SECTION 5
PHYSICAL PROPERTIES

5.1 SOLUBILITIES

TABLE 5.1 Solubility of Gases in Water

The column (or line entry) headed "α" gives the volume of gas (in milliliters) measured at standard conditions (0°C and 760 mm or 101.325 kN · m^{-2}) dissolved in 1 mL of water at the temperature stated (in degrees Celsius) and when the pressure of the gas without that of the water vapor is 760 mm. The line entry "A" indicates the same quantity except that the gas itself is at the uniform pressure of 760 mm when in equilibrium with water.

The column headed "1" gives the volume of the gas (in milliliters) dissolved in 1 mL of water when the pressure of the gas plus that of the water vapor is 760 mm.

The column headed "q" gives the weight of gas (in grams) dissolved in 100 g of water when the pressure of the gas plus that of the water vapor is 760 mm.

	Acetylene		Air*		Ammonia		Bromine	
Temp. °C	α	q	$\alpha(\times 10^3)$	% oxygen in air	α	q	α	q
0	1.73	0.200	29.18	34.91	1130	89.5	60.5	42.9
1	1.68	0.194	28.42	34.87	—	—	—	—
2	1.63	0.188	27.69	34.82	—	—	54.1	38.3
3	1.58	0.182	26.99	34.78	—	—	—	—
4	1.53	0.176	26.32	34.74	1047	79.6	48.3	34.2
5	1.49	0.171	25.68	34.69	—	—	—	—
6	1.45	0.167	25.06	34.65	—	—	43.3	30.6
7	1.41	0.162	24.47	34.60	—	—	—	—
8	1.37	0.157	23.90	34.56	947	72.0	38.9	27.5
9	1.34	0.154	23.36	34.52	—	—	—	—
10	1.31	0.150	22.84	34.47	870	68.4	35.1	24.8
11	1.27	0.146	22.34	34.43	—	—	—	—
12	1.24	0.142	21.87	34.38	857	65.1	31.5	22.2
13	1.21	0.138	21.41	34.34	837	63.6	—	—
14	1.18	0.135	20.97	34.30	—	—	28.4	20.0
15	1.15	0.131	20.55	34.25	770	—	—	—
16	1.13	0.129	20.14	34.21	775	58.7	25.7	18.0
17	1.10	0.125	19.75	34.17	—	—	—	—
18	1.08	0.123	19.38	34.12	—	—	23.4	16.4
19	1.05	0.119	19.02	34.08	—	—	—	—
20	1.03	0.117	18.68	34.03	680	52.9	21.3	14.9
21	1.01	0.115	18.34	33.99	—	—	—	—
22	0.99	0.112	18.01	33.95	—	—	19.4	13.5
23	0.97	0.110	17.69	33.90	—	—	—	—
24	0.95	0.107	17.38	33.86	639	48.2	17.7	12.3
25	0.93	0.105	17.08	33.82	—	—	—	—
26	0.91	0.102	16.79	33.77	—	—	16.3	11.3
27	0.89	0.100	16.50	33.73	—	—	—	—
28	0.87	0.098	16.21	33.68	586	44.0	15.0	10.3
29	0.85	0.095	15.92	33.64	—	—	—	—
30	0.84	0.094	15.64	33.60	530	41.0	13.8	9.5
35	—	—	—	—	—	—	—	—
40	—	—	14.18	—	400	31.6	9.4	6.3
45	—	—	—	—	—	—	—	—
50	—	—	12.97	—	290	23.5	6.5	4.1
60	—	—	12.16	—	200	16.8	4.9	2.9
70	—	—	—	—	—	11.1	3.8	1.9
80	—	—	11.26	—	—	6.5	3.0	1.2
90	—	—	—	—	—	3.0	—	—
100	—	—	11.05	—	—	0.0	—	—

* Free from NH_3 and CO_2; total pressure of air + water vapor is 760 mm.

