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DEFENSE NUCLEAR AGENCY REACTION RATE HANDBOOK. SECOND EDITION. REVISION NUMBER 1

M. H. Bortner, et al

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REACTION RATE HANDBOOK

SECOND EDITION
REVISION NUMBER 1

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MEMORANDUM

To: All Authorized Recipients of the DNA Reaction Rate Handbook (DNA 1948H)

From: The Editors

Enclosed herewith you will find a copy of Revision Number 1 to the Handbook. It comprises:

1. Revised interim version of Chapter 2.
2. Revised pages applicable to Appendices A, F, and G.

You should immediately substitute the enclosed items into your copy of the Handbook, discarding the corresponding pages which they replace.

You should also enter on page iii in front of your Handbook the following information: Revision No. 1; Date of Issue- November 1972; Date of Receipt- whatever day you receive this; and sign your name in the last column.

Revision Number 2 is expected to be issued during the late spring or early summer of 1973. Thank you for your patience and cooperation.

2 THE NATURAL ATMOSPHERE: ATMOSPHERIC STRUCTURE

K.S.W. Champion, Air Force Cambridge Research Laboratories
(Latest Revision 16 March 1972)

N. B.: This chapter is not ready for publication, as of the latest revision date, cited above. However, the author has supplied selected reference data for the use of other authors elsewhere in the Handbook, and those authors therefore are enabled to cite Chapter 2 as the source of the information thus utilized. Chapter 2 will be prepared and distributed to authorized recipients of the Handbook at an early date. In the meantime, readers are encouraged to refer to the predecessor chapter by the same author in the First Edition of the Handbook, to other chapters in this Edition (numbers 4, 5, 13) in which data supplied by Dr. Champion are used as noted above, and to two papers* presented by Dr. Champion and his co-workers at the Fourteenth COSPAR Meeting, Seattle, Washington, June 1971. One of the two preprints referenced below is included herewith, in expanded form, as an interim version of Chapter 2.

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*Champion, K. S. W., "The Properties of the Neutral Atmosphere", Paper R.5; Champion, K. S. W., and R. A. Schweinfurth, "The Mean COSPAR International Reference Atmosphere", Paper F.2, Fourteenth COSPAR Meeting, Seattle, Washington, June, 1971.

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THE MEAN COSPAR INTERNATIONAL REFERENCE ATMOSPHERE

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Bedford, Massachusetts, U. S. A.

This contributed paper has been prepared for presentation at the Fourteenth COSPAR Meeting, June 1971 in Seattle. Paper F.2.

THE MEAN COSPAR INTERNATIONAL REFERENCE ATMOSPHERE

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1. INTRODUCTION

The new mean atmosphere has been developed for the altitude range 25 to 500 km. The basis of the reference atmosphere is as follows:

Between 25 and 75 km the model represents annual mean conditions for latitudes near 30°.

Between 120 and 500 km the model corresponds to diurnal, seasonal, and semiannual variation average conditions for a latitude near 30° and a solar flux $\overline{F}$ of 145×10^{-22} W/m^2/Hz.

Between 75 and 120 km a model has been developed which provides a smooth connection between the lower and upper sections of the mean atmosphere.

In addition, a basis is suggested for extending the model from 25 km to ground-level.

It should be noted that throughout the Mean Reference Atmosphere the same formula (appropriate to a latitude of 30°) has been used for the acceleration due to gravity.

This atmosphere contains temperature, density, pressure, density and pressure scale heights, mean molecular weight, densities of major constituents, and total number densities.

The reasons for providing a Mean Reference Atmosphere are twofold:

(1) For many computations it is unnecessary to include a variety of atmospheric conditions and it is sufficient and economical to use a single typical model of the atmosphere.

(2) The respective low and high altitude models of the Reference Atmospheres are functions of different parameters and do not match at 110 km. Thus, if computations are to span this altitude it will, in general, be most satisfactory to use the mean model.

2. MODEL BETWEEN 25 AND 75 km

The data used to develop this model were the annual mean pressure value at 25 km at 30° latitude and the annual mean temperature values at 30° latitude at 5 km intervals starting at 25 km derived from Groves [1]. The actual values are as follows:

Pressure at 25 km: 2.483×10^3 newtons/m^2

Altitude (km)	25	30	35	40	45	50
Temperature (K)	221.7	230.7	241.5	255.3	267.7	271.6

Altitude (km)	55	60	65	70	75
Temperature (K)	263.9	249.3	232.7	216.2	205.0

Starting at 25 km the atmospheric properties were computed using the following equations. Simpson's Rule was used to integrate numerically the pressure equation:

$$p = p_1 \exp\left[-\frac{M_o}{R}\int_{z_1}^{z} g\,dz/T_M\right] \tag{1}$$

where: p_1 = pressure at reference altitude z_1

p = pressure at altitude z

M_o = sea level value of mean molecular weight = 28.96

R = universal gas constant = 8.31432×10^7 ergs K^{-1} gmole^{-1}

g = acceleration due to gravity

T_M = molecular-scale temperature

$$T_M = \frac{M_o}{M} T \ , \tag{2}$$

where M = mean molecular weight

T = kinetic temperature.

The total density was calculated from the relation:

$$\rho = \frac{pM}{RT} = \frac{pM_o}{RT_M} \quad . \tag{3}$$

The pressure scale height was calculated from:

$$Hp = \frac{RT}{Mg} = \frac{RT_M}{M_o g} \quad . \tag{4}$$

As the aim of the computations was to derive a model for the altitude region 25 to 500 km using a single expression for the acceleration due to gravity the expressions used respectively for the low and high altitude models were investigated. Unfortunately, neither formula was adequate. The formula used by Groves was the same as in CIRA 1965 and was sufficient in all respects except that its accuracy at high altitudes was not acceptable. The error was 1 in 10^4 at 200 km, 4 in 10^4 at 300 km, and increased rapidly with altitude. On the other hand, the expression used by Jacchia [2] is valid only for a latitude near 45° (45°32'33"). The problem was solved by adding another term to the expression used in CIRA 1965. The basic expression due to Lambert [3] includes dependence on latitude ϕ:

$$\begin{aligned} g = g\phi &- (3.085462 \times 10^{-6} + 2.27 \times 10^{-9} \cos 2\phi)z \\ &+ (7.254 \times 10^{-13} + 1.0 \times 10^{-15} \cos 2\phi)z^2 \\ &- (1.517 \times 10^{-19} + 6 \times 10^{-22} \cos 2\phi)z^3 \ \mathrm{m/sec}^2 \end{aligned} \tag{5}$$

where z is in meters.

The form applicable to 30° latitude is

$$\begin{aligned} g = 9.79324 &- 3.086597 \times 10^{-6} z + 7.259 \times 10^{-13} z^2 \\ &- 1.520 \times 10^{-19} z^3 \ \mathrm{m/sec}^2 \ . \end{aligned} \tag{6}$$

3. MODEL BETWEEN 75 AND 120 km

The model in this region has to provide a transition between the low altitude model based on Groves' data [1] and Jacchia's high altitude models [2]. Jacchia's models start at 90 km and Groves' models extend to 110 km and they are not only different but they are functions of different parameters. Obviously a compromise must be devised.

As a starting point a temperature profile had to be chosen. As inputs for this it is interesting to compare the values from several models given below:

Altitude (km)	Temperature (T_M, K) US Std Atm 1962	CIRA 1965	Groves*	Jacchia+
80	180.65	186.0	197.3	-
90	180.65	186.0	189.0	183.8
100	210.65	213.0	215.1	203.5
110	260.65	263.0	284.0	265.5
120	360.65	380.7	-	380.6

*Average annual values for 30° latitude converted from kinetic temperatures using the values of M in reference [1].

+Average values for 45° latitude from model with 1000 K exospheric temperature using the values of M in reference [2] to convert the kinetic temperatures.

Two points should be noted. One is that Groves' temperature at 80 km is substantially higher than that in other models. The second is the differences between the temperatures of the Groves and Jacchia models. A further constraint on the temperature profile used in this altitude region is that it must yield a specified density value at 120 km. The values determined for the molecular-scale temperature (T_M) are:

Altitude (km)	80	90	100	110	120
Temperature (T_M, K)	195.0	183.8	203.5	265.5	380.6

The adjustments in the temperature profile were made between 75 and 90 km.

Composition was calculated for this region by J. D. George using the techniques of George, Zimmerman, and Keneshea [4], which include the effects of chemistry and atmospheric dynamics.

The equations used are a system of mass and momentum conservation equations given below for the i'th species:

$$\frac{\partial n_i}{\partial t} = F_i - n_i R_i - \frac{\partial (n_i u_i)}{\partial z} - \frac{\partial \varphi_i}{\partial z} \tag{7}$$

$$\frac{\partial u_i}{\partial t} = \frac{-kT}{m_1} \left(\frac{1}{n_i} \frac{\partial n_i}{\partial z} + \frac{1}{T} \frac{\partial T}{\partial z} + \frac{1}{H_i} \right) - [N_2] C_i u_i \tag{8}$$

where:

n_i	=	the concentration of the i'th species
u_i	=	the mean velocity of the i'th species
	=	$V_i + \bar{u}$
V_i	=	the diffusion velocity of the i'th species
$\bar{u}$	=	the mean mass velocity
t	=	time
z	=	altitude
F_i	=	chemical formation rate of the i'th species
$n_i R_i$	=	chemical removal rate of the i'th species
k	=	Boltzmann constant
m_i	=	mass of the i'th species
H_i	=	scale height of the i'th species
$n_i [N_2] C_i$		is proportional to the frequency of collisions between N_2 and the i'th species.

φ_i is the turbulent mixing flux for the i'th species given by:

$$\varphi_i = -K_t \left[\frac{\partial n_i}{\partial z} + n_i \left(\frac{1}{T} \frac{\partial T}{\partial z} + \frac{1}{H_m} \right) \right] , \tag{9}$$

where K_t is the turbulent diffusion coefficient and H_m is the scale height of a species with the mean mass.

At the lower boundary at 75 km N_2, O_2, Ar, and He were assumed to have the same mixing ratio as at ground level taken from the U. S. Standard Atmosphere, 1962. At this boundary the species O and O_3 were chemically determined by:

$$\frac{\partial n_i}{\partial t} = F_i - n_i R_i \quad . \tag{10}$$

Although not printed in the tables the following species were included in the computations and their densities determined: H_2O (ground level mixing ratio at 75 km), OH, H, H_2, HO_2, and H_2O_2 (chemically determined at 75 km).

The mean velocity (u_i) was assumed to be zero for all species at the upper boundary at 120 km. The turbulent flux for all species is also zero at that altitude since the assumed turbulent diffusion coefficient K_t is zero above the turbopause at 100 km. The concentrations of N_2, O_2, O, Ar, and He were fixed at the upper boundary at the values for the high altitude portion of the model. The remaining species were assumed to be in diffusive equilibrium.

Since a diurnally varying solar flux was used with equations (7), (8), and (9) periodic solutions are obtained. The solution was continued for 32 problem days for a latitude of 30° N using a fixed declination angle (0° or equinox) resulting in a periodically varying zenith angle. The choice of 32 days was arbitrary but did result in adequate accuracy. The variation in the densities of all species was less than one part per thousand from noon of day 31 to noon of day 32. The mean profiles presented here were obtained by averaging over the final 24 hours at 15-minute intervals. One of the constraints of the solution was to maintain a fixed molecular scale temperature profile. The kinetic temperature profile was derived using the solution mean molecular weight. The kinetic temperatures were used to compute the N_2 concentrations in the diffusive equilibrium region from 101 to 120 km. A transition from diffusive equilibrium at 101 km to mixing at 99 km was made using a cubic to represent $\log_{10}[N_2]$. Below 99 km, the mixing region for N_2, the initial N_2 profile was not changed.

In performing the computations the variation with temperature of the reaction rate constants R_i was included, as well as the effects of absorption by the O_2 and O_3 column densities on the dissociation rates by solar ultraviolet radiation. The finite difference analogues used are essentially those given by Shimazaki [5] with modifications as cited by George, Zimmerman, and Keneshea [4]. However, the technique used is modified in that the equations are treated as fully implicit throughout the solution. This approach should preserve the conservation of atoms within the solution altitude region (75 to 120 km) with the exception of the loss of atoms through the lower boundary.

4. MODEL ABOVE 120 km

The exospheric temperature was calculated to correspond to average diurnal, seasonal, semi-annual, and geomagnetic conditions for 30° latitude and a solar flux of 145×10^{-22} W/m^2/Hz. The resultant exospheric temperature is 1000 K.

Jacchia's models were recomputed from 90 km upwards using the expression for g given in equation (6). This results in a change in the total density and number densities of the constituents at higher altitudes. The densities were then changed (at all altitudes) so that at 120 km they matched the density computed for the intermediate altitude model. These densities are very close to those of the 1000 K Jacchia model at 120 km as shown immediately below, but are slightly different at other altitudes.

Altitude (km)	Temp (K)	Log $[N_2](m^{-3})$	Log $[O_2](m^{-3})$
120	334.5	17.5789	16.7338

Log $[O](m^{-3})$	Log $[Ar](m^{-3})$	Log $[He](m^{-3})$	M
17.1532	15.1732	13.5376	25.45

Density (kgm^{-3})
2.438×10^{-8}

Above the turbopause (assumed to be at 100 km) the number densities of each individual species n_i were computed by integrating the equation for diffusive equilibrium:

$$\frac{dn_i}{n_i} = -\frac{M_i g}{RT} dz - (1 + \alpha_i) \frac{dT}{T} \quad , \tag{11}$$

where α_i is the thermal diffusion coefficient taken to be -0.38 for helium and zero for other constituents.

5. MEAN REFERENCE ATMOSPHERE

The properties of the Mean Reference Atmosphere are presented in Tables 1-4. Table 1 contains values of molecular scale temperature, density, log density, pressure, log pressure, number density, pressure scale height, and acceleration due to gravity over the altitude range 25 to 120 km.* Table 2 contains values of kinetic temperature, mean molecular weight, and log number densities of N_2, O_2, O, Ar, He, and O_3 over the altitude range 75 to 120 km. Densities of O and O_3 are not presented below 80 km because at these altitudes their diurnal variation is so large that average values would have little significance. The O_3 densities presented are for noon. In Table 3 are given molecular scale temperature, density, log density, pressure, log pressure, pressure scale height, and acceleration due to gravity for the altitude range 120 to 500 km. Table 4 contains the corresponding values of kinetic temperature, mean molecular weight, number density, and log number densities of N_2, O_2, O, Ar, and He for the altitudes 120 to 500 km.

The properties of the Mean Reference Atmosphere are illustrated in Figures 1-7. Figure 1 shows the pressure scale height as a function of altitude. Figure 2 shows the kinetic temperature (T) and the molecular-scale temperature (T_M). Figure 3 contains the kinetic

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*The Mean CIRA has been developed for the altitude range 25 to 500 km. At 25 km the Mean CIRA values are almost identical with those of the US Standard Atmosphere Supplements, 1966 midlatitude spring/fall model. Thus the values in Table 1 can be extended to ground level by using the numbers in Table 5.1, page 119 of the Supplements. If an exact match is required for a given parameter, e.g., temperature, density, or pressure, then the Mean CIRA 25-km value can be matched to the Supplement value slightly above 25 km (25.15 km for temperature) and then the Supplement altitude values scaled accordingly. Physically this can be justified because different g values were used in developing the two models (45° N and 30° N values for the Supplement and the Mean CIRA, respectively).

temperature of the mean atmosphere plus curves indicating low extreme and high extreme temperatures whose frequency of occurrence is one per cent or less. The extreme curves attain exospheric temperatures of 550 and 1900 K, respectively. The pressure curve for the Mean Atmosphere is shown in Figure 4. Low extreme, high extreme and mean density values are plotted in Figure 5. Above 180 km these curves correspond to the temperature profiles in Figure 3. The mean molecular weights for the mean atmosphere are plotted in Figure 6. The corresponding number densities of N_2, O_2, O, O_3, Ar, He, and H are shown in Figure 7.

To illustrate very large seasenal variations, Figure 8 contains the mean June-July temperature profile for 80° N and Figure 9 the mean December-January temperature profile for the same location. These profiles are based primarily on data from Heiss Island and are from Reference [6]. At 50 km the temperatures range from 279 K in summer to 247 K in winter, compared with the mean reference value of 271.6 K. At 80 km they range from 177 K in summer to 218 K in winter, compared with the reference value of 195 K.

Figure 10 contains the mean CIRA temperatures, median warm temperatures and those exceeded 10% and 1% of the time and, similarly, median cold temperatures and those above which 90% and 99%, respectively, of the temperatures lie. The extreme temperature profiles are a revised version of those in Reference [7]. The corresponding density curves are shown in Figure 11. In general, the mean atmosphere values are in excellent agreement with the other curves.

6. REFERENCES

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Table 1. Mean Reference Atmosphere structure parameters, 25 to 120 km.

HEIGHT KM	MOLEC TEMP K	DENSITY KG/M3	LOG DEN (KG/M3)	PRESSURE NT/M2	LOG PRESSURE (NT/M2)	NUMBER DENSITY /M3	PRESSURE SCALE HT KM	G M/SEC2
25	221.7	3.899E-02	-1.409	2.483E+03	3.395	8.111E+23	6.55	9.716
26	223.4	3.327E-02	-1.478	2.133E+03	3.329	6.916E+23	6.60	9.714
27	225.1	2.838E-02	-1.547	1.832E+03	3.263	5.902E+23	6.65	9.710
28	226.9	2.427E-02	-1.615	1.578E+03	3.198	5.042E+23	6.71	9.707
29	228.7	2.075E-02	-1.683	1.361E+03	3.134	4.311E+23	6.77	9.704
30	230.7	1.774E-02	-1.751	1.175E+03	3.070	3.690E+23	6.83	9.701
31	232.6	1.521E-02	-1.818	1.016E+03	3.007	3.162E+23	6.89	9.698
32	234.6	1.306E-02	-1.884	8.790E+02	2.944	2.713E+23	6.95	9.695
33	236.8	1.119E-02	-1.951	7.621E+02	2.882	2.329E+23	7.01	9.692
34	239.1	9.638E-03	-2.016	6.607E+02	2.820	2.002E+23	7.08	9.689
35	241.5	8.279E-03	-2.082	5.741E+02	2.759	1.722E+23	7.16	9.686
36	244.4	7.129E-03	-2.147	5.000E+02	2.699	1.481E+23	7.25	9.683
37	247.2	6.138E-03	-2.212	4.355E+02	2.639	1.277E+23	7.33	9.680
38	250.0	5.297E-03	-2.276	3.802E+02	2.580	1.102E+23	7.42	9.677
39	252.7	4.581E-03	-2.339	3.327E+02	2.522	9.536E+22	7.50	9.674
40	255.3	3.972E-03	-2.401	2.911E+02	2.464	8.265E+22	7.58	9.671
41	258.5	3.443E-03	-2.463	2.553E+02	2.407	7.160E+22	7.68	9.668
42	261.3	2.992E-03	-2.524	2.244E+02	2.351	6.222E+22	7.76	9.665
43	263.8	2.606E-03	-2.584	1.972E+02	2.295	5.422E+22	7.84	9.662
44	266.0	2.280E-03	-2.642	1.738E+02	2.240	4.737E+22	7.90	9.659
45	267.7	1.995E-03	-2.700	1.535E+02	2.186	4.148E+22	7.96	9.656
46	269.4	1.750E-03	-2.757	1.352E+02	2.131	3.637E+22	8.01	9.653
47	270.7	1.538E-03	-2.813	1.194E+02	2.077	3.197E+22	8.05	9.650
48	271.4	1.355E-03	-2.868	1.054E+02	2.023	2.816E+22	8.08	9.647
49	271.7	1.194E-03	-2.923	9.333E+01	1.970	2.485E+22	8.09	9.644
50	271.6	1.057E-03	-2.976	8.241E+01	1.916	2.198E+22	8.09	9.641
51	270.6	9.376E-04	-3.028	7.278E+01	1.862	1.949E+22	8.06	9.638
52	269.4	8.318E-04	-3.080	6.427E+01	1.808	1.729E+22	8.03	9.635
53	267.8	7.379E-04	-3.132	5.675E+01	1.754	1.534E+22	7.98	9.632
54	266.0	6.546E-04	-3.184	5.000E+01	1.699	1.362E+22	7.93	9.629
55	263.9	5.821E-04	-3.235	4.406E+01	1.644	1.210E+22	7.87	9.626
56	261.2	5.176E-04	-3.286	3.882E+01	1.589	1.076E+22	7.79	9.623
57	258.3	4.603E-04	-3.337	3.412E+01	1.533	9.563E+21	7.71	9.620
58	255.4	4.083E-04	-3.389	2.992E+01	1.476	8.489E+21	7.62	9.617
59	252.4	3.622E-04	-3.441	2.624E+01	1.419	7.528E+21	7.54	9.614
60	249.3	3.206E-04	-3.494	2.296E+01	1.361	6.669E+21	7.45	9.611
61	246.0	2.838E-04	-3.547	2.004E+01	1.302	5.904E+21	7.35	9.608
62	242.7	2.512E-04	-3.600	1.750E+01	1.243	5.219E+21	7.25	9.605
63	239.4	2.213E-04	-3.655	1.521E+01	1.182	4.606E+21	7.16	9.602
64	236.1	1.950E-04	-3.710	1.321E+01	1.121	4.057E+21	7.06	9.599
65	232.7	1.718E-04	-3.765	1.146E+01	1.059	3.568E+21	6.96	9.596
66	229.0	1.510E-04	-3.821	9.908E+00	.996	3.137E+21	6.85	9.593
67	225.5	1.321E-04	-3.879	8.570E+00	.933	2.751E+21	6.75	9.590
68	222.2	1.156E-04	-3.937	7.379E+00	.868	2.404E+21	6.65	9.587
69	219.1	1.007E-04	-3.997	6.339E+00	.802	2.096E+21	6.56	9.584
70	216.2	8.770E-05	-4.057	5.445E+00	.736	1.822E+21	6.48	9.581
71	213.7	7.586E-05	-4.120	4.656E+00	.668	1.576E+21	6.41	9.578
72	211.3	6.561E-05	-4.183	3.981E+00	.600	1.364E+21	6.34	9.575

Table 1. (Cont'd.)

