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*Radiation
Laboratory*

EQUATIONS OF STATE FOR EVOLUTION
STUDIES OF SUPERNOVAE

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UNIVERSITY OF CALIFORNIA
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Livermore, California

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EQUATIONS OF STATE FOR EVOLUTION STUDIES OF SUPERNOVAE

William H. Grasberger
Joseph B. Yeaton

February 1961

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EQUATIONS OF STATE FOR EVOLUTION STUDIES OF SUPERNOVAE*

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ABSTRACT

Tables of the energy, pressure, and chemical composition for a stellar mixture, originally a pure Fe^{56} , are presented as functions of temperature and density. They cover a range of conditions pertinent to the evolution of supernovae, involving the decomposition of iron into helium plus neutrons, and the later stage of decomposition of helium into neutrons and protons. Relativistic degeneracy of electrons is included in these calculations.

* Work performed under the auspices of the U. S. Atomic Energy Commission.

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I. BASIC ASSUMPTIONS

Our stellar mixture is taken to consist of Fe^{56} nuclei, alpha particles, protons, neutrons, and electrons at a temperature T and density ρ . The mixture is assumed to represent matter undergoing transmutation during the evolution of a supernova. At an earlier stage and lower temperature the mixture is assumed to be pure iron with 26 electrons per nucleus. The electrons are conserved through the evolution, but the iron nuclei transform into 13 alpha particles plus 4 neutrons, according to the considerations of Burbidge, Burbidge, Fowler, and Hoyle (1957;¹ called Paper I hereafter). Furthermore, at still higher temperatures the alpha particles decompose into two protons and two neutrons. We assume that these two stages are sufficiently decoupled that we may neglect decomposition of alpha particles until the iron nuclei are nearly all transformed.

The heavy particles are nondegenerate for the temperatures and densities considered here. We assume they obey a classical perfect-gas law. However, the electrons are partially degenerate, and at these high temperatures relativistic modifications must be also included. We assume that the electrons obey a partially degenerate, relativistic, perfect-gas relation. Thus we have for the pressure and total energy

$$P = P_n + P_e + P_r, \quad (1)$$

$$E = E_n + E_e + E_r + S, \quad (2)$$

where the subscripts n , e , r refer to the nuclei, electrons, and radiation field, respectively, and S is the energy of transmutation due to conversion of iron into helium, and of helium into protons and neutrons. We have

$$P_n = \frac{\rho k T}{H \bar{\mu}_n}; \quad E_n = \frac{3}{2} \frac{k T}{H \bar{\mu}_n}, \quad (3)$$

where $\bar{\mu}_n$ is the mean molecular weight per nucleus and H is the mass of a hydrogen nucleus. We define the ratios of the partially degenerate, relativistic electron-gas pressure and kinetic energies to their classical perfect-gas counterparts as π and χ , respectively. Thus

$$P_e = \pi N_e kT; \quad E_e = \frac{3}{2} \chi N_e kT / \rho, \quad (4)$$

where N_e is the number of electrons per cubic centimeter. The radiation field is assumed to be in thermodynamic equilibrium so that

$$P_r = \frac{a}{3} T^4; \quad E_r = a T^4 / \rho, \quad (5)$$

where "a" is the radiation-density constant.

The quantities π and χ are functions of ϕ and β , where

$$\phi = \frac{3h^3}{8\pi m^3 c^3} N_e, \quad (6)$$

$$\beta = kT / mc^2. \quad (7)$$

These functions have been tabulated elsewhere by Grasberger (1961).² An IBM 7090 machine program code has been used to obtain their values for the pairs of T and ρ given here.

II. CASE OF IRON-HELIUM MIXTURE

Let U be the fraction by weight of the mixture consisting of helium plus neutrons. We assume that each iron nucleus may transform into 13 helium nuclei plus 4 neutrons. Therefore $1 - U$ is the fraction by weight of iron nuclei.

Statistical equations yield the following relation between the number per cubic centimeter of He^4 and Fe^{56} :

$$N(56,26) = \omega(56,26) N(4,2)^{13} N(1,0)^4 \frac{(56)^{3/2}}{2^{43}} \left(\frac{2\pi\hbar}{M_0 kT} \right)^{24} \exp Q/kT, \quad (8)$$

where $\omega(56,26)$ is the statistical weight of iron which we take to be 1.4, Q is the energy of dissociation equal to 123.8 Mev, and $N(1,0)$ is the number of neutrons per cubic centimeter. Expressing the numerical densities in terms of U and the material density, and assuming that the number of neutrons is equal to 4/13 times the number of alpha particles, Eq. (8) may be written in the form

$$\log U - \frac{1}{17} \log (1 - U) = 0.3955 - 0.9412 \log \rho_8 + 1.4118 \log T_{\text{kev}} - \frac{3163}{T_{\text{kev}}}, \quad (9)$$

where ρ_8 is in units of 10^8 grams per cubic centimeter, the temperature is in kilovolts, and the logarithms are to the base ten.

The energy needed to convert one gram of iron into helium plus neutrons is 2.136×10^{18} ergs. Therefore the energy of transmutation used in Eq. (2) for this stage in ergs per gram is

$$S_0 = 2.136 \times 10^{18} U. \quad (10)$$

III. CASE OF HELIUM-NEUTRON-PROTON MIXTURE

After complete decomposition of iron into helium and neutrons, we have a mixture of 92.8% by weight of He^4 and the rest neutrons. The helium will further decompose into two neutrons and two protons. Let Y be the fraction by weight of the mixture consisting of He^4 .

In statistical equilibrium we have

$$N(4,2) = \frac{1}{2} \omega(4,2) N(1,1)^2 N(1,0)^2 \left(\frac{2\pi\hbar}{M_0 kT} \right)^{9/2} \exp Q'/kT, \quad (11)$$

where $\omega(4,2)$ is the statistical weight for helium which we take equal to unity, and Q' is the energy of dissociation equal to 28.21 Mev. We may express Eq. (11) in the form

$$\begin{aligned} \log Y - 2 \log (0.24869 - 0.5Y + 0.25Y^2) &= 3.0140 + 3 \log_{10} \rho_8 \\ &- 4.5 \log_{10} T_{\text{kev}} + 12,252/T_{\text{kev}}. \end{aligned} \quad (12)$$

The energy needed to convert one gram of helium into neutrons plus protons is 6.327×10^{18} ergs per gram. The energy of transmutation used in Eq. (2) for this stage in ergs per gram is

$$S_1 = [2.136 + 6.818 (0.928 - Y)] \times 10^{18}. \quad (13)$$

IV. NUMERICAL RESULTS

For convenience we express densities in units of 10^8 grams per cubic centimeter, temperatures in kilovolts, pressures in units of 10^{16} dynes per square centimeter, and energies in units of 10^{16} ergs per gram. Equations (3), (4), (5) become

$$P_n = 9.6517 \times 10^6 \rho_8 T_{\text{kev}} / \bar{\mu}_n; \quad E_n = 0.14478 T_{\text{kev}} / \bar{\mu}_n. \quad (14)$$

$$P_e = 4.4848 \times 10^6 \rho_8 T_{\text{kev}} \pi; E_e = 0.067272 T_{\text{kev}} \chi. \quad (15)$$

$$P_r = 0.0045681 T_{\text{kev}}^4; E_r = 1.3704 \times 10^{-10} T_{\text{kev}}^4 / \rho_8. \quad (16)$$

