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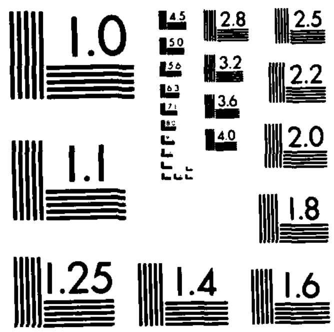

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A Computer Code for a One-Dimensional Dynamic Model of the Mesosphere and Lower Thermosphere

T. J. KENESHEA
S. P. ZIMMERMAN

7 March 1984

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ATMOSPHERIC SCIENCES DIVISION PROJECT 6670
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A one-dimensional computer simulation of the composition and the dynamics of the mesosphere and lower thermosphere between 50 and 400 km is presented. The model is based on a numerical solution of large sets of partial differential equations for the conservation of mass and momentum for individual gases in an atmosphere with constant temperature and turbulent diffusion coefficient profiles. Incorporated into the model are 56 different neutral and ionic atmospheric species involved in 215 chemical and photochemical reactions. Distributions of many of the constituents are presented as determined from an application of the computer code to a midlatitude winter environment. Included are tables of the photodissociation rate coefficients as functions of the column densities of molecular oxygen and ozone for several of the atmospheric gases. Finally, the complete computer code is presented along with a detailed explanation of its structure and instructions for its use.

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Block 19. (Contd)

Model of the Mesosphere and Lower Thermosphere

Contents

Illustrations

Tables

A Computer Code for a One-Dimensional Dynamic Model of the Mesosphere and Lower Thermosphere

1. INTRODUCTION

T.J. Keneshea, one of the authors, pioneered studies of the numerical solution of sets of continuity equations in the atmosphere. He was the first to find that these equations were "stiff" and were not solvable efficiently by any numerical technique then available. His efforts[1,2,3] led to a computer simulation of the composition of the upper atmosphere that could be run inexpensively on the large scale computers available in those days. After these computer codes were applied to the undisturbed atmosphere[4] and to several natural[5] and manmade atmospheric disturbances, it became apparent that they could not predict long term atmospheric behavior.

(Received for publication 1 March 1984)

1. Keneshea, T.J. (1962) A Computer Program for Solving the Reaction Rate Equations in the E Ionospheric Region, AFCRL-62-828.
2. Keneshea, T.J. (1963) A Solution to the Reaction Rate Equations in the Atmosphere Below 150 Kilometers, AFCRL-63-711.
3. Keneshea, T.J. (1967) A Technique for Solving the General Reaction Rate Equations in the Atmosphere, AFCRL-67-0221, AD654010.
4. Keneshea, T.J., Narcisi, R.S., and Swider, W., Jr. (1970) Diurnal model of the E-region, J. Geophys. Res. 75:845-854.
5. Keneshea, T.J., and Fowler, R.J. (1966) Computed Electron, Ion, and Neutral Density Profiles for the Solar Eclipse of 12 November 1966, AFCRL-66-741, AD646975.

Such simple computer codes, in which only chemical reactions among the atmospheric gases are considered, are excellent for determining short term variations of the atmosphere, but give completely erroneous results for solutions beyond a few hours. In fact, these codes are valid only for solution times shorter than the transport time constants for the various atmospheric gases.

It then became obvious that any realistic atmospheric simulation should be based upon the equations of motion for the particles as well as their continuity equations. This report describes in detail a computer scheme for solving large sets of coupled partial differential equations of conservation of mass and momentum and also presents the computer code itself with instructions for using it. Also included are the results of an application of the code to the development of a one-dimensional midlatitude winter simulation of the composition of the mesosphere and lower thermosphere.

2. THE EQUATIONS OF STATE

The equation for the conservation of particles of a particular gas within a multicomponent gas mixture is

$$\frac{\partial n_i}{\partial t} = P_i - n_i L_i - \nabla \cdot \vec{\Phi}_i \tag{1}$$

where n_i is the concentration of species i, P_i is the rate at which it is formed, and $n_i L_i$ is the rate at which it is removed through gas phase chemical reactions with other members of the ensemble. The vector flux of the species, $\vec{\Phi}_i$, is induced by a combination of all nonchemical processes. In this report, only molecular and eddy diffusion will be considered in the flux term

$$\vec{\Phi}_i = n_i \vec{C}_i + n_i \vec{V}_i \tag{2}$$

where $\vec{C}_i$ is the velocity of species i resulting from molecular diffusion and $\vec{V}_i$ is the velocity resulting from eddy diffusion. Since only the vertical distribution of species is to be considered here, the continuity equation can be written as

$$\frac{\partial n_i}{\partial t} = P_i - n_i L_i - \frac{\partial}{\partial Z}(n_i w_i + n_i v_i) \tag{3}$$

where w_i and v_i are the vertical components of the velocities $\vec{C}_i$ and $\vec{V}_i$ respectively.

The equation of motion for a neutral gas particle in a multicomponent gas mixture can be written as[6]

$$\frac{\partial \vec{C}_i}{\partial t} + \frac{1}{\rho_i} \nabla p_i + \frac{\alpha_i p_i}{\rho_i} \nabla \ln T - \vec{g} = - \sum_j \nu_{ij} (\vec{C}_i - \vec{C}_j) \tag{4}$$

where $\rho_i = n_i m_i$ is the mass density of species i, α_i is its thermal diffusion factor in a multicomponent mixture, p_i is its partial pressure, T is the temperature of the mixture, $\vec{g}$ is the acceleration of gravity, and ν_{ij} is the collision frequency of species i with species j. The equation of motion is written here in terms of the collision frequencies between particles rather than the molecular diffusion coefficients in a multicomponent gas as was done by Keneshea and Zimmerman[7] and Keneshea et al.[8] The pressure of the gas is simply

$$p_i = n_i kT \tag{5}$$

where k is Boltzmann's constant. Therefore, in the one-dimensional case

$$\frac{1}{\rho_i} \nabla p_i + \alpha_i \frac{p_i}{\rho_i} \nabla \ln T + g = \frac{kT}{m_i} \left[\frac{1}{n_i} \frac{\partial n_i}{\partial Z} + \frac{(1 + \alpha_i)}{T} \frac{\partial T}{\partial Z} + \frac{1}{H_i} \right] \tag{6}$$

where m_i is the mass of species i and $H_i = kT/m_i g$ is its scale height. The equation of motion in the vertical direction for a neutral gas particle can then be written as

$$\frac{\partial w_i}{\partial t} + \frac{kT}{m_i} \left[\frac{1}{n_i} \frac{\partial n_i}{\partial Z} + \frac{(1 + \alpha_i)}{T} \frac{\partial T}{\partial Z} + \frac{1}{H_i} \right] = - \sum_j \nu_{ij} (w_i - w_j). \tag{7}$$

If inertial effects are ignored, then the equation of motion for ions and electrons in the presence of both magnetic and electric fields are[9]

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6. Chapman, S., and Cowling, T.G. (1970) The Mathematical Theory of Non-Uniform Gases, Cambridge University Press

7. Keneshea, T.J., and Zimmerman, S.P. (1970) The effect of mixing upon atomic and molecular oxygen in the 70-170 km region of the atmosphere, J. Atmos. Sci. 27:831-840.

8. Keneshea, T.J., Zimmerman, S.P., and Philbrick, C.R. (1979) A dynamic model of the mesosphere and lower thermosphere, Planet. Space Sci. 27:385-401.

9. Banks, P.M., and Kockarts, G. (1973) Aeronomy, Part A and Part B, Academic Press, New York.

$$\frac{\partial \vec{C}_i}{\partial t} + \frac{1}{\rho_i}\nabla p_i - \vec{g} - \frac{q_i}{m_i}\left(\vec{E} + \frac{1}{c}\vec{C}_i \times \vec{B}\right) = -\sum_j \nu_{ij}\left(\vec{C}_i - \vec{C}_j\right) \tag{8}$$

and

$$\frac{\partial \vec{C}_e}{\partial t} + \frac{1}{\rho_e}\nabla p_e - \vec{g} - \frac{q_e}{m_e}\left(\vec{E} + \frac{1}{c}\vec{C}_e \times \vec{B}\right) = -\sum_j \nu_{ej}\left(\vec{C}_e - \vec{C}_j\right)$$

where q is the particle charge, m is its mass, $\vec{E}$ is the total electric field vector, c is the speed of light, and $\vec{B}$ is the magnetic field vector. After much algebra, ignoring the horizontal component of the electric field as well as the horizontal velocities of the particles, and assuming that the electron and the ion temperatures are the same as the temperature of the neutral gas mixture, the equation of motion for the vertical velocities of the ionic species becomes

$$\frac{\partial w_i}{\partial t} + \frac{kT}{m_i}\left[\frac{1}{n_i}\frac{\partial n_i}{\partial Z} + \frac{1}{n_e}\frac{\partial n_e}{\partial Z} + \frac{2}{T}\frac{\partial T}{\partial Z} + \frac{1}{H_i}\right]$$

$$= -w_i \sum_j \nu_{ij}\left\{\frac{\Omega_i^2 + \left(\sum_j \nu_{ij}\right)^2}{\Omega_i^2 \sin^2 I + \left(\sum_j \nu_{ij}\right)^2}\right\} + \sum_j \nu_{ij} w_j \tag{9}$$

where n_e is the concentration of the electrons, I is the magnetic dip angle, and

$$\Omega_i = \frac{B_o e}{m_i c} \tag{10}$$

where B_o is the magnitude of the magnetic field and e is the charge on the electron.

The eddy diffusion velocity, taken from the formulation of Colegrove et al,[10] is

$$v_i = -K\left[\frac{1}{n_i}\frac{\partial n_i}{\partial Z} + \frac{1}{T}\frac{\partial T}{\partial Z} + \frac{1}{\overline{H}}\right] \tag{11}$$

where K is the vertical eddy diffusion coefficient and $\overline{H}$ is the scale height of the mean mass.

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10. Colegrove, F.D., Johnson, F.S., and Hanson, W.B. (1966) Atmospheric composition in the lower thermosphere, J. Geophys. Res. 71:2227-2236.

Whenever a photodissociation rate coefficient is needed in the calculations, the O_2 and O_3 column densities are estimated and a simple table look-up is made for the particular J_j required.

A short discussion of each photodissociation process and the photodissociation rate coefficient tables are presented in Appendix B.

6.2 The Photoionization Rate Coefficients

Reactions 185 through 191 and reactions 206 and 207 in the list of reactions in Appendix A are the photoionization processes considered in this report. The EUV solar fluxes, the total absorption cross sections for O_2, N_2, and O, and the ionization cross sections for O_2, N_2, O, H, and He are listed in Table B21. The EUV solar fluxes from 1 to 121.57 nm are from the compilation of Manson.[18] The X-ray fluxes below 1 nm are taken from Swider.[19] The cross sections for total absorption and for total photoionization of O_2, N_2, and O were obtained from a consideration of reported experimental and theoretical values. References, definitions, and a discussion of the absorption spectra can be found in Huffman[20] for wavelengths to 30.4 nm. For shorter wavelengths, the values given by Swider[19] were used. A discussion of some photoionization rate coefficients can be found in Keneshea and Huffman.[21] The photoionization cross sections for N, H, and He are taken from Banks and Kockarts.[9]

The photoionization of the metastable $O_2(^1\Delta g)$ molecule has been included in these calculations. The wavelength region of interest is from 102.7 to 111.8 nm, where ground state O_2 is the primary absorber of the incident solar radiation but is not ionized itself. The effective absorption coefficient for O_2 and the ionization cross section for $O_2(^1\Delta g)$ are taken from Huffman et al.[22] Nitric oxide is ionized readily by Lyman α radiation. The ionization cross section for NO at Lyman α is 2×10^{-18} cm^2 as given by Watanabe.[23]

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18. Manson, J.E. (1976) Satellite Measurements of Solar UV During 1974, AFCRL-TR-76-0006, AD A021490.
19. Swider, W., Jr. (1969) Ionization rates due to the attenuation of 1-100A non-flare solar X rays in the terrestrial atmosphere, Rev. Geophys. 7:573-594.
20. Huffman, R.E. (1972) Photochemical processes. Cross-section data, Chapter 12, in Defense Nuclear Agency Reaction Rate Handbook, DNA 1948H.
21. Keneshea, T.J., and Huffman, R.E. (1972) Solar Photoionization Rate Constants and Ultraviolet Intensities, AFCRL-72-0667.
22. Huffman, R.E., Paulsen, D.E., Larrabee, J.C., and Cairns, R.B. (1971) Decrease in D-region O_2 ($^1\Delta g$) photoionization rates resulting from CO_2 absorption, J. Geophys. Res. 76:1028-1038.
23. Watanabe, K. (1954) Photoionization and total absorption cross sections of gases. I. Ionization potentials of several molecules. Cross sections of NH_3 and NO, J. Chem. Phys. 22:1564-1570.

The total rate coefficient is obtained simply by summing $J_j(\lambda)$ over all the wavelengths.

$$J_j = \sum_{\lambda} \sigma_j'(\lambda)\, I_o(\lambda)\, e^{-\sum_i \sigma_i(\lambda) N_i} . \tag{54}$$

6.1 The Photodissociation Rate Coefficients

Reactions 192 through 205 in the list of reactions in Appendix A are the photodissociation processes considered in this report. In computing the transmittance, only molecular oxygen and ozone are considered as absorbers of the solar radiation. In addition to these two species, the absorption and subsequent photodissociation of H_2O, H_2O_2, NO_2, NO_3, N_2O, HNO_2, CO_2, and HO_2 are discussed in Appendix B. Also presented in Appendix B are the photodissociation of N_2O_5, HNO_3, CH_4, and CH_2O, even though these species are not included in the aeronomic calculations discussed in this report.

The incident solar flux $I_o(\lambda)$ and the absorption cross sections for O_2, O_3, H_2O, H_2O_2, NO_2, NO_3, and N_2O used in calculating the photodissociation rate coefficients are listed in Table B1. The cross sections for O_2 in the wavelength region of the Schumann Runge bands (175-205 nm) are not tabulated here. In this wavelength region, the molecular oxygen dissociation data of Hudson and Mahle[15] are used. The incident solar fluxes listed here are those tabulated by Ackerman.[16] In the wavelength region 123 to 190 nm, however, the Ackerman fluxes have been replaced by the measurements of Heroux and Swirbalus.[17] The absorption cross sections for N_2O_5, HNO_2, HNO_3, CH_4, CO_2, CH_2O, and HO_2 are listed in Table B2.

In computing the time dependence of atmospheric composition, the computation of the photodissociation rate coefficients using Eq. (54) can be a time consuming process. As the solar zenith angle changes, the column densities N_i will change and, with them, the J_j's. It is desirable to have available tables of these coefficients that are not dependent upon specific distributions of molecular oxygen and ozone. To keep the tables perfectly general, therefore, the coefficients are computed and tabulated in Appendix B as functions of the column densities of O_2 and O_3.

---

15. Hudson, R.D., and Mahle, S.H. (1972) Photodissociation rates of molecular oxygen in the mesosphere and lower thermosphere, J. Geophys. Res. 77:2902-2914.

16. Ackerman, M. (1971) Ultraviolet solar radiation related to mesospheric processes, in Mesospheric Models and Related Experiments, G. Fiocco, Ed., D. Reidel, Dordrecht, Netherlands.

17. Heroux, L., and Swirbalus, R.A. (1976) Full-disc solar flares between 1230 and 1940 A, J. Geophys. Res. 81:436-440.

the composition of the atmosphere is computed, the dissociation and ionization of atmospheric gases by incident solar radiation must be considered. In most calculations, these photoprocesses are handled as chemical reactions. Consequently, the rate coefficients for dissociation and ionization of the various gases must be known.

The photodissociation and photoionization rate coefficients for a gas particle at any altitude in the atmosphere is a product of the flux of the solar radiation arriving at that altitude and its photodissociation, or photoionization cross section. Several excellent reviews of the absorption properties of atmospheric gases can be found in the literature. Among these are Hudson[12] and Johnston and Graham.[13] Also, an excellent survey article by Turco[14] includes a discussion of photodissociation processes for several gases.

Beer's Law expresses the fractional transmission of radiation through a gas mixture

$$T(\lambda) = \frac{I(\lambda)}{I_O(\lambda)} = e^{-\tau(\lambda)} \tag{51}$$

where $I_o(\lambda)$ is the intensity of the incident radiation, $I(\lambda)$ is the intensity of the transmitted radiation, and $\tau(\lambda)$ is the optical depth of the absorbing layer, all at the wavelength λ. The optical depth is given by

$$\tau(\lambda) = \sum_i \sigma_i(\lambda) N_i \tag{52}$$

where $\sigma_i(\lambda)$ is the absorption cross section of the i'th type of particle and N_i is the total number of particles of this type in a cm^2 column along the ray path to the sun.

The rate coefficient for the photoprocess for j-type particles at wavelength λ is determined by

$$J_j(\lambda) = \sigma_j' (\lambda)\, I_o(\lambda)\, T(\lambda) \tag{53}$$

where $\sigma_j'(\lambda)$ is the cross section for photodissociation or photoionization of the gas.

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12. Hudson, R.D. (1971) Critical review of ultraviolet photoabsorption cross sections for molecules of astrophysical and aeronomic interest, Rev. Geophys. Space Phys. 9:305-406.

13. Johnston, H.S., and Graham, R. (1974) Photochemistry of NO_x and HNO_x compounds, Can. J. Chem. 52:1415-1423.

14. Turco, R.P. (1975) Photodissociation rates in the atmosphere below 100 km, Geophys. Surveys 2:153-192.

Therefore, the average collision frequency for charge exchange is

$$\bar{\nu}_{in} = 1.73725\ n\ \gamma. \tag{48}$$

The average reduced charge exchange collision frequencies between like particles are given in Table 2. Again, it is assumed that the ion and neutral gas temperatures are equal.

Table 2. The Average Reduced Charge Exchange Collision Frequencies Between Like Particles

$H^+ + H$	$1.0 \times 10^{-10}\ H\ (2T)^{1/2}$
$O^+ + O$	$1.6 \times 10^{-11}\ O\ (2T)^{1/2}$
$N^+ + N$	$1.7 \times 10^{-11}\ N\ (2T)^{1/2}$
$He^+ + He$	$3.0 \times 10^{-11}\ He\ (2T)^{1/2}$
$O_2^+ + O_2$	$1.1 \times 10^{-11}\ O_2\ (2T)^{1/2}$
$N_2^+ + N_2$	$2.2 \times 10^{-11}\ N_2\ (2T)^{1/2}$

The average ion-ion momentum transfer collision frequency is given by

$$\bar{\nu}_{ij} = 1.3\ n_j \left(\frac{1}{\mu^{1/2}\ T^{3/2}} \right) \sec^{-1} \tag{49}$$

assuming that the charge states of the colliding particles are both unity.

The collision frequency between i and j-type particles is then simply

$$\nu_{ij} = \frac{m_i}{(m_i + m_j)} \bar{\nu}_{ij}. \tag{50}$$

6. THE CHEMISTRY AND PHOTOCHEMISTRY

The chemical reactions included in this model are listed in Appendix A. When

Table 1. Polarizabilities of Neutral Gases

GAS	$\alpha(10^{-24}\ cm^3)$
N_2	1.76
O_2	1.59
$O_2(^1\Delta g)$	1.59
O	0.79
H	0.667
H_2	0.82
N	1.1
$N(^2D)$	1.1
NO	1.74
He	0.21
N_2O	3.00
CO_2	2.63
CO	1.97

Let

$$\overline{Q}_E = \sigma = \frac{\gamma}{v} \tag{46}$$

where γ is the chemical reaction rate constant and v is the velocity of the colliding particle.

Since

$$v = \left(\frac{3kT}{m}\right)^{1/2}, \text{ then}$$

$$\overline{\nu}_{in} = \frac{4}{3} n \left(\frac{16kT}{\pi m}\right)^{1/2} \frac{\gamma}{\left(\frac{3kT}{m}\right)^{1/2}} . \tag{47}$$

5. COLLISION FREQUENCIES

A good review of collision processes can be found in Banks and Kockarts.[9] All of the material that follows was taken from that source.

The average neutral-neutral collision frequencies are given by

$$\bar{\nu}_{ij} = 2n_j\, \sigma_{ij}^{\,2} \left(\frac{2\pi kT}{\mu}\right)^{1/2} \text{sec}^{-1} \tag{43}$$

where μ, the reduced mass, is given by

$$\mu = \frac{m_i m_j}{m_i + m_j}$$

and

$$\sigma_{ij} = \frac{1}{2}(\sigma_i + \sigma_j)$$

where σ_i and σ_j are the diameters of the colliding particles.

The average collision frequency for momentum transfer between ions and neutral particles is

$$\bar{\nu}_{in} = 2.6 \times 10^{-9}\, n_n \left(\frac{\alpha}{\mu}\right)^{1/2} \text{sec}^{-1} \tag{44}$$

where n_n is the concentration of the neutral particles, α is the neutral gas atomic polarizability in units of $10^{-24}\,\text{cm}^3$, and μ is in amu. Table 1 lists the polarizability of several atmospheric gases.[9]

The average collision frequency for charge exchange between unlike particles is given by

$$\bar{\nu}_{in} = \frac{4}{3}\, n \left(\frac{8k}{\pi m}\right)^{1/2} (2T)^{1/2}\, \bar{Q}_E \tag{45}$$

where $\bar{Q}_E$ is the average charge transfer cross section for ion-neutral collisions. In Eq. (45), the ion and neutral temperatures are assumed to be equal.

The calculation of F_K, however, requires the upper boundary velocity at the end of the time step. At the upper boundary, O_2^+, NO^+, O_3, OH, H, HO_2, H_2O, H_2O_2, H_2, NO_2, O_2 ($^1\Delta g$), and argon are all minor species. It is assumed, therefore, that they are in diffusive equilibrium there. This means that their diffusion velocities are zero at the upper boundary, but they are still subject to the mean mass motion.

The remaining species, however, do have diffusion velocities at the upper boundary that must be defined. It is impossible to calculate the upper boundary velocities from Eq. (18) because concentrations are required at K + 1. Since this altitude is outside the volume, the concentrations are not known there. Therefore, to estimate the velocities at the upper boundary at the end of the time step, we investigate the continuity equation, Eq. (3), at the upper boundary where $v_i = 0$ (since the upper boundary is outside of the turbulence region).

$$\frac{\partial n_i}{\partial t} = P_i - n_i L_i - \frac{\partial}{\partial Z}(n_i w_i). \tag{41}$$

Setting the time derivative to zero and solving the resulting equation for dw_i/dZ gives

$$\frac{dw_i}{dZ} = -\frac{w_i}{n_i}\frac{dn_i}{dZ} + \frac{P_i - n_i L_i}{n_i}. \tag{42}$$

This ordinary differential equation can be solved numerically over the last height step to give values of w_i at the upper boundary. Since Eq. (42) is solved in every iteration, the final iteration will give the upper boundary value of w_i at the end of the time step.

The new concentration profiles at $t + \Delta t$ are therefore computed as follows: Starting at the lower boundary, the E and F arrays are computed in the increasing height direction up to the upper boundary. The new concentrations are then computed starting at the upper boundary and applying Eq. (27) in the decreasing altitude direction down to the lower boundary. This procedure is repeated over each time step until the solutions converge for that time step. Once a solution has been accepted, the time step is doubled (provided it has not reached the maximum value set by the program). Using the concentrations and velocities computed at the end of the last time step, the equations are solved over the next time step. In this manner, the solution advances.

Eq. (36) can be written as

$$\tilde{B}^{\ell}_{K} n^{\ell+1}_{K} - \tilde{C}^{\ell}_{K} n^{\ell+1}_{K-1} = \tilde{D}^{\ell}_{K} \tag{37}$$

where

$$\tilde{A}^{\ell}_{K} = 0$$

$$\tilde{B}^{\ell}_{K} = -A^{\ell}_{K}\left[1 - \Gamma_{K}\Delta Z_{K} - \frac{m_i\,\Delta Z_K}{k\,T_K}\sum_j \nu_{ij}\,(w_i - w_j)^{\ell+1}_{K}\right] + B^{\ell}_{K}$$

$$\tilde{C}^{\ell}_{K} = C^{\ell}_{K}$$

$$\tilde{D}_{K} = D^{\ell}_{K}. \tag{38}$$

Eq. (28) can be rewritten at level K as

$$E_K = \frac{\tilde{A}^{\ell}_{K}}{[\tilde{B}^{\ell}_{K} - \tilde{C}^{\ell}_{K} E_{K-1}]}$$

and

$$F_K = \frac{\tilde{D}^{\ell}_{K} + \tilde{C}^{\ell}_{K} F_{K-1}}{\tilde{B}^{\ell}_{K} - \tilde{C}^{\ell}_{K} E_{K-1}}. \tag{39}$$

It is obvious, then, that

$$E_K = 0$$

and

$$F_K = \frac{D^{\ell}_{K} + C^{\ell}_{K} F_{K-1}}{B^{\ell}_{K} - A^{\ell}_{K}\left[1 - \Gamma_K \Delta Z_K - \frac{m_i\,\Delta Z_K}{k\,T_K}\sum_j \nu_{ij}(w_i - w_j)^{\ell+1}_{K}\right] - C^{\ell}_{K} E_{K-1}}. \tag{40}$$

$$n_o^{\ell+1} = \frac{n_o^{\ell} + P_o^{\ell+1}\Delta t}{[1 + L_o^{\ell+1}\Delta t]}. \tag{30}$$

E_o and F_o at the lower boundary are simply

$$E_o = O$$

and

$$F_o = n_o^{\ell+1}. \tag{31}$$

At the upper boundary, the time derivative of the velocities in Eq. (7) is set to zero:

$$\frac{kT}{m_i}\left[\frac{1}{n_i}\frac{dn_i}{dZ} + \frac{(1+\alpha_i)}{T}\frac{dT}{dZ} + \frac{1}{H_i}\right] = -\sum_j \nu_{ij}(w_i - w_j). \tag{32}$$

Solving Eq. (32) for dn_i/dZ gives

$$\frac{dn_i}{dZ} = -n_i\,\Gamma_i - \frac{n_i m_i}{kT}\sum_j \nu_{ij}(w_i - w_j). \tag{33}$$

Writing Eq. (33) at the upper boundary (K) in finite difference notation gives

$$\frac{n_{K+1}^{\ell+1} - n_K^{\ell+1}}{\Delta Z_K} = n_K^{\ell+1}\,\Gamma_K - \frac{n_K^{+1}\,m_i}{kT_K}\sum_j \nu_{ij}(w_i - w_j)_K^{\ell+1}. \tag{34}$$

Solving Eq. (34) for $n_{K+1}^{\ell+1}$ gives

$$n_{K+1}^{\ell+1} = n_K^{\ell+1}\left[1 - \Gamma_K\Delta Z_K - \frac{m_i\,\Delta Z_K}{kT_K}\sum_j \nu_{ij}(w_i - w_j)_K^{\ell+1}\right]. \tag{35}$$

Replacing $n_{K+1}^{\ell+1}$ in Eq. (25) written at level K with Eq. (35) gives

$$\left\{-A_K^{\ell}\left[1 - \Gamma_K\Delta Z_K - \frac{m_i\,\Delta Z_K}{kT_K}\sum_j \nu_{ij}(w_i - w_j)_K^{\ell+1}\right] + B_K^{\ell}\right\}$$

$$n_K^{\ell+1} - C_K^{\ell}\,n_{K-1}^{\ell+1} = D_K^{\ell} \tag{36}$$

From Eqs. (26) and (27), the following definitions are obtained:

$$E_k = \frac{A_k^\ell}{\left[B_k^\ell - C_k^\ell E_{k-1}\right]}$$

and

$$F_k = \frac{D_k^\ell + C_k^\ell F_{k-1}}{\left[B_k^\ell - C_k^\ell E_{k-1}\right]} . \tag{28}$$

Using Eqs. (27) and (28), the height profiles for the concentrations can be calculated provided $n_o^{\ell+1}$ and $n_k^{\ell+1}$ can be specified at the lower and upper boundaries respectively. The boundary conditions will be discussed in Section 4.

It should be noted that only some of the terms on the right-hand side of the equations for A_k^ℓ, B_k^ℓ, C_k^ℓ, and D_k^ℓ are specified at the beginning of the time step. The chemistry terms and the velocity sums are specified at the end of the time step. Because of this, the solutions require iteration over the time step. At the end of each iteration of the concentrations, the chemistry and the velocities from Eq. (18) are recomputed. New concentrations are then calculated using these updated values. This procedure is repeated until, on successive iterations, the concentrations of all species change by less than 1 percent at all altitudes.

4. BOUNDARY CONDITIONS

At the lower boundary, the concentrations of N_2, O_2, H_2O, H_2, and Ar are held fixed for all time at their initial values ($n_o^{\ell+1}$ = constant). All of the other species in the transport mode prove to be chemically controlled at 50 km, so their concentrations are computed from the simplified continuity equations. With the divergence of the flux set to zero in Eq. (1), that equation becomes

$$\frac{dn_i}{dt} = P_i - n_i L_i . \tag{29}$$

If the derivative in Eq. (29) is replaced by simple differences, then, at the lower boundary, we have in which

$$Q_k = \frac{1}{[1 + \Delta t\, \lambda \sum_j \nu_{ij}]}$$

$$S_k = (1 - \Gamma_k\, \Delta Z_k)$$

$$\bar{S}_k = (1 - \bar{\Gamma}_k\, \Delta Z_k).$$

It is possible, therefore, to write a tridiagonal matrix between the lower and upper boundaries for each species using Eq. (21). These tridiagonal matrices are then solved for the vertical distribution of the concentration using the method of Richtmyer and Morton.[11]

Substituting the recurrence relation

$$n_{k-1}^{\ell+1} = E_{k-1}\, n_k^{\ell+1} + F_{k-1} \tag{23}$$

into Eq. (21) gives

$$-A_k^{\ell}\, n_{k+1}^{\ell+1} + B_k^{\ell}\, n_k^{\ell+1} - C_k^{\ell}\, E_{k-1}\, n_k^{\ell+1} - C_k^{\ell}\, F_{k-1} = D_k^{\ell}. \tag{24}$$

This can be written as

$$-A_k^{\ell}\, n_{k+1}^{\ell+1} + [B_k^{\ell} - C_k^{\ell}\, E_{k-1}]\, n_k^{\ell+1} = D_k^{\ell} + C_k^{\ell}\, F_{k-1}. \tag{25}$$

Solving Eq. (25) for $n_k^{\ell+1}$ gives

$$n_k^{\ell+1} = \frac{A_k^{\ell}}{\left[B_k^{\ell} - C_k^{\ell}\, E_{k-1}\right]}\, n_{k+1}^{\ell+1} + \frac{D_k^{\ell} + C_k^{\ell}\, F_{k-1}}{\left[B_k^{\ell} - C_k^{\ell}\, E_{k-1}\right]}. \tag{26}$$

Eq. (23) written at level k is

$$n_k^{\ell+1} = E_k\, n_{k+1}^{\ell+1} + F_k. \tag{27}$$

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11. Richtmyer, R.D., and Morton, K.W. (1967) <u>Difference Methods for Initial-Value Problems</u>, Interscience Publishers, New York.

$$\Phi_{k-1}^{\ell+1} = \frac{1}{\left[1 + \Delta t \lambda_i \sum\limits_j \nu_{ij}\right]} \left\{ n_{k-1}^{\ell+1} w_{k-1}^{\ell+1} - \frac{kT_{k-1}}{m_i} \frac{\Delta t}{\Delta Z_{k-1}} \right.$$

$$\left[n_k^{\ell+1} - n_{k-1}^{\ell+1} (1 - \Gamma_{k-1} \Delta Z_{k-1}) \right]$$

$$\left. + n_{k-1}^{\ell+1} \Delta t \sum_{j \neq i} \nu_{ij} w_{j_{k-1}}^{\ell+1} \right\}$$

$$- \frac{K_{k-1}}{\Delta Z_{k-1}} \left\{ n_k^{\ell+1} - n_{k-1}^{\ell+1} (1 - \bar{\Gamma}_{k-1} \Delta Z_{k-1}) \right\}. \tag{20}$$

Substituting Eqs. (19) and (20) into Eq. (12) and collecting like terms in n gives

$$- A_k^\ell n_{k+1}^{\ell+1} + B_k^\ell n_k^{\ell+1} - C_k^\ell n_{k-1}^{\ell+1} = D_k^\ell \tag{21}$$

where

$$A_k^\ell = \frac{\Delta t}{\Delta Z_k \Delta Z_{k-1}} \left[Q_k \frac{kT_k \Delta t}{m} + K_k \right]$$

$$B_k^\ell = 1 + L_k^{\ell+1} \Delta t + \frac{\Delta t}{\Delta Z_k \Delta Z_{k-1}}$$

$$\left[Q_k \left(w_k^\ell \Delta Z_k + S_k \frac{kT_k \Delta t}{m} + \Delta t \Delta Z_k \sum_{j \neq i} \nu_{ij} w_k^{\ell+1} \right) \right.$$

$$\left. + \bar{S}_k K_k + Q_{k-1} \frac{kT_{k-1} \Delta t}{m} \frac{\Delta Z_k}{\Delta Z_{k-1}} + K_{k-1} \frac{\Delta Z_k}{\Delta Z_{k-1}} \right]$$

$$C_k^\ell = \frac{\Delta t}{\Delta Z_k \Delta Z_{k-1}} \left[Q_{k-1} \left(w_{k-1}^\ell \Delta Z_k + S_{k-1} \frac{kt_{k-1} \Delta t}{m} \frac{\Delta Z_k}{\Delta Z_{k-1}} \right. \right.$$

$$\left. \left. + \Delta t \Delta Z_k \sum_{j \neq i} \nu_{ij} w_{k-1}^{\ell+1} \right) + \bar{S}_k K_{k-1} \frac{\Delta Z_k}{\Delta Z_{k-1}} \right]$$

$$D_k^\ell = n_k^\ell + P_k^{\ell+1} \Delta t \tag{22}$$

both computed at level k. Also

$$\lambda_i = \frac{\Omega_i^2 + \left(\sum_j \nu_{ij}\right)^2}{\Omega_i^2 \sin^2 I + \left(\sum_j \nu_{ij}\right)^2} \tag{17}$$

The finite difference equations, Eqs. (13) and (14), can be solved for the velocities $w_k^{\ell+1}$ at the end of the time step:

$$w_k^{\ell+1} = \frac{1}{\left[1 + \Delta t \lambda_i \sum_j \nu_{ij}\right]} \left\{ w_k^{\ell} - \frac{kT_k}{m_i} \frac{\Delta t}{\Delta Z_k} \left[\frac{n_{k+1}^{\ell+1} - n_k^{\ell+1}}{n_k^{\ell+1}} + \Gamma_k \Delta Z_k \right] \right.$$

$$\left. + \Delta t \sum_j \nu_{ij} w_{j_k}^{\ell+1} \right\} \tag{18}$$

This equation holds for both the ionic and neutral species using the above definitions of Γ_k and with $\lambda_i = 1$ for the neutral species. The total molecular and eddy diffusion flux at level k can then be written as

$$n_k^{\ell+1} w_k^{\ell+1} = \Phi_k^{\ell+1} = \frac{1}{\left[1 + \Delta t \lambda_i \sum_j \nu_{ij}\right]} \left\{ n_k^{\ell+1} w_k^{\ell} - \frac{kT_k}{m_i} \frac{\Delta t}{\Delta Z_k} \right.$$

$$\left[n_{k+1}^{\ell+1} - n_k^{\ell+1} \left(1 - \Gamma_k \Delta Z_k\right) \right]$$

$$\left. + n_k^{\ell+1} \Delta t \sum_{j \neq i} \nu_{ij} w_{j_k}^{\ell+1} \right\} - \frac{K_k}{\Delta Z_k} \left\{ n_{k+1}^{\ell+1} - n_k^{\ell+1} \right.$$

$$\left. (1 - \bar{\Gamma}_k \Delta Z_k) \right\} \tag{19}$$

where

$$\bar{\Gamma}_k = \frac{1}{T_k} \frac{\partial T}{\partial Z} + \frac{1}{\bar{H}} \quad \text{and } \bar{H} = \frac{kT}{\bar{m} g}.$$

A similar expression can be derived for $\Phi_{k-1}^{\ell+1}$ at level k-1.

3. THE FINITE DIFFERENCE EQUATIONS

If 1 denotes the grids on the time mesh and k the grids on the height mesh, then the continuity equations, Eq. (1), can be written in finite difference notation at the height level k as

$$\frac{n_k^{\ell+1} - n_k^{\ell}}{\Delta t} = P_k^{\ell+1} - n_k^{\ell+1} L_k^{\ell+1} - \frac{\Phi_k^{\ell+1} - \Phi_{k-1}^{\ell+1}}{\Delta Z_{k-1}} \tag{12}$$

where, for the sake of clarity, the subscript i has been dropped. Using the equations of motion, Eqs. (7) and (9), the $\Phi_k^{\ell+1}$ and $\Phi_{k-1}^{\ell+1}$ will be replaced in Eq. (12) with their equivalent expressions.

The equations of motion, Eq. (7), for the neutral species can be written in finite difference form at height level k as

$$\frac{w_k^{\ell+1} - w_k^{\ell}}{\Delta t} = -\frac{k\,T_k}{m_i}\left[\frac{n_{k+1}^{\ell+1} - n_k^{\ell+1}}{n_k^{\ell+1}\ \Delta Z_k} + \Gamma_k\right] - w_k^{\ell+1}\sum_j \nu_{ij}$$

$$+ \sum_{j \neq i} \nu_{ij}\, w_{jk}^{\ell+1} \tag{13}$$

and Eq. (9) for the ionic species as

$$\frac{w_k^{\ell+1} - w_k^{\ell}}{\Delta t} = -\frac{k\,T_k}{m_i}\left[\frac{n_{k+1}^{\ell+1} - n_k^{\ell+1}}{n_k^{\ell+1}\ \Delta Z_k} + \Gamma_k\right] - w_k^{\ell+1}\lambda_i\sum_j \nu_{ij}$$

$$+ \sum_{j \neq i} \nu_{ij}\, w_{jk}^{\ell+1}. \tag{14}$$

For the neutral species,

$$\Gamma_k = \frac{(1+\alpha_i)}{T}\frac{\partial T}{\partial Z} + \frac{1}{H_i} \tag{15}$$

and for the ionic species

$$\Gamma_k = \frac{1}{n_e}\frac{\partial n_e}{\partial Z} + \frac{2}{T}\frac{\partial T}{\partial Z} + \frac{1}{H_i} \tag{16}$$

In computing the transmittance of EUV radiation, O, O_2, and N_2 are considered as the primary absorbers. The photoionization rate coefficients are computed by using Eq. (54), where the sum is taken from 0.1 to 102.57 nm. Radiation below 15 nm is considered to be X-rays, and its ionization is partitioned among O, O_2, N_2, and N in accordance with Swider.[19]

The calculations also take into account the scattering of some radiation from the sunlit hemisphere into the nighttime hemisphere. These scattered radiations include Lyman α at 121.57 nm, Lyman β at 102.57 nm, the HE I line at 58.4 nm, and the HE II line at 30.4 nm. For simplicity, the amount of radiation that scatters into the dark hemisphere is taken to be a fraction of the direct noontime radiation at the particular altitude under consideration. These fractions are: Lyman α, 0.01; Lyman β, 0.004; HE I, 0.0011; and HE II, 0.001.

Finally, the contribution of cosmic rays to the photoionization rate coefficients is also included. This is simply[24]

$$q_i = 1 \times 10^{-17} n_i. \tag{55}$$

6.3 Electron Impact Ionization

Reactions 208 through 215 in the list of reactions in Appendix A are the energetic electron processes. The flux of energetic electrons appropriate to the calculations made here were supplied by Jasperse.[25] The ionization rate coefficients for the energetic electron reactions are computed from[9]

$$I = \int_{\xi} \sigma(\xi)\Phi(\xi)\, d\xi \tag{56}$$

where $\sigma(\xi)$ is the electron impact ionization cross section and $\Phi(\xi)$ is the energetic electron flux, both at energy ξ. The ionization cross section is given by[9]

$$\sigma(\xi) = \int_{I}^{\frac{\xi + I}{2}} S(\xi, W)\, dW \tag{57}$$

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24. Nicolet, M., and Aikin, A.C. (1960) The formation of the D region of the ionosphere, J. Geophys. Res. 65:1469-1483.
25. Jasperse, J.R. (1978) Private communication.

in which

$$S(\xi, W) = \left(\frac{q_o c_o f_o}{W^2}\right)\left(\frac{I}{W}\right)^P \left[1 - \left(\frac{W}{E}\right)^{\gamma}\right]^{\nu} \left(\frac{W}{\xi}\right)^{\Omega}$$

where I is the ionization threshold for a particular ion state, $q_o = 6.51 \times 10^{-14}$ $ev^2\ cm^2$, $c_o f_o$ is a constant, W is the excitation threshold energy in ev, and P, γ, ν, and Ω are parameters obtained from the best fit of Eq. (58) to experimental and theoretical results. Table B22 lists the values of these parameters used in the model presented here. The values of the rate coefficients computed for the energetic electron reactions are given in Table B23.

6.4 The Thermal Diffusion Factors

The thermal diffusion factors are assumed to be zero except for the following species: O(-0.27), O_2(+0.08), H(-0.39), H_2(-0.31), and He(-0.36). A discussion of the thermal diffusion factors can be found in Zimmerman and Keneshea,[26] from which source these values were taken.

7. A MID-LATITUDE ATMOSPHERE SIMULATION

The computer code presented here describes the distribution of 56 individual atmospheric species. Not all of them have the full coupled sets of equations in the system, however. Some gases in the atmosphere have such short chemical time constants that they will react chemically long before they can be moved out of a unit volume by any transport process. The vertical distribution of these species can be determined quite accurately by considering only the chemical reactions in which they are involved and ignoring any transport effects on them.

The species for which the coupled sets of mass and momentum equations are solved are:

O	H	N	CO	AR	H^+
O_2	H_2	$N(^2D)$	CO_2		HE^+
$O_2(^1\Delta g)$	HO_2	N_2			O^+
O_3	H_2O	NO			O_2^+
OH	H_2O_2	NO_2			NO^+
		N_2O			N^+

Those species whose distributions are determined neglecting transport are

26. Zimmerman, S.P., and Keneshea, T.J. (1976) The thermosphere in motion, J. Geophys. Res. 81:3187-3197.

$O(^1D)$, N_2^+, $O^+(^2D)$, and the electrons. The height distributions of all 56 species are computed over the entire altitude range, which is from 50 to 400 km.

In addition, the vertical distributions of the following species are computed over a reduced altitude range. The temporal variation of these species is also computed with the transport term removed from their continuity equations. The distributions of these species are computed between 50 and 120 km because, above this altitude, they do not exist in significant quantities. These species are:

O^-	O_4^+	$H_5O_2^+.CO_2$	HNO_2
O_2^-	NO_2^+	$O_2^+.H_2O$	NO_3
O_3^-	$H^+.H_2O$	$NO^+.H_2O$	
O_4^-	$H^+.(H_2O)_2$	$NO^+.(H_2O)_2$	
NO_2^-	$H^+.(H_2O)_3$	$NO^+.(H_2O)_3$	
NO_3^-	$H^+.(H_2O)_4$	$NO^+.CO_2$	
CO_3^-	$H_3O^+.N_2$		
CO_4^-	$H_3O^+.OH$		
	$H_3O^+.CO_2$		

Neither negative cluster ions nor metallic ions are considered here. To ensure that the atmosphere remains electrically neutral, one of the negatively charged species is always computed from the imposed condition of balance of charge. Below 120 km, where there are several types of negative ions in addition to the electrons, the most abundant negatively charged species is always computed from conservation of charge. That is, its concentration is computed as the difference between the sum of all the positive and the sum of all the other negative ions. Above 120 km, where the only negatively charged particles are the electrons, their concentration is always set equal to the sum of all the positive ions.

7.1 Initial Conditions

Throughout the development of the time-dependent solution of Eq. (1), the temperatures and the turbulent diffusion coefficients are held fixed at all altitudes in the code presented here. For the simulation developed in this report, both of these parameters were derived from data obtained during the ALADDIN I experiments of

20 November 1970.[27,28] The temperatures shown in Figure 1 between 50 and 125 km were taken from measurements of Theon and Horvath.[29] From 125 to 160 km, the measurements of Golomb[27] were used. Above 160 km, the temperatures were taken from the 900 K exospheric temperature winter model of the U.S. Standard Atmosphere Supplements, 1966. A discussion of the turbulent diffusion coefficients obtained from the ALADDIN I experiments can be found in Keneshea et al.[8] The coefficients presented there represent the minimum turbulent diffusion coefficients determined from the observations on the chemical trails. Following arguments given there, the turbulent diffusion coefficients (Figure 2) used in these calculations are three times larger than those presented in that paper.

Keneshea et al[8] found that stability considerations required that the height steps in the mesosphere not exceed 150 m. In the thermosphere, however, stability could be maintained with somewhat larger height steps. Therefore, to reduce the amount of core storage required for saving the numerous arrays as well as to reduce the amount of computer time per solution, a variable height step array was used. From the lower boundary, 50 km, up to 90 km, the height steps were fixed at 150 m. From 90 km up to the upper boundary, 400 km, the height steps were computed by assuming that they were proportional to the pressure scale height of the atmosphere. This produced an altitude array with 692 grid points, with the maximum height step at the upper boundary of about 1.5 km.

The initial concentration and average velocity profiles were taken from the final solution of an unpublished simulation using turbulent diffusion coefficients one third smaller than those shown in Figure 2. A discussion of a method for establishing initial concentrations on all the species is given in Keneshea et al[8] for a situation where no previous information is available on the vertical distribution of the various species.

The solutions to Eqs. (1) and (18) are started at noon of solution day 1 with the above initial values. Because this is a real time-dependent calculation which takes into account the daily variation of the solar zenith angle, no truly steady state condition on the species concentrations is ever achieved. The calculations are continued, therefore, until all species reproduce their concentrations diurnally at all

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27. Rosenberg, N.W., Golomb, D., Zimmerman, S.P., Vickery, W.K., and Theon, J.S. (1973) The ALADDIN Experiment-Part 1, Dynamics, Space Research XIII, Akademie-Verlag, Berlin, 435-439.

28. Philbrick, C.R., Narcisi, R.S., Good, R.E., Hoffman, H.S., Keneshea, T.J., Macleod, M.A., Zimmerman, S.P., and Reinish, B.W. (1973) The ALADDIN Experiment-Part II, Composition, Space Research XIII, Akademie-Verlag, Berlin, 441-448.

29. Theon, J.S., and Horvath, J.J. (1972) ALADDIN neutral atmosphere measurements, Trans. Am. Geophys. Un. 53:463.

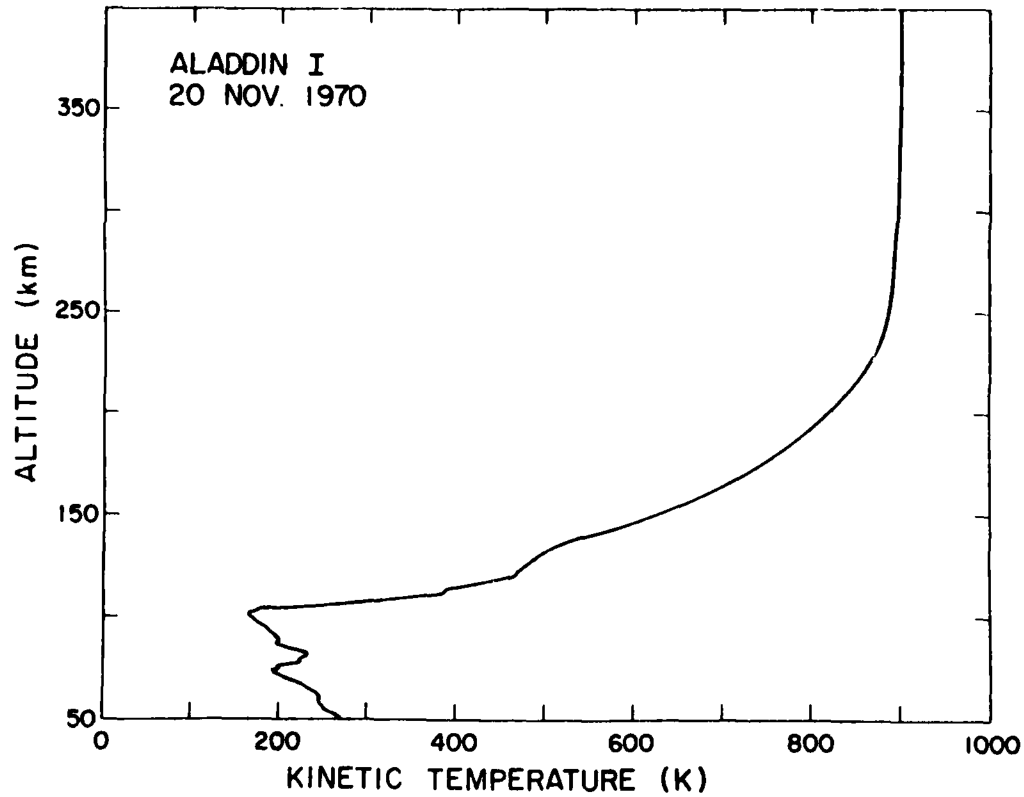

Figure 1. The Static Temperature Profile

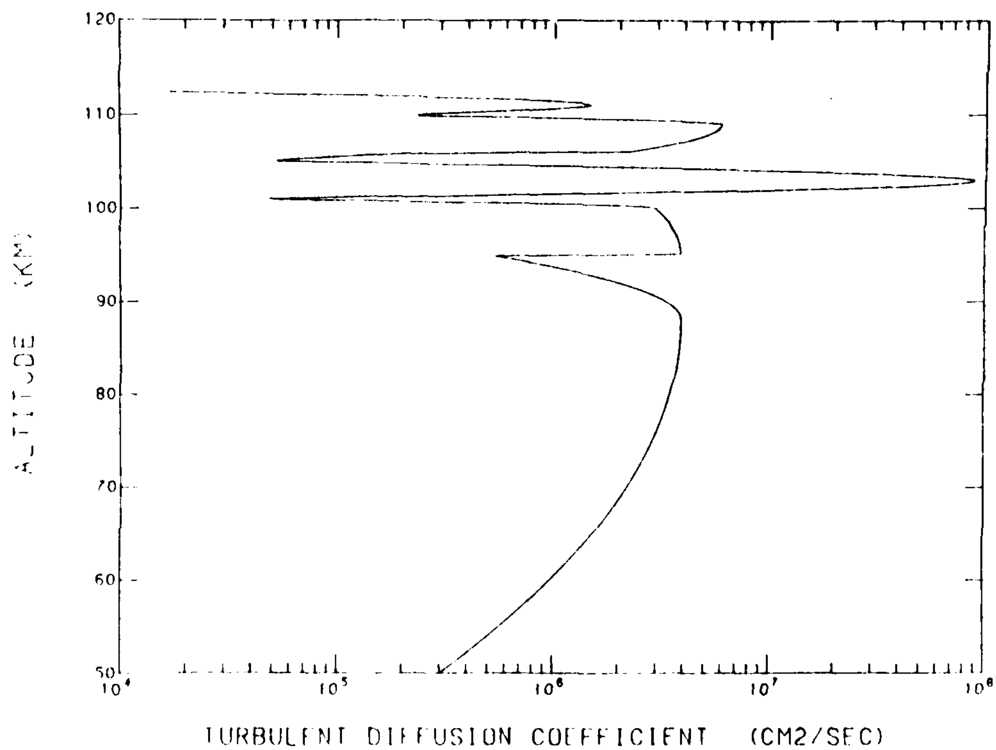

Figure 2. The Turbulent Diffusion Coefficients as Determined From the Chemical Release Data Obtained From the ALADDIN I Experiments

altitudes to within 1 percent. This condition of diurnal reproducibility is generally arrived at after about 20 solution days.

7.2 Thermospheric Results

The results to be discussed here were taken from the final diurnal cycle of the calculations when the major and most of the minor species at all altitudes were varying by no more than 1 percent from values achieved 24 hours earlier. The vertical distribution of the major species N_2, O_2, O, and argon are shown in Figure 3. In this one-dimensional temperature-independent calculation, N_2, O_2, and argon show no diurnal change, having arrived at an equilibrium with the invariant temperature given in Figure 1. Also displayed in Figure 3 is the fixed profile of helium used in these calculations.

Because of the constant temperature profile used here, atomic oxygen also shows no diurnal variation in the thermosphere down to about 120 km. Below this altitude, the chemistry dominates the production (dissociation of O_2) and loss of this species.[7] Thus, we observe in Figures 3 and 4 large diurnal variations of atomic oxygen in the mesosphere.

Presented in Figure 5 are the mesosphere and lower thermosphere noontime profiles of the remaining important neutral species. Carbon dioxide is invariant in the mesosphere and lower thermosphere up to about 140 km. Above this altitude, the diurnal variation of the photodissociation process becomes important in the determination of the carbon dioxide concentrations. The variation of the CO_2/Ar ratio calculated here is shown in Figure 6 and compares well to that determined from atmospheric measurements of Trinks and Fricke.[30]

Isodensity contour plots of the minor neutral species that exhibit a large diurnal variation are shown in Figures 7 to 11. The numbers in all the isodensity plots presented here are the common logarithms of the concentrations. These species, for the most part, are important in the determination of the electron density throughout the atmosphere. Above about 100 km, the charge distribution is dominated by NO^+, O_2^+, O^+, He^+, and H^+. Thus, the resultant thermospheric charge balance follows the chain created primarily by the time-dependent distributions of the neutral species N, NO, and $N(^2D)$ as shown in Figures 7, 8, and 9, respectively. The other neutral thermospheric species in the code have little effect in determining the charge distribution.

The ion and electron isodensity contours determined from these neutrals are shown in Figures 12 to 19. As expected, the dominant positive ion in the upper

30. Trinks, H., and Fricke, K.H. (1978) Carbon dioxide concentrations in the lower thermosphere, J. Geophys. Res. 83:3883-3886.

thermosphere is the O^+ ion. The electron density distribution, therefore, follows the distribution of this ion very closely. Also displayed in Figure 19 is the altitude profile of f_oF_2, the space-time dependence of the peak of the electron density along with the measurements of this parameter by Evans.[31] The correspondence is quite good, clearly demonstrating the midday altitude and amplitude and the night-time transition to higher altitudes and lower amplitudes. No horizontal winds are included in this one-dimensional simulation; yet, we obtain an excellent representation of the F_2 layer maximum.

Our rationale, then, is that the contribution of chemical production and loss coupled to the convergences and divergences created in our calculations are the main mechanisms that control the amplitude and altitude variation of the F_2 layer maximum. The question that arises from this one-dimensional calculation, which apparently gives good agreement with some F_2 layer maximum measurements, is: What is the effect of horizontal winds? The answer to this question may be inferred from measurements of Reinisch,[32] who determined the time dependence of f_oF_{max} for another period from ionosonde measurements. His results for f_oF_{max} are shown in Figure 20. We observe a smaller peak ionization amplitude than Reinisch does, but, generally, the time dependence of his F_2 layer maximum follows our calculations quite well. Also observed are the large variations that presumably arise from local winds that show multireversals during the measuring period. The point we wish to stress is that ionization calculated from internally determined neutral species distributions does result in an internally consistent F_2 layer ionization behavior that compares well with some of the observed ionic behavior. An example of this is the recent work of Sethia et al,[33] who have performed calculations similar to ours but include the effects of horizontal winds. They determine the distributions along magnetic field lines, while we calculate in the vertical direction with the magnetic field entering by way of the Larmor frequency and the magnetic dip angle. They input the neutral atmosphere, while we calculate it as an internally consistent integral part of the model.

In Figure 21, we have superimposed upon our calculation of the total electron content that taken from Figure 3, model 4 (no winds) of Sethia et al.[33] We observe that the shapes of the distributions are almost identical between the two one-dimensional models. The differences in magnitude can be attributed to the

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31. Evans, J.V. (1971) Observations of F-region vertical velocities at Millstone Hill-I. Evidence for drifts due to expansion, contraction, and winds, Radio Sci. 6:609-626.

32. Reinisch, B. (1983) Private communication.

33. Sethia, G.C., Bailey, G.J., Moffett, R.J., and Hargreaves, J.K. (1983) The effects of neutral air winds on the electron content of the mid-latitude ionosphere and protonosphere in summer, Planet. Space Sci. 31:377-387.

different conditions under which the models were computed. We also compare (Figure 22) the total electron content to some measurements taken at Boulder by Sethia et al[33] as shown in their Figure 8 (July 2, no wind, and July 5, with wind). Again, the shape of our distribution compares well with the measured profiles. For those cases where the wind amplitude is not very large, the contribution of the $\vec{v} \times \vec{B}$ mechanism is very much smaller than that of the chemistry. We make another comparison with the work of Poulter et al[34] shown in Figure 23. Here we examine the total electron content for measurements at Boulder and Lancaster (Figure 5 of Poulter et al), and again quite good agreement is seen between the shape of the distributions from the chemical-transport one-dimensional model and the measurements. The observed differences between the Boulder and the Lancaster curves result from the differences in the raypath geometries. Comparison is also quite good between our calculations and the f_oF_2 measured by Kohl et al[35] and discussed by Risbeth.[36]

We reiterate the point we wish to stress (see also Rush et al[37]): A comprehensive, one-dimensional, time-dependent ion-neutral model demonstrates excellent agreement with measurements of electron densities. The inclusion of the effects of winds is necessary, however, to explain the deviation of the ions and/or electrons from their equilibrium distributions, which significantly vary over the diurnal cycle.

7.3 Mesospheric Results

The ionization in the mesosphere is much more complex than the ionization in the thermosphere. Ablating meteorites create long-lived atomic ions from the metallic species present in the atmosphere. These metallic ions are significant and are observed to be the dominant ions in sporadic E layers. Their chemistry, however, is not well known. For this reason and because large amounts of additional computer memory and time would be required for their inclusion in the transport mode, they have been omitted from the calculations presented here. This omission might explain why our electron density is somewhat low in the 90 to 110 km

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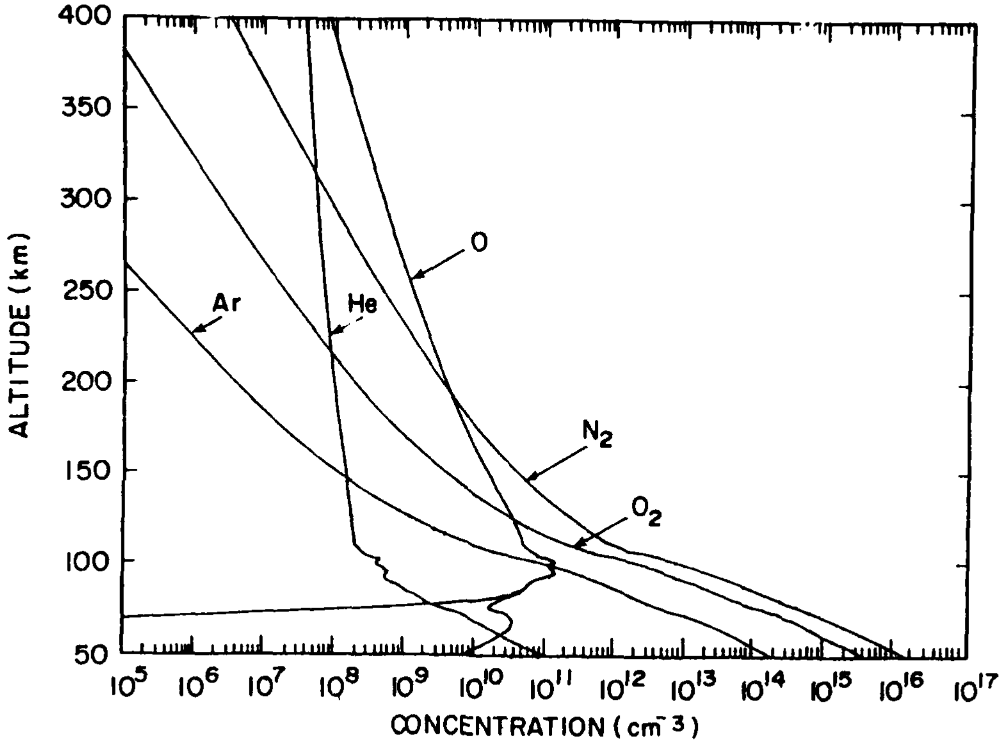

Figure 3. The Time Invariant Height Profiles of N_2, O_2, Helium, and Argon. Above about 100 km, atomic oxygen is also invariant. Below 100 km, the noon and midnight profiles of atomic oxygen are shown

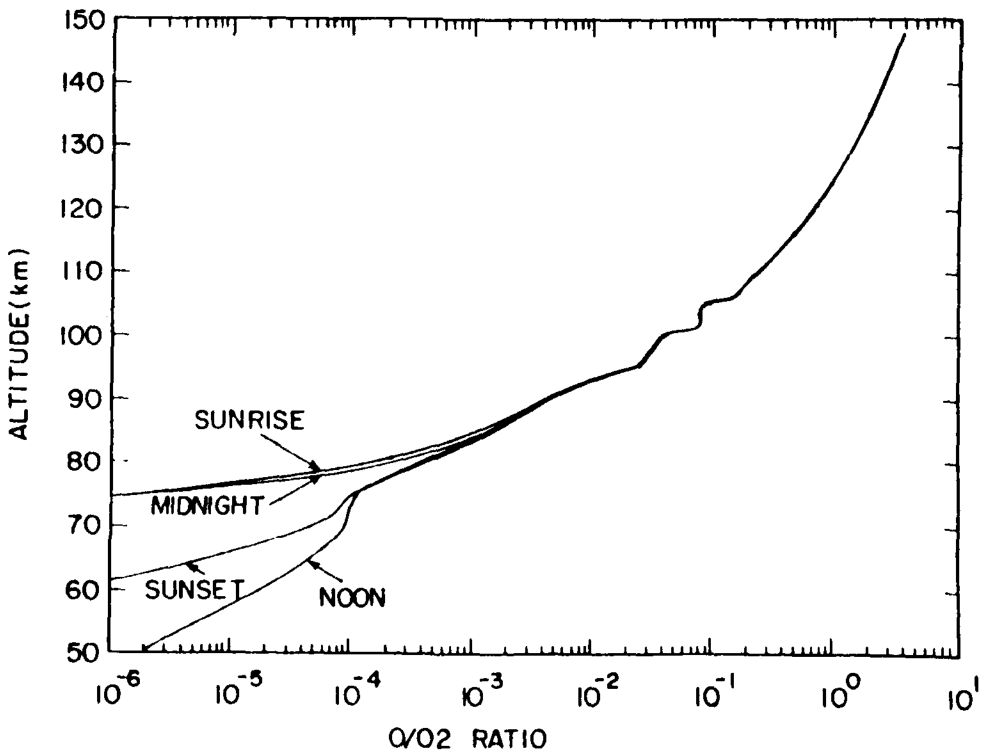

Figure 4. The Ratio of Atomic to Molecular Oxygen at Four Different Times During the Day. These curves reflect the diurnal variations of atomic oxygen in the mesosphere

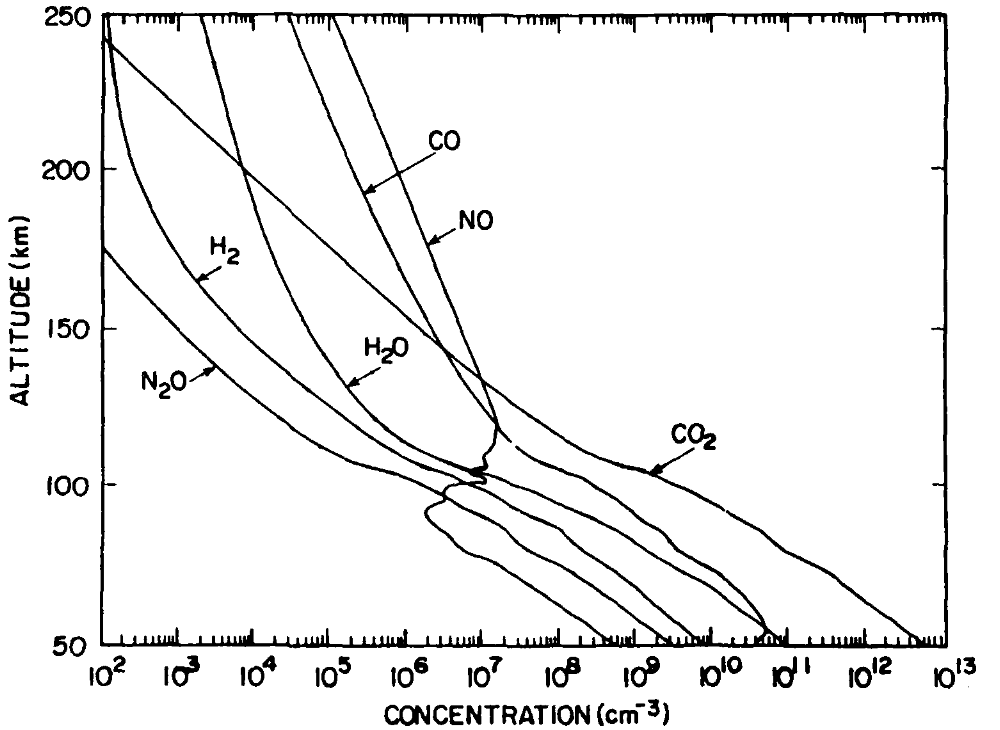

Figure 5. The Noontime Profiles of H_2, H_2O, NO, N_2O, CO, and CO_2 in the Mesosphere and Lower Thermosphere

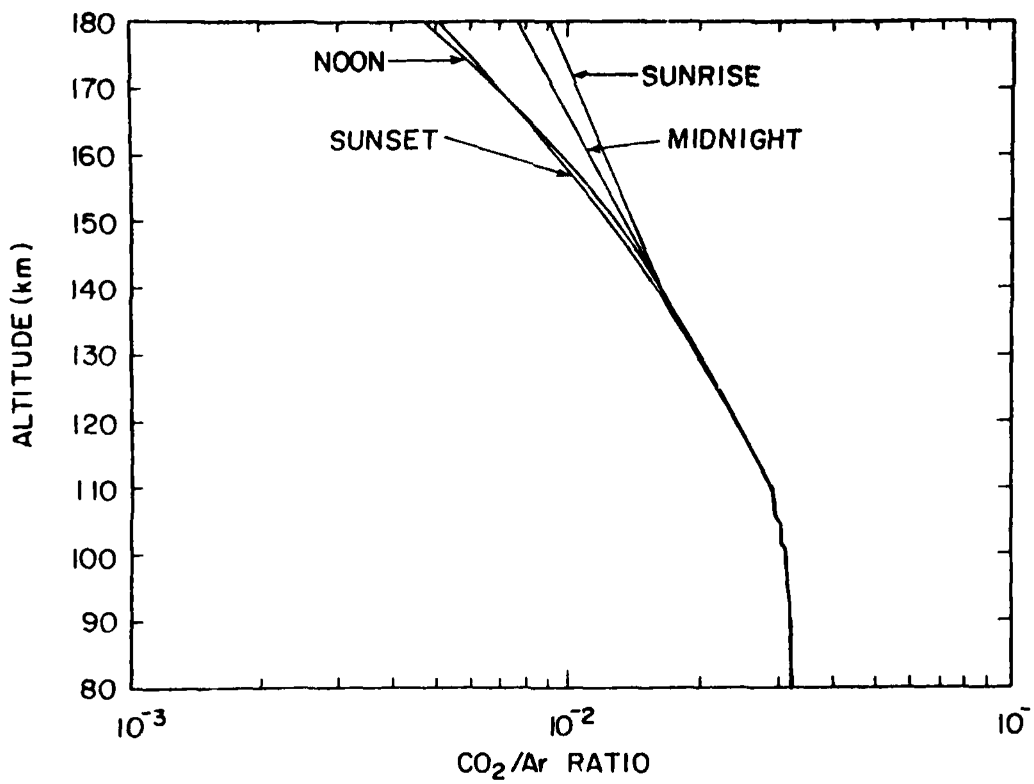

Figure 6. The Ratio of Carbon Dioxide to Argon at Four Different Times During the Day. The curves show the diurnal variation of carbon dioxide in the lower thermosphere

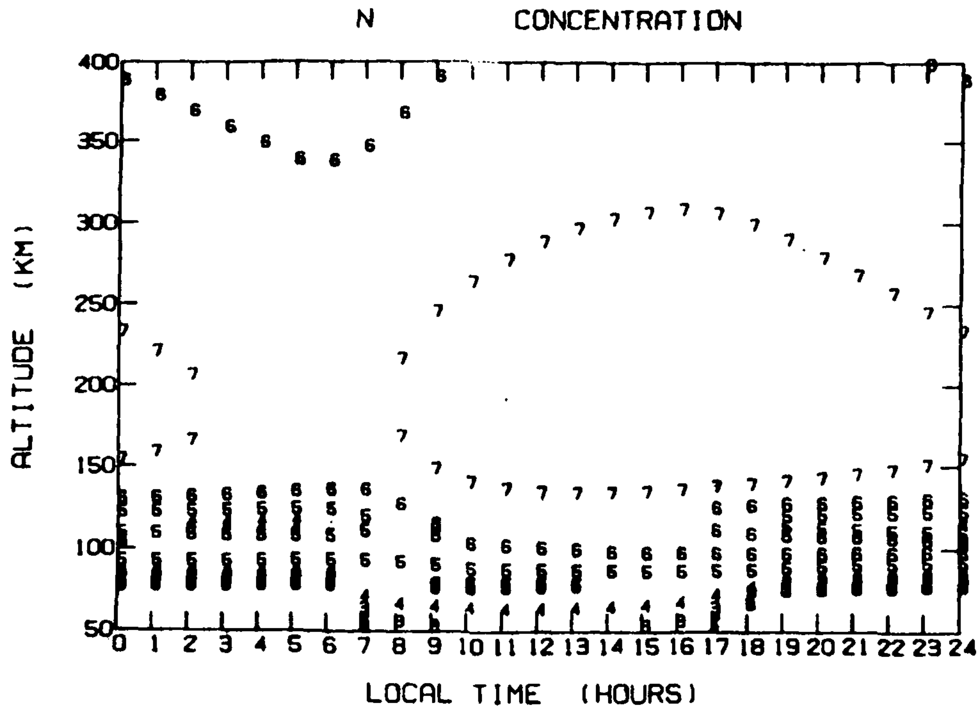

Figure 7. The Iso-Density Contours for Atomic Nitrogen

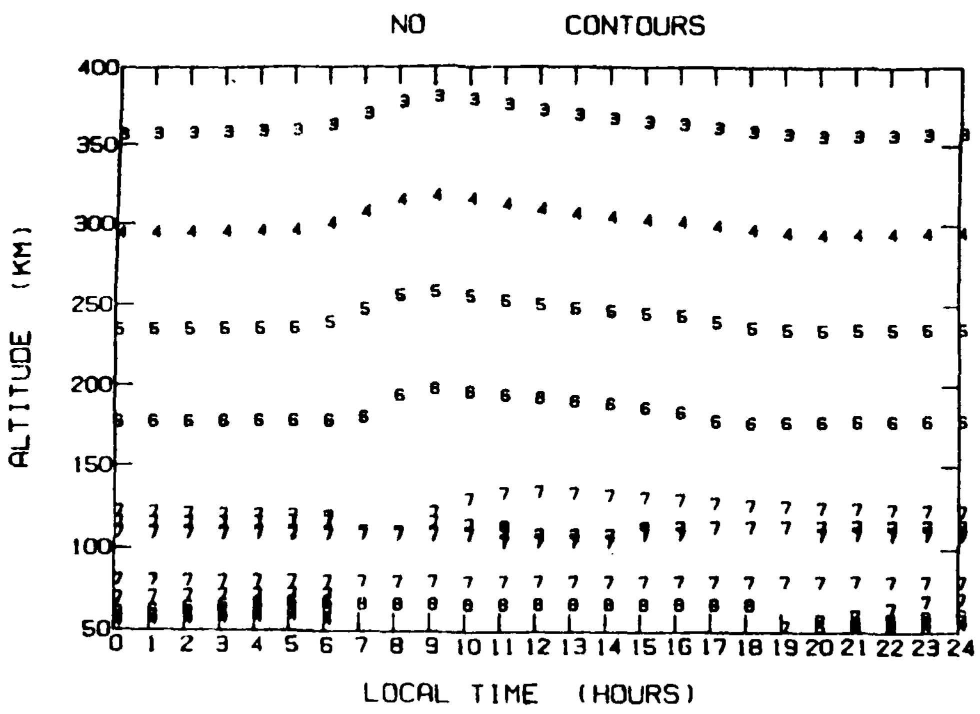

Figure 8. The Iso-Density Contours for Nitric Oxide

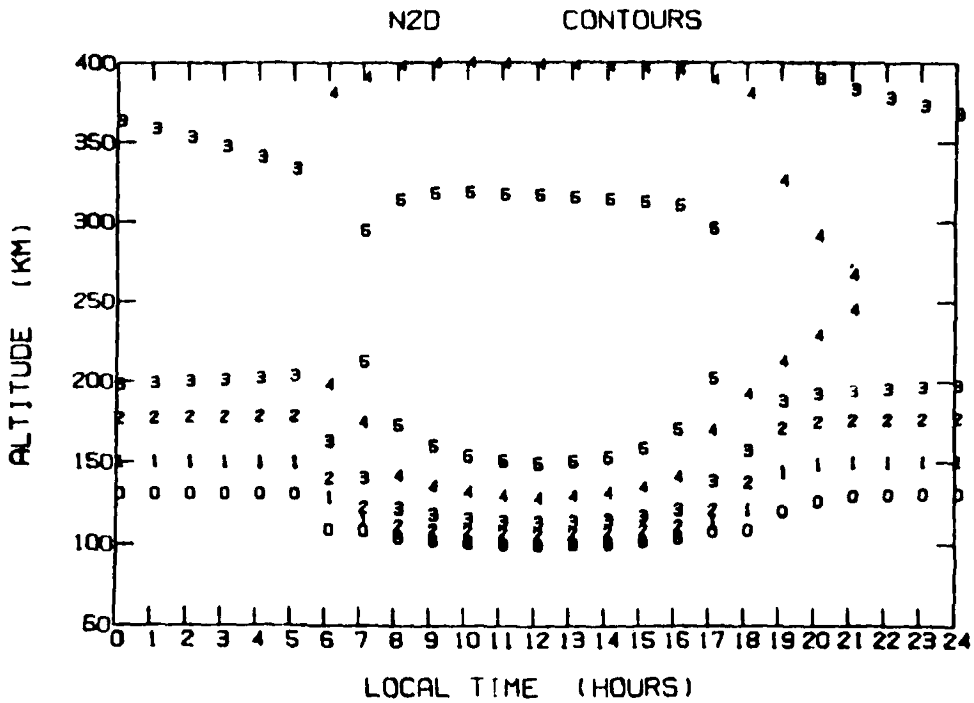

Figure 9. The Iso-Density Contours for N^2D

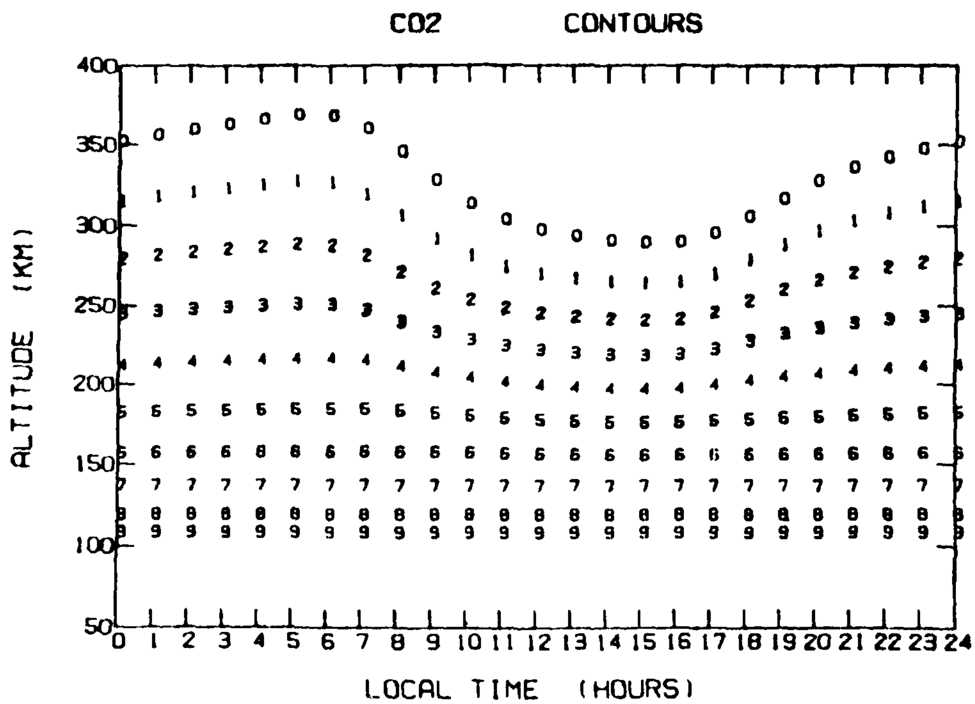

Figure 10. The Iso-Density Contours for Carbon Dioxide. The contours indicate a lack of any diurnal variation for this species below 150 km

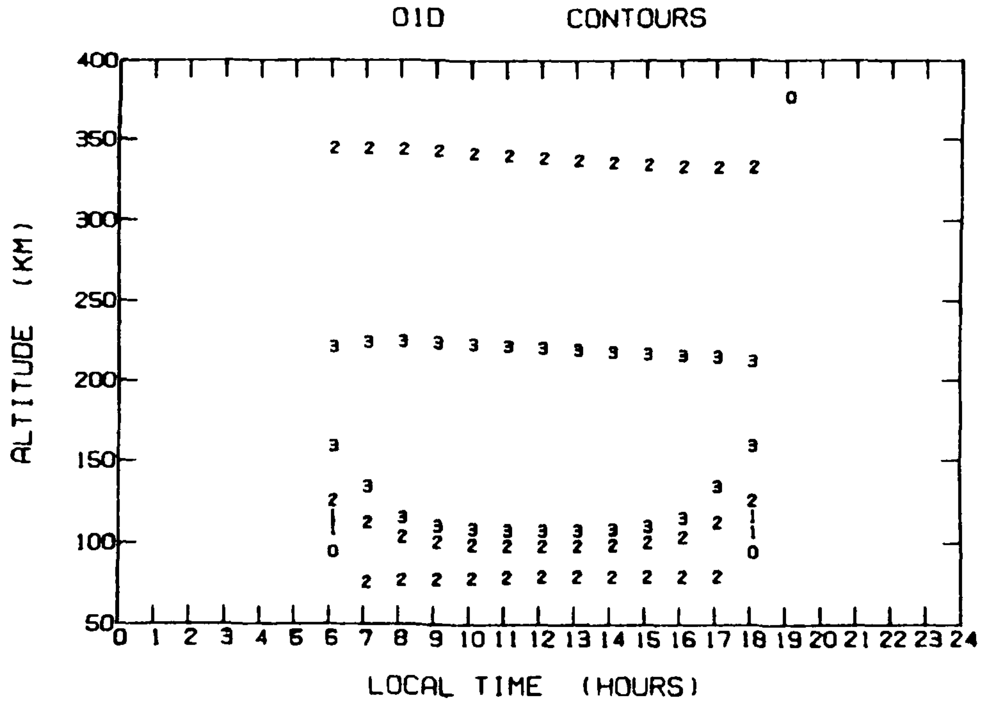

Figure 11. The Iso-Density Contours for O^1D

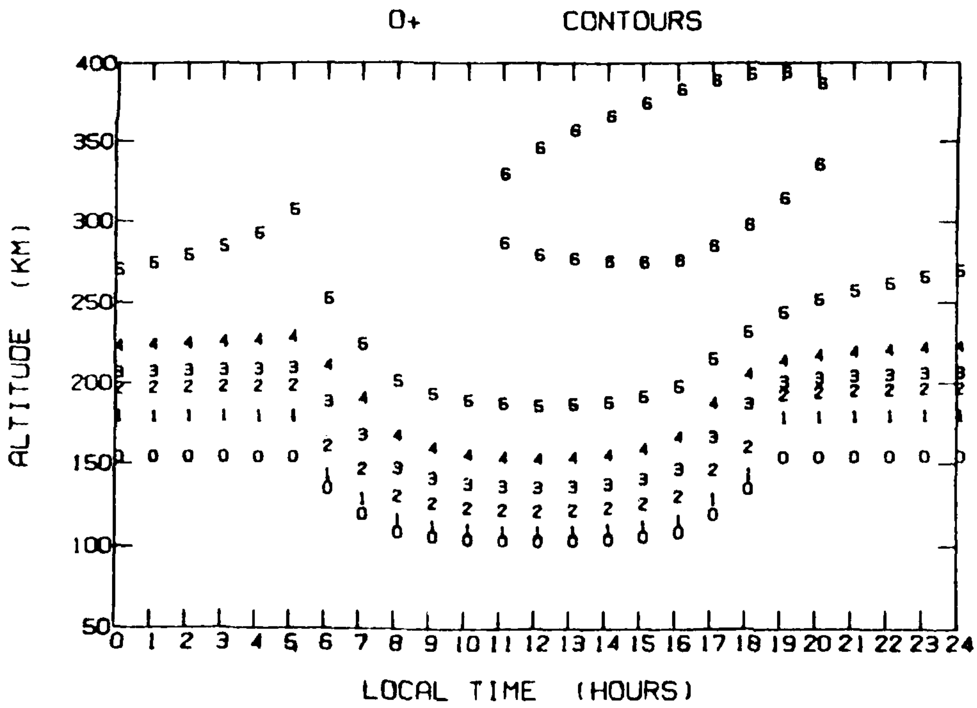

Figure 12. The Iso-Density Contours for O^+. The contours show the daytime F-layer peak ionization in excess of 10^6 cm^{-3}

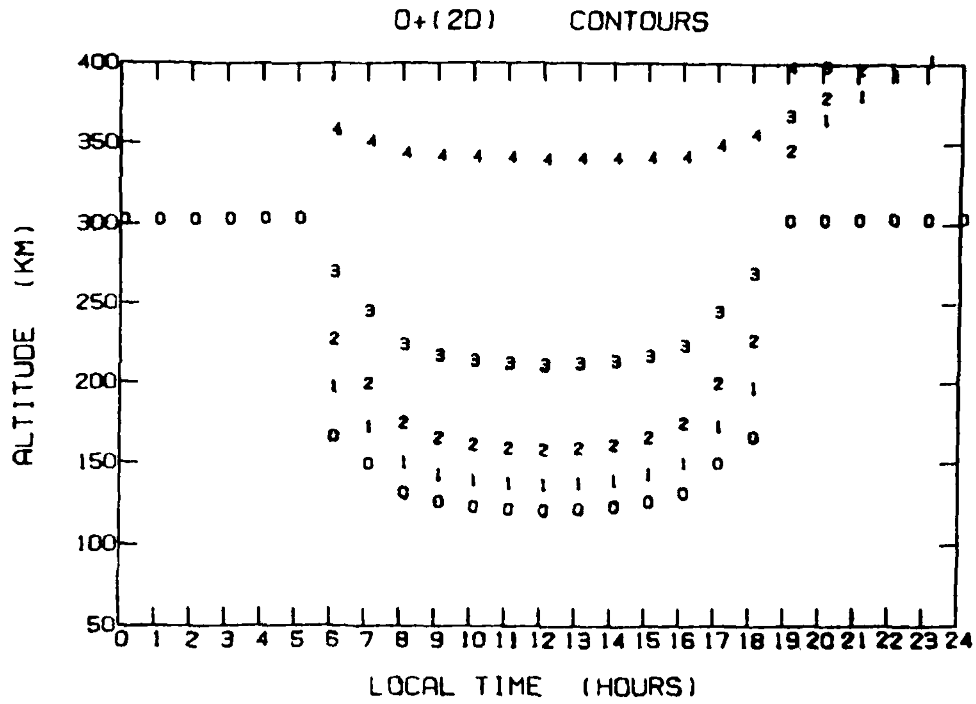

Figure 13. The Iso-Density Contours for $O^+(^2D)$

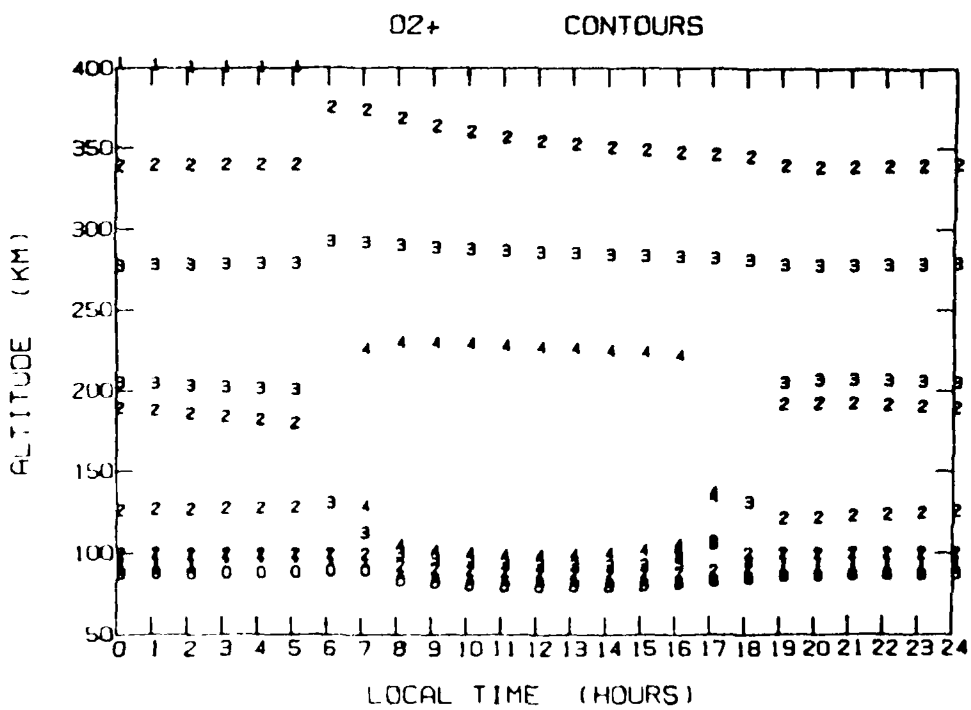

Figure 14. The Iso-Density Contours for O_2^+

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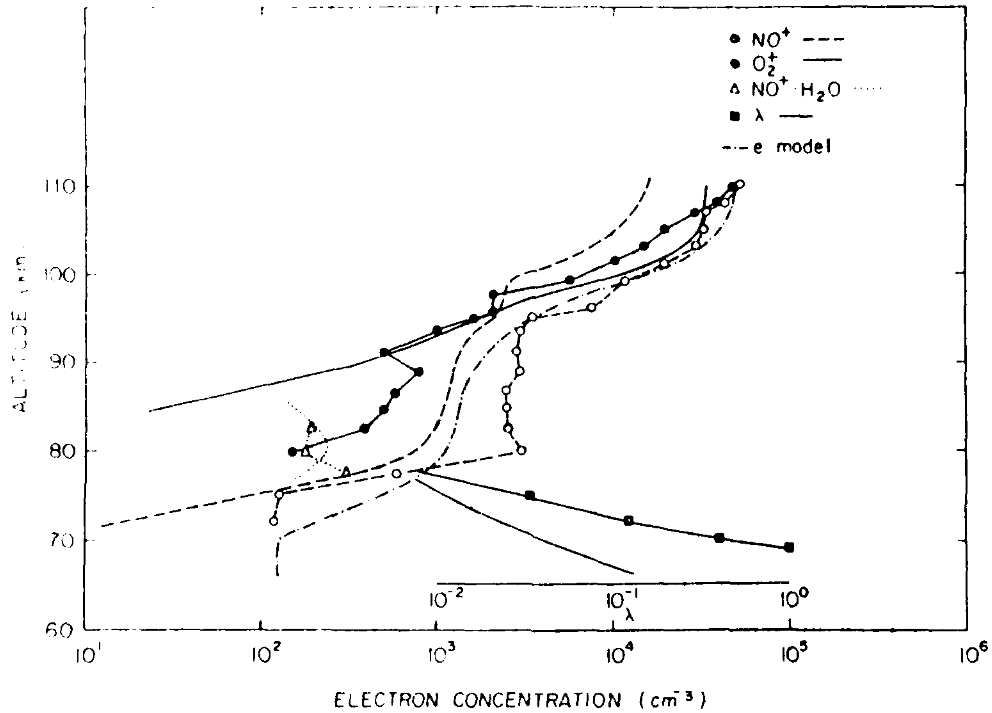

Figure 35. Altitude Profiles of NO_2^+, O^+, $NO^+ \cdot H_2)$, Electrons and λ, the Ratio of Negative Ions to Electrons. The curves with symbols are the measurements reported by Torkar and Freidrich.[40] The curves without symbols are from this model

ions than the distribution determined in the Winter Anomaly campaign. However, there is a key reaction in the production of O_2^- in the early part of the negative ion chemistry scheme used by Viggiano et al,[43] namely

$$O_2 + O_2 + e \rightarrow O_2^- + O_2,$$

They used a rate coefficient of about 1×10^{-29} cm^{-6} sec^{-1} for this reaction. Phelps,[44] however, cites a rate coefficient of $1.4 \times 10^{-29}(300/T) \exp(-600/T)$ for this reaction. This value would result in a theoretical altitude distribution of the negative ions similar to that in our calculations. Therefore, these data of Arnold et al[41] still are unexplained by theory and leave us with D-region negative ions that are still largely not understood.