HEIGHT KM	MOLEC TEMP K	DENSITY KG/M3	LOG DEN (KG/M3)	PRESSURE NT/M2	LOG PRESSURE (NT/M2)	NUMBER DENSITY /M3	PRESSURE SCALE HT KM	G M/SEC2
73	209.1	5.662E-05	-4.247	3.396E+00	.531	1.177E+21	6.27	9.572
74	207.0	4.875E-05	-4.312	2.891E+00	.461	1.013E+21	6.21	9.569
75	205.0	4.178E-05	-4.379	2.460E+00	.391	8.696E+20	6.15	9.566
76	203.0	3.581E-05	-4.446	2.089E+00	.320	7.455E+20	6.09	9.563
77	201.0	3.069E-05	-4.51[illegible]	1.770E+00	.248	6.381E+20	6.04	9.56[illegible]
78	199.0	2.624E-05	-4.581	1.496E+00	.175	5.453E+20	5.98	9.55[illegible]
79	197.0	2.239E-05	-4.650	1.245E+00	.102	4.653E+20	5.92	9.55[illegible]
80	195.0	1.905E-05	-4.720	1.067E+00	.028	3.964E+20	5.86	9.55[illegible]
81	193.0	1.622E-05	-4.790	8.974E-01	-.047	3.371E+20	5.80	9.54[illegible]
82	191.0	1.377E-05	-4.861	7.551E-01	-.122	2.864E+20	5.75	9.545
83	199.0	1.167E-05	-4.933	6.324E-01	-.199	2.428E+20	5.69	9.542
84	87.1	9.863E-06	-5.006	5.297E-01	-.276	2.055E+20	5.63	9.539
85	185.1	8.337E-06	-5.079	4.426E-01	-.354	1.736E+20	5.57	9.536
86	184.8	6.982E-06	-5.156	3.698E-01	-.432	1.453E+20	5.57	9.533
87	184.5	5.834E-06	-5.234	3.090E-01	-.510	1.215E+20	5.56	9.530
88	184.2	4.875E-06	-5.312	2.576E-01	-.589	1.015E+20	5.55	9.527
89	184.0	4.074E-06	-5.390	2.148E-01	-.668	8.482E+19	5.55	9.524
90	183.8	3.396E-06	-5.469	1.795E-01	-.746	7.087E+19	5.54	9.521
91	184.6	2.825E-06	-5.549	1.496E-01	-.825	5.890E+19	5.57	9.518
92	185.4	2.350E-06	-5.629	1.250E-01	-.903	4.901E+19	5.59	9.515
93	186.7	1.950E-06	-5.710	1.045E-01	-.981	4.072E+19	5.64	9.512
94	188.0	1.622E-06	-5.790	8.750E-02	-1.058	3.386E+19	5.68	9.509
95	190.3	1.343E-06	-5.872	7.345E-02	-1.134	2.808E+19	5.75	9.506
96	192.0	1.119E-06	-5.951	6.166E-02	-1.210	2.344E+19	5.80	9.503
97	194.5	9.311E-07	-6.031	5.200E-02	-1.284	1.952E+19	5.88	9.500
98	197.1	7.745E-07	-6.111	4.385E-02	-1.358	1.630E+19	5.96	9.498
99	200.3	6.442E-07	-6.191	3.707E-02	-1.431	1.362E+19	6.06	9.495
100	203.5	5.297E-07	-6.276	3.090E-02	-1.510	1.125E+19	6.16	9.492
101	207.3	4.355E-07	-6.361	2.588E-02	-1.587	9.305E+18	6.27	9.489
102	211.6	3.648E-07	-6.438	2.218E-02	-1.654	7.856E+18	6.40	9.486
103	216.7	3.062E-07	-6.514	1.905E-02	-1.720	6.634E+18	6.56	9.483
104	221.7	2.582E-07	-6.588	1.644E-02	-1.784	5.628E+18	6.71	9.480
105	228.0	2.173E-07	-6.663	1.422E-02	-1.847	4.768E+18	6.91	9.477
106	234.2	1.841E-07	-6.735	1.236E-02	-1.908	4.060E+18	7.10	9.474
107	241.1	1.560E-07	-6.807	1.079E-02	-1.967	3.463E+18	7.31	9.471
108	248.6	1.327E-07	-6.877	9.462E-03	-2.024	2.961E+18	7.54	9.468
109	256.8	1.130E-07	-6.947	8.337E-03	-2.079	2.538E+18	7.79	9.465
110	265.5	9.661E-08	-7.015	7.362E-03	-2.133	2.182E+18	8.06	9.462
111	274.9	8.279E-08	-7.082	6.546E-03	-2.184	1.881E+18	8.34	9.459
112	284.8	7.129E-08	-7.147	5.834E-03	-2.234	1.627E+18	8.65	9.456
113	295.1	6.166E-08	-7.210	5.224E-03	-2.282	1.413E+18	8.96	9.454
114	305.9	5.346E-08	-7.272	4.688E-03	-2.329	1.231E+18	9.29	9.451
115	317.1	4.645E-08	-7.333	4.236E-03	-2.373	1.076E+18	9.64	9.448
116	329.2	4.055E-08	-7.392	3.837E-03	-2.416	9.433E+17	10.01	9.445
117	341.6	3.548E-08	-7.450	3.483E-03	-2.458	8.298E+17	10.39	9.442
118	354.3	3.126E-08	-7.505	3.177E-03	-2.498	7.327E+17	10.78	9.439
119	366.9	2.761E-08	-7.559	2.904E-03	-2.537	6.499E+17	11.16	9.436
120	380.6	2.438E-08	-7.613	2.667E-03	-2.574	5.772E+17	11.58	9.433

Table 2. Kinetic temperature and composition of the Mean Reference Atmosphere, 75 to 120 km.

HEIGHT KM	TEMP K	MEAN MOL WT	LOG N(N2) (/M3)	LOG N(O2) (/M3)	LOG N(O) (/M3)	LOG N(AR) (/M3)	LOG N(HE) (/M3)	LOG N(O3) (/M3)
75	205.0	28.96	20.832	20.261		18.910	15.659	
76	203.0	28.96	20.765	20.193		18.842	15.591	
77	201.0	28.96	20.698	20.124		18.773	15.523	
78	19 .9	28.95	20.630	20.055		18.704	15.454	
79	196.9	28.95	20.562	19.985		18.634	15.385	
80	194.9	28.95	20.492	19.914	16.794	18.563	15.315	14.495
81	192.9	28.94	20.422	19.843	16.896	18.492	15.244	14.434
82	190.9	28.94	20.352	19.771	16.981	18.420	15.172	14.364
83	188.8	28.94	20.280	19.698	17.049	18.347	15.100	14.284
84	186.9	28.93	20.208	19.624	17.102	18.272	15.027	14.195
85	184.9	28.93	20.135	19.550	17.144	18.199	14.954	14.098
86	184.6	28.92	20.058	19.471	17.173	18.120	14.876	13.975
87	184.2	28.91	19.980	19.392	17.194	18.041	14.798	13.845
88	183.9	28.91	19.903	19.312	17.208	17.962	14.721	13.710
89	183.6	28.90	19.825	19.232	17.216	17.882	14.643	13.570
90	183.4	28.89	19.747	19.153	17.220	17.802	14.565	13.425
91	184.1	28.88	19.667	19.070	17.222	17.720	14.486	13.269
92	184.8	28.87	19.587	18.988	17.227	17.638	14.407	13.115
93	186.0	28.86	19.507	18.906	17.235	17.556	14.329	12.959
94	187.2	28.84	19.427	18.823	17.251	17.473	14.253	12.810
95	189.3	28.81	19.346	18.739	17.280	17.389	14.178	12.665
96	190.8	28.77	19.267	18.656	17.334	17.306	14.110	12.549
97	192.9	28.72	19.187	18.570	17.407	17.221	14.050	12.445
98	194.5	28.63	19.107	18.483	17.489	17.133	14.000	12.348
99	197.2	28.51	19.028	18.392	17.562	17.041	13.960	12.236
100	199.4	28.37	18.940	18.299	17.618	16.945	13.928	12.099
101	201.9	28.20	18.853	18.201	17.654	16.842	13.902	11.938
102	204.8	28.03	18.778	18.105	17.670	16.739	13.879	11.766
103	208.4	27.85	18.703	18.009	17.672	16.636	13.855	11.577
104	211.9	27.68	18.630	17.916	17.664	16.536	13.833	11.385
105	216.6	27.51	18.556	17.823	17.647	16.435	13.811	11.178
106	221.2	27.35	18.483	17.734	17.627	16.337	13.791	10.974
107	226.4	27.19	18.411	17.647	17.602	16.241	13.770	10.766
108	232.1	27.03	18.340	17.561	17.573	16.146	13.750	10.555
109	238.4	26.88	18.270	17.479	17.542	16.053	13.730	10.343
110	245.1	26.73	18.200	17.398	17.509	15.961	13.711	10.132
111	252.4	26.59	18.132	17.320	17.475	15.872	13.692	9.920
112	260.1	26.45	18.065	17.245	17.440	15.785	13.673	9.710
113	268.1	26.31	17.999	17.173	17.404	15.701	13.655	9.503
114	276.5	26.18	17.935	17.103	17.368	15.619	13.637	9.299
115	285.2	26.05	17.872	17.036	17.332	15.539	13.620	9.098
116	294.7	25.92	17.811	16.971	17.295	15.461	13.603	8.899
117	304.3	25.80	17.750	16.908	17.259	15.385	13.586	8.703
118	314.2	25.68	17.692	16.847	17.223	15.312	13.569	8.514
119	323.9	25.57	17.635	16.790	17.188	15.242	13.553	8.332
120	334.5	25.45	17.579	16.734	17.153	15.173	13.538	8.167

Table 3. Mean Reference Atmosphere structure parameters, 120 to 500 km.

HEIGHT KM	MOLEC TEMP K	DENSITY KG/M3	LOG DEN (KG/M3)	DENSITY SCALE HT KM	PRESSURE NT/M2	LOG PRESSURE (NT/M2)	PRESSURE SCALE HT KM	G M/SEC2
120	380.6	2.440E-08	-7.613	8.17	2.666E-03	-2.574	11.58	9.433
121	394.5	2.162E-08	-7.665	8.42	2.449E-03	[illegible]	12.01	9.430
122	408.[illegible]	1.924E-08	-7.716	8.67	2.257E-03	-2.[illegible]	12.44	9.427
123	423.[illegible]	1.717E-08	-7.765	8.94	2.085E-03	-2.66[illegible]	12.89	9.424
124	437.6	1.538E-08	-7.813	9.21	1.932E-03	-2.714	13.33	9.421
125	452.[illegible]	1.382E-08	-7.859	9.51	1.795E-03	-2.746	13.79	9.418
126	467.[illegible]	1.246E-08	-7.904	9.80	1.671E-03	-2.777	14.24	9.416
127	482.0	1.127E-08	-7.948	10.10	1.560E-03	-2.807	14.70	9.413
128	497.0	1.022E-08	-7.990	10.41	1.459E-03	-2.836	15.16	9.410
129	511.9	9.300E-09	-8.032	10.73	1.367E-03	-2.864	15.62	9.407
130	526.9	8.484E-09	-8.071	11.05	1.283E-03	-2.892	16.08	9.404
131	541.8	7.759E-09	-8.110	11.37	1.207E-03	-2.918	16.55	9.401
132	556.7	7.115E-09	-8.148	11.70	1.137E-03	-2.944	17.01	9.398
133	571.5	6.540E-09	-8.184	12.03	1.073E-03	-2.969	17.46	9.395
134	586.3	6.025E-09	-8.220	12.36	1.014E-03	-2.994	17.92	9.392
135	600.9	5.563E-09	-8.255	12.70	9.597E-04	-3.018	18.37	9.389
136	615.5	5.147E-09	-8.288	13.04	9.094E-04	-3.041	18.83	9.387
137	629.9	4.772E-09	-8.321	13.39	8.629E-04	-3.064	19.27	9.384
138	644.2	4.432E-09	-8.353	13.73	8.198E-04	-3.086	19.72	9.381
139	658.4	4.125E-09	-8.385	14.08	7.797E-04	-3.108	20.16	9.378
140	672.4	3.845E-09	-8.415	14.44	7.423E-04	-3.129	20.59	9.375
141	686.2	3.591E-09	-8.443	14.79	7.075E-04	-3.150	21.02	9.372
142	699.9	3.359E-09	-8.474	15.14	6.749E-04	-3.171	21.45	9.369
143	713.4	3.147E-09	-8.502	15.50	6.445E-04	-3.191	21.87	9.366
144	726.7	2.952E-09	-8.530	15.85	6.159E-04	-3.210	22.28	9.363
145	739.8	2.774E-09	-8.557	16.21	5.891E-04	-3.230	22.69	9.360
146	752.8	2.609E-09	-8.583	16.56	5.640E-04	-3.249	23.10	9.358
147	765.6	2.458E-09	-8.609	16.92	5.403E-04	-3.267	23.50	9.355
148	778.1	2.318E-09	-8.635	17.27	5.179E-04	-3.286	23.89	9.352
149	790.5	2.189E-09	-8.660	17.63	4.969E-04	-3.304	24.26	9.349
150	802.7	2.070E-09	-8.684	17.98	4.770E-04	-3.321	24.66	9.346
151	814.7	1.959E-09	-8.708	18.32	4.582E-04	-3.339	25.04	9.343
152	826.6	1.856E-09	-8.731	18.67	4.404E-04	-3.356	25.41	9.340
153	838.2	1.760E-09	-8.755	19.02	4.235E-04	-3.373	25.77	9.337
154	849.7	1.670E-09	-8.777	19.36	4.075E-04	-3.390	26.13	9.335
155	861.0	1.587E-09	-8.799	19.70	3.923E-04	-3.406	26.49	9.332
156	872.1	1.509E-09	-8.821	20.04	3.778E-04	-3.423	26.84	9.329
157	883.0	1.436E-09	-8.843	20.37	3.641E-04	-3.439	27.18	9.326
158	893.8	1.368E-09	-8.864	20.71	3.510E-04	-3.455	27.52	9.323
159	904.4	1.304E-09	-8.885	21.04	3.386E-04	-3.470	27.86	9.320
160	914.8	1.244E-09	-8.905	21.37	3.267E-04	-3.486	28.19	9.317

Table 3. (Cont'd.)

HEIGHT KM	MOLEC TEMP K	DENSITY KG/M3	LOG DEN (KG/M3)	DENSITY SCALE HT KM	PRESSURE NT/M2	LOG PRESSURE (NT/M2)	PRESSURE SCALE HT KM	G M/SEC2
161	925.1	1.188E-09	-8.925	21.69	3.154E-04	-3.501	28.51	9.314
162	935.2	1.134E-09	-8.945	22.01	3.046E-04	-3.516	28.83	9.312
163	945.2	1.064E-09	-8.965	22.33	2.943E-04	-3.531	29.15	9.309
164	955.0	1.037E-09	-8.984	22.65	2.844E-04	-3.546	29.46	9.306
165	964.7	9.927E-10	-9.003	22.96	2.749E-04	-3.561	29.77	9.303
166	974.2	9.507E-10	-9.022	23.28	2.659E-04	-3.575	30.07	9.300
167	983.6	9.110E-10	-9.040	23.58	2.573E-04	-3.590	30.37	9.297
168	992.9	8.734E-10	-9.059	23.88	2.490E-04	-3.604	30.67	9.294
169	1002.1	8.378E-10	-9.077	24.17	2.410E-04	-3.618	30.96	9.292
170	1011.1	8.040E-10	-9.095	24.48	2.334E-04	-3.632	31.25	9.289
171	1020.0	7.720E-10	-9.112	24.78	2.261E-04	-3.646	31.53	9.286
172	1028.7	7.417E-10	-9.130	25.06	2.191E-04	-3.659	31.82	9.283
173	1037.4	7.128E-10	-9.147	25.35	2.123E-04	-3.673	32.09	9.280
174	1045.9	6.854E-10	-9.164	25.64	2.058E-04	-3.687	32.37	9.277
175	1054.4	6.593E-10	-9.181	25.92	1.996E-04	-3.700	32.64	9.274
176	1062.7	6.345E-10	-9.198	26.20	1.936E-04	-3.713	32.91	9.272
177	1070.9	6.109E-10	-9.214	26.47	1.878E-04	-3.726	33.17	9.269
178	1079.0	5.883E-10	-9.230	26.75	1.823E-04	-3.739	33.43	9.266
179	1087.1	5.669E-10	-9.247	27.02	1.769E-04	-3.752	33.69	9.263
180	1095.0	5.464E-10	-9.263	27.29	1.718E-04	-3.765	33.95	9.260
181	1102.8	5.268E-10	-9.278	27.56	1.668E-04	-3.778	34.20	9.257
182	1110.5	5.081E-10	-9.294	27.82	1.620E-04	-3.790	34.45	9.255
183	1118.2	4.903E-10	-9.310	28.08	1.574E-04	-3.803	34.70	9.252
184	1125.7	4.732E-10	-9.325	28.34	1.529E-04	-3.816	34.94	9.249
185	1133.2	4.568E-10	-9.340	28.60	1.486E-04	-3.828	35.19	9.246
186	1140.6	4.412E-10	-9.355	28.86	1.445E-04	-3.840	35.43	9.243
187	1147.9	4.262E-10	-9.370	29.11	1.405E-04	-3.852	35.66	9.240
188	1155.1	4.119E-10	-9.385	29.35	1.366E-04	-3.865	35.90	9.238
189	1162.2	3.982E-10	-9.400	29.60	1.329E-04	-3.877	36.13	9.235
190	1169.3	3.850E-10	-9.415	29.85	1.292E-04	-3.889	36.36	9.232
191	1176.2	3.724E-10	-9.429	30.09	1.257E-04	-3.901	36.59	9.229
192	1183.1	3.602E-10	-9.443	30.34	1.224E-04	-3.912	36.82	9.226
193	1190.0	3.486E-10	-9.458	30.58	1.191E-04	-3.924	37.04	9.223
194	1196.7	3.374E-10	-9.472	30.82	1.159E-04	-3.936	37.26	9.221
195	1203.4	3.267E-10	-9.486	31.05	1.129E-04	-3.947	37.48	9.218
196	1210.0	3.164E-10	-9.500	31.28	1.099E-04	-3.959	37.70	9.215
197	1216.6	3.065E-10	-9.514	31.51	1.070E-04	-3.970	37.91	9.212
198	1223.1	2.969E-10	-9.527	31.74	1.043E-04	-3.982	38.13	9.209
199	1229.5	2.878E-10	-9.541	31.98	1.016E-04	-3.993	38.34	9.207
200	1235.8	2.789E-10	-9.555	32.21	9.896E-05	-4.005	38.55	9.204

Table 3. (Cont'd.)