The quantities N_e, ϕ, β become

$$N_e = 2.7998 \times 10^{31} \rho_8. \quad (17)$$

$$\phi = 47.729 \rho_8; \beta = 0.00195706 T_{\text{kev}}. \quad (18)$$

For the iron-helium case we have

$$(\bar{\mu}_n)^{-1} = 0.28526 U + 0.01787. \quad (19)$$

For the helium-neutron-proton case we have

$$(\bar{\mu}_n)^{-1} = 0.99150 - 0.74177 Y \quad (Y \leq 0.928). \quad (20)$$

The gas pressure and gas energy are

$$P_{\text{gas}} = P_n + P_e; E_{\text{gas}} = E_n + E_e + S. \quad (21)$$

The total pressure and energy are

$$P = P_{\text{gas}} + P_r; E = E_{\text{gas}} + E_r \quad (22)$$

Table 1 gives the quantities $U, \pi, \chi, P_{\text{gas}}/P, P_{\text{gas}}, P, E_{\text{gas}},$ and E as functions of ρ_8 and T_{kev} for the iron-helium stage. Table 2 lists the quantities $Y, \pi, \chi, P_{\text{gas}}/P, P_{\text{gas}}, P, E_{\text{gas}},$ and E for the helium-neutron-proton stage.

One of the authors (Grasberger) wishes to thank Dr. Stirling Colgate for some illuminating discussions and for stimulating his interest in the general problem of supernovae evolution.

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- W. H. Grasberger, "A Partially Degenerate, Relativistic, Ideal Electron Gas," Lawrence Radiation Laboratory, University of California (Livermore, California) Report UCRL-6196 (Feb. 1961).

TABLE 1 IRON-HELIUM STAGE *

P_8	T	U	PI	CHI	PGAS/P
0.001	300.	0.0001	1.0014	1.4448	0.0364
	350.	0.0059	1.0010	1.4841	0.0233
	400.	0.0961	1.0007	1.5185	0.0166
	450.	0.7879	1.0005	1.5487	0.0161
	475.	1.0000	1.0004	1.5622	0.0149
	500.	1.0000	1.0004	1.5757	0.0128
	525.	1.0000	1.0003	1.5877	0.0111
	550.	1.0000	1.0003	1.5994	0.0097
	575.	1.0000	1.0002	1.6104	0.0085
	600.	1.0000	1.0002	1.6208	0.0075
0.002	300.	0.0001	1.0029	1.4472	0.0704
	350.	0.0031	1.0020	1.4858	0.0456
	400.	0.0502	1.0014	1.5197	0.0318
	450.	0.4347	1.0010	1.5496	0.0274
	475.	0.9516	1.0009	1.5630	0.0289
	500.	1.0000	1.0008	1.5764	0.0253
	525.	1.0000	1.0007	1.5884	0.0219
	550.	1.0000	1.0006	1.5999	0.0191
	575.	1.0000	1.0005	1.6109	0.0168
	600.	1.0000	1.0005	1.6213	0.0148
0.005	300.	0.0000	1.0072	1.4542	0.1597
	350.	0.0013	1.0050	1.4907	0.1068
	400.	0.0212	1.0035	1.5233	0.0749
	450.	0.1875	1.0026	1.5523	0.0586
	475.	0.4628	1.0023	1.5654	0.0572
	500.	0.9408	1.0020	1.5785	0.0597
	525.	1.0000	1.0017	1.5902	0.0531
	550.	1.0000	1.0015	1.6016	0.0465
	575.	1.0000	1.0014	1.6124	0.0410
	600.	1.0000	1.0012	1.6226	0.0362

P_8	T	PGAS	P	EGAS	E
0.001	300.	1.399E 06	3.840E 07	29.97	1140.02
	350.	1.637E 06	7.019E 07	37.20	2093.70
	400.	1.970E 06	1.189E 08	64.01	3572.31
	450.	3.073E 06	1.904E 08	230.99	5850.61
	475.	3.521E 06	2.361E 08	284.37	7260.76
	500.	3.706E 06	2.892E 08	288.54	8853.73
	525.	3.891E 06	3.509E 08	292.71	10703.75
	550.	4.077E 06	4.221E 08	296.92	12837.20
	575.	4.262E 06	5.036E 08	301.13	15281.69
	600.	4.447E 06	5.965E 08	305.35	18066.12
0.002	300.	2.802E 06	3.980E 07	30.00	585.02
	350.	3.272E 06	7.182E 07	36.59	1064.85
	400.	3.041E 06	1.208E 08	53.48	1807.63
	450.	5.273E 06	1.926E 08	149.00	2958.81
	475.	6.917E 06	2.395E 08	273.11	3761.31
	500.	7.414E 06	2.929E 08	288.57	4571.16
	525.	7.784E 06	3.548E 08	292.74	5498.26
	550.	8.155E 06	4.262E 08	296.93	6567.08
	575.	8.525E 06	5.079E 08	301.15	7791.43
	600.	8.895E 06	6.009E 08	305.37	9185.76
0.005	300.	7.034E 06	4.404E 07	30.13	252.14
	350.	8.196E 06	7.675E 07	36.30	447.60
	400.	9.463E 06	1.264E 08	46.91	748.57
	450.	1.167E 07	1.990E 08	91.68	1215.61
	475.	1.411E 07	2.467E 08	159.19	1554.47
	500.	1.814E 07	3.036E 08	274.77	1987.80
	525.	1.947E 07	3.665E 08	292.80	2375.01
	550.	2.040E 07	4.384E 08	297.00	2805.05
	575.	2.132E 07	5.207E 08	301.20	3297.32
	600.	2.225E 07	6.143E 08	305.43	3857.58

* P_8 in units of 10^8 grams/cm³; T in kilovolts; P, P_{gas} in units of 10^{16} dynes/cm²; E, E_{gas} in units of 10^{16} ergs/gram.

TABLE 1 (CONTD.)

