

Supplementary Materials for

Gibbs Quantum Fields Computed by Action Mechanics Recycle Emissions Absorbed by Greenhouse Gases, Optimising the Elevation of the Troposphere and Surface Temperature Using the Virial Theorem

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Entropy8/Cal, a Windows TRS32 Matthew Reed Emulator Astrocal program for calculation of translational, rotational and vibrational entropy and Gibbs energy of gases in the Earth's atmosphere is available as supplementary materials for the following reference or from the senior author.

Kennedy, I.R.; Hodzic, M. Partitioning entropy with action mechanics: predicting chemical reaction rates and gaseous equilibria of reactions of hydrogen from molecular properties. *Entropy* **2021**, *23*, 1056. <https://doi.org/10.3390/e23081056>.

All code is produced in Vernon Hester's program Astrocal for TRS80 microcomputer, based on Texas Instruments SR52 programmable logic. Programs can easily be prepared in other software, such as R, Mathematica or Python.

Please contact ivan.kennedy@sydney.edu.au or at www.ackle.au for further information, raw data used in figures and suggestions for improvements or reports of errors.

Figure S1

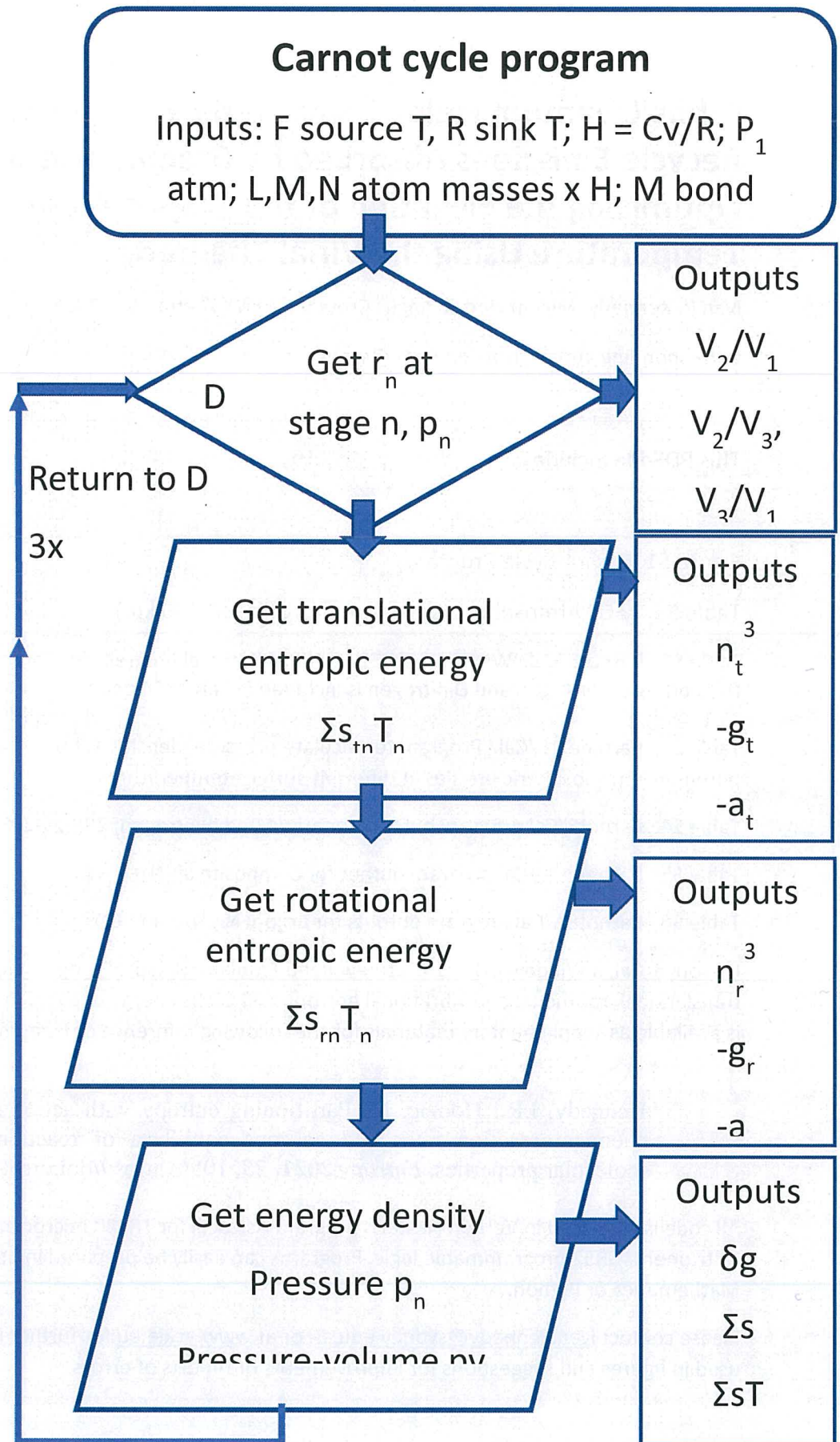


Table S1

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AFGL Atmospheric Constituent Profiles (0-120km)

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15 May 1986



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AFGL Atmospheric Constituent Profiles (0-120km)

1. INTRODUCTION

Atmospheric radiance-transmittance spectral modeling requires an adequate description of the local thermal and constituent environment. A data base consisting of realistic vertical profiles for temperature and gas mixing ratios has been designed expressly for incorporation into such models. Its thermal structure is represented by a subset of the 1966 Atmospheric Supplements¹ (tropical (15N), middle latitude (45N) summer and winter, subarctic (60N) summer and winter) and the U.S. Standard Model Atmosphere, 1976². The accompanying volume mixing ratio profiles rely as much as possible on current measurements and/or theoretical predictions (see Appendix B).

(Received for publication 14 May 1986)

1. NASA (1966), U.S. Standard Atmosphere Supplements, 1966, U.S. Government Printing Office, Washington, DC.
2. NASA (1976), U.S. Standard Atmosphere Supplements, 1976, U.S. Government Printing Office, Washington, DC.

2. ATMOSPHERIC PROFILE DESCRIPTION

The six reference atmospheres, each with associated volume mixing ratio profiles for H_2O , O_3 , N_2O , CO , and CH_4 , are presented in Table 1. Along with CO_2 , these are the most radiatively active molecules. Sample profiles, appropriate for the U. S. Standard atmosphere conditions (Model 6), are shown in Figure 1. Because the mixing ratios of CO_2 and O_2 have been held seasonally invariant, they are listed in Table 2, as part of a set of single profiles numbered according to the AFGL Line Atlas^{6, 7} numbering system; i.e. H_2O is 1, CO_2 is 2, etc. The first seven molecules in Table 2 are the same as those in Figure 1 for the U.S. Standard Atmosphere. The 21 additional species, as identified on the AFGL trace gas compilation⁷, are; NO , SO_2 , NO_2 , NH_3 , HNO_3 , OH , HF , HCl , HBr , HI , ClO , OCS , H_2CO , HOCl , N_2 , HCN , CH_3Cl , H_2O_2 , C_2H_2 , C_2H_6 , and PH_3 . Graphical representations for all the tabular data are available in Appendix A. (Note: although N_2 is the dominant atmospheric gas, it appears as only a trace spectral contributor.)

