



Designation: **D7265 – 12 D7265 – 12 (Reapproved 2018)**

Standard Specification for Hydrogen Thermophysical Property Tables¹

This standard is issued under the fixed designation D7265; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 The thermophysical property tables for normal hydrogen are for use in the calculation of the pressure-volume-temperature (PVT), thermodynamic, and transport properties of hydrogen for process design and operations, particularly as they relate to hydrogen fuel cell applications. Tables are provided for gaseous hydrogen at temperatures between 50 K and 500 K at pressures to 50 MPa. These tables were developed by the National Institute of Standards and Technology from a Standard Reference Database product REFPROP, version 9.0.

1.2 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Applicability

2.1 These tables apply directly only to pure gaseous hydrogen. However, it is expected that they may find substantial use in mathematical models and tables for the thermophysical properties of mixtures containing hydrogen.

3. Tables

3.1 The tabulated thermophysical properties are:

ρ , molar density ($\text{mol}\cdot\text{L}^{-1}$)

V , molar volume ($\text{L}^{-1}\cdot\text{mol}$)

H , molar enthalpy ($\text{J}\cdot\text{mol}^{-1}$)

S , molar entropy ($\text{J}\cdot\text{K}^{-1}\cdot\text{mol}^{-1}$)

C_v , constant volume molar heat capacity ($\text{J}\cdot\text{K}^{-1}\cdot\text{mol}^{-1}$)

C_p , constant pressure molar heat capacity ($\text{J}\cdot\text{K}^{-1}\cdot\text{mol}^{-1}$)

c , speed of sound ($\text{m}\cdot\text{s}^{-1}$)

η , viscosity ($\mu\text{Pa}\cdot\text{s}$)

λ , thermal conductivity ($\text{mW}\cdot\text{m}^{-1}\cdot\text{K}^{-1}$)

3.2 These tables were produced by equations from a computer package, “NIST Standard Reference Database 23; Reference Fluid Thermodynamic and Transport Properties Database (REFPROP): Version 9.0.” A wide selection of units (SI units, engineering units, chemical units) is available with this program.

4. Additional Information

4.1 A comprehensive equation of state for normal hydrogen is not available at this time. The properties in the table were calculated from individual equations for normal hydrogen.

5. Keywords

5.1 hydrogen fuel cell; hydrogen gas tables; thermodynamic properties of hydrogen

¹ This specification is under the jurisdiction of ASTM Committee D03 on Gaseous Fuels and is the direct responsibility of Subcommittee D03.08 on Thermophysical Properties.

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TABLE 1 Hydrogen Thermophysical Property Tables

