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Computer Codes For The Evaluation Of Thermodynamic Properties, Transport Properties, And Equilibrium Constants Of An 11-Species Air Model

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COMPUTER CODES FOR THE EVALUATION OF THERMODYNAMIC PROPERTIES, TRANSPORT PROPERTIES, AND EQUILIBRIUM CONSTANTS FOR AN 11-SPECIES AIR MODEL

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Summary

Among the most important needs for accurate numerical prediction of high-temperature, chemically reacting flowfields are the physical properties and reaction kinetics for the species involved. Equally important are the gross properties of a reacting gas mixture which depend, in part, on the interaction of the various species involved. The computer codes developed in this work attempt to address some of these needs by providing data for thermodynamic and transport properties and reaction rates in a usable and readily accessible format for the 11 species present in a typical reacting air model. The 11 species considered in this model are N_2, O_2, N, O, NO, NO^+, e^-, N^+, O^+, N_2^+, and O_2^+. For thermodynamic properties, these codes compute the specific heat at constant volume, $C_{p,i}$, and static enthalpy, h_i, for the individual species. For transport properties, the individual species viscosities, μ_i, and thermal conductivities, k_i, are computed along with the diffusion coefficients, $\bar{D}_{ij}$; collision cross sections, $\Omega_{ij}^{(1,1)}$ and $\Omega_{ij}^{(2,2)}$; and collision cross-section ratio, B_{ij}^* for the interaction between species i and j. The computed data can be used directly in appropriate mixture formulas. Reaction-rate data are provided from these codes in the form of the equilibrium constant, $K_{eq,r}$, for the prominent reactions occurring in the 11-species air model. Thermodynamic properties, transport properties, and reaction-rate data are computed through the use of curve-fit correlations which are functions of temperature (and number density for the equilibrium constant). These curve fits were made data believed to be the most accurate available. In the numerical simulation of a reacting gas flowfield, the number of gas properties needed and the frequency at which they are needed are significant. Therefore, the use of curve fits, as opposed to table look-up techniques, is desirable for the computational speed advantage offered.

Symbols

A_n	coefficients of polynomial curve fits for thermodynamic properties, n=1,2...,7 (eqs. (1), (2), and (3))
$A_{\bar{D}_{ij}}$, $B_{\bar{D}_{ij}}$, $C_{\bar{D}_{ij}}$, $D_{\bar{D}_{ij}}$	curve-fit coefficients for diffusion coefficient $\bar{D}_{ij}$ (eq. (12))
$A_{K_{eq,r}}$, $B_{K_{eq,r}}$, $C_{K_{eq,r}}$, $D_{K_{eq,r}}$, $E_{K_{eq,r}}$, $F_{K_{eq,r}}$	curve-fit coefficients for equilibrium constants $K_{eq,r}$ (eq. (18))
$A_{K_{f,i}}$, $B_{K_{f,i}}$, $C_{K_{f,i}}$, $D_{K_{f,i}}$, $E_{K_{f,i}}$	curve-fit coefficients for frozen thermal conductivity of species i, $K_{f,i}$, (eq. (10))
A_{μ_i}, B_{μ_i}, C_{μ_i}	curve-fit coefficients for viscosity of species i, μ_i, (eq. (9))

$A_{\overline{\Omega}_{ij}^{(1,1)}}$, $B_{\overline{\Omega}_{ij}^{(1,1)}}$, $C_{\overline{\Omega}_{ij}^{(1,1)}}$, $D_{\overline{\Omega}_{ij}^{(1,1)}}$	curve-fit coefficients for collision cross section $\overline{\Omega}_{ij}^{(1,1)}$, (eq. (13))
$A_{\overline{\Omega}_{ij}^{(2,2)}}$, $B_{\overline{\Omega}_{ij}^{(2,2)}}$, $C_{\overline{\Omega}_{ij}^{(2,2)}}$, $D_{\overline{\Omega}_{ij}^{(2,2)}}$	curve-fit coefficients for collision cross section $\overline{\Omega}_{ij}^{(2,2)}$, (eq. (14))
$A_{B_{ij}^*}$, $B_{B_{ij}^*}$, $C_{B_{ij}^*}$	curve-fit coefficients for collision cross section ratio B_{ij}^*, (eq. (15))
B_{ij}^*	ratio of collision cross sections, $(5\overline{\Omega}_{ij}^{(1,2)} - 4\overline{\Omega}_{ij}^{(1,3)})/\overline{\Omega}_{ij}^{(1,1)}$
$C_{p,i}$	specific heat at constant pressure of species i, $\left[\frac{\partial h_i}{\partial T}\right]_p$, $cal/gm-mole-K$
D_{ij}	binary diffusion coefficient, cm^2/sec
F_i^o	free energy of species i at 1 atm pressure (standard state), $cal/gm-mole$
h_i	enthalpy of species i, $cal/gm-mole$
$K_{eq,r}$	equilibrium constant for reaction r, $k_{f,r}/k_{b,r}$
$K_{f,i}$	frozen thermal conductivity of species i in thermodynamic equilibrium, $K_{tr,i} + K_{int,i}$, $cal/cm-sec-K$
$K_{int,i}$	internal component of the frozen thermal conductivity of species i in thermodynamic equilibrium, $cal/cm-sec-K$
$K_{tr,i}$	translational component of thermal conductivity of species i, $cal/cm-sec-K$
$k_{b,r}$	backward reaction rate coefficient for reaction r, $cm^3/mole-sec$ or $cm^6/mole^2-sec$
$k_{f,r}$	forward reaction rate coefficient for reaction r, $cm^3/mole-sec$
p	pressure, atm
p_e	electron pressure, atm
p_{em}	limiting value of the electron pressure, atm
R_{univ}	universal gas constant, 1.987 $cal/gm-mole-K$
T	temperature under thermodynamic equilibrium, K
μ_i	viscosity of species i, $gm/cm-sec$
$\overline{\Omega}_{ij}^{(1,1)}$	average collision cross section (used for diffusion, viscosity, and translational, internal and reaction components of thermal conductivity) for collisions between the species i and j, $\mathring{A}^2$; $1\ \mathring{A} = 10^{-8} cm$
$\overline{\Omega}_{ij}^{(2,2)}$	average collision cross section (used for viscosity and translational component of thermal conductivity) for collisions between the species i and j, $\mathring{A}^2$
$\overline{\Omega}_{ij}^{(1,2)}$, $\overline{\Omega}_{ij}^{(1,3)}$	average collision cross sections (used for translational component of thermal conductivity) for collisions between the species i and j, $\mathring{A}^2$

Abbreviations:

NATA Nonequilibrium Arc Tunnel Analysis

Analysis

Least-squares polynomial curve fits were employed in the present work to approximate the various species properties. A detailed review of the sources and accuracy of the species data used herein is given in reference 1. Development of appropriate mixture laws for implementing the data generated by the present curve fits is also reviewed in reference 1. This section details the curve fits of the various properties, gives reference to the data sources, and describes the methods involved in the present work.

Thermodynamic Properties

Data for the thermodynamic properties of the air species considered herein were obtained from the work of Browne (refs. 2 and 3). Fourth-order least-squares polynomial curve fits for the temperature range 300 < T < 30000 K were developed for the thermodynamic properties. These curve-fit correlations are given by the following equations:

Specific heat:

$$\frac{C_{p,i}}{R_{univ}} = A_1 + A_2T + A_3T^2 + A_4T^3 + A_5T^4 , \qquad \frac{cal}{gm-mole-K} \tag{1}$$

Specific enthalpy:

$$\frac{h_i}{R_{univ}T} = A_1 + \frac{A_2T}{2} + \frac{A_3T^2}{3} + \frac{A_4T^3}{4} + \frac{A_5T^4}{5} + \frac{A_6}{T} , \qquad \frac{cal}{gm-mole} \tag{2}$$

For equilibrium calculations, the following equation for the free energies F_i may be used:

$$\frac{F_i^o}{R_{univ}T} = A_1[1-ln(T)] - \frac{A_2T}{2} - \frac{A_3T^2}{6} - \frac{A_4T^3}{12} - \frac{A_5T^4}{20} + \frac{A_6}{T} - A_7 , \qquad \frac{cal}{gm-mole} \tag{3}$$

where F_i^o is the free energy of species i at 1 atm pressure (standard state).

Curve fits of the individual species properties for temperatures ranging from 300 K to 30000 K were performed over five separate temperature intervals. The temperature boundaries for these intervals were 1000, 6000, 15000, and 25000 K. Continuity between curve fits was not assured since five separate equations were used to fit the entire range. Therefore, a linear averaging of the curve fit coefficients around the four temperature boundaries is performed to yield continuous data from the thermodynamic curve fits. The boundary regions for this averaging are 800 < T < 1200 K, 5500 < T < 6500 K, 14500 < T < 15500 K, and 24500 < T < 25500 K. The averaging for a boundary region can be written as

$$\bar{A}_n = (1-a)A_n^L + aA_n^U \qquad n=1,2,3,...,7 \tag{4}$$

where

$$a = \left[\frac{T-T_b^L}{T_b^U-T_b^L}\right] \tag{5}$$

Here, T_b^U and T_b^L are the upper and lower limits, respectively, of the boundary region. The superscripts U and L on A_n denote coefficients of the curve fits from the upper and lower

sides of the temperature boundaries. With these definitions, the curve-fit coefficients A_n in equations (1), (2), and (3) are replaced by $\bar{A}_n$ from equation (4) when the temperature is within a temperature boundary region.

The curve-fit coefficients for the thermodynamic properties are presented in table I for the 11 air species. Note that each species has five rows of coefficients which correspond to the five temperature intervals discussed above. Figure 1 shows a typical comparison of the curve fit for diatomic nitrogen with the original data of Browne (refs. 2 and 3) and the results of Hansen (ref. 4).

Transport Properties

The transport properties required in flowfield calculations are typically the viscosity, thermal conductivity, and diffusion coefficients. The collision cross sections needed to calculate these properties were recomputed in reference 1 using the same molecular data used by Yos (refs. 5, 6, and 7) and the NATA (Nonequilibrium Arc Tunnel Analysis) code (refs. 8, 9, and 10). Reference 1 gives a description of the data and methods used in NATA for these calculations along with the equations used to compute the transport properties (viscosity, thermal conductivity, and diffusion coefficient) from the collision cross sections. Curve fits of the individual collision cross sections ($\bar{\Omega}_{ij}^{(1,1)}$, $\bar{\Omega}_{ij}^{(2,2)}$), ratio of collision cross sections (B_{ij}^{*}), and resulting transport properties (μ_i, k_i, and D_{ij}) have been obtained in this work and are described next.

Temperature-dependent curve fits for the transport properties were performed as polynomial least-squares fits of the natural logarithm of the data. This allows a single curve fit for each species and property (in nearly all cases) for the entire temperature range of $1000 \le T \le 30000$ K. A fifth-order polynomial fit for any property P has the general form

$$ln(P) = A_P z^5 + B_P z^4 + C_P z^3 + D_P z^2 + E_P z + F_P \tag{6}$$

where

$$z = ln(T) \tag{7}$$

Equation (6) can also be written as

$$P = e^{F_P} T^{[A_P (ln\,T)^4 + B_P (ln\,T)^3 + C_P (ln\,T)^2 + D_P (ln\,T) + E_P]} \tag{8}$$

It is important to note that the logarithmic form of these equations requires extreme accuracy in the curve-fit coefficients. Therefore, the coefficients presented herein are sometimes carried to five or six decimal places and all digits are significant. Also, the polynomial form of the curve-fit equation (eq. (6)) is more accurate because of less round-off and should be used when evaluating the properties.

The curve-fit polynomials for the transport properties varied from second to fourth order depending upon the nature of the data involved. Viscosity curve fits for the 11 individual species were done using second-order polynomials which yields a curve-fit equation of the form

$$\mu_i = e^{C_{\mu_i}} T^{[A_{\mu_i} \ln T + B_{\mu_i}]}, \qquad \frac{gm}{cm-sec} \tag{9}$$

Coefficients for the viscosity curve fits are presented in table II. Figure 2 illustrates the comparison between the curve-fit equation and the original data for one species.

The curve-fit equations for the thermal conductivity, $K_{f,i}$, are higher order than for the viscosity and have the form

$$K_{f,i} = e^{E_{K_{f,i}}} T^{[A_{K_{f,i}} (ln\,T)^3 + B_{K_{f,i}} (ln\,T)^2 + C_{K_{f,i}} \ln T + D_{K_{f,i}}]}, \qquad \frac{cal}{cm-sec-K} \tag{10}$$

The coefficients for eq. (10) for each species are given in table III and a comparison between the curve-fit equation and original data for diatomic oxygen is presented in figure 3.

In the present work, curve-fit coefficients for the transport properties of the ionic species are provided for the limiting electron pressure $p_e = p_{em}$ at which the shielding factor $\ln\Lambda = 1$. For any other electron pressure, it is necessary to correct the transport properties of the ionic species according to the formula

$$\frac{\mu_i(p_e)}{\mu_i(p_{em})} = \frac{K_{f,i}(p_e)}{K_{f,i}(p_{em})} = \frac{\overline{D}_{ij}(p_e)}{\overline{D}_{ij}(p_{em})} = \frac{1}{\ln\Lambda(p_e)}$$

$$= \frac{2}{\ln\left[2.09\times10^{-2}\left(\frac{T}{1000p_e^{1/4}}\right)^4 + 1.52\left(\frac{T}{1000p_e^{1/4}}\right)^{8/3}\right]} \tag{11}$$

The diffusion coefficients, $\overline{D}_{ij} = pD_{ij}$, for the interaction of species i and j were fitted in the present work using the following equation:

$$\overline{D}_{ij} = e^{D_{\overline{D}_{ij}}} T^{[A_{\overline{D}_{ij}}(\ln T)^2 + B_{\overline{D}_{ij}}\ln T + C_{\overline{D}_{ij}}]}, \quad cm^2\text{–}atm/sec \tag{12}$$

The curve-fit coefficients of equation (12) are given in table IV for the different interactions occurring in the 11-species air model. Note that the diffusion coefficient matrix is symmetric (i.e., $\overline{D}_{ij} = \overline{D}_{ji}$) so that there are only 66 distinct interactions between the 11 species.

The values of $\overline{D}_{ij}$ obtained from equation (12) with the curve-fit coefficients given in table IV are for the limiting electron pressure p_{em}. If the pair of interacting species are both ions, both electrons, or any combination of the two, then $\overline{D}_{ij}$ must be corrected for the given electron pressure by employing eq. (11).

The collision cross sections and collision cross section ratio have been curve fit in the present study as a function of temperature for the limiting electron pressure using the following relations:

$$\overline{\Omega}_{ij}^{(1,1)} = e^{D_{\overline{\Omega}_{ij}^{(1,1)}}} T^{[A_{\overline{\Omega}_{ij}^{(1,1)}}(\ln T)^2 + B_{\overline{\Omega}_{ij}^{(1,1)}}\ln T + C_{\overline{\Omega}_{ij}^{(1,1)}}]}, \quad \text{Å}^2 \tag{13}$$

$$\overline{\Omega}_{ij}^{(2,2)} = e^{D_{\overline{\Omega}_{ij}^{(2,2)}}} T^{[A_{\overline{\Omega}_{ij}^{(2,2)}}(\ln T)^2 + B_{\overline{\Omega}_{ij}^{(2,2)}}\ln T + C_{\overline{\Omega}_{ij}^{(2,2)}}]}, \quad \text{Å}^2 \tag{14}$$

$$B_{ij}^* = e^{C_{B_{ij}^*}} T^{[A_{B_{ij}^*}\ln T + B_{B_{ij}^*}]} \tag{15}$$

These equations are also applicable for $i=j$ (single species). For electron pressures different from p_{em}, the formula given by the following equation is used to correct the cross sections for the interaction of any ionic species or electron with any other ionic species or electron:

$$\frac{\Omega_{ij}^{(l,s)}(p_e)}{\Omega_{ij}^{(l,s)}(p_{em})} = \ln\Lambda(p_e)$$

$$= \frac{1}{2}\ln\left[2.09\times10^{-2}\left(\frac{T}{1000p_e^{1/4}}\right)^4 + 1.52\left(\frac{T}{1000p_e^{1/4}}\right)^{8/3}\right] \tag{16}$$

No correction for electron pressure is required for the cross-section-ratio parameter B_{ij}^{*}.

Curve-fit coefficients appearing in equations (13) through (15) are given in Tables V through VII for all interactions in the 11-species air model. Note in tables V and VI that the collision integrals $\Omega_{ij}^{(l,s)}$ for the charged species pairs show a simple T^{-2} dependence requiring only two curve-fit coefficients. Figure 4 illustrates some typical curve fits obtained by employing equations (12) through (15) with the associated constants. The figure compares the computed values of binary diffusion coefficient, collision integrals, and collision integral ratio with the approximating curve fit for an ion-neutral interaction pair. The collision integral ratio, B_{ij}^{*}, is almost constant with temperature as shown in the figure and was fitted with the lower order curve fit where possible.

Equilibrium Constants

Curve fits for the equilibrium constants as functions of temperature for the 20 reaction equations present in the 11-species air model were calculated for a range of number densities. Data for the equilibrium constants, $K_{eq,r}$, have been computed in reference 1 by using the atomic partition functions and the molecular partition functions provided in reference 11. The computed values of $K_{eq,r}$ have been curve fitted here by the least-squares curve-fit method as a function of temperature using the following expression:

$$K_{eq,r} = e^{F_{K_{eq,r}}} \left[\frac{10^4}{T} \right]^{[A_{K_{eq,r}} z^4 + B_{K_{eq,r}} z^3 + C_{K_{eq,r}} z^2 + D_{K_{eq,r}} z + E_{K_{eq,r}}]} \tag{18}$$

here

$$z = \ln\left[\frac{10^4}{T} \right]$$

Curve fits for each reaction were done for six different values of number density ranging from 10^{14} to 10^{19} $particles/cm^3$ which covers the area of practical interest in aerospace applications. The curve-fit coefficients appearing in equation (18) are given in table VIII. Figure 5 shows the variation of the equilibrium constant with temperature at a fixed total number density for a typical reaction.

User Instructions

The computer codes developed in this work to evaluate the thermodynamic and transport properties and equilibrium constants are in the form of FORTRAN subroutines for easy adaption to existing codes. The subroutines are well commented and can be easily modified to suit the user's needs. In an attempt to maintain generality, a total of 16 subroutines are available for use. These 16 routines are composed of two codes each for the evaluation of the following eight properties:

1) species specific heat and static enthalpy, $C_{p,i}$ and h_i
2) species viscosity, μ_i
3) species frozen thermal conductivity, $K_{f,i}$
4) diffusion coefficient, $\overline{D}_{ij} = pD_{ij}$
5) collision cross section, $\overline{\Omega}_{ij}^{(1,1)}$
6) collision cross section, $\overline{\Omega}_{ij}^{(2,2)}$
7) collision cross-section ratio, B_{ij}^{*}
8) equilibrium constant, $K_{eq,r}$

The routines include coding to correct the transport coefficients and collision cross sections of

ionic species for any electron pressure. The pair of subroutines for each of the eight properties includes one routine to evaluate the property for a single species, interaction pair, or reaction and one routine to evaluate the property for all species, interaction pairs, or reactions. In the former case, the single species, interaction pair, or reaction is denoted by simple indices to the species number, pair of species numbers, or reaction number. The use of an index assumes the species and reaction numbering given in the following two tables.

Species Numbering

Number	Species	Number	Species
1	N_2	7	e^-
2	O_2	8	N^+
3	N	9	O^+
4	O	10	N_2^+
5	NO	11	O_2^+
6	NO^+		

Reaction Numbering

Number	Reaction	Number	Reaction
1	$O_2+M_1 \rightleftarrows 2O+M_1$	11	$O+O_2^+ \rightleftarrows O_2+O^+$
2	$N_2+M_2 \rightleftarrows 2N+M_2$	12	$N_2+N^+ \rightleftarrows N+N_2^+$
3	$N_2+N \rightleftarrows 2N+N$	13	$N+N \rightleftarrows N_2^++e^-$
4	$NO+M_3 \rightleftarrows N+O+M_3$	14	$O_2+N_2 \rightleftarrows NO+NO^++e^-$
5	$NO+O \rightleftarrows O_2+N$	15	$NO+M_4 \rightleftarrows NO^++e^-+M_4$
6	$N_2+O \rightleftarrows NO+N$	16	$O+NO^+ \rightleftarrows NO+O^+$
7	$N+O \rightleftarrows NO^++e^-$	17	$N_2+O^+ \rightleftarrows O+N_2^+$
8	$O+e^- \rightleftarrows O^++e^-+e^-$	18	$N+NO^+ \rightleftarrows NO+N^+$
9	$N+e^- \rightleftarrows N^++e^-+e^-$	19	$O_2+NO^+ \rightleftarrows NO+O_2^+$
10	$O+O \rightleftarrows O_2^++e^-$	20	$O+NO^+ \rightleftarrows O_2+N^+$

Note that the above ordering of the 11-species air model also allows an fewer species model (e.g. 5 or 7 species) to be treated without renumbering. In a 5-species model, only the first five species and first six reactions are used, and in a 7-species model only the first seven species and reactions are needed. Thus, to evaluate the properties for a single species, interaction pair, or reaction, the only quantity needed is the correct index number(s) from the above tables. For example, the viscosity for diatomic oxygen, μ_{O_2}, is simply μ_2, while the diffusion coefficient for the species pair $O_2 \rightarrow e^-$ is given by $\bar{D}_{2,7}$. Evaluation of the properties for all species, interaction pairs, or reactions present requires only the total number of species or reactions in the assumed gas model. These are typically, 11 species/20 reactions, 7 species/7 reactions, and 5 species/6 reactions. Given these limits, the present codes can be used to compute properties for all species, interactions, and/or reactions with single FORTRAN calls. For generality, the present subroutines will return the full matrices of the diffusion coefficient, collision cross section, or collision cross-section ratio although they are symmetric. Because of the symmetry of these matrices, these properties could just as well be

stored as one-dimensional arrays by using a simple index. This would require less storage but also a close coupling of the subroutines with the calling program. A simple indexing scheme to accomplish the one-dimensional ordering from the species numbering can be developed. Given the indices of any species pair (i,j), the index (element) of the one-dimensional array can be computed using the following coding:

```
C ... COMPUTE INTERACTION-PAIR INDEX, N
    IF(I.LT.J) THEN
      II=J
      JJ=I
    ELSE
      II=I
      JJ=J
    END IF
    N=INT(0.5*II*(II-1))+JJ
```

This coding is valid for the pair (i,j) or the equivalent pairing (j,i) and can be used for 11-, 7- or 5-species models if the present numbering scheme is used. This coding is presently used for ordering the curve-fit coefficients in a one-dimensional array in the subroutines which compute a single property. It could be easily implemented in the other subroutines and in the user's calling program to handle one-dimensional arrays of the diffusion coefficient, collision cross section, etc., in place of the two-dimensional matrices (arrays) presently returned. It should be noted that all of the curve-fit coefficients used in the present work are listed in the form of DATA statements in the subroutines where they are used. In this form, it would be a simple task to incorporate the coefficient data into computer codes developed independently of those described in this report.

Subroutine Description and Use

The calling syntax of the 16 subroutines developed in the present work and discussed above are outlined in the following sections. Each subroutine name begins with the letters GAS followed by a number between 1 and 8 corresponding to the property computed and the letter S or A indicating whether a Single property or an Array of properties is computed. In the following descriptions, parameter lists are described for each subroutine.