P ₈	T	U	PI	CHI	PGAS/P
0.010	300.	0.0000	1.0144	1.4657	0.2769
	350.	0.0007	1.0079	1.4989	0.1936
	400.	0.0111	1.0071	1.5293	0.1390
	450.	0.0982	1.0052	1.5569	0.1063
	475.	0.2459	1.0046	1.5694	0.0986
	500.	0.5519	1.0040	1.5820	0.0979
	525.	0.9813	1.0035	1.5934	0.1004
	550.	1.0000	1.0031	1.6044	0.0890
	575.	1.0000	1.0027	1.6148	0.0787
	600.	1.0000	1.0024	1.6248	0.0700
0.020	300.	0.0000	1.0284	1.4883	0.4369
	350.	0.0004	1.0196	1.5150	0.3264
	400.	0.0058	1.0141	1.5412	0.2447
	450.	0.0513	1.0105	1.5659	0.1888
	475.	0.1292	1.0091	1.5773	0.1711
	500.	0.2952	1.0079	1.5890	0.1617
	525.	0.6110	1.0070	1.5995	0.1616
	550.	0.9898	1.0062	1.6099	0.1632
	575.	1.0000	1.0055	1.6198	0.1462
	600.	1.0000	1.0049	1.6293	0.1309
0.050	300.	0.0000	1.0678	1.5525	0.6679
	350.	0.0001	1.0474	1.5613	0.5542
	400.	0.0024	1.0343	1.5756	0.4517
	450.	0.0217	1.0256	1.5922	0.3672
	475.	0.0548	1.0224	1.6005	0.3339
	500.	0.1262	1.0196	1.6094	0.3084
	525.	0.2677	1.0173	1.6177	0.2927
	550.	0.5237	1.0153	1.6261	0.2886
	575.	0.9030	1.0136	1.6343	0.2932
	600.	1.0000	1.0122	1.6424	0.2745

P ₈	T	PGAS	P	EGAS	E
0.010	300.	1.417E 07	5.117E 07	30.36	141.37
	350.	1.646E 07	8.501E 07	36.35	242.00
	400.	1.888E 07	1.358E 08	44.73	395.56
	450.	2.228E 07	2.096E 08	71.10	633.06
	475.	2.544E 07	2.580E 08	108.73	806.37
	500.	3.097E 07	3.165E 08	183.79	1040.31
	525.	3.872E 07	3.858E 08	288.53	1329.63
	550.	4.083E 07	4.588E 08	297.10	1551.13
	575.	4.269E 07	5.420E 08	301.30	1799.35
	600.	4.453E 07	6.366E 08	305.51	2081.59
0.020	300.	2.871E 07	6.571E 07	30.81	86.32
	350.	3.322E 07	1.018E 08	36.66	139.48
	400.	3.789E 07	1.548E 08	43.83	219.25
	450.	4.361E 07	2.307E 08	60.48	341.46
	475.	4.801E 07	2.806E 08	81.75	430.57
	500.	5.505E 07	3.406E 08	123.89	552.15
	525.	6.690E 07	4.139E 08	201.62	722.17
	550.	8.151E 07	4.995E 08	294.89	921.90
	575.	8.550E 07	5.847E 08	301.49	1030.52
	600.	8.919E 07	6.812E 08	305.70	1193.73
0.050	300.	7.442E 07	1.114E 08	32.11	54.31
	350.	8.523E 07	1.538E 08	37.70	78.83
	400.	9.636E 07	2.133E 08	43.99	114.16
	450.	1.087E 08	2.960E 08	54.40	166.79
	475.	1.166E 08	3.491E 08	65.15	204.68
	500.	1.273E 08	4.128E 08	84.99	256.29
	525.	1.436E 08	4.907E 08	121.48	329.70
	550.	1.696E 08	5.876E 08	185.34	436.15
	575.	2.071E 08	7.065E 08	279.04	578.65
	600.	2.240E 08	8.160E 08	306.22	661.44

TABLE 1 (CONTD.)

P ₈	T	U	PI	CHI	PGAS/P
0.100	300.	0.0000	1.1271	1.6502	0.8091
	350.	0.0001	1.0900	1.6331	0.7210
	400.	0.0013	1.0659	1.6298	0.6290
	450.	0.0113	1.0496	1.6339	0.5412
	475.	0.0286	1.0435	1.6376	0.5018
	500.	0.0660	1.0381	1.6422	0.4673
	525.	0.1407	1.0338	1.6470	0.4401
	550.	0.2795	1.0300	1.6523	0.4225
	575.	0.5169	1.0267	1.6579	0.4165
	600.	0.8637	1.0239	1.6636	0.4199
	625.	0.9998	1.0215	1.6693	0.4023
	650.	1.0000	1.0194	1.6751	0.3741
	675.	1.0000	1.0175	1.6809	0.3477
	700.	1.0000	1.0159	1.6866	0.3232
0.200	300.	0.0000	1.2283	1.8199	0.9021
	350.	0.0000	1.1648	1.7607	0.8464
	400.	0.0007	1.1226	1.7280	0.7809
	450.	0.0059	1.0934	1.7109	0.7099
	475.	0.0149	1.0824	1.7063	0.6743
	500.	0.0344	1.0725	1.7034	0.6401
	525.	0.0736	1.0645	1.7020	0.6091
	550.	0.1470	1.0575	1.7018	0.5833
	575.	0.2757	1.0515	1.7025	0.5653
	600.	0.4863	1.0462	1.7040	0.5570
	625.	0.7935	1.0416	1.7060	0.5576
	650.	0.9981	1.0376	1.7085	0.5470
	675.	1.0000	1.0341	1.7113	0.5185
	700.	1.0000	1.0310	1.7144	0.4907

P ₈	T	PGAS	P	EGAS	E
0.100	300.	1.568E 08	1.938E 08	34.08	45.18
	350.	1.771E 08	2.457E 08	39.37	59.94
	400.	1.983E 08	3.152E 08	45.18	80.27
	450.	2.210E 08	4.083E 08	53.25	109.45
	475.	2.342E 08	4.668E 08	60.22	129.99
	500.	2.505E 08	5.360E 08	71.99	157.64
	525.	2.728E 08	6.198E 08	92.64	196.75
	550.	3.059E 08	7.239E 08	128.60	254.00
	575.	3.565E 08	8.559E 08	188.30	338.11
	600.	4.285E 08	1.021E 09	274.59	452.20
	625.	4.692E 08	1.166E 09	311.18	520.29
	650.	4.873E 08	1.303E 09	315.37	560.00
	675.	5.055E 08	1.454E 09	319.55	604.04
	700.	5.237E 08	1.621E 09	323.74	652.78
0.200	300.	3.409E 08	3.779E 08	37.50	43.06
	350.	3.773E 08	4.463E 08	42.37	52.65
	400.	4.167E 08	5.337E 08	47.69	65.23
	450.	4.583E 08	6.456E 08	54.33	82.42
	475.	4.814E 08	7.140E 08	59.23	94.11
	500.	5.077E 08	7.932E 08	66.65	107.40
	525.	5.407E 08	8.877E 08	78.79	130.85
	550.	5.852E 08	1.003E 09	99.13	161.83
	575.	6.494E 08	1.149E 09	132.78	207.68
	600.	7.444E 08	1.336E 09	186.26	275.07
	625.	8.786E 08	1.576E 09	263.32	367.88
	650.	9.846E 08	1.800E 09	316.37	438.68
	675.	1.021E 09	1.969E 09	320.93	463.18
	700.	1.057E 09	2.154E 09	325.05	489.57

TABLE 1 (CONTD.)