TABLE 5.1 Solubility of Gases in Water (*Continued*)

Temp. °C	Carbon dioxide		Carbon monoxide		Chlorine		Ethane		Ethylene		Hydrogen	
	α	q	α	q	l	q	α	q	α	q	α	q
0	1.713	0.334 6	0.035 37	0.004 397	—	—	0.098 74	0.013 17	0.226	0.028 1	0.021 48	0.000 192 2
1	1.646	0.321 3	0.034 55	0.004 293	—	—	0.094 76	0.012 63	0.219	0.027 2	0.021 26	0.000 190 1
2	1.584	0.309 1	0.033 75	0.004 191	—	—	0.090 93	0.012 12	0.211	0.026 2	0.021 05	0.000 188 1
3	1.527	0.297 8	0.032 97	0.004 092	—	—	0.087 25	0.011 62	0.204	0.025 3	0.020 84	0.000 186 2
4	1.473	0.287 1	0.032 22	0.003 996	—	—	0.083 72	0.011 14	0.197	0.024 4	0.020 64	0.000 184 3
5	1.424	0.277 4	0.031 49	0.003 903	—	—	0.080 33	0.010 69	0.191	0.023 7	0.020 44	0.000 182 4
6	1.377	0.268 1	0.030 78	0.003 813	—	—	0.077 09	0.010 25	0.184	0.022 8	0.020 25	0.000 180 6
7	1.331	0.258 9	0.030 09	0.003 725	—	—	0.074 00	0.009 83	0.178	0.022 0	0.020 07	0.000 178 9
8	1.282	0.249 2	0.029 42	0.003 640	—	—	0.071 06	0.009 43	0.173	0.021 4	0.019 89	0.000 177 2
9	1.237	0.240 3	0.028 78	0.003 559	—	—	0.068 26	0.009 06	0.167	0.020 7	0.019 72	0.000 175 6
10	1.194	0.231 8	0.028 16	0.003 479	3.148	0.997 2	0.065 61	0.008 70	0.162	0.020 0	0.019 55	0.000 174 0
11	1.154	0.223 9	0.027 57	0.003 405	3.047	0.965 4	0.063 28	0.008 38	0.157	0.019 4	0.019 40	0.000 172 5
12	1.117	0.216 5	0.027 01	0.003 332	2.950	0.934 6	0.061 06	0.008 08	0.152	0.018 8	0.019 25	0.000 171 0
13	1.083	0.209 8	0.026 46	0.003 261	2.856	0.905 0	0.058 94	0.007 80	0.148	0.018 3	0.019 11	0.000 169 6
14	1.050	0.203 2	0.025 93	0.003 194	2.767	0.876 8	0.056 94	0.007 53	0.143	0.017 6	0.018 97	0.000 168 2
15	1.019	0.197 0	0.025 43	0.003 130	2.680	0.849 5	0.055 04	0.007 27	0.139	0.017 1	0.018 83	0.000 166 8
16	0.985	0.190 3	0.024 94	0.003 066	2.597	0.823 2	0.053 26	0.007 03	0.136	0.016 7	0.018 69	0.000 165 4
17	0.956	0.184 5	0.024 48	0.003 007	2.517	0.797 9	0.051 59	0.006 80	0.132	0.016 2	0.018 56	0.000 164 1
18	0.928	0.178 9	0.024 02	0.002 947	2.440	0.773 8	0.050 03	0.006 59	0.129	0.015 8	0.018 44	0.000 162 8
19	0.902	0.173 7	0.023 60	0.002 891	2.368	0.751 0	0.048 58	0.006 39	0.125	0.015 3	0.018 31	0.000 161 6