Species Enthalpy and Specific Heat

-- GAS1A ----------

Purpose:	Compute species enthalpy and specific heat for an array of species at a given temperature
Use:	CALL GAS1A(NS,T,CPI,HI)
Input:	NS = Number of species (usually 5, 7, or 11) T = Temperature, K $(300 \le T \le 30000)$
Output:	CPI(NS) = $C_{p,i}$, array of specific heats, $cal/gm-mole-K$ HI(NS) = h_i, array of enthalpies, $cal/gm-mole$

-- GAS1S ----------

Purpose: Compute the enthalpy and specific heat for a single species at a given temperature

Use: CALL GAS1S(I,T,CPI,HI)

Input: I = Index of species
T = Temperature, K (300 ≤ T ≤ 30000)

Output: CPI = $C_{p,i}$, specific heat of species i, $cal/gm-mole-K$
HI = h_i, enthalpy of species i, $cal/gm-mole$

Species Viscosity

-- GAS2A ----------

Purpose: Compute an array of species viscosities at a given temperature

Use: CALL GAS2A(NS,T,AMU)

Input: NS = Number of species (usually 5, 7, or 11)
T = Temperature, K (1000 ≤ T ≤ 30000)

Output: AMU(NS) = μ_i, array of species viscosities, $gm/cm-s$

-- GAS2S ----------

Purpose: Compute viscosity for a single species at a given temperature

Use: CALL GAS2S(I,T,AMU)

Input: I = Index of species
T = Temperature, K (1000 ≤ T ≤ 30000)

Output: AMU = μ_i, viscosity of species i, $gm/cm-s$

Species Frozen Thermal Conductivity

-- GAS3A ----------

Purpose: Compute an array of species frozen thermal conductivities at a given temperature

Use: CALL GAS3A(NS,T,AK)

Input: NS = Number of species (usually 5, 7, or 11)
T = Temperature, K (1000 ≤ T ≤ 30000)

Output: AK(NS) = $K_{f,i}$, array of species frozen thermal conductivities, $cal/cm-s-K$

-- GAS3S ----------

Purpose: Compute the frozen thermal conductivity for a single species at a given temperature

Use: CALL GAS3S(I,T,AK)

Input: I = Index of species
T = Temperature, K (1000 ≤ T ≤ 30000)

Output: AK = $K_{f,i}$, thermal conductivity of species i, $cal/cm-s-K$

Diffusion Coefficients

-- GAS4A ----------

Purpose: Compute the matrix of diffusion coefficients for all interacting species at a given temperature

Use: CALL GAS4A(NS,T,DC)

Input: NS = Number of species (usually 5, 7, or 11)
T = Temperature, K (1000 ≤ T ≤ 30000)

Output: DC(NS,NS) = $\bar{D}_{ij} = pD_{ij}$, matrix of diffusion coefficients, $cm-atm/s$

-- GAS4S ----------

Purpose: Compute the diffusion coefficient for a single pair of species at a given temperature

Use: CALL GAS4S(I,J,T,DC)

Input: I = Index of species i
J = Index of species j
T = Temperature, K (1000 ≤ T ≤ 30000)

Output: DC = $\bar{D}_{ij} = pD_{ij}$, diffusion coefficient for pair (i,j), $cm-atm/s$

Collision Cross Sections

-- GAS5A ----------

Purpose: Compute the matrix of collision cross sections for all interacting species at a given temperature

Use: CALL GAS5A(NS,T,OM11)

Input: NS = Number of species (usually 5, 7, or 11)
T = Temperature, K (1000 ≤ T ≤ 30000)

Output: OM11(NS,NS) = $\bar{\Omega}_{ij}^{(1,1)}$, matrix of collision cross sections, Å^2

-- GAS5S ----------

Purpose: Compute the collision cross section for a single interaction pair at a given temperature

Use: CALL GAS5S(I,J,T,OM11)

Input: I = Index of species i
J = Index of species j
T = Temperature, K (1000 ≤ T ≤ 30000)

Output: OM11 = $\bar{\Omega}_{ij}^{(1,1)}$, collision cross section for pair (i,j), Å^2

-- GAS6A ----------

Purpose: Compute the matrix of collision cross sections for all interacting species at a given temperature

Use: CALL GAS6A(NS,T,OM22)

Input: NS = Number of species (usually 5, 7, or 11)
T = Temperature, K $(1000 \leq T \leq 30000)$

Output: OM22(NS,NS) = $\overline{\Omega}_{ij}^{(2,2)}$, matrix of collision cross sections, Å^2

-- GAS6S ----------

Purpose: Compute the collision cross section for a single interaction pair at a given temperature

Use: CALL GAS6S(I,J,T,OM22)

Input: I = Index of species i
J = Index of species j
T = Temperature, K $(1000 \leq T \leq 30000)$

Output: OM22 = $\overline{\Omega}_{ij}^{(2,2)}$, collision cross section for pair (i,j), Å^2

Collision Cross-Section Ratio

-- GAS7A ----------

Purpose: Compute the matrix of collision cross-section ratios for all interacting species at a given temperature

Use: CALL GAS7A(NS,T,BSTAR)

Input: NS = Number of species (usually 5, 7, or 11)
T = Temperature, K $(1000 \leq T \leq 30000)$

Output: BSTAR(NS,NS) = B_{ij}^*, matrix of collision cross-section ratios

-- GAS7S ----------

Purpose: Compute the collision cross-section ratio for the interaction pair at a given temperature

Use: CALL GAS7S(I,J,T,BSTAR)

Input: I = Index of species i
J = Index of species j
T = Temperature, K $(1000 \leq T \leq 30000)$

Output: BSTAR = B_{ij}^*, collision cross-section ratio for pair (i,j)

Equilibrium Constants

-- GAS8A ----------

Purpose: Compute array of equilibrium constants for all reactions at a given temperature and number density

Use: CALL GAS8A(NR,T,DN,AKEQ)

Input: NR = Number of reactions
DN = n, Number density, $particles/cm^3$ $(10^{14} \leq n \leq 10^{19})$
T = Temperature, K $(1000 \leq T \leq 60000)$

Output: AKEQ(NR) = $K_{eq,r}$, array of equilibrium constants

-- GAS8S ----------

Purpose: Compute the equilibrium constant for a single reaction at a given temperature and number density

Use: CALL GAS8S(I,T,DN,AKEQ)

Input: I = r, Index of reaction
T = Temperature, K $(1000 \leq T \leq 60000)$
DN = n, Number density, $particles/cm^3$ $(10^{14} \leq n \leq 10^{19})$

Output: AKEQ = $K_{eq,r}$, equilibrium constant for reaction r

Environmental Characteristics

The computer codes described in this report were developed on a SUN 3/280 computer running the SunOS 3.5 operating system. The codes are written in standard FORTRAN 77 language and should run without modification on other machines. It should be noted that the two routines for the equilibrium constant (GAS8A and GAS8S) required double-precision arithmetic on the 32-bit SUN 3/280 for accuracy near the curve-fit limits. All remaining routines are written with single-precision variables. The memory sizes of the various routines are tabulated in the following table:

Memory Size of Subroutines

Routine	Size, bytes	Routine	Size, bytes
GAS1A	3853	GAS1S	3621
GAS2A	1395	GAS2S	1331
GAS3A	1543	GAS3S	1471
GAS4A	3023	GAS4S	2575
GAS5A	3039	GAS5S	2695
GAS6A	3039	GAS6S	2695
GAS7A	1965	GAS7S	1937
GAS8A	8031	GAS8S	8023

The codes were timed on a SUN 3/280 with global optimization and the floating point accelerator invoked for the FORTRAN compiler (i.e., f77 -O3 -ffpa). Times were monitored for 100 calls to each subroutine, and the average time for a single call was computed as shown in the following table:

CPU Time for Single Subroutine Calls

Routine	Time, s	Routine	Time, s
GAS1A	0.0078	GAS1S	0.0006
GAS2A	0.0086	GAS2S	0.0034
GAS3A	0.0094	GAS3S	0.0044
GAS4A	0.0628	GAS4S	0.0048
GAS5A	0.0386	GAS5S	0.0036
GAS6A	0.0384	GAS6S	0.0048
GAS7A	0.0266	GAS7S	0.0010
GAS8A	0.0622	GAS8S	0.0042

Implementation Instructions

The compilation command for the FORTRAN compiler on the Sun 3/280 system for the subroutines described in this guide is

f77 -ffpa -O3 -c GASXX.f

where *GASXX.f* is the specific program name from the list of names described earlier (i.e., GAS1A, GAS1S, GAS2A,...,GAS8S). The object file from the compilation step above would be linked to a user program by the following command:

f77 -ffpa -O3 -o exec userprogram.o GASXX.o

where *exec* is the executable file to be created, *userprogram.o* is the object file of the user's program after compilation, and *GASXX.o* is the object file from the subroutine compilation. In the compilation and linkage steps above, the command line parameter *-ffpa* is used to invoke the floating point accelerator. If an accelerator is not present, then this parameter may be omitted. Also note that global optimization is used via the *-O3* parameter, which may also be omitted if desired.

Six driver programs are included along with the subroutines described thus far. These driver programs are used to exercise each of the subroutines described herein for typical conditions. These programs are useful for testing the subroutines and could be modified to generate a useful collection of tabulated species properties. Output from these programs is listed in the next section.

The sequence of commands listed below is used to execute the driver programs on the Sun 3/280 system.

f77 -ffpa -O3 -o DRIVER1A DRIVER1A.f GAS1A.f GAS2A.f GAS3A.f
DRIVER1A

f77 -ffpa -O3 -o DRIVER1S DRIVER1S.f GAS1S.f GAS2S.f GAS3S.f
DRIVER1S

f77 -ffpa -O3 -o DRIVER2A DRIVER2A.f GAS4A.f GAS5A.f GAS6A.f GAS7A.f
DRIVER2A

f77 -ffpa -O3 -o DRIVER2S DRIVER2S.f GAS4S.f GAS5S.f GAS6S.f GAS7S.f
DRIVER2S

```
f77 -ffpa -O3 -o DRIVER3A DRIVER3A.f GAS8A.f
DRIVER3A

f77 -ffpa -O3 -o DRIVER3S DRIVER3S.f GAS8S.f
DRIVER3S
```

Sample Input/Output

The driver routines described above are used to exercise each of the subroutines for typical input parameters. This section lists the output from the three driver programs which is generated directly from the various subroutines. Each driver routine calls one or more subroutines to evaluate the properties for eleven species (NS=11) for a range of temperatures (T) from 1000 to 30000 K. The output from each subroutine is gathered by the driver programs for all temperatures and is then printed in tabular form. The driver programs call the individual subroutines as shown in the following table:

Subroutines Called from Driver Programs

Driver	Subroutines
DRIVER1A	GAS1A, GAS2A, GAS3A
DRIVER1S	GAS1S, GAS2S, GAS3S
DRIVER2A	GAS4A, GAS5A, GAS6A, GAS7A
DRIVER2S	GAS4S, GAS5S, GAS6S, GAS7S
DRIVER3A	GAS8A
DRIVER3S	GAS8S

Note that each pair of similarly numbered driver routines (e.g., DRIVER1A and DRIVER1S) evaluate the same properties and differ only in the form of the subroutines called (i.e., single value or array of values). The following tables represent the output from the three driver routines, DRIVER1A, DRIVER2A, and DRIVER3A. Output from the other three corresponding subroutines (DRIVER1S, DRIVER2S, and DRIVER3S) is identical to that shown here.

Output from DRIVER1A/DRIVER1S program

SPECIFIC HEAT AT CONSTANT VOLUME, $C_{P,I}$

CAL/GM-MOLE-K

T, K	N2	O2	N	O	NO	NO+	E-	N+	O+	N2+	O2+
1000	7.8420	8.3236	4.9729	5.0007	8.1113	7.8419	4.9675	5.0485	4.9675	7.8779	8.1049
1500	8.2977	8.7186	4.9677	4.9813	8.5314	8.2951	4.9675	4.9759	4.9671	8.4318	8.5399
2000	8.5792	9.0368	4.9607	4.9755	8.7705	8.5812	4.9675	4.9545	4.9672	9.0206	8.7978
2500	8.7544	9.2972	4.9723	4.9832	8.8917	8.7604	4.9675	4.9694	4.9675	9.5639	8.9347
3000	8.8574	9.5203	5.0142	5.0053	8.9502	8.8664	4.9675	5.0078	4.9699	10.0366	8.9996
3500	8.9164	9.7219	5.0945	5.0415	8.9883	8.9279	4.9675	5.0597	4.9780	10.4215	9.0342
4000	8.9535	9.9130	5.2179	5.0901	9.0357	8.9690	4.9675	5.1170	4.9977	10.7082	9.0733
4500	8.9850	10.0999	5.3856	5.1481	9.1098	9.0090	4.9675	5.1743	5.0365	10.8940	9.1444
5000	9.0210	10.2843	5.5951	5.2112	9.2151	9.0623	4.9675	5.2282	5.1042	10.9834	9.2679
5500	9.0655	10.4631	5.8406	5.2739	9.3435	9.1388	4.9675	5.2779	5.2122	10.9881	9.4571
6000	9.1098	10.6265	6.1198	5.3256	9.4931	9.2681	4.9675	5.3363	5.3362	10.8931	9.6873
6500	9.1225	10.7700	6.3401	5.3636	9.6258	9.3643	4.9675	5.3882	5.4615	10.8908	10.0628
7000	9.1683	10.8985	6.5405	5.4014	9.7387	9.4895	4.9675	5.4262	5.6325	10.9054	10.4828
7500	9.2472	11.0101	6.7239	5.4350	9.8508	9.6769	4.9675	5.4617	5.8073	10.9069	10.9074
8000	9.3647	11.1048	6.8870	5.4645	9.9625	9.9318	4.9675	5.4943	5.9822	10.8993	11.3278
8500	9.5247	11.1828	7.0276	5.4898	10.0741	10.2564	4.9675	5.5238	6.1541	10.8860	11.7362
9000	9.7297	11.2444	7.1447	5.5116	10.1856	10.6497	4.9675	5.5500	6.3201	10.8698	12.1255
9500	9.9807	11.2900	7.2379	5.5304	10.2969	11.1077	4.9675	5.5729	6.4777	10.8529	12.4893
10000	10.2772	11.3200	7.3082	5.5473	10.4079	11.6232	4.9675	5.5925	6.6247	10.8371	12.8221
10500	10.6170	11.3349	7.3573	5.5636	10.5181	12.1859	4.9675	5.6091	6.7593	10.8234	13.1189
11000	10.9967	11.3354	7.3881	5.5808	10.6271	12.7824	4.9675	5.6228	6.8801	10.8124	13.3756
11500	11.4113	11.3221	7.4045	5.6009	10.7342	13.3964	4.9675	5.6340	6.9860	10.8042	13.5888
12000	11.8541	11.2960	7.4113	5.6258	10.8386	14.0082	4.9675	5.6430	7.0763	10.7981	13.7559
12500	12.3173	11.2578	7.4142	5.6580	10.9393	14.5950	4.9675	5.6505	7.1505	10.7930	13.8750
13000	12.7912	11.2085	7.4203	5.7002	11.0353	15.1311	4.9675	5.6570	7.2087	10.7874	13.9448
13500	13.2647	11.1493	7.4373	5.7553	11.1252	15.5876	4.9675	5.6632	7.2512	10.7788	13.9650
14000	13.7255	11.0812	7.4741	5.8267	11.2078	15.9325	4.9675	5.6700	7.2787	10.7646	13.9359
14500	14.1593	11.0056	7.5406	5.9177	11.2815	16.1306	4.9675	5.6781	7.2922	10.7414	13.8586
15000	14.5490	10.9253	7.7078	6.0523	11.3317	16.3209	4.9675	5.6949	7.2957	10.6876	13.7157
15500	14.9399	10.8365	7.9420	6.2067	11.3632	16.7090	4.9675	5.7139	7.2853	10.6147	13.5109
16000	15.2906	10.7412	8.1520	6.3710	11.3975	16.8730	4.9675	5.7271	7.2669	10.5540	13.3127
16500	15.5970	10.6416	8.3973	6.5655	11.4217	16.9897	4.9675	5.7411	7.2437	10.4880	13.1042
17000	15.8575	10.5383	8.6768	6.7899	11.4356	17.0597	4.9675	5.7558	7.2164	10.4173	12.8872
17500	16.0711	10.4321	8.9889	7.0435	11.4395	17.0836	4.9675	5.7715	7.1853	10.3422	12.6639
18000	16.2374	10.3234	9.3311	7.3255	11.4333	17.0630	4.9675	5.7882	7.1512	10.2632	12.4360
18500	16.3564	10.2129	9.7006	7.6343	11.4174	16.9998	4.9675	5.8060	7.1146	10.1807	12.2054
19000	16.4291	10.1010	10.0939	7.9682	11.3921	16.8966	4.9675	5.8251	7.0759	10.0951	11.9736
19500	16.4568	9.9884	10.5069	8.3252	11.3576	16.7565	4.9675	5.8456	7.0359	10.0070	11.7425
20000	16.4414	9.8754	10.9349	8.7027	11.3144	16.5831	4.9675	5.8676	6.9951	9.9168	11.5134
21000	16.2928	9.6504	11.8142	9.5072	11.2040	16.1536	4.9675	5.9162	6.9132	9.7326	11.0673
22000	16.0114	9.4292	12.6826	10.3542	11.0658	15.6482	4.9675	5.9717	6.8348	9.5469	10.6458
23000	15.6349	9.2150	13.4810	11.2102	10.9057	15.1156	4.9675	6.0346	6.7645	9.3644	10.2582
24000	15.2108	9.0101	14.1413	12.0354	10.7309	14.6135	4.9675	6.1055	6.7071	9.1904	9.9124
25000	14.7744	8.8122	14.6307	12.7740	10.5474	14.1659	4.9675	6.1858	6.6621	9.0257	9.5927
26000	14.2520	8.6227	15.0252	13.4413	10.3473	13.6193	4.9675	6.2762	6.6214	8.8590	9.2794
27000	13.7566	8.4462	15.2195	13.9842	10.1472	13.1364	4.9675	6.3772	6.5993	8.7040	9.0093
28000	13.2723	8.2789	15.2650	14.3899	9.9469	12.6787	4.9675	6.4901	6.5925	8.5569	8.7613
29000	12.8042	8.1212	15.1723	14.6595	9.7483	12.2482	4.9675	6.6151	6.6024	8.4179	8.5353
30000	12.3566	7.9733	14.9566	14.7975	9.5530	11.8451	4.9675	6.7523	6.6305	8.2873	8.3307

Output from DRIVER1A/DRIVER1S program (continued)

ENTHALPY, H_I

CAL / GM-MOLE

T, K	N2	O2	N	O	NO	NO+	E-	N+	O+	N2+	O2+
1000	5.1502E+03	5.5667E+03	1.1650E+05	6.3012E+04	2.6756E+04	2.4246E+05	3.4864E+03	4.5307E+05	3.7833E+05	3.7008E+05	2.8556E+05
1500	9.1846E+03	9.9682E+03	1.1898E+05	6.5439E+04	3.0927E+04	2.4651E+05	5.9701E+03	4.5558E+05	3.8081E+05	3.7416E+05	2.8973E+05
2000	1.3409E+04	1.4410E+04	1.2147E+05	6.7928E+04	3.5259E+04	2.5074E+05	8.4539E+03	4.5806E+05	3.8330E+05	3.7852E+05	2.9407E+05
2500	1.7746E+04	1.8995E+04	1.2395E+05	7.0417E+04	3.9678E+04	2.5508E+05	1.0938E+04	4.6054E+05	3.8578E+05	3.8317E+05	2.9851E+05
3000	2.2151E+04	2.3701E+04	1.2644E+05	7.2914E+04	4.4140E+04	2.5948E+05	1.3421E+04	4.6303E+05	3.8826E+05	3.8807E+05	3.0299E+05
3500	2.6596E+04	2.8512E+04	1.2897E+05	7.5425E+04	4.8625E+04	2.6393E+05	1.5905E+04	4.6555E+05	3.9075E+05	3.9319E+05	3.0750E+05
4000	3.1064E+04	3.3421E+04	1.3155E+05	7.7957E+04	5.3130E+04	2.6841E+05	1.8389E+04	4.6809E+05	3.9324E+05	3.9848E+05	3.1203E+05
4500	3.5549E+04	3.8424E+04	1.3419E+05	8.0516E+04	5.7665E+04	2.7290E+05	2.0873E+04	4.7067E+05	3.9575E+05	4.0388E+05	3.1658E+05
5000	4.0050E+04	4.3521E+04	1.3694E+05	8.3106E+04	6.2245E+04	2.7742E+05	2.3356E+04	4.7327E+05	3.9828E+05	4.0936E+05	3.2118E+05
5500	4.4571E+04	4.8708E+04	1.3980E+05	8.5728E+04	6.6884E+04	2.8197E+05	2.5840E+04	4.7589E+05	4.0086E+05	4.1485E+05	3.2586E+05
6000	4.9175E+04	5.3909E+04	1.4280E+05	8.8439E+04	7.1591E+04	2.8657E+05	2.8324E+04	4.7855E+05	4.0349E+05	4.2033E+05	3.3061E+05
6500	5.3788E+04	5.9186E+04	1.4594E+05	9.1170E+04	7.6377E+04	2.9123E+05	3.0808E+04	4.8124E+05	4.0615E+05	4.2577E+05	3.3550E+05
7000	5.8360E+04	6.4604E+04	1.4916E+05	9.3861E+04	8.1218E+04	2.9594E+05	3.3291E+04	4.8394E+05	4.0893E+05	4.3122E+05	3.4064E+05
7500	6.2962E+04	7.0082E+04	1.5248E+05	9.6571E+04	8.6115E+04	3.0073E+05	3.5775E+04	4.8667E+05	4.1179E+05	4.3667E+05	3.4599E+05
8000	6.7613E+04	7.5612E+04	1.5589E+05	9.9296E+04	9.1069E+04	3.0563E+05	3.8259E+04	4.8941E+05	4.1473E+05	4.4212E+05	3.5155E+05
8500	7.2334E+04	8.1184E+04	1.5936E+05	1.0203E+05	9.6078E+04	3.1068E+05	4.0743E+04	4.9216E+05	4.1777E+05	4.4757E+05	3.5731E+05
9000	7.7146E+04	8.6792E+04	1.6291E+05	1.0478E+05	1.0114E+05	3.1590E+05	4.3226E+04	4.9493E+05	4.2089E+05	4.5301E+05	3.6328E+05
9500	8.2071E+04	9.2426E+04	1.6651E+05	1.0755E+05	1.0626E+05	3.2134E+05	4.5710E+04	4.9771E+05	4.2409E+05	4.5844E+05	3.6943E+05
10000	8.7134E+04	9.8079E+04	1.7014E+05	1.1031E+05	1.1144E+05	3.2702E+05	4.8194E+04	5.0050E+05	4.2736E+05	4.6386E+05	3.7576E+05
10500	9.2356E+04	1.0374E+05	1.7381E+05	1.1309E+05	1.1667E+05	3.3297E+05	5.0678E+04	5.0330E+05	4.3071E+05	4.6928E+05	3.8225E+05
11000	9.7758E+04	1.0941E+05	1.7750E+05	1.1588E+05	1.2196E+05	3.3921E+05	5.3161E+04	5.0611E+05	4.3412E+05	4.7469E+05	3.8888E+05
11500	1.0336E+05	1.1508E+05	1.8120E+05	1.1867E+05	1.2730E+05	3.4575E+05	5.5645E+04	5.0892E+05	4.3759E+05	4.8009E+05	3.9562E+05
12000	1.0917E+05	1.2073E+05	1.8490E+05	1.2148E+05	1.3269E+05	3.5261E+05	5.8129E+04	5.1174E+05	4.4110E+05	4.8549E+05	4.0246E+05
12500	1.1522E+05	1.2637E+05	1.8861E+05	1.2430E+05	1.3814E+05	3.5976E+05	6.0613E+04	5.1457E+05	4.4466E+05	4.9089E+05	4.0937E+05
13000	1.2149E+05	1.3199E+05	1.9231E+05	1.2714E+05	1.4363E+05	3.6719E+05	6.3096E+04	5.1739E+05	4.4825E+05	4.9628E+05	4.1632E+05
13500	1.2801E+05	1.3758E+05	1.9603E+05	1.3000E+05	1.4917E+05	3.7488E+05	6.5580E+04	5.2022E+05	4.5187E+05	5.0168E+05	4.2330E+05
14000	1.3476E+05	1.4314E+05	1.9976E+05	1.3290E+05	1.5475E+05	3.8276E+05	6.8064E+04	5.2306E+05	4.5550E+05	5.0706E+05	4.3028E+05
14500	1.4173E+05	1.4866E+05	2.0351E+05	1.3583E+05	1.6038E+05	3.9078E+05	7.0548E+04	5.2589E+05	4.5914E+05	5.1244E+05	4.3723E+05
15000	1.4923E+05	1.5417E+05	2.0735E+05	1.3885E+05	1.6603E+05	3.9884E+05	7.3031E+04	5.2874E+05	4.6279E+05	5.1773E+05	4.4413E+05
15500	1.5692E+05	1.5964E+05	2.1133E+05	1.4194E+05	1.7170E+05	4.0711E+05	7.5515E+04	5.3160E+05	4.6643E+05	5.2299E+05	4.5092E+05
16000	1.6448E+05	1.6503E+05	2.1535E+05	1.4509E+05	1.7739E+05	4.1551E+05	7.7999E+04	5.3446E+05	4.7007E+05	5.2828E+05	4.5763E+05
16500	1.7221E+05	1.7038E+05	2.1949E+05	1.4832E+05	1.8310E+05	4.2398E+05	8.0483E+04	5.3732E+05	4.7370E+05	5.3354E+05	4.6424E+05
17000	1.8007E+05	1.7567E+05	2.2375E+05	1.5166E+05	1.8881E+05	4.3249E+05	8.2966E+04	5.4020E+05	4.7731E+05	5.3876E+05	4.7073E+05
17500	1.8806E+05	1.8092E+05	2.2817E+05	1.5511E+05	1.9453E+05	4.4103E+05	8.5450E+04	5.4308E+05	4.8091E+05	5.4396E+05	4.7712E+05
18000	1.9614E+05	1.8611E+05	2.3275E+05	1.5870E+05	2.0025E+05	4.4957E+05	8.7934E+04	5.4597E+05	4.8450E+05	5.4911E+05	4.8340E+05
18500	2.0429E+05	1.9124E+05	2.3750E+05	1.6244E+05	2.0596E+05	4.5809E+05	9.0418E+04	5.4887E+05	4.8807E+05	5.5422E+05	4.8956E+05
19000	2.1248E+05	1.9632E+05	2.4245E+05	1.6634E+05	2.1166E+05	4.6656E+05	9.2901E+04	5.5178E+05	4.9161E+05	5.5929E+05	4.9560E+05
19500	2.2071E+05	2.0134E+05	2.4760E+05	1.7042E+05	2.1735E+05	4.7498E+05	9.5385E+04	5.5469E+05	4.9514E+05	5.6431E+05	5.0153E+05
20000	2.2893E+05	2.0631E+05	2.5296E+05	1.7467E+05	2.2302E+05	4.8331E+05	9.7869E+04	5.5762E+05	4.9865E+05	5.6929E+05	5.0734E+05
21000	2.4531E+05	2.1607E+05	2.6433E+05	1.8377E+05	2.3428E+05	4.9969E+05	1.0284E+05	5.6351E+05	5.0560E+05	5.7912E+05	5.1863E+05
22000	2.6147E+05	2.2561E+05	2.7659E+05	1.9370E+05	2.4542E+05	5.1560E+05	1.0780E+05	5.6946E+05	5.1248E+05	5.8876E+05	5.2949E+05
23000	2.7730E+05	2.3493E+05	2.8968E+05	2.0448E+05	2.5641E+05	5.3098E+05	1.1277E+05	5.7546E+05	5.1928E+05	5.9821E+05	5.3994E+05
24000	2.9273E+05	2.4404E+05	3.0350E+05	2.1611E+05	2.6722E+05	5.4584E+05	1.1774E+05	5.8153E+05	5.2601E+05	6.0749E+05	5.5002E+05
25000	3.0773E+05	2.5295E+05	3.1784E+05	2.2849E+05	2.7787E+05	5.6026E+05	1.2271E+05	5.8767E+05	5.3270E+05	6.1660E+05	5.5975E+05
26000	3.2223E+05	2.6166E+05	3.3265E+05	2.4157E+05	2.8831E+05	5.7416E+05	1.2767E+05	5.9390E+05	5.3934E+05	6.2555E+05	5.6914E+05
27000	3.3623E+05	2.7019E+05	3.4779E+05	2.5529E+05	2.9856E+05	5.8754E+05	1.3264E+05	6.0023E+05	5.4595E+05	6.3433E+05	5.7829E+05
28000	3.4974E+05	2.7855E+05	3.6304E+05	2.6949E+05	3.0861E+05	6.0044E+05	1.3761E+05	6.0666E+05	5.5254E+05	6.4296E+05	5.8717E+05
29000	3.6278E+05	2.8675E+05	3.7827E+05	2.8403E+05	3.1846E+05	6.1290E+05	1.4258E+05	6.1321E+05	5.5914E+05	6.5145E+05	5.9582E+05
30000	3.7536E+05	2.9480E+05	3.9335E+05	2.9877E+05	3.2811E+05	6.2495E+05	1.4754E+05	6.1990E+05	5.6575E+05	6.5980E+05	6.0425E+05

Output from DRIVER1A/DRIVER1S program (continued)