Table 1b. Reference Atmospheric Model Profiles, Model 2. Midlatitude Summer

MODEL = 2 MIDLATITUDE SUMMER								
ALT (KM)	PRES (MB)	TEMP (K)	DENSITY (CM-3)	H2O (PPMV)	O3 (PPMV)	N2O (PPMV)	CO (PPMV)	CH4 (PPMV)
0.00	1.013E+03	294.2	2.496E+19	1.88E+04	3.02E-02	3.20E-01	1.50E-01	1.70E+00
1.00	9.020E+02	289.7	2.257E+19	1.38E+04	3.34E-02	3.20E-01	1.45E-01	1.70E+00
2.00	8.020E+02	285.2	2.038E+19	9.68E+03	3.69E-02	3.20E-01	1.40E-01	1.70E+00
3.00	7.100E+02	279.2	1.843E+19	5.98E+03	4.22E-02	3.20E-01	1.35E-01	1.70E+00
4.00	6.280E+02	273.2	1.666E+19	3.81E+03	4.82E-02	3.20E-01	1.31E-01	1.70E+00
5.00	5.540E+02	267.2	1.503E+19	2.23E+03	5.51E-02	3.20E-01	1.30E-01	1.69E+00
6.00	4.870E+02	261.2	1.351E+19	1.51E+03	6.41E-02	3.20E-01	1.29E-01	1.67E+00
7.00	4.260E+02	254.7	1.212E+19	1.02E+03	7.76E-02	3.20E-01	1.25E-01	1.65E+00
8.00	3.720E+02	248.2	1.086E+19	6.46E+02	9.13E-02	3.20E-01	1.19E-01	1.63E+00
9.00	3.240E+02	241.7	9.716E+18	4.13E+02	1.11E-01	3.16E-01	1.09E-01	1.62E+00
10.00	2.810E+02	235.3	8.656E+18	2.47E+02	1.30E-01	3.10E-01	9.96E-02	1.58E+00
11.00	2.430E+02	228.8	7.698E+18	9.56E+01	1.79E-01	2.99E-01	8.96E-02	1.54E+00
12.00	2.090E+02	222.3	6.814E+18	2.94E+01	2.23E-01	2.94E-01	7.81E-02	1.51E+00
13.00	1.790E+02	215.8	6.012E+18	8.00E+00	3.00E-01	2.86E-01	6.37E-02	1.48E+00
14.00	1.530E+02	215.7	5.141E+18	5.00E+00	4.40E-01	2.80E-01	5.03E-02	1.45E+00
15.00	1.300E+02	215.7	4.368E+18	3.40E+00	5.00E-01	2.72E-01	3.94E-02	1.42E+00
16.00	1.110E+02	215.7	3.730E+18	3.30E+00	6.00E-01	2.61E-01	3.07E-02	1.39E+00
17.00	9.500E+01	215.7	3.192E+18	3.20E+00	7.00E-01	2.42E-01	2.49E-02	1.36E+00
18.00	8.120E+01	216.8	2.715E+18	3.15E+00	1.00E+00	2.17E-01	1.97E-02	1.32E+00
19.00	6.950E+01	217.9	2.312E+18	3.20E+00	1.50E+00	1.84E-01	1.55E-02	1.28E+00
20.00	5.950E+01	219.2	1.967E+18	3.30E+00	2.00E+00	1.61E-01	1.33E-02	1.22E+00
21.00	5.100E+01	220.4	1.677E+18	3.45E+00	2.40E+00	1.32E-01	1.23E-02	1.15E+00
22.00	4.370E+01	221.6	1.429E+18	3.60E+00	2.90E+00	1.15E-01	1.23E-02	1.07E+00
23.00	3.760E+01	222.8	1.223E+18	3.85E+00	3.40E+00	1.04E-01	1.31E-02	9.73E-01
24.00	3.220E+01	223.9	1.042E+18	4.00E+00	4.00E+00	9.62E-02	1.40E-02	8.80E-01
25.00	2.770E+01	225.1	8.919E+17	4.20E+00	4.80E+00	8.96E-02	1.52E-02	7.89E-01
27.50	1.907E+01	228.5	6.050E+17	4.45E+00	6.00E+00	8.01E-02	1.72E-02	7.05E-01
30.00	1.320E+01	233.7	4.094E+17	4.70E+00	7.00E+00	6.70E-02	2.00E-02	6.32E-01
32.50	9.300E+00	239.0	2.820E+17	4.85E+00	8.10E+00	4.96E-02	2.27E-02	5.59E-01
35.00	6.520E+00	245.2	1.927E+17	4.95E+00	8.90E+00	3.70E-02	2.49E-02	5.01E-01
37.50	4.640E+00	251.3	1.338E+17	5.00E+00	8.70E+00	2.52E-02	2.72E-02	4.45E-01
40.00	3.330E+00	257.5	9.373E+16	5.10E+00	7.55E+00	1.74E-02	2.96E-02	3.92E-01
42.50	2.410E+00	263.7	6.624E+16	5.30E+00	5.90E+00	1.16E-02	3.14E-02	3.39E-01
45.00	1.760E+00	269.9	4.726E+16	5.45E+00	4.50E+00	7.67E-03	3.31E-02	2.87E-01
47.50	1.290E+00	275.2	3.398E+16	5.50E+00	3.50E+00	5.32E-03	3.49E-02	2.38E-01
50.00	9.510E-01	275.7	2.500E+16	5.50E+00	2.80E+00	3.22E-03*	3.65E-02	1.94E-01
55.00	5.150E-01	269.3	1.386E+16	5.35E+00	1.80E+00	2.03E-03	3.92E-02	1.57E-01
60.00	2.720E-01	257.1	7.668E+15	5.00E+00	1.30E+00	1.40E-03	4.67E-02	1.50E-01
65.00	1.390E-01	240.1	4.196E+15	4.40E+00	8.00E-01	1.02E-03	6.40E-02	1.50E-01
70.00	6.700E-02	218.1	2.227E+15	3.70E+00	4.00E-01	7.77E-04	1.18E-01	1.50E-01
75.00	3.000E-02	196.1	1.109E+15	2.95E+00	1.90E-01	6.26E-04	2.94E-01	1.50E-01
80.00	1.200E-02	174.1	4.996E+14	2.10E+00	2.00E-01	5.17E-04	6.82E-01	1.50E-01
85.00	4.480E-03	165.1	1.967E+14	1.33E+00	5.70E-01	4.35E-04	1.47E+00	1.50E-01
90.00	1.640E-03	165.0	7.204E+13	8.50E-01	7.50E-01	3.73E-04	2.85E+00	1.40E-01
95.00	6.250E-04	178.3	2.541E+13	5.40E-01	7.00E-01	3.24E-04	5.17E+00	1.30E-01
100.00	2.580E-04	190.5	9.816E+12	4.00E-01	4.00E-01	2.84E-04	1.01E+01	1.20E-01
105.00	1.170E-04	222.2	3.816E+12	3.40E-01	2.00E-01	2.52E-04	1.87E+01	1.10E-01
110.00	6.110E-05	262.4	1.688E+12	2.80E-01	5.00E-02	2.26E-04	2.86E+01	9.50E-02
115.00	3.560E-05	316.8	8.145E+11	2.40E-01	5.00E-03	2.04E-04	3.89E+01	6.00E-02
120.00	2.270E-05	380.0	4.330E+11	2.00E-01	5.00E-04	1.85E-04	5.00E+01	3.00E-02

