.343-27	5.332-33	0. 0	0. 0	0. 0

PARTICLE DENSITIES,1/CM**3

TOTAL	6.658 17	4.914 17	3.861 17	2.926 17	2.686 17	3.474 17

NEGATIVE EXCESS THERMODYNAMIC PROPERTIES

-(H/RT)COUL	2.7005-2	1.5992-2	8.1155-3	1.7594-3	2.8461-5	0. 0
-(S/R)COUL	1.3525-2	8.0040-3	4.0598-3	8.7977-4	1.4223-5	0. 0

TABLE I. CONTINUED. THERMODYNAMIC PROPERTIES FOR EQUILIBRIUM STATES BEHIND INCIDENT AND REFLECTED SHOCKS THROUGH A 0.70 Ne - 0.25 H_2 - 0.05 He MIXTURE

(a) P_1 = 1.0 MM Hg

INITIAL GAS (1)

P/PO	1.3158-3	M, MOL WT	14.83221
T, DEG K	298	CP/R	2.7423
H/RT	0.0000	GAMMA (S)	1.5740
S/R	24.3736	SON VEL,M/SEC	512.9

MACH NO.	29.2460	23.3968	19.4973	15.5979	12.6733	9.7487
U1, M/SEC	15000.00	12000.00	10000.00	8000.00	6500.00	5000.00
SHOCKED GAS (5)--REFLECTED--EQUILIBRIUM						
U5, M/SEC	2605.92	2050.20	1892.81	1757.12	1684.09	1642.34
P/P0	2.1451 1	1.1449 1	6.8885 0	3.6486 0	2.3554 0	2.0419 0
T, DEG K	29424	22092	19196	16092	13689	11106
H/RT	6.1392	6.1483	5.5906	4.8683	4.2646	3.6948
S/R	19.7480	21.1153	22.2939	23.6574	24.6530	24.9758
M, MOL WT	6.23848	7.47472	8.52233	9.74969	10.74653	11.58835
(DLV/DLP)T	-1.06038	-1.15855	-1.14456	-1.10160	-1.06258	-1.01644
(DLV/DLT)P	1.3752	2.2423	2.1794	1.8571	1.5845	1.1890
CP/R	6.1637	18.9992	19.3644	14.7739	11.3185	5.8078
GAMMA (S)	1.3270	1.1187	1.1120	1.1519	1.1894	1.2937
GAMMA	1.4072	1.2960	1.2728	1.2689	1.2638	1.3149
SON VEL,M/SEC	7213.8	5243.1	4563.4	3975.8	3549.1	3210.6
COULOMBIC PARAMETERS						
IP LOWER,CM-1	2230.7	1914.6	1487.7	1024.9	703.0	401.4
DEBYE LNG,CM	5.2063-7	6.0661-7	7.8065-7	1.1331-6	1.6521-6	2.8933-6
DEBN/BETN	7.5855-1	7.4199-1	7.5595-1	7.8107-1	8.0960-1	8.5833-1
NUMBER OF CHARGED PARTICLES IN DEBYE SPHERE						
	3.0569 0	2.6731 0	2.9900 0	3.6368 0	4.5099 0	6.3957 0
COUL COMPRESS	0.98274	0.98462	0.98953	0.99455	0.99768	0.99959
P5/P2	13.273	11.255	9.920	8.436	8.302	11.616
T5/T2	1.640	1.448	1.451	1.482	1.766	2.990
M5/M2	0.7640	0.7943	0.8196	0.8561	0.9074	0.9517
RHO5/RHO2	6.2475	6.2449	5.6509	4.8964	4.2767	3.6986
U5+V2,M/SEC	16280.46	12803.38	10696.03	8603.58	7202.33	6074.44
MOLE FRACTIONS						
E	4.7425-1	3.7006-1	2.8177-1	1.7834-1	9.4332-2	2.3396-2
H2	1.8189-9	6.4316-8	2.2741-7	9.7706-7	3.3225-6	1.4367-5
H2+	2.2103-7	1.4220-6	2.4247-6	3.5726-6	3.5906-6	2.1777-6
H	1.4683-2	4.7748-2	8.4848-2	1.6695-1	2.7029-1	3.6731-1
H+	1.9562-1	2.0422-1	2.0243-1	1.6171-1	9.1965-2	2.3298-2
H-	6.0530-7	2.7911-6	3.6660-6	4.2860-6	3.9807-6	2.2960-6
HE	9.3980-3	2.3733-2	2.8349-2	3.2819-2	3.6223-2	3.9065-2
HE+	1.1632-2	1.4641-3	3.8010-4	4.7344-5	4.4758-6	1.0234-7
HE++	3.262 -8	3.884-12	2.073-14	8.698-18	1.636-21	1.847-27
NE	2.7926-2	1.8839-1	3.2325-1	4.4354-1	5.0482-1	5.4681-1
NE+	2.6600-1	1.6437-1	7.8961-2	1.6588-2	2.3629-3	9.7904-5
NE++	5.009 -4	1.646 -6	4.475 -8	1.410-10	2.122-13	6.050-18
NE+++	1.907-11	1.806-17	5.044-21	1.916-26	1.791-32	0. 0
PARTICLE DENSITIES,1/CM3**						
TOTAL	5.445 18	3.863 18	2.662 18	1.673 18	1.266 18	1.350 18
NEGATIVE EXCESS THERMODYNAMIC PROPERTIES						
-(H/RT)COUL	6.9046-2	6.1524-2	4.1895-2	2.1791-2	9.2937-3	1.6224-3
-(S/R)COUL	3.4674-2	3.0882-2	2.1003-2	1.0911-2	4.6495-3	8.1129-4

TABLE I. CONTINUED. THERMODYNAMIC PROPERTIES FOR EQUILIBRIUM STATES BEHIND INCIDENT AND REFLECTED SHOCKS THROUGH A 0.70 Ne - 0.25 H_2 - 0.05 He MIXTURE

(b) P_1 = 0.8 MM Hg

INITIAL GAS (1)

P/P0	1.0526-3	M, MOL WT	14.83221
T, DEG K	298	CP/R	2.7423
H/RT	0.0000	GAMMA (S)	1.5740
S/R	24.5968	SON VEL,M/SEC	512.9

MACH NO.	29.2460	23.3968	19.4973	15.5979	12.6733	9.7487
U1, M/SEC	15000.00	12000.00	10000.00	8000.00	6500.00	5000.00
SHOCKED GAS (2)--INCIDENT						
U2, M/SEC	1310.75	1234.10	1183.50	1143.54	980.10	562.95
P/P0	1.2943 0	8.1473-1	5.5634-1	3.4652-1	2.2703-1	1.4078-1
T, DEG K	17707	15066	13070	10762	7741	3680
H/RT	6.1780	5.3350	4.7069	3.9841	3.7983	4.9039
S/R	23.3029	24.5472	25.6025	26.5061	26.4101	25.3015
M, MOL WT	8.14718	9.38066	10.37519	11.37302	11.84138	12.15613
(DLV/DLP)T	-1.11676	-1.08887	-1.06789	-1.02504	-1.00118	-1.01963
(DLV/DLT)P	2.2614	1.9314	1.7584	1.3400	1.0237	1.2965
CP/R	22.1850	16.4687	14.2022	8.5170	3.0483	7.0300
GAMMA (S)	1.1283	1.1596	1.1762	1.2282	1.5212	1.2812
GAMMA	1.2601	1.2626	1.2561	1.2589	1.5230	1.3063
SON VEL,M/SEC	4515.5	3935.0	3509.9	3108.5	2875.4	1795.6

COULOMBIC PARAMETERS

IP LOWER,CM-1	735.7	560.1	412.8	227.3	57.1	0.2
DEBYE LNG,CM	1.579 -6	2.074 -6	2.813 -6	5.109 -6	2.033 -5	0. -19
DEBN/BETN	8.387 -1	8.544 -1	8.778 -1	9.389 -1	1.119 0	0. -19

NUMBER OF CHARGED PARTICLES IN DEBYE SPHERE

	5.574 0	6.226 0	7.316 0	1.098 1	3.135 1	0. -19
COUL COMPRESS	0.99376	0.99627	0.99810	0.99958	0.99999	1.00000

P2/P1	1229.617	773.996	528.524	329.198	215.679	133.743
T2/T1	59.391	50.531	43.838	36.097	25.964	12.341
M2/M1	0.5493	0.6325	0.6995	0.7668	0.7984	0.8196
RHO2/RHO1	11.4438	9.7237	8.4495	6.9958	6.6320	8.8818
V2=U1-U2,M/SEC	13689.25	10765.90	8816.50	6856.46	5519.90	4437.05

