Designation: D4651 – 08

Standard Specification for Isobutane Thermophysical Property Tables[1]

This standard is issued under the fixed designation D4651; 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 isobutane are for use in the calculation of the pressure-volume-temperature (PVT), thermodynamic, and transport properties of isobutane for process design and operations. Tables are provided for gaseous and liquid isobutane at temperatures between 120 and 570 K at pressures to 20 MPa. One table provides properties at the conditions of liquid-vapor equilibrium (saturation properties). The other table provides properties at selected T, p points for the equilibrium phase at those conditions. The tables were developed by the National Institute of Standards and Technology from a Standard Reference Database product REFPROP, version 8.0.

1.2 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

2. Applicability

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

3. Tables

3.1 These thermophysical property tables are:

3.1.1 *Thermophysical Properties of Coexisting Gaseous and Liquid Isobutane*, in SI units. See Table 1.

3.1.2 *Thermophysical Properties of Isobutane Along Isobars*, in SI units. See Table 2.

3.2 The tabulated thermophysical properties are:

ρ, molar density ($mol \cdot l^{-1}$)
H, molar enthalpy ($J \cdot mol^{-1}$)
S, molar entropy ($J \cdot K^{-1} \cdot mol^{-1}$)
C_v, constant volume molar heat capacity ($J \cdot K^{-1} \cdot mol^{-1}$)
C_p, constant pressure molar heat capacity ($J \cdot K^{-1} \cdot mol^{-1}$)
c, speed of sound ($m \cdot s^{-1}$)
η, viscosity (μPa·s)
λ, thermal conductivity ($mW \cdot m^{-1} \cdot K^{-1}$)

3.3 These tables were produced by equations from a computer package, "NIST Standard Reference Database 23; Reference Fluid Thermodynamic and Transport Properties Database (REFPROP): Version =8.0" A wide selection of units (SI units, engineering units, chemical units) is available with this program.[2]

4. Additional Information

4.1 Reference state properties are required to calculate certain of the thermodynamic properties (enthalpy, entropy, etc.) from an equation of state formulation. The reference state properties used to generate the tables in this specification are: enthalpy, H, and entropy, S, at 298.15 K and 0.101325 MPa (H = 17932.6 J/mol and S = 295.390 J/(mol K). The molar mass of isobutane is 58.122 g/mol.

5. Keywords

5.1 isobutane gas tables; natural gas; thermodynamic properties of isobutane; transport properties of isobutane

[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.

Current edition approved Dec. 1, 2008. Published January 2009. Originally approved in 1987. Last previous edition approved in 2003 as D4651 – 93 (2003). DOI: 10.1520/D4651-08.

[2] Available from Standard Reference Data, National Institute of Standards and Technology (NIST), 100 Bureau Drive, Stop 3460, Gaithersburg, MD 20899.

TABLE 1 Thermophysical Properties of Coexisting Gaseous and Liquid Isobutane

T K	P MPa	ρ mol·l^{-1}	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}	η μPa·s	λ mW·m^{-1}·K^{-1}
114	2.455E-08	12.733	-23331	110.20	68.27	98.21	1997.4	8618	157.88