T (K)	ρ (mol·L ⁻¹)	V (L ⁻¹ ·mol)	H (J·mol ⁻¹)	S (J·mol ⁻¹ ·K ⁻¹)	C_v (J·mol ⁻¹ ·K ⁻¹)	C_p (J·mol ⁻¹ ·K ⁻¹)	c (m·s ⁻¹)	λ (mW·m ⁻¹ ·K ⁻¹)	η (μPa·s)
0.1 MPa									
50	0.24247	4.1243	1549.8	64.230	12.543	21.131	584.8	38.40	2.4717
55	0.21997	4.5461	1655.4	66.243	12.579	21.113	613.4	41.52	2.6729
60	0.20134	4.9668	1761.0	68.081	12.643	21.137	640.4	44.60	2.8655
65	0.18565	5.3866	1866.8	69.775	12.740	21.204	665.8	47.68	3.0502
70	0.17224	5.8057	1973.1	71.350	12.871	21.312	689.7	50.78	3.2281
75	0.16066	6.2244	2080.0	72.825	13.037	21.460	712.3	53.61	3.3999
80	0.15054	6.6426	2187.7	74.216	13.235	21.643	733.6	56.47	3.5663
85	0.14163	7.0605	2296.5	75.534	13.462	21.858	753.8	59.35	3.7280
90	0.13372	7.4781	2406.4	76.791	13.712	22.098	773.0	62.17	3.8855
95	0.12665	7.8955	2517.5	77.992	13.981	22.359	791.3	65.26	4.0392
100	0.12030	8.3127	2630.0	79.146	14.264	22.635	808.9	68.33	4.1896
105	0.11455	8.7298	2743.9	80.257	14.556	22.921	825.8	71.65	4.3368
110	0.10933	9.1467	2859.2	81.330	14.852	23.212	842.1	74.97	4.4813
115	0.10456	9.5635	2976.0	82.369	15.150	23.506	858.0	78.22	4.6232
120	0.10020	9.9802	3094.2	83.375	15.446	23.798	873.5	81.48	4.7629
125	0.09618	10.3970	3214.0	84.352	15.738	24.086	888.6	84.78	4.9004
130	0.09248	10.8130	3335.1	85.303	16.023	24.368	903.4	88.09	5.0359
135	0.08905	11.2300	3457.6	86.228	16.300	24.643	917.9	91.36	5.1696
140	0.08587	11.6460	3581.5	87.129	16.568	24.908	932.2	94.62	5.3015
145	0.08290	12.0630	3706.7	88.007	16.825	25.164	946.3	97.79	5.4318
150	0.08014	12.4790	3833.1	88.864	17.073	25.410	960.1	100.96	5.5606
155	0.07755	12.8950	3960.8	89.701	17.309	25.645	973.8	104.24	5.6880
160	0.07512	13.3110	4089.6	90.519	17.535	25.869	987.3	107.51	5.8140
165	0.07285	13.7280	4219.4	91.318	17.750	26.082	1000.6	110.74	5.9387
170	0.07070	14.1440	4350.4	92.100	17.954	26.285	1013.8	113.98	6.0622
175	0.06868	14.5600	4482.3	92.865	18.147	26.477	1026.9	117.11	6.1845
180	0.06677	14.9760	4615.1	93.613	18.330	26.659	1039.8	120.25	6.3056
185	0.06497	15.3920	4748.8	94.346	18.503	26.831	1052.6	123.34	6.4257
190	0.06326	15.8080	4883.4	95.064	18.666	26.994	1065.3	126.44	6.5447
195	0.06164	16.2240	5018.8	95.767	18.821	27.147	1077.8	129.44	6.6627
200	0.06010	16.6400	5154.9	96.456	18.966	27.292	1090.2	132.44	6.7798
205	0.05863	17.0560	5291.7	97.132	19.103	27.428	1102.6	135.39	6.8958
210	0.05723	17.4720	5429.1	97.794	19.231	27.556	1114.8	138.34	7.0110
215	0.05590	17.8880	5567.2	98.444	19.352	27.676	1126.9	141.20	7.1253
220	0.05463	18.3040	5705.9	99.082	19.465	27.789	1138.9	144.07	7.2387
225	0.05342	18.7200	5845.1	99.707	19.572	27.895	1150.8	146.88	7.3513
230	0.05226	19.1360	5984.8	100.320	19.672	27.994	1162.6	149.70	7.4631
235	0.05115	19.5520	6125.0	100.920	19.765	28.087	1174.4	152.46	7.5741
240	0.05008	19.9680	6265.7	101.520	19.852	28.174	1186.0	155.24	7.6843
245	0.04906	20.3840	6406.7	102.100	19.934	28.255	1197.6	157.91	7.7938
250	0.04808	20.8000	6548.2	102.670	20.010	28.331	1209.0	160.59	7.9025
255	0.04714	21.2150	6690.0	103.230	20.081	28.402	1220.4	163.21	8.0105
260	0.04623	21.6310	6832.2	103.780	20.148	28.468	1231.7	165.84	8.1178
265	0.04536	22.0470	6974.7	104.330	20.209	28.529	1242.9	168.43	8.2245
270	0.04452	22.4630	7117.5	104.860	20.267	28.587	1254.1	171.01	8.3305
275	0.04371	22.8790	7260.6	105.390	20.320	28.640	1265.1	173.50	8.4358
280	0.04293	23.2950	7403.9	105.900	20.370	28.689	1276.1	175.99	8.5405
285	0.04218	23.7110	7547.5	106.410	20.416	28.735	1287.0	178.48	8.6445
290	0.04145	24.1260	7691.2	106.910	20.459	28.777	1297.9	180.97	8.7480
295	0.04075	24.5420	7835.2	107.400	20.498	28.817	1308.6	183.37	8.8508
300	0.04007	24.9580	7979.4	107.890	20.534	28.853	1319.3	185.76	8.9531
305	0.03941	25.3740	8123.8	108.360	20.568	28.886	1329.9	188.16	9.0548
310	0.03878	25.7900	8268.3	108.830	20.599	28.917	1340.5	190.56	9.1559
315	0.03816	26.2050	8412.9	109.300	20.628	28.946	1351.0	192.86	9.2565
320	0.03756	26.6210	8557.7	109.750	20.654	28.972	1361.4	195.17	9.3566
325	0.03699	27.0370	8702.6	110.200	20.679	28.996	1371.8	197.72	9.4561
330	0.03643	27.4530	8847.7	110.650	20.701	29.018	1382.0	200.28	9.5551
335	0.03588	27.8690	8992.8	111.080	20.722	29.039	1392.3	202.79	9.6536
340	0.03536	28.2840	9138.1	111.510	20.740	29.058	1402.4	205.30	9.7515
345	0.03484	28.7000	9283.4	111.940	20.758	29.075	1412.5	207.81	9.8490
350	0.03435	29.1160	9428.8	112.360	20.773	29.090	1422.6	210.32	9.9461
355	0.03386	29.5320	9574.3	112.770	20.788	29.105	1432.5	212.79	10.0430
360	0.03339	29.9480	9719.9	113.180	20.801	29.118	1442.4	215.26	10.1390
365	0.03293	30.3630	9865.5	113.580	20.813	29.130	1452.3	217.58	10.2340
370	0.03249	30.7790	10011.0	113.970	20.824	29.141	1462.1	219.90	10.3300
375	0.03206	31.1950	10157.0	114.360	20.834	29.151	1471.8	222.32	10.4240
380	0.03164	31.6110	10303.0	114.750	20.843	29.160	1481.5	224.74	10.5190
385	0.03122	32.0260	10448.0	115.130	20.852	29.168	1491.1	227.07	10.6130
390	0.03082	32.4420	10594.0	115.510	20.859	29.175	1500.7	229.40	10.7060
395	0.03043	32.8580	10740.0	115.880	20.866	29.182	1510.2	231.72	10.7990
400	0.03005	33.2740	10886.0	116.250	20.873	29.189	1519.6	234.06	10.8920
405	0.02968	33.6900	11032.0	116.610	20.878	29.194	1529.0	236.14	10.9840
410	0.02932	34.1050	11178.0	116.970	20.884	29.200	1538.4	238.22	11.0760