MOLE FRACTIONS

E	3.1339-1	2.0944-1	1.2562-1	4.1531-2	2.0724-3	1.2814-8
H2	1.9804-8	1.5610-7	6.7432-7	2.4852-6	1.6730-5	2.4470-2
H2+	3.751 -7	8.626 -7	1.104 -6	6.831 -7	9.537 -8	3.532-11
H	5.1359-2	1.2402-1	2.2677-1	3.4199-1	3.9707-1	3.6085-1
H+	2.2328-1	1.9221-1	1.2298-1	4.1390-2	2.0722-3	1.2786-8
H-	5.727 -7	1.021 -6	1.214 -6	7.145 -7	8.560 -8	6.859-12
HE	2.7076-2	3.1580-2	3.4971-2	3.8339-2	3.9918-2	4.0979-2
HE+	3.883 -4	4.248 -5	4.440 -6	1.329 -7	5.899-11	5.162-24
HE++	4.269-15	1.427-18	4.243-22	1.200-27	0. 0	0. 0
NE	2.9479-1	4.2553-1	4.8701-1	5.3660-1	5.5885-1	5.7370-1
NE+	8.972 -2	1.719 -2	2.641 -3	1.405 -4	2.177 -7	2.730-18
NE++	2.206 -8	5.852-11	1.208-13	7.570-18	4.802-27	0. 0
NE+++	4.179-22	1.188-27	2.370-33	0. 0	0. 0	0. 0

PARTICLE DENSITIES,1/CM**3

TOTAL	5.399 17	3.984 17	3.130 17	2.364 17	2.153 17	2.808 17

NEGATIVE EXCESS THERMODYNAMIC PROPERTIES

-(H/RT)COUL	2.4978-2	1.4937-2	7.6115-3	1.6829-3	2.9355-5	0. 0
-(S/R)COUL	1.2508-2	7.4755-3	3.8076-3	8.4154-4	1.4670-5	0. 0

TABLE I. CONTINUED. THERMODYNAMIC PROPERTIES FOR EQUILIBRIUM STATES BEHIND INCIDENT AND REFLECTED SHOCKS THROUGH A 0.70 Ne - 0.25 H_2 - 0.05 He MIXTURE

(b) P_1 = 0.8 MM Hg

INITIAL GAS (1)

P/P0	1.0526-3	M, MOL WT	14.83221
T, DEG K	298	CP/R	2.7423
H/RT	0.0000	GAMMA (S)	1.5740
S/R	24.5968	SON VEL,M/SEC	512.9

MACH NO.	29.2460	23.3968	19.4973	15.5979	12.6733	9.7487
U1, M/SEC	15000.00	12000.00	10000.00	8000.00	6500.00	5000.00
SHOCKED GAS (5)--REFLECTED--EQUILIBRIUM						
U5, M/SEC	2586.09	2031.49	1875.38	1740.23	1665.08	1630.76
P/P0	1.7353 1	9.2523 0	5.5729 0	2.9436 0	1.8837 0	1.6469 0
T, DEG K	29058	21791	18950	15892	13516	11021
H/RT	6.1922	6.2085	5.6443	4.9130	4.3034	3.7170
S/R	19.8768	21.2414	22.4276	23.7970	24.8291	25.1640
M, MOL WT	6.21422	7.44625	8.49365	9.72021	10.72992	11.57701
(DLV/DLP)T	-1.05572	-1.15338	-1.13984	-1.09934	-1.06186	-1.01676
(DLV/DLT)P	1.3592	2.2520	2.1862	1.8675	1.5976	1.1980
CP/R	6.0678	19.3048	19.6414	14.9575	11.5929	5.9834
GAMMA (S)	1.3311	1.1227	1.1154	1.1545	1.1881	1.2872
GAMMA	1.4053	1.2949	1.2714	1.2692	1.2616	1.3088
SON VEL,M/SEC	7193.9	5226.6	4548.7	3961.5	3527.5	3191.9
COULOMBIC PARAMETERS						
IP LOWER,CM-1	2034.7	1749.6	1360.8	938.5	641.3	370.6
DEBYE LNG,CM	5.7079-7	6.6379-7	8.5345-7	1.2375-6	1.8110-6	3.1341-6
DEBR/BETN	7.6868-1	7.5150-1	7.6568-1	7.9098-1	8.2036-1	8.6860-1
NUMBER OF CHARGED PARTICLES IN DEBYE SPHERE						
	3.3100 0	2.8852 0	3.2315 0	3.9225 0	4.8821 0	6.8565 0
COUL COMPRESS	0.98399	0.98566	0.99021	0.99488	0.99782	0.99961
P5/P2	13.407	11.356	10.017	8.495	8.297	11.698
T5/T2	1.641	1.446	1.450	1.477	1.746	2.995
M5/M2	0.7627	0.7938	0.8186	0.8547	0.9061	0.9524
RHO5/RHO2	6.2934	6.2995	5.7012	4.9400	4.3151	3.7209
U5+V2,M/SEC	16275.34	12797.39	10691.87	8596.69	7184.98	6067.81
MOLE FRACTIONS						
E	4.7629-1	3.7246-1	2.8419-1	1.8082-1	9.5731-2	2.4349-2
H2	1.2572-9	4.8685-8	1.7697-7	7.9267-7	2.7609-6	1.1960-5
H2+	1.6854-7	1.1420-6	1.9822-6	2.9860-6	3.0164-6	1.8713-6
H	1.2948-2	4.4645-2	8.0805-2	1.6291-1	2.6819-1	3.6598-1
H+	1.9653-1	2.0637-1	2.0551-1	1.6475-1	9.3508-2	2.4253-2
H-	4.5871-7	2.2329-6	2.9783-6	3.5644-6	3.3344-6	1.9691-6
HE	9.0942-3	2.3662-2	2.8264-2	3.2723-2	3.6167-2	3.9026-2
HE+	1.1854-2	1.4394-3	3.6805-4	4.4474-5	4.0690-6	9.7851-8
HE++	2.979 -8	3.009-12	1.531-14	5.821-18	9.718-22	1.337-27
NE	2.5856-2	1.8677-1	3.2254-1	4.4271-1	5.0417-1	5.4628-1
NE+	2.6694-1	1.6465-1	7.8312-2	1.6029-2	2.2193-3	9.5871-5
NE++	4.801 -4	1.425 -6	3.748 -8	1.096-10	1.505-13	4.985-18
NE+++	1.611-11	1.189-17	3.085-21	1.002-26	7.715-33	0. 0
PARTICLE DENSITIES,1/CM**3						
TOTAL	4.454 18	3.162 18	2.180 18	1.366 18	1.025 18	1.097 18
NEGATIVE EXCESS THERMODYNAMIC PROPERTIES						
-(H/RT)COUL	6.4045-2	5.7370-2	3.9152-2	2.0485-2	8.7138-3	1.5707-3
-(S/R)COUL	3.2152-2	2.8789-2	1.9624-2	1.0256-2	4.3592-3	7.8540-4

TABLE I. CONTINUED. THERMODYNAMIC PROPERTIES FOR EQUILIBRIUM STATES BEHIND INCIDENT AND REFLECTED SHOCKS THROUGH A 0.70 Ne - 0.25 H_2 - 0.05 He MIXTURE

(c) P_1 = 0.4 MM Hg

INITIAL GAS (1)