114	2.455E-08	2.59E-08	4595.2	355.17	42.89	51.20	139.53	2.855	2.287
118	6.643E-08	12.668	-22937	113.60	68.75	98.94	1962.5	6774	157.1
118	6.643E-08	6.771E-08	4802.2	348.68	43.96	52.28	141.68	2.960	2.512
122	1.673E-07	12.603	-22540	116.91	69.25	99.68	1928.5	5441	156.3
122	1.673E-07	1.65E-07	5013.4	342.75	45.02	53.34	143.79	3.066	2.741
126	3.952E-07	12.538	-22140	120.14	69.75	100.43	1895.5	4451	155.4
126	3.952E-07	3.773E-07	5228.8	337.35	46.06	54.38	145.87	3.171	2.974
130	8.806E-07	12.473	-21736	123.29	70.26	101.18	1863.4	3698	154.4
130	8.806E-07	8.147E-07	5448.4	332.40	47.09	55.40	147.92	3.276	3.211
134	1.861E-06	12.408	-21330	126.36	70.75	101.93	1832.2	3115	153.3
134	1.861E-06	1.67E-06	5672.0	327.87	48.09	56.41	149.94	3.381	3.453
138	3.748E-06	12.343	-20921	129.37	71.25	102.68	1801.7	2656	152.9
138	3.748E-06	3.267E-06	5899.6	323.72	49.09	57.40	151.94	3.486	3.699
142	7.225E-06	12.278	-20509	132.32	71.74	103.42	1772.0	2289	151.0
142	7.225E-06	6.12E-06	6131.1	319.92	50.06	58.38	153.90	3.591	3.948
146	1.338E-05	12.213	-20094	135.20	72.23	104.16	1742.9	1991	149.7
146	1.338E-05	1.102E-05	6366.5	316.43	51.03	59.34	155.84	3.695	4.202
150	2.388E-05	12.147	-19675	138.03	72.72	104.89	1714.4	1748	148.4
150	2.388E-05	1.915E-05	6605.6	313.23	51.98	60.30	157.76	3.799	4.461
154	4.121E-05	12.082	-19254	140.80	73.21	105.63	1686.4	1546	147.1
154	4.121E-05	3.219E-05	6848.5	310.30	52.93	61.25	159.65	3.903	4.723
158	6.893E-05	12.016	-18830	143.51	73.70	106.36	1658.9	1377	145.7
158	6.893E-05	5.248E-05	7095.1	307.60	53.87	62.19	161.51	4.007	4.989
162	0.000112	11.951	-18403	146.18	74.19	107.10	1631.8	1234	144.2
162	0.000112	8.319E-05	7345.3	305.12	54.80	63.12	163.35	4.110	5.260
166	0.0001773	11.885	-17974	148.80	74.68	107.83	1605.0	1113	142.7
166	0.0001773	0.0001285	7599.0	302.85	55.73	64.05	165.16	4.214	5.534
170	0.0002739	11.819	-17541	151.38	75.18	108.57	1578.6	1008	141.2
170	0.0002739	0.0001938	7856.2	300.77	56.65	64.99	166.95	4.317	5.813
174	0.0004134	11.752	-17105	153.91	75.68	109.32	1552.6	918.4	139.7
174	0.0004134	0.000286	8116.8	298.87	57.58	65.92	168.70	4.420	6.095
178	0.0006111	11.686	-16666	156.41	76.20	110.07	1526.8	840.0	138.1
178	0.0006111	0.0004133	8380.8	297.12	58.50	66.85	170.43	4.522	6.382
182	0.0008856	11.619	-16224	158.86	76.72	110.83	1501.3	771.3	136.5
182	0.0008856	0.0005859	8648.1	295.52	59.43	67.79	172.13	4.624	6.672
186	0.0012602	11.552	-15780	161.28	77.25	111.60	1476.0	710.8	134.9
186	0.0012602	0.0008161	8918.6	294.06	60.36	68.74	173.80	4.726	6.967
190	0.0017628	11.485	-15332	163.66	77.79	112.37	1450.9	657.2	133.2
190	0.0017628	0.0011181	9192.1	292.73	61.29	69.69	175.44	4.828	7.265
194	0.002427	11.418	-14880	166.01	78.35	113.16	1426.1	609.5	131.6
194	0.002427	0.0015085	9468.7	291.52	62.23	70.65	177.05	4.929	7.567
198	0.0032918	11.350	-14426	168.33	78.91	113.96	1401.4	566.8	129.9
198	0.0032918	0.0020061	9748.2	290.42	63.18	71.63	178.61	5.029	7.873
202	0.0044031	11.282	-13969	170.62	79.49	114.78	1376.9	528.5	128.2
202	0.0044031	0.0026324	10031	289.42	64.14	72.62	180.14	5.130	8.183
206	0.005813	11.213	-13508	172.87	80.08	115.61	1352.6	493.8	126.5
206	0.005813	0.0034111	10316	288.52	65.10	73.62	181.63	5.230	8.496