HEIGHT KM	MOLEC TEMP K	DENSITY KG/M3	LOG DEN (KG/M3)	DENSITY SCALE HT KM	PRESSURE NT/M2	LOG PRESSURE (NT/M2)	PRESSURE SCALE HT KM	G M/SEC2
202	1248.3	2.622E-10	-9.581	32.66	9.399E-05	-4.027	38.96	9.198
204	1260.6	2.468E-10	-9.608	33.10	8.931E-05	-4.049	39.37	9.192
206	1272.6	2.324E-10	-9.634	33.54	8.491E-05	-4.071	39.77	9.187
208	1284.4	2.190E-10	-9.660	33.97	8.076E-05	-4.093	40.16	9.181
210	1295.9	2.066E-10	-9.685	34.40	7.686E-05	-4.114	40.55	9.176
212	1307.2	1.950E-10	-9.710	34.82	7.317E-05	-4.136	40.93	9.170
214	1318.3	1.842E-10	-9.735	35.24	6.970E-05	-4.157	41.30	9.164
216	1329.2	1.741E-10	-9.759	35.65	6.642E-05	-4.178	41.66	9.159
218	1339.9	1.646E-10	-9.784	36.06	6.332E-05	-4.198	42.03	9.153
220	1350.5	1.558E-10	-9.808	36.45	6.039E-05	-4.219	42.38	9.148
222	1360.6	1.475E-10	-9.831	36.85	5.762E-05	-4.239	42.73	9.142
224	1370.6	1.398E-10	-9.855	37.24	5.499E-05	-4.260	43.07	9.137
226	1380.5	1.325E-10	-9.878	37.63	5.251E-05	-4.280	43.41	9.131
228	1390.2	1.257E-10	-9.901	38.01	5.015E-05	-4.300	43.74	9.125
230	1399.6	1.192E-10	-9.924	38.39	4.792E-05	-4.320	44.06	9.120
232	1408.9	1.132E-10	-9.946	38.77	4.580E-05	-4.339	44.38	9.114
234	1418.1	1.076E-10	-9.968	39.13	4.379E-05	-4.359	44.70	9.109
236	1427.0	1.022E-10	-9.990	39.49	4.188E-05	-4.378	45.00	9.103
238	1435.8	9.720E-11	-10.012	39.85	4.006E-05	-4.397	45.31	9.098
240	1444.4	9.246E-11	-10.034	40.21	3.834E-05	-4.416	45.61	9.092
242	1452.8	8.799E-11	-10.056	40.56	3.670E-05	-4.435	45.90	9.087
244	1461.0	8.378E-11	-10.077	40.91	3.514E-05	-4.454	46.19	9.081
246	1469.1	7.979E-11	-10.098	41.25	3.366E-05	-4.473	46.47	9.076
248	1477.1	7.603E-11	-10.119	41.59	3.224E-05	-4.492	46.75	9.070
250	1484.9	7.248E-11	-10.140	41.92	3.090E-05	-4.510	47.03	9.065
252	1492.5	6.911E-11	-10.160	42.25	2.961E-05	-4.529	47.30	9.059
254	1499.9	6.593E-11	-10.181	42.58	2.839E-05	-4.547	47.56	9.054
256	1507.3	6.292E-11	-10.201	42.90	2.723E-05	-4.565	47.83	9.048
258	1514.4	6.006E-11	-10.221	43.21	2.611E-05	-4.583	48.08	9.043
260	1521.5	5.735E-11	-10.241	43.52	2.505E-05	-4.601	48.33	9.037
262	1528.4	5.478E-11	-10.261	43.83	2.404E-05	-4.619	48.58	9.032
264	1535.1	5.235E-11	-10.281	44.13	2.307E-05	-4.637	48.83	9.026
266	1541.7	5.004E-11	-10.301	44.43	2.215E-05	-4.655	49.07	9.021
268	1548.2	4.784E-11	-10.320	44.74	2.127E-05	-4.672	49.30	9.015
270	1554.6	4.576E-11	-10.340	45.03	2.042E-05	-4.690	49.54	9.010
272	1560.8	4.378E-11	-10.359	45.32	1.962E-05	-4.707	49.76	9.004
274	1566.9	4.189E-11	-10.378	45.60	1.885E-05	-4.725	49.99	8.999
276	1572.9	4.010E-11	-10.397	45.88	1.811E-05	-4.742	50.21	8.993
278	1578.7	3.839E-11	-10.416	46.16	1.740E-05	-4.759	50.43	8.988
280	1584.5	3.677E-11	-10.434	46.43	1.673E-05	-4.777	50.64	8.983
282	1590.1	3.522E-11	-10.453	46.70	1.608E-05	-4.794	50.85	8.977
284	1595.6	3.375E-11	-10.472	46.96	1.546E-05	-4.811	51.06	8.972
286	1601.0	3.235E-11	-10.490	47.22	1.487E-05	-4.828	51.26	8.966
288	1606.3	3.101E-11	-10.508	47.48	1.430E-05	-4.845	51.46	8.961
290	1611.5	2.974E-11	-10.527	47.73	1.376E-05	-4.861	51.66	8.955
292	1616.6	2.852E-11	-10.545	47.98	1.324E-05	-4.878	51.86	8.950
294	1621.6	2.736E-11	-10.563	48.23	1.274E-05	-4.895	52.05	8.945
296	1626.5	2.625E-11	-10.581	48.47	1.226E-05	-4.912	52.24	8.939
298	1631.2	2.519E-11	-10.599	48.71	1.180E-05	-4.928	52.42	8.934
300	1636.0	2.418E-11	-10.617	48.95	1.136E-05	-4.945	52.60	8.928

Table 3. (Cont'd.)

HEIGHT KM	MOLEC TEMP K	DENSITY KG/M3	LOG DEN (KG/M3)	DENSITY SCALE HT KM	PRESSURE NT/M2	LOG PRESSURE (NT/M2)	PRESSURE SCALE HT KM	G M/SEC2
302	1640.6	2.321E-11	-10.634	49.19	1.093E-05	-4.961	52.78	8.923
304	1645.1	2.229E-11	-10.652	49.42	1.053E-05	-4.978	52.96	8.918
306	1649.5	2.141E-11	-10.669	49.64	1.014E-05	-4.994	53.14	8.912
308	1653.8	2.056E-11	-10.687	49.86	9.764E-06	-5.010	53.31	8.907
310	1658.1	1.976E-11	-10.704	50.07	9.405E-06	-5.027	53.48	8.902
312	1662.3	1.899E-11	-10.722	50.28	9.061E-06	-5.043	53.64	8.896
314	1666.4	1.825E-11	-10.739	50.50	8.730E-06	-5.059	53.81	8.891
316	1670.4	1.754E-11	-10.756	50.70	8.412E-06	-5.075	53.97	8.886
318	1674.3	1.686E-11	-10.773	50.91	8.106E-06	-5.091	54.13	8.880
320	1678.2	1.621E-11	-10.790	51.12	7.812E-06	-5.107	54.29	8.875
322	1682.0	1.559E-11	-10.807	51.32	7.530E-06	-5.123	54.44	8.870
324	1685.7	1.500E-11	-10.824	51.51	7.259E-06	-5.139	54.60	8.864
326	1689.4	1.443E-11	-10.841	51.71	6.998E-06	-5.155	54.75	8.859
328	1693.0	1.388E-11	-10.858	51.90	6.747E-06	-5.171	54.90	8.854
330	1696.5	1.336E-11	-10.874	52.09	6.507E-06	-5.187	55.05	8.848
332	1700.0	1.286E-11	-10.891	52.28	6.275E-06	-5.202	55.19	8.843
334	1703.4	1.237E-11	-10.907	52.46	6.052E-06	-5.218	55.34	8.838
336	1706.8	1.191E-11	-10.924	52.64	5.837E-06	-5.234	55.48	8.832
338	1710.1	1.147E-11	-10.940	52.81	5.631E-06	-5.249	55.62	8.827
340	1713.4	1.104E-11	-10.957	52.98	5.432E-06	-5.265	55.76	8.822
342	1716.6	1.063E-11	-10.973	53.16	5.241E-06	-5.281	55.90	8.816
344	1719.7	1.024E-11	-10.990	53.32	5.057E-06	-5.296	56.03	8.811
346	1722.8	9.866E-12	-11.006	53.49	4.880E-06	-5.312	56.17	8.806
348	1725.8	9.505E-12	-11.022	53.65	4.709E-06	-5.327	56.30	8.801
350	1728.8	9.158E-12	-11.038	53.81	4.545E-06	-5.342	56.43	8.795
352	1731.8	8.824E-12	-11.054	53.97	4.387E-06	-5.358	56.56	8.790
354	1734.7	8.503E-12	-11.070	54.13	4.235E-06	-5.373	56.69	8.785
356	1737.6	8.195E-12	-11.086	54.29	4.088E-06	-5.388	56.82	8.780
358	1740.4	7.899E-12	-11.102	54.44	3.947E-06	-5.404	56.95	8.774
360	1743.2	7.615E-12	-11.118	54.59	3.811E-06	-5.419	57.07	8.769
362	1746.0	7.341E-12	-11.134	54.74	3.680E-06	-5.434	57.20	8.764
364	1748.7	7.078E-12	-11.150	54.89	3.554E-06	-5.449	57.32	8.759
366	1751.4	6.825E-12	-11.166	55.03	3.432E-06	-5.464	57.44	8.753
368	1754.1	6.582E-12	-11.182	55.17	3.315E-06	-5.480	57.57	8.748
370	1756.7	6.348E-12	-11.197	55.31	3.202E-06	-5.495	57.69	8.743
372	1759.2	6.123E-12	-11.213	55.45	3.093E-06	-5.510	57.81	8.738
374	1761.8	5.906E-12	-11.229	55.59	2.988E-06	-5.525	57.93	8.732
376	1764.3	5.698E-12	-11.244	55.72	2.886E-06	-5.540	58.05	8.727
378	1767.0	5.497E-12	-11.260	55.85	2.789E-06	-5.555	58.16	8.722
380	1769.5	5.304E-12	-11.275	55.98	2.694E-06	-5.570	58.28	8.717
382	1772.0	5.118E-12	-11.291	56.11	2.604E-06	-5.584	58.40	8.712
384	1774.5	4.939E-12	-11.306	56.24	2.516E-06	-5.599	58.51	8.706
386	1776.9	4.767E-12	-11.322	56.35	2.432E-06	-5.614	58.63	8.701
388	1779.4	4.600E-12	-11.337	56.48	2.350E-06	-5.629	58.74	8.696
390	1781.8	4.441E-12	-11.353	56.60	2.272E-06	-5.644	58.86	8.691
392	1784.2	4.287E-12	-11.368	56.72	2.196E-06	-5.658	58.97	8.686
394	1786.6	4.138E-12	-11.383	56.84	2.123E-06	-5.673	59.09	8.681
396	1788.9	3.995E-12	-11.398	56.96	2.052E-06	-5.688	59.20	8.675
398	1791.3	3.858E-12	-11.414	57.09	1.984E-06	-5.702	59.32	8.670
400	1793.7	3.725E-12	-11.429	57.20	1.918E-06	-5.717	59.43	8.665

Table 3. (Cont'd.)

HEIGHT KM	MOLEC TEMP K	DENSITY KG/M3	LOG DEN (KG/M3)	DENSITY SCALE HT KM	PRESSURE NT/M2	LOG PRESSURE (NT/M2)	PRESSURE SCALE HT KM	G M/SEC2
402	179[illegible].3	3.597E-12	-11.444	57.32	1.855E-06	-5.732	59.54	8.660
404	179[illegible]	3.47[illegible]E-12	-11.459	57.43	1.794E-06	-5.746	59.66	8.655
406	1800.7	3.355E-12	-11.474	57.54	1.735E-06	-5.761	59.77	8.650
408	1803.1	3.241E-12	-11.489	57.65	1.677E-06	-5.775	59.88	8.644
410	1805.[illegible]	3.130E-12	-11.504	57.75	1.622E-06	-5.790	60.00	8.639
412	1807.[illegible]	3.024E-12	-11.519	57.86	1.569E-06	-5.804	60.11	8.634
414	1810.1	2.921E-12	-11.534	57.97	1.518E-06	-5.819	60.22	8.629
416	181[illegible].5	2.822E-12	-11.549	58.07	1.468E-06	-5.833	60.34	8.624
418	1814.3	2.7[illegible]E-12	-11.564	58.18	1.421E-06	-5.848	60.45	8.619
420	1817.2	2.635E-12	-11.579	58.28	1.374E-06	-5.862	60.57	8.614
422	1819.5	2.546E-12	-11.594	58.38	1.3[illegible]E-06	-5.876	60.68	8.609
424	1821.[illegible]	2.460E-12	-11.609	58.49	1.287E-06	-5.890	60.80	8.603
426	1824.3	2.377E-12	-11.624	58.59	1.245E-06	-5.905	60.91	8.598
428	1826.7	2.298E-12	-11.639	58.69	1.20[illegible]E-06	-5.919	61.03	8.593
430	1829.1	2.221E-12	-11.653	58.79	1.166E-06	-5.933	61.14	8.588
432	1831.5	2.147E-12	-11.668	58.89	1.129E-06	-5.947	61.26	8.583
434	1833.[illegible]	2.075E-12	-11.683	58.98	1.092E-06	-5.962	61.38	8.578
436	1836.3	2.006E-12	-11.698	59.08	1.057E-06	-5.976	61.50	8.573
438	1838.5	1.939E-12	-11.712	59.17	1.024E-06	-5.990	61.62	8.568
440	1841.3	1.875E-12	-11.727	59.26	9.910E-07	-6.004	61.74	8.563
442	1843.3	1.813E-12	-11.742	59.36	9.595E-07	-6.018	61.86	8.558
444	1846.3	1.753E-12	-11.756	59.45	9.290E-07	-6.032	61.98	8.553
446	1848.3	1.695E-12	-11.771	59.5[illegible]	8.995E-07	-6.046	62.10	8.548
448	1851.[illegible]	1.639E-12	-11.786	59.64	8.710E-07	-6.060	62.22	8.5[illegible]2
450	1854.3	1.585E-12	-11.800	59.73	8.435E-07	-6.074	62.35	8.537
452	1856.5	1.533E-12	-11.815	59.82	8.169E-07	-6.088	62.47	8.532
454	1859.3	1.482E-12	-11.829	59.91	7.912E-07	-6.102	62.60	8.527
456	1861.[illegible]	1.434E-12	-11.844	60.00	7.663E-07	-6.116	62.72	8.522
458	1864.5	1.387E-12	-11.858	60.09	7.423E-07	-6.129	62.85	8.517
460	1867.[illegible]	1.341E-12	-11.872	60.18	7.191E-07	-6.143	62.98	8.512
462	1870.2	1.297E-12	-11.887	60.27	6.966E-07	-6.157	63.11	8.507
464	1873.0	1.255E-12	-11.901	60.36	6.749E-07	-6.171	63.25	8.502
466	1875.1	1.214E-12	-11.916	60.45	6.539E-07	-6.184	63.38	8.497
468	1878.[illegible]	1.175E-12	-11.930	60.54	6.337E-07	-6.198	63.51	8.492
470	1881.[illegible]	1.137E-12	-11.944	60.63	6.140E-07	-6.212	63.65	8.487
472	1884.[illegible]	1.100E-12	-11.959	60.72	5.950E-07	-6.225	63.79	8.482
474	1887.[illegible]	1.064E-12	-11.973	60.81	5.767E-07	-6.239	63.93	8.477
476	1890.[illegible]	1.030E-12	-11.987	60.90	5.590E-07	-6.253	64.07	8.472
478	1893.5	9.965E-13	-12.002	60.98	5.418E-07	-6.266	64.21	8.467
480	1896.[illegible]	9.644E-13	-12.016	61.06	5.252E-07	-6.280	64.36	8.462
482	1900.1	9.333E-13	-12.030	61.16	5.092E-07	-6.293	64.50	8.457
484	1903.[illegible]	9.033E-13	-12.044	61.25	4.936E-07	-6.30[illegible]	64.65	8.452
486	1906.[illegible]	8.743E-13	-12.058	61.34	4.786E-07	-6.320	64.80	8.447
488	1910.[illegible]	8.463E-13	-12.072	61.43	4.641E-07	-6.333	64.96	8.442
490	1913.[illegible]	8.192E-13	-12.087	61.52	4.500E-07	-6.347	65.11	8.437
492	1916.[illegible]	7.930E-13	-12.101	61.60	4.364E-07	-6.360	65.27	8.432
494	1920.5	7.677E-13	-12.115	61.69	4.233E-07	-6.373	65.43	8.427
496	1924.0	7.432E-13	-12.129	61.78	4.106E-07	-6.387	65.59	8.422
498	1927.[illegible]	7.196E-13	-12.143	61.87	3.982E-07	-6.400	65.75	8.417
500	1931.[illegible]	6.967E-13	-12.157	61.95	3.863E-07	-6.413	65.92	8.412

Table 4. Kinetic temperature and composition of the Mean Reference Atmosphere, 120 to 500 km.

HEIGHT KM	TEMP K	MEAN MOL WT	NUMBER DENSITY /M3	LOG N(N2) (/M3)	LOG N(O2) (/M3)	LOG N(O) (/M3)	LOG N(AR) (/M3)	LOG N(HE) (/M3)
120	334.5	25.45	5.772E+17	17.579	16.734	17.153	15.173	13.538
121	345.3	25.35	5.137E+17	17.524	16.674	17.118	15.102	13.523
122	356.2	25.25	4.589E+17	17.472	16.615	17.080	15.032	13.509
123	367.3	25.15	4.112E+17	17.420	16.558	17.045	14.964	13.496
124	378.5	25.05	3.698E+17	17.370	16.503	17.011	14.898	13.482
125	389.7	24.95	3.336E+17	17.322	16.449	16.978	14.835	13.469
126	400.9	24.85	3.019E+17	17.274	16.397	16.946	14.773	13.457
127	412.1	24.76	2.741E+17	17.229	16.347	16.914	14.712	13.444
128	423.3	24.66	2.496E+17	17.184	16.297	16.884	14.654	13.432
129	434.4	24.57	2.279E+17	17.141	16.249	16.854	14.597	13.421
130	445.4	24.48	2.087E+17	17.098	16.203	16.826	14.541	13.410
131	456.4	24.39	1.916E+17	17.057	16.157	16.798	14.487	13.399
132	467.2	24.31	1.763E+17	17.017	16.113	16.770	14.434	13.388
133	478.0	24.22	1.626E+17	16.978	16.070	16.744	14.382	13.378
134	488.6	24.13	1.503E+17	16.940	16.028	16.719	14.333	13.368
135	499.0	24.[illegible]	1.393E+17	16.903	15.987	16.693	14.284	13.358
136	509.4	23.97	1.293E+17	16.867	15.947	16.668	14.236	13.349
137	519.6	23.89	1.203E+17	16.832	15.908	16.645	14.190	13.340
138	529.6	23.81	1.121E+17	16.798	15.870	16.621	14.144	13.331
139	539.4	23.73	1.047E+17	16.764	15.832	16.599	14.059	13.322
140	549.0	23.65	9.793E+16	16.731	15.796	16.577	14.056	13.314
141	558.5	23.57	9.176E+16	16.699	15.760	16.555	14.013	13.306
142	567.8	23.49	8.610E+16	16.667	15.725	16.534	13.971	13.298
143	576.9	23.42	8.092E+16	16.636	15.691	16.513	13.930	13.290
144	585.8	23.35	7.616E+16	16.606	15.657	16.493	13.890	13.282
145	594.5	23.27	7.178E+16	16.577	15.624	16.474	13.850	13.275
146	603.0	23.20	6.774E+16	16.548	15.592	16.454	13.811	13.268
147	611.4	23.13	6.401E+16	16.519	15.560	16.436	13.773	13.261
148	619.5	23.06	6.056E+16	16.491	15.529	16.417	13.736	13.254
149	627.4	22.99	5.736E+16	16.464	15.499	16.399	13.699	13.248
150	635.2	22.92	5.439E+16	16.437	15.469	16.381	13.663	13.241
151	642.8	22.85	5.163E+16	16.410	15.439	16.364	13.627	13.235
152	650.2	22.78	4.906E+16	16.384	15.410	16.347	13.592	13.229
153	657.4	22.71	4.666E+16	16.358	15.381	16.330	13.557	13.223
154	664.4	22.63	4.442E+16	16.333	15.353	16.314	13.523	13.217
155	671.3	22.58	4.233E+16	16.308	15.325	16.298	13.490	13.212
156	678.0	22.51	4.037E+16	16.283	15.298	16.282	13.457	13.206
157	684.5	22.45	3.853E+16	16.259	15.271	16.266	13.424	13.201
158	690.9	22.39	3.681E+16	16.235	15.244	16.251	13.392	13.195
159	697.1	22.32	3.518E+16	16.212	15.218	16.236	13.360	13.190
160	703.1	22.26	3.366E+16	16.189	15.192	16.221	13.328	13.185

Table 4. (Cont'd.)