VISCOSITY, MU
I
GM/CM-SEC

T, K	N2	O2	N	O	NO	NO+	E-	N+	O+	N2+	O2+
1000	3.8731e-04	4.9119e-04	4.4761e-04	4.7062e-04	4.4232e-04	1.7704e-06	7.9788e-09	1.2069e-06	1.2917e-06	1.7054e-06	1.8253e-06
1500	5.1895e-04	6.1212e-04	6.1005e-04	6.2945e-04	5.6002e-04	1.3848e-06	6.2407e-09	9.4397e-07	1.0103e-06	1.3339e-06	1.4277e-06
2000	6.4127e-04	7.2251e-04	7.6176e-04	7.7687e-04	6.6807e-04	1.8817e-06	8.4804e-09	1.2827e-06	1.3729e-06	1.8127e-06	1.9400e-06
2500	7.5742e-04	8.2621e-04	9.0620e-04	9.1674e-04	7.6999e-04	2.6015e-06	1.1724e-08	1.7734e-06	1.8980e-06	2.5060e-06	2.6821e-06
3000	8.6908e-04	9.2521e-04	1.0452e-03	1.0511e-03	8.6760e-04	3.5033e-06	1.5788e-08	2.3881e-06	2.5559e-06	3.3747e-06	3.6118e-06
3500	9.7727e-04	1.0207e-03	1.1801e-03	1.1812e-03	9.6197e-04	4.5805e-06	2.0643e-08	3.1224e-06	3.3418e-06	4.4124e-06	4.7223e-06
4000	1.0827e-03	1.1133e-03	1.3114e-03	1.3079e-03	1.0538e-03	5.8333e-06	2.6289e-08	3.9764e-06	4.2558e-06	5.6192e-06	6.0140e-06
4500	1.1857e-03	1.2038e-03	1.4399e-03	1.4318e-03	1.1436e-03	7.2639e-06	3.2736e-08	4.9516e-06	5.2995e-06	6.9972e-06	7.4888e-06
5000	1.2868e-03	1.2924e-03	1.5659e-03	1.5532e-03	1.2317e-03	8.8748e-06	3.9996e-08	6.0497e-06	6.4748e-06	8.5490e-06	9.1496e-06
5500	1.3862e-03	1.3794e-03	1.6897e-03	1.6726e-03	1.3183e-03	1.0669e-05	4.8081e-08	7.2728e-06	7.7837e-06	1.0277e-05	1.0999e-05
6000	1.4841e-03	1.4650e-03	1.8117e-03	1.7902e-03	1.4038e-03	1.2649e-05	5.7005e-08	8.6226e-06	9.2284e-06	1.2185e-05	1.3041e-05
6500	1.5807e-03	1.5495e-03	1.9319e-03	1.9061e-03	1.4881e-03	1.4818e-05	6.6780e-08	1.0101e-05	1.0811e-05	1.4274e-05	1.5277e-05
7000	1.6761e-03	1.6330e-03	2.0506e-03	2.0206e-03	1.5716e-03	1.7179e-05	7.7419e-08	1.1710e-05	1.2533e-05	1.6548e-05	1.7711e-05
7500	1.7705e-03	1.7155e-03	2.1679e-03	2.1338e-03	1.6542e-03	1.9733e-05	8.8931e-08	1.3452e-05	1.4397e-05	1.9009e-05	2.0344e-05
8000	1.8638e-03	1.7973e-03	2.2839e-03	2.2458e-03	1.7361e-03	2.2485e-05	1.0133e-07	1.5327e-05	1.6404e-05	2.1659e-05	2.3181e-05
8500	1.9563e-03	1.8783e-03	2.3988e-03	2.3568e-03	1.8173e-03	2.5435e-05	1.1463e-07	1.7338e-05	1.8556e-05	2.4501e-05	2.6222e-05
9000	2.0480e-03	1.9587e-03	2.5126e-03	2.4668e-03	1.8979e-03	2.8586e-05	1.2883e-07	1.9487e-05	2.0856e-05	2.7537e-05	2.9471e-05
9500	2.1390e-03	2.0385e-03	2.6254e-03	2.5758e-03	1.9781e-03	3.1941e-05	1.4395e-07	2.1774e-05	2.3303e-05	3.0769e-05	3.2930e-05
10000	2.2293e-03	2.1177e-03	2.7372e-03	2.6840e-03	2.0577e-03	3.5502e-05	1.5999e-07	2.4201e-05	2.5901e-05	3.4199e-05	3.6601e-05
10500	2.3189e-03	2.1965e-03	2.8482e-03	2.7915e-03	2.1369e-03	3.9270e-05	1.7698e-07	2.6770e-05	2.8650e-05	3.7829e-05	4.0486e-05
11000	2.4079e-03	2.2748e-03	2.9584e-03	2.8981e-03	2.2156e-03	4.3248e-05	1.9491e-07	2.9481e-05	3.1553e-05	4.1661e-05	4.4588e-05
11500	2.4964e-03	2.3527e-03	3.0678e-03	3.0041e-03	2.2940e-03	4.7438e-05	2.1379e-07	3.2337e-05	3.4609e-05	4.5697e-05	4.8907e-05
12000	2.5843e-03	2.4302e-03	3.1765e-03	3.1095e-03	2.3721e-03	5.1842e-05	2.3363e-07	3.5339e-05	3.7822e-05	4.9939e-05	5.3447e-05
12500	2.6717e-03	2.5074e-03	3.2844e-03	3.2143e-03	2.4499e-03	5.6461e-05	2.5445e-07	3.8488e-05	4.1192e-05	5.4388e-05	5.8209e-05
13000	2.7587e-03	2.5842e-03	3.3918e-03	3.3184e-03	2.5273e-03	6.1297e-05	2.7624e-07	4.1785e-05	4.4720e-05	5.9047e-05	6.3195e-05
13500	2.8452e-03	2.6607e-03	3.4985e-03	3.4221e-03	2.6045e-03	6.6352e-05	2.9903e-07	4.5231e-05	4.8409e-05	6.3916e-05	6.8407e-05
14000	2.9313e-03	2.7370e-03	3.6046e-03	3.5252e-03	2.6814e-03	7.1628e-05	3.2281e-07	4.8827e-05	5.2258e-05	6.8999e-05	7.3847e-05
14500	3.0170e-03	2.8129e-03	3.7102e-03	3.6278e-03	2.7581e-03	7.7127e-05	3.4758e-07	5.2575e-05	5.6269e-05	7.4296e-05	7.9515e-05
15000	3.1023e-03	2.8887e-03	3.8152e-03	3.7300e-03	2.8346e-03	8.2850e-05	3.7338e-07	5.6477e-05	6.0445e-05	7.9808e-05	8.5415e-05
15500	3.1873e-03	2.9642e-03	3.9197e-03	3.8317e-03	2.9109e-03	8.8798e-05	4.0018e-07	6.0531e-05	6.4784e-05	8.5538e-05	9.1548e-05
16000	3.2719e-03	3.0395e-03	4.0237e-03	3.9330e-03	2.9870e-03	9.4974e-05	4.2801e-07	6.4741e-05	6.9290e-05	9.1487e-05	9.7915e-05
16500	3.3562e-03	3.1146e-03	4.1273e-03	4.0339e-03	3.0629e-03	1.0138e-04	4.5688e-07	6.9107e-05	7.3963e-05	9.7657e-05	1.0452e-04
17000	3.4402e-03	3.1895e-03	4.2304e-03	4.1345e-03	3.1387e-03	1.0801e-04	4.8678e-07	7.3630e-05	7.8803e-05	1.0405e-04	1.1136e-04
17500	3.5238e-03	3.2642e-03	4.3330e-03	4.2346e-03	3.2143e-03	1.1488e-04	5.1773e-07	7.8311e-05	8.3813e-05	1.1066e-04	1.1844e-04
18000	3.6072e-03	3.3387e-03	4.4353e-03	4.3344e-03	3.2897e-03	1.2198e-04	5.4972e-07	8.3151e-05	8.8993e-05	1.1750e-04	1.2576e-04
18500	3.6903e-03	3.4131e-03	4.5371e-03	4.4339e-03	3.3650e-03	1.2932e-04	5.8278e-07	8.8151e-05	9.4345e-05	1.2457e-04	1.3332e-04
19000	3.7731e-03	3.4873e-03	4.6385e-03	4.5330e-03	3.4402e-03	1.3689e-04	6.1690e-07	9.3312e-05	9.9868e-05	1.3186e-04	1.4113e-04
19500	3.8557e-03	3.5614e-03	4.7396e-03	4.6318e-03	3.5153e-03	1.4470e-04	6.5209e-07	9.8635e-05	1.0557e-04	1.3938e-04	1.4918e-04
20000	3.9380e-03	3.6354e-03	4.8403e-03	4.7303e-03	3.5902e-03	1.5274e-04	6.8836e-07	1.0412e-04	1.1144e-04	1.4714e-04	1.5747e-04
21000	4.1020e-03	3.7830e-03	5.0406e-03	4.9265e-03	3.7398e-03	1.6956e-04	7.6416e-07	1.1559e-04	1.2371e-04	1.6334e-04	1.7481e-04
22000	4.2650e-03	3.9301e-03	5.2396e-03	5.1215e-03	3.8890e-03	1.8735e-04	8.4433e-07	1.2771e-04	1.3669e-04	1.8047e-04	1.9315e-04
23000	4.4272e-03	4.0768e-03	5.4374e-03	5.3156e-03	4.0378e-03	2.0612e-04	9.2893e-07	1.4051e-04	1.5038e-04	1.9856e-04	2.1251e-04
24000	4.5887e-03	4.2232e-03	5.6340e-03	5.5086e-03	4.1864e-03	2.2589e-04	1.0180e-06	1.5398e-04	1.6480e-04	2.1760e-04	2.3289e-04
25000	4.7494e-03	4.3692e-03	5.8295e-03	5.7008e-03	4.3347e-03	2.4666e-04	1.1116e-06	1.6814e-04	1.7996e-04	2.3760e-04	2.5430e-04
26000	4.9094e-03	4.5150e-03	6.0239e-03	5.8922e-03	4.4827e-03	2.6844e-04	1.2098e-06	1.8299e-04	1.9585e-04	2.5859e-04	2.7675e-04
27000	5.0687e-03	4.6605e-03	6.2174e-03	6.0827e-03	4.6306e-03	2.9124e-04	1.3125e-06	1.9853e-04	2.1248e-04	2.8055e-04	3.0026e-04
28000	5.2275e-03	4.8057e-03	6.4098e-03	6.2725e-03	4.7782e-03	3.1508e-04	1.4199e-06	2.1478e-04	2.2987e-04	3.0351e-04	3.2483e-04
29000	5.3856e-03	4.9508e-03	6.6014e-03	6.4615e-03	4.9257e-03	3.3995e-04	1.5320e-06	2.3174e-04	2.4802e-04	3.2747e-04	3.5048e-04
30000	5.5432e-03	5.0957e-03	6.7921e-03	6.6499e-03	5.0731e-03	3.6587e-04	1.6489e-06	2.4941e-04	2.6693e-04	3.5244e-04	3.7720e-04

Output from DRIVER1A/DRIVER1S program (concluded)

THERMAL CONDUCTIVITY, K_I

CAL/CM-SEC-K

T, K	N2	O2	N	O	NO	NO+	E-	N+	O+	N2+	O2+
1000	1.6114E-04	1.8257E-04	2.3673E-04	2.1945E-04	1.7298E-04	4.3775E-07	1.0892E-04	6.4427E-07	6.0616E-07	8.1190E-07	8.0274E-07
1500	2.2775E-04	2.3694E-04	3.2486E-04	2.9136E-04	2.3117E-04	5.8146E-07	8.5131E-05	5.0444E-07	4.7701E-07	6.9826E-07	6.7046E-07
2000	2.8801E-04	2.9856E-04	4.0795E-04	3.5862E-04	2.8581E-04	9.1030E-07	1.1563E-04	6.9021E-07	6.4343E-07	1.0209E-06	9.1244E-07
2500	3.4322E-04	3.5850E-04	4.8767E-04	4.2290E-04	3.3667E-04	1.3015E-06	1.5982E-04	9.6271E-07	8.9104E-07	1.4931E-06	1.2661E-06
3000	3.9509E-04	4.1460E-04	5.6492E-04	4.8507E-04	3.8440E-04	1.7568E-06	2.1517E-04	1.3088E-06	1.2132E-06	2.1005E-06	1.7290E-06
3500	4.4501E-04	4.6660E-04	6.4024E-04	5.4566E-04	4.2977E-04	2.2898E-06	2.8128E-04	1.7279E-06	1.6140E-06	2.8423E-06	2.3127E-06
4000	4.9412E-04	5.1509E-04	7.1401E-04	6.0499E-04	4.7346E-04	2.9149E-06	3.5817E-04	2.2216E-06	2.1009E-06	3.7190E-06	3.0310E-06
4500	5.4339E-04	5.6075E-04	7.8647E-04	6.6330E-04	5.1601E-04	3.6515E-06	4.4596E-04	2.7923E-06	2.6808E-06	4.7312E-06	3.8981E-06
5000	5.9340E-04	6.0423E-04	8.5783E-04	7.2077E-04	5.5784E-04	4.5177E-06	5.4482E-04	3.4427E-06	3.3612E-06	5.8788E-06	4.9271E-06
5500	6.4488E-04	6.4658E-04	9.2823E-04	7.7754E-04	5.9941E-04	5.5347E-06	6.5491E-04	4.1753E-06	4.1494E-06	7.1610E-06	6.1315E-06
6000	6.9822E-04	6.8797E-04	9.9779E-04	8.3369E-04	6.4101E-04	6.7263E-06	7.7641E-04	4.9926E-06	5.0512E-06	8.5764E-06	7.5207E-06
6500	7.5391E-04	7.2928E-04	1.0666E-03	8.8931E-04	6.8283E-04	8.1145E-06	9.0950E-04	5.8972E-06	6.0737E-06	1.0124E-05	9.1072E-06
7000	8.1236E-04	7.7089E-04	1.1347E-03	9.4447E-04	7.2520E-04	9.7331E-06	1.0543E-03	6.8915E-06	7.2229E-06	1.1800E-05	1.0896E-05
7500	8.7399E-04	8.1315E-04	1.2023E-03	9.9921E-04	7.6826E-04	1.1605E-05	1.2111E-03	7.9780E-06	8.5029E-06	1.3604E-05	1.2893E-05
8000	9.3904E-04	8.5650E-04	1.2693E-03	1.0536E-03	8.1222E-04	1.3770E-05	1.3799E-03	9.1588E-06	9.9192E-06	1.5533E-05	1.5106E-05
8500	1.0080E-03	9.0134E-04	1.3358E-03	1.1077E-03	8.5716E-04	1.6260E-05	1.5609E-03	1.0436E-05	1.1476E-05	1.7583E-05	1.7531E-05
9000	1.0811E-03	9.4798E-04	1.4018E-03	1.1614E-03	9.0336E-04	1.9120E-05	1.7542E-03	1.1813E-05	1.3176E-05	1.9752E-05	2.0174E-05
9500	1.1589E-03	9.9666E-04	1.4674E-03	1.2149E-03	9.5079E-04	2.2393E-05	1.9601E-03	1.3291E-05	1.5023E-05	2.2037E-05	2.3025E-05
10000	1.2417E-03	1.0478E-03	1.5326E-03	1.2682E-03	9.9967E-04	2.6117E-05	2.1786E-03	1.4871E-05	1.7019E-05	2.4435E-05	2.6084E-05
10500	1.3298E-03	1.1016E-03	1.5974E-03	1.3212E-03	1.0501E-03	3.0356E-05	2.4098E-03	1.6558E-05	1.9167E-05	2.6942E-05	2.9351E-05
11000	1.4237E-03	1.1582E-03	1.6619E-03	1.3740E-03	1.1023E-03	3.5156E-05	2.6538E-03	1.8351E-05	2.1467E-05	2.9556E-05	3.2804E-05
11500	1.5236E-03	1.2180E-03	1.7261E-03	1.4267E-03	1.1562E-03	4.0579E-05	2.9109E-03	2.0254E-05	2.3919E-05	3.2272E-05	3.6451E-05
12000	1.6304E-03	1.2813E-03	1.7900E-03	1.4792E-03	1.2120E-03	4.6703E-05	3.1811E-03	2.2269E-05	2.6523E-05	3.5089E-05	4.0268E-05
12500	1.7441E-03	1.3485E-03	1.8536E-03	1.5315E-03	1.2699E-03	5.3584E-05	3.4645E-03	2.4397E-05	2.9279E-05	3.8003E-05	4.4248E-05
13000	1.8655E-03	1.4196E-03	1.9169E-03	1.5836E-03	1.3297E-03	6.1292E-05	3.7612E-03	2.6640E-05	3.2186E-05	4.1010E-05	4.8366E-05
13500	1.9950E-03	1.4955E-03	1.9799E-03	1.6357E-03	1.3920E-03	6.9925E-05	4.0714E-03	2.9000E-05	3.5246E-05	4.4108E-05	5.2628E-05
14000	2.1332E-03	1.5759E-03	2.0427E-03	1.6876E-03	1.4564E-03	7.9565E-05	4.3951E-03	3.1479E-05	3.8450E-05	4.7294E-05	5.7000E-05
14500	2.2807E-03	1.6614E-03	2.1053E-03	1.7394E-03	1.5233E-03	9.0297E-05	4.7324E-03	3.4080E-05	4.1804E-05	5.0563E-05	6.1477E-05
15000	2.4381E-03	1.7523E-03	2.1677E-03	1.7911E-03	1.5928E-03	1.0222E-04	5.0836E-03	3.6803E-05	4.5297E-05	5.3914E-05	6.6028E-05
15500	2.6060E-03	1.8488E-03	2.2298E-03	1.8427E-03	1.6650E-03	1.1544E-04	5.4485E-03	3.9650E-05	4.8930E-05	5.7344E-05	7.0652E-05
16000	2.7851E-03	1.9522E-03	2.2918E-03	1.8942E-03	1.7400E-03	1.3009E-04	5.8274E-03	4.2624E-05	5.2700E-05	6.0849E-05	7.5315E-05
16500	2.9763E-03	2.0625E-03	2.3535E-03	1.9456E-03	1.8178E-03	1.4626E-04	6.2204E-03	4.5726E-05	5.6599E-05	6.4427E-05	8.0023E-05
17000	3.1805E-03	2.1794E-03	2.4151E-03	1.9969E-03	1.8988E-03	1.6410E-04	6.6275E-03	4.8958E-05	6.0631E-05	6.8075E-05	8.4735E-05
17500	3.3982E-03	2.3043E-03	2.4765E-03	2.0481E-03	1.9829E-03	1.8372E-04	7.0489E-03	5.2322E-05	6.4783E-05	7.1790E-05	8.9457E-05
18000	3.6305E-03	2.4374E-03	2.5377E-03	2.0993E-03	2.0703E-03	2.0526E-04	7.4845E-03	5.5818E-05	6.9055E-05	7.5569E-05	9.4146E-05
18500	3.8781E-03	2.5790E-03	2.5988E-03	2.1504E-03	2.1611E-03	2.2893E-04	7.9346E-03	5.9450E-05	7.3437E-05	7.9411E-05	9.8800E-05
19000	4.1423E-03	2.7308E-03	2.6597E-03	2.2015E-03	2.2556E-03	2.5484E-04	8.3991E-03	6.3218E-05	7.7922E-05	8.3312E-05	1.0339E-04
19500	4.4244E-03	2.8919E-03	2.7205E-03	2.2524E-03	2.3536E-03	2.8315E-04	8.8783E-03	6.7125E-05	8.2523E-05	8.7270E-05	1.0792E-04
20000	4.7249E-03	3.0642E-03	2.7811E-03	2.3034E-03	2.4555E-03	3.1405E-04	9.3721E-03	7.1172E-05	8.7210E-05	9.1283E-05	1.1237E-04
21000	5.3874E-03	3.4447E-03	2.9019E-03	2.4051E-03	2.6718E-03	3.8440E-04	1.0404E-02	7.9692E-05	9.6862E-05	9.9463E-05	1.2098E-04
22000	6.1401E-03	3.8779E-03	3.0223E-03	2.5066E-03	2.9054E-03	4.6752E-04	1.1496E-02	8.8791E-05	1.0682E-04	1.0783E-04	1.2906E-04
23000	6.9951E-03	4.3712E-03	3.1421E-03	2.6079E-03	3.1578E-03	5.6503E-04	1.2648E-02	9.8483E-05	1.1706E-04	1.1638E-04	1.3660E-04
24000	7.9661E-03	4.9335E-03	3.2615E-03	2.7092E-03	3.4302E-03	6.7915E-04	1.3861E-02	1.0878E-04	1.2751E-04	1.2508E-04	1.4345E-04
25000	9.0679E-03	5.5761E-03	3.3804E-03	2.8102E-03	3.7244E-03	8.1175E-04	1.5135E-02	1.1969E-04	1.3812E-04	1.3393E-04	1.4963E-04
26000	1.0318E-02	6.3091E-03	3.4989E-03	2.9112E-03	4.0424E-03	9.6515E-04	1.6472E-02	1.3124E-04	1.4886E-04	1.4290E-04	1.5506E-04
27000	1.1735E-02	7.1476E-03	3.6171E-03	3.0121E-03	4.3855E-03	1.1420E-03	1.7871E-02	1.4342E-04	1.5968E-04	1.5199E-04	1.5970E-04
28000	1.3341E-02	8.1018E-03	3.7349E-03	3.1129E-03	4.7554E-03	1.3451E-03	1.9334E-02	1.5626E-04	1.7054E-04	1.6118E-04	1.6357E-04
29000	1.5160E-02	9.1937E-03	3.8523E-03	3.2136E-03	5.1548E-03	1.5771E-03	2.0861E-02	1.6977E-04	1.8135E-04	1.7046E-04	1.6667E-04
30000	1.7221E-02	1.0441E-02	3.9695E-03	3.3142E-03	5.5858E-03	1.8408E-03	2.2451E-02	1.8395E-04	1.9209E-04	1.7982E-04	1.6899E-04