Table 1d. Reference Atmospheric Model Profiles, Model 4. Subarctic Summer

MODEL = 4 SUBARCTIC SUMMER								
ALT (KM)	PRES (MB)	TEMP (K)	DENSITY (CM-3)	H2O (PPMV)	O3 (PPMV)	N2O (PPMV)	CO (PPMV)	CH4 (PPMV)
0.00	1.010E+03	287.2	2.549E+19	1.19E+04	2.41E-02	3.10E-01	1.50E-01	1.70E+00
1.00	8.960E+02	281.7	2.305E+19	8.70E+03	2.94E-02	3.10E-01	1.45E-01	1.70E+00
2.00	7.929E+02	276.3	2.080E+19	6.75E+03	3.38E-02	3.10E-01	1.40E-01	1.70E+00
3.00	7.000E+02	270.9	1.873E+19	4.82E+03	3.89E-02	3.10E-01	1.35E-01	1.70E+00
4.00	6.160E+02	265.5	1.682E+19	3.38E+03	4.48E-02	3.08E-01	1.31E-01	1.70E+00
5.00	5.410E+02	260.1	1.508E+19	2.22E+03	5.33E-02	3.02E-01	1.30E-01	1.69E+00
6.00	4.740E+02	253.1	1.357E+19	1.33E+03	6.56E-02	2.91E-01	1.29E-01	1.67E+00
7.00	4.130E+02	246.1	1.216E+19	7.97E+02	7.74E-02	2.82E-01	1.25E-01	1.65E+00
8.00	3.590E+02	239.2	1.088E+19	4.00E+02	9.11E-02	2.76E-01	1.19E-01	1.63E+00
9.00	3.108E+02	232.2	9.701E+18	1.30E+02	1.42E-01	2.70E-01	1.09E-01	1.62E+00
10.00	2.677E+02	225.2	8.616E+18	4.24E+01	1.89E-01	2.65E-01	9.96E-02	1.58E+00
11.00	2.300E+02	225.2	7.402E+18	1.33E+01	3.05E-01	2.60E-01	8.96E-02	1.54E+00
12.00	1.977E+02	225.2	6.363E+18	6.00E+00	4.10E-01	2.55E-01	7.81E-02	1.51E+00
13.00	1.700E+02	225.2	5.471E+18	4.45E+00	5.00E-01	2.49E-01	6.37E-02	1.47E+00
14.00	1.460E+02	225.2	4.699E+18	4.00E+00	6.00E-01	2.43E-01	5.03E-02	1.43E+00
15.00	1.260E+02	225.2	4.055E+18	4.00E+00	7.00E-01	2.36E-01	3.94E-02	1.39E+00
16.00	1.080E+02	225.2	3.476E+18	4.00E+00	8.50E-01	2.28E-01	3.07E-02	1.34E+00
17.00	9.280E+01	225.2	2.987E+18	4.05E+00	1.00E+00	2.18E-01	2.49E-02	1.29E+00
18.00	7.980E+01	225.2	2.568E+18	4.30E+00	1.30E+00	2.04E-01	1.97E-02	1.23E+00
19.00	6.860E+01	225.2	2.208E+18	4.50E+00	1.70E+00	1.82E-01	1.55E-02	1.16E+00
20.00	5.900E+01	225.2	1.899E+18	4.60E+00	2.10E+00	1.57E-01	1.33E-02	1.07E+00
21.00	5.070E+01	225.2	1.632E+18	4.70E+00	2.70E+00	1.35E-01	1.23E-02	9.90E-01
22.00	4.360E+01	225.2	1.403E+18	4.80E+00	3.30E+00	1.22E-01	1.23E-02	9.17E-01
23.00	3.750E+01	225.2	1.207E+18	4.83E+00	3.70E+00	1.10E-01	1.31E-02	8.57E-01
24.00	3.228E+01	226.6	1.033E+18	4.85E+00	4.20E+00	9.89E-02	1.40E-02	8.01E-01
25.00	2.780E+01	228.1	8.834E+17	4.90E+00	4.50E+00	8.78E-02	1.51E-02	7.48E-01
27.50	1.923E+01	231.0	6.034E+17	4.95E+00	5.30E+00	7.33E-02	1.65E-02	6.96E-01
30.00	1.340E+01	235.1	4.131E+17	5.00E+00	5.70E+00	5.94E-02	1.81E-02	6.44E-01
32.50	9.400E+00	240.0	2.839E+17	5.00E+00	6.90E+00	4.15E-02	2.00E-02	5.89E-01
35.00	6.610E+00	247.2	1.938E+17	5.00E+00	7.70E+00	3.03E-02	2.18E-02	5.24E-01
37.50	4.720E+00	254.6	1.344E+17	5.00E+00	7.80E+00	1.95E-02	2.34E-02	4.51E-01
40.00	3.400E+00	262.1	9.402E+16	5.00E+00	7.00E+00	1.27E-02	2.50E-02	3.71E-01
42.50	2.480E+00	269.5	6.670E+16	5.00E+00	5.40E+00	9.00E-03	2.65E-02	2.99E-01
45.00	1.820E+00	273.6	4.821E+16	5.00E+00	4.20E+00	6.29E-03	2.81E-02	2.45E-01
47.50	1.340E+00	276.2	3.516E+16	5.00E+00	3.20E+00	4.56E-03	3.00E-02	2.00E-01
50.00	9.870E-01	277.2	2.581E+16	4.95E+00	2.50E+00	2.80E-03	3.22E-02	1.66E-01
55.00	5.370E-01	274.0	1.421E+16	4.85E+00	1.70E+00	1.77E-03	3.65E-02	1.50E-01
60.00	2.880E-01	262.7	7.946E+15	4.50E+00	1.20E+00	1.21E-03	4.59E-02	1.50E-01
65.00	1.470E-01	239.7	4.445E+15	4.00E+00	8.00E-01	8.87E-04	6.38E-02	1.50E-01
70.00	7.100E-02	216.6	2.376E+15	3.30E+00	4.00E-01	6.76E-04	1.18E-01	1.50E-01
75.00	3.200E-02	193.6	1.198E+15	2.70E+00	2.00E-01	5.54E-04	3.03E-01	1.50E-01
80.00	1.250E-02	170.6	5.311E+14	2.00E+00	1.80E-01	4.65E-04	7.89E-01	1.50E-01
85.00	4.510E-03	161.7	2.022E+14	1.33E+00	6.50E-01	3.98E-04	1.82E+00	1.50E-01
90.00	1.610E-03	161.6	7.221E+13	8.50E-01	9.00E-01	3.46E-04	3.40E+00	1.40E-01
95.00	6.060E-04	176.8	2.484E+13	5.40E-01	8.00E-01	3.05E-04	5.92E+00	1.30E-01
100.00	2.480E-04	190.4	9.441E+12	4.00E-01	4.00E-01	2.71E-04	1.04E+01	1.20E-01
105.00	1.130E-04	226.0	3.624E+12	3.40E-01	2.00E-01	2.44E-04	1.88E+01	1.10E-01
110.00	6.000E-05	270.1	1.610E+12	2.80E-01	5.00E-02	2.21E-04	2.67E+01	9.50E-02
115.00	3.540E-05	322.7	7.951E+11	2.40E-01	5.00E-03	2.02E-04	3.89E+01	6.00E-02
120.00	2.260E-05	380.0	4.311E+11	2.00E-01	5.00E-04	1.85E-04	5.00E+01	3.00E-02

Table 1f. Reference Atmospheric Model Profiles, Model 6. U. S. Standard

MODEL = 6 U. S. STANDARD, 1976								
ALT (KM)	PRES (MB)	TEMP (K)	DENSITY (CM-3)	H2O (PPMV)	O3 (PPMV)	N2O (PPMV)	CO (PPMV)	CH4 (PPMV)
0.00	1.013E+03	288.2	2.548E+19	7.75E+03	2.66E-02	3.20E-01	1.50E-01	1.70E+00
1.00	8.988E+02	281.7	2.313E+19	6.07E+03	2.93E-02	3.20E-01	1.45E-01	1.70E+00
2.00	7.950E+02	275.2	2.094E+19	4.63E+03	3.24E-02	3.20E-01	1.40E-01	1.70E+00
3.00	7.012E+02	268.7	1.891E+19	3.18E+03	3.32E-02	3.20E-01	1.35E-01	1.70E+00
4.00	6.166E+02	262.2	1.704E+19	2.16E+03	3.39E-02	3.20E-01	1.31E-01	1.70E+00
5.00	5.405E+02	255.7	1.532E+19	1.40E+03	3.77E-02	3.20E-01	1.30E-01	1.70E+00
6.00	4.722E+02	249.2	1.373E+19	9.25E+02	4.11E-02	3.20E-01	1.29E-01	1.70E+00
7.00	4.111E+02	242.7	1.228E+19	5.72E+02	5.01E-02	3.20E-01	1.25E-01	1.70E+00
8.00	3.565E+02	236.2	1.094E+19	3.67E+02	5.97E-02	3.20E-01	1.19E-01	1.70E+00
9.00	3.080E+02	229.7	9.719E+18	1.58E+02	9.17E-02	3.20E-01	1.09E-01	1.69E+00
10.00	2.650E+02	223.3	8.602E+18	7.00E+01	1.31E-01	3.18E-01	9.96E-02	1.69E+00
11.00	2.270E+02	216.8	7.589E+18	3.61E+01	2.15E-01	3.14E-01	8.96E-02	1.68E+00
12.00	1.940E+02	216.7	6.489E+18	1.91E+01	3.10E-01	3.10E-01	7.81E-02	1.66E+00
13.00	1.658E+02	216.7	5.546E+18	1.09E+01	3.85E-01	3.05E-01	6.37E-02	1.65E+00
14.00	1.417E+02	216.7	4.739E+18	5.93E+00	5.03E-01	3.00E-01	5.03E-02	1.63E+00
15.00	1.211E+02	216.7	4.050E+18	5.00E+00	6.51E-01	2.94E-01	3.94E-02	1.61E+00
16.00	1.035E+02	216.7	3.462E+18	3.95E+00	8.70E-01	2.88E-01	3.07E-02	1.58E+00
17.00	8.850E+01	216.7	2.960E+18	3.85E+00	1.19E+00	2.78E-01	2.49E-02	1.55E+00
18.00	7.565E+01	216.7	2.530E+18	3.83E+00	1.59E+00	2.67E-01	1.97E-02	1.52E+00
19.00	6.467E+01	216.7	2.163E+18	3.85E+00	2.03E+00	2.53E-01	1.55E-02	1.48E+00
20.00	5.529E+01	216.7	1.849E+18	3.90E+00	2.58E+00	2.37E-01	1.33E-02	1.42E+00
21.00	4.729E+01	217.6	1.575E+18	3.98E+00	3.03E+00	2.19E-01	1.23E-02	1.36E+00
22.00	4.047E+01	218.6	1.342E+18	4.07E+00	3.65E+00	2.05E-01	1.23E-02	1.27E+00
23.00	3.467E+01	219.6	1.144E+18	4.20E+00	4.17E+00	1.97E-01	1.31E-02	1.19E+00
24.00	2.972E+01	220.6	9.765E+17	4.30E+00	4.63E+00	1.88E-01	1.40E-02	1.12E+00
25.00	2.549E+01	221.6	8.337E+17	4.43E+00	5.12E+00	1.76E-01	1.50E-02	1.08E+00
27.50	1.743E+01	224.0	5.640E+17	4.58E+00	5.80E+00	1.59E-01	1.60E-02	9.87E-01
30.00	1.197E+01	226.5	3.830E+17	4.73E+00	6.55E+00	1.42E-01	1.71E-02	9.14E-01
32.50	8.010E+00	230.0	2.524E+17	4.83E+00	7.37E+00	1.17E-01	1.85E-02	8.30E-01
35.00	5.746E+00	236.5	1.761E+17	4.90E+00	7.84E+00	9.28E-02	2.01E-02	7.46E-01
37.50	4.150E+00	242.9	1.238E+17	4.95E+00	7.80E+00	6.69E-02	2.22E-02	6.62E-01
40.00	2.871E+00	250.4	8.310E+16	5.03E+00	7.30E+00	4.51E-02	2.50E-02	5.64E-01
42.50	2.060E+00	257.3	5.803E+16	5.15E+00	6.20E+00	2.75E-02	2.82E-02	4.61E-01
45.00	1.491E+00	264.2	4.090E+16	5.23E+00	5.25E+00	1.59E-02	3.24E-02	3.63E-01
47.50	1.090E+00	270.6	2.920E+16	5.25E+00	4.10E+00	9.38E-03	3.72E-02	2.77E-01
50.00	7.978E-01	270.7	2.136E+16	5.23E+00	3.10E+00	4.75E-03	4.60E-02	2.10E-01
55.00	4.250E-01	260.8	1.181E+16	5.10E+00	1.80E+00	3.00E-03	6.64E-02	1.65E-01
60.00	2.190E-01	247.0	6.426E+15	4.75E+00	1.10E+00	2.07E-03	1.07E-01	1.50E-01
65.00	1.090E-01	233.3	3.386E+15	4.20E+00	7.00E-01	1.51E-03	1.86E-01	1.50E-01
70.00	5.220E-02	219.6	1.723E+15	3.50E+00	3.00E-01	1.15E-03	3.06E-01	1.50E-01
75.00	2.400E-02	208.4	8.347E+14	2.83E+00	2.50E-01	8.89E-04	6.38E-01	1.50E-01
80.00	1.050E-02	198.6	3.832E+14	2.05E+00	3.00E-01	7.06E-04	1.50E+00	1.50E-01
85.00	4.460E-03	188.9	1.711E+14	1.33E+00	5.00E-01	5.72E-04	3.24E+00	1.50E-01
90.00	1.840E-03	186.9	7.136E+13	8.50E-01	7.00E-01	4.71E-04	5.84E+00	1.40E-01
95.00	7.600E-04	188.4	2.924E+13	5.40E-01	7.00E-01	3.93E-04	1.01E+01	1.30E-01
100.00	3.200E-04	195.1	1.189E+13	4.00E-01	4.00E-01	3.32E-04	1.69E+01	1.20E-01
105.00	1.450E-04	208.8	5.033E+12	3.40E-01	2.00E-01	2.84E-04	2.47E+01	1.10E-01
110.00	7.100E-05	240.0	2.144E+12	2.80E-01	5.00E-02	2.44E-04	3.36E+01	9.50E-02
115.00	4.010E-05	300.0	9.688E+11	2.40E-01	5.00E-03	2.12E-04	4.15E+01	6.00E-02
120.00	2.540E-05	360.0	5.114E+11	2.00E-01	5.00E-04	1.85E-04	5.00E+01	3.00E-02