HEIGHT KM	TEMP K	MEAN MOL WT	NUMBER DENSITY /M3	LOG N(N2) (/M3)	LOG N(O2) (/M3)	LOG N(O) (/M3)	LOG N(AR) (/M3)	LOG N(HE) (/M3)
161	709.0	22.20	3.222E+16	16.166	15.166	16.206	13.297	13.180
162	714.8	22.13	3.087E+16	16.143	15.141	16.192	13.266	13.175
163	720.4	22.07	2.959E+16	16.121	15.115	16.177	13.236	13.170
164	725.9	22.01	2.838E+16	16.099	15.091	16.163	13.205	13.166
165	731.2	21.95	2.723E+16	16.077	15.066	16.150	13.176	13.161
166	736.5	21.89	2.615E+16	16.055	15.042	16.136	13.146	13.156
167	741.6	21.83	2.513E+16	16.034	15.018	16.122	13.117	13.152
168	746.6	21.78	2.416E+16	16.012	14.994	16.109	13.088	13.147
169	751.5	21.72	2.323E+16	15.991	14.970	16.096	13.059	13.143
170	756.2	21.66	2.236E+16	15.971	14.947	16.083	13.031	13.139
171	760.8	21.60	2.152E+16	15.950	14.924	16.070	13.003	13.135
172	765.4	21.55	2.073E+16	15.930	14.901	16.057	12.975	13.130
173	769.8	21.49	1.998E+16	15.909	14.878	16.045	12.947	13.126
174	774.1	21.43	1.926E+16	15.889	14.856	16.032	12.919	13.122
175	778.4	21.38	1.857E+16	15.870	14.834	16.020	12.892	13.118
176	782.5	21.32	1.792E+16	15.850	14.811	16.007	12.865	13.114
177	786.5	21.27	1.730E+16	15.830	14.789	15.995	12.838	13.111
178	790.5	21.22	1.670E+16	15.811	14.768	15.983	12.811	13.107
179	794.4	21.16	1.613E+16	15.792	14.746	15.971	12.785	13.103
180	798.1	21.11	1.559E+16	15.773	14.724	15.960	12.758	13.099
181	801.8	21.06	1.507E+16	15.754	14.703	15.948	12.732	13.096
182	805.5	21.00	1.457E+16	15.735	14.682	15.936	12.706	13.092
183	809.0	20.95	1.409E+16	15.716	14.661	15.925	12.680	13.088
184	812.5	20.90	1.363E+16	15.698	14.640	15.914	12.655	13.085
185	815.9	20.85	1.319E+16	15.679	14.619	15.902	12.629	13.081
186	819.2	20.80	1.277E+16	15.661	14.598	15.891	12.604	13.078
187	822.5	20.75	1.237E+16	15.643	14.578	15.880	12.579	13.075
188	825.7	20.70	1.198E+16	15.625	14.557	15.869	12.554	13.071
189	828.8	20.65	1.161E+16	15.607	14.537	15.858	12.529	13.068
190	831.9	20.60	1.125E+16	15.589	14.517	15.847	12.504	13.064
191	834.9	20.55	1.091E+16	15.571	14.497	15.836	12.479	13.061
192	837.8	20.51	1.058E+16	15.553	14.477	15.825	12.455	13.057
193	840.7	20.46	1.026E+16	15.536	14.457	15.815	12.430	13.054
194	843.5	20.41	9.956E+15	15.518	14.437	15.804	12.406	13.052
195	846.3	20.37	9.661E+15	15.501	14.418	15.794	12.382	13.048
196	849.0	20.32	9.378E+15	15.484	14.398	15.783	12.358	13.045
197	851.7	20.27	9.104E+15	15.466	14.379	15.773	12.334	13.042
198	854.3	20.23	8.841E+15	15.449	14.359	15.762	12.310	13.039
199	856.8	20.18	8.587E+15	15.432	14.340	15.752	12.286	13.036
200	859.3	20.14	8.342E+15	15.415	14.321	15.742	12.262	13.033

Table 4. (Cont'd.)

HEIGHT KM	TEMP K	MEAN MOL WT	NUMBER DENSITY /M3	LOG N(N2) (/M3)	LOG N(O2) (/M3)	LOG N(O) (/M3)	LOG N(AR) (/M3)	LOG N(HE) (/M3)
202	854.2	20.05	7.878E+15	15.382	14.283	15.721	12.215	13.027
204	868.9	19.96	7.445E+15	15.348	14.245	15.701	12.169	13.021
206	873.4	19.88	7.041E+15	15.315	14.207	15.682	12.122	13.015
208	877.8	19.79	6.665E+15	15.282	14.170	15.662	12.077	13.010
210	882.0	19.71	6.312E+15	15.250	14.133	15.642	12.031	13.004
212	886.0	19.63	5.982E+15	15.217	14.096	15.623	11.986	12.998
214	889.9	19.55	5.673E+15	15.185	14.060	15.604	11.941	12.993
216	893.7	19.47	5.384E+15	15.153	14.024	15.585	11.896	12.987
218	897.3	19.39	5.112E+15	15.122	13.988	15.566	11.852	12.982
220	900.7	19.32	4.856E+15	15.090	13.952	15.547	11.807	12.977
222	904.1	19.24	4.616E+15	15.059	13.917	15.529	11.763	12.971
224	907.3	19.17	4.390E+15	15.028	13.881	15.510	11.720	12.966
226	910.5	19.10	4.177E+15	14.997	13.846	15.492	11.676	12.961
228	913.5	19.03	3.977E+15	14.966	13.811	15.474	11.633	12.956
230	916.4	18.96	3.788E+15	14.936	13.777	15.456	11.590	12.951
232	919.2	18.89	3.609E+15	14.905	13.742	15.438	11.547	12.946
234	921.8	18.83	3.441E+15	14.875	13.708	15.420	11.505	12.941
236	924.4	18.76	3.281E+15	14.845	13.674	15.402	11.462	12.936
238	927.0	18.70	3.131E+15	14.815	13.640	15.385	11.420	12.931
240	929.4	18.63	2.988E+15	14.785	13.606	15.367	11.378	12.927
242	931.7	18.57	2.853E+15	14.755	13.572	15.350	11.336	12.922
244	933.9	18.51	2.725E+15	14.726	13.538	15.333	11.295	12.917
246	936.1	18.45	2.604E+15	14.696	13.505	15.315	11.253	12.913
248	938.2	18.39	2.489E+15	14.667	13.472	15.298	11.212	12.908
250	940.2	18.34	2.380E+15	14.638	13.438	15.281	11.171	12.903
252	942.2	18.28	2.277E+15	14.609	13.405	15.264	11.129	12.899
254	944.0	18.23	2.178E+15	14.580	13.372	15.247	11.089	12.894
256	945.8	18.17	2.085E+15	14.551	13.339	15.230	11.048	12.890
258	947.6	18.12	1.996E+15	14.522	13.307	15.214	11.007	12.885
260	949.3	18.07	1.912E+15	14.494	13.274	15.197	10.967	12.881
262	950.9	18.02	1.831E+15	14.465	13.242	15.180	10.926	12.876
264	952.4	17.97	1.755E+15	14.437	13.209	15.164	10.886	12.872
266	953.9	17.92	1.682E+15	14.408	13.177	15.147	10.846	12.867
268	955.4	17.87	1.612E+15	14.380	13.145	15.131	10.806	12.863
270	956.8	17.82	1.546E+15	14.352	13.112	15.114	10.766	12.859
272	958.2	17.78	1.483E+15	14.324	13.080	15.098	10.726	12.854
274	959.5	17.73	1.423E+15	14.295	13.048	15.082	10.686	12.850
276	960.7	17.69	1.365E+15	14.267	13.016	15.065	10.646	12.846
278	961.9	17.65	1.310E+15	14.240	12.985	15.049	10.607	12.842
280	963.1	17.60	1.258E+15	14.212	12.953	15.033	10.567	12.837
282	964.2	17.56	1.208E+15	14.184	12.921	15.017	10.528	12.833
284	965.3	17.52	1.160E+15	14.156	12.890	15.0[illegible]	10.488	12.829
286	966.4	17.48	1.114E+15	14.129	12.858	14.985	10.449	12.825
288	967.4	17.44	1.071E+15	14.101	12.827	14.969	10.410	12.821
290	968.4	17.40	1.029E+15	14.073	12.795	14.[illegible]	10.371	12.816
292	969.3	17.36	9.891E+14	14.046	12.764	14.937	10.332	12.812
294	970.2	17.33	9.508E+14	14.019	12.733	14.921	10.293	12.808
296	971.1	17.29	9.142E+14	13.991	12.702	14.906	10.254	12.804
298	972.0	17.26	8.792E+14	13.964	12.670	14.890	10.215	12.800
300	972.8	17.22	8.456E+14	13.937	12.639	14.874	10.177	12.796

Table 4. (Cont'd.)

HEIGHT KM	TEMP K	MEAN MOL WT	NUMBER DENSITY /M3	LOG N(N2) (/M3)	LOG N(O2) (/M3)	LOG N(O) (/M3)	LOG N(AR) (/M3)	LOG N(HE) (/M3)
302	973.6	17.19	8.134E+14	13.909	12.[illegible]08	14.859	10.138	12.792
304	974.4	17.15	7.826E+14	13.882	12.577	14.843	10.100	12.788
306	975.1	17.12	7.531E+14	13.855	12.[illegible]46	14.827	10.061	12.784
308	975.8	17.09	7.248E+14	13.828	12.[illegible]16	14.812	10.023	12.780
310	976.5	17.06	6.977E+14	13.801	12.485	14.796	9.984	12.776
312	977.2	17.02	6.716E+14	13.774	12.454	14.781	9.946	12.772
314	977.8	16.99	6.467E+14	13.747	12.423	14.765	9.908	12.768
316	978.5	16.96	6.227E+14	13.720	12.393	14.750	9.870	12.764
318	979.1	16.93	5.997E+14	13.694	12.362	14.734	9.831	12.760
320	979.7	16.91	5.776E+14	13.667	12.332	14.719	9.793	12.756
322	980.2	16.88	5.565E+14	13.640	12.301	14.703	9.755	12.752
324	980.8	16.85	5.361E+14	13.613	12.271	14.688	9.717	12.748
326	981.3	16.82	5.166E+14	13.587	12.240	14.673	9.67[illegible]	12.744
328	981.8	16.79	4.978E+14	13.560	12.210	14.657	9.641	12.740
330	982.3	16.77	4.798E+14	13.533	12.179	14.642	9.604	12.736
332	982.8	16.74	4.625E+14	13.507	12.149	14.627	9.[illegible]	12.732
334	983.3	16.72	4.458E+14	13.480	12.119	14.612	9.528	12.729
336	983.7	16.69	4.298E+14	13.454	12.089	14.596	9.490	12.725
338	984.1	16.67	4.1[illegible]E+14	13.427	12.058	14.581	9.453	12.721
340	984.6	16.64	3.997E+14	13.401	12.028	14.566	9.415	12.717
342	985.0	16.62	3.854E+14	13.375	11.998	14.551	9.378	12.713
344	985.4	16.59	3.718E+14	13.348	11.968	14.536	9.340	12.709
346	985.7	16.57	3.586E+14	13.322	11.938	14.521	9.303	12.705
348	986.1	16.55	3.459E+14	13.296	11.908	14.506	9.265	12.702
350	986.5	16.52	3.338E+14	13.269	11.878	14.490	9.228	12.698
352	986.8	16.50	3.220E+14	13.243	11.848	14.475	9.1[illegible]	12.694
354	987.2	16.48	3.108E+14	13.217	11.818	14.460	9.153	12.690
356	987.5	16.46	2.999E+14	13.191	11.788	14.445	9.[illegible]	12.686
358	987.8	16.44	2.894E+14	13.165	11.758	14.430	9.079	12.683
360	988.1	16.42	2.794E+14	13.139	11.729	14.415	9.041	12.679
362	988.4	16.39	2.697E+14	13.112	11.699	14.400	9.004	12.675
364	988.7	16.37	2.604E+14	13.086	11.669	14.386	8.967	12.671
366	989.0	16.35	2.514E+14	13.060	11.639	14.371	8.930	12.667
368	989.2	16.33	2.427E+14	13.034	11.610	14.356	8.893	12.664
370	989.5	16.31	2.344E+14	13.008	11.580	14.341	8.856	12.660
372	989.8	16.29	2.263E+14	12.982	11.550	14.326	8.819	12.656
374	990.0	16.27	2.186E+14	12.956	11.521	14.311	8.782	12.652
376	990.2	16.25	2.111E+14	12.931	11.491	14.296	8.745	12.649
378	990.5	16.23	2.039E+14	12.905	11.462	14.281	8.708	12.645
380	990.7	16.21	1.970E+14	12.879	11.432	14.267	8.672	12.641
382	990.9	16.19	1.903E+14	12.853	11.403	14.252	8.635	12.637
384	991.1	16.18	1.839E+14	12.827	11.373	14.237	8.598	12.634
386	991.3	16.16	1.777E+14	12.801	11.344	14.222	8.561	12.630
388	991.5	16.14	1.717E+14	12.776	11.314	14.208	8.525	12.626
390	991.7	16.12	1.659E+14	12.750	11.285	14.193	8.488	12.622
392	991.9	16.10	1.603E+14	12.724	11.255	14.178	8.451	12.619
394	992.1	16.08	1.550E+14	12.698	11.226	14.163	8.415	12.615
396	992.3	16.06	1.498E+14	12.673	11.197	14.149	8.378	12.611
398	992.5	16.04	1.448E+14	12.647	11.166	14.134	8.342	12.608
400	992.6	16.03	1.400E+14	12.621	11.138	14.119	8.305	12.604

Table 4. (Cont'd.)

HEIGHT KM	TEMP K	MEAN MOL WT	NUMBER DENSITY /M3	LOG N(N2) (/M3)	LOG N(O2) (/M3)	LOG N(O) (/M3)	LOG N(AR) (/M3)	LOG N(HE) (/M3)
402	992.3	16.01	1.353E+14	12.596	11.109	14.105	8.269	12.600
404	993.0	15.99	1.308E+14	12.570	11.080	14.090	8.232	12.596
406	993.1	15.97	1.265E+14	12.545	11.051	14.075	8.196	12.593
408	993.3	15.95	1.223E+14	12.519	11.021	14.061	8.159	12.589
410	993.4	15.93	1.183E+14	12.494	10.992	14.046	8.123	12.585
412	993.6	15.92	1.144E+14	12.468	10.963	14.032	8.087	12.582
414	993.7	15.90	1.107E+14	12.443	10.934	14.017	8.050	12.578
416	993.8	15.88	1.070E+14	12.417	10.905	14.002	8.014	12.574
418	994.0	15.86	1.035E+14	12.392	10.876	13.988	7.978	12.571
420	994.1	15.84	1.001E+14	12.366	10.847	13.973	7.941	12.567
422	994.3	15.82	9.689E+13	12.341	10.818	13.959	7.905	12.563
424	994.5	15.81	9.374E+13	12.316	10.789	13.944	7.869	12.560
426	994.5	15.79	9.070E+13	12.290	10.760	13.930	7.833	12.556
428	994.6	15.77	8.776E+13	12.265	10.731	13.915	7.797	12.553
430	994.7	15.75	8.493E+13	12.239	10.702	13.901	7.761	12.549
432	994.8	15.73	8.219E+13	12.214	10.673	13.886	7.725	12.545
434	994.9	15.71	7.954E+13	12.189	10.644	13.872	7.689	12.542
436	995.0	15.69	7.699E+13	12.164	10.615	13.857	7.653	12.538
438	995.1	15.67	7.452E+13	12.138	10.587	13.843	7.617	12.534
440	995.2	15.65	7.213E+13	12.113	10.558	13.829	7.581	12.531
442	995.3	15.63	6.983E+13	12.088	10.529	13.814	7.545	12.527
444	995.4	15.61	6.760E+13	12.063	10.500	13.800	7.509	12.523
446	995.5	15.59	6.545E+13	12.038	10.471	13.785	7.473	12.520
448	995.6	15.57	6.337E+13	12.012	10.443	13.771	7.437	12.516
450	995.7	15.55	6.136E+13	11.987	10.414	13.757	7.401	12.513
452	995.8	15.53	5.942E+13	11.962	10.385	13.742	7.365	12.509
454	995.8	15.51	5.755E+13	11.937	10.357	13.728	7.330	12.505
456	995.9	15.49	5.574E+13	11.912	10.328	13.713	7.294	12.502
458	996.0	15.47	5.399E+13	11.887	10.299	13.699	7.258	12.498
460	996.1	15.45	5.229E+13	11.862	10.271	13.685	7.222	12.495
462	996.2	15.43	5.066E+13	11.837	10.242	13.670	7.187	12.491
464	996.2	15.40	4.907E+13	11.812	10.214	13.656	7.151	12.487
466	996.3	15.38	4.754E+13	11.787	10.185	13.642	7.115	12.484
468	996.4	15.36	4.607E+13	11.762	10.157	13.628	7.080	12.480
470	996.4	15.34	4.464E+13	11.737	10.128	13.613	7.044	12.477
472	996.5	15.31	4.325E+13	11.712	10.100	13.599	7.009	12.473
474	996.6	15.29	4.192E+13	11.687	10.071	13.585	6.973	12.470
476	996.6	15.27	4.063E+13	11.662	10.043	13.571	6.938	12.466
478	996.7	15.24	3.938E+13	11.637	10.014	13.556	6.902	12.462
480	996.8	15.22	3.817E+13	11.612	9.986	13.542	6.867	12.459
482	996.8	15.19	3.700E+13	11.587	9.957	13.528	6.831	12.455
484	996.9	15.17	3.587E+13	11.563	9.929	13.514	6.796	12.452
486	996.9	15.14	3.478E+13	11.538	9.901	13.500	6.760	12.448
488	997.0	15.12	3.372E+13	11.513	9.872	13.485	6.725	12.445
490	997.0	15.09	3.269E+13	11.488	9.844	13.471	6.690	12.441
492	997.1	15.06	3.171E+13	11.463	9.816	13.457	6.654	12.437
494	997.1	15.04	3.075E+13	11.439	9.787	13.443	6.619	12.434
496	997.2	15.01	2.982E+13	11.414	9.759	13.429	6.584	12.430
498	997.2	14.98	2.893E+13	11.389	9.731	13.415	6.548	12.427
500	997.3	14.95	2.806E+13	11.364	9.703	13.400	6.513	12.423

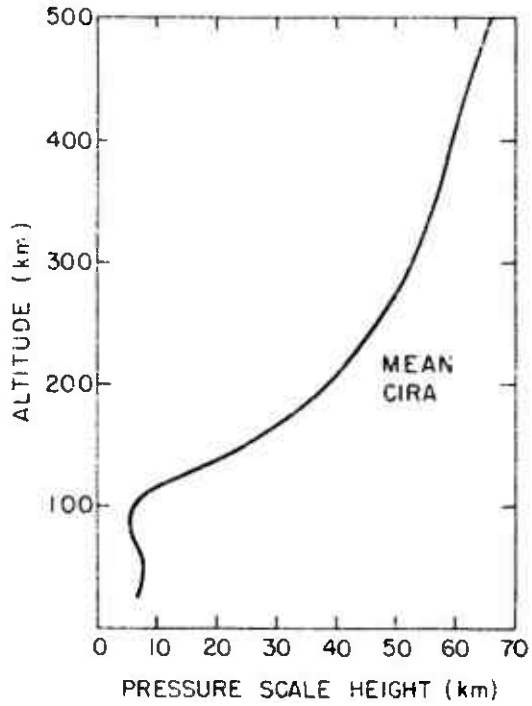

Figure 1. Pressure scale heights of the mean CIRA atmosphere.