TABLE 1 *Continued*

T K	P MPa	ρ mol·l^{-1}	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}	η μPa·s	λ mW·m^{-1}·K^{-1}
210	0.0075808	11.145	-13043	175.11	80.69	116.46	1328.4	462.4	124.8
210	0.0075808	0.0043687	10603	287.71	66.08	74.64	183.08	5.329	8.813
214	0.0097734	11.075	-12576	177.31	81.31	117.32	1304.4	433.9	123.1
214	0.0097734	0.0055342	10893	286.98	67.06	75.68	184.48	5.428	9.133
218	0.012465	11.006	-12105	179.49	81.95	118.20	1280.5	407.9	121.4
218	0.012465	0.006939	11186	286.33	68.06	76.74	185.83	5.527	9.457
222	0.015736	10.936	-11630	181.65	82.60	119.10	1256.7	384.1	119.7
222	0.015736	0.0086174	11481	285.75	69.07	77.82	187.12	5.625	9.784
226	0.019678	10.865	-11151	183.78	83.26	120.02	1233.0	362.2	118.0
226	0.019678	0.010606	11778	285.24	70.10	78.93	188.37	5.723	10.12
230	0.024387	10.794	-10669	185.89	83.94	120.96	1209.5	342.1	116.3
230	0.024387	0.012943	12077	284.79	71.14	80.06	189.56	5.821	10.45
234	0.029967	10.723	-10183	187.99	84.64	121.92	1186.1	323.6	114.6
234	0.029967	0.015671	12377	284.40	72.19	81.21	190.68	5.918	10.79
238	0.03653	10.651	-9693.1	190.06	85.35	122.90	1162.8	306.4	112.9
238	0.03653	0.018834	12680	284.07	73.26	82.39	191.75	6.015	11.13
242	0.044196	10.578	-9199.1	192.12	86.08	123.91	1139.6	290.5	111.3
242	0.044196	0.022477	12984	283.78	74.34	83.60	192.74	6.112	11.47
246	0.053092	10.505	-8700.9	194.15	86.82	124.94	1116.4	275.8	109.6
246	0.053092	0.026651	13290	283.55	75.44	84.83	193.67	6.208	11.82
250	0.06335	10.431	-8198.5	196.18	87.58	126.00	1093.4	262.0	107.9
250	0.06335	0.031405	13597	283.36	76.55	86.10	194.52	6.304	12.17
254	0.075109	10.357	-7691.7	198.18	88.35	127.08	1070.4	249.2	106.3
254	0.075109	0.036794	13905	283.21	77.68	87.40	195.30	6.401	12.53
258	0.088516	10.281	-7180.5	200.18	89.14	128.19	1047.5	237.3	104.7
258	0.088516	0.042874	14214	283.10	78.82	88.73	196.00	6.497	12.89
262	0.10372	10.205	-6664.7	202.15	89.94	129.33	1024.7	226.1	103.0
262	0.10372	0.049705	14525	283.03	79.98	90.10	196.62	6.594	13.26
266	0.12089	10.128	-6144.2	204.12	90.76	130.50	1002.0	215.7	101.4
266	0.12089	0.057348	14836	282.99	81.15	91.50	197.15	6.690	13.62
270	0.14017	10.051	-5618.9	206.07	91.59	131.70	979.29	205.9	99.87
270	0.14017	0.065869	15147	282.98	82.34	92.94	197.59	6.787	14.00
274	0.16174	9.9721	-5088.6	208.01	92.44	132.94	956.65	196.6	98.30
274	0.16174	0.075336	15459	283.01	83.54	94.42	197.94	6.885	14.38
278	0.18577	9.8925	-4553.3	209.94	93.29	134.21	934.06	188.0	96.75
278	0.18577	0.085821	15772	283.06	84.76	95.94	198.20	6.983	14.77
282	0.21243	9.8118	-4012.7	211.87	94.17	135.52	911.50	179.8	95.22
282	0.21243	0.0974	16084	283.13	85.99	97.51	198.35	7.082	15.16
286	0.24192	9.7300	-3466.7	213.78	95.05	136.87	888.97	172.1	93.72
286	0.24192	0.11015	16397	283.23	87.24	99.13	198.41	7.183	15.56
290	0.2744	9.6470	-2915.2	215.68	95.95	138.26	866.47	164.8	92.23
290	0.2744	0.12417	16709	283.35	88.50	100.79	198.35	7.284	15.97
294	0.31008	9.5628	-2358	217.58	96.86	139.70	843.98	157.9	90.76
294	0.31008	0.13954	17021	283.49	89.78	102.51	198.19	7.388	16.38
298	0.34914	9.4773	-1794.9	219.46	97.78	141.18	821.50	151.4	89.32
298	0.34914	0.15635	17332	283.65	91.07	104.29	197.92	7.492	16.81
302	0.39177	9.3902	-1225.8	221.35	98.71	142.72	799.01	145.2	87.89
302	0.39177	0.17472	17643	283.82	92.38	106.13	197.52	7.600	17.24