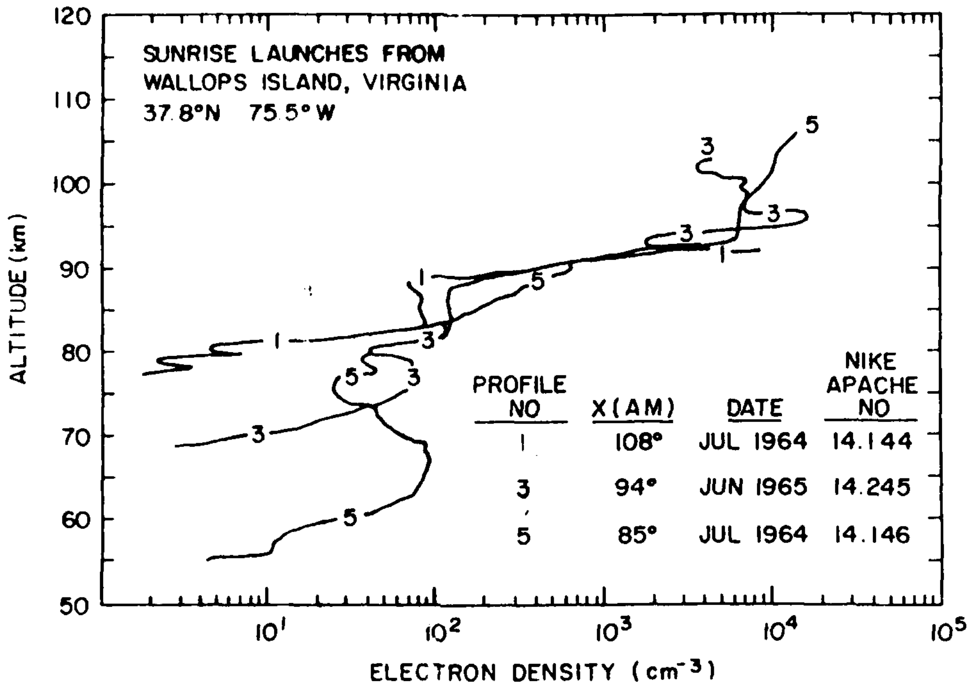

Figure 33. Altitude Profiles of Electron Density From Three Rocket Experiments at Wallops Island by Mechtly and Smith[39]

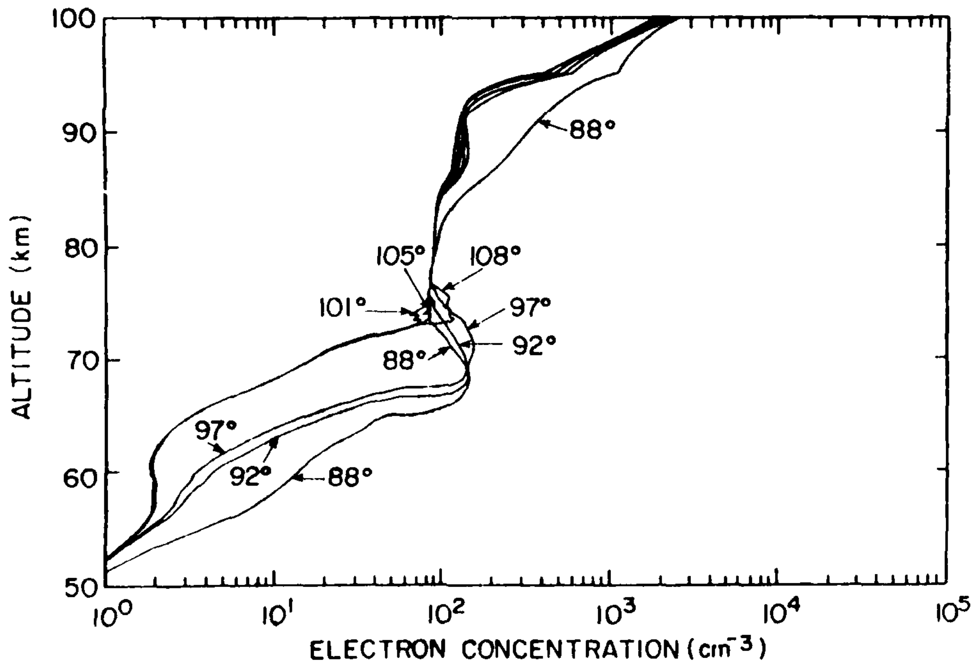

Figure 34. Altitude Profiles of the Electron Concentration From This Model at Several Zenith Angles During Sunrise

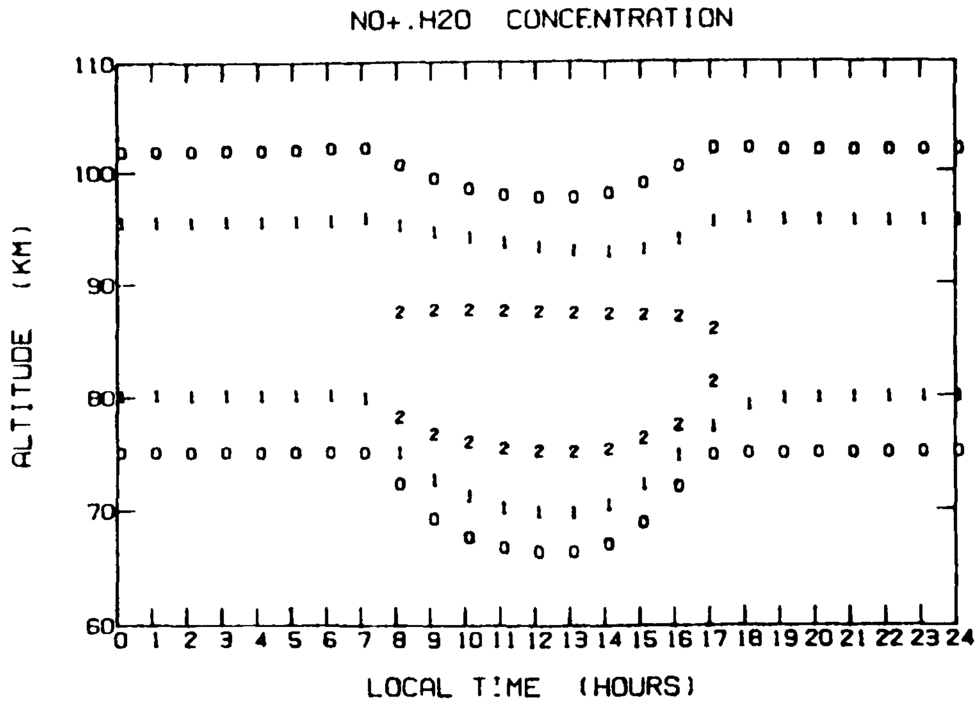

Figure 31. The Iso-Density Contours for $NO^+ \cdot H_2O$ in the Mesosphere

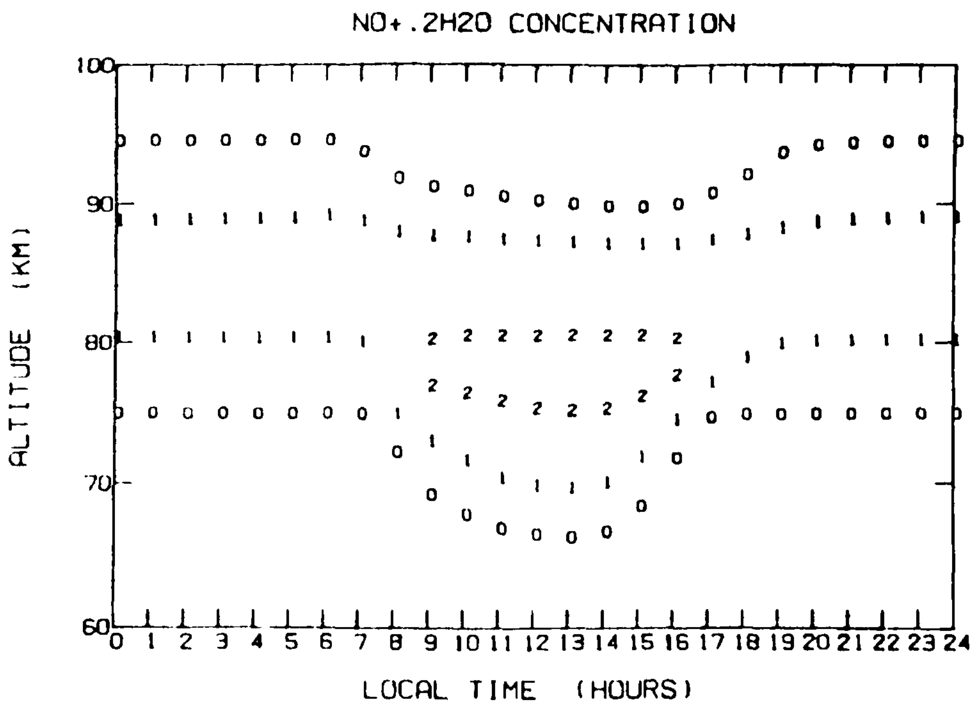

Figure 32. The Iso-Density Contours for $NO^+ \cdot (H_2O)_2$ in the Mesosphere

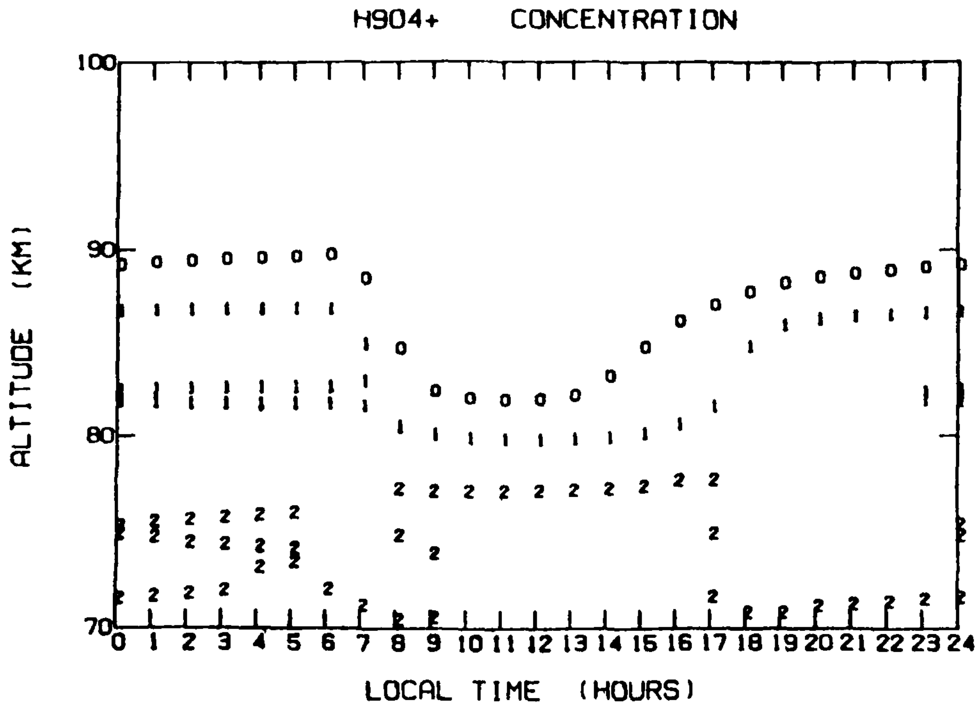

Figure 29. The Iso-Density Contours for $H_9O_4^+$ in the Mesosphere

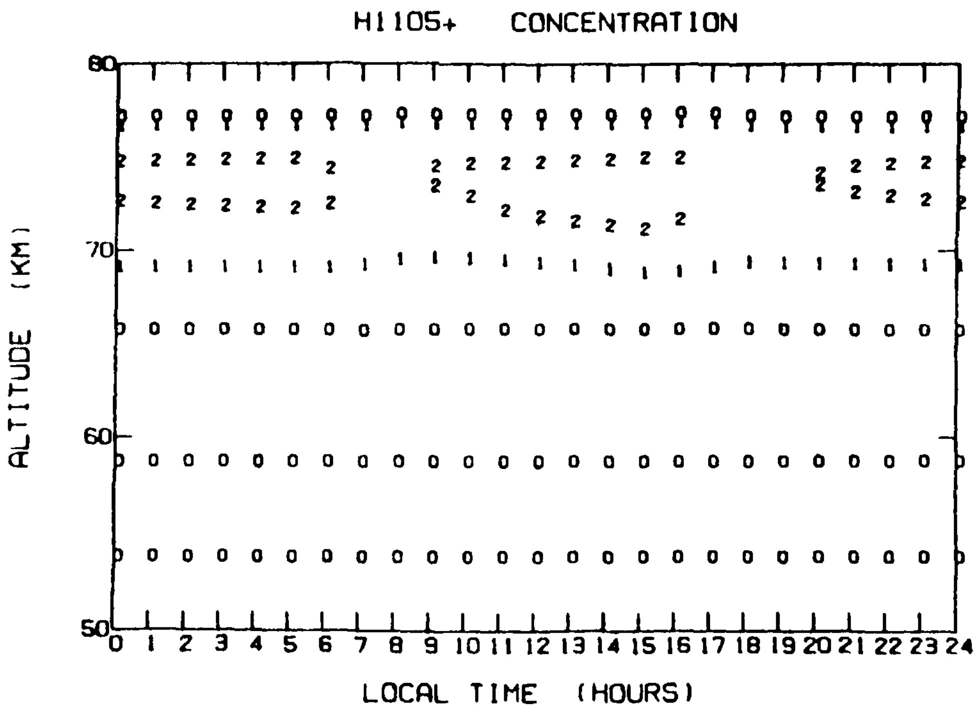

Figure 30. The Iso-Density Contours for $H_{11}O_5^+$ in the Mesosphere

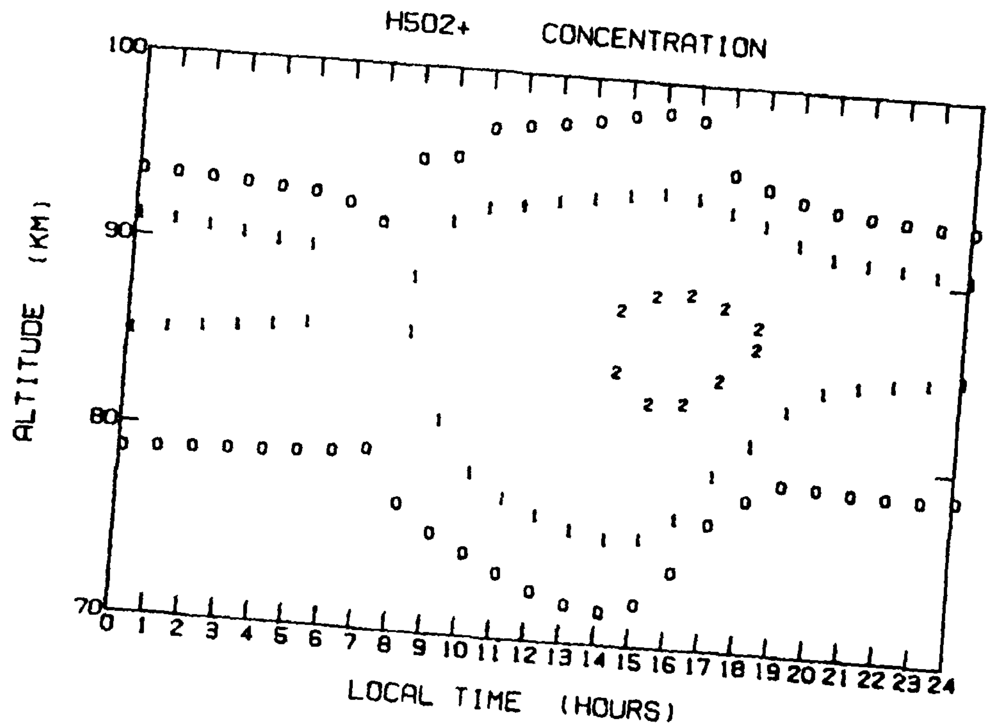

Figure 27. The Iso-Density Contours for $H_5O_2^+$ in the Mesosphere

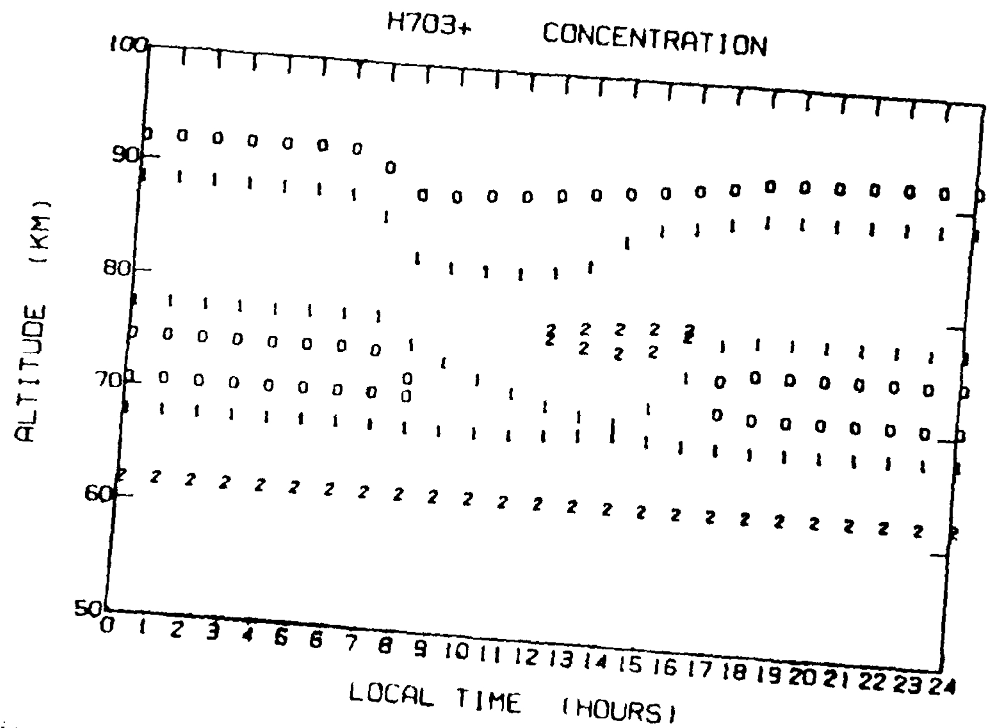

Figure 28. The Iso-Density Contours for $H_7O_3^+$ in the Mesosphere

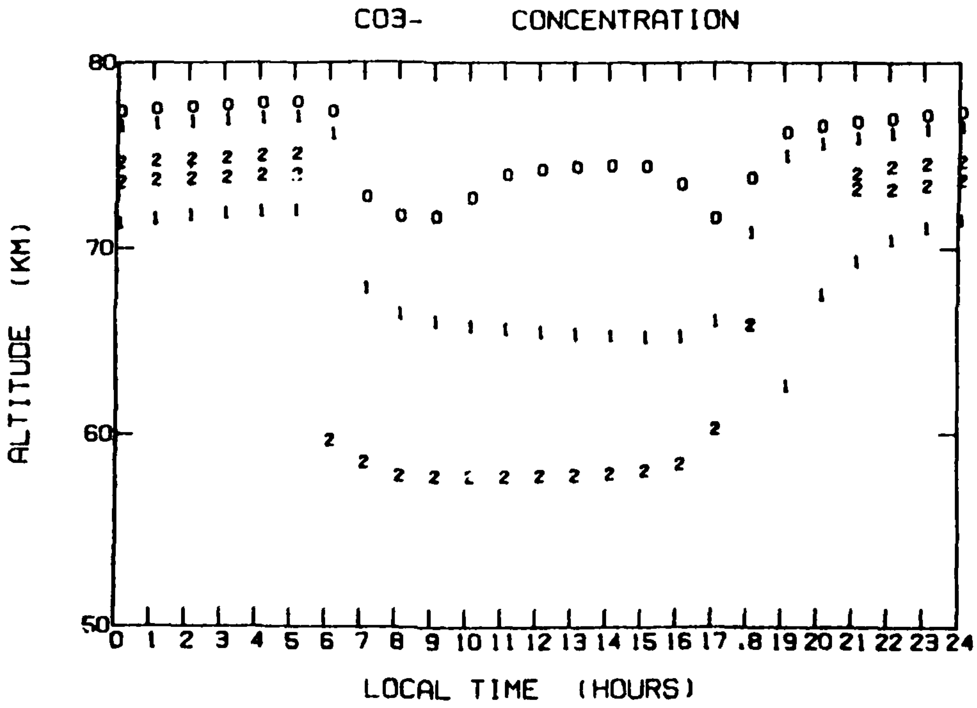

Figure 25. The Iso-Density Contours for CO_3^- in the Mesosphere

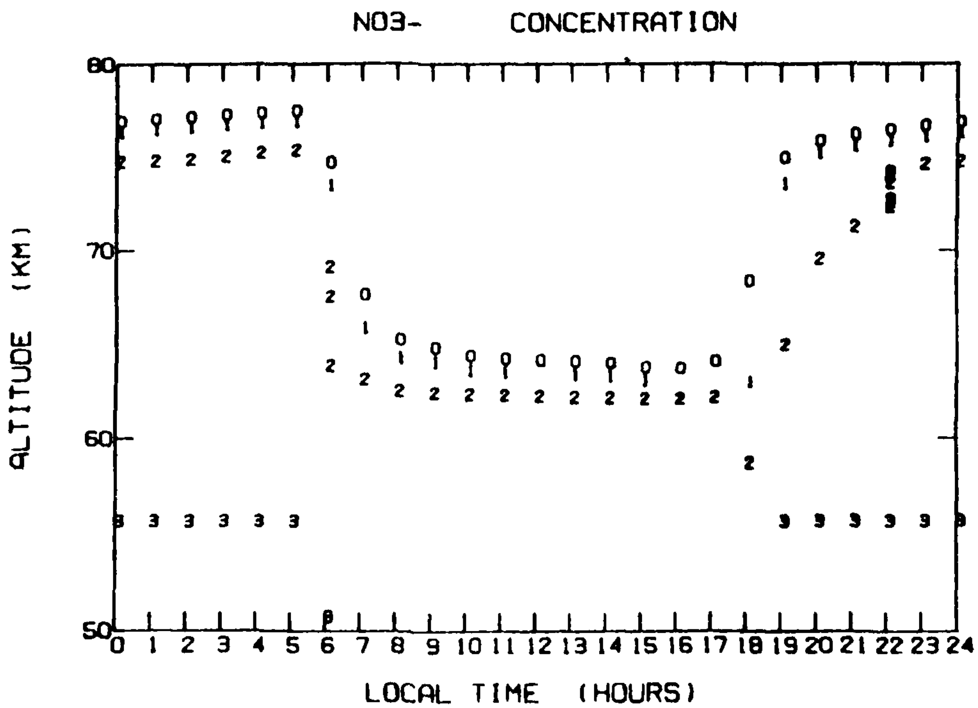

Figure 26. The Iso-Density Contours for NO_3^- in the Mesosphere

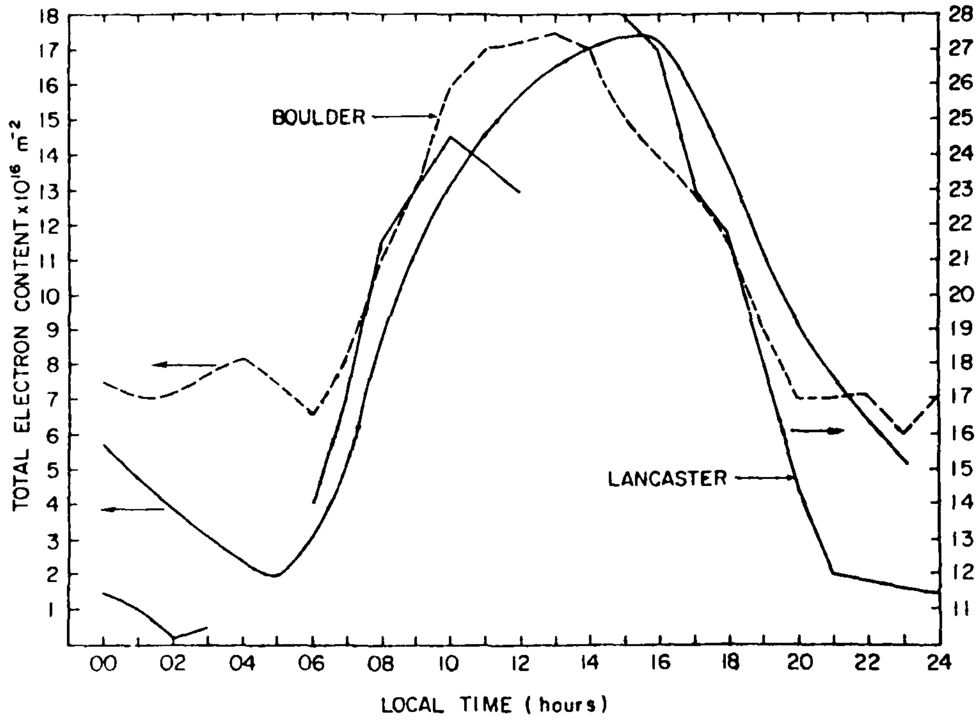

Figure 23. The Total Electron Content. The continuous curve is for this model. The dashed and broken curves are the measurements of Poulter et al.[34]

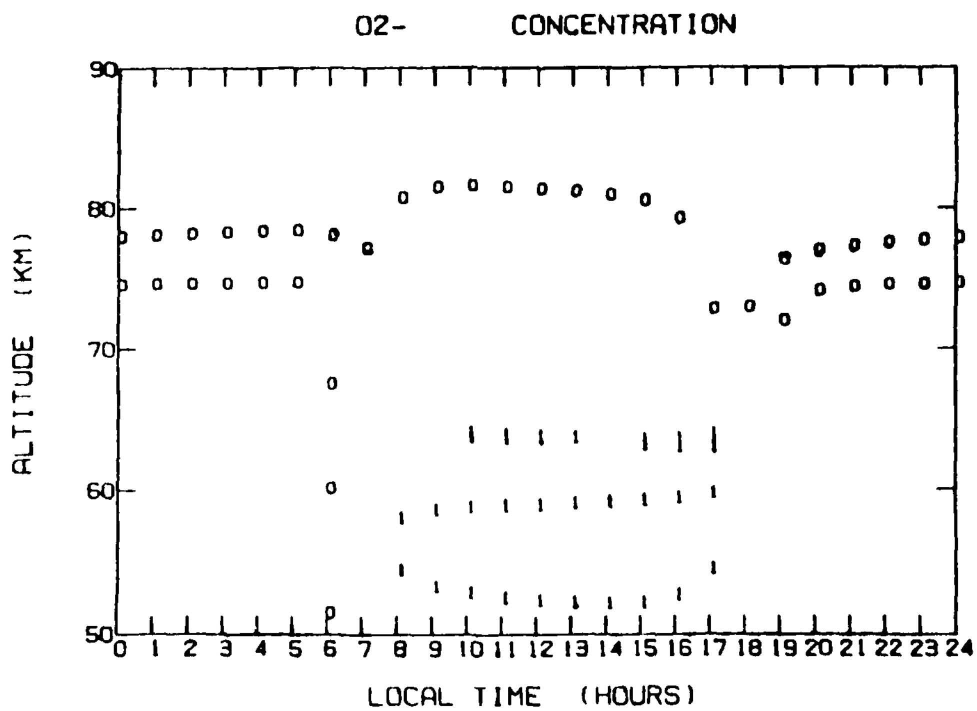

Figure 24. The Iso-Density Contours for O_2^- in the Mesosphere

region (Figure 19) compared to the work of Solomon et al.[38] Below 90 km, the cluster and negative ions change the effective electron density to a point where it disappears completely between 60 and 70 km.

The isodensity contours for the negative ions and the positive water cluster ions for the chemistry given in Appendix A are displayed in Figures 24 to 32. Isodensity plots for the remaining positive and negative mesospheric ions are not presented here because these ions never achieve a concentration greater than 1 cm^{-3} at any time during the diurnal cycle. Of course, the dominant negative ions in the mesosphere are apparently the cluster ions. Because their chemistry is still not fully understood, they have not been included in this work.

Particular emphasis is given to the sunrise period and a comparison of our electron density profiles with sequential measurements made at Wallops Island by Mechtly and Smith.[39] For clarity, the measured profiles are displayed in Figure 33, and our calculated profiles are shown in Figure 34. In some instances, the comparison of theory with experiment is fairly good. Substantial differences, however, do exist. These are, in part, a result of the differences in the seasons (summer for the measurement and winter for the model).

In explaining the D and lower E regions of the ionosphere, there is a question, still not completely answered, of the distribution of the positive and negative ions. To exemplify the puzzle, we cite two works. First, there is the report by Torkar and Freidrich[40] of the measurements taken during the "Winter Anomaly" campaign in Spain. The comparison between our calculations and those measurements, shown in Figure 35, is surprisingly good. In contrast are the measurements of Arnold et al[41] and Viggiano and Arnold.[42] These measurements, supposedly explained by Viggiano et al,[43] show an extremely different distribution of the negative

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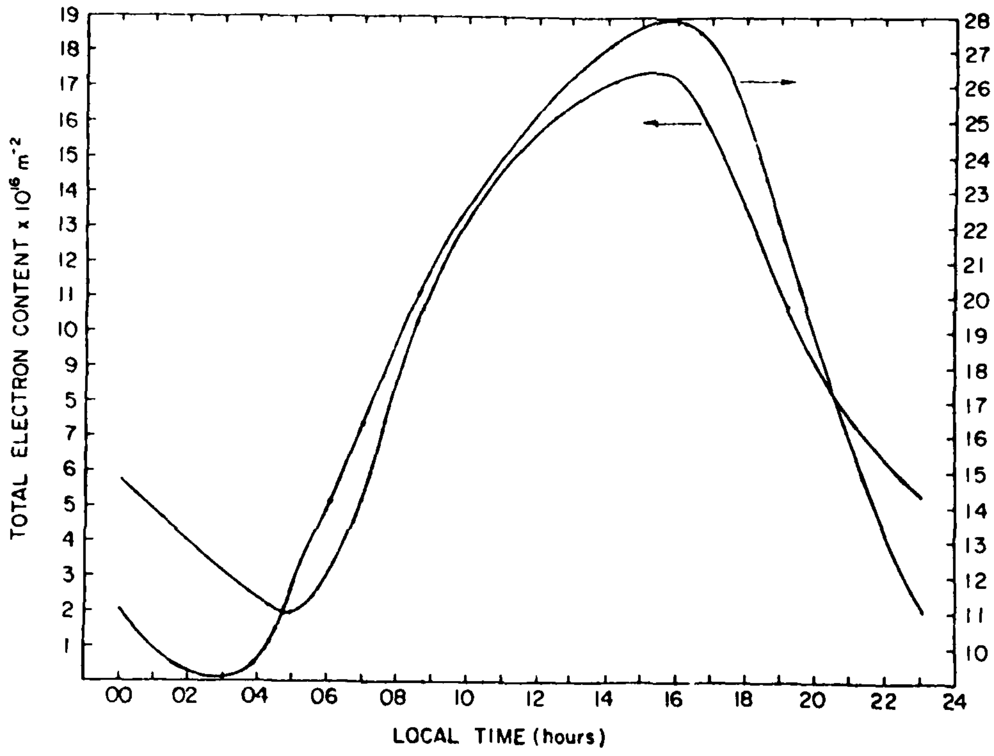

Figure 21. The Total Electron Content. The left-hand scale is for this model. The right-hand scale is for the calculations of Sethia et al[33]

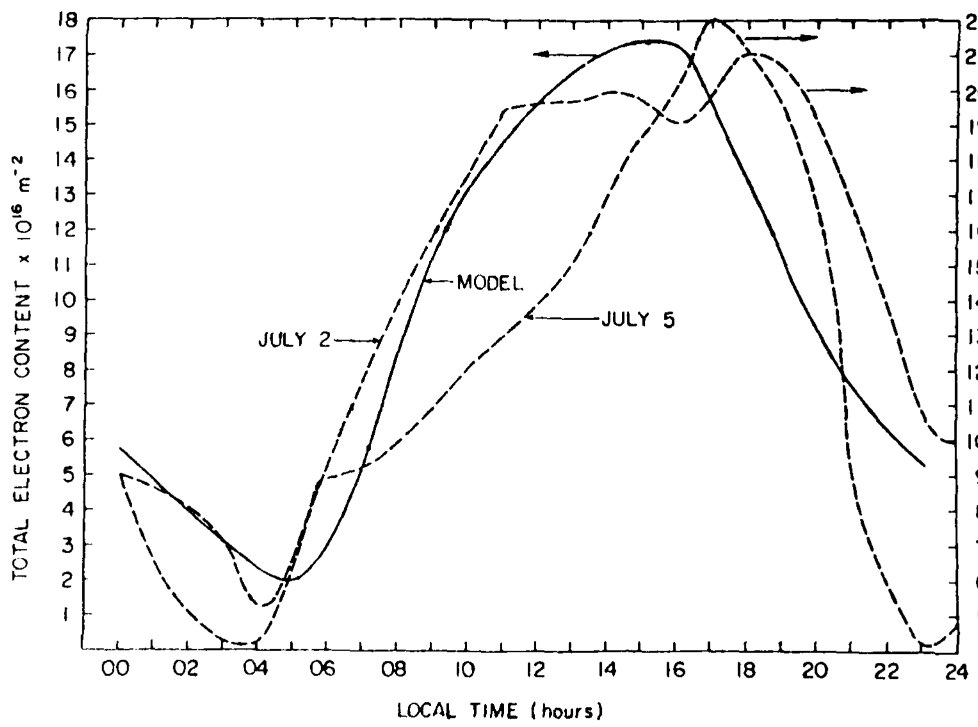

Figure 22. The Total Electron Content. The solid curve is for this model. The dashed curves are the measurements of Sethia et al[33]

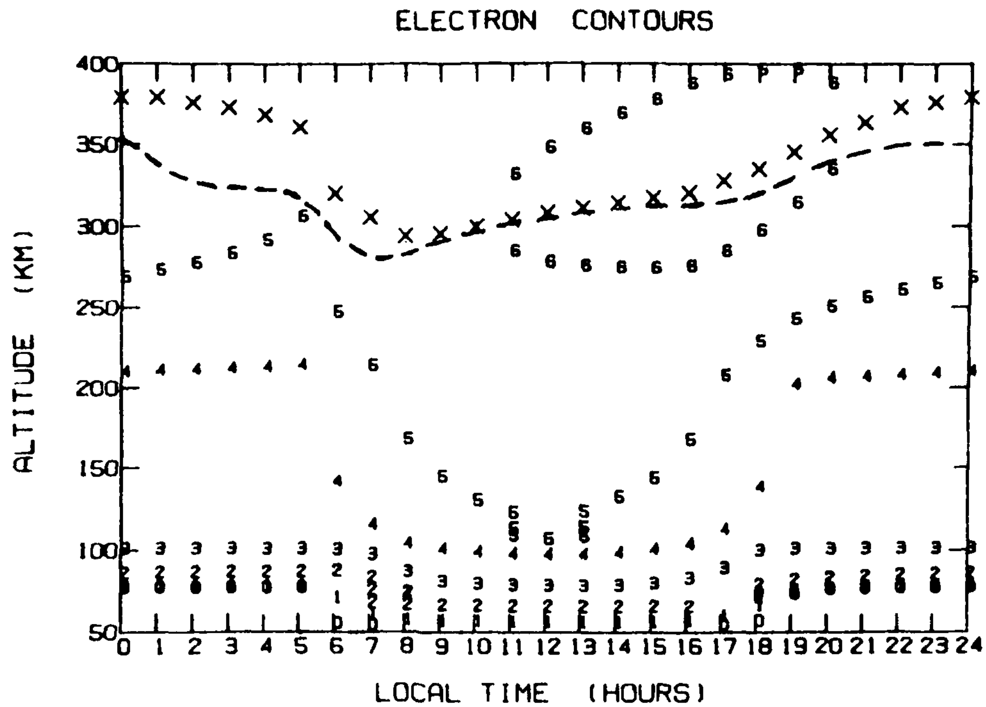

Figure 19. The Iso-Density Contours for the Electrons. The crosses show the diurnal change in the altitude of the peak electron concentration in the model. The dashed curve indicates the measurement of this parameter by Evans[31]

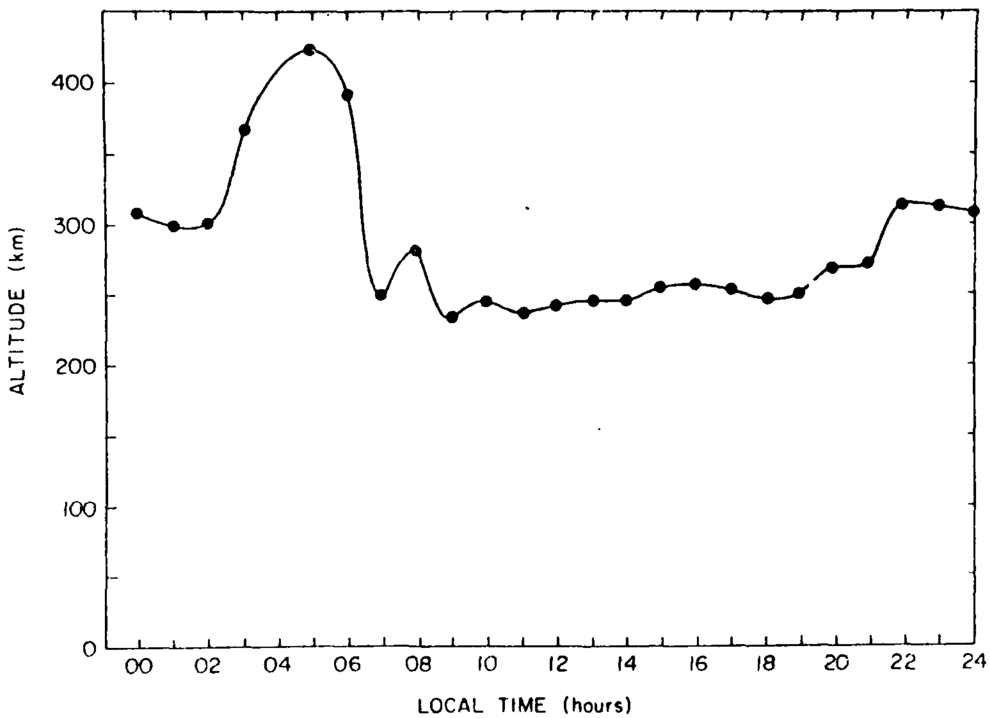

Figure 20. Measurements of Reinisch[32] of the Height of the F-Layer Peak at Eglin AFB, Fla., on 20/21 November 1970

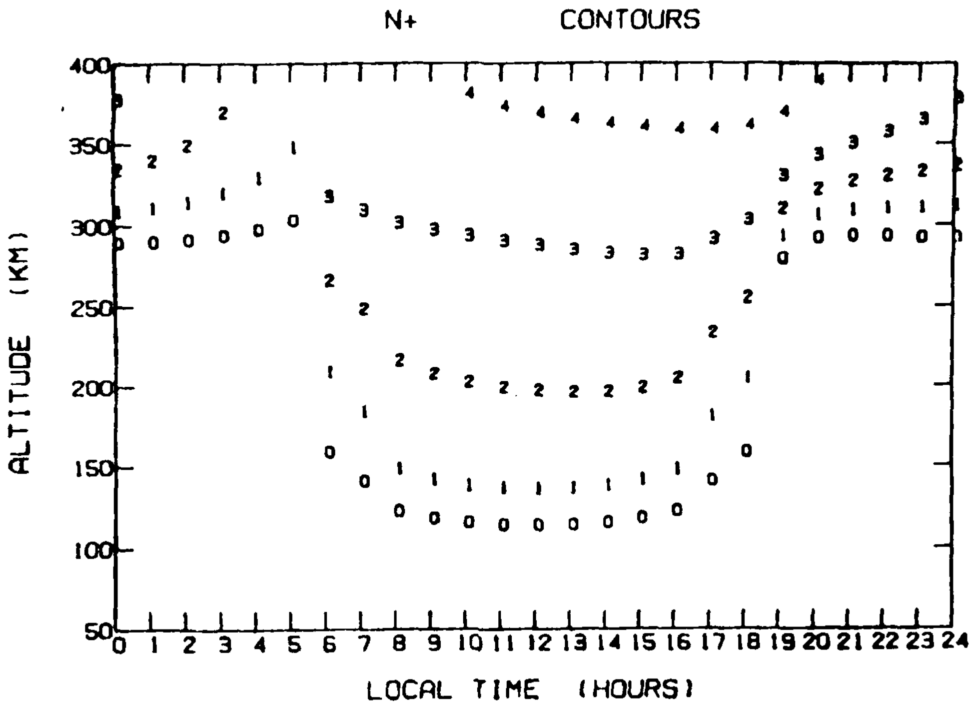

Figure 17. The Iso-Density Contours for N^+

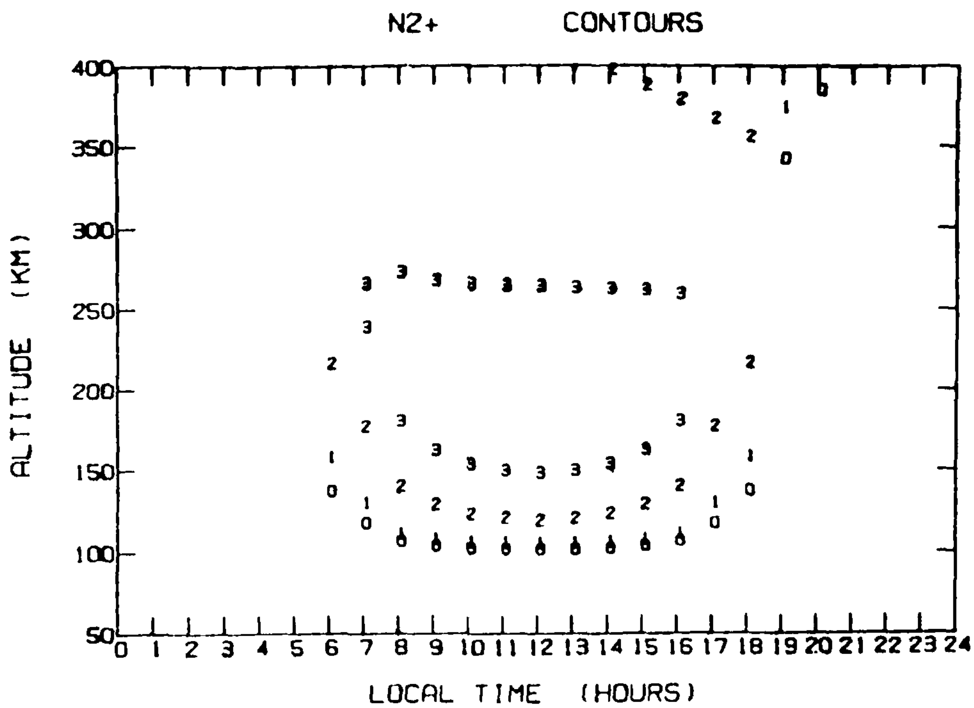

Figure 18. The Iso-Density Contours for N_2^+. At night, the concentration of N_2^+ falls below $1\,cm^{-3}$ at all altitudes

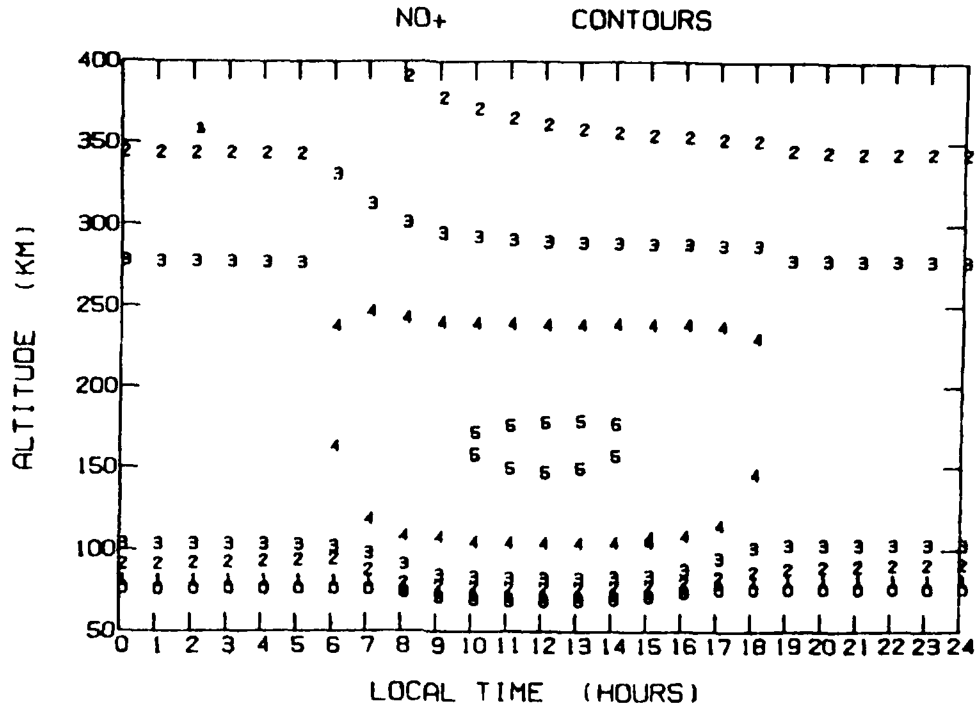

Figure 15. The Iso-Density Contours for NO^+

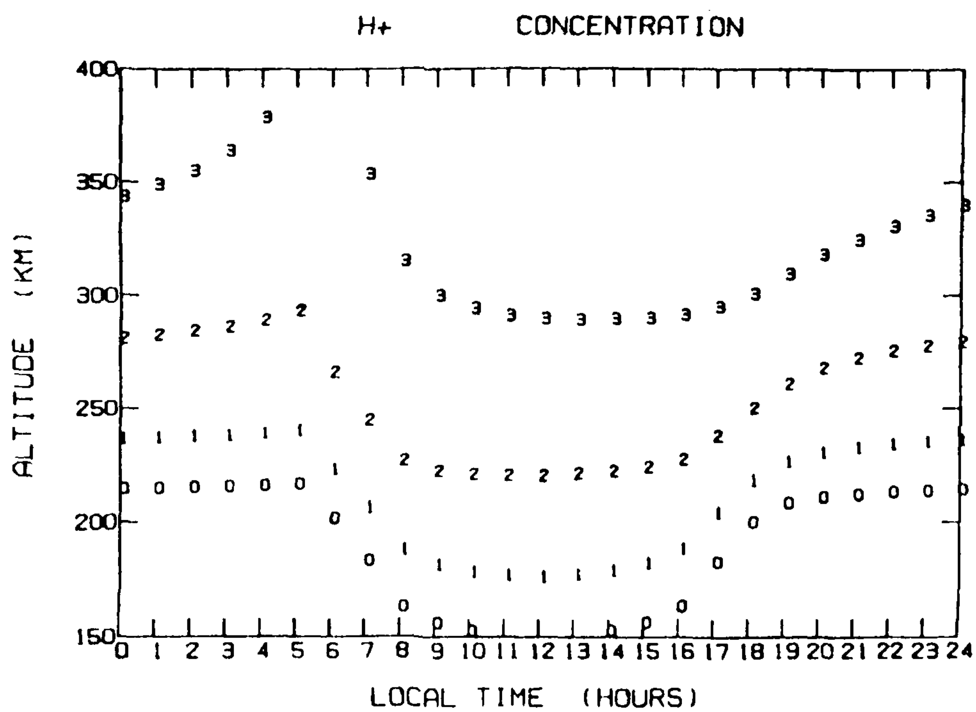

Figure 16. The Iso-Density Contours for H^+

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Appendix A

The Chemical Reactions

Table A1 lists the complete set of chemical reactions used in this report. Reactions 1 through 127 have temperature invariant rate coefficients that are listed after each reaction along with the source from which the rate coefficient was taken. Reactions 128 through 184 are temperature dependent. The rate coefficients for these reactions are of the form

$$k(z) = A \left(\frac{T(z)}{300}\right)^{B} \exp\left(\frac{C}{T(z)}\right) \tag{A1}$$

where the A's, B's, and C's are listed in that order after each reaction and T(z) is the temperature at altitude z. Reactions 185 through 207 are the photo-reactions, and are functions of the wavelength of the solar radiation and the local solar flux. Reactions 208 through 215 are the energetic electron processes. Some of the rate coefficients in the list of reactions have not been measured in the laboratory. Therefore, these rate coefficients are given as estimates.

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Table A1. Chemical Reaction Scheme

NO.	CHEMICAL REACTION						A	B	C		REFERENCE
1	O	+ N2O		= N	+ O		1.00E-12	0.00	0.	A1	DAVENPORT ET AL (1976)
2	O	+ OH		= O2	+ H		2.20E-11	0.00	0.	A2	BAULCH ET AL (1972)
3	O	+ HO2		= O2	+ OH		1.00E-11	0.00	0.	A3	KAUFMAN (1964)
4	O	+ NO2		= O2	+ NO		9.10E-12	0.00	0.	A4	DAVIS ET AL (1973)
5	H	+ HO2		= O2	+ H2		1.40E-11	0.00	0.	A2	BAULCH ET AL (1972)
6	H	+ HO2		= OH	+ OH		1.00E-11	0.00	0.	A3	KAUFMAN (1964)
7	H	+ O3		= O2	+ OH		2.60E-11	0.00	0.	A5	PHILLIPS AND SCHIFF (1962B)
8	N	+ O3		= O2	+ NO		5.70E-13	0.00	0.	A6	PHILLIPS AND SCHIFF (1962A)
9	N	+ NO2		= N2O	+ O		8.00E-12	0.00	0.	A7	PHILLIPS AND SCHIFF (1965)
10	N	+ NO2		= NO	+ NO		6.00E-12	0.00	0.	A7	PHILLIPS AND SCHIFF (1965)
11	N	+ NO2		= N2	+ O2		4.00E-12	0.00	0.	A7	PHILLIPS AND SCHIFF (1965)
12	OH	+ OH		= O	+ H2O		2.00E-12	0.00	0.	A5	KAUFMAN (1969)
13	OH	+ HO2		= O2	+ H2O		2.00E-10	0.00	0.	A9	HOCHANADEL ET AL (1972)
14	N2O	+ O2		= O	+ NO		6.00E-12	0.00	0.	A10	LIN AND KAUFMAN (1971)
15	O1D	+ H2O		= OH	+ OH		2.10E-10	0.00	0.	A11	DAVIDSON ET AL (1976)
16	O1D	+ M		= O	+ M		3.00E-11	0.00	0.	A11	DAVIDSON ET AL (1976)
17	O1D	+ H2		= H	+ OH		1.30E-10	0.00	0.	A11	DAVIDSON ET AL (1976)
18	O21D	+ M		= O2	+ M		4.40E-19	0.00	0.	A12	CLARK AND WAYNE (1969)
19	O21D			= O2			2.58E-04	0.00	0.	A13	BADGER ET AL (1965)
20	HNO2	+ O		= OH	+ NO2		1.00E-15	0.00	0.	A14	KAISER AND JAPER (1978)
21	HNO2	+ OH		= H2O	+ NO2		6.60E-12	0.00	0.	A15	COX ET AL (1976)
22	N2+	+ E		= N	+ N		1.50E-07	0.00	0.	A16	BIONDI (1969)
23	N2+	+ E		= N2D	+ N2D		1.50E-07	0.00	0.	A16	BIONDI (1969)
24	H3O+	+ E		= H2	+ OH		1.00E-06	0.00	0.	A17	BIONDI (1973)
25	H5O2+	+ E		= H2O	+ H2	+ OH	2.00E-06	0.00	0.	A17	BIONDI (1973)
26	H7O3+	+ E		= 2H2O	+ H2	+ OH	4.00E-06	0.00	0.	A17	BIONDI (1973)
27	H9O4+	+ E		= 3H2O	+ H2	+ OH	5.00E-06	0.00	0.	A17	BIONDI (1973)
28	H11O5+	+ E		= 4H2O	+ H2	+ OH	7.50E-06	0.00	0.		ESTIMATED
29	H3O+.OH	+ E		= H2O	+ OH	+ H	2.00E-06	0.00	0.		ESTIMATED
30	H5O2+.CO2+	E		= 2H2O	+ CO2	+ H	2.00E-06	0.00	0.		ESTIMATED
31	O	+ E		= O-			1.30E-15	0.00	0.	A18	BRANSCOMB (1964)
32	O2	+ N2	+ E	= O2-	+ N2		1.00E-31	0.00	0.	A19	PHELPS (1969)
33	O2+	+ NO		= NO+	+ O2		6.00E-10	0.00	0.	A20	FERGUSON (1973)
34	O2+	+ N		= NO+	+ O		1.80E-10	0.00	0.	A21	GOLDAN ET AL (1966)
35	O2+	+ NO2		= NO2+	+ O2		6.60E-10	0.00	0.	A22	FEHSENFELD ET AL (1973)
36	O4+	+ O		= O2+	+ O3		3.00E-10	0.00	0.	A20	FERGUSON (1973)
37	O4+	+ H2O		= O2+.H2O	+ O2		1.50E-09	0.00	0.	A23	HOWARD ET AL (1972)
38	N2+	+ O		= NO+	+ N		7.50E-11	0.00	0.	A24	FERGUSON (1974)
39	N2+	+ O		= NO+	+ N2D		7.50E-11	0.00	0.	A24	FERGUSON (1974)
40	O+	+ H		= H+	+ O		6.00E-10	0.00	0.	A24	FERGUSON (1974)
41	H+	+ O		= O+	+ H		4.00E-10	0.00	0.	A24	FERGUSON (1974)
42	N+	+ O2		= NO+	+ O		6.00E-10	0.00	0.	A25	DUNKIN ET AL (1968)
43	N+	+ O2		= O2+	+ N		6.00E-10	0.00	0.	A25	DUNKIN ET AL (1968)
44	N+	+ O2		= O2+	+ N2D		2.00E-10	0.00	0.	A24	FERGUSON (1974)
45	HE+	+ O2		= O+	+ O	+ HE	1.50E-09	0.00	0.	A24	FERGUSON (1974)
46	HE+	+ O2		= O2+	+ HE		2.00E-10	0.00	0.	A24	FERGUSON (1974)
47	HE+	+ N2		= N+	+ N	+ HE	1.50E-09	0.00	0.	A24	FERGUSON (1974)

Table A1. Chemical Reaction Scheme (Contd)

NO.	CHEMICAL REACTION						A	B	C	REFERENCE
48	HE+	+ N2		= N2+	+ HE		3.50E-10	0.00	0.	A24 FERGUSON (1974)
49	HE+	+ NO		= N+	+ O	+ HE	1.50E-09	0.00	0.	A26 FEHSENFELD ET AL (1966)
50	NO2+	+ NO		= NO+	+ NO2		2.90E-10	0.00	0.	A26 FEHSENFELD ET AL (1969A)
51	H5O2+	+ CO2	+ M	= H5O2+.CO2+	M		3.00E-30	0.00	0.	ESTIMATED
52	H9O4+	+ H2O	+ M	= H11O5+	+ M		1.00E-27	0.00	0.	ESTIMATED
53	O2+.H2O	+ H2O		= H3O+.OH	+ O2		1.00E-09	0.00	0.	A23 HOWARD ET AL (1972)
54	O2+.H2O	+ H2O		= H3O+	+ OH	+ O2	2.00E-10	0.00	0.	A23 HOWARD ET AL (1972)
55	NO+.3H2O	+ H2O		= H7O3+	+ HNO2		7.00E-11	0.00	0.	A25 PUCKETT AND TEAGUE (1971)
56	NO+.CO2	+ H2O		= NO+.H2O	+ CO2		1.00E-09	0.00	0.	A27 DUNKIN ET AL (1971)
57	H3O+.N2	+ CO2		= H3O+.CO2	+ N2		1.00E-10	0.00	0.	ESTIMATED
58	H3O+.CO2	+ H2O	+ N2	= H5O2+.CO2+	N2		1.00E-27	0.00	0.	ESTIMATED
59	H5O2+.CO2+	H2O		= H7O3+	+ CO2		1.00E-10	0.00	0.	ESTIMATED
60	H3O+.CO2	+ H2O		= H5O2+	+ CO2		1.00E-10	0.00	0.	ESTIMATED
61	H3O+.OH	+ H2O		= H5O2+	+ OH		1.40E-09	0.00	0.	A23 HOWARD ET AL (1972)
62	H3O+	+ NO2-		= H2O	+ NO2	+ H	6.00E-08	0.00	0.	ESTIMATED
63	H3O+	+ NO3-		= H2O	+ NO2	+ OH	6.00E-08	0.00	0.	ESTIMATED
64	H3O+	+ CO3-		= H2O	+ CO2	+ OH	6.00E-08	0.00	0.	ESTIMATED
65	H5O2+	+ O2-		= H2O	+ H2O	+ HO2	6.00E-08	0.00	0.	ESTIMATED
66	H5O2+	+ NO2-		= 2H2O	+ NO2	+ H	6.00E-08	0.00	0.	ESTIMATED
67	H5O2+	+ NO3-		= 2H2O	+ NO2	+ OH	6.00E-08	0.00	0.	ESTIMATED
68	H5O2+	+ CO3-		= 2H2O	+ CO2	+ OH	6.00E-08	0.00	0.	ESTIMATED
69	H5O2+	+ CO4-		= 2H2O	+ CO2	+ HO2	6.00E-08	0.00	0.	ESTIMATED
70	H7O3+	+ NO2-		= 3H2O	+ NO2	+ H	6.00E-08	0.00	0.	ESTIMATED
71	H7O3+	+ NO3-		= 3H2O	+ NO2	+ OH	6.00E-08	0.00	0.	ESTIMATED
72	H7O3+	+ CO3-		= 3H2O	+ CO2	+ OH	6.00E-08	0.00	0.	ESTIMATED
73	H7O3+	+ CO4-		= 3H2O	+ CO2	+ HO2	6.00E-08	0.00	0.	ESTIMATED
74	H9O4+	+ NO2-		= 4H2O	+ NO2	+ H	6.00E-08	0.00	0.	ESTIMATED
75	H9O4+	+ NO3-		= 4H2O	+ NO2	+ OH	6.00E-08	0.00	0.	ESTIMATED
76	H9O4+	+ CO3-		= 4H2O	+ CO2	+ OH	6.00E-08	0.00	0.	ESTIMATED
77	H9O4+	+ CO4-		= 4H2O	+ CO2	+ HO2	6.00E-08	0.00	0.	ESTIMATED
78	H11O5+	+ NO2-		= 5H2O	+ NO2	+ H	6.00E-08	0.00	0.	ESTIMATED
79	H11O5+	+ NO3-		= 5H2O	+ NO2	+ OH	6.00E-08	0.00	0.	ESTIMATED
80	H11O5+	+ CO3-		= 5H2O	+ CO2	+ OH	6.00E-08	0.00	0.	ESTIMATED
81	H11O5+	+ CO4-		= 5H2O	+ CO2	+ HO2	6.00E-08	0.00	0.	ESTIMATED
82	NO+.H2O	+ NO2-		= H2O	+ NO2	+ NO	6.00E-08	0.00	0.	ESTIMATED
83	NO+.H2O	+ NO3-		= H2O	+ NO2	+ NO2	6.00E-08	0.00	0.	ESTIMATED
84	NO+.H2O	+ CO3-		= H2O	+ NO2	+ CO2	6.00E-08	0.00	0.	ESTIMATED
85	NO+.2H2O	+ NO2-		= 2H2O	+ NO2	+ NO	6.00E-08	0.00	0.	ESTIMATED
86	NO+.2H2O	+ NO3-		= 2H2O	+ NO2	+ NO2	6.00E-08	0.00	0.	ESTIMATED
87	NO+.2H2O	+ CO3-		= 2H2O	+ NO2	+ CO2	6.00E-08	0.00	0.	ESTIMATED
88	NO+.3H2O	+ NO2-		= 3H2O	+ NO2	+ NO	6.00E-08	0.00	0.	ESTIMATED
89	NO+.3H2O	+ NO3-		= 3H2O	+ NO2	+ NO2	6.00E-08	0.00	0.	ESTIMATED
90	NO+.3H2O	+ CO3-		= 3H2O	+ NO2	+ CO2	6.00E-08	0.00	0.	ESTIMATED
91	H3O+.CO2	+ NO3-		= H2O2	+ HNO2	+ CO2	6.00E-08	0.00	0.	ESTIMATED
92	H3O+.CO2	+ CO3-		= 2CO2	+ H2O	+ OH	6.00E-08	0.00	0.	ESTIMATED
93	H3O+.CO2	+ CO4-		= 2CO2	+ H2O	+ HO2	6.00E-08	0.00	0.	ESTIMATED
94	H5O2+.CO2+	CO3-		= 2CO2	+ 2H2O	+ OH	6.00E-08	0.00	0.	ESTIMATED

Table A1. Chemical Reaction Scheme (Contd)

NO.	CHEMICAL REACTION						A	B	C		REFERENCE
95	H5O2+.CO2+	CO4-		= 2CO2	+ 2H2O	+ HO2	6.00E-08	0.00	0.		ESTIMATED
96	O-	+ HV		= O	+ E		1.40E+00	0.00	0.	A30	BRANSCOMB ET AL (1958)
97	O-	+ O		= O2	+ E		2.00E-10	0.00	0.	A31	FEHSENFELD ET AL (1967)
98	O-	+ O3		= O3-	+ O		5.30E-10	0.00	0.	A31	FEHSENFELD ET AL (1967)
99	O2-	+ HV		= O2	+ E		3.30E-01	0.00	0.	A32	WOO ET AL (1969)
100	O2-	+ O		= O3	+ E		1.50E-10	0.00	0.	A33	FEHSENFELD ET AL (1969C)
101	O2-	+ O		= O-	+ O2		1.50E-10	0.00	0.	A34	BORTNER AND BAURER 1979)
102	O2-	+ O3		= O3-	+ O2		4.00E-10	0.00	0.	A31	FEHSENFELD ET AL (1967B)
103	O2-	+ O21D		= O2	+ O2	+ E	2.00E-10	0.00	0.	A31	FEHSENFELD ET AL (1969C)
104	O3-	+ HV		= O3	+ E		7.00E-02	0.00	0.	A35	WONG ET AL (1972)
105	O3-	+ HV		= O-	+ O2		5.00E-01	0.00	0.	A36	PETERSON (1976)
106	O3-	+ O		= O2-	+ O2		3.20E-10	0.00	0.	A34	BORTNER AND BAURER (1979)
107	O4-	+ O		= O3-	+ O2		3.00E-10	0.00	0.	A37	FEHSENFELD ET AL (1969B)
108	O4-	+ O		= O-	+ O2	+ O2	1.00E-10	0.00	0.	A37	FEHSENFELD ET AL (1969B)
109	O4-	+ CO2		= CO4-	+ O2		4.30E-10	0.00	0.	A38	ADAMS ET AL (1970)
110	CO3-	+ HV		= O-	+ CO2		2.00E-01	0.00	0.	A36	PETERSON (1976)
111	CO3-	+ O		= O2-	+ CO2		8.00E-11	0.00	0.	A24	FERGUSON (1974)
112	CO3-	+ NO2		= NO3-	+ CO2		2.00E-10	0.00	0.	A39	FEHSENFELD AND FERGUSON (1974)
113	CO4-	+ HV		= O2-	+ CO2		1.40E-02	0.00	0.	A34	BORTNER AND BAURER (1979)
114	CO4-	+ HV		= O2	+ CO2	+ E	3.00E-01	0.00	0.	A35	WONG ET AL (1972)
115	CO4-	+ O		= CO3-	+ O2		1.50E-10	0.00	0.	A37	FEHSENFELD ET AL (1969B)
116	CO4-	+ O3		= O3-	+ CO2	+ O2	1.30E-10	0.00	0.	A39	FEHSENFELD AND FERGUSON (1974)
117	CO4-	+ NO		= NO3-	+ CO2		4.80E-11	0.00	0.	A37	FEHSENFELD ET AL (1969B)
118	NO2-	+ HV		= NO2	+ E		3.00E-02	0.00	0.	A34	BORTNER AND BAURER (1979)
119	NO2-	+ O3		= NO3-	+ O2		1.80E-11	0.00	0.	A40	FEHSENFELD AND FERGUSON (1968)
120	NO3-	+ HV		= NO2-	+ O		3.00E-02	0.00	0.	A34	BORTNER AND BAURER (1979)
121	NO3-	+ O		= NO2-	+ O2		1.00E-12	0.00	0.	A37	FEHSENFELD ET AL (1969B)
122	NO3	+ NO		= NO2	+ NO2		2.00E-11	0.00	0.	A41	GRAHAM AND JOHNSTON (1978)
123	NO3-	+ HV		= NO3	+ E		2.00E-02	0.00	0.	A34	BORTNER AND BAURER (1979)
124	O-	+ O3		= O2-	+ O2		4.40E-10	0.00	0.	A34	BORTNER AND BAURER (1976)
125	O+(2D)	+ N2		= N2+	+ O		3.00E-10	0.00	0.	A42	STEBBINGS ET AL (1966)
126	O+(2D)	+ O2		= O2+	+ O		3.00E-10	0.00	0.	A42	STEBBINGS ET AL (1966)
127	O+	+ CO2		= O2+	+ CO		1.00E-09	0.00	0.	A43	LINDBERGER ET AL (1974)
128	O	+ O	+ M	= O2	+ M		4.80E-33	-2.00	0.	A44	CAMPBELL AND GRAY (1973)
129	O	+ O2	+ M	= O3	+ M		5.50E-34	-2.60	0.	A45	KAUFMAN AND KELSO (1964)
130	O	+ O3		= O2	+ O2		1.20E-11	0.00	-2.00E+03	A46	SCHIFF (1969)
131	O	+ H2		= OH	+ H		7.00E-11	0.00	-5.10E+03	A47	WONG AND POTTER (1965)
132	O	+ H2O2		= OH	+ HO2		1.20E-12	0.00	-2.20E+03	A48	DAVIS ET AL (1974A)
133	O	+ H2O2		= O2	+ H2O		1.80E-12	0.00	-2.20E+03	A48	DAVIS ET AL (1974A)
134	H	+ H2O2		= H2	+ HO2		2.30E-12	0.00	-1.40E+03	A49	KLEMM ET AL (1975)
135	H	+ H2O2		= OH	+ H2O		2.90E-12	0.00	-1.40E+03	A49	KLEMM ET AL (1975)
136	H	+ O2	+ M	= HO2	+ M		4.40E-33	0.00	5.00E+02	A2	BAULCH ET AL (1972)
137	N	+ O2		= O	+ NO		5.50E-12	0.00	-3.22E+03	A50	BECKER ET AL (1969)
138	N	+ NO		= O	+ N2		8.20E-11	0.00	-4.10E+02	A51	CLYNE AND MCDERMID (1975)
139	N	+ O	+ M	= NO	+ M		1.80E-31	-.50	0.	A52	BAULCH ET AL (1973)
140	OH	+ O3		= O2	+ HO2		1.30E-12	0.00	-9.50E+02	A53	ANDERSON AND KAUFMAN (1973)
141	OH	+ H2O2		= HO2	+ H2O		1.00E-11	0.00	-7.50E+02	A34	BORTNER AND BAURER (1979)

Table A1. Chemical Reaction Scheme (Contd)

NO.	CHEMICAL REACTION						A	B	C		REFERENCE
142	NO	+ O3		= O2	+ NO2		1.70E-12	0.00	-1.31E+03	A52	BAULCH ET AL (1973)
143	NO	+ O	+ M	= NO2	+ M		1.55E-32	0.00	-5.84E+02	A54	WHYTLOCK ET AL (1976)
144	HO2	+ HO2		= O2	+ H2O2		7.55E-12	0.00	-5.00E+02	A34	BORTNER AND BAURER (1979)
145	HO2	+ O3		= O2	+ O2	+ OH	1.00E-13	0.00	-1.25E+03	A53	GARVIN (1973)
146	NO2	+ H		= NO	+ OH		4.80E-10	0.00	-4.00E+02	A52	CLYNE AND MONKHOUSE (1977)
147	CO	+ OH		= H	+ CO2		2.20E-13	0.00	-8.00E+01	A57	DAVIS ET AL (1974B)
148	CO	+ O	+ M	= CO2	+ M		6.50E-33	0.00	-2.18E+03	A58	BAULCH ET AL (1976)
149	N2D	+ E		= N	+ E		3.20E-10	.80	0.	A34	BORTNER AND BAURER (1979)
150	NO+	+ E		= N	+ O		2.00E-07	-1.00	0.	A17	BIONDI (1973)
151	NO+	+ E		= N2D	+ O		2.00E-07	-1.00	0.	A17	BIONDI (1973)
152	O2+	+ E		= O	+ O		2.00E-07	-1.00	0.	A17	BIONDI (1973)
153	O+	+ E		= O	+ HV		3.50E-12	-.70	0.	A34	BORTNER AND BAURER (1979)
154	N+	+ E		= N	+ HV		3.50E-12	-.70	0.	A34	BORTNER AND BAURER (1979)
155	H+	+ E		= H	+ HV		3.50E-12	-.70	0.	A34	BORTNER AND BAURER (1979)
156	NO2+	+ E		= NO	+ O		3.00E-07	-.50	0.	A34	BORTNER AND BAURER (1979)
157	NO+.H2O	+ E		= H2O	+ NO		1.50E-06	-.20	0.	A34	BORTNER AND BAURER (1979)
158	NO+.2H2O	+ E		= H2O	+ H2O	+ NO	2.00E-06	-.20	0.	A34	BORTNER AND BAURER (1979)
159	NO+.3H2O	+ E		= 3H2O	+ NO		3.00E-06	-.20	0.	A34	BORTNER AND BAURER (1979)
160	O2	+ O2	+ E	= O2-	+ O2		1.40E-29	-1.00	-6.00E+02	A19	PHELPS (1969)
161	O3	+ E		= O-	+ O2		9.00E-12	1.50	0.	A59	STELMAN ET AL (1972)
162	O2+	+ O2	+ M	= O4+	+ M		3.90E-30	-3.20	0.	A60	PAYZANT ET AL (1973)
163	O4+	+ M		= O2+	+ O2	+ M	2.00E-05	-3.20	-5.40E+03	A34	BORTNER AND BAURER (1979)
164	O4+	+ O21D		= O2+	+ O2	+ O2	2.00E-05	-3.20	-5.40E+03	A34	BORTNER AND BAURER (1979)
165	NO+	+ CO2	+ N2	= NO+.CO2	+ N2		3.00E-29	-2.00	0.	A34	BORTNER AND BAURER (1979)
166	NO+	+ H2O	+ M	= NO+.H2O	+ M		1.50E-28	-2.00	0.	A34	BORTNER AND BAURER (1979)
167	N2+	+ O2		= O2+	+ N2		5.00E-11	-.80	0.	A43	LINDBERGER ET AL (1974)
168	O+	+ N2		= NO+	+ N		1.20E-12	-.50	0.	A43	LINDBERGER ET AL (1974)
169	O+	+ O2		= O2+	+ O		2.00E-11	-.40	0.	A43	LINDBERGER ET AL (1974)
170	H3O+	+ H2O	+ M	= H5O2+	+ M		3.50E-27	-4.00	0.	A61	GOOD ET AL (1970)
171	H3O+	+ N2	+ N2	= H3O+.N2	+ N2		1.40E-30	-2.00	0.	A34	BORTNER AND BAURER (1979)
172	H5O2+	+ H2O	+ M	= H7O3+	+ M		2.20E-27	-2.80	0.	A34	BORTNER AND BAURER (1979)
173	H7O3+	+ H2O	+ M	= H9O4+	+ M		2.30E-27	-2.80	0.	A34	BORTNER AND BAURER (1979)
174	H7O3+	+ M		= H5O2+	+ H2O	+ M	2.50E-03	-4.00	-1.00E+04	A34	BORTNER AND BAURER (1979)
175	H9O4+	+ M		= H7O3+	+ H2O	+ M	1.20E-01	-4.00	-8.80E+03	A34	BORTNER AND BAURER (1979)
176	H11O5+	+ M		= H9O4+	+ H2O	+ M	4.00E-01	0.00	-7.67E+03	A34	BORTNER AND BAURER (1979)
177	NO+.H2O	+ H2O	+ M	= NO+.2H2O	+ M		1.10E-27	-4.70	0.	A62	HOWARD ET AL (1971)
178	NO+.2H2O	+ H2O	+ M	= NO+.3H2O	+ M		1.10E-27	-4.70	0.	A62	HOWARD ET AL (1971)
179	O-	+ O2	+ O2	= O3-	+ O2		1.10E-30	-1.00	0.	A34	BORTNER AND BAURER (1979)
180	O2-	+ O2	+ O2	= O4-	+ O2		3.50E-31	-1.00	0.	A34	BORTNER AND BAURER (1979)
181	O2-	+ O2	+ CO2	= CO4-	+ O2		2.00E-29	-1.00	0.	A34	BORTNER AND BAURER (1979)
182	O3-	+ CO2		= CO3-	+ O2		5.50E-10	-.49	0.	A34	BORTNER AND BAURER (1979)
183	O4-	+ M		= O2-	+ O2	+ M	2.00E-05	-1.00	-6.30E+03	A34	BORTNER AND BAURER (1979)
184	CO3-	+ NO		= NO2-	+ CO2		1.10E-11	-1.10	0.	A34	BORTNER AND BAURER (1979)
185	O	+ HV		= O+	+ E		0.	0.00	0.		Wavelength Dependent (See Text)
186	O2	+ HV		= O2+	+ E		0.	0.00	0.		
187	N2	+ HV		= N2+	+ E		0.	0.00	0.		
188	NO	+ HV		= NO+	+ E		0.	0.00	0.		

Table A1. Chemical Reaction Scheme (Contd)

NO.	CHEMICAL REACTION	A	B	C	REFERENCE
189	N + HV = N+ + E	0.	0.00	0.	
190	H + HV = H+ + E	0.	0.00	0.	
191	HE + HV = HE+ + E	0.	0.00	0.	
192	O2 + HV = O + O	0.	0.00	0.	
193	O2 + HV = O1D + O	0.	0.00	0.	
194	O3 + HV = O2 + O	0.	0.00	0.	
195	O3 + HV = O21D + O1D	0.	0.00	0.	
196	H2O + HV = OH + H	0.	0.00	0.	
197	H2O2 + HV = OH + OH	0.	0.00	0.	
198	HO2 + HV = O2 + H	0.	0.00	0.	
199	NO + HV = N + O	0.	0.00	0.	
200	NO2 + HV = NO + O1D	0.	0.00	0.	
201	N2O + HV = N2 + O1D	0.	0.00	0.	
202	HNO2 + HV = OH + NO	0.	0.00	0.	
203	CO2 + HV = CO + O1D	0.	0.00	0.	
204	CO2 + HV = CO + O	0.	0.00	0.	
205	NO3 + HV = NO + O2	0.	0.00	0.	
206	O + HV = O+(2D) + E	0.	0.00	0.	
207	O21D + HV = O2+ + E	0.	0.00	0.	
208	E* + N2 = N + N+ + 2E	0.	0.00	0.	
209	E* + O2 = O + O+ + 2E	0.	0.00	0.	
210	E* + O2 = O + O+(2D) + 2E	0.	0.00	0.	
211	E* + O = O+ + 2E	0.	0.00	0.	
212	E* + O = O+(2D) + 2E	0.	0.00	0.	
213	E* + N2 = N2+ + 2E	0.	0.00	0.	
214	E* + O2 = O2+ + 2E	0.	0.00	0.	
215	E* + N2 = N + N2D + E	0.	0.00	0.	

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Appendix B

Photodissociation processes and Their Rate Coefficients

Appendix B contains information on the photodissociation, photoionization, and energetic electron impact reactions. Table B1 lists the solar fluxes in the wavelength region 116.2 to 730.0 nm along with the absorption cross sections for O_2, O_3, H_2O, H_2O_2, NO_2, NO_3, and N_2O. Table B2 contains the absorption cross sections for N_2O_5, HNO_2, HNO_3, CH_4, CO_2, CH_2O, and HO_2.

Table B3 lists the photodissociation processes along with their total photodissociation rate coefficient. The units of all the rate coefficients presented in this table and in all the tables that follow (Tables B4-B23) are sec^{-1}. The constants in Table B3 were computed from Eq. (52) using the entire unattenuated solar flux. The values listed here are indications of the maximum rate coefficient that each process can attain.

B1. MOLECULAR OXYGEN

Two distinct processes for O_2 photodissociation are considered,

$$O_2 + h\nu \rightarrow O + O(^1D), \quad \lambda < 175\,\text{nm}$$

and

$$O_2 + h\nu \rightarrow O + O, \quad 175 < \lambda < 242.2\,\text{nm}.$$

The cross sections for this molecule are taken from the compilation of Ackerman[16] with the exception of those wavelengths in the Schumann Range bands. The photodissociation rate coefficients for the first process above are listed in Table B4, and those for the second process are listed in Table B5. The column densities given in these and all the other tables that follow (Tables B6 - B23) are in units of cm^{-2} column.

B2. OZONE

For ozone, two processes are also considered,

$$O_3 + h\nu \rightarrow O(^1D) + O_2(^1\Delta g),\ \lambda < 310\,nm$$

and

$$O_3 + h\nu \rightarrow O + O_2,\ 310 < \lambda < 730\,nm.$$

The absorption cross sections for ozone are also taken from the compilation of Ackerman.[16] The photodissociation rate coefficients for the process with the excited products are listed in Table B6, and those for the process with the ground state products are listed in Table B7.

B3. WATER VAPOR

Water vapor is photodissociated primarily through the process

$$H_2O + h\nu \rightarrow OH + H,\ 121.6 < \lambda < 186.4\,nm.$$

The absorption cross sections for this molecule are taken from Watanabe and Zelikoff.[21] The photodissociation rate coefficients for this process are tabulated in Table B8.

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21. Watanabe, K., and Zelikoff, M.J. (1953) Absorption coefficients of water vapor in the vacuum ultraviolet, J. Opt. Soc. Am. 43:753-755.

B4. HYDROGEN PEROXIDE

According to Urey et al[B2] and Holt et al,[B3] the photodissociation process for hydrogen peroxide is probably

$$H_2O_2 + h\nu \rightarrow OH + OH, \lambda < 300\,\text{nm}.$$

The absorption cross sections above 225 nm are from Urey et al, and those below 225 nm are from Holt et al. The photodissociation rate coefficients for this molecule are presented in Table B9.

B5. NITROGEN DIOXIDE

The primary quantum yield for nitrogen dioxide is unity for the process

$$NO_2 + h\nu \rightarrow NO + O$$

for wavelengths from 398 to 244 nm. The process

$$NO_2 + h\nu \rightarrow NO + O(^1D)$$

has unity primary quantum yield from 244 to 190 nm. For these computations, however, all of the photodissociation of NO_2 is assumed to take place according to the later process. The absorption cross sections for this molecule are taken from Nakayama et al[B4] and from Hall and Blacet.[B5] The photodissociation rate coefficients for this process are listed in Table B10.

B6. THE NO_3 RADICAL

According to Johnston and Graham,[13] the photolysis of NO_3 can proceed as

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Table B4. Total Photodissociation Rate Coefficients for the Process $O_2 + h\nu \rightarrow O + O(^1D)$ for the Wavelengths Below 1[illegible] nm (Contd)

O2 COLUMN DENSITY	O3 COLUMN DENSITY 2.0E+15	5.0E+15	1.0E+16	2.0E+16	5.0E+16	1.0E+17	2.0E+17	5.0E+17	1.0E+18	2.0E+18
1.0E+13	1.66806E-06	1.65171E-06	1.62513E-06	1.57431E-06	1.43824E-06	1.25387E-06	9.88396E-07	5.71980E-07	2.94155E-07	1.02772E-07
2.0E+13	1.66793E-06	1.65158E-06	1.62500E-06	1.57419E-06	1.43814E-06	1.25378E-06	9.88334E-07	5.71953E-07	2.94145E-07	1.02770E-07
5.0E+13	1.66754E-06	1.65119E-06	1.62462E-06	1.57383E-06	1.43782E-06	1.25351E-06	9.88149E-07	5.71873E-07	2.94115E-07	1.02762E-07
1.0E+14	1.66688E-06	1.65055E-06	1.62399E-06	1.57322E-06	1.43728E-06	1.25307E-06	9.87839E-07	5.71740E-07	2.94066E-07	1.02750E-07
2.0E+14	1.66558E-06	1.64926E-06	1.62273E-06	1.57201E-06	1.43621E-06	1.25219E-06	9.87221E-07	5.71474E-07	2.93967E-07	1.02725E-07
5.0E+14	1.66167E-06	1.64540E-06	1.61895E-06	1.56839E-06	1.43302E-06	1.24956E-06	9.85369E-07	5.70676E-07	2.93670E-07	1.02651E-07
1.0E+15	1.65518E-06	1.63899E-06	1.61268E-06	1.56238E-06	1.42771E-06	1.24519E-06	9.82294E-07	5.69351E-07	2.93177E-07	1.02528E-07
2.0E+15	1.64230E-06	1.62629E-06	1.60024E-06	1.55047E-06	1.41718E-06	1.23652E-06	9.76187E-07	5.66715E-07	2.92195E-07	1.02282E-07
5.0E+15	1.60450E-06	1.58897E-06	1.56372E-06	1.51546E-06	1.38623E-06	1.21102E-06	9.58212E-07	5.58929E-07	2.89282E-07	1.01550E-07
1.0E+16	1.54414E-06	1.52939E-06	1.50540E-06	1.45956E-06	1.33677E-06	1.17020E-06	9.29361E-07	5.46341E-07	2.84538E-07	1.00349E-07
2.0E+16	1.43268E-06	1.41934E-06	1.39766E-06	1.35621E-06	1.24522E-06	1.09445E-06	8.75550E-07	5.22546E-07	2.75441E-07	9.80170E-08
5.0E+16	1.16040E-06	1.15043E-06	1.13421E-06	1.10323E-06	1.02023E-06	9.07081E-07	7.40652E-07	4.60789E-07	2.50972E-07	9.15433E-08
1.0E+17	8.54413E-07	8.47991E-07	8.37554E-07	8.17620E-07	7.64191E-07	6.90938E-07	5.80801E-07	3.82530E-07	2.17829E-07	8.22435E-08
2.0E+17	5.36644E-07	5.33460E-07	5.28291E-07	5.18431E-07	4.92011E-07	4.55440E-07	3.98265E-07	2.82798E-07	1.70978E-07	6.78314E-08
5.0E+17	2.54983E-07	2.53852E-07	2.52020E-07	2.48539E-07	2.39264E-07	2.26352E-07	2.05261E-07	1.56698E-07	1.01221E-07	4.28533E-08
1.0E+18	1.36289E-07	1.35699E-07	1.34746E-07	1.32943E-07	1.28181E-07	1.21616E-07	1.10911E-07	8.58965E-08	5.64943E-08	2.44971E-08
2.0E+18	6.00193E-08	5.97393E-08	5.92891E-08	5.84436E-08	5.62472E-08	5.32901E-08	4.85643E-08	3.76423E-08	2.48191E-08	1.08074E-08
5.0E+18	1.13865E-08	1.13204E-08	1.12151E-08	1.10204E-08	1.05331E-08	9.91549E-09	8.98713E-09	6.92906E-09	4.54882E-09	1.96587E-09
1.0E+19	1.66447E-09	1.65246E-09	1.63346E-09	1.59880E-09	1.51493E-09	1.41452E-09	1.27268E-09	9.73832E-10	6.36991E-10	2.74164E-10
2.0E+19	9.58961E-11	9.48877E-11	9.32951E-11	9.04033E-11	8.35107E-11	7.55905E-11	6.54293E-11	4.79128E-11	3.10048E-11	1.33560E-11
5.0E+19	1.95990E-12	1.91295E-12	1.83731E-12	1.69528E-12	1.33423E-12	9.00690E-13	4.20783E-13	5.68626E-14	9.60759E-15	3.42372E-15
1.0E+20	4.57705E-13	4.46221E-13	4.27722E-13	3.93016E-13	3.05030E-13	2.00223E-13	8.67228E-14	7.32785E-15	1.33288E-16	7.01575E-20
2.0E+20	4.61935E-14	4.50798E-14	4.32836E-14	3.99043E-14	3.12770E-14	2.08583E-14	9.30490E-15	6.43112E-16	1.61428E-17	6.38520E-21
5.0E+20	9.31927E-17	9.10317E-17	8.75410E-17	8.09560E-17	6.40283E-17	4.33116E-17	1.98226E-17	1.90290E-18	3.84043E-20	1.57073E-23
1.0E+21	4.18059E-21	4.08390E-21	3.92769E-21	3.63397E-21	2.87498E-21	1.94652E-21	8.92285E-22	8.59497E-23	1.73975E-24	7.12828E-28
2.0E+21	8.61614E-30	8.41687E-30	8.09493E-30	7.48752E-30	5.92534E-30	4.01179E-30	1.83903E-30	1.77149E-31	3.58584E-33	1.46924E-36
5.0E+21	7.54474E-56	7.37024E-56	7.08833E-56	6.55046E-56	5.18853E-56	3.51293E-56	1.61035E-56	1.55121E-57	3.13995E-59	1.28655E-62
1.0E+22	2.80670E-99	2.74178E-99	2.63691E-99	2.43905E-99	1.93017E-99	1.30684E-99	5.99062-100	5.77062-101	1.16808-102	4.78605-106

Table B3. Total Photodissociation Rate Coefficients for the Process $O_2 + h\nu \rightarrow O + O(^1D)$ for the Wavelengths Below 175 nm

O3 COLUMN DENSITY

O2 COLUMN DENSITY	1.0E+12	2.0E+12	5.0E+12	1.0E+13	2.0E+13	5.0E+13	1.0E+14	2.0E+14	5.0E+14	1.0E+15
1.0E+13	1.67913E-06	1.67912E-06	1.67911E-06	1.67908E-06	1.67902E-06	1.67885E-06	1.67858E-06	1.67802E-06	1.67635E-06	1.67358E-06
2.0E+13	1.67900E-06	1.67899E-06	1.67897E-06	1.67895E-06	1.67889E-06	1.67872E-06	1.67844E-06	1.67789E-06	1.67622E-06	1.67345E-06
5.0E+13	1.67860E-06	1.67854E-06	1.67853E-06	1.67855E-06	1.67849E-06	1.67833E-06	1.67805E-06	1.67749E-06	1.67583E-06	1.67305E-06
1.0E+14	1.67794E-06	1.67793E-06	1.677[illegible]E-06	1.67789E-06	1.67783E-06	1.67767E-06	1.67739E-06	1.67683E-06	1.67517E-06	1.67240E-06
2.0E+14	1.67662E-06	1.67662E-06	1.67660E-06	1.67657E-06	1.67652E-06	1.67635E-06	1.67607E-06	1.67552E-06	1.67385E-06	1.67109E-06
5.0E+14	1.67268E-06	1.67267E-06	1.67266E-06	1.67263E-06	1.67257E-06	1.67241E-06	1.67213E-06	1.67158E-06	1.66992E-06	1.66716E-06
1.0E+15	1.66613E-06	1.66613E-06	1.66611E-06	1.66608E-06	1.66603E-06	1.66586E-06	1.66558E-06	1.66503E-06	1.66338E-06	1.66064E-06
2.0E+15	1.65314E-06	1.65314E-06	1.65312E-06	1.65309E-06	1.65304E-06	1.65288E-06	1.65260E-06	1.65206E-06	1.65042E-06	1.64771E-06
5.0E+15	1.61501E-06	1.61501E-06	1.61499E-06	1.61496E-06	1.61491E-06	1.61475E-06	1.61449E-06	1.61396E-06	1.61237E-06	1.60974E-06
1.0E+16	1.55413E-06	1.55413E-06	1.55411E-06	1.55409E-06	1.55404E-06	1.55388E-06	1.55363E-06	1.55313E-06	1.55163E-06	1.54912E-06
2.0E+16	1.44170E-06	1.44170E-06	1.44169E-06	1.44166E-06	1.44162E-06	1.44148E-06	1.44125E-06	1.44080E-06	1.43944E-06	1.43718E-06
5.0E+16	1.16715E-06	1.16715E-06	1.16714E-06	1.16712E-06	1.16709E-06	1.16699E-06	1.16682E-06	1.16648E-06	1.16546E-06	1.16377E-06
1.0E+17	8.58763E-07	8.58761E-07	8.58754E-07	8.58743E-07	8.58721E-07	8.58656E-07	8.58546E-07	8.58327E-07	8.57672E-07	8.56582E-07
2.0E+17	5.38802E-07	5.38800E-07	5.38797E-07	5.38792E-07	5.38781E-07	5.38748E-07	5.38694E-07	5.38585E-07	5.38260E-07	5.37720E-07
5.0E+17	2.55751E-07	2.55751E-07	2.55750E-07	2.55749E-07	2.55744E-07	2.55732E-07	2.55713E-07	2.55674E-07	2.55556E-07	2.55366E-07
1.0E+18	1.36690E-07	1.36690E-07	1.36690E-07	1.36689E-07	1.36686E-07	1.36680E-07	1.36670E-07	1.36650E-07	1.36590E-07	1.36489E-07
2.0E+18	6.02102E-08	6.02101E-08	6.02098E-08	6.02093E-08	6.02083E-08	6.02055E-08	6.02006E-08	6.01910E-08	6.01622E-08	6.01143E-08
5.0E+18	1.14317E-08	1.14317E-08	1.14316E-08	1.14315E-08	1.14313E-08	1.14306E-08	1.14295E-08	1.14272E-08	1.14203E-08	1.14090E-08
1.0E+19	1.67274E-09	1.67273E-09	1.67272E-09	1.67270E-09	1.67266E-09	1.67253E-09	1.67232E-09	1.67190E-09	1.67065E-09	1.66858E-09
2.0E+19	9.65914E-11	9.65911E-11	9.65900E-11	9.65883E-11	9.65847E-11	9.65742E-11	9.65565E-11	9.65213E-11	9.64160E-11	9.62415E-11
5.0E+19	1.99185E-12	1.99183E-12	1.99178E-12	1.99170E-12	1.99154E-12	1.99106E-12	1.99025E-12	1.98864E-12	1.98382E-12	1.97581E-12
1.0E+20	4.65523E-13	4.65519E-13	4.65508E-13	4.65488E-13	4.65448E-13	4.65330E-13	4.65133E-13	4.64739E-13	4.63559E-13	4.61600E-13
2.0E+20	4.69508E-14	4.69504E-14	4.69493E-14	4.69474E-14	4.69436E-14	4.69321E-14	4.69130E-14	4.68749E-14	4.67606E-14	4.65708E-14
5.0E+20	9.46611E-17	9.46603E-17	9.46581E-17	9.46544E-17	9.46470E-17	9.46248E-17	9.45878E-17	9.45139E-17	9.42924E-17	9.39244E-17
1.0E+21	4.24629E-21	4.24626E-21	4.24616E-21	4.24599E-21	4.24566E-21	4.24467E-21	4.24301E-21	4.23971E-21	4.22980E-21	4.21333E-21
2.0E+21	8.75154E-30	8.75147E-30	8.75127E-30	8.75093E-30	8.75024E-30	8.74820E-30	8.74479E-30	8.73797E-30	8.71754E-30	8.68361E-30
5.0E+21	7.66330E-56	7.66324E-56	7.66306E-56	7.66276E-56	7.66216E-56	7.66037E-56	7.65738E-56	7.65141E-56	7.63353E-56	7.60381E-56
1.0E+22	2.85080E-99	2.85078E-99	2.85072E-99	2.85060E-99	2.85038E-99	2.84972E-99	2.84860E-99	2.84638E-99	2.83973E-99	2.82868E-99

Table B3. Total Photodissociation Rate Coefficients for Unattenuated Solar Flux

O2 + HV = O + O1D	1.67927E-06 SEC-1
O2 + HV = O + O	8.36798E-08 SEC-1
O3 + HV = O1D + O21D	9.72665E-03 SEC-1
O3 + HV = O + O2	4.17996E-04 SEC-1
H2O + HV = OH + H	7.38662E-06 SEC-1
H2O2 + HV = OH + OH	1.59387E-04 SEC-1
NO2 + HV = NO + O1D	1.51039E-02 SEC-1
NO3 + HV = NO + O2	7.04137E-02 SEC-1
N2O + HV = N2 + O1D	7.76688E-07 SEC-1
N2O5 + HV = NO2 + NO2	6.92337E-04 SEC-1
HNO2 + HV = OH + NO	5.84756E-04 SEC-1
HNO3 + HV = OH + NO2	1.16540E-04 SEC-1
CH4 + HV = CH3 + H	9.08606E-06 SEC-1
CO2 + HV = CO + O1D	8.84043E-08 SEC-1
CO2 + HV = CO + O	8.24894E-09 SEC-1
CH2O + HV = CHO + H	2.58902E-04 SEC-1
HO2 + HV = O2 + H	1.13657E-03 SEC-1

Table B2. Absorption Cross Sections for N_2O_5, HNO_2, HNO_3, CH_4, CO_2, CH_2O, and HO_2 (Contd)

WAVELENGTH BAND ANGSTROMS	CROSS SECTIONS (CM2) N2O5	HNO2	HNO3	CH4	CO2	CH2O	HO2
3200.00-3250.00	6.00E-21	2.00E-20	1.00E-22	0.	0.	2.20E-20	0.
3250.00-3300.00	5.00E-21	2.00E-20	0.	0.	0.	3.40E-20	0.
3300.00-3350.00	3.40E-21	3.00E-20	0.	0.	0.	1.50E-20	0.
3350.00-3400.00	3.00E-21	2.80E-20	0.	0.	0.	1.20E-20	0.
3400.00-3450.00	2.40E-21	3.10E-20	0.	0.	0.	2.00E-20	0.
3450.00-3500.00	2.00E-21	3.00E-20	0.	0.	0.	5.00E-21	0.
3500.00-3550.00	1.50E-21	5.00E-20	0.	0.	0.	2.80E-21	0.
3550.00-3600.00	1.20E-21	5.00E-20	0.	0.	0.	1.20E-21	0.
3600.00-3650.00	9.00E-22	2.90E-20	0.	0.	0.	0.	0.
3650.00-3700.00	7.00E-22	8.00E-20	0.	0.	0.	0.	0.
3700.00-3750.00	4.00E-22	4.00E-20	0.	0.	0.	0.	0.
3750.00-3800.00	2.50E-22	2.00E-20	0.	0.	0.	0.	0.
3800.00-3850.00	0.	4.00E-20	0.	0.	0.	0.	0.
3850.00-3900.00	0.	5.00E-20	0.	0.	0.	0.	0.
3900.00-3950.00	0.	0.	0.	0.	0.	0.	0.
3950.00-4000.00	0.	0.	0.	0.	0.	0.	0.
4000.00-4050.00	0.	0.	0.	0.	0.	0.	0.
4050.00-4100.00	0.	0.	0.	0.	0.	0.	0.
4100.00-4150.00	0.	0.	0.	0.	0.	0.	0.
4150.00-4200.00	0.	0.	0.	0.	0.	0.	0.
4200.00-4250.00	0.	0.	0.	0.	0.	0.	0.
4250.00-4300.00	0.	0.	0.	0.	0.	0.	0.
4300.00-4350.00	0.	0.	0.	0.	0.	0.	0.
4350.00-4400.00	0.	0.	0.	0.	0.	0.	0.
4400.00-4450.00	0.	0.	0.	0.	0.	0.	0.
4450.00-4500.00	0.	0.	0.	0.	0.	0.	0.
4500.00-4550.00	0.	0.	0.	0.	0.	0.	0.
4550.00-4600.00	0.	0.	0.	0.	0.	0.	0.
4600.00-4650.00	0.	0.	0.	0.	0.	0.	0.
4650.00-4700.00	0.	0.	0.	0.	0.	0.	0.
4700.00-4750.00	0.	0.	0.	0.	0.	0.	0.
4750.00-4800.00	0.	0.	0.	0.	0.	0.	0.
4800.00-4850.00	0.	0.	0.	0.	0.	0.	0.
4850.00-4900.00	0.	0.	0.	0.	0.	0.	0.
4900.00-4950.00	0.	0.	0.	0.	0.	0.	0.
4950.00-5000.00	0.	0.	0.	0.	0.	0.	0.
5000.00-5050.00	0.	0.	0.	0.	0.	0.	0.
5050.00-5100.00	0.	0.	0.	0.	0.	0.	0.
5100.00-5150.00	0.	0.	0.	0.	0.	0.	0.
5150.00-5200.00	0.	0.	0.	0.	0.	0.	0.
5200.00-5250.00	0.	0.	0.	0.	0.	0.	0.
5250.00-5300.00	0.	0.	0.	0.	0.	0.	0.
5300.00-5350.00	0.	0.	0.	0.	0.	0.	0.
5350.00-5400.00	0.	0.	0.	0.	0.	0.	0.
5400.00-5450.00	0.	0.	0.	0.	0.	0.	0.
5450.00-5500.00	0.	0.	0.	0.	0.	0.	0.
5500.00-5550.00	0.	0.	0.	0.	0.	0.	0.
[illegible]	0.	0.	0.	0.	0.	0.	0.
[illegible]	0.	0.	0.	0.	0.	0.	0.
[illegible]	0.	0.	0.	0.	0.	0.	0.