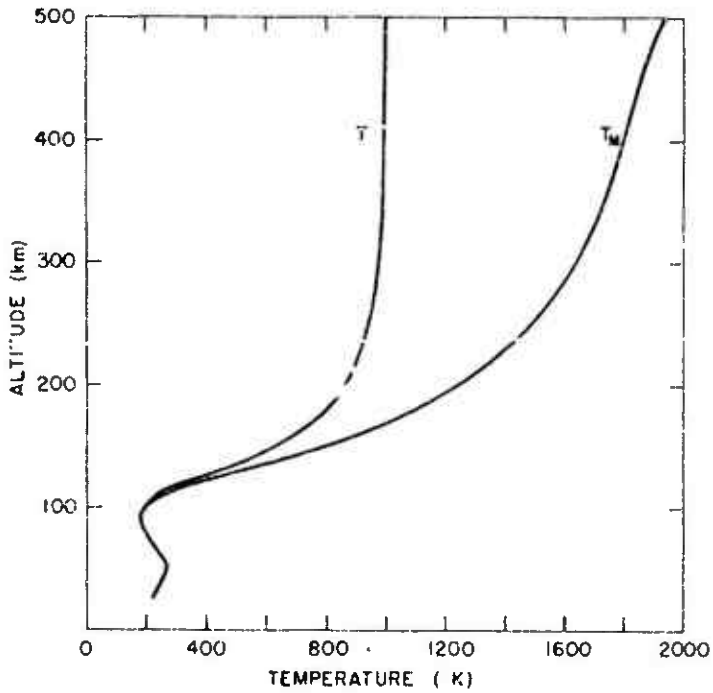

Figure 2. Kinetic temperatures (T) and molecular-scale temperatures (T_M) of the mean atmosphere.

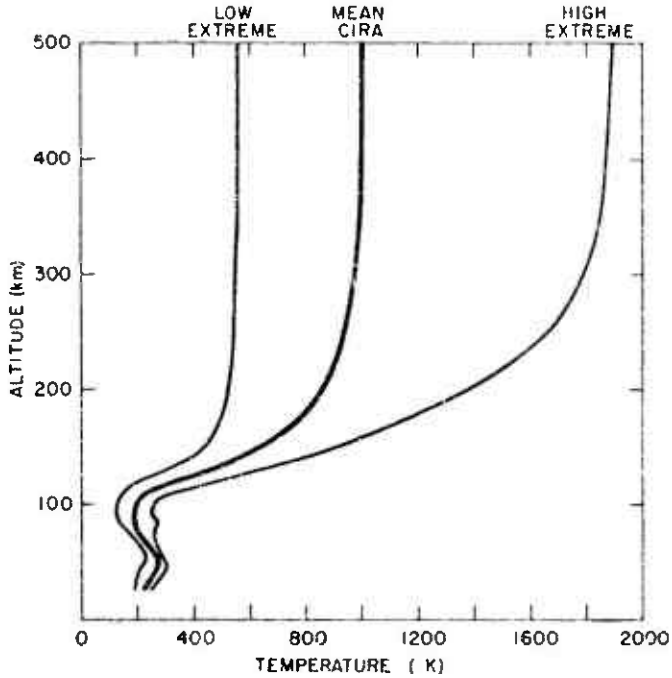

Figure 3. Mean CIRA temperatures and low extreme and high extreme temperatures.

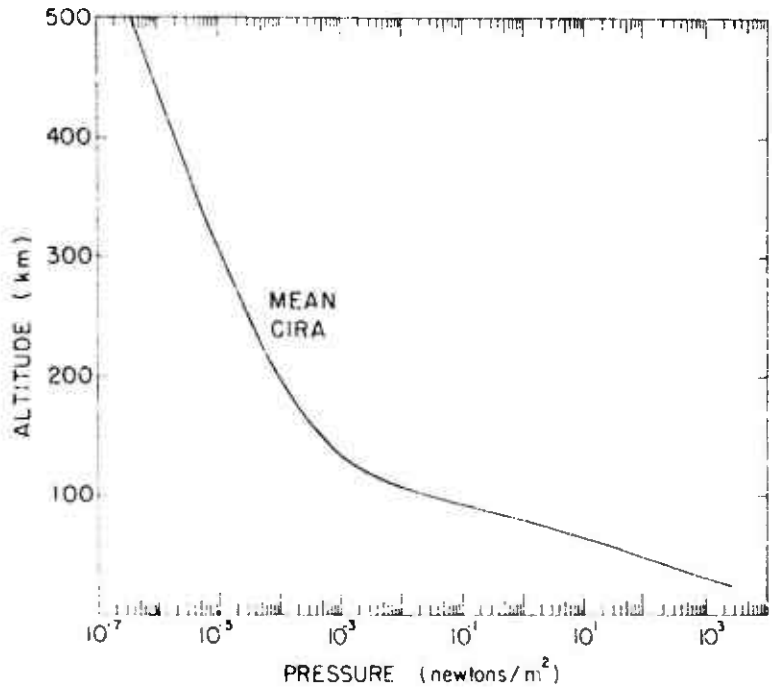

Figure 4. Pressure curve of the mean atmosphere, from 25 to 500 km.

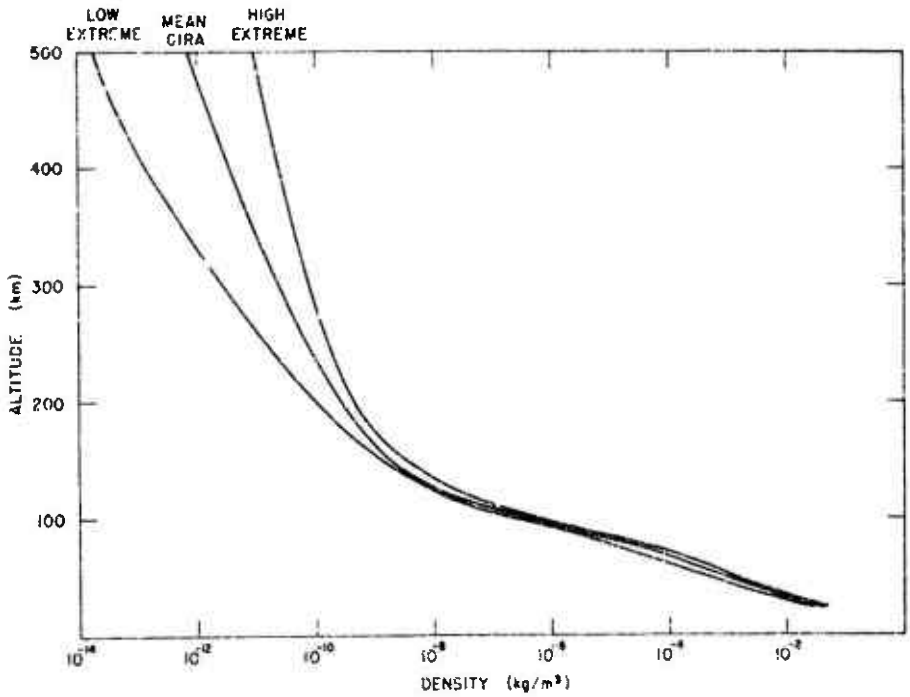

Figure 5. Mean CIRA densities and curves of extreme densities.

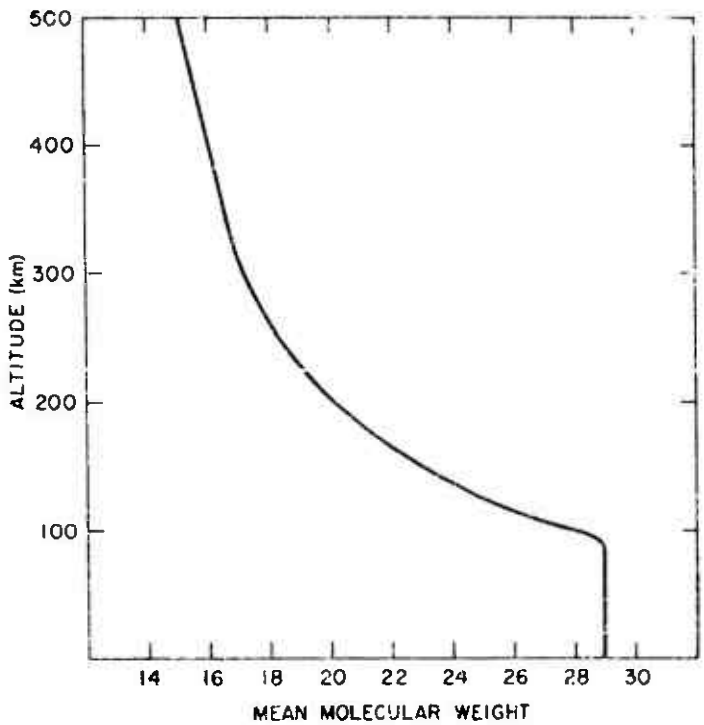

Figure 6. Mean molecular weights of Mean CIRA atmosphere.

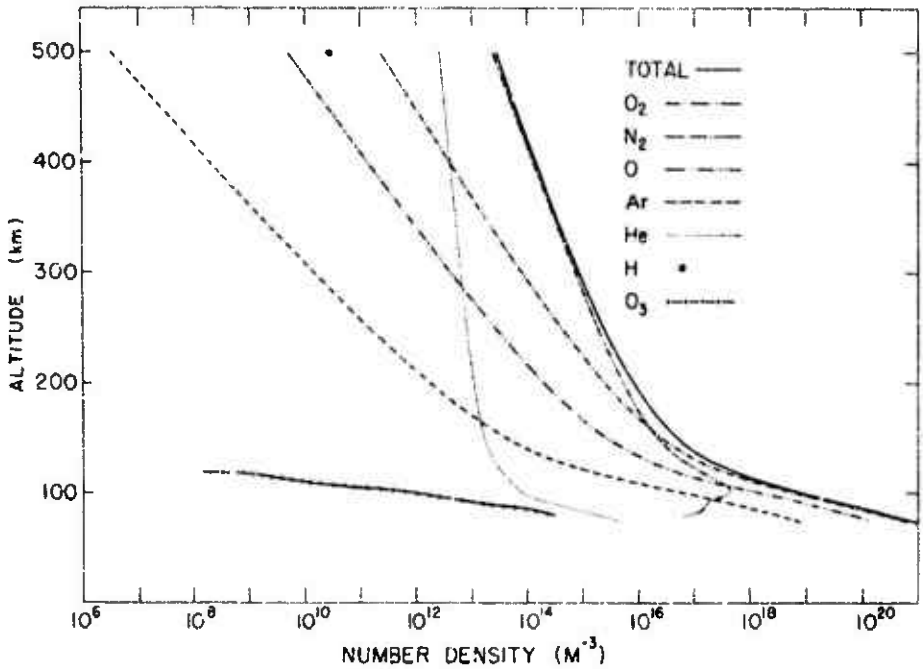

Figure 7. Total number densities and densities of N_2, O_2, O, O_3, Ar, He, and H.

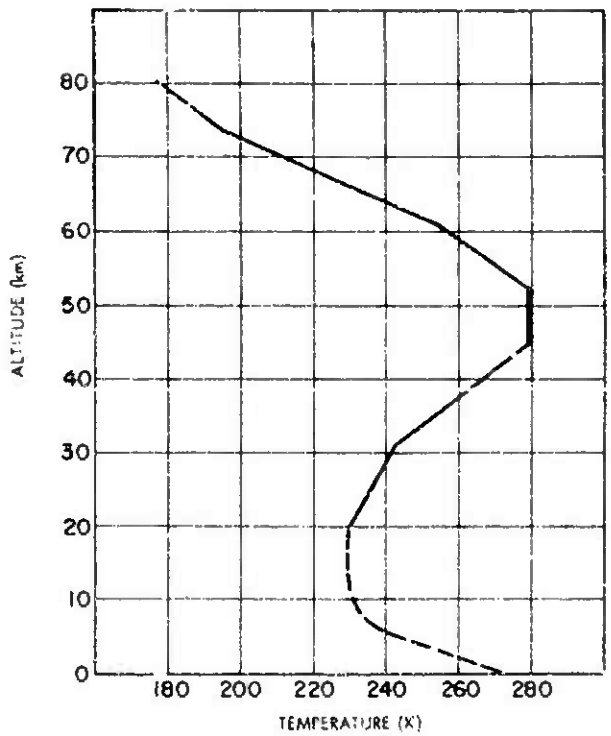

Figure 8. Mean June-July temperature profile for 80° N.

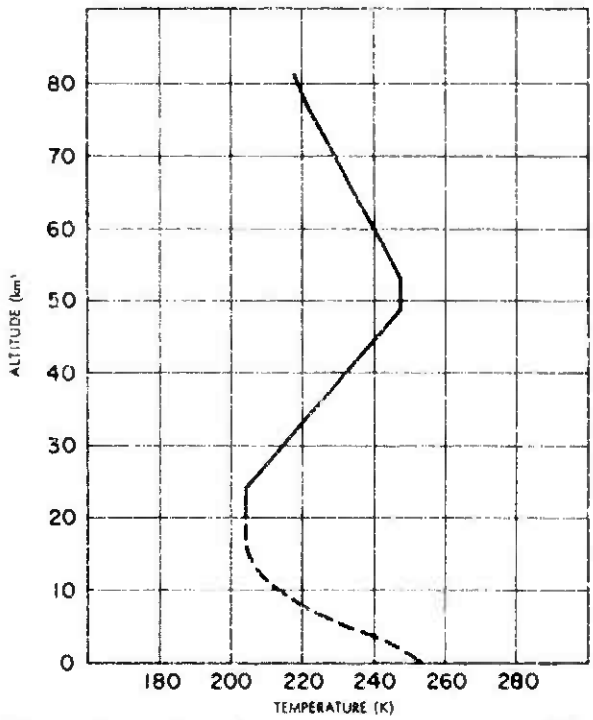

Figure 9. Mean December-January temperature profile for 80° N.

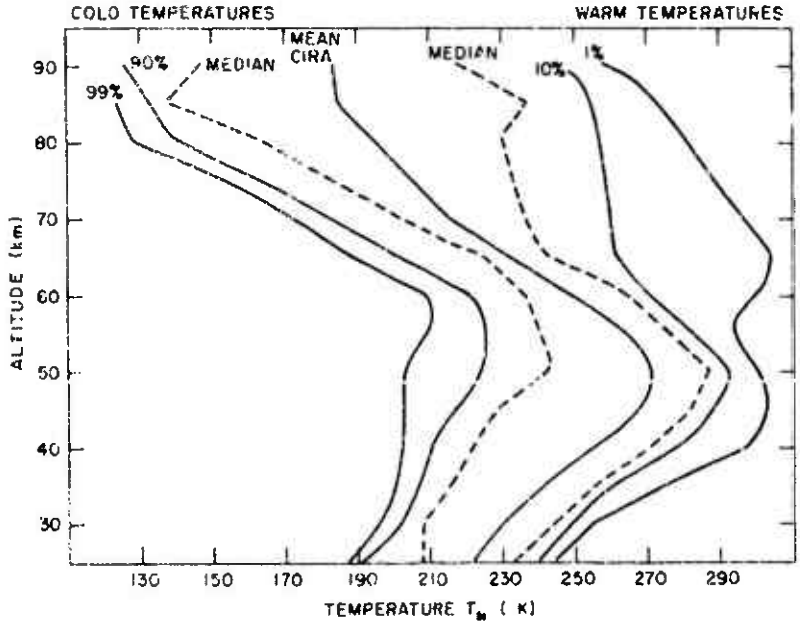

Figure 10. Mean CIRA temperatures, temperatures which are exceeded 50, 10, and 1% of the time during warmest months and temperatures exceeded 50, 90, and 99% of the time during coldest months at latitudes between 0° and 80° N.

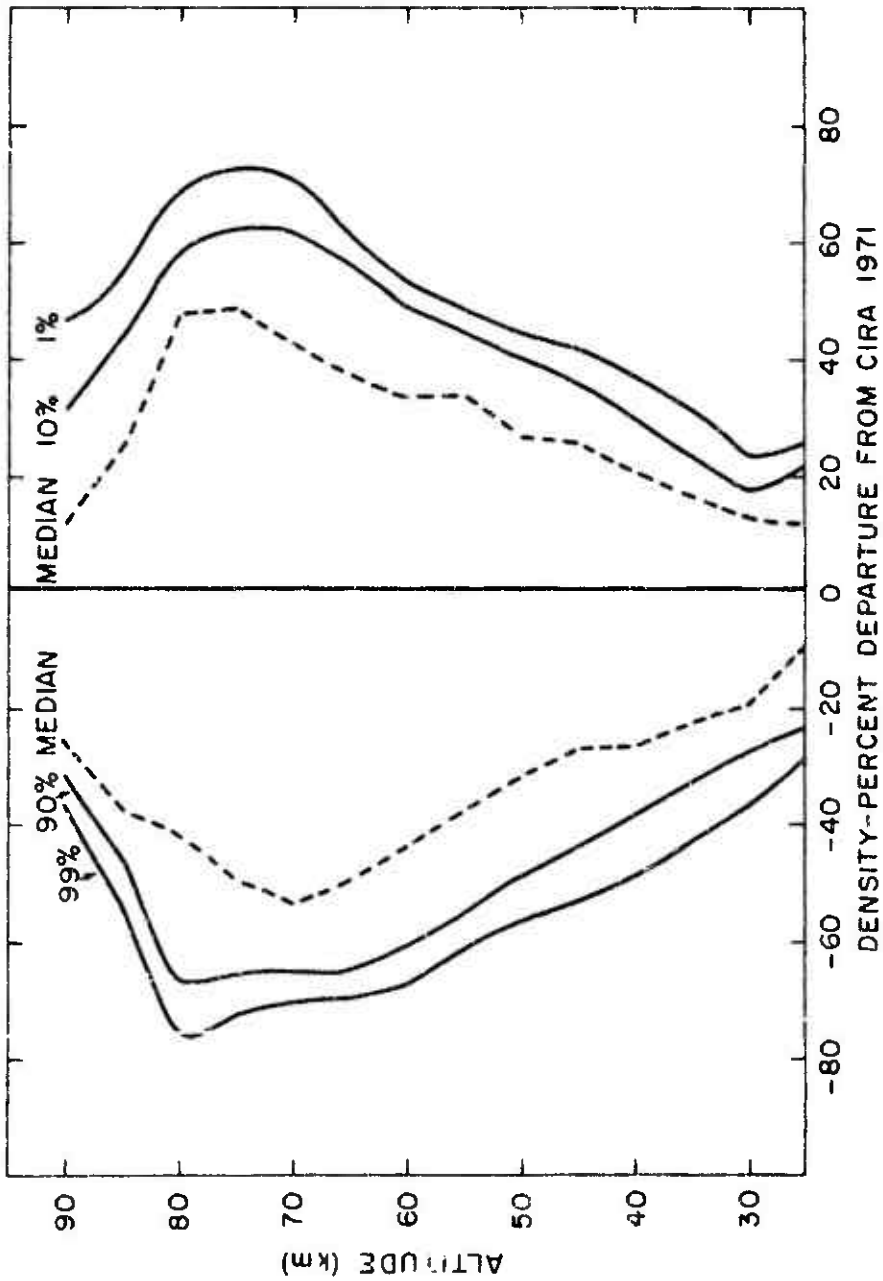

Figure 11. Densities relative to mean CIRA exceeded 50, 10, and 1% of the time during months with highest densities and densities exceeded 50, 90, and 99% of the time during months with lowest densities at latitudes between 0° and 80° N.

B (cont'd) Designation in Figure 16-2, for work of Bardsley, Reference 16-28 (16).