TABLE 1 *Continued*

<i>T</i> (K)	ρ (mol·L ⁻¹)	<i>V</i> (L ⁻¹ ·mol)	<i>H</i> (J·mol ⁻¹)	<i>S</i> (J·mol ⁻¹ ·K ⁻¹)	<i>C_v</i> (J·mol ⁻¹ ·K ⁻¹)	<i>C_p</i> (J·mol ⁻¹ ·K ⁻¹)	<i>c</i> (m·s ⁻¹)	λ (mW·m ⁻¹ ·K ⁻¹)	η (μ Pa·s)
415	0.02897	34.5210	11324.0	117.320	20.889	29.205	1547.7	240.56	11.1680
420	0.02862	34.9370	11470.0	117.670	20.893	29.209	1556.9	242.89	11.2590
425	0.02829	35.3530	11616.0	118.020	20.897	29.213	1566.1	245.23	11.3500
430	0.02796	35.7680	11762.0	118.360	20.901	29.217	1575.2	247.57	11.4400
435	0.02764	36.1840	11908.0	118.700	20.905	29.221	1584.3	249.91	11.5300
440	0.02732	36.6000	12054.0	119.030	20.908	29.224	1593.4	252.26	11.6200
445	0.02702	37.0160	12201.0	119.360	20.912	29.227	1602.3	254.60	11.7090
450	0.02672	37.4310	12347.0	119.690	20.915	29.230	1611.3	256.95	11.7980
455	0.02642	37.8470	12493.0	120.010	20.917	29.233	1620.2	259.30	11.8870
460	0.02614	38.2630	12639.0	120.330	20.920	29.236	1629.0	261.65	11.9750
465	0.02585	38.6790	12785.0	120.650	20.923	29.238	1637.8	264.00	12.0630
470	0.02558	39.0940	12931.0	120.960	20.926	29.241	1646.5	266.35	12.1510
475	0.02531	39.5100	13078.0	121.270	20.928	29.244	1655.2	268.71	12.2390
480	0.02505	39.9260	13224.0	121.580	20.931	29.246	1663.9	271.06	12.3260
485	0.02479	40.3420	13370.0	121.880	20.933	29.249	1672.5	273.42	12.4130
490	0.02454	40.7570	13516.0	122.180	20.936	29.251	1681.1	275.78	12.4990
495	0.02429	41.1730	13663.0	122.480	20.939	29.254	1689.6	278.14	12.5860
500	0.02405	41.5890	13809.0	122.770	20.941	29.256	1698.0	280.50	12.6720
0.2 MPa									
50	0.48886	2.0456	1539.6	58.330	12.577	21.451	583.6	38.74	2.4854
55	0.44256	2.2596	1646.6	60.370	12.606	21.366	612.8	41.83	2.6855
60	0.40446	2.4724	1753.4	62.228	12.665	21.343	640.1	44.89	2.8770
65	0.37252	2.6844	1860.2	63.937	12.758	21.374	665.8	47.94	3.0609
70	0.34534	2.8957	1967.2	65.524	12.886	21.456	689.9	51.02	3.2381
75	0.32191	3.1065	2074.8	67.008	13.050	21.582	712.6	53.85	3.4093
80	0.30149	3.3168	2183.1	68.406	13.246	21.749	734.1	56.72	3.5752
85	0.28354	3.5269	2292.3	69.731	13.472	21.950	754.4	59.62	3.7364
90	0.26762	3.7366	2402.7	70.992	13.721	22.179	773.6	62.43	3.8935
95	0.25341	3.9462	2514.2	72.197	13.989	22.430	792.0	65.50	4.0468
100	0.24064	4.1555	2627.0	73.355	14.271	22.698	809.6	68.57	4.1968
105	0.22911	4.3647	2741.2	74.469	14.562	22.978	826.6	71.88	4.3437
110	0.21864	4.5738	2856.8	75.544	14.858	23.264	843.0	75.19	4.4878
115	0.20909	4.7827	2973.8	76.585	15.156	23.552	858.9	78.43	4.6295
120	0.20034	4.9916	3092.3	77.593	15.451	23.840	874.4	81.67	4.7689
125	0.19230	5.2003	3212.2	78.572	15.742	24.125	889.5	84.97	4.9061
130	0.18488	5.4090	3333.5	79.524	16.027	24.404	904.3	88.28	5.0414
135	0.17801	5.6176	3456.2	80.450	16.304	24.675	918.9	91.53	5.1749
140	0.17164	5.8261	3580.3	81.352	16.572	24.938	933.2	94.79	5.3066
145	0.16571	6.0346	3705.6	82.232	16.829	25.192	947.2	97.96	5.4368
150	0.16018	6.2431	3832.2	83.090	17.076	25.436	961.1	101.12	5.5654
155	0.15500	6.4515	3959.9	83.928	17.313	25.669	974.8	104.39	5.6926
160	0.15015	6.6598	4088.8	84.746	17.538	25.891	988.3	107.67	5.8185
165	0.14560	6.8682	4218.8	85.546	17.753	26.103	1001.6	110.89	5.9431
170	0.14131	7.0764	4349.9	86.329	17.957	26.304	1014.8	114.12	6.0664
175	0.13727	7.2847	4481.9	87.094	18.150	26.496	1027.8	117.25	6.1886
180	0.13346	7.4929	4614.8	87.843	18.333	26.676	1040.7	120.39	6.3096
185	0.12985	7.7012	4748.6	88.576	18.506	26.848	1053.5	123.48	6.4296
190	0.12643	7.9093	4883.3	89.294	18.669	27.009	1066.2	126.57	6.5485
195	0.12319	8.1175	5018.7	89.998	18.823	27.162	1078.7	129.56	6.6664
200	0.12011	8.3257	5154.9	90.687	18.968	27.305	1091.2	132.56	6.7833
205	0.11718	8.5338	5291.7	91.363	19.105	27.441	1103.5	135.51	6.8993
210	0.11439	8.7419	5429.3	92.026	19.234	27.568	1115.7	138.47	7.0144
215	0.11173	8.9500	5567.4	92.676	19.354	27.688	1127.8	141.32	7.1286
220	0.10919	9.1581	5706.1	93.314	19.468	27.800	1139.8	144.18	7.2420
225	0.10677	9.3662	5845.4	93.940	19.574	27.905	1151.7	146.99	7.3545
230	0.10445	9.5743	5985.2	94.554	19.674	28.004	1163.6	149.81	7.4662
235	0.10223	9.7823	6125.4	95.158	19.767	28.097	1175.3	152.57	7.5771
240	0.10010	9.9904	6266.1	95.750	19.854	28.183	1186.9	155.34	7.6873
245	0.09806	10.1980	6407.2	96.332	19.936	28.264	1198.5	158.02	7.7967
250	0.09610	10.4060	6548.7	96.904	20.012	28.339	1209.9	160.69	7.9054
255	0.09421	10.6140	6690.6	97.466	20.083	28.410	1221.3	163.32	8.0133
260	0.09240	10.8220	6832.8	98.018	20.150	28.476	1232.6	165.95	8.1206
265	0.09066	11.0300	6975.4	98.561	20.211	28.537	1243.8	168.53	8.2272
270	0.08898	11.2380	7118.2	99.095	20.269	28.594	1254.9	171.11	8.3331
275	0.08736	11.4460	7261.3	99.620	20.322	28.646	1266.0	173.60	8.4384
280	0.08580	11.6540	7404.7	100.140	20.372	28.696	1277.0	176.08	8.5430
285	0.08430	11.8620	7548.3	100.650	20.418	28.741	1287.9	178.57	8.6470
290	0.08285	12.0700	7692.1	101.150	20.460	28.783	1298.7	181.06	8.7505
295	0.08144	12.2780	7836.1	101.640	20.500	28.822	1309.5	183.46	8.8533
300	0.08009	12.4860	7980.3	102.120	20.536	28.858	1320.2	185.85	8.9555
305	0.07878	12.6940	8124.7	102.600	20.570	28.892	1330.8	188.25	9.0571
310	0.07751	12.9020	8269.2	103.070	20.601	28.922	1341.3	190.65	9.1582
315	0.07628	13.1100	8413.9	103.530	20.630	28.951	1351.8	192.95	9.2588
320	0.07509	13.3180	8558.7	103.990	20.656	28.977	1362.2	195.26	9.3588