Partial output from DRIVER2A/DRIVER2S program

DIFFUSION COEFFICIENT, $D_{I,J}$

INTERACTION INDEX

T, K	1	2	3	4	5	6	7	8	9	10	11
1000	1.4970e+00	1.6642e+00	1.6826e+00	2.3252e+00	2.2928e+00	7.8085e-01	2.0482e+00	2.4083e+00	3.0171e+00	7.7577e-01	1.5794e+00
1500	3.0776e+00	3.1688e+00	3.2000e+00	4.7569e+00	4.6414e+00	1.4964e+00	4.2178e+00	4.7814e+00	6.3911e+00	1.4875e+00	3.1230e+00
2000	5.1436e+00	5.0509e+00	5.0907e+00	7.9354e+00	7.6827e+00	2.3754e+00	7.0611e+00	7.8133e+00	1.0876e+01	2.3623e+00	5.0953e+00
2500	7.6705e+00	7.2900e+00	7.3315e+00	1.1828e+01	1.1381e+01	3.4008e+00	1.0548e+01	1.1465e+01	1.6417e+01	3.3833e+00	7.4733e+00
3000	1.0641e+01	9.8724e+00	9.9072e+00	1.6413e+01	1.5710e+01	4.5606e+00	1.4655e+01	1.5710e+01	2.2976e+01	4.5383e+00	1.0241e+01
3500	1.4043e+01	1.2788e+01	1.2806e+01	2.1672e+01	2.0651e+01	5.8458e+00	1.9368e+01	2.0529e+01	3.0519e+01	5.8187e+00	1.3388e+01
4000	1.7864e+01	1.6031e+01	1.6020e+01	2.7593e+01	2.6190e+01	7.2493e+00	2.4672e+01	2.5905e+01	3.9022e+01	7.2173e+00	1.6904e+01
4500	2.2097e+01	1.9594e+01	1.9543e+01	3.4165e+01	3.2313e+01	8.7654e+00	3.0557e+01	3.1825e+01	4.8462e+01	8.7284e+00	2.0783e+01
5000	2.6733e+01	2.3472e+01	2.3367e+01	4.1379e+01	3.9011e+01	1.0389e+01	3.7014e+01	3.8280e+01	5.8818e+01	1.0347e+01	2.5018e+01
5500	3.1767e+01	2.7663e+01	2.7489e+01	4.9226e+01	4.6274e+01	1.2116e+01	4.4035e+01	4.5258e+01	7.0075e+01	1.2070e+01	2.9604e+01
6000	3.7192e+01	3.2163e+01	3.1905e+01	5.7701e+01	5.4095e+01	1.3944e+01	5.1612e+01	5.2754e+01	8.2216e+01	1.3892e+01	3.4537e+01
6500	4.3004e+01	3.6969e+01	3.6611e+01	6.6797e+01	6.2466e+01	1.5868e+01	5.9740e+01	6.0759e+01	9.5228e+01	1.5811e+01	3.9814e+01
7000	4.9197e+01	4.2079e+01	4.1605e+01	7.6509e+01	7.1383e+01	1.7886e+01	6.8413e+01	6.9268e+01	1.0910e+02	1.7824e+01	4.5430e+01
7500	5.5769e+01	4.7491e+01	4.6883e+01	8.6833e+01	8.0838e+01	1.9995e+01	7.7626e+01	7.8274e+01	1.2382e+02	1.9928e+01	5.1384e+01
8000	6.2715e+01	5.3203e+01	5.2443e+01	9.7764e+01	9.0828e+01	2.2194e+01	8.7376e+01	8.7773e+01	1.3937e+02	2.2122e+01	5.7672e+01
8500	7.0032e+01	5.9215e+01	5.8283e+01	1.0930e+02	1.0135e+02	2.4479e+01	9.7656e+01	9.7760e+01	1.5575e+02	2.4403e+01	6.4292e+01
9000	7.7716e+01	6.5523e+01	6.4402e+01	1.2143e+02	1.1239e+02	2.6849e+01	1.0847e+02	1.0823e+02	1.7295e+02	2.6769e+01	7.1242e+01
9500	8.5766e+01	7.2129e+01	7.0798e+01	1.3417e+02	1.2396e+02	2.9303e+01	1.1980e+02	1.1918e+02	1.9095e+02	2.9218e+01	7.8520e+01
10000	9.4177e+01	7.9029e+01	7.7468e+01	1.4749e+02	1.3604e+02	3.1839e+01	1.3165e+02	1.3061e+02	2.0976e+02	3.1749e+01	8.6124e+01
10500	1.0295e+02	8.6225e+01	8.4413e+01	1.6141e+02	1.4864e+02	3.4454e+01	1.4403e+02	1.4251e+02	2.2936e+02	3.4360e+01	9.4053e+01
11000	1.1208e+02	9.3713e+01	9.1630e+01	1.7592e+02	1.6175e+02	3.7148e+01	1.5691e+02	1.5489e+02	2.4974e+02	3.7050e+01	1.0231e+02
11500	1.2156e+02	1.0150e+02	9.9118e+01	1.9101e+02	1.7538e+02	3.9920e+01	1.7031e+02	1.6773e+02	2.7091e+02	3.9818e+01	1.1088e+02
12000	1.3139e+02	1.0957e+02	1.0688e+02	2.0669e+02	1.8950e+02	4.2768e+01	1.8422e+02	1.8103e+02	2.9285e+02	4.2662e+01	1.1977e+02
12500	1.4158e+02	1.1794e+02	1.1490e+02	2.2295e+02	2.0413e+02	4.5691e+01	1.9864e+02	1.9480e+02	3.1555e+02	4.5581e+01	1.2899e+02
13000	1.5211e+02	1.2659e+02	1.2320e+02	2.3979e+02	2.1926e+02	4.8687e+01	2.1357e+02	2.0902e+02	3.3901e+02	4.8574e+01	1.3852e+02
13500	1.6300e+02	1.3554e+02	1.3176e+02	2.5721e+02	2.3489e+02	5.1756e+01	2.2900e+02	2.2371e+02	3.6323e+02	5.1640e+01	1.4837e+02
14000	1.7422e+02	1.4478e+02	1.4059e+02	2.7521e+02	2.5102e+02	5.4897e+01	2.4493e+02	2.3885e+02	3.8820e+02	5.4777e+01	1.5853e+02
14500	1.8579e+02	1.5431e+02	1.4969e+02	2.9378e+02	2.6764e+02	5.8109e+01	2.6136e+02	2.5444e+02	4.1392e+02	5.7986e+01	1.6901e+02
15000	1.9771e+02	1.6413e+02	1.5905e+02	3.1292e+02	2.8476e+02	6.1391e+01	2.7828e+02	2.7049e+02	4.4037e+02	6.1265e+01	1.7981e+02
15500	2.0996e+02	1.7424e+02	1.6868e+02	3.3264e+02	3.0237e+02	6.4742e+01	2.9571e+02	2.8699e+02	4.6756e+02	6.4613e+01	1.9092e+02
16000	2.2255e+02	1.8464e+02	1.7857e+02	3.5293e+02	3.2046e+02	6.8161e+01	3.1363e+02	3.0393e+02	4.9547e+02	6.8030e+01	2.0234e+02
16500	2.3549e+02	1.9533e+02	1.8872e+02	3.7379e+02	3.3905e+02	7.1647e+01	3.3204e+02	3.2132e+02	5.2412e+02	7.1514e+01	2.1407e+02
17000	2.4875e+02	2.0631e+02	1.9914e+02	3.9522e+02	3.5812e+02	7.5201e+01	3.5094e+02	3.3916e+02	5.5348e+02	7.5065e+01	2.2612e+02
17500	2.6236e+02	2.1758e+02	2.0982e+02	4.1722e+02	3.7767e+02	7.8820e+01	3.7034e+02	3.5744e+02	5.8357e+02	7.8682e+01	2.3847e+02
18000	2.7629e+02	2.2913e+02	2.2076e+02	4.3978e+02	3.9771e+02	8.2505e+01	3.9022e+02	3.7616e+02	6.1437e+02	8.2364e+01	2.5114e+02
18500	2.9056e+02	2.4098e+02	2.3197e+02	4.6291e+02	4.1823e+02	8.6254e+01	4.1059e+02	3.9532e+02	6.4587e+02	8.6112e+01	2.6411e+02
19000	3.0517e+02	2.5311e+02	2.4343e+02	4.8660e+02	4.3923e+02	9.0067e+01	4.3144e+02	4.1492e+02	6.7808e+02	8.9923e+01	2.7740e+02
19500	3.2010e+02	2.6553e+02	2.5516e+02	5.1086e+02	4.6070e+02	9.3944e+01	4.5278e+02	4.3496e+02	7.1100e+02	9.3799e+01	2.9099e+02
20000	3.3536e+02	2.7824e+02	2.6715e+02	5.3568e+02	4.8266e+02	9.7883e+01	4.7461e+02	4.5544e+02	7.4461e+02	9.7737e+01	3.0489e+02
21000	3.6687e+02	3.0453e+02	2.9191e+02	5.8700e+02	5.2800e+02	1.0595e+02	5.1970e+02	4.9770e+02	8.1392e+02	1.0580e+02	3.3362e+02
22000	3.9969e+02	3.3198e+02	3.1770e+02	6.4056e+02	5.7524e+02	1.1426e+02	5.6672e+02	5.4170e+02	8.8599e+02	1.1411e+02	3.6357e+02
23000	4.3380e+02	3.6058e+02	3.4453e+02	6.9635e+02	6.2436e+02	1.2281e+02	6.1565e+02	5.8742e+02	9.6079e+02	1.2266e+02	3.9475e+02
24000	4.6921e+02	3.9033e+02	3.7240e+02	7.5438e+02	6.7537e+02	1.3159e+02	6.6648e+02	6.3486e+02	1.0383e+03	1.3144e+02	4.2715e+02
25000	5.0591e+02	4.2124e+02	4.0130e+02	8.1462e+02	7.2825e+02	1.4061e+02	7.1922e+02	6.8402e+02	1.1185e+03	1.4046e+02	4.6076e+02
26000	5.4389e+02	4.5331e+02	4.3124e+02	8.7709e+02	7.8299e+02	1.4986e+02	7.7384e+02	7.3488e+02	1.2013e+03	1.4972e+02	4.9560e+02
27000	5.8314e+02	4.8654e+02	4.6220e+02	9.4176e+02	8.3960e+02	1.5933e+02	8.3035e+02	7.8744e+02	1.2868e+03	1.5919e+02	5.3164e+02
28000	6.2366e+02	5.2093e+02	4.9420e+02	1.0087e+03	8.9805e+02	1.6903e+02	8.8874e+02	8.4169e+02	1.3750e+03	1.6890e+02	5.6890e+02
29000	6.6544e+02	5.5647e+02	5.2722e+02	1.0777e+03	9.5835e+02	1.7895e+02	9.4901e+02	8.9762e+02	1.4657e+03	1.7882e+02	6.0737e+02
30000	7.0848e+02	5.9318e+02	5.6128e+02	1.1490e+03	1.0205e+03	1.8909e+02	1.0111e+03	9.5525e+02	1.5590e+03	1.8896e+02	6.4705e+02

Partial output from DRIVER2A/DRIVER2S program (continued)

COLLISION CROSS SECTION, OMEGA (1,1)
I,J

INTERACTION INDEX

T, K	1	2	3	4	5	6	7	8	9	10	11
1000	3.2966e+01	2.8706e+01	2.7434e+01	2.6101e+01	2.5802e+01	8.9354e+01	2.8370e+01	2.3474e+01	2.2391e+01	8.4162e+01	3.0722e+01
1500	2.9458e+01	2.7696e+01	2.6501e+01	2.3452e+01	2.3416e+01	8.5660e+01	2.5324e+01	2.1721e+01	1.9418e+01	8.0636e+01	2.8544e+01
2000	2.7137e+01	2.6751e+01	2.5648e+01	2.1653e+01	2.1780e+01	8.3078e+01	2.3298e+01	2.0465e+01	1.7569e+01	7.8171e+01	2.6935e+01
2500	2.5431e+01	2.5903e+01	2.4888e+01	2.0308e+01	2.0548e+01	8.1098e+01	2.1805e+01	1.9491e+01	1.6266e+01	7.6282e+01	2.5665e+01
3000	2.4097e+01	2.5144e+01	2.4211e+01	1.9244e+01	1.9568e+01	7.9495e+01	2.0634e+01	1.8698e+01	1.5278e+01	7.4753e+01	2.4619e+01
3500	2.3011e+01	2.4460e+01	2.3602e+01	1.8369e+01	1.8758e+01	7.8152e+01	1.9680e+01	1.8032e+01	1.4494e+01	7.3472e+01	2.3732e+01
4000	2.2100e+01	2.3840e+01	2.3051e+01	1.7631e+01	1.8071e+01	7.6997e+01	1.8879e+01	1.7459e+01	1.3849e+01	7.2370e+01	2.2964e+01
4500	2.1319e+01	2.3274e+01	2.2548e+01	1.6994e+01	1.7477e+01	7.5985e+01	1.8192e+01	1.6957e+01	1.3307e+01	7.1405e+01	2.2287e+01
5000	2.0639e+01	2.2755e+01	2.2086e+01	1.6437e+01	1.6955e+01	7.5085e+01	1.7593e+01	1.6512e+01	1.2841e+01	7.0546e+01	2.1685e+01
5500	2.0038e+01	2.2275e+01	2.1660e+01	1.5943e+01	1.6490e+01	7.4276e+01	1.7063e+01	1.6112e+01	1.2435e+01	6.9775e+01	2.1142e+01
6000	1.9501e+01	2.1829e+01	2.1264e+01	1.5499e+01	1.6073e+01	7.3541e+01	1.6590e+01	1.5750e+01	1.2076e+01	6.9073e+01	2.0648e+01
6500	1.9017e+01	2.1414e+01	2.0894e+01	1.5099e+01	1.5694e+01	7.2868e+01	1.6164e+01	1.5419e+01	1.1756e+01	6.8432e+01	2.0197e+01
7000	1.8578e+01	2.1026e+01	2.0548e+01	1.4734e+01	1.5349e+01	7.2247e+01	1.5776e+01	1.5116e+01	1.1468e+01	6.7840e+01	1.9781e+01
7500	1.8175e+01	2.0661e+01	2.0223e+01	1.4399e+01	1.5031e+01	7.1672e+01	1.5421e+01	1.4835e+01	1.1206e+01	6.7292e+01	1.9396e+01
8000	1.7805e+01	2.0317e+01	1.9917e+01	1.4091e+01	1.4738e+01	7.1136e+01	1.5095e+01	1.4574e+01	1.0968e+01	6.6781e+01	1.9038e+01
8500	1.7463e+01	1.9993e+01	1.9627e+01	1.3805e+01	1.4466e+01	7.0634e+01	1.4793e+01	1.4331e+01	1.0749e+01	6.6303e+01	1.8703e+01
9000	1.7145e+01	1.9685e+01	1.9352e+01	1.3539e+01	1.4212e+01	7.0163e+01	1.4513e+01	1.4103e+01	1.0546e+01	6.5854e+01	1.8390e+01
9500	1.6848e+01	1.9393e+01	1.9092e+01	1.3291e+01	1.3974e+01	6.9719e+01	1.4251e+01	1.3889e+01	1.0359e+01	6.5430e+01	1.8095e+01
10000	1.6571e+01	1.9115e+01	1.8843e+01	1.3058e+01	1.3751e+01	6.9299e+01	1.4006e+01	1.3687e+01	1.0184e+01	6.5030e+01	1.7816e+01
10500	1.6310e+01	1.8851e+01	1.8606e+01	1.2839e+01	1.3541e+01	6.8901e+01	1.3776e+01	1.3497e+01	1.0021e+01	6.4650e+01	1.7553e+01
11000	1.6064e+01	1.8598e+01	1.8379e+01	1.2633e+01	1.3343e+01	6.8522e+01	1.3560e+01	1.3316e+01	9.8684e+00	6.4289e+01	1.7304e+01
11500	1.5832e+01	1.8356e+01	1.8162e+01	1.2438e+01	1.3155e+01	6.8161e+01	1.3355e+01	1.3145e+01	9.7247e+00	6.3945e+01	1.7066e+01
12000	1.5613e+01	1.8124e+01	1.7954e+01	1.2253e+01	1.2977e+01	6.7817e+01	1.3162e+01	1.2982e+01	9.5893e+00	6.3617e+01	1.6841e+01
12500	1.5405e+01	1.7901e+01	1.7754e+01	1.2077e+01	1.2808e+01	6.7487e+01	1.2978e+01	1.2826e+01	9.4613e+00	6.3303e+01	1.6625e+01
13000	1.5207e+01	1.7688e+01	1.7562e+01	1.1911e+01	1.2646e+01	6.7171e+01	1.2804e+01	1.2677e+01	9.3401e+00	6.3002e+01	1.6419e+01
13500	1.5018e+01	1.7482e+01	1.7377e+01	1.1751e+01	1.2493e+01	6.6868e+01	1.2637e+01	1.2535e+01	9.2250e+00	6.2714e+01	1.6222e+01
14000	1.4838e+01	1.7284e+01	1.7199e+01	1.1599e+01	1.2345e+01	6.6577e+01	1.2479e+01	1.2399e+01	9.1156e+00	6.2436e+01	1.6033e+01
14500	1.4666e+01	1.7093e+01	1.7027e+01	1.1454e+01	1.2204e+01	6.6296e+01	1.2327e+01	1.2268e+01	9.0114e+00	6.2169e+01	1.5852e+01
15000	1.4501e+01	1.6909e+01	1.6861e+01	1.1315e+01	1.2069e+01	6.6026e+01	1.2182e+01	1.2142e+01	8.9120e+00	6.1911e+01	1.5677e+01
15500	1.4343e+01	1.6731e+01	1.6700e+01	1.1182e+01	1.1939e+01	6.5765e+01	1.2043e+01	1.2021e+01	8.8169e+00	6.1662e+01	1.5510e+01
16000	1.4191e+01	1.6558e+01	1.6544e+01	1.1053e+01	1.1815e+01	6.5513e+01	1.1909e+01	1.1905e+01	8.7259e+00	6.1422e+01	1.5348e+01
16500	1.4046e+01	1.6392e+01	1.6394e+01	1.0930e+01	1.1695e+01	6.5269e+01	1.1781e+01	1.1792e+01	8.6387e+00	6.1190e+01	1.5192e+01
17000	1.3906e+01	1.6230e+01	1.6247e+01	1.0812e+01	1.1579e+01	6.5033e+01	1.1657e+01	1.1684e+01	8.5550e+00	6.0965e+01	1.5041e+01
17500	1.3770e+01	1.6074e+01	1.6106e+01	1.0697e+01	1.1467e+01	6.4804e+01	1.1539e+01	1.1579e+01	8.4746e+00	6.0747e+01	1.4896e+01
18000	1.3640e+01	1.5922e+01	1.5968e+01	1.0587e+01	1.1360e+01	6.4582e+01	1.1424e+01	1.1477e+01	8.3972e+00	6.0536e+01	1.4755e+01
18500	1.3515e+01	1.5774e+01	1.5834e+01	1.0481e+01	1.1256e+01	6.4367e+01	1.1313e+01	1.1379e+01	8.3227e+00	6.0331e+01	1.4619e+01
19000	1.3393e+01	1.5631e+01	1.5704e+01	1.0378e+01	1.1155e+01	6.4157e+01	1.1206e+01	1.1284e+01	8.2509e+00	6.0131e+01	1.4487e+01
19500	1.3276e+01	1.5492e+01	1.5578e+01	1.0278e+01	1.1057e+01	6.3954e+01	1.1103e+01	1.1192e+01	8.1816e+00	5.9938e+01	1.4359e+01
20000	1.3162e+01	1.5356e+01	1.5455e+01	1.0182e+01	1.0963e+01	6.3756e+01	1.1003e+01	1.1102e+01	8.1146e+00	5.9749e+01	1.4235e+01
21000	1.2945e+01	1.5096e+01	1.5218e+01	9.9982e+00	1.0782e+01	6.3375e+01	1.0812e+01	1.0931e+01	7.9873e+00	5.9386e+01	1.3997e+01
22000	1.2741e+01	1.4849e+01	1.4993e+01	9.8252e+00	1.0612e+01	6.3013e+01	1.0633e+01	1.0769e+01	7.8679e+00	5.9042e+01	1.3772e+01
23000	1.2548e+01	1.4614e+01	1.4779e+01	9.6620e+00	1.0451e+01	6.2669e+01	1.0463e+01	1.0616e+01	7.7556e+00	5.8714e+01	1.3559e+01
24000	1.2366e+01	1.4390e+01	1.4574e+01	9.5075e+00	1.0299e+01	6.2340e+01	1.0303e+01	1.0470e+01	7.6498e+00	5.8401e+01	1.3356e+01
25000	1.2193e+01	1.4176e+01	1.4378e+01	9.3611e+00	1.0154e+01	6.2026e+01	1.0152e+01	1.0331e+01	7.5497e+00	5.8101e+01	1.3164e+01
26000	1.2029e+01	1.3971e+01	1.4191e+01	9.2220e+00	1.0017e+01	6.1724e+01	1.0007e+01	1.0199e+01	7.4550e+00	5.7815e+01	1.2980e+01
27000	1.1873e+01	1.3775e+01	1.4012e+01	9.0895e+00	9.8855e+00	6.1435e+01	9.8703e+00	1.0072e+01	7.3650e+00	5.7539e+01	1.2805e+01
28000	1.1724e+01	1.3587e+01	1.3839e+01	8.9633e+00	9.7602e+00	6.1157e+01	9.7395e+00	9.9516e+00	7.2794e+00	5.7275e+01	1.2637e+01
29000	1.1582e+01	1.3407e+01	1.3673e+01	8.8426e+00	9.6404e+00	6.0890e+01	9.6147e+00	9.8357e+00	7.1979e+00	5.7020e+01	1.2476e+01
30000	1.1446e+01	1.3233e+01	1.3514e+01	8.7273e+00	9.5256e+00	6.0632e+01	9.4953e+00	9.7246e+00	7.1200e+00	5.6775e+01	1.2322e+01

Partial output from DRIVER2A/DRIVER2S program (continued)

COLLISION CROSS SECTION, OMEGA (2,2)
I,J

INTERACTION INDEX

T, K	1	2	3	4	5	6	7	8	9	10	11
1000	3.6348e+01	3.2326e+01	3.0545e+01	3.1083e+01	3.0490e+01	2.2176e+01	3.3592e+01	2.7241e+01	2.6234e+01	2.2575e+01	3.4220e+01
1500	3.3241e+01	3.1877e+01	3.0026e+01	2.8129e+01	2.7937e+01	1.9926e+01	3.0297e+01	2.5397e+01	2.2724e+01	2.0679e+01	3.2530e+01
2000	3.1073e+01	3.1212e+01	2.9378e+01	2.6106e+01	2.6150e+01	1.8426e+01	2.8062e+01	2.4045e+01	2.0549e+01	1.9351e+01	3.1142e+01
2500	2.9421e+01	3.0512e+01	2.8726e+01	2.4584e+01	2.4786e+01	1.7318e+01	2.6392e+01	2.2982e+01	1.9020e+01	1.8337e+01	2.9974e+01
3000	2.8094e+01	2.9828e+01	2.8103e+01	2.3374e+01	2.3689e+01	1.6448e+01	2.5070e+01	2.2108e+01	1.7865e+01	1.7521e+01	2.8970e+01
3500	2.6991e+01	2.9177e+01	2.7518e+01	2.2375e+01	2.2775e+01	1.5736e+01	2.3983e+01	2.1367e+01	1.6948e+01	1.6841e+01	2.8091e+01
4000	2.6050e+01	2.8564e+01	2.6970e+01	2.1529e+01	2.1995e+01	1.5138e+01	2.3065e+01	2.0726e+01	1.6196e+01	1.6261e+01	2.7311e+01
4500	2.5232e+01	2.7987e+01	2.6458e+01	2.0797e+01	2.1316e+01	1.4625e+01	2.2273e+01	2.0162e+01	1.5564e+01	1.5756e+01	2.6611e+01
5000	2.4511e+01	2.7445e+01	2.5978e+01	2.0155e+01	2.0717e+01	1.4176e+01	2.1579e+01	1.9659e+01	1.5022e+01	1.5310e+01	2.5976e+01
5500	2.3867e+01	2.6935e+01	2.5529e+01	1.9584e+01	2.0181e+01	1.3779e+01	2.0963e+01	1.9205e+01	1.4549e+01	1.4912e+01	2.5396e+01
6000	2.3286e+01	2.6454e+01	2.5105e+01	1.9071e+01	1.9698e+01	1.3423e+01	2.0411e+01	1.8793e+01	1.4132e+01	1.4552e+01	2.4863e+01
6500	2.2758e+01	2.6000e+01	2.4706e+01	1.8606e+01	1.9259e+01	1.3103e+01	1.9911e+01	1.8416e+01	1.3760e+01	1.4226e+01	2.4370e+01
7000	2.2274e+01	2.5570e+01	2.4329e+01	1.8182e+01	1.8856e+01	1.2811e+01	1.9456e+01	1.8068e+01	1.3426e+01	1.3926e+01	2.3911e+01
7500	2.1829e+01	2.5162e+01	2.3971e+01	1.7793e+01	1.8486e+01	1.2543e+01	1.9038e+01	1.7746e+01	1.3123e+01	1.3650e+01	2.3483e+01
8000	2.1417e+01	2.4775e+01	2.3631e+01	1.7433e+01	1.8142e+01	1.2297e+01	1.8652e+01	1.7446e+01	1.2846e+01	1.3395e+01	2.3082e+01
8500	2.1034e+01	2.4406e+01	2.3308e+01	1.7099e+01	1.7823e+01	1.2069e+01	1.8295e+01	1.7166e+01	1.2592e+01	1.3157e+01	2.2705e+01
9000	2.0676e+01	2.4055e+01	2.3000e+01	1.6789e+01	1.7524e+01	1.1857e+01	1.7962e+01	1.6903e+01	1.2357e+01	1.2935e+01	2.2349e+01
9500	2.0341e+01	2.3719e+01	2.2706e+01	1.6498e+01	1.7244e+01	1.1659e+01	1.7651e+01	1.6655e+01	1.2140e+01	1.2727e+01	2.2013e+01
10000	2.0026e+01	2.3397e+01	2.2424e+01	1.6225e+01	1.6981e+01	1.1473e+01	1.7360e+01	1.6422e+01	1.1938e+01	1.2531e+01	2.1694e+01
10500	1.9728e+01	2.3089e+01	2.2154e+01	1.5968e+01	1.6733e+01	1.1299e+01	1.7086e+01	1.6200e+01	1.1749e+01	1.2346e+01	2.1390e+01
11000	1.9447e+01	2.2794e+01	2.1895e+01	1.5726e+01	1.6498e+01	1.1134e+01	1.6827e+01	1.5991e+01	1.1573e+01	1.2172e+01	2.1102e+01
11500	1.9181e+01	2.2510e+01	2.1646e+01	1.5496e+01	1.6275e+01	1.0979e+01	1.6582e+01	1.5791e+01	1.1406e+01	1.2006e+01	2.0826e+01
12000	1.8927e+01	2.2237e+01	2.1406e+01	1.5279e+01	1.6064e+01	1.0832e+01	1.6350e+01	1.5601e+01	1.1250e+01	1.1849e+01	2.0563e+01
12500	1.8686e+01	2.1974e+01	2.1175e+01	1.5072e+01	1.5862e+01	1.0692e+01	1.6130e+01	1.5419e+01	1.1102e+01	1.1699e+01	2.0311e+01
13000	1.8457e+01	2.1720e+01	2.0953e+01	1.4875e+01	1.5670e+01	1.0559e+01	1.5920e+01	1.5246e+01	1.0962e+01	1.1556e+01	2.0069e+01
13500	1.8237e+01	2.1475e+01	2.0738e+01	1.4687e+01	1.5486e+01	1.0432e+01	1.5720e+01	1.5079e+01	1.0829e+01	1.1420e+01	1.9837e+01
14000	1.8027e+01	2.1239e+01	2.0530e+01	1.4508e+01	1.5311e+01	1.0311e+01	1.5529e+01	1.4920e+01	1.0702e+01	1.1289e+01	1.9614e+01
14500	1.7826e+01	2.1010e+01	2.0329e+01	1.4336e+01	1.5142e+01	1.0195e+01	1.5346e+01	1.4767e+01	1.0582e+01	1.1164e+01	1.9399e+01
15000	1.7633e+01	2.0789e+01	2.0135e+01	1.4171e+01	1.4980e+01	1.0085e+01	1.5171e+01	1.4619e+01	1.0467e+01	1.1043e+01	1.9192e+01
15500	1.7447e+01	2.0575e+01	1.9946e+01	1.4013e+01	1.4825e+01	9.9783e+00	1.5002e+01	1.4477e+01	1.0357e+01	1.0928e+01	1.8992e+01
16000	1.7268e+01	2.0367e+01	1.9763e+01	1.3861e+01	1.4675e+01	9.8761e+00	1.4841e+01	1.4341e+01	1.0252e+01	1.0817e+01	1.8799e+01
16500	1.7096e+01	2.0166e+01	1.9586e+01	1.3715e+01	1.4531e+01	9.7779e+00	1.4686e+01	1.4208e+01	1.0152e+01	1.0710e+01	1.8613e+01
17000	1.6930e+01	1.9970e+01	1.9414e+01	1.3574e+01	1.4392e+01	9.6833e+00	1.4536e+01	1.4081e+01	1.0055e+01	1.0606e+01	1.8432e+01
17500	1.6770e+01	1.9780e+01	1.9246e+01	1.3438e+01	1.4258e+01	9.5922e+00	1.4392e+01	1.3958e+01	9.9622e+00	1.0507e+01	1.8258e+01
18000	1.6616e+01	1.9595e+01	1.9084e+01	1.3307e+01	1.4129e+01	9.5043e+00	1.4252e+01	1.3838e+01	9.8729e+00	1.0410e+01	1.8088e+01
18500	1.6466e+01	1.9416e+01	1.8925e+01	1.3181e+01	1.4003e+01	9.4194e+00	1.4118e+01	1.3722e+01	9.7870e+00	1.0317e+01	1.7924e+01
19000	1.6321e+01	1.9241e+01	1.8771e+01	1.3058e+01	1.3882e+01	9.3373e+00	1.3988e+01	1.3610e+01	9.7041e+00	1.0227e+01	1.7765e+01
19500	1.6181e+01	1.9071e+01	1.8621e+01	1.2940e+01	1.3764e+01	9.2579e+00	1.3862e+01	1.3501e+01	9.6242e+00	1.0139e+01	1.7610e+01
20000	1.6045e+01	1.8905e+01	1.8474e+01	1.2825e+01	1.3650e+01	9.1810e+00	1.3740e+01	1.3396e+01	9.5470e+00	1.0055e+01	1.7459e+01
21000	1.5785e+01	1.8586e+01	1.8192e+01	1.2606e+01	1.3432e+01	9.0342e+00	1.3508e+01	1.3193e+01	9.4002e+00	9.8926e+00	1.7170e+01
22000	1.5540e+01	1.8282e+01	1.7923e+01	1.2399e+01	1.3226e+01	8.8960e+00	1.3289e+01	1.3002e+01	9.2626e+00	9.7396e+00	1.6897e+01
23000	1.5308e+01	1.7993e+01	1.7666e+01	1.2204e+01	1.3031e+01	8.7655e+00	1.3082e+01	1.2820e+01	9.1332e+00	9.5949e+00	1.6637e+01
24000	1.5088e+01	1.7716e+01	1.7421e+01	1.2019e+01	1.2847e+01	8.6419e+00	1.2886e+01	1.2647e+01	9.0112e+00	9.4576e+00	1.6389e+01
25000	1.4878e+01	1.7451e+01	1.7186e+01	1.1844e+01	1.2671e+01	8.5247e+00	1.2700e+01	1.2482e+01	8.8960e+00	9.3271e+00	1.6153e+01
26000	1.4679e+01	1.7197e+01	1.6960e+01	1.1677e+01	1.2504e+01	8.4133e+00	1.2523e+01	1.2325e+01	8.7868e+00	9.2028e+00	1.5927e+01
27000	1.4489e+01	1.6954e+01	1.6744e+01	1.1518e+01	1.2344e+01	8.3072e+00	1.2355e+01	1.2175e+01	8.6832e+00	9.0842e+00	1.5711e+01
28000	1.4308e+01	1.6720e+01	1.6536e+01	1.1366e+01	1.2191e+01	8.2059e+00	1.2195e+01	1.2031e+01	8.5847e+00	8.9709e+00	1.5504e+01
29000	1.4134e+01	1.6495e+01	1.6335e+01	1.1221e+01	1.2045e+01	8.1091e+00	1.2041e+01	1.1894e+01	8.4908e+00	8.8624e+00	1.5306e+01
30000	1.3967e+01	1.6279e+01	1.6142e+01	1.1083e+01	1.1905e+01	8.0165e+00	1.1894e+01	1.1761e+01	8.4012e+00	8.7584e+00	1.5115e+01