P ₈	T	U	PI	CHI	PGAS/P
0.500	300.	0.0000	1.4556	2.2130	0.9645
	350.	0.0000	1.3399	2.0668	0.9404
	400.	0.0003	1.2600	1.9707	0.9088
	450.	0.0025	1.2030	1.9063	0.8701
	475.	0.0063	1.1809	1.8827	0.8485
	500.	0.0146	1.1608	1.8622	0.8259
	525.	0.0312	1.1443	1.8461	0.8030
	550.	0.0624	1.1297	1.8327	0.7807
	575.	0.1177	1.1169	1.8217	0.7602
	600.	0.2106	1.1057	1.8127	0.7432
	625.	0.3581	1.0958	1.8054	0.7314
	650.	0.5780	1.0871	1.7996	0.7257
	675.	0.8630	1.0794	1.7949	0.7246
	700.	0.9990	1.0725	1.7913	0.7116
1.000	300.	0.0000	1.7188	2.6836	0.9846
	350.	0.0000	1.5500	2.4447	0.9732
	400.	0.0001	1.4305	2.2791	0.9575
	450.	0.0013	1.3432	2.1614	0.9371
	475.	0.0033	1.3087	2.1160	0.9251
	500.	0.0076	1.2771	2.0750	0.9120
	525.	0.0162	1.2508	2.0416	0.8981
	550.	0.0326	1.2272	2.0122	0.8835
	575.	0.0615	1.2064	1.9869	0.8688
	600.	0.1104	1.1880	1.9649	0.8547
	625.	0.1891	1.1716	1.9460	0.8421
	650.	0.3099	1.1570	1.9296	0.8320
	675.	0.4864	1.1439	1.9152	0.8254
	700.	0.7255	1.1322	1.9028	0.8222
	725.	0.9657	1.1217	1.8922	0.8187
	750.	0.9999	1.1122	1.8828	0.8042
	775.	1.0000	1.1037	1.8748	0.7874
	800.	1.0000	1.0960	1.8679	0.7702

P ₈	T	PGAS	P	EGAS	E
0.500	300.	1.005E 09	1.042E 09	45.44	47.66
	350.	1.082E 09	1.150E 09	49.57	53.69
	400.	1.165E 09	1.282E 09	54.13	61.14
	450.	1.254E 09	1.442E 09	59.45	70.69
	475.	1.303E 09	1.535E 09	62.86	76.81
	500.	1.355E 09	1.640E 09	67.34	84.47
	525.	1.415E 09	1.762E 09	73.89	94.71
	550.	1.488E 09	1.906E 09	83.98	109.06
	575.	1.583E 09	2.082E 09	99.90	129.86
	600.	1.713E 09	2.305E 09	124.91	160.43
	625.	1.898E 09	2.595E 09	163.25	205.08
	650.	2.158E 09	2.973E 09	219.36	268.28
	675.	2.495E 09	3.443E 09	291.85	348.75
	700.	2.707E 09	3.803E 09	328.44	394.25
1.000	300.	2.364E 09	2.401E 09	54.94	56.05
	350.	2.493E 09	2.562E 09	58.47	60.53
	400.	2.635E 09	2.752E 09	62.40	65.90
	450.	2.790E 09	2.977E 09	66.90	72.52
	475.	2.874E 09	3.107E 09	69.61	76.58
	500.	2.960E 09	3.246E 09	72.86	81.43
	525.	3.059E 09	3.406E 09	77.29	87.70
	550.	3.171E 09	3.589E 09	83.57	96.11
	575.	3.308E 09	3.807E 09	92.95	107.93
	600.	3.483E 09	4.075E 09	107.19	124.95
	625.	3.717E 09	4.414E 09	128.70	149.61
	650.	4.039E 09	4.855E 09	160.57	185.03
	675.	4.483E 09	5.432E 09	206.17	234.62
	700.	5.073E 09	6.170E 09	267.36	300.27
	725.	5.700E 09	6.962E 09	329.36	367.22
	750.	5.935E 09	7.380E 09	341.49	384.85
	775.	6.104E 09	7.752E 09	345.36	394.80
	800.	6.273E 09	8.144E 09	349.24	405.37

TABLE 1 (CONTD.)