Table 2. Constituent Profiles (ppmv):

Molecules 1-7 are Model 6 (U.S. Standard) compatible and are repeated here because they duplicate the AFGL Line Parameter and Trace Gas numbering scheme. In addition, CO₂ and O₂ are only defined by a single profile so have not been included in Table 1.

Molecules 8-28 are provided as single representative profiles. Their natural variability can be very different from the selected profile.

[(*) indicates subsequent extrapolation adopted for that species]

Table 2a. Constituent Profiles (ppmv), H₂O, CO₂, O₃, N₂O, CO, CH₄, O₂

	1 H2O	2 CO2	3 O3	4 N2O	5 CO	6 CH4	7 O2
(KM)	(PPMV)	(PPMV)	(PPMV)	(PPMV)	(PPMV)	(PPMV)	(PPMV)
0.0	7.75E+03	3.30E+02	2.66E-02	3.20E-01	1.50E-01	1.70E+00	2.09E+05
1.0	6.07E+03	3.30E+02	2.93E-02	3.20E-01	1.45E-01	1.70E+00	2.09E+05
2.0	4.63E+03	3.30E+02	3.24E-02	3.20E-01	1.40E-01	1.70E+00	2.09E+05
3.0	3.18E+03	3.30E+02	3.32E-02	3.20E-01	1.35E-01	1.70E+00	2.09E+05
4.0	2.16E+03	3.30E+02	3.39E-02	3.20E-01	1.31E-01	1.70E+00	2.09E+05
5.0	1.40E+03	3.30E+02	3.77E-02	3.20E-01	1.30E-01	1.70E+00	2.09E+05
6.0	9.25E+02	3.30E+02	4.11E-02	3.20E-01	1.29E-01	1.70E+00	2.09E+05
7.0	5.72E+02	3.30E+02	5.01E-02	3.20E-01	1.25E-01	1.70E+00	2.09E+05
8.0	3.67E+02	3.30E+02	5.97E-02	3.20E-01	1.19E-01	1.70E+00	2.09E+05
9.0	1.58E+02	3.30E+02	9.17E-02	3.20E-01	1.09E-01	1.68E+00	2.09E+05
10.0	7.00E+01	3.30E+02	1.31E-01	3.18E-01	9.96E-02	1.68E+00	2.09E+05
11.0	3.61E+01	3.30E+02	2.15E-01	3.14E-01	8.96E-02	1.66E+00	2.09E+05
12.0	1.91E+01	3.30E+02	3.10E-01	3.10E-01	7.81E-02	1.66E+00	2.09E+05
13.0	1.09E+01	3.30E+02	3.85E-01	3.05E-01	6.37E-02	1.65E+00	2.09E+05
14.0	5.93E+00	3.30E+02	5.03E-01	3.00E-01	5.03E-02	1.63E+00	2.09E+05
15.0	5.00E+00	3.30E+02	6.51E-01	2.94E-01	3.94E-02	1.61E+00	2.09E+05
16.0	3.95E+00	3.30E+02	8.70E-01	2.88E-01	3.07E-02	1.58E+00	2.09E+05
17.0	3.85E+00	3.30E+02	1.19E+00	2.78E-01	2.49E-02	1.55E+00	2.09E+05
18.0	3.83E+00	3.30E+02	1.59E+00	2.67E-01	1.97E-02	1.52E+00	2.09E+05
19.0	3.85E+00	3.30E+02	2.03E+00	2.53E-01	1.55E-02	1.48E+00	2.09E+05
20.0	3.90E+00	3.30E+02	2.58E+00	2.37E-01	1.33E-02	1.42E+00	2.09E+05
21.0	3.98E+00	3.30E+02	3.03E+00	2.19E-01	1.23E-02	1.36E+00	2.09E+05
22.0	4.07E+00	3.30E+02	3.65E+00	2.05E-01	1.23E-02	1.27E+00	2.09E+05
23.0	4.20E+00	3.30E+02	4.17E+00	1.97E-01	1.31E-02	1.19E+00	2.09E+05
24.0	4.30E+00	3.30E+02	4.63E+00	1.88E-01	1.40E-02	1.12E+00	2.09E+05
25.0	4.43E+00	3.30E+02	5.12E+00	1.76E-01	1.50E-02	1.06E+00	2.09E+05
27.5	4.58E+00	3.30E+02	5.80E+00	1.59E-01	1.60E-02	9.87E-01	2.09E+05
30.0	4.73E+00	3.30E+02	6.55E+00	1.42E-01	1.71E-02	9.14E-01	2.09E+05
32.5	4.83E+00	3.30E+02	7.37E+00	1.17E-01	1.85E-02	8.30E-01	2.09E+05
35.0	4.90E+00	3.30E+02	7.84E+00	9.28E-02	2.01E-02	7.46E-01	2.09E+05
37.5	4.95E+00	3.30E+02	7.80E+00	6.69E-02	2.22E-02	6.62E-01	2.09E+05
40.0	5.03E+00	3.30E+02	7.30E+00	4.51E-02	2.50E-02	5.64E-01	2.09E+05
42.5	5.15E+00	3.30E+02	6.20E+00	2.75E-02	2.82E-02	4.61E-01	2.09E+05
45.0	5.23E+00	3.30E+02	5.25E+00	1.59E-02	3.24E-02	3.63E-01	2.09E+05
47.5	5.25E+00	3.30E+02	4.10E+00	9.38E-03	3.72E-02	2.77E-01	2.09E+05
50.0	5.23E+00	3.30E+02	3.10E+00	4.75E-03*	4.60E-02	2.10E-01	2.09E+05
55.0	5.10E+00	3.30E+02	1.80E+00	3.00E-03	6.64E-02	1.65E-01	2.09E+05
60.0	4.75E+00	3.30E+02	1.10E+00	2.07E-03	1.07E-01	1.50E-01	2.09E+05
65.0	4.20E+00	3.30E+02	7.00E-01	1.51E-03	1.86E-01	1.50E-01	2.09E+05
70.0	3.50E+00	3.30E+02	3.00E-01	1.15E-03	3.06E-01	1.50E-01	2.09E+05
75.0	2.83E+00	3.30E+02	2.50E-01	8.89E-04	6.38E-01	1.50E-01	2.09E+05
80.0	2.05E+00	3.28E+02	3.00E-01	7.06E-04	1.50E+00	1.50E-01	2.09E+05
85.0	1.33E+00	3.20E+02	5.00E-01	5.72E-04	3.24E+00	1.50E-01	2.09E+05
90.0	8.50E-01	3.10E+02	7.00E-01	4.71E-04	5.84E+00	1.40E-01	1.90E+05
95.0	5.40E-01	2.70E+02	7.00E-01	3.93E-04	1.01E+01	1.30E-01	1.80E+05
100.0	4.00E-01	1.95E+02	4.00E-01	3.32E-04	1.69E+01	1.20E-01	1.60E+05
105.0	3.40E-01	1.10E+02	2.00E-01	2.84E-04	2.47E+01	1.10E-01	1.40E+05
110.0	2.80E-01	6.00E+01	5.00E-02	2.44E-04	3.36E+01	9.50E-02	1.20E+05
115.0	2.40E-01	4.00E+01	5.00E-03	2.12E-04	4.15E+01	6.00E-02	9.40E+04
120.0	2.00E-01	3.50E+01	5.00E-04	1.85E-04	5.00E+01	3.00E-02	7.25E+04