TABLE 1 *Continued*

T K	*P* MPa	ρ mol·l^{-1}	*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}	η μPa·s	λ mW·m^{-1}·K^{-1}
306	0.43819	9.3017	-650.4	223.22	99.66	144.32	776.50	139.3	86.49
306	0.43819	0.19476	17952	284.01	93.70	108.04	197.01	7.709	17.69
310	0.48858	9.2114	-68.6	225.09	100.62	145.98	753.97	133.6	85.12
310	0.48858	0.21659	18259	284.22	95.03	110.03	196.37	7.822	18.15
314	0.54317	9.1194	519.9	226.96	101.59	147.71	731.40	128.3	83.76
314	0.54317	0.24034	18565	284.43	96.38	112.10	195.59	7.938	18.63
318	0.60215	9.0255	1115.4	228.83	102.57	149.52	708.78	123.2	82.44
318	0.60215	0.26617	18870	284.66	97.75	114.27	194.68	8.057	19.12
322	0.66573	8.9295	1718	230.69	103.56	151.42	686.10	118.2	81.13
322	0.66573	0.29422	19171	284.89	99.13	116.54	193.62	8.181	19.63
326	0.73415	8.8312	2328.2	232.55	104.57	153.41	663.33	113.5	79.85
326	0.73415	0.3247	19470	285.13	100.51	118.93	192.41	8.310	20.16
330	0.80761	8.7304	2946.1	234.40	105.59	155.52	640.46	109.0	78.60
330	0.80761	0.35779	19766	285.37	101.91	121.44	191.05	8.445	20.71
334	0.88635	8.6270	3572.3	236.26	106.63	157.75	617.48	104.6	77.36
334	0.88635	0.39372	20058	285.62	103.31	124.10	189.52	8.586	21.29
338	0.97059	8.5206	4207.0	238.12	107.68	160.13	594.36	100.4	76.16
338	0.97059	0.43277	20345	285.87	104.71	126.93	187.82	8.735	21.89
342	1.0606	8.4109	4850.8	239.98	108.74	162.69	571.08	96.38	74.97
342	1.0606	0.47521	20627	286.11	106.11	129.97	185.94	8.893	22.53
346	1.1565	8.2977	5504.1	241.85	109.83	165.44	547.62	92.43	73.81
346	1.1565	0.5214	20903	286.36	107.52	133.26	183.86	9.061	23.21
350	1.2587	8.1805	6167.6	243.72	110.93	168.44	523.94	88.59	72.68
350	1.2587	0.57173	21172	286.59	108.95	136.89	181.59	9.241	23.93
354	1.3674	8.0588	6842.0	245.60	112.06	171.73	500.02	84.84	71.57
354	1.3674	0.62668	21433	286.82	110.41	140.94	179.11	9.44	24.70
358	1.4829	7.9321	7528.1	247.49	113.21	175.38	475.82	81.18	70.48
358	1.4829	0.68681	21684	287.03	111.93	145.55	176.40	9.645	25.53
362	1.6054	7.7996	8226.8	249.38	114.39	179.48	451.29	77.58	69.42
362	1.6054	0.7528	21924	287.22	113.53	150.87	173.45	9.875	26.43
366	1.7352	7.6606	8939.5	251.30	115.60	184.15	426.38	74.03	68.37
366	1.7352	0.82548	22152	287.39	115.23	157.11	170.25	10.13	27.41
370	1.8727	7.5139	9667.7	253.22	116.86	189.58	401.01	70.53	67.36
370	1.8727	0.90588	22364	287.54	117.03	164.55	166.77	10.41	28.50
374	2.0181	7.358	10413	255.18	118.17	196.03	375.12	67.04	66.36
374	2.0181	0.99533	22559	287.65	118.96	173.60	163.00	10.72	29.71
378	2.1718	7.1913	11179	257.16	119.54	203.88	348.59	63.54	65.40
378	2.1718	1.0956	22732	287.72	121.02	184.89	158.90	11.08	31.09
382	2.3343	7.0111	11968	259.17	121.01	213.80	321.32	60.03	64.46
382	2.3343	1.2090	22878	287.73	123.23	199.43	154.46	11.49	32.68
386	2.5058	6.8138	12785	261.24	122.62	226.90	293.15	56.45	63.58
386	2.5058	1.3389	22991	287.68	125.63	218.98	149.63	11.97	34.55
390	2.6869	6.5941	13638	263.36	124.42	245.34	263.93	52.77	62.76
390	2.6869	1.4904	23060	287.52	128.27	246.92	144.37	12.55	36.83
394	2.8782	6.3430	14539	265.59	126.52	273.75	233.42	48.92	62.09
394	2.8782	1.6716	23068	287.23	131.24	290.57	138.63	13.26	39.74
398	3.0802	6.0444	15510	267.96	129.14	324.44	201.26	44.76	61.76
398	3.0802	1.8978	22982	286.73	134.75	369.40	132.32	14.18	43.73