TABLE 1 *Continued*

<i>T</i> (K)	ρ (mol·L ⁻¹)	<i>V</i> (L ⁻¹ ·mol)	<i>H</i> (J·mol ⁻¹)	<i>S</i> (J·mol ⁻¹ ·K ⁻¹)	<i>C_v</i> (J·mol ⁻¹ ·K ⁻¹)	<i>C_p</i> (J·mol ⁻¹ ·K ⁻¹)	<i>c</i> (m·s ⁻¹)	λ (mW·m ⁻¹ ·K ⁻¹)	η (μPa·s)
325	0.07393	13.5260	8703.6	104.440	20.680	29.001	1372.6	197.81	9.4583
330	0.07281	13.7340	8848.7	104.880	20.703	29.023	1382.9	200.36	9.5572
335	0.07173	13.9420	8993.9	105.320	20.723	29.043	1393.1	202.87	9.6557
340	0.07067	14.1500	9139.1	105.750	20.742	29.062	1403.2	205.38	9.7537
345	0.06965	14.3580	9284.5	106.170	20.759	29.079	1413.3	207.89	9.8511
350	0.06866	14.5660	9429.9	106.590	20.775	29.094	1423.4	210.40	9.9481
355	0.06769	14.7740	9575.4	107.000	20.789	29.108	1433.3	212.87	10.0450
360	0.06675	14.9820	9721.0	107.410	20.802	29.121	1443.2	215.34	10.1410
365	0.06584	15.1890	9866.6	107.810	20.814	29.133	1453.1	217.65	10.2360
370	0.06495	15.3970	10012.0	108.210	20.825	29.144	1462.9	219.97	10.3310
375	0.06408	15.6050	10158.0	108.600	20.835	29.154	1472.6	222.40	10.4260
380	0.06324	15.8130	10304.0	108.990	20.845	29.163	1482.3	224.82	10.5210
385	0.06242	16.0210	10450.0	109.370	20.853	29.171	1491.9	227.14	10.6140
390	0.06162	16.2290	10596.0	109.740	20.861	29.178	1501.4	229.47	10.7080
395	0.06084	16.4370	10741.0	110.120	20.868	29.185	1510.9	231.80	10.8010
400	0.06008	16.6450	10887.0	110.480	20.874	29.191	1520.4	234.13	10.8940
405	0.05934	16.8530	11033.0	110.850	20.880	29.197	1529.8	236.21	10.9860
410	0.05862	17.0610	11179.0	111.200	20.885	29.202	1539.1	238.29	11.0780
415	0.05791	17.2680	11325.0	111.560	20.890	29.207	1548.4	240.63	11.1690
420	0.05722	17.4760	11471.0	111.910	20.894	29.212	1557.6	242.97	11.2600
425	0.05655	17.6840	11618.0	112.250	20.899	29.216	1566.8	245.30	11.3510
430	0.05589	17.8920	11764.0	112.600	20.902	29.219	1576.0	247.64	11.4420
435	0.05525	18.1000	11910.0	112.930	20.906	29.223	1585.0	249.98	11.5320
440	0.05462	18.3080	12056.0	113.270	20.909	29.226	1594.1	252.33	11.6210
445	0.05401	18.5160	12202.0	113.600	20.913	29.229	1603.1	254.67	11.7110
450	0.05341	18.7240	12348.0	113.920	20.916	29.232	1612.0	257.02	11.8000
455	0.05282	18.9320	12494.0	114.250	20.919	29.235	1620.9	259.37	11.8890
460	0.05225	19.1400	12640.0	114.570	20.921	29.238	1629.7	261.71	11.9770
465	0.05169	19.3470	12787.0	114.880	20.924	29.240	1638.5	264.07	12.0650
470	0.05114	19.5550	12933.0	115.200	20.927	29.243	1647.2	266.42	12.1530
475	0.05060	19.7630	13079.0	115.510	20.929	29.245	1655.9	268.77	12.2400
480	0.05007	19.9710	13225.0	115.810	20.932	29.248	1664.6	271.13	12.3270
485	0.04956	20.1790	13372.0	116.110	20.934	29.250	1673.2	273.49	12.4140
490	0.04905	20.3870	13518.0	116.410	20.937	29.253	1681.7	275.84	12.5010
495	0.04856	20.5950	13664.0	116.710	20.940	29.255	1690.2	278.20	12.5870
500	0.04807	20.8030	13810.0	117.010	20.942	29.258	1698.7	280.57	12.6730
0.5 MPa									
50	1.25300	0.7981	1508.6	50.290	12.677	22.483	580.4	39.86	2.5283
55	1.12660	0.8876	1620.1	52.417	12.685	22.169	611.0	42.82	2.7243
60	1.02480	0.9758	1730.5	54.337	12.729	21.985	639.5	45.78	2.9126
65	0.94060	1.0632	1840.1	56.093	12.811	21.901	666.0	48.75	3.0938
70	0.86974	1.1498	1949.6	57.715	12.931	21.895	690.7	51.76	3.2687
75	0.80916	1.2358	2059.2	59.228	13.088	21.955	713.9	54.59	3.4379
80	0.75671	1.3215	2169.2	60.648	13.279	22.069	735.7	57.48	3.6021
85	0.71082	1.4068	2280.0	61.990	13.500	22.227	756.2	60.43	3.7618
90	0.67030	1.4919	2391.6	63.266	13.746	22.422	775.7	63.21	3.9175
95	0.63424	1.5767	2504.2	64.484	14.012	22.645	794.3	66.23	4.0696
100	0.60193	1.6613	2618.1	65.652	14.292	22.890	812.0	69.26	4.2185
105	0.57281	1.7458	2733.2	66.775	14.581	23.149	829.1	72.53	4.3643
110	0.54641	1.8301	2849.6	67.858	14.876	23.418	845.6	75.81	4.5075
115	0.52237	1.9143	2967.3	68.905	15.172	23.692	861.6	79.02	4.6483
120	0.50039	1.9985	3086.5	69.919	15.466	23.967	877.1	82.25	4.7869
125	0.48020	2.0825	3207.0	70.903	15.757	24.241	892.3	85.52	4.9234
130	0.46159	2.1664	3328.9	71.859	16.040	24.510	907.1	88.81	5.0580
135	0.44438	2.2503	3452.1	72.789	16.317	24.773	921.7	92.04	5.1909
140	0.42842	2.3341	3576.6	73.695	16.584	25.029	936.0	95.29	5.3220
145	0.41358	2.4179	3702.4	74.577	16.841	25.276	950.1	98.44	5.4517
150	0.39974	2.5016	3829.4	75.438	17.087	25.513	963.9	101.59	5.5798
155	0.38680	2.5853	3957.5	76.279	17.323	25.741	977.6	104.84	5.7065
160	0.37468	2.6689	4086.7	77.099	17.548	25.958	991.1	108.10	5.8320
165	0.36330	2.7525	4217.1	77.901	17.763	26.166	1004.5	111.32	5.9561
170	0.35260	2.8361	4348.4	78.685	17.966	26.363	1017.7	114.53	6.0791
175	0.34251	2.9197	4480.7	79.452	18.159	26.551	1030.7	117.66	6.2009
180	0.33298	3.0032	4613.9	80.203	18.342	26.728	1043.6	120.78	6.3216
185	0.32397	3.0867	4747.9	80.937	18.514	26.896	1056.4	123.86	6.4412
190	0.31544	3.1701	4882.8	81.657	18.677	27.055	1069.0	126.94	6.5598
195	0.30735	3.2536	5018.5	82.362	18.831	27.205	1081.6	129.93	6.6774
200	0.29967	3.3370	5154.9	83.052	18.976	27.346	1094.0	132.92	6.7941
205	0.29236	3.4204	5291.9	83.729	19.112	27.480	1106.3	135.86	6.9098
210	0.28540	3.5038	5429.7	84.393	19.241	27.605	1118.5	138.81	7.0247
215	0.27877	3.5872	5568.0	85.044	19.361	27.723	1130.6	141.66	7.1387
220	0.27244	3.6706	5706.9	85.682	19.475	27.833	1142.6	144.51	7.2518
225	0.26639	3.7539	5846.3	86.309	19.581	27.937	1154.5	147.32	7.3641
230	0.26060	3.8373	5986.2	86.924	19.680	28.034	1166.3	150.13	7.4756