P ₈	T	U	PI	CHI	PCAS/P
2.000	300.	0.0000	2.0785	3.3452	0.9935
	350.	0.0000	1.8440	2.9871	0.9885
	400.	0.0001	1.6748	2.7315	0.9813
	450.	0.0007	1.5490	2.5436	0.9716
	475.	0.0017	1.4986	2.4691	0.9657
	500.	0.0039	1.4518	2.4006	0.9591
	525.	0.0085	1.4126	2.3435	0.9518
	550.	0.0170	1.3771	2.2924	0.9439
	575.	0.0321	1.3454	2.2472	0.9355
	600.	0.0577	1.3171	2.2071	0.9267
	625.	0.0991	1.2918	2.1717	0.9180
	650.	0.1632	1.2690	2.1402	0.9096
	675.	0.2589	1.2484	2.1120	0.9023
	700.	0.3958	1.2298	2.0869	0.8964
	725.	0.5826	1.2129	2.0645	0.8924
	750.	0.8145	1.1975	2.0443	0.8899
	775.	0.9889	1.1836	2.0263	0.8853
5.000	800.	1.0000	1.1709	2.0101	0.8749
	850.	1.0000	1.1486	1.9826	0.8520
	300.	0.0000	2.7342	4.5858	0.9980
	350.	0.0000	2.3905	4.0222	0.9964
	400.	0.0000	2.1383	3.6106	0.9940
	450.	0.0003	1.9474	3.3003	0.9907
	475.	0.0007	1.8699	3.1749	0.9887
	500.	0.0017	1.7973	3.0579	0.9863
	525.	0.0036	1.7358	2.9589	0.9837
	550.	0.0072	1.6797	2.8689	0.9807
	575.	0.0136	1.6292	2.7882	0.9774
	600.	0.0244	1.5835	2.7155	0.9738
	625.	0.0420	1.5423	2.6500	0.9700
	650.	0.0693	1.5048	2.5909	0.9659
	675.	0.1105	1.4706	2.5370	0.9618
	700.	0.1702	1.4394	2.4881	0.9577
	725.	0.2545	1.4108	2.4436	0.9539
2.000	750.	0.3695	1.3845	2.4028	0.9505
	775.	0.5208	1.3605	2.3657	0.9477
	800.	0.7095	1.3383	2.3316	0.9456
	850.	0.9975	1.2990	2.2718	0.9397
	900.	1.0000	1.2653	2.2210	0.9281
P ₈	T	PCAS	P	EGAS	E
2.000	300.	5.696E 09	5.733E 09	60.29	68.84
	350.	5.910E 09	5.978E 09	71.24	72.27
	400.	6.147E 09	6.264E 09	74.55	76.31
	450.	6.409E 09	6.576E 09	78.32	81.13
	475.	6.553E 09	6.786E 09	80.53	84.01
	500.	6.694E 09	6.980E 09	82.97	87.25
	525.	6.859E 09	7.205E 09	86.12	91.32
	550.	7.035E 09	7.453E 09	90.25	96.52
	575.	7.239E 09	7.738E 09	96.03	103.52
	600.	7.466E 09	8.078E 09	104.39	113.27
	625.	7.778E 09	8.495E 09	116.65	127.10
	650.	8.207E 09	9.022E 09	134.51	146.74
	675.	8.753E 09	9.702E 09	160.16	174.38
	700.	9.489E 09	1.059E 10	196.07	212.52
	725.	1.046E 10	1.173E 10	244.45	263.38
	750.	1.168E 10	1.312E 10	304.28	325.46
	775.	1.272E 10	1.436E 10	350.52	375.24
5.000	800.	1.308E 10	1.495E 10	356.88	384.95
	850.	1.373E 10	1.612E 10	364.27	400.04
	300.	1.865E 10	1.869E 10	93.32	93.55
	350.	1.906E 10	1.913E 10	95.61	96.02
	400.	1.952E 10	1.964E 10	98.20	98.90
	450.	2.004E 10	2.023E 10	101.14	102.26
	475.	2.033E 10	2.056E 10	102.85	104.24
	500.	2.059E 10	2.088E 10	104.54	106.25
	525.	2.091E 10	2.126E 10	106.70	108.78
	550.	2.124E 10	2.166E 10	109.27	111.77
	575.	2.161E 10	2.211E 10	112.56	115.56
	600.	2.202E 10	2.262E 10	116.78	120.53
	625.	2.252E 10	2.321E 10	123.09	127.27
	650.	2.311E 10	2.393E 10	131.65	136.54
	675.	2.387E 10	2.482E 10	143.62	149.31
	700.	2.484E 10	2.593E 10	160.26	166.84
	725.	2.610E 10	2.736E 10	183.03	190.60
2.000	750.	2.775E 10	2.919E 10	213.53	222.20
	775.	2.987E 10	3.152E 10	253.26	263.15
	800.	3.291E 10	3.438E 10	302.53	313.76
	850.	3.716E 10	3.955E 10	380.19	394.50
	900.	3.870E 10	4.170E 10	387.57	405.55

TABLE 1 (CONTD.)

P ₈	T	U	PI	CHI	PGAS/P
10.000	625.	0.0219	1.8185	3.1851	0.9869
	650.	0.0362	1.7668	3.0985	0.9849
	675.	0.0577	1.7194	3.0193	0.9828
	700.	0.0891	1.6758	2.9467	0.9806
	725.	0.1337	1.6359	2.8802	0.9784
	750.	0.1952	1.5988	2.8186	0.9761
	775.	0.2779	1.5648	2.7623	0.9740
	800.	0.3861	1.5331	2.7100	0.9720
	850.	0.6902	1.4767	2.6171	0.9687
	900.	0.9891	1.4278	2.5370	0.9654
	1000.	1.0000	1.3491	2.4097	0.9518
20.000	625.	0.0114	2.1913	3.9145	0.9945
	650.	0.0189	2.1221	3.7938	0.9936
	675.	0.0301	2.0583	3.6826	0.9926
	700.	0.0466	1.9996	3.5803	0.9916
	725.	0.0699	1.9454	3.4862	0.9905
	750.	0.1023	1.8949	3.3985	0.9894
	775.	0.1462	1.8485	3.3178	0.9881
	800.	0.2042	1.8051	3.2427	0.9869
	850.	0.3746	1.7272	3.1079	0.9846
	900.	0.6335	1.6591	2.9905	0.9825
	1000.	0.9999	1.5475	2.7988	0.9774
50.000	625.	0.0048	2.8650	5.2436	0.9983
	650.	0.0080	2.7664	5.0648	0.9980
	675.	0.0127	2.6752	4.8996	0.9977
	700.	0.0197	2.5909	4.7470	0.9974
	725.	0.0296	2.5130	4.6060	0.9970
	750.	0.0434	2.4400	4.4741	0.9966
	775.	0.0620	2.3727	4.3523	0.9961
	800.	0.0869	2.3096	4.2383	0.9957
	850.	0.1609	2.1956	4.0326	0.9947
	900.	0.2783	2.0954	3.8517	0.9936
	1000.	0.6901	1.9291	3.5524	0.9916

P ₈	T	PGAS	P	EGAS	E
10.000	625.	5.243E 10	5.312E 10	140.77	142.87
	650.	5.327E 10	5.409E 10	145.87	148.32
	675.	5.429E 10	5.524E 10	152.79	155.63
	700.	5.553E 10	5.663E 10	162.19	165.48
	725.	5.711E 10	5.837E 10	174.91	178.70
	750.	5.910E 10	6.055E 10	191.89	196.23
	775.	6.165E 10	6.330E 10	214.27	219.21
	800.	6.489E 10	6.676E 10	243.14	248.76
	850.	7.391E 10	7.630E 10	323.51	330.66
	900.	8.369E 10	8.669E 10	403.97	412.96
	1000.	8.976E 10	9.433E 10	419.59	433.30
20.000	625.	1.254E 11	1.261E 11	168.93	169.98
	650.	1.266E 11	1.275E 11	172.11	173.33
	675.	1.281E 11	1.290E 11	176.24	177.66
	700.	1.298E 11	1.309E 11	181.70	183.34
	725.	1.318E 11	1.331E 11	188.93	190.83
	750.	1.343E 11	1.357E 11	198.43	200.60
	775.	1.374E 11	1.391E 11	210.88	213.35
	800.	1.413E 11	1.432E 11	226.94	229.75
	850.	1.522E 11	1.545E 11	273.08	276.66
	900.	1.684E 11	1.714E 11	342.24	346.74
	1000.	1.973E 11	2.019E 11	445.75	452.60
50.000	625.	4.073E 11	4.080E 11	223.24	223.66
	650.	4.095E 11	4.104E 11	225.07	225.55
	675.	4.119E 11	4.129E 11	227.30	227.87
	700.	4.146E 11	4.157E 11	230.12	230.70
	725.	4.178E 11	4.190E 11	233.73	234.48
	750.	4.213E 11	4.227E 11	238.28	239.15
	775.	4.256E 11	4.273E 11	244.15	245.14
	800.	4.308E 11	4.327E 11	251.60	252.72
	850.	4.446E 11	4.470E 11	272.81	274.24
	900.	4.651E 11	4.681E 11	305.31	307.11
	1000.	5.362E 11	5.408E 11	417.48	420.22