TABLE 1 *Continued*

T K	P MPa	ρ $mol \cdot l^{-1}$	H $J \cdot mol^{-1}$	S $J \cdot mol^{-1} \cdot K^{-1}$	C_v $J \cdot mol^{-1} \cdot K^{-1}$	C_p $J \cdot mol^{-1} \cdot K^{-1}$	c $m \cdot s^{-1}$	η μPa·s	λ $mW \cdot m^{-1} \cdot K^{-1}$
402	3.294	5.6611	16603	270.60	132.80	444.47	166.79	40.03	62.50
402	3.294	2.2035	22733	285.85	139.26	557.25	125.27	15.48	50.08
406	3.521	5.0501	18021	274.00	139.62	1125.70	128.12	33.65	69.00
406	3.521	2.7246	22042	283.91	146.50	1601.40	116.78	17.90	66.35
407	3.580	4.7629	18568	275.32	143.30	2459.70	116.97	31.07	77.26
407	3.580	2.9844	21611	282.79	149.68	3556.20	113.83	19.21	81.05

TABLE 2 Thermophysical Properties of Isobutane Along Isobars

T K	ρ mol·l^{-1}	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}	η μPa·s	λ mW·m^{-1}·K^{-1}
Pressure = 0.1 MPa								
120	12.636	-22732	115.25	69.01	99.31	1945.6	6063	156.7
130	12.474	-21730	123.28	70.26	101.18	1863.7	3702	154.4
140	12.311	-20709	130.84	71.51	103.04	1787.1	2465	151.6
150	12.148	-19669	138.01	72.73	104.89	1714.8	1749	148.5
160	11.985	-18611	144.84	73.95	106.72	1645.7	1304	145.0
170	11.820	-17534	151.37	75.19	108.57	1579.1	1009	141.2
180	11.654	-16439	157.63	76.46	110.44	1514.5	805.3	137.3
190	11.486	-15325	163.65	77.80	112.37	1451.5	657.9	133.3
200	11.317	-14192	169.46	79.21	114.36	1389.7	547.7	129.1
210	11.146	-13038	175.09	80.70	116.44	1329.0	462.9	124.9
220	10.972	-11863	180.56	82.28	118.63	1269.2	396.1	120.6
230	10.796	-10665	185.88	83.95	120.94	1210.1	342.4	116.4
240	10.616	-9443.3	191.08	85.72	123.39	1151.6	298.5	112.1
250	10.432	-8196.6	196.17	87.58	125.99	1093.7	262.2	108.0
260	10.244	-6923.0	201.16	89.54	128.76	1036.2	231.6	103.9
261.07	10.223	-6785.7	201.69	89.76	129.06	1030.1	228.7	103.4
261.07	0.048038	14452	283.04	79.71	89.77	196.48	6.571	13.17
270	0.046232	15263	286.10	81.85	91.69	200.26	6.797	14.03
280	0.044385	16191	289.47	84.33	93.96	204.32	7.048	15.02
290	0.042696	17142	292.81	86.87	96.34	208.25	7.297	16.04
300	0.041143	18118	296.12	89.47	98.80	212.04	7.544	17.08
320	0.038379	20144	302.65	94.79	103.90	219.32	8.032	19.24
340	0.035985	22275	309.11	100.19	109.15	226.26	8.515	21.50
360	0.033886	24511	315.50	105.61	114.45	232.90	8.992	23.86
380	0.032029	26853	321.83	111.00	119.76	239.30	9.463	26.32
400	0.030372	29301	328.11	116.31	125.01	245.50	9.929	28.88
420	0.028882	31853	334.33	121.52	130.16	251.51	10.39	31.54
440	0.027536	34506	340.50	126.61	135.21	257.36	10.85	34.31
460	0.026312	37260	346.62	131.56	140.12	263.07	11.30	37.18
480	0.025194	40110	352.69	136.36	144.89	268.64	11.75	40.16
500	0.024169	43055	358.70	141.01	149.52	274.09	12.20	43.23
520	0.023225	46090	364.65	145.51	154.00	279.42	12.64	46.41
540	0.022353	49214	370.54	149.87	158.34	284.65	13.07	49.69
560	0.021545	52423	376.38	154.08	162.54	289.78	13.51	53.08
570	0.021163	54059	379.27	156.13	164.58	292.31	13.72	54.81
Pressure = 1 MPa								
120	12.642	-22672	115.16	69.09	99.28	1947.80	6125	156.9
130	12.480	-21670	123.18	70.34	101.14	1866.30	3738	154.6
140	12.318	-20649	130.75	71.58	103.00	1790.10	2488	151.8
150	12.156	-19610	137.91	72.80	104.84	1718.10	1765	148.7
160	11.993	-18552	144.74	74.02	106.67	1649.40	1315	145.2
170	11.829	-17476	151.26	75.25	108.50	1583.20	1018	141.6
180	11.663	-16382	157.52	76.53	110.37	1519.00	812.5	137.6
190	11.497	-15269	163.53	77.86	112.28	1456.30	663.8	133.6
200	11.329	-14136	169.34	79.27	114.26	1395.00	552.6	129.5
210	11.158	-12983	174.97	80.76	116.33	1334.70	467.2	125.3
220	10.986	-11809	180.43	82.34	118.50	1275.40	399.9	121.0
230	10.811	-10613	185.75	84.01	120.78	1216.80	345.8	116.8
240	10.632	-9393.2	190.94	85.78	123.20	1158.90	301.6	112.6
250	10.450	-8148.6	196.02	87.64	125.76	1101.60	265.0	108.5
260	10.264	-6877.5	201.00	89.60	128.48	1044.70	234.4	104.4
270	10.073	-5578.3	205.91	91.64	131.39	988.22	208.3	100.4
280	9.8753	-4249.0	210.74	93.77	134.50	931.89	186.0	96.54
290	9.6707	-2887.5	215.52	95.98	137.85	875.56	166.7	92.76
300	9.4575	-1491.0	220.25	98.27	141.50	819.00	149.9	89.09
320	8.9965	1420.8	229.64	103.07	150.01	703.88	121.6	82.11
339.34	8.4843	4421.1	238.74	108.03	160.97	586.60	99.07	75.76
339.34	0.44655	20440	285.95	105.18	127.92	187.21	8.787	22.10
340	0.44469	20525	286.20	105.28	127.80	187.76	8.800	22.17
360	0.39823	23064	293.46	109.15	126.93	202.25	9.225	24.47
380	0.36400	25620	300.37	113.65	128.89	214.08	9.673	26.95
400	0.33698	28227	307.05	118.33	132.00	224.30	10.13	29.56
420	0.31474	30904	313.58	123.10	135.73	233.45	10.59	32.28
440	0.29591	33658	319.99	127.87	139.75	241.82	11.04	35.12
460	0.27964	36495	326.29	132.59	143.92	249.58	11.50	38.05
480	0.26537	39415	332.51	137.22	148.11	256.88	11.94	41.09
500	0.25270	42420	338.64	141.74	152.29	263.78	12.39	44.23
520	0.24135	45507	344.69	146.13	156.41	270.37	12.83	47.47
540	0.23109	48676	350.67	150.40	160.46	276.68	13.27	50.81