20	0.878	0.168 8	0.023 19	0.002 838	2.299	0.729 3	0.047 24	0.006 20	0.122	0.014 9	0.018 19	0.000 160 3
21	0.854	0.164 0	0.022 81	0.002 789	2.238	0.710 0	0.045 89	0.006 02	0.119	0.014 6	0.018 05	0.000 158 8
22	0.829	0.159 0	0.022 44	0.002 739	2.180	0.691 8	0.044 59	0.005 84	0.116	0.014 2	0.017 92	0.000 157 5
23	0.804	0.154 0	0.022 08	0.002 691	2.123	0.673 9	0.043 35	0.005 67	0.114	0.013 9	0.017 79	0.000 156 1
24	0.781	0.149 3	0.021 74	0.002 646	2.070	0.657 2	0.042 17	0.005 51	0.111	0.013 5	0.017 66	0.000 154 8
25	0.759	0.144 9	0.021 42	0.002 603	2.019	0.641 3	0.041 04	0.005 35	0.108	0.013 1	0.017 54	0.000 153 5
26	0.738	0.140 6	0.021 10	0.002 560	1.970	0.625 9	0.039 97	0.005 20	0.106	0.012 9	0.017 42	0.000 152 2
27	0.718	0.136 6	0.020 80	0.002 519	1.923	0.611 2	0.038 95	0.005 06	0.104	0.012 6	0.017 31	0.000 150 9
28	0.699	0.132 7	0.020 51	0.002 479	1.880	0.597 5	0.037 99	0.004 93	0.102	0.012 3	0.017 20	0.000 149 6
29	0.682	0.129 2	0.020 24	0.002 442	1.839	0.584 7	0.037 09	0.004 80	0.100	0.012 1	0.017 09	0.000 148 4
30	0.665	0.125 7	0.019 98	0.002 405	1.799	0.572 3	0.036 24	0.004 68	0.098	0.011 8	0.016 99	0.000 147 4
35	0.592	0.110 5	0.018 77	0.002 231	1.602	0.510 4	0.032 30	0.004 12	—	—	0.016 66	0.000 142 5
40	0.530	0.097 3	0.017 75	0.002 075	1.438	0.459 0	0.029 15	0.003 66	—	—	0.016 44	0.000 138 4
45	0.479	0.086 0	0.016 90	0.001 933	1.322	0.422 8	0.026 60	0.003 27	—	—	0.016 24	0.000 134 1
50	0.436	0.076 1	0.016 15	0.001 797	1.225	0.392 5	0.024 59	0.002 94	—	—	0.016 08	0.000 128 7
60	0.359	0.057 6	0.014 88	0.001 522	1.023	0.329 5	0.021 77	0.002 39	—	—	0.016 00	0.000 117 8
70	—	—	0.014 40	0.001 276	0.862	0.279 3	0.019 48	0.001 85	—	—	0.016 0	0.000 102
80	—	—	0.014 30	0.000 980	0.683	0.222 7	0.018 26	0.001 34	—	—	0.016 0	0.000 079
90	—	—	0.014 2	0.000 57	0.39	0.127	0.017 6	0.000 8	—	—	0.016 0	0.000 046
100	—	—	0.014 1	0.000 00	0.00	0.000	0.017 2	0.000 0	—	—	0.016 0	0.000 000

TABLE 5.1 Solubility of Gases in Water (*Continued*)