P/P0	5.2632-4	M, MOL WT	14.83221
T, DEG K	298	CP/R	2.7423
H/RT	0.0000	GAMMA (S)	1.5740
S/R	25.2899	SON VEL,M/SEC	512.9

MACH NO.	29.2460	23.3968	19.4973	15.5979	12.6733	9.7487
U1, M/SEC	15000.00	12000.00	10000.00	8000.00	6500.00	5000.00
SHOCKED GAS (2)--INCIDENT						
U2, M/SEC	1269.76	1193.31	1144.05	1112.06	974.12	548.48
P/P0	6.4911-1	4.0891-1	2.7941-1	1.7406-1	1.1364-1	7.0619-2
T, DEG K	17037	14493	12600	10469	7697	3579
H/RT	6.3704	5.5044	4.8537	4.0831	3.8186	5.0204
S/R	23.7927	25.0357	26.1163	27.0864	27.0852	25.8717
M, MOL WT	8.07840	9.30424	10.30398	11.32525	11.83339	12.09785
(DLV/DLP)T	-1.10697	-1.08210	-1.06652	-1.02619	-1.00151	-1.01640
(DLV/DLT)P	2.2717	1.9301	1.8044	1.3806	1.0314	1.2545
CP/R	23.1245	16.7724	15.1627	9.3746	3.2290	6.4899
GAMMA (S)	1.1315	1.1628	1.1740	1.2152	1.4880	1.2921
GAMMA	1.2525	1.2583	1.2521	1.2471	1.4902	1.3133
SON VEL,M/SEC	4454.2	3880.7	3454.8	3056.2	2836.7	1782.8

COULOMBIC PARAMETERS

IP LOWER,CM-1	546.1	418.6	310.6	173.5	46.7	0.1
DEBYE LNG,CM	2.127 -6	2.774 -6	3.739 -6	6.695 -6	2.486 -5	0. -19
DEBN/BETN	8.758 -1	8.911 -1	9.149 -1	9.786 -1	1.156 0	0. -19

NUMBER OF CHARGED PARTICLES IN DEBYE SPHERE

	7.228 0	8.017 0	9.391 0	1.424 1	3.809 1	0. -19
COUL COMPRESS	0.99509	0.99701	0.99844	0.99964	0.99999	1.00000
P2/P1	1233.305	776.925	530.884	330.705	215.912	134.175
T2/T1	57.142	48.610	42.259	35.114	25.816	12.005
M2/M1	0.5447	0.6273	0.6947	0.7636	0.7978	0.8156
RHO2/RHO1	11.8133	10.0561	8.7409	7.1938	6.6727	9.1162
V2=U1-U2,M/SEC	13730.24	10806.69	8855.95	6887.94	5525.88	4451.52

MOLE FRACTIONS

E	3.1918-1	2.1588-1	1.3162-1	4.5555-2	2.7377-3	9.6888-9
H2	7.9415-9	7.5870-8	3.7021-7	1.3979-6	8.6867-6	1.9559-2
H2+	1.801 -7	4.635 -7	6.335 -7	4.091 -7	6.451 -8	1.758-11
H	4.2903-2	1.1320-1	2.1793-1	3.3634-1	3.9615-1	3.6871-1
H+	2.2942-1	2.0045-1	1.2942-1	4.5432-2	2.7374-3	9.6743-9
H-	2.727 -7	5.413 -7	6.908 -7	4.245 -7	5.766 -8	3.049-12
HE	2.6874-2	3.1330-2	3.4732-2	3.8178-2	3.9891-2	4.0782-2
HE+	3.589 -4	3.459 -5	3.349 -6	1.060 -7	7.086-11	1.442-24
HE++	1.724-15	3.890-19	9.124-23	3.138-28	0. 0	0. 0
NE	2.9185-1	4.2372-1	4.8409-1	5.3437-1	5.5847-1	5.7095-1
NE+	8.940 -2	1.539 -2	2.202 -3	1.227 -4	2.689 -7	9.935-19
NE++	1.313 -8	2.553-11	4.340-14	3.151-18	6.053-27	0. 0
NE+++	8.771-23	1.341-28	1.827-34	0. 0	0. 0	0. 0

PARTICLE DENSITIES,1/CM**3

TOTAL	2.810 17	2.077 17	1.630 17	1.221 17	1.084 17	1.448 17

NEGATIVE EXCESS THERMODYNAMIC PROPERTIES

-(H/RT)COUL	1.9627-2	1.1962-2	6.2245-3	1.4480-3	3.1888-5	0. 0
-(S/R)COUL	9.8257-3	5.9854-3	3.1135-3	7.2405-4	1.5944-5	0. 0

TABLE I. CONTINUED. THERMODYNAMIC PROPERTIES FOR EQUILIBRIUM STATES BEHIND INCIDENT AND REFLECTED SHOCKS THROUGH A 0.70 Ne - 0.25 H_2 - 0.05 He MIXTURE

(c) P_1 = 0.4 MM Hg

INITIAL GAS (1)

P/P0	5.2632-4	M, MOL WT	14.83221
T, DEG K	298	CP/R	2.7423
H/RT	0.0000	GAMMA (S)	1.5740
S/R	25.2899	SON VEL,M/SEC	512.9

MACH NO.	29.2460	23.3968	19.4973	15.5979	12.6733	9.7487
U1, M/SEC	15000.00	12000.00	10000.00	8000.00	6500.00	5000.00
SHOCKED GAS (5)--REFLECTED--EQUILIBRIUM						
U5, M/SEC	2521.52	1966.49	1820.01	1685.11	1609.46	1594.42
P/P0	8.9503 0	4.7801 0	2.8820 0	1.5118 0	9.4217-1	8.4326-1
T, DEG K	27994	20888	18218	15279	13008	10756
H/RT	6.3641	6.4205	5.8189	5.0648	4.4230	3.7882
S/R	20.3350	21.7176	22.8808	24.2668	25.3653	25.7456
M, MOL WT	6.15697	7.38783	8.41945	9.64440	10.67449	11.54110
(DLV/DLP)T	-1.04415	-1.14001	-1.12683	-1.09243	-1.06018	-1.01774
(DLV/DLT)P	1.3113	2.2723	2.1994	1.8881	1.6411	1.2271
CP/R	5.7521	20.2748	20.4035	15.5169	12.4460	6.5477
GAMMA (S)	1.3419	1.1295	1.1239	1.1592	1.1851	1.2694
GAMMA	1.4011	1.2877	1.2665	1.2663	1.2565	1.2919
SON VEL,M/SEC	7122.2	5152.8	4496.6	3907.5	3465.2	3136.4
COULOMBIC PARAMETERS						
IP LOWER,CM-1	1521.7	1318.7	1028.0	711.4	482.5	288.0
DEBYE LNG,CM	7.6321-7	8.8073-7	1.1297-6	1.6325-6	2.4068-6	4.0320-6
DEBW/BETN	8.0174-1	7.8222-1	7.9700-1	8.2293-1	8.5470-1	9.0218-1
NUMBER OF CHARGED PARTICLES IN DEBYE SPHERE						
	4.2565 0	3.6693 0	4.1060 0	4.9749 0	6.2435 0	8.6093 0
COUL COMPRESS	0.98745	0.98857	0.99214	0.99582	0.99821	0.99965
P5/P2	13.789	11.690	10.314	8.686	8.291	11.941
T5/T2	1.643	1.441	1.446	1.459	1.690	3.005
M5/M2	0.7622	0.7940	0.8171	0.8516	0.9021	0.9540
RHO5/RHO2	6.4452	6.4954	5.8659	5.0875	4.4334	3.7919
U5+V2,M/SEC	16251.76	12773.18	10675.96	8573.05	7135.34	6045.94
MOLE FRACTIONS						
E	4.8112-1	3.7738-1	2.9044-1	1.8721-1	1.0040-1	2.7370-2
H2	3.803-10	1.990 -8	7.822 -8	4.134 -7	1.555 -6	6.791 -6
H2+	6.9572-8	5.6226-7	1.0282-6	1.6945-6	1.7568-6	1.1617-6
H	9.8919-3	3.8565-2	7.0685-2	1.5215-1	2.6126-1	3.6176-1
H+	1.9766-1	2.1048-1	2.1313-1	1.7296-1	9.8571-2	2.7282-2
H-	1.8758-7	1.0930-6	1.5235-6	1.9931-6	1.9254-6	1.2146-6
HE	8.1633-3	2.3538-2	2.8047-2	3.2476-2	3.5981-2	3.8905-2
HE+	1.2592-2	1.3667-3	3.3516-4	3.6009-5	3.0264-6	8.3482-8
HE++	2.324 -8	1.345-12	6.010-15	1.567-18	1.932-22	4.548-28
NE	2.0147-2	1.8313-1	3.2038-1	4.4095-1	5.0195-1	5.4459-1
NE+	2.6999-1	1.6554-1	7.6975-2	1.4217-2	1.8265-3	8.8393-5
NE++	4.336 -4	9.060 -7	2.191 -8	4.783-11	5.193-14	2.585-18
NE+++	1.008-11	3.129-18	6.703-22	1.191-27	5.604-34	0. 0
PARTICLE DENSITIES,1/CM**3						
TOTAL	2.376 18	1.699 18	1.170 18	7.293 17	5.326 17	5.756 17
NEGATIVE EXCESS THERMODYNAMIC PROPERTIES						
-(H/RT)COUL	5.0216-2	4.5705-2	3.1443-2	1.6722-2	7.1453-3	1.4061-3
-(S/R)COUL	2.5188-2	2.2918-2	1.5753-2	8.3700-3	3.5742-3	7.0313-4