TABLE 2 *Continued*

T K	ρ mol·l^{-1}	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}	η μPa·s	λ mW·m^{-1}·K^{-1}
560	0.22176	51924	356.58	154.54	164.41	282.75	13.70	54.25
570	0.21740	53578	359.50	156.56	166.35	285.70	13.92	56.01
				Pressure = 2 MPa				
120	12.649	-22605	115.06	69.18	99.25	1950.20	6194	157.1
130	12.488	-21603	123.08	70.43	101.11	1869.10	3778	154.8
140	12.326	-20583	130.64	71.66	102.96	1793.30	2514	152.1
150	12.164	-19544	137.80	72.88	104.79	1721.80	1783	149.0
160	12.002	-18487	144.63	74.09	106.61	1653.50	1328	145.6
170	11.839	-17412	151.14	75.33	108.44	1587.70	1028	141.9
180	11.674	-16318	157.39	76.60	110.29	1523.90	820.4	138.0
190	11.509	-15206	163.41	77.93	112.19	1461.70	670.3	134.0
200	11.341	-14074	169.21	79.34	114.15	1400.80	558.2	129.9
210	11.172	-12922	174.83	80.82	116.20	1341.00	472.0	125.7
220	11.001	-11750	180.29	82.40	118.35	1282.20	404.1	121.5
230	10.827	-10555	185.60	84.07	120.61	1224.10	349.6	117.3
240	10.651	-9337.2	190.78	85.84	123.00	1166.90	305.1	113.2
250	10.471	-8094.8	195.85	87.71	125.52	1110.20	268.3	109.0
260	10.286	-6826.3	200.82	89.66	128.20	1054.10	237.4	105.0
270	10.098	-5530.3	205.72	91.70	131.04	998.39	211.2	101.1
280	9.9033	-4204.9	210.54	93.83	134.07	942.99	188.8	97.21
290	9.7024	-2848.1	215.30	96.04	137.33	887.74	169.4	93.47
300	9.4937	-1457.5	220.01	98.32	140.83	832.46	152.5	89.85
320	9.0456	1436.9	229.35	103.09	148.88	720.78	124.2	82.98
340	8.5374	4512.5	238.67	108.16	159.20	604.95	101.2	76.59
360	7.9214	7838.7	248.17	113.69	174.85	478.61	80.96	70.54
373.51	7.3775	10322	254.94	118.00	195.18	378.30	67.46	66.48
373.51	0.98392	22536	287.64	118.71	172.40	163.47	10.68	29.56
380	0.92017	23614	290.50	119.20	161.27	172.92	10.68	29.72
400	0.79285	26685	298.38	121.72	148.88	194.12	10.88	31.42
420	0.71151	29632	305.57	125.43	146.67	209.69	11.20	33.80
440	0.65172	32572	312.41	129.60	147.62	222.44	11.58	36.46
460	0.60463	35546	319.02	133.93	149.92	233.43	11.99	39.31
480	0.56594	38573	325.46	138.29	152.88	243.22	12.40	42.31
500	0.53324	41663	331.76	142.61	156.19	252.12	12.82	45.44
520	0.50501	44821	337.96	146.86	159.67	260.33	13.25	48.68
540	0.48027	48050	344.05	151.01	163.23	268.00	13.67	52.03
560	0.45831	51351	350.05	155.07	166.81	275.22	14.09	55.49
570	0.44822	53028	353.02	157.05	168.59	278.69	14.30	57.26
				Pressure = 3 MPa				
120	12.655	-22538	114.96	69.27	99.22	1952.7	6264	157.3
130	12.495	-21536	122.97	70.51	101.07	1872.0	3819	155.0
140	12.334	-20516	130.53	71.74	102.92	1796.6	2540	152.3
150	12.173	-19478	137.70	72.95	104.74	1725.4	1801	149.2
160	12.011	-18422	144.51	74.17	106.55	1657.5	1342	145.8
170	11.848	-17347	151.03	75.40	108.37	1592.2	1038	142.2
180	11.685	-16254	157.27	76.67	110.21	1528.8	828.4	138.4
190	11.520	-15143	163.28	78.00	112.10	1467.0	676.9	134.4
200	11.354	-14012	169.08	79.40	114.05	1406.5	563.8	130.3
210	11.186	-12862	174.69	80.89	116.08	1347.2	476.8	126.2
220	11.016	-11690	180.14	82.47	118.21	1288.9	408.4	122.0
230	10.844	-10497	185.45	84.14	120.44	1231.4	353.4	117.8
240	10.669	-9280.9	190.62	85.91	122.80	1174.7	308.6	113.7
250	10.490	-8040.6	195.69	87.77	125.29	1118.7	271.4	109.6
260	10.308	-6774.6	200.65	89.72	127.92	1063.2	240.3	105.6
270	10.122	-5481.6	205.53	91.76	130.71	1008.3	214.0	101.7
280	9.9306	-4159.8	210.34	93.89	133.68	953.80	191.4	97.87
290	9.7332	-2807.4	215.08	96.09	136.84	899.56	172.0	94.18
300	9.5287	-1422.3	219.78	98.36	140.23	845.45	155.0	90.60
320	9.0922	1456.6	229.06	103.11	147.89	736.83	126.8	83.83
340	8.6038	4505.1	238.30	108.13	157.36	625.77	103.9	77.58
360	8.0288	7774.8	247.64	113.51	170.53	508.19	84.19	71.76
380	7.2749	11397	257.43	119.65	195.26	373.75	65.44	66.19
396.44	6.1683	15120	267.01	128.03	300.48	214.04	46.43	61.83
396.44	1.8026	23030	286.96	133.29	332.05	134.86	13.78	41.99
400	1.6415	24027	289.46	130.29	246.25	145.97	13.29	39.01
420	1.2752	27931	299.00	128.90	172.95	179.78	12.61	37.09
440	1.106	31254	306.73	131.82	161.78	200.34	12.65	38.70
460	0.99497	34456	313.85	135.51	159.16	216.07	12.87	41.08
480	0.91283	37640	320.62	139.48	159.52	229.11	13.17	43.82
500	0.84799	40846	327.17	143.55	161.26	240.43	13.52	46.80
520	0.79471	44095	333.54	147.62	163.70	250.51	13.89	49.95