Temp. °C	Hydrogen sulfide		Methane		Nitric oxide		Nitrogen*		Oxygen		Sulfur dioxide	
	α	q	α	q	α	q	α	q	α	q	l	q
0	4.670	0.706 6	0.055 63	0.003 959	0.073 81	0.009 833	0.023 54	0.002 942	0.048 89	0.006 945	79.789	22.83
1	4.522	0.683 9	0.054 01	0.003 842	0.071 84	0.009 564	0.022 97	0.002 869	0.047 58	0.006 756	77.210	22.09
2	4.379	0.661 9	0.052 44	0.003 728	0.069 93	0.009 305	0.022 41	0.002 798	0.046 33	0.006 574	74.691	21.37
3	4.241	0.640 7	0.050 93	0.003 619	0.068 09	0.009 057	0.021 87	0.002 730	0.045 12	0.006 400	72.230	20.66
4	4.107	0.620 1	0.049 46	0.003 513	0.066 32	0.008 816	0.021 35	0.002 663	0.043 97	0.006 232	69.828	19.98
5	3.977	0.600 1	0.048 05	0.003 410	0.064 61	0.008 584	0.020 86	0.002 600	0.042 87	0.006 072	67.485	19.31
6	3.852	0.580 9	0.046 69	0.003 312	0.062 98	0.008 361	0.020 37	0.002 537	0.041 80	0.005 918	65.200	18.65
7	3.732	0.562 4	0.045 39	0.003 217	0.061 40	0.008 147	0.019 90	0.002 477	0.040 80	0.005 773	62.973	18.02
8	3.616	0.544 6	0.044 13	0.003 127	0.059 90	0.007 943	0.019 45	0.002 419	0.039 83	0.005 632	60.805	17.40
9	3.505	0.527 6	0.042 92	0.003 039	0.058 46	0.007 747	0.019 02	0.002 365	0.038 91	0.005 498	58.697	16.80
10	3.399	0.511 2	0.041 77	0.002 955	0.057 09	0.007 560	0.018 61	0.002 312	0.038 02	0.005 368	56.647	16.21
11	3.300	0.496 0	0.040 72	0.002 879	0.055 87	0.007 393	0.018 23	0.002 263	0.037 18	0.005 246	54.655	15.64
12	3.206	0.481 4	0.039 70	0.002 805	0.054 70	0.007 233	0.017 86	0.002 216	0.036 37	0.005 128	52.723	15.09
13	3.115	0.467 4	0.038 72	0.002 733	0.053 57	0.007 078	0.017 50	0.002 170	0.035 59	0.005 014	50.849	14.56
14	3.028	0.454 0	0.037 79	0.002 665	0.052 50	0.006 930	0.017 17	0.002 126	0.034 86	0.004 906	49.033	14.04
15	2.945	0.441 1	0.036 90	0.002 599	0.051 47	0.006 788	0.016 85	0.002 085	0.034 15	0.004 802	47.276	13.54
16	2.865	0.428 7	0.036 06	0.002 538	0.050 49	0.006 652	0.016 54	0.002 045	0.033 48	0.004 703	45.578	13.05
17	2.789	0.416 9	0.035 25	0.002 478	0.049 56	0.006 524	0.016 25	0.002 006	0.032 83	0.004 606	43.939	12.59
18	2.717	0.405 6	0.034 48	0.002 422	0.048 68	0.006 400	0.015 97	0.001 970	0.032 20	0.004 514	42.360	12.14
19	2.647	0.394 8	0.033 76	0.002 369	0.047 85	0.006 283	0.015 70	0.001 935	0.031 61	0.004 426	40.838	11.70