TABLE 1 *Continued*

<i>T</i> (K)	ρ (mol·L ⁻¹)	<i>V</i> (L ⁻¹ ·mol)	<i>H</i> (J·mol ⁻¹)	<i>S</i> (J·mol ⁻¹ ·K ⁻¹)	<i>C_v</i> (J·mol ⁻¹ ·K ⁻¹)	<i>C_p</i> (J·mol ⁻¹ ·K ⁻¹)	<i>c</i> (m·s ⁻¹)	λ (mW·m ⁻¹ ·K ⁻¹)	η (μ Pa·s)
235	0.25506	3.9206	6126.6	87.528	19.773	28.125	1178.0	152.89	7.5863
240	0.24975	4.0040	6267.5	88.121	19.861	28.211	1189.6	155.65	7.6963
245	0.24466	4.0873	6408.7	88.704	19.942	28.290	1201.2	158.32	7.8055
250	0.23977	4.1706	6550.4	89.276	20.018	28.364	1212.6	160.99	7.9140
255	0.23508	4.2539	6692.4	89.838	20.089	28.434	1224.0	163.61	8.0218
260	0.23056	4.3372	6834.7	90.391	20.155	28.499	1235.3	166.23	8.1289
265	0.22622	4.4205	6977.3	90.934	20.217	28.559	1246.5	168.81	8.2353
270	0.22204	4.5037	7120.3	91.469	20.274	28.615	1257.6	171.39	8.3411
275	0.21801	4.5870	7263.5	91.994	20.328	28.667	1268.6	173.87	8.4462
280	0.21412	4.6703	7406.9	92.511	20.377	28.715	1279.6	176.35	8.5507
285	0.21037	4.7535	7550.6	93.020	20.423	28.760	1290.5	178.84	8.6546
290	0.20675	4.8368	7694.5	93.520	20.465	28.801	1301.3	181.33	8.7579
295	0.20325	4.9200	7838.6	94.013	20.505	28.840	1312.0	183.72	8.8606
300	0.19987	5.0033	7982.9	94.498	20.541	28.875	1322.7	186.11	8.9627
305	0.19660	5.0865	8127.4	94.976	20.575	28.908	1333.3	188.50	9.0642
310	0.19343	5.1697	8272.0	95.446	20.606	28.938	1343.8	190.90	9.1652
315	0.19037	5.2530	8416.7	95.909	20.634	28.966	1354.3	193.20	9.2656
320	0.18740	5.3362	8561.6	96.366	20.661	28.991	1364.7	195.50	9.3655
325	0.18452	5.4194	8706.7	96.815	20.685	29.015	1375.0	198.05	9.4649
330	0.18173	5.5026	8851.8	97.258	20.707	29.036	1385.3	200.60	9.5638
335	0.17902	5.5859	8997.0	97.695	20.727	29.056	1395.5	203.10	9.6621
340	0.17640	5.6691	9142.3	98.126	20.746	29.074	1405.6	205.61	9.7600
345	0.17384	5.7523	9287.8	98.550	20.763	29.091	1415.7	208.12	9.8574
350	0.17137	5.8355	9433.2	98.969	20.779	29.106	1425.7	210.63	9.9543
355	0.16896	5.9187	9578.8	99.382	20.793	29.120	1435.7	213.09	10.0510
360	0.16661	6.0019	9724.4	99.789	20.807	29.132	1445.6	215.56	10.1470
365	0.16434	6.0851	9870.1	100.190	20.819	29.144	1455.4	217.87	10.2420
370	0.16212	6.1683	10016.0	100.590	20.829	29.154	1465.2	220.19	10.3370
375	0.15996	6.2515	10162.0	100.980	20.839	29.164	1474.9	222.61	10.4320
380	0.15786	6.3347	10308.0	101.370	20.848	29.172	1484.6	225.03	10.5260
385	0.15581	6.4179	10453.0	101.750	20.857	29.180	1494.2	227.35	10.6200
390	0.15382	6.5011	10599.0	102.120	20.864	29.187	1503.7	229.68	10.7130
395	0.15188	6.5842	10745.0	102.500	20.871	29.194	1513.2	232.00	10.8060
400	0.14998	6.6674	10891.0	102.860	20.878	29.200	1522.6	234.33	10.8990
405	0.14813	6.7506	11037.0	103.230	20.883	29.205	1532.0	236.61	10.9910