TABLE 2 HELIUM-NEUTRON-PROTON STAGE *

P_8	T	Y	PI	CHI	PGAS/P
0.100	700.	0.9271	1.0159	1.6866	0.3234
	750.	0.9184	1.0132	1.6978	0.2812
	800.	0.8463	1.0110	1.7085	0.2559
	850.	0.6183	1.0093	1.7188	0.2563
	900.	0.0908	1.0080	1.7286	0.2875
0.200	700.	0.9275	1.0310	1.7144	0.4909
	750.	0.9264	1.0258	1.7212	0.4389
	800.	0.9121	1.0217	1.7284	0.3946
	850.	0.8302	1.0184	1.7358	0.3687
	900.	0.6152	1.0157	1.7432	0.3686
0.500	700.	0.9276	1.0725	1.7913	0.7118
	750.	0.9275	1.0609	1.7866	0.6660
	800.	0.9265	1.0516	1.7844	0.6206
	850.	0.9169	1.0441	1.7841	0.5781
	900.	0.8655	1.0379	1.7851	0.5466

P_8	T	PGAS	P	EGAS	E
0.100	700.	5.242E 08	1.621E 09	324.42	653.46
	750.	5.654E 08	2.011E 09	339.52	773.13
	800.	6.436E 08	2.515E 09	403.40	964.72
	850.	8.219E 08	3.206E 09	588.62	1304.00
	900.	1.210E 09	4.207E 09	1009.46	1908.60
0.200	700.	1.057E 09	2.154E 09	325.40	489.92
	750.	1.131E 09	2.576E 09	334.59	551.40
	800.	1.219E 09	3.091E 09	353.90	634.56
	850.	1.393E 09	3.777E 09	425.74	783.42
	900.	1.750E 09	4.747E 09	602.13	1051.70
0.500	700.	2.709E 09	3.805E 09	328.98	394.78
	750.	2.883E 09	4.328E 09	337.02	423.74
	800.	3.061E 09	4.932E 09	345.89	458.16
	850.	3.267E 09	5.652E 09	361.51	504.59
	900.	3.613E 09	6.610E 09	409.86	589.69

* P_8 in units of 10^8 grams/cm³; T in kilovolts; P, P_{gas} in units of 10^{16} dynes/cm²; E, E_{gas} in units of 10^{16} ergs/gram.

TABLE 2 (CONTD.)

P ₈	T	Y	PI	CHI	PGAS/P
1.000	850.	0.9262	1.0826	1.8569	0.7353
	900.	0.9167	1.0715	1.8488	0.7011
	1000.	0.7605	1.0546	1.8392	0.6597
	1200.	0.0136	1.0336	1.8349	0.6412
	1500.	0.0000	1.0180	1.8437	0.4783
	2000.	0.0000	1.0079	1.8657	0.2783
	3000.	0.0000	1.0023	1.9005	0.1024
	4000.	0.0000	1.0010	1.9220	0.0459
	5000.	0.0000	1.0005	1.9361	0.0240
	7000.	0.0000	1.0001	1.9533	0.0089
	10000.	0.0000	1.0000	1.9667	0.0031
	20000.	0.0000	1.0000	1.9721	0.0004
2.000	850.	0.9274	1.1406	1.8926	0.8521
	900.	0.9261	1.1299	1.9602	0.8270
	1000.	0.8867	1.1009	1.9279	0.7813
	1200.	0.0818	1.0636	1.8929	0.7770
	1500.	0.0004	1.0349	1.8766	0.6483
	2000.	0.0000	1.0156	1.8808	0.4360
	3000.	0.0000	1.0047	1.9052	0.1858
	4000.	0.0000	1.0020	1.9241	0.0878
	5000.	0.0000	1.0010	1.9372	0.0469
	7000.	0.0000	1.0003	1.9537	0.0176
	10000.	0.0000	1.0001	1.9669	0.0061
	20000.	0.0000	1.0000	1.9722	0.0008
5.000	850.	0.9276	1.2990	2.2718	0.9398
	900.	0.9275	1.2653	2.2210	0.9282
	1000.	0.9242	1.2117	2.1420	0.9018
	1200.	0.6850	1.1396	2.0404	0.8610
	1500.	0.0059	1.0802	1.9650	0.8234
	2000.	0.0000	1.0373	1.9236	0.6605
	3000.	0.0000	1.0118	1.9191	0.3638
	4000.	0.0000	1.0050	1.9301	0.1940
	5000.	0.0000	1.0026	1.9403	0.1097
	7000.	0.0000	1.0009	1.9548	0.0429
	10000.	0.0000	1.0003	1.9673	0.0152
	20000.	0.0000	1.0001	1.9724	0.0019
P ₈	T	PGAS	P	EGAS	E
1.000	850.	6.625E 09	9.010E 09	358.50	430.04
	900.	7.031E 09	1.003E 10	373.85	463.77
	1000.	8.855E 09	1.342E 10	513.44	650.48
	1200.	1.693E 10	2.640E 10	1155.63	1439.80
	1500.	2.120E 10	4.433E 10	1247.64	1941.42
	2000.	2.818E 10	1.013E 11	1384.43	3577.12
	3000.	4.219E 10	4.122E 11	1660.51	12760.99
	4000.	5.624E 10	1.226E 12	1937.69	37020.70
	5000.	7.028E 10	2.925E 12	2215.28	87867.15
	7000.	9.838E 10	1.107E 13	2770.97	331811.18
	10000.	1.405E 11	4.502E 13	3604.84	1374034.69
	20000.	2.811E 11	7.312E 14	6370.64	21933248.25
2.000	850.	1.374E 10	1.612E 10	364.72	400.49
	900.	1.441E 10	1.741E 10	373.23	418.19
	1000.	1.632E 10	2.089E 10	419.79	488.31
	1200.	3.301E 10	4.248E 10	1105.04	1747.12
	1500.	4.262E 10	6.575E 10	1250.68	1597.57
	2000.	5.650E 10	1.296E 11	1386.46	2482.80
	3000.	8.445E 10	4.545E 11	1661.46	7211.70
	4000.	1.125E 11	1.282E 12	1938.26	19479.76
	5000.	1.406E 11	2.996E 12	2215.65	45041.59
	7000.	1.968E 11	1.110E 13	2771.16	167291.27
	10000.	2.811E 11	4.596E 13	3604.98	688819.91
	20000.	5.622E 11	7.315E 14	6370.77	10969809.62
5.000	850.	3.721E 10	3.959E 10	381.12	395.43
	900.	3.072E 10	4.171E 10	387.95	405.93
	1000.	4.194E 10	4.650E 10	404.60	432.00
	1200.	5.866E 10	6.813E 10	628.00	684.83
	1500.	1.078E 11	1.309E 11	1254.98	1393.74
	2000.	1.422E 11	2.153E 11	1392.20	1830.74
	3000.	2.116E 11	5.816E 11	1664.26	3884.36
	4000.	2.815E 11	1.451E 12	1939.87	4956.68
	5000.	3.517E 11	3.207E 12	2216.70	19347.07
	7000.	4.920E 11	1.146E 13	2771.68	68579.72
	10000.	7.028E 11	4.638E 13	3605.25	277691.21
	20000.	1.405E 12	7.323E 14	6371.04	4391746.50

TABLE 2 (CONTD.)