Power of the pre-exponential thermal dependence, a characteristic term of the rate-constant function (19).

Magnetic field strength (21).

Indexing use: target species (15).

BH Designation for Birge-Hopfield system (9).

B_o Comparison real function plotted in Figure 21-2, from Reference 21-2, assuming $j = 0$ and $\nu(\epsilon) = \nu_o$ (21).

B&T Designation in Figure 20-6, for work of Bauer and Tsang, Reference 20-143 (20).

B_2 Real function plotted in Figure 21-2, from Equation 21-5 (21).

b Power of the pre-exponential thermal dependence, a characteristic term of the rate-constant function (6, 16, 19, 24).

Parameter defined in Equation 15-10 (15).

Impact parameter (15).

Indexing uses: bound state of species (8).
trajectory point (15).
impact parameter (15).
colliding species in the Firsov model (15).
magnetic field (21).

b_j Interaction or capture radius (15).

$|b_j|^2$ Capture probability (15).

buoy Indexing use only; buoyancy subrange (3).

b_1 Cut-off radius (15).

C Designation for unspecified chemical species (6, 19, 20).

Linear slope in a Boltzmann system (6).

Designation in Table 9-5, for chemical association process (9).

C (cont'd)	Designation in Table 15-2, for fast-particle detection (15).
	Constant ≅ 3.49 in the Thomas theory (15).
	Least-squares fit constant (16).
C_i	Collision proportionality constant for species "i" (2).
$\mathfrak{C}_p(X)$	Integral function of X used in Equation 21-5 and explained and tabulated in Reference 21-28 (21).
c	Speed of sound (3).
	Speed of light (4, 7, 11).
	Activation temperature of chemical reaction, a characteristic term of the rate-constant function (6, 19, 24).
	Indexing uses: chemical change (3). chemical energy (3). cyclotron (7). cone (7). collisional (20).
$\bar{c}$	Mean thermal speed (3).
$\bar{c}_j$	Mean thermal speed of species "j" (3).
c_o	Speed of sound in unperturbed medium (3).
col	Indexing use only; column (11).
crit	Indexing use only; critical value (3).
c_v	Specific heat at constant volume per unit mass (3).
$c(\rho)$	$\equiv \left\| b_j(\pm m) \right\|^2$ (15).
D	Effective diffusion coefficient (3).
	Dissociation energy (4).
	Distance from nuclear burst measured along surface of earth (5).
	Designation for unspecified chemical species (6).
	Designation in Table 15-2, for slow-particle detection (15).
	Least-squares fit constant (16).

E_{XA} Activation energy for collisional excitation (X→A) reaction (20).

E_1 $\equiv MR^2(E_i/13.6)^2$, in the me hod of Fleischmann, Dehmel, and Lee (15).

Kinetic energy of incident ion before collision (15).

E_2 Kinetic energy of incident ion after collision (15).

e Ionic or electronic charge (7, 11, 15, 21).

Designation in Table 9-5, for photoelectron process (9).

Indexing uses: energy equation (3).
electron (4, 5, 7, 8, 11, 16, 20, 21, 22, 24).
electronic transition (11).
bound electron (15).
electron acting as third body (16).

eddy Indexing use only; eddy (3).

eff Indexing use only; effective (9, 15).

ex Indexing use only; excitation (4, 11).

F Solar flux at 10.7-cm wavelength (5).

Designation in Table 9-5, for fluorescence process (9).

Free energy (10).

Fraction of optically active molecules under irradiation, whi are radiatively excited per second (11).

Designation on Page 18A-8, of work of Ferguson, from Reference 18A-9 (18A).

Designation on Page 18A-9, of work of Fehsenfeld et al, from Reference 18A-40 (18A).

$\overline{F}$ Mean solar flux (2).

$\underset{\sim}{F}$ Total external force per unit mass (3).

$\underset{\sim}{F}'$ Miscellaneous external forces acting on atmosphere (3).

$\underset{\sim}{F}_a$ External force per unit mass on species "a" (3).

F_i Chemical formation rate of species "i" (2).

$F(k)$ Turbulent power spectrum, in wavenumber space (3).

$F(k)_{Kolm}$ $F(k)$ in the inertial subrange, according to Kolmogoroff's Law (3).

f Oscillator strength or "f-number" of transition (11).

Range of reciprocal electron densities over which a linear variation with time is obtained, to within one percent (16).

Indexing uses: fluorescence (11).
final (11).

f_o Resonant frequency (7).

f_v Fraction of collisions having relative velocities between v and $v + dv$ (6).

$f(X)$ Fractional atmospheric concentration of species "X" (4).

$f(\epsilon)$ Electron energy distribution function (21).

G Fractional energy loss per collision (21).

$G(\ell, t)$ Probability for separation distance "ℓ" between two particles (3).

GS Designation in Figure 16-2, of work of Gunton and Shaw, from Reference 16-7 (16).

g Gravitational acceleration (2, 4).

Production rate factor (9).

Statistical weight (11).

Indexing use: gas-kinetic (21).

$\underset{\sim}{g}$ Gravitational force per unit mass (3).

gas Indexing use only; gas-kinetic (16).

g_{ion} Statistical weight of ionic ground state (11).

$g_{n\ell}$ Statistical weight of a recombining level "$n\ell$" (11).

$g_n(\nu)$	Statistical weight of a recombining level in a hydrogenic species (11).
g(X)	Electronic statistical weight of species "X" (4).
g(y)	Firsov model parameter $\equiv \left[y^{0.1} - 1\right]$ (15).
H	Atmospheric scale height (3).
	Magnetic field (7).
	Scale height of atomic oxygen (9).
	Enthalpy (10, 17, 19).
	Total Hamiltonian (15).
	Designation in Figure 16-1, of work of Hagen, from Reference 16-22 (16).
	Designation on Page 18A-9, of work of Howard et al, from Reference 18A-12 (18A).
	Scale height (20).
	Indexing use: hydrogen atom (15).
Ha	Designation in Figure 16-1, of work of Hackam, from Reference 16-19 (16).
HCE	Designation for Handbook Committee Estimate (24).
H_i	Scale height of species "i" (2).
H_m	Scale height of species having mean mass (2).
H_p	Pressure scale height (2).
H(X)	Scale height of species "X" (4).
h	Planck constant (3, 4, 6, 7, 11, 17, 19, 20, 24).
	Altitude (4, 5).
	Indexing use: altitude (4).
$\hbar$	Modified Planck constant, $h/2\pi$ (11, 15).
h_{ii}	$\equiv (\phi_i, V_b\phi_i)$ (15).
h_{ij}	$\equiv (\phi_i, V_a\phi_j)$ (15).

h_{ji} $\equiv (\phi_j, V_b\phi_i)$
h_{jj} $\equiv (\phi_j, V_a\phi_j)$ (15).

$\bar{h}_j^{-1}$ A measure of chemical effect in turbulence, from Equation 3-67a (3).

h_o Turbopause altitude (4).

Indexing use: turbopause altitude (4).

horiz Indexing use only; horizontal (3).

h_q Quenching height (9).

I Ionization potential (4, 15).

Photon flux after transmission (7).

Intensity of indicated radiation (9).

Geomagnetic dip angle (9).

Designation in Table 9-5, of ionic reaction process (9).

I_{col} Line-of-sight column emission rate = line integral of I_{vol} (11).

ICR Designation for Ion Cyclotron Resonance (7).

IGY Designation for International Geophysical Year (9).

I_H Ionization potential (13.6 eV) of ground-state hydrogen atom (15).

Im Designation for imaginary portion of function (21).

$\mathrm{Im}\Delta K_i$ Imaginary portion of ΔK_i, in the low-frequency limit (21).

I_o Photon flux before transmission (7).

$I_o(\lambda)$ Incident light intensity (12).

IP Ionization potential (18A).

IR Infrared.

K_t	Turbulent diffusion coefficient (2).
K'	Collisional rate (11).
K'_{01}	Collisional excitation rate (11).
K'_{10}	Collisional deexcitation rate (11).
$\mathbf{K}$	Thermal conductivity coefficient (3).
$\mathbf{K}_i$	Degree of ionization of plasma (3).
k	Wavenumber (3).
	Boltzmann constant (2, 4, 11, 20, 21).
	Rate constant or rate-constant function, of chemical reaction, in the forward direction as written (6, 11, 18A, 19, 20, 21).
	Total absorption coefficient (7).
	Rate coefficient of ion-molecule reaction (8).
	Total three-body recombination rate coefficient (16).
	Indexing use; kinetic (4).
$\underset{\sim}{k}$	Wavenumber vector (3).
k_g	Upper limit of wavenumber for buoyancy subrange (3).
k_i	Photoionization coefficient (7).
	Rate constant for inelastic scattering from species "i" (20).
k^i_{3n}	Rate coefficient for Thomson recombination, three-body neutral-molecule-stabilized, positive-ion-negative-ion recombination (16).
kin	Indexing use only; kinetic (11).
$k_j(z)$	First-order rate constant for photoionization of species "j", at altitude "z" (13).
k_M	Rate constant for quenching reaction where "M" is the quenchant (20).
kn	Reactive collision frequency (20).

$k(NO^+)$	Rate coefficient for NO^+ production (13).
k_o	$\equiv 2\pi/L_o$ (3).
k_r	Rate constant for reverse reaction (18A).
k_T	Rate constant for a system having Maxwellian distribution (6, 14).
	Absorption coefficient (12).
$k(v)$	Rate constant for formation of vibrationally excited species in level "v" (11).
k_x, k_y, k_z	Wavenumber directional components (3).
k_ν	$\equiv 2\pi/L_\nu = (\epsilon_\nu/\nu^3)^{1/4}$ (3).
k_{10}	Rate constant for deactivation of first vibrational level (20).
k_{3e}	Three-body recombination rate coefficient with electron as third body (16).
k_{3n}	Three-body recombination rate coefficient with neutral species as third body (16).
k_{3r}	Three-body recombination rate coefficient (16).
k_{300}	Rate constant at 300 K (24).
k'	Rate constant or rate-constant function of chemical reaction, in the reverse direction as written (6).
k	Boltzmann constant (3, 6).
L	Designation for Lyman radiation (5).
	Optical pathlength (13).
LBH	Designation for Lyman-Birge-Hopfield system (9).

$L_{ij}(\epsilon)$	Inelastic cross-section for low-energy electron in gas (21).
L_j	Rate of process "j" leading to electron loss (16).
L_j^{-1}	A measure of the effect of wind shear in turbulence, in Equation 3-67h (3).
$L_j(\epsilon)$	Energy loss function for the jth vibrational level (21).
L_o	Length scale of large (turbulent) disturbances (3).
LT	Designation in Figure 16-2, of work of Lin and Teare, from Reference 16-27 (16).
LTE	Designation for Local Thermodynamic Equilibrium (4, 11).
Ly	Designation for Lyman radiation (12).
$L(\epsilon)$	Energy loss function (21).
L_ν	Length scale of the smallest of eddies (3).
L_{2r}	Rate of electron loss via two-body electron-ion recombination (16).
L_{3r}	Rate of electron loss via three-body electron-ion recombination (16).
ℓ	Distance (3).
	Charged rearrangement rate constant for negative ions (9).
	Light path (12).
ℓ_m	Gas-kinetic mean free path (3).
M	Mean molecular weight (2).
	Gram molecular weight (3).
	Reduced molecular weight (6).
	Designation for third body or collisional partner (6, 16, 17, 18A, 19, 20, 24).
	Reduced mass of ion-molecule reaction pair (8).

M (cont'd)	Projectile mass, in the method of Fleischmann, Dehmel, and Lee (15).
	Designation for unspecified chemical species (17, 18A, 20).
	Number of density of collision partner (20).
	Mass number (21).
	Indexing use: molecular-scale (2).
MB	Designation in Figures 16-1 and 16-3, of work of Mehr and Biondi, from Reference 16-21 (16).
Me	Designation for unspecified metallic species (11).
M_i	Molecular weight of species "i" (2).
	Mass number for an ionic species (21).
	Reduced mass of ion + neutral pair (21).
M_o	Sea-level mean atmospheric molecular weight = 28.96 (2).
M(X)	Mass of species "X" (4).
m	Mean mass of an "air molecule" (3).
	Unspecified function of altitude, time of day, and sunspot cycle (5).
	Ionic mass (7, 15).
	Concentration of attaching neutral species (9).
	Mass of electron (21).
	Indexing uses: mean-mass (2). equation of motion (3). combining proportions (6). molecular (9). momentum-transfer (11, 21). number of electrons stripped (15).
m_a	Molecular mass of species "a" (3).
m_{av}	Mass of average "air molecule" (3).
max	Indexing use only; maximum (11).

m_e	Mass of electron (4, 11).
	Mass of bound electron on target atom (15).
m_i	Mass of species "i" (2).
m_j	Molecular mass of species "j" (3).
mn	Indexing use only; mutual neutralization (16).
mol	Indexing use only; molecular (3).
m_1	Mass of incident ion (15).
N	Designation for north latitude (2).
	Number of observations (3).
	Brunt-Väisälä frequency (3).
	Electron concentration (9).
	Number of collisions per second per molecule at altitude (11).
	Total number of optically active molecules under irradiation (11).
	Designation for unspecified chemical species (16).
	Molecular density (21).
	Indexing use: neutral product (12).
N_{col}	Column density of molecules under radiative excitation (11).
NED	Designation for No Experimental Data (24).
N_{ex}	Total number of optically active molecules under irradiation which become excited (11).
N_i	Positive-ion density (21).
$[N_j]$	Concentration of species "j" (13).
N^+	Positive-ion concentration (9).
N_a^+	Density of atomic ions (9).
N_{mi}^+	Density of molecular ions (9).

N^- Negative-ion concentration (9).

n Species concentration (3).

Gas density (7).

Concentration of detaching neutral species (9).

Level of hydrogenic species into which recombination is taking place (11).

Density of absorbing gas (12).

$\equiv -b$ for certain recombination reactions (19).

Electron density (21).

Indexing uses: combining proportions (5, 6, 16, 17, 21, 24).
level of hydrogenic species (11).
final charge on initially neutral target species (15).
neutral species acting as third body (16).
electron noise (21).

n_B Number density of target species (15).

n_e Electron density (4, 5, 7, 8, 11, 16, 22).

$\langle n_e(t) \rangle$ Space-averaged electron density at time "t" (16).

$\langle n_e(0) \rangle$ Space-averaged electron density at zero time (16).

$n_e(\infty)$ Stationary electron density long after ionizing source is turned on (16).

n_{eff} Number of electrons effectively available for ionization in the outer shell of projectile species, in the method of Fleischmann, Dehmel, and Lee (15).

n_i Number density of species "i" (2, 20).

Ion density (11).

$n_i R_i$ Chemical removal rate of species "i" (2).

n_j Number density of species "j" (3).

n_j' Fluctuation of n_j (3).

$\bar{n}_j$ Mean value of n_j (3).

$n\ell$ A particular level into which radiative recombination is taking place (11).

Indexing use: level into which radiative recombination is taking place (11).

n_{N_2} N_2 species density (24).

n_o Loschmidt number (7, 12).

n_s Density of stabilizing agent (16).

n_{tot} Total species density (4).

n(X) Species density of "X" (4).

n_1 Vertical distribution of atomic-oxygen concentration (3).

n_2 Vertical distribution of molecular-oxygen concentration (3).

n_+ Positive-ion density (16).

n_- Negative-ion density (16).

o Indexing uses: sea-level (2).
unperturbed-medium (3).
reference (3).
turbopause (4).
pre-magnetic storm (5).
pre-transmission (7).
resonant (7).
Loschmidt (7, 12).
standard-state (10).
band-origin (11).
atomic species (11).
incidence (12).
impact, in the Firsov model (15).
Bohr (15, 21).
collision-free (20).
free-space (21).
energy-independent (21).
pre-integration (21).

P — Designation on Page 18A-9, of work of Puckett and Teague, from Reference 18A-41 (18A).

P(b, u) — Probability for charge transfer on collision at impact parameter "b" and relative velocity "u" (15).

PCA — Designation for Polar Cap Absorption (5, 9).

P_i — Rate of process "i" leading to electron production (16).

p — Pressure at altitude (2).

Pressure or partial pressure (3, 8, 10, 20, 21).

Indexing uses: pressure (2).
combining proportions (6).
projectile species (15).
plasma (21).
half-integer spacing (21).

p' — Pressure for small perturbation or fluctuation (3).

$\bar{p}$ — Mean pressure (3).

p_a — Partial pressure for species "a" (3).

p_{N_2} — Pressure of N_2 (20).

p_o — Pressure for unperturbed background (3).

pop — Indexing use only; population (4).

p_1 — Pressure at reference altitude (2).

Q — Diffusional rate (3).

Characteristic Q-number of a resonant cavity (7).

Partition function (11).

Cross-section (15).

Capture cross-section (15).

Source term (21).

Indexing use: quenching (11).

Q_a Net rate of radiative heat absorption by species "a" (3).

Q_c Net rate of chemical energy evolution per unit mass (3).

$Q_m(\epsilon)$ Source term for electron momentum-transfer collisions (21).

Q_n Specific slow-ion production cross-section (15).

Q_R Net rate of radiant energy absorption per unit mass (3).

$Q_{rot}(X)$ Rotational partition function for a rigid rotator (4).

Q_v Vibrational partition function (11).

$Q_{vib}(X)$ Vibrational partition function for a harmonic oscillator (4).

$Q(X)$ Partition function of (molecular)species "X" (4).

Q_{ii}^{0n} Ionization cross-section (ambiguous term) where $i = j$ (15).

Q_{ij}^{0n} Cross-section for collisional charge exchange in heavy-particle collisions, where $i = n + j$ (15).

Q_{10}^{01} Cross-section for collisional charge exchange where $i = 1$ (15).

Q_+ Total slow positive-charge production cross-section (15).

Q_- Electron production cross-section (15).

q Ion-pair production rate due to beta-particle ionization of air (5).

Electron production rate (9).

Bremsstrahlung radiation (11).

Electron source function (22).

Indexing use: quenching (9).

$\underset{\sim}{q}$ Total heat flux vector (3).

$\underset{\sim}{q}_a$ Heat flux carried by species "a" (3).

q_o $\equiv \sum_j \sigma_{0j} \approx \sigma_{01}$ at low energies (15).

$q_{v'v''}$ Franck-Condon factor for electronic transition involving v=v' in excited state and v=v'' in ground state (11).

R Gas constant (2, 3, 19).

Designation in Table 9-5, for resonance scattering process (9).

Interaction distance, in the method of Fleischmann, Dehmel, and Lee (15).

Internuclear separation (15).

Indexing uses: radiant energy (3).
chemical destruction (11).

Re Reynolds number (3).

Designation for real portion of function (21).

$\mathrm{Re}\Delta K_i$ Real portion of ΔK_i, in the low-frequency limit (21).

Ri Richardson number (3).

R_i Chemical removal rate constant of species "i" (2).

R_o Impact parameter, in the Firsov model (15).

Ryd Indexing use only; Rydberg (11).

$R_{\lambda\mu}$ Irradiance incident on volume element (11).

$R_{\lambda\mu e}$ Solar irradiance upon the atmosphere at center wavelength λ_e of electronic transition (11).

r Radius of interaction (15).

Indexing uses: radiative recombination (3, 9).
recombination (16).
reference (16, 19).
reverse (18A).

$\underset{\sim}{r}$ Position vector measured from earth center (3).

Electron position vector, with respect to trajectory midpoint (15).

Indexing use: trajectory midpoint electron position vector (15).