CARNOT8A

Corrected 26 Aug 2022, for use of Zt
Estimates ratios frequency w/w, radii
Estimates θ , hv, v, wavelength in cycl
Inputs Y,F,R,P,H,L,M,N,A,B,C,Q,Z
Input rotational symmetry

0240 096 LABEL
0241 089 Y
0242 107 STO MEM
0243 056 8
0244 057 9
0245 119 print
0246 002 HALT
0247 048 0

Furnace degrees Kelvin

0288 096 LABEL
0289 070 F
0290 107 STO MEM
0291 048 0
0292 049 1
0293 119 print
0294 002 HALT
0295 048 0

Temperature of refrigerator

0336 096 LABEL
0337 082 R
0338 107 STO MEM
0339 048 0
0340 050 2
0341 119 print
0342 002 HALT
0343 048 0

Pressure in atm

0384 096 LABEL
0385 080 P
0386 107 STO MEM
0387 048 0
0388 051 3
0389 119 print
0390 002 HALT
0391 048 0

Stow heat capacity Cv/R

0432 096 LABEL
0433 072 H
0434 107 STO MEM
0435 048 0
0436 052 4
0437 119 print
0438 002 HALT
0439 048 0

Stow mass H1 polyatomic

480 096 LABEL
481 076 L
482 107 STO MEM
483 048 0
484 055 7
485 119 print
486 002 HALT

Stow monatomic Ar, or M1 or central M

527 096 LABEL

0526

0529

0530

0531

0532

0533

0534

Stow molecular mass 2 N or O

0575

0576

0577

0578

0579

0580

0581

0582

Bond length diatomic

0623

0624

0625

0626

0627

0628

0629

0630

Moment 1 polyatomic

0671

0672

0673

0674

0675

0676

0677

Moment 2 polyatomic

0718

0719

0720

0721

0722

0723

0724

Stow moment 3 polyatomic

0765

0766

0767

0768

0769

0770

0771

Input source heat nkT=Qf ergs/molecule

Input q for nkT1 as n

0852

0853

0854

0855

0856

0857

0858

Execute <SH>X

0899

077

107

048

053

119

002

048

096

078

107

049

053

119

002

048

096

070

107

048

049

107

049

054

119

002

048

096

065

107

048

056

119

002

096

066

107

048

057

119

002

096

067

107

049

048

119

002

096

081

107

048

054

119

002

096

M

STO MEM

0

5

print

HALT

0

Stow molecular mass 2 N or O

LABEL

N

STO MEM

1

5

print

HALT

0

LABEL

Z

STO MEM

1

6

print

HALT

0

LABEL

A

STO MEM

0

8

print

HALT

0

LABEL

B

STO MEM

0

9

print

HALT

0

LABEL

C

STO MEM

1

0

print

HALT

0

LABEL

Q

STO MEM

0

6

print

HALT

0

LABEL

0

Execute <SH>X

LABEL

0711 M

Table S2

```

1332 114 print
store r1 radial separation
1373 107 STO MEM
1374 057 9
1375 048 0
go to LABEL 8
1416 083 S
Subroutine snTn entropic energy n=1-4
1457 096 LABEL
1458 068 D
1459 040 (
1460 040 (
1461 040 (
1462 109 RCL MEM
1463 048 0
1464 053 5
1465 043 +
1466 109 RCL MEM
1467 049 1
1468 053 5
1469 041 )
1470 042 x
1471 109 RCL MEM
1472 057 9
1473 054 6
1474 041 )
print mass
515 119 print
516 107 STO MEM
517 056 8
518 052 4
519 042 x
520 040 (
521 109 RCL MEM
522 053 5
523 048 0
524 113 Square
525 041 )
526 061 =
print In moment of inertia mr^2
567 119 print
568 042 x
569 051 3
570 042 x
571 109 RCL MEM
572 057 9
573 055 7
574 042 x
recall temperature r51
615 109 RCL MEM
616 053 5
617 049 1
618 041 )
619 061 =
print 3kTnIn=@tn^2 uncorrected
660 119 print
661 092 Root
662 050 2
663 047 /
664 040 (

```

```

1663 109 RCL MEM
1666 057 9
1667 057 9
1668 092 Root
1669 051 3
1670 041 )
1671 061 =
Print @tn translational action 1-D
1712 119 print
1713 107 STO MEM
1714 056 8
1715 053 5
1716 047 /
1717 109 RCL MEM
1718 057 9
1719 056 8
1720 061 =
Print quantum number
1761 119 print
1762 107 STO MEM
1763 052 4
1764 048 0
1765 121 Cube
1766 110 LOG e
1767 042 x
1768 109 RCL MEM
1769 057 9
1770 055 7
1771 061 =
Print translational -gt/T Gibbs/K
1812 119 print
1813 107 STO MEM
1814 055 7
1815 048 0
1816 042 x
1817 109 RCL MEM
1818 053 5
1819 049 1
Print kTnln[@nt/h-)^3/zt]=-gtn
1860 061 =
1861 119 print
1862 107 STO MEM
1863 055 7
1864 049 1
1865 043 +
1866 040 (
1867 109 RCL MEM
1868 048 0
1869 052 4
1870 042 x
1871 109 RCL MEM
1872 057 9
1873 055 7
1874 042 x
1875 109 RCL MEM
1876 053 5
1877 049 1
1878 041 )
1879 061 =
1880 119 print

```

```

2430 0A7 /
2431 109 RCL MEM
2432 053 5
2433 048 0
2434 041 )
Print v
2475 119 print
2476 047 /
2477 109 RCL MEM
2478 053 5
2479 048 0
Print w
2520 041 )
2521 119 print
2522 114 1/x
2523 042 x
2524 109 RCL MEM
2525 056 8
2526 051 3
2527 041 )
Print v/w
2568 119 print
Test if diatomic
2609 109 RCL MEM
2610 049 1
2611 053 5
2612 038 If zero
2613 084 T
Test if triatomic H2O
2654 109 RCL MEM
2655 048 0
2656 056 8
2657 038 If zero
2658 069 E
Test if non-linear
2699 040 (
2700 048 0
2701 045 -
2702 109 RCL MEM
2703 049 1
2704 050 2
2705 041 )
2706 064 Inverse
2707 037 If pos
2708 116 Tangent
Calculate Sr for water
 $Sr = R \ln[\pi^{1/2} e^{3/2} a^3 b^3 c / h^{3/2} z]$ 
Calculate @rA
2829 096 LABEL
2830 116 Tangent
2831 040 (
2832 109 RCL MEM
2833 048 0
2834 056 8
2835 042 x
2836 109 RCL MEM
2837 053 5
2838 049 1
2839 042 x
2840 050 2