TABLE 2 *Continued*

T K	ρ mol·l^{-1}	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}	η μPa·s	λ mW·m^{-1}·K^{-1}
540	0.74967	47396	339.77	151.64	166.53	259.68	14.27	53.25
560	0.71081	50757	345.88	155.60	169.57	268.14	14.66	56.68
570	0.69325	52461	348.90	157.54	171.14	272.14	14.86	58.43
				Pressure = 5 MPa				
120	12.668	-22404	114.76	69.44	99.16	1957.5	6406	157.6
130	12.509	-21403	122.77	70.68	101.00	1877.6	3901	155.4
140	12.349	-20384	130.32	71.90	102.84	1803.0	2592	152.8
150	12.189	-19346	137.48	73.11	104.65	1732.7	1837	149.8
160	12.029	-18291	144.29	74.31	106.44	1665.6	1368	146.4
170	11.868	-17218	150.80	75.54	108.24	1601.0	1059	142.8
180	11.706	-16126	157.03	76.81	110.06	1538.4	844.6	139.1
190	11.543	-15016	163.04	78.14	111.92	1477.5	690.1	135.1
200	11.379	-13888	168.82	79.54	113.85	1417.9	574.9	131.1
210	11.213	-12739	174.43	81.02	115.85	1359.5	486.4	127.0
220	11.045	-11570	179.86	82.60	117.94	1302.1	416.8	122.9
230	10.876	-10380	185.16	84.27	120.13	1245.6	361.0	118.8
240	10.704	-9167.3	190.32	86.03	122.43	1190.0	315.5	114.7
250	10.529	-7930.9	195.36	87.89	124.86	1135.2	277.8	110.7
260	10.351	-6669.7	200.31	89.84	127.41	1081.0	246.3	106.8
270	10.1691	-5382.2	205.17	91.88	130.11	1027.6	219.6	102.9
280	9.9830	-4067.0	209.95	94.00	132.95	974.64	196.8	99.2
290	9.7920	-2722.6	214.67	96.19	135.96	922.21	177.1	95.54
300	9.5950	-1347.2	219.33	98.46	139.15	870.18	160.0	92.04
320	9.1790	1504.7	228.53	103.17	146.20	766.80	131.7	85.45
340	8.7232	4508.7	237.63	108.12	154.46	663.34	109.0	79.43
360	8.2075	7696.4	246.74	113.31	164.75	558.07	89.95	73.96
380	7.5925	11126	256.01	118.84	179.22	448.12	72.92	68.98
400	6.7797	14940	265.79	125.20	205.84	328.20	56.35	64.36
420	5.3358	19794	277.61	134.37	312.81	190.64	36.89	60.48
440	2.8386	27054	294.51	138.28	277.95	154.34	19.33	51.40
460	2.1337	31627	304.68	139.42	200.91	181.55	16.73	47.73
480	1.8130	35428	312.77	142.19	182.61	202.39	16.04	48.34
500	1.6118	39008	320.08	145.56	176.44	219.06	15.87	50.27
520	1.4676	42514	326.96	149.19	174.67	233.09	15.92	52.82
540	1.3564	46008	333.55	152.91	174.94	245.30	16.09	55.75
560	1.2667	49519	339.93	156.64	176.28	256.18	16.32	58.93
570	1.2277	51286	343.06	158.50	177.20	261.23	16.46	60.60
				Pressure = 7.5 MPa				
120	12.684	-22236	114.51	69.66	99.09	1963.4	6587	158.1
130	12.526	-21236	122.52	70.88	100.92	1884.6	4005	156.0
140	12.368	-20218	130.06	72.10	102.74	1811.0	2659	153.4
150	12.209	-19182	137.21	73.29	104.53	1741.7	1883	150.4
160	12.051	-18127	144.01	74.49	106.31	1675.5	1402	147.2
170	11.892	-17056	150.51	75.71	108.08	1611.9	1084	143.6
180	11.732	-15966	156.74	76.98	109.88	1550.3	864.9	139.9
190	11.571	-14858	162.73	78.30	111.72	1490.3	706.8	136.1
200	11.409	-13731	168.51	79.70	113.61	1431.8	589.0	132.1
210	11.246	-12585	174.10	81.18	115.58	1374.4	498.5	128.1
220	11.081	-11419	179.52	82.76	117.63	1318.1	427.5	124.0
230	10.915	-10232	184.80	84.43	119.77	1262.9	370.5	120.0
240	10.746	-9023.6	189.94	86.19	122.02	1208.5	324.1	116.0
250	10.575	-7791.8	194.97	88.05	124.37	1155.0	285.8	112.1
260	10.402	-6535.8	199.90	89.99	126.84	1102.4	253.7	108.2
270	10.225	-5254.5	204.73	92.03	129.44	1050.5	226.5	104.4
280	10.045	-3946.4	209.49	94.14	132.16	999.38	203.4	100.7
290	9.8612	-2610.9	214.18	96.33	135.01	948.91	183.4	97.19
300	9.6723	-1245.9	218.80	98.58	138.01	899.07	166.2	93.77
320	9.2775	1578.2	227.91	103.27	144.50	801.03	137.6	87.36
340	8.8533	4539.6	236.89	108.15	151.79	704.70	115.0	81.56
360	8.3883	7657.1	245.80	113.21	160.19	609.53	96.31	76.37
380	7.8648	10958	254.72	118.45	170.30	515.01	80.23	71.80
400	7.2534	14489	263.77	123.93	183.38	421.09	65.76	67.82
420	6.5011	18332	273.14	129.76	202.34	329.40	52.22	64.40
440	5.5189	22653	283.19	135.82	231.33	247.80	39.38	61.53
460	4.3390	27507	293.97	141.01	246.32	201.75	28.94	58.92
480	3.4163	32217	304.00	144.49	222.57	198.44	23.45	56.68
500	2.8541	36451	312.64	147.58	202.77	209.80	21.08	56.21
520	2.4935	40392	320.37	150.84	192.64	223.47	19.99	57.22
540	2.2404	44192	327.54	154.27	187.97	236.64	19.48	59.17
560	2.0503	47930	334.34	157.78	186.22	248.79	19.27	61.70
570	1.9712	49791	337.64	159.54	186.02	254.49	19.23	63.12