TABLE I. CONTINUED. THERMODYNAMIC PROPERTIES FOR EQUILIBRIUM STATES BEHIND INCIDENT AND REFLECTED SHOCKS THROUGH A 0.70 Ne - 0.25 H_2 - 0.05 He MIXTURE

(d) P_1 = 0.2 MM Hg

INITIAL GAS (1)

P/P0	2.6316-4	M, MOL WT	14.83221
T, DEG K	298	CP/R	2.7423
H/RT	0.0000	GAMMA (S)	1.5740
S/R	25.9830	SON VEL,M/SEC	512.9

MACH NO.	29.2460	23.3968	19.4973	15.5979	12.6733	9.7487
U1, M/SEC	15000.00	12000.00	10000.00	8000.00	6500.00	5000.00
SHOCKED GAS (2)--INCIDENT						
U2, M/SEC	1231.39	1155.27	1105.87	1081.24	966.76	535.44
P/P0	3.2546-1	2.0517-1	1.4031-1	8.7416-2	5.6894-2	3.5412-2
T, DEG K	16415	13955	12149	10181	7643	3489
H/RT	6.5601	5.6731	5.0060	4.1856	3.8438	5.1307
S/R	24.2838	25.5167	26.6378	27.6636	27.7557	26.4525
M, MOL WT	8.01212	9.22707	10.23727	11.27747	11.82262	12.04601
(DLV/DLP)T	-1.09874	-1.07587	-1.06535	-1.02741	-1.00193	-1.01325
(DLV/DLT)P	2.2839	1.9240	1.8483	1.4227	1.0410	1.2107
CP/R	24.0777	16.9828	16.1640	10.2801	3.4570	5.8838
GAMMA (S)	1.1337	1.1657	1.1709	1.2041	1.4526	1.3087
GAMMA	1.2456	1.2541	1.2475	1.2371	1.4554	1.3261
SON VEL,M/SEC	4394.3	3828.5	3399.0	3006.2	2794.0	1775.4
COULOMBIC PARAMETERS						
IP LOWER,CM-1	404.6	312.5	233.0	131.9	38.0	0.1
DEBYE LNG,CM	2.870 -6	3.717 -6	4.983 -6	8.807 -6	3.060 -5	0. -19
DEBK/BETA	9.152 -1	9.297 -1	9.540 -1	1.019 0	1.195 0	0. -19
NUMBER OF CHARGED PARTICLES IN DEBYE SPHERE						
	9.441 0	1.035 1	1.208 1	1.801 1	4.656 1	0. -19
COUL COMPRESS	0.99616	0.99761	0.99874	0.99969	0.99999	1.00000
P2/P1	1236.740	779.661	533.171	332.180	216.198	134.566
T2/T1	55.055	46.806	40.747	34.146	25.633	11.703
M2/M1	0.5402	0.6221	0.6902	0.7603	0.7972	0.8122
RHO2/RHO1	12.1813	10.3872	9.0427	7.3989	6.7235	9.3382
V2=U1-U2,M/SEC	13768.61	10844.73	8894.13	6918.76	5533.24	4464.56
MOLE FRACTIONS						
E	3.2477-1	2.2238-1	1.3724-1	4.9580-2	3.5574-3	7.5773-9
H2	3.0908-9	3.6733-8	2.0408-7	7.9064-7	4.5527-6	1.5190-2
H2+	8.497 -8	2.476 -7	3.620 -7	2.437 -7	4.318 -8	8.897-12
H	3.5295-2	1.0242-1	2.0967-1	3.3069-1	3.9501-1	3.7570-1
H+	2.3480-1	2.0862-1	1.3543-1	4.9475-2	3.5571-3	7.5698-9
H-	1.279 -7	2.857 -7	3.914 -7	2.507 -7	3.839 -8	1.385-12
HE	2.6675-2	3.1077-2	3.4508-2	3.8017-2	3.9858-2	4.0608-2
HE+	3.340 -4	2.803 -5	2.485 -6	8.280 -8	8.188-11	4.399-25
HE++	7.029-16	1.035-19	1.838-23	7.568-29	0. 0	0. 0
NE	2.8849-1	4.2174-1	4.8133-1	5.3213-1	5.5801-1	5.6851-1
NE+	8.964 -2	1.373 -2	1.811 -3	1.052 -4	3.214 -7	3.895-19
NE++	7.419 -9	1.029-11	1.396-14	1.161-18	6.444-27	0. 0
NE+++	1.866-23	1.454-29	1.268-35	0. 0	0. 0	0. 0
PARTICLE DENSITIES,1/CM**3						
TOTAL	1.461 17	1.082 17	8.487 16	6.304 16	5.464 16	7.449 16
NEGATIVE EXCESS THERMODYNAMIC PROPERTIES						
-(H/RT)COUL	1.5358-2	9.5522-3	5.0507-3	1.2321-3	3.3915-5	0. 0
-(S/R)COUL	7.6865-3	4.7789-3	2.5261-3	6.1607-4	1.6958-5	0. 0

TABLE I. CONTINUED. THERMODYNAMIC PROPERTIES FOR EQUILIBRIUM STATES BEHIND INCIDENT AND REFLECTED SHOCKS THROUGH A 0.70 Ne - 0.25 H_2 - 0.05 He MIXTURE

(d) P_1 = 0.2 MM Hg

INITIAL GAS (1)