Table B2. Absorption Cross Sections for N_2O_5, HNO_2, HNO_3, CH_4, CO_2, CH_2O, and HO_2 (Contd)

WAVELENGTH BAND ANGSTROMS	CROSS SECTIONS (CM2) N2O5	HNO2	HNO3	CH4	CO2	CH2O	HO2
1792.60-1803.60	0.	0.	0.	0.	1.30E-21	0.	5.50E-18
1803.60-1816.40	0.	0.	0.	0.	1.00E-21	0.	5.50E-18
1816.40-1830.60	0.	0.	0.	0.	6.00E-22	0.	5.50E-18
1830.60-1846.20	0.	0.	0.	0.	4.00E-22	0.	5.50E-18
1846.20-1863.40	0.	0.	0.	0.	3.00E-22	0.	5.60E-18
1863.40-1882.20	0.	0.	0.	0.	1.50E-22	0.	5.70E-18
1882.20-1902.40	0.	0.	0.	0.	8.00E-23	0.	5.80E-18
1902.40-1924.00	0.	0.	0.	0.	3.00E-23	0.	5.80E-18
1924.00-1947.00	0.	0.	0.	0.	2.00E-23	0.	5.80E-18
1947.00-1971.80	0.	0.	0.	0.	1.00E-23	0.	5.80E-18
1971.80-1985.00	0.	0.	8.00E-18	0.	8.00E-24	0.	5.80E-18
1985.00-2000.00	0.	0.	7.00E-18	0.	5.50E-24	0.	5.90E-18
2000.00-2025.00	0.	0.	5.00E-18	0.	4.00E-24	0.	5.90E-18
2025.00-2050.00	0.	0.	3.80E-18	0.	3.20E-24	0.	5.90E-18
2050.00-2061.86	0.	0.	3.00E-18	0.	3.00E-24	0.	5.90E-18
2061.86-2083.33	0.	0.	2.40E-18	0.	3.00E-24	0.	6.00E-18
2083.33-2105.26	0.	0.	1.70E-18	0.	2.80E-24	0.	6.00E-18
2105.26-2127.66	5.00E-18	0.	6.00E-19	0.	2.40E-24	0.	6.00E-18
2127.66-2150.54	4.00E-18	0.	4.60E-19	0.	2.00E-24	0.	6.00E-18
2150.54-2173.91	3.30E-18	0.	3.40E-19	0.	0.	0.	5.80E-18
2173.91-2197.80	2.80E-18	0.	2.40E-19	0.	0.	0.	5.50E-18
2197.80-2222.22	2.20E-18	0.	1.50E-19	0.	0.	0.	5.00E-18
2222.22-2247.19	2.00E-18	0.	1.10E-19	0.	0.	0.	4.50E-18
2247.19-2272.73	1.50E-18	0.	9.00E-20	0.	0.	0.	4.00E-18
2272.73-2298.85	1.10E-18	0.	8.00E-20	0.	0.	0.	3.70E-18
2298.85-2325.58	1.00E-18	0.	5.50E-20	0.	0.	0.	3.00E-18
2325.58-2352.94	9.00E-19	0.	4.50E-20	0.	0.	0.	2.70E-18
2352.94-2380.95	8.00E-19	0.	3.80E-20	0.	0.	0.	2.30E-18
2380.95-2409.64	7.00E-19	0.	3.00E-20	0.	0.	0.	2.10E-18
2409.64-2439.02	6.00E-19	0.	2.80E-20	0.	0.	3.50E-21	1.70E-18
2439.02-2469.14	5.00E-19	0.	2.10E-20	0.	0.	3.80E-21	1.20E-18
2469.14-2500.00	4.00E-19	0.	2.00E-20	0.	0.	4.00E-21	1.00E-18
2500.00-2531.65	3.80E-19	0.	2.00E-20	0.	0.	6.00E-21	5.00E-19
2531.65-2564.10	3.20E-19	0.	2.00E-20	0.	0.	7.00E-21	3.80E-19
2564.10-2597.40	3.00E-19	0.	2.00E-20	0.	0.	8.00E-21	2.60E-19
2597.40-2631.58	2.40E-19	0.	2.00E-20	0.	0.	9.00E-21	1.10E-19
2631.58-2666.67	2.10E-19	0.	2.00E-20	0.	0.	1.00E-20	8.00E-20
2666.67-2702.70	1.80E-19	0.	2.00E-20	0.	0.	1.20E-20	5.00E-20
2702.70-2739.73	1.50E-19	0.	1.80E-20	0.	0.	1.50E-20	2.20E-20
2739.73-2777.78	1.30E-19	0.	1.60E-20	0.	0.	1.70E-20	0.
2777.78-2816.90	1.00E-19	0.	1.20E-20	0.	0.	1.90E-20	0.
2816.90-2857.14	8.00E-20	0	1.10E-20	0.	0.	2.10E-20	0.
2857.14-2898.55	6.00E-20	0.	9.00E-21	0.	0.	2.50E-20	0.
2898.55-2941.18	4.00E-20	0.	6.50E-21	0.	0.	3.00E-20	0.
2941.18-2985.07	3.30E-20	0.	5.00E-21	0.	0.	3.80E-20	0.
2985.07-3030.30	2.80E-20	7.00E-21	3.20E-21	0.	0.	3.00E-20	0.
3030.30-3076.92	2.10E-20	7.50E-21	2.30E-21	0.	0.	4.00E-20	0.
3076.92-3100.00	1.90E-20	9.00E-21	1.80E-21	0.	0.	3.50E-20	0.
3100.00-3150.00	1.10E-20	1.00E-20	7.00E-22	0.	0.	4.50E-20	0.
3150.00-3200.00	9.00E-21	1.10E-20	3.90E-22	0.	0.	3.00E-20	0.

Table B2. Absorption Cross Sections for N_2O_5, HNO_2, HNO_3, CH_4, CO_2, CH_2O, and HO_2

WAVELENGTH BAND ANGSTROMS	CROSS SECTIONS (CM2) N2O5	HNO2	HNO3	CH4	CO2	CH2O	HO2
1215.67-1215.67	0.	0.	0.	2.80E-17	7.30E-20	9.00E-18	0.
1162.79-1169.59	0.	0.	0.	2.80E-17	1.10E-19	0.	0.
1169.59-1176.47	0.	0.	0.	2.80E-17	8.80E-20	0.	0.
1176.47-1183.43	0.	0.	0.	2.80E-17	6.00E-20	0.	0.
1183.43-1190.48	0.	0.	0.	2.80E-17	4.70E-20	0.	0.
1190.48-1197.60	0.	0.	0.	2.80E-17	3.80E-20	0.	0.
1197.60-1204.82	0.	0.	0.	2.80E-17	4.00E-20	0.	0.
1204.82-1212.12	0.	0.	0.	2.80E-17	6.10E-20	0.	0.
1212.12-1219.51	0.	0.	0.	2.80E-17	7.40E-20	0.	0.
1219.51-1226.99	0.	0.	0.	2.80E-17	1.00E-19	0.	0.
1226.99-1234.57	0.	0.	0.	2.80E-17	1.20E-19	0.	0.
1234.57-1242.24	0.	0.	0.	2.80E-17	1.60E-19	0.	0.
1242.24-1250.00	0.	0.	0.	2.80E-17	1.80E-19	0.	0.
1250.00-1257.86	0.	0.	0.	2.80E-17	2.10E-19	0.	0.
1257.86-1265.82	0.	0.	0.	2.80E-17	2.80E-19	0.	0.
1265.82-1273.89	0.	0.	0.	2.80E-17	3.30E-19	0.	0.
1273.89-1282.05	0.	0.	0.	2.80E-17	4.20E-19	0.	0.
1282.05-1290.32	0.	0.	0.	2.80E-17	5.90E-19	0.	0.
1290.32-1298.70	0.	0.	0.	2.80E-17	7.00E-19	0.	0.
1298.70-1307.19	0.	0.	0.	2.47E-17	8.00E-19	0.	0.
1307.19-1315.79	0.	0.	0.	2.24E-17	8.30E-19	0.	0.
1315.79-1324.50	0.	0.	0.	2.07E-17	8.50E-19	0.	0.
1324.50-1333.33	0.	0.	0.	1.57E-17	8.70E-19	0.	0.
1333.33-1342.28	0.	0.	0.	1.33E-17	8.70E-19	0.	0.
1342.28-1351.35	0.	0.	0.	1.20E-17	8.70E-19	0.	0.
1351.35-1360.54	0.	0.	0.	1.00E-17	8.60E-19	0.	0.
1360.54-1369.86	0.	0.	0.	8.40E-18	8.10E-19	0.	0.
1369 86-1379.31	0.	0.	0.	5.90E-18	7.20E-19	0.	0.
1379.31-1388.89	0.	0.	0.	3.93E-18	6.40E-19	0.	0.
1388.89-1408.45	0.	0.	0.	2.24E-18	6.00E-19	0.	0.
1408.45-1428.57	0.	0.	0.	6.72E-19	5.70E-19	1.00E-17	0.
1428.57-1449.28	0.	0.	0.	6.72E-20	5.50E-19	7.00E-18	0.
1449.28-1470.59	0.	0.	0.	1.68E-20	5.70E-19	4.00E-18	0.
1470.59-1492.54	0.	0.	0.	1.12E-20	5.70E-19	5.50E-18	0.
1492.54-1515.15	0.	0.	0.	9.00E-21	5.00E-19	1.20E-17	0.
1515.15-1538.46	0.	0.	0.	5.60E-21	4.00E-19	1.80E-17	0.
1538.46-1562.50	0.	0.	0.	4.48E-21	3.00E-19	9.00E-18	0.
1552.50-1587.30	0.	0.	0.	2.80E-21	2.50E-19	8.00E-19	0.
1587.30-1612.90	0.	0.	0.	1.12E-21	1.60E-19	0.	0.
1612.90-1639.34	0.	0.	0.	8.00E-22	1.00E-19	0.	0.
1639.34-1666.67	0.	0.	0.	0.	7.00E-20	0.	0.
1666.67-1694.92	0.	0.	0.	0.	4.00E-20	1.50E-18	0.
1694.92-1724.14	0.	0.	0.	0.	1.50E-20	1.20E-17	0.
1724.14-1739.13	0.	0.	0.	0.	1.00E-20	6.00E-18	0.
1739.13-1750.00	0.	0.	0.	0.	8.00E-21	1.80E-18	0.
1750.00-1763.20	0.	0.	0.	0.	5.00E-21	0.	0.
1763.20-1768.60	0.	0.	0.	0.	3.50E-21	0.	0.
1768.60-1774.60	0.	0.	0.	0.	3.00E-21	0.	0.
[illegible]	0.	0.	0.	0.	2.00E-21	0.	0.
[illegible]	0.	0.	0.	0.	1.50E-21	0.	0.

Table B1. Solar Fluxes and Absorption Cross Sections for O_2, O_3, H_2O, H_2O_2, NO_2, NO_3, and N_2O (Contd)

WAVELENGTH BAND ANGSTROMS	FLUX PH/CM2/S/A	CROSS SECTIONS (CM2) O2	O3	H2O	H2O2	NO2	NO3	N2O
5700.00-5750.00	5.38E+13	0.	4.75E-21	0.	0.	0.	6.00E-19	0.
5750.00-5800.00	5.42E+13	0.	4.55E-21	0.	0.	0.	7.00E-19	0.
5800.00-5850.00	5.42E+13	0.	4.35E-21	0.	0.	0.	7.00E-19	0.
5850.00-5900.00	5.42E+13	0.	4.42E-21	0.	0.	0.	9.00E-19	0.
5900.00-5950.00	5.44E+13	0.	4.61E-21	0.	0.	0.	1.00E-18	0.
5950.00-6000.00	5.44E+13	0.	4.89E-21	0.	0.	0.	9.00E-19	0.
6000.00-6050.00	5.42E+13	0.	4.84E-21	0.	0.	0.	8.00E-19	0.
6050.00-6100.00	5.40E+13	0.	4.54E-21	0.	0.	0.	7.00E-19	0.
6100.00-6150.00	5.40E+13	0.	4.24E-21	0.	0.	0.	5.00E-19	0.
6150.00-6200.00	5.40E+13	0.	3.90E-21	0.	0.	0.	4.00E-19	0.
6200.00-6250.00	5.38E+13	0.	3.60E-21	0.	0.	0.	2.00E-18	0.
6250.00-6300.00	5.36E+13	0.	3.43E-21	0.	0.	0.	1.80E-18	0.
6300.00-6350.00	5.34E+13	0.	3.17E-21	0.	0.	0.	6.00E-19	0.
6350.00-6400.00	5.32E+13	0.	2.74E-21	0.	0.	0.	4.00E-19	0.
6400.00-6450.00	5.30E+13	0.	2.61E-21	0.	0.	0.	2.20E-19	0.
6450.00-6500.00	7.90E+13	0.	2.40E-21	0.	0.	0.	2.00E-19	0.
6500.00-6600.00	5.22E+13	0.	2.07E-21	0.	0.	0.	3.00E-19	0.
6600.00-6700.00	5.18E+13	0.	1.72E-21	0.	0.	0.	2.00E-18	0.
6700.00-6800.00	5.14E+13	0.	1.37E-21	0.	0.	0.	2.00E-19	0.
6800.00-6900.00	5.09E+13	0.	1.11E-21	0.	0.	0.	0.	0.
6900.00-7000.00	5.04E+13	0.	9.13E-22	0.	0.	0.	0.	0.
7000.00-7100.00	4.99E+13	0.	7.93E-22	0.	0.	0.	0.	0.
7100.00-7200.00	4.94E+13	0.	6.40E-22	0.	0.	0.	0.	0.
7200.00-7300.00	4.90E+13	0.	5.14E-22	0.	0.	0.	0.	0.

Table B1. Solar Fluxes and Absorption Cross Sections for O_2, O_3, H_2O, H_2O_2, NO_2, NO_3, and N_2O (Contd)

WAVELENGTH BAND ANGSTROMS	FLUX PH/CM2/S,A	CROSS SECTIONS (CM2) O2	O3	H2O	H2O2	NO2	NO3	N2O
3200.00-3250.00	1.62E+13	0.	1.50E-20	0.	0.	2.94E-19	0.	0.
3250.00-3300.00	1.94E+13	0.	7.78E-21	0.	0.	3.38E-19	0.	0.
3300.00-3350.00	1.79E+13	0.	3.72E-21	0.	0.	3.61E-19	0.	0.
3350.00-3400.00	1.89E+13	0.	1.71E-21	0.	0.	4.17E-19	0.	0.
3400.00-3450.00	2.02E+13	0.	7.46E-22	0.	0.	4.30E-19	0.	0.
3450.00-3500.00	2.06E+13	0.	2.66E-22	0.	0.	4.48E-19	0.	0.
3500.00-3550.00	2.06E+13	0.	1.09E-22	0.	0.	5.53E-19	0.	0.
3550.00-3600.00	2.08E+13	0.	5.49E-23	0.	0.	4.96E-19	0.	0.
3600.00-3650.00	2.36E+13	0.	0.	0.	0.	5.84E-19	0.	0.
3650.00-3700.00	2.46E+13	0.	0.	0.	0.	5.70E-19	0.	0.
3700.00-3750.00	2.48E+13	0.	0.	0.	0.	5.74E-19	0.	0.
3750.00-3800.00	2.34E+13	0.	0.	0.	0.	6.52E-19	0.	0.
3800.00-3850.00	2.22E+13	0.	0.	0.	0.	6.45E-19	0.	0.
3850.00-3900.00	2.18E+13	0.	0.	0.	0.	6.51E-19	0.	0.
3900.00-3950.00	2.38E+13	0.	0.	0.	0.	6.08E-19	0.	0.
3950.00-4000.00	3.08E+13	0.	0.	0.	0.	6.68E-19	0.	0.
4000.00-4050.00	3.80E+13	0.	0.	0.	0.	6.52E-19	0.	0.
4050.00-4100.00	3.98E+13	0.	2.91E-23	0.	0.	6.59E-19	0.	0.
4100.00-4150.00	3.98E+13	0.	3.14E-23	0.	0.	6.03E-19	0.	0.
4150.00-4200.00	4.04E+13	0.	3.99E-23	0.	0.	6.24E-19	0.	0.
4200.00-4250.00	4.02E+13	0.	6.54E-23	0.	0.	0.	0.	0.
4250.00-4300.00	3.88E+13	0.	6.83E-23	0.	0.	0.	0.	0.
4300.00-4350.00	3.96E+13	0.	8.66E-23	0.	0.	0.	0.	0.
4350.00-4400.00	4.50E+13	0.	1.25E-22	0.	0.	0.	0.	0.
4400.00-4450.00	4.78E+13	0.	1.49E-22	0.	0.	0.	0.	0.
4450.00-4500.00	4.96E+13	0.	1.71E-22	0.	0.	0.	0.	0.
4500.00-4550.00	4.98E+13	0.	2.12E-22	0.	0.	0.	6.00E-20	0.
4550.00-4600.00	4.96E+13	0.	3.57E-22	0.	0.	0.	1.00E-19	0.
4600.00-4650.00	5.00E+13	0.	3.68E-22	0.	0.	0.	8.00E-20	0.
4650.00-4700.00	5.10E+13	0.	4.06E-22	0.	0.	0.	1.20E-19	0.
4700.00-4750.00	5.22E+13	0.	4.89E-22	0.	0.	0.	1.80E-19	0.
4750.00-4800.00	5.18E+13	0.	7.11E-22	0.	0.	0.	2.40E-19	0.
4800.00-4850.00	4.92E+13	0.	8.43E-22	0.	0.	0.	2.10E-19	0.
4850.00-4900.00	4.88E+13	0.	8.28E-22	0.	0.	0.	2.40E-19	0.
4900.00-4950.00	5.06E+13	0.	9.09E-22	0.	0.	0.	2.40E-19	0.
4950.00-5000.00	4.96E+13	0.	1.22E-21	0.	0.	0.	3.00E-19	0.
5000.00-5050.00	4.98E+13	0.	1.62E-21	0.	0.	0.	3.00E-19	0.
5050.00-5100.00	5.00E+13	0.	1.58E-21	0.	0.	0.	4.00E-19	0.
5100.00-5150.00	4.86E+13	0.	1.60E-21	0.	0.	0.	4.50E-19	0.
5150.00-5200.00	4.86E+13	0.	1.78E-21	0.	0.	0.	5.00E-19	0.
5200.00-5250.00	5.04E+13	0.	2.07E-21	0.	0.	0.	5.00E-19	0.
5250.00-5300.00	5.16E+13	0.	2.55E-21	0.	0.	0.	6.00E-19	0.
5300.00-5350.00	5.28E+13	0.	2.74E-21	0.	0.	0.	6.00E-19	0.
5350.00-5400.00	5.34E+13	0.	2.88E-21	0.	0.	0.	5.00E-19	0.
5400.00-5450.00	5.40E+13	0.	3.07E-21	0.	0.	0.	4.00E-19	0.
5450.00-5500.00	5.36E+13	0.	3.17E-21	0.	0.	0.	6.00E-19	0.
[illegible]0.[illegible]5550.00	5.32E+13	0.	3.36E-21	0.	0.	0.	6.50E-19	0.
[illegible]	[illegible]	0.	3.88E-21	0.	0.	0.	7.00E-19	0.
[illegible]	5.34E+13	0.	4.31E-21	0.	0.	0.	6.00E-19	0.
5650.00-5700.00	5.34E+13	0.	4.67E-21	0.	0.	0.	6.00E-19	0.

Table B1. Solar Fluxes and Absorption Cross Sections for O_2, O_3, H_2O, H_2O_2, NO_2, NO_3, and N_2O (Contd)

WAVELENGTH BAND ANGSTROMS	FLUX PH/CM2/S/A	CROSS SECTIONS (CM2) O2	O3	H2O	H2O2	NO2	NO3	N2O
1792.60-1803.60	1.01E+10	0.	7.77E-19	1.02E-18	0.	0.	0.	0.
1803.60-1816.40	1.27E+10	0.	7.60E-19	6.98E-19	0.	0.	0.	0.
1816.40-1830.60	1.42E+10	0.	7.33E-19	3.64E-19	0.	0.	0.	0.
1830.60-1846.20	1.29E+10	0.	6.99E-19	1.80E-19	0.	0.	0.	0.
1846.20-1863.40	1.31E+10	0.	6.56E-19	6.51E-20	0.	0.	0.	0.
1863.40-1882.20	1.63E+10	0.	6.06E-19	0.	0.	0.	0.	0.
1882.20-1902.40	1.92E+10	0.	5.45E-19	0.	9.79E-19	0.	0.	0.
1902.40-1924.00	2.29E+10	0.	4.86E-19	0.	8.10E-19	5.25E-19	0.	1.26E-19
1924.00-1947.00	3.61E+10	0.	4.36E-19	0.	7.03E-19	4.83E-19	0.	9.00E-20
1947.00-1971.80	4.68E+10	0.	4.01E-19	0.	6.15E-19	4.00E-19	0.	8.00E-20
1971.80-1985.00	6.21E+10	0.	3.42E-19	0.	5.64E-19	3.50E-19	0.	7.00E-20
1985.00-2000.00	6.85E+10	0.	3.28E-19	0.	5.43E-19	3.30E-19	0.	5.50E-20
2000.00-2025.00	7.33E+10	0.	3.26E-19	0.	5.16E-19	3.50E-19	0.	4.00E-20
2025.00-2050.00	8.74E+10	0.	3.28E-19	0.	4.79E-19	4.00E-19	0.	2.50E-20
2050.00-2061.86	1.10E+11	1.05E-23	3.51E-19	0.	4.66E-19	4.20E-19	0.	2.00E-20
2061.86-2083.33	1.96E+11	1.00E-23	4.11E-19	0.	4.42E-19	4.30E-19	0.	1.70E-20
2083.33-2105.26	3.33E+11	9.55E-24	4.84E-19	0.	4.22E-19	4.40E-19	0.	1.10E-20
2105.26-2127.66	4.21E+11	8.93E-24	6.26E-19	0.	3.92E-19	4.54E-19	0.	4.00E-21
2127.66-2150.54	4.63E+11	8.28E-24	8.57E-19	0.	3.63E-19	4.58E-19	0.	2.00E-21
2150.54-2173.91	5.73E+11	7.60E-24	1.17E-18	0.	3.40E-19	4.62E-19	0.	1.10E-21
2173.91-2197.80	5.53E+11	6.92E-24	1.52E-18	0.	3.19E-19	4.50E-19	0.	1.00E-21
2197.80-2222.22	7.08E+11	6.28E-24	1.97E-18	0.	2.98E-19	4.25E-19	0.	4.00E-22
2222.22-2247.19	7.21E+11	5.65E-24	2.55E-18	0.	2.67E-19	4.00E-19	0.	2.80E-22
2247.19-2272.73	7.13E+11	5.03E-24	3.24E-18	0.	2.49E-19	3.50E-19	0.	2.00E-22
2272.73-2298.85	8.65E+11	4.40E-24	4.00E-18	0.	2.36E-19	3.00E-19	0.	1.20E-22
2298.85-2325.58	8.98E+11	3.76E-24	4.83E-18	0.	2.16E-19	2.50E-19	0.	7.00E-23
2325.58-2352.94	8.22E+11	3.09E-24	5.79E-18	0.	1.99E-19	2.00E-19	0.	5.00E-23
2352.94-2380.95	7.89E+11	2.44E-24	6.86E-18	0.	1.81E-19	1.18E-19	0.	3.00E-23
2380.95-2409.64	8.09E+11	1.75E-24	7.97E-18	0.	1.66E-19	1.00E-19	0.	2.00E-23
2409.64-2439.02	8.51E+11	6.74E-25	9.00E-18	0.	1.48E-19	7.00E-20	0.	1.10E-23
2439.02-2469.14	9.07E+11	0.	1.00E-17	0.	1.30E-19	5.00E-20	0.	9.00E-24
2469.14-2500.00	9.33E+11	0.	1.07E-17	0.	1.22E-19	3.60E-20	0.	8.00E-24
2500.00-2531.65	9.54E+11	0.	1.11E-17	0.	1.08E-19	2.50E-20	0.	7.00E-24
2531.65-2564.10	1.22E+12	0.	1.12E-17	0.	9.30E-20	1.50E-20	0.	6.00E-24
2564.10-2597.40	2.14E+12	0.	1.11E-17	0.	8.43E-20	1.70E-20	0.	5.00E-24
2597.40-2631.58	1.28E+12	0.	1.03E-17	0.	7.49E-20	1.90E-20	0.	5.00E-24
2631.58-2666.67	3.19E+12	0.	9.43E-18	0.	6.39E-20	2.10E-20	0.	5.00E-24
2666.67-2702.70	3.47E+12	0.	8.23E-18	0.	5.64E-20	2.90E-20	0.	5.00E-24
2702.70-2739.73	3.13E+12	0.	6.81E-18	0.	5.00E-20	3.70E-20	0.	5.20E-24
2739.73-2777.78	3.13E+12	0.	5.31E-18	0.	4.33E-20	4.20E-20	0.	5.90E-24
2777.78-2816.90	3.53E+12	0.	3.99E-18	0.	3.62E-20	5.00E-20	0.	6.00E-24
2816.90-2857.14	4.22E+12	0.	2.84E-18	0.	3.27E-20	6.50E-20	0.	5.40E-24
2857.14-2898.55	5.94E+12	0.	1.92E-18	0.	2.91E-20	8.00E-20	0.	5.20E-24
2898.55-2941.18	9.15E+12	0.	1.14E-18	0.	2.53E-20	9.00E-20	0.	5.00E-24
2941.18-2985.07	9.09E+12	0.	6.60E-19	0.	2.15E-20	1.20E-19	0.	5.10E-24
2985.07-3030.30	6.53E+12	0.	3.69E-19	0.	1.75E-20	1.33E-19	0.	5.00E-24
3030.30-3076.92	1.09E+13	0.	1.97E-19	0.	0.	1.65E-19	0.	4.20E-24
3076.92-3100.00	2.57E+13	0.	1.05E-19	0.	0.	1.97E-19	0.	3.40E-24
3100.00-3150.00	1.21E+13	0.	5.23E-20	0.	0.	2.24E-19	0.	1.70E-24
3150.00-3200.00	1.39E+13	0.	2.91E-20	0.	0.	2.61E-19	0.	0.

Table B1. Solar Fluxes and Absorption Cross Sections for O_2, O_3, H_2O, H_2O_2, NO_2, NO_3, and N_2O

WAVELENGTH BAND ANGSTROMS	FLUX PH/CM2/S/A	CROSS SECTIONS (CM2) O2	O3	H2O	H2O2	NO2	NO3	N2O
1215.67-1215.67	3.00E+11	1.00E-20	2.32E-17	0.	0.	0.	0.	0.
1162.79-1169.59	1.51E+07	2.00E-20	7.80E-18	0.	0.	0.	0.	0.
1169.59-1176.47	3.87E+07	1.25E-18	7.97E-18	0.	0.	0.	0.	0.
1176.47-1183.43	1.61E+07	2.55E-19	8.66E-18	0.	0.	0.	0.	0.
1183.43-1190.48	1.76E+07	3.00E-20	9.51E-18	0.	0.	0.	0.	0.
1190.48-1197.60	2.55E+07	3.75E-19	1.25E-17	0.	0.	0.	0.	0.
1197.60-1204.82	[illegible]	4.45E-18	1.84E-17	0.	0.	0.	0.	0.
1204.82-1212.12	1.01E+08	8.35E-18	2.19E-17	0.	0.	0.	0.	0.
1212.12-1219.51	3.08E+08	6.00E-19	2.30E-17	0.	0.	0.	0.	0.
1219.51-1226.99	4.91E+08	2.35E-19	2.26E-17	1.99E-17	0.	0.	0.	0.
1226.99-1234.57	1.80E+08	4.50E-19	2.06E-17	6.15E-18	0.	0.	0.	0.
1234.57-1242.24	1.51E+08	3.35E-19	1.30E-17	5.16E-18	0.	0.	0.	0.
1242.24-1250.00	9.69E+07	1.75E-17	8.91E-18	1.10E-17	0.	0.	0.	0.
1250.00-1257.86	1.05E+08	8.95E-19	7.24E-18	6.39E-18	0.	0.	0.	0.
1257.86-1265.82	1.19E+08	4.30E-19	6.09E-18	7.13E-18	0.	0.	0.	0.
1265.82-1273.89	1.03E+08	1.10E-19	5.66E-18	7.84E-18	0.	0.	0.	0.
1273.89-1282.05	7.96E+07	2.05E-19	5.87E-18	7.48E-18	0.	0.	0.	0.
1282.05-1290.32	5.71E+07	4.43E-19	6.47E-18	7.82E-18	0.	0.	0.	0.
1290.32-1298.70	7.16E+07	5.55E-19	8.14E-18	7.64E-18	0.	0.	0.	0.
1298.70-1307.19	3.89E+08	4.20E-19	1.24E-17	6.71E-18	0.	0.	0.	0.
1307.19-1315.79	2.06E+08	6.85E-19	1.52E-17	6.75E-18	0.	0.	0.	0.
1315.79-1324.50	8.68E+07	1.45E-18	1.47E-17	5.67E-18	0.	0.	0.	0.
1324.50-1333.33	1.73E+08	2.25E-18	1.51E-17	4.93E-18	0.	0.	0.	0.
1333.33-1342.28	2.79E+08	2.30E-18	1.51E-17	5.00E-18	0.	0.	0.	0.
1342.28-1351.35	1.03E+08	4.55E-18	1.65E-17	3.69E-18	0.	0.	0.	0.
1351.35-1360.54	1.62E+08	7.23E-18	1.54E-17	3.36E-18	0.	0.	0.	0.
1360.54-1369.86	1.23E+08	9.50E-18	1.35E-17	2.42E-18	0.	0.	0.	0.
1369.86-1379.31	1.37E+08	1.23E-17	1.05E-17	1.80E-18	0.	0.	0.	0.
1379.31-1388.89	1.20E+08	1.32E-17	7.97E-18	1.60E-18	0.	0.	0.	0.
1388.89-1408.45	2.93E+08	1.36E-17	7.17E-18	1.19E-18	0.	0.	0.	0.
1408.45-1428.57	2.10E+08	1.40E-17	6.28E-18	7.00E-19	0.	0.	0.	0.
1428.57-1449.28	2.49E+08	1.48E-17	5.66E-18	5.03E-19	0.	0.	0.	0.
1449.28-1470.59	2.94E+08	1.41E-17	5.23E-18	4.96E-19	0.	0.	0.	0.
1470.59-1492.54	4.06E+08	1.29E-17	4.47E-18	6.87E-19	0.	0.	0.	0.
1492.54-1515.15	4.55E+08	1.15E-17	3.69E-18	9.45E-19	0.	0.	0.	0.
1515.15-1538.46	5.96E+08	9.91E-18	2.93E-18	1.38E-18	0.	0.	0.	0.
1538.46-1562.50	9.36E+08	8.24E-18	2.19E-18	1.84E-18	0.	0.	0.	0.
1562.50-1587.30	8.59E+09	6.58E-18	1.63E-18	2.44E-18	0.	0.	0.	0.
1587.30-1612.90	8.05E+08	4.97E-18	1.20E-18	3.20E-18	0.	0.	0.	0.
1612.90-1639.34	1.29E+09	3.45E-18	9.77E-19	3.91E-18	0.	0.	0.	0.
1639.34-1666.67	2.06E+09	2.08E-18	8.66E-19	4.64E-18	0.	0.	0.	0.
1666.67-1694.92	2.84E+09	1.23E-18	9.14E-19	4.57E-18	0.	0.	0.	0.
1694.92-1724.14	4.72E+09	7.22E-19	8.17E-19	4.35E-18	0.	0.	0.	0.
1724.14-1739.13	4.93E+09	4.56E-19	8.57E-19	3.57E-18	0.	0.	0.	0.
1739.13-1750.00	5.49E+09	2.74E-19	8.40E-19	2.64E-18	0.	0.	0.	0.
1750.00-1763.20	6.25E+09	0.	8.18E-19	2.64E-18	0.	0.	0.	0.
1763.20-1769.60	[illegible]	0.	8.04E-19	2.22E-18	0.	0.	0.	0.
[illegible]	[illegible]	0.	8.00E-19	2.04E-18	0.	0.	0.	0.
[illegible]	[illegible]	0.	[illegible]	1.80E-18	0.	0.	0.	0.
[illegible]	[illegible]	0.	7.89E-19	1.42E-18	0.	0.	0.	0.

and

$$CH_2O + h\nu \rightarrow CO + H_2$$

for wavelengths from 240 to 360 nmn. The absorption cross sections for this molecule are taken from McQuigg and Calvert[B14] and Calvert et al.[B15] These authors also give the quantum efficiencies for these processes. Table B19 lists the total photodissociation rate coefficients for formaldehyde. If both of the above processes are considered to occur for this molecule, then the values presented in Table B19 must be multiplied by the relative efficiencies as given by McQuigg and Calvert[B14] and Calvert et al[B15] for each of these reactions.

B11. THE HYDROPEROXYL RADICAL

The primary photodissociation process for the hydroperoxyl radical is

$$HO_2 + h\nu \rightarrow OH + O \quad \lambda < 456\,\text{nm}.$$

The absorption cross sections used for HO_2 are a composite of the measurements of Hochanadel et al[B16] and Paukert and Johnston.[B17] The photodissociation rate coefficients for this radical are listed in Table B20.

B14. McQuigg, R.D., and Calvert, J.G. (1969) The photodecomposition of CH_2O, CD_2O, CHDO and CH_2O-CD_2O mixtures at xenon flash lamp intensities, J. Am. Chem. Soc. 91:1590-1599.

B15. Calvert, J.G., Kerr, J.A., Demerjian, K.L., and McQuigg, R.D. (1972) Photolysis of formaldehyde as a hydrogen atom source in the lower atmosphere, Science 175:751-752.

B16. Hochanadel, C.J., Ghormley, A., and Ogren, P.J. (1972) Absorption spectrum and reaction kinetics of the HO_2 radical in the gas phase, J. Chem. Phys. 56:4426-4432.

B17. Paukert, T.T., and Johnston, A.S. (1972) Spectra and kinetics of the hydroperoxyl free radical in the gas phase, J. Chem. Phys. 56:2824-2838.

for wavelengths from 116 to 164 nm. Most of the CH_4 photodissociation occurs at the Lyman α line 121.6 nm. The values listed in Table B16 are the total photodissociation rate coefficients for methane. If the above processes have equal efficiencies, then each process would have rate coefficients equal to half of the values shown in the table. The absorption cross sections for this molecule are taken from Watanabe et al.[B10]

B12. CARBON DIOXIDE

The photolysis of carbon dioxide can be proceed by two different processes:

$$CO_2 + h\nu \rightarrow CO + O(^1D) \quad 116.2 < \lambda < 166\,\text{nm}$$

and

$$CO_2 + h\nu \rightarrow CO + O \quad 166 < \lambda < 215\,\text{nm}.$$

The absorption cross sections for this molecule are taken from Inn et al,[B11] Heimerl,[B12] and Ogawa.[B13] The photodissociation rate coefficients for the process yielding excited atomic oxygen are listed in Table B17, and those for the process yielding ground state atomic oxygen are listed in Table B18.

B13. FORMALDEHYDE

Although formaldehyde can be photodissociated in several ways, the primary photolytic processes are

$$CH_2O + h\nu \rightarrow CHO + H$$

B10. Watanabe, K., Zelikoff, M., and Inn, E.C.Y. (1953) Absorption Coefficient of Several Atmospheric Gases, Geophys. Res. Paper, 21, Tech Rpt. AFCRL-53-23.

B11. Inn, E.C.Y., Watanabe, K., and Zelikoff, M. (1953) Absorption coefficients of gases in the vacuum ultraviolet. Part III. CO_2, J. Chem. Phys. 21:1648-1651.

B12. Heimerl, J. (1970) CO_2 absorption coefficient 1655-1825 A, J. Geophys. Res. 75:5574-5575.

B13. Ogawa, M. (1971) Absorption cross sections of O_2 and CO_2 continua in the Schumann and UV regions, J. Chem. Phys. 54:2550-2556.

cule are taken from Jones and Wulf[B9] and Johnston and Graham.[13] Its photodissociation rate coefficients are listed in Table B13.

B9. NITROUS ACID

The photodissociation of nitrous acid probably proceeds as

$$HNO_2 + h\nu \rightarrow OH + NO.$$

The absorption cross sections for this molecule between 300 and 390 nm are those given by Johnston and Graham.[13] Since O_2 is not an efficient absorber of radiation in this wavelength interval, the photodissociation rate coefficients for HNO_2 are listed in Table B14 only as a function of the column density of ozone.

B10. NITRIC ACID

The primary photolytic process for nitric acid is

$$HNO_3 + h\nu \rightarrow OH + NO_2$$

over the broad wavelength region from 192 to 325 nm. The values for the absorption cross sections for this gas are taken from Johnston and Graham.[13] The nitric acid photodissociation rate coefficients are listed in Table B15.

B11. METHANE

The photodissociation processes for methane are

$$CH_4 + h\nu \rightarrow CH_3 + H$$

and

$$CH_4 + h\nu \rightarrow CH_2 + H_2$$

B9. Jones, E.J., and Wulf, O.R. (1937) The absorption coefficient of nitrogen pentoxide in the ultraviolet and the visible absorption spectrum of NO_3, J. Chem. Phys. 5:873-877.

$$NO_3 + h\nu \rightarrow NO + O_2$$

for wavelengths longer than 578 nm. For wavelengths below 578 nm, it is not known whether the products are $NO_2 + O$ or $NO + O_2$. In Table B11, all the photodissociation of this radical is assumed to produce $NO + O_2$. The absorption cross sections for this molecule are taken from Johnston and Graham.[13] Since molecular oxygen is not an efficient absorber for radiations above 450 nm, the photodissociation rate coefficients for this molecule are given only as a function of the ozone column density.

B7. NITROUS OXIDE

The primary photolytic process for nitrous oxide according to Preston and Barr[B6] is

$$N_2O + h\nu \rightarrow N_2 + O(^1D), \lambda < 337\,nm.$$

Below 210 nm, oxygen atoms in the ^1S state may be produced. For the calculations presented in this report, Table B12 was computed with all of the photodissociation of N_2O producing $O(^1D)$. The absorption cross sections below 205 nm are from Zelikoff et al[B7] and above 205 nm, from Bates and Hayes.[B8]

B8. DINITROGEN PENTOXIDE

The primary processes in the photolysis of N_2O_5 are not well understood. Jones and Wulf[B9] attribute the photodissociation of this molecule to

$$N_2O_5 + h\nu \rightarrow N_2O_4 + O \rightarrow 2NO_2 + O$$

for wavelengths from 210 to 380 nm. The absorption cross sections for this mol

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B6. Preston, K.F., and Barr, R.F. (1971) Primary processes in the photolysis of nitrous oxide, J. Chem. Phys. 54,3347-3348.

B7. Zelikoff, M., Watanabe, K., and Inn, E.C.Y. (1953) Absorption coefficients of gases in the vacuum ultraviolet. Part II. Nitrous oxide, J. Chem. Phys. 21,1643-1647.

B8. Bates, D.R., and Hays, P.B. (1967) Atmospheric nitrous oxide, Planet. Space Sci. 15,18[illegible].

Table E4. Total Photodissociation Rate Coefficients for the Process $O_2 + h\nu \rightarrow O + O(^1D)$ (Cont'd)

O2 COLUMN DENSITY	O3 COLUMN DENSITY 5.0E+18	1.0E+19	2.0E+19	5.0E+19	1.0E+20	2.0E+20
1.0E+13	6.79834E-09	9.47067E-11	2.23187E-14	4.24957E-25	7.77344E-43	3.03675E-78
2.0E+13	6.79822E-09	9.47055E-11	2.23184E-14	4.24953E-25	7.77336E-43	3.03671E-78
5.0E+13	6.79788E-09	9.47016E-11	2.23177E-14	4.24940E-25	7.77312E-43	3.03662E-78
1.0E+14	6.79731E-09	9.46952E-11	2.23164E-14	4.24919E-25	7.77273E-43	3.03646E-78
2.0E+14	6.79618E-09	9.46824E-11	2.23139E-14	4.24876E-25	7.77195E-43	3.03614E-78
5.0E+14	6.79277E-09	9.46440E-11	2.23062E-14	4.24746E-25	7.76959E-43	3.03519E-78
1.0E+15	6.78709E-09	9.45800E-11	2.22935E-14	4.24531E-25	7.76567E-43	3.03360E-78
2.0E+15	6.77575E-09	9.44522E-11	2.22680E-14	4.24101E-25	7.75783E-43	3.03042E-78
5.0E+15	6.74192E-09	9.40702E-11	2.21919E-14	4.22813E-25	7.73437E-43	3.02091E-78
1.0E+16	6.68610E-09	9.34384E-11	2.20657E-14	4.20676E-25	7.69544E-43	3.00512E-78
2.0E+16	6.57656E-09	9.21926E-11	2.18161E-14	4.16438E-25	7.61821E-43	2.97381E-78
5.0E+16	6.26383E-09	8.85918E-11	2.10884E-14	4.04011E-25	7.39145E-43	2.88193E-78
1.0E+17	5.79071E-09	8.30146E-11	1.99426E-14	3.84213E-25	7.02941E-43	2.73539E-78
2.0E+17	4.99391E-09	7.32432E-11	1.78774E-14	3.47802E-25	6.36107E-43	2.46540E-78
5.0E+17	3.39109E-09	5.19651E-11	1.31032E-14	2.59836E-25	4.73406E-43	1.81176E-78
1.0E+18	2.01269E-09	3.17454E-11	8.18451E-15	1.63393E-25	2.93529E-43	1.09807E-78
2.0E+18	8.94428E-10	1.41535E-11	3.62480E-15	6.95328E-26	1.18981E-43	4.23429E-79
5.0E+18	1.58965E-10	2.41572E-12	5.68530E-16	8.57694E-27	1.14044E-44	3.39320E-80
1.0E+19	2.18886E-11	3.24585E-13	7.18573E-17	8.26195E-28	6.12377E-46	9.18129E-82
2.0E+19	1.07208E-12	1.60175E-14	3.57869E-18	4.01515E-29	2.29144E-47	8.03806E-84
5.0E+19	2.75090E-16	4.12506E-18	9.27565E-22	1.05462E-32	6.06327E-51	2.00427E-87
1.0E+20	3.08714E-22	4.62933E-24	1.04099E-27	1.18365E-38	6.80543E-57	2.24967E-93
2.0E+20	4.49203E-31	5.83243E-36	1.31152E-39	1.49127E-50	8.57407E-69	2.83433-105
5.0E+20	1.08004E-33	1.24725E-50	2.62283E-75	2.98228E-86	1.71467-104	5.66818-141
1.0E+21	4.90335E-38	5.66250E-55	7.55159E-89	9.46683-146	5.44298-164	1.79928-200
2.0E+21	1.01066E-48	1.16713E-63	1.55650E-97	3.69182-199	5.48464-283	0.
5.0E+21	8.84982E-73	1.02200E-89	1.36295-123	3.23274-225	0.	0.
1.0E+22	3.29220-118	3.80190-133	5.07028-167	1.20260-268	0.	0.

Table B5. Total Photodissociation Rate Coefficients for the Process $O_2 + h\nu \rightarrow O + O$ for Wavelengths From 175 to 242.2 nm

O2 COLUMN DENSITY	O3 COLUMN DENSITY									
	1.0E+13	2.0E+13	5.0E+13	1.0E+14	2.0E+14	5.0E+14	1.0E+15	2.0E+15	5.0E+15	1.0E+16
1.0E+17	8.36791E-08	8.36784E-08	8.36764E-08	8.36731E-08	8.36664E-08	8.36464E-08	8.36131E-08	8.35466E-08	8.33473E-08	8.30164E-08
2.0E+17	7.96609E-08	7.96602E-08	7.96583E-08	7.96551E-08	7.96488E-08	7.96298E-08	7.95980E-08	7.95346E-08	7.93448E-08	7.90296E-08
5.0E+17	6.94462E-08	6.94456E-08	6.94440E-08	6.94412E-08	6.94357E-08	6.94190E-08	6.93913E-08	6.93359E-08	6.91701E-08	6.88949E-08
1.0E+18	5.78378E-08	5.78373E-08	5.78359E-08	5.78336E-08	5.78290E-08	5.78151E-08	5.77919E-08	5.77456E-08	5.76070E-08	5.73770E-08
2.0E+18	4.48169E-08	4.48165E-08	4.48154E-08	4.48136E-08	4.48100E-08	4.47991E-08	4.47811E-08	4.47450E-08	4.46369E-08	4.44575E-08
5.0E+18	2.84480E-08	2.84478E-08	2.84471E-08	2.84459E-08	2.84435E-08	2.84365E-08	2.84248E-08	2.84014E-08	2.83314E-08	2.82154E-08
1.0E+19	1.87404E-08	1.87402E-08	1.87397E-08	1.87390E-08	1.87374E-08	1.87326E-08	1.87246E-08	1.87087E-08	1.86612E-08	1.85824E-08
2.0E+19	1.19434E-08	1.19433E-08	1.19429E-08	1.19424E-08	1.19413E-08	1.19381E-08	1.19327E-08	1.19220E-08	1.18898E-08	1.18367E-08
5.0E+19	6.78508E-09	6.78501E-09	6.78480E-09	6.78445E-09	6.78375E-09	6.78166E-09	6.77816E-09	6.77119E-09	6.75038E-09	6.71603E-09
1.0E+20	4.62169E-09	4.62163E-09	4.62147E-09	4.62120E-09	4.62065E-09	4.61901E-09	4.61628E-09	4.61083E-09	4.59459E-09	4.56784E-09
2.0E+20	3.25814E-09	3.25810E-09	3.25796E-09	3.25773E-09	3.25728E-09	3.25592E-09	3.25365E-09	3.24914E-09	3.23568E-09	3.21355E-09
5.0E+20	3.25604E-09	3.25599E-09	3.25586E-09	3.25563E-09	3.25518E-09	3.25382E-09	3.25155E-09	3.24704E-09	3.23359E-09	3.21149E-09
1.0E+21	2.19971E-09	2.19968E-09	2.19956E-09	2.19937E-09	2.19898E-09	2.19783E-09	2.19591E-09	2.19209E-09	2.18071E-09	2.16203E-09
2.0E+21	1.75578E-09	1.75574E-09	1.75563E-09	1.75546E-09	1.75510E-09	1.75403E-09	1.75225E-09	1.74870E-09	1.73815E-09	1.72086E-09
5.0E+21	1.49053E-09	1.49050E-09	1.49040E-09	1.49023E-09	1.48989E-09	1.48887E-09	[illegible]	1.48381E-09	1.47379E-09	1.45738E-09
1.0E+22	1.29543E-09	1.29540E-09	1.29530E-09	1.29514E-09	1.29482E-09	1.29385E-09	1.29223E-09	1.28901E-09	1.27944E-09	1.26378E-09
2.0E+22	1.16776E-09	1.16775E-09	1.16766E-09	1.16750E-09	1.16720E-09	1.16627E-09	1.16474E-09	1.16168E-09	1.15259E-09	1.13770E-09
5.0E+22	9.58654E-10	9.58627E-10	9.58546E-10	9.58410E-10	9.58139E-10	9.57328E-10	9.55977E-10	9.53286E-10	9.45287E-10	9.32204E-10
1.0E+23	7.03317E-10	7.03295E-10	7.03229E-10	7.03118E-10	7.02897E-10	7.02234E-10	7.01131E-10	6.98933E-10	6.92405E-10	6.81737E-10
2.0E+23	4.12219E-10	4.12204E-10	4.12158E-10	4.12081E-10	4.11928E-10	4.11471E-10	4.10709E-10	4.09192E-10	4.04690E-10	3.97346E-10
5.0E+23	1.18661E-10	1.18655E-10	1.18636E-10	1.18606E-10	1.18545E-10	1.18362E-10	1.18058E-10	1.17454E-10	1.15664E-10	1.12756E-10
1.0E+24	3.05886E-11	3.05866E-11	3.05804E-11	3.05702E-11	3.05498E-11	3.04886E-11	3.03869E-11	3.01848E-11	2.95873E-11	2.86217E-11
2.0E+24	8.54771E-12	8.54716E-12	8.54551E-12	8.54276E-12	8.53727E-12	8.52082E-12	8.49349E-12	8.43918E-12	8.27895E-12	8.02063E-12
5.0E+24	2.90822E-12	2.90815E-12	2.90794E-12	2.90758E-12	2.90687E-12	2.90473E-12	2.90117E-12	2.89410E-12	2.87318E-12	2.83924E-12
1.0E+25	2.34202E-12	2.34200E-12	2.34193E-12	2.34183E-12	2.34163E-12	2.34101E-12	2.33999E-12	2.33794E-12	2.33181E-12	2.32165E-12
2.0E+25	2.32211E-12	2.32209E-12	2.32204E-12	2.32194E-12	2.32176E-12	2.32120E-12	2.32026E-12	2.31839E-12	2.31278E-12	2.30346E-12

Table B-. Total Photodissociation Rate Coefficients for the Process $O_2 + h\nu \rightarrow O + O$ for Wavelengths From 175 to 242.2 nm (Contd)

O2 COLUMN DENSITY	O3 COLUMN DENSITY 2.0E+16	5.0E+16	1.0E+17	2.0E+17	5.0E+17	1.0E+18	2.0E+18	5.0E+18	1.0E+19	2.0E+19
1.0E+17	8.23593E-08	8.04246E-08	7.73159E-08	7.14945E-08	5.66739E-08	3.86203E-08	1.80502E-08	1.93497E-09	6.22227E-11	3.88685E-13
2.0E+17	7.84037E-08	7.65612E-08	7.36013E-08	6.80606E-08	5.39608E-08	3.67881E-08	1.72141E-08	1.85505E-09	6.05895E-11	3.87938E-13
5.0E+17	6.83484E-08	6.67403E-08	6.41590E-08	5.93323E-08	4.70661E-08	3.21332E-08	1.50907E-08	1.65214E-09	5.64206E-11	3.85817E-13
1.0E+18	5.69205E-08	5.55781E-08	5.34[illegible]1E-08	4.94087E-08	3.92220E-08	2.68312E-08	1.26659E-08	1.41812E-09	5.14674E-11	3.82177E-13
2.0E+18	4.41017E-08	4.30567E-08	4.13851E-08	3.82738E-08	3.04156E-08	2.08730E-08	9.93541E-09	1.15254E-09	4.57406E-11	3.78163E-13
5.0E+18	2.79855E-08	2.73124E-08	2.62414E-08	2.42635E-08	1.93198E-08	1.33475E-08	6.46744E-09	8.07455E-10	3.77590E-11	3.70179E-1[illegible]
1.0E+19	1.84265E-08	1.79722E-08	1.72547E-08	1.59439E-08	1.27178E-08	8.85386E-09	4.38021E-09	5.93023E-10	3.23310E-11	3.62676E-[illegible]
2.0E+19	1.17318E-08	1.14281E-08	1.09541E-08	1.01032E-08	8.06359E-09	5.66293E-09	2.87414E-09	4.28336E-10	2.73964E-11	3.50925[illegible]
5.0E+19	6.64858E-09	6.45547E-09	6.[illegible]0043E-09	5.64812E-09	4.48576E-09	3.17666E-09	1.66625E-09	2.81839E-10	2.18888E-11	3.3017[illegible]
1.0E+20	4.51550[illegible]-09	4.36707E-09	4.[illegible]4439[illegible]-09	3.76924E-09	2.96396E-09	2.10352E-09	1.12840E-09	2.09148E-10	1.84843E-11	3.110[illegible]
2.0E+20	3.17041E-0[illegible]	3.04920E-09	2.87[illegible]63E-09	2.57918E-09	1.99268E-09	1.40941E-09	7.70327E-10	1.55452E-10	1.53759E-11	2.8[illegible]13
5.0E+20	3.16838[illegible]-0[illegible]	3.04728E-09	2.86888E-09	2.57769E-09	1.99168E-09	1.40879E-09	7.70035E-10	1.55397E-10	1.53705E-11	2.[illegible]E-13
1.0E+21	2.12576E-09	2.02486E-09	1.87920E-09	1.65023E-09	1.22740E-09	8.53232E-10	4.72751E-10	1.04948E-10	1.17558E-11	[illegible]877E-13
2.0E+21	1.68732E-09	1.59453E-09	1.46199E-09	1.25788E-09	9.00217E-10	6.10129E-10	3.36480E-10	7.83265E-11	9.43953E-12	2.14125E-13
5.0E+21	1.42560E-09	1.33794E-09	1.21357E-09	1.02460E-09	7.05255E-10	4.63424E-10	2.51417E-10	5.99429E-11	7.63448E-12	1.85954E-13
1.0E+22	1.23347[illegible]-09	1.15007E-09	1.03236E-09	8.55318E-10	5.64536E-10	3.56948E-10	1.88097E-10	4.50794E-11	6.02269E-12	1.57677E-13
2.0E+22	1.10893E-09	1.02987E-09	9.18651E-10	7.52459E-10	4.64043E-10	2.98625E-10	1.54032E-10	3.66700E-11	5.00513E-12	1.36236E-13
5.0E+22	9.0693[illegible]E-10	8.37738E-10	7.40991E-10	5.98057E-10	3.73317E-10	2.24810E-10	1.14036E-10	2.71906E-11	3.81188E-12	1.08378E-13
1.0E+23	6.61173E-10	6.05122E-10	5.27515E-10	4.14905E-10	2.45244E-10	1.40952E-10	6.87819E-11	1.59798E-11	2.25926E-12	6.61797E-14
2.0E+23	3.83235E-10	3.45100E-10	2.93210E-10	2.20309E-10	1.18551E-10	6.35160E-11	2.96893E-11	6.85088E-12	1.00007E-12	3.07726E-14
5.0E+23	1.07213E-10	9.25449E-11	7.34312E-11	4.86877E-11	2.03970E-11	9.64924E-12	4.57852E-12	1.21106E-12	2.05296E-13	7.24282E-15
1.0E+24	2.67951E-11	2.20719E-11	1.62007E-11	9.26161E-12	2.93456E-12	1.29966E-12	5.41249E-13	6.31005E-14	4.84552E-15	1.52144E-16
2.0E+24	7.53517E-12	6.29823E-12	4.80552E-12	3.12606E-12	1.65148E-12	1.03930E-12	4.63488E-13	4.24045E-14	1.07364E-15	1.33514E-17
5.0E+24	2.77466E-12	2.60425E-12	2.38066E-12	2.07309E-12	1.55767E-12	1.03654E-12	4.63449E-13	4.24[illegible]42E-14	1.07363E-15	1.33513E-17
1.0E+25	2.30156E-12	2.24295E-12	2.15012E-12	1.97922E-12	1.55133E-12	1.03647E-12	4.63449E-13	4.24042E-14	1.07363E-15	1.33513E-17
2.0E+25	2.28494E-12	2.23026E-12	2.14203E-12	1.97593E-12	1.55111E-12	1.03647E-12	4.63449E-13	4.24042E-14	1.07363E-15	1.33513E-17

Table B5. Total Photodissociation Rate Coefficients for the Process $O_2 + h\nu \rightarrow O + O$ for Wavelengths From 175 to 242.2 nm (Contd)

O2 COLUMN DENSITY	O3 COLUMN DENSITY 5.0E+19	1.0E+20	2.0E+20	5.0E+20	1.0E+21
1.0E+17	8.73391E-18	5.25966E-25	2.73918E-39	6.48784E-82	7.83393-153
2.0E+17	8.73401E-18	5.25969E-25	2.73918E-39	6.48784E-82	7.83393-153
5.0E+17	8.73431E-18	5.25972E-25	2.73915E-39	6.48771E-82	7.83377-153
1.0E+18	8.70961E-18	5.25049E-25	2.73786E-39	6.48769E-82	7.83385-153
2.0E+18	8.70936E-18	5.25076E-25	2.73786E-39	6.48763E-82	7.83385-153
5.0E+18	8.70805E-18	5.25147E-25	2.73783E-39	6.48732E-82	7.83366-153
1.0E+19	8.68652E-18	5.24339E-25	2.73649E-39	6.48685E-82	7.83351-153
2.0E+19	8.64264E-18	5.22092E-25	2.72619E-39	6.46929E-82	7.82302-153
5.0E+19	8.55010E-18	5.19131E-25	2.72091E-39	6.46673E-82	7.82211-153
1.0E+20	8.43410E-18	5.15784E-25	2.71819E-39	6.47105E-82	7.82488-153
2.0E+20	8.21772E-18	5.09124E-25	2.70931E-39	6.47191E-82	7.82630-153
5.0E+20	8.21654E-18	5.09100E-25	2.70929E-39	6.47191E-82	7.82630-153
1.0E+21	7.75047E-18	4.94050E-25	2.68714E-39	6.46964E-82	7.82824-153
2.0E+21	7.29024E-18	4.77981E-25	2.65499E-39	6.44707E-82	7.81927-153
5.0E+21	6.81167E-18	4.59358E-25	2.60309E-39	6.36972E-82	7.73855-153
1.0E+22	6.22360E-18	4.31292E-25	2.48965E-39	6.13959E-82	7.47824-153
2.0E+22	5.60679E-18	3.94657E-25	2.30204E-39	5.70753E-82	6.97128-153
5.0E+22	4.67258E-18	3.34875E-25	1.97407E-39	4.91590E-82	6.01377-153
1.0E+23	2.96441E-18	2.16146E-25	1.28895E-39	3.23148E-82	3.96684-153
2.0E+23	1.44765E-18	1.07621E-25	6.48120E-40	1.62614E-82	1.98836-153
5.0E+23	3.74534E-19	2.86729E-26	1.74848E-40	4.38425E-83	5.32466-154
1.0E+24	8.08785E-21	6.25749E-28	3.82194E-42	9.39947E-85	1.10288-155
2.0E+24	6.83445E-22	5.20470E-29	3.13298E-43	7.54866E-86	8.60985-157
5.0E+24	6.83445E-22	5.20470E-29	3.13298E-43	7.54866E-86	8.60985-157
1.0E+25	6.83445E-22	5.20470E-29	3.13298E-43	7.54866E-86	8.60985-157
2.0E+25	6.83445E-22	5.20470E-29	3.13298E-43	7.54866E-86	8.60985-157

Table B6. Total Photodissociation Rate Coefficients for the Process $O_3 + h\nu \rightarrow O(^1D) + O_2(^1\Delta g)$ for Wavelengths Below 310 nm

O3 COLUMN DENSITY

O2 COLUMN DENSITY

	1.0E+12	2.0E+12	5.0E+12	1.0E+13	2.0E+13	5.0E+13	1.0E+14	2.0E+14	5.0E+14	1.0E+15
1.0E+15	9.72657E-03	9.72651E-03	9.72631E-03	9.72597E-03	9.72530E-03	9.72328E-03	9.71992E-03	9.71321E-03	9.69311E-03	9.65972E-03
2.0E+15	9.72657E-03	9.72650E-03	9.72630E-03	9.72596E-03	9.72529E-03	9.72328E-03	9.71992E-03	9.71321E-03	9.69311E-03	9.65972E-03
5.0E+15	9.72655E-03	9.72649E-03	9.72628E-03	9.72595E-03	9.72528E-03	9.72326E-03	9.71990E-03	9.71319E-03	9.69309E-03	9.65970E-03
1.0E+16	9.72653E-03	9.72646E-03	9.72626E-03	9.72592E-03	9.72525E-03	9.72323E-03	9.71988E-03	9.71316E-03	9.69306E-03	9.65968E-03
2.0E+16	9.72648E-03	9.72641E-03	9.72621E-03	9.72587E-03	9.72520E-03	9.72319E-03	9.71983E-03	9.71312E-03	9.69302E-03	9.65963E-03
5.0E+16	9.72636E-03	9.72629E-03	9.72609E-03	9.72576E-03	9.72508E-03	9.72307E-03	9.71971E-03	9.71300E-03	9.69290E-03	9.65951E-03
1.0E+17	9.72622E-03	9.72616E-03	9.72596E-03	9.72562E-03	9.72495E-03	9.72293E-03	9.71957E-03	9.71266E-03	9.69276E-03	9.65938E-03
2.0E+17	9.72606E-03	9.72600E-03	9.72579E-03	9.72546E-03	9.72479E-03	9.72277E-03	9.71941E-03	9.71270E-03	9.69260E-03	9.65922E-03
5.0E+17	9.72586E-03	9.72579E-03	9.72559E-03	9.72526E-03	9.72458E-03	9.72257E-03	9.71921E-03	9.71250E-03	9.69240E-03	9.65902E-03
1.0E+18	9.72570E-03	9.72563E-03	9.72543E-03	9.72509E-03	9.72442E-03	9.72241E-03	9.71905E-03	9.71234E-03	9.69224E-03	9.65885E-03
2.0E+18	9.72552E-03	9.72545E-03	9.72525E-03	9.72491E-03	9.72424E-03	9.72223E-03	9.71887E-03	9.71216E-03	9.69206E-03	9.65867E-03
5.0E+18	9.72528E-03	9.72522E-03	9.72502E-03	9.72468E-03	9.72401E-03	9.72199E-03	9.71863E-03	9.71192E-03	9.69182E-03	9.65844E-03
1.0E+19	9.72514E-03	9.72507E-03	9.72487E-03	9.72453E-03	9.72386E-03	9.72184E-03	9.71849E-03	9.71178E-03	9.69168E-03	9.65830E-03
2.0E+19	9.72499E-03	9.72492E-03	9.72472E-03	9.72439E-03	9.72372E-03	9.72170E-03	9.71834E-03	9.71153E-03	9.69153E-03	9.65815E-03
5.0E+19	9.72474E-03	9.72467E-03	9.72447E-03	9.72413E-03	9.72346E-03	9.72145E-03	9.71809E-03	9.71138E-03	9.69128E-03	9.65790E-03
1.0E+20	9.72443E-03	9.72436E-03	9.72416E-03	9.72393E-03	9.72316E-03	9.72114E-03	9.71778E-03	9.71107E-03	9.69097E-03	9.65759E-03
2.0E+20	9.72394E-03	9.72387E-03	9.72367E-03	9.72333E-03	9.72266E-03	9.72065E-03	9.71729E-03	9.71058E-03	9.69048E-03	9.65710E-03
5.0E+20	9.72295E-03	9.72289E-03	9.72268E-03	9.72235E-03	9.72168E-03	9.71966E-03	9.71630E-03	9.70959E-03	9.68950E-03	9.65612E-03
1.0E+21	9.72106E-03	9.72100E-03	9.72080E-03	9.72046E-03	9.71979E-03	9.71777E-03	9.71442E-03	9.70771E-03	9.68761E-03	9.65424E-03
2.0E+21	9.71759E-03	9.71752E-03	9.71732E-03	9.71698E-03	9.71631E-03	9.71430E-03	9.71094E-03	9.70423E-03	9.68414E-03	9.65078E-03
5.0E+21	9.70763E-03	9.70757E-03	9.70736E-03	9.70703E-03	9.70636E-03	9.70434E-03	9.70099E-03	9.69429E-03	9.67421E-03	9.64087E-03
1.0E+22	9.69134E-03	9.69128E-03	9.69108E-03	9.69074E-03	9.69007E-03	9.68806E-03	9.68471E-03	9.67801E-03	9.65796E-03	9.62465E-03
2.0E+22	9.66011E-03	9.66005E-03	9.65985E-03	9.65951E-03	9.65884E-03	9.65684E-03	9.65349E-03	9.64681E-03	9.62680E-03	9.59356E-03
5.0E+22	9.57430E-03	9.57423E-03	9.57404E-03	9.57370E-03	9.57304E-03	9.57104E-03	9.56772E-03	9.56108E-03	9.54119E-03	9.50815E-03
1.0E+23	9.45231E-03	9.45224E-03	9.45205E-03	9.45172E-03	9.45106E-03	9.44908E-03	9.44579E-03	9.43921E-03	9.41949E-03	9.38676E-03
2.0E+23	9.26856E-03	9.26850E-03	9.26830E-03	9.26798E-03	9.26733E-03	9.26538E-03	9.26213E-03	9.25565E-03	9.23622E-03	9.20395E-03
5.0E+23	8.97590E-03	8.97584E-03	8.97565E-03	8.97534E-03	8.97470E-03	8.97281E-03	8.96965E-03	8.96333E-03	8.94443E-03	8.91302E-03
1.0E+24	8.79801E-03	8.79795E-03	8.79776E-03	8.79745E-03	8.79683E-03	8.79497E-03	8.79188E-03	8.78569E-03	8.76715E-03	8.73637E-03
2.0E+24	8.69314E-03	8.69308E-03	8.69290E-03	8.69259E-03	8.69198E-03	8.69015E-03	8.68709E-03	8.68099E-03	8.66271E-03	8.63235E-03
5.0E+24	8.63538E-03	8.63532E-03	8.63514E-03	8.63483E-03	8.63423E-03	8.63241E-03	8.62938E-03	8.62333E-03	8.60520E-03	8.57509E-03
1.0E+25	8.62788E-03	8.62782E-03	8.62763E-03	8.62733E-03	8.62673E-03	8.62491E-03	8.62188E-03	8.61584E-03	8.59773E-03	8.56766E-03
2.0E+25	8.62761E-03	8.62755E-03	8.62737E-03	8.62707E-03	8.62646E-03	8.62464E-03	8.62162E-03	8.61557E-03	8.59747E-03	8.56739E-03

Table B6. Total Photodissociation Rate Coefficients for the Process $O_3 + h\nu \rightarrow O(^1D) + O_2(^1\Delta g)$ for Wavelengths Below 310 nm (Contd)

O3 COLUMN DENSITY

O2 COLUMN DENSITY	2.0E+15	5.0E+15	1.0E+16	2.0E+16	5.0E+16	1.0E+17	2.0E+17	5.0E+17	1.0E+18	2.0E+18
1.0E+15	9.59339E-03	9.39780E-03	9.08291E-03	8.49245E-03	6.99530E-03	5.19826E-03	3.16694E-03	1.30466E-03	6.63680E-04	3.24841E-04
2.0E+15	9.59338E-03	9.39779E-03	9.08290E-03	8.49245E-03	6.99530E-03	5.19826E-03	3.16694E-03	1.30466E-03	6.63680E-04	3.24840E-04
5.0E+15	9.59337E-03	9.39778E-03	9.08289E-03	8.49244E-03	6.99528E-03	5.19825E-03	3.16693E-03	1.30466E-03	6.63679E-04	3.24840E-04
1.0E+16	9.59334E-03	9.39775E-03	9.08286E-03	8.49241E-03	6.99526E-03	5.19823E-03	3.16692E-03	1.30465E-03	6.63677E-04	3.24840E-04
2.0E+16	9.59329E-03	9.39770E-03	9.08282E-03	8.49237E-03	6.99523E-03	5.19821E-03	3.16690E-03	1.30465E-03	6.63674E-04	3.24839E-04
5.0E+16	9.59318E-03	9.39759E-03	9.08271E-03	8.49227E-03	6.99514E-03	5.19814E-03	3.16686E-03	1.30462E-03	6.63665E-04	3.24836E-04
1.0E+17	9.59304E-03	9.39746E-03	9.08258E-03	8.49214E-03	6.99504E-03	5.19805E-03	3.16680E-03	1.30460E-03	6.63653E-04	3.24832E-04
2.0E+17	9.59288E-03	9.39730E-03	9.08243E-03	8.49200E-03	6.99492E-03	5.19796E-03	3.16672E-03	1.30456E-03	6.63630E-04	3.24824E-04
5.0E+17	9.59268E-03	9.39711E-03	9.08224E-03	8.49182E-03	6.99476E-03	5.19783E-03	3.16662E-03	1.30448E-03	6.63587E-04	3.24806E-04
1.0E+18	9.59252E-03	9.39695E-03	9.08208E-03	8.49168E-03	6.99464E-03	5.19772E-03	3.16653E-03	1.30442E-03	6.63544E-04	3.24787E-04
2.0E+18	9.59234E-03	9.39677E-03	9.08191E-03	8.49152E-03	6.99450E-03	5.19760E-03	3.16643E-03	1.30434E-03	6.63494E-04	3.24765E-04
5.0E+18	9.59211E-03	9.39655E-03	9.08170E-03	8.49131E-03	6.99432E-03	5.19745E-03	3.16630E-03	1.30425E-03	6.63429E-04	3.24736E-04
1.0E+19	9.59197E-03	9.39640E-03	9.08156E-03	8.49118E-03	6.99420E-03	5.19734E-03	3.16621E-03	1.30418E-03	6.63382E-04	3.24713E-04
2.0E+19	9.59182E-03	9.39626E-03	9.08142E-03	8.49104E-03	6.99407E-03	5.19722E-03	3.16611E-03	1.30410E-03	6.63331E-04	3.24689E-04
5.0E+19	9.59157E-03	9.39601E-03	9.08117E-03	8.49080E-03	6.99384E-03	5.19702E-03	3.16593E-03	1.30397E-03	6.63247E-04	3.24647E-04
1.0E+20	9.59127E-03	9.39571E-03	9.08087E-03	8.49051E-03	6.99357E-03	5.19678E-03	3.16573E-03	1.30384E-03	6.63163E-04	3.24606E-04
2.0E+20	9.59078E-03	9.39522E-03	9.08039E-03	8.49005E-03	6.99315E-03	5.19641E-03	3.16544E-03	1.30366E-03	6.63053E-04	3.24552E-04
5.0E+20	9.58980E-03	9.39425E-03	9.07945E-03	8.48915E-03	6.99236E-03	5.19577E-03	3.16500E-03	1.30348E-03	6.62982E-04	3.24529E-04
1.0E+21	9.58793E-03	9.39241E-03	9.07763E-03	8.48740E-03	6.99081E-03	5.19447E-03	3.16405E-03	1.30299E-03	6.62727E-04	3.24414E-04
2.0E+21	9.58448E-03	9.38901E-03	9.07430E-03	8.48421E-03	6.98799E-03	5.19214E-03	3.16241E-03	1.30223E-03	6.62374E-04	3.24269E-04
5.0E+21	9.57461E-03	9.37927E-03	9.06478E-03	8.47510E-03	6.97998E-03	5.18561E-03	3.15788E-03	1.30027E-03	6.61546E-04	3.23966E-04
1.0E+22	9.55847E-03	9.36335E-03	9.04921E-03	8.46020E-03	6.96689E-03	5.17494E-03	3.15051E-03	1.29710E-03	6.60209E-04	3.23471E-04
2.0E+22	9.52753E-03	9.33282E-03	9.01937E-03	8.43168E-03	6.94189E-03	5.15466E-03	3.13662E-03	1.29129E-03	6.57873E-04	3.22661E-04
5.0E+22	9.44251E-03	9.24900E-03	8.93748E-03	8.35348E-03	6.87359E-03	5.09956E-03	3.09934E-03	1.27624E-03	6.52088E-04	3.20770E-04
1.0E+23	9.32171E-03	9.12994E-03	8.82126E-03	8.24270E-03	6.77734E-03	5.02258E-03	3.04812E-03	1.25639E-03	6.44724E-04	3.18394E-04
2.0E+23	9.13986E-03	8.95089E-03	8.64678E-03	8.07693E-03	6.63473E-03	4.91042E-03	2.97595E-03	1.23084E-03	6.36150E-04	3.15880E-04
5.0E+23	8.85063E-03	8.66673E-03	8.37083E-03	7.81962E-03	6.41556E-03	4.74424E-03	2.87670E-03	1.20232E-03	6.26553E-04	3.14046E-04
1.0E+24	8.67521E-03	8.43436E-03	8.20496E-03	7.66191E-03	6.28974E-03	4.65444E-03	2.82956E-03	1.19333E-03	6.27124E-04	3.13801E-04
2.0E+24	8.57203E-03	8.3042[illegible]E-03	8.10827E-03	7.[illegible]7274E-03	6.21975E-03	4.60753E-03	2.80818E-03	1.19096E-03	6.26930E-04	3.13794E-04
5.0E+24	8.51528E-03	8.[illegible]389[illegible]E-03	8.05530E-03	7.[illegible]2433E-03	6.18260E-03	4.58363E-03	2.79826E-03	1.19023E-03	6.26979E-04	3.13794E-04
1.0E+25	8.50791E-03	8.33132E-03	8.04853E-03	7.51806E-03	6.17782E-03	4.58058E-03	2.79702E-03	1.19015E-03	6.26978E-04	3.13794E-04
2.0E+25	8.50765E-03	8.33157E-03	8.04825E-03	7.517[illegible]4E-03	6.17765E-03	4.58047E-03	2.79697E-03	1.19015E-03	6.26978E-04	3.13794E-04

Table B6. Total Photodissociation Rate Coefficients for the Process $O_3 + h\nu \rightarrow O(^1D) + O_2(^1\Delta g)$ for Wavelengths Below 310 nm (Contd)

O2 COLUMN DENSITY	O3 COLUMN DENSITY							
	5.0E+18	1.0E+19	2.0E+19	5.0E+19	1.0E+20	2.0E+20	5.0E+20	1.0E+21
1.0E+15	1.09487E-04	3.98002E-05	9.65152E-06	3.31466E-07	1.71194E-09	4.71332E-14	9.84126E-28	1.55808E-50
2.0E+15	1.09487E-04	3.98002E-05	9.65152E-06	3.31466E-07	1.71194E-09	4.71332E-14	9.84126E-28	1.55808E-50
5.0E+15	1.09487E-04	3.98002E-05	9.65152E-06	3.31466E-07	1.71194E-09	4.71332E-14	9.84126E-28	1.55808E-50
1.0E+16	1.09487E-04	3.98002E-05	9.65152E-06	3.31466E-07	1.71194E-09	4.71332E-14	9.84126E-28	1.55808E-50
2.0E+16	1.09486E-04	3.980[illegible]E-05	9.65152E-06	3.31466E-07	1.71194E-09	4.71332E-14	9.84126E-28	1.55808E-50
5.0E+16	1.09486E-04	3.98002E-05	9.65152E-06	3.31466E-07	1.71194E-09	4.71332E-14	9.84126E-28	1.55808E-50
1.0E+17	1.09486E-04	3.98002E-05	9.65152E-06	3.31466E-07	1.71194E-09	4.71332E-14	9.84126E-28	1.55808E-50
2.0E+17	1.09485E-04	3.98002E-05	9.65152E-06	3.31466E-07	1.71194E-09	4.71332E-14	9.84126E-28	1.55808E-50
5.0E+17	1.09484E-04	3.9[illegible]02E-05	9.65152E-06	3.31466E-07	1.71194E-09	4.71332E-14	9.84126E-28	1.55808E-50
1.0E+18	1.09482E-04	3.9[illegible]02E-05	9.65152E-06	3.31466E-07	1.71194E-09	4.71332E-14	9.84126E-28	1.55808E-50
2.0E+18	1.09480E-04	3.98[illegible]E-05	9.65152E-06	3.31466E-07	1.71194E-09	4.71332E-14	9.84126E-28	1.55808E-50
5.0E+18	1.09477E-04	3.98000E-05	9.65152E-06	3.31466E-07	1.71194E-09	4.71332E-14	9.84126E-28	1.55808E-50
1.0E+19	1.09475E-04	3.97[illegible]E-05	9.65152E-06	3.31466E-07	1.71194E-09	4.71332E-14	9.84126E-28	1.55808E-50
2.0E+19	1.09472E-04	3.97[illegible]8E-05	9.65152E-06	3.31466E-07	1.71194E-09	4.71332E-14	9.84126E-28	1.55808E-50
5.0E+19	1.09456E-04	3.97994E-05	9.65151E-06	3.31466E-07	1.71194E-09	4.71332E-14	9.84126E-28	1.55808E-50
1.0E+20	1.09[illegible]9E-04	3.97989E-05	9.65150E-06	3.31466E-07	1.71194E-09	4.71332E-14	9.84126E-28	1.55808E-50
2.0E+20	1.09[illegible]0E-04	3.97982E-05	9.65149E-06	3.31466E-07	1.71194E-09	4.71332E-14	9.84126E-28	1.55808E-50
5.0E+20	1.09[illegible]7E-04	3.97980E-05	9.65149E-06	3.31466E-07	1.71194E-09	4.71332E-14	9.84126E-28	1.55808E-50
1.0E+21	1.09[illegible]7E-04	3.97961E-05	9.65146E-06	3.31466E-07	1.71194E-09	4.71332E-14	9.84126E-28	1.55808E-50
2.0E+21	1.09[illegible]1E-04	3.97935E-05	9.65141E-06	3.31466E-07	1.71194E-09	4.71332E-14	9.84126E-28	1.55808E-50
5.0E+21	1.09[illegible]2E-04	3.97885E-05	9.65131E-06	3.31466E-07	1.71194E-09	4.71332E-14	9.84126E-28	1.55808E-50
1.0E+22	1.09[illegible]7E-04	3.97792E-05	9.65111E-06	3.31466E-07	1.71194E-09	4.71332E-14	9.84126E-28	1.55808E-50
2.0E+22	1.09[illegible]7E-04	3.97652E-05	9.65080E-06	3.31466E-07	1.71194E-09	4.71332E-14	9.84126E-28	1.55808E-50
5.0E+22	1.08[illegible]1E-04	3.97372E-05	9.65022E-06	3.31466E-07	1.71194E-09	4.71332E-14	9.84126E-28	1.55808E-50
1.0E+23	1.08[illegible]8E-04	3.96965E-05	9.64923E-06	3.31466E-07	1.71194E-09	4.71332E-14	9.84126E-28	1.55808E-50
2.0E+23	1.08[illegible]7E-04	3.96586E-05	9.64832E-06	3.31466E-07	1.71194E-09	4.71332E-14	9.84126E-28	1.55808E-50
5.0E+23	1.079[illegible]1E-04	3.96340E-05	9.64769E-06	3.31466E-07	1.71194E-09	4.71332E-14	9.84126E-28	1.55808E-50
1.0E+24	1.078[illegible]5E-04	3.96286E-05	9.64750E-06	3.31466E-07	1.71194E-09	4.71332E-14	9.84126E-28	1.55808E-50
2.0E+24	1.07834E-04	3.96285E-05	9.64750E-06	3.31466E-07	1.71194E-09	4.71332E-14	9.84126E-28	1.55808E-50
5.0E+24	1.07834E-04	3.96285E-05	9.64750E-06	3.31466E-07	1.71194E-09	4.71332E-14	9.84126E-28	1.55808E-50
1.0E+25	1.07834E-04	3.96285E-05	9.64750E-06	3.31466E-07	1.71194E-09	4.71332E-14	9.84126E-28	1.55808E-50
2.0E+25	1.07834E-04	3.96285E-05	9.64750E-06	3.31466E-07	1.71194E-09	4.71332E-14	9.84126E-28	1.55808E-50

Table B7. Total Photodissociation Rate Coefficients for the Process $O_3 + h\nu \rightarrow O + O_2$ for Wavelengths From 310 to 730 nm

O3 COLUMN DENSITY	
1.0E+14	4.17996E-04
2.0E+14	4.17995E-04
5.0E+14	4.1799[illegible]E-04
1.0E+15	4.17992E-04
2.0E+15	4.17989E-04
5.0E+15	4.17978E-04
1.0E+16	4.17960E-04
2.0E+16	4.17924E-04
5.0E+16	4.17816E-04
1.0E+17	4.17636E-04
2.0E+17	4.17276E-04
5.0E+17	4.16205E-04
1.0E+18	4.14441E-04
2.0E+18	4.10992E-04
5.0E+18	4.01237E-04
1.0E+19	3.86702E-04
2.0E+19	3.62634E-04
5.0E+19	3.13047E-04
1.0E+20	2.60086E-04
2.0E+20	1.90049E-04
5.0E+20	8.70967E-05
1.0E+21	3.45505E-05

Table B8. Total Photodissociation Rate Coefficients for the Process $H_2O + h\nu \rightarrow OH + H$ for Wavelengths From 121.9 to 186.4 nm

O2 COLUMN DENSITY	O3 COLUMN DENSITY 1.0E+11	2.0E+11	5.0E+11	1.0E+12	2.0E+12	5.0E+12	1.0E+13	2.0E+13	5.0E+13	1.0E+14
1.0E+13	7.38657E-06	7.38656E-06	7.38653E-06	7.38647E-06	7.38637E-06	7.38606E-06	7.38554E-06	7.38451E-06	7.38141E-06	7.37625E-06
2.0E+13	7.38653E-06	7.38652E-06	7.38649E-06	7.38643E-06	7.38633E-06	7.38602E-06	7.38550E-06	7.38447E-06	7.38137E-06	7.37621E-06
5.0E+13	7.38640E-06	7.38639E-06	7.38636E-06	7.38631E-06	7.38621E-06	7.38590E-06	7.38538E-06	7.38435E-06	7.38125E-06	7.37609E-06
1.0E+14	7.38620E-06	7.38619E-06	7.38616E-06	7.38611E-06	7.38600E-06	7.38569E-06	7.38518E-06	7.38414E-06	7.38104E-06	7.37588E-06
2.0E+14	7.38579E-06	7.38578E-06	7.38575E-06	7.38570E-06	7.38560E-06	7.38529E-06	7.38477E-06	7.38374E-06	7.38064E-06	7.37547E-06
5.0E+14	7.38457E-06	7.38456E-06	7.38453E-06	7.38448E-06	7.38437E-06	7.38406E-06	7.38355E-06	7.38251E-06	7.37941E-06	7.37425E-06
1.0E+15	7.38254E-06	7.38253E-06	7.38250E-06	7.38245E-06	7.38234E-06	7.38203E-06	7.38152E-06	7.38048E-06	7.37738E-06	7.37222E-06
2.0E+15	7.37849E-06	7.37848E-06	7.37845E-06	7.37840E-06	7.37829E-06	7.37798E-06	7.37747E-06	7.37643E-06	7.37333E-06	7.36817E-06
5.0E+15	7.36647E-06	7.36646E-06	7.36643E-06	7.36638E-06	7.36627E-06	7.36596E-06	7.36545E-06	7.36441E-06	7.36132E-06	7.35616E-06
1.0E+16	7.34685E-06	7.34684E-06	7.34680E-06	7.34675E-06	7.34665E-06	7.34634E-06	7.34582E-06	7.34479E-06	7.34169E-06	7.33654E-06
2.0E+16	7.30904E-06	7.30903E-06	7.30900E-06	7.30895E-06	7.30885E-06	7.30854E-06	7.30802E-06	7.30699E-06	7.30390E-06	7.29875E-06
5.0E+16	7.20579E-06	7.20577E-06	7.20574E-06	7.20569E-06	7.20559E-06	7.20528E-06	7.20477E-06	7.20374E-06	7.20065E-06	7.19552E-06
1.0E+17	7.06019E-06	7.06018E-06	7.06015E-06	7.06010E-06	7.06000E-06	7.05969E-06	7.05918E-06	7.05815E-06	7.05508E-06	7.04996E-06
2.0E+17	6.82192E-06	6.82191E-06	6.82188E-06	6.82183E-06	6.82172E-06	6.82142E-06	6.82091E-06	6.81989E-06	6.81683E-06	6.81174E-06
5.0E+17	6.35730E-06	6.35729E-06	6.35726E-06	6.35721E-06	6.35711E-06	6.35681E-06	6.35631E-06	6.35530E-06	6.35227E-06	6.34723E-06
1.0E+18	5.89929E-06	5.89928E-06	5.89925E-06	5.89920E-06	5.89910E-06	5.89880E-06	5.89830E-06	5.89730E-06	5.89431E-06	5.88934E-06
2.0E+18	5.40915E-06	5.40914E-06	5.40912E-06	5.40907E-06	5.40897E-06	5.40867E-06	5.40819E-06	5.40721E-06	5.40427E-06	5.39939E-06
5.0E+18	4.82323E-06	4.82322E-06	4.82319E-06	4.82314E-06	4.82305E-06	4.82277E-06	4.82230E-06	4.82136E-06	4.81854E-06	4.81385E-06
1.0E+19	4.41601E-06	4.41600E-06	4.41598E-06	4.41593E-06	4.41584E-06	4.41558E-06	4.41513E-06	4.41424E-06	4.41158E-06	4.40715E-06
2.0E+19	3.91448E-06	3.91447E-06	3.91445E-06	3.91441E-06	3.91433E-06	3.91409E-06	3.91369E-06	3.91289E-06	3.91048E-06	3.90648E-06
5.0E+19	2.88069E-06	2.88069E-06	2.88067E-06	2.88064E-06	2.88058E-06	2.88040E-06	2.88011E-06	2.87951E-06	2.87773E-06	2.87477E-06
1.0E+20	1.78257E-06	1.78256E-06	1.78255E-06	1.78254E-06	1.78250E-06	1.78239E-06	1.78221E-06	1.78185E-06	1.78077E-06	1.77897E-06
2.0E+20	7.20230E-07	7.20228E-07	7.20224E-07	7.20218E-07	7.20204E-07	7.20165E-07	7.20098E-07	7.19965E-07	7.19566E-07	7.18902E-07
5.0E+20	1.80122E-07	1.80122E-07	1.80122E-07	1.80121E-07	1.80121E-07	1.80118E-07	1.80114E-07	1.80107E-07	1.80084E-07	1.80045E-07
1.0E+21	6.60228E-08	6.60228E-08	6.60227E-08	6.60227E-08	6.60227E-08	6.60225E-08	6.60222E-08	6.60217E-08	6.60201E-08	6.60174E-08
2.0E+21	2.82041E-08	2.82041E-08	2.82040E-08	2.82040E-08	2.82040E-08	2.82040E-08	2.82039E-08	2.82036E-08	2.82030E-08	2.82020E-08
5.0E+21	1.06830E-08	1.06830E-08	1.06830E-08	1.06830E-08	1.06830E-08	1.06830E-08	1.06830E-08	1.06829E-08	1.06827E-08	1.06823E-08
1.0E+22	2.28878E-09	2.28878E-09	2.28878E-09	2.28878E-09	2.28878E-09	2.28877E-09	2.28877E-09	2.28875E-09	2.28870E-09	2.28862E-09
2.0E+22	6.07985E-10	6.07985E-10	6.07985E-10	6.07985E-10	6.07984E-10	6.07983E-10	6.07981E-10	6.07976E-10	6.07963E-10	6.07940E-10
5.0E+22	3.05080E-10	3.05080E-10	3.05080E-10	3.05080E-10	3.05080E-10	3.05079E-10	3.05078E-10	3.05076E-10	3.05068E-10	3.05056E-10
1.0E+23	2.82473E-10	2.82473E-10	2.82473E-10	2.82473E-10	2.82472E-10	2.82472E-10	2.82471E-10	2.82468E-10	2.82462E-10	2.82450E-10

Table B8. Total Photodissociation Rate Coefficients for the Process $H_2O + h\nu \rightarrow OH + H$ for Wavelengths From 121.9 to 186.4 nm (Contd)

O2 COLUMN DENSITY	O3 COLUMN DENSITY									
	2.0E+14	5.0E+14	1.0E+15	2.0E+15	5.0E+15	1.0E+16	2.0E+16	5.0E+16	1.0E+17	2.0E+17
1.0E+13	7.36594E-06	7.33516E-06	7.28433E-06	7.18434E-06	6.89750E-06	6.46021E-06	5.71905E-06	4.26319E-06	3.18727E-06	2.55012E-06
2.0E+13	7.36590E-06	7.33512E-06	7.28423E-06	7.18430E-06	6.89746E-06	6.46017E-06	5.71901E-06	4.26316E-06	3.18724E-06	2.55009E-06
5.0E+13	7.36578E-06	7.33500E-06	7.28418E-06	7.18418E-06	6.89734E-06	6.46005E-06	5.71890E-06	4.26305E-06	3.18714E-06	2.55001E-06
1.0E+14	7.36558E-06	7.33480E-06	7.28396E-06	7.18398E-06	6.89714E-06	6.45985E-06	5.71871E-06	4.26287E-06	3.18698E-06	2.54987E-06
2.0E+14	7.36517E-06	7.33439E-06	7.28355E-06	7.18357E-06	6.89673E-06	6.45946E-06	5.71832E-06	4.26251E-06	3.18665E-06	2.54960E-06
5.0E+14	7.36395E-06	7.33317E-06	7.28233E-06	7.18236E-06	6.89553E-06	6.45827E-06	5.71716E-06	4.26143E-06	3.18568E-06	2.54878E-06
1.0E+15	7.36192E-06	7.33114E-06	7.28031E-06	7.18034E-06	6.89353E-06	6.45629E-06	5.71524E-06	4.25964E-06	3.18407E-06	2.54741E-06
2.0E+15	7.35787E-06	7.32710E-06	7.27627E-06	7.17631E-06	6.88953E-06	6.45235E-06	5.71140E-06	4.25607E-06	3.18084E-06	2.54468E-06
5.0E+15	7.34586E-06	7.31510E-06	7.26429E-06	7.16436E-06	6.87768E-06	6.44066E-06	5.70001E-06	4.24547E-06	3.17126E-06	2.53656E-06
1.0E+16	7.32624E-06	7.29550E-06	7.24472E-06	7.14484E-06	6.85833E-06	6.42157E-06	5.68141E-06	4.22813E-06	3.15557E-06	2.52325E-06
2.0E+16	7.28846E-06	7.25775E-06	7.20702E-06	7.10725E-06	6.82104E-06	6.38477E-06	5.64554E-06	4.19465E-06	3.12523E-06	2.49740E-06
5.0E+16	7.18526E-06	7.15463E-06	7.10403E-06	7.00454E-06	6.71913E-06	6.28416E-06	5.54735E-06	4.10273E-06	3.04146E-06	2.42547E-06
1.0E+17	7.03974E-06	7.00922E-06	6.95880E-06	6.85967E-06	6.57532E-06	6.14205E-06	5.40844E-06	3.97202E-06	2.92136E-06	2.32094E-06
2.0E+17	6.80157E-06	6.77121E-06	6.72107E-06	6.62247E-06	6.33970E-06	5.90896E-06	5.18004E-06	3.75553E-06	2.72019E-06	2.14258E-06
5.0E+17	6.33717E-06	6.30713E-06	6.25752E-06	6.15996E-06	5.88026E-06	5.45437E-06	4.73437E-06	3.33178E-06	2.32344E-06	1.78536E-06
1.0E+18	5.87940E-06	5.84973E-06	5.80072E-06	5.70437E-06	5.42817E-06	5.00780E-06	4.29774E-06	2.91851E-06	1.93689E-06	1.43551E-06
2.0E+18	5.38963E-06	5.36050E-06	5.31239E-06	5.21782E-06	4.94676E-06	4.53438E-06	3.83845E-06	2.49069E-06	1.54144E-06	1.07926E-06
5.0E+18	4.80449E-06	4.77654E-06	4.73038E-06	4.63963E-06	4.37960E-06	3.98419E-06	3.31750E-06	2.03036E-06	1.13368E-06	7.19502E-07
1.0E+19	4.39830E-06	4.37187E-06	4.32822E-06	4.24242E-06	3.99658E-06	3.62282E-06	2.99288E-06	1.77826E-06	9.35994E-07	5.55924E-07
2.0E+19	3.89849E-06	3.87464E-06	3.83524E-06	3.75781E-06	3.53595E-06	3.19868E-06	2.63035E-06	1.53522E-06	7.77633E-07	4.40097E-07
5.0E+19	2.86886E-06	2.85119E-06	2.82202E-06	2.76469E-06	2.60042E-06	2.35070E-06	1.92994E-06	1.11935E-06	5.59076E-07	3.10607E-07
1.0E+20	1.77538E-06	1.76466E-06	1.74696E-06	1.71216E-06	1.61244E-06	1.46086E-06	1.20539E-06	7.12988E-07	3.71940E-07	2.18914E-07
2.0E+20	7.17577E-07	7.13618E-07	7.07081E-07	6.94231E-07	6.57405E-07	6.01393E-07	5.06945E-07	3.24393E-07	1.96655E-07	1.36061E-07
5.0E+20	1.79968E-07	1.79739E-07	1.79359E-07	1.78610E-07	1.76451E-07	1.73122E-07	1.67344E-07	1.55077E-07	1.43577E-07	1.30845E-07
1.0E+21	6.60121E-08	6.59962E-08	6.59696E-08	6.59165E-08	6.57585E-08	6.54974E-08	6.49837E-08	6.34979E-08	6.11503E-08	5.67694E-08
2.0E+21	2.82000E-08	2.81938E-08	2.81836E-08	2.81632E-08	2.81021E-08	2.80004E-08	2.77982E-08	2.72005E-08	2.62327E-08	2.43995E-08
5.0E+21	1.06815E-08	1.06793E-08	1.06755E-08	1.06679E-08	1.06452E-08	1.06075E-08	1.05325E-08	1.03107E-08	9.95128E-09	9.26975E-09
1.0E+22	2.28846E-09	2.28797E-09	2.28717E-09	2.28555E-09	2.28071E-09	2.27267E-09	2.25667E-09	2.20936E-09	2.13270E-09	1.98730E-09
2.0E+22	6.07896E-10	6.07761E-10	6.07537E-10	6.07089E-10	6.05748E-10	6.03520E-10	5.99088E-10	5.85988E-10	5.64791E-10	5.24684E-10
5.0E+22	3.05032E-10	3.04960E-10	3.04840E-10	3.04599E-10	3.03880E-10	3.02684E-10	3.00306E-10	2.93283E-10	2.81943E-10	2.60565E-10
1.0E+23	2.82429E-10	2.82360E-10	2.82248E-10	2.82023E-10	2.81349E-10	2.80229E-10	2.78003E-10	2.71431E-10	2.60821E-10	2.40830E-10

Table B8. Total Photodissociation Rate Coefficients for the Process $H_2O + h\nu \rightarrow OH + H$ for Wavelengths From 121.9 to 186.4nm (Contd)