410	0.14633	6.8338	11183.0	103.580	20.889	29.210	1541.4	238.99	11.0830
415	0.14457	6.9170	11329.0	103.940	20.893	29.215	1550.6	240.83	11.1740
420	0.14285	7.0002	11475.0	104.290	20.898	29.219	1559.9	243.16	11.2660
425	0.14118	7.0833	11622.0	104.630	20.902	29.223	1569.0	245.50	11.3560
430	0.13954	7.1665	11768.0	104.980	20.906	29.226	1578.1	247.84	11.4470
435	0.13794	7.2497	11914.0	105.310	20.909	29.230	1587.2	250.18	11.5370
440	0.13637	7.3329	12060.0	105.650	20.913	29.233	1596.2	252.52	11.6260
445	0.13484	7.4160	12206.0	105.980	20.916	29.236	1605.2	254.86	11.7160
450	0.13335	7.4992	12352.0	106.300	20.919	29.238	1614.1	257.20	11.8050
455	0.13188	7.5824	12499.0	106.630	20.922	29.241	1623.0	259.55	11.8930
460	0.13045	7.6655	12645.0	106.950	20.925	29.244	1631.8	261.90	11.9820
465	0.12905	7.7487	12791.0	107.260	20.927	29.246	1640.6	264.25	12.0700
470	0.12768	7.8319	12937.0	107.580	20.930	29.248	1649.3	266.60	12.1570
475	0.12634	7.9150	13083.0	107.890	20.932	29.251	1658.0	268.95	12.2450
480	0.12503	7.9982	13230.0	108.190	20.935	29.253	1666.6	271.31	12.3320
485	0.12374	8.0814	13376.0	108.500	20.938	29.256	1675.2	273.66	12.4190
490	0.12248	8.1645	13522.0	108.800	20.940	29.258	1683.8	276.02	12.5050
495	0.12125	8.2477	13669.0	109.090	20.943	29.260	1692.3	278.38	12.5910
500	0.12004	8.3308	13815.0	109.390	20.945	29.263	1700.7	280.74	12.6770
1.0 MPa									
50	2.61740	0.3821	1454.7	43.785	12.837	24.482	576.1	42.10	2.6078
55	2.32380	0.4303	1574.9	46.076	12.810	23.649	609.2	44.74	2.7944
60	2.09580	0.4772	1691.7	48.110	12.830	23.135	639.3	47.46	2.9756
65	1.91220	0.5230	1806.6	49.949	12.895	22.823	667.0	50.26	3.1512
70	1.76050	0.5680	1920.2	51.633	13.002	22.654	692.6	53.12	3.3215
75	1.63250	0.6126	2033.3	53.193	13.149	22.591	716.5	55.91	3.4869
80	1.52290	0.6566	2146.3	54.652	13.332	22.611	738.8	58.79	3.6479
85	1.42780	0.7004	2259.5	56.025	13.547	22.695	759.8	61.80	3.8048
90	1.34440	0.7438	2373.3	57.326	13.788	22.830	779.6	64.51	3.9581
95	1.27060	0.7871	2487.9	58.564	14.049	23.005	798.4	67.46	4.1080
100	1.20470	0.8301	2603.4	59.750	14.326	23.208	816.3	70.41	4.2550
105	1.14550	0.8730	2720.0	60.887	14.612	23.434	833.6	73.62	4.3990
110	1.09200	0.9157	2837.8	61.983	14.905	23.674	850.2	76.84	4.5405
115	1.04350	0.9584	2956.8	63.041	15.199	23.923	866.2	80.01	4.6798
120	0.99912	1.0009	3077.0	64.064	15.491	24.178	881.8	83.19	4.8170
125	0.95847	1.0433	3198.5	65.056	15.780	24.433	897.1	86.43	4.9523
130	0.92107	1.0857	3321.3	66.020	16.063	24.686	911.9	89.68	5.0857
135	0.88653	1.1280	3445.4	66.956	16.337	24.935	926.5	92.89	5.2175
140	0.85453	1.1702	3570.7	67.867	16.603	25.178	940.8	96.10	5.3477