TID	Designation for Traveling Ionospheric Disturbance (3).
T_{ion}	Ion-kinetic temperature (17).
T_j	Effective temperature of species "j" (3).
T_j'	Fluctuation of T_j (3).
$\bar{T}_j$	Mean value of T_j (3).
T_k	Kinetic temperature (4).
T_{kin}	Kinetic temperature (11).
T_M	Molecular-scale temperature (2).
TM	Indexing use only; normalization, in the method of Fleischmann, Dehmel, and Lee (15).
T_n	Electron noise "temperature" (21).
TOF	Designation for Time-of-Flight (7).
T_{pop}	Population temperature (4).
T_r	Reference temperature (16, 19).
T_{ref}	Reference temperature (24).
T_{rot}	Rotational temperature (11).
T_{tr}	Translational temperature (20).
T_v	Vibrational temperature (4, 20, 24).
T_{vib}	Vibrational temperature (11, 18A).
T-V	Designation for translational-vibrational energy transfer (11).
T_+	Positive-ion temperature (16).

t	Time (2, 3, 5, 11, 15, 16, 19, 20, 21). Indexing uses: turbulent (2). threshold (6). target species (15).
th	Indexing use only; thermal (3).
t_o	Initial time of integration (21).
tot	Indexing use only; total (4).
tr	Indexing use only; translational (20).
U_e	Potential energy of bound electron (15).
UHF	Designation for Ultra High Frequency (7).
UV	Designation for Ultraviolet.
u	Speed (3). $\equiv 2.855\ \theta/\lambda$ (11). Relative velocity (15). Radial component of relative velocity on collision, in the Firsov model (15). Indexing uses: relative velocity (15). energy exchange (21).
$\bar{u}$	Mean mass velocity (2).
$\underset{\sim}{u}$	Velocity vector (3).
$\underset{\sim}{u}'$	Velocity vector for small perturbation or fluctuation (3).
$\underset{\sim}{\bar{u}}$	Mean velocity vector (3).
$\underset{\sim}{u}_a$	Velocity vector for species "a" (3).
u_c	Arbitrary reference velocity (3).
u_i	Mean velocity of species "i" (2). Directional components of velocity (3).
$\bar{u}_i$	Mean directional components of velocity (3).

u_o	Ionizational impact velocity, in the Firsov model (15).
uv	Designation for ultraviolet.
u_1	Vertical component of diffusion velocity of atomic oxygen (3).
u_2	Vertical component of diffusion velocity of molecular oxygen (3).
V	Volume (10).
$V_a(r_a)$	Potential centered on trajectory point (15).
$V_b(r_b)$	Potential centered on trajectory point (15).
V_i	Diffusion velocity of species "i" (2).
VT	Designation for vibrational-translational energy transfer (20).
V-T	Designation for vibrational-translational energy transfer (11).
VV	Designation for vibrational-vibrational energy transfer (20, 24).
V-V	Designation for vibrational-vibrational energy transfer (11).
v	Initial velocity (3).
	Relative collisional velocity (6).
	Vibrational level or quantum number (9, 11, 16, 20, 24).
	Velocity (15, 21).
	Indexing uses: constant volume (3). vibrational (4, 11, 20, 24).
$\underset{\sim}{v}$	Velocity vector (15).
$\vec{v}$	Velocity vector (15).
v'	Vibrational level in excited electronic state (11).
	Vibrational level in unspecified electronic state (20).

$v'v''$	Indexing use only; electronic transition involving two states for which $v = v'$ and $v = v''$, respectively (11).
v''	Vibrational level in ground electronic state (11).
	Vibrational level in unspecified electronic state (20).
$\bar{v}''$	Mean number of vibrational quanta excited in ground electronic state through fluorescence (11).
v_e	Velocity of bound electron on target atom (15).
v_e'	Parameter defined in Equation 15-11 (15).
vib	Indexing use only; vibrational (4, 11, 18A).
v_{max}	Maximum vibrational level (11).
vol	Indexing use only; volume (11).
v_1	Velocity of incident ion (15).
v_1'	Parameter defined in Equation 15-11 (15).
W	Designation for west (3).
	Designation for unspecified chemical species (6, 10).
WB	Designation in Figure 16-2, for work of Weller and Biondi, from Reference 16-24 (16).
W-K	Designation for Watson-Koontz system (9).
w	Electron drift velocity (21).
X	Designation for unspecified chemical species (6, 9, 10, 11, 14, 16, 17, 24).
	Indexing uses: chemical species (4, 8, 14). functional (21).
[X]	Concentration of species "x" (11).
X'	Indexing use only; chemical species for product atom which may be in a bound excited state (8).

σ_0 Absorption cross-section for O_2 at zero atmosphere pressure, by extrapolation (Herzberg continuum) (12).

σ_{01} $\approx \sum_j \sigma_{0j}$ at low energies (15).

σ_{0j} Electron stripping cross-section from neutrals (15).

σ_1 Absorption cross-section for O_2 at one atmosphere pressure (Herzberg continuum) (12).

σ_{1m} Cross-section for stripping "m" electrons in N^+ upon N_2 impact (15).

σ_{10} σ_{10}^{01} in the low-energy limit (15).

τ Time for onset of turbulent dispersion (3).

Recovery time (9).

Relaxation time, or the e-folding time of ϵ (20).

τ_c Effective lifetime for collisional deexcitation (20).

$\tau_j(\Delta\lambda)$ Optical depth in wavelength range "$\Delta\lambda$" for species "j" (13).

τ_o Collision-free radiative lifetime of excited species (20).

$\tau(\Delta\lambda)$ Optical depth in wavelength range "$\Delta\lambda$" (13).

Φ Rayleigh dissipation function (3).

$\Phi_z(\Delta\lambda)$ Local photon flux in the wavelength range "$\Delta\lambda$" at altitude "z" (13).

$\Phi_\infty(\Delta\lambda)$ Photon flux in the wavelength range "$\Delta\lambda$" at the top of the atmosphere (13).

φ_i Turbulent mixing flux for species "i" (2).

ϕ Latitude (2, 3).

$\psi_i(\underset{\sim}{r}_a)$ Bound-state wavefunction for the charge state "i" at a trajectory point (15).

$\phi_i(\underset{\sim}{r}_a, \underset{\sim}{r})$ Wavefunction defined in Equation 15-18 (15).

$\phi_j(\underset{\sim}{r}_b)$ Bound-state wavefunction for the charge state "j" at a trajectory point (15).

$\phi_j(\underset{\sim}{r}_b, \underset{\sim}{r})$ Wavefunction defined in Equation 15-1° (15).

ψ Total wavefunction (15).

Ω $\equiv \omega$ or $\omega \pm \omega_{be}$ or $\omega \pm \omega_{bi}$ (21).

$\underset{\sim}{\Omega}$ Angular velocity of earth's rotation (3).

ω Frequency (3).

Frequency of alternating electric field (7).

Angular frequency of applied electric field (21).

ω_a $\equiv c_o/2H$ (3).

ω_{be} Cyclotron frequency for electrons in a magnetic field (21).

ω_{bi} Cyclotron frequency for ions in a magnetic field (21).

ω_c Angular or cyclotron frequency of orbital motion (7).

ω_e Vibrational constant (4, 11).

$\omega_e x_e$ First anharmonic correction term (11).

ω_{pe} Plasma resonance frequency for electrons (21).

ω_s Wind shear (3).

Numbers used as indices:

0 Reference condition (3).

Temperature of 0 K (10, 19).

Zero atmosphere pressure (12).

Initial charge on neutral target species (15).

Zero time (16).

Functional (21).

01	Excitation (11).
1	Reference condition (2).
	Atomic oxygen (3).
	Molecular (3).
	Vibrational level (10).
	One atmosphere pressure (12).
	Incident particles before collision (15).
	Cut-off (15).
	Stripping, in collision of N^+ on N_2 (15).
10	Deexcitation (11).
	Deactivation of first vibrational level (20).
2	Molecular oxygen (3).
	Turbulent (3).
	Vibrational level (10).
	Incident particles after collision (15).
	Number of electrons stripped, in collision of N^+ on N_2 (15).
	Two-body process (16).
	Functional (21).
3	Vibrational level (10).
	Number of electrons stripped, in collision of N^+ on N_2 (15).
	Three-body process (16).
4	Number of electrons stripped, in collision of N^+ on N_2 (15).
300	Temperature of 300 K (24).

∞ Top of atmosphere (13).

End of trajectory (15).

Designation of long time after ionizing source is turned on (16).

Miscellaneous symbols used as indices (where "X" is taken as an anonymous symbol modified by each index):

X' Fluctuation or perturbation (3).

Miscellaneous (3)

Reverse (6).

Bound excited state (8).

Collisional (11).

Excited electronic state (11).

Ionization (13).

Secondary of a type (14).

Upper electronic state (14).

For special parameter (15).

Unspecified electronic state (20).

X'' Ground electronic state (11).

Lower electronic state (14).

Unspecified electronic state (20).

$\underset{\sim}{X}$ Vector (3, 15).

$\underset{\approx}{X}$ Tensor (3).

$\vec{X}$ Vector (15, 16).

$\overline{X}$ Mean (2, 3, 11, 21).

$\langle X \rangle$ Space-averaged (16, 21).

$\{X\}$ Variation (3, 16).

APPENDIX F
SPECIES INDEX

N. B.: The entries are listed by chapter and page. For instance, the designation 5-7, 8 indicates the presence of information on pages 7 and 8 of Chapter 5, and 5-(6-9) designates information on pages 6 through 9 of Chapter 5. In a few cases, a species is treated continuously throughout an entire chapter; when this occurs, the chapter number is given. Where information is contained in a figure or table, the figure number or table number is given separately from the chapter and page numbers, which are used only for textual reference. Certain tables are subdivided, e.g., 16-1 into 16-1.1, 16-1.2, etc., and 24-1 into Roman Numeral categories. These subdivisions are included in the designations, where applicable, for greater clarity. Entries are listed alphabetically by standard chemical symbol, with the added features that the invented symbol "Me" is used to indicate metallic species generally, and that "air", "air ions", "electron", and "teflon" are entered as words, in their proper alphabetical order. Electronically excited states are listed either as specific state designations (in alphabetical and numerical order) where these are known, or by the use of the asterisk (*) to indicate electronic excitation generally. Vibrationally excited states are designated by the double-dagger (‡). Unless otherwise noted, all species listed are gas-phase species. A few solids and liquids are included, and are appropriately designated as such, viz., by the respective standard indicators (s) and (ℓ).

Ag	Figure 15-2.
Ag^+	Page 15-36.

Air	Pages 3-5. 33; 5-18; 7-27, 29; 17-7; 21-4, 5, (7-9), (16-18), 25. Tables 11-2; 16-1.2; 21-2, 4; 24-1 (VI). Figures 7-8; 9-2, 3; 21-3, 5.
Air Ions	Pages 16-21, 23. Tables 16-1.1; 24-1 (VI).
Al	Pages 5-13; 7-20; 15-1, 21, 29. Figures 5-10; 15-1, 5.
Al^+	Pages 15-6, 15, 31, 35, 39, 44, 45, 47; 16-18; 20-18. Table 16-1.1. Figure 15-4.
$Al(CH_3)_3$	Page 5-19.
AlO	Pages 11-23, 25. Table 11-1.
AlO^*	Page 11-25.
Ar	Pages 2-(9-12); 4-1; 10-2; 11-27; 15-21, 25, 34, 36, 37, 43; 16-14, 16, 17, 24; 17-3; 18A-9; 19-8, 9, 12; 21-5, 24. Tables 2-2, 4; 10-1, 10; 15-1; 18A-5; 20-2, 6, 8; 24-1 (XXVI). Figures 2-7; 4-1; 10-10; 14-10; 15-1, 2, 5.
Ar^*	Table 10-10.
Ar^+	Pages 15-31. 43; 16-18. Tables 10-1, 11; 16-1.1.
Ar^{+*}	Table 10-11.
Ar^{++}	Page 15-43. Table 10-1.
Ar^{3+}	Page 15-43.
Ar^{4+}	Page 15-43.
Ar^{5+}	Page 15-43.

Cs^+	Pages 15-37, 41. Table 20-10.
D^-	Pages 16-22, 23. Table 16-1.2.
D_2	Page 16-24.
Electron	Chapters 17; 21. Pages 4-6, 13; 5-(5-8), 19; 6-2, 3, (7-12), 14; 7-2, 4, 8, 11, 20, 23, 25, 27, 29; 8-(1-7), 10, 11; 9-1, 4, 6, (8-16), 30; 11-(25-33); 12-1, 5; 13-1; 15-1, (5-7), 20, 25, (29-47); 16-(1-21); 20-3, 5, 7, 8, 10, 11, (13-17); 22-2. Tables 6-1; 8-(1-3); 9-1, 4; 12-1; 16-1.1; 18A-4; 20-7, 9, 10; 24-1 (I, II, III, IV, VII, VIII, IX, X, XI, XII, XXX). Figures 4-3; 5-9; 7-6, 7; 9-1; 14-17; 16-(1-4); 20-(3-5), (7-9).
F	Page 17-18. Table 17-7. Figures 15-1, 2.
F^+	Page 16-18. Table 16-1.1.
Fe	Pages 11-20; 15-1, 21, 30; 20-7. Table 18A-7. Figures 15-1, 5.
Fe^+	Pages 15-6, 15, 32, 35, 40, 44, 46, 47; 20-18. Tables 18A-3, 5, 7; 24-1 (XIV). Figures 15-3; 20-1.
FeO	Page 11-20. Table 11-1.
FeO^+	Tables 18A-3; 24-1 (XIV).
FeO_2^+	Table 18A-5.

H	Pages 2-9, 12; 6-8; 7-7; 8-(6-8); 10-4; 11-15, 17; 15-1, 18, 19; 19-3, 12; 20-16. Tables 6-1; 8-2; 9-1, 5, 6; 10-1, 2; 12-2; 18A-(1-4), 7; 19-1; 20-10; 24-1 (I, IV, XIII, XIV, XV, XXIV, XXV, XXVII). Figures 2-7; 10-1, 10; 14-1, 3, 4, 17; 15-1, 2.
H^*	Tables 10-2; 20-10. Figure 10-1.
$H(3\ ^2P)$	Tables 9-5; 20-10.
$H(^2S)$	Table 20-10.
H^+	Pages 6-8; 7-17; 8-1, 8; 9-6, 8; 10-3; 16-18, 20, 22, 23. Tables 8-1; 9-1; 10-1; 16-1.1, 1.2; 18A-1, 3, 7; 20-10; 24-1 (I, XIII). Figures 14-3, 4, 64, 89; 16-4.
H^-	Pages 7-17; 8-6, 7; 10-3; 16-22, 23; 17-2, 8. Tables 10-1; 16-1.2; 17-3; 18A-2; 24-1 (XV). Figures 10-9; 14-1, 16.
HCO^+	See CHO^+
HNO_2	Page 18A-9. Tables 18A-3, 4; 24-1 (XIV).
HNO_3	Page 11-13. Table 11-1.
HO_2	Pages 2-9; 11-16; 19-12; 20-16. Tables 11-1; 19-1; 24-1 (XII, XXIV, XXV, XXVII).
HO_2^-	Page 17-2.
HS	Table 18A-2.
HS^-	Table 18A-2.

H_2	Pages 2-9; 10-2; 11-31, 33; 16-17, 18, 24; 17-4; 19-4, 12; 20-16. Tables 9-5; 10-1, 19; 17-4; 18A-3; 20-10; 24-1 (XII, XIV, XXV, XXVII). Figures 10-8; 14-(12-20); 15-1, 2.
$H_2^{\ddagger}$	Table 20-10.
H_2^{+}	Page 16-18. Tables 10-1, 19; 16-1.2. Figures 14-13, 64, 89.
$H_2^{+\ddagger}$	Page 16-18.
H_2^{-}	Page 17-9.
$H_2NO_2^{+}$	See $NO^{+}(H_2O)$.
$H_2NO_3^{-}$	See $NO_2^{-}(H_2O)$.
$H_2NO_4^{-}$	See $NO_3^{-}(H_2O)$.
H_2O	Pages 2-9; 4-15; 6-8; 9-11; 11-1, 11; 12-6, 29; 17-3, 4, 8, 12; 18A-2, 3, (8-10); 19-12; 20-15, 16; 21-5, 6, 8, 16, 18, 27, 28. Tables 6-1; 10-1, 20; 11-1, 2; 12-2; 17-(3-5), 7; 18A-1, (3-7); 20-5, 6, 8, 10; 21-1, 2; 24-1 (IV, IX, XII, XIII, XIV, XVI, XVIII, XIX, XXI, XXIV, XXV, XXVII, XXX, XXXIII). Figures 4-2, 8; 11-1; 12-17; 14-(62-65); 20-6; 21-1, 3, 5.
$H_2O^{\ddagger}$	Page 4-15. Tables 10-20; 20-5; 24-1 (XXXIII).
H_2O^{+}	Tables 10-1, 20; 18A-1, 3, 7; 24-1 (XIII, XIV). Figure 14-63.
$H_2O^{+\ddagger}$	Table 10-20.
H_2O^{-}	Page 17-9.
H_2O_2	Page 2-9. Table 24-1 (XXIV, XXVII).

$H_2O_2^-$	See $O^-(H_2O)$.
$H_2O_3^+$	See $O_2^+(H_2O)$.
$H_2O_3^-$	See $O_2^-(H_2O)$.
$H_2O_4^-$	See $O_3^-(H_2O)$.
$H_2SO_4(\ell)$	Page 19-4.
H_3O	Table 18A-7.
H_3O^+	Pages 9-11; 16-17; 18A-8; 21-20. Tables 16-1.1; 18A-3, 5, 7; 21-4; 24-1 (IV, XIV, XVIII, XIX).
$H_3O^+(H_2O)$	Pages 18A-8; 21-25. Tables 16-1.1; 18A-3, 5; 21-4; 24-1 (IV, XIV, XVIII, XIX).
$H_3O^+(H_2O)_2$	Pages 16-17; 18A-9. Tables 16-1.1; 18A-3, 5; 24-1 (IV, XIV, XVIII, XIX).
$H_3O^+(H_2O)_3$	Tables 16-1.1; 18A-5; 24-1 (IV, XVIII, XIX).
$H_3O^+(H_2O)_4$	Tables 16-1.1; 18A-5; 24-1 (IV, XVIII, XIX).
$H_3O^+(H_2O)_5$	Page 16-17. Tables 16-1.1; 24-1 (IV).
$H_3O^+(H_2O)_n$	Pages 9-11; 16-17; 18A-8; 21-20. Tables 16-1.1; 24-1 (IV, XVIII, XIX).
$H_3O^+(OH)$	Page 18A-8. Tables 18A-3; 24-1 (IV, XIV, XIX).
$H_3O_2^-$	See $OH^-(H_2O)$.
$H_3PO_4(\ell)$	Page 19-4.
$H_4NO_3^+$	See $NO^+(H_2O)_2$.
$H_4O_2^+$	See $H_3O^+(OH)$.

$H_4O_4^-$	See $O_2^-(H_2O)_2$.
$H_5O_2^+$	See $H_3O^+(H_2O)$.
$H_6NO_4^+$	See $NO^+(H_2O)_3$.
$H_6O_5^-$	See $O_2^-(H_2O)_3$.
$H_7O_3^+$	See $H_3O^+(H_2O)_2$.
$H_8O_6^-$	See $O_2^-(H_2O)_4$.
$H_9O_4^+$	See $H_3O^+(H_2O)_3$.
$H_{10}O_7^-$	See $O_2^-(H_2O)_5$.
$H_{11}O_5^+$	See $H_3O^+(H_2O)_4$.
$H_{13}O_6^+$	See $H_3O^+(H_2O)_5$.
$H_{2n}NO_{n+3}^-$	See $NO_3^-(H_2O)_n$.
$H_{2n}O_{n+2}^-$	See $O_2^-(H_2O)_n$.
$H_{2n+3}O_{n+1}^+$	See $H_3O^+(H_2O)_n$.
He	Pages 2-(9-12); 4-1; 7-4, 10, 23; 8-4; 11-33; 15-1; 16-12, 14, 15, 17, 20, 21, 24; 18A-4, 7, 9; 19-12; 20-15; 21-17. Tables 2-2, 4; 8-2; 9-1, 3, 5; 12-2; 16-1.1, 1.2; 18A-1, 5, 6; 20-8, 10; 21-3; 24-1 (XVIII, XXI). Figures 2-7; 4-1; 7-3, 6; 15-1, 2; 21-4.
He^*	Table 20-10.
$He(^3P)$	Table 9-5.
$He(2\,^1S)$	Table 20-10.
$He(^3S)$	Tables 9-5; 20-10.
He^+	Pages 8-3; 15-45, 46; 16-18, 20, 22, 23; 18A-3, 4. Tables 9-1, 3, 5; 16-1.1; 18A-1; 20-10.