P/P0	2.6316-4	M, MOL WT	14.83221
T, DEG K	298	CP/R	2.7423
H/RT	0.0000	GAMMA (S)	1.5740
S/R	25.9830	SON VEL,M/SEC	512.9

MACH NO.	29.2460	23.3968	19.4973	15.5979	12.6733	9.7487
U1, M/SEC	15000.00	12000.00	10000.00	8000.00	6500.00	5000.00
SHOCKED GAS (5)--REFLECTED--EQUILIBRIUM						
U5, M/SEC	2461.23	1908.65	1768.76	1632.71	1556.42	1556.97
P/P0	4.6115 0	2.4672 0	1.4906 0	7.7669-1	4.7219-1	4.3070-1
T, DEG K	27059	20054	17535	14701	12526	10484
H/RT	6.5296	6.6206	5.9896	5.2185	4.5461	3.8639
S/R	20.8264	22.1574	23.3203	24.7351	25.9010	26.3267
M, MOL WT	6.11021	7.31807	8.34210	9.56971	10.62022	11.50567
(DLV/DLP)T	-1.03483	-1.12809	-1.11527	-1.08637	-1.05890	-1.01868
(DLV/DLT)P	1.2635	2.2950	2.2094	1.9040	1.6852	1.2572
CP/R	5.3698	21.2401	21.1580	16.0082	13.3466	7.1621
GAMMA (S)	1.3559	1.1362	1.1305	1.1629	1.1819	1.2531
GAMMA	1.4031	1.2818	1.2608	1.2634	1.2515	1.2765
SON VEL,M/SEC	7065.6	5087.9	4444.9	3854.0	3404.3	3081.2
COULOMBIC PARAMETERS						
IP LOWER,CM-1	1133.0	993.3	776.1	538.6	362.7	222.4
DEBYE LNG,CM	1.0250-6	1.1693-6	1.4964-6	2.1562-6	3.2022-6	5.2221-6
DEBN/BETN	8.3740-1	8.1452-1	8.2989-1	8.5647-1	8.9074-1	9.3767-1
NUMBER OF CHARGED PARTICLES IN DEBYE SPHERE						
	5.5263 0	4.6783 0	5.2305 0	6.3222 0	7.9999 0	1.0820 1
COUL COMPRESS	0.99025	0.99090	0.99370	0.99660	0.99854	0.99969
P5/P2	14.169	12.025	10.624	8.885	8.299	12.162
T5/T2	1.648	1.437	1.443	1.444	1.639	3.005
M5/M2	0.7626	0.7931	0.8149	0.8486	0.8982	0.9551
RHO5/RHO2	6.5942	6.6819	6.0284	5.2376	4.5551	3.8675
U5+V2,M/SEC	16229.83	12753.38	10662.90	8551.47	7089.66	6021.53
MOLE FRACTIONS						
E	4.8506-1	3.8326-1	2.9696-1	1.9350-1	1.0497-1	3.0353-2
H2	1.063-10	8.038 -9	3.424 -8	2.152 -7	8.798 -7	3.883 -6
H2+	2.7674-8	2.7507-7	5.2978-7	9.5636-7	1.0212-6	7.1365-7
H	7.3064-3	3.1626-2	6.0265-2	1.4165-1	2.5452-1	3.5758-1
H+	1.9867-1	2.1507-1	2.2095-1	1.8095-1	1.0348-1	3.0273-2
H-	7.4190-8	5.3193-7	7.7457-7	1.1099-6	1.1099-6	7.4078-7
HE	7.1206-3	2.3367-2	2.7816-2	3.2231-2	3.5799-2	3.8786-2
HE+	1.3477-2	1.3025-3	3.0559-4	2.8909-5	2.2229-6	6.8684-8
HE++	1.952 -8	6.076-13	2.363-15	4.090-19	3.682-23	1.350-28
NE	1.5873-2	1.7848-1	3.1799-1	4.3911-1	4.9973-1	5.4293-1
NE+	2.7208-1	1.6689-1	7.5707-2	1.2526-2	1.4877-3	7.9083-5
NE++	4.125 -4	5.832 -7	1.286 -8	2.042-11	1.737-14	1.210-18
NE+++	7.038-12	8.255-19	1.437-22	1.329-28	3.750-35	0. 0
PARTICLE DENSITIES,1/CM**3						
TOTAL	1.263 18	9.113 17	6.279 17	3.891 17	2.771 17	3.016 17
NEGATIVE EXCESS THERMODYNAMIC PROPERTIES						
-(H/RT)CELL	3.8996-2	3.6417-2	2.5215-2	1.3601-2	5.8309-3	1.2352-3
-(S/R)CELL	1.9546-2	1.8250-2	1.2627-2	6.8064-3	2.9165-3	6.1764-4

TABLE I. CONTINUED. THERMODYNAMIC PROPERTIES FOR EQUILIBRIUM STATES BEHIND INCIDENT AND REFLECTED SHOCKS THROUGH A 0.70 Ne - 0.25 H_2 - 0.05 He MIXTURE

(e) P_1 = 0.1 MM Hg

INITIAL GAS (1)

P/P0	1.3158-4	M, MOL WT	14.83221
T, DEG K	298	CP/R	2.7423
H/RT	0.0000	GAMMA (S)	1.5740
S/R	26.6762	SON VEL,M/SEC	512.9

MACH NO.	29.2460	23.3968	19.4973	15.5979	12.6733	9.7487
U1, M/SEC	15000.00	12000.00	10000.00	8000.00	6500.00	5000.00
SHOCKED GAS (2)--INCIDENT						
U2, M/SEC	1194.07	1118.45	1069.06	1051.03	957.96	523.89
P/P0	1.6317-1	1.0293-1	7.0444-2	4.3898-2	2.8492-2	1.7752-2
T, DEG K	15833	13446	11718	9898	7578	3410
H/RT	6.7553	5.8460	5.1622	4.2918	3.8746	5.2326
S/R	24.7985	26.0116	27.1659	28.2400	28.4210	27.0450
M, MOL WT	7.95484	9.15691	10.17493	11.23052	11.81192	12.00078
(DLV/DLP)T	-1.09202	-1.07007	-1.06436	-1.02861	-1.00242	-1.01027
(DLV/DLT)P	2.2961	1.9090	1.8903	1.4658	1.0527	1.1671
CP/R	25.1115	17.0798	17.2008	11.2431	3.7378	5.2410
GAMMA (S)	1.1337	1.1673	1.1674	1.1940	1.4166	1.3326
GAMMA	1.2380	1.2491	1.2425	1.2282	1.4200	1.3463
SON VEL,M/SEC	4331.3	3775.1	3343.3	2957.9	2748.7	1774.4

COULOMBIC PARAMETERS

IP LOWER,CM-1	299.1	232.7	174.4	99.9	30.6	0.1
DEBYE LNG,CM	3.883 -6	4.992 -6	6.658 -6	1.163 -5	3.795 -5	0. -19
DEBN/BETN	9.565 -1	9.711 -1	9.959 -1	1.062 0	1.237 0	0. -19

NUMBER OF CHARGED PARTICLES IN DEBYE SPHERE

	1.227 1	1.352 1	1.577 1	2.298 1	5.725 1	0. -19
COUL COMPRESS	0.99701	0.99811	0.99898	0.99974	0.99999	1.00000
P2/P1	1240.088	782.300	535.371	333.626	216.540	134.916
T2/T1	53.103	45.100	39.303	33.196	25.415	11.438
M2/M1	0.5363	0.6174	0.6860	0.7572	0.7964	0.8091
RHO2/RHO1	12.5620	10.7292	9.3540	7.6116	6.7852	9.5440
V2=U1-U2,M/SEC	13805.93	10881.55	8930.94	6948.97	5542.04	4476.11

MOLE FRACTIONS

E	3.2960-1	2.2829-1	1.4250-1	5.3537-2	4.5406-3	6.1988-9
H2	1.1771-9	1.7675-8	1.1305-7	4.4923-7	2.4105-6	1.1378-2
H2+	3.938 -8	1.311 -7	2.061 -7	1.442 -7	2.857 -8	4.614-12
H	2.9071-2	9.2592-2	2.0197-1	3.2514-1	3.9364-1	3.8180-1
H+	2.3909-1	2.1609-1	1.4103-1	5.3448-2	4.5403-3	6.1948-9
H-	5.904 -8	1.495 -7	2.209 -7	1.471 -7	2.523 -8	6.487-13
HE	2.6504-2	3.0846-2	3.4298-2	3.7858-2	3.9818-2	4.0455-2
HE+	3.123 -4	2.256 -5	1.816 -6	6.330 -8	9.066-11	1.510-25
HE++	2.869-16	2.660-20	3.486-24	1.685-29	0. 0	0. 0
NE	2.8523-1	4.1998-1	4.7873-1	5.2993-1	5.5746-1	5.6637-1
NE+	9.020 -2	1.218 -2	1.471 -3	8.869 -5	3.705 -7	1.685-19
NE++	4.587 -9	4.419-12	4.686-15	4.396-19	6.657-27	0. 0
NE+++	3.961-24	1.489-30	7.967-37	0. 0	0. 0	0. 0

PARTICLE DENSITIES,1/CM**3

TOTAL	7.587 16	5.629 16	4.417 16	3.256 16	2.760 16	3.821 16

NEGATIVE EXCESS THERMODYNAMIC PROPERTIES

-(H/RT)COUL	1.1945-2	7.5781-3	4.0690-3	1.0365-3	3.5197-5	0. 0
-(S/R)COUL	5.9770-3	3.7909-3	2.0350-3	5.1827-4	1.7591-5	0. 0

TABLE I. CONTINUED. THERMODYNAMIC PROPERTIES FOR EQUILIBRIUM STATES BEHIND INCIDENT AND REFLECTED SHOCKS THROUGH A 0.70 Ne - 0.25 H_2 - 0.05 He MIXTURE

(e) P_1 = 0.1 MM Hg

INITIAL GAS (1)