```

```

2841 0A2 x
2842 109 RCL MEM
2843 057 9
2844 055 7
2845 041 )
2846 064 Inverse
2847 113 Square
2848 061 =
Print, stow @rA in r17
2889 119 print
2890 107 STO MEM
2891 049 1
2892 055 7
2893 109 RCL MEM
2894 049 1
2895 055 7
2896 047 /
Recall h-
2937 109 RCL MEM
2938 057 9
2939 056 8
2940 061 =
Print, stow @rA/h- in r17
2981 119 print
2982 107 STO MEM
2983 049 1
2984 055 7
Calculate @rB
3025 109 RCL MEM
3026 048 0
3027 057 9
3028 042 x
3029 109 RCL MEM
3030 053 5
3031 049 1
3032 042 x
3033 050 2
Recall k
3074 042 x
3075 109 RCL MEM
3076 057 9
3077 055 7
3078 041 )
3079 092 Root
3080 050 2
3081 061 =
Print, stow @rB in r18
3122 119 print
3123 107 STO MEM
3124 049 1
3125 056 8
3126 109 RCL MEM
3127 049 1
3128 056 8
3129 047 /
Recall h-
3170 109 RCL MEM
3171 057 9
3172 056 8
3173 061 =

```

3840	055	7
3841	052	4
3842	047	/
3843	109	RCL MEM
3844	053	5
3845	049	1
3846	061	=
Print -grn/Tn - gtn/Tn		
3887	119	print
3888	107	STD MEM
3889	055	7
3890	053	5
3891	040	(
3892	109	RCL MEM
3893	056	8
3894	048	0
3895	043	+
3896	109	RCL MEM
3897	055	7
3898	051	3
3899	041	)
Print total snTn		
3940	119	print
3941	107	STD MEM
3942	056	8
3943	050	2
3944	047	/
3945	109	RCL MEM
3946	053	5
3947	049	1
3948	061	=
Print stn + Srn		
3989	119	print
3990	040	(
3991	109	RCL MEM
3992	055	7
3993	051	3
3994	047	/
3995	109	RCL MEM
3996	054	6
3997	049	1
3998	041	)
3999	061	=
Print virtual hvr		
040	119	print
041	047	/
042	109	RCL MEM
043	057	9
044	056	8
045	047	/
046	050	2
047	047	/
048	112	pi
049	061	=
Print vr		
090	119	print
091	114	1/x
092	042	x
093	109	RCL MEM
094	057	9

4095	055	5
4096	061	=
Print virtual rotational wavelength		
4137	119	print
4138	063	Goto
4139	084	T
Calculate rotational quantum no.		
4180	096	LABEL
4181	069	E
4182	109	RCL MEM
4183	048	0
4184	053	5
4185	042	x
4186	109	RCL MEM
4187	049	1
4188	053	5
4189	041	)
4190	047	/
4191	040	(
4192	109	RCL MEM
4193	048	0
4194	053	5
4195	043	+
4196	109	RCL MEM
4197	049	1
4198	053	5
4199	041	)
4200	042	x
Recall H atom mass		
4241	109	RCL MEM
4242	057	9
4243	054	6
4244	042	x
4245	040	(
4246	109	RCL MEM
4247	049	1
4248	054	6
4249	113	Square
4250	041	)
4251	061	=
Print Ir		
4292	119	print
4293	042	x
4294	040	(
4295	050	2
4296	042	x
4297	109	RCL MEM
4298	057	9
4299	055	7
4300	042	x
4301	109	RCL MEM
4302	053	5
4303	049	1
4304	041	)
4305	061	=
4306	047	/
4307	109	RCL MEM
4308	056	8
4309	057	9
4310	061	=

~~Unit 2~~ 2 777 C

```

4900 109 RCL MEM
4901 052 4
4902 048 0
4903 121 Cube
4904 042 x
4905 109 RCL MEM
4906 052 4
4907 049 1
4908 113 Square
4909 041 )

```

Print nt^3xjr^2

```

4950 119 print
4951 096 LABEL
4952 084 T
4953 040 (
4954 109 RCL MEM
4955 053 5
4956 048 0
4957 121 Cube
4958 042 x
4959 056 8
4960 041 )

```

Print vn

```

5001 119 print
5002 107 STD MEM
5003 054 6
5004 048 0
5005 040 (
5006 109 RCL MEM
5007 055 7
5008 049 1
5009 047 /
5010 109 RCL MEM
5011 054 6
5012 048 0
5013 041 )

```

Print -gt/a^3 density Gibbs

```

5054 119 print
5055 107 STD MEM
5056 052 4
5057 053 5
5058 040 (
5059 109 RCL MEM
5060 055 7
5061 052 4
5062 047 /
5063 109 RCL MEM
5064 054 6
5065 048 0
5066 041 )

```

Print -gt+-gr/a^3 Gibbs density

```

1107 119 print
1108 040 (
1109 109 RCL MEM
1110 057 9
1111 055 7
1112 042 x
1113 109 RCL MEM
1114 053 5

```

```

2143 049 1
5116 041 )
5117 047 /
5118 040 (
5119 109 RCL MEM
5120 053 5
5121 048 0
5122 121 Cube
5123 041 )
5124 047 /
5125 056 8
5126 061 =

```

Print pressure pn

```

5167 119 print
5168 107 STD MEM
5169 052 4
5170 054 6
5171 042 x
5172 109 RCL MEM
5173 054 6
5174 048 0
5175 061 =

```

Print pnv

```

5216 119 print
5217 047 /
5218 109 RCL MEM
5219 053 5
5220 049 1
5221 061 =

```

Print pnv/Tn

```

5262 119 print
5263 040 (
5264 109 RCL MEM
5265 052 4
5266 053 5
5267 047 /
5268 109 RCL MEM
5269 052 4
5270 054 6
5271 041 )

```

Print quantum p vs. molecular pressure

```

5312 119 print
5313 060 Return

```

Set up V values

```

5354 096 LABEL
5355 083 S

```

Calculate q1 source heat/molecule

```

5396 040 (
Input n for Qs
5437 109 RCL MEM
5438 048 0
5439 054 6
5440 042 x
5441 109 RCL MEM
5442 057 9
5443 055 7
5444 042 x
5445 109 RCL MEM
5446 048 0
5447 049 1

```

0000	056	8	6099	189	RCL MEM
0001	057	9	6100	056	8
0002	061	=	6101	054	6
0003	107	STO MEM	6102	042	x
0004	056	8	6103	109	RCL MEM
0005	053	5	6104	048	0
0006	109	RCL MEM	6105	055	7
0007	056	8	6106	041	)
0008	055	7	6107	061	=
0009	038	If zero	6108	092	Root
0010	123	101	6109	050	2
0011	109	RCL MEM	6110	061	=
0012	056	8	6111	119	print
0013	053	5	6112	107	STO MEM
0014	047	/	6113	053	5
0015	109	RCL MEM	6114	051	3
0016	056	8	6115	121	Cube
0017	055	7	6116	114	1/x
0018	061	=	6117	047	/
0019	107	STO MEM	6118	056	8
0020	056	8	6119	061	=
0021	053	5	6120	119	print
0022	096	LABEL	6121	107	STO MEM
0023	123	101	6122	053	5
Print and store @A/h- in r15			6123	052	4
0064	109	RCL MEM	6124	109	RCL MEM
0065	056	8	6125	049	1
0066	053	5	6126	052	4
0067	064	Inverse	6127	042	x
0068	121	Cube	6128	109	RCL MEM
0069	061	=	6129	053	5
0070	119	print	6130	052	4
0071	107	STO MEM	6131	061	=
0072	049	1	Print and store n^3ktln(@/h-)^30e/zt		
0073	053	5	6172	119	print
0074	042	x	6173	107	STO MEM
0075	109	RCL MEM	6174	053	5
0076	057	9	6175	053	5
0077	056	8	6176	109	RCL MEM
0078	061	=	6177	053	5
0079	119	print	6178	052	4
0080	107	STO MEM	6179	064	Inverse
0081	049	1	6180	121	Cube
0082	054	6	6181	061	=
0083	113	Square	6182	119	print
0084	047	/	6183	107	STO MEM
0085	040	(	6184	053	5
0086	051	3	6185	054	6
0087	042	x	Obtain kinetic energy per cm^3		
0088	109	RCL MEM	6226	109	RCL MEM
0089	057	9	6227	053	5
0090	055	7	6228	052	4
0091	042	x	6229	042	x
0092	109	RCL MEM	6230	109	RCL MEM
0093	053	5	6231	057	9
0094	050	2	6232	055	7
0095	041	)	6233	042	x
0096	061	=	6234	109	RCL MEM
0097	047	/	6235	053	5
0098	040	(	6236	050	2

Baromet 10/Col
Baromet formula polyatoms
Calculate using action potential
 $-mgh + kT \ln(nton)^{3Q/z} - kT \ln[(nro)^{2/s}]$
 $= kT \ln[(ntn)^{3Q/z}] - kT \ln[(nrn)^{2/s}]$
 $K = e/\sigma$ or $e^{3/2}/\sigma$
Input rotational symmetry factor sigma
Input lapse rate version K for air
Lodge linear m01 in m77 2146 9/6/15
Revised 16/9/24