Partial output from DRIVER2A/DRIVER2S program (concluded)

COLLISION CROSS SECTION RATIO, $B^*_{I,J}$

INTERACTION INDEX

T, K	1	2	3	4	5	6	7	8	9	10	11
1000	1.0905e+00	1.1137e+00	1.1043e+00	1.1606e+00	1.1478e+00	1.0668e+00	1.1616e+00	1.1344e+00	1.1977e+00	1.0666e+00	1.1005e+00
1500	1.1086e+00	1.1288e+00	1.1131e+00	1.1661e+00	1.1526e+00	1.0681e+00	1.1675e+00	1.1388e+00	1.1719e+00	1.0678e+00	1.1171e+00
2000	1.1200e+00	1.1392e+00	1.1194e+00	1.1711e+00	1.1568e+00	1.0691e+00	1.1727e+00	1.1425e+00	1.1573e+00	1.0687e+00	1.1281e+00
2500	1.1280e+00	1.1471e+00	1.1243e+00	1.1755e+00	1.1605e+00	1.0698e+00	1.1774e+00	1.1457e+00	1.1480e+00	1.0694e+00	1.1361e+00
3000	1.1339e+00	1.1534e+00	1.1283e+00	1.1795e+00	1.1638e+00	1.0705e+00	1.1816e+00	1.1485e+00	1.1417e+00	1.0701e+00	1.1422e+00
3500	1.1385e+00	1.1586e+00	1.1317e+00	1.1832e+00	1.1668e+00	1.0711e+00	1.1853e+00	1.1511e+00	1.1373e+00	1.0706e+00	1.1472e+00
4000	1.1422e+00	1.1631e+00	1.1347e+00	1.1866e+00	1.1696e+00	1.0716e+00	1.1888e+00	1.1534e+00	1.1341e+00	1.0711e+00	1.1514e+00
4500	1.1453e+00	1.1670e+00	1.1374e+00	1.1897e+00	1.1721e+00	1.0720e+00	1.1921e+00	1.1555e+00	1.1318e+00	1.0715e+00	1.1549e+00
5000	1.1478e+00	1.1705e+00	1.1398e+00	1.1927e+00	1.1745e+00	1.0724e+00	1.1951e+00	1.1575e+00	1.1302e+00	1.0719e+00	1.1579e+00
5500	1.1499e+00	1.1736e+00	1.1419e+00	1.1954e+00	1.1768e+00	1.0728e+00	1.1979e+00	1.1593e+00	1.1290e+00	1.0722e+00	1.1605e+00
6000	1.1517e+00	1.1763e+00	1.1439e+00	1.1980e+00	1.1789e+00	1.0731e+00	1.2006e+00	1.1610e+00	1.1282e+00	1.0725e+00	1.1629e+00
6500	1.1532e+00	1.1789e+00	1.1457e+00	1.2005e+00	1.1808e+00	1.0734e+00	1.2031e+00	1.1626e+00	1.1276e+00	1.0728e+00	1.1649e+00
7000	1.1546e+00	1.1812e+00	1.1474e+00	1.2029e+00	1.1827e+00	1.0737e+00	1.2055e+00	1.1642e+00	1.1273e+00	1.0731e+00	1.1668e+00
7500	1.1558e+00	1.1834e+00	1.1490e+00	1.2051e+00	1.1845e+00	1.0740e+00	1.2078e+00	1.1656e+00	1.1272e+00	1.0734e+00	1.1685e+00
8000	1.1568e+00	1.1854e+00	1.1504e+00	1.2072e+00	1.1863e+00	1.0743e+00	1.2100e+00	1.1670e+00	1.1272e+00	1.0736e+00	1.1700e+00
8500	1.1577e+00	1.1872e+00	1.1518e+00	1.2093e+00	1.1879e+00	1.0745e+00	1.2121e+00	1.1684e+00	1.1274e+00	1.0739e+00	1.1715e+00
9000	1.1585e+00	1.1890e+00	1.1531e+00	1.2113e+00	1.1895e+00	1.0748e+00	1.2141e+00	1.1696e+00	1.1277e+00	1.0741e+00	1.1727e+00
9500	1.1591e+00	1.1906e+00	1.1544e+00	1.2132e+00	1.1910e+00	1.0750e+00	1.2161e+00	1.1709e+00	1.1280e+00	1.0743e+00	1.1739e+00
10000	1.1598e+00	1.1922e+00	1.1556e+00	1.2150e+00	1.1925e+00	1.0752e+00	1.2180e+00	1.1720e+00	1.1284e+00	1.0745e+00	1.1750e+00
10500	1.1603e+00	1.1936e+00	1.1567e+00	1.2168e+00	1.1939e+00	1.0754e+00	1.2198e+00	1.1732e+00	1.1289e+00	1.0747e+00	1.1761e+00
11000	1.1608e+00	1.1950e+00	1.1578e+00	1.2185e+00	1.1953e+00	1.0756e+00	1.2215e+00	1.1743e+00	1.1294e+00	1.0749e+00	1.1770e+00
11500	1.1612e+00	1.1963e+00	1.1588e+00	1.2202e+00	1.1966e+00	1.0758e+00	1.2232e+00	1.1753e+00	1.1300e+00	1.0751e+00	1.1779e+00
12000	1.1616e+00	1.1976e+00	1.1598e+00	1.2218e+00	1.1979e+00	1.0760e+00	1.2249e+00	1.1763e+00	1.1306e+00	1.0752e+00	1.1788e+00
12500	1.1619e+00	1.1988e+00	1.1607e+00	1.2234e+00	1.1991e+00	1.0761e+00	1.2265e+00	1.1773e+00	1.1313e+00	1.0754e+00	1.1795e+00
13000	1.1622e+00	1.1999e+00	1.1616e+00	1.2249e+00	1.2004e+00	1.0763e+00	1.2280e+00	1.1783e+00	1.1319e+00	1.0756e+00	1.1803e+00
13500	1.1625e+00	1.2010e+00	1.1625e+00	1.2264e+00	1.2015e+00	1.0765e+00	1.2295e+00	1.1792e+00	1.1326e+00	1.0757e+00	1.1810e+00
14000	1.1627e+00	1.2021e+00	1.1634e+00	1.2279e+00	1.2027e+00	1.0766e+00	1.2310e+00	1.1802e+00	1.1334e+00	1.0759e+00	1.1816e+00
14500	1.1629e+00	1.2031e+00	1.1642e+00	1.2293e+00	1.2038e+00	1.0768e+00	1.2325e+00	1.1810e+00	1.1341e+00	1.0760e+00	1.1822e+00
15000	1.1630e+00	1.2040e+00	1.1650e+00	1.2307e+00	1.2049e+00	1.0769e+00	1.2339e+00	1.1819e+00	1.1348e+00	1.0762e+00	1.1828e+00
15500	1.1632e+00	1.2050e+00	1.1657e+00	1.2320e+00	1.2060e+00	1.0771e+00	1.2352e+00	1.1827e+00	1.1356e+00	1.0763e+00	1.1834e+00
16000	1.1633e+00	1.2059e+00	1.1665e+00	1.2334e+00	1.2070e+00	1.0772e+00	1.2366e+00	1.1836e+00	1.1364e+00	1.0764e+00	1.1839e+00
16500	1.1634e+00	1.2067e+00	1.1672e+00	1.2346e+00	1.2080e+00	1.0773e+00	1.2379e+00	1.1844e+00	1.1371e+00	1.0765e+00	1.1844e+00
17000	1.1635e+00	1.2076e+00	1.1679e+00	1.2359e+00	1.2090e+00	1.0775e+00	1.2391e+00	1.1852e+00	1.1379e+00	1.0767e+00	1.1849e+00
17500	1.1636e+00	1.2084e+00	1.1686e+00	1.2371e+00	1.2100e+00	1.0776e+00	1.2404e+00	1.1859e+00	1.1387e+00	1.0768e+00	1.1853e+00
18000	1.1636e+00	1.2092e+00	1.1692e+00	1.2384e+00	1.2109e+00	1.0777e+00	1.2416e+00	1.1867e+00	1.1395e+00	1.0769e+00	1.1858e+00
18500	1.1636e+00	1.2099e+00	1.1699e+00	1.2395e+00	1.2119e+00	1.0779e+00	1.2428e+00	1.1874e+00	1.1403e+00	1.0770e+00	1.1862e+00
19000	1.1637e+00	1.2107e+00	1.1705e+00	1.2407e+00	1.2128e+00	1.0780e+00	1.2440e+00	1.1881e+00	1.1411e+00	1.0771e+00	1.1866e+00
19500	1.1637e+00	1.2114e+00	1.1711e+00	1.2419e+00	1.2137e+00	1.0781e+00	1.2452e+00	1.1888e+00	1.1419e+00	1.0773e+00	1.1870e+00
20000	1.1637e+00	1.2121e+00	1.1717e+00	1.2430e+00	1.2146e+00	1.0782e+00	1.2463e+00	1.1895e+00	1.1427e+00	1.0774e+00	1.1873e+00
21000	1.1636e+00	1.2134e+00	1.1729e+00	1.2452e+00	1.2163e+00	1.0784e+00	1.2485e+00	1.1909e+00	1.1444e+00	1.0776e+00	1.1880e+00
22000	1.1636e+00	1.2147e+00	1.1740e+00	1.2473e+00	1.2179e+00	1.0786e+00	1.2506e+00	1.1922e+00	1.1460e+00	1.0778e+00	1.1886e+00
23000	1.1635e+00	1.2159e+00	1.1750e+00	1.2493e+00	1.2195e+00	1.0788e+00	1.2527e+00	1.1934e+00	1.1476e+00	1.0780e+00	1.1892e+00
24000	1.1634e+00	1.2170e+00	1.1760e+00	1.2513e+00	1.2211e+00	1.0790e+00	1.2547e+00	1.1946e+00	1.1492e+00	1.0781e+00	1.1897e+00
25000	1.1632e+00	1.2181e+00	1.1770e+00	1.2532e+00	1.2226e+00	1.0792e+00	1.2566e+00	1.1958e+00	1.1508e+00	1.0783e+00	1.1902e+00
26000	1.1630e+00	1.2191e+00	1.1779e+00	1.2551e+00	1.2241e+00	1.0794e+00	1.2585e+00	1.1969e+00	1.1524e+00	1.0785e+00	1.1907e+00
27000	1.1628e+00	1.2201e+00	1.1788e+00	1.2569e+00	1.2255e+00	1.0796e+00	1.2603e+00	1.1980e+00	1.1540e+00	1.0787e+00	1.1911e+00
28000	1.1626e+00	1.2211e+00	1.1797e+00	1.2586e+00	1.2268e+00	1.0797e+00	1.2621e+00	1.1991e+00	1.1556e+00	1.0788e+00	1.1915e+00
29000	1.1624e+00	1.2220e+00	1.1805e+00	1.2604e+00	1.2282e+00	1.0799e+00	1.2639e+00	1.2001e+00	1.1572e+00	1.0790e+00	1.1918e+00
30000	1.1622e+00	1.2228e+00	1.1813e+00	1.2620e+00	1.2295e+00	1.0801e+00	1.2655e+00	1.2012e+00	1.1588e+00	1.0791e+00	1.1922e+00

Output from DRIVER3A/DRIVER3S program

LOG OF THE EQUILIBRIUM CONSTANT, LN($K_{EQ,R}$) FOR N= 1.0E17 PARTICLES/CM3

REACTION NUMBER

T, K	1	2	3	4	5	6	7	8	9	10	11
1000	-56.8762	-111.2207	-111.2207	-74.7875	-21.4581	-36.4333	-43.2208	-166.9394	-176.5531	-91.5600	-28.5244
1500	-36.1906	-72.0033	-72.0033	-48.5462	-14.6843	-23.4571	-32.4882	-113.6043	-119.5059	-64.5919	-19.5915
2000	-26.0294	-52.5892	-52.5892	-35.6144	-11.3044	-16.9748	-26.9743	-86.9803	-91.0112	-51.0228	-15.1067
2500	-20.1403	-41.2281	-41.2281	-28.0810	-9.3011	-13.1472	-23.4774	-70.9776	-73.8695	-42.7225	-12.3311
3000	-16.3623	-33.8617	-33.8617	-23.2168	-7.9812	-10.6450	-20.9938	-60.2508	-62.3726	-37.0427	-10.4050
3500	-13.7603	-28.7325	-28.7325	-19.8418	-7.0454	-8.8908	-19.1081	-52.5272	-54.0938	-32.8690	-8.9730
4000	-11.8687	-24.9647	-24.9647	-17.3692	-6.3449	-7.5956	-17.6150	-46.6798	-47.8288	-29.6503	-7.8604
4500	-10.4328	-22.0772	-22.0772	-15.4772	-5.7978	-6.6001	-16.3995	-42.0865	-42.9123	-27.0818	-6.9701
5000	-9.3027	-19.7863	-19.7863	-13.9768	-5.3560	-5.8096	-15.3910	-38.3757	-38.9465	-24.9801	-6.2430
5500	-8.3852	-17.9153	-17.9153	-12.7503	-4.9891	-5.1651	-14.5430	-35.3116	-35.6783	-23.2278	-5.6404
6000	-7.6203	-16.3491	-16.3491	-11.7215	-4.6775	-4.6277	-13.8231	-32.7370	-32.9389	-21.7454	-5.1359
6500	-6.9673	-15.0100	-15.0100	-10.8390	-4.4078	-4.1710	-13.2078	-30.5428	-30.6109	-20.4772	-4.7105
7000	-6.3984	-13.8441	-13.8441	-10.0673	-4.1706	-3.7768	-12.6794	-28.6509	-28.6101	-19.3825	-4.3498
7500	-5.8939	-12.8128	-12.8128	-9.3812	-3.9592	-3.4316	-12.2243	-27.0037	-26.8743	-18.4309	-4.0432
8000	-5.4394	-11.8882	-11.8882	-8.7625	-3.7687	-3.1257	-11.8317	-25.5577	-25.3564	-17.5990	-3.7820
8500	-5.0244	-11.0493	-11.0493	-8.1974	-3.5954	-2.8519	-11.4929	-24.2793	-24.0203	-16.8685	-3.5596
9000	-4.6410	-10.2806	-10.2806	-7.6760	-3.4365	-2.6046	-11.2008	-23.1424	-22.8373	-16.2247	-3.3704
9500	-4.2833	-9.5698	-9.5698	-7.1903	-3.2896	-2.3795	-10.9494	-22.1259	-21.7847	-15.6558	-3.2098
10000	-3.9466	-8.9076	-8.9076	-6.7345	-3.1532	-2.1731	-10.7338	-21.2130	-20.8441	-15.1522	-3.0742
10500	-3.6275	-8.2866	-8.2866	-6.3038	-3.0258	-1.9829	-10.5498	-20.3896	-20.0004	-14.7056	-2.9604
11000	-3.3231	-7.7010	-7.7010	-5.8945	-2.9064	-1.8066	-10.3938	-19.6445	-19.2412	-14.3093	-2.8656
11500	-3.0312	-7.1461	-7.1461	-5.5037	-2.7939	-1.6425	-10.2627	-18.9679	-18.5560	-13.9577	-2.7875
12000	-2.7500	-6.6180	-6.6180	-5.1289	-2.6878	-1.4892	-10.1537	-18.3519	-17.9360	-13.6457	-2.7243
12500	-2.4781	-6.1135	-6.1135	-4.7682	-2.5872	-1.3454	-10.0647	-17.7896	-17.3737	-13.3691	-2.6741
13000	-2.2143	-5.6301	-5.6301	-4.4201	-2.4917	-1.2102	-9.9935	-17.2750	-16.8627	-13.1243	-2.6354
13500	-1.9578	-5.1656	-5.1656	-4.0831	-2.4009	-1.0827	-9.9383	-16.8032	-16.3974	-12.9080	-2.6070
14000	-1.7076	-4.7182	-4.7182	-3.7563	-2.3144	-0.9622	-9.8974	-16.3697	-15.9731	-12.7175	-2.5878
14500	-1.4632	-4.2864	-4.2864	-3.4386	-2.2318	-0.8480	-9.8696	-15.9707	-15.5857	-12.5503	-2.5766
15000	-1.2240	-3.8688	-3.8688	-3.1294	-2.1529	-0.7398	-9.8535	-15.6029	-15.2313	-12.4042	-2.5726
15500	-0.9896	-3.4644	-3.4644	-2.8279	-2.0773	-0.6369	-9.8479	-15.2632	-14.9068	-12.2773	-2.5749
16000	-0.7596	-3.0722	-3.0722	-2.5335	-2.0049	-0.5390	-9.8519	-14.9491	-14.6094	-12.1678	-2.5830
16500	-0.5336	-2.6913	-2.6913	-2.2458	-1.9356	-0.4458	-9.8645	-14.6583	-14.3365	-12.0742	-2.5960
17000	-0.3114	-2.3210	-2.3210	-1.9644	-1.8690	-0.3570	-9.8849	-14.3887	-14.0859	-11.9950	-2.6136
17500	-0.0928	-1.9607	-1.9607	-1.6889	-1.8051	-0.2722	-9.9124	-14.1384	-13.8555	-11.9291	-2.6350
18000	0.1224	-1.6098	-1.6098	-1.4190	-1.7436	-0.1913	-9.9462	-13.9057	-13.6435	-11.8753	-2.6599
18500	0.3345	-1.2678	-1.2678	-1.1543	-1.6846	-0.1140	-9.9858	-13.6893	-13.4483	-11.8325	-2.6879
19000	0.5436	-0.9343	-0.9343	-0.8947	-1.6279	-0.0401	-10.0306	-13.4876	-13.2684	-11.7998	-2.7185
19500	0.7498	-0.6088	-0.6088	-0.6399	-1.5733	0.0305	-10.0801	-13.2996	-13.1025	-11.7765	-2.7515
20000	0.9532	-0.2911	-0.2911	-0.3897	-1.5208	0.0980	-10.1338	-13.1240	-12.9495	-11.7616	-2.7865
21000	1.3521	0.3226	0.3226	0.0976	-1.4216	0.2244	-10.2522	-12.8065	-12.6774	-11.7546	-2.8614
22000	1.7411	0.9091	0.9091	0.5685	-1.3298	0.3400	-10.3828	-12.5278	-12.4447	-11.7738	-2.9413
23000	2.1208	1.4703	1.4703	1.0239	-1.2448	0.4456	-10.5231	-12.2822	-12.2447	-11.8150	-3.0246
24000	2.4915	2.0077	2.0077	1.4648	-1.1660	0.5421	-10.6709	-12.0647	-12.0723	-11.8748	-3.1098
25000	2.8538	2.5228	2.5228	1.8920	-1.0932	0.6301	-10.8245	-11.8710	-11.9229	-11.9499	-3.1959
26000	3.2079	3.0168	3.0168	2.3061	-1.0259	0.7100	-10.9822	-11.6976	-11.7926	-12.0379	-3.2818
27000	3.5542	3.4909	3.4909	2.7077	-0.9638	0.7825	-11.1428	-11.5413	-11.6780	-12.1365	-3.3668
28000	3.8929	3.9459	3.9459	3.0973	-0.9066	0.8478	-11.3052	-11.3995	-11.5764	-12.2438	-3.4501
29000	4.2243	4.3828	4.3828	3.4755	-0.8541	0.9066	-11.4685	-11.2698	-11.4854	-12.3581	-3.5313
30000	4.5487	4.8024	4.8024	3.8426	-0.8060	0.9590	-11.6317	-11.1503	-11.4027	-12.4779	-3.6098

Output from DRIVER3A/DRIVER3S program (concluded)

LOG OF THE EQUILIBRIUM CONSTANT, LN($K_{EQ,R}$) FOR N= 1.0E17 PARTICLES/CM3

REACTION NUMBER

T, K	12	13	14	15	16	17	18	19	20
1000	-12.7095	-77.7368	-148.0353	-118.0881	-49.6524	-21.6425	-58.4651	-31.7987	-76.3322
1500	-8.4502	-55.2638	-99.9021	-81.0387	-33.0973	-13.7042	-38.4672	-20.3101	-50.8632
2000	-6.4200	-43.8698	-75.9144	-62.5465	-24.8318	-9.7825	-28.4647	-14.5581	-38.1453
2500	-5.2373	-36.8025	-61.5946	-51.4950	-19.8010	-7.4743	-22.3744	-11.1670	-30.4344
3000	-4.4522	-31.8981	-52.0766	-44.1412	-16.3754	-5.9604	-18.2313	-8.9606	-25.2093
3500	-3.8799	-28.2515	-45.2796	-38.8830	-13.8725	-4.8893	-15.2107	-7.4249	-21.4091
4000	-3.4324	-25.4148	-40.1702	-34.9243	-11.9557	-4.0873	-12.9044	-6.3019	-18.5094
4500	-3.0637	-23.1387	-36.1786	-31.8260	-10.4387	-3.4596	-11.0862	-5.4485	-16.2201
5000	-2.7475	-21.2717	-32.9661	-29.3271	-9.2093	-2.9506	-9.6193	-4.7796	-14.3670
5500	-2.4682	-19.7157	-30.3184	-27.2626	-8.1953	-2.5257	-8.4156	-4.2418	-12.8385
6000	-2.2160	-18.4032	-28.0939	-25.5235	-7.3478	-2.1626	-7.4154	-3.8000	-11.5595
6500	-1.9843	-17.2864	-26.1951	-24.0345	-6.6322	-1.8459	-6.5763	-3.4305	-10.4772
7000	-1.7688	-16.3297	-24.5527	-22.7425	-6.0235	-1.5653	-5.8675	-3.1164	-9.5531
7500	-1.5664	-15.5062	-23.1159	-21.6085	-5.5026	-1.3132	-5.2657	-2.8457	-8.7586
8000	-1.3750	-14.7949	-21.8470	-20.6035	-5.0550	-1.0841	-4.7529	-2.6097	-8.0718
8500	-1.1929	-14.1791	-20.7170	-19.7050	-4.6691	-0.8739	-4.3152	-2.4016	-7.4756
9000	-1.0189	-13.6455	-19.7034	-18.8961	-4.3358	-0.6795	-3.9411	-2.2165	-6.9562
9500	-0.8521	-13.1831	-18.7885	-18.1629	-4.0477	-0.4985	-3.6217	-2.0504	-6.5027
10000	-0.6918	-12.7826	-17.9580	-17.4947	-3.7986	-0.3290	-3.3493	-1.9003	-6.1062
10500	-0.5373	-12.4366	-17.2004	-16.8826	-3.5835	-0.1695	-3.1178	-1.7637	-5.7591
11000	-0.3883	-12.1384	-16.5063	-16.3193	-3.3981	-0.0188	-2.9219	-1.6388	-5.4552
11500	-0.2443	-11.8826	-15.8677	-15.7988	-3.2387	0.1241	-2.7571	-1.5239	-5.1892
12000	-0.1050	-11.6644	-15.2782	-15.3161	-3.1024	0.2600	-2.6198	-1.4178	-4.9568
12500	0.0299	-11.4798	-14.7321	-14.8671	-2.9863	0.3896	-2.5065	-1.3194	-4.7539
13000	0.1606	-11.3251	-14.2248	-14.4480	-2.8884	0.5134	-2.4146	-1.2278	-4.5774
13500	0.2874	-11.1971	-13.7523	-14.0557	-2.8064	0.6320	-2.3416	-1.1423	-4.4244
14000	0.4104	-11.0933	-13.3109	-13.6877	-2.7387	0.7457	-2.2853	-1.0623	-4.2922
14500	0.5298	-11.0110	-12.8978	-13.3417	-2.6838	0.8549	-2.2439	-0.9871	-4.1789
15000	0.6457	-10.9482	-12.5103	-13.0155	-2.6402	0.9599	-2.2157	-0.9165	-4.0823
15500	0.7583	-10.9029	-12.1461	-12.7075	-2.6068	1.0609	-2.1993	-0.8499	-4.0007
16000	0.8677	-10.8734	-11.8031	-12.4160	-2.5826	1.1583	-2.1933	-0.7871	-3.9328
16500	0.9741	-10.8582	-11.4795	-12.1398	-2.5665	1.2521	-2.1967	-0.7277	-3.8770
17000	1.0775	-10.8558	-11.1738	-11.8775	-2.5577	1.3427	-2.2083	-0.6715	-3.8322
17500	1.1780	-10.8650	-10.8844	-11.6281	-2.5554	1.4302	-2.2273	-0.6183	-3.7973
18000	1.2757	-10.8848	-10.6102	-11.3906	-2.5590	1.5146	-2.2528	-0.5679	-3.7713
18500	1.3708	-10.9140	-10.3500	-11.1641	-2.5677	1.5962	-2.2841	-0.5200	-3.7533
19000	1.4633	-10.9518	-10.1026	-10.9479	-2.5812	1.6751	-2.3204	-0.4746	-3.7426
19500	1.5532	-10.9973	-9.8673	-10.7412	-2.5988	1.7514	-2.3613	-0.4315	-3.7383
20000	1.6407	-11.0497	-9.6431	-10.5433	-2.6201	1.8253	-2.4061	-0.3906	-3.7399
21000	1.8086	-11.1726	-9.2250	-10.1718	-2.6722	1.9657	-2.5056	-0.3147	-3.7584
22000	1.9675	-11.3156	-8.8431	-9.8292	-2.7345	2.0973	-2.6154	-0.2464	-3.7937
23000	2.1179	-11.4746	-8.4926	-9.5120	-2.8046	2.2206	-2.7327	-0.1848	-3.8425
24000	2.2602	-11.6462	-8.1698	-9.2173	-2.8804	2.3361	-2.8550	-0.1294	-3.9018
25000	2.3949	-11.8273	-7.8714	-8.9425	-2.9603	2.4442	-2.9803	-0.0799	-3.9692
26000	2.5223	-12.0155	-7.5946	-8.6854	-3.0427	2.5455	-3.1070	-0.0357	-4.0425
27000	2.6427	-12.2087	-7.3369	-8.4443	-3.1266	2.6402	-3.2337	0.0035	-4.1201
28000	2.7565	-12.4051	-7.0963	-8.2173	-3.2107	2.7287	-3.3590	0.0380	-4.2003
29000	2.8640	-12.6032	-6.8708	-8.0032	-3.2943	2.8113	-3.4821	0.0680	-4.2820
30000	2.9654	-12.8016	-6.6588	-7.8005	-3.3766	2.8884	-3.6021	0.0939	-4.3640