TABLE 2 *Continued*

T K	ρ mol·l^{-1}	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}	η μPa·s	λ mW·m^{-1}·K^{-1}
Pressure = 10 MPa								
120	12.7	-22069	114.27	69.87	99.02	1969.4	6773	158.5
130	12.543	-21069	122.27	71.08	100.84	1891.5	4111	156.5
140	12.386	-20052	129.80	72.29	102.64	1818.9	2727	154.0
150	12.230	-19017	136.95	73.47	104.42	1750.5	1930	151.1
160	12.072	-17964	143.74	74.67	106.18	1685.3	1436	147.9
170	11.915	-16893	150.23	75.88	107.94	1622.6	1110	144.4
180	11.757	-15805	156.45	77.14	109.72	1562.0	885.5	140.8
190	11.598	-14699	162.43	78.46	111.53	1502.9	723.6	137.0
200	11.438	-13574	168.20	79.86	113.39	1445.4	603.1	133.1
210	11.278	-12431	173.78	81.34	115.33	1389.0	510.7	129.2
220	11.116	-11267	179.19	82.91	117.34	1333.8	438.2	125.2
230	10.952	-10084	184.45	84.58	119.44	1279.6	380.1	121.2
240	10.787	-8878.2	189.58	86.34	121.63	1226.4	332.8	117.2
250	10.620	-7650.5	194.59	88.19	123.93	1174.2	293.7	113.4
260	10.451	-6399.3	199.50	90.14	126.33	1122.9	261.0	109.6
270	10.279	-5123.5	204.31	92.17	128.84	1072.4	233.4	105.8
280	10.104	-3822.0	209.05	94.28	131.47	1022.8	209.9	102.2
290	9.9261	-2493.8	213.71	96.46	134.20	974.08	189.6	98.77
300	9.7443	-1137.6	218.31	98.71	137.05	926.11	172.1	95.42
320	9.3673	1663.5	227.34	103.37	143.14	832.42	143.3	89.17
340	8.9679	4591.6	236.22	108.22	149.78	741.55	120.6	83.53
360	8.5393	7659.4	244.98	113.20	157.09	653.38	102.1	78.55
380	8.0724	10881	253.69	118.29	165.26	568.06	86.44	74.23
400	7.5550	14277	262.40	123.49	174.56	486.23	72.80	70.56
420	6.9716	17873	271.17	128.77	185.35	409.42	60.61	67.54
440	6.3060	21703	280.07	134.08	197.83	340.61	49.69	65.16
460	5.5567	25787	289.15	139.21	210.20	285.43	40.23	63.38
480	4.7816	30065	298.25	143.85	215.74	251.50	32.92	62.13
500	4.0999	34347	306.99	147.86	211.37	239.25	28.15	61.48
520	3.5719	38500	315.14	151.49	203.99	240.03	25.37	61.66
540	3.1766	42519	322.72	155.01	198.28	246.56	23.78	62.72
560	2.8758	46448	329.86	158.50	194.89	255.28	22.86	64.50
570	2.7513	48391	333.30	160.24	193.91	259.93	22.57	65.61
Pressure = 20 MPa								
130	12.61	-20401	121.29	71.85	100.55	1918.6	4558	158.5
140	12.458	-19387	128.81	73.01	102.30	1849.7	3010	156.2
150	12.307	-18355	135.92	74.16	104.03	1784.9	2124	153.6
160	12.156	-17306	142.69	75.33	105.73	1723.2	1577	150.7
170	12.005	-16240	149.15	76.52	107.43	1663.9	1217	147.5
180	11.854	-15158	155.34	77.77	109.13	1606.6	970.1	144.1
190	11.702	-14058	161.29	79.07	110.87	1551.1	792.7	140.5
200	11.551	-12940	167.02	80.46	112.65	1496.9	660.9	136.9
210	11.398	-11805	172.56	81.93	114.48	1444.1	560.2	133.2
220	11.246	-10650	177.93	83.49	116.38	1392.5	481.4	129.4
230	11.093	-9476.8	183.15	85.15	118.35	1342.1	418.5	125.7
240	10.939	-8283.1	188.23	86.91	120.40	1292.8	367.3	122.0
250	10.784	-7068.4	193.18	88.75	122.53	1244.7	325.2	118.3
260	10.628	-5832.1	198.03	90.69	124.74	1197.6	290.0	114.7
270	10.471	-4573.3	202.78	92.71	127.03	1151.7	260.4	111.2
280	10.313	-3291.2	207.45	94.81	129.40	1106.9	235.2	107.9
290	10.154	-1985.0	212.03	96.98	131.84	1063.2	213.7	104.6
300	9.9930	-654.2	216.54	99.21	134.34	1020.6	195.0	101.5
320	9.6660	2084.3	225.38	103.83	139.54	938.76	164.6	95.66
340	9.3310	4928.9	234.00	108.60	144.95	861.43	140.9	90.45
360	8.9867	7883.4	242.44	113.46	150.52	788.70	122.0	85.91
380	8.6320	10951	250.73	118.36	156.20	720.81	106.6	82.04
400	8.2663	14132	258.89	123.26	161.93	658.06	93.56	78.83
420	7.8894	17428	266.93	128.12	167.62	600.86	82.44	76.28
440	7.5027	20836	274.85	132.91	173.18	549.61	72.80	74.36
460	7.1084	24353	282.67	137.59	178.48	504.65	64.40	73.03
480	6.7107	27972	290.37	142.14	183.39	466.17	57.11	72.24
500	6.3153	31685	297.95	146.54	187.76	434.25	50.89	71.94
520	5.9290	35478	305.39	150.77	191.46	408.85	45.68	72.09
540	5.5594	39338	312.67	154.84	194.40	389.73	41.44	72.63
560	5.2132	43249	319.78	158.75	196.63	376.31	38.09	73.53
570	5.0505	45220	323.27	160.65	197.54	371.47	36.70	74.11

The symbols are:

T, temperature (K)	S, molar entropy ($J \cdot K^{-1} \cdot mol^{-1}$)	c, speed of sound ($m \cdot s^{-1}$)
ρ, molar density ($mol \cdot l^{-1}$)	C_v, constant volume molar heat capacity ($J \cdot K^{-1} \cdot mol^{-1}$)	η, viscosity ($\mu Pa \cdot s$)
H, molar enthalpy ($J \cdot mol^{-1}$)	C_p, constant pressure molar heat capacity ($J \cdot K^{-1} \cdot mol^{-1}$)	λ, thermal conductivity ($mW \cdot m^{-1} \cdot K^{-1}$)