0360 096 LABEL

0361 089 Y

0362 107 STO MEM

0363 057 9

0364 057 9

0365 119 print

0366 002 HALT

0367 048 0

Input pressure atm in r88

0408 096 LABEL

0409 080 P

0410 107 STO MEM

0411 056 8

0412 056 8

0413 119 print

0414 002 HALT

0415 048 0

Input Q_e electron multiplicity in r88

0456 096 LABEL

0457 081 Q

0458 107 STO MEM

0459 056 8

0460 055 7

0461 119 print

0462 002 HALT

0463 048 0

Input surface temperature T in r08

0504 096 LABEL

0505 084 T

0506 107 STO MEM

0507 048 0

0508 056 8

0509 119 print

0510 002 HALT

Input translational symmetry factor

0551 096 LABEL

0552 090 Z

0553 107 STO MEM

0554 056 8

0555 057 9

0556 119 print

0557 002 HALT

0558 048 0

Input temperature gradient K per cm

0599 096 LABEL

0600 075 K

0601 107 STO MEM

0602 048 0

0603 049 1

0604 119 print

0605 002 HALT

0606

048

0

Altitude increment H cm in r02

0647 096 LABEL

0648 072 H

0649 107 STO MEM

0650 048 0

0651 050 2

0652 119 print

0653 002 HALT

0654 048 0

Centre atom m r03 eg C in CO2

or N in N2O

0735 096 LABEL

0736 076 L

0737 107 STO MEM

0738 048 0

0739 051 3

0740 119 print

0741 002 HALT

Atom weight 1 in r04 eg O in CO2 or O2

or O in N2O and polyatomics

0822 048 0

0823 096 LABEL

0824 077 M

0825 107 STO MEM

0826 048 0

0827 052 4

0828 119 print

0829 002 HALT

0830 048 0

Atom wt.2 in r05 eg O in CO2 or O2

N in N2O, and monatomics

0911 096 LABEL

0912 078 N

0913 107 STO MEM

0914 048 0

0915 053 5

0916 119 print

0917 002 HALT

0918 048 0

Atomic weight 3 in r06 eg Cl in CF2Cl2

0959 096 LABEL

0960 079 O

0961 107 STO MEM

0962 048 0

0963 054 6

0964 119 print

0965 002 HALT

0966 048 0

Input bond length r1=R in r39

eg. CO2, N2 or O2

1047 096 LABEL

1048 082 R

1049 107 STO MEM

1050 051 3

1051 057 9

1052 119 print

1053 002 HALT

1054 048 0

Input bond length r2=S r40 eg. CO2

1095	096	LABEL
1096	083	S
1097	107	STD MEM
1098	052	4
1099	048	0
1100	119	print
1101	002	HALT
1102	048	0
Input IrA moment of inertia in r42		
1143	096	LABEL
1144	065	A
1145	107	STD MEM
1146	052	4
1147	050	2
1148	119	print
1149	002	HALT
1150	048	0
Input IrB moment inertia in r43		
1191	096	LABEL
1192	066	B
1193	107	STD MEM
1194	052	4
1195	051	3
1196	119	print
1197	002	HALT
1198	048	0
Input IrC moment inertia in r44		
1239	096	LABEL
1240	067	C
1241	107	STD MEM
1242	052	4
1243	052	4
1244	119	print
1245	002	HALT
Execute program <X>		
1286	096	LABEL
1287	088	X
Input translational symmetry factor		
1328	049	1
1329	048	0
1330	046	.
1331	050	2
1332	050	2
1333	057	9
1334	054	6
1335	055	7
1336	050	2
1337	107	STD MEM
1338	056	8
1339	057	9
1340	119	print
Input g in r91		
1381	057	9
1382	056	8
1383	048	0
1384	046	.
1385	054	6
1386	054	6
1387	053	5
1388	107	STD MEM

1387	057	G
1390	049	1
Input Boltzmann's k in r97		
1431	049	1
1432	046	.
1433	051	3
1434	056	8
1435	048	0
1436	054	6
1437	050	2
1438	050	2
1439	053	5
1440	057	9
1441	101	EE
1442	049	1
1443	054	6
1444	111	+/-
1445	107	STD MEM
1446	057	9
1447	055	7
Input Planck's h- in r98		
1488	049	1
1489	046	.
1490	048	0
1491	053	5
1492	052	4
1493	053	5
1494	057	9
1495	049	1
1496	056	8
1497	053	5
1498	101	EE
1499	050	2
1500	055	7
1501	111	+/-
Store h- in r98		
1542	107	STD MEM
1543	057	9
1544	056	8
1545	049	1
1546	046	.
1547	054	6
1548	055	7
1549	050	2
1550	054	6
1551	049	1
1552	052	4
1553	101	EE
1554	050	2
1555	052	4
1556	111	+/-
Store mass H-atom in r07		
1597	107	STD MEM
1598	048	0
1599	055	7
Recall pressure from r88, find rt		
1640	040	(
1641	109	RCL MEM
1642	048	0
1643	056	8

2232	109	RCL MEM	2404	055	7
2233	052	4	2410	047	/
2234	050	2	2411	051	3
Continue if Ira found			2412	061	=
2275	038	If zero	Store gradient and print for monatomic		
2276	115	Sine	2453	107	STD MEM
2277	109	RCL MEM	2454	048	0
2278	048	0	2455	049	1
2279	052	4	2456	119	print
2280	107	STD MEM	Store kinetic + kT factor		
2281	056	8	2497	048	0
2282	054	6	2498	046	.
2283	042	x	2499	053	5
2284	109	RCL MEM	2500	107	STD MEM
2285	048	0	2501	056	8
2286	055	7	2502	052	4
2287	042	x	2503	119	print
2288	109	RCL MEM	2504	096	LABEL
2289	057	9	2505	116	Tangent
2290	049	1	Get translational energy and entropy		
2291	047	/	2546	040	(
2292	109	RCL MEM	2547	040	(
2293	057	9	2548	109	RCL MEM
2294	055	7	2549	056	8
2295	061	=	2550	054	6
2296	047	/	2551	042	x
2297	054	6	2552	109	RCL MEM
2298	061	=	2553	048	0
2299	119	print	2554	055	7
Store, print gradient for polyatomics			2555	042	x
2340	107	STD MEM	2556	040	(
2341	048	0	2557	109	RCL MEM
2342	049	1	2558	057	9
Store kinetic factor + kT 4			2559	048	0
2383	052	4	2560	113	Square
2384	107	STD MEM	2561	041	)
2385	056	8	2562	041	)
2386	052	4	2563	061	=
2387	119	print	Print Io		
2388	063	Goto	2604	119	print
2389	116	Tangent	2605	042	x
2390	096	LABEL	2606	040	(
2391	115	Sine	2607	109	RCL MEM
2392	109	RCL MEM	2608	057	9
2393	048	0	2609	055	7
2394	053	5	2610	042	x
2395	107	STD MEM	2611	109	RCL MEM
2396	056	8	2612	048	0
2397	054	6	2613	056	8
2398	042	x	2614	041	)
2399	109	RCL MEM	2615	041	)
2400	048	0	2616	042	x
2401	055	7	2617	051	3
2402	042	x	2618	061	=
2403	109	RCL MEM	Print 3kToIo		
2404	057	9	2659	119	print
2405	049	1	2660	092	Root
2406	047	/	2661	050	2
2407	109	RCL MEM	2662	061	=
2408	057	9	Print @to		

3213	041	)	Print and store $\bar{w}r_o/h^-$ in r41
3214	042	x	3586 119 print
Recall H atom mass			3587 107 STO MEM
3255	109	RCL MEM	3588 050 2
3256	048	0	3589 049 1
3257	055	7	3590 113 Square
3258	042	x	3591 047 /
3259	040	(	Insert rotational symmetry factor
3260	109	RCL MEM	3632 109 RCL MEM
3261	051	3	3633 057 9
3262	057	9	3634 057 9
3263	043	+	$=\ln(nr_o)^2/\sigma_{mar}$
3264	109	RCL MEM	3675 061 =
3265	052	4	3676 110 LOG e
3266	048	0	3677 119 print
3267	041	)	3678 107 STO MEM
3268	113	Square	3679 054 6
3269	041	)	3680 048 0
Print and store I_r in r41			3681 042 x
3310	119	print	Recall k
3311	107	STO MEM	3722 109 RCL MEM
3312	052	4	3723 057 9
3313	049	1	3724 055 7
3314	040	(	3725 042 x
3315	109	RCL MEM	3726 109 RCL MEM
3316	052	4	3727 048 0
3317	049	1	3728 056 8
3318	042	x	3729 061 =
Recall T_o to degrees Kelvin from r08			Print and store T_{osro}
3359	109	RCL MEM	3770 119 print
3360	048	0	3771 107 STO MEM
3361	056	8	3772 050 2
3362	042	x	3773 050 2
Recall k			3774 063 Goto
3403	109	RCL MEM	3775 071 G
3404	057	9	3776 096 LABEL
3405	055	7	3777 085 U
3406	042	x	Estimate sro for polyatomic gases
3407	050	2	$sro = k \ln[\pi^{1/2} l e^{3/2} \bar{w} A \bar{w} B \bar{w} C / h^-^{3/2}]$
3408	041	)	Calculate $\bar{w}r_A$
3409	061	=	3898 040 (
3410	092	Root	3899 109 RCL MEM
3411	050	2	3900 052 4
3412	061	=	3901 050 2
Print and store $\bar{w}r_o$ in r20			3902 042 x
3453	119	print	3903 109 RCL MEM
3454	107	STO MEM	3904 048 0
3455	050	2	3905 056 8
3456	048	0	3906 042 x
Calculate Sro			3907 050 2
3497	040	(	3908 042 x
3498	109	RCL MEM	Recall k
3499	050	2	3949 109 RCL MEM
3500	048	0	3950 057 9
3501	047	/	3951 055 7
REcall h^-			3952 041)
3542	109	RCL MEM	3953 092 Root
3543	057	9	3954 050 2
3544	056	8	3955 061 =
3545	041	)	Print and store $\bar{w}r_A$ in r23