P/P0	1.3158-4	M, MOL WT	14.83221
T, DEG K	298	CP/R	2.7423
H/RT	0.0000	GAMMA (S)	1.5740
S/R	26.6762	SON VEL,M/SEC	512.9

MACH NO.	29.2460	23.3968	19.4973	15.5979	12.6733	9.7487
U1, M/SEC	15000.00	12000.00	10000.00	8000.00	6500.00	5000.00
SHOCKED GAS (5)--REFLECTED--EQUILIBRIUM						
U5, M/SEC	2406.58	1848.36	1717.21	1582.79	1505.18	1519.16
P/P0	2.3768 0	1.2730 0	7.7077-1	3.9917-1	2.3713-1	2.1939-1
T, DEG K	26254	19266	16891	14154	12067	10210
H/RT	6.6858	6.8368	6.1688	5.3743	4.6739	3.9430
S/R	21.3497	22.6516	23.7937	25.2036	26.4418	26.9076
M, MOL WT	6.07283	7.26754	8.27839	9.49688	10.56957	11.47067
(DLV/DLP)T	-1.02754	-1.11845	-1.10528	-1.08095	-1.05789	-1.01959
(DLV/DLT)P	1.2180	2.3105	2.2111	1.9152	1.7282	1.2882
CP/R	4.9648	22.2490	21.9225	16.4246	14.3070	7.8176
GAMMA (S)	1.3722	1.1383	1.1334	1.1660	1.1777	1.2387
GAMMA	1.4100	1.2731	1.2528	1.2604	1.2459	1.2629
SON VEL,M/SEC	7023.0	5008.9	4384.9	3801.1	3343.5	3027.7
COULOMBIC PARAMETERS						
IP LOWER,CM-1	840.1	746.0	584.2	407.2	272.1	170.7
DEBYE LNG,CM	1.3824-6	1.5568-6	1.9880-6	2.8520-6	4.2680-6	6.8029-6
DEBN/BETN	8.7577-1	8.4867-1	8.6466-1	8.9169-1	9.2852-1	9.7549-1
NUMBER OF CHARGED PARTICLES IN DEBYE SPHERE						
	7.2308 0	5.9892 0	6.6861 0	8.0516 0	1.0250 1	1.3697 1
COUL COMPRESS	0.99250	0.99280	0.99498	0.99725	0.99882	0.99973
P5/P2	14.567	12.367	10.942	9.093	8.223	12.358
T5/T2	1.658	1.433	1.441	1.430	1.592	2.994
M5/M2	0.7634	0.7937	0.8136	0.8456	0.8948	0.9558
RHO5/RHO2	6.7367	6.8871	6.2008	5.3903	4.6820	3.9464
U5+V2,M/SEC	16212.51	12729.92	10648.15	8531.75	7047.22	5995.27
MOLE FRACTIONS						
E	4.9821-1	3.8752-1	3.0233-1	1.9964-1	1.0924-1	3.3300-2
H2	2.750-11	3.193 -9	1.468 -8	1.119 -7	5.009 -7	2.233 -6
H2+	1.0489-8	1.3250-7	2.6795-7	5.3686-7	5.9215-7	4.3452-7
H	5.9673-3	2.6539-2	5.1537-2	1.3149-1	2.4826-1	3.5344-1
H+	1.9875-1	2.1845-1	2.2753-1	1.8866-1	1.0804-1	3.3231-2
H-	2.8137-8	2.5529-7	3.8739-7	6.1539-7	6.3819-7	4.4739-7
HE	6.0194-3	2.3259-2	2.7628-2	3.1991-2	3.5629-2	3.8668-2
HE+	1.4452-2	1.2399-3	2.7878-4	2.3020-5	1.6076-6	5.4843-8
HE++	1.781 -8	2.697-13	9.199-16	1.036-19	6.650-24	3.579-29
NE	1.2021-2	1.7516-1	3.1617-1	4.3724-1	4.9763-1	5.4128-1
NE+	2.7416-1	1.6783-1	7.4522-2	1.0963-2	1.1961-3	6.9024-5
NE++	4.191 -4	3.714 -7	7.522 -9	8.537-12	5.583-15	5.205-19
NE+++	5.679-12	2.080-19	2.990-23	1.397-29	2.275-36	0. 0
PARTICLE DENSITIES,1/CM**3						
TOTAL	6.695 17	4.885 17	3.366 17	2.076 17	1.444 17	1.578 17
NEGATIVE EXCESS THERMODYNAMIC PROPERTIES						
-(H/RT)COUL	2.9996-2	2.8787-2	2.0060-2	1.1019-2	4.7258-3	1.0682-3
-(S/R)COUL	1.5026-2	1.4419-2	1.0043-2	5.5132-3	2.3636-3	5.3412-4

TABLE 1. CONTINUED. THERMODYNAMIC PROPERTIES FOR EQUILIBRIUM STATES BEHIND INCIDENT AND REFLECTED SHOCKS THROUGH A 0.70 Ne - 0.25 H_2 - 0.05 He MIXTURE

(f) P_1 = 0.05 MM Hg

INITIAL GAS (1)

P/P0	6.5789-5	M, MOL WT	14.83221
T, DEG K	298	CP/R	2.7423
H/RT	0.0000	GAMMA (S)	1.5740
S/R	27.3693	SON VEL,M/SEC	512.9

MACH NO.	29.2460	23.3968	19.4973	15.5979	12.6733	9.7487
U1, M/SEC	15000.00	12000.00	10000.00	8000.00	6500.00	5000.00
SHOCKED GAS (2)--INCIDENT						
U2, M/SEC	1158.75	1083.55	1034.46	1021.56	947.71	514.05
P/P0	8.1793-2	5.1632-2	3.5358-2	2.2042-2	1.4272-2	8.8953-3
T, DEG K	15289	12968	11311	9621	7502	3343
H/RT	6.9508	6.0207	5.3192	4.4015	3.9112	5.3236
S/R	25.3200	26.5109	27.6899	28.8164	29.0810	27.6505
M, MOL WT	7.90112	9.08990	10.11265	11.18469	11.79831	11.96232
(DLV/DLP)T	-1.08644	-1.06460	-1.06364	-1.02980	-1.00299	-1.00756
(DLV/DLT)P	2.3117	1.9876	1.9333	1.5096	1.0666	1.1254
CP/R	26.2292	17.0694	18.2545	12.2638	4.0753	4.5971
GAMMA (S)	1.1329	1.1684	1.1643	1.1849	1.3815	1.3660
GAMMA	1.2308	1.2439	1.2384	1.2202	1.3856	1.3764
SON VEL,M/SEC	4269.3	3722.8	3290.5	2911.0	2702.4	1781.5
COULOMBIC PARAMETERS						
IP LOWER,CM-1	220.7	172.9	130.3	75.4	24.5	0.0
DEBYE LNG,CM	5.262 -6	6.716 -6	8.910 -6	1.540 -5	4.743 -5	0. -19
DEBN/BETN	1.000 0	1.014 0	1.039 0	1.107 0	1.281 0	0. -19
NUMBER OF CHARGED PARTICLES IN DEBYE SPHERE						
	1.604 1	1.744 1	2.021 1	2.951 1	7.084 1	0. -19
COUL COMPRESS	0.99769	0.99850	0.99918	0.99978	0.99999	1.00000
P2/P1	1243.259	784.806	537.441	335.037	216.939	135.208
T2/T1	51.280	43.494	37.937	32.268	25.160	11.211
M2/M1	0.5327	0.6128	0.6818	0.7541	0.7955	0.8065
RHO2/RHO1	12.9450	11.0747	9.6669	7.8312	6.8586	9.7267
V2=U1-U2,M/SEC	13841.25	10916.45	8965.54	6978.44	5552.29	4485.95
MOLE FRACTIONS						
E	3.3412-1	2.3394-1	1.4775-1	5.7399-2	5.6869-3	5.3855-9
H2	4.406-10	8.460 -9	6.284 -8	2.568 -7	1.290 -6	8.137 -3
H2+	1.801 -8	6.884 -8	1.171 -7	8.500 -8	1.868 -8	2.473-12
H	2.3609-2	8.3278-2	1.9434-1	3.1971-1	3.9204-1	3.8698-1
H+	2.4274-1	2.2315-1	1.4656-1	5.7325-2	5.6865-3	5.3833-9
H-	2.694 -8	7.763 -8	1.245 -7	8.580 -8	1.636 -8	3.173-13
HE	2.6342-2	3.0624-2	3.4089-2	3.7704-2	3.9773-2	4.0325-2
HE+	2.933 -4	1.809 -5	1.315 -6	4.745 -8	9.595-11	6.060-26
HE++	1.177-16	6.697-21	6.373-25	3.490-30	0. 0	0. 0
NE	2.8180-1	4.1822-1	4.7608-1	5.2778-1	5.5682-1	5.6456-1
NE+	9.109 -2	1.078 -2	1.186 -3	7.356 -5	4.112 -7	8.311-20
NE++	2.852 -9	1.871-12	1.530-15	1.576-19	6.073-27	0. 0
NE+++	8.461-25	1.474-31	4.718-38	0. 0	0. 0	0. 0
PARTICLE DENSITIES,1/CM**3						
TOTAL	3.936 16	2.927 16	2.296 16	1.682 16	1.396 16	1.953 16
NEGATIVE EXCESS THERMODYNAMIC PROPERTIES						
-(H/RT)COUL	9.2536-3	5.9849-3	3.2664-3	8.6290-4	3.5614-5	0. 0
-(S/R)COUL	4.6295-3	2.9935-3	1.6335-3	4.3146-4	1.7799-5	0. 0