O3 COLUMN DENSITY

O2 COLUMN DENSITY	5.0E+17	1.0E+18	2.0E+18	5.0E+18	1.0E+19	2.0E+19	5.0E+19	1.0E+20	2.0E+20	5.0E+20
1.0E+13	1.92246E-06	1.25722E-06	5.46968E-07	4.69360E-08	8.30989E-10	3.13497E-13	1.24002E-22	4.70744E-37	1.40762E-65	4.19584-151
2.0E+13	1.92245E-06	1.25721E-06	5.46964E-07	4.69357E-08	8.30985E-10	3.13496E-13	1.24002E-22	4.70744E-37	1.40762E-65	4.19584-151
5.0E+13	1.92239E-06	1.25717E-06	5.46952E-07	4.69349E-08	8.30972E-10	3.13493E-13	1.24002E-22	4.70744E-37	1.40762E-65	4.19584-151
1.0E+14	1.92230E-06	1.25712E-08	5.469[illegible]E-07	4.69334E-08	8.30952E-10	3.13488E-13	1.24002E-22	4.70744E-37	1.40762E-65	4.19584-151
2.0E+14	1.92211E-06	1.25701E-06	5.46890E-07	4.69305E-08	8.30911E-10	3.13478E-13	1.24001E-22	4.70744E-37	1.40762E-65	4.19584-151
5.0E+14	1.92156E-06	1.25669E-06	5.46767E-07	4.69219E-08	8.30788E-10	3.13449E-13	1.24001E-22	4.70744E-37	1.40762E-65	4.19584-151
1.0E+15	1.92063E-06	1.25615E-06	5.46561E-07	4.69075E-08	8.30584E-10	3.13400E-13	1.24000E-22	4.70744E-37	1.40762E-65	4.19584-151
2.0E+15	1.91878E-06	1.25507E-06	5.46151E-07	4.68787E-08	8.30176E-10	3.13303E-13	1.23998E-22	4.70743E-37	1.40762E-65	4.19584-151
5.0E+15	1.91328E-06	1.25186E-06	5.44326E-07	4.67928E-08	8.28955E-10	3.13012E-13	1.23992E-22	4.70743E-37	1.40762E-65	4.19584-151
1.0E+16	1.90422E-06	1.24657E-06	5.42901E-07	4.66504E-08	8.26930E-10	3.12529E-13	1.23983E-22	4.70743E-37	1.40762E-65	4.19584-151
2.0E+16	1.88[illegible]4E-06	1.23619E-06	5.38514E-07	4.63691E-08	8.22923E-10	3.11572E-13	1.23965E-22	4.70743E-37	1.40762E-65	4.19584-151
5.0E+16	1.83662E-06	1.20658E-06	5.27438E-07	4.55517E-08	8.11219E-10	3.08767E-13	1.23910E-22	4.70743E-37	1.40762E-65	4.19584-151
1.0E+17	1.76241E-06	1.16175E-06	5.09773E-07	4.42723E-08	7.92723E-10	3.04302E-13	1.23823E-22	4.70743E-37	1.40762E-65	4.19584-151
2.0E+17	1.63141E-06	1.08022E-06	4.76607E-07	4.17655E-08	7.55026E-10	2.94565E-13	1.23433E-22	4.70286E-37	1.40632E-65	4.19197-151
5.0E+17	1.36039E-06	9.06076E-07	4.03288E-07	3.59825E-08	6.65582E-10	2.70930E-13	1.22406E-22	4.68932E-37	1.40246E-65	4.18046-151
1.0E+18	1.09022E-06	7.28659E-07	3.26428E-07	2.96381E-08	5.63528E-10	2.42722E-13	1.20955E-22	4.66731E-37	1.39616E-65	4.16168-151
2.0E+18	8.14274E-07	5.46233E-07	2.46519E-07	2.28901E-08	4.52332E-10	2.10869E-13	1.18777E-22	4.62521E-37	1.38401E-65	4.12548-151
5.0E+18	5.36387E-07	3.62213E-07	1.65588E-07	1.59748E-08	3.35915E-10	1.75261E-13	1.14401E-22	4.51179E-37	1.35090E-65	4.02684-151
1.0E+19	4.10798E-07	2.78686E-07	1.28502E-07	1.27069E-08	2.77544E-10	1.54356E-13	1.09395E-22	4.35489E-37	1.30460E-65	3.88884-151
2.0E+19	3.22841E-07	2.19694E-07	1.01880E-07	1.02443E-08	2.29857E-10	1.34277E-13	1.02431E-22	4.11734E-37	1.23403E-65	3.67851-151
5.0E+19	2.27430E-07	1.55232E-07	7.24053E-08	7.41035E-09	1.71387E-10	1.06409E-13	8.99826E-23	3.67342E-37	1.10184E-65	3.28448-151
1.0E+20	1.62437E-07	1.11127E-07	5.20745E-08	5.40725E-09	1.28313E-10	8.40530E-14	7.80227E-23	3.23362E-37	9.70704E-66	2.89361-151
2.0E+20	1.04156E-07	7.14751E-08	3.37009E-08	3.56743E-09	8.75905E-11	6.15006E-14	6.38836E-23	2.69464E-37	8.09655E-66	2.41356-151
5.0E+20	1.04151E-07	7.14751E-08	3.37009E-08	3.56743E-09	8.75905E-11	6.15006E-14	6.38836E-23	2.69464E-37	8.09655E-66	2.41356-151
1.0E+21	4.54621E-08	3.14083E-08	1.50104E-08	1.65583E-09	4.35838E-11	3.47797E-14	4.29870E-23	1.85582E-37	5.58139E-66	1.66381-151
2.0E+21	1.96353E-08	1.36752E-08	6.64109E-09	7.67802E-10	2.17352E-11	1.94766E-14	2.73702E-23	1.19715E-37	3.60025E-66	1.07323-151
5.0E+21	7.49321E-09	5.25744E-09	2.59052E-09	3.12148E-10	9.39104E-12	9.21005E-15	1.42319E-23	6.27559E-38	1.88588E-66	5.62169-152
1.0E+22	1.60809E-09	1.13033E-09	5.59159E-10	6.83291E-11	2.11332E-12	2.19137E-15	3.69045E-24	1.65256E-38	4.96672E-67	1.48054-152
2.0E+22	4.20746E-10	2.91428E-10	1.40184E-10	1.59283E-11	4.52356E-13	4.37401E-16	7.55264E-25	3.48454E-39	1.05148E-67	3.13457-153
5.0E+22	2.05689E-10	1.38726E-10	6.31726E-11	6.02498E-12	1.25114E-13	6.79248E-17	6.95153E-26	3.27616E-40	9.97526E-69	2.97413-154
1.0E+23	1.89593E-10	1.27265E-10	5.73596E-11	5.26449E-12	9.92411E-14	3.69711E-17	3.79418E-27	1.41534E-42	2.33328E-71	6.90008-157

Table B[illegible]. Total Photodissociation Rate Coefficients for the Process $H_2O_2 + h\nu \rightarrow OH + OH$ for Wavelengths From 188.2 to 303 nm

O3 COLUMN DENSITY

O2 COLUMN DENSITY	1.0E+12	2.0E+12	5.0E+12	1.0E+13	2.0E+13	5.0E+13	1.0E+14	2.0E+14	5.0E+14	1.0E+15
1.0E+17	1.59387E-04	1.59386E-04	1.59384E-04	1.59380E-04	1.59373E-04	1.59351E-04	1.59314E-04	1.59241E-04	1.59021E-04	1.58655E-04
2.0E+17	1.59386E-04	1.59386E-04	1.59384E-04	1.59380E-04	1.59373E-04	1.59350E-04	1.59314E-04	1.59240E-04	1.59020E-04	1.58655E-04
5.0E+17	1.59386E-04	1.59385E-04	1.59383E-04	1.59379E-04	1.59372E-04	1.59350E-04	1.59313E-04	1.59240E-04	1.59020E-04	1.58654E-04
1.0E+18	1.59385E-04	1.59384E-04	1.59382E-04	1.59378E-04	1.59371E-04	1.59349E-04	1.59312E-04	1.59239E-04	1.59019E-04	1.58653E-04
2.0E+18	1.59382E-04	1.59382E-04	1.59380E-04	1.59376E-04	1.59368E-04	1.59346E-04	1.59310E-04	1.59236E-04	1.59016E-04	1.58651E-04
5.0E+18	1.59376E-04	1.59375E-04	1.59373E-04	1.59369E-04	1.59362E-04	1.59340E-04	1.59303E-04	1.59230E-04	1.59010E-04	1.58644E-04
1.0E+19	1.59366E-04	1.59365E-04	1.59363E-04	1.59359E-04	1.59352E-04	1.59330E-04	1.59293E-04	1.59219E-04	1.59000E-04	1.58634E-04
2.0E+19	1.59347E-04	1.59346E-04	1.59344E-04	1.59340E-04	1.59333E-04	1.59311E-04	1.59274E-04	1.59200E-04	1.58981E-04	1.58615E-04
5.0E+19	1.59298E-04	1.59297E-04	1.59295E-04	1.59291E-04	1.59284E-04	1.59262E-04	1.59225E-04	1.59151E-04	1.58932E-04	1.58566E-04
1.0E+20	1.59230E-04	1.59229E-04	1.59227E-04	1.59223E-04	1.59216E-04	1.59194E-04	1.59157E-04	1.59084E-04	1.58864E-04	1.58498E-04
2.0E+20	1.59117E-04	1.59116E-04	1.59114E-04	1.59110E-04	1.59103E-04	1.59081E-04	1.59044E-04	1.58971E-04	1.58751E-04	1.58386E-04
5.0E+20	1.59015E-04	1.59014E-04	1.59012E-04	1.59008E-04	1.59001E-04	1.58979E-04	1.58942E-04	1.58869E-04	1.58649E-04	1.58284E-04
1.0E+21	1.58681E-04	1.58680E-04	1.58678E-04	1.58674E-04	1.58667E-04	1.58645E-04	1.58608E-04	1.58535E-04	1.58315E-04	1.57951E-04
2.0E+21	1.58161E-04	1.58160E-04	1.58158E-04	1.58154E-04	1.58147E-04	1.58125E-04	1.58088E-04	1.58015E-04	1.57796E-04	1.57431E-04
5.0E+21	1.56917E-04	1.56916E-04	1.56914E-04	1.56911E-04	1.56903E-04	1.56881E-04	1.56845E-04	1.56772E-04	1.56553E-04	1.56190E-04
1.0E+22	1.54846E-04	1.54845E-04	1.54843E-04	1.54839E-04	1.54832E-04	1.54810E-04	1.54774E-04	1.54701E-04	1.54484E-04	1.54122E-04
2.0E+22	1.51283E-04	1.51282E-04	1.51280E-04	1.51277E-04	1.51269E-04	1.51248E-04	1.51212E-04	1.51140E-04	1.50925E-04	1.50567E-04
5.0E+22	1.42514E-04	1.42513E-04	1.42511E-04	1.42508E-04	1.42501E-04	1.42480E-04	1.42445E-04	1.42375E-04	1.42166E-04	1.41818E-04
1.0E+23	1.30898E-04	1.30897E-04	1.30895E-04	1.30891E-04	1.30885E-04	1.30865E-04	1.30831E-04	1.30764E-04	1.30563E-04	1.30229E-04
2.0E+23	1.16527E-04	1.16527E-04	1.16525E-04	1.16522E-04	1.16515E-04	1.16496E-04	1.16465E-04	1.16402E-04	1.16213E-04	1.15899E-04
5.0E+23	1.00617E-04	1.00616E-04	1.00614E-04	1.00612E-04	1.00606E-04	1.00589E-04	1.00560E-04	1.00503E-04	1.00332E-04	1.00048E-04
1.0E+24	9.47553E-05	9.47547E-05	9.47531E-05	9.47504E-05	9.47450E-05	9.47288E-05	9.47019E-05	9.46480E-05	9.44867E-05	9.42188E-05
2.0E+24	9.25138E-05	9.25132E-05	9.25117E-05	9.25091E-05	9.25038E-05	9.24882E-05	9.24621E-05	9.24099E-05	9.22537E-05	9.19942E-05
5.0E+24	9.15194E-05	9.15188E-05	9.15173E-05	9.15147E-05	9.15096E-05	9.14942E-05	9.14685E-05	9.14172E-05	9.12636E-05	9.10085E-05
1.0E+25	9.13956E-05	9.13951E-05	9.13936E-05	9.13910E-05	9.13859E-05	9.13705E-05	9.13449E-05	9.12937E-05	9.11405E-05	9.08859E-05
2.0E+25	9.13912E-05	9.13907E-05	9.13892E-05	9.13866E-05	9.13815E-05	9.13661E-05	9.13405E-05	9.12894E-05	9.11361E-05	9.08815E-05
5.0E+25	9.13912E-05	9.13907E-05	9.13892E-05	9.13866E-05	9.13815E-05	9.13661E-05	9.13405E-05	9.12894E-05	9.11361E-05	9.08815E-05

Table B-. Total Photodissociation Rate Coefficients for the Process $H_2O_2 + h\nu \rightarrow OH + OH$ for Wavelengths From 188.2 to 303 nm (Contd)

O3 COLUMN DENSITY

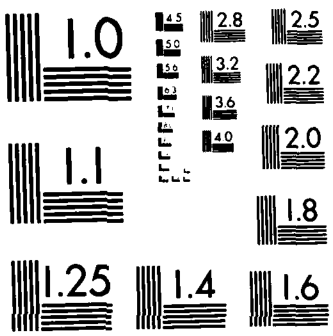
O2 COLUMN DENSITY	2.0E+15	5.0E+15	1.0E+16	2.0E+16	5.0E+16	1.0E+17	2.0E+17	5.0E+17	1.0E+18	2.0E+18
1.0E+17	1.57929E-04	1.55782E-04	1.52310E-04	1.45746E-04	1.28723E-04	1.07248E-04	8.02864E-05	4.71942E-05	2.81931E-05	1.39291E-05
2.0E+17	1.57928E-04	1.55781E-04	1.52310E-04	1.45746E-04	1.28723E-04	1.07248E-04	8.02862E-05	4.71940E-05	2.81930E-05	1.39290E-05
5.0E+17	1.57928E-04	1.55781E-04	1.52309E-04	1.45746E-04	1.28722E-04	1.07247E-04	8.02856E-05	4.71935E-05	2.81926E-05	1.39288E-05
1.0E+18	1.57927E-04	1.55779E-04	1.52308E-04	1.45744E-04	1.28721E-04	1.07246E-04	8.02846E-05	4.71927E-05	2.81919E-05	1.39284E-05
2.0E+18	1.57924E-04	1.55777E-04	1.52306E-04	1.45742E-04	1.28719E-04	1.07244E-04	8.02827E-05	4.71911E-05	2.81907E-05	1.39277E-05
5.0E+18	1.57918E-04	1.55771E-04	1.52299E-04	1.45736E-04	1.28713E-04	1.07238E-04	8.02770E-05	4.71863E-05	2.81871E-05	1.39255E-05
1.0E+19	1.57908E-04	1.55761E-04	1.52289E-04	1.45726E-04	1.28703E-04	1.07228E-04	8.02681E-05	4.71789E-05	2.81814E-05	1.39221E-05
2.0E+19	1.57835E-04	1.55742E-04	1.52270E-04	1.45707E-04	1.28685E-04	1.07211E-04	8.02516E-05	4.71651E-05	2.81709E-05	1.39158E-05
5.0E+19	1.57840E-04	1.55693E-04	1.52222E-04	1.45659E-04	1.28638E-04	1.07166E-04	8.02095E-05	4.71302E-05	2.81443E-05	1.38998E-05
1.0E+20	1.57772E-04	1.55625E-04	1.52154E-04	1.45592E-04	1.28573E-04	1.07103E-04	8.01518E-05	4.70826E-05	2.81082E-05	1.38779E-05
2.0E+20	1.57659E-04	1.55513E-04	1.52043E-04	1.45482E-04	1.28465E-04	1.07001E-04	8.00571E-05	4.70053E-05	2.80498E-05	1.38426E-05
5.0E+20	1.57558E-04	1.55412E-04	1.51943E-04	1.45384E-04	1.28374E-04	1.06918E-04	7.99879E-05	4.69599E-05	2.80225E-05	1.38297E-05
1.0E+21	1.57225E-04	1.55081E-04	1.51614E-04	1.45059E-04	1.28061E-04	1.06623E-04	7.97232E-05	4.67539E-05	2.78732E-05	1.37421E-05
2.0E+21	1.56706E-04	1.54565E-04	1.51102E-04	1.44555E-04	1.27560E-04	1.06175E-04	7.93277E-05	4.64582E-05	2.76662E-05	1.36243E-05
5.0E+21	1.55467E-04	1.53333E-04	1.49882E-04	1.43358E-04	1.26445E-04	1.05132E-04	7.84280E-05	4.58194E-05	2.72420E-05	1.33956E-05
1.0E+22	1.53404E-04	1.51281E-04	1.47849E-04	1.41362E-04	1.24553E-04	1.03389E-04	7.69211E-05	4.47408E-05	2.65175E-05	1.29974E-05
2.0E+22	1.49856E-04	1.47755E-04	1.44359E-04	1.37942E-04	1.21327E-04	1.00443E-04	7.44119E-05	4.30064E-05	2.53946E-05	1.24042E-05
5.0E+22	1.41127E-04	1.39085E-04	1.35785E-04	1.29557E-04	1.13463E-04	9.33263E-05	6.84478E-05	3.90351E-05	2.29249E-05	1.11594E-05
1.0E+23	1.29566E-04	1.27606E-04	1.24442E-04	1.18474E-04	1.03104E-04	8.39956E-05	6.06861E-05	3.39183E-05	1.97384E-05	9.52302E-06
2.0E+23	1.15275E-04	1.13435E-04	1.10466E-04	1.04876E-04	9.05393E-05	7.28821E-05	5.17291E-05	2.83883E-05	1.64855E-05	7.93577E-06
5.0E+23	9.94636E-05	9.78186E-05	9.51356E-05	9.00952E-05	7.72450E-05	6.16097E-05	4.32964E-05	2.39161E-05	1.41448E-05	6.88049E-06
1.0E+24	9.36864E-05	9.21162E-05	8.95869E-05	8.48393E-05	7.27602E-05	5.81211E-05	4.10755E-05	2.30816E-05	1.37856E-05	6.71577E-06
2.0E+24	9.14786E-05	8.99582E-05	8.75092E-05	8.29128E-05	7.12219E-05	5.70570E-05	4.05524E-05	2.29988E-05	1.37732E-05	6.71252E-06
5.0E+24	9.05015E-05	8.90064E-05	8.65982E-05	8.20783E-05	7.05801E-05	5.66424E-05	4.03767E-05	2.29854E-05	1.37729E-05	6.71251E-06
1.0E+25	9.03800E-05	8.88881E-05	8.64851E-05	8.19749E-05	7.05012E-05	5.65921E-05	4.03582E-05	2.29841E-05	1.37729E-05	6.71251E-06
2.0E+25	9.03757E-05	8.88839E-05	8.64811E-05	8.19713E-05	7.04984E-05	5.65903E-05	4.03575E-05	2.29840E-05	1.37729E-05	6.71251E-06
5.0E+25	9.03757E-05	8.88839E-05	8.64811E-05	8.19713E-05	7.04984E-05	5.65903E-05	4.03575E-05	2.29840E-05	1.37729E-05	6.71251E-06

Table B-[illegible]. Total Photodissociation Rate Coefficients for the Process $H_2O_2 + h\nu \rightarrow OH + OH$ for Wavelengths From 188.2 to 305 nm (Contd)

O2 COLUMN DENSITY	O3 COLUMN DENSITY 5.0E+18	1.0E+19	2.0E+19	5.0E+19	1.0E+20	2.0E+20	5.0E+20	1.0E+21
1.0E+17	3.06840E-06	3.98495E-07	1.00025E-08	3.00632E-13	1.72372E-20	9.76796E-35	2.44366E-77	3.00780-148
2.0E+17	3.06839E-06	3.98494E-07	1.00025E-08	3.00632E-13	1.72372E-20	9.76795E-35	2.44365E-77	3.00780-148
5.0E+17	3.06834E-06	3.98489E-07	1.00024E-08	3.00630E-13	1.72371E-20	9.76790E-35	2.44364E-77	3.00779-148
1.0E+18	3.06825E-06	3.98480E-07	1.00023E-08	3.00628E-13	1.72369E-20	9.76782E-35	2.44362E-77	3.00776-148
2.0E+18	3.05808E-06	3.98464E-07	1.00021E-08	3.00623E-13	1.72366E-20	9.76765E-35	2.44358E-77	3.00771-148
5.0E+18	3.08758E-06	3.98416E-07	1.00014E-08	3.00607E-13	1.72357E-20	9.76717E-35	2.44347E-77	3.00757-148
1.0E+19	3.06679E-06	3.98339E-07	1.00003E-08	3.00582E-13	1.72341E-20	9.76635E-35	2.44327E-77	3.00733-148
2.0E+19	3.06532E-06	3.98192E-07	9.99808E-09	3.00531E-13	1.72311E-20	9.76473E-35	2.44288E-77	3.00684-148
5.0E+19	3.06150E-06	3.97797E-07	9.99183E-09	3.00381E-13	1.72219E-20	9.75986E-35	2.44171E-77	3.00540-148
1.0E+20	3.05619E-06	3.97223E-07	9.98207E-09	3.00134E-13	1.72067E-20	9.75178E-35	2.43976E-77	3.00299-148
2.0E+20	3.04744E-06	3.96238E-07	9.96411E-09	2.99651E-13	1.71767E-20	9.73577E-35	2.43589E-77	2.99822-148
5.0E+20	3.04502E-06	3.95999E-07	9.96032E-09	2.99599E-13	1.71756E-20	9.73571E-35	2.43589E-77	2.99822-148
1.0E+21	3.02346E-06	3.93483E-07	9.91092E-09	2.98192E-13	1.70881E-20	9.68854E-35	2.42444E-77	2.98414-148
2.0E+21	2.99480E-06	3.90040E-07	9.83867E-09	2.95988E-13	1.69486E-20	9.61232E-35	2.40587E-77	2.96130-148
5.0E+21	2.94191E-06	3.83712E-07	9.70263E-09	2.91766E-13	1.66824E-20	9.46598E-35	2.37008E-77	2.91741-148
1.0E+22	2.84524E-06	3.71293E-07	9.40340E-09	2.81018E-13	1.59618E-20	9.05682E-35	2.26929E-77	2.79392-148
2.0E+22	2.70660E-06	3.53507E-07	8.96473E-09	2.64835E-13	1.48690E-20	8.43140E-35	2.11448E-77	2.60398-148
5.0E+22	2.43341E-06	3.19813E-07	8.15846E-09	2.35940E-13	1.29412E-20	7.32892E-35	1.84046E-77	2.25691-148
1.0E+23	2.04965E-06	2.67769E-07	6.73786E-09	1.76935E-13	8.76265E-21	4.87091E-35	1.22464E-77	1.50709-148
2.0E+23	1.69456E-06	2.20257E-07	5.43161E-09	1.21507E-13	4.78734E-21	2.51090E-35	6.30669E-78	7.73536-149
5.0E+23	1.46600E-06	1.88854E-07	4.52037E-09	8.03634E-14	1.75909E-21	6.90188E-36	1.71700E-78	2.08641-149
1.0E+24	1.42056E-06	1.80997E-07	4.24356E-09	6.60642E-14	6.63379E-22	2.12690E-37	3.75249E-80	4.40693-151
2.0E+24	1.41973E-06	1.80846E-07	4.23803E-09	6.57690E-14	6.40503E-22	7.27530E-38	3.02906E-81	3.46487-152
5.0E+24	1.41973E-06	1.80846E-07	4.23803E-09	6.57690E-14	6.40503E-22	7.27530E-38	3.02906E-81	3.46487-152
1.0E+25	1.41973E-06	1.80846E-07	4.23803E-09	6.57690E-14	6.40503E-22	7.27530E-38	3.02906E-81	3.46487-152
2.0E+25	1.41973E-06	1.80846E-07	4.23803E-09	6.57690E-14	6.40503E-22	7.27530E-38	3.02906E-81	3.46487-152
5.0E+25	1.41973E-06	1.80846E-07	4.23803E-09	6.57690E-14	6.40503E-22	7.27530E-38	3.02906E-81	3.46487-152

AD-A157 122 A COMPUTER CODE FOR A ONE-DIMENSIONAL DYNAMIC MODEL OF THE MESOSPHERS AND. (U) AIR FORCE GEOPHYSICS LAB HANSCOM AFB MA T J KENESHEA ET AL. 07 MAR 84 2/3

UNCLASSIFIED AFGL-TR-84-0183 F/G 4/1 NL



MICROCOPY RESOLUTION TEST CHART

ARDS-1963-A

Table B10. Total Photodissociation Rate Coefficients for the Process $NO_2 + h\nu \rightarrow NO + O(^1D)$ for Wavelengths From 190 to 420 nm

O2 COLUMN DENSITY	O3 COLUMN DENSITY									
	1.0E+14	2.0E+14	5.0E+14	1.0E+15	2.0E+15	5.0E+15	1.0E+16	2.0E+16	5.0E+16	1.0E+17
1.0E+19	1.51038E-02	1.51038E-02	1.51036E-02	1.51033E-02	1.51027E-02	1.51008E-02	1.50978E-02	1.50920E-02	1.50759E-02	1.50530E-02
2.0E+19	1.51038E-02	1.51038E-02	1.51036E-02	1.51033E-02	1.51026E-02	1.51008E-02	1.50978E-02	1.50920E-02	1.50759E-02	1.50530E-02
5.0E+19	1.51038E-02	1.51037E-02	1.51035E-02	1.51032E-02	1.51026E-02	1.51008E-02	1.50978E-02	1.50920E-02	1.50759E-02	1.50530E-02
1.0E+20	1.51037E-02	1.51037E-02	1.51035E-02	1.51032E-02	1.51026E-02	1.51007E-02	1.50977E-02	1.50919E-02	1.50759E-02	1.50529E-02
2.0E+20	1.51037E-02	1.51036E-02	1.51034E-02	1.51031E-02	1.51025E-02	1.51007E-02	1.50977E-02	1.50918E-02	1.50758E-02	1.50529E-02
5.0E+20	1.51035E-02	1.51035E-02	1.51033E-02	1.51030E-02	1.51024E-02	1.51005E-02	1.50975E-02	1.50917E-02	1.50757E-02	1.50528E-02
1.0E+21	1.51033E-02	1.51032E-02	1.51030E-02	1.51027E-02	1.51021E-02	1.51003E-02	1.50973E-02	1.50914E-02	1.50754E-02	1.50525E-02
2.0E+21	1.51028E-02	1.51027E-02	1.51025E-02	1.51022E-02	1.51016E-02	1.50998E-02	1.50968E-02	1.50910E-02	1.50750E-02	1.50521E-02
5.0E+21	1.51014E-02	1.51013E-02	1.51011E-02	1.51008E-02	1.51002E-02	1.50984E-02	1.50954E-02	1.50897E-02	1.50737E-02	1.50510E-02
1.0E+22	1.50991E-02	1.50991E-02	1.50989E-02	1.50986E-02	1.50980E-02	1.50962E-02	1.50932E-02	1.50875E-02	1.50717E-02	1.50491E-02
2.0E+22	1.50951E-02	1.50950E-02	1.50948E-02	1.50945E-02	1.50939E-02	1.50922E-02	1.50892E-02	1.50836E-02	1.50680E-02	1.50457E-02
5.0E+22	1.50847E-02	1.50847E-02	1.50845E-02	1.50842E-02	1.50836E-02	1.50819E-02	1.50791E-02	1.50737E-02	1.50587E-02	1.50373E-02
1.0E+23	1.50712E-02	1.50711E-02	1.50709E-02	1.50707E-02	1.50701E-02	1.50685E-02	1.50658E-02	1.50607E-02	1.50465E-02	1.50263E-02
2.0E+23	1.50543E-02	1.50543E-02	1.50541E-02	1.50538E-02	1.50533E-02	1.50519E-02	1.50494E-02	1.50447E-02	1.50316E-02	1.50131E-02
5.0E+23	1.50364E-02	1.50364E-02	1.50362E-02	1.50360E-02	1.50356E-02	1.50342E-02	1.50321E-02	1.50279E-02	1.50164E-02	1.49999E-02
1.0E+24	1.50309E-02	1.50309E-02	1.50308E-02	1.50306E-02	1.50301E-02	1.50289E-02	1.50268E-02	1.50229E-02	1.50120E-02	1.49964E-02
2.0E+24	1.50294E-02	1.50294E-02	1.50293E-02	1.50291E-02	1.50287E-02	1.50275E-02	1.50255E-02	1.50216E-02	1.50110E-02	1.49956E-02
5.0E+24	1.50289E-02	1.50289E-02	1.50288E-02	1.50286E-02	1.50282E-02	1.50270E-02	1.50250E-02	1.50212E-02	1.50106E-02	1.49954E-02
1.0E+25	1.50289E-02	1.50288E-02	1.50287E-02	1.50285E-02	1.50281E-02	1.50269E-02	1.50250E-02	1.50211E-02	1.50106E-02	1.49954E-02

Table B10. Total Photodissociation Rate Coefficients for the Process $NO_2 + h\nu \rightarrow NO + O(^1D)$ for Wavelengths From 190 to 420 nm (Contd)

O2 COLUMN DENSITY	O3 COLUMN DENSITY				
	2.0E+17	5.0E+17	1.0E+18	2.0E+18	5.0E+18
1.0E+19	1.50170E-02	1.49479E-02	1.48792E-02	1.47941E-02	1.46491E-02
2.0E+19	1.50170E-02	1.49479E-02	1.48791E-02	1.47941E-02	1.46491E-02
5.0E+19	1.50170E-02	1.49479E-02	1.48791E-02	1.47941E-02	1.46491E-02
1.0E+20	1.50170E-02	1.49479E-02	1.48791E-02	1.47940E-02	1.46491E-02
2.0E+20	1.50169E-02	1.49478E-02	1.48791E-02	1.47940E-02	1.46491E-02
5.0E+20	1.50168E-02	1.49478E-02	1.48790E-02	1.47940E-02	1.46491E-02
1.0E+21	1.50166E-02	1.49476E-02	1.48789E-02	1.47940E-02	1.46491E-02
2.0E+21	1.50162E-02	1.49473E-02	1.48788E-02	1.47939E-02	1.46490E-02
5.0E+21	1.50153E-02	1.49467E-02	1.48784E-02	1.47937E-02	1.46490E-02
1.0E+22	1.50137E-02	1.49456E-02	1.48777E-02	1.47933E-02	1.46489E-02
2.0E+22	1.50108E-02	1.49437E-02	1.48765E-02	1.47928E-02	1.46488E-02
5.0E+22	1.50038E-02	1.49391E-02	1.48738E-02	1.47915E-02	1.46485E-02
1.0E+23	1.49947E-02	1.49333E-02	1.48704E-02	1.47899E-02	1.46482E-02
2.0E+23	1.49840E-02	1.49268E-02	1.48668E-02	1.47883E-02	1.46479E-02
5.0E+23	1.49739E-02	1.49214E-02	1.48641E-02	1.47872E-02	1.46477E-02
1.0E+24	1.49715E-02	1.49204E-02	1.48637E-02	1.47870E-02	1.46477E-02
2.0E+24	1.49711E-02	1.49204E-02	1.48637E-02	1.47870E-02	1.46476E-02
5.0E+24	1.49710E-02	1.49204E-02	1.48637E-02	1.47870E-02	1.46476E-02
1.0E+25	1.49710E-02	1.49204E-02	1.48637E-02	1.47870E-02	1.46476E-02

Table B11. Total Photodissociation Rate Coefficients for the Process $NO_3 + h\nu \rightarrow NO + O_2$ for Wavelengths From 450 to 680 nm

O3 COLUMN DENSITY	
1.0E+14	7.04137E-02
2.0E+14	7.04137E-02
5.0E+14	7.04136E-02
1.0E+15	7.04135E-02
2.0E+15	7.04133E-02
5.0E+15	7.04126E-02
1.0E+16	7.04115E-02
2.0E+16	7.04093E-02
5.0E+16	7.04027E-02
1.0E+17	7.03918E-02
2.0E+17	7.03699E-02
5.0E+17	7.03042E-02
1.0E+18	7.01948E-02
2.0E+18	6.99767E-02
5.0E+18	6.93271E-02
1.0E+19	6.82601E-02
2.0E+19	6.61829E-02
5.0E+19	6.03813E-02
1.0E+20	5.19884E-02
2.0E+20	3.90163E-02
5.0E+20	1.81717E-02
1.0E+21	6.74160E-03

Table B12. Total Photodissociation Rate Coefficients for the Process $N_2O + h\nu \rightarrow N_2 + O(^1D)$ for Wavelengths From 190 to 315 nm

O2 COLUMN DENSITY	O3 COLUMN DENSITY									
	1.0E+11	2.0E+11	5.0E+11	1.0E+12	2.0E+12	5.0E+12	1.0E+13	2.0E+13	5.0E+13	1.0E+14
1.0E+17	7.76688E-07	7.76688E-07	7.76687E-07	7.76687E-07	7.76687E-07	7.76685E-07	7.76683E-07	7.76678E-07	7.76665E-07	7.76642E-07
2.0E+17	7.76675E-07	7.76675E-07	7.76675E-07	7.76674E-07	7.76674E-07	7.76673E-07	7.76670E-07	7.76666E-07	7.76652E-07	7.76629E-07
5.0E+17	7.76637E-07	7.76637E-07	7.76636E-07	7.76636E-07	7.76636E-07	7.76634E-07	7.76632E-07	7.76628E-07	7.76614E-07	7.76591E-07
1.0E+18	7.76573E-07	7.76573E-07	7.76573E-07	7.76573E-07	7.76572E-07	7.76571E-07	7.76569E-07	7.76564E-07	7.76550E-07	7.76527E-07
2.0E+18	7.76447E-07	7.76447E-07	7.76446E-07	7.76446E-07	7.76446E-07	7.76444E-07	7.76442E-07	7.76438E-07	7.76424E-07	7.76401E-07
5.0E+18	7.76072E-07	7.76072E-07	7.76071E-07	7.76071E-07	7.76071E-07	7.76069E-07	7.76067E-07	7.76062E-07	7.76049E-07	7.76026E-07
1.0E+19	7.75460E-07	7.75460E-07	7.75460E-07	7.75460E-07	7.75459E-07	7.75458E-07	7.75456E-07	7.75451E-07	7.75437E-07	7.75414E-07
2.0E+19	7.74287E-07	7.74287E-07	7.74287E-07	7.74287E-07	7.74286E-07	7.74285E-07	7.74282E-07	7.74278E-07	7.74264E-07	7.74241E-07
5.0E+19	7.71086E-07	7.71086E-07	7.71086E-07	7.71085E-07	7.71085E-07	7.71084E-07	7.71081E-07	7.71077E-07	7.71063E-07	7.71040E-07
1.0E+20	7.66513E-07	7.66513E-07	7.66512E-07	7.66512E-07	7.66512E-07	7.66510E-07	7.66508E-07	7.66504E-07	7.66490E-07	7.66467E-07
2.0E+20	7.59021E-07	7.59021E-07	7.59021E-07	7.59021E-07	7.59020E-07	7.59019E-07	7.59017E-07	7.59012E-07	7.58999E-07	7.56976E-07
5.0E+20	7.58248E-07	7.58248E-07	7.58248E-07	7.58248E-07	7.58247E-07	7.58246E-07	7.58244E-07	7.58239E-07	7.58226E-07	7.58203E-07
1.0E+21	7.41207E-07	7.41207E-07	7.41207E-07	7.41207E-07	7.41206E-07	7.41205E-07	7.41203E-07	7.41198E-07	7.41185E-07	7.41163E-07
2.0E+21	7.20595E-07	7.20595E-07	7.20595E-07	7.20594E-07	7.20594E-07	7.20593E-07	7.20590E-07	7.20586E-07	7.20573E-07	7.20551E-07
5.0E+21	6.88458E-07	6.88458E-07	6.88458E-07	6.88458E-07	6.88457E-07	6.88456E-07	6.88454E-07	6.88450E-07	6.88437E-07	6.88416E-07
1.0E+22	6.30746E-07	6.30746E-07	6.30746E-07	6.30746E-07	6.30746E-07	6.30744E-07	6.30742E-07	6.30739E-07	6.30727E-07	6.30707E-07
2.0E+22	5.60380E-07	5.60380E-07	5.60380E-07	5.60380E-07	5.60380E-07	5.60379E-07	5.60377E-07	5.60373E-07	5.60363E-07	5.60345E-07
5.0E+22	4.41787E-07	4.41787E-07	4.41787E-07	4.41787E-07	4.41787E-07	4.41786E-07	4.41784E-07	4.41781E-07	4.41773E-07	4.41758E-07
1.0E+23	2.74667E-07	2.74667E-07	2.74667E-07	2.74667E-07	2.74667E-07	2.74666E-07	2.74665E-07	2.74663E-07	2.74657E-07	2.74646E-07
2.0E+23	1.31564E-07	1.31564E-07	1.31564E-07	1.31564E-07	1.31564E-07	1.31563E-07	1.31563E-07	1.31561E-07	1.31557E-07	1.31551E-07
5.0E+23	3.86021E-08	3.86021E-08	3.86021E-08	3.86020E-08	3.86020E-08	3.86018E-08	3.86014E-08	3.86008E-08	3.85988E-08	3.85955E-08
1.0E+24	1.89016E-08	1.89016E-08	1.89016E-08	1.89015E-08	1.89015E-08	1.89013E-08	1.89011E-08	1.89006E-08	1.88990E-08	1.88965E-08
2.0E+24	1.82305E-08	1.82305E-08	1.82305E-08	1.82305E-08	1.82305E-08	1.82303E-08	1.82301E-08	1.82296E-08	1.82281E-08	1.82257E-08
5.0E+24	1.81457E-08	1.81457E-08	1.81457E-08	1.81456E-08	1.81456E-08	1.81455E-08	1.81452E-08	1.81447E-08	1.81433E-08	1.81409E-08
1.0E+25	1.81365E-08	1.81365E-08	1.81365E-08	1.81364E-08	1.81364E-08	1.81362E-08	1.81360E-08	1.81355E-08	1.81341E-08	1.81317E-08
2.0E+25	1.81362E-08	1.81361E-08	1.81361E-08	1.81361E-08	1.81361E-08	1.81359E-08	1.81357E-08	1.81352E-08	1.81338E-08	1.81314E-08

Table B12. Total Photodissociation Rate Coefficients for the Process $N_2O + h\nu \rightarrow N_2 + O(^1D)$ for Wavelengths From 190 to 315 nm (Contd)

O2 COLUMN DENSITY	O3 COLUMN DENSITY									
	2.0E+14	5.0E+14	1.0E+15	2.0E+15	5.0E+15	1.0E+16	2.0E+16	5.0E+16	1.0E+17	2.0E+17
1.0E+17	7.76596E-07	7.76458E-07	7.76229E-07	7.75772E-07	7.74405E-07	7.72142E-07	7.67675E-07	7.54704E-07	7.34323E-07	6.97141E-07
2.0E+17	7.76583E-07	7.76446E-07	7.76217E-07	7.75759E-07	7.74392E-07	7.72129E-07	7.67662E-07	7.54692E-07	7.34311E-07	6.97129E-07
5.0E+17	7.76545E-07	7.76407E-07	7.76178E-07	7.75721E-07	7.74354E-07	7.72091E-07	7.67624E-07	7.54654E-07	7.34274E-07	6.97094E-07
1.0E+18	7.76481E-07	7.76344E-07	7.76115E-07	7.75658E-07	7.74291E-07	7.72028E-07	7.67561E-07	7.54592E-07	7.34214E-07	6.97036E-07
2.0E+18	7.76355E-07	7.76218E-07	7.75989E-07	7.75531E-07	7.74164E-07	7.71902E-07	7.67436E-07	7.54469E-07	7.34093E-07	6.96921E-07
5.0E+18	7.75980E-07	7.75843E-07	7.75614E-07	7.75157E-07	7.73790E-07	7.71529E-07	7.67064E-07	7.54102E-07	7.33735E-07	6.96579E-07
1.0E+19	7.75369E-07	7.75231E-07	7.75003E-07	7.74546E-07	7.73180E-07	7.70920E-07	7.66459E-07	7.53505E-07	7.33151E-07	6.96021E-07
2.0E+19	7.74196E-07	7.74058E-07	7.73830E-07	7.73374E-07	7.72010E-07	7.69752E-07	7.65296E-07	7.52358E-07	7.32030E-07	6.94950E-07
5.0E+19	7.70995E-07	7.70858E-07	7.70630E-07	7.70175E-07	7.68816E-07	7.66566E-07	7.62124E-07	7.49229E-07	7.28972E-07	6.92028E-07
1.0E+20	7.66422E-07	7.66286E-07	7.66059E-07	7.65606E-07	7.64253E-07	7.62013E-07	7.57592E-07	7.44758E-07	7.24601E-07	6.87850E-07
2.0E+20	7.58931E-07	7.58796E-07	7.58571E-07	7.58121E-07	7.56778E-07	7.54555E-07	7.50168E-07	7.37433E-07	7.17439E-07	6.81002E-07
5.0E+20	7.58158E-07	7.58023E-07	7.57799E-07	7.57350E-07	7.56008E-07	7.53788E-07	7.49405E-07	7.36686E-07	7.16715E-07	6.80321E-07
1.0E+21	7.41119E-07	7.40986E-07	7.40765E-07	7.40324E-07	7.39005E-07	7.36824E-07	7.32518E-07	7.20026E-07	7.00426E-07	6.64748E-07
2.0E+21	7.20508E-07	7.20378E-07	7.20162E-07	7.19731E-07	7.18440E-07	7.16305E-07	7.12093E-07	6.99879E-07	6.80733E-07	6.45925E-07
5.0E+21	6.88375E-07	6.88249E-07	6.88041E-07	6.87625E-07	6.86381E-07	6.84323E-07	6.80263E-07	6.68501E-07	6.50088E-07	6.16682E-07
1.0E+22	6.30668E-07	6.30551E-07	6.30356E-07	6.29967E-07	6.28803E-07	6.26879E-07	6.23086E-07	6.12112E-07	5.94981E-07	5.64024E-07
2.0E+22	5.60309E-07	5.60202E-07	5.60024E-07	5.59669E-07	5.58608E-07	5.56855E-07	5.53400E 7	5.43429E-07	5.27919E-07	5.00042E-07
5.0E+22	4.41729E-07	4.41641E-07	4.41494E-07	4.41202E-07	4.40329E-07	4.38888E-07	4.36054E-07	4.27910E-07	4.15340E-07	3.92990E-07
1.0E+23	2.74625E-07	2.74563E-07	2.74459E-07	2.74251E-07	2.73632E-07	2.72611E-07	2.70613E-07	2.64931E-07	2.56323E-07	2.41429E-07
2.0E+23	1.31538E-07	1.31500E-07	1.31436E-07	1.31308E-07	1.30929E-07	1.30307E-07	1.29099E-07	1.25731E-07	1.20814E-07	1.12767E-07
5.0E+23	3.85889E-08	3.85692E-08	3.85364E-08	3.84712E-08	3.82778E-08	3.79634E-08	3.73623E-08	3.57555E-08	3.35931E-08	3.05016E-08
1.0E+24	1.88914E-08	1.88762E-08	1.88508E-08	1.88004E-08	1.86514E-08	1.84099E-08	1.79518E-08	1.67513E-08	1.52016E-08	1.31551E-08
2.0E+24	1.82208E-08	1.82063E-08	1.81822E-08	1.81341E-08	1.79921E-08	1.77620E-08	1.73255E-08	1.61820E-08	1.47065E-08	1.27561E-08
5.0E+24	1.81361E-08	1.81218E-08	1.80980E-08	1.80507E-08	1.79108E-08	1.76841E-08	1.72539E-08	1.61266E-08	1.46702E-08	1.27403E-08
1.0E+25	1.81269E-08	1.81127E-08	1.80889E-08	1.80417E-08	1.79020E-08	1.76756E-08	1.72462E-08	1.61207E-08	1.46664E-08	1.27388E-08
2.0E+25	1.81266E-08	1.81123E-08	1.80886E-08	1.80413E-08	1.79017E-08	1.76753E-08	1.72459E-08	1.61205E-08	1.46663E-08	1.27387E-08

Table B12. Total Photodissociation Rate Coefficients for the Process $N_2O + h\nu \rightarrow N_2 + O(^1D)$ for Wavelengths From 190 to 315 nm (Contd)

O2 COLUMN DENSITY	O3 COLUMN DENSITY 5.0E+17	1.0E+18	2.0E+18	5.0E+18	1.0E+19	2.0E+19	5.0E+19
1.0E+17	6.03763E-07	4.83551E-07	3.18465E-07	9.86375E-08	1.63090E-08	1.07089E-09	8.59453E-11
2.0E+17	6.03753E-07	4.83543E-07	3.18460E-07	9.86362E-08	1.63089E-08	1.07089E-09	8.59453E-11
5.0E+17	6.03723E-07	4.83519E-07	3.18444E-07	9.86322E-08	1.63084E-08	1.07088E-09	8.59453E-11
1.0E+18	6.03672E-07	4.83479E-07	3.18419E-07	9.86255E-08	1.63077E-08	1.07087E-09	8.59453E-11
2.0E+18	6.03572E-07	4.83399E-07	3.18368E-07	9.86123E-08	1.63062E-08	1.07085E-09	8.59453E-11
5.0E+18	6.03273E-07	4.83161E-07	3.18217E-07	9.85730E-08	1.63018E-08	1.07078E-09	8.59453E-11
1.0E+19	6.02787E-07	4.82774E-07	3.17971E-07	9.85087E-08	1.62946E-08	1.07066E-09	8.59453E-11
2.0E+19	6.01853E-07	4.82030E-07	3.17497E-07	9.83847E-08	1.62806E-08	1.07044E-09	8.59453E-11
5.0E+19	5.99303E-07	4.79995E-07	3.16199E-07	9.80421E-08	1.62413E-08	1.06979E-09	8.59453E-11
1.0E+20	5.95653E-07	4.77078E-07	3.14330E-07	9.75427E-08	1.61828E-08	1.06877E-09	8.59453E-11
2.0E+20	5.89662E-07	4.72279E-07	3.11242E-07	9.67042E-08	1.60817E-08	1.06692E-09	8.59452E-11
5.0E+20	5.89092E-07	4.71844E-07	3.10977E-07	9.66372E-08	1.60738E-08	1.06678E-09	8.59452E-11
1.0E+21	5.75467E-07	4.60915E-07	3.03913E-07	9.46837E-08	1.58296E-08	1.06198E-09	8.59451E-11
2.0E+21	5.59003E-07	4.47700E-07	2.95339E-07	9.22722E-08	1.55172E-08	1.05539E-09	8.59449E-11
5.0E+21	5.33511E-07	4.27298E-07	2.82119E-07	8.85198E-08	1.50175E-08	1.04420E-09	8.59446E-11
1.0E+22	4.87436E-07	3.90206E-07	2.57815E-07	8.13909E-08	1.40144E-08	1.01943E-09	8.59437E-11
2.0E+22	4.31625E-07	3.45375E-07	2.28419E-07	7.26317E-08	1.27358E-08	9.85761E-10	8.59425E-11
5.0E+22	3.38947E-07	2.71525E-07	1.80395E-07	5.83839E-08	1.06352E-08	9.29097E-10	8.59403E-11
1.0E+23	2.06846E-07	1.65135E-07	1.09845E-07	3.63482E-08	7.14610E-09	8.25112E-10	8.59359E-11
2.0E+23	9.55816E-08	7.61533E-08	5.11481E-08	1.79497E-08	4.17913E-09	7.33719E-10	8.59318E-11
5.0E+23	2.52507E-08	2.03050E-08	1.43418E-08	6.21662E-09	2.22475E-09	6.70637E-10	8.59289E-11
1.0E+24	1.02400E-08	8.04676E-09	5.85509E-09	3.22418E-09	1.67355E-09	6.50942E-10	8.59279E-11
2.0E+24	9.95878E-09	7.83253E-09	5.70855E-09	3.17142E-09	1.66353E-09	6.50572E-10	8.59278E-11
5.0E+24	9.95734E-09	7.83247E-09	5.70855E-09	3.17142E-09	1.66353E-09	6.50572E-10	8.59278E-11
1.0E+25	9.95724E-09	7.83247E-09	5.70855E-09	3.17142E-09	1.66353E-09	6.50572E-10	8.59278E-11
2.0E+25	9.95723E-09	7.83247E-09	5.70855E-09	3.17142E-09	1.66353E-09	6.50572E-10	8.59278E-11

Table B13. Total Photodissociation Rate Coefficients for the Process $N_2O_5 + h\nu \rightarrow NO_2 + NO_2 + O$ for Wavelengths From 210 to 380 nm

O2 COLUMN DENSITY	O3 COLUMN DENSITY									
	1.0E+11	2.0E+11	5.0E+11	1.0E+12	2.0E+12	5.0E+12	1.0E+13	2.0E+13	5.0E+13	1.0E+14
1.0E+17	6.92337E-04	6.92337E-04	6.92336E-04	6.92334E-04	6.92331E-04	6.92323E-04	6.92309E-04	6.92281E-04	6.92198E-04	6.92059E-04
2.0E+17	6.92337E-04	6.92336E-04	6.92335E-04	6.92334E-04	6.92331E-04	6.92323E-04	6.92309E-04	6.92281E-04	6.92198E-04	6.92058E-04
5.0E+17	6.92336E-04	6.92336E-04	6.92335E-04	6.92333E-04	6.92331E-04	6.92322E-04	6.92308E-04	6.92280E-04	6.92197E-04	6.92058E-04
1.0E+18	6.92335E-04	6.92334E-04	6.92334E-04	6.92332E-04	6.92329E-04	6.92321E-04	6.92307E-04	6.92279E-04	6.92196E-04	6.92056E-04
2.0E+18	6.92332E-04	6.92332E-04	6.92331E-04	6.92330E-04	6.92327E-04	6.92319E-04	6.92305E-04	6.92277E-04	6.92193E-04	6.92054E-04
5.0E+18	6.92326E-04	6.92325E-04	6.92324E-04	6.92323E-04	6.92320E-04	6.92312E-04	6.92298E-04	6.92270E-04	6.92187E-04	6.92047E-04
1.0E+19	6.92314E-04	6.92314E-04	6.92313E-04	6.92312E-04	6.92309E-04	6.92300E-04	6.92287E-04	6.92259E-04	6.92175E-04	6.92036E-04
2.0E+19	6.92291E-04	6.92291E-04	6.92290E-04	6.92289E-04	6.92286E-04	6.92278E-04	6.92264E-04	6.92236E-04	6.92152E-04	6.92013E-04
5.0E+19	6.92223E-04	6.92222E-04	6.92222E-04	6.92220E-04	6.92217E-04	6.92209E-04	6.92195E-04	6.92167E-04	6.92084E-04	6.91944E-04
1.0E+20	6.92108E-04	6.92108E-04	6.92107E-04	6.92106E-04	6.92103E-04	6.92095E-04	6.92081E-04	6.92053E-04	6.91969E-04	6.91830E-04
2.0E+20	6.91880E-04	6.91880E-04	6.91879E-04	6.91877E-04	6.91875E-04	6.91866E-04	6.91852E-04	6.91824E-04	6.91741E-04	6.91602E-04
5.0E+20	6.91195E-04	6.91195E-04	6.91194E-04	6.91193E-04	6.91190E-04	6.91182E-04	6.91168E-04	6.91140E-04	6.91057E-04	6.90917E-04
1.0E+21	6.90058E-04	6.90057E-04	6.90057E-04	6.90055E-04	6.90052E-04	6.90044E-04	6.90030E-04	6.90002E-04	6.89919E-04	6.89780E-04
2.0E+21	6.87794E-04	6.87793E-04	6.87793E-04	6.87791E-04	6.87788E-04	6.87780E-04	6.87766E-04	6.87738E-04	6.87655E-04	6.87516E-04
5.0E+21	6.81093E-04	6.81093E-04	6.81092E-04	6.81090E-04	6.81088E-04	6.81079E-04	6.81066E-04	6.81038E-04	6.80955E-04	6.80817E-04
1.0E+22	6.70223E-04	6.70222E-04	6.70222E-04	6.70220E-04	6.70217E-04	6.70209E-04	6.70195E-04	6.70168E-04	6.70086E-04	6.69949E-04
2.0E+22	6.49550E-04	6.49550E-04	6.49549E-04	6.49548E-04	6.49545E-04	6.49537E-04	6.49524E-04	6.49497E-04	6.49416E-04	6.49281E-04
5.0E+22	5.95214E-04	5.95214E-04	5.95213E-04	5.95212E-04	5.95210E-04	5.95202E-04	5.95189E-04	5.95163E-04	5.95086E-04	5.94957E-04
1.0E+23	5.25402E-04	5.25402E-04	5.25401E-04	5.25400E-04	5.25398E-04	5.25390E-04	5.25378E-04	5.25354E-04	5.25281E-04	5.25160E-04
2.0E+23	4.37587E-04	4.37587E-04	4.37586E-04	4.37585E-04	4.37583E-04	4.37576E-04	4.37565E-04	4.37543E-04	4.37477E-04	4.37367E-04
5.0E+23	3.45059E-04	3.45059E-04	3.45059E-04	3.45058E-04	3.45056E-04	3.45050E-04	3.45041E-04	3.45022E-04	3.44965E-04	3.44870E-04
1.0E+24	3.16513E-04	3.16513E-04	3.16512E-04	3.16511E-04	3.16509E-04	3.16504E-04	3.16495E-04	3.16478E-04	3.15425E-04	3.16338E-04
2.0E+24	3.06849E-04	3.06849E-04	3.06848E-04	3.06847E-04	3.06846E-04	3.06840E-04	3.06832E-04	3.06815E-04	3.06765E-04	3.06681E-04
5.0E+24	3.02786E-04	3.02785E-04	3.02785E-04	3.02784E-04	3.02783E-04	3.02778E-04	3.02769E-04	3.02753E-04	3.02704E-04	3.02622E-04
1.0E+25	3.02285E-04	3.02285E-04	3.02284E-04	3.02283E-04	3.02282E-04	3.02277E-04	3.02269E-04	3.02252E-04	3.02203E-04	3.02121E-04
2.0E+25	3.02267E-04	3.02267E-04	3.02267E-04	3.02266E-04	3.02264E-04	3.02259E-04	3.02251E-04	3.02235E-04	3.02185E-04	3.02104E-04

Table B13. Total Photodissociation Rate Coefficients for the Process $N_2O_5 + h\nu \rightarrow NO_2 + NO_2 + O$ for Wavelengths From 210 to 380 nm (Contd)

O2 COLUMN DENSITY	O3 COLUMN DENSITY 2.0E+14	5.0E+14	1.0E+15	2.0E+15	5.0E+15	1.0E+16	2.0E+16	5.0E+16	1.0E+17	2.0E+17
1.0E+17	6.91780E-04	6.90946E-04	6.89561E-04	6.86805E-04	6.78656E-04	7.72142E-07	7.67675E-07	7.54704E-07	7.34323E-07	6.97141E-07
2.0E+17	6.91780E-04	6.90946E-04	6.89561E-04	6.86805E-04	6.78656E-04	7.72129E-07	7.67662E-07	7.54692E-07	7.34311E-07	6.97129E-07
5.0E+17	6.91779E-04	6.90946E-04	6.89560E-04	6.86804E-04	6.78655E-04	7.72091E-07	7.67624E-07	7.54654E-07	7.34274E-07	6.97094E-07
1.0E+18	6.91778E-04	6.90944E-04	6.89559E-04	6.86803E-04	6.78654E-04	7.72028E-07	7.67561E-07	7.54592E-07	7.34214E-07	6.97036E-07
2.0E+18	6.91776E-04	6.90942E-04	6.89557E-04	6.86801E-04	6.78652E-04	7.71902E-07	7.67436E-07	7.54469E-07	7.34093E-07	6.96921E-07
5.0E+18	6.91769E-04	6.90935E-04	6.89550E-04	6.86794E-04	6.78645E-04	7.71529E-07	7.67064E-07	7.54102E-07	7.33735E-07	6.96579E-07
1.0E+19	6.91758E-04	6.90924E-04	6.89538E-04	6.86782E-04	6.78634E-04	7.70920E-07	7.66459E-07	7.53505E-07	7.33151E-07	6.96021E-07
2.0E+19	6.91735E-04	6.90901E-04	6.89516E-04	6.86760E-04	6.78611E-04	7.69752E-07	7.65296E-07	7.52358E-07	7.32030E-07	6.94950E-07
5.0E+19	6.91666E-04	6.90833E-04	6.89447E-04	6.86691E-04	6.78543E-04	7.66566E-07	7.62124E-07	7.49229E-07	7.28972E-07	6.92028E-07
1.0E+20	6.91552E-04	6.90718E-04	6.89333E-04	6.86577E-04	6.78430E-04	7.62013E-07	7.57592E-07	7.44758E-07	7.24601E-07	6.87850E-07
2.0E+20	6.91324E-04	6.90490E-04	6.89105E-04	6.86350E-04	6.78204E-04	7.54555E-07	7.50168E-07	7.37433E-07	7.17439E-07	6.81002E-07
5.0E+20	6.90639E-04	6.89806E-04	6.88422E-04	6.85668E-04	6.77526E-04	7.53788E-07	7.49405E-07	7.36686E-07	7.16715E-07	6.80321E-07
1.0E+21	6.89502E-04	6.88670E-04	6.87286E-04	6.84535E-04	6.76400E-04	7.36824E-07	7.32518E-07	7.20026E-07	7.00426E-07	6.64748E-07
2.0E+21	6.87239E-04	6.86408E-04	6.85027E-04	6.82280E-04	6.74158E-04	7.16305E-07	7.12093E-07	6.99879E-07	6.80733E-07	6.45925E-07
5.0E+21	6.80541E-04	6.79714E-04	6.78340E-04	6.75607E-04	6.67525E-04	6.84323E-07	6.80263E-07	6.68501E-07	6.50088E-07	6.16682E-07
1.0E+22	6.69675E-04	6.68855E-04	6.67492E-04	6.64781E-04	6.56765E-04	6.26879E-07	6.23086E-07	6.12112E-07	5.94981E-07	5.64024E-07
2.0E+22	6.49011E-04	6.48204E-04	6.46862E-04	6.44194E-04	6.36305E-04	5.56855E-07	5.53400E-07	5.43429E-07	5.27919E-07	5.00042E-07
5.0E+22	5.94699E-04	5.93926E-04	5.92642E-04	5.90089E-04	5.82543E-04	4.38888E-07	4.[illegible]054E-07	4.27910E-07	4.15340E-07	3.92990E-07
1.0E+23	5.24918E-04	5.24193E-04	5.22987E-04	5.20591E-04	5.13514E-04	2.72611E-07	2.70613E-07	2.64931E-07	2.56323E-07	2.41429E-07
2.0E+23	4.37147E-04	4.36488E-04	4.35394E-04	4.33218E-04	4.26798E-04	1.30307E-07	1.29099E-07	1.25731E-07	1.20814E-07	1.12767E-07
5.0E+23	3.44680E-04	3.44112E-04	3.43169E-04	3.41296E-04	3.35771E-04	3.79634E-08	3.73623E-08	3.57555E-08	3.35931E-08	3.05016E-08
1.0E+24	3.16163E-04	3.15639E-04	3.14769E-04	3.13042E-04	3.07949E-04	1.84099E-08	1.79518E-08	1.67513E-08	1.52016E-08	1.31551E-08
2.0E+24	3.06513E-04	3.06011E-04	3.05177E-04	3.03521E-04	2.98638E-04	1.77620E-08	1.73255E-08	1.61820E-08	1.47065E-08	1.27561E-08
5.0E+24	3.02457E-04	3.01966E-04	3.01150E-04	2.99528E-04	2.94749E-04	1.76841E-08	1.72539E-08	1.61266E-08	1.46702E-08	1.27403E-08
1.0E+25	3.01958E-04	3.01467E-04	3.00653E-04	2.99036E-04	2.94271E-04	1.76756E-08	1.72462E-08	1.61207E-08	1.46664E-08	1.27388E-08
2.0E+25	3.01940E-04	3.01450E-04	3.00636E-04	2.99019E-04	2.94254E-04	1.76753E-08	1.72459E-08	1.61205E-08	1.46663E-08	1.27387E-08

Table B13. Total Photodissociation Rate Coefficients for the Process $N_2O_5 + h\nu \rightarrow NO_2 + NO_2 + O$ for Wavelengths From 210 to 380 nm (Contd)

O2 COLUMN DENSITY	O3 COLUMN DENSITY 5.0E+17	1.0E+18	2.0E+18	5.0E+18	1.0E+19
1.0E+17	6.03763E-07	4.83551E-07	3.18465E-07	9.86375E-08	1.63090E-08
2.0E+17	6.03753E-07	4.83543E-07	3.18460E-07	9.86362E-08	1.63089E-08
5.0E+17	6.03723E-07	4.83519E-07	3.18444E-07	9.86322E-08	1.63084E-08
:.0E+18	6.03672E-07	4.83479E-07	3.18419E-07	9.86255E-08	1.63077E-08
2.0E+18	6.03572E-07	4.83399E-07	3.18368E-07	9.86123E-08	1.63062E-08
5.0E+18	6.03273E-07	4.83161E-07	3.18217E-07	9.85730E-08	1.63018E-08
1.0E+19	6.02787E-07	4.82774E-07	3.17971E-07	9.85087E-08	1.62946E-08
2.0E+19	6.01853E-07	4.82030E-07	3.17497E-07	9.83847E-08	1.62806E-08
5.0E+19	5.99303E-07	4.79995E-07	3.16199E-07	9.80421E-08	1.62413E-08
1.0E+20	5.95653E-07	4.77078E-07	3.14330E-07	9.75427E-08	1.61828E-08
2.0E+20	5.89662E-07	4.72279E-07	3.11242E-07	9.67042E-08	1.60817E-08
5.0E+20	5.89092E-07	4.71844E-07	3.10977E-07	9.66372E-08	1.60738E-08
1.0E+21	5.75467E-07	4.60915E-07	3.03913E-07	9.46837E-08	1.58296E-08
2.0E+21	5.59003E-07	4.47700E-07	2.95339E-07	9.22722E-08	1.55172E-08
5.0E+21	5.33511E-07	4.27298E-07	2.82119E-07	8.85198E-08	1.50175E-08
1.0E+22	4.87436E-07	3.90206E-07	2.57815E-07	8.13909E-08	1.40144E-08
2.0E+22	4.31625E-07	3.45375E-07	2.28419E-07	7.26317E-08	1.27358E-08
5.0E+22	3.38947E-07	2.71525E-07	1.80395E-07	5.83839E-08	1.06352E-08
1.0E+23	2.06846E-07	1.65135E-07	1.09845E-07	3.63482E-08	7.14610E-09
2.0E+23	9.55816E-08	7.61533E-08	5.11481E-08	1.79497E-08	4.17913E-09
5.0E+23	2.52507E-08	2.03050E-08	1.43418E-08	6.21662E-09	2.22475E-09
1.0E+24	1.02400E-08	8.04676E-09	5.85509E-09	3.22418E-09	1.67355E-09
2.0E+24	9.95878E-09	7.83253E-09	5.70855E-09	3.17142E-09	1.66353E-09
5.0E+24	9.95734E-C9	7.83247E-09	5.70855E-09	3.17142E-09	1.66353E-09
1.0E+25	9.95724E-09	7.83247E-09	5.70855E-09	3.17142E-09	1.66353E-09
2.0E+25	9.95723E-09	7.83247E-09	5.70855E-09	3.17142E-09	1.66353E-09

Table B14. Total Photodissociation Rate Coefficients for the Process $HNO_2 + h\nu \rightarrow OH + NO$ for Wavelengths From 300 to 390 nm

O3 COLUMN DENSITY	
1.0E+14	5.84756E-04
2.0E+14	5.84755E-04
5.0E+14	5.84754E-04
1.0E+15	5.84753E-04
2.0E+15	5.84749E-04
5.0E+15	5.84739E-04
1.0E+16	5.84722E-04
2.0E+16	5.84688E-04
5.0E+16	5.84585E-04
1.0E+17	5.84416E-04
2.0E+17	5.84083E-04
5.0E+17	5.83115E-04
1.0E+18	5.81605E-04
2.0E+18	5.78914E-04
5.0E+18	5.72656E-04
1.0E+19	5.65442E-04
2.0E+19	5.55729E-04
5.0E+19	5.37947E-04
1.0E+20	5.20145E-04
2.0E+20	4.99103E-04
5.0E+20	4.68331E-04
1.0E+21	4.43897E-04

Table B15. Total Photodissociation Rate Coefficients for the Process $HNO_3 + h\nu \rightarrow OH + NO_2$ for Wavelengths From 192 to 325 nm

O2 COLUMN DENSITY	O3 COLUMN DENSITY 1.0E+12	2.0E+12	5.0E+12	1.0E+13	2.0E+13	5.0E+13	1.0E+14	2.0E+14	5.0E+14	1.0E+15
1.0E+17	1.16539E-04	1.16539E-04	1.16539E-04	1.16537E-04	1.16535E-04	1.16528E-04	1.16516E-04	1.16493E-04	1.16424E-04	1.16309E-04
2.0E+17	1.16539E-04	1.16539E-04	1.16538E-04	1.16537E-04	1.16535E-04	1.16528E-04	1.16516E-04	1.16493E-04	1.16424E-04	1.16308E-04
5.0E+17	1.16539E-04	1.16539E-04	1.16538E-04	1.16537E-04	1.16534E-04	1.16528E-04	1.16516E-04	1.16493E-04	1.16423E-04	1.16308E-04
1.0E+18	1.16538E-04	1.16538E-04	1.16537E-04	1.16536E-04	1.16534E-04	1.16527E-04	1.16515E-04	1.16492E-04	1.16423E-04	1.16307E-04
2.0E+18	1.16537E-04	1.16537E-04	1.16536E-04	1.16535E-04	1.16532E-04	1.16525E-04	1.16514E-04	1.16491E-04	1.16421E-04	1.16306E-04
5.0E+18	1.16532E-04	1.16532E-04	1.16532E-04	1.16530E-04	1.16528E-04	1.16521E-04	1.16510E-04	1.16486E-04	1.16417E-04	1.16302E-04
1.0E+19	1.16525E-04	1.16525E-04	1.16524E-04	1.16523E-04	1.16521E-04	1.16514E-04	1.16502E-04	1.16479E-04	1.16410E-04	1.16295E-04
2.0E+19	1.16511E-04	1.16511E-04	1.16510E-04	1.16509E-04	1.16507E-04	1.16500E-04	1.16488E-04	1.16465E-04	1.16396E-04	1.16280E-04
5.0E+19	1.16469E-04	1.16469E-04	1.16468E-04	1.16467E-04	1.16465E-04	1.16458E-04	1.16446E-04	1.16423E-04	1.16354E-04	1.16238E-04
1.0E+20	1.16400E-04	1.16400E-04	1.16399E-04	1.16398E-04	1.16396E-04	1.16389E-04	1.16377E-04	1.16354E-04	1.16285E-04	1.16169E-04
2.0E+20	1.16265E-04	1.16265E-04	1.16264E-04	1.16263E-04	1.16261E-04	1.16254E-04	1.16242E-04	1.16219E-04	1.16150E-04	1.16035E-04
5.0E+20	1.16127E-04	1.16127E-04	1.16126E-04	1.16125E-04	1.16122E-04	1.16116E-04	1.16104E-04	1.16081E-04	1.16012E-04	1.15896E-04
1.0E+21	1.15652E-04	1.15652E-04	1.15652E-04	1.15650E-04	1.15648E-04	1.15641E-04	1.15630E-04	1.15606E-04	1.15537E-04	1.15422E-04
2.0E+21	1.14835E-04	1.14835E-04	1.14834E-04	1.14833E-04	1.14831E-04	1.14824E-04	1.14812E-04	1.14789E-04	1.14720E-04	1.14605E-04
5.0E+21	1.12858E-04	1.12857E-04	1.12857E-04	1.12856E-04	1.12853E-04	1.12846E-04	1.12835E-04	1.12812E-04	1.12743E-04	1.12629E-04
1.0E+22	1.09086E-04	1.09085E-04	1.09085E-04	1.09084E-04	1.09081E-04	1.09075E-04	1.09063E-04	1.09041E-04	1.08973E-04	1.08860E-04

Table B15. Total Photodissociation Rate Coefficients for the Process $HNO_3 + h\nu \rightarrow OH + NO_2$ for Wavelengths From 192 to 325 nm (Contd)

O2 COLUMN DENSITY	O3 COLUMN DENSITY 2.0E+15	5.0E+15	1.0E+16	2.0E+16	5.0E+16	1.0E+17	2.0E+17	5.0E+17	1.0E+18	2.0E+18
1.0E+17	1.16079E-04	1.15398E-04	1.14292E-04	1.12176E-04	1.06523E-04	9.89202E-05	8.80795E-05	6.98619E-05	5.31722E-05	3.41525E-05
2.0E+17	1.16079E-04	1.15398E-04	1.14292E-04	1.12176E-04	1.06523E-04	9.89201E-05	8.80794E-05	6.98618E-05	5.31721E-05	3.41525E-05
5.0E+17	1.16078E-04	1.15398E-04	1.14291E-04	1.12176E-04	1.06522E-04	9.89197E-05	8.80790E-05	6.98614E-05	5.31718E-05	3.41523E-05
1.0E+18	1.16078E-04	1.15397E-04	1.14290E-04	1.12175E-04	1.06522E-04	9.89190E-05	8.80784E-05	6.98609E-05	5.31713E-05	3.41520E-05
2.0E+18	1.16076E-04	1.15396E-04	1.14289E-04	1.12174E-04	1.06520E-04	9.89177E-05	8.80771E-05	6.98597E-05	5.31704E-05	3.41514E-05
5.0E+18	1.16072E-04	1.15391E-04	1.14285E-04	1.12169E-04	1.06516E-04	9.89136E-05	8.80733E-05	6.98564E-05	5.31677E-05	3.41495E-05
1.0E+19	1.16065E-04	1.15384E-04	1.14278E-04	1.12162E-04	1.06509E-04	9.89069E-05	8.80669E-05	6.98508E-05	5.31631E-05	3.41464E-05
2.0E+19	1.16051E-04	1.15370E-04	1.14264E-04	1.12148E-04	1.06495E-04	9.88935E-05	8.80541E-05	6.98396E-05	5.31540E-05	3.41402E-05
5.0E+19	1.16009E-04	1.15328E-04	1.14222E-04	1.12107E-04	1.06454E-04	9.88536E-05	8.80161E-05	6.98064E-05	5.31269E-05	3.41217E-05
1.0E+20	1.15940E-04	1.15260E-04	1.14153E-04	1.12038E-04	1.06387E-04	9.87880E-05	8.79536E-05	6.97518E-05	5.30825E-05	3.40914E-05
2.0E+20	1.15805E-04	1.15125E-04	1.14019E-04	1.11905E-04	1.06256E-04	9.86602E-05	8.78319E-05	6.96455E-05	5.29960E-05	3.40325E-05
5.0E+20	1.15667E-04	1.14987E-04	1.13882E-04	1.11769E-04	1.06124E-04	9.85336E-05	8.77152E-05	6.95513E-05	5.29266E-05	3.39918E-05
1.0E+21	1.15193E-04	1.14514E-04	1.13411E-04	1.11301E-04	1.05664E-04	9.80871E-05	8.72930E-05	6.91883E-05	5.26366E-05	3.37992E-05
2.0E+21	1.14377E-04	1.13700E-04	1.12599E-04	1.10494E-04	1.04873E-04	9.73209E-05	8.65711E-05	6.85728E-05	5.21498E-05	3.34803E-05
5.0E+21	1.12402E-04	1.11730E-04	1.10636E-04	1.08546E-04	1.02968E-04	9.54811E-05	8.48483E-05	6.71253E-05	5.10251E-05	3.27621E-05
1.0E+22	1.08636E-04	1.07971E-04	1.06890E-04	1.04826E-04	9.93215E-05	9.19509E-05	8.15257E-05	6.42989E-05	4.87946E-05	3.13045E-05

Table B20. Total Photodissociation Rate Coefficients for the Process $HO_2 + h\nu \rightarrow O_2 + H$ for Wavelengths From 180 to 274 nm

O2 COLUMN DENSITY	O3 COLUMN DENSITY									
	2.0E+15	5.0E+15	1.0E+16	2.0E+16	5.0E+16	1.0E+17	2.0E+17	5.0E+17	1.0E+18	2.0E+18
1.0E+17	1.12764E-03	1.11447E-03	1.09309E-03	1.05241E-03	9.45069E-04	8.04875E-04	6.17887E-04	3.63050E-04	2.08833E-04	9.88600E-05
2.0E+17	1.12762E-03	1.11445E-03	1.09307E-03	1.05239E-03	9.45050E-04	8.04857E-04	6.17870E-04	3.63037E-04	2.08824E-04	9.88554E-05
5.0E+17	1.12757E-03	1.11439E-03	1.09302E-03	1.05234E-03	9.44997E-04	8.04805E-04	6.17823E-04	3.62998E-04	2.08797E-04	9.88421E-05
1.0E+18	1.12748E-03	1.11431E-03	1.09293E-03	1.05226E-03	9.44916E-04	8.04728E-04	6.17751E-04	3.62940E-04	2.08757E-04	9.88220E-05
2.0E+18	1.12734E-03	1.11417E-03	1.09279E-03	1.05212E-03	9.44778E-04	8.04595E-04	6.17628E-04	3.62841E-04	2.08687E-04	9.87871E-05
5.0E+18	1.12701E-03	1.11384E-03	1.09247E-03	1.05179E-03	9.44463E-04	8.04292E-04	6.17346E-04	3.62614E-04	2.08526E-04	9.87059E-05
1.0E+19	1.12662E-03	1.11344E-03	1.09207E-03	1.05140E-03	9.44081E-04	8.03924E-04	6.17003E-04	3.62337E-04	2.08330E-04	9.86049E-05
2.0E+19	1.12604E-03	1.11287E-03	1.09150E-03	1.05083E-03	9.43523E-04	8.03387E-04	6.16506E-04	3.61934E-04	2.08042E-04	9.84546E-05
5.0E+19	1.12487E-03	1.11170E-03	1.09034E-03	1.04968E-03	9.42404E-04	8.02312E-04	6.15510E-04	3.61130E-04	2.07465E-04	9.81468E-05
1.0E+20	1.12355E-03	1.11039E-03	1.08903E-03	1.04838E-03	9.41138E-04	8.01099E-04	6.14391E-04	3.60232E-04	2.06818E-04	9.77951E-05
2.0E+20	1.12165E-03	1.10849E-03	1.08714E-03	1.04652E-03	9.39327E-04	7.99371E-04	6.12808E-04	3.58970E-04	2.05910E-04	9.72939E-05
5.0E+20	1.12007E-03	1.10692E-03	1.08559E-03	1.04500E-03	9.37898E-04	7.98076E-04	6.11722E-04	3.58261E-04	2.05491E-04	9.71014E-05
1.0E+21	1.11508E-03	1.10195E-03	1.08066E-03	1.04013E-03	9.33225E-04	7.93687E-04	6.07804E-04	3.55288E-04	2.03424E-04	9.59730E-05
2.0E+21	1.10762E-03	1.09454E-03	1.07330E-03	1.03290E-03	9.26328E-04	7.87288E-04	6.02206E-04	3.51219E-04	2.00694E-04	9.45129E-05
5.0E+21	1.08948E-03	1.07650E-03	1.05544E-03	1.01537E-03	9.09742E-04	7.72075E-04	5.89175E-04	3.42196E-04	1.94936E-04	9.15811E-05
1.0E+22	1.05983E-03	1.04702E-03	1.02624E-03	9.86722E-04	8.82631E-04	7.47200E-04	5.67849E-04	3.27368E-04	1.85390E-04	8.66197E-05
2.0E+22	1.00734E-03	9.94850E-04	9.74605E-04	9.36127E-04	8.34937E-04	7.03715E-04	5.30998E-04	3.02450E-04	1.69846E-04	7.88314E-05
5.0E+22	8.75133E-04	8.63526E-04	8.44722E-04	8.09046E-04	7.15656E-04	5.95698E-04	4.40585E-04	2.43079E-04	1.34025E-04	6.16213E-05
1.0E+23	7.01310E-04	6.90918E-04	6.74107E-04	6.42298E-04	5.59643E-04	4.55085E-04	3.23772E-04	1.67262E-04	8.83747E-05	3.93658E-05
2.0E+23	4.85107E-04	4.76452E-04	4.62485E-04	4.36185E-04	3.68712E-04	2.85655E-04	1.86793E-04	8.33320E-05	4.04439E-05	1.71553E-05
5.0E+23	2.50555E-04	2.44369E-04	2.34434E-04	2.15894E-04	1.69502E-04	1.15414E-04	5.79847E-05	1.45263E-05	5.33679E-06	2.20992E-06
1.0E+24	1.70615E-04	1.65677E-04	1.57771E-04	1.43098E-04	1.06935E-04	6.61750E-05	2.59885E-05	2.17455E-06	2.00761E-07	4.65079E-08
2.0E+24	1.42977E-04	1.38649E-04	1.31728E-04	1.18914E-04	8.75310E-05	5.26373E-05	1.92008E-05	1.01890E-06	1.52165E-08	2.52692E-09
5.0E+24	1.31568E-04	1.27536E-04	1.21090E-04	1.09166E-04	8.00283E-05	4.77828E-05	1.71599E-05	8.59583E-07	1.19301E-08	2.49510E-09
1.0E+25	1.30174E-04	1.26179E-04	1.19793E-04	1.07980E-04	7.91231E-05	4.72054E-05	1.69250E-05	8.43752E-07	1.17530E-08	2.49508E-09
2.0E+25	1.30125E-04	1.26131E-04	1.19747E-04	1.07939E-04	7.90911E-05	4.71850E-05	1.69167E-05	8.43194E-07	1.17468E-08	2.49508E-09

Table B20. Total Photodissociation Rate Coefficients for the Process $HO_2 + h\nu \rightarrow O_2 + H$ for Wavelengths From 180 to 274 nm

O2 COLUMN DENSITY	O3 COLUMN DENSITY 1.0E+12	2.0E+12	5.0E+12	1.0E+13	2.0E+13	5.0E+13	1.0E+14	2.0E+14	5.0E+14	1.0E+15
1.0E+17	1.13657E-03	1.13656E-03	1.13655E-03	1.13653E-03	1.13648E-03	1.13635E-03	1.13612E-03	1.13567E-03	1.13433E-03	1.13209E-03
2.0E+17	1.13655E-03	1.13654E-03	[illegible]	1.13651E-03	1.13646E-03	1.13633E-03	1.13610E-03	1.13565E-03	1.13431E-03	1.13207E-03
5.0E+17	1.13649E-03	1.13649E-03	[illegible]	1.13645E-03	1.13641E-03	1.13627E-03	1.13605E-03	1.13560E-03	1.13425E-03	1.13202E-03
1.0E+18	1.13641E-03	1.13640E-03	1.13639E-03	1.13637E-03	1.13632E-03	1.13619E-03	1.13596E-03	1.13551E-03	1.13417E-03	1.13193E-03
2.0E+18	1.13627E-03	1.13626E-03	1.13625E-03	1.13623E-03	1.13618E-03	1.13605E-03	1.13582E-03	1.13537E-03	1.13403E-03	1.13179E-03
5.0E+18	1.13594E-03	1.13593E-03	1.13592E-03	1.13590E-03	1.13585E-03	1.13572E-03	1.13549E-03	1.13504E-03	1.13370E-03	1.13146E-03
1.0E+19	1.13554E-03	1.13554E-03	1.13552E-03	1.13550E-03	1.13546E-03	1.13532E-03	1.13510E-03	1.13465E-03	1.13330E-03	1.13107E-03
2.0E+19	1.13496E-03	1.13496E-03	1.13494E-03	1.13492E-03	1.13488E-03	1.13474E-03	1.13452E-03	1.13407E-03	1.13272E-03	1.13049E-03
5.0E+19	1.13379E-03	1.13379E-03	1.13378E-03	1.13375E-03	1.13371E-03	1.13357E-03	1.13335E-03	1.13290E-03	1.13156E-03	1.12932E-03
1.0E+20	1.13247E-03	1.13246E-03	1.13245E-03	1.13243E-03	1.13238E-03	1.13225E-03	1.13202E-03	1.13158E-03	1.13023E-03	1.12800E-03
2.0E+20	1.13056E-03	1.13056E-03	1.13055E-03	1.13052E-03	1.13048E-03	1.13034E-03	1.13012E-03	1.12967E-03	1.12833E-03	1.12609E-03
5.0E+20	1.12898E-03	1.12897E-03	1.12896E-03	1.12894E-03	1.12889E-03	1.12876E-03	1.12853E-03	1.12808E-03	1.12674E-03	1.12451E-03
1.0E+21	1.12397E-03	1.12397E-03	1.12396E-03	1.12393E-03	1.12389E-03	1.12376E-03	1.12353E-03	1.12308E-03	1.12174E-03	1.11951E-03
2.0E+21	1.11649E-03	1.11649E-03	1.11648E-03	1.11645E-03	1.11641E-03	1.11628E-03	1.11605E-03	1.11561E-03	1.11427E-03	1.11205E-03
5.0E+21	1.09828E-03	1.09827E-03	1.09826E-03	1.09824E-03	1.09819E-03	1.09806E-03	1.09784E-03	1.09740E-03	1.09607E-03	1.09387E-03
1.0E+22	1.06851E-03	1.06851E-03	1.06850E-03	1.06847E-03	1.06843E-03	1.06830E-03	1.06808E-03	1.06764E-03	1.06633E-03	1.06416E-03
2.0E+22	1.01580E-03	1.01580E-03	1.01578E-03	1.01576E-03	1.01572E-03	1.01559E-03	1.01538E-03	1.01495E-03	1.01368E-03	1.01156E-03
5.0E+22	8.83007E-04	8.83003E-04	8.82991E-04	8.82971E-04	8.82932E-04	8.82813E-04	8.82614E-04	8.82218E-04	8.81031E-04	8.79058E-04
1.0E+23	7.08365E-04	7.08363E-04	7.08352E-04	7.08334E-04	7.08299E-04	7.08192E-04	7.08014E-04	7.07659E-04	7.06595E-04	7.04827E-04
2.0E+23	4.90993E-04	4.90990E-04	4.90981E-04	4.90967E-04	4.90937E-04	4.90848E-04	4.90699E-04	4.90403E-04	4.89515E-04	4.88040E-04
5.0E+23	2.54775E-04	2.54772E-04	2.54766E-04	2.54755E-04	2.54734E-04	2.54670E-04	2.54564E-04	2.54351E-04	2.53714E-04	2.52656E-04
1.0E+24	1.73989E-04	1.73987E-04	1.73982E-04	1.73974E-04	1.73957E-04	1.73905E-04	1.73820E-04	1.73650E-04	1.73140E-04	1.72294E-04
2.0E+24	1.45936E-04	1.45934E-04	1.45930E-04	1.45922E-04	1.45907E-04	1.45862E-04	1.45788E-04	1.45638E-04	1.45191E-04	1.44449E-04
5.0E+24	1.34326E-04	1.34325E-04	1.34321E-04	1.34314E-04	1.34300E-04	1.34258E-04	1.34188E-04	1.34049E-04	1.33632E-04	1.32941E-04
1.0E+25	1.32907E-04	1.32906E-04	1.32901E-04	1.32894E-04	1.32881E-04	1.32839E-04	1.32770E-04	1.32632E-04	1.32219E-04	1.31534E-04
2.0E+25	1.32857E-04	1.32855E-04	1.32851E-04	1.32844E-04	1.32830E-04	1.32789E-04	1.32720E-04	1.32582E-04	1.32169E-04	1.31484E-04

Table B19. Total Photodissociation Rate Coefficients for the Process $CH_2O + h\nu$ CHO + H and $CH_2O + h\nu \rightarrow CO + H_2$ for Wavelengths From 240 to 360 nm (Contd)

O2 COLUMN DENSITY	O3 COLUMN DENSITY 5.0E+15	1.0E+16	2.0E+16	5.0E+16	1.0E+17	2.0E+17	5.0E+17	1.0E+18	2.0E+18	5.0E+18
1.0E+13	2.58223E-04	2.57561E-04	2.56282E-04	2.52774E-04	2.47810E-04	2.40115E-04	2.25324E-04	2.10458E-04	1.92675E-04	1.66137E-04
2.0E+13	2.58223E-04	2.57561E-04	2.56282E-04	2.52774E-04	2.47810E-04	2.40115E-04	2.25324E-04	2.10458E-04	1.92675E-04	1.66137E-04
5.0E+13	2.58223E-04	2.57561E-04	2.56282E-04	2.52774E-04	2.47810E-04	2.40115E-04	2.25324E-04	2.10458E-04	1.92675E-04	1.66137E-04
1.0E+14	2.58222E-04	2.57560E-04	2.56281E-04	2.52773E-04	2.47809E-04	2.40114E-04	2.25324E-04	2.10458E-04	1.92675E-04	1.66137E-04
2.0E+14	2.58221E-04	2.57559E-04	2.56280E-04	2.52772E-04	2.47809E-04	2.40114E-04	2.25324E-04	2.10458E-04	1.92675E-04	1.66137E-04
5.0E+14	2.58219E-04	2.57556E-04	2.56278E-04	2.52770E-04	2.47806E-04	2.40112E-04	2.25323E-04	2.10457E-04	1.92675E-04	1.66137E-04
1.0E+15	2.58214E-04	2.57552E-04	2.56273E-04	2.52766E-04	2.47803E-04	2.40110E-04	2.25321E-04	2.10457E-04	1.92675E-04	1.66137E-04
2.0E+15	2.58205E-04	2.57543E-04	2.56265E-04	2.52758E-04	2.47796E-04	2.40104E-04	2.25319E-04	2.10456E-04	1.92675E-04	1.66137E-04
5.0E+15	2.58178E-04	2.57517E-04	2.56239E-04	2.52735E-04	2.47776E-04	2.40089E-04	2.25311E-04	2.10453E-04	1.92674E-04	1.66137E-04
1.0E+16	2.58135E-04	2.57474E-04	2.56198E-04	2.52697E-04	2.47743E-04	2.40064E-04	2.25299E-04	2.10447E-04	1.92672E-04	1.66137E-04
2.0E+16	2.58054E-04	2.57395E-04	2.56121E-04	2.52626E-04	2.47682E-04	2.40017E-04	2.25275E-04	2.10437E-04	1.92669E-04	1.66137E-04
5.0E+16	2.57850E-04	2.57193E-04	2.55925E-04	2.52446E-04	2.47525E-04	2.39895E-04	2.25211E-04	2.10408E-04	1.92659E-04	1.66136E-04
1.0E+17	2.57602E-04	2.56948E-04	2.55687E-04	2.52225E-04	2.47329E-04	2.39739E-04	2.25124E-04	2.10366E-04	1.92644E-04	1.66135E-04
2.0E+17	2.57296E-04	2.56645E-04	2.55390E-04	2.51946E-04	2.47076E-04	2.39529E-04	2.24991E-04	2.10293E-04	1.92615E-04	1.66132E-04
5.0E+17	2.56836E-04	2.56189E-04	2.54939E-04	2.51511E-04	2.46666E-04	2.39163E-04	2.24723E-04	2.10124E-04	1.92544E-04	1.66126E-04
1.0E+18	2.56368E-04	2.55722E-04	2.54476E-04	2.51060E-04	2.46234E-04	2.38765E-04	2.24414E-04	2.09920E-04	1.92454E-04	1.66119E-04
2.0E+18	2.55808E-04	2.55164E-04	2.53923E-04	2.50520E-04	2.45716E-04	2.38288E-04	2.24041E-04	2.09673E-04	1.92346E-04	1.66110E-04
5.0E+18	2.55285E-04	2.54644E-04	2.53407E-04	2.50017E-04	2.45233E-04	2.37844E-04	2.23695E-04	2.09444E-04	1.92246E-04	1.66101E-04
1.0E+19	2.55180E-04	2.54540E-04	2.53303E-04	2.49916E-04	2.45136E-04	2.37755E-04	2.23626E-04	2.09399E-04	1.92226E-04	1.66100E-04
2.0E+19	2.55168E-04	2.54528E-04	2.53291E-04	2.49904E-04	2.45125E-04	2.37745E-04	2.23618E-04	2.09393E-04	1.92224E-04	1.66099E-04
5.0E+19	2.55169E-04	2.54527E-04	2.53291E-04	2.49904E-04	2.45125E-04	2.37744E-04	2.23617E-04	2.09393E-04	1.92224E-04	1.66099E-04
1.0E+20	2.55168E-04	2.54527E-04	2.53291E-04	2.49904E-04	2.45125E-04	2.37744E-04	2.23617E-04	2.09393E-04	1.92224E-04	1.66099E-04
2.0E+20	2.55168E-04	2.54527E-04	2.53291E-04	2.49904E-04	2.45125E-04	2.37744E-04	2.23617E-04	2.09393E-04	1.92224E-04	1.66099E-04
5.0E+20	2.55168E-04	2.54527E-04	2.53291E-04	2.49904E-04	2.45125E-04	2.37744E-04	2.23617E-04	2.09393E-04	1.92224E-04	1.66099E-04
1.0E+21	2.55168E-04	2.54527E-04	2.53291E-04	2.49904E-04	2.45125E-04	2.37744E-04	2.23617E-04	2.09393E-04	1.92224E-04	1.66099E-04
2.0E+21	2.55168E-04	2.54527E-04	2.53291E-04	2.49904E-04	2.45125E-04	2.37744E-04	2.23617E-04	2.09393E-04	1.92224E-04	1.66099E-04
5.0E+21	2.55168E-04	2.54527E-04	2.53291E-04	2.49904E-04	2.45124E-04	2.37744E-04	2.23617E-04	2.09393E-04	1.92224E-04	1.66099E-04
1.0E+22	2.55167E-04	2.54527E-04	2.53290E-04	2.49904E-04	2.45124E-04	2.37744E-04	2.23617E-04	2.09393E-04	1.92224E-04	1.66099E-04
2.0E+22	2.55167E-04	2.54526E-04	2.53290E-04	2.49903E-04	2.45124E-04	2.37744E-04	2.23617E-04	2.09393E-04	1.92224E-04	1.66099E-04
5.0E+22	2.55165E-04	2.54525E-04	2.53288E-04	2.49902E-04	2.45123E-04	2.37744E-04	2.23617E-04	2.09393E-04	1.92224E-04	1.66099E-04
1.0E+23	2.55162E-04	2.54522E-04	2.53286E-04	2.49900E-04	2.45122E-04	2.37743E-04	2.23617E-04	2.09393E-04	1.92224E-04	1.66099E-04
2.0E+23	2.55157E-04	2.54517E-04	2.53282E-04	2.49897E-04	2.45120E-04	2.37742E-04	2.23617E-04	2.09393E-04	1.92224E-04	1.66099E-04
5.0E+23	2.55144E-04	2.54504E-04	2.53270E-04	2.49888E-04	2.45114E-04	2.37740E-04	2.23617E-04	2.09393E-04	1.92224E-04	1.66099E-04
1.0E+24	2.55127E-04	2.54488E-04	2.53255E-04	2.49877E-04	2.45107E-04	2.37737E-04	2.23617E-04	2.09393E-04	1.92224E-04	1.66099E-04
2.0E+24	2.55106E-04	2.54468E-04	2.53237E-04	2.49863E-04	2.45098E-04	2.37733E-04	2.23617E-04	2.09393E-04	1.92224E-04	1.66099E-04
5.0E+24	2.55087E-04	2.54450E-04	2.53220E-04	2.49850E-04	2.45090E-04	2.37730E-04	2.23616E-04	2.09393E-04	1.92224E-04	1.66099E-04
1.0E+25	2.55084E-04	2.54447E-04	2.53218E-04	2.49848E-04	2.45089E-04	2.37730E-04	2.23616E-04	2.09393E-04	1.92224E-04	1.66099E-04

Table B19. Total Photodissociation Rate Coefficients for the Process $CH_2O + h\nu$ $CHO + H$ and $CH_2O + h\nu \rightarrow CO + H_2$ for Wavelengths From 240 to 360 nm