4506	049	1
4507	046	.
4508	053	5
4509	061	=
4510	042	x
4511	040	(
4512	112	pi
4513	092	Root
4514	050	2
4515	041	)
4516	061	=
4517	110	LOG e

Print, store action potential r0 > r60

4558	119	print
4559	107	STD MEM
4560	054	6
4561	048	0
4562	042	x

Recall k

4603	109	RCL MEM
4604	057	9
4605	055	7
4606	042	x
4607	109	RCL MEM
4608	048	0
4609	056	8
4610	061	=

Print and store Tosro in r29

4651	119	print
4652	107	STD MEM
4653	050	2
4654	057	9
4655	040	(
4656	109	RCL MEM
4657	053	5
4658	057	9
4659	043	+
4660	109	RCL MEM
4661	054	6
4662	048	0
4663	041	)

Store total @ in r61 and print

4704	107	STD MEM
4705	054	6
4706	049	1
4707	061	=
4708	119	print

Recall altitude Ho
Re-entry step from END

4789	096	LABEL
4790	071	G
4791	109	RCL MEM
4792	048	0
4793	050	2

Print and store Hn in r51

4834	117	SUM MEM
4835	053	5
4836	049	1
4837	109	RCL MEM
4838	053	5

4839	049	1
4840	119	print
4841	040	(
4842	109	RCL MEM
4843	048	0
4844	056	8
4845	045	-
4846	040	(
4847	109	RCL MEM
4848	053	5
4849	049	1
4850	042	x
4851	109	RCL MEM
4852	048	0
4853	049	1
4854	041	)
4855	041	)

Print and store Tn in r52

4896	119	print
4897	107	STD MEM
4898	053	5
4899	050	2

Recall masses from r03-r06

4940	040	(
4941	109	RCL MEM
4942	056	8
4943	054	6
4944	042	x
4945	109	RCL MEM
4946	048	0
4947	055	7
4948	042	x
4949	109	RCL MEM
4950	053	5
4951	049	1
4952	042	x
4953	109	RCL MEM
4954	057	9
4955	049	1
4956	041	)

Print and store mghn in r11

4997	111	+/-
4998	119	print
4999	107	STD MEM
5000	049	1
5001	049	1
5002	040	(
5003	040	(
5004	109	RCL MEM
5005	048	0
5006	051	3
5007	043	+
5008	109	RCL MEM
5009	048	0
5010	052	4
5011	043	+
5012	109	RCL MEM
5013	048	0
5014	053	5
5015	045	-

5409	051	3	5489	004	=
5410	042	x	5470	119	print
5411	109	RCL MEM	5471	107	STO MEM
5412	053	5	5472	050	2
5413	050	2	5473	056	8
5414	042	x	5474	040	(
5415	050	2	5475	109	RCL MEM
5416	042	x	5476	050	2
5417	109	RCL MEM	5477	052	4
5418	057	9	5478	042	x
5419	055	7	5479	109	RCL MEM
5420	041	)	5480	050	2
5421	092	Root	5481	054	6
5422	050	2	5482	042	x
5423	061	=	5483	109	RCL MEM
5424	119	print	5484	050	2
5425	107	STO MEM	5485	056	8
5426	050	2	5486	041	)
5427	053	5	Print nrA*nrB*nrC		
5428	109	RCL MEM	5527	119	print
5429	050	2	5528	047	/
5430	053	5	5529	109	RCL MEM
5431	047	/	5530	057	9
5432	109	RCL MEM	5531	057	9
5433	057	9	5532	061	=
5434	056	8	5533	042	x
5435	061	=	5534	040	(
5436	119	print	5535	049	1
5437	107	STO MEM	5536	064	Inverse
5438	050	2	5537	110	LOG e
5439	054	6	5538	041	)
5440	040	(	5539	091	Exponent
5441	109	RCL MEM	5540	049	1
5442	052	4	5541	046	.
5443	052	4	5542	053	5
5444	042	x	5543	061	=
5445	109	RCL MEM	5544	042	x
5446	053	5	5545	040	(
5447	050	2	5546	112	pi
5448	042	x	5547	092	Root
5449	050	2	5548	050	2
5450	042	x	5549	041	)
5451	109	RCL MEM	5550	061	=
5452	057	9	5551	110	LOG e
5453	055	7	5552	119	print
5454	041	)	5553	107	STO MEM
5455	092	Root	5554	054	6
5456	050	2	5555	048	0
5457	061	=	5556	042	x
5458	119	print	5557	109	RCL MEM
5459	107	STO MEM	5558	057	9
5460	050	2	5559	055	7
5461	055	7	5560	042	x
5462	109	RCL MEM	5561	109	RCL MEM
5463	050	2	5562	053	5
5464	055	7	5563	050	2
5465	047	/	5564	061	=
5466	109	RCL MEM	5565	119	print
5467	057	9	5566	107	STO MEM
5468	056	8	5567	051	3

6237 061 =
6238 119 print
6239 107 STD MEM
6240 053 5
6241 055 7
6242 040 (
6243 109 RCL MEM
6244 053 5
6245 049 1
6246 045 -

6247 049 1
6248 048 0
6249 101 EE
6250 053 5
6251 041)
6252 064 Inverse
6253 037 If pos
6254 071 G
6255 002 HALT

Table S4

CANNOT8 OUTPUT

Argon

288.15

208.15

0.01

1.5

40.

1.

10.229672

1.3806259 -0016

1.05459185 -0027

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7.7998253833752 -0007

3.97827353085 -0014

1.3806259 -0016

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4.4274920999643 0000

6.690456 -0023

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8.795722637338 -0013

3.0524805265792 -0015

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8.5161677103047 -0016

1.2852272538372 0011

2.332602713683 -0001

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0. 0000

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1.3806259 -0016

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1.088553321854 -0006

6.690456 -0023

7.9278446943757 -0035

9.4617404112973 -0048

1.4169839945727 -0024

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2.9834492315792 -0015

8.5968089607955 -0013

9.193549990423 -0013

3.1905431165792 -0015

8.3310197989923 0004

6.3981842425791 -0016

9.6558934057677 0010

3.104761469518 -0001

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3.0759942150949 -0024

4.2235738084284 0004
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0. 0000
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3.97827353085 -0014
1.3806259 -0016
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6.690456 -0023
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2.4886400283432 0000
1.680747300371 -0017
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0. 0000
1.7098184897965 0003
2.87377281085 -0014
1.3806259 -0016
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9.1771109963226 -0007
6.690456 -0023
5.6346596416874 -0035
4.8578195030025 -0048
1.0153133986933 -0024
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2.8453866415792 -0015
5.9226722944472 -0013
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2.8815	0002	F
2.0815	0002	R
1.	0000	P
2.5	0000	H
1.13	-0008	Z
1.4	0001	M
1.4	0001	N
2.	0000	Q
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2.7612518	-0016	
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2.4808761934885	-0015	
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CARNOT8 OUTPUT

NEN

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7.9442994577071 -0013
2.7570013734885 -0015
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25/9/24

ROYLE
AIR

BAROMETRIC
(BAROMETRIC)

[N₂ + O₂ + Argon]

Dry lapse rate

@
n₆

@
jr

1 km

@
r

@
t

p
T

2.	Y
1.	P
1.41	Q
288.15	T
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1.45	0001 N
1.13	-0008 L
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1.7863076274135	0002
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6.1885726256185	-0013
1.5899552396598	0001
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 2.6628690854936 0006
 6.9728746400065 0005
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CANNOT 8/Cal Output

ARGON

12/3/25

CONTACT

316

NO H=LS

✓ Table S6

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3.1106879202933 -0024
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3.1951885335274 -0015
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288.15
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0.78

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15/3/25

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15/3/25

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17/3/25

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