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Table I. Constants for Polynomial Curve-fits of Thermodynamic Properties For a Reference State of 298.15† *K* and 1 *atm* Pressure with N_2, O_2, and e^- as Reference Elements (300 *K* ≤ T ≤ 30000 *K*)‡

Species	A_1	A_2	A_3	A_4	A_5	A_6	A_7
	0.36748*E*+01	−0.12081*E*−02	0.23240*E*−05	−0.63218*E*−09	−0.22577*E*−12	−0.10430*E*+04	0.23580*E*+01
	0.32125*E*+01	0.10137*E*−02	−0.30467*E*−06	0.41091*E*−10	−0.20170*E*−14	−0.10430*E*+04	0.43661*E*+01
N_2	0.31811*E*+01	0.89745*E*−03	−0.20216*E*−06	0.18266*E*−10	−0.50334*E*−15	−0.10430*E*+04	0.46264*E*+01
	0.96377*E*+01	−0.25728*E*−02	0.33020*E*−06	−0.14315*E*−10	0.20333*E*−15	−0.10430*E*+04	−0.37587*E*+02
	−0.51681*E*+01	0.23337*E*−02	−0.12953*E*−06	0.27872*E*−11	−0.21360*E*−16	−0.10430*E*+04	0.66217*E*+02
	0.36146*E*+01	−0.18598*E*−02	0.70814*E*−05	−0.68070*E*−08	0.21628*E*−11	−0.10440*E*+04	0.43628*E*+01
	0.35949*E*+01	0.75213*E*−03	−0.18732*E*−06	0.27913*E*−10	−0.15774*E*−14	−0.10440*E*+04	0.38353*E*+01
O_2	0.38599*E*+01	0.32510*E*−03	−0.92131*E*−08	−0.78684*E*−12	0.29426*E*−16	−0.10440*E*+04	0.23789*E*+01
	0.34867*E*+01	0.52384*E*−03	−0.39123*E*−07	0.10094*E*−11	−0.88718*E*−17	−0.10440*E*+04	0.48179*E*+01
	0.39620*E*+01	0.39446*E*−03	−0.29506*E*−07	0.73975*E*−12	−0.64209*E*−17	−0.10440*E*+04	0.13985*E*+01
	0.25031*E*+01	−0.21800*E*−04	0.54205*E*−07	−0.56476*E*−10	0.20999*E*−13	0.56130*E*+05	0.41676*E*+01
	0.24820*E*+01	0.69258*E*−04	−0.63065*E*−07	0.18387*E*−10	−0.11747*E*−14	0.56130*E*+05	0.42618*E*+01
N	0.27480*E*+01	−0.39090*E*−03	0.13380*E*−06	−0.11910*E*−10	0.33690*E*−15	0.56130*E*+05	0.28720*E*+01
	−0.12280*E*+01	0.19268*E*−02	−0.24370*E*−06	0.12193*E*−10	−0.19918*E*−15	0.56130*E*+05	0.28469*E*+02
	0.15520*E*+02	−0.38858*E*−02	0.32288*E*−06	−0.96053*E*−11	0.95472*E*−16	0.56130*E*+05	−0.88120*E*+02
	0.28236*E*+01	−0.89478*E*−03	0.83060*E*−06	−0.16837*E*−09	−0.73205*E*−13	0.29150*E*+05	0.35027*E*+01
	0.25421*E*+01	−0.27551*E*−04	−0.31028*E*−08	0.45511*E*−11	−0.43681*E*−15	0.29150*E*+05	0.49203*E*+01
O	0.25460*E*+01	−0.59520*E*−04	0.27010*E*−07	−0.27980*E*−11	0.93800*E*−16	0.29150*E*+05	0.50490*E*+01
	−0.97871*E*−02	0.12450*E*−02	−0.16154*E*−06	0.80380*E*−11	−0.12624*E*−15	0.29150*E*+05	0.21711*E*+02
	0.16428*E*+02	−0.39313*E*−02	0.29840*E*−06	−0.81613*E*−11	0.75004*E*−16	0.29150*E*+05	−0.94358*E*+02
	0.35887*E*+01	−0.12479*E*−02	0.39786*E*−05	−0.28651*E*−08	0.63015*E*−12	0.97640*E*+04	0.51497*E*+01
	0.32047*E*+01	0.12705*E*−02	−0.46603*E*−06	0.75007*E*−10	−0.42314*E*−14	0.97640*E*+04	0.66867*E*+01
NO	0.38543*E*+01	0.23409*E*−03	−0.21354*E*−07	0.16689*E*−11	−0.49070*E*−16	0.97640*E*+04	0.31541*E*+01
	0.43309*E*+01	−0.58086*E*−04	0.28059*E*−07	−0.15694*E*−11	0.24104*E*−16	0.97640*E*+04	0.10735*E*+00
	0.23507*E*+01	0.58643*E*−03	−0.31316*E*−07	0.60495*E*−12	−0.40557*E*−17	0.97640*E*+04	0.14026*E*+02
	0.35294*E*+01	−0.30342*E*−03	0.38544*E*−06	0.10519*E*−08	−0.72777*E*−12	0.11840*E*+06	0.37852*E*+01
	0.32152*E*+01	0.99742*E*−03	−0.29030*E*−06	0.36925*E*−10	−0.15994*E*−14	0.11840*E*+06	0.51508*E*+01
NO^+	0.26896*E*+01	0.13796*E*−02	−0.33985*E*−06	0.33776*E*−10	−0.10427*E*−14	0.11840*E*+06	0.83904*E*+01
	0.59346*E*+01	−0.13178*E*−02	0.23297*E*−06	−0.11733*E*−10	0.18402*E*−15	0.11840*E*+06	−0.11079*E*+02
	−0.51595*E*+01	0.26290*E*−02	−0.16254*E*−06	0.39381*E*−11	−0.34311*E*−16	0.11840*E*+06	0.65896*E*+02
	0.25000*E*+01	0.00000*E*+00	0.00000*E*+00	0.00000*E*+00	0.00000*E*+00	−0.74542*E*+03	−0.11734*E*+02
	0.25000*E*+01	0.00000*E*+00	0.00000*E*+00	0.00000*E*+00	0.00000*E*+00	−0.74542*E*+03	−0.11734*E*+02
e^-	0.25000*E*+01	0.00000*E*+00	0.00000*E*+00	0.00000*E*+00	0.00000*E*+00	−0.74542*E*+03	−0.11733*E*+02
	0.25000*E*+01	0.00000*E*+00	0.00000*E*+00	0.00000*E*+00	0.00000*E*+00	−0.74542*E*+03	−0.11733*E*+02
	0.25000*E*+01	0.00000*E*+00	0.00000*E*+00	0.00000*E*+00	0.00000*E*+00	−0.74542*E*+03	−0.11733*E*+02
	0.27270*E*+01	−0.28200*E*−03	0.11050*E*−06	−0.15510*E*−10	0.78470*E*−15	0.22540*E*+06	0.36450*E*+01
	0.27270*E*+01	−0.28200*E*−03	0.11050*E*−06	−0.15510*E*−10	0.78470*E*−15	0.22540*E*+06	0.36450*E*+01
N^+	0.24990*E*+01	−0.37250*E*−05	0.11470*E*−07	−0.11020*E*−11	0.30780*E*−16	0.22540*E*+06	0.49500*E*+01

	0.23856E+01	0.83495E−04	−0.58815E−08	0.18850E−12	−0.16120E−17	0.22540E+06	0.56462E+01
	0.22286E+01	0.12458E−03	−0.87636E−08	0.26204E−12	−0.21674E−17	0.22540E+06	0.67811E+01
	0.24985E+01	0.11411E−04	−0.29761E−07	0.32247E−10	−0.12376E−13	0.18790E+06	0.43864E+01
	0.25060E+01	−0.14464E−04	0.12446E−07	−0.46858E−11	0.65549E−15	0.18790E+06	0.43480E+01
O^+	0.29440E+01	−0.41080E−03	0.91560E−07	−0.58480E−11	0.11900E−15	0.18790E+06	0.17500E+01
	0.12784E+01	0.40866E−03	−0.21731E−07	0.33252E−12	0.63160E−18	0.18790E+06	0.12761E+02
	0.12889E+01	0.43343E−03	−0.26758E−07	0.62159E−12	−0.45131E−17	0.18790E+06	0.12604E+02
	0.35498E+01	−0.60810E−03	0.14690E−05	−0.65091E−10	−0.35649E−12	0.18260E+06	0.36535E+01
	0.33970E+01	0.45250E−03	0.12720E−06	−0.38790E−10	0.24590E−14	0.18260E+06	0.42050E+01
N_2^+	0.33780E+01	0.86290E−03	−0.12760E−06	0.80870E−11	−0.18800E−15	0.18260E+06	0.40730E+01
	0.43942E+01	0.18868E−03	−0.71272E−08	−0.17511E−12	0.67176E−17	0.18260E+06	−0.23693E+01
	0.39493E+01	0.36795E−03	−0.26910E−07	0.67110E−12	−0.58244E−17	0.18260E+06	0.65472E+00
	0.32430E+01	0.11740E−02	−0.39000E−06	0.54370E−10	−0.23920E−14	0.14000E+06	0.59250E+01
	0.32430E+01	0.11740E−02	−0.39000E−06	0.54370E−10	−0.23920E−14	0.14000E+06	0.59250E+01
O_2^+	0.51690E+01	−0.86200E−03	0.20410E−06	−0.13000E−10	0.24940E−15	0.14000E+06	−0.52960E+01
	−0.28017E+00	0.16674E−02	−0.12107E−06	0.32113E−11	−0.28349E−16	0.14000E+06	0.31013E+02
	0.20445E+01	0.10313E−02	−0.74046E−07	0.19257E−11	−0.17461E−16	0.14000E+06	0.14310E+02

† The specific enthalpy for a reference state of 0 K and 1 *atm* pressure can be obtained from the relation

$$[h_i]_{\substack{Referenced \\ to\ 0\ K}} = [h_i]_{\substack{Referenced \\ to\ 298.15\ K}} + (\Delta h_i^f)_0 - (\Delta h_i^f)_{298.15} + 298.15\, C_{p,i}$$

where the first term on the right-hand side is obtained from the curve fits given here, and the second and third terms (which are the heats of formation at 0 K and 298.15 K, respectively) are provided in reference 1. Various values of $C_{p,i}$ needed in the above equation are provided below.

‡ There are five rows of constants provided for each species which correspond to the following five temperature ranges, respectively.

300 K ≤ T ≤ 1000 K
1000 K ≤ T ≤ 6000 K
6000 K ≤ T ≤ 15000 K
15000 K ≤ T ≤ 25000 K
25000 K ≤ T ≤ 30000 K

For temperatures less than 300 K, the specific heats of O, O_2, N, and N_2 are practically constant. For such cases, the specific enthalpy may be obtained from the relation

$$h_i = C_{p,i}(T - T_{ref}) + (\Delta h_i^f)_{T_{ref}}$$

with T_{ref} = 298 K and $C_{p,O}$ = 5.44 $cal/gm-mole-K$, C_{p,O_2} = 7.00 $cal/gm-mole-K$, $C_{p,N}$ = 4.97 $cal/gm-mole-K$, C_{p,N_2} = 6.96 $cal/gm-mole-K$.

Table II. Constants for Viscosity Curve Fits†
(1000 K ≤ T ≤ 30000 K)††

Species‡	A_{μ_i}	B_{μ_i}	C_{μ_i}
N_2	0.0203	0.4329	-11.8153
O_2	0.0484	-0.1455	-8.9231
N	0.0120	0.5930	-12.3805
O	0.0205	0.4257	-11.5803
NO	0.0452	-0.0609	-9.4596
NO^+	0.0	2.5	-32.0453
e^-	0.0	2.5	-37.4475
N^+	0.0	2.5	-32.4285
O^+	0.0	2.5	-32.3606
N_2^+	0.0	2.5	-32.0827
O_2^+	0.0	2.5	-32.0148

† Viscosity is obtained in $gm/cm-sec$. Note that all digits in these coefficients are significant and should be used when evaluating the curve fits. Also, the viscosity should be evaluated using eq. (9) in the polynomial form of eq. (6) for greater accuracy.

†† For temperatures less than 1000 K, Sutherland's viscosity law for air may be used for all species.

‡ The ionic species viscosities given here are for the limiting electron pressure $p_{em} = 0.0975\left[\frac{T}{10^3}\right]^4$. For different electron pressures, these values should be corrected by the formula given in eq. (11) in the main text.

Table III. Constants for Frozen Thermal Conductivity Curve Fits †
(1000 K ≤ T ≤ 30000 K)††

Species‡	$A_{K_{f,i}}$	$B_{K_{f,i}}$	$C_{K_{f,i}}$	$D_{K_{f,i}}$	$E_{K_{f,i}}$
N_2	0.03607	-1.07503	11.95029	-57.90063	93.21782
O_2	0.07987	-2.58428	31.25959	-166.76267	321.69820
N	0.0	0.0	0.01619	0.55022	-12.92190
O	0.0	0.0	0.03310	0.22834	-11.58116
NO	0.02792	-0.87133	10.17967	-52.03466	88.67060
NO^+	-0.06836	2.57829	-35.72737	219.09215	-519.00261
e^-	0.0	0.0	0.00032	2.49375	-27.89805
N^+	0.0	0.0	0.03088	2.06339	-31.51368
O^+	-0.04013	1.32468	-16.22091	89.96782	-208.57442
N_2^+	0.0	-0.03723	0.84192	-3.59040	-18.65620
O_2^+	-0.08373	2.75459	-33.74529	185.13274	-401.50753

† Thermal conductivity is obtained in $cal/cm-sec-K$. Note that all digits in these coefficients are significant and should be used when evaluating the curve fits. Also, the thermal conductivity should be evaluated using eq. (10) in the polynomial form of eq. (6) for greater accuracy.

†† For temperatures lower than 1000 K, Sutherland's law for thermal conductivity of air may be used for each species.

‡ The ionic species frozen thermal conductivities given here are for the limiting electron pressure $p_{em} = 0.0975\left[\frac{T}{10^3}\right]^4$. For different electron pressures, these values should be corrected by employing the formula given in eq. (11) in the main text.

Table IV. Constants for Diffusion Coefficient Curve Fits†

No.††	Interaction Pair (i-j)	$A_{\bar{D}_{ij}}$	$B_{\bar{D}_{ij}}$	$C_{\bar{D}_{ij}}$	$D_{\bar{D}_{ij}}$	Temperature Range, K‡
1	N_2-N_2	0.0	0.0112	1.6182	-11.3091	
2	O_2-N_2	0.0	0.0465	0.9271	-8.1137	
3	O_2-O_2	0.0	0.0410	1.0023	-8.3597	
4	$N-N_2$	0.0	0.0195	1.4880	-10.3654	
5	$N-O_2$	0.0	0.0179	1.4848	-10.2810	
6	$N-N$	0.0	0.0033	1.5572	-11.1616	
7	$O-N_2$	0.0	0.0140	1.5824	-10.8819	
8	$O-O_2$	0.0	0.0226	1.3700	-9.6631	
9	$O-N$	0.0	-0.0048	1.9195	-11.9261	
10	$O-O$	0.0	0.0034	1.5572	-11.1729	
11	$NO-N_2$	0.0	0.0291	1.2676	-9.6878	
12	$NO-O_2$	0.0	0.0438	0.9647	-8.2380	
13	$NO-N$	0.0	0.0185	1.4882	-10.3301	
14	$NO-O$	0.0	0.0179	1.4848	-10.3155	
15	$NO-NO$	0.0	0.0364	1.1176	-8.9695	
16	NO^+-N_2	0.0	0.0	1.9000	-13.3343	
17	NO^+-O_2	0.0	0.0	1.9001	-13.3677	
18	NO^+-N	0.0	0.0	1.8999	-13.1254	
19	NO^+-O	0.0	0.0	1.9000	-13.1701	
20	NO^+-NO	0.0	0.0047	1.5552	-11.3713	
21	NO^+-NO^+	0.0000	0.0000	3.5000	-30.3210	
22	e^--N_2	-0.1147	2.8945	-23.0085	65.9815	
23	e^--O_2	-0.0241	0.3464	0.1136	-1.3848	1000-9000
		-0.0029	0.0856	0.6655	-0.8205	9000-30000
24	e^--N	0.0	0.0	1.5000	-2.9987	
25	e^--O	0.0581	-1.5975	15.4508	-40.7370	
26	e^--NO	0.2202	-5.2261	42.0630	-106.0937	1000-8000
		0.2871	-8.3759	82.8802	-267.0227	8000-30000
27	e^--NO^+	0.0000	0.0000	3.5000	-25.2128	
28	e^--e^-	0.0000	0.0000	3.5000	-24.8662	
29	N^+-N_2	0.0	0.0	1.9000	-13.1144	
30	N^+-O_2	0.0	0.0	1.9000	-13.1357	
31	N^+-N	0.0	0.0033	1.5572	-11.1616	
32	N^+-O	0.0	0.0	1.9000	-13.0028	
33	N^+-NO	0.0	0.0	1.8999	-13.1254	
34	N^+-NO^+	0.0000	0.0000	3.5000	-30.0951	
35	N^+-e^-	0.0000	0.0000	3.5000	-25.2128	
36	N^+-N^+	0.0000	0.0000	3.5000	-29.9401	
37	O^+-N_2	0.0	0.0	1.9000	-13.1578	
38	O^+-O_2	0.0	0.0	1.9000	-13.1810	
39	O^+-N	0.0	0.0	1.9000	-13.0028	
40	O^+-O	0.0	0.0034	1.5572	-11.1729	
41	O^+-NO	0.0	0.0	1.9000	-13.1701	
42	O^+-NO^+	0.0000	0.0000	3.5000	-30.1395	
43	O^+-e^-	0.0000	0.0000	3.5000	-25.2128	

44	$O^+ - N^+$	0.0000	0.0000	3.5000	-29.9722
45	$O^+ - O^+$	0.0000	0.0000	3.5000	-30.0066
46	$N_2^+ - N_2$	0.0	0.0	1.9000	-13.3173
47	$N_2^+ - O_2$	0.0	0.0	1.9000	-13.3495
48	$N_2^+ - N$	0.0	0.0	1.9000	-13.1144
49	$N_2^+ - O$	0.0	0.0	1.9000	-13.1578
50	$N_2^+ - NO$	0.0	0.0	1.9000	-13.3343
51	$N_2^+ - NO^+$	0.0000	0.0000	3.5000	-30.3036
52	$N_2^+ - e^-$	0.0000	0.0000	3.5000	-25.2128
53	$N_2^+ - N^+$	0.0000	0.0000	3.5000	-30.0839
54	$N_2^+ - O^+$	0.0000	0.0000	3.5000	-30.1273
55	$N_2^+ - N_2^+$	0.0000	0.0000	3.5000	-30.2867
56	$O_2^+ - N_2$	0.0	0.0	1.9000	-13.3173
57	$O_2^+ - O_2$	0.0	0.0	1.9000	-13.3495
58	$O_2^+ - N$	0.0	0.0	1.9000	-13.1144
59	$O_2^+ - O$	0.0	0.0	1.9000	-13.1578
60	$O_2^+ - NO$	0.0	0.0	1.9000	-13.3343
61	$O_2^+ - NO^+$	0.0000	0.0000	3.5000	-30.3036
62	$O_2^+ - e^-$	0.0000	0.0000	3.5000	-25.2128
63	$O_2^+ - N^+$	0.0000	0.0000	3.5000	-30.0839
64	$O_2^+ - O^+$	0.0000	0.0000	3.5000	-30.1273
65	$O_2^+ - N_2^+$	0.0000	0.0000	3.5000	-30.2867
66	$O_2^+ - O_2^+$	0.0000	0.0000	3.5000	-30.2867

† Diffusion coefficients are obtained in cm^2–atm/sec. Note that all digits in these coefficients are significant and should be used when evaluating the curve fits. Also, the diffusion coefficients should be evaluated using eq. (12) in the polynomial form of eq. (6) for greater accuracy. Diffusion coefficients obtained from these curve fits are for the limiting electron pressure $p_{em} = 0.0975\left[\frac{T}{10^3}\right]^4$. For different electron pressures, the cross sections should be corrected by the formula given in the main text (eq. (16)) when the interacting pair of species are both ions or electrons or a combination of the two. Note that diffusion coefficients for N_2^+ and O_2^+ are taken to be the same.

†† Cross section Nos. 1-15 are used in a 5-species air model and Nos. 1-28 in a 7-species model.

‡ The temperature range for all curve fits is $1000 \leq T \leq 30000$ K, except where noted.

Table V. Curve-Fit Constants for Collision Cross Section, $\bar{\Omega}_{ij}^{(1,1)}$†

No.††	Interaction Pair (i-j)	$A_{\bar{\Omega}_{ij}^{(1,1)}}$	$B_{\bar{\Omega}_{ij}^{(1,1)}}$	$C_{\bar{\Omega}_{ij}^{(1,1)}}$	$D_{\bar{\Omega}_{ij}^{(1,1)}}$	Temperature Range, K‡
1	N_2-N_2	0.0	-0.0112	-0.1182	4.8464	
2	O_2-N_2	0.0	-0.0465	0.5729	1.6185	
3	O_2-O_2	0.0	-0.0410	0.4977	1.8302	
4	$N-N_2$	0.0	-0.0194	0.0119	4.1055	
5	$N-O_2$	0.0	-0.0179	0.0152	3.9996	
6	$N-N$	0.0	-0.0033	-0.0572	5.0452	
7	$O-N_2$	0.0	-0.0139	-0.0825	4.5785	
8	$O-O_2$	0.0	-0.0226	0.1300	3.3363	
9	$O-N$	0.0	0.0048	-0.4195	5.7774	
10	$O-O$	0.0	-0.0034	-0.0572	4.9901	
11	$NO-N_2$	0.0	-0.0291	0.2324	3.2082	
12	$NO-O_2$	0.0	-0.0438	0.5352	1.7252	
13	$NO-N$	0.0	-0.0185	0.0118	4.0590	
14	$NO-O$	0.0	-0.0179	0.0152	3.9996	
15	$NO-NO$	0.0	-0.0364	0.3825	2.4718	
16	NO^+-N_2	0.0	0.0	-0.4000	6.8543	
17	NO^+-O_2	0.0	0.0	-0.4000	6.8543	
18	NO^+-N	0.0	0.0	-0.4000	6.8543	
19	NO^+-O	0.0	0.0	-0.4000	6.8543	
20	NO^+-NO	0.0	-0.0047	-0.0551	4.8737	
21	NO^+-NO^+	0.0000	0.0000	-2.0000	23.8237	
22	e^--N_2	0.1147	-2.8945	24.5080	-67.3691	
23	e^--O_2	0.0241	-0.3467	1.3887	-0.0110	1000-9000
		0.0025	-0.0742	0.7235	-0.2116	9000-30000
24	e^--N	0.0	0.0	0.0	1.6094	
25	e^--O	0.0164	-0.2431	1.1231	-1.5561	1000-9000
		-0.2027	5.6428	-51.5646	155.6091	9000-30000
26	e^--NO	-0.2202	5.2265	-40.5659	104.7126	1000-8000
		-0.2871	8.3757	-81.3787	265.6292	8000-30000
27	e^--NO^+	0.0000	0.0000	-2.0000	23.8237	
28	e^--e^-	0.0000	0.0000	-2.0000	23.8237	
29	N^+-N_2	0.0	0.0	-0.4000	6.8543	
30	N^+-O_2	0.0	0.0	-0.4000	6.8543	
31	N^+-N	0.0	-0.0033	-0.0572	5.0452	
32	N^+-O	0.0	0.0	-0.4000	6.8543	
33	N^+-NO	0.0	0.0	-0.4000	6.8543	
34	N^+-NO^+	0.0000	0.0000	-2.0000	23.8237	
35	N^+-e^-	0.0000	0.0000	-2.0000	23.8237	
36	N^+-N^+	0.0000	0.0000	-2.0000	23.8237	
37	O^+-N_2	0.0	0.0	-0.4000	6.8543	
38	O^+-O_2	0.0	0.0	-0.4000	6.8543	
39	O^+-N	0.0	0.0	-0.4000	6.8543	
40	O^+-O	0.0	-0.0034	-0.0572	4.9901	
41	O^+-NO	0.0	0.0	-0.4000	6.8543	
42	O^+-NO^+	0.0000	0.0000	-2.0000	23.8237	

43	$O^+ - e^-$	0.0000	0.0000	-2.0000	23.8237
44	$O^+ - N^+$	0.0000	0.0000	-2.0000	23.8237
45	$O^+ - O^+$	0.0000	0.0000	-2.0000	23.8237
46	$N_2^+ - N_2$	0.0	0.0	-0.4000	6.8543
47	$N_2^+ - O_2$	0.0	0.0	-0.4000	6.8543
48	$N_2^+ - N$	0.0	0.0	-0.4000	6.8543
49	$N_2^+ - O$	0.0	0.0	-0.4000	6.8543
50	$N_2^+ - NO$	0.0	0.0	-0.4000	6.8543
51	$N_2^+ - NO^+$	0.0000	0.0000	-2.0000	23.8237
52	$N_2^+ - e^-$	0.0000	0.0000	-2.0000	23.8237
53	$N_2^+ - N^+$	0.0000	0.0000	-2.0000	23.8237
54	$N_2^+ - O^+$	0.0000	0.0000	-2.0000	23.8237
55	$N_2^+ - N_2^+$	0.0000	0.0000	-2.0000	23.8237
56	$O_2^+ - N_2$	0.0	0.0	-0.4000	6.8543
57	$O_2^+ - O_2$	0.0	0.0	-0.4000	6.8543
58	$O_2^+ - N$	0.0	0.0	-0.4000	6.8543
59	$O_2^+ - O$	0.0	0.0	-0.4000	6.8543
60	$O_2^+ - NO$	0.0	0.0	-0.4000	6.8543
61	$O_2^+ - NO^+$	0.0000	0.0000	-2.0000	23.8237
62	$O_2^+ - e^-$	0.0000	0.0000	-2.0000	23.8237
63	$O_2^+ - N^+$	0.0000	0.0000	-2.0000	23.8237
64	$O_2^+ - O^+$	0.0000	0.0000	-2.0000	23.8237
65	$O_2^+ - N_2^+$	0.0000	0.0000	-2.0000	23.8237
66	$O_2^+ - O_2^+$	0.0000	0.0000	-2.0000	23.8237

† Cross sections are obtained in $Å^2$; $1\,Å^2 = 10^{-16}\,cm^2$. Note that all digits in these coefficients are significant and should be used when evaluating the curve fits. Also, the collision cross sections should be evaluated using eq. (13) in the polynomial form of eq. (6) for greater accuracy. Collision cross sections obtained from these curve fits are for the limiting electron pressure $p_{em} = 0.0975\left[\frac{T}{10^3}\right]^4$. For different electron pressures, the cross sections should be corrected by the formula given in the main text (eq. (16)) when the interacting pair of species are both ions or electrons or a combination of the two. Note that cross sections for N_2^+ and O_2^+ are taken to be the same.