O2 COLUMN DENSITY	O3 COLUMN DENSITY									
	2.0E+12	5.0E+12	1.0E+13	2.0E+13	5.0E+13	1.0E+14	2.0E+14	5.0E+14	1.0E+15	2.0E+15
1.0E+13	2.58901E-04	2.58901E-04	2.58900E-04	2.58899E-04	2.58895E-04	2.58888E-04	2.58874E-04	2.58833E-04	2.58764E-04	2.58628E-04
2.0E+13	2.58901E-04	2.58901E-04	2.58900E-04	2.58899E-04	2.58895E-04	2.58888E-04	2.58874E-04	2.58833E-04	2.58764E-04	2.58628E-04
5.0E+13	2.58901E-04	2.58900E-04	2.58900E-04	2.58898E-04	2.58894E-04	2.58887E-04	2.58874E-04	2.58833E-04	2.58764E-04	2.58628E-04
1.0E+14	2.58900E-04	2.58900E-04	2.58899E-04	2.58898E-04	2.58894E-04	2.58887E-04	2.58873E-04	2.58832E-04	2.58764E-04	2.58627E-04
2.0E+14	2.58899E-04	2.58899E-04	2.58898E-04	2.58897E-04	2.58893E-04	2.58886E-04	2.58872E-04	2.58831E-04	2.58763E-04	2.58626E-04
5.0E+14	2.58897E-04	2.58896E-04	2.58896E-04	2.58894E-04	2.58890E-04	2.58883E-04	2.58869E-04	2.58828E-04	2.58760E-04	2.58624E-04
1.0E+15	2.58892E-04	2.58892E-04	2.58891E-04	2.58889E-04	2.58885E-04	2.58879E-04	2.58865E-04	2.58824E-04	2.58755E-04	2.58619E-04
2.0E+15	2.58883E-04	2.58882E-04	2.58882E-04	2.58880E-04	2.58876E-04	2.58869E-04	2.58856E-04	2.58814E-04	2.58746E-04	2.58610E-04
5.0E+15	2.58856E-04	2.58855E-04	2.58854E-04	2.58853E-04	2.58849E-04	2.58842E-04	2.58828E-04	2.58787E-04	2.58719E-04	2.58583E-04
1.0E+16	2.58812E-04	2.58811E-04	2.58811E-04	2.58809E-04	2.58805E-04	2.58798E-04	2.58785E-04	2.58744E-04	2.58675E-04	2.58539E-04
2.0E+16	2.58730E-04	2.58729E-04	2.58729E-04	2.58727E-04	2.58723E-04	2.58716E-04	2.58703E-04	2.58662E-04	2.58594E-04	2.58458E-04
5.0E+16	2.58523E-04	2.58522E-04	2.58522E-04	2.58520E-04	2.58516E-04	2.58509E-04	2.58496E-04	2.58455E-04	2.58387E-04	2.58252E-04
1.0E+17	2.58271E-04	2.58271E-04	2.58270E-04	2.58269E-04	2.58265E-04	2.58258E-04	2.58245E-04	2.58204E-04	2.58136E-04	2.58002E-04
2.0E+17	2.57962E-04	2.57961E-04	2.57961E-04	2.57959E-04	2.57955E-04	2.57949E-04	2.57935E-04	2.57895E-04	2.57828E-04	2.57694E-04
5.0E+17	2.57499E-04	2.57499E-04	2.57498E-04	2.57497E-04	2.57493E-04	2.57486E-04	2.57473E-04	2.57433E-04	2.57366E-04	2.57232E-04
1.0E+18	2.57029E-04	2.57028E-04	2.57028E-04	2.57026E-04	2.57022E-04	2.57016E-04	2.57002E-04	2.56962E-04	2.56895E-04	2.56763E-04
2.0E+18	2.56466E-04	2.56465E-04	2.56465E-04	2.56464E-04	2.56460E-04	2.56453E-04	2.56440E-04	2.56400E-04	2.56334E-04	2.56201E-04
5.0E+18	2.55942E-04	2.55941E-04	2.55941E-04	2.55939E-04	2.55935E-04	2.55929E-04	2.55915E-04	2.55876E-04	2.55809E-04	2.55677E-04
1.0E+19	2.55837E-04	2.55836E-04	2.55836E-04	2.55834E-04	2.55830E-04	2.55824E-04	2.55810E-04	2.55771E-04	2.55704E-04	2.55572E-04
2.0E+19	2.55824E-04	2.55824E-04	2.55823E-04	2.55822E-04	2.55818E-04	2.55811E-04	2.55798E-04	2.55758E-04	2.55692E-04	2.55560E-04
5.0E+19	2.55824E-04	2.55824E-04	2.55823E-04	2.55822E-04	2.55818E-04	2.55811E-04	2.55798E-04	2.55758E-04	2.55692E-04	2.55560E-04
1.0E+20	2.55824E-04	2.55824E-04	2.55823E-04	2.55822E-04	2.55818E-04	2.55811E-04	2.55798E-04	2.55758E-04	2.55692E-04	2.55560E-04
2.0E+20	2.55824E-04	2.55824E-04	2.55823E-04	2.55822E-04	2.55818E-04	2.55811E-04	2.55798E-04	2.55758E-04	2.55692E-04	2.55560E-04
5.0E+20	2.55824E-04	2.55824E-04	2.55823E-04	2.55822E-04	2.55818E-04	2.55811E-04	2.55798E-04	2.55758E-04	2.55692E-04	2.55560E-04
1.0E+21	2.55824E-04	2.55824E-04	2.55823E-04	2.55822E-04	2.55818E-04	2.55811E-04	2.55798E-04	2.55758E-04	2.55692E-04	2.55560E-04
2.0E+21	2.55824E-04	2.55823E-04	2.55823E-04	2.55821E-04	2.55817E-04	2.55811E-04	2.55798E-04	2.55758E-04	2.55692E-04	2.55560E-04
5.0E+21	2.55824E-04	2.55823E-04	2.55823E-04	2.55821E-04	2.55817E-04	2.55811E-04	2.55797E-04	2.55758E-04	2.55691E-04	2.55559E-04
1.0E+22	2.55823E-04	2.55823E-04	2.55822E-04	2.55821E-04	2.55817E-04	2.55810E-04	2.55797E-04	2.55757E-04	2.55691E-04	2.55559E-04
2.0E+22	2.55823E-04	2.55822E-04	2.55822E-04	2.55820E-04	2.55816E-04	2.55810E-04	2.55797E-04	2.55757E-04	2.55690E-04	2.55559E-04
5.0E+22	2.55821E-04	2.55821E-04	2.55820E-04	2.55819E-04	2.55815E-04	2.55808E-04	2.55795E-04	2.55755E-04	2.55689E-04	2.55557E-04
1.0E+23	2.55818E-04	2.55818E-04	2.55817E-04	2.55816E-04	2.55812E-04	2.55805E-04	2.55792E-04	2.55752E-04	2.55686E-04	2.55554E-04
2.0E+23	2.55813E-04	2.55813E-04	2.55812E-04	2.55811E-04	2.55807E-04	2.55800E-04	2.55787E-04	2.55747E-04	2.55681E-04	2.55549E-04
5.0E+23	2.55799E-04	2.55799E-04	2.55798E-04	2.55797E-04	2.55793E-04	2.55786E-04	2.55773E-04	2.55733E-04	2.55667E-04	2.55535E-04
1.0E+24	2.55781E-04	2.55781E-04	2.55780E-04	2.55779E-04	2.55775E-04	2.55768E-04	2.55755E-04	2.55715E-04	2.55649E-04	2.55518E-04
2.0E+24	2.55759E-04	2.55759E-04	2.55758E-04	2.55757E-04	2.55753E-04	2.55746E-04	2.55733E-04	2.55693E-04	2.55627E-04	2.55496E-04
5.0E+24	2.55739E-04	2.55739E-04	2.55738E-04	2.55737E-04	2.55733E-04	2.55727E-04	2.55713E-04	2.55674E-04	2.55608E-04	2.55477E-04
1.0E+25	2.55737E-04	2.55736E-04	2.55736E-04	2.55734E-04	2.55730E-04	2.55724E-04	2.55710E-04	2.55671E-04	2.55605E-04	2.55474E-04

Table B18. Total Photodissociation Rate Coefficients for the Process $CO_2 + h\nu \rightarrow CO + O$ for Wavelengths From 166 to 215 nm (Contd)

O2 COLUMN DENSITY	O3 COLUMN DENSITY 5.0E+18	1.0E+19	2.0E+19	5.0E+19	1.0E+20	2.0E+20	5.0E+20	1.0E+21
1.0E+13	1.11969E-11	1.51540E-12	4.02055E-14	1.62200E-18	1.13333E-25	6.57859E-40	1.63313E-82	2.00839-153
2.0E+13	1.11969E-11	1.51540E-12	4.02055E-14	1.62200E-18	1.13333E-25	6.57859E-40	1.63313E-82	2.00839-153
5.0E+13	1.11969E-11	1.51540E-12	4.02055E-14	1.62200E-18	1.13333E-25	6.57859E-40	1.63313E-82	2.00839-153
1.0E+14	1.11969E-11	1.51540E-12	4.02055E-14	1.62200E-18	1.13333E-25	6.57859E-40	1.63313E-82	2.00839-153
2.0E+14	1.11969E-11	1.51540E-12	4.02055E-14	1.62200E-18	1.13333E-25	6.57859E-40	1.63313E-82	2.00839-153
5.0E+14	1.11969E-11	1.51540E-12	4.02055E-14	1.62200E-18	1.13333E-25	6.57859E-40	1.63313E-82	2.00839-153
1.0E+15	1.11969E-11	1.51540E-12	4.02055E-14	1.62200E-18	1.13333E-25	6.57859E-40	1.63313E-82	2.00839-153
2.0E+15	1.11969E-11	1.51540E-12	4.02055E-14	1.62200E-18	1.13333E-25	6.57859E-40	1.63313E-82	2.00839-153
5.0E+15	1.11969E-11	1.51540E-12	4.02055E-14	1.62200E-18	1.13333E-25	6.57859E-40	1.63313E-82	2.00839-153
1.0E+16	1.11969E-11	1.51540E-12	4.02055E-14	1.62200E-18	1.13333E-25	6.57859E-40	1.63313E-82	2.00839-153
2.0E+16	1.11969E-11	1.51540E-12	4.02055E-14	1.62200E-18	1.13333E-25	6.57859E-40	1.63313E-82	2.00839-153
5.0E+16	1.11969E-11	1.51540E-12	4.02055E-14	1.62200E-18	1.13333E-25	6.57859E-40	1.63313E-82	2.00839-153
1.0E+17	1.11969E-11	1.51540E-12	4.02055E-14	1.62200E-18	1.13333E-25	6.57859E-40	1.63313E-82	2.00839-153
2.0E+17	1.11969E-11	1.51540E-12	4.02055E-14	1.62200E-18	1.13333E-25	6.57859E-40	1.63313E-82	2.00839-153
5.0E+17	1.11969E-11	1.51540E-12	4.02055E-14	1.62200E-18	1.13333E-25	6.57859E-40	1.63313E-82	2.00839-153
1.0E+18	1.11969E-11	1.51540E-12	4.02055E-14	1.62200E-18	1.13333E-25	6.57859E-40	1.63313E-82	2.00839-153
2.0E+18	1.11969E-11	1.51540E-12	4.02055E-14	1.62200E-18	1.13333E-25	6.57859E-40	1.63313E-82	2.00839-153
5.0E+18	1.11969E-11	1.51540E-12	4.02055E-14	1.62200E-18	1.13333E-25	6.57859E-40	1.63313E-82	2.00839-153
1.0E+19	1.11969E-11	1.51540E-12	4.02055E-14	1.62200E-18	1.13333E-25	6.57859E-40	1.63313E-82	2.00839-153
2.0E+19	1.11969E-11	1.51540E-12	4.02055E-14	1.62200E-18	1.13333E-25	6.57859E-40	1.63313E-82	2.00839-153
5.0E+19	1.11969E-11	1.51540E-12	4.02055E-14	1.62200E-18	1.13333E-25	6.57859E-40	1.63313E-82	2.00839-153
1.0E+20	1.11969E-11	1.51540E-12	4.02055E-14	1.62200E-18	1.13333E-25	6.57859E-40	1.63313E-82	2.00839-153
2.0E+20	1.11969E-11	1.51540E-12	4.02055E-14	1.62200E-18	1.13333E-25	6.57859E-40	1.63313E-82	2.00839-153
5.0E+20	1.11969E-11	1.51540E-12	4.02055E-14	1.62200E-18	1.13333E-25	6.57859E-40	1.63313E-82	2.00839-153
1.0E+21	1.11969E-11	1.51540E-12	4.02055E-14	1.62200E-18	1.13333E-25	6.57859E-40	1.63313E-82	2.00839-153
2.0E+21	1.11969E-11	1.51540E-12	4.02055E-14	1.62200E-18	1.13333E-25	6.57859E-40	1.63313E-82	2.00839-153
5.0E+21	1.11969E-11	1.51540E-12	4.02055E-14	1.62200E-18	1.13333E-25	6.57859E-40	1.63313E-82	2.00839-153
1.0E+22	1.11969E-11	1.51540E-12	4.02055E-14	1.62200E-18	1.13333E-25	6.57859E-40	1.63313E-82	2.00839-153
2.0E+22	1.11969E-11	1.51540E-12	4.02055E-14	1.62200E-18	1.13333E-25	6.57859E-40	1.63313E-82	2.00839-153
5.0E+22	1.11969E-11	1.51540E-12	4.02055E-14	1.62200E-18	1.13333E-25	6.57859E-40	1.63313E-82	2.00839-153
1.0E+23	1.11969E-11	1.51540E-12	4.02055E-14	1.62200E-18	1.13333E-25	6.57859E-40	1.63313E-82	2.00839-153
2.0E+23	1.11969E-11	1.51540E-12	4.02055E-14	1.62200E-18	1.13333E-25	6.57859E-40	1.63313E-82	2.00839-153
5.0E+23	1.11969E-11	1.51540E-12	4.02055E-14	1.62200E-18	1.13333E-25	6.57859E-40	1.63313E-82	2.00839-153
1.0E+24	1.11969E-11	1.51540E-12	4.02055E-14	1.62200E-18	1.13333E-25	6.57859E-40	1.63313E-82	2.00839-153
2.0E+24	1.11969E-11	1.51540E-12	4.02055E-14	1.62200E-18	1.13333E-25	6.57859E-40	1.63313E-82	2.00839-153

Table B18. Total Photodissociation Rate Coefficients for the Process $CO_2 + h\nu \rightarrow CO + O$ for Wavelengths From 166 to 215 nm (Contd)

O3 COLUMN DENSITY

O2 COLUMN DENSITY	2.0E+15	5.0E+15	1.0E+16	2.0E+16	5.0E+16	1.0E+17	2.0E+17	5.0E+17	1.0E+18	2.0E+18
1.0E+13	8.23559E-09	8.21569E-09	8.18264E-09	8.11694E-09	7.92300E-09	7.61006E-09	7.02095E-09	5.51462E-09	3.69031E-09	1.65855E-09
2.0E+13	8.23553E-09	8.21563E-09	8.18258E-09	8.11688E-09	7.92294E-09	7.61000E-09	7.02090E-09	5.51458E-09	3.69028E-09	1.65854E-09
5.0E+13	8.23535E-09	8.21546E-09	8.18241E-09	8.11671E-09	7.92277E-09	7.60984E-09	7.02075E-09	5.51446E-09	3.69021E-09	1.65850E-09
1.0E+14	8.23506E-09	8.21516E-09	8.18211E-09	8.11642E-09	7.92249E-09	7.60957E-09	7.02050E-09	5.51427E-09	3.69008E-09	1.65845E-09
2.0E+14	8.23447E-09	8.21457E-09	8.18153E-09	8.11584E-09	7.92192E-09	7.60902E-09	7.02000E-09	5.51388E-09	3.68982E-09	1.65833E-09
5.0E+14	8.23270E-09	8.21281E-09	8.17977E-09	8.11409E-09	7.92022E-09	7.60739E-09	7.01849E-09	5.51270E-09	3.68903E-09	1.65799E-09
1.0E+15	8.22975E-09	8.20987E-09	8.17[illegible]84E-09	8.11119E-09	7.91739E-09	7.60467E-09	7.01599E-09	5.51074E-09	3.68773E-09	1.65741E-09
2.0E+15	8.22386E-09	8.20400E-09	8.17099E-09	8.10538E-09	7.91172E-09	7.59923E-09	7.01098E-09	5.50682E-09	3.68513E-09	1.65626E-09
5.0E+15	8.20623E-09	8.18641E-09	8.15347E-09	8.08801E-09	7.89477E-09	7.58296E-09	6.99598E-09	5.49508E-09	3.67733E-09	1.65282E-09
1.0E+16	8.17696E-09	8.15721E-09	8.12440E-09	8.05917E-09	7.86663E-09	7.55595E-09	6.97109E-09	5.47561E-09	3.66439E-09	1.64711E-09
2.0E+16	8.11889E-09	8.09928E-09	8.06670E-09	8.00194E-09	7.81079E-09	7.50234E-09	6.92170E-09	5.43696E-09	3.63871E-09	1.63577E-09
5.0E+16	7.94821E-09	7.92902E-09	7.89714E-09	7.83376E-09	7.64668E-09	7.34481E-09	6.77654E-09	5.32339E-09	3.56326E-09	1.60246E-09
1.0E+17	7.67522E-09	7.65670E-09	7.62593E-09	7.56476E-09	7.38421E-09	7.09286E-09	6.54437E-09	5.14173E-09	3.44258E-09	1.54920E-09
2.0E+17	7.15081E-09	7.13357E-09	7.10493E-09	7.04801E-09	6.87997E-09	6.60881E-09	6.09833E-09	4.79270E-09	3.21064E-09	1.44677E-09
5.0E+17	5.85974E-09	5.84567E-09	5.82229E-09	5.77581E-09	5.63861E-09	5.41720E-09	5.00030E-09	3.93360E-09	2.63989E-09	1.19483E-09
1.0E+18	4.38135E-09	4.37090E-09	4.35355E-09	4.31905E-09	4.21719E-09	4.05279E-09	3.74314E-09	2.95019E-09	1.98678E-09	9.06714E-10
2.0E+18	2.83407E-09	2.82743E-09	2.81639E-09	2.79445E-09	2.72966E-09	2.62504E-09	2.42783E-09	1.92180E-09	1.30434E-09	6.06123E-10
5.0E+18	1.55073E-09	1.54725E-09	1.54147E-09	1.52998E-09	1.49604E-09	1.44116E-09	1.33751E-09	1.07004E-09	7.39870E-10	3.58122E-10
1.0E+19	1.14257E-09	1.14010E-09	1.13598E-09	1.12780E-09	1.10361E-09	1.06448E-09	9.90439E-10	7.98532E-10	5.59504E-10	2.78444E-10
2.0E+19	9.20991E-10	9.19045E-10	9.15810E-10	9.09377E-10	8.90355E-10	8.59560E-10	8.01226E-10	6.49564E-10	4.59465E-10	2.33258E-10
5.0E+19	7.11624E-10	7.10164E-10	7.07738E-10	7.02911E-10	6.88636E-10	6.65510E-10	6.21645E-10	5.07214E-10	3.62768E-10	1.88543E-10
1.0E+20	5.73567E-10	5.72422E-10	5.70518E-10	5.66731E-10	5.55524E-10	5.37359E-10	5.02866E-10	4.12617E-10	2.97993E-10	1.58086E-10
2.0E+20	4.47148E-10	4.46286E-10	4.44854E-10	4.42003E-10	4.33565E-10	4.19877E-10	3.93849E-10	3.25484E-10	2.37963E-10	1.29490E-10
5.0E+20	4.46927E-10	4.46066E-10	4.44634E-10	4.41784E-10	4.33350E-10	4.19669E-10	3.93652E-10	3.25319E-10	2.37839E-10	1.29419E-10
1.0E+21	3.08433E-10	3.07875E-10	3.06947E-10	3.05101E-10	2.99633E-10	2.90751E-10	2.73817E-10	2.29036E-10	1.70898E-10	9.68980E-11
2.0E+21	2.34369E-10	2.33967E-10	2.33299E-10	2.31968E-10	2.28025E-10	2.21612E-10	2.09361E-10	1.76783E-10	1.34005E-10	7.83751E-11
5.0E+21	1.84499E-10	1.84196E-10	1.83691E-10	1.82687E-10	1.79710E-10	1.74864E-10	1.65593E-10	1.40837E-10	1.08055E-10	6.47265E-11
1.0E+22	1.41710E-10	1.41484E-10	1.41109E-10	1.40362E-10	1.38148E-10	1.34542E-10	1.27637E-10	1.09152E-10	8.45402E-11	5.16358E-11
2.0E+22	1.15859E-10	1.15677E-10	1.15373E-10	1.14768E-10	1.12973E-10	1.10051E-10	1.04455E-10	8.94741E-11	6.95121E-11	4.27606E-11
5.0E+22	8.48856E-11	8.47527E-11	8.45316E-11	8.40914E-11	8.27862E-11	8.06608E-11	7.65907E-11	6.56940E-11	5.11706E-11	3.16775E-11
1.0E+23	4.98125E-11	4.97335E-11	4.96020E-11	4.93402E-11	4.85642E-11	4.73012E-11	4.48846E-11	3.84294E-11	2.98619E-11	1.84374E-11
2.0E+23	2.07956E-11	2.07625E-11	2.07075E-11	2.05980E-11	2.02734E-11	1.97452E-11	1.87351E-11	1.60400E-11	1.24702E-11	7.72202E-12
5.0E+23	3.00891E-12	3.00448E-12	2.99711E-12	2.98243E-12	2.93890E-12	2.86802E-12	2.73219E-12	2.36794E-12	1.88005E-12	1.21561E-12
1.0E+24	4.35417E-13	4.34426E-13	4.32780E-13	4.29508E-13	4.19844E-13	4.04232E-13	3.74777E-13	2.99008E-13	2.06060E-13	9.97381E-14
2.0E+24	3.94567E-13	3.93629E-13	3.92071E-13	3.88973E-13	3.79825E-13	3.65056E-13	3.37227E-13	2.65877E-13	1.79013E-13	8.13910E-14

Table B18. Total Photodissociation Rate Coefficients for the Process $CO_2 + h\nu \rightarrow CO + O$ for Wavelengths From 166 to 215 nm

O3 COLUMN DENSITY

O2 COLUMN DENSITY	1.0E+12	2.0E+12	5.0E+12	1.0E+13	2.0E+13	5.0E+13	1.0E+14	2.0E+14	5.0E+14	1.0E+15
1.0E+13	8.24887E-09	8.24886E-09	8.24884E-09	8.24881E-09	8.24875E-09	8.24855E-09	8.24821E-09	8.24755E-09	8.24555E-09	8.24223E-09
2.0E+13	8.24881E-09	8.24881E-09	8.24879E-09	8.24875E-09	8.24869E-09	8.24849E-09	8.24815E-09	8.24749E-09	8.24549E-09	8.24217E-09
5.0E+13	8.24864E-09	8.24863E-09	8.24861E-09	8.24858E-09	8.24851E-09	8.24831E-09	8.24798E-09	8.24731E-09	8.24532E-09	8.24199E-09
1.0E+14	8.24834E-09	8.24833E-09	8.24831E-09	8.24828E-09	8.24821E-09	8.24801E-09	8.24768E-09	8.24702E-09	8.24502E-09	8.24170E-09
2.0E+14	8.24775E-09	8.24774E-09	8.24772E-09	8.24769E-09	8.24762E-09	8.24742E-09	8.24709E-09	8.24643E-09	8.24443E-09	8.24111E-09
5.0E+14	8.24598E-09	8.24597E-09	8.24595E-09	8.24592E-09	8.24585E-09	8.24565E-09	8.24532E-09	8.24465E-09	8.24266E-09	8.23934E-09
1.0E+15	8.24303E-09	8.24302E-09	8.24300E-09	8.24297E-09	8.24290E-09	8.24270E-09	8.24237E-09	8.24170E-09	8.23971E-09	8.23639E-09
2.0E+15	8.23713E-09	8.23712E-09	8.23710E-09	8.23707E-09	8.23700E-09	8.23680E-09	8.23647E-09	8.23580E-09	8.23381E-09	8.23049E-09
5.0E+15	8.21947E-09	8.21946E-09	8.21944E-09	8.21941E-09	8.21934E-09	8.21914E-09	8.21881E-09	8.21815E-09	8.21616E-09	8.21285E-09
1.0E+16	8.19015E-09	8.19015E-09	8.19013E-09	8.19009E-09	8.19003E-09	8.18983E-09	8.18950E-09	8.18884E-09	8.18686E-09	8.18356E-09
2.0E+16	8.13198E-09	8.13197E-09	8.13195E-09	8.13192E-09	8.13185E-09	8.13166E-09	8.13133E-09	8.13067E-09	8.12871E-09	8.12543E-09
5.0E+16	7.96102E-09	7.96102E-09	7.96100E-09	7.96097E-09	7.96090E-09	7.96071E-09	7.96039E-09	7.95975E-09	7.95782E-09	7.95462E-09
1.0E+17	7.68759E-09	7.68758E-09	7.68756E-09	7.68753E-09	7.68747E-09	7.68729E-09	7.68698E-09	7.68636E-09	7.68450E-09	7.68141E-09
2.0E+17	7.16231E-09	7.16231E-09	7.16229E-09	7.16226E-09	7.16220E-09	7.16203E-09	7.16174E-09	7.16117E-09	7.15944E-09	7.15656E-09
5.0E+17	5.86913E-09	5.86913E-09	5.86912E-09	5.86909E-09	5.86905E-09	5.86890E-09	5.86867E-09	5.86820E-09	5.86679E-09	5.86444E-09
1.0E+18	4.38832E-09	4.38832E-09	4.38831E-09	4.38829E-09	4.38826E-09	4.38815E-09	4.38798E-09	4.38763E-09	4.38658E-09	4.38484E-09
2.0E+18	2.83851E-09	2.83851E-09	2.83850E-09	2.83849E-09	2.83847E-09	2.83840E-09	2.83829E-09	2.83807E-09	2.83740E-09	2.83629E-09
5.0E+18	1.55305E-09	1.55305E-09	1.55304E-09	1.55304E-09	1.55303E-09	1.55299E-09	1.55293E-09	1.55282E-09	1.55247E-09	1.55189E-09
1.0E+19	1.14423E-09	1.14423E-09	1.14422E-09	1.14422E-09	1.14421E-09	1.14419E-09	1.14415E-09	1.14406E-09	1.14381E-09	1.14340E-09
2.0E+19	9.22290E-10	9.22289E-10	9.22287E-10	9.22284E-10	9.22278E-10	9.22258E-10	9.22225E-10	9.22160E-10	9.21965E-10	9.21640E-10
5.0E+19	7.12598E-10	7.12597E-10	7.12596E-10	7.12594E-10	7.12589E-10	7.12574E-10	7.12550E-10	7.12501E-10	7.12355E-10	7.12111E-10
1.0E+20	5.74332E-10	5.74331E-10	5.74330E-10	5.74328E-10	5.74325E-10	5.74313E-10	5.74294E-10	5.74256E-10	5.74141E-10	5.73950E-10
2.0E+20	4.47723E-10	4.47723E-10	4.47722E-10	4.47721E-10	4.47718E-10	4.47709E-10	4.47695E-10	4.47666E-10	4.47580E-10	4.47436E-10
5.0E+20	4.47502E-10	4.47502E-10	4.47501E-10	4.47500E-10	4.47497E-10	4.47488E-10	4.47474E-10	4.47445E-10	4.47359E-10	4.47215E-10
1.0E+21	3.08805E-10	3.08805E-10	3.08804E-10	3.08803E-10	3.08802E-10	3.08796E-10	3.08787E-10	3.08768E-10	3.08712E-10	3.08619E-10
2.0E+21	2.34638E-10	2.34637E-10	2.34637E-10	2.34636E-10	2.34635E-10	2.34631E-10	2.34624E-10	2.34611E-10	2.34571E-10	2.34504E-10
5.0E+21	1.84702E-10	1.84702E-10	1.84701E-10	1.84701E-10	1.84700E-10	1.84697E-10	1.84692E-10	1.84681E-10	1.84651E-10	1.84600E-10
1.0E+22	1.41860E-10	1.41860E-10	1.41860E-10	1.41860E-10	1.41859E-10	1.41857E-10	1.41853E-10	1.41845E-10	1.41823E-10	1.41785E-10
2.0E+22	1.15981E-10	1.15981E-10	1.15981E-10	1.15981E-10	1.15980E-10	1.15978E-10	1.15975E-10	1.15969E-10	1.15951E-10	1.15920E-10
5.0E+22	8.49743E-11	8.49743E-11	8.49741E-11	8.49739E-11	8.49735E-11	8.49721E-11	8.49699E-11	8.49655E-11	8.49522E-11	8.49300E-11
1.0E+23	4.98653E-11	4.98653E-11	4.98652E-11	4.98651E-11	4.98648E-11	4.98640E-11	4.98627E-11	4.98601E-11	4.98521E-11	4.98389E-11
2.0E+23	2.08177E-11	2.08176E-11	2.08176E-11	2.08176E-11	2.08174E-11	2.08171E-11	2.08166E-11	2.08155E-11	2.08121E-11	2.08066E-11
5.0E+23	3.01187E-12	3.01186E-12	3.01186E-12	3.01185E-12	3.01184E-12	3.01179E-12	3.01172E-12	3.01157E-12	3.01113E-12	3.01039E-12
1.0E+24	4.36078E-13	4.36078E-13	4.36077E-13	4.36075E-13	4.36072E-13	4.36062E-13	4.36045E-13	4.36012E-13	4.35913E-13	4.35747E-13
2.0E+24	3.95193E-13	3.95193E-13	3.95192E-13	3.95190E-13	3.95187E-13	3.95178E-13	3.95162E-13	3.95131E-13	3.95037E-13	3.94880E-13

Table B17. Total Photodissociation Rate Coefficients for the Process $CO_2 + h\nu \rightarrow CO + O(^1D)$ for Wavelengths From 116.2 to 166 nm (Contd)

O2 COLUMN DENSITY	O3 COLUMN DENSITY								
	5.0E+17	1.0E+18	2.0E+18	5.0E+18	1.0E+19	2.0E+19	5.0E+19	1.0E+20	2.0E+20
1.0E+13	1.44282E-08	6.24892E-09	1.78563E-09	8.73281E-11	8.97046E-13	1.29487E-16	6.18488E-28	9.65893E-47	2.37149E-84
2.0E+13	1.44273E-08	6.24861E-09	1.78556E-09	8.73257E-11	8.97025E-13	1.29484E-16	6.18475E-28	9.65873E-47	2.37144E-84
5.0E+13	1.44245E-08	6.24766E-09	1.78536E-09	8.73182E-11	8.96959E-13	1.29476E-16	6.18436E-28	9.65812E-47	2.37129E-84
1.0E+14	1.44198E-08	6.24608E-09	1.78502E-09	8.73058E-11	8.96849E-13	1.29461E-16	6.18371E-28	9.65712E-47	2.37104E-84
2.0E+14	1.44104E-08	6.24293E-09	1.78433E-09	8.72810E-11	8.96630E-13	1.29433E-16	6.18243E-28	9.65511E-47	2.37055E-84
5.0E+14	1.43823E-08	6.23348E-09	1.78228E-09	8.72066E-11	8.95973E-13	1.29348E-16	6.17856E-28	9.64909E-47	2.36907E-84
1.0E+15	1.43356E-08	6.21777E-09	1.77887E-09	8.70829E-11	8.94879E-13	1.29205E-16	6.17212E-28	9.63906E-47	2.36661E-84
2.0E+15	1.42429E-08	6.18650E-09	1.77208E-09	8.68360E-11	8.92695E-13	1.28921E-16	6.15927E-28	9.61903E-47	2.36169E-84
5.0E+15	1.39692E-08	6.09393E-09	1.75189E-09	8.60999E-11	8.86177E-13	1.28073E-16	6.12087E-28	9.55919E-47	2.34700E-84
1.0E+16	1.35281E-08	5.94358E-09	1.71889E-09	8.48891E-11	8.75429E-13	1.26673E-16	6.05741E-28	9.46029E-47	2.32272E-84
2.0E+16	1.26987E-08	5.65705E-09	1.65517E-09	8.25252E-11	8.54351E-13	1.23919E-16	5.93245E-28	9.26555E-47	2.27491E-84
5.0E+16	1.05782E-08	4.89851E-09	1.48097E-09	7.58722E-11	7.94332E-13	1.16022E-16	5.57285E-28	8.70504E-47	2.13729E-84
1.0E+17	7.97646E-09	3.90476E-09	1.23854E-09	6.60946E-11	7.04143E-13	1.03993E-16	5.02135E-28	7.84520E-47	1.92618E-84
2.0E+17	4.87398E-09	2.58936E-09	8.85155E-10	5.05224E-11	5.55023E-13	8.36308E-17	4.07685E-28	6.37192E-47	1.56446E-84
5.0E+17	1.62428E-09	9.52031E-10	3.65897E-10	2.36286E-11	2.77408E-13	4.37894E-17	2.18249E-28	3.41404E-47	8.38231E-85
1.0E+18	4.54105E-10	2.58205E-10	1.04641E-10	7.34631E-12	9.15228E-14	1.51281E-17	7.70764E-29	1.20671E-47	2.96277E-85
2.0E+18	8.08768E-11	2.89490E-11	1.13689E-11	8.34787E-13	1.08426E-14	1.85701E-18	9.62304E-30	1.50754E-48	3.70139E-86
5.0E+18	1.89959E-11	1.01080E-12	2.41356E-14	1.57727E-15	2.07641E-17	3.59944E-21	1.87595E-32	2.93947E-51	7.21718E-89
1.0E+19	8.09561E-12	4.35638E-13	1.41722E-15	4.80283E-20	6.31712E-22	1.09529E-25	5.70897E-37	8.94555E-56	2.19637E-93
2.0E+19	2.38741E-12	1.22251E-13	4.06649E-16	1.63975E-23	5.85059E-31	1.01439E-34	5.28729E-46	8.28480E-65	2.03413-102
5.0E+19	2.84047E-13	5.74015E-15	1.43921E-17	5.76535E-25	2.94718E-37	1.57837E-61	4.20008E-73	6.58122E-92	1.61586-129
1.0E+20	1.07654E-13	6.66417E-16	3.14633E-19	2.36667E-27	1.20319E-39	3.15692E-64	2.86175-118	4.48415-137	1.10098-174
2.0E+20	3.14917E-14	8.63465E-17	3.49187E-20	2.43571E-30	2.01228E-44	5.27258E-69	9.52402-143	2.08175-227	5.11123-265
5.0E+20	1.36298E-15	2.23290E-19	8.63655E-23	5.94019E-33	6.85986E-50	3.37128E-83	4.43713-157	5.51778-280	0.
1.0E+21	9.11393E-18	9.31033E-23	3.92055E-27	2.69684E-37	3.11437E-54	4.15337E-88	5.76641-181	0.	0.
2.0E+21	4.13750E-22	3.79249E-27	8.39948E-36	5.55861E-46	6.41920E-63	8.56074E-97	2.03050-198	0.	0.
5.0E+21	3.87172E-35	3.54885E-40	2.98165E-50	4.86740E-72	5.62098E-89	7.49622-123	1.77801-224	0.	0.
1.0E+22	7.46758E-57	6.84485E-62	5.75085E-72	3.41064-102	2.09105-132	2.78865-166	6.61433-268	0.	0.
2.0E+22	2.77800-100	2.54634-105	2.13936-115	1.26878-145	5.31163-196	3.85921-253	0.	0.	0.
5.0E+22	1.43017-230	1.31090-235	1.10139-245	6.53196-276	0.	0.	0.	0.	0.

Table B17. Total Photodissociation Rate Coefficients for the Process $CO_2 + h\nu \rightarrow CO + O(^1D)$ for Wavelengths From 116.2 to 166 nm (Contd)

O3 COLUMN DENSITY

O2 COLUMN DENSITY	2.0E+14	5.0E+14	1.0E+15	2.0E+15	5.0E+15	1.0E+16	2.0E+16	5.0E+16	1.0E+17	2.0E+17
1.0E+13	8.82221E-08	8.79581E-08	8.75211E-08	8.66585E-08	8.41591E-08	8.02701E-08	7.34105E-08	5.83252E-08	4.37704E-08	2.98301E-08
2.0E+13	8.82167E-08	8.79527E-08	8.75157E-08	8.66532E-08	8.41539E-08	8.02650E-08	7.34056E-08	5.83210E-08	4.37669E-08	2.98278E-08
5.0E+13	8.82006E-08	8.79366E-08	8.74997E-08	8.66372E-08	8.41381E-08	8.02496E-08	7.33910E-08	5.83082E-08	4.37567E-08	2.98208E-08
1.0E+14	8.81738E-08	8.79098E-08	8.74730E-08	8.66107E-08	8.41119E-08	8.02240E-08	7.33666E-08	5.82870E-08	4.37395E-08	2.98091E-08
2.0E+14	8.81202E-08	8.78563E-08	8.74196E-08	8.65575E-08	8.40596E-08	8.01729E-08	7.33179E-08	5.82446E-08	4.37053E-08	2.97857E-08
5.0E+14	8.79597E-08	8.76960E-08	8.72597E-08	8.63984E-08	8.39028E-08	8.00200E-08	7.31721E-08	5.81176E-08	4.36028E-08	2.97157E-08
1.0E+15	8.76933E-08	8.74301E-08	8.69944E-08	8.61344E-08	8.36427E-08	7.97661E-08	7.29302E-08	5.79069E-08	4.34327E-08	2.95996E-08
2.0E+15	8.71649E-08	8.69024E-08	8.64681E-08	8.56107E-08	8.31267E-08	7.92625E-08	7.24502E-08	5.74889E-08	4.30952E-08	2.93691E-08
5.0E+15	8.56136E-08	8.53534E-08	8.49229E-08	8.40732E-08	8.16116E-08	7.77840E-08	7.10409E-08	5.62614E-08	4.21037E-08	2.86911E-08
1.0E+16	8.31372E-08	8.28807E-08	8.24563E-08	8.16187E-08	7.91930E-08	7.54235E-08	6.87908E-08	5.43007E-08	4.05187E-08	2.76052E-08
2.0E+16	7.85653E-08	7.83156E-08	7.79024E-08	7.70871E-08	7.47276E-08	7.10652E-08	6.46355E-08	5.06776E-08	3.75855E-08	2.55877E-08
5.0E+16	6.74127E-08	6.71794E-08	6.67935E-08	6.60325E-08	6.38334E-08	6.04304E-08	5.44922E-08	4.18188E-08	3.03855E-08	2.05860E-08
1.0E+17	5.49301E-08	5.47151E-08	5.43595E-08	5.36587E-08	5.16375E-08	4.85219E-08	4.31265E-08	3.18623E-08	2.22316E-08	1.48077E-08
2.0E+17	4.21191E-08	4.19228E-08	4.15984E-08	4.09596E-08	3.91210E-08	3.62994E-08	3.14552E-08	2.15994E-08	1.37268E-08	8.57459E-09
5.0E+17	3.12219E-08	3.10436E-08	3.07491E-08	3.01694E-08	2.85041E-08	2.59585E-08	2.16222E-08	1.30026E-08	6.54646E-09	3.04871E-09
1.0E+18	2.69793E-08	2.68113E-08	2.65338E-08	2.59879E-08	2.44211E-08	2.20304E-08	1.79729E-08	9.99335E-09	4.18178E-09	1.27610E-09
2.0E+18	2.42727E-08	2.41140E-08	2.38519E-08	2.33365E-08	2.18582E-08	1.96063E-08	1.57966E-08	8.37242E-09	3.09299E-09	6.20073E-10
5.0E+18	2.16428E-08	2.14958E-08	2.12531E-08	2.07760E-08	1.94088E-08	1.73297E-08	1.38239E-08	7.05849E-09	2.37318E-09	3.42583E-10
1.0E+19	1.99580E-08	1.98205E-08	1.95934E-08	1.91471E-08	1.78686E-08	1.59254E-08	1.26528E-08	6.36014E-09	2.04692E-09	2.40989E-10
2.0E+19	1.78972E-08	1.77733E-08	1.75687E-08	1.71666E-08	1.60146E-08	1.42642E-08	1.13171E-08	5.65592E-09	1.78723E-09	1.86582E-10
5.0E+19	1.32281E-08	1.31364E-08	1.29850E-08	1.26873E-08	1.18346E-08	1.05388E-08	8.35753E-09	4.16853E-09	1.30843E-09	1.29718E-10
1.0E+20	8.02109E-09	7.96546E-09	7.87361E-09	7.69307E-09	7.17592E-09	6.39010E-09	5.06723E-09	2.52684E-09	7.92565E-10	7.81748E-11
2.0E+20	2.95034E-09	2.92988E-09	2.89609E-09	2.82968E-09	2.63944E-09	2.35037E-09	1.86375E-09	9.29273E-10	2.91368E-10	2.86697E-11
5.0E+20	1.46878E-10	1.45860E-10	1.44178E-10	1.40871E-10	1.31400E-10	1.17008E-10	9.27814E-11	4.62587E-11	1.45016E-11	1.42521E-12
1.0E+21	9.89656E-13	9.82792E-13	9.71457E-13	9.49179E-13	8.85363E-13	7.88393E-13	6.25154E-13	3.11686E-13	9.77094E-14	9.60225E-15
2.0E+21	4.49303E-17	4.46187E-17	4.41041E-17	4.30927E-17	4.01954E-17	3.57930E-17	2.83819E-17	1.41505E-17	4.43600E-18	4.35941E-19
5.0E+21	4.20441E-30	4.17525E-30	4.12709E-30	4.03245E-30	3.76133E-30	3.34937E-30	2.65587E-30	1.32415E-30	4.15104E-31	4.07937E-32
1.0E+22	8.10925E-52	8.05301E-52	7.96013E-52	7.77758E-52	7.25467E-52	6.46011E-52	5.12252E-52	2.55396E-52	8.00632E-53	7.86809E-54
2.0E+22	3.01670E-95	2.99578E-95	2.96123E-95	2.89332E-95	2.69879E-95	2.40321E-95	1.90561E-95	9.50093E-96	2.97841E-96	2.92699E-97
5.0E+22	1.55306-225	1.54229-225	1.52450-225	1.48954-225	1.38939-225	1.23722-225	9.81049-226	4.89127-226	1.53335-226	1.50687-227

Table B17. Total Photodissociation Rate Coefficients for the Process $CO_2 + h\nu \rightarrow CO + O(^1D)$ for Wavelengths From 116.2 to 166 nm

O2 COLUMN DENSITY	O3 COLUMN DENSITY									
	1.0E+11	2.0E+11	5.0E+11	1.0E+12	2.0E+12	5.0E+12	1.0E+13	2.0E+13	5.0E+13	1.0E+14
1.0E+13	8.83988E-08	8.83987E-08	8.83984E-08	8.83980E-08	8.83971E-08	8.83945E-08	8.83900E-08	8.83812E-08	8.83546E-08	8.83104E-08
2.0E+13	8.83934E-08	8.83933E-08	8.83931E-08	8.83926E-08	8.83917E-08	8.83891E-08	8.83847E-08	8.83758E-08	8.83493E-08	8.83050E-08
5.0E+13	8.83773E-08	8.83772E-08	8.83769E-08	8.83765E-08	8.83756E-08	8.83730E-08	8.83685E-08	8.83597E-08	8.83331E-08	8.82889E-08
1.0E+14	8.83504E-08	8.83504E-08	8.83501E-08	8.83496E-08	8.83488E-08	8.83461E-08	8.83417E-08	8.83328E-08	8.83063E-08	8.82621E-08
2.0E+14	8.82968E-08	8.82967E-08	8.82964E-08	8.82960E-08	8.82951E-08	8.82924E-08	8.82880E-08	8.82792E-08	8.82526E-08	8.82084E-08
5.0E+14	8.81361E-08	8.81360E-08	8.81357E-08	8.81353E-08	8.81344E-08	8.81318E-08	8.81273E-08	8.81185E-08	8.80920E-08	8.80478E-08
1.0E+15	8.78695E-08	8.78694E-08	8.78691E-08	8.78687E-08	8.78678E-08	8.78651E-08	8.78607E-08	8.78519E-08	8.78254E-08	8.77814E-08
2.0E+15	8.73405E-08	8.73405E-08	8.73402E-08	8.73398E-08	8.73389E-08	8.73362E-08	8.73318E-08	8.73230E-08	8.72966E-08	8.72527E-08
5.0E+15	8.57877E-08	8.57876E-08	8.57874E-08	8.57869E-08	8.57861E-08	8.57834E-08	8.57791E-08	8.57703E-08	8.57442E-08	8.57006E-08
1.0E+16	8.33088E-08	8.33087E-08	8.33085E-08	8.33081E-08	8.33072E-08	8.33046E-08	8.33003E-08	8.32917E-08	8.32659E-08	8.32230E-08
2.0E+16	7.87324E-08	7.87323E-08	7.87321E-08	7.87317E-08	7.87308E-08	7.87283E-08	7.87241E-08	7.87157E-08	7.86906E-08	7.86486E-08
5.0E+16	6.75689E-08	6.75688E-08	6.75686E-08	6.75682E-08	6.75674E-08	6.75651E-08	6.75611E-08	6.75533E-08	6.75298E-08	6.74908E-08
1.0E+17	5.50741E-08	5.50741E-08	5.50739E-08	5.50735E-08	5.50728E-08	5.50706E-08	5.50670E-08	5.50598E-08	5.50381E-08	5.50021E-08
2.0E+17	4.22505E-08	4.22505E-08	4.22503E-08	4.22499E-08	4.22493E-08	4.22473E-08	4.22440E-08	4.22374E-08	4.22177E-08	4.21848E-08
5.0E+17	3.13414E-08	3.13413E-08	3.13412E-08	3.13409E-08	3.13403E-08	3.13385E-08	3.13355E-08	3.13295E-08	3.13115E-08	3.12816E-08
1.0E+18	2.70919E-08	2.70919E-08	2.70917E-08	2.70914E-08	2.70908E-08	2.70891E-08	2.70863E-08	2.70807E-08	2.70638E-08	2.70356E-08
2.0E+18	2.43791E-08	2.43790E-08	2.43789E-08	2.43786E-08	2.43781E-08	2.43765E-08	2.43738E-08	2.43685E-08	2.43525E-08	2.43259E-08
5.0E+18	2.17413E-08	2.17412E-08	2.17411E-08	2.17408E-08	2.17403E-08	2.17388E-08	2.17364E-08	2.17314E-08	2.17166E-08	2.16920E-08
1.0E+19	2.00502E-08	2.00501E-08	2.00500E-08	2.00497E-08	2.00493E-08	2.00479E-08	2.00456E-08	2.00410E-08	2.00271E-08	2.00041E-08
2.0E+19	1.79802E-08	1.79802E-08	1.79801E-08	1.79798E-08	1.79794E-08	1.79782E-08	1.79761E-08	1.79719E-08	1.79595E-08	1.79387E-08
5.0E+19	1.32896E-08	1.32896E-08	1.32895E-08	1.32893E-08	1.32890E-08	1.32881E-08	1.32865E-08	1.32835E-08	1.32742E-08	1.32588E-08
1.0E+20	8.05837E-09	8.05835E-09	8.05829E-09	8.05820E-09	8.05801E-09	8.05745E-09	8.05652E-09	8.05465E-09	8.04905E-09	8.03972E-09
2.0E+20	2.96406E-09	2.96405E-09	2.96403E-09	2.96400E-09	2.96393E-09	2.96372E-09	2.96338E-09	2.96269E-09	2.96063E-09	2.95720E-09
5.0E+20	1.47561E-10	1.47561E-10	1.47560E-10	1.47558E-10	1.47555E-10	1.47544E-10	1.47527E-10	1.47493E-10	1.47390E-10	1.47220E-10
1.0E+21	9.94256E-13	9.94254E-13	9.94247E-13	9.94235E-13	9.94212E-13	9.94143E-13	9.94028E-13	9.93797E-13	9.93106E-13	9.91954E-13
2.0E+21	4.51392E-17	4.51391E-17	4.51387E-17	4.51382E-17	4.51372E-17	4.51340E-17	4.51288E-17	4.51183E-17	4.50869E-17	4.50347E-17
5.0E+21	4.22395E-30	4.22394E-30	4.22391E-30	4.22386E-30	4.22377E-30	4.22347E-30	4.22298E-30	4.22200E-30	4.21907E-30	4.21417E-30
1.0E+22	8.14695E-52	8.14693E-52	8.14687E-52	8.14678E-52	8.14659E-52	8.14602E-52	8.14508E-52	8.14319E-52	8.13752E-52	8.12809E-52
2.0E+22	3.03073E-95	3.03072E-95	3.03070E-95	3.03066E-95	3.03059E-95	3.03038E-95	3.03003E-95	3.02933E-95	3.02722E-95	3.02371E-95
5.0E+22	1.56028-225	1.56027-225	1.56026-225	1.56025-225	1.56021-225	1.56010-225	1.55992-225	1.55956-225	1.55847-225	1.55667-225

Table B16. Total Photodissociation Rate Coefficients for the Process $CH_4 + h\nu \rightarrow CH_3 + H$ and $CH_4 + h\nu \rightarrow CH_2 + H_2$ for Wavelengths From 116 to 164 nm (Contd)

O3 COLUMN DENSITY

O2 COLUMN DENSITY	5.0E+16	1.0E+17	2.0E+17	5.0E+17	1.0E+18	2.0E+18	5.0E+18	1.0E+19	2.0E+19	5.0E+19
1.0E+13	2.97405E-06	1.00972E-06	1.47022E-07	6.68945E-09	3.08733E-10	1.04272E-11	2.81811E-13	1.70092E-15	8.96768E-20	1.65681E-32
2.0E+13	2.97404E-06	1.00971E-06	1.47020E-07	6.68929E-09	3.08726E-10	1.04267E-11	2.81800E-13	1.70086E-15	8.96737E-20	1.65676E-32
5.0E+13	2.97402E-06	1.00970E-06	1.47014E-07	6.68880E-09	3.08705E-10	1.04251E-11	2.81767E-13	1.70068E-15	8.96644E-20	1.65659E-32
1.0E+14	2.97397E-06	1.00967E-06	1.47005E-07	6.68799E-09	3.08670E-10	1.04225E-11	2.81711E-13	1.70037E-15	8.96489E-20	1.65630E-32
2.0E+14	2.97388E-06	1.00962E-06	1.46986E-07	6.68636E-09	3.08599E-10	1.04172E-11	2.81598E-13	1.69976E-15	8.96178E-20	1.65573E-32
5.0E+14	2.97362E-06	1.00947E-06	1.46929E-07	6.68149E-09	3.08388E-10	1.04015E-11	2.81262E-13	1.69793E-15	8.95247E-20	1.65402E-32
1.0E+15	2.97318E-06	1.00922E-06	1.46836E-07	6.67341E-09	3.08038E-10	1.03752E-11	2.80703E-13	1.69489E-15	8.93698E-20	1.65116E-32
2.0E+15	2.97231E-06	1.00872E-06	1.46650E-07	6.65742E-09	3.07343E-10	1.03230E-11	2.79588E-13	1.68883E-15	8.90607E-20	1.64548E-32
5.0E+15	2.96975E-06	1.00726E-06	1.46106E-07	6.61059E-09	3.05298E-10	1.01682E-11	2.76272E-13	1.67076E-15	8.81398E-20	1.62854E-32
1.0E+16	2.96565E-06	1.00493E-06	1.45243E-07	6.53631E-09	3.02018E-10	9.91629E-12	2.70837E-13	1.64108E-15	8.66261E-20	1.60068E-32
2.0E+16	2.95803E-06	1.00064E-06	1.43663E-07	6.40065E-09	2.95910E-10	9.43464E-12	2.60304E-13	1.58332E-15	8.35763E-20	1.54640E-32
5.0E+16	2.93901E-06	9.90083E-07	1.39868E-07	6.07711E-09	2.80612E-10	8.14992E-12	2.31223E-13	1.42213E-15	7.54172E-20	1.39435E-32
1.0E+17	2.91601E-06	9.77741E-07	1.35633E-07	5.72204E-09	2.62314E-10	6.44865E-12	1.90115E-13	1.18956E-15	6.34261E-20	1.17343E-32
2.0E+17	2.88619E-06	9.62535E-07	1.30789E-07	5.32920E-09	2.40182E-10	4.18544E-12	1.29258E-13	8.33362E-16	4.48667E-20	8.31044E-33
5.0E+17	2.83373E-06	9.36986E-07	1.23131E-07	4.71518E-09	2.08904E-10	1.51164E-12	4.20697E-14	2.88918E-16	1.58959E-20	2.95208E-33
1.0E+18	2.77549E-06	9.09088E-07	1.14694E-07	3.99244E-09	1.79477E-10	6.26779E-13	6.94862E-15	5.03308E-17	2.82533E-21	5.25979E-34
2.0E+18	2.69502E-06	8.71894E-07	1.03686E-07	2.99423E-09	1.39490E-10	4.00527E-13	2.10012E-16	1.57316E-18	8.95419E-23	1.66975E-35
5.0E+18	2.55052E-06	8.11447E-07	8.81038E-08	1.56412E-09	7.64515E-11	2.35014E-13	1.48820E-20	5.01132E-23	2.86337E-27	5.34200E-40
1.0E+19	2.39877E-06	7.56935E-07	7.80292E-08	7.53982E-10	3.59062E-11	1.15361E-13	4.41494E-21	1.61778E-30	9.23199E-35	1.72236E-47
2.0E+19	2.16097E-06	6.79243E-07	6.80557E-08	2.87603E-10	1.07921E-11	3.40741E-14	1.37660E-21	6.86985E-34	9.59700E-50	1.79046E-62
5.0E+19	1.59844E-06	5.01530E-07	4.95741E-08	8.04976E-11	8.25926E-13	1.34214E-15	4.88948E-23	2.50008E-35	6.55496E-60	2.01134-107
1.0E+20	9.69103E-07	3.03930E-07	2.99520E-08	3.77365E-11	1.74347E-13	7.11941E-17	2.03812E-25	1.02089E-37	2.67860E-62	4.83842-136
2.0E+20	3.56417E-07	1.11747E-07	1.09914E-08	1.15635E-11	2.23765E-14	8.91530E-18	6.13352E-28	1.71209E-42	4.47371E-67	8.08099-141
5.0E+20	1.77430E-08	5.56222E-09	5.46641E-10	5.21449E-13	5.84820E-17	2.19873E-20	1.51205E-30	1.74615E-47	4.41294E-81	3.76484-155
1.0E+21	1.19551E-10	3.74776E-11	3.68306E-12	3.49569E-15	3.44764E-20	9.97961E-25	6.86469E-35	7.92750E-52	1.05722E-85	4.89272-179
2.0E+21	5.42760E-15	1.70148E-15	1.67210E-16	1.58699E-19	1.45465E-24	2.17916E-33	1.41492E-43	1.63398E-60	2.17910E-94	5.16854-196
5.0E+21	5.07895E-28	1.59218E-28	1.56469E-29	1.48504E-32	1.36120E-37	1.14364E-47	1.23897E-69	1.43060E-86	1.90813-120	4.52584-222
1.0E+22	9.79602E-50	3.07092E-50	3.01790E-51	2.86428E-54	2.62542E-59	2.20581E-69	1.30819E-99	5.32267-130	7.09839-164	1.68365-265
2.0E+22	3.64419E-93	1.14240E-93	1.12268E-94	1.06553E-97	9.76677-103	8.20576-113	4.86657-143	2.03734-193	9.82343-251	3.13457-153
5.0E+22	1.87610-223	5.86132-224	5.77979-225	5.48558-228	5.02813-233	4.22449-243	2.50541-273	1.55808E-50	9.97526E-69	2.97413-154

Table B16. Total Photodissociation Rate Coefficients for the Process $CH_4 + h\nu \rightarrow CH_3 + H$ and $CH_4 + h\nu \rightarrow CH_2 + H_2$ for Wavelengths From 116 to 164 nm (Contd)

O3 COLUMN DENSITY

O2 COLUMN DENSITY	2.0E+13	5.0E+13	1.0E+14	2.0E+14	5.0E+14	1.0E+15	2.0E+15	5.0E+15	1.0E+16	2.0E+16
1.0E+13	9.08194E-06	9.07579E-06	9.06555E-06	9.04511E-06	8.98408E-06	8.88328E-06	8.68510E-06	8.11710E-06	7.25294E-06	5.79465E-06
2.0E+13	9.08192E-06	9.07577E-06	9.06554E-06	9.04510E-06	8.98406E-06	8.88326E-06	8.68509E-06	8.11708E-06	7.25293E-06	5.79464E-06
5.0E+13	9.08187E-06	9.07573E-06	9.06549E-06	9.04505E-06	8.98401E-06	8.88321E-06	8.68504E-06	8.11704E-06	7.25289E-06	5.79460E-06
1.0E+14	9.08179E-06	9.07564E-06	9.06541E-06	9.04497E-06	8.98393E-06	8.88313E-06	8.68496E-06	8.11696E-06	7.25281E-06	5.79454E-06
2.0E+14	9.08163E-06	9.07548E-06	9.06524E-06	9.04480E-06	8.98377E-06	8.88297E-06	8.68480E-06	8.11680E-06	7.25267E-06	5.79441E-06
5.0E+14	9.08113E-06	9.07499E-06	9.06475E-06	9.04431E-06	8.98328E-06	8.88248E-06	8.68432E-06	8.11634E-06	7.25224E-06	5.79403E-06
1.0E+15	9.08031E-06	9.07417E-06	9.06393E-06	9.04349E-06	8.98246E-06	8.88167E-06	8.68352E-06	8.11557E-06	7.25152E-06	5.79340E-06
2.0E+15	9.07869E-06	9.07254E-06	9.06231E-06	9.04187E-06	8.98085E-06	8.88007E-06	8.68193E-06	8.11405E-06	7.25009E-06	5.79214E-06
5.0E+15	9.07390E-06	9.06775E-06	9.05752E-06	9.03709E-06	8.97609E-06	8.87534E-06	8.67727E-06	8.10957E-06	7.24589E-06	5.78844E-06
1.0E+16	9.06620E-06	9.06006E-06	9.04983E-06	9.02941E-06	8.96844E-06	8.86774E-06	8.66977E-06	8.10236E-06	7.23914E-06	5.78251E-06
2.0E+16	9.05178E-06	9.04565E-06	9.03543E-06	9.01503E-06	8.95411E-06	8.85351E-06	8.65573E-06	8.08888E-06	7.22652E-06	5.77144E-06
5.0E+16	9.01504E-06	9.00892E-06	8.99873E-06	8.97838E-06	8.91762E-06	8.81727E-06	8.61999E-06	8.05459E-06	7.19451E-06	5.74346E-06
1.0E+17	8.96886E-06	8.96276E-06	8.95260E-06	8.93232E-06	8.87176E-06	8.77175E-06	8.57514E-06	8.01166E-06	7.15458E-06	5.70883E-06
2.0E+17	8.90571E-06	8.89964E-06	8.88953E-06	8.86935E-06	8.80909E-06	8.70957E-06	8.51393E-06	7.95327E-06	7.10056E-06	5.66249E-06
5.0E+17	8.78855E-06	8.78254E-06	8.77253E-06	8.75255E-06	8.69287E-06	8.59433E-06	8.40061E-06	7.84552E-06	7.00142E-06	5.57836E-06
1.0E+18	8.65430E-06	8.64836E-06	8.63847E-06	8.61872E-06	8.55976E-06	8.46238E-06	8.27097E-06	7.72252E-06	6.88866E-06	5.48332E-06
2.0E+18	8.45984E-06	8.45401E-06	8.44430E-06	8.42492E-06	8.36703E-06	8.27144E-06	8.08355E-06	7.54522E-06	6.72692E-06	5.34834E-06
5.0E+18	8.07597E-06	8.07037E-06	8.06105E-06	8.04245E-06	7.98690E-06	7.89516E-06	7.71484E-06	7.19828E-06	6.41325E-06	5.09131E-06
1.0E+19	7.62587E-06	7.62057E-06	7.61175E-06	7.59414E-06	7.54156E-06	7.45473E-06	7.28406E-06	6.79516E-06	6.05224E-06	4.80145E-06
2.0E+19	6.88190E-06	6.87711E-06	6.86914E-06	6.85324E-06	6.80573E-06	6.72730E-06	6.57313E-06	6.13150E-06	5.46043E-06	4.33069E-06
5.0E+19	5.09443E-06	5.09088E-06	5.08498E-06	5.07320E-06	5.03802E-06	4.97993E-06	4.86576E-06	4.53870E-06	4.04172E-06	3.20510E-06
1.0E+20	3.08932E-06	3.08717E-06	3.08359E-06	3.07644E-06	3.05511E-06	3.01988E-06	2.95063E-06	2.75228E-06	2.45087E-06	1.94347E-06
2.0E+20	1.13635E-06	1.13556E-06	1.13424E-06	1.13162E-06	1.12377E-06	1.11081E-06	1.08533E-06	1.01237E-06	9.01491E-07	7.14841E-07
5.0E+20	5.65726E-08	5.65333E-08	5.64677E-08	5.63369E-08	5.59461E-08	5.53009E-08	5.40327E-08	5.03999E-08	4.48799E-08	3.55873E-08
1.0E+21	3.81183E-10	3.80917E-10	3.80476E-10	3.79594E-10	3.76961E-10	3.72614E-10	3.64069E-10	3.39591E-10	3.02397E-10	2.39785E-10
2.0E+21	1.73057E-14	1.72936E-14	1.72736E-14	1.72335E-14	1.71140E-14	1.69166E-14	1.65287E-14	1.54174E-14	1.37288E-14	1.08862E-14
5.0E+21	1.61940E-27	1.61827E-27	1.61640E-27	1.61265E-27	1.60146E-27	1.58300E-27	1.54669E-27	1.44270E-27	1.28469E-27	1.01869E-27
1.0E+22	3.12341E-49	3.12124E-49	3.11762E-49	3.11040E-49	3.08882E-49	3.05320E-49	2.98318E-49	2.78261E-49	2.47785E-49	1.96480E-49
2.0E+22	1.16193E-92	1.16113E-92	1.15978E-92	1.15709E-92	1.14907E-92	1.13581E-92	1.10977E-92	1.03515E-92	9.21779E-93	7.30921E-93
5.0E+22	5.98187-223	5.97771-223	5.97078-223	5.95694-223	5.91562-223	5.84740-223	5.71330-223	5.32918-223	4.74550-223	3.76293-223

Table B16. Total Photodissociation Rate Coefficients for the Process $CH_4 + h\nu \rightarrow CH_3 + H$ and $CH_4 + h\nu \rightarrow CH_2 + H_2$ for Wavelengths From 116 to 164 nm

O2 COLUMN DENSITY	O3 COLUMN DENSITY									
	1.0E+10	2.0E+10	5.0E+10	1.0E+11	2.0E+11	5.0E+11	1.0E+12	2.0E+12	5.0E+12	1.0E+13
1.0E+13	9.08604E-06	9.08604E-06	9.08603E-06	9.08602E-06	9.08600E-06	9.08594E-06	9.08583E-06	9.08563E-06	9.08501E-06	9.08399E-06
2.0E+13	9.08602E-06	9.06602E-06	9.08601E-06	9.08600E-06	9.08598E-06	9.08592E-06	9.08582E-06	9.08561E-06	9.08500E-06	9.08397E-06
5.0E+13	9.08597E-06	9.08597E-06	9.08596E-06	9.08595E-06	9.08593E-06	9.08587E-06	9.08577E-06	9.08556E-06	9.08495E-06	9.08392E-06
1.0E+14	9.08589E-06	9.08589E-06	9.08588E-06	9.08587E-06	9.08585E-06	9.08579E-06	9.08569E-06	9.08548E-06	9.08487E-06	9.08384E-06
2.0E+14	9.08572E-06	9.08572E-06	9.08572E-06	9.08571E-06	9.08569E-06	9.08562E-06	9.08552E-06	9.08532E-06	9.08470E-06	9.08368E-06
5.0E+14	9.08523E-06	9.08523E-06	9.08522E-06	9.08521E-06	9.08519E-06	9.08513E-06	9.08503E-06	9.08482E-06	9.08421E-06	9.08318E-06
1.0E+15	9.08441E-06	9.08441E-06	9.08440E-06	9.08439E-06	9.08437E-06	9.08431E-06	9.08421E-06	9.08400E-06	9.08339E-06	9.08236E-06
2.0E+15	9.08279E-06	9.08278E-06	9.08278E-06	9.08277E-06	9.08275E-06	9.08269E-06	9.08258E-06	9.08238E-06	9.08176E-06	9.08074E-06
5.0E+15	9.07799E-06	9.07799E-06	9.07799E-06	9.07798E-06	9.07796E-06	9.07789E-06	9.07779E-06	9.07759E-06	9.07697E-06	9.07595E-06
1.0E+16	9.07029E-06	9.07029E-06	9.07028E-06	9.07027E-06	9.07025E-06	9.07019E-06	9.07009E-06	9.06988E-06	9 6927E-06	9.06825E-06
2.0E+16	9.05587E-06	9.05587E-06	9.05587E-06	9.05586E-06	9.05584E-06	9.05577E-06	9.05567E-06	9.05547E-06	9 05485E-06	9.05383E-06
5.0E+16	9.01912E-06	9.01912E-06	9.01912E-06	9.01911E-06	9.01909E-06	9.01902E-06	9.01892E-06	9.01872E-06	9.01811E-06	9.01708E-06
1.0E+17	8.97293E-06	8.97292E-06	8.97292E-06	8.97291E-06	8.97289E-06	8.97283E-06	8.97273E-06	8.97252E-06	8.97191E-06	8.97089E-06
2.0E+17	8.90976E-06	8.90975E-06	8.90975E-06	8.90974E-06	8.90972E-06	8.90966E-06	8.90956E-06	8.90935E-06	8.90875E-06	8.90773E-06
5.0E+17	8.79256E-06	8.79255E-06	8.79255E-06	8.79254E-06	8.79252E-06	8.79246E-06	8.79236E-06	8.79216E-06	8.79156E-06	8.79055E-06
1.0E+18	8.65826E-06	8.65826E-06	8.65825E-06	8.65824E-06	8.65822E-06	8.65816E-06	8.65806E-06	8.65787E-06	8.65727E-06	8.65628E-06
2.0E+18	8.46373E-06	8.46373E-06	8.46372E-06	8.46371E-06	8.46369E-06	8.46363E-06	8.46353E-06	8.46334E-06	8.46276E-06	8.46178E-06
5.0E+18	8.07970E-06	8.07970E-06	8.07969E-06	8.07968E-06	8.07966E-06	8.07961E-06	8.07952E-06	8.07933E-06	8.07877E-06	8.07784E-06
1.0E+19	7.62940E-06	7.62940E-06	7.62939E-06	7.62938E-06	7.62937E-06	7.62931E-06	7.62922E-06	7.62905E-06	7.62852E-06	7.62763E-06
2.0E+19	6.88509E-06	6.88508E-06	6.88508E-06	6.88507E-06	6.88505E-06	6.88501E-06	6.88493E-06	6.88477E-06	6.88429E-06	6.88349E-06
5.0E+19	5.09679E-06	5.09679E-06	5.09678E-06	5.09678E-06	5.09677E-06	5.09673E-06	5.09667E-06	5.09655E-06	5.09620E-06	5.09561E-06
1.0E+20	3.09075E-06	3.09075E-06	3.09075E-06	3.09074E-06	3.09074E-06	3.09072E-06	3.09068E-06	3.09061E-06	3.09039E-06	3.09003E-06
2.0E+20	1.13688E-06	1.13688E-06	1.13688E-06	1.13688E-06	1.13687E-06	1.13686E-06	1.13685E-06	1.13683E-06	1.13675E-06	1.13661E-06
5.0E+20	5.65989E-08	5.65989E-08	5.65988E-08	5.65988E-08	5.65986E-08	5.65982E-08	5.65976E-08	5.65963E-08	5.65923E-08	5.65858E-08
1.0E+21	3.81359E-10	3.81359E-10	3.81359E-10	3.81359E-10	3.81358E-10	3.81355E-10	3.81351E-10	3.81342E-10	3.81315E-10	3.81271E-10
2.0E+21	1.73137E-14	1.73137E-14	1.73137E-14	1.73137E-14	1.73136E-14	1.73135E-14	1.73133E-14	1.73129E-14	1.73117E-14	1.73097E-14
5.0E+21	1.62015E-27	1.62015E-27	1.62015E-27	1.62015E-27	1.62014E-27	1.62013E-27	1.62011E-27	1.62007E-27	1.61996E-27	1.61977E-27
1.0E+22	3.12486E-49	3.12486E-49	3.12486E-49	3.12486E-49	3.12485E-49	3.12483E-49	3.12479E-49	3.12472E-49	3.12450E-49	3.12414E-49
2.0E+22	1.16247E-92	1.16247E-92	1.16247E-92	1.16247E-92	1.16247E-92	1.16246E-92	1.16245E-92	1.16242E-92	1.16234E-92	1.16220E-92
5.0E+22	5.98464-223	5.98464-223	5.98464-223	5.98463-223	5.98462-223	5.98457-223	5.98451-223	5.98437-223	5.98395-223	5.98326-223

Table B15. Total Photodissociation Rate Coefficients for the Process $HNO_3 + h\nu \rightarrow OH + NO_2$ for Wavelengths From 192 to 325 nm (Contd)

O2 COLUMN DENSITY	O3 COLUMN DENSITY 5.0E+18	1.0E+19	2.0E+19
1.0E+17	1.13617E-05	2.63273E-06	5.63548E-07
2.0E+17	1.13616E-05	2.63273E-06	5.63547E-07
5.0E+17	1.13616E-05	2.63272E-06	5.63547E-07
1.0E+18	1.13615E-05	2.63270E-06	5.63546E-07
2.0E+18	1.13613E-05	2.63266E-06	5.63545E-07
5.0E+18	1.13606E-05	2.63255E-06	5.63541E-07
1.0E+19	1.13596E-05	2.63236E-06	5.63535E-07
2.0E+19	1.13575E-05	2.63199E-06	5.63523E-07
5.0E+19	1.13512E-05	2.63089E-06	5.63486E-07
1.0E+20	1.13409E-05	2.62909E-06	5.63426E-07
2.0E+20	1.13210E-05	2.62559E-06	5.63309E-07
5.0E+20	1.13110E-05	2.62442E-06	5.63288E-07
1.0E+21	1.12486E-05	2.61386E-06	5.62947E-07
2.0E+21	1.11479E-05	2.59721E-06	5.62421E-07
5.0E+21	1.09320E-05	2.56332E-06	5.61404E-07
1.0E+22	1.04726E-05	2.48729E-06	5.58976E-07

Table B20. Total Photodissociation Rate Coefficients for the Process $HO_2 + h\nu \rightarrow O_2 + H$ for Wavelengths From 180 to 274 nm (Contd)

O2 COLUMN DENSITY	O3 COLUMN DENSITY 5.0E+18	1.0E+19	2.0E+19	5.0E+19	1.0E+20	2.0E+20	5.0E+20	1.0E+21
1.0E+17	2.07907E-05	2.61694E-06	6.76290E-08	2.73147E-12	1.93021E-19	1.13611E-33	2.83493E-76	3.46592-147
2.0E+17	2.07901E-05	2.61691E-06	6.76288E-08	2.73146E-12	1.93020E-19	1.13610E-33	2.83492E-76	3.46592-147
5.0E+17	2.07884E-05	2.61683E-06	6.76281E-08	2.73145E-12	1.93019E-19	1.13610E-33	2.83491E-76	3.46590-147
1.0E+18	2.07857E-05	2.61671E-06	6.76269E-08	2.73142E-12	1.93017E-19	1.13609E-33	2.83489E-76	3.46587-147
2.0E+18	2.07810E-05	2.61648E-06	6.76246E-08	2.73136E-12	1.93014E-19	1.13607E-33	2.83484E-76	3.46582-147
5.0E+18	2.07695E-05	2.61584E-06	6.76178E-08	2.73119E-12	1.93003E-19	1.13601E-33	2.83471E-76	3.46565-147
1.0E+19	2.07543E-05	2.61491E-06	6.76067E-08	2.73091E-12	1.92986E-19	1.13592E-33	2.83448E-76	3.46537-147
2.0E+19	2.07301E-05	2.61326E-06	6.75849E-08	2.73035E-12	1.92951E-19	1.13573E-33	2.83403E-76	3.46482-147
5.0E+19	2.06766E-05	2.60908E-06	6.75224E-08	2.72868E-12	1.92847E-19	1.13517E-33	2.83268E-76	3.46316-147
1.0E+20	2.06103E-05	2.60322E-06	6.74242E-08	2.72592E-12	1.92674E-19	1.13425E-33	2.83043E-76	3.46040-147
2.0E+20	2.05089E-05	2.59329E-06	6.72410E-08	2.72054E-12	1.92334E-19	1.13240E-33	2.82596E-76	3.45491-147
5.0E+20	2.04746E-05	2.59002E-06	6.71908E-08	2.71987E-12	1.92320E-19	1.13240E-33	2.82596E-76	3.45491-147
1.0E+21	2.02330E-05	2.56402E-06	6.66700E-08	2.70405E-12	1.91321E-19	1.12696E-33	2.81276E-76	3.43872-147
2.0E+21	1.99118E-05	2.52725E-06	6.58848E-08	2.67907E-12	1.89725E-19	1.11818E-33	2.79132E-76	3.41247-147
5.0E+21	1.92876E-05	2.45557E-06	6.43467E-08	2.63067E-12	1.86663E-19	1.10128E-33	2.74998E-76	3.36199-147
1.0E+22	1.81656E-05	2.31546E-06	6.09623E-08	2.50741E-12	1.78360E-19	1.05394E-33	2.63347E-76	3.21992-147
2.0E+22	1.64708E-05	2.10592E-06	5.58782E-08	2.32054E-12	1.65729E-19	9.81483E-34	2.45436E-76	3.00131-147
5.0E+22	1.29553E-05	1.69200E-06	4.63024E-08	1.98438E-12	1.43372E-19	8.53578E-34	2.13714E-76	2.61328-147
1.0E+23	8.11202E-06	1.06391E-06	2.96259E-08	1.29948E-12	9.48660E-20	5.67955E-34	1.42349E-76	1.73821-147
2.0E+23	3.52091E-06	4.80146E-07	1.41310E-08	6.52939E-13	4.85590E-20	2.93040E-34	7.34125E-77	8.92785-148
5.0E+23	5.60412E-07	9.47195E-08	3.31736E-09	1.71564E-13	1.31614E-20	8.03035E-35	2.00348E-77	2.41106-148
1.0E+24	1.09755E-08	1.96109E-09	7.17647E-11	3.82061E-15	2.95631E-22	1.80327E-36	4.40430E-79	5.10966-150
2.0E+24	8.94604E-10	1.68185E-10	6.17187E-12	3.23815E-16	2.47282E-23	1.48928E-37	3.56769E-80	4.02630-151
5.0E+24	8.94366E-10	1.68179E-10	6.17183E-12	3.23815E-16	2.47282E-23	1.48928E-37	3.56769E-80	4.02630-151
1.0E+25	8.94366E-10	1.68179E-10	6.17183E-12	3.23815E-16	2.47282E-23	1.48928E-37	3.56769E-80	4.02630-151
2.0E+25	8.94366E-10	1.68179E-10	6.17183E-12	3.23815E-16	2.47282E-23	1.48928E-37	3.56769E-80	4.02630-151

Table B21. EUV Solar Fluxes and Cross Sections

WAVELENGTH A	PHOTON FLUX X10^{9} PH/CM /SEC	O2 X10^{-18}	N2 X10^{-18}	O X10^{-18}	O2 X10^{-18}	N2 X10^{-18}	O X10^{-18}	H X10^{-18}	HE X10^{-18}
1215.7	251.4000	.0100	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1025.7	2.6670	1.5800	.0005	0.0000	.9800	0.0000	0.0000	0.0000	0.0000
991.0	.5994	1.6000	1.5000	0.0000	1.1000	0.0000	0.0000	0.0000	0.0000
977.0	4.4070	4.0000	.7000	0.0000	2.5000	0.0000	0.0000	0.0000	0.0000
972.5	.6066	32.0000	360.0000	0.0000	25.0000	0.0000	0.0000	0.0000	0.0000
949.7	.3044	6.3000	5.2000	0.0000	4.0000	0.0000	0.0000	0.0000	0.0000
944.5	.1340	3.2000	1.0000	0.0000	2.6000	0.0000	0.0000	0.0000	0.0000
937.8	.1635	5.0000	10.0000	0.0000	3.0000	0.0000	0.0000	0.0000	0.0000
933.4	.1433	18.0000	.2000	0.0000	8.0000	0.0000	0.0000	0.0000	0.0000
930.7	.2631	26.0000	4.8000	0.0000	17.0000	0.0000	0.0000	0.0000	0.0000
926.2	.1129	6.7000	2.0000	0.0000	6.7000	0.0000	0.0000	0.0000	0.0000
	.0284	7.4000	100.0000	0.0000	3.3000	0.0000	0.0000	0.0000	0.0000
	.1134	7.4000	50.0000	0.0000	3.3000	0.0000	0.0000	0.0000	0.0000
911-1027	.3970	7.4000	10.0000	0.0000	3.3000	0.0000	0.0000	0.0000	0.0000
	.5388	7.4000	2.0000	0.0000	3.3000	0.0000	0.0000	0.0000	0.0000
	.3403	7.4000	.2000	0.0000	3.3000	0.0000	0.0000	0.0000	0.0000
890-911	1.1064	9.3000	10.0000	3.0000	4.5000	0.0000	3.0000	6.1000	0.0000
	2.5816	9.3000	2.0000	3.0000	4.5000	0.0000	3.0000	6.1000	0.0000
904	.3625	11.0000	6.3000	3.0000	6.3000	0.0000	3.0000	6.1200	0.0000
860-890	1.1852	7.0000	10.0000	2.9000	4.0000	0.0000	2.9000	5.8000	0.0000
	1.7778	7.0000	2.0000	2.9000	4.0000	0.0000	2.9000	5.8000	0.0000
830- 60	.5436	9.0000	10.0000	2.8000	4.0000	0.0000	2.8000	5.2000	0.0000
	.8154	9.0000	2.0000	2.8000	4.0000	0.0000	2.8000	5.2000	0.0000
835.3	.0950	10.0000	20.0000	2.6000	3.7000	0.0000	2.6000	5.0000	0.0000
835.1	.0950	10.0000	41.0000	2.6000	3.7000	0.0000	2.6000	5.0000	0.0000
834.5	.0950	1..0000	7.5000	2.6000	4.0000	0.0000	2.6000	5.0000	0.0000
833.7	.0950	13.0000	6.0000	2.6000	5.1000	0.0000	2.6000	5.0000	0.0000
833.3	.0950	15.0000	2.3000	2.6000	6.0000	0.0000	2.6000	5.0000	0.0000
832.9	.0950	26.0000	7.0000	2.6000	10.0000	0.0000	2.6000	5.0000	0.0000
832.8	.0950	26.0000	2.1000	2.6000	10.0000	0.0000	2.6000	5.0000	0.0000
	.0654	19.0000	50.0000	2.9000	7.0000	0.0000	2.9000	4.8000	0.0000
800-830	.1962	19.0000	10.0000	2.9000	7.0000	0.0000	2.9000	4.8000	0.0000
	.3924	19.0000	2.0000	2.9000	7.0000	0.0000	2.9000	4.8000	0.0000
	.0027	26.0000	100.0000	3.0000	10.0000	65.0000	3.0000	4.3000	0.0000
770-800	.0539	26.0000	50.0000	3.0000	10.0000	33.0000	3.0000	4.3000	0.0000
	.2129	26.0000	25.0000	3.0000	10.0000	16.0000	3.0000	4.3000	0.0000
790.1	.3814	28.0000	25.0000	2.9000	10.0000	11.0000	2.9000	4.4000	0.0000
787.7	.2107	24.0000	10.0000	2.9000	13.0000	8.0000	2.9000	4.3000	0.0000
786.5	.1103	23.0000	44.0000	2.9000	7.0000	33.0000	2.9000	4.3000	0.0000
780.3	.2289	28.0000	30.0000	2.0000	11.0000	17.0000	2.9000	4.3000	0.0000
770.4	.2869	18.0000	12.0000	7.0000	11.0000	7.8000	7.0000	4.1000	0.0000
740-770	.0128	19.0000	50.0000	3.3000	11.0000	35.0000	3.3000	3.9000	0.0000
	.1698	19.0000	24.0000	3.3000	11.0000	17.0000	3.3000	3.9000	0.0000
765.1	.1659	23.0000	67.0000	3.0000	12.0000	51.0000	3.0000	4.0000	0.0000
760.4	.0934	20.0000	40.0000	2.9000	10.0000	22.0000	2.9000	3.9000	0.0000
710-740	.0895	30.0000	23.0000	5.5000	22.0000	21.0000	5.5000	3.5000	0.0000

Table B21. EUV Solar Fluxes and Cross Sections (Contd)

WAVELENGTH A	PHOTON FLUX $\times 10^9$ PH/CM /SEC	O2 $\times 10^{-18}$	N2 $\times 10^{-18}$	O $\times 10^{-18}$	O2 $\times 10^{-18}$	N2 $\times 10^{-18}$	O $\times 10^{-18}$	H $\times 10^{-18}$	HE $\times 10^{-18}$
680-710	.1290	24.0000	23.0000	6.5000	20.0000	21.0000	6.5000	3.1000	0.0000
703	.0673	26.0000	23.0000	6.5000	23.0000	21.0000	6.5000	3.1000	0.0000
630-680	.0004	22.0000	50.0000	6.0000	19.0000	50.0000	6.0000	3.4000	0.0000
	.0627	22.0000	24.0000	6.0000	19.0000	24.0000	6.0000	3.4000	0.0000
629.7	1.5203	30.0000	23.0000	9.0000	29.0000	23.0000	9.0000	2.4000	0.0000
625.3	.2103	25.0000	24.0000	9.0000	24.0000	23.0000	9.0000	2.4000	0.0000
609.8	.5302	27.0000	24.0000	9.0000	25.0000	24.0000	9.0000	2.1000	0.0000
599.6	.1600	28.0000	23.0000	9.0000	27.0000	22.0000	9.0000	2.0000	0.0000
584.3	1.2700	23.0000	23.0000	9.5000	23.0000	23.0000	9.5000	1.9000	0.0000
554	.7200	26.0000	25.0000	9.5000	25.0000	24.0000	9.5000	1.6000	0.0000
521.0	.0600	21.0000	24.0000	9.3000	21.0000	23.0000	9.3000	1.3000	0.0000
507	.1600	23.0000	23.0000	9.3000	22.0000	23.0000	9.3000	1.2000	0.0000
425-504	.4429	22.0000	23.0000	9.5000	22.0000	23.0000	9.5000	1.0000	7.0000
499.3	.1139	22.0000	23.0000	9.5000	22.0000	23.0000	9.5000	1.2000	8.2000
465.2	.2724	21.0000	23.0000	10.0000	21.0000	23.0000	10.0000	1.0000	6.6000
417	.0782	20.0000	21.0000	10.5000	20.0000	21.0000	10.5000	.7400	5.6000
370-460	.1715	20.0000	20.0000	10.0000	20.0000	20.0000	10.0000	.7600	5.6000
368.1	.6500	18.0000	17.0000	9.5000	18.0000	17.0000	9.5000	.5400	4.6000
365	.1500	18.0000	16.0000	9.5000	18.0000	16.0000	9.5000	.5400	4.6000
360.7	.3200	17.0000	16.0000	9.5000	17.0000	16.0000	9.5000	.5000	4.6000
335.4	.1600	17.0000	14.0000	9.0000	17.0000	14.0000	9.0000	.4000	4.1000
303.8	7.7000	17.0000	12.0000	8.5000	17.0000	12.0000	8.5000	.3000	3.5000
284.1	.2100	15.0000	11.0000	8.5000	15.0000	11.0000	8.5000	.2500	2.7000
270-370	1.1770	16.0000	13.0000	8.5000	18.0000	13.0000	8.5000	.3700	3.6000
230-270	2.3960	13.0000	10.0000	7.5000	22.0000	13.0000	15.0000	.1900	2.1000
205-230	.6035	10.0000	7.0000	6.5000	20.0000	14.0000	13.0000	.1100	1.5000
176-205	2.0881	6.4000	5.6000	4.0000	12.8000	11.0000	8.0000	.0740	1.0000
153-176	1.2133	5.2000	4.4000	3.0000	10.4000	9.0000	6.0000	.0470	.7300
100-153	.2017	3.0000	2.7000	1.7000	7.5000	5.4000	5.1000	.0250	.3800
90-100	.0942	2.0000	1.2000	1.0000	6.0000	3.6000	3.0000	.0085	.1800
80-90	.1070	1.5000	.8900	.7500	4.5000	2.7000	2.3000	.0063	.1500
76.0	.0167	1.1000	.6700	.5500	4.4000	2.7000	2.3000	.0042	.1000
70-80	.0648	1.1000	.6500	.5500	4.4000	2.6000	2.3000	.0045	.1100
60-70	.0742	.8000	.4500	.3900	4.0000	1.8000	2.0000	.0025	.0900
50-60	.0643	.5100	.3000	.2500	3.1000	1.8000	1.5000	.0012	.0200
40-50	.0284	.3100	.1800	.1600	2.2000	1.4000	1.1000	0.0000	.0190
10-40	.0040	.1500	.0900	.0800	1.5000	.9000	.8000	0.0000	.0050
9	0.0000	.1000	.0650	.0500	3.9000	2.5000	2.0000	0.0000	0.0000
7	0.0000	.0520	.0300	.0260	2.6000	1.5000	1.3000	0.0000	0.0000
5	0.0000	.0200	.0120	.0100	1.4000	.8400	.7100	0.0000	0.0000
3	0.0000	.0046	.0028	.0023	.5400	.3300	.2700	0.0000	0.0000
1	0.0000	.0002	.0001	.0001	.0600	.0350	.2300	0.0000	0.0000

Table B22. Electron Impact Ionization Cross Sections

PROCESS	I	$c_o f_o$	Ω	ν	γ	P
$e + N_2 \rightarrow N + N^+ + 2e$	25.0	0.380	0.96	2.0	1.0	1.2
$e + O_2 \rightarrow O + O^+(^4S) + 2e$	18.0	0.400	0.93	3.0	1.0	1.1
$e + O_2 \rightarrow O + O^+(^2D) + 2e$	22.0	0.250	0.93	3.0	1.0	1.1
$e + O \rightarrow O^+(^4S) + 2e$	14.0	0.290	0.85	1.0	0.3	1.2
$e + O \rightarrow O^+(^2D) + 2e$	17.0	0.360	0.85	1.0	0.3	1.2
$e + N_2 \rightarrow N_2^+ + 2e$	15.0	0.370	0.80	3.0	1.0	1.2
$e + O_2 \rightarrow O_2^+ + 2e$	12.0	0.058	0.80	2.0	1.0	1.1

Table B23. Rate Coefficients for Energetic Electron Impact Reactions

1. $N_2 + e \rightarrow N + N^+ + 2e$

z(km)	Solar Zenith Angle 49.78°	61.50°	76.22°	97.16°
95	0	0	0	0
100	3.54E-12	7.83E-13	3.37E-15	0
130	7.46E-10	5.79E-10	3.07E-10	0
170	2.60E-09	2.25E-09	1.45E-09	0
210	3.92E-09	3.69E-09	3.03E-09	0
250	4.73E-09	4.61E-09	4.22E-09	0
300	5.27E-09	5.21E-09	5.04E-09	0
400	2.63E-09	2.60E-09	2.52E-09	0

2. $O_2 + e \rightarrow O + O^+(^4S) + 2e$

z(km)	Solar Zenith Angle 49.78°	61.50°	76.22°	97.16°
95	0	0	0	0
100	4.38E-12	9.68E-13	4.16E-15	0
130	1.00E-09	7.49E-10	3.87E-10	0
170	4.60E-09	3.84E-09	2.20E-09	0
210	7.31E-09	6.81E-09	5.35E-09	0
250	8.86E-09	8.59E-09	7.73E-09	0
300	9.76E-09	9.61E-09	9.25E-09	0
400	4.38E-09	4.81E-09	4.62E-09	0

Table B23. Rate Coefficients for Energetic Electron Impact Reactions (Contd)

3. $0_2 + e \rightarrow 0 + 0^+(^2D) + 2e$

z(km)	Solar Zenith Angle			
	49.78°	61.50°	76.22°	97.16°
95	0	0	0	0
100	2.06E-12	4.56E-13	1.97E-15	0
130	4.11E-10	3.22E-10	1.74E-10	0
170	1.35E-09	1.17E-09	7.74E-10	0
210	2.01E-09	1.90E-09	1.57E-09	0
250	2.42E-09	2.36E-09	2.17E-09	0
300	2.70E-09	2.67E-09	2.59E-09	0
400	1.35E-09	1.33E-09	1.29E-09	0

4. $0 - e \rightarrow 0^+(^4S) + 2e$

z(km)	Solar Zenith Angle			
	49.78°	61.50°	76.22°	97.16°
95	0	0	0	0
100	5.90E-12	1.29E-12	5.53E-15	0
130	2.08E-09	1.29E-09	5.73E-10	0
170	2.37E-09	1.79E-08	7.26E-09	0
210	4.26E-08	3.85E-08	2.70E-08	0
250	5.09E-08	4.88E-08	4.22E-08	0
300	5.22E-08	5.08E-08	4.82E-08	0
400	2.61E-08	2.54E-08	2.41E-08	0

5. $0 + e \rightarrow 0^+(^2D) + 2e$

z(km)	Solar Zenith Angle			
	49.78°	61.50°	76.22°	97.16°
95	0	0	0	0
100	4.23E-12	9.30E-13	3.98E-15	0
130	1.28E-09	8.51E-10	3.40E-10	0
170	1.07E-08	8.35E-09	3.80E-09	0
210	1.84E-08	1.68E-08	1.22E-08	0
250	2.22E-08	2.13E-08	1.86E-08	0
300	2.36E-08	2.31E-08	2.20E-08	0
400	1.18E-08	1.15E-08	1.10E-08	0

Table B23. Rate Coefficients for Energetic Electron Impact Reactions (Contd)

6. $N_2 + e \rightarrow N_2^+ + 2e$

z(km)	Solar Zenith Angle			
	49.78°	61.50°	76.22°	97.16°
95	0	0	0	0
100	6.12E-12	1.34E-12	5.80E-15	0
130	1.55E-09	1.11E-09	5.52E-10	0
170	9.31E-09	7.51E-09	3.86E-09	0
210	1.54E-08	1.42E-08	1.07E-08	0
250	1.87E-08	1.80E-08	1.60E-08	0
300	2.02E-08	1.98E-08	1.90E-08	0
400	1.01E-08	9.91E-09	9.49E-09	0

7. $O_2 + e \rightarrow O_2^+ + 2e$

z(km)	Solar Zenith Angle			
	49.78°	61.50°	76.22°	97.16°
95	0	0	0	0
100	1.81E-12	3.97E-13	1.70E-15	0
130	6.32E-10	3.94E-10	1.76E-10	0
170	7.14E-09	5.40E-09	2.19E-09	0
210	1.29E-08	1.17E-08	8.18E-09	0
250	1.55E-08	1.48E-08	1.28E-08	0
300	1.60E-08	1.53E-08	1.45E-08	0
400	7.90E-09	7.67E-09	7.27E-09	0

8. $N_2 + e \rightarrow N + N(^2D) + e$

z(km)	Solar Zenith Angle			
	49.78°	61.50°	76.22°	97.16°
95	0	0	0	0
100	1.64E-11	3.59E-12	1.54E-14	0
130	6.27E-09	3.71E-09	1.60E-09	0
170	9.42E-08	6.93E-08	2.53E-08	0
210	1.82E-07	1.63E-07	1.11E-07	0
250	2.22E-07	2.12E-07	1.81E-07	0
300	2.11E-07	2.03E-07	1.91E-07	0
400	1.05E-07	1.01E-07	9.55E-08	0

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Appendix C

The Computer Code

The computer code used to develop the simulated atmosphere described in this report is presented in detail in this Appendix.

To conserve computer memory, the code was written in OVERLAYs. Once all the initialization is completed at the beginning of a run, there is no need to retain in memory all the code that accomplished this.

The code is written in FORTRAN IV for a CDC 6600 mainframe computer. It also utilizes a large block of extended core storage for saving the concentration arrays, the average velocity arrays, and the reaction rate coefficient arrays at the beginning of each time step. If extended core is not available, these sections of the code have to be rewritten to use whatever disk or, as a last resort, tape storage is available. Using disk or tape storage significantly increases the residence time of the code on the computer.

C.1. THE MAIN OVERLAY (0,0)

The main overlay is relatively short. It defines all the blank COMMON variables shared by all the overlays. It also defines the parameters that describe the simulation to be generated as well as the error criteria. It calls OVERLAYs (1,0) and (2,0).

C1.1 Blank COMMON

There are 692 height steps between the lower and the upper boundaries in this model. The 424 height steps between the lower boundary and 120 km represent the region over which the negative ions and the cluster ions are calculated.

N is one of the dependent variable arrays. It contains the altitude distribution of the concentrations of the 26 species in the transport mode plus the arrays for $O(^1D)$, N_2^+, $O^+(^2D)$, and the electrons.

CONC is also a dependent variable array. It contains the height distributions for those species considered over the smaller altitude region.

U is another dependent variable array. Here are stored the values at each altitude of the average velocities of those species in the transport mode.

NZERO and UZERO are working arrays that contain the values of N and U for the particular species whose set of equations is being solved at any given time.

FORM and REMV contain the altitude arrays of the rate of chemical formation [P in Eq. (1)] and chemical removal [L in Eq. (1)] for the species whose equations are being solved.

E and F contain the altitude arrays of E and F in Eq. (28) for the species under consideration.

Z is the altitude array in kilometers.

DEDY is the array containing the fixed vertical turbulent diffusion coefficients.

TEMP is the array containing the fixed temperature profile.

DTEMDZ is the array of the values

$$\frac{1}{T(z)} \frac{dT(z)}{dz} \tag{C1}$$

DELTAZ is the array of height increments in centimeters.

SUNSET is the array containing the sunset solar zenith angle at each altitude.

GRAV is the sea level acceleration of gravity.

COSD = cos (declination)*cos (latitude).

SIND = sin (declination)*sin (latitude). Both COSD and SIND are used in computing the solar zenith angle.

TIME is the independent variable. Time is measured in seconds, with time = 0 as noontime of solution day 1.

CXI is the solar zenith angle in radians and is a function of the local time.