TABLE 1 *Continued*

<i>T</i> (K)	ρ (mol·L ⁻¹)	<i>V</i> (L ⁻¹ ·mol)	<i>H</i> (J·mol ⁻¹)	<i>S</i> (J·mol ⁻¹ ·K ⁻¹)	<i>C_v</i> (J·mol ⁻¹ ·K ⁻¹)	<i>C_p</i> (J·mol ⁻¹ ·K ⁻¹)	<i>c</i> (m·s ⁻¹)	λ (mW·m ⁻¹ ·K ⁻¹)	η (μ Pa·s)
145	0.82480	1.2124	3697.1	68.755	16.860	25.413	954.9	99.22	5.4764
150	0.79709	1.2546	3824.8	69.620	17.105	25.641	968.8	102.35	5.6037
155	0.77121	1.2967	3953.5	70.465	17.341	25.860	982.5	105.58	5.7297
160	0.74699	1.3387	4083.4	71.289	17.565	26.069	996.0	108.82	5.8544
165	0.72425	1.3807	4214.2	72.094	17.778	26.269	1009.3	112.01	5.9778
170	0.70287	1.4227	4346.0	72.881	17.981	26.460	1022.5	115.21	6.1002
175	0.68273	1.4647	4478.8	73.651	18.174	26.642	1035.5	118.31	6.2214
180	0.66373	1.5066	4612.4	74.404	18.356	26.814	1048.4	121.42	6.3415
185	0.64576	1.5486	4746.9	75.141	18.528	26.977	1061.2	124.49	6.4606
190	0.62875	1.5904	4882.2	75.862	18.691	27.131	1073.8	127.55	6.5787
195	0.61262	1.6323	5018.2	76.569	18.844	27.277	1086.3	130.53	6.6958
200	0.59731	1.6742	5155.0	77.261	18.989	27.414	1098.7	133.50	6.8120
205	0.58274	1.7160	5292.4	77.940	19.125	27.544	1111.0	136.43	6.9273
210	0.56888	1.7578	5430.4	78.605	19.253	27.666	1123.2	139.37	7.0417
215	0.55566	1.7997	5569.0	79.257	19.373	27.780	1135.3	142.20	7.1553
220	0.54305	1.8414	5708.2	79.897	19.486	27.888	1147.2	145.04	7.2680
225	0.53100	1.8832	5847.9	80.525	19.592	27.989	1159.1	147.84	7.3800
230	0.51948	1.9250	5988.1	81.141	19.691	28.084	1170.9	150.64	7.4911
235	0.50845	1.9668	6128.7	81.746	19.784	28.173	1182.6	153.39	7.6015
240	0.49788	2.0085	6269.8	82.340	19.871	28.256	1194.2	156.14	7.7112
245	0.48774	2.0503	6411.2	82.924	19.952	28.333	1205.7	158.80	7.8201
250	0.47801	2.0920	6553.1	83.497	20.028	28.406	1217.1	161.46	7.9283
255	0.46867	2.1337	6695.3	84.060	20.099	28.473	1228.4	164.07	8.0358
260	0.45968	2.1754	6837.8	84.614	20.165	28.536	1239.7	166.69	8.1426
265	0.45103	2.2171	6980.7	85.158	20.226	28.595	1250.9	169.26	8.2488
270	0.44270	2.2588	7123.8	85.693	20.283	28.649	1262.0	171.83	8.3543
275	0.43468	2.3005	7267.1	86.219	20.337	28.700	1273.0	174.31	8.4592
280	0.42694	2.3422	7410.8	86.736	20.386	28.747	1283.9	176.78	8.5635
285	0.41948	2.3839	7554.6	87.246	20.432	28.790	1294.8	179.26	8.6671
290	0.41227	2.4256	7698.7	87.747	20.474	28.831	1305.6	181.74	8.7702
295	0.40531	2.4673	7842.9	88.240	20.513	28.868	1316.3	184.13	8.8727
300	0.39857	2.5089	7987.3	88.725	20.549	28.902	1326.9	186.51	8.9746
305	0.39206	2.5506	8131.9	89.203	20.583	28.934	1337.5	188.90	9.0759
310	0.38576	2.5923	8276.7	89.674	20.614	28.963	1348.0	191.29	9.1767
315	0.37966	2.6339	8421.5	90.138	20.642	28.990	1358.5	193.59	9.2770
320	0.37375	2.6756	8566.6	90.594	20.668	29.015	1368.8	195.88	9.3767