He_2^+	Page 16-20. Tables 16-1.1; 18A-1.
Hg	Page 20-7.
I	Pages 15-21; 19-3. Table 18A-2. Figures 15-5, 7.
I^+	Pages 15-37, 41. Table 15-1.
I^-	Page 16-21. Tables 16-1.2; 18A-2.
I_2	Page 16-21.
I_2^+	Page 16-21. Table 16-1.2.
K	Pages 15-21, 29. Table 8-2. Figures 15-2, 5, 8.
K^*	Table 9-5.
K^+	Pages 15-32, 35, 40; 16-18. Tables 15-1; 16-1.1; 18A-3, 5.
$K^+(CO_2)$	Table 18A-5.
KO^+	Table 18A-3.
Kr	Pages 15-30; 16-24. Table 20-8. Figures 15-1, 2.
Kr^+	Pages 15-32, 36, 40.
Li	Page 15-1. Table 8-2. Figures 15-1, 2.
Li^*	Table 9-5.

N_2	Pages 2-(9-12); 4-1, 8, 13; 6-8, 14, 15; 8-11, 12; 9-4, 12, 13, 31; 10-2, 4; 11-13, 14, 18, 27, 32; 12-6, 16, 17, 30; 13-(1-4); 14-1; 15-1, 21, 22, 25, (34-38); 16-8, 10, 22, 24; 17-3, 5, 8; 18A-(3-5), 7, 9; 19-4, (7-10), (12-14); 20-(3-10), 13, (15-17); 21-4, 5, 8, 15, 20, 25, 26, 28, 31; 22-1. Tables 2-2, 4; 9-2, 3, 6, 7; 10-1, 13; 11-2; 12-(2-4), 6a, 6b; 13-1, 2, 4, 6; 14-(1-3); 15-1; 16-1.2; 17-(4-6); 18A-1, (3-7); 19-1; 20-1, 2, (4-6), (8-10); 21-(1-4); 24-1 (I, II, IV, IX, X, XII, XIII, XIV, XVI, XVIII, XXI, XXIII, XXIV, XXV, XXVI, XXVII, XXVIII, XXX, XXXII, XXXIII). Figures 2-7; 4-1, 4, 8; 10-5, 8, 11; 12-7; 14-(29-41); 15-1, 2, (6-9); 20-1, 3, 4, 6; 21-1, 3, 4.
$N_2^{\ddagger}$	Pages 4-13; 5-17; 6-7; 11-14, 34; 19-7, 14; 20-(3-6); 21-4; 22-1. Tables 9-6; 20-2, 3, 10; 24-1 (XXVII, XXXII, XXXIII). Figures 10-5; 20-1, 3, 4.
N_2^{*}	Pages 20-3, (6-8). Tables 10-13; 20-1, 10. Figures 10-5; 20-1.
$N_2(a\,^1\Pi_g)$	Tables 9-5, 6; 10-13; 20-1, 10. Figure 10-5.
$N_2(a\,^1\Pi_g)^{\ddagger}$	Table 20-10.
$N_2(a'\,^1\Sigma_u^-)$	Tables 10-13; 20-1. Figure 10-5.
$N_2(A\,^3\Sigma_u^+)$	Pages 6-15; 20-3, (6-8). Tables 9-6, 7; 10-13; 20-1, 4, 10; 24-1 (XXVIII, XXX). Figures 10-5; 20-1.
$N_2(A\,^3\Sigma_u^+)^{\ddagger}$	Pages 20-3, 7. Figure 20-1.
$N_2(b'\,^1\Sigma_u^+)$	Figure 10-5.

$N_2(B\ ^3\Pi_g)$	Pages 6-15; 20-6, 7. Tables 9-5, 6; 10-13; 20-1, 10; 24-1 (XXV). Figures 10-5; 20-1.
$N_2(B\ ^3\Pi_g)^{\ddagger}$	Figure 20-1.
$N_2(B'\ ^3\Sigma_u^-)$	Page 20-7. Tables 9-5; 10-13; 20-1. Figure 10-5.
$N_2(C\ ^3\Pi_u)$	Pages 20-6, 7. Tables 9-5, 6; 20-10. Figure 10-5.
$N_2(C\ ^3\Pi_u)^{\ddagger}$	Table 20-10.
$N_2(C'\ ^3\Pi_u)$	Figure 10-5.
$N_2(D\ ^3\Sigma_u^+)$	Page 20-7.
$N_2(E\ ^3\Sigma_g^+)$	Page 20-7. Figure 10-5.
$N_2(h\ ^1\Sigma_u^+)$	Tables 9-6; 12-6a.
$N_2(w\ ^1\Delta_u)$	Tables 10-13; 20-1. Figure 10-5.
$N_2(W\ ^3\Delta_u)$	Page 20-7. Tables 10-13; 20-1.
$N_2(^1\Pi_u)$	Tables 12-6a, 6b.
$N_2(^5\Pi_u)$	Figure 10-5.
N_2^+	Pages 6-15; 8-12; 9-4, 11, 21, 31; 13-1, 3, 4; 14-1; 15-5, 43; 16-7, 8, 10, 18, 22; 18A-(4-7); 20-(6-10), 15, 17; 21-20. Tables 9-2, 3, 6; 10-1, 14; 13-3, 5, 7; 14-1, 2; 16-1.1, 1 2; 18A-1, 3, 5, 7; 20-1, 9, 10; 21-4; 24-1 (I, II, IV, V, XIII, XIV, XVIII, XXX). Figures 10-5; 12-7; 14-(30-37), 90; 16-1; 20-2.

N_3^+	Pages 16-7, 8, 10; 20-9. Tables 18A-3; 21-4; 24-1 (IV, XIV, XVIII).
N_4^+	Pages 16-7, 10, 16; 18A-7. Tables 16-1.1; 18A-1, 3, 5; 21-4; 24-1 (IV, XIV, XVIII). Figure 16-1
Na	Pages 5-19; 18A-3, 6; 20-7. Tables 8-2; 9-6; 18A-1, 3, 7; 20-10; 24-1 (XIII, XIV). Figures 15-2; 20-1.
Na^*	Tables 9-5; 20-1, 10.
Na^+	Pages 16-18, 23; 18A-6; 20-18. Tables 16-1.1; 18A-1, 3, 5, 7; 24-1 (XIII). Figure 20-1.
$Na^+(CO_2)$	Table 18A-5.
$Na^+(CO_2)_2$	Table 18A-5.
NaO^+	Tables 18A-3; 24-1 (XIV).
Ne	Pages 15-25, 43, 44; 16-8, 10, 11, 14, 16, 24. Tables 8-2; 15-1. Figures 15-1, 2.
Ne^*	Page 16-8.
Ne^+	Pages 15-34, 39, 43; 16-18. Table 16-1.1.
Ne^{++}	Page 15-43.
Ne^{3+}	Page 15-43.
Ne^{4+}	Page 15-43.
Ne^{5+}	Page 15-43.
Ne_2^+	Page 16-16.

O	Pages 2-(9-12); 3-33, 34; 4-13, 15; 5-18; 6-2, 8, 12, 14, 15; 7-7; 8-7, 8, 10, 11; 9-12, 13, 15, 30, 31; 10-4; 11-13, (16-20), 31, 32; 12-6, (8-23), 30; 13-1, 3, 4; 15-1, 6, 15, 25, (29-33); 16-10, 11, 16; 17-2, 6, 9, 12, 14; 18A-5, 6, 8; 19-(2-14); 20-3, 6, 7, (10-12), (14-18); 21-6, 16, 20, 25, 29. Tables 2-2, 4; 6-1; 8-2; 9-(2-6); 10-1, 8; 12-(1-5), 7a, 7b, 8a, 8b; 13-1, 2, 4, 6; 15-2; 17-(1-4), 6, 7; 18A-(1-4), 6, 7; 19-1; 20-1, 2, (4-7), 9, 10; 21-(1-4); 24-1 (I, II, IV, V, VII, VIII, IX, X, XI, XII, XIII, XIV, XV, XVI, XVIII, XXIII, XXIV, XXV, XXVI, XXVII, XXVIII, XXX, XXXII). Figures 2-7; 4-1, 7; 10-3, 6, 7, 10; 12-(8-10); 14-2, (7-9); 15-(1-4); 20-1, 4, 6, 9; 21-1, 4.
O^*	Pages 12-(17-23). Tables 10-8; 12-5; 20-1, 7, 10. Figures 10-3; 12-8, 9; 20-1, 9.
$O(^1D)$	Pages 4-13; 5-17, 18; 6-15; 8-10; 12-9, 21, 27, 28; 16-16; 19-14; 20-3, 4, 12, (14-16); 22-1. Tables 9-(5-7); 12-3, 5, 7a, 7b; 20-1, 7, 8, 10; 24-1 (IV, XXIV, XXVII, XXVIII, XXX). Figures 4-2, 4, 5; 10-6, 7, 10; 20-1, 9.
$O(4\,^3P)$	Table 9-5.
$O(^5P)$	Table 9-6.
$O(^1S)$	Pages 5-18, 8-10, 9-31; 12-21; 16-16; 19-14; 20-4, 14, 15. Tables 9-(5-7); 12-7a, 7b; 20-1, 7, 10; 24-1 (IV, XXV, XXVIII, XXX). Figures 10-6, 7; 12-10; 20-1, 9.
$O(^3S)$	Tables 9-5, 6; 20-1.
$O(^5S)$	Tables 9-5, 6; 20-1. Figure 20-1.
O^+	Pages 4-6; 6-7, 14, 15; 8-2, 8; 9-(11-13), 15; 10-4; 12-14, 21; 13-3, 4; 15-31, 34, 39, (43-45), 47; 16-18, 22, 23; 18A-5; 20-5, 11, (15-17).

O^+ (Cont'd.) Tables 9-2, 3, 5, 6; 10-1, 9; 12-1, 7b, 8a, 8b; 13-3, 5, 7; 16-1.1, 1.2; 18A-1, 3, 5, 7; 20-1, 3; 21-4; 24-1 (I, II, V, XIII, XIV, XVIII, XXVIII, XXX).

Figures 4-3, 4; 10-4, 6, 7; 12-8, 10, 11; 14-8, 64, 73, 74; 20-2, 4.

O^{+*} Pages 12-20, 21; 20-(15-17).
Tables 10-9; 20-1.
Figures 10-4; 12-(8-11); 20-2.

$O^+(^2D)$ Pages 6-15; 12-20; 20-8, (16-18).
Tables 9-3, 6; 12-8a, 8b; 20-1, 9, 10; 24-1 (II, XIII, XXVIII, XXX).
Figures 10-7; 12-8, 9, 11; 14-73; 20-2.

$O^+(^2P)$ Pages 12-21; 20-16, 17.
Tables 9-6; 12-8a, 8b; 20-1; 24-1 (II, XXVIII).
Figures 12-(9-11).

$O^+(^4P)$ Figure 14-74.

O^{++} Page 15-43.
Tables 10-1; 12-1.

O^{3+} Page 15-43.

O^- Pages 5-7; 6-12, 14; 8-7; 9-15, 30; 10-3; 11-25; 16-22, 23; 17-2, 4, 5, 8, 9, 12, 13; 18A-3; 20-11, 13.
Tables 10-1, 7; 16-1.2; 17-(1, 4), 6, 7; 18A-2, 4, 6; 20-10; 24-1 (V, VII, VIII, IX, X, XI, XII, XV, XVI, XX, XXI).
Figures 10-6, 7, 9; 14-2.

O^{-*} Table 10-7.

$O^-(CO_2)$ See CO_3^-.

$O^-(H_2O)$ Tables 18A-6; 24-1 (XXI).

OCS Page 19-6.

OH	Pages 2-9; 7-7; 11-1, 16, 17; 17-2; 18A-8; 19-3, 12; 20-16; 21-6. Tables 6-1; 10-1, 19; 11-1; 17-(1-3); 18A-(1-3); 19-1; 20-10; 24-1 (VII, VIII, XIII, XIV, XV, XIX) XXIV, XXV, XXVII). Figure 4-6.
$OH^{\ddagger}$	Pages 11-(15-17). Tables 9-5; 20-10.
OH^{*}	Page 12-29. Tables 10-19; 20-10.
OH^{+}	Tables 10-1, 19; 18A-1, 3; 24-1 (XIII, XIV). Figure 14-64.
OH^{+*}	Table 10-19.
OH^{-}	Page 17-2. Tables 10-1, 19; 17-1, 2, 7; 18A-2, 4; 24-1 (VII, VIII, XII, XV).
$OH^{-}(H_2O)$	Table 17-7.
$OONO^{-}$ (Cf. NO_3^{-})	Page 18A-7. Tables 18A-4; 24-1 (XVI).
O_2	Pages 2-(9-12); 3-33, 38; 4-1, 6, 8, 10, 15; 5-19; 6-2, 8, 12, 14, 15; 8-11; 9-12, 15, 30; 10-2, 4; 11-(13-20), 27, 32, 33; 12-(6-16), 20, 27, 28, 30; 13-1, 3, 4; 15-1, 21, 34, 36, (39-43), 46, 47, 16-14, 15, 17, 22, 23, 17-2, 4, (6-8), 12, 14, 17; 18A-(5-9); 19-(4-6), (8-14); 20-6, (9-18); 21-4, 5, 8, 16, 20, 25, 27, 28. Tables 2-2, 4; 9-2, 4, 6, 7; 10-1, 17; 11-2; 12-(1-4), 7a, 7b; 13-1, 2, 4, 6; 15-1; 16-1.2; 17-(1-7); 18A-(1-7); 19-1; 20-1, 2, (4-6), (8-10); 21-(1-4); 24-1 (I, II, IV, VII, VIII, IX, X, XI, XII, XIII, XIV, XV, XVI, XVIII, XIX, XX, XXI, XXII, XXIII, XXIV, XXV, XXVI, XXVII, XXVIII, XXIX, XXX, XXXII, XXXIII). Figures 2-7; 3-7; 4-1, 4, (6-8); 10-7, 8, 11; 11-(8-10); 12-(1-6); 14-(45-61); 15-1, 2, (6-8); 20-1, 4 (6-8); 21-1, 3, 4.

$O_2^+(H_2O)$	Page 18A-8. Tables 18A-3, 5; 24-1 (IV, XIV, XVIII).
$O_2^+(N_2)$	Tables 18A-3, 5; 24-1 (XIV, XVIII).
$O_2^+(N_2O)$	Table 18A-5.
$O_2^+(O_2)$	See O_4^+.
O_2^{++}	Table 10-1.
O_2^-	Pages 5-7; 6-12; 9-30; 16-22; 17-2, 4, (7-9), (12-14); 18A-3, 7; 20-13. Tables 9-4; 10-1, 19; 12-1; 16-1.2; 17-1, 2, (4-7); 18A-2, 4, 6; 20-10; 21-4; 24-1 (V, VII, VIII, IX, X, XI, XII, XV, XVI, XXI, XXII). Figures 10-7, 9.
$O_2^-(CO_2)$	See CO_4^-.
$O_2^-(H_2O)$	Pages 17-2, 9, 17. Tables 17-7; 18A-4, 6; 24-1 (XVI, XXI).
$O_2^-(H_2O)_2$	Tables 17-7; 18A-6; 24-1 (XXI).
$O_2^-(H_2O)_3$	Table 17-7.
$O_2^-(H_2O)_4$	Table 17-7.
$O_2^-(H_2O)_5$	Table 17-7.
$O_2^-(H_2O)_n$	Page 17-16.
$O_2^-(N_2)$	Tables 18A-6; 24-1 (XXI).
$O_2^-(O_2)$	See O_4^-.
O_3	Pages 2-9-12); 4-15; 5-18; 6-2, 12; 9-30; 11-1, 11, 15, 17, 19; 12-6, 24, 27; 17-2, 4, 9, 12; 18A-6, 8; 19-2, (4-8), 14; 20-12, 13; 21-17. Tables 2-2; 10-1, 20; 11-1; 12-2; 17-(1-4), 7; 18A-(2-4); 19-1; 20-6, 10; 21-2; 24-1 (VII, VIII, XI, XII, XIV, XV, XVI, XXIV, XXV, XXVI, XXVII, XXX). Figures 2-7; 4-2, 7, 8; 11-1, 2; 12-14, 15; 21-3.

$O_3^{\ddagger}$	Page 11-19. Table 10-20.
O_3^{+}	Page 16-14. Tables 10-1, 20; 24-1 (XVIII).
$O_3^{+\ddagger}$	Table 10-20.
O_3^{-}	Pages 17-2, 9, 12. Tables 10-I, 20; I7-1, 2, 4, 7; 18A-2, 4, 6; 21-4; 24-I (VII, VIII, XII, XV, XVI, XX, XXI).
$O_3^{-\ddagger}$	Table 10-20.
$O_3^{-}(H_2O)$	Tables 18A-6; 24-1 (XXI).
O_4^{*}	Page 20-13.
O_4^{+}	Pages I6-14, 16; 18A-(6-8). Tables 16-1.1; 18A-3, 5; 2I-4: 24-1 (IV, XIV, XVIII, XIX).
O_4^{-}	Pages 17-9, 14, 17; 18A-7. Tables 17-7; 18A-4, 6; 21-4; 24-1 (XVI, XXI, XXII).
P^{+}	Page 16-18. Table 16-1.1.
PH_2^{-}	Page 7-9.
Pt	Page 7-22.
Rb^{+}	Page 15-36.
S^{+}	Page 16-18. Table 16-1.1.
SF_5^{-}	Page 17-18. Table 17-7.
SF_6	Pages 17-17, 18. Table 17-7.

Aubrey, B. B.: 21-7

Awajobi, O. A.: 9-34

Axworthy, A. E., Jr.: 19-4

Bachynski, M. P.: 21-10

Badger, R. M.: 20-32

Bahr, J. L.: 12-88

Baiamonte, V.: 6-17

Bailey, A. D.: 9-19, 27; 17-10; 20-203; 21-61

Bailey, D. K.: 9-22

Bailey, T. L.: 17-25

Bailey, V. A.: 21-16

Bair, E.: 6-17

Baisley, V. C.: 12-72

Baker, A. D.: 7-78

Baker, C.: 7-78

Baker, D. M.: 3-33; 20-166

Baker, K.: 20-166

Baldeschwieler, J. D.: 7-22

Baldwin, R. R.: 19-33

Bamford, C. H.: 11-18 (Ed.)

Banks, P.: 21-70

Bardsley, J. N.: 8-15, 21, 61, 64; 11-66; 16-28; 17-39, 60

Barrow, R. F.: 10-32

Barth, C. A.: 9-74, 92; 19-35; 20-69

Basco, N.: 20-217

Bates, D. R.: 4-4 (Ed.); 7-9 (Ed.), 57 (Ed.), 89 (Ed.); 8-1, 4, 6, 7, 8, 9, 10, 12, 14, 16, 17, 25, 26, 30; 9-25; 11-68, 69; 15-2 (Ed.), 4, 19, 20 (Ed.), 32; 16-42 (Ed.), 43; 17-21; 20-4, 43, 76, 235

Bauer, E.: 3 (Author) -2, 44; 4 (Author) -14, 15; 20-6, 7, 55, 56, 80, 143, 222, 232

Baulch, D. L.: 15-54; 24-16, 35, 32

Baum, C. E.: 21-58

Baurer, T.: 1 (Author); 6 (Author); 19-37; 23 (Author); 24 (Author)

Bayes, K.: 20-155

Beaty, E. C.: 10-36; 17-5, 44, 45; 21-41; 24-3

Beauchamp, J. L.: 7-20, 21; 21-74

Becker, R. A.: 7-70; 12-42

Bederson, B.: 7-2 (Ed.), 58 (Ed.); 21-7

Bekefi, G.: 21-45

Bell, G.: 15-13

Belles, F. E.: 20-236

Belon, A. E.: 9-11

Belrose, J. S.: 5-14; 9-95; 21-29

Belyaev, V. A.: 7-61

Benesch, W.: 10-52; 20-19

Bennett, R. A.: 17-40, 62

Bennett, W. R.: 20-46 (Ed.)

Benson, S. W.: 19-4

Berkowitz, J.: 7-85; 17-58

Berlande, J.: 16-47

Berning, W. W.: 9-53

Bernstein, R.: 20-220

Berry, R. E.: 16-40

Berry, R. S.: 7-64; 8-75; 10-14, 43; 16-62

Bethe, H. A.: 11-44

Bethke, G. W.: 12-15

Beyer, R. A.: 18-65, 66

Beynon, W. J. G.: 9-58 (Ed.), 62 (Ed.)