RADIUS is the radius of the earth in kilometers.

ISPECI is the total number of species included in the code.

KSPECI is the number of species in the transport mode.

NREAC is the number of temperature independent chemical reactions.

NREAC2 is the number of temperature dependent chemical reactions.

K is the number of height steps over which the equations are to be integrated.

KMIN1 = K - 1.

ITURB is the index of the height of the turbopause in the Z array.

CXINOON is the noontime solar zenith angle.

SCXI is the local solar zenith angle in degrees.

C1.2 Labeled COMMON

C1.2.1. COMMON/ESM/

OLDN, OLDCON, and OLDU are the extended core arrays corresponding to N, CONC, and U respectively.

RATES is the extended core array containing the values of the height dependent reaction rate constants for the 88 temperature dependent reactions. These four variables are also defined in the LEVEL statement in all programs where they apply.

C1.2.2 COMMON/TIMES/

DAYS is the variable that contains the number of solution days over which the equations will be solved.

DELT always contains the current value of the time step in seconds.

TMAX is the maximum value in seconds that the time step will be allowed to have. This value is 1800 seconds in code presented here.

TSET is the time in seconds after noontime of sunset at the lower boundary.

TRISE is the time in seconds after noontime of sunrise at the upper boundary.

C1.2.3 COMMON/ALTITUD/

ZBOT is the altitude of the lower boundary in kilometers.

ZTOP is the altitude of the upper boundary in kilometers.

TURB is the altitude of the turbopause in kilometers.

ZTRANS is the altitude of the day-night transition height. During the day, it is set at [illegible] km, and, during the night, it is set at 400 km.

C1.2.4 COMMON/RESTART/

IFRAME is the number given to a particular solution file on the interrupt file Tape 4. These files are numbered sequentially from 1.

TOFF is the number of seconds that must be allowed the program to dump onto the interrupt file all the information needed to restart the code at the point when it was interrupted. The final solution of these sets of equations takes many hours of CDC [illegible] computer time. Because of this, the code is normally run for a few hours (usually 4), then stopped, and a dump is taken. Later, the code is restarted at this point, continued for another period of time, and another dump is taken.

This routine is repeated until the calculations reach a point where they repeat the solution over each diurnal cycle (usually about 20 days of problem time).

TYME is the time in seconds of the current computer run. The computer stops executing the code and dumps when

TYME - (time running) < TOFF.

TODAY is the date when the run was made and is printed out as XX/XX/XX.

C1.2.5 COMMON/OUTPUTS/

TIMOUT is a variable that gives the code the frequency in hours with which to send the solutions to the OUTPUT and the interrupt files. The solutions after every time step are not saved. Only those solutions occurring at TIMOUT hours and at interrupts are sent to OUTPUT and are preserved on Tape 4.

OPRINT is the variable containing the frequency in hours at which solutions are to be written on Tape 4. Except on interrupts, TIMOUT is incremented by OPRINT every time a solution set is written to Tape 4.

PRINT is a logical parameter under program control that determines whether writing to Tape 4 will take place after a solution is accepted (PRINT =.TRUE.) or will not (PRINT=.FALSE.).

C1.2.6 COMMON/ERRORS/

ERRMAX is the criterion for acceptance of a solution. When the relative change of all species at all altitudes over successive iterations is less than ERRMAX, the iteration is stopped and the solution for that time step accepted.

ERSPECI is the criterion for stopping the iteration of individual species. Since the solutions converge faster for some species than for others, a good deal of computer time can be saved by no longer iterating the equations for those species whose relative change is less than ERSPECI. Of course, ERSPECI must be much smaller than ERRMAX.

ITMAX is the maximum number of iterations to be allowed for any given solution. If any species have not converged after ITMAX iterations, the iterating is stopped and the last solutions computed are accepted. With ITMAX = 100, this situation has never arisen.

C1.2.7 COMMON/CONSTAN/

PI = 3.14159265359.

RADDEG = PI/180 is the conversion factor for degrees to radians.

DEGRAD = 180/PI is the conversion factor for radians to degrees.

RADSEC = PI/43200 is the conversion factor for changing local time in seconds to local hour angle in radians.

BOLTZ = 1.38047 x 10^{-16} ergs/K is Boltzmann's constant.

SIN2I is the square of the sine of the magnetic dip angle.

ATCON = 1.660356 x 10^{-24} is the mass of the hydrogen atom in grams.

C1.2.8 COMMON/JAYS/

The labeled COMMON/JAYS/ contains the photodissociation rate coefficients for reactions 192 through 205. The locations reserved in this labeled COMMON are initialized from file Tape 3 by PROGRAM INITIAL.

C1.2.9 COMMON/COLFRE/

The array D contains the invariant part of the collision frequencies ν_{ij}.

$$D[J,I] = \frac{1}{2}(\sigma_I + \sigma_J)^2 \left[2\pi k \frac{(m_I + m_J)}{m_I m_J}\right]^{1/2} . \qquad \text{(C2)}$$

C1.2.10 COMMON/ATCONS/

The arrays in the labeled COMMON/ATCONS/ all pertain to the atomic and molecular constants.

ATWT contains the atomic or molecular weights of the 26 species in the transport mode.

MASS=ATWT*ATCON contains the mass in grams of the 26 species in the transport mode.

THERM contains the thermal diffusion factors for the 26 species in the transport mode. Where values are not known, the thermal diffusion factor is set to zero, which removes any thermal diffusion effect for that species.

SYMBOL contains the alphanumeric identification of each of the 56 species in the model.

POLAR contains the polarizabilities of the species in the transport mode. For species whose polarizabilities are not known, the value is set to zero to remove the polarizability effect.

C1.2.11 COMMON/RATECON/

The arrays in labeled COMMON/RATECON/ all pertain to the rate coefficients [illegible] chemical reactions.

The arrays AK, BK, and CK contain the A's, B's, and C's of Eq. (A1) for the 45 height dependent reaction rate coefficients.

The array DK contains the rate coefficients for the 215 chemical reactions at the particular altitude under consideration.

The array CYMB contains the alphanumeric equivalence of the 215 chemical reactions themselves.

C1.2.12 COMMON/IONS/

The arrays in labeled COMMON/IONS/ all pertain to the ionization of the atmospheric gases.

WAVE contains the alphanumeric identification of the lines or wavelength bands in the EUV.

FLUX contains the solar flux in photons/cm^2/sec/Å at the top of the atmosphere at each of the above lines or in each of the wavelength bands.

SIGMA contains the absorption and the ionization cross sections for O_2, N_2, and O, in that order.

R contains the rate coefficients for the eight energetic electron reactions at the four zenith angles and eight heights listed in Table B22.

The main overlay sets the values of the control parameters before calling OVERLAY (1,0). Upon return from OVERLAY (1,0), the initialization of the code for the run to be made is completed. The initial values of all of the dependent variables N, CONC, and U are then saved in extended core storage. Finally, OVERLAY (2,0) is called and retains control until the calculations are terminated.

C2. OVERLAY (1,0) PROGRAM INITIAL

The purpose of OVERLAY (1,0) PROGRAM INITIAL is to initialize the code for the particular run to be made. In the dimension statement—

S contains the collision cross sections in cm^2 of each of the species in the transport mode. This information is required in the computation of the collision frequencies ν_{ij}.

RMIX contains the ground level mixing ratios for the transport species.

SIG contains the photoionization cross sections for atomic nitrogen for the lines and bands given in array WAVE. These cross sections scaled by 10^{18} are listed in the DATA statement of this overlay.

Following this DATA statement are the FUNCTION definitions. The first is for the sea level value for the acceleration of gravity as a function of the latitude Φ. It is given by[C1]

$$GRAV(\Phi) = 978.0356\,[1 + 0.0052885 \sin^2(\Phi) - 5.9 \times 10^{-6} \sin^2(2\Phi)]. \qquad (C3)$$

The second is for the radius of the earth as a function of the colatitude and the sea level acceleration of gravity. It is given by[C1]

C1. List, R.J., Ed. (1963) Smithsonian Meteorological Tables, Sixth Revised Edition, Washington, D.C.

altitude whose index is IALT. First, this subroutine computes the total concentration M as

$$Y(57) = \sum_{i=i}^{56} n_i.$$

Then it moves the rate coefficients for the 215 reactions at the altitude under consideration into the K region. Following this, it ensures that the photodetachment and photodissociation of the negative ions are removed if the code is in the nighttime. The remainder of the code computes the P and L for species KIND and stores them in the appropriate FORM and REMV regions, respectively. The bulk of this subroutine as well as SUBROUTINE CHEMPR were not hand-coded for obvious reasons. To avoid the very tedious task of hand-coding these routines every time the chemistry set or the species set is changed, a set of programs was written to perform the task of writing these codes. These programs can be found in Keneshea.[3]

C.3.11 SUBROUTINE RATECN

SUBROUTINE RATECN sets the reaction rate coefficients for all the photoreactions at the altitude whose index is IALT. The first three DATA statements in this subroutine contain, respectively, the solar fluxes (x 10^{-9} photons), the ionization cross sections (x 10^{18} cm^2), and the effective absorption cross sections (x 10^{18} cm^2) for $O_2(^1\Delta g)$ as given by Huffman.[22] The next two DATA statements contain the altitudes (km) and the solar zenith angles corresponding to the input arrays of the rate coefficients for the energetic electrons. Following this is the DATA statement specifying the rate coefficient for ionization by cosmic rays. The first executable statement of the program is the FUNCTION definition for the correction at altitude ZZ for the sea level acceleration of gravity.

The code first computes all the rate coefficients for the current altitude and stores them in the DK array. On the initial call to this subroutine, the fluxes and the cross sections given in the DATA statements are scaled to their proper orders of magnitude, and the rate coefficients for the energetic electron processes are replaced by their natural logarithms. Next, the noontime values of H x F for O_2, N_2, and O are computed and saved for later use in computing the scattered radiation. Here, H is the scale height of the species and F is the Chapman approximation used in computing the absorption. If the code is in the nighttime, then transfer is made to statements near the end of the code since all photo processes are zero during the night. If the code is in the daytime, then the photo rate coefficients are determined for the immediate daytime conditions. If the code is in the where, as before, ℓ and $\ell + 1$ represent values at the beginning and at the end of the time step, respectively. The profile of $O(^1D)$ is computed once from Eq. (C21) each time that this subroutine is called, with P_k^{ℓ} and L_k^{ℓ} used instead of $P_k^{\ell+1}$ and $L_k^{\ell+1}$. Also computed in this subroutine are the concentrations of : (1) all the positive ions not in the transport mode; (2) all the negative species; (3) all the positive cluster ions; and (4) HNO_2 and NO_3 between 50 and 120 km.

Eq. (C21) requires the value of the chemistry terms P and L at the end of the time step which in turn require the value of n at the end of the time step. Since this is the quantity being determined, Eq. (C21) will have to be iterated. Upon each iteration, the chemistry terms are computed with the latest values of n. When the solution has converged, the value of n at $\ell + 1$ will have been achieved and the chemistry will have been computed with this value.

At the beginning of each iteration, the value of the concentration at the current altitude is saved temporarily in the array H. The new value is stored in the appropriate cell of the F array. To ensure a more rapid convergence of the solution, the value of the concentration after the current iteration is replaced by the average value

$$n = \frac{H + F}{2}$$

Then the relative difference

$$\frac{H - n}{H}$$

is computed for each species. If the relative change for each species over the current iteration is less than 20 percent, the solution is accepted for that height step and the iterations are started at the next higher altitude. If any species has a relative change greater than 20 percent, all the concentrations are iterated again. This procedure is repeated until all species have relative changes at all altitudes of less than 20 percent. The total number of iterations allowed at each altitude is [illegible]. This number has always been more than sufficient to generate a solution.

When the concentrations of all the required species have been computed between 50 and 120 km, this subroutine then computes the electron concentration between 120 km and the upper boundary from charge balance.

C3.13 SUBROUTINE CHEM

SUBROUTINE CHEM computes the quantities P and L for species KIND at the

The variable TIMOUT is used to keep account of the next hour in problem time when a solution will be sent to the output file. The code ensures that this time will occur exactly by resetting the time step if the current time exceeds this time. The RESET and PRINT switches are set to .TRUE., and the value of TIMOUT is incremented by OPRINT to update it for the next printout. When this routine is exited, DELT contains the time increment in seconds over which the next solution will be made, TIME contains the total elapsed problem time in seconds, and CHI contains the solar zenith angle in radians at the end of the current time step.

C3.12 SUBROUTINE CHEMION

SUBROUTINE CHEMION computes the concentrations of all species in the chemistry mode. This subroutine also computes the largest negative species from charge balance. Below 120 km, this could be a negative ion or the electrons. Above 120 km, it is always the electrons.

If the divergence of the flux in Eq. (1) is set to zero, then that equation can be written as

$$\frac{dn_i}{dt} = P_i - n_i L_i \ . \tag{C19}$$

Two convenient choices exist for solving these ordinary differential equations. They can be solved using the Kutta-Merson numerical integration scheme available in SUBROUTINE ODE, or they can be solved using simple finite differences. Since much more computer time is required to solve the equations by the Kutta-Merson scheme and since it is generally a minor species whose concentration is being computed, the more economical finite differences are used to solve Eq. (C19). Writing Eq. (C19) in finite difference notation at level k gives

$$\frac{n_k^{\ell+1} - n_k}{\Delta t} = P_k^{\ell+1} - n_k^{\ell+1} L_k^{\ell+1} \ . \tag{C20}$$

The concentration $n_k^{\ell+1}$ at the end of the time step is then

$$n_k^{\ell+1} = \frac{n_k^{\ell} + \Delta t \, P_k^{\ell+1}}{1 + \Delta t \, L_k^{\ell+1}} \tag{C21}$$

C3.8 SUBROUTINE ODE

SUBROUTINE ODE solves a set of N ordinary differential equations using the Kutta-Merson numerical integration scheme. This program is explained in detail elsewhere.[2] The solution is taken over the altitude range DZ starting at altitude SZ. The solutions are returned in array START.

C3.9 SUBROUTINE RHS

SUBROUTINE RHS is called by SUBROUTINE ODE to supply to ODE the values of the right hand side of Eq. (42). The values are computed at altitude ZE using the intermediate values v computed in SUBROUTINE ODE. The results of the evaluation are returned in the array SLOPE. The intermediate values at altitude ZE are computed using the linear interpolation coefficients derived in SUBROUTINE VELOCITY.

C3.10 SUBROUTINE COLFRE

SUBROUTINE COLFRE computes the sum of the collision frequencies (SNU) of species i with all the other species at the altitude whose index is j. It also computes the quantities $\sum_j \nu_{ij} w_j$ required in Eq. (22) for species i. In addition, it sets the values of omega (OMEG) in Eq. (17). OMEG is computed from Eq. (10) if i represents an ion, and is set equal to unity if i represents a neutral species.

C3.11 SUBROUTINE TIMER

Except for doubling of the time step after a successful integration and halving of the time step on an error, all changes to the time and the time step are done in SUBROUTINE TIMER. This subroutine decides whether or not the next integration will end at a print step. It also determines if the next time step will be in the daytime, nighttime, or in morning or evening twilight. The code advances normally in time until this subroutine determines that the sun is about to rise at the upper boundary or is about to set at the lower boundary. When either of these situations is about to happen, this subroutine adjusts the time step so that the next integration will end at the beginning of morning or evening twilight. During these twilight periods, the concentrations of some of the atmospheric species change rapidly. These changes force the code to reduce the time step to successively smaller and smaller values before a solution can be accepted. To avoid the large amount of computer time required to accompoish this, the code automatically reduces the time step to 15 seconds with the onset of morning or evening twilight. The LOGICAL switch SET controls this. The time increment is then allowed to double in PROGRAM INTEG after each successful integration until it reaches TMAX.

$$\frac{n_{j+1}}{n_j} < 100.$$

If the ratio $n_{j+1}/n_j > 100$, the velocity is set to zero at that altitude.

C3.7 SUBROUTINE VELOCITY

SUBROUTINE VELOCITY sets up the parameters required for computing the upper boundary value of the velocity of species i. In order to use any numerical integration scheme to solve Eq. (42) for the velocity w at the upper boundary, some means of interpolating values of n, P, L, and dn/dz between the upper boundary and one step below must be provided. What is used here is a simple linear interpolation:

$$\begin{cases} n_K = az_K + b \\ n_{K-1} = az_{K-1} + b \end{cases} \tag{C17}$$

Solving these equations for a and b gives

$$a = \frac{n_K - n_{K-1}}{\Delta z_K}.$$

and

$$b = \frac{n_{K-1}\, z_K - n_K\, z_{K-1}}{\Delta z_K}. \tag{C18}$$

In the function definitions at the beginning of SUBROUTINE VELOCITY, AF is the definition of a and BF is the definition of b. The subroutine then procedes to compute the a and b coefficients for the equations n(AN, BN), P(AP, BP), and L(AL, BL). These are stored in labeled COMMON/RHSIDE/ for use by SUBROUTINE RHS later. This subroutine then calls SUBROUTINE ODE to solve the ordinary differential equations Eq. (42) for species i over the last height step.

the total concentration

$$N = \sum_{i=1}^{26} n_i,$$

the mean molecular weight in grams of the atmosphere

$$\overline{m} = \frac{\rho}{N}, \tag{C15}$$

and the mean mass velocity

$$w_o = \frac{\sum_{i=1}^{26} \rho_i w_i}{\sum_{i=1}^{26} \rho_i} \tag{C16}$$

The negative ions and the positive cluster ions, which are always very minor species, are excluded from the above sums.

C3.6 SUBROUTINE EFORU

For the species whose number is ICF, SUBROUTINE EFORU computes its E and F arrays of Eq. (28) if ICF is positive, or its average velocity array from Eq. (18) if ICF is negative.

The computation of the E and F arrays is fairly straightforward. At each altitude, the A(AJ), B(BJ), C(CJ), and D(DJ) values of Eq. (21) are computed. Then the E and F arrays are computed with the upper and lower boundary conditions imposed.

The specific velocities are also calculated in this subroutine since their evaluation requires much of the same coding as do the E and F arrays. Both computations call SUBROUTINE VELOCITY to obtain the upper boundary velocity for those species that are not assumed to be in diffusive equilibrium there. To avoid unrealistically large values of the velocities when the concentration is very small, the concentration of each species n_j and the ratio of n_{j+1}/n_j are investigated at each altitude. If $n_j > 1.0 \times 10^{-10}$ cm^{-3}, then its velocity at altitude j is computed. For values of $n_j < 1.0 \times 10^{-10}$, the velocity is computed if the ratio

Performing the integration results in

$$n = n_K \exp\left\{- \frac{mg_o}{kT_K}\left[\frac{(z - z_K)}{\left(\frac{z_K}{R} + 1\right)\left(\frac{z}{R} + 1\right)}\right]\right\} \tag{C12}$$

where the subscript K refers to quantities at the upper boundary. After the concentrations have been extrapolated to 500 km, the actual smoothing routine is called, where the profile is smoothed with a 7-point running mean. At this point, the code continues to loop back until all the required smoothing is accomplished. If no ion profile was smoothed, the subroutine is exited here. If at least one of the smoothed profiles was a positive ion profile, then the negative species must be readjusted to ensure charge neutrality in the atmosphere. Below 120 km, the largest negative species is recomputed from charge balance.

$$n_i = \sum_j n_j^+ - \sum_{j \neq i} n_j^- . \tag{C13}$$

Above 120 km the electron concentration is recomputed from

$$n_e = \sum_j n_j^+ .$$

C3.4 SUBROUTINE SMOOTH

SUBROUTINE SMOOTH computes the smooth array B corresponding to the unsmoothed array A. Both arrays contain N points. M, which must be odd, is the number of points in the running mean. In this smoothing routine, the beginning and the end points are not changed.

C3.5 SUBROUTINE CO

[illegible] altitude corresponding to the index j, SUBROUTINE CO computes the [illegible] density

$$[illegible] \sum_{i=1}^{[illegible]} n_i m_i \tag{C14}$$

assuming the concentration is in diffusive equilibrium above the upper boundary. That is,

$$\frac{dp}{dz} = -\rho g \tag{C6}$$

or

$$\frac{d(nkT)}{dz} = -nmg \tag{C7}$$

which reduces to

$$\frac{1}{n}\frac{dn}{dz} + \frac{1}{T}\frac{dT}{dz} = -\frac{mg}{kT}. \tag{C8}$$

It is also assumed that above 400 km

$$\frac{dT}{dz} = 0.$$

Therefore, Eq. (C8) becomes

$$\frac{1}{n}\frac{dn}{dz} = -\frac{mg}{kT} \tag{C9}$$

An approximation to the acceleration of gravity at any altitude Z can be written as

$$g = \frac{g_o}{\left(1 + \frac{z}{R}\right)^2} = \frac{g_o R^2}{(R + z)^2} \tag{C10}$$

where g_o is the sea level value of the acceleration of gravity and R is the radius of the earth. Using Eq. (C10) and the assumption that the temperature is constant above the upper boundary, the solution to Eq. (C9) is

$$\ln\left(\frac{n}{n_o}\right) = -\frac{mg_oR}{kT}\int_{z_o}^{z}\frac{dz}{(R + z)^2} \tag{C11}$$

have been computed for the species in the transport mode. It then calls SUBROUTINE CHEMION to compute the concentration profiles at the end of the current time step of all the remaining species. After all the new concentrations have been computed, the code then calls SUBROUTINE EFORU to compute the average velocities for those species in the transport mode.

Following this, a check is made to see if the solution for any species has converged at all altitudes. That is, is its largest relative change less than ERSPECI. If so, its IWHICH switch is set to zero and its ITER counter set to the current iteration number. The equations for this species will be skipped on the next iteration of the equation set.

A check is then made to see if the largest relative change among all the species is less than ERRMAX. If so, the iteration loop is exited and the solution accepted for this time step. If not, transfer is made back to the beginning of the DO 130 loop for the next iteration.

When the solution is accepted, the code then asks whether or not this solution should be sent to the output file. If printing has not been requested (PRINT= .FALSE.), transfer is made to that section of the code where the time step is doubled if possible, and the new concentrations and velocities are saved in extended core storage. Transfer is then made to STATEMENT 1000, where a new solution is generated over the next time step. If the solution is to be sent to the output file, the code then calculates all the subsidiary parameters to be printed out along with the concentrations and the average velocities. The code at this point is fairly explicit as to which quantities it is computing and sending to the output file. When all the information has been sent to the output file, the code then writes an interrupt file on Tape 4. This file contains all the information necessary to restart the code at this point at some later time. Since the development of a complete time dependent solution takes many hours of CDC 6600 CP time, it has to be accomplished in many short runs (about 4 hours each). The code is restarted from Tape 4 each time.

C3.3 SUBROUTINE SMOOTHY

SMOOTHY controls the smoothing of those profiles that PROGRAM INTEG has determined should ne smoothed. If no profiles are to be smoothed (NUM=0), then the subroutine is exited immediately upon entry. Because of the nature of the smoothing process, it is necessary to extrapolate the concentration profile above the upper boundary. The altitude above the upper boundary to which the extrapolation is done should be far enough away so that the effects of the smoothing at the top of the array are not felt at the upper boundary. In this code, the profiles are extrapolated to 500 km in 1=km=height steps. The extrapolation is accomplished solution. This may be a new solution over the next time step or another try using a smaller time step because an error was encountered.

The code then saves the time, the solar zenith angle, the day-night transition height, and the day and night logical switches at the beginning of the time step. If an error is encountered later, these parameters will have to be reinitialized. The code then calls SUBROUTINE TIMER to compute the time and solar zenith angle at the end of the current time step. It then sets the JLOOK switch depending upon whether it is day or night. Following this, the IWHICH switches are all initialized to unity and the ITER locations to 999. Then, since the equations for helium will not be solved in this calculation, its IWHICH switch is set to zero.

The statement DO 130 is the beginning of the iteration loop. The loop beginning with the next statement is taken over all the species in the transport mode. The equations will be solved over the altitude extent for each species in succession. On the first pass through the loop, the quantities

$$\frac{1}{n_e}\frac{\partial n_e}{\partial Z} \approx \frac{1}{n_e}\frac{\Delta n_e}{\Delta Z} = \frac{n_{e_j} - n_{e_{j-1}}}{n_{e_j}\ \Delta Z_{j-1}} \tag{C5}$$

are computed and saved in the working array H. Next, the altitude dependent rate coefficients are computed using the current atmosphere and the values saved in extended core storage. If the JLOOK switch is on .TRUE., then the photodissociation rate coefficients are sent to the output file. If any of the concentration profiles need smoothing, this is done next and an acknowledgement is sent to the output file. To remain internally consistent, it is necessary now to recompute the velocity profiles for those species whose concentration profiles have been modified by smoothing. All the concentrations and velocities are then saved in extended core storage.

The code then brings into memory the values of the concentrations and velocities for the current species at the beginning of the time step. It then proceeds to compute a new concentration profile in the DO 100 loop. It also saves the largest relative change for this species in the BIGEST region. The relative change is defined as

$$\frac{\left| n_j^{\ell+1} - n_j^{\ell} \right|}{n_j^{\ell+1}} .$$

The code then loops back to solve the continuity equation for the next species in turn. When the code exits at 105 CONTINUE, all the new concentration profiles

NSPEC is an array containing the order number from 1 to 56 of each species whose concentration is to be smoothed before the iteration procedure is started. The variable NUM indicates how many profiles are to be smoothed. If NUM=0, no smoothing will be done.

Two new labeled COMMONs are defined in PROGRAM INTEG.

C3.1 Labeled COMMON/LOGIC/

All the parameters listed in Labeled COMMON/LOGIC/ are logical variables. NIGHT is .TRUE. whenever the entire altitude region between the upper and lower boundaries is in darkness. Otherwise, it is .FALSE..

DAY is .TRUE. whenever the entire altitude region between the upper and lower boundaries is in daylight. Otherwise, it is .FALSE..

Both NIGHT and DAY variables are .FALSE. when the sun is rising or setting and only part of the altitude region between the upper and lower boundaries is in darkness.

JLOOK is set to .TRUE. to send to the output file, before the iteration begins, a table of the altitude distribution of the 0_2 concentrations, the 0_2 column densities, the 0_3 concentrations, the 0_3 column densities, and the rate coefficients for all the photodissociation reactions. If JLOOK is .FALSE., this table is not printed.

RESET is set to .TRUE. in SUBROUTINE TIMER whenever the time step has been recomputed because the next solution will be sent to the output file and the interrupt file.

END is set to .TRUE. whenever the computations for the current run are to be terminated.

C3.2 Labeled COMMON/COLUM/

The Labeled COMMON/COLUM/ contains information pertaining to the photodissociation rate coefficients.

02COL is used to transfer the 0_2 column density from SUBROUTINE DISSOC to SUBROUTINE RATECN.

03COL is used to transfer the 0_3 column density from SUBROUTINE DISSOC to SUBROUTINE RATECN.

DIS is the array where the photodissociation information is stored in SUBROUTINE RATECN for printing in PROGRAM INTEG. To avoid excessively long printouts, only every twelfth altitude value between the lower and the upper boundaries is stored in these arrays.

PROGRAM INTEG starts by initializing some of its variables. STATEMENT 1000 CONTINUE marks the beginning of the working code. After every successful or unsuccessful solution, the code will loop back to this statement to begin the next and (9). This overlay uses two DIMENSION statements that contain the following variables:

PHI is an array EQUIVALENCED to the array U(1, 21) and is used as temporary storage of the total flux ϕ of each species during the printout phase of the code. The array U(1, 21) would normally contain the velocity profile of helium, but, since this species is held invariant in these calculations, these memory locations are available for other uses.

DED is an array EQUIVALENCED to the array E in COMMON. It is used as temporary storage of the turbulent diffusion velocity of each species successively during the printout phase of the code.

DEDZ is an array EQUIVALENCED to the array NZERO and is used as temporary storage of the vertical gradient of the turbulent velocity for each species during the printout phase of the code.

VBAR is an array EQUIVALENCED to the array F and is used as temporary storage of the molecular diffusion velocity of each species during the printout phase of the code. The molecular diffusion velocity of a species is equal to its average velocity minus the mean mass velocity.

H is an array used in various places in the code for temporary storage of arrays.

OUTP contains four words each of which contains one hollerith character of the local time in hours. It is computed by SUBROUTINE HOUR.

IWHICH is an array of integer switches, one for each species in the transport mode. If a switch is set to 1, the equations for that species will be iterated. If the switch is set to 0, the equations for that species will not be iterated. If IWHICH (21) is set to 0 before entering the iteration loop, the concentration of helium will remain fixed at its initial value throughout the calculations since its equations will not be iterated.

ITER is an array that stores the number of iterations required by each of the sets of equations before a final solution was obtained for a given time step.

BIGEST is an array that contains the largest relative difference in each species concentration profile. It contains the maximum value of

$$\frac{n_j^{\ell+1} - n_j^{\ell}}{n_j^{\ell+1}}$$

in the array as j varies from the lower boundary to the upper boundary. This array is recomputed after each iteration.

given time. The first file, which is slightly different from all the others, must be prepared before this code is first run. It contains the initial conditions on all the dependent variables. (See the discussion on the initial conditions in Section 7.1.) Since this is an unformatted file, it must be written exactly as it is read here. First, it reads the date that the first file was written, the file number (1 in this case), and the height in kilometers of the turbopause. It then skips over six words in the file that are not necessary to the current calculations. Then it reads the number of altitude steps in the complete arrays (K = 692), the number of altitude steps in the reduced arrays (K2 = 424), and the altitude array in kilometers. After this, it reads the height step array, the fixed temperature array, the array $1/T\ dT/dZ$, and the fixed turbulent diffusion coefficient array. Next, it reads the initial velocities and initial concentrations.

In the following loop, the remainder of the interrupt files are skipped over and the tape is positioned at the beginning of a new file. At the completion of this loop, the locations containing the dependent variables will have been updated with the values obtained after the last successful solution. These values are then used as initial conditions for the next time step.

All files after file 1 on the interrupt tape are written in OVERLAY (2,0). Care must be taken not to write so many files on Tape 4 that it becomes full. Before this happens, a new Tape 4 must be made containing file 1 and the last file from the old Tape 4.

After the dependent variables have been initialized, the code initializes the solar zenith angle to the current time and computes the noontime solar zenith angle. It then reads from input Tape 5 and, where required, converts to proper units the wavelengths, solar fluxes, and absorption and ionization cross sections to be used in the photoionization calculations. Finally, from this same file, it reads the rate coefficient arrays for the energetic electron reactions. All that remains now is the calculation of the sunset (sunrise) solar zenith angles as a function of altitude. Also calculated are the times of sunset at the lower boundary and of sunrise at the upper boundary.

When all this initialization is complete, the concentration profiles corresponding to the initialized time are written to the output file. Finally, the current value of the variable TIMOUT is written to the output file in case the frequency of the output of solutions is to be changed for the next run.

C.3. OVERLAY (2,0) PROGRAM INTEG

OVERLAY (2,0) contains all the programs that actually solve Eqs. (1), (7),

RADUS (GRAV, ϕ)

$$= \frac{2 \cdot \text{GRAV}}{2.27 \times 10^{-9} \cos(2\phi) - 2 \times 10^{-2} \cos(4\phi) + 3.085426 \times 10^{-6}} \qquad \text{(C4)}$$

Next, the constants in labeled COMMON/CONSTAN/ are defined. After this, the constants for the particular solution to be generated are defined.

CLAT is the latitude in degrees.

DECL is the solar declination for the time of year when the calculations are to be made.

DIP is the magnetic dip angle appropriate to CLAT.

Next, the acceleration of gravity, the radius of the earth, and the constants required for later computing the solar zenith angles are computed. Information pertaining to the current calculations is then written to the output file (Tape 6).

The next section of this OVERLAY sets the chemical symbols along with the atomic or molecular weight, the mixing ratio, the collision cross section, the polarizability, and the thermal diffusion factor for the 26 transport species. Following this, the symbols for the species computed from chemistry only are written. The atomic or molecular weight of each species is then converted to mass in grams. The ground level mixing ratio of N_2 is computed to ensure that the sum of all the mixing ratios is identically unity. The mixing ratios of the species are not necessary for the code described here. However, if other initial conditions are to be computed as discussed in Keneshea et al,[8] then the values of the mixing ratios are required.

The following section of INITIAL obtains input information from various sources. The list of chemical reactions with their rate coefficients must be prepared separately and saved for use here as the tile called Tape 5. This information is coded according to the FORMAT defined in statements 770 or 771, depending upon whether the reaction is not height dependent (770) or is height dependent (771). As the reactions are read in, they are also sent to the OUTPUT file (Tape 6). After the reaction set is read in, the code reads in the photodissociation rate coefficient tables (Tables B4 through B20). All values in these tables are in log base 10. These tables also are computed and saved separately. Since these numbers are functions only of the O_2 and O_3 column densities, they are universal. They need be computed only once and can then be input to any calculation regardless of geographic location, season of the year, or time of day.

After the photodissociation rate coefficients are initialized, the invariant part of the collision frequencies ν_{ij} are computed and saved in the D array.

The next section of the code reads the interrupt file Tape 4. This tape is structured in files, each containing the solution for all the dependent variables at a morning or evening twilight periods and the current altitude is below the day-night transition altitude, then the computation of the rate coefficients is skipped. Otherwise, they are computed.

During the daytime, SUBROUTINE DISSOC is called for the computation of the photodissociation rate coefficients. These are then stored in the proper cells of the DK array. If the JLOOK switch is on .TRUE., these rate coefficients along with the concentrations and column densities of O_2 and O_3 are stored in the DIS region for later printing in the output file. Following this, the rate coefficients for the energetic electron reactions are computed. The values in the tables are interpolated to the current solar zenith angle and altitude. Next, the column densities of O_2, N_2, and O at the current solar zenith angle are approximated. These column densities are then used to compute the EUV attenuated flux at each wavelength. The rate coefficients for the photoionization processes are then computed. All EUV radiation below 0.15 nm is considered to be X radiation, which is handled differently from the longer EUV radiation. The total x-ray ionization is computed and partitioned among the species according to Swider.[19] Finally, the total EUV rate coefficients are computed as well as the rate coefficients for the ionization of nitric oxide by Lyman alpha and the ionization of $O_2(^1\Delta g)$.

If the code is in the nighttime, the above computations are skipped and the code continues from this point. The contributions of the scattered radiations to the ionization rates are computed next. Finally, the contribution of cosmic rays is added into the rate coefficients and the subroutine is exited.

C3.15 FUNCTION YINT

FUNCTION YINT performs interpolation where it is required. This function essentially computes a cubic spline fit to the parameter under consideration. It then returns the interpolated value in YINT corresponding to XII in the (X, Y) arrays.

C3.16 SUBROUTINE CHAPMAN

SUBROUTINE CHAPMAN computes an approximation to the Chapman function, which is required in computing the attenuation of solar energy in its transmission through the atmosphere. The approximations computed are those given by Swider and Gardner.[C2]

C2. Swider, W. Jr., and Gardner, M.E. (1967) On the Accuracy of Certain Approximations for the Chapman Function, AFCRL-67-0468, AD 658826.

C3.17 SUBROUTINE DISSOC

SUBROUTINE DISSOC returns the value of the photodissociation rate coefficients appropriate to the current solar zenith angle and the altitude whose index is IALT. The rate coefficients for all species except nitric oxide are determined as follows: The column densities of O_2 and O_3 are first approximated for the current O_2 and O_3 concentration distributions in the code. A linear interpolation is then made in the appropriate photodissociation table to determine the current photodissociation rate coefficient for each of the photodissociation processes. Finally, using the data of Cieslik and Nicolet[C3] as given in the DATA statement of this subroutine, the photodissociation rate coefficient for nitric oxide is computed.

C3.18 FUNCTION TRPLT2

FUNCTION TRPLT2 interpolates in the two-dimensional photodissociation rate coefficient tables. The two-dimensional array to be interpolated is fed to this function through the parameter ARRAY. The dimensions of ARRAY are (N, M). The indices of elements in ARRAY are IO2 and IO3. The increments required to perform the interpolation are DELO2 and DELO3.

C3.19 FUNCTION TRPLT1

FUNCTION TRPLT1 interpolates in the one-dimensional photodissociation rate coefficient tables. The array to be interpolated is fed to the function through the parameter ARRAY. The index in ARRAY is IO3 and the interpolation increment is DELO3.

C3.20 SUBROUTINE INDEX

SUBROUTINE INDEX computes an index I and an increment DEL corresponding to the column density COL. LIM is the lowest power of 10 of the column densities of O_2 and O_3 in the photodissociation tables under consideration.

C3.21 SUBROUTINE CHEMPR

Each time SUBROUTINE CHEMPR is called, it sends to the output file the complete list of chemical reactions for the altitude whose index is IZ. It also sends the rate coefficient for each reaction and its forward rate. This subroutine is also written by the WRITER codes given in Keneshea.[3] The output from this subroutine is used to determine the relative importance of the chemical reactions in different altitude regions.

C3. Cieslik, S., and Nicolet, M. (1973) The aeronomic dissociation of nitric oxide, Planet. Space Sci. 21:925-938.

C.3.22 SUBROUTINE HOUR

SUBROUTINE HOUR converts the value of TIME, which is in accumulated seconds from the noontime of the day on which the simulation was started, to the local time in hours (0000 to 2359). The digits of the hour are returned in hollerith in successive words of the OUTP array.

```
      OVERLAY(MIONE...)
      PROGRAM MAIN(INPUT=65,OUTPUT=65,TAPE5=510,TAPE4=510,TAPE5=65,
     1              TAPE6=OUTPUT)
C
      COMMON N(692,30),CONC(424,26),U(692,26),NZERO(692),UZERO(692)
C
      COMMON FORM(692),REMV(692),E(692),F(692),Z(692),
     2       DEDY(692),TEMP(692),DTEMDZ(692),DELTAZ(692),SUNSET(692)
C
      COMMON GRAV,COSD,SIND,TIME,CXI,RADIUS,ISPECI,KSPECI,NREAC,K,
     1       K2,KMIN1,ITURB,CXINOON,SCXI,NREAC2
C
      COMMON/ESM/OLDN(692,30),OLDCON(424,26),OLDU(692,26),RATES(88,692)
C
      COMMON/TIMES/DAYS,DELT,TMAX,TSET,TRISE
C
      COMMON/ALTITUD/ZBOT,ZTOP,TURB,ZTRANS
C
      COMMON/RESTART/IFRAME,TOFF,TYME,TODAY
C
      COMMON/OUTPUTS/TIMOUT,OPRINT,PRINT
C
      COMMON/ERRORS/ERRMAX,ERSPECI,ITMAX
C
      COMMON/CONSTAN/PI,RADDEG,DEGRAD,RADSEC,BOLTZ,SIN2I,ATCON
C
      COMMON/JAYS/J192(26,25),J193(26,26),J194(22),J195(32,28),
     1            J196(31,30),J197(27,28),J198(26,28),J200(19,15),
     2           J201(26,27),J202(22),J203(30,29),J204(35,28),J205(22)
C
      COMMON/COLFRE/D(26,26)
C
      COMMON/ATCONS/ATWT(26),MASS(26),THERM(26),SYMBOL(56),POLAR(26)
C
      COMMON/RATECON/AK(88),BK(88),CK(88),DK(215),CYMB(6,215)
C
      COMMON/IONS/WAVE(88),FLUX(88),SIGMA(9,88),R(8,4,8)
C
      REAL N,NZERO
      LEVEL 3, OLDN,OLDCON,OLDU,RATES
C
C  ISPECI IS THE TOTAL NUMBER OF SPECIES IN THE MODEL.  KSPECI IS
C  THE NUMBER OF SPECIES IN THE TRANSPORT MODE WITH ALL THE
C  OTHERS IN THE CHEMISTRY MODE.
C
      ISPECI=56
      KSPECI=26
      NREAC=127
      NREAC2=68
C
C  ALTITUDES
C
      ZBOT=50.
      ZTOP=400.
      TURB=112.
      K=692
      K2=424
```

```
C
C  RESTART
C
      TOFF=250.
      IFRAME=1
      TYME=14400.
      CALL DATE(TODAY)
      WRITE(6,50) TODAY
C
C  TIMES
C
      TIME=0.
      TIMOUT=0.
      DELT=2.0**(-10)
      TMAX=1800.
      DAYS=40.
C
C  OUTPUTS
C
      OPRINT=12.
C
C  ERRORS
C
      ERRMAX=0.3
      ERSPECI=0.01
      ITMAX=100
C
C***********************************************************************
C
      CALL OVERLAY(6HIONEUT,1,0)
C
C***********************************************************************
C
C  SAVE INITIAL CONDITIONS IN ESM.
C
      CALL MOVLEV(N,OLDN,20760)
      CALL MOVLEV(CONC,OLDCON,11024)
      CALL MOVLEV(U,OLDU,17992)
C
C START COMPUTING TIME-HEIGHT PROFILES.
C
C*******************************************************************
C
      CALL OVERLAY(6HIONEUT,2,0)
C
C*******************************************************************
C
      REWIND 4
   50 FORMAT(1H1,* THIS RUN WAS MADE ON *,A10)
      END
```

```
      OVERLAY(1,0)                                                      IIONEUT    2
      PROGRAM INIT.AL                                                   IIONEUT    3
C                                                                       IIONEUT    4
      DIMENSION S(26),RMIX(26),SIG(88)                                  IIONEUT    5
C                                                                       IIONEUT    6
      COMMON N(692,30),CONC(424,26),U(692,26),NZERO(692),UZERO(692)     IIONEUT    7
C                                                                       IIONEUT    8
      COMMON FORM(692),REMV(692),E(692),F(692),Z(692),                  IIONEUT    9
     2       DEDY(692),TEMP(692),DTEMDZ(692),DELTAZ(692),SUNSET(692)    IIONEUT   10
C                                                                       IIONEUT   11
      COMMON GRAV,COSD,SIND,TIME,CXI,RADIUS,ISPECI,KSPECI,NREAC,K,      IIONEUT   12
     1       K2,KMIN1,ITURB,CXINOON,SCXI,NREAC2                         IIONEUT   13
C                                                                       IIONEUT   14
      COMMON/ATCONS/ATWT(26),MASS(26),THERM(26),SYMBOL(56),POLAR(26)    IIONEUT   15
C                                                                       IIONEUT   16
      COMMON/TIMES/DAYS,DELT,TMAX,TSET,TRISE                            IIONEUT   17
C                                                                       IIONEUT   18
      COMMON/ALTITUD/ZBOT,ZTOP,TURB,ZTRANS                              IIONEUT   19
C                                                                       IIONEUT   20
      COMMON/RESTART/IFRAME,TOFF,TYME,TODAY                             IIONEUT   21
C                                                                       IIONEUT   22
      COMMON/OUTPUTS/TIMOUT,OPRINT,PRINT                                IIONEUT   23
C                                                                       IIONEUT   24
      COMMON/CONSTAN/PI,RADDEG,DEGRAD,RADSEC,BOLTZ,SIN21,ATCON          IIONEUT   25
C                                                                       IIONEUT   26
      COMMON/JAYS/J192(26,25),J193(28,26),J194(22),J195(32,28),         IIONEUT   27
     1            J196(31,30),J197(27,28),J198(26,28),J200(19,15),      IIONEUT   28
     2            J201(26,27),J202(22),J203(30,29),J204(35,28),J205(22) IIONEUT   29
C                                                                       IIONEUT   30
      COMMON/IONS/WAVE(88),FLUX(88),SIGMA(9,88),R(8,4,8)                IIONEUT   31
C                                                                       IIONEUT   32
      COMMON/RATECON/AK(88),BK(88),CK(88),DK(215),CYMB(6,215)           IIONEUT   33
C                                                                       IIONEUT   34
      COMMON/COLFRE/D(26,26)                                            IIONEUT   35
C                                                                       IIONEUT   36
      REAL N,MASS,J192,J193,J194,J195,J196,J197,J198,J200,J201,J202     IIONEUT   37
      REAL J203,J204,J205                                               IIONEUT   38
C                                                                       IIONEUT   39
C  THE FOLLOWING DATA STATMENT CONTAINS THE PHOTOIONIZATION             IIONEUT   40
C  CROSS SECTIONS FOR ATOMIC NITROGEN SCALED BY 1E18.                   IIONEUT   41
C  SEE "AERONOMY" BY BANKS AND KOCHARTS, PART A, P102-104.              IIONEUT   42
C                                                                       IIONEUT   43
      DATA SIG/21*(0.),20*(10.0),2*(10.5),2*(10.4),10.75,4*(11.0),      IIONEUT   44
     1         11.8,11.9,2*(12.0),11.9,11.5,11.1,11.0,9.3,10.0,9.7,     IIONFUT   45
     2         8.5,8.8,2*(8.0),7.3,6.7,6.0,5.3,6.3,4.3,3.4,2.8,2.2,1.3, IIONEUT   46
     3         0.58,0.45,0.36,0.32,0.23,0.16,0.093,0.04,0.03,0.015,     IIONEUT   47
     4         0.006,0.001,0.0001/                                      IIONEUT   48
C                                                                       IIONEUT   49
C  FUNCTION DEFINITION FOR SEA LEVEL ACCELERATION OF GRAVITY AS         IIONEUT   50
C  A FUNCTION OF LATI'UDE IN CM/SEC**2.                                 IIONEUT   51
C                                                                       IIONEUT   52
      GRAVTY(ALAT)=978.0356*(1.0+0.0052885*(SIN(ALAT))**2               IIONEUT   53
     1              -5.9E-06*(SIN(2.0*ALAT))**2)                        IIONEUT   54
C                                                                       IIONEUT   55
C  FUNCTION DEFINITION FOR RADIUS OF THE EARTH IN KILOMETERS AS         IIONEUT   56
C  A FUNCTION OF LATITUDE AND SEA LEVEL GRAVITY.                        IIONEUT   57
C                                                                       IIONEUT   58
```

```
      RADUS(GRAV,ALAT)=(2.0*GRAV*1.0E-5)/(2.27E-09*COS(2.0*ALAT)          IIONEUT   59
     1                  -2.0E-12*COS(4.0*ALAT)+3.085462E-06)               IIONEUT   60
C                                                                          IIONEUT   61
C  CONSTANTS                                                               IIONEUT   62
C                                                                          IIONEUT   63
      PI=3.14159265359                                                     IIONEUT   64
      RADDEG=PI/180.                                                       IIONEUT   65
      DEGRAD=180./PI                                                       IIONEUT   66
      RADSEC=PI/43200.                                                     IIONEUT   67
      BOLTZ=1.38047E-16                                                    IIONEUT   68
C                                                                          IIONEUT   69
C  SET CONSTANTS FOR PARTICULAR MODEL CALCULATION.                         IIONEUT   70
C                                                                          IIONEUT   71
      CLAT=30.0                                                            IIONEUT   72
      DECL=-19.55                                                          IIONEUT   73
      DIP=60.0                                                             IIONEUT   74
      PHILAT=CLAT*RADDEG                                                   IIONEUT   75
      GRAV=GRAVTY(PHILAT)                                                  IIONEUT   76
      RADIUS=RADUS(GRAV,PHILAT)                                            IIONEUT   77
      DECLAT=DECL*RADDEG                                                   IIONEUT   78
      COSD=COS(DECLAT)*COS(PHILAT)                                         IIONEUT   79
      SIND=SIN(DECLAT)*SIN(PHILAT)                                         IIONEUT   80
      SIN2I=(SIN(DIP*RADDEG))**2                                           IIONEUT   81
      WRITE(6,25) CLAT,DECL,DIP,GRAV,RADIUS                                IIONEUT   82
   25 FORMAT(1H0,5X,"LATITUDE OF MODEL =",0PF6.2," DEGREES."/              IIONEUT   83
     16X,"SOLAR DECLINATION =",F6.2," DEGREES."/6X,"MAGNETIC DIP ",        IIONEUT   84
     2"ANGLE =",F6.2," DEGREES."/6X,"ACCELERATION OF GRAVITY =",1PE12.5,   IIONEUT   85
     3" CM/SEC**2."/6X,"RADIUS OF THE EARTH =",E12.5," KM.")               IIONEUT   86
C                                                                          IIONEUT   87
C  SET ATOMIC AND MOLECULAR WEIGHTS, MIXING RATIOS, COLLISION CROSS        IIONEUT   88
C  SECTIONS. THERMAL DIFFUSION FACTORS AND POLARIZABILITIES.               IIONEUT   89
C                                                                          IIONEUT   90
      ATCON=1.66035E-24                                                    IIONEUT   91
      DO 60 I=1,KSPECI                                                     IIONEUT   92
      THERM(I)=1.0                                                         IIONEUT   93
      POLAR(I)=0.0                                                         IIONEUT   94
       RMIX(I)=0.0                                                         IIONEUT   95
   60 CONTINUE                                                             IIONEUT   96
      SYMBOL(1)=10H H+                                                     IIONEUT   97
        ATWT(1)=1.00797                                                    IIONEUT   98
           S(1)=3.04E-08                                                   IIONEUT   99
      SYMBOL(2)=10H HE+                                                    IIONEUT  100
        ATWT(2)=4.0026                                                     IIONEUT  101
           S(2)=2.04E-08                                                   IIONEUT  102
      SYMBOL(3)=10H O+                                                     IIONEUT  103
        ATWT(3)=15.9994                                                    IIONEUT  104
           S(3)=1.2E-08                                                    IIONEUT  105
      SYMBOL(4)=10H O2+                                                    IIONEUT  106
        ATWT(4)=31.9988                                                    IIONEUT  107
           S(4)=3.3E-08                                                    IIONEUT  108
      SYMBOL(5)=10H NO+                                                    IIONEUT  109
        ATWT(5)=30.006132                                                  IIONEUT  110
           S(5)=3.4E-08                                                    IIONEUT  111
      SYMBOL(6)=10H N+                                                     IIONEUT  112
        ATWT(6)=14.006732                                                  IIONEUT  113
           S(6)=1.42E-08                                                   IIONEUT  114
      SYMBOL(7)=10H O                                                      IIONEUT  115
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      THERM(7) [illegible]                                      IIONEUT  116
      POLAR(7) [illegible]                                      IIONEUT  117
        ATWT(7)= [illegible]                                    IIONEUT  118
        RMIX(7)= [illegible]E-08                                IIONEUT  119
           S(7)=2.65E-08                                        IIONEUT  120
      SYMBOL(8)=10H O2                                          IIONEUT  121
       THERM(8)=1.0+0.[illegible]                               IIONEUT  122
       POLAR(8)=1.59                                            IIONEUT  123
        ATWT(8)=31.9988                                         IIONEUT  124
        RMIX(8)=0.209545                                        IIONEUT  125
           S(8)=3.40E-08                                        IIONEUT  126
      SYMBOL(9)=10H O3                                          IIONEUT  127
        ATWT(9)=47.9982                                         IIONEUT  128
        RMIX(9)=7.0E-06                                         IIONEUT  129
           S(9)=4.0E-08                                         IIONEUT  130
      SYMBOL(10)=10H OH                                         IIONEUT  131
        ATWT(10)=17.00737                                       IIONEUT  132
        RMIX(10)=1.0E-10                                        IIONEUT  133
           S(10)=3.0E-08                                        IIONEUT  134
      SYMBOL(11)=10H H                                          IIONEUT  135
       THERM(11)=1.0-0.39                                       IIONEUT  136
       POLAR(11)=0.667                                          IIONEUT  137
        ATWT(11)=1.00797                                        IIONEUT  138
        RMIX(11)=1.6E-13                                        IIONEUT  139
           S(11)=3.04E-08                                       IIONEUT  140
      SYMBOL(12)=10H HO2                                        IIONEUT  141
        ATWT(12)=33.00677                                       IIONEUT  142
        RMIX(12)=1.0E-12                                        IIONEUT  143
           S(12)=4.0E-08                                        IIONEUT  144
      SYMBOL(13)=10H H2O                                        IIONEUT  145
        ATWT(13)=18.01534                                       IIONEUT  146
        RMIX(13)=5.0E-06                                        IIONEUT  147
           S(13)=3.5E-08                                        IIONEUT  148
      SYMBOL(14)=10H H2O2                                       IIONEUT  149
        ATWT(14)=34.01474                                       IIONEUT  150
        RMIX(14)=1.0E-10                                        IIONEUT  151
           S(14)=4.0E-08                                        IIONEUT  152
      SYMBOL(15)=10H H2                                         IIONEUT  153
       THERM(15)=1.0-0.31                                       IIONEUT  154
       POLAR(15)=0.82                                           IIONEUT  155
        ATWT(15)=2.01594                                        IIONEUT  156
        RMIX(15)=4.5E-07                                        IIONEUT  157
           S(15)=2.97E-08                                       IIONEUT  158
      SYMBOL(16)=10H N                                          IIONEUT  159
       POLAR(16)=1.1                                            IIONEUT  160
        ATWT(16)=14.006732                                      IIONEUT  161
        RMIX(16)=1.0E-11                                        IIONEUT  162
           S(16)=1.42E-08                                       IIONEUT  163
      SYMBOL(17)=10H N2D                                        IIONEUT  164
       POLAR(17)=1.1                                            IIONEUT  165
        ATWT(17)=14.006732                                      IIONEUT  166
        RMIX(17)=1.0E-16                                        IIONEUT  167
           S(17)=1.42E-08                                       IIONEUT  168
      SYMBOL(18)=10H NO                                         IIONEUT  169
       POLAR(18)=1.74                                           IIONEUT  170
        ATWT(18)=30.006132                                      IIONEUT  171
        RMIX(18)=1.0E-11                                        IIONEUT  172
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      S(18)=3.4E-08                                          IIONEUT  173
   SYMBOL(19)=10H NO2                                        IIONEUT  174
     ATWT(19)=46.005532                                      IIONEUT  175
     RMIX(19)=1.0E-11                                        IIONEUT  176
        S(19)=3.8E-08                                        IIONEUT  177
   SYMBOL(20)=10H O21D                                       IIONEUT  178
    POLAR(20)=1.59                                           IIONEUT  179
     ATWT(20)=31.9988                                        IIONEUT  180
     RMIX(20)=2.0E-06                                        IIONEUT  181
        S(20)=3.3E-08                                        IIONEUT  182
   SYMBOL(21)=10H HELIUM                                     IIONEUT  183
    THERM(21)=1.0-0.36                                       IIONEUT  184
    POLAR(21)=0.21                                           IIONEUT  185
     ATWT(21)=4.0026                                         IIONEUT  186
     RMIX(21)=5.24E-06                                       IIONEUT  187
        S(21)=2.04E-08                                       IIONEUT  188
   SYMBOL(22)=10H ARGON                                      IIONEUT  189
     ATWT(22)=39.948                                         IIONEUT  190
     RMIX(22)=0.00934                                        IIONEUT  191
        S(22)=2.97E-08                                       IIONEUT  192
   SYMBOL(23)=10H N2                                         IIONEUT  193
    POLAR(23)=1.76                                           IIONEUT  194
     ATWT(23)=28.013464                                      IIONEUT  195
     RMIX(23)=0.78                                           IIONEUT  196
        S(23)=3.15E-08                                       IIONEUT  197
   SYMBOL(24)=10H N2O                                        IIONEUT  198
    POLAR(24)=3.00                                           IIONEUT  199
     ATWT(24)=44.012864                                      IIONEUT  200
     RMIX(24)=2.7E-07                                        IIONEUT  201
        S(24)=3.7E-08                                        IIONEUT  202
   SYMBOL(25)=10H CO2                                        IIONEUT  203
    POLAR(25)=2.63                                           IIONEUT  204
     ATWT(25)=44.00995                                       IIONEUT  205
     RMIX(25)=3.14E-04                                       IIONEUT  206
        S(25)=3.8E-08                                        IIONEUT  207
   SYMBOL(26)=10H CO                                         IIONEUT  208
    POLAR(26)=1.97                                           IIONEUT  209
     ATWT(26)=28.01055                                       IIONEUT  210
     RMIX(26)=1.0E-08                                        IIONEUT  211
        S(26)=3.0E-08                                        IIONEUT  212
C                                                            IIONEUT  213
C  THE FOLLOWING SPECIES ARE COMPUTED FROM CHEMISTRY ONLY.   IIONEUT  214
C                                                            IIONEUT  215
   SYMBOL(27)=10H O1D                                        IIONEUT  216
   SYMBOL(28)=10H N2+                                        IIONEUT  217
   SYMBOL(29)=10H O+(2D)                                     IIONEUT  218
   SYMBOL(30)=10H E                                          IIONEUT  219
   SYMBOL(31)=10H O-                                         IIONEUT  220
   SYMBOL(32)=10H O2-                                        IIONEUT  221
   SYMBOL(33)=10H O3-                                        IIONEUT  222
   SYMBOL(34)=10H O4-                                        IIONEUT  223
   SYMBOL(35)=10H NO2-                                       IIONEUT  224
   SYMBOL(36)=10H NO3-                                       IIONEUT  225
   SYMBOL(37)=10H CO3-                                       IIONEUT  226
   SYMBOL(38)=10H CO4-                                       IIONEUT  227
   SYMBOL(39)=10H O4+                                        IIONEUT  228
   SYMBOL(40)=10H NO2+                                       IIONEUT  229
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      SYMBOL(41)=10H H3O+                                                IIONEUT
      SYMBOL(42)=10H H5O2+                                               IIONEUT
      SYMBOL(43)=10H H7O3+                                               IIONEUT
      SYMBOL(44)=10H H9O4+                                               IIONEUT
      SYMBOL(45)=10H H11O5+                                              IIONEUT
      SYMBOL(46)=10H H3O+.N2                                             IIONEUT
      SYMBOL(47)=10H H3O+.OH                                             IIONEUT
      SYMBOL(48)=10H H3O+.CO2                                            IIONEUT
      SYMBOL(49)=10H H5O2+.CO2                                           IIONEUT
      SYMBOL(50)=10H O2+.H2O                                             IIONEUT
      SYMBOL(51)=10H NO+.H2O                                             IIONEUT
      SYMBOL(52)=10H NO+.2H2O                                            IIONEUT
      SYMBOL(53)=10H NO+.3H2O                                            IIONEUT
      SYMBOL(54)=10H NO+.CO2                                             IIONEUT
      SYMBOL(55)=10H HNO2                                                IIONEUT
      SYMBOL(56)=10H NO3                                                 IIONEUT
      SUMMIX=0.                                                          IIONEUT
      DO 2 I=1,KSPECI                                                    IIONEUT
      MASS(I)=ATWT(I)*ATCON                                              IIONEUT
      IF(I .EQ. 23) GO TO 2                                              IIONEUT
      SUMMIX=SUMMIX+RMIX(I)                                              IIONEUT
2     CONTINUE                                                           IIONEUT
      RMIX(23)=1.0-SUMMIX                                                IIONEUT
C                                                                        IIONEUT
C  READ CHEMICAL REACTIONS AND RATE CONSTANTS.                           IIONEUT
C                                                                        IIONEUT
      WRITE(6,650)                                                       IIONEUT
650   FORMAT(1H0,*  THE CHEMICAL REACTIONS USED IN THIS RUN ARE:*)       IIONEUT
      DO 765 J=1,NREAC                                                   IIONEUT
      READ(5,770) IREAC,(CYMB(I,J),I=1,6),DK(J)                          IIONEUT
770   FORMAT(I3,5A10,A5,1PE8.2)                                          IIONEUT
      WRITE(6,771) IREAC,(CYMB(I,J),I=1,6),DK(J)                         IIONEUT
771   FORMAT(2X,I3,5A10,A5,1PE9.2)                                       IIONEUT
  765 CONTINUE                                                           IIONEUT
      DO 35 J=1,NREAC2                                                   IIONEUT
      READ(5,772) IREAC,(CYMB(I,NREAC+J),I=1,6),AK(J),BK(J),CK(J)        IIONEUT
772   FORMAT(I3,5A10,A5,1PE8.2,0PF5.2,1PE9.2)                            IIONEUT
      WRITE(6,773) IREAC,(CYMB(I,NREAC+J),I=1,6),AK(J),BK(J),CK(J)       IIONEUT
773   FORMAT(2X,I3,5A10,A5,1PE9.2,0PF6.2,1PE10.2)                        IIONEUT
35    CONTINUE                                                           IIONEUT
C                                                                        IIONEUT
C  READ PHOTODISSOCIATION RATE COEFFICIENTS AS LOG BASE 10.              IIONEUT
C                                                                        IIONEUT
      REWIND 3                                                           IIONEUT
      READ(3) ((J193(L,M),L=1,28),M=1,26)                                IIONEUT
      READ(3) ((J192(L,M),L=1,26),M=1,25)                                IIONEUT
      READ(3) ((J196(L,M),L=1,31),M=1,30)                                IIONEUT
      READ(3) ((J197(L,M),L=1,27),M=1,28)                                IIONEUT
      READ(3) ((J195(L,M),L=1,32),M=1,28)                                IIONEUT
      READ(3) (J194(L),L=1,22)                                           IIONEUT
      READ(3) ((J200(L,M),L=1,19),M=1,15)                                IIONEUT
      READ(3) (J205(L),L=1,22)                                           IIONEUT
      READ(3) ((J201(L,M),L=1,26),M=1,27)                                IIONEUT
      READ(3) ((N(L,M),L=1,26),M=1,25)                                   IIONEUT
      READ(3) (J202(L),L=1,22)                                           IIONEUT
      READ(3) ((N(L,M),L=1,26),M=1,23)                                   IIONEUT
      READ(3) ((N(J,M),L=1,30),M=1,30)                                   IIONEUT
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      READ(3) ((J203(L,M),L=1,30),M=1,29)
      READ(3) ((J204(L,M),L=1,35),M=1,28)
      READ(3) ((N(L,M),L=1,37),M=1,20)
      READ(3) ((J198(L,M),L=1,26),M=1,28)
C
C  COMPUTE INVARIANT PART OF COLLISION FREQUENCIES.
C
      DO 22 I=1,KSPECI
      DO 22 J=1,KSPECI
      D(J,I)=0.5*((S(I)+S(J))**2)*SQRT(2.0*PI*BOLTZ*((MASS(I)+MASS(J))
     1        /(MASS(I)*MASS(J))))
22    CONTINUE
      IFRAM=IFRAME-1
      REWIND 4
      READ(4) DATEOF,IFRAME,TURB,(N(J,1),J=1,6),K,K2,(Z(J),J=1,K)
      READ(4) (DELTAZ(L),L=1,K)
      READ(4) (TEMP(L),L=1,K)
      READ(4) (DTEMDZ(L),L=1,K)
      READ(4) (DEDY(L),L=1,K)
      DO 1 J=1,K
      DEDY(J)=3.0*DEDY(J)
1     CONTINUE
      DO 5 L=1,KSPECI
      READ(4) (U(J,L),J=1,K)
5     CONTINUE
      DO 20 L=1,ISPECI
      IF(L .GT. 30) GO TO 10
      READ(4) (N(J,L),J=1,K)
      GO TO 20
10    READ(4) (CONC(J,L-30),J=1,K2)
20    CONTINUE
      KMIN1=K-1
13    READ(4)
      IF(EOF(4)) 14,13
14    IF(IFRAM .EQ. 0) GO TO 15
      DO 140 I=1,IFRAM
      READ(4) DATEOF,IFRAME,TIME,SCXI,CXI,DELT,TIMOUT
      DO 18 L=1,KSPECI
      READ(4) (U(J,L),J=1,K)
18    CONTINUE
      DO 19 L=1,ISPECI
      IF(L .GT. 30) GO TO 11
      READ(4) (N(J,L),J=1,K)
      GO TO 19
11    READ(4) (CONC(J,L-30),J=1,K2)
19    CONTINUE
16    READ(4)
      IF(EOF(4)) 140,16
140   CONTINUE
15    CXI=ACOS(COSD*COS(RADSEC*TIME)+SIND)
      CXINOON=ACOS(COSD+SIND)
      SCXI=CXI*DEGRAD
      DO 4 J=1,K
      IF(Z(J) .GT. TURB) GO TO 6
4     CONTINUE
6     ITURB=J-1
C
```

```
C  READ WAVELENGTH, FLUX AND CROSS SECTION DATA FOR PHOTOIONIZATION.
C
      READ(5,200) (WAVE(L),FLUX(L),(SIGMA(I,L),I=1,8),L=1,88)
200   FORMAT(A8,9F8.4)
      READ(5,205) (FLUX(J),J=84,88)
205   FORMAT(5E9.2)
      DO 220 L=1,88
      IF(L .GE. 84) GO TO 210
      FLUX(L)=FLUX(L)*1.0E+09
210   DO 215 I=1,8
      SIGMA(I,L)=SIGMA(I,L)*1.0E-18
215   CONTINUE
      SIGMA(9,L)=SIG(L)*1.0E-18
220   CONTINUE
C
C  READ RATE COEFFICIENTS FOR ENERGETIC ELECTRON REACTIONS.
C
      READ(5,225) (((R(J,I,L),J=1,8),I=1,4),L=1,8)
225   FORMAT(1P4E12.5)
C
C  COMPUTE SUNSET CHI ANGLES AS A FUNCTION OF ALTITUDE AND TIME
C  OF SUNSET(TSET) AT THE LOWER BOUNDARY AND TIME OF SUNRISE AT THE
C  UPPER BOUNDARY(TRISE).  TIMES ARE IN SECONDS AFTER NOONTIME.
C
C     GEORAD  = GEOMETRIC RADIUS OF EARTH IN KM
C               USE SWIDER PLANET SPACE SCI 1964,V12,P766,TABLE 1
C               ASSUME EARTH LOCALLY SPHERICAL FOR SUNSET/SUNRISE
C               (NEGLECT LATITUDE CHANGE WHERE RAYPATH TANGENT EARTH)
C
      AE=6378.4
      AP = 6356.9
      GEORAD=AE/SQRT(1.0+(((AE/AP)**2-1.0)*SIN(PHILAT)**2))
      DO 3015 J=1,K
      SUNSET(J)=(PI/2.0)+ACOS(1.0/(1.0+Z(J)/GEORAD))
      EPSILON=2.0**(-20)
3025  TS=(ACOS((COS(SUNSET(J))-SIND)/COSD)/RADSEC)+EPSILON
      TR=86400.-TS+2.0*EPSILON
      CHIS=ACOS(COSD*COS(RADSEC*TS)+SIND)
      IF(CHIS .GT. SUNSET(J)) GO TO 3027
 3026 EPSILON=2*EPSILON
      GOTO 3025
3027  CHIR=ACOS(COSD*COS(RADSEC*TR)+SIND)
      IF(CHIR .GE. SUNSET(J)) GO TO 3026
      IF(J .EQ. 1) TSET=TS
      IF(J .EQ. K) TRISE=TR
3015  CONTINUE
C
C WRITE OUT INITIAL PROFILES.
C
      N1=1
      N2=11
      DO 100 L=1,2
      WRITE(6,605)
      WRITE(6,315) TIME,SCXI,IFRAME
      WRITE(6,610) (SYMBOL(M),M=N1,N2)
      WRITE(6,320) (Z(J),(N(J,M),M=N1,N2),J=1,K,12)
      WRITE(6,320) Z(K),(N(K,M),M=N1,N2)
```

```
      N1=12
      N2=22
  100 CONTINUE
      WRITE(6,605)
      WRITE(6,315) TIME,SCXI,IFRAME
      WRITE(6,611) (SYMBOL(J),J=23,30)
      WRITE(6,320) (Z(J),(N(J,I),I=23,30),TEMP(J),DTEMDZ(J),DEDY(J),
     1J=1,K,12)
      WRITE(6,320) Z(KMIN1),(N(KMIN1,I),I=23,30),TEMP(KMIN1),
     1DTEMDZ(KMIN1),DEDY(KMIN1)
      WRITE(6,320) Z(K),(N(K,I),I=23,30),TEMP(K),DTEMDZ(K),DEDY(K)
  511 FORMAT(*  ALT(KM)*,4X,8A10,*TEMP    (1/T)DT/DZ   K-EDDY*)
      WRITE(6,605)
      WRITE(6,315) TIME,SCXI,IFRAME
      WRITE(6,125) (SYMBOL(M),M=31,43)
  125 FORMAT(*  ALT(KM)*,13A9)
      WRITE(6,130) (Z(J),(CONC(J,M),M=1,13),J=1,K2,12)
      WRITE(6,130) Z(K2),(CONC(K2,M),M=1,13)
  130 FORMAT(0PF8.2,1X,1P13E9.2)
      WRITE(6,605)
      WRITE(6,315) TIME,SCXI,IFRAME
      WRITE(6,125) (SYMBOL(M),M=44,56)
      WRITE(6,130) (Z(J),(CONC(J,M),M=14,26),J=1,K2,12)
      WRITE(6,130) Z(K2),(CONC(K2,M),M=14,26)
  605 FORMAT(1H1,60X17HINITIAL PROFILES.)
  610 FORMAT(*  ALT(KM)*,11A10)
  315 FORMAT(1H ,10X,*TIME =*,1PE12.5,* SEC.*,10X,*CXI =*,E12.5,
     1* DEGREES.*,10X,*FRAME NO.*,I4)
  320 FORMAT(0PF8.2,2X,1P11E10.3)
      WRITE(6,325) TIMOUT
  325 FORMAT(1H0,*  TIMOUT =*,1PE13.5)
      END
```

```
      OVERLAY(2,0)                                                      GIONEUT    2
      PROGRAM INTEG                                                     GIONEUT    3
C                                                                       GIONEUT    4
      DIMENSION PHI(1),DED(1),DEDZ(1),DFDZ(1),VBAR(1),H(692)            GIONEUT    5
      DIMENSION OUTP(4),IWHICH(26),ITER(26),BIGEST(26),NSPEC(56)        GIONEUT    6
C                                                                       GIONEUT    7
      COMMON N(692,30),CONC(424,26),U(692,26),NZERO(692),UZERO(692)     GIONEUT    8
C                                                                       GIONEUT    9
      COMMON FORM(692),REMV(692),E(692),F(692),Z(692),                  GIONEUT   10
     2       DEDY(692),TEMP(692),DTEMDZ(692),DELTAZ(692),SUNSET(692)    GIONEUT   11
C                                                                       GIONEUT   12
      COMMON GRAV,COSD,SIND,TIME,CXI,RADIUS,ISPECI,KSPECI,NREAC,K,      GIONEUT   13
     1       K2,KMIN1,ITURB,CXINOON,SCXI,NREAC2                         GIONEUT   14
C                                                                       GIONEUT   15
      COMMON/ESN/OLDN(692,30),OLDCON(424,26),OLDU(692,26),RATES(88,692) GIONEUT   16
C                                                                       GIONEUT   17
      COMMON/TIMES/DAYS,DELT,TMAX,TSET,TRISE                            GIONEUT   18
C                                                                       GIONEUT   19
      COMMON/ALTITUD/ZSET,ZTOP,TURB,ZTRANS                              GIONEUT   20
C                                                                       GIONEUT   21
      COMMON/RESTART/IFRAME,TOFF,TYME,TODAY                             GIONEUT   22
C                                                                       GIONEUT   23
      COMMON/OUTPUTS/TIMOUT,OPRINT,PRINT                                GIONEUT   24
C                                                                       GIONEUT   25
      COMMON/ERRORS/ERRMAX,ERSPECI,ITMAX                                GIONEUT   26
C                                                                       GIONEUT   27
      COMMON/LOGIC/NIGHT,DAY,JLOOK,RESET,END                            GIONEUT   28
C                                                                       GIONEUT   29
      COMMON/ATCONS/ATWT(26),MASS(26),THERM(26),SYMBOL(56),POLAR(26)    GIONEUT   30
C                                                                       GIONEUT   31
      COMMON/CONSTAN/PI,RADDEG,DEGRAD,RADSEC,BOLTZ,SIN2I,ATCON          GIONEUT   32
C                                                                       GIONEUT   33
      COMMON/COLUM/O2COL,O3COL,DIS(19,59)                               GIONEUT   34
C                                                                       GIONEUT   35
      COMMON/RATECON/AK(88),BK(88),CK(88),DK(215),CYMB(6,215)           GIONEUT   36
C                                                                       GIONEUT   37
      LEVEL 3, OLDN,OLDCON,OLDU,RATES                                   GIONEUT   38
      REAL N,NZERO,NEWN,MASS,MBAR,NTOTAL                                GIONEUT   39
      LOGICAL JLOOK,NIGHT,DAY,RESET,PRINT,END,LASTNT,LASTDA             GIONEUT   40
      EQUIVALENCE (U(1,21),H,PHI),(E,DED),(F,VBAR),(NZERO,DEDZ)         GIONEUT   41
      EQUIVALENCE (UZERO,DFDZ)                                          GIONEUT   42
C                                                                       GIONEUT   43
      DATA NSWTCH/1/                                                    GIONEUT   44
C                                                                       GIONEUT   45
C  FUNCTION DEFINITION FOR CORRECTION TO ACCELERATION OF GRAVITY.       GIONEUT   46
C                                                                       GIONEUT   47
      GRAVCOR(ZZ)=1.0/((1.0+ZZ/RADIUS)**2)                              GIONEUT   48
C                                                                       GIONEUT   49
C  IF ANY SMOOTHING IS TO BE DONE, SET NUM TO THE NUMBER OF SPECIES     GIONEUT   50
C  TO BE SMOOTHED AND PUT THEIR SPECI NUMBERS INTO THE NSPEC REGION.    GIONEUT   51
C  IF NO SMOOTHING IS TO BE DONE, SET NUM TO ZERO.                      GIONEUT   52
C                                                                       GIONEUT   53
      NUM=0                                                             GIONEUT   54
      END=.FALSE.                                                       GIONEUT   55
      JLOOK=.TRUE.                                                      GIONEUT   56
      DAY=TIME.LT.SUNSET(1)                                             GIONEUT   57
      NIGHT=TIME.GT.SUNSET(K)                                           GIONEUT   58
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```
      EDDYL=EDDY
      EDDY=DEDY(J)
      DZDZ=1.0/(DZ*DZL)
      DZODZL=DZ/DZL
      IF(J .GT. ITURB) GO TO 15
      TTL=0.
      WBAR=0.
      DO 10 L=1,KSPECI
      EN=N(J,L)
      WBAR=WBAR+MASS(L)*EN
      TTL=TTL+EN
   10 CONTINUE
      WBAR=WBAR/TTL
      GAMBAL=GAMBA
      GAMBA=1.0-(DLNTDZ+GRAV*GCRN*WBAR/(BOLTZ*T))*DZ
   15 DTDZ=DELT*DZDZ
      IF(J .EQ. 1) GO TO 20
      AJ=DTDZ*(PJ*DTKTM+EDDY)
      BJ=1.0+DTDZ*(PJ*(UJ*DZ+DTKTM*GAM)+PJL*DTKTML*DZODZL
     1   +EDDY*GAMBA+EDDYL*DZODZL)+(REMV(J)+PJ*SNUW*DELT/DZL)*DELT
      CJ=DTDZ*(PJL*(UJL*DZ+DTKTML*GAML*DZODZL)+EDDYL*GAMBAL*DZODZL)
     1   +(PJL*SNUWL*DELT/DZL)*DELT
      GO TO 35
C
C COMPUTE LOWER BOUNDARY VALUES OF E AND F USING THE LOWER
C BOUNDARY CONDITIONS.
C
   20 EJL=0.
      IF((I.EQ.8).OR.(I.EQ.13).OR.(I.EQ.15).OR.(I.EQ.21)) GO TO 30
      IF((I.EQ. 22).OR.(I.EQ.23)) GO TO 30
      FJL=(NZERO(1)+DELT*FORM(1))/(1.0+DELT*REMV(1))
      GO TO 70
   30 FJL=N(1,I)
      GO TO 70
   35 IF(J .EQ. K) GO TO 50
      DENOM=1.0/(BJ-CJ*EJL)
      EJL=AJ*DENOM
      DJ=NZERO(J)+DELT*FORM(J)
      FJL=(DJ+CJ*FJL)*DENOM
      GO TO 70
C
C COMPUTE UPPER BOUNDARY VALUES OF E AND F USING THE UPPER
C BOUNDARY CONDITIONS.
C
   50 DJ=NZERO(K)+DELT*FORM(K)
   56 VEL(I)=0.
      IF((I.EQ.4).OR.(I.EQ.5).OR.(I.EQ.9)) GO TO 57
      IF(I .EQ. 11) GO TO 57
      IF((I.GE.12).AND.(I.LE.15)) GO TO 57
      IF((I.EQ.10).OR.(I.EQ.19).OR.(I.EQ.20).OR.(I.EQ.22)) GO TO 57
      IF((I.GE.27).AND.(I.LE.29)) GO TO 57
      CALL VELOCTY(I)
   57 IF(ICF .LT. 0) GO TO 65
      IF(I .EQ. 11) GO TO 80
      CALL DIFFRE(I,K,SNU,SNUW,OMEG)
      SS=SNUW-VEL(I)*SNU
      FJL=(DJ+CJ*FJL)/(BJ-AJ*(GAM+SS*(DELTAZ(K)*WGT/(BOLTZ*TEMP(K)))))
```

```
      SUBROUTINE EFORU(ICF)                                             GIONEUT  757
C                                                                       GIONEUT  758
C  IF(IFC .GT. 0), COMPUTE THE E AND F ARRAYS.                          GIONEUT  759
C  IF(ICF .LT. 0), COMPUTE THE SPECIFIC VELOCITIES.                     GIONEUT  760
C                                                                       GIONEUT  761
      DIMENSION H(1)                                                    GIONEUT  762
C                                                                       GIONEUT  763
      COMMON N(692,30),CONC(424,26),U(692,26),NZERO(692),UZERO(692)    GIONEUT  764
C                                                                       GIONEUT  765
      COMMON FORM(692),REMV(692),E(692),F(692),Z(692),                  GIONEUT  766
     2       DEDY(692),TEMP(692),DTEMDZ(692),DELTAZ(692),SUNSET(692)    GIONEUT  767
C                                                                       GIONEUT  768
      COMMON GRAV,COSD,SIND,TIME,CXI,RADIUS,ISPECI,KSPECI,NREAC,K,      GIONEUT  769
     1       K2,KMIN1,ITURB,CXINOON,SCXI,NREAC2                         GIONEUT  770
C                                                                       GIONEUT  771
      COMMON/TIMES/DAYS,DELT,TMAX                                       GIONEUT  772
C                                                                       GIONEUT  773
      COMMON/ALTITUD/ZBOT,ZTOP,TURB,TURBVAR                             GIONEUT  774
C                                                                       GIONEUT  775
      COMMON/BOUNDRY/VEL(26)                                            GIONEUT  776
C                                                                       GIONEUT  777
      COMMON/CONSTAN/PI,RADDEG,DEGRAD,RADSEC,BOLTZ,SIN2I,ATCON          GIONEUT  778
C                                                                       GIONEUT  779
      COMMON/ATCONS/ATWT(26),MASS(26),THERM(26),SYMBOL(56),POLAR(26)    GIONEUT  780
C                                                                       GIONEUT  781
      REAL N,NZERO,MASS                                                 GIONEUT  782
      EQUIVALENCE (U(1,21),H)                                           GIONEUT  783
C                                                                       GIONEUT  784
      I=ICF                                                             GIONEUT  785
      IF(I .GT. 0) GO TO 1                                              GIONEUT  786
      I=-I                                                              GIONEUT  787
    1 WGT=MASS(I)                                                       GIONEUT  788
      GMOVK=GRAV*WGT/BOLTZ                                              GIONEUT  789
      DTKOVM=DELT*BOLTZ/WGT                                             GIONEUT  790
      DZ=1.5E+04                                                        GIONEUT  791
      DO 75 J=1,K                                                       GIONEUT  792
      ZE=Z(J)                                                           GIONEUT  793
      T=TEMP(J)                                                         GIONEUT  794
      DZL=DZ                                                            GIONEUT  795
      DZ=DELTAZ(J)                                                      GIONEUT  796
      DLNTDZ=DTEMDZ(J)                                                  GIONEUT  797
      IF(I .GT. 6) GO TO 6                                              GIONEUT  798
      DLNTDZ=2.0*DLNTDZ                                                 GIONEUT  799
    6 GCRN=1.0/((1.0+ZE/RADIUS)**2)                                     GIONEUT  800
      DTKTML=DTKTM                                                      GIONEUT  801
      DTKTM=DTKOVM*T                                                    GIONEUT  802
      GAML=GAM                                                          GIONEUT  803
      GAM=1.0-(THERM(I)*DLNTDZ+GCRN*GMOVK/T)*DZ                         GIONEUT  804
      IF(I .GT. 6) GO TO 11                                             GIONEUT  805
      GAM=GAM-H(J)*DZ                                                   GIONEUT  806
   11 PJL=PJ                                                            GIONEUT  807
      SNUWL=SNUW                                                        GIONEUT  808
      CALL COLFRE(I,J,SNU,SNUW,OMEG)                                    GIONEUT  809
      PJ=1.0/(1.0+SNU*OMEG*DELT)                                        GIONEUT  810
      UJL=UJ                                                            GIONEUT  811
      UJ=UZERO(J)                                                       GIONEUT  812
      IF(ICF .LT. 0) GO TO 60                                           GIONEUT  813
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      SUBROUTINE CO(J,RHO,NTOTAL,MBAR,VO)                               GIONEUT  724
C                                                                       GIONEUT  725
C  THIS SUBROUTINE COMPUTES THE TOTAL MASS DENSITY, RHO, THE TOTAL      GIONEUT  726
C  CONCENTRATION, NTOTAL, THE MEAN MOLECULAR WEIGHT, MBAR, AND THE      GIONEUT  727
C  MEAN MASS VELOCITY, VO, AT ALTITUDE WHERE THE INDEX IS J.            GIONEUT  728
C                                                                       GIONEUT  729
      COMMON N(692,30),CONC(424,26),U(692,26),NZERO(692),UZERO(692)     GIONEUT  730
C                                                                       GIONEUT  731
      COMMON FORM(692),REMV(692),E(692),F(692),Z(692),                  GIONEUT  732
     2       DEM(692),TEMP(692),DTEMDZ(692),DELTAZ(692),SUNSET(692)     GIONEUT  733
C                                                                       GIONEUT  734
      COMMON GRAV,COSD,SIND,TIME,CXI,RADIUS,ISPECI,KSPECI,NREAC,K,      GIONEUT  735
     1       K2,KMIN1,ITURB,CXINOON,SCXI,NREAC2                         GIONEUT  736
C                                                                       GIONEUT  737
      COMMON/ATCONS/ATWT(26),MASS(26),THERM(26),SYMBOL(56),POLAR(26)    GIONEUT  738
C                                                                       GIONEUT  739
      REAL N,MBAR,NTOTAL,MASS                                           GIONEUT  740
C                                                                       GIONEUT  741
      RHO=0.                                                            GIONEUT  742
      NTOTAL=0.                                                         GIONEUT  743
      RHOC=0.                                                           GIONEUT  744
      DO 5 M=1,KSPECI                                                   GIONEUT  745
      EN=N(J,M)                                                         GIONEUT  746
      ENM=MASS(M)*EN                                                    GIONEUT  747
      RHO=RHO+ENM                                                       GIONEUT  748
      NTOTAL=NTOTAL+EN                                                  GIONEUT  749
      IF(M .EQ. 21) GO TO 5                                             GIONEUT  750
      RHOC=RHOC+ENM*U(J,M)                                              GIONEUT  751
    5 CONTINUE                                                          GIONEUT  752
      MBAR=RHO/NTOTAL                                                   GIONEUT  753
      VO=RHOC/RHO                                                       GIONEUT  754
      RETURN                                                            GIONEUT  755
      END                                                               GIONEUT  756
```

```
      SUBROUTINE SMOOTH(A,N,M,B)                                        GIONEUT   675
C                                                                       GIONEUT   676
C  THIS SUBROUTINE SMOOTHS ARRAY A OF N POINTS WITH AN M POINT          GIONEUT   677
C  RUNNING MEAN.  THE SMOOTHED ARRAY IS STORED IN B.                    GIONEUT   678
C                                                                       GIONEUT   679
      DIMENSION A(1),B(1)                                               GIONEUT   680
C                                                                       GIONEUT   681
      IF(M .EQ. 0) GO TO 10                                             GIONEUT   682
      I=(M-1)/2                                                         GIONEUT   683
      K=N-M+1                                                           GIONEUT   684
      C=M                                                               GIONEUT   685
      DO 2 J=1,K                                                        GIONEUT   686
      S=0.                                                              GIONEUT   687
      JJ=J+M-1                                                          GIONEUT   688
      DO 1 L=J,JJ                                                       GIONEUT   689
    1 S=S+A(L)                                                          GIONEUT   690
      JAY=J+I                                                           GIONEUT   691
    2 B(JAY)=S/C                                                        GIONEUT   692
      I1=0                                                              GIONEUT   693
      K=M-2                                                             GIONEUT   694
    3 C=K                                                               GIONEUT   695
      S=0.                                                              GIONEUT   696
      DO 4 J=1,K                                                        GIONEUT   697
    4 S=S+A(J)                                                          GIONEUT   698
      JAY=I-I1                                                          GIONEUT   699
      B(JAY)=S/C                                                        GIONEUT   700
      K=K-2                                                             GIONEUT   701
      I1=I1+1                                                           GIONEUT   702
      IF(K .NE. 1) GO TO 3                                              GIONEUT   703
      I1=1                                                              GIONEUT   704
      K=N-M+3                                                           GIONEUT   705
      C=M-2                                                             GIONEUT   706
    5 S=0.                                                              GIONEUT   707
      DO 6 J=K,N                                                        GIONEUT   708
    6 S=S+A(J)                                                          GIONEUT   709
      JAY=N-I+I1                                                        GIONEUT   710
      B(JAY)=S/C                                                        GIONEUT   711
      K=K+2                                                             GIONEUT   712
      C=C-2.                                                            GIONEUT   713
      I1=I1+1                                                           GIONEUT   714
      IF(K .NE. N) GO TO 5                                              GIONEUT   715
      B(1)=A(1)                                                         GIONEUT   716
      B(N)=A(N)                                                         GIONEUT   717
      RETURN                                                            GIONEUT   718
   10 DO 20 J=1,N                                                       GIONEUT   719
      B(J)=A(J)                                                         GIONEUT   720
   20 CONTINUE                                                          GIONEUT   721
      RETURN                                                            GIONEUT   722
      END                                                               GIONEUT   723
```

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      RETURN                                                            GIONEUT  627
C                                                                       GIONEUT  628
C  ADJUST THE LARGEST NEGATIVE SPECIES CONCENTRATIONS TO                GIONEUT  629
C  INSURE CONSERVATION OF CHARGE.                                       GIONEUT  630
C                                                                       GIONEUT  631
C                                                                       GIONEUT  632
25    DO 50 J=1,K2                                                      GIONEUT  633
      SUMP=0.                                                           GIONEUT  634
      SUMM=0.                                                           GIONEUT  635
      DO 30 I=1,6                                                       GIONEUT  636
      SUMP=SUMP+N(J,I)                                                  GIONEUT  637
30    CONTINUE                                                          GIONEUT  638
      DO 35 I=28,29                                                     GIONEUT  639
      SUMP=SUMP+N(J,I)                                                  GIONEUT  640
35    CONTINUE                                                          GIONEUT  641
      DO 40 I=9,24                                                      GIONEUT  642
      SUMP=SUMP+CONC(J,I)                                               GIONEUT  643
40    CONTINUE                                                          GIONEUT  644
      BIG=N(J,30)                                                       GIONEUT  645
      JBIG=1                                                            GIONEUT  646
      DO 70 I=1,8                                                       GIONEUT  647
      IF(CONC(J,I) .LE. BIG) GO TO 70                                   GIONEUT  648
      BIG=CONC(J,I)                                                     GIONEUT  649
      JBIG=I+1                                                          GIONEUT  650
70    CONTINUE                                                          GIONEUT  651
      DO 75 I=1,9                                                       GIONEUT  652
      IF(I .EQ. JBIG) GO TO 75                                          GIONEUT  653
      IF(I .EQ. 1) SUMM=SUMM+N(J,30)                                    GIONEUT  654
      IF(I .NE. 1) SUMM=SUMM+CONC(J,I-1)                                GIONEUT  655
75    CONTINUE                                                          GIONEUT  656
      BAL=SUMP-SUMM                                                     GIONEUT  657
      IF(BAL .LT. 0.) STOP 7                                            GIONEUT  658
      IF(JBIG .EQ. 1) N(J,30)=BAL                                       GIONEUT  659
      IF(JBIG .NE. 1) CONC(J,JBIG-1)=BAL                                GIONEUT  660
50    CONTINUE                                                          GIONEUT  661
      KK=K2+1                                                           GIONEUT  662
      DO 65 J=KK,K                                                      GIONEUT  663
      SUMP=0.                                                           GIONEUT  664
      DO 55 I=1,6                                                       GIONEUT  665
      SUMP=SUMP+N(J,I)                                                  GIONEUT  666
55    CONTINUE                                                          GIONEUT  667
      DO 60 I=28,29                                                     GIONEUT  668
      SUMP=SUMP+N(J,I)                                                  GIONEUT  669
60    CONTINUE                                                          GIONEUT  670
      N(J,30)=SUMP                                                      GIONEUT  671
65    CONTINUE                                                          GIONEUT  672
      RETURN                                                            GIONEUT  673
      END                                                               GIONEUT  674
```