†† Cross section Nos. 1-15 are used in a 5-species air model and Nos. 1-28 in a 7-species model.

‡ The temperature range for all curve fits is $1000 \leq T \leq 30000$ K, except where noted.

Table VI. Curve-Fit Constants for Collision Cross Section, $\overline{\Omega}_{ij}^{(2,2)}$†

No.††	Interaction Pair (i-j)	$A_{\overline{\Omega}_{ij}^{(2,2)}}$	$B_{\overline{\Omega}_{ij}^{(2,2)}}$	$C_{\overline{\Omega}_{ij}^{(2,2)}}$	$D_{\overline{\Omega}_{ij}^{(2,2)}}$	Temperature Range, K‡
1	N_2-N_2	0.0	-0.0203	0.0683	4.0900	
2	O_2-N_2	0.0	-0.0558	0.7590	0.8955	
3	O_2-O_2	0.0	-0.0485	0.6475	1.2607	
4	$N-N_2$	0.0	-0.0190	0.0239	4.1782	
5	$N-O_2$	0.0	-0.0203	0.0730	3.8818	
6	$N-N$	0.0	-0.0118	-0.0960	4.3252	
7	$O-N_2$	0.0	-0.0169	-0.0143	4.4195	
8	$O-O_2$	0.0	-0.0247	0.1783	3.2517	
9	$O-N$	0.0	0.0065	-0.4467	6.0426	
10	$O-O$	0.0	-0.0207	0.0780	3.5658	
11	$NO-N_2$	0.0	-0.0385	0.4226	2.4507	
12	$NO-O_2$	0.0	-0.0522	0.7045	1.0738	
13	$NO-N$	0.0	-0.0196	0.0478	4.0321	
14	$NO-O$	0.0	-0.0203	0.0730	3.8818	
15	$NO-NO$	0.0	-0.0453	0.5624	1.7669	
16	NO^+-N_2	0.0	0.0	-0.4000	6.7760	
17	NO^+-O_2	0.0	0.0	-0.4000	6.7760	
18	NO^+-N	0.0	0.0	-0.4000	6.7760	
19	NO^+-O	0.0	0.0	-0.4000	6.7760	
20	NO^+-NO	0.0	0.0	-0.4000	6.7760	
21	NO^+-NO^+	0.0000	0.0000	-2.0000	24.3602	
22	e^--N_2	0.1147	-2.8945	24.5080	-67.3691	
23	e^--O_2	0.0241	-0.3467	1.3887	-0.0110	1000-9000
		0.0025	-0.0742	0.7235	-0.2116	9000-30000
24	e^--N	0.0	0.0	0.0	1.6094	
25	e^--O	0.0164	-0.2431	1.1231	-1.5561	1000-9000
		-0.2027	5.6428	-51.5646	155.6091	9000-30000
26	e^--NO	-0.2202	5.2265	-40.5659	104.7126	1000-8000
		-0.2871	8.3757	-81.3787	265.6292	8000-30000
27	e^--NO^+	0.0000	0.0000	-2.0000	24.3061	
28	e^--e^-	0.0000	0.0000	-2.0000	24.3061	
29	N^+-N_2	0.0	0.0	-0.4000	6.7760	
30	N^+-O_2	0.0	0.0	-0.4000	6.7760	
31	N^+-N	0.0	0.0	-0.4146	6.9078	
32	N^+-O	0.0	0.0	-0.4000	6.7760	
33	N^+-NO	0.0	0.0	-0.4000	6.7760	
34	N^+-NO^+	0.0000	0.0000	-2.0000	24.3602	
35	N^+-e^-	0.0000	0.0000	-2.0000	24.3061	
36	N^+-N^+	0.0000	0.0000	-2.0000	24.3602	
37	O^+-N_2	0.0	0.0	-0.4000	6.7760	
38	O^+-O_2	0.0	0.0	-0.4000	6.7760	
39	O^+-N	0.0	0.0	-0.4000	6.7760	
40	O^+-O	0.0	0.0	-0.4235	6.7787	
41	O^+-NO	0.0	0.0	-0.4000	6.7760	
42	O^+-NO^+	0.0000	0.0000	-2.0000	24.3602	

43	$O^+ - e^-$	0.0000	0.0000	-2.0000	24.3061
44	$O^+ - N^+$	0.0000	0.0000	-2.0000	24.3602
45	$O^+ - O^+$	0.0000	0.0000	-2.0000	24.3602
46	$N_2^+ - N_2$	0.0	0.0	-0.4000	6.7760
47	$N_2^+ - O_2$	0.0	0.0	-0.4000	6.7760
48	$N_2^+ - N$	0.0	0.0	-0.4000	6.7760
49	$N_2^+ - O$	0.0	0.0	-0.4000	6.7760
50	$N_2^+ - NO$	0.0	0.0	-0.4000	6.7760
51	$N_2^+ - NO^+$	0.0000	0.0000	-2.0000	24.3602
52	$N_2^+ - e^-$	0.0000	0.0000	-2.0000	24.3061
53	$N_2^+ - N^+$	0.0000	0.0000	-2.0000	24.3602
54	$N_2^+ - O^+$	0.0000	0.0000	-2.0000	24.3602
55	$N_2^+ - N_2^+$	0.0000	0.0000	-2.0000	24.3602
56	$O_2^+ - N_2$	0.0	0.0	-0.4000	6.7760
57	$O_2^+ - O_2$	0.0	0.0	-0.4000	6.7760
58	$O_2^+ - N$	0.0	0.0	-0.4000	6.7760
59	$O_2^+ - O$	0.0	0.0	-0.4000	6.7760
60	$O_2^+ - NO$	0.0	0.0	-0.4000	6.7760
61	$O_2^+ - NO^+$	0.0000	0.0000	-2.0000	24.3602
62	$O_2^+ - e^-$	0.0000	0.0000	-2.0000	24.3061
63	$O_2^+ - N^+$	0.0000	0.0000	-2.0000	24.3602
64	$O_2^+ - O^+$	0.0000	0.0000	-2.0000	24.3602
65	$O_2^+ - N_2^+$	0.0000	0.0000	-2.0000	24.3602
66	$O_2^+ - O_2^+$	0.0000	0.0000	-2.0000	24.3602

† Cross sections are obtained in $Å^2$; $1\,Å^2 = 10^{-16} cm^2$. Note that all digits in these coefficients are significant and should be used when evaluating the curve fits. Also, the collision cross sections should be evaluated using eq. (14) in the polynomial form of eq. (6) for greater accuracy. Collision cross sections obtained from these curve fits are for the limiting electron pressure $p_{em} = 0.0975\left[\frac{T}{10^3}\right]^4$. For different electron pressures, the cross sections should be corrected by the formula given in the main text when the interacting pair of species are both ions or electrons or a combination of the two. Note that cross sections for N_2^+ and O_2^+ are taken to be the same.

†† Cross section Nos. 1-15 are used in a 5-species air model and Nos. 1-28 in a 7-species model.

‡ The temperature range for all curve fits is $1000 \leq T \leq 30000$ K, except where noted.

Table VII. Curve-Fit Constants for Collision Cross Section Ratio, B_{ij}^{*}†
(1000 K≤ T ≤ 30000 K)

No.††	Interaction Pair (i-j)	$A_{B_{ij}^{*}}$	$B_{B_{ij}^{*}}$	$C_{B_{ij}^{*}}$
1	N_2-N_2	-0.0073	0.1444	-0.5625
2	O_2-N_2	-0.0019	0.0602	-0.2175
3	O_2-O_2	0.0001	0.0181	-0.0306
4	$N-N_2$	0.0043	-0.0494	0.2850
5	$N-O_2$	0.0033	-0.0366	0.2332
6	$N-N$	0.0002	0.0002	0.0537
7	$O-N_2$	0.0042	-0.0471	0.2747
8	$O-O_2$	0.0024	-0.0245	0.1808
9	$O-N$	0.0147	-0.2628	1.2943
10	$O-O$	0.0002	0.0	0.0549
11	$NO-N_2$	-0.0045	0.1010	-0.3872
12	$NO-O_2$	-0.0010	0.0410	-0.1312
13	$NO-N$	0.0038	-0.0425	0.2574
14	$NO-O$	0.0033	-0.0366	0.2332
15	$NO-NO$	-0.0027	0.0700	-0.2553
16	$NO^{+}-N_2$	0.0	0.0	0.1933
17	$NO^{+}-O_2$	0.0	0.0	0.1933
18	$NO^{+}-N$	0.0	0.0	0.1933
19	$NO^{+}-O$	0.0	0.0	0.1933
20	$NO^{+}-NO$	0.0003	-0.0006	0.0632
21	$NO^{+}-NO^{+}$	0.0	0.0	0.4463
22	$e^{-}-N_2$	0.0	0.0	0.0
23	$e^{-}-O_2$	0.0	0.0	0.0
24	$e^{-}-N$	0.0	0.0	0.0
25	$e^{-}-O$	0.0	0.0	0.0
26	$e^{-}-NO$	0.0	0.0	0.0
27	$e^{-}-NO^{+}$	0.0	0.0	0.4463
28	$e^{-}-e^{-}$	0.0	0.0	0.4463
29	$N^{+}-N_2$	0.0	0.0	0.1933
30	$N^{+}-O_2$	0.0	0.0	0.1933
31	$N^{+}-N$	0.0002	0.0002	0.0537
32	$N^{+}-O$	0.0	0.0	0.1933
33	$N^{+}-NO$	0.0	0.0	0.1933
34	$N^{+}-NO^{+}$	0.0	0.0	0.4463
35	$N^{+}-e^{-}$	0.0	0.0	0.4463
36	$N^{+}-N^{+}$	0.0	0.0	0.4463
37	$O^{+}-N_2$	0.0	0.0	0.1933
38	$O^{+}-O_2$	0.0	0.0	0.1933
39	$O^{+}-N$	0.0	0.0	0.1933
40	$O^{+}-O$	0.0002	0.0	0.0549
41	$O^{+}-NO$	0.0	0.0	0.1933
42	$O^{+}-NO^{+}$	0.0	0.0	0.4463
43	$O^{+}-e^{-}$	0.0	0.0	0.4463
44	$O^{+}-N^{+}$	0.0	0.0	0.4463

45	$O^+ - O^+$	0.0	0.0	0.4463
46	$N_2^+ - N_2$	0.0	0.0	0.1933
47	$N_2^+ - O_2$	0.0	0.0	0.1933
48	$N_2^+ - N$	0.0	0.0	0.1933
49	$N_2^+ - O$	0.0	0.0	0.1933
50	$N_2^+ - NO$	0.0	0.0	0.1933
51	$N_2^+ - NO^+$	0.0	0.0	0.4463
52	$N_2^+ - e^-$	0.0	0.0	0.4463
53	$N_2^+ - N^+$	0.0	0.0	0.4463
54	$N_2^+ - O^+$	0.0	0.0	0.4463
55	$N_2^+ - N_2^+$	0.0	0.0	0.4463
56	$O_2^+ - N_2$	0.0	0.0	0.1933
57	$O_2^+ - O_2$	0.0	0.0	0.1933
58	$O_2^+ - N$	0.0	0.0	0.1933
59	$O_2^+ - O$	0.0	0.0	0.1933
60	$O_2^+ - NO$	0.0	0.0	0.1933
61	$O_2^+ - NO^+$	0.0	0.0	0.4463
62	$O_2^+ - e^-$	0.0	0.0	0.4463
63	$O_2^+ - N^+$	0.0	0.0	0.4463
64	$O_2^+ - O^+$	0.0	0.0	0.4463
65	$O_2^+ - N_2^+$	0.0	0.0	0.4463
66	$O_2^+ - O_2^+$	0.0	0.0	0.4463

† The collision cross-section ratios are dimensionless parameters and are valid as given for all electron pressures. Note that all digits in these coefficients are significant and should be used when evaluating the curve fits. Also, the collision cross-section ratio should be evaluated using eq. (15) in the polynomial form of eq. (6) for greater accuracy.

†† Cross section Nos. 1-15 are used in a 5-species air model and Nos. 1-28 in a 7-species model.

Table VIII. Curve-fit Coefficients for the Equilibrium Constant K_{eq} at Different Number Densities†

Number density, *particles/cm*^{3}	$A_{K_{eq,f}}$	$B_{K_{eq,f}}$	$C_{K_{eq,f}}$	$D_{K_{eq,f}}$	$E_{K_{eq,f}}$	$F_{K_{eq,f}}$
			‡**Reaction 1: $O_2+M_1 \rightleftarrows 2O+M_1$**			
10^{14}	0.000000*E*+00	−0.828621*E*+00	−0.105568*E*+01	0.151416*E*+01	−0.107091*E*+02	−0.307176*E*+01
10^{15}	0.000000*E*+00	−0.719241*E*+00	−0.135815*E*+01	0.973802*E*+00	−0.913167*E*+01	−0.352942*E*+01
10^{16}	0.000000*E*+00	−0.616239*E*+00	−0.160998*E*+01	0.365775*E*+00	−0.768180*E*+01	−0.382001*E*+01
10^{17}	0.000000*E*+00	−0.538034*E*+00	−0.176687*E*+01	−0.214344*E*+00	−0.655629*E*+01	−0.394645*E*+01
10^{18}	0.000000*E*+00	−0.481290*E*+00	−0.183099*E*+01	−0.828353*E*+00	−0.562039*E*+01	−0.396649*E*+01
10^{19}	0.000000*E*+00	−0.466031*E*+00	−0.178672*E*+01	−0.124877*E*+01	−0.515926*E*+01	−0.392801*E*+01
			Reaction 2: $N_2+M_2 \rightleftarrows 2N+M_2$			
10^{14}	0.000000*E*+00	−0.142518*E*+01	−0.179191*E*+01	−0.152245*E*+00	−0.172635*E*+02	−0.777060*E*+01
10^{15}	0.000000*E*+00	−0.131460*E*+01	−0.211364*E*+01	−0.655486*E*+00	−0.156315*E*+02	−0.831884*E*+01
10^{16}	0.000000*E*+00	−0.120533*E*+01	−0.240055*E*+01	−0.123908*E*+01	−0.140810*E*+02	−0.870302*E*+01
10^{17}	0.000000*E*+00	−0.111597*E*+01	−0.260376*E*+01	−0.181730*E*+01	−0.128199*E*+02	−0.890679*E*+01
10^{18}	0.000000*E*+00	−0.104068*E*+01	−0.273172*E*+01	−0.246330*E*+01	−0.116894*E*+02	−0.898864*E*+01
10^{19}	0.000000*E*+00	−0.100734*E*+01	−0.274128*E*+01	−0.293912*E*+01	−0.110496*E*+02	−0.897632*E*+01
			Reaction 3: $N_2+N \rightleftarrows 2N+N$			
10^{14}	0.000000*E*+00	−0.142518*E*+01	−0.179191*E*+01	−0.152245*E*+00	−0.172635*E*+02	−0.777060*E*+01
10^{15}	0.000000*E*+00	−0.131460*E*+01	−0.211364*E*+01	−0.655486*E*+00	−0.156315*E*+02	−0.831884*E*+01
10^{16}	0.000000*E*+00	−0.120533*E*+01	−0.240055*E*+01	−0.123908*E*+01	−0.140810*E*+02	−0.870302*E*+01
10^{17}	0.000000*E*+00	−0.111597*E*+01	−0.260376*E*+01	−0.181730*E*+01	−0.128199*E*+02	−0.890679*E*+01
10^{18}	0.000000*E*+00	−0.104068*E*+01	−0.273172*E*+01	−0.246330*E*+01	−0.116894*E*+02	−0.898864*E*+01
10^{19}	0.000000*E*+00	−0.100734*E*+01	−0.274128*E*+01	−0.293912*E*+01	−0.110496*E*+02	−0.897632*E*+01
			Reaction 4: $NO+M_3 \rightleftarrows N+O+M_3$			
10^{14}	0.000000*E*+00	−0.102874*E*+01	−0.121018*E*+01	0.111429*E*+01	−0.131595*E*+02	−0.572854*E*+01
10^{15}	0.000000*E*+00	−0.918760*E*+00	−0.152228*E*+01	0.592488*E*+00	−0.115548*E*+02	−0.623150*E*+01
10^{16}	0.000000*E*+00	−0.812622*E*+00	−0.179165*E*+01	−0.332370*E*−02	−0.100546*E*+02	−0.656888*E*+01
10^{17}	0.000000*E*+00	−0.728842*E*+00	−0.197170*E*+01	−0.582492*E*+00	−0.886131*E*+01	−0.673398*E*+01
10^{18}	0.000000*E*+00	−0.662823*E*+00	−0.206774*E*+01	−0.121250*E*+01	−0.782813*E*+01	−0.678492*E*+01
10^{19}	0.000000*E*+00	−0.638527*E*+00	−0.205038*E*+01	−0.166061*E*+01	−0.727765*E*+01	−0.675953*E*+01
			Reaction 5: $NO+O \rightleftarrows O_2+N$			
10^{14}	0.000000*E*+00	−0.233168*E*+00	−0.225679*E*+00	−0.517639*E*+00	−0.278006*E*+01	−0.302215*E*+01
10^{15}	0.000000*E*+00	−0.232567*E*+00	−0.235307*E*+00	−0.499081*E*+00	−0.275280*E*+01	−0.306745*E*+01
10^{16}	0.000000*E*+00	−0.229430*E*+00	−0.252843*E*+00	−0.486866*E*+00	−0.270247*E*+01	−0.311424*E*+01
10^{17}	0.000000*E*+00	−0.223855*E*+00	−0.276009*E*+00	−0.485915*E*+00	−0.263469*E*+01	−0.315291*E*+01
10^{18}	0.000000*E*+00	−0.214580*E*+00	−0.307925*E*+00	−0.501912*E*+00	−0.253742*E*+01	−0.318381*E*+01
10^{19}	0.000000*E*+00	−0.205544*E*+00	−0.334842*E*+00	−0.529614*E*+00	−0.244806*E*+01	−0.319689*E*+01

†Note that all digits in these coefficients are significant and should be used when evaluating the curve fits. Also, the diffusion coefficients should be evaluated using eq. (18) in the polynomial form of eq. (6) for greater accuracy.

‡Reaction numbers here correspond to those given in the text. The third bodies, M_i, are defined in ref. 1.

Table VIII. Continued.

Number density, *particles/cm*^{3}	$A_{K_{eq,r}}$	$B_{K_{eq,r}}$	$C_{K_{eq,r}}$	$D_{K_{eq,r}}$	$E_{K_{eq,r}}$	$F_{K_{eq,r}}$
			Reaction 6: N_2+O $\rightleftarrows$ NO+N			
10^{14}	0.000000*E*+00	−0.396440*E*+00	−0.581737*E*+00	−0.126653*E*+01	−0.410395*E*+01	−0.204206*E*+01
10^{15}	0.000000*E*+00	−0.395839*E*+00	−0.591364*E*+00	−0.124797*E*+01	−0.407669*E*+01	−0.208735*E*+01
10^{16}	0.000000*E*+00	−0.392703*E*+00	−0.608901*E*+00	−0.123576*E*+01	−0.402636*E*+01	−0.213415*E*+01
10^{17}	0.000000*E*+00	−0.387127*E*+00	−0.632066*E*+00	−0.123481*E*+01	−0.395858*E*+01	−0.217281*E*+01
10^{18}	0.000000*E*+00	−0.377852*E*+00	−0.663983*E*+00	−0.125081*E*+01	−0.386131*E*+01	−0.220371*E*+01
10^{19}	0.000000*E*+00	−0.368817*E*+00	−0.690900*E*+00	−0.127851*E*+01	−0.377195*E*+01	−0.221680*E*+01
			Reaction 7: N+O $\rightleftarrows$ NO^++e^-			
10^{14}	−0.308374*E*+00	0.831634*E*+00	0.276168*E*+00	−0.715691*E*+01	−0.310632*E*+00	−0.114489*E*+02
10^{15}	−0.283546*E*+00	0.654679*E*+00	0.483584*E*+00	−0.641636*E*+01	−0.179311*E*+01	−0.110019*E*+02
10^{16}	−0.237256*E*+00	0.423671*E*+00	0.557781*E*+00	−0.541270*E*+01	−0.306540*E*+01	−0.107689*E*+02
10^{17}	−0.180028*E*+00	0.185513*E*+00	0.496540*E*+00	−0.432931*E*+01	−0.397692*E*+01	−0.107328*E*+02
10^{18}	−0.110967*E*+00	−0.668014*E*−01	0.301396*E*+00	−0.309083*E*+01	−0.467007*E*+01	−0.108375*E*+02
10^{19}	−0.636990*E*−01	−0.218605*E*+00	0.847459*E*−01	−0.222625*E*+01	−0.498783*E*+01	−0.109694*E*+02
			Reaction 8: O+e^- $\rightleftarrows$ O^++e^-+e^-			
10^{14}	−0.454142*E*+00	0.169029*E*−01	−0.205312*E*+01	−0.105613*E*+02	−0.154030*E*+02	−0.215570*E*+02
10^{15}	−0.442619*E*+00	−0.930789*E*−01	−0.182913*E*+01	−0.103294*E*+02	−0.161706*E*+02	−0.213094*E*+02
10^{16}	−0.410741*E*+00	−0.261721*E*+00	−0.170184*E*+01	−0.984387*E*+01	−0.168396*E*+02	−0.212010*E*+02
10^{17}	−0.368429*E*+00	−0.445136*E*+00	−0.168076*E*+01	−0.923660*E*+01	−0.173180*E*+02	−0.212121*E*+02
10^{18}	−0.319211*E*+00	−0.634295*E*+00	−0.174946*E*+01	−0.852603*E*+01	−0.176715*E*+02	−0.213010*E*+02
10^{19}	−0.289041*E*+00	−0.737514*E*+00	−0.184624*E*+01	−0.805937*E*+01	−0.178217*E*+02	−0.213843*E*+02
			Reaction 9: N+e^- $\rightleftarrows$ N^++e^-+e^-			
10^{14}	−0.474396*E*+00	0.614580*E*−02	−0.229468*E*+01	−0.114334*E*+02	−0.157101*E*+02	−0.213937*E*+02
10^{15}	−0.474831*E*+00	−0.654883*E*−01	−0.202828*E*+01	−0.113511*E*+02	−0.165058*E*+02	−0.210712*E*+02
10^{16}	−0.453275*E*+00	−0.204988*E*+00	−0.185082*E*+01	−0.109883*E*+02	−0.172377*E*+02	−0.208889*E*+02
10^{17}	−0.417456*E*+00	−0.373700*E*+00	−0.178585*E*+01	−0.104515*E*+02	−0.177927*E*+02	−0.208436*E*+02
10^{18}	−0.370274*E*+00	−0.564285*E*+00	−0.182040*E*+01	−0.975050*E*+01	−0.182364*E*+02	−0.208947*E*+02
10^{19}	−0.337233*E*+00	−0.682777*E*+00	−0.190692*E*+01	−0.923376*E*+01	−0.184523*E*+02	−0.209704*E*+02
			Reaction 10: O+O $\rightleftarrows$ O_2^++e^-			
10^{14}	−0.404633*E*+00	0.587134*E*+00	−0.944981*E*−01	−0.965358*E*+01	−0.601891*E*+01	−0.157055*E*+02
10^{15}	−0.374219*E*+00	0.395710*E*+00	0.797369*E*−01	−0.884526*E*+01	−0.744662*E*+01	−0.153164*E*+02
10^{16}	−0.322759*E*+00	0.153892*E*+00	0.114598*E*+00	−0.778383*E*+01	−0.864313*E*+01	−0.151418*E*+02
10^{17}	−0.262628*E*+00	−0.865210*E*−01	0.179512*E*−01	−0.667391*E*+01	−0.947258*E*+01	−0.151509*E*+02
10^{18}	−0.194432*E*+00	−0.327225*E*+00	−0.205459*E*+00	−0.545905*E*+01	−0.100727*E*+02	−0.152846*E*+02
10^{19}	−0.151657*E*+00	−0.457874*E*+00	−0.430084*E*+00	−0.466176*E*+01	−0.103232*E*+02	−0.154195*E*+02

Table VIII. Continued.