P _g	T	Y	PI	CHI	PGAS/P
10.000	850.	0.9276	1.4767	2.6171	0.9715
	900.	0.9276	1.4278	2.5370	0.9655
	1000.	0.9272	1.3491	2.4097	0.9516
	1200.	0.8587	1.2390	2.2345	0.9192
	1500.	0.0406	1.1435	2.0893	0.9033
	2000.	0.0001	1.0700	1.9881	0.7972
	3000.	0.0000	1.0230	1.9415	0.5344
	4000.	0.0000	1.0100	1.9400	0.3254
	5000.	0.0000	1.0052	1.9455	0.1978
	7000.	0.0000	1.0019	1.9567	0.0824
	10000.	0.0000	1.0006	1.9679	0.0299
	20000.	0.0000	1.0003	1.9728	0.0038
20.000	850.	0.9276	1.7272	3.1079	0.9870
	900.	0.9276	1.6591	2.9905	0.9842
	1000.	0.9276	1.5475	2.7988	0.9774
	1200.	0.9151	1.3885	2.5282	0.9591
	1500.	0.1760	1.2445	2.2881	0.9474
	2000.	0.0010	1.1264	2.0996	0.8889
	3000.	0.0000	1.0441	1.9833	0.6980
	4000.	0.0000	1.0197	1.9593	0.4917
	5000.	0.0000	1.0103	1.9557	0.3306
	7000.	0.0000	1.0038	1.9606	0.1523
	10000.	0.0000	1.0013	1.9693	0.0580
	20000.	0.0000	1.0007	1.9736	0.0076
50.000	850.	0.9276	2.1956	4.0326	0.9956
	900.	0.9276	2.0954	3.8517	0.9946
	1000.	0.9276	1.9291	3.5524	0.9922
	1200.	0.9267	1.6865	3.1172	0.9852
	1500.	0.8040	1.4574	2.7093	0.9711
	2000.	0.0141	1.2561	2.3565	0.9538
	3000.	0.0000	1.0991	2.0926	0.8546
	4000.	0.0000	1.0466	2.0129	0.7092
	5000.	0.0000	1.0250	1.9851	0.5537
	7000.	0.0000	1.0094	1.9718	0.3103
	10000.	0.0000	1.0032	1.9732	0.1334
	20000.	0.0000	1.0018	1.9759	0.0189
P _g	T	PGAS	P	EGAS	E
10.000	850.	8.119E 10	8.357E 10	400.86	408.01
	900.	8.399E 10	8.699E 10	407.02	416.01
	1000.	8.982E 10	9.439E 10	420.25	433.95
	1200.	1.077E 11	1.172E 11	502.84	531.26
	1500.	2.161E 11	2.392E 11	1238.24	1307.62
	2000.	2.874E 11	3.604E 11	1400.79	1620.06
	3000.	4.247E 11	7.947E 11	1668.78	2778.83
	4000.	5.640E 11	1.733E 12	1942.54	5450.84
	5000.	7.039E 11	3.559E 12	2218.45	10783.63
	7000.	9.844E 11	1.195E 13	2772.57	35676.60
	10000.	1.406E 12	4.709E 13	3605.65	140648.63
	20000.	2.811E 12	7.337E 14	6371.58	2199059.34
20.000	850.	1.815E 11	1.839E 11	428.92	432.50
	900.	1.866E 11	1.896E 11	434.47	438.96
	1000.	1.974E 11	2.020E 11	446.12	452.98
	1200.	2.219E 11	2.314E 11	480.79	495.00
	1500.	4.167E 11	4.399E 11	1144.16	1178.85
	2000.	5.846E 11	6.577E 11	1415.05	1524.68
	3000.	8.551E 11	1.225E 12	1677.22	2232.24
	4000.	1.131E 12	2.301E 12	1947.73	3701.88
	5000.	1.410E 12	4.265E 12	2221.88	6504.47
	7000.	1.970E 12	1.294E 13	2774.41	19226.42
	10000.	2.812E 12	4.849E 13	3606.59	72128.08
	20000.	5.623E 12	7.365E 14	6372.66	1102716.55
50.000	850.	5.430E 11	5.453E 11	481.80	483.23
	900.	5.547E 11	5.577E 11	486.61	488.41
	1000.	5.790E 11	5.836E 11	496.78	499.52
	1200.	6.299E 11	6.394E 11	518.93	524.62
	1500.	7.762E 11	7.994E 11	657.34	671.22
	2000.	1.510E 12	1.583E 12	1437.83	1481.68
	3000.	2.175E 12	2.545E 12	1699.26	1721.27
	4000.	2.853E 12	4.022E 12	1962.15	2663.81
	5000.	3.542E 12	6.397E 12	2231.77	3944.80
	7000.	4.934E 12	1.590E 13	2779.68	3960.49
	10000.	7.034E 12	5.272E 13	3609.22	31017.81
	20000.	1.406E 13	7.450E 14	6375.75	444913.30

TABLE 2 (CONTD.)

P ₈	T	Y	PI	CHI	PGAS/P
100,000	1000.	0.9276	2.3309	4.3496	0.9966
	1200.	0.9275	2.0000	3.7552	0.9934
	1500.	0.9006	1.6963	3.1837	0.9858
	2000.	0.0839	1.4120	2.6663	0.9767
	3000.	0.0002	1.1738	2.2413	0.9232
	4000.	0.0000	1.0862	2.0918	0.8316
	5000.	0.0000	1.0478	2.0305	0.7142
	7000.	0.0000	1.0185	1.9900	0.4743
	10000.	0.0000	1.0065	1.9797	0.2357
	20000.	0.0000	1.0037	1.9797	0.0371
200,000	1000.	0.9276	2.8558	5.3939	0.9986
	1200.	0.9276	2.4337	4.6022	0.9972
	1500.	0.9236	2.0203	3.8285	0.9936
	2000.	0.5993	1.6328	3.1059	0.9857
	3000.	0.0014	1.2898	2.4725	0.9614
	4000.	0.0000	1.1528	2.2246	0.9098
	5000.	0.0000	1.0882	2.1111	0.8350
	7000.	0.0000	1.0357	2.0244	0.6447
	10000.	0.0000	1.0128	1.9924	0.3819
	20000.	0.0000	1.0075	1.9872	0.0716
500,000	1000.	0.9276	3.7888	7.2539	0.9995
	1200.	0.9276	3.1989	6.1279	0.9991
	1500.	0.9273	2.6136	5.0114	0.9979
	2000.	0.8603	2.0518	3.9414	0.9942
	3000.	0.0201	1.5289	2.9494	0.9851
	4000.	0.0006	1.3018	2.5219	0.9634
	5000.	0.0001	1.1855	2.3055	0.9287
	7000.	0.0000	1.0815	2.1159	0.8215
	10000.	0.0000	1.0310	2.0287	0.6084
	20000.	0.0000	1.0184	2.0090	0.1621