```
      SUBROUTINE SMOOTHY(NUM,NSPEC)                                     GIONEUT  570
C                                                                       GIONEUT  571
C  THIS SUBROUTINE SMOOTHS SPECIFIED PROFILES WITH AN 'IRUN' POINT      GIONEUT  572
C  RUNNING MEAN.                                                        GIONEUT  573
C                                                                       GIONEUT  574
      DIMENSION NSPEC(1),ZNEW(792),DENS(792),SMUTHN(1)                  GIONEUT  575
C                                                                       GIONEUT  576
      COMMON N(692,30),CONC(424,26),U(692,26),NZERO(692),UZERO(692)     GIONEUT  577
C                                                                       GIONEUT  578
      COMMON FORM(692),REMV(692),E(692),F(692),Z(692),                  GIONEUT  579
     2       DEDY(692),TEMP(692),DTEMDZ(692),DELTAZ(692),SUNSET(692)    GIONEUT  580
C                                                                       GIONEUT  581
      COMMON GRAV,COSD,SIND,TIME,CXI,RADIUS,ISPECI,KSPECI,NREAC,K,      GIONEUT  582
     1       K2,KMIN1,ITURB,CXINCON,SCXI,NREAC2                         GIONEUT  583
C                                                                       GIONEUT  584
      COMMON/ATCONS/ATWT(26),MASS(26),THERM(26),SYMBOL(56),POLAR(26)    GIONEUT  585
C                                                                       GIONEUT  586
      COMMON/CONSTAN/PI,RADDEG,DEGRAD,RADSEC,BOLTZ,SIN2I,ATCON          GIONEUT  587
C                                                                       GIONEUT  588
      REAL N,NZERO,MASS                                                 GIONEUT  589
C                                                                       GIONEUT  590
      EQUIVALENCE (NZERO,DENS),(FORM,SMUTHN)                            GIONEUT  591
      EQUIVALENCE (E,ZNEW)                                              GIONEUT  592
C                                                                       GIONEUT  593
      DATA IRUN/7/                                                      GIONEUT  594
C                                                                       GIONEUT  595
      IF(NUM .EQ. 0) RETURN                                             GIONEUT  596
C                                                                       GIONEUT  597
      GOVKT=(GRAV*(1.0/((1.0+400./RADIUS)**2)))/(BOLTZ*TEMP(K))         GIONEUT  598
      R=6.35107E+08                                                     GIONEUT  599
      DO 5 J=1,692                                                      GIONEUT  600
      ZNEW(J)=Z(J)                                                      GIONEUT  601
    5 CONTINUE                                                          GIONEUT  602
      DO 6 J=693,792                                                    GIONEUT  603
      ZNEW(J)=ZNEW(692)+FLOAT(J-692)                                    GIONEUT  604
    6 CONTINUE                                                          GIONEUT  605
      DO 15 I=1,NUM                                                     GIONEUT  606
      L=NSPEC(I)                                                        GIONEUT  607
      DO 7 J=1,692                                                      GIONEUT  608
      DENS(J)=N(J,L)                                                    GIONEUT  609
    7 CONTINUE                                                          GIONEUT  610
C                                                                       GIONEUT  611
C  EXTRAPOLATE THE CONCENTRAION OF SPECIES L TO 500 KM ASSUMING         GIONEUT  612
C  DIFFUSIVE EQUILIBRIUM ABOVE THE UPPER BOUNDARY.                      GIONEUT  613
C                                                                       GIONEUT  614
      DO 8 J=693,792                                                    GIONEUT  615
      DENS(J)=DENS(692)*EXP(-(GOVKT*MASS(L)*(ZNEW(J)-400.)*1.0E5)       GIONEUT  616
     1/(((400.*1.0E5/R)+1.0)*((ZNEW(J)*1.0E5/R)+1.0)))                  GIONEUT  617
    8 CONTINUE                                                          GIONEUT  618
      CALL SMOOTH(DENS,792,IRUN,SMUTHN)                                 GIONEUT  619
      DO 10 J=1,K                                                       GIONEUT  620
      N(J,L)=SMUTHN(J)                                                  GIONEUT  621
   10 CONTINUE                                                          GIONEUT  622
   15 CONTINUE                                                          GIONEUT  623
      DO 20 I=1,NUM                                                     GIONEUT  624
      IF(NSPEC(I) .LT. 7) GO TO 25                                      GIONEUT  625
   20 CONTINUE                                                          GIONEUT  626
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```
228   FORMAT(1H0,* DAY IS *,L1,5X,*NIGHT IS *,L1,5X,*DAY-NIGHT*,        GIONEUT   515
     1* TRANSITION HEIGHT IS *,F7.2)                                    GIONEUT   516
      IF(END) GO TO 270                                                 GIONEUT   517
      CALL MOVLEV(U,OLDU,17992)                                         GIONEUT   518
      CALL MOVLEV(N,OLDN,20760)                                         GIONEUT   519
      CALL MOVLEV(CONC,OLDCON,11024)                                    GIONEUT   520
      CALL SECOND(T1)                                                   GIONEUT   521
      GO TO 1000                                                        GIONEUT   522
C                                                                       GIONEUT   523
C  ENTER HERE WHEN TIME IS RUNNING OUT OR SENSE SWITCH ONE IS ON.       GIONEUT   524
C                                                                       GIONEUT   525
230   CXI=OLDCXI                                                        GIONEUT   526
      SCXI=CXI*DEGRAD                                                   GIONEUT   527
      TIME=TIME-DELT                                                    GIONEUT   528
      DELT=OLDELT                                                       GIONEUT   529
      ZTRANS=OLDZTR                                                     GIONEUT   530
      IF(PRINT) TIMOUT=TIMOUT-OPRINT                                    GIONEUT   531
      PRINT=.TRUE.                                                      GIONEUT   532
      END=.TRUE.                                                        GIONEUT   533
      LM=1                                                              GIONEUT   534
      GO TO 235                                                         GIONEUT   535
C                                                                       GIONEUT   536
C  ENTER HERE ON CALCULATION OF A NEGATIVE CONCENTRATION.               GIONEUT   537
C                                                                       GIONEUT   538
  245 KFAIL=2                                                           GIONEUT   539
      J=K                                                               GIONEUT   540
      GO TO 255                                                         GIONEUT   541
  250 KFAIL=3                                                           GIONEUT   542
      J=L                                                               GIONEUT   543
255   WRITE(6,256)KFAIL,SYMBOL(I),Z(J),NEWN,N(J,I),TIME,DELT,SCXI,      GIONEUT   544
     1ITRATE                                                            GIONEUT   545
256   FORMAT(I3,A10,0PF7.1,1P5E20.12,I5)                                GIONEUT   546
C                                                                       GIONEUT   547
C  ENTER HERE ON ERROR FROM SUBROUTINE CHEMION.                         GIONEUT   548
C                                                                       GIONEUT   549
254   TIME=OLDTIME                                                      GIONEUT   550
      END=.FALSE.                                                       GIONEUT   551
      CXI=OLDCXI                                                        GIONEUT   552
      DELT=DELT*0.5                                                     GIONEUT   553
      IF(RESET) GO TO 257                                               GIONEUT   554
      IF(DELT .LT. 2.0**(-40)) 265,258                                  GIONEUT   555
  257 RESET=.FALSE.                                                     GIONEUT   556
      TIMOUT=TIMOUT-OPRINT                                              GIONEUT   557
258   LM=2                                                              GIONEUT   558
235   NIGHT=LASTNT                                                      GIONEUT   559
      DAY=LASTDA                                                        GIONEUT   560
      CALL MOVLEV(OLDN,N,20760)                                         GIONEUT   561
      CALL MOVLEV(OLDCON,CONC,11024)                                    GIONEUT   562
      CALL MOVLEV(OLDU,U,17992)                                         GIONEUT   563
      IF(LM .EQ. 1) 162,1000                                            GIONEUT   564
  265 WRITE(6,345) TIME                                                 GIONEUT   565
  345 FORMAT(30H THE INCREMENT IS VANISHING AT1PE12.5,5H SEC.)          GIONEUT   566
      GO TO 230                                                         GIONEUT   567
  270 CONTINUE                                                          GIONEUT   568
      END                                                               GIONEUT   569
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      WRITE(6,340)                                                      GIONEUT
  340 FORMAT(1H1)                                                       GIONEUT
      WRITE(6,196) TIME,SCXI,IFRAME,IDAY,(OUTP(J),J=1,4)                GIONEUT
      WRITE(6,310)                                                      GIONEUT
  310 FORMAT(*  ALT(KM) NO+/O2+ RATIO MEAN MOL WT  MASS DENSITY*,       GIONEUT
     1*   TOTAL NUMBER    MEAN MASS VEL        K-EDDY*)                 GIONEUT
      DO 325 J=1,K,12                                                   GIONEUT
      CALL CO(J,RHO,NTOTAL,MBAR,VMEAN)                                  GIONEUT
      MBAR=MBAR/ATCON                                                   GIONEUT
      RNOTO2=N(J,5)/N(J,4)                                              GIONEUT
      WRITE(6,330) Z(J),RNOTO2,MBAR,RHO,NTOTAL,VMEAN,DEDY(J)            GIONEUT
  325 CONTINUE                                                          GIONEUT
      CALL CO(KMIN1,RHO,NTOTAL,MBAR,VMEAN)                              GIONEUT
      MBAR=MBAR/ATCON                                                   GIONEUT
      RNOTO2=N(KMIN1,5)/N(KMIN1,4)                                      GIONEUT
      WRITE(6,330) Z(KMIN1),RNOTO2,MBAR,RHO,NTOTAL,VMEAN,DEDY(KMIN1)    GIONEUT
      CALL CO(K,RHO,NTOTAL,MBAR,VMEAN)                                  GIONEUT
      MBAR=MBAR/ATCON                                                   GIONEUT
      RNOTO2=N(K,5)/N(K,4)                                              GIONEUT
      WRITE(6,330) Z(K),RNOTO2,MBAR,RHO,NTOTAL,VMEAN,DEDY(K)            GIONEUT
  330 FORMAT(0PF8.2,1PE13.5,0PF10.3,4(3X,1PE13.5))                      GIONEUT
C                                                                       GIONEUT
C  PRINT LIST OF CHEMICAL REACTIONS WITH THE RATE OF EACH AT            GIONEUT
C  SELECTED ALTITUDES.                                                  GIONEUT
C                                                                       GIONEUT
      CALL CHEMPR(1)                                                    GIONEUT
      CALL CHEMPR(253)                                                  GIONEUT
      CALL CHEMPR(337)                                                  GIONEUT
      CALL CHEMPR(457)                                                  GIONEUT
      CALL CHEMPR(K)                                                    GIONEUT
  160 DELT=AMIN1(2.0*DELT,TMAX)                                         GIONEUT
      IF(.NOT. PRINT) GO TO 161                                         GIONEUT
C                                                                       GIONEUT
C  WRITE INTERRUPT FILE ON TAPE 4.                                      GIONEUT
C                                                                       GIONEUT
      WRITE(4) TODAY,IFRAME,TIME,SCXI,CXI,DELT,TIMOUT                   GIONEUT
      DO 2224 L=1,KSPECI                                                GIONEUT
      WRITE(4) (U(J,L),J=1,K)                                           GIONEUT
 2224 CONTINUE                                                          GIONEUT
      DO 280 L=1,ISPECI                                                 GIONEUT
      IF(L .GT. 30) GO TO 281                                           GIONEUT
      WRITE(4) (N(J,L),J=1,K)                                           GIONEUT
      GO TO 280                                                         GIONEUT
  281 WRITE(4) (CONC(J,L-30),J=1,K2)                                    GIONEUT
  280 CONTINUE                                                          GIONEUT
      ENDFILE 4                                                         GIONEUT
      CALL CLOCK(A1)                                                    GIONEUT
      WRITE(6,315) A1,IFRAME                                            GIONEUT
  315 FORMAT(1H0,A10,* FRAME NO. *,I4,* HAS BEEN WRITTEN ON THE*,       GIONEUT
     1* INTERUPT TAPE.*)                                                GIONEUT
  161 CALL HOUR(TIME,OUTP)                                              GIONEUT
      CALL CLOCK(A1)                                                    GIONEUT
      WRITE(6,227) A1,TIME,DELT,SCXI,ITRATE,(OUTP(J),J=1,4),DTIME       GIONEUT
  227 FORMAT(1H0,A10,* TIME =*,1PE12.5,* SEC.  TIME INCREMENT =*,       GIONEUT
     1E12.5,*  CHI =*,0PF7.2,*  ITERATIONS =*,I4,*  HOUR =*,4A1,        GIONEUT
     2*  CP TIME =*,F10.2,* SEC.*)                                      GIONEUT
      WRITE(6,228) DAY,NIGHT,ZTRANS                                     GIONEUT
```

```
     1*NUMBER   CHEMISTRY CHEMISTRY*,6X,*   ALT    NUMBER    *,               GIONEUT   401
     2*CHEMISTRY CHEMISTRY*)                                                  GIONEUT   402
 201  FORMAT(*    KM    DENSITY  FORMATION REMOVAL*,8X,*    KM    *,          GIONEUT   403
     1*DENSITY  FORMATION REMOVAL*,8X,*    KM   DENSITY*,                     GIONEUT   404
     2*  FORMATION REMOVAL*)                                                  GIONEUT   405
      WRITE(6,200)                                                            GIONEUT   406
      WRITE(6,201)                                                            GIONEUT   407
      WRITE(6,202) (Z(J),CONC(J,I-3),E(J),H(J),Z(J),CONC(J,I-2),F(J),        GIONEUT   408
     1              UZERO(J),Z(J),CONC(J,I-1),FORM(J),REMV(J),J=1,K2,12)      GIONEUT   409
      WRITE(6,202) Z(K2),CONC(K2,I-3),E(K2),H(K2),Z(K2),CONC(K2,I-2),         GIONEUT   410
     1             F(K2),UZERO(K2),Z(K2),CONC(K2,I-1),FORM(K2),REMV(K2)       GIONEUT   411
 202  FORMAT(3(0PF7.2,1P3E10.3,6X))                                           GIONEUT   412
 210  CONTINUE                                                                GIONEUT   413
      I=25                                                                    GIONEUT   414
      DO 237 LL=1,2                                                           GIONEUT   415
      DO 211 J=1,K2                                                           GIONEUT   416
      CALL CHEM(I+30,J)                                                       GIONEUT   417
      REMV(J)=REMV(J)*CONC(J,I)                                               GIONEUT   418
 211  CONTINUE                                                                GIONEUT   419
      IF(LL .EQ. 2) GO TO 240                                                 GIONEUT   420
      DO 236 J=1,K2                                                           GIONEUT   421
      NZERO(J)=FORM(J)                                                        GIONEUT   422
      UZERO(J)=REMV(J)                                                        GIONEUT   423
 236  CONTINUE                                                                GIONEUT   424
      I=I+1                                                                   GIONEUT   425
 237  CONTINUE                                                                GIONEUT   426
 240  DO 241 J=1,K2                                                           GIONEUT   427
      E(J)=0.                                                                 GIONEUT   428
      F(J)=0.                                                                 GIONEUT   429
      H(J)=0.                                                                 GIONEUT   430
      DO 312 I=1,6                                                            GIONEUT   431
      E(J)=E(J)+N(J,I)                                                        GIONEUT   432
 312  CONTINUE                                                                GIONEUT   433
      E(J)=E(J)+N(J,28)+N(J,29)                                               GIONEUT   434
      DO 313 I=9,24                                                           GIONEUT   435
      E(J)=E(J)+CONC(J,I)                                                     GIONEUT   436
 313  CONTINUE                                                                GIONEUT   437
      DO 314 I=1,8                                                            GIONEUT   438
      F(J)=F(J)+CONC(J,I)                                                     GIONEUT   439
 314  CONTINUE                                                                GIONEUT   440
      H(J)=F(J)/N(J,30)                                                       GIONEUT   441
 241  CONTINUE                                                                GIONEUT   442
      WRITE(6,340)                                                            GIONEUT   443
      WRITE(6,196) TIME,SCXI,IFRAME,IDAY,(OUTP(J),J=1,4)                      GIONEUT   444
      WRITE(6,212) SYMBOL(55),SYMBOL(56)                                      GIONEUT   445
 212  FORMAT(10X,A10,* PROFILE*,20X,A10,* PROFILE*)                           GIONEUT   446
      WRITE(6,213)                                                            GIONEUT   447
 213  FORMAT(*   ALT    NUMBER   CHEMISTRY CHEMISTRY  ALT    NUMBER    *,     GIONEUT   448
     1*CHEMISTRY CHEMISTRY  TOTAL IONS  TOTAL IONS  LAMBDA*)                  GIONEUT   449
      WRITE(6,214)                                                            GIONEUT   450
 214  FORMAT(*    KM    DENSITY  FORMATION REMOVAL    KM    DENSITY  *,       GIONEUT   451
     1*FORMATION REMOVAL     POSITIVE     NEGATIVE*)                          GIONEUT   452
      WRITE(6,215) (Z(J),CONC(J,25),NZERO(J),UZERO(J),Z(J),CONC(J,26),        GIONEUT   453
     1FORM(J),REMV(J),E(J),F(J),H(J),J=1,K2,12)                               GIONEUT   454
      WRITE(6,215) Z(K2),CONC(K2,25),NZERO(K2),UZERO(K2),Z(K2),               GIONEUT   455
     1CONC(K2,26),FORM(K2),REMV(K2),E(K2),F(K2),H(K2)                         GIONEUT   456
 215  FORMAT(0PF7.2,1P3E10.3,0PF7.2,1P3E10.3,3E12.5)                          GIONEUT   457
```

```
C
C  COMPUTE EDDY DIFFUSION VELOCITIES.
C
      BIG=N(J+1,I)/EN
      IF(EN .GT. 1.0E-10) GO TO 165
      IF(BIG .GT. 100.) GO TO 170
165   DED(J)=-(DEDY(J)/DELTAZ(J))*(BIG-1.0+GAMA*DELTAZ(J))
 170  CONTINUE
C
C  COMPUTE FLUX GRADIENTS.
C
      DEDZ(1)=0.
      DFDZ(1)=0.
      DO 175 J=2,K
      DEDZ(J)=0.
      DFDZ(J)=(N(J,I)*U(J,I)-N(J-1,I)*U(J-1,I))/DELTAZ(J)
      IF(J .GT. ITURB) GO TO 175
      DEDZ(J)=(N(J,I)*DED(J)-N(J-1,I)*DED(J-1))/DELTAZ(J)
 175  CONTINUE
C
C  COMPUTE CHEMISTRY PROFILES.
C
      DO 180 J=  K
      CALL CHEM(I,J)
      REMV(J)=REMV(J)*N(J,I)
180   CONTINUE
C
C  COMPUTE THE TOTAL FLUX FOR EACH SPECIES.
C
      DO 181 J=1,K
      PHI(J)=(U(J,I)+DED(J))*N(J,I)
181   CONTINUE
      CALL HOUR(TIME,OUTP)
      WRITE(6,335) SYMBOL(I)
335   FORMAT(1H1,60X,A10,* PROFILE*)
      WRITE(6,390) TIME,DELT,SCXI,ITER(I),IFRAME,IDAY,(OUTP(J),J=1,4)
390   FORMAT(1H ,* TIME =*,1PE12.5,* SEC.  TIME INCREMENT =*,E12.5,
     1*  CHI =*,0PF7.2,* DEGREES  ITERATIONS =*,I3,*  FRAME*,
     2I4,*  DAY *,I3,* HOUR *,4A1)
      WRITE(6,295)
295   FORMAT(*  ALT       NUMBER      SPECIFIC      SPECIFIC*,
     1*     TURBULENT    TURBULENT    CHEMISTRY     CHEMISTRY*,
     2*      TOTAL         DIFFUSION*)
      WRITE(6,300)
300   FORMAT(*  KM        DENSITY     VELOCITY      GRADIENT      VELOCITY*
     1,*      GRADIENT      FORMATION     REMOVAL        FLUX*,
     2*         VELOCITY*)
      WRITE(6,320) (Z(J),N(J,I),U(J,I),DFDZ(J),DED(J),DEDZ(J),FORM(J),
     1REMV(J),PHI(J),VBAR(J),J=1,K,12)
320   FORMAT(0PF8.2,1P9E13.5)
      WRITE(6,320) Z(K),N(K,I),U(K,I),DFDZ(K),DED(K),DEDZ(K),FORM(K),
     1REMV(K),PHI(K),VBAR(K)
195   CONTINUE
      L=1
      DO 194 I=27,30
      DO 191 J=1,K
      CALL CHEM(I,J)
```

```
      IF(ITMAX .EQ. 1) GO TO 139                                         GIONEUT  230
      IF(ITRATE.EQ.1) GOTO 130                                           GIONEUT  231
C                                                                        GIONEUT  232
C  DETERMINE WHICH SPECIES REQUIRE FURTHER ITERATION.                    GIONEUT  233
C                                                                        GIONEUT  234
      BIG=0.                                                             GIONEUT  235
      DO 120 I=1,KSPECI                                                  GIONEUT  236
      IF(IWHICH(I).EQ.0) GOTO 120                                        GIONEUT  237
      IF(BIGEST(I) .GT. ERSPECI) GO TO 117                               GIONEUT  238
      IWHICH(I)=0                                                        GIONEUT  239
      ITER(I)=ITRATE                                                     GIONEUT  240
117   IF(BIGEST(I) .LT. BIG) GO TO 120                                   GIONEUT  241
      BIG=BIGEST(I)                                                      GIONEUT  242
      IBIG=I                                                             GIONEUT  243
  120 CONTINUE                                                           GIONEUT  244
C                                                                        GIONEUT  245
      ERS=ERRMAX                                                         GIONEUT  246
      IF(IBIG .EQ. 10) ERS=0.5                                           GIONEUT  247
      IF(BIG .LE. ERS) GO TO 139                                         GIONEUT  248
  130 CONTINUE                                                           GIONEUT  249
139   DO 135 I=1,KSPECI                                                  GIONEUT  250
      IF(IWHICH(I) .EQ. 0) GO TO 135                                     GIONEUT  251
      ITER(I)=ITRATE                                                     GIONEUT  252
135   CONTINUE                                                           GIONEUT  253
      CALL SECOND(T2)                                                    GIONEUT  254
      DTIME=T2-T1                                                        GIONEUT  255
C                                                                        GIONEUT  256
C  IF THIS IS A PRINT STEP, COMPUTE FLUXES AND FLUX GRADIENTS FOR OUTPUT GIONEUT  257
C                                                                        GIONEUT  258
      IF(PRINT) GO TO 162                                                GIONEUT  259
      IF(TIME .LT. (DAYS*8.64E+04)) GO TO 160                            GIONEUT  260
      END=.TRUE.                                                         GIONEUT  261
162   IDAY=((TIME+4.32E+04)/8.65E+04)+1                                  GIONEUT  262
      IFRAME=IFRAME+1                                                    GIONEUT  263
      DO 163 J=1,K                                                       GIONEUT  264
      CALL RATECN(J)                                                     GIONEUT  265
      CALL MOVLEV(DK(128),RATES(1,J),88)                                 GIONEUT  266
163   CONTINUE                                                           GIONEUT  267
C                                                                        GIONEUT  268
C  COMPUTE MOLECULAR AND EDDY DIFFUSION FLUXES.                          GIONEUT  269
C                                                                        GIONEUT  270
      DO 195 I=1,KSPECI                                                  GIONEUT  271
      IF(I .EQ. 21) GO TO 195                                            GIONEUT  272
      DO 170 J=1,K                                                       GIONEUT  273
C                                                                        GIONEUT  274
C  COMPUTE MOLECULAR DIFFUSION VELOCITIES.                               GIONEUT  275
C                                                                        GIONEUT  276
      CALL CO(J,RHO,NTOTAL,MBAR,VMEAN)                                   GIONEUT  277
      VBAR(J)=0.                                                         GIONEUT  278
      EN=N(J,I)                                                          GIONEUT  279
      DED(J)=0.                                                          GIONEUT  280
      IF(EN .EQ. 0.) GO TO 170                                           GIONEUT  281
      VBAR(J)=U(J,I)-VMEAN                                               GIONEUT  282
      IF(J .GT. ITURB) GO TO 170                                         GIONEUT  283
      T=TEMP(J)                                                          GIONEUT  284
      ZZ=Z(J)                                                            GIONEUT  285
      GAMA=DTEMDZ(J)+(GRAV*GRAVCOR(ZZ)*MBAR)/(BOLTZ*T)                   GIONEUT  286
```

```
      CALL EFORU(I)                                                     GIONEUT  173
C                                                                       GIONEUT  174
C  COMPUTE HEIGHT PROFILES AT (T+DELTA T) USING THE RECURSION           GIONEUT  175
C  RELATION N(J)=N(J+1)*E(J)+F(J).                                      GIONEUT  176
C                                                                       GIONEUT  177
      NEWN=F(K)                                                         GIONEUT  178
C                                                                       GIONEUT  179
      IF(NEWN .GT. 0.) GO TO 10                                         GIONEUT  180
      IF(N(K,I) .GT. 1.0E-02) GO TO 245                                 GIONEUT  181
      NEWN=N(K,I)                                                       GIONEUT  182
10    IF(ITRATE .EQ. 1) GO TO 70                                        GIONEUT  183
      IF(NEWN .LT. 1.0) GO TO 70                                        GIONEUT  184
      RELER=ABS(NEWN-N(K,I))/NEWN                                       GIONEUT  185
      BIGEST(I)=RELER                                                   GIONEUT  186
70    N(K,I)=NEWN                                                       GIONEUT  187
      DO 100 J=1,KMIN1                                                  GIONEUT  188
      L=K-J                                                             GIONEUT  189
      NEWN=E(L)*N(L+1,I)+F(L)                                           GIONEUT  190
      IF(NEWN .GT. 0.) GO TO 11                                         GIONEUT  191
      IF(N(L,I) .GT. 1.0E-02) GO TO 250                                 GIONEUT  192
      NEWN=N(L,I)                                                       GIONEUT  193
11    IF(ITRATE .EQ. 1) GO TO 95                                        GIONEUT  194
      IF(NEWN .LT. 1.0) GO TO 95                                        GIONEUT  195
      RELER=ABS(NEWN-N(L,I))/NEWN                                       GIONEUT  196
      IF(BIGEST(I) .LT. RELER) BIGEST(I)=RELER                          GIONEUT  197
95    N(L,I)=NEWN                                                       GIONEUT  198
  100 CONTINUE                                                          GIONEUT  199
  105 CONTINUE                                                          GIONEUT  200
C                                                                       GIONEUT  201
C  COMPUTE THOSE SPECIES TO BE DETERMINED FROM CHEMISTRY ONLY.          GIONEUT  202
C                                                                       GIONEUT  203
      CALL CHEMION                                                      GIONEUT  204
C                                                                       GIONEUT  205
      IF(END) GO TO 254                                                 GIONEUT  206
C                                                                       GIONEUT  207
C  GO GET THE VELOCITIES FOR SPECIES IN THE TRANSPORT MODE.             GIONEUT  208
C                                                                       GIONEUT  209
      DO 110 I=1,KSPECI                                                 GIONEUT  210
      IF(I .EQ. 21) GO TO 110                                           GIONEUT  211
      CALL MOVLEV(OLDU(1,I),UZERO,K)                                    GIONEUT  212
      CALL CHEM(I,KMIN1)                                                GIONEUT  213
      CALL CHEM(I,K)                                                    GIONEUT  214
      IF(I .NE. 1) GO TO 108                                            GIONEUT  215
      DO 107 J=2,K                                                      GIONEUT  216
      H(J)=(1.0-(N(J-1,30)/N(J,30)))/DELTAZ(J-1)                        GIONEUT  217
107   CONTINUE                                                          GIONEUT  218
      H(1)=H(2)                                                         GIONEUT  219
108   CALL EFORU(-I)                                                    GIONEUT  220
C                                                                       GIONEUT  221
C  TEST FOR TERMINATION OF CALCULATIONS.                                GIONEUT  222
C                                                                       GIONEUT  223
      CALL SSWTCH(NSWTCH,NSTATUS)                                       GIONEUT  224
      IF(NSTATUS.NE.2) GOTO 230                                         GIONEUT  225
      CALL SECOND(TA)                                                   GIONEUT  226
      IF((TYME-TA).LT.TOFF) GOTO 230                                    GIONEUT  227
110   CONTINUE                                                          GIONEUT  228
C                                                                       GIONEUT  229
```

```
      DO 625 J=1,59
      WRITE(6,610) (DIS(15,J),(DIS(LL,J),LL=7,14))
625   CONTINUE
      LOOK=.FALSE.
24    IF(ITRATE .NE. 1) GO TO 6
      IF(I .NE. 1) GO TO 6
      IF(NUM .EQ. 0) GO TO 6
      CALL SMOOTHY(NUM,NSPEC)
      WRITE(6,2)
2     FORMAT(1HO,'  THE FOLLOWING SPECIES PROFILES HAVE BEEN',
     1' SMOOTHED.')
      DO 4 II=1,NUM
      L=NSPEC(II)
      WRITE(6,3) SYMBOL(L)
3     FORMAT(10X A10)
4     CONTINUE
C
C  RECOMPUTE THE VELOCITY PROFILES FOR THOSE SPECIES WHOSE
C  CONCENTRATION PROFILES HAVE BEEN SMOOTHED.
C
      IP=0
      DO 29 IM=1,NUM
      II=NSPEC(IM)
40    IP=IP+1
      IF(IP .NE. II) GO TO 40
      CALL MOVLEV(OLDU(1,II),UZERO,K)
      CALL CHEM(II,KMIN1)
      CALL CHEM(II,K)
      IF(IM .NE. 1) GO TO 28
      DO 27 J=2,K
      H(J)=(1.0-(N(J-1,30)/N(J,30)))/DELTAZ(J-1)
27    CONTINUE
      H(1)=H(2)
28    CALL EFORU(-II)
29    CONTINUE
      CALL MOVLEV(U,OLDU,17992)
      CALL MOVLEV(N,OLDN,20760)
      CALL MOVLEV(CONC,OLDCON,11024)
6     IF(IWHICH(I) .EQ. 0) GO TO 105
      CALL MOVLEV(OLDN(1,I),NZERO,K)
      CALL MOVLEV(OLDU(1,I),UZERO,K)
C
C  GO GET CHEMISTRY FORMATION AND REMOVAL RATES FOR SPECIES I.
C
      DO 30 J=1,K
      CALL CHEM(I,J)
C
C  TEST FOR TERMINATION OF CALCULATIONS.
C
      CALL SSWTCH(NSWTCH,NSTATUS)
      IF(NSTATUS .NE. 2) GO TO 230
      CALL SECOND(TUSED)
      IF((TYME-TUSED) .LT. TOFF) GO TO 230
30    CONTINUE
C
C  GO GET E AND F ARRAYS.
C
```

```
      CONTINUE
      OLDTME=TIME
      OLDCXI=CXI
      OLDZTR=ZTRANS
      LASTNT=NIGHT
      LASTDA=DAY
      CALL TIMER
      OLDELT=DELT
      IF(.NOT. DAY .OR. NIGHT) JLOOK=.TRUE.
      IF(NIGHT) JLOOK=.FALSE.
      SCXI=CXI*DEGRAD
      DO 20 I=1,KSPECI
      IWHICH(I)=1
      ITER(I)=999
   20 CONTINUE
      IWHICH(21)=0
C
C  BEGINNING OF ITERATION LOOP.
C
      DO 130 ITRATE=1,ITMAX
      DO 105 I=1,KSPECI
      BIGEST(I)=0.
      IF(I .NE. 1) GO TO 24
      DO 22 J=2,K
      H(J)=(1.0-(N(J-1,30)/N(J,30)))/DELTAZ(J-1)
22    CONTINUE
      H(1)=H(2)
C
C  TEST FOR TERMINATION OF CALCULATIONS.
C
      CALL SSWTCH(NSWTCH,NSTATUS)
      IF(NSTATUS .NE. 2) GO TO 230
      CALL SECOND(TUSED)
      IF((TYME-TUSED) .LT. TOFF) GO TO 230
      DO 21 J=1,K
      CALL RATECN(J)
      CALL MOVLEV(DK(128),RATES(1,J),88)
21    CONTINUE
      IF(.NOT. JLOOK) GO TO 24
      WRITE(6,600) SCXI
600   FORMAT(1H1,10X,* CHI =*,F7.2,* DEGREES.*)
      WRITE(6,605)
605   FORMAT(1H0,*   ALT (KM)  O2 DENSITY  O2 COLUMN   O3 DENSITY*,
     1*  O3 COLUMN     JO2 K192     JO2 K193     JO3 K194     *,
     2*JO3 K195     JH2O K196  JH2O2 K197*)
      DO 615 J=1,59
      WRITE(6,610) ((DIS(LL,J),LL=15,19),(DIS(LL,J),LL=1,6))
610   FORMAT(0PF10.2,2X,1P10E12.5)
615   CONTINUE
      WRITE(6,600) SCXI
      WRITE(6,620)
620   FORMAT(1H0,*   ALT (KM)   JHO2 K198   JNO K199    JNO2 K200*,
     1*    JN2O K201  JHNO2 K202   JCO2 K203   JCO2 K204    JNO3 K205*)
```

```
     1     -CJ*EJL)
      EJL=0.
      GO TO 70
   80 FJL=(NZERO(K)+FORM(K)*DELT)/(1.0+REMV(K)*DELT)
      EJL=0.
      GO TO 70
C
C  COMPUTE THE SPECIFIC VELOCITY ARRAY FOR SPECIES ICF.
C
   60 IF(J .EQ. K) GO TO 56
      AJ=N(J+1,I)/N(J,I)
      IF(N(J,I) .GT. 1.0E-10) GO TO 61
      IF(AJ .LT. 100.) GO TO 61
      U(J,I)=0.
      GO TO 75
   61 U(J,I)=PJ*(UJ-(DTKTM/DZ)*(AJ-GAM)+DELT*SNUW)
      GO TO 75
   65 U(K,I)=VEL(I)
      GO TO 75
   70 E(J)=EJL
      F(J)=FJL
   75 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE COLFRE(I,J,SNU,SNUW,OMEG)
C
C THIS SUBROUTINE COMPUTES THE SUM OF THE COLLISION FREQUENCIES
C AND THE SUM OF THE COLLISION FREQUENCIES TIMES THE VELOCITIES.
C SEE BANKS AND KOCKARTS, "AERONOMY", CHAPTER 9.
C
      COMMON N(692,30),CONC(424,26),U(692,26),NZERO(692),UZERO(692)
C
      COMMON FORM(692),REMV(692),E(692),F(692),Z(692),
     2       DEDY(692),TEMP(692),DTEMDZ(692),DELTAZ(692),SUNSET(692)
C
      COMMON GRAV,COSD,SIND,TIME,CXI,RADIUS,ISPECI,KSPECI,NREAC,K,
     1       K2,KMIN1,ITURB,CXINCON,SCXI,NREAC2
C
      COMMON/ATCONS/ATWT(26),MASS(26),THERM(26),SYMBOL(56),POLAR(26)
C
      COMMON/CONSTAN/PI,RADDEG,DEGRAD,RADSEC,BOLTZ,SIN2I,ATCON
C
      COMMON/COLFRE/D(26,26)
C
      REAL N,MASS
C
      DATA GAUS/0.25/,CHARG/4.803E-10/
C
      SNU =0.
      SNUW=0.
      OMEG=1.0
      AMUI=ATWT(I)
      T=TEMP(J)
      ST=SQRT(T)
      T1=1.0/(T**1.5)
      T2=300.0/T
      T3=SQRT(2.0*T)
      DO 50 L=1,KSPECI
      AMUL=ATWT(L)
      RMAS=1.0/(SQRT((AMUI*AMUL)/(AMUI+AMUL)))
      IF(I .LE. 6) GO TO 15
      IF(L .LE. 6) GO TO 25
C
C COMPUTE NEUTRAL-NEUTRAL COLLISION FREQUENCIES.
C
      ANU=N(J,L)*D(I,L)*ST
      SNU=SNU+ANU
      IF(L .EQ. 21) GO TO 50
      SNUW=SNUW+ANU*U(J,L)
      GO TO 50
15    IF(L .GT. 6) GO TO 24
C
C COMPUTE ION-ION COLLISION FREQUENCIES.
C
      ANU=1.3*N(J,L)*RMAS*T1
      GO TO 26
C
C COMPUTE ION-NEUTRAL COLLISION FREQUENCIES.
C
25    II=I
      GO TO 27
```

```
24    II=L                                                                     GIONEUT   952
27    ALF=POLAR(II)                                                            GIONEUT   953
      IF(ALF .EQ. 0.) GO TO 50                                                 GIONEUT   954
C                                                                              GIONEUT   955
C  AVERAGE ION-NEUTRAL COLLISION FREQUENCY FOR MOMENTUM TRANSFER.              GIONEUT   956
C  BANKS AND KOCHARTS, EQUATION 9.73.                                          GIONEUT   957
C                                                                              GIONEUT   958
      ANU=2.6E-09*N(J,L)*SQRT(ALF)*RMAS                                        GIONEUT   959
      IF(((I.EQ.1).AND.(L.EQ.7 )).OR.((I.EQ.7 ).AND.(L.EQ.1))) GO TO 1         GIONEUT   960
      IF(((I.EQ.1).AND.(L.EQ.11)).OR.((I.EQ.11).AND.(L.EQ.1))) GO TO 11        GIONEUT   961
      IF(((I.EQ.2).AND.(L.EQ.8 )).OR.((I.EQ.8 ).AND.(L.EQ.2))) GO TO 2         GIONEUT   962
      IF(((I.EQ.2).AND.(L.EQ.21)).OR.((I.EQ.21).AND.(L.EQ.2))) GO TO 21        GIONEUT   963
      IF(((I.EQ.2).AND.(L.EQ.23)).OR.((I.EQ.23).AND.(L.EQ.2))) GO TO 3         GIONEUT   964
      IF(((I.EQ.3).AND.(L.EQ.7 )).OR.((I.EQ.7 ).AND.(L.EQ.3))) GO TO 31        GIONEUT   965
      IF(((I.EQ.3).AND.(L.EQ.8 )).OR.((I.EQ.8 ).AND.(L.EQ.3))) GO TO 4         GIONEUT   966
      IF(((I.EQ.3).AND.(L.EQ.11)).OR.((I.EQ.11).AND.(L.EQ.3))) GO TO 5         GIONEUT   967
      IF(((I.EQ.4).AND.(L.EQ.18)).OR.((I.EQ.18).AND.(L.EQ.4))) GO TO 6         GIONEUT   968
      IF(((I.EQ.4).AND.(L.EQ.8 )).OR.((I.EQ.8 ).AND.(L.EQ.4))) GO TO 61        GIONEUT   969
      IF(((I.EQ.6).AND.(L.EQ.8 )).OR.((I.EQ.8 ).AND.(L.EQ.6))) GO TO 7         GIONEUT   970
      IF(((I.EQ.6).AND.(L.EQ.16)).OR.((I.EQ.16).AND.(L.EQ.6))) GO TO 71        GIONEUT   971
26    BNU=ANU*(AMUL/(AMUI+AMUL))                                               GIONEUT   972
      SNU =SNU+BNU                                                             GIONEUT   973
      IF(I .EQ. L) GO TO 50                                                    GIONEUT   974
      IF(L .EQ. 21) GO TO 50                                                   GIONEUT   975
      SNUW=SNUW+BNU*U(J,L)                                                     GIONEUT   976
      GO TO 50                                                                 GIONEUT   977
C                                                                              GIONEUT   978
C  AVERAGE COLLISION FREQUENCY FOR CHARGE EXCHANGE REACTION H+ - O.            GIONEUT   979
C                                                                              GIONEUT   9
1     ENG=3.8E-10*N(J,L)                                                       GIONEUT
      GO TO 8                                                                  GIONEUT   982
C                                                                              GIONEUT   983
C  AVERAGE REDUCED CHARGE EXCHANGE COLLISION FREQUENCY FOR H+ - H.             GIONEUT   984
C                                                                              GIONEUT   985
11    ANU=ANU+1.0E-10*T3*N(J,L)                                                GIONEUT   986
      GO TO 26                                                                 GIONEUT   987
C                                                                              GIONEUT   988
C  AVERAGE COLLISION FREQUENCY FOR CHARGE EXCHANGE REACTION HE+ + O2.          GIONEUT   989
C                                                                              GIONEUT   990
2     ENG=2.0E-10*N(J,L)                                                       GIONEUT   991
      GO TO 8                                                                  GIONEUT   992
C                                                                              GIONEUT   993
C  AVERAGE REDUCED CHARGE EXCHANGE COLLISION FREQUENCY FOR HE+ + HE.           GIONEUT   994
C                                                                              GIONEUT   995
21    ANU=ANU+3.0E-11*T3*N(J,L)                                                GIONEUT   996
      GO TO 26                                                                 GIONEUT   997
C                                                                              GIONEUT   998
C  AVERAGE COLLISION FREQUENCY FOR CHARGE EXCHANGE REACTION HE+ + N2.          GIONEUT   999
3     ENG=3.5E-10*N(J,L)                                                       GIONEUT  1000
      GO TO 8                                                                  GIONEUT  1001
C                                                                              GIONEUT  1002
C  AVERAGE REDUCED CHARGE EXCHANGE COLLISION FREQUENCY FOR O+ + O.             GIONEUT  1003
C                                                                              GIONEUT  1004
31    ANU=ANU+1.6E-11*T3*N(J,L)                                                GIONEUT  1005
      GO TO 26                                                                 GIONEUT  1006
C                                                                              GIONEUT  1007
C  AVERAGE COLLISION FREQUENCY FOR CHARGE EXCHANGE REATION O+ + O2.            GIONEUT  1008
```

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C                                                                       GIONEUT  1009
    4    ENG=2.0E-11*(T2**0.4)*N(J,L)                                   GIONEUT  1010
         GO TO 8                                                        GIONEUT  1011
C                                                                       GIONEUT  1012
C   AVERAGE COLLISION FREQUENCY FOR CHARGE EXCHANGE REACTION O+ + H.    GIONEUT  1013
C                                                                       GIONEUT  1014
    5    ENG=6.8E-10*N(J,L)                                             GIONEUT  1015
         GO TO 8                                                        GIONEUT  1016
C                                                                       GIONEUT  1017
C   AVERAGE COLLISION FREQUENCY FOR CHARGE EXCHANGE REACTION O2+ + NO.  GIONEUT  1018
C                                                                       GIONEUT  1019
    6    ENG=4.4E-10*N(J,L)                                             GIONEUT  1020
         GO TO 8                                                        GIONEUT  1021
C                                                                       GIONEUT  1022
C   AVERAGE REDUCED CHARGE EXCHANGE COLLISION FREQUENCY FOR O2+ + O2.   GIONEUT  1023
C                                                                       GIONEUT  1024
   61    ANU=ANU+1.1E-11*T3*N(J,L)                                      GIONEUT  1025
         GO TO 26                                                       GIONEUT  1026
C                                                                       GIONEUT  1027
C   AVERAGE REDUCED CHARGE EXCHANGE COLLISION FREQUENCY FOR N+ + N.     GIONEUT  1028
C                                                                       GIONEUT  1029
   71    ANU=ANU+1.7E-11*T3*N(J,L)                                      GIONEUT  1030
         GO TO 26                                                       GIONEUT  1031
C                                                                       GIONEUT  1032
C   AVERAGE COLLISION FREQUENCY FOR CHARGE EXCHANGE REACTION N+ + O2.   GIONEUT  1033
C                                                                       GIONEUT  1034
    7    ENG=5.5E-10*(T2**0.17)*2.0*N(J,L)                              GIONEUT  1035
    8    ANU=ANU+1.73725*ENG                                            GIONEUT  1036
         GO TO 26                                                       GIONEUT  1037
   50    CONTINUE                                                       GIONEUT  1038
         IF(I .GT. 6) RETURN                                            GIONEUT  1039
         G1=((GAUS*CHARG)/(MASS(I)*3.0E10))**2                          GIONEUT  1040
         G2=SNU**2                                                      GIONEUT  1041
         OMEG=(G1+G2)/(G1*SIN2I+G2)                                     GIONEUT  1042
         RETURN                                                         GIONEUT  1043
         END                                                            GIONEUT  1044
```

```
      SUBROUTINE VELOCTY(I)                                             GIONEUT  1045
C                                                                       GIONEUT  1046
C                                                                       GIONEUT  1047
C  THIS SUBROUTINE COMPUTES THE VELOCITIES AT THE UPPER BOUNDARY        GIONEUT  1048
C  BY SOLVING OVER THE TOPMOST HEIGHT STEP THE ORDINARY DIFFERENTIAL    GIONEUT  1049
C  EQUATION RESULTING FROM SETTING DN/DT=0 IN THE CONTINUITY EQUATION.  GIONEUT  1050
C                                                                       GIONEUT  1051
      COMMON N(692,30),CONC(424,26),U(692,26),NZERO(692),UZERO(692)     GIONEUT  1052
C                                                                       GIONEUT  1053
      COMMON FORM(692),REMV(692),E(692),F(692),Z(692),                  GIONEUT  1054
     2       DEDY(692),TEMP(692),DTEMDZ(692),DELTAZ(692),SUNSET(692)    GIONEUT  1055
C                                                                       GIONEUT  1056
      COMMON GRAV,COSD,SIND,TIME,CXI,RADIUS,ISPECI,KSPECI,NREAC,K,      GIONEUT  1057
     1       K2,KMIN1,ITURB,CXINOON,SCXI,NREAC2                         GIONEUT  1058
C                                                                       GIONEUT  1059
      COMMON/BOUNDRY/VEL(26)                                            GIONEUT  1060
C                                                                       GIONEUT  1061
      COMMON/RHSIDE/AN,BN,AP,BP,AL,BL                                   GIONEUT  1062
C                                                                       GIONEUT  1063
      REAL N                                                            GIONEUT  1064
      AF(D1,D2,DZ)=(D1-D2)/DZ                                           GIONEUT  1065
      BF(D1,D2,D3,D4,DZ)=(D2*D3-D1*D4)/DZ                               GIONEUT  1066
C                                                                       GIONEUT  1067
      ZE=Z(KMIN1)                                                       GIONEUT  1068
      START=U(KMIN1,I)                                                  GIONEUT  1069
      DZ=DELTAZ(K)                                                      GIONEUT  1070
      D1=N(K,I)                                                         GIONEUT  1071
      D2=N(KMIN1,I)                                                     GIONEUT  1072
      D3=Z(K)*1.0E+05                                                   GIONEUT  1073
      D4=Z(KMIN1)*1.0E+05                                               GIONEUT  1074
      AN=AF(D1,D2,DZ)                                                   GIONEUT  1075
      BN=BF(D1,D2,D3,D4,DZ)                                             GIONEUT  1076
      D1=FORM(K)                                                        GIONEUT  1077
      D2=FORM(KMIN1)                                                    GIONEUT  1078
      AP=AF(D1,D2,DZ)                                                   GIONEUT  1079
      BP=BF(D1,D2,D3,D4,DZ)                                             GIONEUT  1080
      D1=REMV(K)*N(K,I)                                                 GIONEUT  1081
      D2=REMV(KMIN1)*N(KMIN1,I)                                         GIONEUT  1082
      AL=AF(D1,D2,DZ)                                                   GIONEUT  1083
      BL=BF(D1,D2,D3,D4,DZ)                                             GIONEUT  1084
      CALL ODE(1,START,ZE,DZ)                                           GIONEUT  1085
      VEL(I)=START                                                      GIONEUT  1086
      RETURN                                                            GIONEUT  1087
      END                                                               GIONEUT  1088
```

```
      SUBROUTINE ODE(N,START,SZ,DZ)                                     GIONEUT  1089
C                                                                       GIONEUT  1090
C  SUBPROGRAM TO SOLVE A SET OF ORDINARY DIFFERENTIAL EQUATIONS OF      GIONEUT  1091
C  SIZE N USING THE KUTTA-MERSON SCHEME.                                GIONEUT  1092
C                                                                       GIONEUT  1093
      DIMENSION V(7,2),START(2),SLOPE(2)                                GIONEUT  1094
C                                                                       GIONEUT  1095
      DATA IPASS/0/                                                     GIONEUT  1096
C                                                                       GIONEUT  1097
      IF(IPASS .NE. 0) GO TO 1                                          GIONEUT  1098
      C1=1.0/3.0                                                        GIONEUT  1099
      C2=1.0/6.0                                                        GIONEUT  1100
      C3=1.0/8.0                                                        GIONEUT  1101
      C4=3.0/8.0                                                        GIONEUT  1102
      C5=1.0/2.0                                                        GIONEUT  1103
      C6=3.0/2.0                                                        GIONEUT  1104
      C7=2.0/3.0                                                        GIONEUT  1105
      IPASS=1                                                           GIONEUT  1106
    1 DO 5 J=1,N                                                        GIONEUT  1107
      V(3,J)=V(1,J)=START(J)                                            GIONEUT  1108
    5 CONTINUE                                                          GIONEUT  1109
      ZE=SZ                                                             GIONEUT  1110
      DO 55 II=1,5                                                      GIONEUT  1111
      CALL RHS(ZE,SLOPE,N,V)                                            GIONEUT  1112
      DO 6 J=1,N                                                        GIONEUT  1113
      V(2,J)=SLOPE(J)                                                   GIONEUT  1114
    6 CONTINUE                                                          GIONEUT  1115
      GO TO(10,15,20,25,30),II                                          GIONEUT  1116
   10 DO 11 J=1,N                                                       GIONEUT  1117
      V(4,J)=V(2,J)*DZ                                                  GIONEUT  1118
      V(1,J)=V(3,J)+C1*V(4,J)                                           GIONEUT  1119
   11 CONTINUE                                                          GIONEUT  1120
      GO TO 40                                                          GIONEUT  1121
   15 DO 16 J=1,N                                                       GIONEUT  1122
      V(1,J)=V(3,J)+C2*V(4,J)+C2*V(2,J)*DZ                              GIONEUT  1123
   16 CONTINUE                                                          GIONEUT  1124
      GO TO 55                                                          GIONEUT  1125
   20 DO 21 J=1,N                                                       GIONEUT  1126
      V(5,J)=V(2,J)*DZ                                                  GIONEUT  1127
      V(1,J)=V(3,J)+C3*V(4,J)+C4*V(5,J)                                 GIONEUT  1128
   21 CONTINUE                                                          GIONEUT  1129
      GO TO 45                                                          GIONEUT  1130
   25 DO 26 J=1,N                                                       GIONEUT  1131
      V(6,J)=V(2,J)*DZ                                                  GIONEUT  1132
      V(1,J)=V(3,J)+C5*V(4,J)-C6*V(5,J)+2.0*V(6,J)                      GIONEUT  1133
      V(7,J)=V(1,J)                                                     GIONEUT  1134
   26 CONTINUE                                                          GIONEUT  1135
      GO TO 50                                                          GIONEUT  1136
   30 DO 31 J=1,N                                                       GIONEUT  1137
      V(1,J)=V(3,J)+C2*V(4,J)+C7*V(6,J)+C2*V(2,J)*DZ                    GIONEUT  1138
   31 CONTINUE                                                          GIONEUT  1139
      GO TO 55                                                          GIONEUT  1140
   40 ZE=SZ+C1*DZ*1.0E-05                                               GIONEUT  1141
      GO TO 55                                                          GIONEUT  1142
   45 ZE=SZ+C5*DZ*1.0E-05                                               GIONEUT  1143
      GO TO 55                                                          GIONEUT  1144
   50 ZE=SZ+DZ*1.0E-05                                                  GIONEUT  1145
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```
   55    CONTINUE                                                   GIONEUT  1146
         DO 60 J=1,N                                                GIONEUT  1147
60       START(J)=V(1,J)                                            GIONEUT  1148
   60    CONTINUE                                                   GIONEUT  1149
         RETURN                                                     GIONEUT  1150
         END                                                        GIONEUT  1151
```

```
      SUBROUTINE RHS(ZE,SLOPE,N,V)                                      GIONEUT  1152
C                                                                       GIONEUT  1153
C  THIS SUBROUTINE COMPUTES THE RIGHT HAND SIDE OF THE ORDINARY         GIONEUT  1154
C  DIFFERENTAL EQUATION FOR THE VELOCITY AT THE UPPER BOUNDARY.         GIONEUT  1155
C                                                                       GIONEUT  1156
      DIMENSION V(7,2),SLOPE(2)                                         GIONEUT  1157
C                                                                       GIONEUT  1158
      COMMON/RHSIDE/AN,BN,AP,BP,AL,BL                                   GIONEUT  1159
C                                                                       GIONEUT  1160
      EF(D1,D2,D3)=D1*D2*1.0E+05+D3                                     GIONEUT  1161
C                                                                       GIONEUT  1162
      EN=EF(AN,ZE,BN)                                                   GIONEUT  1163
      EP=EF(AP,ZE,BP)                                                   GIONEUT  1164
      EL=EF(AL,ZE,BL)                                                   GIONEUT  1165
      SLOPE(1)=(EP-EL-V(1,1)*AN)/EN                                     GIONEUT  1166
      RETURN                                                            GIONEUT  1167
      END                                                               GIONEUT  1168
```

```
      SUBROUTINE TIMER
C
C  THIS SUBROUTINE CONTROLS THE TIME AND THE TIME STEP.
C
      COMMON N(692,30),CONC(424,26),U(692,26),NZERO(69_,,UZERO(692)
C
      COMMON FORM(692),REMV(692),E(692),F(692),Z(692),
     2       DEDY(692),TEMP(692),DTEMDZ(692),DELTAZ(692),SUNSET(692)
C
      COMMON GRAV,COSD,SIND,TIME,CHI,RADIUS,ISPECI,KSPECI,NREAC,K,
     1       K2,KMIN1,ITURB,CXINOON,SCXI,NREAC2
C
      COMMON/TIMES/DAYS,DELT,TMAX,TSET,TRISE
C
      COMMON/OUTPUTS/TIMOUT,OPRINT,PRINT
C
      COMMON/CONSTAN/PI,RADDEG,DEGRAD,RADSEC,BOLTZ,SIN2I,ATCON
C
      COMMON/LOGIC/NIGHT,DAY,JLOOK,RESET,END
C
      LOGICAL NIGHT,DAY,JLOOK,RESET,END,PRINT,SET
C
      COMMON/ALTITUD/ZBOT,ZTOP,TURB,ZTRANS
C
      DATA SET/.FALSE./
C
      IF(.NOT. SET) GO TO 1
      SET=.FALSE.
      DELT=15
    1 RESET=.FALSE.
      TSEC=TIME+DELT
      THRS=TSEC/3600.
      IF(TIMOUT .EQ. 0.) GO TO 8
      IF(THRS.LT.TIMOUT) GOTO 10
      IF(THRS.EQ.TIMOUT) GOTO 8
      TSEC=TIMOUT*3600
      THRS=TIMOUT
      DELT=TSEC-TIME
      RESET=.TRUE.
    8 PRINT=.TRUE.
      TIMOUT=TIMOUT+OPRINT
      IF(.NOT. NIGHT) JLOOK=.TRUE.
      GO TO 11
   10 PRINT=.FALSE.
   11 OLDMOD=AMOD(TIME,8.64E+04)
C
      CHINU=ACOS(COSD*COS(TSEC*RADSEC)+SIND)
C
C  DETERMINE WHETHER DAY, NIGHT, OR TWILIGHT.
C
      IF(NIGHT .AND. CHINU .GT. SUNSET(K)) GO TO 15
      IF(NIGHT .AND. CHINU .LT. SUNSET(K)) GO TO 5
      IF(DAY  .AND. CHINU .LT. SUNSET(1)) GO TO 13
      IF(DAY  .AND. CHINU .GT. SUNSET(1)) GO TO 9
      IF(CHINU .GT. SUNSET(K)) NIGHT=.TRUE.
      IF(CHINU .LT. SUNSET(1)) DAY =.TRUE.
C
```

```
C  FIND ALTITUDE OF DAY-NIGHT TRANSITION.                                GIONEUT  1226
C                                                                        GIONEUT  1227
      IF(DAY .OR. NIGHT) GO TO 26                                        GIONEUT  1228
      DO 6 J=1,K                                                         GIONEUT  1229
      IF(CHINU .LE. SUNSET(J)) GO TO 7                                   GIONEUT  1230
6     CONTINUE                                                           GIONEUT  1231
7     ZTRANS=Z(J)                                                        GIONEUT  1232
      GO TO 26                                                           GIONEUT  1233
C                                                                        GIONEUT  1234
C  RESET THE TIME STEP SO THAT THE NEXT TIME INCREMENT WILL BEGIN        GIONEUT  1235
C  EXACTLY AT SUNRISE AT THE UPPER BOUNDARY.                             GIONEUT  1236
C                                                                        GIONEUT  1237
5     DELT=TRISE-OLDMOD                                                  GIONEUT  1238
      TSEC=TIME+DELT                                                     GIONEUT  1239
      CHINU=SUNSET(K)                                                    GIONEUT  1240
      SET=.TRUE.                                                         GIONEUT  1241
      NIGHT=.FALSE.                                                      GIONEUT  1242
      GO TO 15                                                           GIONEUT  1243
C                                                                        GIONEUT  1244
C  RESET THE TIME STEP SO THAT THE NEXT TIME INCREMENT WILL BEGIN        GIONEUT  1245
C  EXACTLY AT SUNSET AT THE LOWER BOUNDARY.                              GIONEUT  1246
C                                                                        GIONEUT  1247
9     DELT=TSET-OLDMOD                                                   GIONEUT  1248
      TSEC=TIME+DELT                                                     GIONEUT  1249
      CHINU=SUNSET(1)                                                    GIONEUT  1250
      SET=.TRUE.                                                         GIONEUT  1251
      DAY=.FALSE.                                                        GIONEUT  1252
13    ZTRANS=50.                                                         GIONEUT  1253
      GO TO 26                                                           GIONEUT  1254
15    ZTRANS=400.                                                        GIONEUT  1255
26    CHI=CHINU                                                          GIONEUT  1256
      TIME=TSEC                                                          GIONEUT  1257
      RETURN                                                             GIONEUT  1258
      END                                                                GIONEUT  1259
```

```
      SUBROUTINE CHEMION                                                GIONEUT  1260
C                                                                       GIONEUT  1261
C  THIS SUBROUTINE COMPUTES THE SPECIES CONCENTRATIONS TO BE DETERMINED GIONEUT  1262
C  FROM CHEMISTRY ONLY.  THE LARGEST NEGATIVE SPECIES IS COMPUTED       GIONEUT  1263
C  FROM CHARGE BALANCE.                                                 GIONEUT  1264
C                                                                       GIONEUT  1265
      DIMENSION H(1)                                                    GIONEUT  1266
C                                                                       GIONEUT  1267
      COMMON N(692,30),CONC(424,26),U(692,26),NZERO(692),UZERO(692)     GIONEUT  1268
C                                                                       GIONEUT  1269
      COMMON FORM(692),REMV(692),E(692),F(692),Z(692),                  GIONEUT  1270
     2       DEDY(692),TEMP(692),DTEMDZ(692),DELTAZ(692),SUNSET(692)    GIONEUT  1271
C                                                                       GIONEUT  1272
      COMMON GRAV,DSD,FIND,TIME,CXI,RADIUS,ISPECI,KSPECI,NREAC,K,        GIONEUT  1273
     *       K2,KMIN1,ITURB,CXINION,SCYI,NREAC2                         GIONEUT  1274
                                                                        GIONEUT  1275
      COMMON/ESM/OLDN(692,30),OLDCON(424,26),OLDU(692,26),RATES(88,692) GIONEUT  1276
C                                                                       GIONEUT  1277
      COMMON/LOGIC/NIGHT,DAY,JLOOK,RESET,END                            GIONEUT  1278
C                                                                       GIONEUT  1279
      COMMON/TIMES/DAYS,DELT,TMAX,TSET,TRISE                            GIONEUT  1280
C                                                                       GIONEUT  1281
      COMMON/RATECON/AK(88),BK(88),CK(88),DK(215),CYMB(6,215)           GIONEUT  1282
C                                                                       GIONEUT  1283
      COMMON/ATCONS/ATWT(26),MASS(26),THERM(26),SYMBOL(56),POLAR(26)    GIONEUT  1284
C                                                                       GIONEUT  1285
      LEVEL 3, OLDN,OLDCON,OLDU,RATES                                   GIONEUT  1286
      REAL N,NZERO                                                      GIONEUT  1287
      LOGICAL END                                                       GIONEUT  1288
      EQUIVALENCE (U(1,21),H)                                           GIONEUT  1289
C                                                                       GIONEUT  1290
C  COMPUTE O1D PROFILE.                                                 GIONEUT  1291
C                                                                       GIONEUT  1292
      CALL MOVLEV(OLDN(1,27),NZERO,K)                                   GIONEUT  1293
      DO 5 J=1,K                                                        GIONEUT  1294
      CALL CHEM(27,J)                                                   GIONEUT  1295
      N(J,27)=(NZERO(J)+DELT*FORM(J))/(1.0+DELT*REMV(J))                GIONEUT  1296
    5 CONTINUE                                                          GIONEUT  1297
C                                                                       GIONEUT  1298
C  COMPUTE ELECTRON, NEGATIVE ION AND CLUSTER ION PROFILES.             GIONEUT  1299
C                                                                       GIONEUT  1300
      DO 45 J=1,K2                                                      GIONEUT  1301
      DO 10 I=1,3                                                       GIONEUT  1302
      CALL MOVLEV(OLDN(J,I+27),NZERO(I),1)                              GIONEUT  1303
   10 CONTINUE                                                          GIONEUT  1304
      DO 11 I=1,26                                                      GIONEUT  1305
      CALL MOVLEV(OLDCON(J,I),NZERO(I+3),1)                             GIONEUT  1306
   11 CONTINUE                                                          GIONEUT  1307
      DO 60 L=1,500                                                     GIONEUT  1308
      DO 25 I=1,24                                                      GIONEUT  1309
      [illegible] I [illegible] 3) [illegible] N(J,I+27)                GIONEUT  1310
      [illegible] I [illegible] 3) H [illegible] N(J,I-3)               GIONEUT  1311
      [illegible]                                                       GIONEUT  1312
      [illegible] *FORM(J))/(1.0+DELT*REMV(J))                          GIONEUT  1313
   25 CONTINUE                                                          GIONEUT  1314
      [illegible] I=1,3)                                                GIONEUT  1315
      [illegible]                                                       GIONEUT  1316
```

```
      IF(I .LE. 3) N(J,I+27)=DENS                                       GIONEUT  1317
      IF(I .GT. 3) CONC(J,I-3)=DENS                                     GIONEUT  1318
25    CONTINUE                                                          GIONEUT  1319
C                                                                       GIONEUT  1320
C  FIND LARGEST NEGATIVE SPECIES.                                       GIONEUT  1321
C                                                                       GIONEUT  1322
      BIG=N(J,30)                                                       GIONEUT  1323
      JBIG=1                                                            GIONEUT  1324
      DO 20 I=1,8                                                       GIONEUT  1325
      IF(CONC(J,I) .LT. BIG) GO TO 20                                   GIONEUT  1326
      BIG=CONC(J,I)                                                     GIONEUT  1327
      JBIG=I+1                                                          GIONEUT  1328
20    CONTINUE                                                          GIONEUT  1329
C                                                                       GIONEUT  1330
C  SUM ALL POSITIVE SPECIES.                                            GIONEUT  1331
C                                                                       GIONEUT  1332
      SUMP=0.                                                           GIONEUT  1333
      DO 30 I=1,6                                                       GIONEUT  1334
      SUMP=SUMP+N(J,I)                                                  GIONEUT  1335
30    CONTINUE                                                          GIONEUT  1336
      DO 31 I=23,29                                                     GIONEUT  1337
      SUMP=SUMP+N(J,I)                                                  GIONEUT  1338
31    CONTINUE                                                          GIONEUT  1339
      DO 35 I=9,24                                                      GIONEUT  1340
      SUMP=SUMP+CONC(J,I)                                               GIONEUT  1341
35    CONTINUE                                                          GIONEUT  1342
C                                                                       GIONEUT  1343
C  SUM ALL NEGATIVE SPECIES EXCEPT LARGEST.                             GIONEUT  1344
C                                                                       GIONEUT  1345
      SUMM=0.                                                           GIONEUT  1346
      DO 40 I=1,9                                                       GIONEUT  1347
      IF(I .EQ. JBIG) GO TO 40                                          GIONEUT  1348
      IF(I .EQ. 1) SUMM=SUMM+N(J,30)                                    GIONEUT  1349
      IF(I .NE. 1) SUMM=SUMM+CONC(J,I-1)                                GIONEUT  1350
40    CONTINUE                                                          GIONEUT  1351
      DENS=SUMP-SUMM                                                    GIONEUT  1352
      IF(DENS .GT. 0.) GO TO 70                                         GIONEUT  1353
      WRITE(6,75) Z(J),L,JBIG,SUMP,SUMM,DELT                            GIONEUT  1354
      WRITE(6,76) N(J,30),(CONC(J,I),I=1,8)                             GIONEUT  1355
76    FORMAT(1P9E13.5)                                                  GIONEUT  1356
75    FORMAT(*  ERROR IN CHEMION.  ALT=*,F8.2,I4,I3,1P3E12.5)           GIONEUT  1357
      END=.TRUE.                                                        GIONEUT  1358
      RETURN                                                            GIONEUT  1359
70    IF(JBIG .EQ. 1) N(J,30)=DENS                                      GIONEUT  1360
      IF(JBIG .NE. 1) CONC(J,JBIG-1)=DENS                               GIONEUT  1361
      DO 65 I=1,29                                                      GIONEUT  1362
      IF(I .LE. 3) DENS=N(J,I+27)                                       GIONEUT  1363
      IF(I .GT. 3) DENS=CONC(J,I-3)                                     GIONEUT  1364
      IF(DENS .EQ. 0.) GO TO 65                                         GIONEUT  1365
      IF(H(I) .EQ. 0.) GO TO 65                                         GIONEUT  1366
      IF(ABS(1.0-DENS/H(I))) .GT. 0.20) GO TO 60                        GIONEUT  1367
65    CONTINUE                                                          GIONEUT  1368
      GO TO 45                                                          GIONEUT  1369
60    CONTINUE                                                          GIONEUT  1370
      WRITE(6,90)                                                       GIONEUT  1371
90    FORMAT(*  ITERATIONS NOT CONVERGING IN CHEMION.*)                 GIONEUT  1372
      WRITE(6,81) Z(J),SYMBOL(I+27),DENS,H(I)                           GIONEUT  1373
```

```
81    FORMAT(*  FAILURE AT ALTITUDE*,OPF8.2,* FOR SPECIES*,A10,1P2E13.5) GIONEUT 1374
      END=.TRUE.                                                        GIONEUT 1375
      RETURN                                                            GIONEUT 1376
45    CONTINUE                                                          GIONEUT 1377
C                                                                       GIONEUT 1378
C  COMPUTE THE MAJOR POSITIVE IONS AND ELECTRONS ABOVE 120 KM.          GIONEUT 1379
C                                                                       GIONEUT 1380
      KB=K2+1                                                           GIONEUT 1381
      CALL MOVLEV(OLDN(1,28),E,K)                                       GIONEUT 1382
      CALL MOVLEV(OLDN(1,29),F,K)                                       GIONEUT 1383
      DO 105 J=KB,K                                                     GIONEUT 1384
      DO 100 L=1,500                                                    GIONEUT 1385
      DO 110 I=1,2                                                      GIONEUT 1386
      H(I)=N(J,I+27)                                                    GIONEUT 1387
      CALL CHEM(I+27,J)                                                 GIONEUT 1388
      IF(I .EQ. 1) DENS=E(J)                                            GIONEUT 1389
      IF(I .EQ. 2) DENS=F(J)                                            GIONEUT 1390
      H(I+3)=(DENS+DELT*FORM(J))/(1.0+DELT*REMV(J))                     GIONEUT 1391
110   CONTINUE                                                          GIONEUT 1392
      DO 91 I=1,2                                                       GIONEUT 1393
      N(J,I+27)=H(I+3)                                                  GIONEUT 1394
91    CONTINUE                                                          GIONEUT 1395
      DO 95 I=1,2                                                       GIONEUT 1396
      IF(H(I) .EQ. 0.) GO TO 95                                         GIONEUT 1397
      IF(ABS(1.0-(N(J,I+27)/H(I))) .GT. 0.1) GO TO 100                  GIONEUT 1398
95    CONTINUE                                                          GIONEUT 1399
      GO TO 105                                                         GIONEUT 1400
100   CONTINUE                                                          GIONEUT 1401
105   CONTINUE                                                          GIONEUT 1402
      DO 55 J=KB,K                                                      GIONEUT 1403
      SUMP=0.                                                           GIONEUT 1404
      DO 50 I=1,6                                                       GIONEUT 1405
      SUMP=SUMP+N(J,I)                                                  GIONEUT 1406
50    CONTINUE                                                          GIONEUT 1407
      DO 51 I=28,29                                                     GIONEUT 1408
      SUMP=SUMP+N(J,I)                                                  GIONEUT 1409
51    CONTINUE                                                          GIONEUT 1410
      N(J,30)=SUMP                                                      GIONEUT 1411
55    CONTINUE                                                          GIONEUT 1412
      RETURN                                                            GIONEUT 1413
      END                                                               GIONEUT 1414
```

```
      SUBROUTINE CHEM(KIND,IALT)
C
C     SUBROUTINE  MPUTES THE CHEMICAL FORMATION AND REMOVAL RATES
C     SPECIE  KIND AT THE ALTITUDE WHOSE INDEX IS J.
C
      DIMENSION Y(57),K(215)
C
      COMMON N(692,30),CONC(424,26),U(692,26),NZERO(692),UZERO(692)
C
      COMMON FORM(692),REMV(692),E(692),F(692),Z(692),
     1       LED(692),TEMP(692),DTEMDZ(692),DELTAZ(692),SUNSET(692)
C
      COMMON GRAV,COSD,SIND,TIME,CXI,RADIUS,ISPECI,KSPECI,NREAC,KTOP,
     1       K2,KMIN1,ITURB,CXINOON,SCXI,NREAC2
C
      COMMON/RATECON,AK(88),BK(88),CK(88),DK(215),CYMB(6,215)
C
      COMMON/ESN/DN(692,30),OLDCON(424,26),OLDU(692,26),RATES(88,692)
C
      COMMON/LOGIC/NIGHT,DAY,OLOOK,RESET,END
C
      LEVEL 3, DN,OLDCON,OLDU,RATES
C
      LOGICAL NIGHT
      REAL K,N
C
      DO 500 I=1,ISPECI
      IF(I .GT. 30) GO TO 200
      Y(I)=N(IALT,I)
      GO TO 500
  200 IF(IALT .GT. K2) GO TO 475
      Y(I)=CONC(IALT,I-30)
      GO TO 500
  475 Y(I)=0.
  500 CONTINUE
      Y(57)=0.
      DO 600 I=1,ISPECI
      Y(57)=Y(57)+Y(I)
  600 CONTINUE
      DO 205 I=1,NREAC
      K(I)=DK(I)
  205 CONTINUE
      IF(.NOT. NIGHT) GO TO 210
      K(96)=K(99)=K(104)=K(105)=K(110)=0.
      K(113)=K(114)=K(118)=K(120)=K(123)=0.
  210 CALL MOVLEV(RATES(1,IALT),K(128),88)
      IF(IALT .LE. K2) GO TO 215
      K(31)=K(32)=K(35)=0.
      K(160)=K(161)=K(162)=K(165)=K(166)=0.
  215 GO TO(1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,
     124,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,
     246,47,48,49,50,51,52,53,54,55,56),KIND
    1 CONTINUE
      RMOV=(K(4)*Y( )+K(159)*Y(30))
      FORM=
      GO TO  0
    2 CONTINUE
```

AD-A157 122   A COMPUTER CODE FOR A ONE-DIMENSIONAL DYNAMIC MODEL OF   3/3
THE MESOSPHERS AND.. (U) AIR FORCE GEOPHYSICS LAB
HANSCOM AFB MA   T J KENESHEA ET AL. 07 MAR 84
UNCLASSIFIED   AFGL-TR-84-0183   F/G 4/1   NL

END
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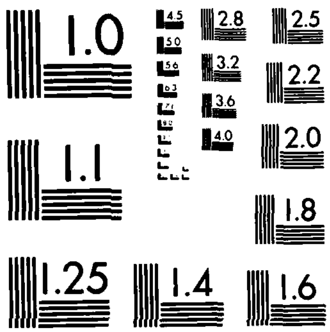