Number density, *particles/cm*^{3}	$A_{K_{eq\,r}}$	$B_{K_{eq\,r}}$	$C_{K_{eq\,r}}$	$D_{K_{eq\,r}}$	$E_{K_{eq\,r}}$	$F_{K_{eq\,r}}$
			Reaction 11: $O+O_2^+ \rightleftarrows O_2+O^+$			
10^{14}	−0.238630*E*+00	0.672246*E*+00	−0.312986*E*+00	−0.443140*E*+01	−0.566846*E*+00	−0.341823*E*+01
10^{15}	−0.227108*E*+00	0.562265*E*+00	−0.890019*E*−01	−0.419943*E*+01	−0.133444*E*+01	−0.317067*E*+01
10^{16}	−0.195230*E*+00	0.393622*E*+00	0.382875*E*−01	−0.371395*E*+01	−0.200352*E*+01	−0.306225*E*+01
10^{17}	−0.152918*E*+00	0.210208*E*+00	0.593682*E*−01	−0.310667*E*+01	−0.248187*E*+01	−0.307338*E*+01
10^{18}	−0.103699*E*+00	0.210489*E*−01	−0.933321*E*−02	−0.239611*E*+01	−0.283537*E*+01	−0.316226*E*+01
10^{19}	−0.735291*E*−01	−0.821705*E*−01	−0.106106*E*+00	−0.192945*E*+01	−0.298555*E*+01	−0.324557*E*+01
			Reaction 12: $N_2+N^+ \rightleftarrows N+N_2^+$			
10^{14}	0.000000*E*+00	−0.454093*E*+00	0.710863*E*+00	0.878489*E*+00	−0.551525*E*+01	−0.128042*E*−01
10^{15}	0.000000*E*+00	−0.381287*E*+00	0.446289*E*+00	0.792372*E*+00	−0.472167*E*+01	−0.334316*E*+00
10^{16}	0.000000*E*+00	−0.299935*E*+00	0.177941*E*+00	0.619510*E*+00	−0.388369*E*+01	−0.565230*E*+00
10^{17}	0.000000*E*+00	−0.227847*E*+00	−0.380430*E*−01	0.398254*E*+00	−0.315226*E*+01	−0.691244*E*+00
10^{18}	0.000000*E*+00	−0.164537*E*+00	−0.202432*E*+00	0.112950*E*+00	−0.247625*E*+01	−0.746487*E*+00
10^{19}	0.000000*E*+00	−0.135176*E*+00	−0.255223*E*+00	−0.112672*E*+00	−0.209774*E*+01	−0.745209*E*+00
			Reaction 13: $N+N \rightleftarrows N_2^++e^-$			
10^{14}	−0.412910*E*+00	0.821758*E*+00	−0.287790*E*−01	−0.982394*E*+01	−0.355555*E*+01	−0.136596*E*+02
10^{15}	−0.393669*E*+00	0.659271*E*+00	0.211819*E*+00	−0.915117*E*+01	−0.509279*E*+01	−0.131548*E*+02
10^{16}	−0.352549*E*+00	0.439073*E*+00	0.325352*E*+00	−0.820528*E*+01	−0.644087*E*+01	−0.128633*E*+02
10^{17}	−0.298223*E*+00	0.203171*E*+00	0.299515*E*+00	−0.714841*E*+01	−0.743445*E*+01	−0.127819*E*+02
10^{18}	−0.228297*E*+00	−0.607538*E*−01	0.132638*E*+00	−0.588631*E*+01	−0.822061*E*+01	−0.128577*E*+02
10^{19}	−0.176536*E*+00	−0.233712*E*+00	−0.760369*E*−01	−0.495445*E*+01	−0.860561*E*+01	−0.129867*E*+02
			Reaction 14: $O_2+N_2 \rightleftarrows NO+NO^++e^-$			
10^{14}	−0.231244*E*+00	−0.711962*E*+00	−0.192440*E*+01	−0.662339*E*+01	−0.158460*E*+02	−0.179580*E*+02
10^{15}	−0.231244*E*+00	−0.711962*E*+00	−0.192440*E*+01	−0.662339*E*+01	−0.158460*E*+02	−0.179580*E*+02
10^{16}	−0.231244*E*+00	−0.711962*E*+00	−0.192440*E*+01	−0.662339*E*+01	−0.158460*E*+02	−0.179580*E*+02
10^{17}	−0.231244*E*+00	−0.711962*E*+00	−0.192440*E*+01	−0.662339*E*+01	−0.158460*E*+02	−0.179580*E*+02
10^{18}	−0.231244*E*+00	−0.711962*E*+00	−0.192440*E*+01	−0.662339*E*+01	−0.158460*E*+02	−0.179580*E*+02
10^{19}	−0.231244*E*+00	−0.711962*E*+00	−0.192440*E*+01	−0.662339*E*+01	−0.158460*E*+02	−0.179580*E*+02
			Reaction 15: $NO+M_4 \rightleftarrows NO^++e^-+M_4$			
10^{14}	−0.167618*E*+00	−0.576804*E*+00	−0.152748*E*+01	−0.480246*E*+01	−0.127771*E*+02	−0.174947*E*+02
10^{15}	−0.167618*E*+00	−0.576804*E*+00	−0.152748*E*+01	−0.480246*E*+01	−0.127771*E*+02	−0.174947*E*+02
10^{16}	−0.167618*E*+00	−0.576804*E*+00	−0.152748*E*+01	−0.480246*E*+01	−0.127771*E*+02	−0.174947*E*+02
10^{17}	−0.167618*E*+00	−0.576804*E*+00	−0.152748*E*+01	−0.480246*E*+01	−0.127771*E*+02	−0.174947*E*+02
10^{18}	−0.167618*E*+00	−0.576804*E*+00	−0.152748*E*+01	−0.480246*E*+01	−0.127771*E*+02	−0.174947*E*+02
10^{19}	−0.167618*E*+00	−0.576804*E*+00	−0.152748*E*+01	−0.480246*E*+01	−0.127771*E*+02	−0.174947*E*+02

Table VIII. Concluded.

Number density, $particles/cm^3$	$A_{K_{eq,r}}$	$B_{K_{eq,r}}$	$C_{K_{eq,r}}$	$D_{K_{eq,r}}$	$E_{K_{eq,r}}$	$F_{K_{eq,r}}$
			Reaction 16: $O+NO^+ \rightleftarrows NO+O^+$			
10^{14}	−0.287924E+00	0.589931E+00	−0.536001E+00	−0.579812E+01	−0.270809E+01	−0.414258E+01
10^{15}	−0.276402E+00	0.479949E+00	−0.312017E+00	−0.556615E+01	−0.347569E+01	−0.389502E+01
10^{16}	−0.244524E+00	0.311307E+00	−0.184728E+00	−0.508067E+01	−0.414477E+01	−0.378660E+01
10^{17}	−0.202212E+00	0.127893E+00	−0.163647E+00	−0.447339E+01	−0.462312E+01	−0.379773E+01
10^{18}	−0.152993E+00	−0.612664E−01	−0.232348E+00	−0.376282E+01	−0.497662E+01	−0.388661E+01
10^{19}	−0.122823E+00	−0.164486E+00	−0.329121E+00	−0.329617E+01	−0.512679E+01	−0.396992E+01
			Reaction 17: $N_2+O^+ \rightleftarrows O+N_2^+$			
10^{14}	0.000000E+00	−0.510046E+00	0.404235E+00	0.218493E+00	−0.562846E+01	0.209226E+00
10^{15}	0.000000E+00	−0.431146E+00	0.131669E+00	0.880469E−01	−0.480413E+01	−0.643024E−01
10^{16}	0.000000E+00	−0.348496E+00	−0.130027E+00	−0.116570E+00	−0.397810E+01	−0.244581E+00
10^{17}	0.000000E+00	−0.279222E+00	−0.329509E+00	−0.351046E+00	−0.329143E+01	−0.328820E+00
10^{18}	0.000000E+00	−0.222833E+00	−0.468329E+00	−0.627963E+00	−0.269560E+01	−0.350877E+00
10^{19}	0.000000E+00	−0.200998E+00	−0.498762E+00	−0.828803E+00	−0.239688E+01	−0.335574E+00
			Reaction 18: $N+NO^+ \rightleftarrows NO+N^+$			
10^{14}	−0.306778E+00	0.582950E+00	−0.767203E+00	−0.663096E+01	−0.293297E+01	−0.389893E+01
10^{15}	−0.307212E+00	0.511315E+00	−0.500797E+00	−0.654867E+01	−0.372868E+01	−0.357644E+01
10^{16}	−0.285656E+00	0.371815E+00	−0.323335E+00	−0.618588E+01	−0.446054E+01	−0.339411E+01
10^{17}	−0.249838E+00	0.203103E+00	−0.258375E+00	−0.564904E+01	−0.501561E+01	−0.334883E+01
10^{18}	−0.202656E+00	0.125187E−01	−0.292918E+00	−0.494803E+01	−0.545932E+01	−0.339994E+01
10^{19}	−0.169615E+00	−0.105973E+00	−0.379439E+00	−0.443130E+01	−0.567515E+01	−0.347569E+01
			Reaction 19: $O_2+NO^+ \rightleftarrows NO+O_2^+$			
10^{14}	0.000000E+00	−0.311598E+00	−0.638297E+00	−0.127561E+01	−0.285932E+01	−0.190026E+01
10^{15}	0.000000E+00	−0.311598E+00	−0.638297E+00	−0.127561E+01	−0.285932E+01	−0.190026E+01
10^{16}	0.000000E+00	−0.311598E+00	−0.638297E+00	−0.127561E+01	−0.285932E+01	−0.190026E+01
10^{17}	0.000000E+00	−0.311598E+00	−0.638297E+00	−0.127561E+01	−0.285932E+01	−0.190026E+01
10^{18}	0.000000E+00	−0.311598E+00	−0.638297E+00	−0.127561E+01	−0.285932E+01	−0.190026E+01
10^{19}	0.000000E+00	−0.311598E+00	−0.638297E+00	−0.127561E+01	−0.285932E+01	−0.190026E+01
			Reaction 20: $O+NO^+ \rightleftarrows O_2+N^+$			
10^{14}	−0.337408E+00	0.464795E+00	−0.793976E+00	−0.730306E+01	−0.554075E+01	−0.649398E+01
10^{15}	−0.332256E+00	0.378693E+00	−0.560752E+00	−0.715299E+01	−0.628170E+01	−0.622937E+01
10^{16}	−0.305530E+00	0.228382E+00	−0.422626E+00	−0.673244E+01	−0.693777E+01	−0.610550E+01
10^{17}	−0.266808E+00	0.574151E−01	−0.393071E+00	−0.616907E+01	−0.741078E+01	−0.610542E+01
10^{18}	−0.220492E+00	−0.121559E+00	−0.455881E+00	−0.549169E+01	−0.776148E+01	−0.618548E+01
10^{19}	−0.191944E+00	−0.218897E+00	−0.550376E+00	−0.504223E+01	−0.791007E+01	−0.626419E+01

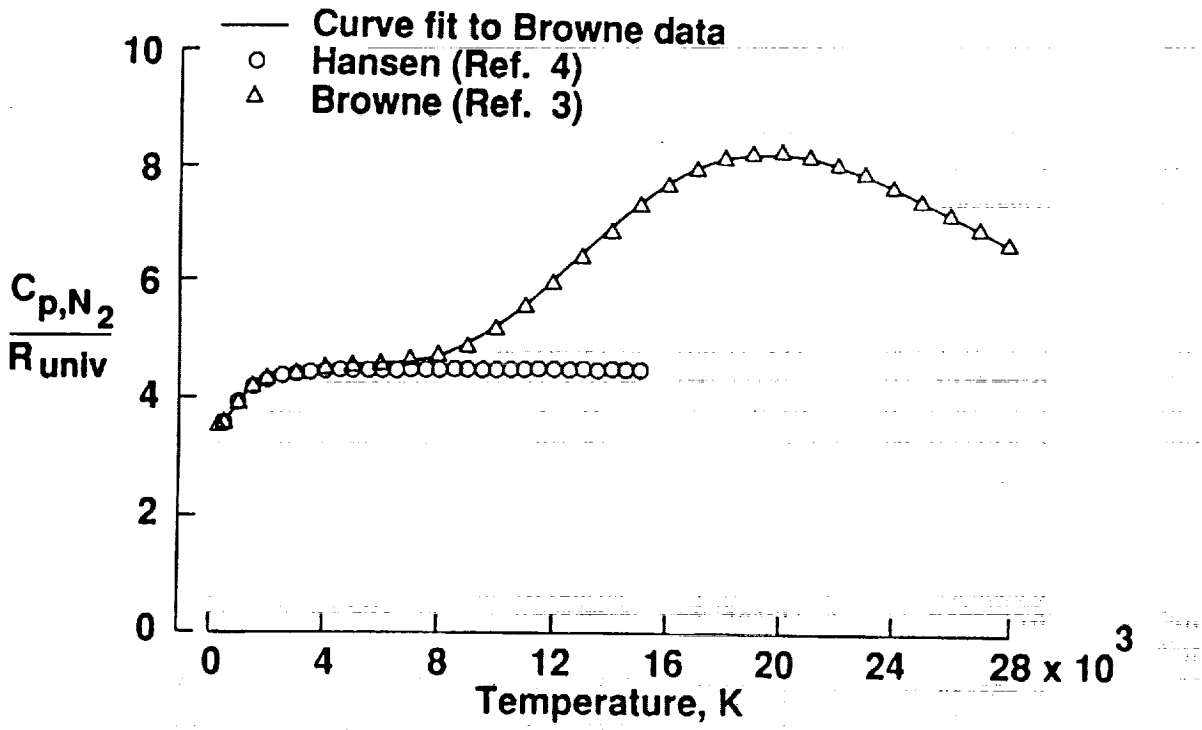

Figure 1. Curve fit to the specific heat values obtained by Browne (ref. 3) and comparison with Hansen's values (ref. 4).

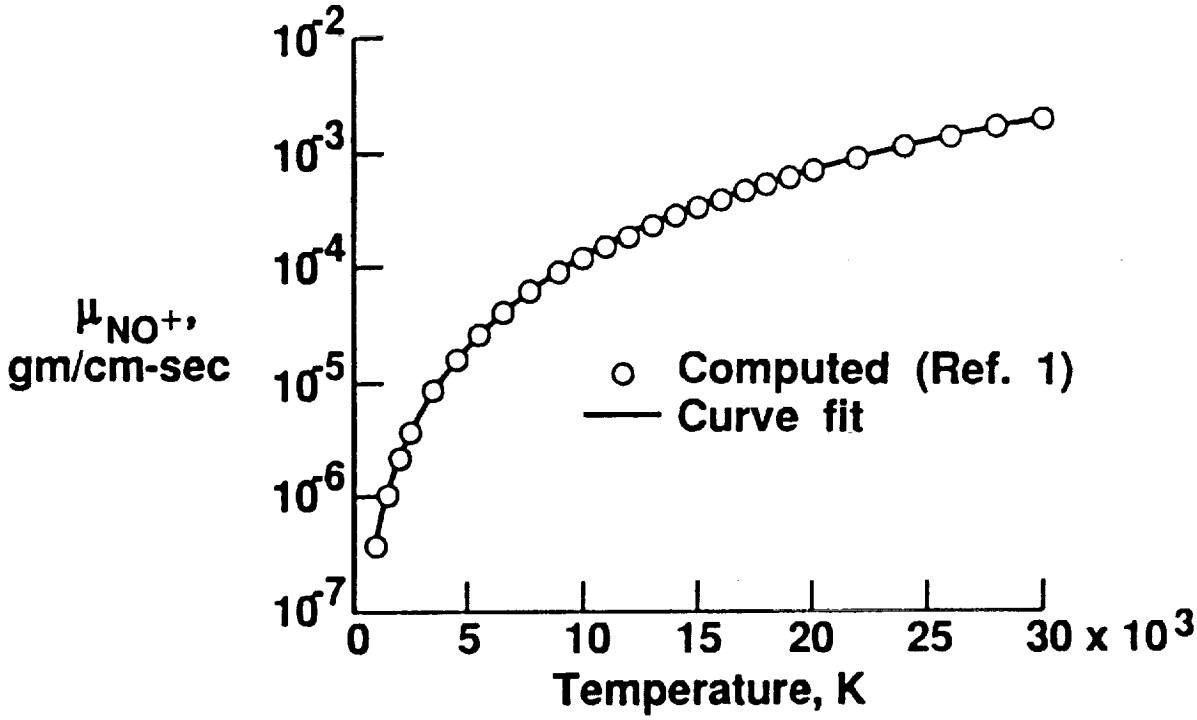

Figure 2. Curve fit to the viscosity of ionized nitric oxide obtained by employing the collision cross sections from reference 1.

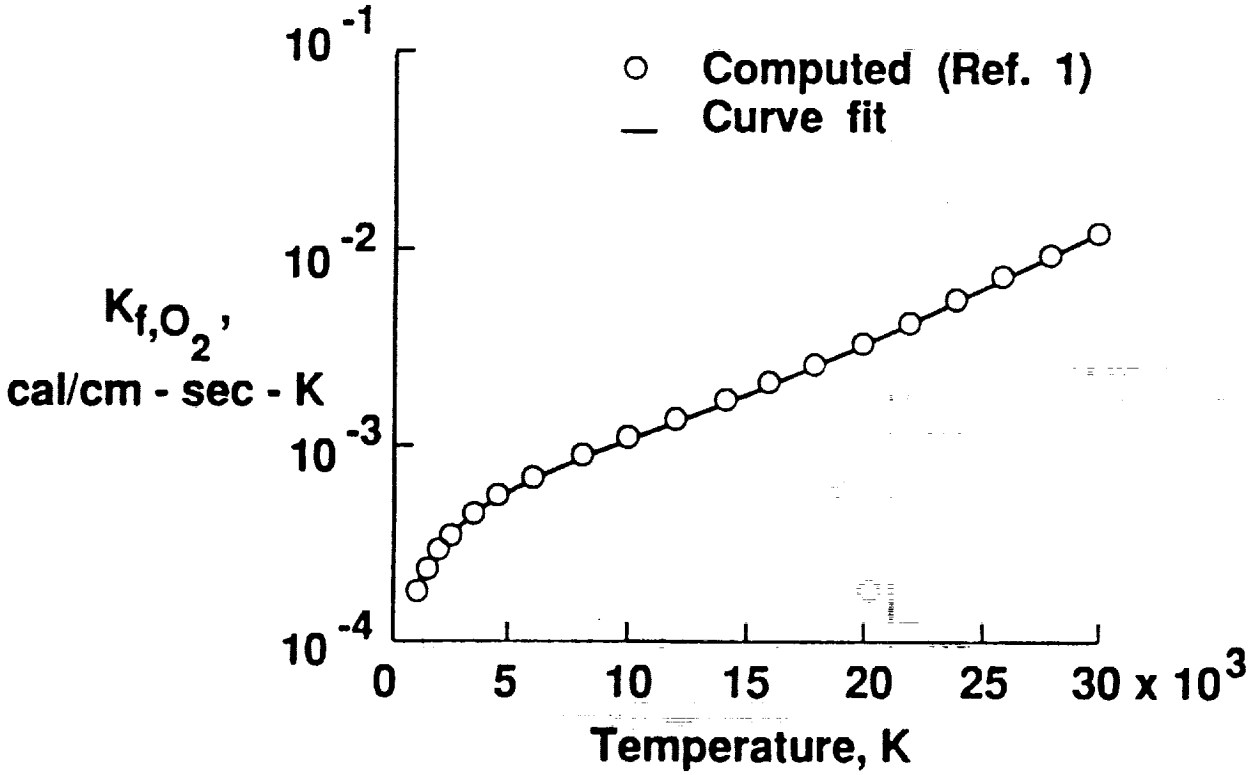

Figure 3. Curve fit to the frozen thermal conductivity of diatomic oxygen by employing the collision cross sections from reference 1.

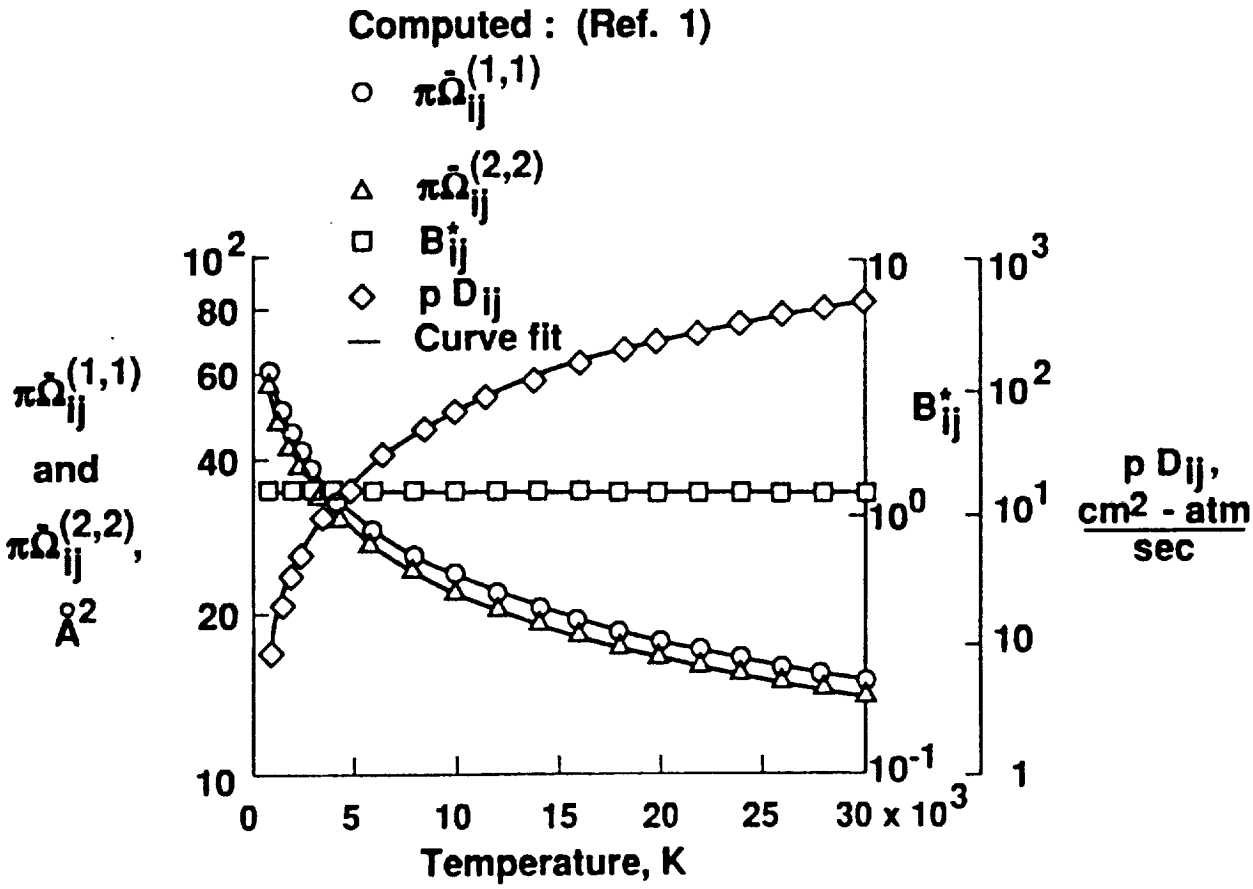

Figure 4. Curve fits to the computed values from reference 1 of collision integrals, collision integral ratio, and binary diffusion coefficient for the ion-neutral molecular interaction $NO^+ \leftrightarrow O_2$.

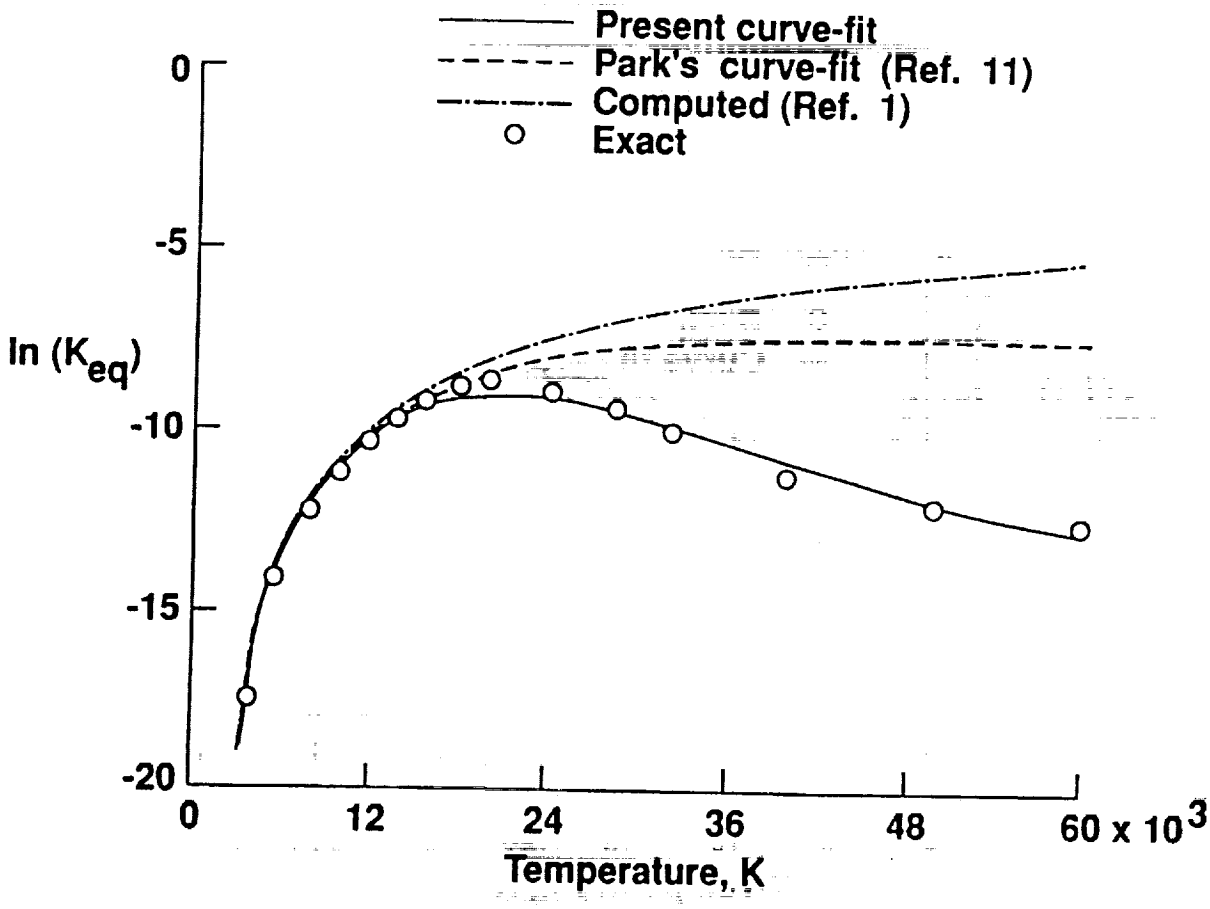

Figure 5. Curve fit to the variation of equilibrium constant with temperature for the reaction $N+O \rightleftarrows NO^{+}+e^{-}$ and total number density of 10^{18} *particles/cm*^{3}.

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16. Abstract

The computer codes developed in this work provide data to 30000 K for the thermodynamic and transport properties of individual species and reaction rates for the prominent reactions occurring in an 11-species nonequilibrium air model. These properties and the reaction-rate data are computed through the use of curve-fit relations which are functions of temperature (and number density for the equilibrium constant). The curve fits were made using the most accurate data believed available. A detailed review and discussion of the sources and accuracy of the curve-fitted data used herein are given in NASA RP 1232.

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