P ₈	T	PGAS	P	EGAS	E
100,000	1000.	1.338E 12	1.343E 12	550.41	551.78
	1200.	1.432E 12	1.442E 12	569.82	572.66
	1500.	1.609E 12	1.633E 12	623.81	630.75
	2000.	3.060E 12	3.133E 12	1416.94	1438.86
	3000.	4.450E 12	4.820E 12	1729.11	1840.12
	4000.	5.776E 12	6.946E 12	1983.38	2334.21
	5000.	7.134E 12	9.989E 12	2247.04	3103.55
	7000.	9.896E 12	2.006E 13	2788.25	6078.66
	10000.	1.408E 13	5.976E 13	3613.59	17317.89
	20000.	2.814E 13	7.590E 14	6380.86	225649.64
200,000	1000.	3.147E 12	3.152E 12	620.66	621.34
	1200.	3.322E 12	3.332E 12	638.12	639.54
	1500.	3.605E 12	3.628E 12	669.46	672.93
	2000.	5.041E 12	5.114E 12	1013.96	1024.92
	3000.	9.207E 12	9.577E 12	1774.55	1830.06
	4000.	1.179E 13	1.296E 13	2019.08	2194.50
	5000.	1.445E 13	1.731E 13	2274.14	2702.40
	7000.	1.990E 13	3.087E 13	2804.45	4449.65
	10000.	2.822E 13	7.390E 13	3622.13	10474.28
	20000.	5.635E 13	7.872E 14	6390.96	116025.34
500,000	1000.	9.960E 12	9.965E 12	745.78	746.06
	1200.	1.037E 13	1.037E 13	761.27	761.84
	1500.	1.099E 13	1.101E 13	785.68	787.06
	2000.	1.261E 13	1.269E 13	892.35	896.73
	3000.	2.442E 13	2.479E 13	1851.99	1874.19
	4000.	3.081E 13	3.198E 13	2098.49	2168.65
	5000.	3.722E 13	4.007E 13	2339.47	2510.78
	7000.	5.047E 13	6.144E 13	2847.54	3505.62
	10000.	7.097E 13	1.166E 14	3646.55	6387.41
	20000.	1.414E 14	8.723E 14	6420.29	50274.04

TABLE 2 (CONTD.)

P _g	T	Y	PI	CHI	PGAS/P
1000.000	1000.	0.9276	4.7244	9.1217	0.9998
	1200.	0.9276	3.9713	7.6698	0.9996
	1500.	0.9276	3.2195	6.2209	0.9991
	2000.	0.9155	2.4897	4.8156	0.9974
	3000.	0.1095	1.7930	3.4767	0.9927
	4000.	0.0045	1.4770	2.8719	0.9822
	5000.	0.0004	1.3073	2.5486	0.9643
	7000.	0.0000	1.1451	2.2429	0.9037
	10000.	0.0000	1.0585	2.0838	0.7581
	20000.	0.0000	1.0356	2.0433	0.2800
2000.000	1000.	0.9276	5.9131	11.4962	0.9999
	1200.	0.9276	4.9561	9.6371	0.9998
	1500.	0.9276	3.9970	7.7742	0.9996
	2000.	0.9260	3.0589	5.9529	0.9989
	3000.	0.6525	2.1479	4.1858	0.9958
	4000.	0.0320	1.7219	3.3611	0.9915
	5000.	0.0032	1.4848	2.7033	0.9827
	7000.	0.0001	1.2458	2.4442	0.9508
	10000.	0.0000	1.1067	2.1799	0.8642
	20000.	0.0000	1.0668	2.1056	0.4400
5000.000	1000.	0.9276	7.9841	15.6353	1.0000
	1200.	0.9276	6.6765	13.0755	1.0000
	1500.	0.9276	5.3618	10.5018	0.9999
	2000.	0.9275	4.0681	7.9697	0.9997
	3000.	0.8768	2.7936	5.4763	0.9984
	4000.	0.2150	2.1815	4.2797	0.9967
	5000.	0.0428	1.8300	3.5933	0.9935
	7000.	0.0022	1.4575	2.8673	0.9809
	10000.	0.0001	1.2196	2.4058	0.9427
	20000.	0.0000	1.1444	2.2609	0.6679

P _g	T	PGAS	P	EGAS	E
1000.000	1000.	2.412E 13	2.412E 13	871.43	871.57
	1200.	2.489E 13	2.490E 13	885.74	886.03
	1500.	2.605E 13	2.607E 13	907.53	908.22
	2000.	2.836E 13	2.844E 13	960.49	962.68
	3000.	5.049E 13	5.085E 13	1868.63	1879.73
	4000.	6.465E 13	6.582E 13	2188.32	2223.41
	5000.	7.715E 13	8.000E 13	2420.81	2506.46
	7000.	1.029E 14	1.139E 14	2907.32	3236.36
	10000.	1.432E 14	1.888E 14	3683.62	5054.05
	20000.	2.843E 14	1.015E 15	6466.43	28393.31
2000.000	1000.	5.890E 13	5.890E 13	1031.17	1031.24
	1200.	6.037E 13	6.038E 13	1044.55	1044.70
	1500.	6.256E 13	6.259E 13	1064.25	1064.59
	2000.	6.664E 13	6.671E 13	1104.13	1105.22
	3000.	8.719E 13	9.756E 13	1466.59	1472.14
	4000.	1.365E 14	1.377E 14	2289.36	2306.90
	5000.	1.621E 14	1.649E 14	2536.69	2579.51
	7000.	2.122E 14	2.231E 14	3001.93	3166.45
	10000.	2.907E 14	3.363E 14	3748.25	4433.47
	20000.	5.742E 14	1.305E 15	6550.26	17513.69
5000.000	1000.	1.937E 14	1.937E 14	1309.62	1309.64
	1200.	1.972E 14	1.972E 14	1322.12	1322.18
	1500.	2.023E 14	2.023E 14	1339.48	1339.62
	2000.	2.117E 14	2.118E 14	1374.10	1374.54
	3000.	2.373E 14	2.377E 14	1501.85	1504.07
	4000.	3.563E 14	3.574E 14	2333.17	2340.14
	5000.	4.368E 14	4.396E 14	2720.59	2737.72
	7000.	5.632E 14	5.741E 14	3198.20	3264.01
	10000.	7.519E 14	7.976E 14	3900.00	4174.08
	20000.	1.470E 15	2.201E 15	6759.20	11144.57

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