TABLE I. CONCLUDED. THERMODYNAMIC PROPERTIES FOR EQUILIBRIUM STATES BEHIND INCIDENT AND REFLECTED SHOCKS THROUGH A 0.70 Ne - 0.25 H_2 - 0.05 He MIXTURE

(f) P_1 = 0.05 MM Hg

INITIAL GAS (1)			
P/P0	6.5789-5	M, MOL WT	14.89221
T, DEG K	298	CP/R	2.7423
H/RT	0.0000	GAMMA (S)	1.5740
S/R	27.3693	SON VEL,M/SEC	512.9

MACH NO.	29.2460	23.3968	19.4973	15.5979	12.6733	9.7487
U1, M/SEC	15000.00	12000.00	10000.00	8000.00	6500.00	5000.00
SHOCKED GAS (5)--REFLECTED--EQUILIBRIUM						
U5, M/SEC	2358.19	1792.19	1669.45	1534.88	1456.63	1481.28
P/P0	1.2244 0	6.5643-1	3.9819-1	2.0518-1	1.1934-1	1.1139-1
T, DEG K	25577	18535	16294	13637	11634	9936
H/RT	6.8298	7.0503	6.3441	5.5332	4.8045	4.0252
S/R	21.9081	23.1410	24.2631	25.6762	26.9819	27.4895
M, MOL WT	6.04504	7.21612	8.21445	9.42733	10.51988	11.43644
(DLV/DLP)T	-1.02219	-1.11025	-1.09672	-1.07603	-1.05718	-1.02048
(DLV/DLT)P	1.1763	2.3279	2.2137	1.9212	1.7719	1.3200
CP/R	4.5500	23.2744	22.6538	16.7852	15.3137	8.5144
GAMMA (S)	1.3926	1.1397	1.1359	1.1681	1.1735	1.2258
GAMMA	1.4235	1.2654	1.2457	1.2569	1.2406	1.2509
SON VEL,M/SEC	6999.1	4933.5	4328.1	3748.0	3284.8	2975.6

COULOMBIC PARAMETERS

IP LOWER,CM-1	619.9	559.5	438.9	307.4	204.0	130.3
DEBYE LNG,CM	1.8735-6	2.0757-6	2.6460-6	3.7784-6	5.6931-6	8.9132-6
DEBM/BETN	9.1723-1	8.8457-1	9.0132-1	9.2871-1	9.6825-1	1.0158 0

NUMBER OF CHARGED PARTICLES IN DEBYE SPHERE

	9.5410 0	7.6740 0	8.5645 0	1.0277 1	1.3173 1	1.7459 1
COUL COMPRESS	0.99429	0.99433	0.99602	0.99778	0.99905	0.99977

P5/P2	14.969	12.714	11.262	9.309	8.362	12.522
T5/T2	1.673	1.429	1.441	1.417	1.551	2.972
M5/M2	0.7651	0.7939	0.8123	0.8429	0.8916	0.9560
RHO5/RHO2	6.8694	7.0911	6.3703	5.5466	4.8117	4.0284
U5+V2,M/SEC	16199.44	12708.64	10634.99	8513.32	7008.92	5967.23

MOLE FRACTIONS

E	4.9055-1	3.9185-1	3.0772-1	2.0550-1	1.1343-1	3.6184-2
H2	6.573-12	1.245 -9	6.121 -9	5.814 -8	2.865 -7	1.289 -6
H2+	3.8049-9	6.2962-8	1.3297-7	2.9992-7	3.4298-7	2.6208-7
H	4.6796-3	2.1907-2	4.3408-2	1.2183-1	2.4216-1	3.4940-1
H+	1.9910-1	2.2135-1	2.3350-1	1.9596-1	1.1247-1	3.6125-2
H-	1.0210-8	1.2116-7	1.9063-7	3.3984-7	3.6651-7	2.6760-7
HE	4.8459-3	2.3141-2	2.7435-2	3.1762-2	3.5462-2	3.8553-2
HE+	1.5532-2	1.1849-3	2.5655-4	1.8157-5	1.1519-6	4.2588-8
HE++	1.796 -8	1.207-13	3.663-16	2.536-20	1.165-24	8.534-30
NE	9.8367-3	1.7124-1	3.1372-1	4.3540-1	4.9553-1	5.3968-1
NE+	2.7500-1	1.6932-1	7.3958-2	9.5198-3	9.5435-4	5.8878-5
NE++	4.587 -4	2.388 -7	4.495 -9	3.479-12	1.754-15	2.068-19
NE+++	5.454-12	5.251-20	6.378-24	1.374-30	1.300-37	0. 0

PARTICLE DENSITIES,1/CM**3

TOTAL	3.534 17	2.614 17	1.801 17	1.107 17	7.536 16	8.230 16

NEGATIVE EXCESS THERMODYNAMIC PROPERTIES

-(H/RT)CELL	2.2830-2	2.2693-2	1.5902-2	8.8862-3	3.8154-3	9.1034-4
-(S/R)CELL	1.1431-2	1.1362-2	7.9590-3	4.4455-3	1.9082-3	4.5519-4