MICROCOPY RESOLUTION TEST CHART

DARDS-1963-A

```
      RMOV=(Y(8)*(+K(45)+K(46))+Y(23)*(+K(47)+K(48))+K(49)*Y(18))        GIONEUT  1472
      FARM=(+K(191)*Y(21))                                                GIONEUT  1473
      GO TO 100                                                           GIONEUT  1474
    3 CONTINUE                                                            GIONEUT  1475
      RMOV=(+K(40)*Y(11)+K(127)*Y(25)+K(153)*Y(30)+K(168)*Y(23)+K(169)*Y GIONEUT  1476
     1(8))                                                                GIONEUT  1477
      FARM=(Y(7)*(+K(41)*Y(1)+K(185)+K(211))+Y(8)*(+K(45)*Y(2)+K(209)))  GIONEUT  1478
      GO TO 100                                                           GIONEUT  1479
    4 CONTINUE                                                            GIONEUT  1480
      RMOV=(+K(33)*Y(18)+K(34)*Y(16)+K(35)*Y(19)+K(152)*Y(30)+K(162)*Y(8 GIONEUT  1481
     1)*Y(57))                                                            GIONEUT  1482
      FARM=(Y(8)*(Y(6)*(+K(43)+K(44))+K(46)*Y(2)+K(126)*Y(29)+K(167)*Y(2 GIONEUT  1483
     18)+K(169)*Y(3)+K(186)+K(214))+Y(39)*(+K(36)*Y(7)+K(163)*Y(57)+K(16 GIONEUT  1484
     14)*Y(20))+K(127)*Y(3)*Y(25)+K(207)*Y(20))                           GIONEUT  1485
      GO TO 100                                                           GIONEUT  1486
    5 CONTINUE                                                            GIONEUT  1487
      RMOV=(Y(30)*(+K(150)+K(151))+K(165)*Y(25)*Y(23)+K(166)*Y(13)*Y(57) GIONEUT  1488
     1)                                                                   GIONEUT  1489
      FARM=(Y(18)*(+K(33)*Y(4)+K(50)*Y(40)+K(188))+Y(7)*(+K(38)*Y(28)+K( GIONEUT  1490
     139)*Y(28))+K(34)*Y(4)*Y(16)+K(42)*Y(6)*Y(8)+K(168)*Y(3)*Y(23))     GIONEUT  1491
      GO TO 100                                                           GIONEUT  1492
    6 CONTINUE                                                            GIONEUT  1493
      RMOV=(Y(8)*(+K(42)+K(43)+K(44))+K(154)*Y(30))                       GIONEUT  1494
      FARM=(Y(2)*(+K(47)*Y(23)+K(49)*Y(18))+K(189)*Y(16)+K(208)*Y(23))   GIONEUT  1495
      GO TO 100                                                           GIONEUT  1496
    7 CONTINUE                                                            GIONEUT  1497
      RMOV=(Y(57)*(Y(7)*(+K(128)+K(128))+K(129)*Y(8)+K(139)*Y(16)+K(143) GIONEUT  1498
     1*Y(18)+K(148)*Y(26))+Y(14)*(+K(132)+K(133))+Y(28)*(+K(38)+K(39))+Y GIONEUT  1499
     1(32)*(+K(100)+K(101))+Y(34)*(+K(107)+K(108))+K(2)*Y(10)+K(3)*Y(12) GIONEUT  1500
     1+K(4)*Y(19)+K(20)*Y(55)+K(31)*Y(30)+K(36)*Y(39)+K(41)*Y(1)+K(97)*Y GIONEUT  1501
     1(31)+K(106)*Y(33)+K(111)*Y(37)+K(115)*Y(38)+K(121)*Y(36)+K(130)*Y( GIONEUT  1502
     19)+K(131)*Y(15)+K(185)+K(206)+K(211)+K(212))                       GIONEUT  1503
      FARM=(Y(8)*(+K(14)*Y(17)+K(42)*Y(6)+K(45)*Y(2)+K(126)*Y(29)+K(137) GIONEUT  1504
     1*Y(16)+K(169)*Y(3)+K(192)+K(192)+K(193)+K(209)+K(210))+Y(30)*(Y(4) GIONEUT  1505
     1*(+K(152)+K(152))+Y(5)*(+K(150)+K(151))+K(153)*Y(3)+K(156)*Y(40))+ GIONEUT  1506
     1Y(16)*(+K(9)*Y(19)+K(34)*Y(4)+K(138)*Y(18))+Y(9)*(+K(98)*Y(31)+K(1 GIONEUT  1507
     194))+Y(18)*(+K(49)*Y(2)+K(199))+K(12)*Y(10)*Y(10)+K(16)*Y(27)*Y(57 GIONEUT  1508
     1)+K(40)*Y(3)*Y(11)+K(96)*Y(31)+K(120)*Y(36)+K(125)*Y(29)*Y(23)+K(2 GIONEUT  1509
     104)*Y(25))                                                          GIONEUT  1510
      GO TO 100                                                           GIONEUT  1511
    8 CONTINUE                                                            GIONEUT  1512
      RMOV=(Y(8)*(Y(30)*(+K(160)+K(160))+Y(31)*(+K(179)+K(179))+Y(32)*(+ GIONEUT  1513
     1K(180)+K(180)))+Y(6)*(+K(42)+K(43)+K(44))+Y(57)*(+K(129)*Y(7)+K(13 GIONEUT  1514
     16)*Y(11)+K(162)*Y(4))+Y(2)*(+K(45)+K(46))+K(14)*Y(17)+K(32)*Y(23)* GIONEUT  1515
     1Y(30)+K(126)*Y(29)+K(137)*Y(16)+K(167)*Y(28)+K(169)*Y(3)+K(186)+K( GIONEUT  1516
     1192)+K(193)+K(209)+K(210)+K(214))                                   GIONEUT  1517
      FARM=(Y(7)*(Y(34)*(+K(107)+K(108))+Y(9)*(+K(130)+K(130))+K( GIONEUT  1518
     12)*Y(10)+K(3)*Y(12)+K(4)*Y(19)+K(97)*Y(31)+K(101)*Y(32)+K(106)*Y(3 GIONEUT  1519
     13)+K(115)*Y(38)+K(121)*Y(36)+K(128)*Y(7)*Y(57)+K(133)*Y(14))+Y(9)* GIONEUT  1520
     1(Y(12)*(+K(145)+K(145))+K(7)*Y(11)+K(8)*Y(16)+K(102)*Y(32)+K(116)* GIONEUT  1521
     1Y(38)+K(119)*Y(35)+K(124)*Y(31)+K(140)*Y(10)+K(142)*Y(18)+K(161)*Y GIONEUT  1522
     1(30)+K(194))+Y(20)*(Y(32)*(+K(103)+K(103))+Y(39)*(+K(164)+K(164))+ GIONEUT  1523
     1K(18)*Y(57)+K(19))+Y(12)*(+K(5)*Y(11)+K(13)*Y(10)+K(144)*Y(12)+K(1 GIONEUT  1524
     198))+Y(8)*(Y(8)*(+K(160)*Y(30)+K(179)*Y(31)+K(180)*Y(32)))+Y(13)*( GIONEUT  1525
     1Y(50)*(+K(53)+K(54))+K(37)*Y(39))+Y(4)*(+K(33)*Y(18)+K(35)*Y(19))+ GIONEUT  1526
     1Y(25)*(+K(109)*Y(34)+K(182)*Y(33))+Y(57)*(+K(163)*Y(39)+K(183)*Y(3 GIONEUT  1527
     14))+K(11)*Y(16)*Y(19)+K(99)*Y(32)+K(105)*Y(33)+K(114)*Y(38)+K(205) GIONEUT  1528
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     1*Y(56))                                                            GIONEUT  1529
      GO TO 100                                                          GIONEUT  1530
    9 CONTINUE                                                           GIONEUT  1531
      RMOV=(Y(31)*(+K(98)+K(124))+K(7)*Y(11)+K(8)*Y(16)+K(102)*Y(32)+K(1 GIONEUT  1532
     116)*Y(38)+K(119)*Y(35)+K(130)*Y(7)+K(140)*Y(10)+K(142)*Y(18)+K(145 GIONEUT  1533
     1)*Y(12)+K(161)*Y(30)+K(194)+K(195))                                GIONEUT  1534
      FARM=(Y(7)*(+K(36)*Y(39)+K(100)*Y(32)+K(129)*Y(8)*Y(57))+K(104)*Y( GIONEUT  1535
     133))                                                               GIONEUT  1536
      GO TO 100                                                          GIONEUT  1537
   10 CONTINUE                                                           GIONEUT  1538
      RMOV=(Y(10)*(+K(12)+K(12))+K(2)*Y(7)+K(13)*Y(12)+K(21)*Y(55)+K(140 GIONEUT  1539
     1)*Y(9)+K(141)*Y(14)+K(147)*Y(26))                                  GIONEUT  1540
      FARM=(Y(37)*(+K(64)*Y(41)+K(68)*Y(42)+K(72)*Y(43)+K(76)*Y(44)+K(80 GIONEUT  1541
     1)*Y(45)+K(92)*Y(48)+K(94)*Y(49))+Y(30)*(+K(24)*Y(41)+K(25)*Y(42)+K GIONEUT  1542
     1(26)*Y(43)+K(27)*Y(44)+K(28)*Y(45)+K(29)*Y(47))+Y(11)*(Y(12)*(+K(6 GIONEUT  1543
     1)+K(6))+K(7)*Y(9)+K(135)*Y(14)+K(146)*Y(19))+Y(13)*(Y(27)*(+K(15)+ GIONEUT  1544
     1K(15))+K(54)*Y(50)+K(61)*Y(47)+K(196))+Y(36)*(+K(63)*Y(41)+K(67)*Y GIONEUT  1545
     1(42)+K(71)*Y(43)+K(75)*Y(44)+K(79)*Y(45))+Y(7)*(+K(3)*Y(12)+K(20)* GIONEUT  1546
     1Y(55)+K(131)*Y(15)+K(132)*Y(14))+Y(14)*(+K(197)+K(197))+K(17)*Y(27 GIONEUT  1547
     1)*Y(15)+K(145)*Y(12)*Y(9)+K(202)*Y(55))                            GIONEUT  1548
      GO TO 100                                                          GIONEUT  1549
   11 CONTINUE                                                           GIONEUT  1550
      RMOV=(Y(12)*(+K(5)+K(6))+Y(14)*(+K(134)+K(135))+K(7)*Y(9)+K(40)*Y( GIONEUT  1551
     13)+K(136)*Y(8)*Y(57)+K(146)*Y(19)+K(190))                          GIONEUT  1552
      FARM=(Y(35)*(+K(62)*Y(41)+K(66)*Y(42)+K(70)*Y(43)+K(74)*Y(44)+K(78 GIONEUT  1553
     1)*Y(45))+Y(7)*(+K(2)*Y(10)+K(41)*Y(1)+K(131)*Y(15))+Y(30)*(+K(29)* GIONEUT  1554
     1Y(47)+K(30)*Y(49)+K(155)*Y(1))+K(17)*Y(27)*Y(15)+K(147)*Y(26)*Y(10 GIONEUT  1555
     1)+K(196)*Y(13)+K(198)*Y(12))                                       GIONEUT  1556
      GO TO 100                                                          GIONEUT  1557
   12 CONTINUE                                                           GIONEUT  1558
      RMOV=(Y(11)*(+K(5)+K(6))+Y(12)*(+K(144)+K(144))+K(3)*Y(7)+K(13)*Y( GIONEUT  1559
     110)+K(145)*Y(9)+K(198))                                            GIONEUT  1560
      FARM=(Y(38)*(+K(69)*Y(42)+K(73)*Y(43)+K(77)*Y(44)+K(81)*Y(45)+K(93 GIONEUT  1561
     1)*Y(48)+K(95)*Y(49))+Y(14)*(+K(132)*Y(7)+K(134)*Y(11)+K(141)*Y(10) GIONEUT  1562
     1)+K(65)*Y(42)*Y(32)+K(136)*Y(11)*Y(8)*Y(57)+K(140)*Y(10)*Y(9))     GIONEUT  1563
      GO TO 100                                                          GIONEUT  1564
   13 CONTINUE                                                           GIONEUT  1565
      RMOV=(Y(57)*(+K(52)*Y(44)+K(166)*Y(5)+K(170)*Y(41)+K(172)*Y(42)+K( GIONEUT  1566
     1173)*Y(43)+K(177)*Y(51)+K(178)*Y(52))+Y(48)*(+K(58)*Y(23)+K(60))+Y GIONEUT  1567
     1(50)*(+K(53)+K(54))+K(15)*Y(27)+K(37)*Y(39)+K(55)*Y(53)+K(56)*Y(54 GIONEUT  1568
     1)+K(59)*Y(49)+K(61)*Y(47)+K(196))                                  GIONEUT  1569
      FARM=(Y(30)*(Y(52)*(+K(158)+K(158))+K(25)*Y(42)+K(29)*Y(47)+K(157) GIONEUT  1570
     1*Y(51))+Y(10)*(+K(12)*Y(10)+K(13)*Y(12)+K(21)*Y(55)+K(141)*Y(14))+ GIONEUT  1571
     1Y(37)*(+K(64)*Y(41)+K(84)*Y(51)+K(92)*Y(48))+Y(57)*(+K(174)*Y(43)+ GIONEUT  1572
     1K(175)*Y(44)+K(176)*Y(45))+Y(14)*(+K(133)*Y(7)+K(135)*Y(11))+Y(32) GIONEUT  1573
     1*(+K(65)*Y(42)+K(65)*Y(42))+Y(35)*(+K(62)*Y(41)+K(82)*Y(51))+Y(36) GIONEUT  1574
     1*(+K(63)*Y(41)+K(83)*Y(51))+K(93)*Y(48)*Y(38))                     GIONEUT  1575
      FARM=FARM+2.0*(Y(42)*(K(66)*Y(35)+K(67)*Y(36)+K(68)*Y(37)          GIONEUT  1576
     1+K(69)*Y(38))+Y(49)*(K(30)*Y(30)+K(94)*Y(37)+K(95)*Y               GIONEUT  1577
     2(38))+Y(52)*(K(85)*Y(35)+K(86)*Y(36)+K(87)*Y(37))                  GIONEUT  1578
     3+K(26)*Y(43)*Y(30))+3.0*(Y(43)*(K(70)*Y(35)+K(71)*                 GIONEUT  1579
     4Y(36)+K(72)*Y(37)+K(73)*Y(38))+Y(53)*(K(88)*Y(35)                  GIONEUT  1580
     5+K(89)*Y(36)+K(90)*Y(37)+K(159)*Y(30))+K(27)*Y(44)                 GIONEUT  1581
     6*Y(30))+4.0*(Y(44)*(K(74)*Y(35)+K(75)*Y(36)+K(76)*Y(               GIONEUT  1582
     737)+K(77)*Y(38))+K(28)*Y(45)*Y(30))+5.0*(Y(45)*(                   GIONEUT  1583
     8K(78)*Y(35)+K(79)*Y(36)+K(80)*Y(37)+K(81)*Y(38)))                  GIONEUT  1584
      GO TO 100                                                          GIONEUT  1585
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   14 CONTINUE                                                              GIDNEUT 1586
      RMOV=(Y(7)*(+K(132)+K(133))+Y(11)*(+K(134)+K(135))+K(141)*Y(10)+K(  GIDNEUT 1587
     1197))                                                                 GIDNEUT 1588
      FARM=(+K(91)*Y(48)*Y(36)+K(144)*Y(12)*Y(12))                          GIDNEUT 1589
      GO TO 100                                                             GIDNEUT 1590
   15 CONTINUE                                                              GIDNEUT 1591
      RMOV=(+K(17)*Y(27)+K(131)*Y(7))                                       GIDNEUT 1592
      FARM=(Y(30)*(+K(24)*Y(41)+K(25)*Y(42)+K(26)*Y(43)+K(27)*Y(44)+K(28   GIDNEUT 1593
     1)*Y(45))+Y(11)*(+K(5)*Y(12)+K(134)*Y(14)))                            GIDNEUT 1594
      GO TO 100                                                             GIDNEUT 1595
   16 CONTINUE                                                              GIDNEUT 1596
      RMOV=(Y(19)*(+K(9)+K(10)+K(11))+K(8)*Y(9)+K(34)*Y(4)+K(137)*Y(8)+K   GIDNEUT 1597
     1(138)*Y(18)+K(139)*Y(7)*Y(57)+K(189))                                 GIDNEUT 1598
      FARM=(Y(30)*(Y(28)*(+K(22)+K(22))+K(149)*Y(17)+K(150)*Y(5)+K(154)*   GIDNEUT 1599
     1Y(6))+Y(23)*(+K(47)*Y(2)+K(168)*Y(3)+K(208)+K(215))+Y(7)*(+K(1)*Y(   GIDNEUT 1600
     117)+K(38)*Y(28))+K(43)*Y(6)*Y(8)+K(199)*Y(18))                        GIDNEUT 1601
      GO TO 100                                                             GIDNEUT 1602
   17 CONTINUE                                                              GIDNEUT 1603
      RMOV=(+K(1)*Y(7)+K(14)*Y(8)+K(149)*Y(30))                             GIDNEUT 1604
      FARM=(Y(28)*(Y(30)*(+K(23)+K(23))+K(39)*Y(7))+K(44)*Y(6)*Y(8)+K(15   GIDNEUT 1605
     11)*Y(5)*Y(30)+K(215)*Y(23))                                           GIDNEUT 1606
      GO TO 100                                                             GIDNEUT 1607
   18 CONTINUE                                                              GIDNEUT 1608
      RMOV=(+K(33)*Y(4)+K(49)*Y(2)+K(50)*Y(40)+K(117)*Y(38)+K(122)*Y(56)   GIDNEUT 1609
     1+K(138)*Y(16)+K(142)*Y(9)+K(143)*Y(7)*Y(57)+K(184)*Y(37)+K(188)+K(   GIDNEUT 1610
     1199))                                                                 GIDNEUT 1611
      FARM=(Y(16)*(Y(19)*(+K(10)+K(10))+K(8)*Y(9)+K(137)*Y(8)+K(139)*Y(7   GIDNEUT 1612
     1)*Y(57))+Y(30)*(+K(156)*Y(40)+K(157)*Y(51)+K(158)*Y(52)+K(159)*Y(5   GIDNEUT 1613
     13))+Y(19)*(+K(4)*Y(7)+K(146)*Y(11)+K(200))+Y(35)*(+K(82)*Y(51)+K(8   GIDNEUT 1614
     15)*Y(52)+K(88)*Y(53))+K(14)*Y(17)*Y(8)+K(202)*Y(55)+K(205)*Y(56))    GIDNEUT 1615
      GO TO 100                                                             GIDNEUT 1616
   19 CONTINUE                                                              GIDNEUT 1617
      RMOV=(Y(16)*(+K(9)+K(10)+K(11))+K(4)*Y(7)+K(35)*Y(4)+K(112)*Y(37)+   GIDNEUT 1618
     1K(146)*Y(11)+K(200))                                                  GIDNEUT 1619
      FARM=(Y(36)*(Y(51)*(+K(83)+K(83))+Y(52)*(+K(86)+K(86))+Y(53)*(+K(8   GIDNEUT 1620
     19)+K(89))+K(63)*Y(41)+K(67)*Y(42)+K(71)*Y(43)+K(75)*Y(44)+K(79)*Y(   GIDNEUT 1621
     145))+Y(35)*(+K(62)*Y(41)+K(66)*Y(42)+K(70)*Y(43)+K(74)*Y(44)+K(78)   GIDNEUT 1622
     1*Y(45)+K(82)*Y(51)+K(85)*Y(52)+K(88)*Y(53)+K(118))+Y(18)*(Y(56)*(+   GIDNEUT 1623
     1K(122)+K(122))+K(50)*Y(40)+K(142)*Y(9)+K(143)*Y(7)*Y(57))+Y(37)*(+   GIDNEUT 1624
     1K(84)*Y(51)+K(87)*Y(52)+K(90)*Y(53))+Y(55)*(+K(20)*Y(7)+K(21)*Y(10   GIDNEUT 1625
     1)))                                                                   GIDNEUT 1626
      GO TO 100                                                             GIDNEUT 1627
   20 CONTINUE                                                              GIDNEUT 1628
      RMOV=(+K(18)*Y(57)+K(19)+K(103)*Y(32)+K(164)*Y(39)+K(207))           GIDNEUT 1629
      FARM=(+K(195)*Y(9))                                                   GIDNEUT 1630
      GO TO 100                                                             GIDNEUT 1631
   21 CONTINUE                                                              GIDNEUT 1632
      RMOV=(+K(191))                                                        GIDNEUT 1633
      FARM=(Y(2)*(Y(8)*(+K(45)+K(46))+Y(23)*(+K(47)+K(48))+K(49)*Y(18)))   GIDNEUT 1634
      GO TO 100                                                             GIDNEUT 1635
   22 CONTINUE                                                              GIDNEUT 1636
      RMOV=0.                                                               GIDNEUT 1637
      FARM=0.                                                               GIDNEUT 1638
      GO TO 100                                                             GIDNEUT 1639
   23 CONTINUE                                                              GIDNEUT 1640
      RMOV=(Y(2)*(+K(47)+K(48))+Y(23)*(-K(171)*Y(41)+K(171)*Y(41))+K(125   GIDNEUT 1641
     1)*Y(29)+K(168)*Y(3)+K(187)+K(208)+K(213)+K(215))                      GIDNEUT 1642
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      FARM=(Y(16)*(+K(11)*Y(19)+K(138)*Y(18))+K(57)*Y(46)*Y(25)+K(167)*Y GIONEUT 1643
     1(28)*Y(8)+K(171)*Y(41)*Y(23)*Y(23)+K(201)*Y(24))                  GIONEUT 1644
      GO TO 100                                                         GIONEUT 1645
   24 CONTINUE                                                          GIONEUT 1646
      RMOV=(+K(201))                                                    GIONEUT 1647
      FARM=(+K(9)*Y(16)*Y(19))                                          GIONEUT 1648
      GO TO 100                                                         GIONEUT 1649
   25 CONTINUE                                                          GIONEUT 1650
      RMOV=(+K(51)*Y(42)*Y(57)+K(57)*Y(46)+K(109)*Y(34)+K(127)*Y(3)+K(16 GIONEUT 1651
     15)*Y(5)*Y(23)+K(181)*Y(32)*Y(8)+K(182)*Y(33)+K(203)+K(204))       GIONEUT 1652
      FARM=(Y(37)*(+K(64)*Y(41)+K(68)*Y(42)+K(72)*Y(43)+K(76)*Y(44)+K(80 GIONEUT 1653
     1)*Y(45)+K(84)*Y(51)+K(87)*Y(52)+K(90)*Y(53)+K(110)+K(111)*Y(7)+K(1 GIONEUT 1654
     112)*Y(19)+K(184)*Y(18))+Y(38)*(+K(69)*Y(42)+K(73)*Y(43)+K(77)*Y(44 GIONEUT 1655
     1)+K(81)*Y(45)+K(113)+K(114)+K(116)*Y(9)+K(117)*Y(18))+Y(13)*(+K(56 GIONEUT 1656
     1)*Y(54)+K(59)*Y(49)+K(60)*Y(48))+Y(26)*(+K(147)*Y(10)+K(148)*Y(7)* GIONEUT 1657
     1Y(57))+K(30)*Y(45)*Y(30)+K(91)*Y(48)*Y(36))                       GIONEUT 1658
      FARM=FARM+2.0*(Y(37)*(K(92)*Y(48)+K(94)*Y(49))+Y(38)*(            GIONEUT 1659
     1K(93)*Y(48)+K(95)*Y(49)))                                         GIONEUT 1660
      GO TO 100                                                         GIONEUT 1661
   26 CONTINUE                                                          GIONEUT 1662
      RMOV=(+K(147)*Y(10)+K(148)*Y(7)*Y(57))                            GIONEUT 1663
      FARM=(Y(25)*(+K(127)*Y(3)+K(203)+K(204)))                         GIONEUT 1664
      GO TO 100                                                         GIONEUT 1665
   27 CONTINUE                                                          GIONEUT 1666
      RMOV=(+K(15)*Y(13)+K(16)*Y(57)+K(17)*Y(15))                       GIONEUT 1667
      FARM=(+K(193)*Y(8)+K(195)*Y(9)+K(200)*Y(19)+K(201)*Y(24)+K(203)*Y( GIONEUT 1668
     125))                                                              GIONEUT 1669
      GO TO 100                                                         GIONEUT 1670
   28 CONTINUE                                                          GIONEUT 1671
      RMOV=(Y(7)*(+K(38)+K(39))+Y(30)*(+K(22)+K(23))+K(167)*Y(8))       GIONEUT 1672
      FARM=(Y(23)*(+K(48)*Y(2)+K(125)*Y(29)+K(187)+K(213)))             GIONEUT 1673
      GO TO 100                                                         GIONEUT 1674
   29 CONTINUE                                                          GIONEUT 1675
      RMOV=(+K(125)*Y(23)+K(126)*Y(8))                                  GIONEUT 1676
      FARM=(Y(7)*(+K(206)+K(212))+K(210)*Y(8))                          GIONEUT 1677
      GO TO 100                                                         GIONEUT 1678
   30 CONTINUE                                                          GIONEUT 1679
      RMOV=(Y(5)*(+K(150)+K(151))+Y(8)*(+K(32)*Y(23)+K(160)*Y(8))+Y(28)* GIONEUT 1680
     1(+K(22)+K(23))+K(24)*Y(41)+K(25)*Y(42)+K(26)*Y(43)+K(27)*Y(44)+K(2 GIONEUT 1681
     18)*Y(45)+K(29)*Y(47)+K(30)*Y(49)+K(31)*Y(7)+K(152)*Y(4)+K(153)*Y(3 GIONEUT 1682
     1)+K(154)*Y(6)+K(155)*Y(1)+K(156)*Y(40)+K(157)*Y(51)+K(158)*Y(52)+K GIONEUT 1683
     1(159)*Y(53)+K(161)*Y(9))                                          GIONEUT 1684
      FARM=(Y(7)*(+K(97)*Y(31)+K(100)*Y(32)+K(185)+K(206))+Y(20)*(+K(103 GIONEUT 1685
     1)*Y(32)+K(207))+Y(23)*K(187)+K(96)*Y(31)+K(99)*Y(32)+K(1          GIONEUT 1686
     104)*Y(33)+K(114)*Y(38)+K(118)*Y(35)+K(123)*Y(36)+K(186)*Y(8)+K(188 GIONEUT 1687
     1)*Y(18)+K(189)*Y(16)+K(190)*Y(11)+K(191)*Y(21))                   GIONEUT 1688
      FARM=FARM+Y(23)*(K(208)+K(213))+Y(8)*(K(209)+K(210)+K(214))       GIONEUT 1689
     1+Y(7)*(K(211)+K(212))                                             GIONEUT 1690
      GO TO 100                                                         GIONEUT 1691
   31 CONTINUE                                                          GIONEUT 1692
      RMOV=(Y(9)*(+K(98)+K(124))+K(96)+K(97)*Y(7)+K(179)*Y(8)*Y(8))     GIONEUT 1693
      FARM=(Y(7)*(+K(31)*Y(30)+K(101)*Y(32)+K(108)*Y(34))+K(105)*Y(33)+K GIONEUT 1694
     1(110)*Y(37)+K(161)*Y(9)*Y(30))                                    GIONEUT 1695
      GO TO 100                                                         GIONEUT 1696
   32 CONTINUE                                                          GIONEUT 1697
      RMOV=(Y(7)*(-K(100)+K(101))+Y(8)*(+K(180)*Y(8)+K(181)*Y(25))+K(65) GIONEUT 1698
     1*Y(42)+K(99)+K(102)*Y(9)+K(103)*Y(20))                            GIONEUT 1699
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      FARM=(Y(7)*(+K(106)*Y(33)+K(111)*Y(37))+Y(8)*(Y(30)*(+K(32)*Y(23)+ GIONEUT   1700
     1K(160)*Y(8)))+K(113)*Y(38)+K(124)*Y(31)*Y(9)+K(183)*Y(34)*Y(57))   GIONEUT   1701
      GO TO 100                                                          GIONEUT   1702
   33 CONTINUE                                                           GIONEUT   1703
      RMOV=(+K(104)+K(105)+K(106)*Y(7)+K(182)*Y(25))                     GIONEUT   1704
      FARM=(Y(9)*(+K(98)*Y(31)+K(102)*Y(32)+K(116)*Y(38))+K(107)*Y(34)*Y GIONEUT   1705
     1(7)+K(179)*Y(31)*Y(8)*Y(8))                                        GIONEUT   1706
      GO TO 100                                                          GIONEUT   1707
   34 CONTINUE                                                           GIONEUT   1708
      RMOV=(Y(7)*(+K(107)+K(108))+K(109)*Y(25)+K(183)*Y(57))             GIONEUT   1709
      FARM=(+K(180)*Y(32)*Y(8)*Y(8))                                     GIONEUT   1710
      GO TO 100                                                          GIONEUT   1711
   35 CONTINUE                                                           GIONEUT   1712
      RMOV=(+K(62)*Y(41)+K(66)*Y(42)+K(70)*Y(43)+K(74)*Y(44)+K(78)*Y(45) GIONEUT   1713
     1+K(82)*Y(51)+K(85)*Y(52)+K(88)*Y(53)+K(118)+K(119)*Y(9))           GIONEUT   1714
      FARM=(Y(36)*(+K(120)+K(121)*Y(7))+K(184)*Y(37)*Y(18))              GIONEUT   1715
      GO TO 100                                                          GIONEUT   1716
   36 CONTINUE                                                           GIONEUT   1717
      RMOV=(+K(63)*Y(41)+K(67)*Y(42)+K(71)*Y(43)+K(75)*Y(44)+K(79)*Y(45) GIONEUT   1718
     1+K(83)*Y(51)+K(86)*Y(52)+K(89)*Y(53)+K(91)*Y(48)+K(120)+K(121)*Y(7 GIONEUT   1719
     1)+K(123))                                                          GIONEUT   1720
      FARM=(+K(112)*Y(37)*Y(19)+K(117)*Y(38)*Y(18)+K(119)*Y(35)*Y(9))    GIONEUT   1721
      GO TO 100                                                          GIONEUT   1722
   37 CONTINUE                                                           GIONEUT   1723
      RMOV=(+K(64)*Y(41)+K(68)*Y(42)+K(72)*Y(43)+K(76)*Y(44)+K(80)*Y(45) GIONEUT   1724
     1+K(84)*Y(51)+K(87)*Y(52)+K(90)*Y(53)+K(92)*Y(48)+K(94)*Y(49)+K(110 GIONEUT   1725
     1)+K(111)*Y(7)+K(112)*Y(19)+K(184)*Y(18))                           GIONEUT   1726
      FARM=(+K(115)*Y(38)*Y(7)+K(182)*Y(33)*Y(25))                       GIONEUT   1727
      GO TO 100                                                          GIONEUT   1728
   38 CONTINUE                                                           GIONEUT   1729
      RMOV=(+K(69)*Y(42)+K(73)*Y(43)+K(77)*Y(44)+K(81)*Y(45)+K(93)*Y(48) GIONEUT   1730
     1+K(95)*Y(49)+K(113)+K(114)+K(115)*Y(7)+K(116)*Y(9)+K(117)*Y(18))   GIONEUT   1731
      FARM=(Y(25)*(+K(109)*Y(34)+K(181)*Y(32)*Y(8)))                     GIONEUT   1732
      GO TO 100                                                          GIONEUT   1733
   39 CONTINUE                                                           GIONEUT   1734
      RMOV=(+K(36)*Y(7)+K(37)*Y(13)+K(163)*Y(57)+K(164)*Y(20))           GIONEUT   1735
      FARM=(+K(162)*Y(4)*Y(8)*Y(57))                                     GIONEUT   1736
      GO TO 100                                                          GIONEUT   1737
   40 CONTINUE                                                           GIONEUT   1738
      RMOV=(+K(50)*Y(18)+K(156)*Y(30))                                   GIONEUT   1739
      FARM=(+K(35)*Y(4)*Y(19))                                           GIONEUT   1740
      GO TO 100                                                          GIONEUT   1741
   41 CONTINUE                                                           GIONEUT   1742
      RMOV=(+K(24)*Y(30)+K(62)*Y(35)+K(63)*Y(36)+K(64)*Y(37)+K(170)*Y(13 GIONEUT   1743
     1)*Y(57)+K(171)*Y(23)*Y(23))                                        GIONEUT   1744
      FARM=(+K(54)*Y(50)*Y(13))                                          GIONEUT   1745
      GO TO 100                                                          GIONEUT   1746
   42 CONTINUE                                                           GIONEUT   1747
      RMOV=(Y(57)*(+K(51)*Y(25)+K(172)*Y(13))+K(25)*Y(30)+K(65)*Y(32)+K( GIONEUT   1748
     1166)*Y(35)+K(67)*Y(36)+K(68)*Y(37)+K(69)*Y(38))                    GIONEUT   1749
      FARM=(Y(13)*(+K(60)*Y(48)+K(61)*Y(47)+K(170)*Y(41)*Y(57))+K(174)*Y GIONEUT   1750
     1(43)*Y(57))                                                        GIONEUT   1751
      GO TO 100                                                          GIONEUT   1752
   43 CONTINUE                                                           GIONEUT   1753
      RMOV=(Y(57)*(+K(173)*Y(13)+K(174))+K(26)*Y(30)+K(70)*Y(35)+K(71)*Y GIONEUT   1754
     1(36)+K(72)*Y(37)+K(73)*Y(36))                                      GIONEUT   1755
      FARM=(Y(13)*(+K(55)*Y(53)+K(59)*Y(49)+K(172)*Y(42)*Y(57))+K(175)*Y GIONEUT   1756
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     1(44)*Y(57))                                                          GIONEUT  1757
      GO TO 100                                                            GIONEUT  1758
   44 CONTINUE                                                             GIONEUT  1759
      RMOV=(Y(57)*(+K(52)*Y(13)+K(175))+K(27)*Y(30)+K(74)*Y(35)+K(75)*Y(   GIONEUT  1760
     136)+K(76)*Y(37)+K(77)*Y(38))                                         GIONEUT  1761
      FARM=(Y(57)*(+K(173)*Y(43)*Y(13)+K(176)*Y(45)))                      GIONEUT  1762
      GO TO 100                                                            GIONEUT  1763
   45 CONTINUE                                                             GIONEUT  1764
      RMOV=(+K(28)*Y(30)+K(78)*Y(35)+K(79)*Y(36)+K(80)*Y(37)+K(81)*Y(38)   GIONEUT  1765
     1+K(176)*Y(57))                                                       GIONEUT  1766
      FARM=(+K(52)*Y(44)*Y(13)*Y(57))                                      GIONEUT  1767
      GO TO 100                                                            GIONEUT  1768
   46 CONTINUE                                                             GIONEUT  1769
      RMOV=(+K(57)*Y(25))                                                  GIONEUT  1770
      FARM=(+K(171)*Y(41)*Y(23)*Y(23))                                     GIONEUT  1771
      GO TO 100                                                            GIONEUT  1772
   47 CONTINUE                                                             GIONEUT  1773
      RMOV=(+K(29)*Y(30)+K(61)*Y(13))                                      GIONEUT  1774
      FARM=(+K(53)*Y(50)*Y(13))                                            GIONEUT  1775
      GO TO 100                                                            GIONEUT  1776
   48 CONTINUE                                                             GIONEUT  1777
      RMOV=(Y(13)*(+K(58)*Y(23)+K(60))+K(91)*Y(36)+K(92)*Y(37)+K(93)*Y(3   GIONEUT  1778
     18))                                                                  GIONEUT  1779
      FARM=(+K(57)*Y(46)*Y(25))                                            GIONEUT  1780
      GO TO 100                                                            GIONEUT  1781
   49 CONTINUE                                                             GIONEUT  1782
      RMOV=(+K(30)*Y(30)+K(59)*Y(13)+K(94)*Y(37)+K(95)*Y(38))              GIONEUT  1783
      FARM=(+K(51)*Y(42)*Y(25)*Y(57)+K(58)*Y(48)*Y(13)*Y(23))              GIONEUT  1784
      GO TO 100                                                            GIONEUT  1785
   50 CONTINUE                                                             GIONEUT  1786
      RMOV=(+K(53)*Y(13)+K(54)*Y(13))                                      GIONEUT  1787
      FARM=(+K(37)*Y(39)*Y(13))                                            GIONEUT  1788
      GO TO 100                                                            GIONEUT  1789
   51 CONTINUE                                                             GIONEUT  1790
      RMOV=(+K(82)*Y(35)+K(83)*Y(36)+K(84)*Y(37)+K(157)*Y(30)+K(177)*Y(1   GIONEUT  1791
     13)*Y(57))                                                            GIONEUT  1792
      FARM=(Y(13)*(+K(56)*Y(54)+K(166)*Y(5)*Y(57)))                        GIONEUT  1793
      GO TO 100                                                            GIONEUT  1794
   52 CONTINUE                                                             GIONEUT  1795
      RMOV=(+K(85)*Y(35)+K(86)*Y(36)+K(87)*Y(37)+K(158)*Y(30)+K(178)*Y(1   GIONEUT  1796
     13)*Y(57))                                                            GIONEUT  1797
      FARM=(+K(177)*Y(51)*Y(13)*Y(57))                                     GIONEUT  1798
      GO TO 100                                                            GIONEUT  1799
   53 CONTINUE                                                             GIONEUT  1800
      RMOV=(+K(55)*Y(13)+K(88)*Y(35)+K(89)*Y(36)+K(90)*Y(37)+K(159)*Y(30   GIONEUT  1801
     1))                                                                   GIONEUT  1802
      FARM=(+K(178)*Y(52)*Y(13)*Y(57))                                     GIONEUT  1803
      GO TO 100                                                            GIONEUT  1804
   54 CONTINUE                                                             GIONEUT  1805
      RMOV=(+K(56)*Y(13))                                                  GIONEUT  1806
      FARM=(+K(165)*Y(5)*Y(25)*Y(23))                                      GIONEUT  1807
      GO TO 100                                                            GIONEUT  1808
   55 CONTINUE                                                             GIONEUT  1809
      RMOV=(+K(20)*Y(7)+K(21)*Y(10)+K(202))                                GIONEUT  1810
      FARM=(+K(55)*Y(53)*Y(13)+K(91)*Y(48)*Y(36))                          GIONEUT  1811
      GO TO 100                                                            GIONEUT  1812
   56 CONTINUE                                                             GIONEUT  1813
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      RMOV=(+K(122)*Y(18)+K(205))                                       GIONEUT 1814
      FARM=(+K(123)*Y(36))                                              GIONEUT 1815
  100 FORM(IALT)=FARM                                                   GIONEUT 1816
      REMV(IALT)=RMOV                                                   GIONEUT 1817
      RETURN                                                            GIONEUT 1818
      END                                                               GIONEUT 1819
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      SUBROUTINE RATECN(IALT)                                          GIONEUT 1820
C                                                                      GIONEUT 1821
C  THIS SUBROUTINE COMPUTES THE IONIZATION RATES.  ON THE INITIAL      GIONEUT 1822
C  ENTRY IT COMPUTES AND SAVES H*F AT NOON FOR O2, N2, AND O.          GIONEUT 1823
C                                                                      GIONEUT 1824
      DIMENSION SX(6),QE(6),EX(6),PHI(16),SIGI(16),SIGEFF(16)          GIONEUT 1825
      DIMENSION DISOC(14),XIN(8),YIN(8),ZS(8),CHIS(4)                  GIONEUT 1826
C                                                                      GIONEUT 1827
      COMMON N(692,30),CONC(424,26),U(692,26),NZERO(692),UZERO(692)    GIONEUT 1828
C                                                                      GIONEUT 1829
      COMMON FORM(692),REMV(692),E(692),F(692),Z(692),                 GIONEUT 1830
     2       DEDY(692),TEMP(692),DTEMDZ(692),DELTAZ(692),SUNSET(692)   GIONEUT 1831
C                                                                      GIONEUT 1832
      COMMON GRAV,COSD,SIND,TIME,CXI,RADIUS,ISPECI,KSPECI,NREAC,K,     GIONEUT 1833
     1       K2,KMIN1,ITURB,CXINOON,SCXI,NREAC2                        GIONEUT 1834
C                                                                      GIONEUT 1835
      COMMON/IONS/WAVE(88),FLUX(88),SIGMA(9,88),R(8,4,8)               GIONEUT 1836
C                                                                      GIONEUT 1837
      COMMON/CONSTAN/PI,RADDEG,DEGRAD,RADSEC,BOLTZ,SIN2I,ATCON         GIONEUT 1838
C                                                                      GIONEUT 1839
      COMMON/RATECON/AK(88),BK(88),CK(88),DK(215),CYMB(6,215)          GIONEUT 1840
C                                                                      GIONEUT 1841
      COMMON/ATCONS/ATWT(26),MASS(26),THERM(26),SYMBOL(56),POLAR(26)   GIONEUT 1842
C                                                                      GIONEUT 1843
      COMMON/LOGIC/NIGHT,DAY,JLOOK,RESET,END                           GIONEUT 1844
C                                                                      GIONEUT 1845
      COMMON/COLUM/O2COL,O3COL,DIS(19,59)                              GIONEUT 1846
C                                                                      GIONEUT 1847
      REAL N2NOON,N,MASS,LYALFA,LYBETA                                 GIONEUT 1848
C                                                                      GIONEUT 1849
      COMMON/ALTITUD/ZBOT,ZTOP,TURB,ZTRANS                             GIONEUT 1850
C                                                                      GIONEUT 1851
      LOGICAL NIGHT,DAY,JLOOK                                          GIONEUT 1852
C                                                                      GIONEUT 1853
C  THE FOLLOWING THREE DATA STATMENTS CONTAIN THE SOLAR FLUX (X10-9)   GIONEUT 1854
C  THE IONIZATION CROSS SECTIONS AND THE EFFECTIVE ABSORPTION CROSS    GIONEUT 1855
C  SECTIONS (X10+18) FOR O2(1DG).                                      GIONEUT 1856
C                                                                      GIONEUT 1857
      DATA PHI/0.123,0.202,0.18,0.06,0.16,0.208,0.432,0.092,0.626,0.59, GIONEUT 1858
     1         0.08,0.08,0.11,1.63,2.29,0.13/                          GIONEUT 1859
C                                                                      GIONEUT 1860
      DATA SIGI/2.0,3.0,4.0,3.6,4.0,10.0,4.0,4.0,5.0,3.0,5.0,5.0,3.8,  GIONEUT 1861
     1          5.5,5.0,5.0/                                           GIONEUT 1862
C                                                                      GIONEUT 1863
      DATA SIGEFF/0.186,0.186,0.04,0.021,1.0,0.1,1.0,0.12,1.0,2.0,0.4, GIONEUT 1864
     1            0.7,0.2,1.15,1.12,1.0/                               GIONEUT 1865
C                                                                      GIONEUT 1866
C  THE FOLLOWING TWO DATA STATMENTS CONTAIN THE ALTITUDES AND THE      GIONEUT 1867
C  SOLAR ZENITH ANGLE ARRAYS CORRESPONDING TO THE INPUT ARRAYS OF      GIONEUT 1868
C  THE RATE COEFFICIENTS FOR THE ENERGETIC ELECTRONS.                  GIONEUT 1869
C                                                                      GIONEUT 1870
      DATA ZS/95.,100.,130.,170.,210.,250.,300.,400./                  GIONEUT 1871
C                                                                      GIONEUT 1872
      DATA CHIS/49.77,61.50,76.22,109.7976/                            GIONEUT 1873
C                                                                      GIONEUT 1874
      DATA COSMIC/1.0E-17/                                             GIONEUT 1875
      DATA IPASS/1/                                                    GIONEUT 1876
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C                                                                GIONEUT  1877
      GRAVCOR(ZZ)=1.0/((1.0+ZZ/RADIUS)**2)                      GIONEUT  1878
C                                                                GIONEUT  1879
      T1=TEMP(IALT)                                              GIONEUT  1880
      ZZ=Z(IALT)                                                 GIONEUT  1881
      T2=T1/300.                                                 GIONEUT  1882
      O2COL=0.                                                   GIONEUT  1883
      O3COL=0.                                                   GIONEUT  1884
      DO 1 J=1,NREAC2                                            GIONEUT  1885
      A1=AK(J)                                                   GIONEUT  1886
      B1=BK(J)                                                   GIONEUT  1887
      C1=CK(J)                                                   GIONEUT  1888
      IF(B1 .NE. 0.) A1=A1*(T2**B1)                              GIONEUT  1889
      IF(C1 .NE. 0.) A1=A1*EXP(C1/T1)                            GIONEUT  1890
      DK(J+NREAC)=A1                                             GIONEUT  1891
1     CONTINUE                                                   GIONEUT  1892
      IF(IPASS .NE. 1) GO TO 30                                  GIONEUT  1893
      DO 26 L=1,16                                               GIONEUT  1894
      PHI(L)=PHI(L)*1.0E+09                                      GIONEUT  1895
      SIGI(L)=SIGI(L)*1.0E-18                                    GIONEUT  1896
      SIGEFF(L)=SIGEFF(L)*1.0E-18                                GIONEUT  1897
26    CONTINUE                                                   GIONEUT  1898
      IPASS=2                                                    GIONEUT  1899
      DO 5 L=1,8                                                 GIONEUT  1900
      DO 5 I=1,4                                                 GIONEUT  1901
      DO 5 J=1,8                                                 GIONEUT  1902
      IF(R(J,I,L) .EQ. 0.) GO TO 3                               GIONEUT  1903
      R(J,I,L)=ALOG(R(J,I,L))                                    GIONEUT  1904
      GO TO 5                                                    GIONEUT  1905
3     R(J,I,L)=-300.                                             GIONEUT  1906
5     CONTINUE                                                   GIONEUT  1907
C                                                                GIONEUT  1908
C  SAVE H*F AT NOONTIME FOR O2, O, AND N2.                       GIONEUT  1909
C                                                                GIONEUT  1910
30    GRAVTY=GRAV*GRAVCOR(ZZ)                                    GIONEUT  1911
      T=BOLTZ*TEMP(IALT)/GRAVTY                                  GIONEUT  1912
      DO 20 I=1,3                                                GIONEUT  1913
      IF(I .EQ. 1) F(I)=MASS(8)                                  GIONEUT  1914
      IF(I .EQ. 2) F(I)=MASS(23)                                 GIONEUT  1915
      IF(I .EQ. 3) F(I)=MASS(7)                                  GIONEUT  1916
      SCALE=T/F(I)                                               GIONEUT  1917
      CALL CHAPMAN(CXINOON,ZZ,RADIUS,SCALE,APPROX)               GIONEUT  1918
      PR=SCALE*APPROX                                            GIONEUT  1919
      IF(I .EQ. 1) O2NOON=PR                                     GIONEUT  1920
      IF(I .EQ. 2) N2NOON=PR                                     GIONEUT  1921
      IF(I .EQ. 3) ONOON=PR                                      GIONEUT  1922
20    CONTINUE                                                   GIONEUT  1923
      IF(NIGHT) GO TO 95                                         GIONEUT  1924
      IF(DAY  ) GO TO 10                                         GIONEUT  1925
      IF(ZZ .LT. ZTRANS) GO TO 11                                GIONEUT  1926
C                                                                GIONEUT  1927
C  GO GET PHOTODISSOCIATION RATE COEFFICIENTS.                   GIONEUT  1928
C                                                                GIONEUT  1929
10    CALL DISSOC(DISOC,IALT)                                    GIONEUT  1930
      DK(192)=DISOC(2)                                           GIONEUT  1931
      DK(193)=DISOC(1)                                           GIONEUT  1932
      DK(194)=DISOC(6)                                           GIONEUT  1933
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      DK(195)=DISOC(5)                                                   GIONEUT  1934
      DK(196)=DISOC(3)                                                   GIONEUT  1935
      DK(197)=DISOC(4)                                                   GIONEUT  1936
      DK(198)=DISOC(12)                                                  GIONEUT  1937
      DK(199)=DISOC(13)                                                  GIONEUT  1938
      DK(200)=DISOC(7)                                                   GIONEUT  1939
      DK(201)=DISOC(8)                                                   GIONEUT  1940
      DK(202)=DISOC(9)                                                   GIONEUT  1941
      DK(203)=DISOC(10)                                                  GIONEUT  1942
      DK(204)=DISOC(11)                                                  GIONEUT  1943
      DK(205)=DISOC(14)                                                  GIONEUT  1944
11    IF(.NOT. JLOOK) GO TO 52                                           GIONEUT  1945
      IF(IALT .EQ. 1) GO TO 35                                           GIONEUT  1946
      IF(IALT .EQ. K) GO TO 40                                           GIONEUT  1947
      IF(MOD(IALT-1,12) .NE. 0) GO TO 52                                 GIONEUT  1948
35    IA=IALT/12+1                                                       GIONEUT  1949
      GO TO 45                                                           GIONEUT  1950
40    IA=IALT/12+2                                                       GIONEUT  1951
45    DO 50 J=1,14                                                       GIONEUT  1952
      DIS(J,IA)=DK(J+191)                                                GIONEUT  1953
50    CONTINUE                                                           GIONEUT  1954
      DIS(15,IA)=Z(IALT)                                                 GIONEUT  1955
      DIS(16,IA)=N(IALT,8)                                               GIONEUT  1956
      DIS(17,IA)=O2COL                                                   GIONEUT  1957
      DIS(18,IA)=N(IALT,9)                                               GIONEUT  1958
      DIS(19,IA)=O3COL                                                   GIONEUT  1959
52    IF(ZZ .LT. ZTRANS) GO TO 95                                        GIONEUT  1960
C                                                                        GIONEUT  1961
C  COMPUTE RATE COEFFICIENTS FOR ENERGETIC ELECTRON REACTIONS.           GIONEUT  1962
C                                                                        GIONEUT  1963
      IF(ZZ .LT. ZS(1)) GO TO 280                                        GIONEUT  1964
      DO 200 I=1,4                                                       GIONEUT  1965
      IF(SCXI .EQ. CHIS(I)) GO TO 240                                    GIONEUT  1966
      IF(SCXI .LT. CHIS(I)) GO TO 210                                    GIONEUT  1967
200   CONTINUE                                                           GIONEUT  1968
210   DO 220 J=1,8                                                       GIONEUT  1969
      IF(ZZ .EQ. ZS(J)) GO TO 270                                        GIONEUT  1970
220   CONTINUE                                                           GIONEUT  1971
      DO 235 L=1,8                                                       GIONEUT  1972
      DO 225 J=1,8                                                       GIONEUT  1973
      XIN(J)=ZS(J)                                                       GIONEUT  1974
      YIN(J)=R(J,I-1,L)                                                  GIONEUT  1975
225   CONTINUE                                                           GIONEUT  1976
      A1=YINT(ZZ,XIN,YIN,0)                                              GIONEUT  1977
      B1=YINT(ZZ,XIN,YIN,8)                                              GIONEUT  1978
      DO 230 J=1,8                                                       GIONEUT  1979
      YIN(J)=R(J,I,L)                                                    GIONEUT  1980
230   CONTINUE                                                           GIONEUT  1981
      A1=YINT(ZZ,XIN,YIN,0)                                              GIONEUT  1982
      C1=YINT(ZZ,XIN,YIN,8)                                              GIONEUT  1983
      A1=(SCXI-CHIS(I-1))/(CHIS(I)-CHIS(I-1))                            GIONEUT  1984
      DK(L+207)=EXP(B1-A1*(B1-C1))                                       GIONEUT  1985
235   CONTINUE                                                           GIONEUT  1986
      GO TO 55                                                           GIONEUT  1987
240   DO 245 J=1,8                                                       GIONEUT  1988
      IF(ZZ .EQ. ZS(J)) GO TO 260                                        GIONEUT  1989
245   CONTINUE                                                           GIONEUT  1990
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      DO 255 L=1,8                                                      GIONEUT 1991
      DO 250 J=1,8                                                      GIONEUT 1992
      XIN(J)=ZS(J)                                                      GIONEUT 1993
      YIN(J)=R(J,I,L)                                                   GIONEUT 1994
  250 CONTINUE                                                          GIONEUT 1995
      A1=YINT(ZZ,XIN,YIN,0)                                             GIONEUT 1996
      DK(L+207)=EXP(YINT(ZZ,XIN,YIN,8))                                 GIONEUT 1997
  255 CONTINUE                                                          GIONEUT 1998
      GO TO 55                                                          GIONEUT 1999
  260 DO 265 L=1,8                                                      GIONEUT 2000
      DK(L+207)=EXP(R(J,I,L))                                           GIONEUT 2001
  265 CONTINUE                                                          GIONEUT 2002
      GO TO 55                                                          GIONEUT 2003
  270 DO 275 L=1,8                                                      GIONEUT 2004
      A1=(SCXI-CHIS(I-1))/(CHIS(I)-CHIS(I-1))                           GIONEUT 2005
      DK(L+207)=EXP(R(J,I-1,L)-A1*(R(J,I-1,L)-R(J,I,L)))                GIONEUT 2006
  275 CONTINUE                                                          GIONEUT 2007
      GO TO 55                                                          GIONEUT 2008
  280 DO 285 L=1,8                                                      GIONEUT 2009
      DK(L+207)=0.                                                      GIONEUT 2010
  285 CONTINUE                                                          GIONEUT 2011
C                                                                       GIONEUT 2012
C  COMPUTE N*H*F FOR O2, N2, AND O AT SOLAR ZENITH ANGLE CXI.           GIONEUT 2013
C                                                                       GIONEUT 2014
   55 GRAVTY=GRAV*GRAVCOR(ZZ)                                           GIONEUT 2015
      T=BOLTZ*TEMP(IALT)/GRAVTY                                         GIONEUT 2016
      DO 60 I=1,3                                                       GIONEUT 2017
      SCALE=T/F(I)                                                      GIONEUT 2018
      CALL CHAPMAN(CXI,ZZ,RADIUS,SCALE,APPROX)                          GIONEUT 2019
      IF(I .EQ. 1) E(I)=N(IALT,8)                                       GIONEUT 2020
      IF(I .EQ. 2) E(I)=N(IALT,23)                                      GIONEUT 2021
      IF(I .EQ. 3) E(I)=N(IALT,7)                                       GIONEUT 2022
      EX(I)=E(I)*SCALE*APPROX                                           GIONEUT 2023
   60 CONTINUE                                                          GIONEUT 2024
C                                                                       GIONEUT 2025
C  COMPUTE THE ATTENUATED FLUX AT EACH WAVELENGTH.                      GIONEUT 2026
C  SEPARATE THE EUV AND X RAY FLUXES.                                   GIONEUT 2027
C                                                                       GIONEUT 2028
      DO 65 I=1,6                                                       GIONEUT 2029
      QE(I)=0.                                                          GIONEUT 2030
      SX(I)=0.                                                          GIONEUT 2031
   65 CONTINUE                                                          GIONEUT 2032
      DO 90 L=1,88                                                      GIONEUT 2033
      ABS=0.                                                            GIONEUT 2034
      DO 70 I=1,3                                                       GIONEUT 2035
      ABS=ABS+SIGMA(I,L)*EX(I)                                          GIONEUT 2036
   70 CONTINUE                                                          GIONEUT 2037
      AFLUX=0.                                                          GIONEUT 2038
      IF(ABS .GT. 650.) GO TO 71                                        GIONEUT 2039
      AFLUX=FLUX(L)*EXP(-ABS)                                           GIONEUT 2040
C                                                                       GIONEUT 2041
C  COMPUTE THE IONIZATION COEFFICIENTS,  SKIP LYMAN ALPHA LINE.         GIONEUT 2042
C                                                                       GIONEUT 2043
   71 IF(L .EQ. 1) GO TO 86                                             GIONEUT 2044
      IF(L .GE. 74) GO TO 80                                            GIONEUT 2045
      DO 75 I=1,6                                                       GIONEUT 2046
      QE(I)=QE(I)+SIGMA(I+3,L)*AFLUX                                    GIONEUT 2047
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75    CONTINUE                                                         GIONEUT  2048
      GO TO 90                                                         GIONEUT  2049
80    DO 85 I=1,6                                                      GIONEUT  2050
      SX(I)=SX(I)+SIGMA(I+3,L)*AFLUX                                   GIONEUT  2051
85    CONTINUE                                                         GIONEUT  2052
      GO TO 90                                                         GIONEUT  2053
86    SFLUX=AFLUX                                                      GIONEUT  2054
90    CONTINUE                                                         GIONEUT  2055
C                                                                      GIONEUT  2056
C  PARTITION THE X-RAY IONIZATION ACCORDING TO SWIDER, REVIEWS OF      GIONEUT  2057
C  GEOPHYSICS, 7, PG 573, 1969.                                        GIONEUT  2058
C                                                                      GIONEUT  2059
      AX=N(IALT,8)+0.5*N(IALT,7)                                       GIONEUT  2060
      BX=1.0/(1.0+(N(IALT,23)/(1.15*AX)))                              GIONEUT  2061
      CX=0.71*N(IALT,8)/AX                                             GIONEUT  2062
      XTOTAL=SX(1)*N(IALT,8)+SX(2)*N(IALT,23)+SX(3)*N(IALT,7)          GIONEUT  2063
     1      +SX(4)*N(IALT,11)+SX(5)*N(IALT,21)+SX(6)*N(IALT,16)        GIONEUT  2064
      SX(1)=BX*CX*XTOTAL                                               GIONEUT  2065
      SX(2)=0.81*(1.0-BX)*XTOTAL                                       GIONEUT  2066
      SX(3)=(1.0-CX)*BX*XTOTAL                                         GIONEUT  2067
      SX(6)=0.19*(1.0-BX)*XTOTAL                                       GIONEUT  2068
C                                                                      GIONEUT  2069
C  COMPUTE TOTAL EUV AND X-RAY IONIZATION RATE COEFFICIENT FOR EACH ION. GIONEUT  2070
C                                                                      GIONEUT  2071
      DK(185)=QE(3)+SX(3)/N(IALT,7)                                    GIONEUT  2072
      DK(186)=QE(1)+SX(1)/N(IALT,8)                                    GIONEUT  2073
      DK(187)=QE(2)+SX(2)/N(IALT,23)                                   GIONEUT  2074
      DK(189)=QE(6)+SX(6)/N(IALT,16)                                   GIONEUT  2075
      DK(190)=QE(4)+SX(4)                                              GIONEUT  2076
      DK(191)=QE(5)+SX(5)                                              GIONEUT  2077
C                                                                      GIONEUT  2078
C  COMPUTE IONIZATION RATE COEFFICIENT FOR NO BY LYMAN ALPHA.          GIONEUT  2079
C                                                                      GIONEUT  2080
      DK(188)=2.08E-18*SFLUX                                           GIONEUT  2081
C                                                                      GIONEUT  2082
C  COMPUTE IONIZATION RATE COEFFICIENT FOR O2(1DG) FOR WAVELENGTHS     GIONEUT  2083
C  1027-1117 A.                                                        GIONEUT  2084
C                                                                      GIONEUT  2085
      DO 92 L=1,16                                                     GIONEUT  2086
      SFLUX=SIGEFF(L)*EX(1)                                            GIONEUT  2087
      IF(SFLUX .GT. 650.) GO TO 92                                     GIONEUT  2088
      DK(207)=DK(207)+PHI(L)*SIGI(L)*EXP(-SFLUX)                       GIONEUT  2089
92    CONTINUE                                                         GIONEUT  2090
C                                                                      GIONEUT  2091
C  ADD CONTRIBUTIONS FROM SCATTERED RADIATIONS AT LYMAN ALPHA,          GIONEUT  2092
C  LYMAN BETA, HE(I)(584A), AND HE(II)(304A).                          GIONEUT  2093
C                                                                      GIONEUT  2094
95    AA=N(IALT,8)*O2NOON                                              GIONEUT  2095
      AB=N(IALT,23)*N2NOON                                             GIONEUT  2096
      AC=N(IALT,7)*ONOON                                               GIONEUT  2097
      POWER=AA*SIGMA(1,1)                                              GIONEUT  2098
      EXPON=0.                                                         GIONEUT  2099
      IF(POWER .GT. 650.) GO TO 91                                     GIONEUT  2100
      EXPON=EXP(-POWER)                                                GIONEUT  2101
91    LYALFA=1.0E-02*2.02E-18*FLUX(1)*EXPON                            GIONEUT  2102
      POWER=AA*SIGMA(1,2)+AB*SIGMA(2,2)                                GIONEUT  2103
      EXPON=0.                                                         GIONEUT  2104
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      R(1)=K(1)*Y(7)*Y(17)                                        GIONEUT  2595
      R(2)=K(2)*Y(7)*Y(10)                                        GIONEUT  2596
      R(3)=K(3)*Y(7)*Y(12)                                        GIONEUT  2597
      R(4)=K(4)*Y(7)*Y(19)                                        GIONEUT  2598
      R(5)=K(5)*Y(11)*Y(12)                                       GIONEUT  2599
      R(6)=K(6)*Y(11)*Y(12)                                       GIONEUT  2600
      R(7)=K(7)*Y(11)*Y(9)                                        GIONEUT  2601
      R(8)=K(8)*Y(16)*Y(9)                                        GIONEUT  2602
      R(9)=K(9)*Y(16)*Y(19)                                       GIONEUT  2603
      R(10)=K(10)*Y(16)*Y(19)                                     GIONEUT  2604
      R(11)=K(11)*Y(16)*Y(19)                                     GIONEUT  2605
      R(12)=K(12)*Y(10)*Y(10)                                     GIONEUT  2606
      R(13)=K(13)*Y(10)*Y(12)                                     GIONEUT  2607
      R(14)=K(14)*Y(17)*Y(8)                                      GIONEUT  2608
      R(15)=K(15)*Y(27)*Y(13)                                     GIONEUT  2609
      R(16)=K(16)*Y(27)*Y(57)                                     GIONEUT  2610
      R(17)=K(17)*Y(27)*Y(15)                                     GIONEUT  2611
      R(18)=K(18)*Y(20)*Y(57)                                     GIONEUT  2612
      R(19)=K(19)*Y(20)                                           GIONEUT  2613
      R(20)=K(20)*Y(55)*Y(7)                                      GIONEUT  2614
      R(21)=K(21)*Y(55)*Y(10)                                     GIONEUT  2615
      R(22)=K(22)*Y(28)*Y(30)                                     GIONEUT  2616
      R(23)=K(23)*Y(28)*Y(30)                                     GIONEUT  2617
      R(24)=K(24)*Y(41)*Y(30)                                     GIONEUT  2618
      R(25)=K(25)*Y(42)*Y(30)                                     GIONEUT  2619
      R(26)=K(26)*Y(43)*Y(30)                                     GIONEUT  2620
      R(27)=K(27)*Y(44)*Y(30)                                     GIONEUT  2621
      R(28)=K(28)*Y(45)*Y(30)                                     GIONEUT  2622
      R(29)=K(29)*Y(47)*Y(30)                                     GIONEUT  2623
      R(30)=K(30)*Y(49)*Y(30)                                     GIONEUT  2624
      R(31)=K(31)*Y(7)*Y(30)                                      GIONEUT  2625
      R(32)=K(32)*Y(8)*Y(23)*Y(30)                                GIONEUT  2626
      R(33)=K(33)*Y(4)*Y(18)                                      GIONEUT  2627
      R(34)=K(34)*Y(4)*Y(16)                                      GIONEUT  2628
      R(35)=K(35)*Y(4)*Y(19)                                      GIONEUT  2629
      R(36)=K(36)*Y(39)*Y(7)                                      GIONEUT  2630
      R(37)=K(37)*Y(39)*Y(13)                                     GIONEUT  2631
      R(38)=K(38)*Y(28)*Y(7)                                      GIONEUT  2632
      R(39)=K(39)*Y(28)*Y(7)                                      GIONEUT  2633
      R(40)=K(40)*Y(3)*Y(11)                                      GIONEUT  2634
      R(41)=K(41)*Y(1)*Y(7)                                       GIONEUT  2635
      R(42)=K(42)*Y(6)*Y(8)                                       GIONEUT  2636
      R(43)=K(43)*Y(6)*Y(8)                                       GIONEUT  2637
      R(44)=K(44)*Y(6)*Y(8)                                       GIONEUT  2638
      R(45)=K(45)*Y(2)*Y(8)                                       GIONEUT  2639
      R(46)=K(46)*Y(2)*Y(8)                                       GIONEUT  2640
      R(47)=K(47)*Y(2)*Y(23)                                      GIONEUT  2641
      R(48)=K(48)*Y(2)*Y(23)                                      GIONEUT  2642
      R(49)=K(49)*Y(2)*Y(18)                                      GIONEUT  2643
      R(50)=K(50)*Y(40)*Y(18)                                     GIONEUT  2644
      R(51)=K(51)*Y(42)*Y(25)*Y(57)                               GIONEUT  2645
      R(52)=K(52)*Y(44)*Y(13)*Y(57)                               GIONEUT  2646
      R(53)=K(53)*Y(50)*Y(13)                                     GIONEUT  2647
      R(54)=K(54)*Y(50)*Y(13)                                     GIONEUT  2648
      R(55)=K(55)*Y(53)*Y(13)                                     GIONEUT  2649
      R(56)=K(56)*Y(54)*Y(13)                                     GIONEUT  2650
      R(57)=K(57)*Y(46)*Y(25)                                     GIONEUT  2651
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      SUBROUTINE CHEMPR(IZ)                                               GIONEUT  2538
C                                                                         GIONEUT  2539
C  THIS SUBROUTINE PRINTS OUT THE FULL CHEMISTRY LIST ALONG WITH          GIONEUT  2540
C  THE RATE COEFFICIENTS AND THE RATES OF ALL REACTIONS AT THE            GIONEUT  2541
C  ALTITUDE CORPESPONDING TO THE INDEX IZ.                                GIONEUT  2542
C                                                                         GIONEUT  2543
C                                                                         GIONEUT  2544
      DIMENSION Y(57),R(215),K(215)                                       GIONEUT  2545
C                                                                         GIONEUT  2546
      COMMON N(692,30),CONC(424,26),U(692,26),NZERO(692),UZERO(692)       GIONEUT  2547
C                                                                         GIONEUT  2548
      COMMON FORM(692),REMV(692),E(692),F(692),Z(692),                    GIONEUT  2549
     2       DEDY(692),TEMP(692),DTEMDZ(692),DELTAZ(692),SUNSET(692)      GIONEUT  2550
C                                                                         GIONEUT  2551
      COMMON GRAV,COSD,SIND,TIME,CXI,RADIUS ISPECI,KSPECI,NREAC,KTOP,     GIONEUT  2552
     1       K2,KMIN1,ITURB,CXINOON,SCXI,NREAC2                           GIONEUT  2553
C                                                                         GIONEUT  2554
      COMMON/ESM/OLDN(692,30),OLDCON(424,26),OLDU(692,26),RATES(88,692)   GIONEUT  2555
C                                                                         GIONEUT  2556
      COMMON/LOGIC/NIGHT,DAY,JLOOK,RESET,END                              GIONEUT  2557
C                                                                         GIONEUT  2558
      COMMON/RATECON/AK(88),BK(88),CK(88),DK(215),CYMB(6,215)             GIONEUT  2559
C                                                                         GIONEUT  2560
      LEVEL 3, OLDN,OLDCON,OLDU,RATES                                     GIONEUT  2561
      REAL K,N,NZERO                                                      GIONEUT  2562
      LOGICAL NIGHT                                                       GIONEUT  2563
      EQUIVALENCE (Y,E),(R,F),(NZERO,K)                                   GIONEUT  2564
C                                                                         GIONEUT  2565
      WRITE(6,1) Z(IZ),SCXI                                               GIONEUT  2566
    1 FORMAT(1H1," CHEMISTRY AT ",F7.2," KM. AND AT",      1PE12.5        GIONEUT  2567
     1"DEGREES.")                                                         GIONEUT  2568
      WRITE(6,5)                                                          GIONEUT  2569
    5 FORMAT(1H0,18X,*CHEMICAL REACTION*,35X,*RATE CONSTANT*,5X,          GIONEUT  2570
     1*FORWARD RATE(/CM3/SEC)*)                                           GIONEUT  2571
      DO 6 I=1,NREAC                                                      GIONEUT  2572
      K(I)=DK(I)                                                          GIONEUT  2573
    6 CONTINUE                                                            GIONEUT  2574
      IF(.NOT. NIGHT) GO TO 10                                            GIONEUT  2575
      K(96)=K(99)=K(104)=K(105)=K(110)=0.                                 GIONEUT  2576
      K(113)=K(114)=K(118)=K(120)=K(123)=0.                               GIONEUT  2577
   10 CALL MOVLEV(RATES(1,IZ),K(128),88)                                  GIONEUT  2578
      IF(IZ .LE. K2) GO TO 11                                             GIONEUT  2579
      K(31)=K(32)=K(35)=0.                                                GIONEUT  2580
      K(160)=K(161)=K(162)=K(165)=K(166)=0.                               GIONEUT  2581
   11 DO 25 I=1,ISPECI                                                    GIONEUT  2582
      IF(I .GT. 30) GO TO 4                                               GIONEUT  2583
      Y(I)=N(IZ,I)                                                        GIONEUT  2584
      GO TO 25                                                            GIONEUT  2585
    4 IF(IZ .GT. K2) GO TO 15                                             GIONEUT  2586
      Y(I)=CONC(IZ,I-30)                                                  GIONEUT  2587
      GO TO 25                                                            GIONEUT  2588
   15 Y(I)=0.                                                             GIONEUT  2589
   25 CONTINUE                                                            GIONEUT  2590
      Y(57)=0.                                                            GIONEUT  2591
      DO 30 I=1,ISPECI                                                    GIONEUT  2592
      Y(57)=Y(57)+Y(I)                                                    GIONEUT  2593
   30 CONTINUE                                                            GIONEUT  2594
```

```
      SUBROUTINE INDEX(COL,LIM,I,DEL)                                   GIONEUT  2509
C                                                                       GIONEUT  2510
C  THIS SUBROUTINE COMPUTES AN INDEX I AND AN INCREMENT DEL FROM        GIONEUT  2511
C  THE COLUMN DENSITY COL.                                              GIONEUT  2512
C                                                                       GIONEUT  2513
      REAL LOG2,LOG5                                                    GIONEUT  2514
      LOGICAL ISKIP                                                     GIONEUT  2515
      DATA ISKIP/.FALSE./                                               GIONEUT  2516
C                                                                       GIONEUT  2517
      IF(ISKIP) GO TO 5                                                 GIONEUT  2518
      LOG2=ALOG10(2.0)                                                  GIONEUT  2519
      LOG5=ALOG10(5.0)                                                  GIONEUT  2520
      ISKIP=.TRUE.                                                      GIONEUT  2521
C                                                                       GIONEUT  2522
5     A=ALOG10(COL)                                                     GIONEUT  2523
      INTA=INT(A)                                                       GIONEUT  2524
      FA=A-INTA                                                         GIONEUT  2525
      I=3*(INTA-LIM)+1                                                  GIONEUT  2526
      IF(FA .GT. LOG2) GO TO 10                                         GIONEUT  2527
      DEL=FA/LOG2                                                       GIONEUT  2528
      RETURN                                                            GIONEUT  2529
10    IF(FA .GT. LOG5) GO TO 20                                         GIONEUT  2530
      DEL=(FA-LOG2)/(LOG5-LOG2)                                         GIONEUT  2531
      I=I+1                                                             GIONEUT  2532
      RETURN                                                            GIONEUT  2533
20    DEL=(FA-LOG5)/(1.0-LOG5)                                          GIONEUT  2534
      I=I+2                                                             GIONEUT  2535
      RETURN                                                            GIONEUT  2536
      END                                                               GIONEUT  2537
```

```
      FUNCTION TRPLT1(ARRAY,IO3,DELO3)                                  GIONEUT  2497
C                                                                       GIONEUT  2498
C  THIS FUNCTION INTERPOLATES IN THE ONE DIMENSIONAL PHOTODISSOCIATION  GIONEUT  2499
C  RATE COEFFICIENT TABLES.                                             GIONEUT  2500
C                                                                       GIONEUT  2501
      DIMENSION ARRAY(1)                                                GIONEUT  2502
C                                                                       GIONEUT  2503
      A=ARRAY(IO3)                                                      GIONEUT  2504
      B=ARRAY(IO3+1)                                                    GIONEUT  2505
      TRPLT1=10.0**(A-DELO3*(A-B))                                      GIONEUT  2506
      RETURN                                                            GIONEUT  2507
      END                                                               GIONEUT  2508
```

```
      FUNCTION TRPLT2(ARRAY,N,M,IO2,DELO2,IO3,DELO3)                    GIONEUT  2481
C                                                                       GIONEUT  2482
C  THIS FUNCTION INTERPOLATES IN THE TWO DIMENSIONAL PHOTODISSOCIATION  GIONEUT  2483
C  RATE COEFFICIENT TABLES.                                             GIONEUT  2484
C                                                                       GIONEUT  2485
      DIMENSION ARRAY(N,M)                                              GIONEUT  2486
C                                                                       GIONEUT  2487
      A=ARRAY(IO2,IO3)                                                  GIONEUT  2488
      B=ARRAY(IO2,IO3+1)                                                GIONEUT  2489
      C=ARRAY(IO2+1,IO3)                                                GIONEUT  2490
      D=ARRAY(IO2+1,IO3+1)                                              GIONEUT  2491
      Y1=A-DELO3*(A-B)                                                  GIONEUT  2492
      Y2=C-DELO3*(C-D)                                                  GIONEUT  2493
      TRPLT2=10.0**(Y1-DELO2*(Y1-Y2))                                   GIONEUT  2494
      RETURN                                                            GIONEUT  2495
      END                                                               GIONEUT  2496
```

```
      IF(O2COL .GT. 23.5) GO TO 210                               GIONEUT  2467
      DO 200 II=1,12                                              GIONEUT  2468
      IF(O2COL .LT. O2C(II)) GO TO 215                            GIONEUT  2469
  200 CONTINUE                                                    GIONEUT  2470
      STOP 7                                                      GIONEUT  2471
  205 DISOC(13)=10.0**(PNO(1))                                    GIONEUT  2472
      GO TO 220                                                   GIONEUT  2473
  210 DISOC(13)=0.                                                GIONEUT  2474
      GO TO 220                                                   GIONEUT  2475
  215 DELO2=(O2COL-O2C(II-1))/(O2C(II)-O2C(II-1))                 GIONEUT  2476
      DISOC(13)=10.0**(PNO(II-1)-DELO2*(PNO(II-1)-PNO(II)))       GIONEUT  2477
  220 O2COL=10.0**(O2COL)                                         GIONEUT  2478
      RETURN                                                      GIONEUT  2479
      END                                                         GIONEUT  2480
```

```
      IF(O3COLM .GT. 1.0E+21)  O3COL=1.0E+21                          GIONEUT  2410
      LIMIT=14                                                         GIONEUT  2411
      CALL INDEX(O3COL,LIMIT,IO3,DELO3)                                GIONEUT  2412
      DISOC(9)=TRPLT1(J202,IO3,DELO3)                                  GIONEUT  2413
C                                                                      GIONEUT  2414
C  REACTION CO2 + HV = CO + O1D IN DISOC(10)                           GIONEUT  2415
C                                                                      GIONEUT  2416
      O2COL=O2COLM                                                     GIONEUT  2417
      IF(O2COLM .LT. 1.0E+13)  O2COL=1.1E+13                          GIONEUT  2418
      IF(O2COLM .GT. 5.0E+22)  O2COL=5.0E+22                          GIONEUT  2419
      LIMIT=13                                                         GIONEUT  2420
      CALL INDEX(O2COL,LIMIT,IO2,DELO2)                                GIONEUT  2421
      O3COL=O3COLM                                                     GIONEUT  2422
      IF(O3COLM .LT. 1.0E+11)  O3COL=1.1E+11                          GIONEUT  2423
      IF(O3COLM .GT. 2.0E+20)  O3COL=2.0E+20                          GIONEUT  2424
      LIMIT=11                                                         GIONEUT  2425
      CALL INDEX(O3COL,LIMIT,IO3,DELO3)                                GIONEUT  2426
      DISOC(10)=TRPLT2(J203,30,29,IO2,DELO2,IO3,DELO3)                 GIONEUT  2427
C                                                                      GIONEUT  2428
C  REACTION CO2 + HV = CO + O IN DISOC(11)                             GIONEUT  2429
C                                                                      GIONEUT  2430
      O2COL=O2COLM                                                     GIONEUT  2431
      IF(O2COLM .LT. 1.0E+13)  O2COL=1.1E+13                          GIONEUT  2432
      IF(O2COLM .GT. 2.0E+24)  O2COL=2.0E+24                          GIONEUT  2433
      LIMIT=13                                                         GIONEUT  2434
      CALL INDEX(O2COL,LIMIT,IO2,DELO2)                                GIONEUT  2435
      O3COL=O3COLM                                                     GIONEUT  2436
      IF(O3COLM .LT. 1.0E+12)  O3COL=1.1E+12                          GIONEUT  2437
      IF(O3COLM .GT. 1.0E+21)  O3COL=1.0E+21                          GIONEUT  2438
      LIMIT=12                                                         GIONEUT  2439
      CALL INDEX(O3COL,LIMIT,IO3,DELO3)                                GIONEUT  2440
      DISOC(11)=TRPLT2(J204,35,28,IO2,DELO2,IO3,DELO3)                 GIONEUT  2441
C                                                                      GIONEUT  2442
C  REACTION HO2 + HV = O2 + H IN DISOC(12)                             GIONEUT  2443
C                                                                      GIONEUT  2444
      O2COL=O2COLM                                                     GIONEUT  2445
      IF(O2COLM .LT. 1.0E+17)  O2COL=1.1E+17                          GIONEUT  2446
      IF(O2COLM .GT. 2.0E+25)  O2COL=2.0E+25                          GIONEUT  2447
      LIMIT=17                                                         GIONEUT  2448
      CALL INDEX(O2COL,LIMIT,IO2,DELO2)                                GIONEUT  2449
      O3COL=O3COLM                                                     GIONEUT  2450
      IF(O3COLM .LT. 1.0E+12)  O3COL=1.1E+12                          GIONEUT  2451
      IF(O3COLM .GT. 1.0E+21)  O3COL=1.0E+21                          GIONEUT  2452
      LIMIT=12                                                         GIONEUT  2453
      CALL INDEX(O3COL,LIMIT,IO3,DELO3)                                GIONEUT  2454
      DISOC(12)=TRPLT2(J198,26,28,IO2,DELO2,IO3,DELO3)                 GIONEUT  2455
C                                                                      GIONEUT  2456
C  REACTION NO3 + HV = NO2 + O2 IN DISOC(14)                           GIONEUT  2457
C                                                                      GIONEUT  2458
      O3COL=O3COLM                                                     GIONEUT  2459
      IF(O3COLM .LT. 1.0E+14)  O3COL=1.1E+14                          GIONEUT  2460
      IF(O3COLM .GT. 1.0E+21)  O3COL=1.0E+21                          GIONEUT  2461
      LIMIT=14                                                         GIONEUT  2462
      CALL INDEX(O3COL,LIMIT,IO3,DELO3)                                GIONEUT  2463
      DISOC(14)=TRPLT1(J205,IO3,DELO3)                                 GIONEUT  2464
      O2COL=ALOG10(O2COLM)                                             GIONEUT  2465
      IF(O2COL .LT. 18.0) GO TO 205                                    GIONEUT  2466
```

```
      DISOC(4)=TRPLT2(J197,27,28,IO2,DELO2,IO3,DELO3)                   GIONEUT  2353
C                                                                       GIONEUT  2354
C  REACTION O3 + HV = O1D + O21D IN DISOC(5)                            GIONEUT  2355
C                                                                       GIONEUT  2356
      O2COL=O2COLM                                                      GIONEUT  2357
      IF(O2COLM .LT. 1.0E+15)  O2COL=1.1E+15                            GIONEUT  2358
      IF(O2COLM .GT. 2.0E+25)  O2COL=2.0E+25                            GIONEUT  2359
      LIMIT=15                                                          GIONEUT  2360
      CALL INDEX(O2COL,LIMIT,IO2,DELO2)                                 GIONEUT  2361
      O3COL=O3COLM                                                      GIONEUT  2362
      IF(O3COLM .LT. 1.0E+12)  O3COL=1.1E+12                            GIONEUT  2363
      IF(O3COLM .GT. 1.0E+21)  O3COL=1.0E+21                            GIONEUT  2364
      LIMIT=12                                                          GIONEUT  2365
      CALL INDEX(O3COL,LIMIT,IO3,DELO3)                                 GIONEUT  2366
      DISOC(5)=TRPLT2(J195,32,28,IO2,DELO2,IO3,DELO3)                   GIONEUT  2367
C                                                                       GIONEUT  2368
C  REACTION O3 + HV = O + O2 IN DISOC(6)                                GIONEUT  2369
C                                                                       GIONEUT  2370
      O3COL=O3COLM                                                      GIONEUT  2371
      IF(O3COLM .LT. 1.0E+14)  O3COL=1.1E+14                            GIONEUT  2372
      IF(O3COLM .GT. 1.0E+21)  O3COL=1.0E+21                            GIONEUT  2373
      LIMIT=14                                                          GIONEUT  2374
      CALL INDEX(O3COL,LIMIT,IO3,DELO3)                                 GIONEUT  2375
      DISOC(6)=TRPLT1(J194,IO3,DELO3)                                   GIONEUT  2376
C                                                                       GIONEUT  2377
C  REACTION NO2 + HV = NO + O1D IN DISOC(7)                             GIONEUT  2378
C                                                                       GIONEUT  2379
      O2COL=O2COLM                                                      GIONEUT  2380
      IF(O2COLM .LT. 1.0E+19)  O2COL=1.1E+19                            GIONEUT  2381
      IF(O2COLM .GT. 1.0E+25)  O2COL=1.0E+25                            GIONEUT  2382
      LIMIT=19                                                          GIONEUT  2383
      CALL INDEX(O2COL,LIMIT,IO2,DELO2)                                 GIONEUT  2384
      O3COL=O3COLM                                                      GIONEUT  2385
      IF(O3COLM .LT. 1.0E+14)  O3COL=1.1E+14                            GIONEUT  2386
      IF(O3COLM .GT. 5.0E+18)  O3COL=5.0E+18                            GIONEUT  2387
      LIMIT=14                                                          GIONEUT  2388
      CALL INDEX(O3COL,LIMIT,IO3,DELO3)                                 GIONEUT  2389
      DISOC(7)=TRPLT2(J200,19,15,IO2,DELO2,IO3,DELO3)                   GIONEUT  2390
C                                                                       GIONEUT  2391
C  REACTION N2O + HV = N2 + O1D IN DISOC(8)                             GIONEUT  2392
C                                                                       GIONEUT  2393
      O2COL=O2COLM                                                      GIONEUT  2394
      IF(O2COLM .LT. 1.0E+17)  O2COL=1.1E+17                            GIONEUT  2395
      IF(O2COLM .GT. 2.0E+25)  O2COL=2.0E+25                            GIONEUT  2396
      LIMIT=17                                                          GIONEUT  2397
      CALL INDEX(O2COL,LIMIT,IO2,DELO2)                                 GIONEUT  2398
      O3COL=O3COLM                                                      GIONEUT  2399
      IF(O3COLM .LT. 1.0E+11)  O3COL=1.1E+11                            GIONEUT  2400
      IF(O3COLM .GT. 5.0E+19)  O3COL=5.0E+19                            GIONEUT  2401
      LIMIT=11                                                          GIONEUT  2402
      CALL INDEX(O3COL,LIMIT,IO3,DELO3)                                 GIONEUT  2403
      DISOC(8)=TRPLT2(J201,26,27,IO2,DELO2,IO3,DELO3)                   GIONEUT  2404
C                                                                       GIONEUT  2405
C  REACTION HNO2 + HV = OH + OH IN DISOC(9)                             GIONEUT  2406
C                                                                       GIONEUT  2407
      O3COL=O3COLM                                                      GIONEUT  2408
      IF(O3COLM .LT. 1.0E+14)  O3COL=1.1E+14                            GIONEUT  2409
```

```
    1 CONTINUE                                                    GIONEUT  2296
   35 O3COL=O3COLM                                                GIONEUT  2297
      O2COL=O2COLM                                                GIONEUT  2298
C                                                                 GIONEUT  2299
C  REACTION  O2 + HV = O + O1D IN DISOC(1)                        GIONEUT  2300
C                                                                 GIONEUT  2301
      IF(O2COLM .LT. 1.0E+13)  O2COL=1.1E+13                      GIONEUT  2302
      IF(O2COLM .GT. 1.0E+22)  O2COL=1.0E+22                      GIONEUT  2303
      LIMIT=13                                                    GIONEUT  2304
      CALL INDEX(O2COL,LIMIT,IO2,DELO2)                           GIONEUT  2305
      O3COL=O3COLM                                                GIONEUT  2306
      IF(O3COLM .LT. 1.0E+12)  O3COL=1.1E+12                      GIONEUT  2307
      IF(O3COLM .GT. 2.0E+19)  O3COL=1.9E+19                      GIONEUT  2308
      LIMIT=12                                                    GIONEUT  2309
      CALL INDEX(O3COL,LIMIT,IO3,DELO3)                           GIONEUT  2310
      DISOC(1)=TRPLT2(J193,28,26,IO2,DELO2,IO3,DELO3)             GIONEUT  2311
C                                                                 GIONEUT  2312
C  REACTION O2 + HV = O + O IN DISOC(2)                           GIONEUT  2313
C                                                                 GIONEUT  2314
      O2COL=O2COLM                                                GIONEUT  2315
      IF(O2COLM .LT. 1.0E+17)  O2COL=1.1E+17                      GIONEUT  2316
      IF(O2COLM .GT. 2.0E+25)  O2COL=2.0E+25                      GIONEUT  2317
      LIMIT=17                                                    GIONEUT  2318
      CALL INDEX(O2COL,LIMIT,IO2,DELO2)                           GIONEUT  2319
      O3COL=O3COLM                                                GIONEUT  2320
      IF(O3COLM .LT. 1.0E+13)  O3COL=1.1E+13                      GIONEUT  2321
      IF(O3COLM .GT. 1.0E+21)  O3COL=1.0E+21                      GIONEUT  2322
      LIMIT=13                                                    GIONEUT  2323
      CALL INDEX(O3COL,LIMIT,IO3,DELO3)                           GIONEUT  2324
      DISOC(2)=TRPLT2(J192,26,25,IO2,DELO2,IO3,DELO3)             GIONEUT  2325
C                                                                 GIONEUT  2326
C  REACTION H2O + HV = OH + H IN DISOC(3)                         GIONEUT  2327
C                                                                 GIONEUT  2328
      O2COL=O2COLM                                                GIONEUT  2329
      IF(O2COLM .LT. 1.0E+13)  O2COL=1.1E+13                      GIONEUT  2330
      IF(O2COLM .GT. 1.0E+23)  O2COL=1.0E+23                      GIONEUT  2331
      LIMIT=13                                                    GIONEUT  2332
      CALL INDEX(O2COL,LIMIT,IO2,DELO2)                           GIONEUT  2333
      O3COL=O3COLM                                                GIONEUT  2334
      IF(O3COLM .LT. 1.0E+11)  O3COL=1.1E+11                      GIONEUT  2335
      IF(O3COLM .GT. 5.0E+20)  O3COL=5.0E+20                      GIONEUT  2336
      LIMIT=11                                                    GIONEUT  2337
      CALL INDEX(O3COL,LIMIT,IO3,DELO3)                           GIONEUT  2338
      DISOC(3)=TRPLT2(J196,31,30,IO2,DELO2,IO3,DELO3)             GIONEUT  2339
C                                                                 GIONEUT  2340
C  REACION H2O2 + HV = OH + OH IN DISOC(4)                        GIONEUT  2341
C                                                                 GIONEUT  2342
      O2COL=O2COLM                                                GIONEUT  2343
      IF(O2COLM .LT. 1.0E+17)  O2COL=1.1E+17                      GIONEUT  2344
      IF(O2COLM .GT. 5.0E+25)  O2COL=5.0E+25                      GIONEUT  2345
      LIMIT=17                                                    GIONEUT  2346
      CALL INDEX(O2COL,LIMIT,IO2,DELO2)                           GIONEUT  2347
      O3COL=O3COLM                                                GIONEUT  2348
      IF(O3COLM .LT. 1.0E+12)  O3COL=1.1E+12                      GIONEUT  2349
      IF(O3COLM .GT. 1.0E+21)  O3COL=1.0E+21                      GIONEUT  2350
      LIMIT=12                                                    GIONEUT  2351
      CALL INDEX(O3COL,LIMIT,IO3,DELO3)                           GIONEUT  2352
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      SUBROUTINE DISSOC(DISOC,IALT)                                     GIONEUT  2239
C                                                                       GIONEUT  2240
      DIMENSION DISOC(14),O2C(12),PNO(12)                               GIONEUT  2241
C                                                                       GIONEUT  2242
      COMMON N(692,30),CONC(424,26),U(692,26),NZERO(692),UZERO(692)     GIONEUT  2243
C                                                                       GIONEUT  2244
      COMMON FORM(692),REMV(692),E(692),F(692),Z(692),                  GIONEUT  2245
     2       DEDY(692),TEMP(692),DTEMDZ(692),DELTAZ(692),SUNSET(692)    GIONEUT  2246
C                                                                       GIONEUT  2247
      COMMON GRAV,COSD,SIND,TIME,CXI,RADIUS,ISPECI,KSPECI,NREAC,K,      GIONEUT  2248
     1       K2,KMIN1,ITURB,CXINOON,SCXI,NREAC2                         GIONEUT  2249
C                                                                       GIONEUT  2250
      COMMON/ATCONS/ATWT(26),MASS(26),THERM(26),SYMBOL(56),POLAR(26)    GIONEUT  2251
C                                                                       GIONEUT  2252
      COMMON/CONSTAN/PI,RADDEG,DEGRAD,RADSEC,BOLTZ,SIN2I,ATCON          GIONEUT  2253
C                                                                       GIONEUT  2254
      COMMON/JAYS/J192(26,25),J193(28,26),J194(22),J195(32,28),         GIONEUT  2255
     1            J196(31,30),J197(27,28),J198(26,28),J200(19,15),      GIONEUT  2256
     2            J201(26,27),J202(22),J203(30,29),J204(35,28),J205(22) GIONEUT  2257
C                                                                       GIONEUT  2258
      COMMON/COLUM/O2COLM,O3COLM,DIS(19,59)                             GIONEUT  2259
C                                                                       GIONEUT  2260
      REAL N,MASS,J192,J193,J194,J195,J196,J197,J198,J200,J201,J202     GIONEUT  2261
      REAL J203,J204,J205                                               GIONEUT  2262
      LOGICAL JSTART                                                    GIONEUT  2263
      DATA JSTART/.TRUE./                                               GIONEUT  2264
C                                                                       GIONEUT  2265
C  THE FOLLOWING TWO DATA STATMENTS CONTAIN THE NO PHOTODISSOCIATION    GIONEUT  2266
C  RATE COEFFICIENTS (PNO) AS FUNCTIONS OF THE COLUMN DENSITY OF        GIONEUT  2267
C  O2 (O2C).  DATA FROM CIESLIK AND NICOLET, PLANET SPACE SCI.          GIONEUT  2268
C  21, 925, 1973.                                                       GIONEUT  2269
C                                                                       GIONEUT  2270
      DATA O2C/18.0,18.5,19.0,19.5,20.0,20.5,21.0,21.5,22.0,22.5,23.0,  GIONEUT  2271
     1         23.5/                                                    GIONEUT  2272
      DATA PNO/1.41E-5,1.40E-5,1.38E-5,1.33E-5,1.22E-5,1.02E-5,         GIONEUT  2273
     1         6.98E-6,3.58E-6,8.93E-7,1.26E-7,4.45E-12,1.50E-29/       GIONEUT  2274
C                                                                       GIONEUT  2275
      GRAVCOR(ZE)=1.0/((1.0+ZE/RADIUS)**2)                              GIONEUT  2276
C                                                                       GIONEUT  2277
C  COMPUTE COLUMN DENSITIES OF O2  AND O3 USING THE SWIDER              GIONEUT  2278
C  APPROXIMATION TO THE CHAPMAN FUNCTION.                               GIONEUT  2279
C                                                                       GIONEUT  2280
      ALT=Z(IALT)                                                       GIONEUT  2281
      T=(BOLTZ*TEMP(IALT))/(GRAV*GRAVCOR(ALT))                          GIONEUT  2282
      SCALE=T/MASS(8)                                                   GIONEUT  2283
      CALL CHAPMAN(CXI,ALT,RADIUS,SCALE,APPROX)                         GIONEUT  2284
      O2COLM=N(IALT,8)*SCALE*APPROX                                     GIONEUT  2285
      SCALE=T/MASS(9)                                                   GIONEUT  2286
      CALL CHAPMAN(CXI,ALT,RADIUS,SCALE,APPROX)                         GIONEUT  2287
      O3COLM=N(IALT,9)*SCALE*APPROX                                     GIONEUT  2288
      IF(.NOT. JSTART) GO TO 35                                         GIONEUT  2289
      JSTART=.FALSE.                                                    GIONEUT  2290
C                                                                       GIONEUT  2291
C  REDUCE THE NO PHOTODISSOCIATION RATE COFFICIENTS BY FACTOR OF 4.     GIONEUT  2292
C                                                                       GIONEUT  2293
      DO 1 II=1,12                                                      GIONEUT  2294
      PNO(II)=ALOG10(PNO(II)/4.0)                                       GIONEUT  2295
```

```
      SUBROUTINE CHAPMAN(CXI,Z,R,H,F)                                   GIONEUT  2210
C                                                                       GIONEUT  2211
C  THIS SUBROUTINE COMPUTES AN APPROXIMATION FOR THE CHAPMAN            GIONEUT  2212
C  FUNCTION USING EQUATIONS F(2) AND FN OF SWIDER FROM                  GIONEUT  2213
C  "ON THE ACCURACY OF CERTAIN APPROXIMATIONS FOR THE CHAPMAN           GIONEUT  2214
C  FUNCTION" AFCRL-67-0468.                                             GIONEUT  2215
C                                                                       GIONEUT  2216
      DATA PIOV2/1.570796326795/,SQPI2/8.862269254528E-01/              GIONEUT  2217
      DATA PI/3.14159265359/                                            GIONEUT  2218
      X=(R+Z)/(H*1.0E-05)                                               GIONEUT  2219
      Y=X*SIN(CXI)                                                      GIONEUT  2220
      IF(CXI .GT. PIOV2) GO TO 10                                       GIONEUT  2221
      W=X-Y                                                             GIONEUT  2222
      IF(W .NE. 0.) GO TO 1                                             GIONEUT  2223
      F=SQRT(1.0+2.0*X)*SQPI2                                           GIONEUT  2224
      RETURN                                                            GIONEUT  2225
    1 A=SQRT(W)                                                         GIONEUT  2226
      IF(W .GE. 9.5) GO TO 5                                            GIONEUT  2227
      COM=ERFC(A)                                                       GIONEUT  2228
      F=-X*COS(CXI)+SQRT(1.0+2.0*X-W)*(A+SQPI2*COM*EXP(W))              GIONEUT  2229
      RETURN                                                            GIONEUT  2230
    5 F=-X*COS(CXI)+SQRT(1.0+2.0*X-W)*(A+(1.0/(2.0*A))*(1.0             GIONEUT  2231
     1  -(1.0/(2.0*W))+(3.0/(4.0*(W**2)))-(15.0/(8.0*(W**3)))))         GIONEUT  2232
      RETURN                                                            GIONEUT  2233
   10 A=-SQRT(Y/2.0)/TAN(CXI)                                           GIONEUT  2234
      EF=ERF(A)                                                         GIONEUT  2235
      F=SQRT(PI*Y/2.0)*(1.0+EF)                                         GIONEUT  2236
      RETURN                                                            GIONEUT  2237
      END                                                               GIONEUT  2238
```

```
      RETURN                                                            GIONEUT  2190
C                                                                       GIONEUT  2191
C  ERROR EXITS.                                                         GIONEUT  2192
C                                                                       GIONEUT  2193
20    PRINT 902, J,J1,JX,JH,X(J),X(J1),DX                               GIONEUT  2194
902   FORMAT(" ERROR IN YINT.     DX .LE. 0.",                          GIONEUT  2195
     1/" J=",I4," J1=",I4," JX=",I4," JH=",I4," X(J)=",1PE13.5,         GIONEUT  2196
     2" X(J1)=",E13.5," DX=",E13.5)                                     GIONEUT  2197
      GO TO 910                                                         GIONEUT  2198
30    PRINT 903, JX,JH,XI,X(JX-1),X(JH)                                 GIONEUT  2199
903   FORMAT(" ERROR IN YINT.     XI OUTSIDE RANGE OF X.",              GIONEUT  2200
     1/" JX=",I4," JH=",I4," XI=",1PE13.5," X(JX-1)=",E13.5,            GIONEUT  2201
     2" X(JH)=",E13.5)                                                  GIONEUT  2202
      GO TO 910                                                         GIONEUT  2203
40    PRINT 904, J,J1,JX,JH,X(J),X(J+1),DX1                             GIONEUT  2204
904   FORMAT(" ERROR IN YINT.     DX1 .LE. 0.",                         GIONEUT  2205
     1/" J=",I4," J1=",I4," JX=",I4," JH=",I4," X(J)=",1PE13.5,         GIONEUT  2206
     2" X(J+1)=",E13.5," DX1=",E13.5)                                   GIONEUT  2207
910   STOP                                                              GIONEUT  2208
      END                                                               GIONEUT  2209
```

```
      FUNCTION YINT(XII,X,Y,JHI)                                        GIONEUT  2133
C                                                                       GIONEUT  2134
C  THIS FUNCTION RETURNS INTERPOLATED YINT FOR INPUT XII.  ARRAY X      GIONEUT  2135
C  MUST BE MONOTONICALLY INCREASING.  JHI IS NUMBER OF POINTS IN        GIONEUT  2136
C  X AND Y ARRAYS.                                                      GIONEUT  2137
C                                                                       GIONEUT  2138
C  INITIALIZE BY CALL WITH JHI=0 BEFORE EACH ARRAY CALL.                GIONEUT  2139
C                                                                       GIONEUT  2140
C  EXAMPLE                                                              GIONEUT  2141
C  INITIALIZE                                                           GIONEUT  2142
C   YY=YINT(XII,X,Y,0)                                                  GIONEUT  2143
C  LOOP ARRAY INTERPOLATE                                               GIONEUT  2144
C  DO 10 K=1,100                                                        GIONEUT  2145
C  XII=K                                                                GIONEUT  2146
C  10 YI(K)=YINT(XII,X,Y,JHI)                                           GIONEUT  2147
C                                                                       GIONEUT  2148
      DIMENSION X(1),Y(1)                                               GIONEUT  2149
      JH=JHI                                                            GIONEUT  2150
      XI=XII                                                            GIONEUT  2151
      IF(JH .GT. 0) GO TO 8                                             GIONEUT  2152
C  INITIALIZE                                                           GIONEUT  2153
      J1=0                                                              GIONEUT  2154
      RETURN                                                            GIONEUT  2155
8     IF(J1 .LT. 1) JX=2                                                GIONEUT  2156
      IF(J1 .LT. 1) GO TO 1                                             GIONEUT  2157
C  TEST IF XI BETWEEN CURRENT X(J1),X(J1+1)                             GIONEUT  2158
      IF(XI .GE. X(J1) .AND. XI .LE. X(J1+1)) GO TO 2                   GIONEUT  2159
C  SEARCH FOR STRADDLING X VALUES                                       GIONEUT  2160
1     DO 10 J=JX,JH                                                     GIONEUT  2161
      J1=J-1                                                            GIONEUT  2162
      DX=X(J)-X(J1)                                                     GIONEUT  2163
C  TEST FOR NON-ZERO DX                                                 GIONEUT  2164
      IF(DX .LE. 0.) GO TO 20                                           GIONEUT  2165
      IF(XI .GE. X(J1) .AND. XI .LE. X(J)) GO TO 4                      GIONEUT  2166
10    CONTINUE                                                          GIONEUT  2167
C ERROR                                                                 GIONEUT  2168
      GO TO 30                                                          GIONEUT  2169
C  COMPUTE SA=AVG SLOPE BETWEEN X(J1) AND X(J1+1)                       GIONEUT  2170
4     SA=(Y(J)-Y(J1))/DX                                                GIONEUT  2171
      JX=J                                                              GIONEUT  2172
C  SET PV,NXT SLOPE TO SA TEMPORARILY                                   GIONEUT  2173
      SAP=SAN=SA                                                        GIONEUT  2174
C  SET PVS SLOPE IF J1.GT.1                                             GIONEUT  2175
      IF(J1 .GT. 1) SAP=(Y(J1)-Y(J1-1))/(X(J1)-X(J1-1))                 GIONEUT  2176
      IF(J .GE. JH) GO TO 6                                             GIONEUT  2177
      DX1=X(J+1)-X(J)                                                   GIONEUT  2178
      IF(DX1 .LE. 0.) GO TO 40                                          GIONEUT  2179
C  SET NEXT SLOPE IF J1 .LT. JH1-1                                      GIONEUT  2180
      SAN=(Y(J+1)-Y(J))/DX1                                             GIONEUT  2181
6     S1=S2=0.                                                          GIONEUT  2182
      IF(SA*SAP .GT. 0.) S1=2.*SA*SAP/(SA+SAP)                          GIONEUT  2183
      IF(SA*SAN .GT. 0.) S2=2.*SA*SAN/(SA+SAN)                          GIONEUT  2184
      A2=(3.*SA-2.*S1-S2)/DX                                            GIONEUT  2185
      A3=(SA-S1-A2*DX)/DX/DX                                            GIONEUT  2186
C  THIS IS CUBIC FIT FOR STRADDLES XI                                   GIONEUT  2187
2     DXI=XI-X(J1)                                                      GIONEUT  2188
      YINT=Y(J1)+DXI*(S1+DXI*(A2+DXI*A3))                               GIONEUT  2189
```

```
      IF(POWER .GT. 650.) GO TO 96                                      GIONEUT  2105
      EXPON=EXP(-POWER)                                                 GIONEUT  2106
 96   LYBETA=4.0E-03*SIGMA(4,2)*FLUX(2)*EXPON                           GIONEUT  2107
      POWER=AA*SIGMA(1,55)+AB*SIGMA(2,55)+AC*SIGMA(3,55)                GIONEUT  2108
      EXPON=0.                                                          GIONEUT  2109
      IF(POWER .GT. 650.) GO TO 100                                     GIONEUT  2110
      EXPON=EXP(-POWER)                                                 GIONEUT  2111
 100  HEI=1.1E-03*FLUX(55)*EXPON                                        GIONEUT  2112
      POWER=AA*SIGMA(1,68)+AB*SIGMA(2,68)+AC*SIGMA(3,68)                GIONEUT  2113
      EXPON=0.                                                          GIONEUT  2114
      IF(POWER .GT. 650.) GO TO 105                                     GIONEUT  2115
      EXPON=EXP(-POWER)                                                 GIONEUT  2116
 105  HEII=1.0E-03*FLUX(68)*EXPON                                       GIONEUT  2117
      DK(185)=DK(185)+HEI*SIGMA(6,55)+HEII*SIGMA(6,68)                  GIONEUT  2118
      DK(186)=DK(186)+LYBETA+HEI*SIGMA(4,55)+HEII*SIGMA(4,68)           GIONEUT  2119
      DK(187)=DK(187)+HEI*SIGMA(5,55)+HEII*SIGMA(5,68)                  GIONEUT  2120
      DK(188)=DK(188)+LYALFA                                            GIONEUT  2121
      DK(190)=DK(190)+HEI*SIGMA(7,55)+HEII*SIGMA(7,68)                  GIONEUT  2122
      DK(191)=DK(191)+HEI*SIGMA(8,55)+HEII*SIGMA(8,68)                  GIONEUT  2123
C                                                                       GIONEUT  2124
C  ADD COSMIC RAY IONIZATION.  Q=1.0E-17*N                              GIONEUT  2125
C                                                                       GIONEUT  2126
      DO 110 I=185,191                                                  GIONEUT  2127
      DK(I)=DK(I)+COSMIC                                                GIONEUT  2128
 110  CONTINUE                                                          GIONEUT  2129
      DK(206)=DK(185)                                                   GIONEUT  2130
      RETURN                                                            GIONEUT  2131
      END                                                               GIONEUT  2132
```

```
R(58)=K(58)*Y(48)*Y(13)*Y(23)                                    GIONEUT   2652
R(59)=K(59)*Y(49)*Y(13)                                          GIONEUT   2653
R(60)=K(60)*Y(48)*Y(13)                                          GIONEUT   2654
R(61)=K(61)*Y(47)*Y(13)                                          GIONEUT   2655
R(62)=K(62)*Y(41)*Y(35)                                          GIONEUT   2656
R(63)=K(63)*Y(41)*Y(36)                                          GIONEUT   2657
R(64)=K(64)*Y(41)*Y(37)                                          GIONEUT   2658
R(65)=K(65)*Y(42)*Y(32)                                          GIONEUT   2659
R(66)=K(66)*Y(42)*Y(35)                                          GIONEUT   2660
R(67)=K(67)*Y(42)*Y(36)                                          GIONEUT   2661
R(68)=K(68)*Y(42)*Y(37)                                          GIONEUT   2662
R(69)=K(69)*Y(42)*Y(38)                                          GIONEUT   2663
R(70)=K(70)*Y(43)*Y(35)                                          GIONEUT   2664
R(71)=K(71)*Y(43)*Y(36)                                          GIONEUT   2665
R(72)=K(72)*Y(43)*Y(37)                                          GIONEUT   2666
R(73)=K(73)*Y(43)*Y(38)                                          GIONEUT   2667
R(74)=K(74)*Y(44)*Y(35)                                          GIONEUT   2668
R(75)=K(75)*Y(44)*Y(36)                                          GIONEUT   2669
R(76)=K(76)*Y(44)*Y(37)                                          GIONEUT   2670
R(77)=K(77)*Y(44)*Y(38)                                          GIONEUT   2671
R(78)=K(78)*Y(45)*Y(35)                                          GIONEUT   2672
R(79)=K(79)*Y(45)*Y(36)                                          GIONEUT   2673
R(80)=K(80)*Y(45)*Y(37)                                          GIONEUT   2674
R(81)=K(81)*Y(45)*Y(38)                                          GIONEUT   2675
R(82)=K(82)*Y(51)*Y(35)                                          GIONEUT   2676
R(83)=K(83)*Y(51)*Y(36)                                          GIONEUT   2677
R(84)=K(84)*Y(51)*Y(37)                                          GIONEUT   2678
R(85)=K(85)*Y(52)*Y(35)                                          GIONEUT   2679
R(86)=K(86)*Y(52)*Y(36)                                          GIONEUT   2680
R(87)=K(87)*Y(52)*Y(37)                                          GIONEUT   2681
R(88)=K(88)*Y(53)*Y(35)                                          GIONEUT   2682
R(89)=K(89)*Y(53)*Y(36)                                          GIONEUT   2683
R(90)=K(90)*Y(53)*Y(37)                                          GIONEUT   2684
R(91)=K(91)*Y(48)*Y(36)                                          GIONEUT   2685
R(92)=K(92)*Y(48)*Y(37)                                          GIONEUT   2686
R(93)=K(93)*Y(48)*Y(38)                                          GIONEUT   2687
R(94)=K(94)*Y(49)*Y(37)                                          GIONEUT   2688
R(95)=K(95)*Y(49)*Y(38)                                          GIONEUT   2689
R(96)=K(96)*Y(31)                                                GIONEUT   2690
R(97)=K(97)*Y(31)*Y(7)                                           GIONEUT   2691
R(98)=K(98)*Y(31)*Y(9)                                           GIONEUT   2692
R(99)=K(99)*Y(32)                                                GIONEUT   2693
R(100)=K(100)*Y(32)*Y(7)                                         GIONEUT   2694
R(101)=K(101)*Y(32)*Y(7)                                         GIONEUT   2695
R(102)=K(102)*Y(32)*Y(9)                                         GIONEUT   2696
R(103)=K(103)*Y(32)*Y(20)                                        GIONEUT   2697
R(104)=K(104)*Y(33)                                              GIONEUT   2698
R(105)=K(105)*Y(33)                                              GIONEUT   2699
R(106)=K(106)*Y(33)*Y(7)                                         GIONEUT   2700
R(107)=K(107)*Y(34)*Y(7)                                         GIONEUT   2701
R(108)=K(108)*Y(34)*Y(7)                                         GIONEUT   2702
R(109)=K(109)*Y(34)*Y(25)                                        GIONEUT   2703
R(110)=K(110)*Y(37)                                              GIONEUT   2704
R(111)=K(111)*Y(37)*Y(7)                                         GIONEUT   2705
R(112)=K(112)*Y(37)*Y(19)                                        GIONEUT   2706
R(113)=K(113)*Y(38)                                              GIONEUT   2707
R(114)=K(114)*Y(38)                                              GIONEUT   2708
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R(115)=K(115)*Y(38)*Y(7)                          GIONEUT  2709
R(116)=K(116)*Y(38)*Y(9)                          GIONEUT  2710
R(117)=K(117)*Y(38)*Y(18)                         GIONEUT  2711
R(118)=K(118)*Y(35)                               GIONEUT  2712
R(119)=K(119)*Y(35)*Y(9)                          GIONEUT  2713
R(120)=K(120)*Y(36)                               GIONEUT  2714
R(121)=K(121)*Y(36)*Y(7)                          GIONEUT  2715
R(122)=K(122)*Y(56)*Y(18)                         GIONEUT  2716
R(123)=K(123)*Y(36)                               GIONEUT  2717
R(124)=K(124)*Y(31)*Y(9)                          GIONEUT  2718
R(125)=K(125)*Y(29)*Y(23)                         GIONEUT  2719
R(126)=K(126)*Y(29)*Y(8)                          GIONEUT  2720
R(127)=K(127)*Y(3)*Y(25)                          GIONEUT  2721
R(128)=K(128)*Y(7)*Y(7)*Y(57)                     GIONEUT  2722
R(129)=K(129)*Y(7)*Y(8)*Y(57)                     GIONEUT  2723
R(130)=K(130)*Y(7)*Y(9)                           GIONEUT  2724
R(131)=K(131)*Y(7)*Y(15)                          GIONEUT  2725
R(132)=K(132)*Y(7)*Y(14)                          GIONEUT  2726
R(133)=K(133)*Y(7)*Y(14)                          GIONEUT  2727
R(134)=K(134)*Y(11)*Y(14)                         GIONEUT  2728
R(135)=K(135)*Y(11)*Y(14)                         GIONEUT  2729
R(136)=K(136)*Y(11)*Y(8)*Y(57)                    GIONEUT  2730
R(137)=K(137)*Y(16)*Y(8)                          GIONEUT  2731
R(138)=K(138)*Y(16)*Y(18)                         GIONEUT  2732
R(139)=K(139)*Y(16)*Y(7)*Y(57)                    GIONEUT  2733
R(140)=K(140)*Y(10)*Y(9)                          GIONEUT  2734
R(141)=K(141)*Y(10)*Y(14)                         GIONEUT  2735
R(142)=K(142)*Y(18)*Y(9)                          GIONEUT  2736
R(143)=K(143)*Y(18)*Y(7)*Y(57)                    GIONEUT  2737
R(144)=K(144)*Y(12)*Y(12)                         GIONEUT  2738
R(145)=K(145)*Y(12)*Y(9)                          GIONEUT  2739
R(146)=K(146)*Y(19)*Y(11)                         GIONEUT  2740
R(147)=K(147)*Y(26)*Y(10)                         GIONEUT  2741
R(148)=K(148)*Y(26)*Y(7)*Y(57)                    GIONEUT  2742
R(149)=K(149)*Y(17)*Y(30)                         GIONEUT  2743
R(150)=K(150)*Y(5)*Y(30)                          GIONEUT  2744
R(151)=K(151)*Y(5)*Y(30)                          GIONEUT  2745
R(152)=K(152)*Y(4)*Y(30)                          GIONEUT  2746
R(153)=K(153)*Y(3)*Y(30)                          GIONEUT  2747
R(154)=K(154)*Y(6)*Y(30)                          GIONEUT  2748
R(155)=K(155)*Y(1)*Y(30)                          GIONEUT  2749
R(156)=K(156)*Y(40)*Y(30)                         GIONEUT  2750
R(157)=K(157)*Y(51)*Y(30)                         GIONEUT  2751
R(158)=K(158)*Y(52)*Y(30)                         GIONEUT  2752
R(159)=K(159)*Y(53)*Y(30)                         GIONEUT  2753
R(160)=K(160)*Y(8)*Y(8)*Y(30)                     GIONEUT  2754
R(161)=K(161)*Y(9)*Y(30)                          GIONEUT  2755
R(162)=K(162)*Y(4)*Y(8)*Y(57)                     GIONEUT  2756
R(163)=K(163)*Y(39)*Y(57)                         GIONEUT  2757
R(164)=K(164)*Y(39)*Y(29)                         GIONEUT  2758
R(165)=K(165)*Y(5)*Y(29)*Y(23)                    GIONEUT  2759
R(166)=K(166)*Y(5)*Y(13)*Y(57)                    GIONEUT  2760
R(167)=K(167)*Y(28)*Y(8)                          GIONEUT  2761
R(168)=K(168)*Y(3)*Y(23)                          GIONEUT  2762
R(169)=K(169)*Y(3)*Y(8)                           GIONEUT  2763
R(170)=K(170)*Y(41)*Y(13)*Y(57)                   GIONEUT  2764
R(171)=K(171)*Y(41)*Y(23)*Y(23)                   GIONEUT  2765
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      R(172)=K(172)*Y(42)*Y(13)*Y(57)                                   GIONEUT  2766
      R(173)=K(173)*Y(43)*Y(13)*Y(57)                                   GIONEUT  2767
      R(174)=K(174)*Y(43)*Y(57)                                         GIONEUT  2768
      R(175)=K(175)*Y(44)*Y(57)                                         GIONEUT  2769
      R(176)=K(176)*Y(45)*Y(57)                                         GIONEUT  2770
      R(177)=K(177)*Y(51)*Y(13)*Y(57)                                   GIONEUT  2771
      R(178)=K(178)*Y(52)*Y(13)*Y(57)                                   GIONEUT  2772
      R(179)=K(179)*Y(31)*Y(8)*Y(8)                                     GIONEUT  2773
      R(180)=K(180)*Y(32)*Y(8)*Y(8)                                     GIONEUT  2774
      R(181)=K(181)*Y(32)*Y(8)*Y(25)                                    GIONEUT  2775
      R(182)=K(182)*Y(33)*Y(25)                                         GIONEUT  2776
      R(183)=K(183)*Y(34)*Y(57)                                         GIONEUT  2777
      R(184)=K(184)*Y(37)*Y(18)                                         GIONEUT  2778
      R(185)=K(185)*Y(7)                                                GIONEUT  2779
      R(186)=K(186)*Y(8)                                                GIONEUT  2780
      R(187)=K(187)*Y(23)                                               GIONEUT  2781
      R(188)=K(188)*Y(18)                                               GIONEUT  2782
      R(189)=K(189)*Y(16)                                               GIONEUT  2783
      R(190)=K(190)*Y(11)                                               GIONEUT  2784
      R(191)=K(191)*Y(21)                                               GIONEUT  2785
      R(192)=K(192)*Y(8)                                                GIONEUT  2786
      R(193)=K(193)*Y(8)                                                GIONEUT  2787
      R(194)=K(194)*Y(9)                                                GIONEUT  2788
      R(195)=K(195)*Y(9)                                                GIONEUT  2789
      R(196)=K(196)*Y(13)                                               GIONEUT  2790
      R(197)=K(197)*Y(14)                                               GIONEUT  2791
      R(198)=K(198)*Y(12)                                               GIONEUT  2792
      R(199)=K(199)*Y(18)                                               GIONEUT  2793
      R(200)=K(200)*Y(19)                                               GIONEUT  2794
      R(201)=K(201)*Y(24)                                               GIONEUT  2795
      R(202)=K(202)*Y(55)                                               GIONEUT  2796
      R(203)=K(203)*Y(25)                                               GIONEUT  2797
      R(204)=K(204)*Y(25)                                               GIONEUT  2798
      R(205)=K(205)*Y(56)                                               GIONEUT  2799
      R(206)=K(206)*Y(7)                                                GIONEUT  2800
      R(207)=K(207)*Y(20)                                               GIONEUT  2801
      R(208)=K(208)*Y(23)                                               GIONEUT  2802
      R(209)=K(209)*Y(8)                                                GIONEUT  2803
      R(210)=K(210)*Y(8)                                                GIONEUT  2804
      R(211)=K(211)*Y(7)                                                GIONEUT  2805
      R(212)=K(212)*Y(7)                                                GIONEUT  2806
      R(213)=K(213)*Y(23)                                               GIONEUT  2807
      R(214)=K(214)*Y(8)                                                GIONEUT  2808
      R(215)=K(215)*Y(23)                                               GIONEUT  2809
      NN=NREAC+NREAC2                                                   GIONEUT  2810
      WRITE(6,20) (J,(CYMB(I,J),I=1,6),K(J),R(J),J=1,NN)                GIONEUT  2811
   20 FORMAT(I4,5A10,A8,9X,1PE12.5,9X,E12.5)                            GIONEUT  2812
      RETURN                                                            GIONEUT  2813
      END                                                               GIONEUT  2814
```

```
      SUBROUTINE HOUR(TIME,OUTP)                                        GIONEUT  2815
C                                                                       GIONEUT  2816
C  THIS SUBROUTINE CONVERTS THE VALUE OF TIME IN SECONDS TO             GIONEUT  2817
C  HOURS.                                                               GIONEUT  2818
C                                                                       GIONEUT  2819
      DIMENSION W(10),OUTP(1)                                           GIONEUT  2820
      DATA W/1H1,1H2,1H3,1H4,1H5,1H6,1H7,1H8,1H9,1H0/                   GIONEUT  2821
      T=TIME+4.32E+04                                                   GIONEUT  2822
      R=AMOD(T,8.64E+04)                                                GIONEUT  2823
      HR=R/3600.+0.00001                                                GIONEUT  2824
      IHR=HR                                                            GIONEUT  2825
      FHR=HR-FLOAT(IHR)                                                 GIONEUT  2826
      IFHR=FHR*60.01                                                    GIONEUT  2827
      JL=4                                                              GIONEUT  2828
      DO 5 L=1,2                                                        GIONEUT  2829
      IF(L .EQ. 1) IW=IFHR                                              GIONEUT  2830
      IF(L .EQ. 2) IW=IHR                                               GIONEUT  2831
      DO 5 M=1,2                                                        GIONEUT  2832
      II=MOD(IW,10)                                                     GIONEUT  2833
      IF(II .EQ. 0) II=10                                               GIONEUT  2834
      OUTP(JL)=W(II)                                                    GIONEUT  2835
      JL=JL-1                                                           GIONEUT  2836
      IW=IW/10                                                          GIONEUT  2837
    5 CONTINUE                                                          GIONEUT  2838
      RETURN                                                            GIONEUT  2839
      END                                                               GIONEUT  2840
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References

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