325	0.36802	2.7172	8711.7	91.044	20.692	29.037	1379.1	198.43	9.4759
330	0.36247	2.7589	8856.9	91.488	20.715	29.058	1389.4	200.97	9.5746
335	0.35708	2.8005	9002.3	91.925	20.735	29.077	1399.6	203.47	9.6728
340	0.35184	2.8422	9147.7	92.356	20.754	29.094	1409.7	205.97	9.7705
345	0.34676	2.8838	9293.2	92.781	20.771	29.110	1419.7	208.48	9.8677
350	0.34183	2.9254	9438.8	93.200	20.786	29.125	1429.7	210.98	9.9645
355	0.33703	2.9671	9584.5	93.613	20.800	29.138	1439.7	213.44	10.0610
360	0.33237	3.0087	9730.2	94.021	20.813	29.150	1449.5	215.90	10.1570
365	0.32783	3.0503	9876.0	94.423	20.825	29.161	1459.3	218.22	10.2520
370	0.32342	3.0919	10022.0	94.820	20.836	29.171	1469.1	220.53	10.3470
375	0.31913	3.1336	10168.0	95.211	20.846	29.180	1478.8	222.94	10.4410
380	0.31494	3.1752	10314.0	95.598	20.855	29.188	1488.4	225.36	10.5360
385	0.31087	3.2168	10460.0	95.979	20.863	29.195	1498.0	227.68	10.6290
390	0.30690	3.2584	10606.0	96.356	20.871	29.202	1507.5	230.00	10.7230
395	0.30303	3.3000	10752.0	96.728	20.878	29.208	1517.0	232.33	10.8150
400	0.29925	3.3416	10898.0	97.096	20.884	29.214	1526.4	234.65	10.9080
405	0.29557	3.3833	11044.0	97.459	20.889	29.219	1535.8	236.97	11.0000
410	0.29198	3.4249	11190.0	97.817	20.895	29.223	1545.1	239.81	11.0920
415	0.28848	3.4665	11336.0	98.171	20.899	29.227	1554.3	241.14	11.1830
420	0.28506	3.5081	11482.0	98.521	20.904	29.231	1563.5	243.47	11.2740
425	0.28172	3.5497	11628.0	98.867	20.908	29.235	1572.7	245.80	11.3650
430	0.27845	3.5913	11774.0	99.209	20.912	29.238	1581.8	248.14	11.4550
435	0.27526	3.6329	11921.0	99.547	20.915	29.241	1590.8	250.47	11.5450
440	0.27215	3.6745	12067.0	99.882	20.918	29.244	1599.8	252.81	11.6340
445	0.26910	3.7161	12213.0	100.210	20.922	29.246	1608.8	255.15	11.7240
450	0.26612	3.7577	12359.0	100.540	20.924	29.249	1617.7	257.49	11.8130
455	0.26321	3.7993	12506.0	100.860	20.927	29.251	1626.5	259.84	11.9010
460	0.26036	3.8409	12652.0	101.180	20.930	29.253	1635.3	262.18	11.9890
465	0.25757	3.8825	12798.0	101.500	20.933	29.256	1644.1	264.53	12.0770
470	0.25484	3.9241	12944.0	101.810	20.935	29.258	1652.8	266.88	12.1650
475	0.25217	3.9657	13091.0	102.120	20.938	29.260	1661.5	269.23	12.2520
480	0.24955	4.0072	13237.0	102.430	20.940	29.262	1670.1	271.58	12.3390
485	0.24698	4.0488	13383.0	102.730	20.943	29.264	1678.7	273.94	12.4260
490	0.24447	4.0904	13530.0	103.030	20.945	29.266	1687.2	276.29	12.5130
495	0.24201	4.1320	13676.0	103.330	20.948	29.268	1695.7	278.65	12.5990
500	0.23960	4.1736	13822.0	103.620	20.950	29.271	1704.1	281.01	12.6850
2.0 MPa									
50	5.73450	0.1744	1340.3	36.406	13.137	29.720	575.3	48.33	2.8287