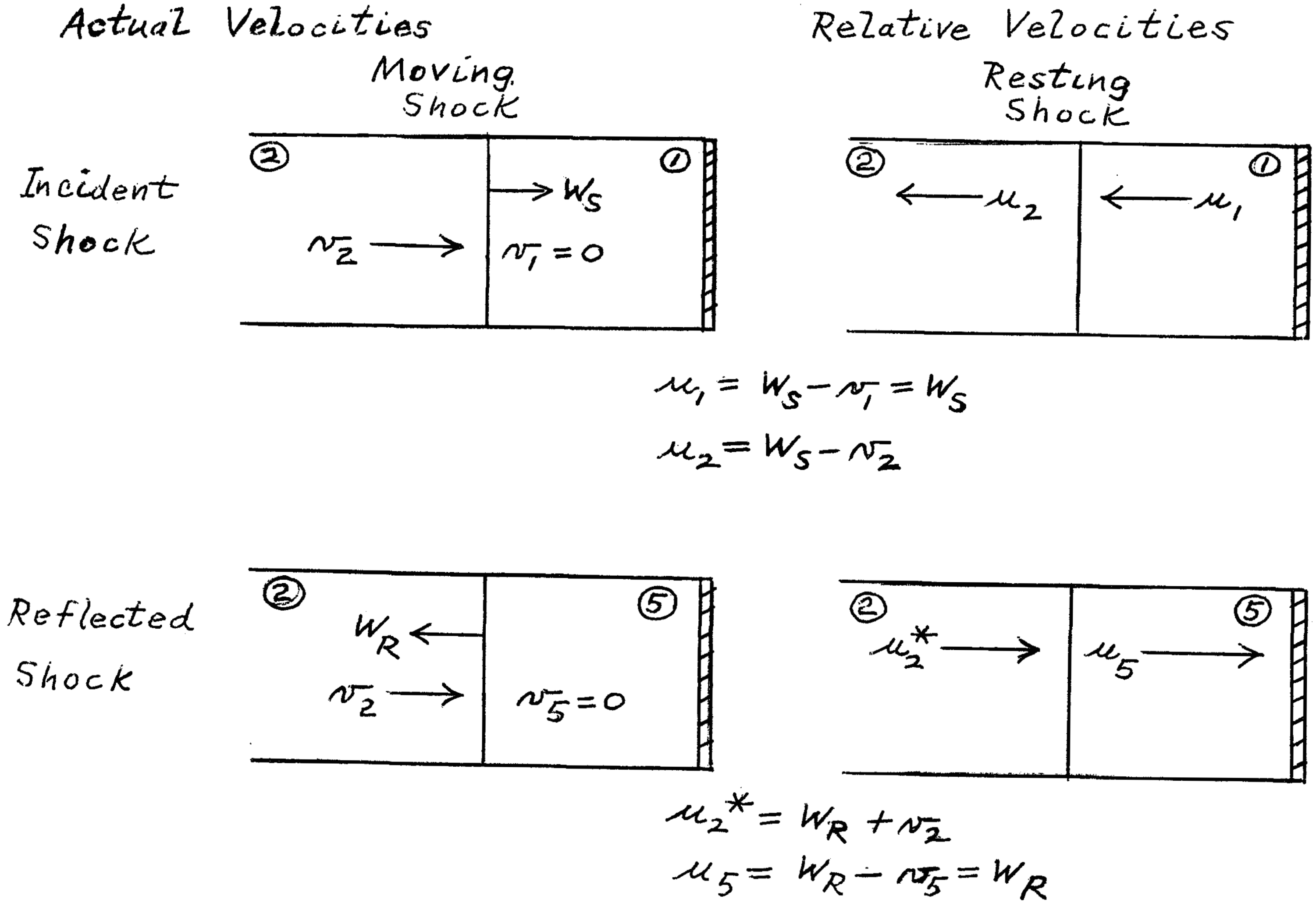

Figure 1. – Comparison between actual and relative velocities of gases in a shock tube.

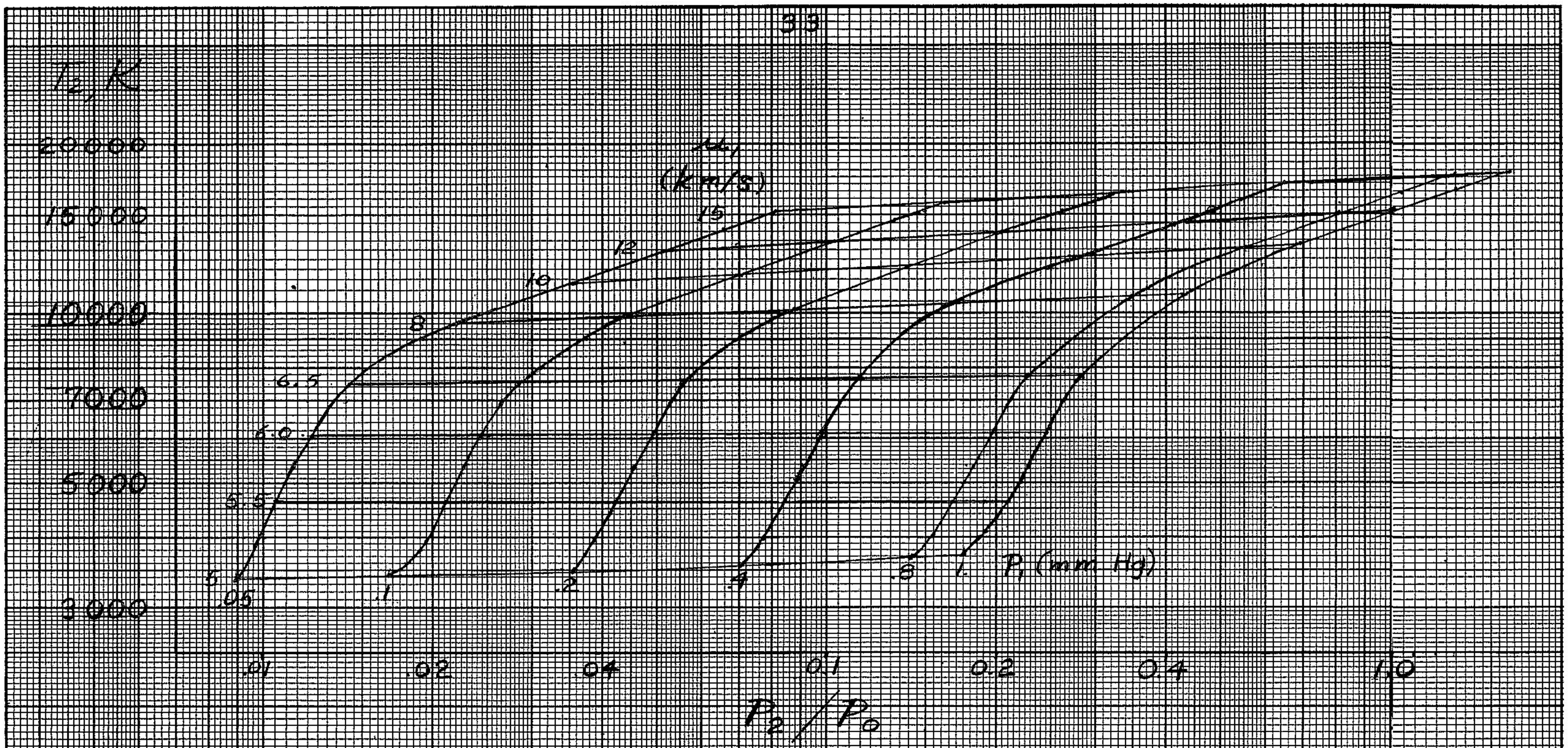

FIGURE 2. Theoretical temperature and pressure for equilibrium states behind shocks through a 0.70 Ne - 0.25 H_2 - 0.05 He mixture in the Debye-Huckel approximation

(a) Incident shocks

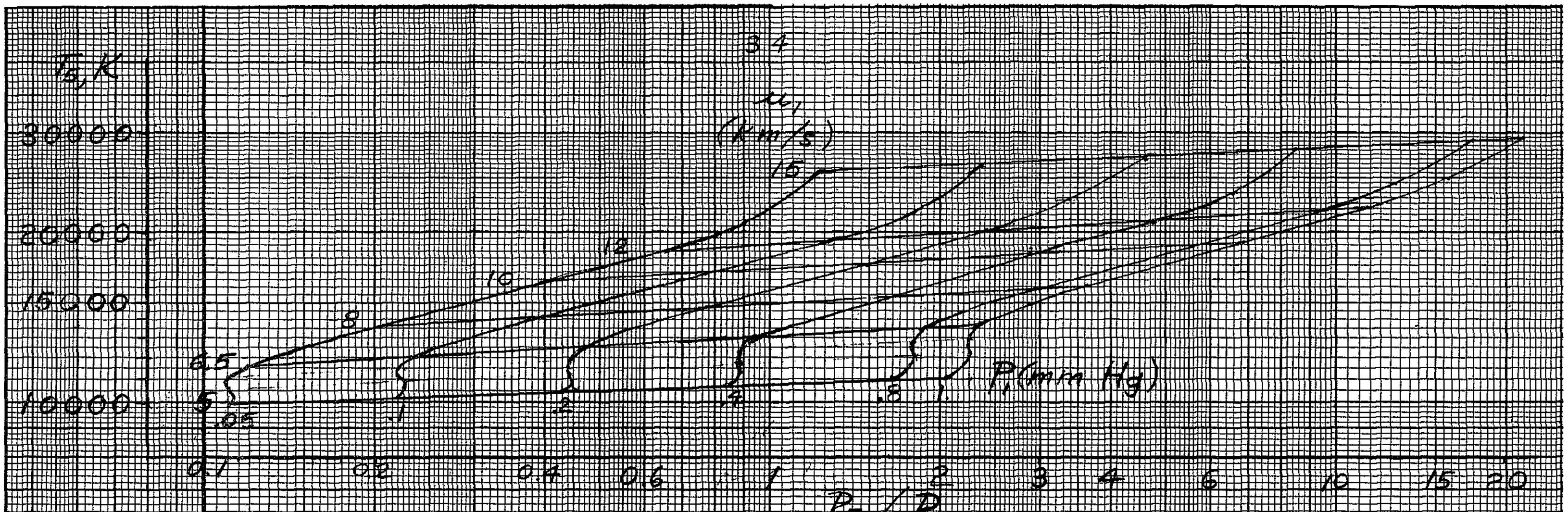

Figure 2.- Concluded

(b) Reflected shocks

Figure 3 – Theoretical density and temperature for equilibrium states behind incident shocks through a 0.5 H_2 – 0.5 He mixture in the ideal-gas approximation