20	2.582	0.384 6	0.033 08	0.002 319	0.047 06	0.006 173	0.015 45	0.001 901	0.031 02	0.004 339	39.374	11.28
21	2.517	0.374 5	0.032 43	0.002 270	0.046 25	0.006 059	0.015 22	0.001 869	0.030 44	0.004 252	37.970	10.88
22	2.456	0.364 8	0.031 80	0.002 222	0.045 45	0.005 947	0.014 98	0.001 838	0.029 88	0.004 169	36.617	10.50
23	2.396	0.355 4	0.031 19	0.002 177	0.044 69	0.005 838	0.014 75	0.001 809	0.029 34	0.004 087	35.302	10.12
24	2.338	0.346 3	0.030 61	0.002 133	0.043 95	0.005 733	0.014 54	0.001 780	0.028 81	0.004 007	34.026	9.76
25	2.282	0.337 5	0.030 06	0.002 091	0.043 23	0.005 630	0.014 34	0.001 751	0.028 31	0.003 931	32.786	9.41
26	2.229	0.329 0	0.029 52	0.002 050	0.042 54	0.005 530	0.014 13	0.001 724	0.027 83	0.003 857	31.584	9.06
27	2.177	0.320 8	0.029 01	0.002 011	0.041 88	0.005 435	0.013 94	0.001 698	0.027 36	0.003 787	30.422	8.73
28	2.128	0.313 0	0.028 52	0.001 974	0.041 24	0.005 342	0.013 76	0.001 672	0.026 91	0.003 718	29.314	8.42
29	2.081	0.305 5	0.028 06	0.001 938	0.040 63	0.005 252	0.013 58	0.001 647	0.026 49	0.003 651	28.210	8.10
30	2.037	0.298 3	0.027 62	0.001 904	0.040 04	0.005 165	0.013 42	0.001 624	0.026 08	0.003 588	27.161	7.80
35	1.831	0.264 8	0.025 46	0.001 733	0.037 34	0.004 757	0.012 56	0.001 501	0.024 40	0.003 315	22.489	6.47
40	1.660	0.236 1	0.023 69	0.001 586	0.035 07	0.004 394	0.011 84	0.001 391	0.023 06	0.003 082	18.766	5.41
45	1.516	0.211 0	0.022 38	0.001 466	0.033 11	0.004 059	0.011 30	0.001 300	0.021 87	0.002 858	—	—
50	1.392	0.188 3	0.021 34	0.001 359	0.031 52	0.003 758	0.010 88	0.001 216	0.020 90	0.002 657	—	—
60	1.190	0.148 0	0.019 54	0.001 144	0.029 54	0.003 237	0.010 23	0.001 052	0.019 46	0.002 274	—	—
70	1.022	0.110 1	0.018 25	0.000 926	0.028 10	0.002 668	0.009 77	0.000 851	0.018 33	0.001 856	—	—
80	0.917	0.076 5	0.017 70	0.000 695	0.027 00	0.001 984	0.009 58	0.000 660	0.017 61	0.001 381	—	—
90	0.84	0.041	0.017 35	0.000 40	0.026 5	0.001 13	0.009 5	0.000 38	0.017 2	0.000 79	—	
100	0.81	0.000	0.017 0	0.000 00	0.026 3	0.000 00	0.009 5	0.000 00	0.017 0	0.000 00	—	—

* Atmospheric nitrogen containing 98.815% N_2 by volume + 1.185% inert gases.

TABLE 5.1 Solubility of Gases in Water (*Continued*)

Substance		0°	10°	20°	30°	40°	60°	80°
Argon	α	0.052 8	0.041 3	0.033 7	0.028 8	0.025 1	0.020 9	0.018 4
Helium	A	0.009 8	0.009 11	0.008 6	0.008 39	0.008 41	0.009 02	$0.009\ 42^{70^\circ}$
Hydrogen bromide	l	612	582		533^{25°		469^{50°	406^{75°
Hydrogen chloride	α	512	475	442	412	385	339	
Krypton	α	0.110 5	0.081 0	0.062 6	0.051 1	0.043 3	0.035 7	
Neon	A		$0.011\ 7^{9^\circ}$	0.010 6	0.010 0	$0.009\ 48^{42^\circ}$		$0.009\ 84^{73^\circ}$
Nitrous oxide	A		0.88	0.63				
Ozone	$g \cdot L^{-1}$	0.039 4	$0.029\ 9^{12^\circ}$	$0.021\ 0^{19^\circ}$	0.0139^{27°	0.004 2	0	
Radon	α	0.510	0.326	0.222	0.162	0.126	0.085	
Xenon	α	0.242	0.174	0.123	0.098	0.082		

TABLE 5.2 Solubilities of Inorganic Compounds and Metal Salts of Organic Acids in Water at Various Temperatures

Solubilities are expressed as the number of grams of substance of stated molecular formula which when dissolved in 100 g of water make a saturated solution at the temperature stated (°C).

Substance	Formula	0°	10°	20°	30°	40°	60°	80°	90°	100°
Aluminum chloride	$AlCl_3$	43.9	44.9	45.8	46.6	47.3	48.1	48.6		49.0
fluoride	AlF_3	0.56	0.56	0.67	0.78	0.91	1.1	1.32		1.72
nitrate	$Al(NO_3)_3$	60.0	66.7	73.9	81.8	88.7	106	132	153	160
perchlorate	$Al(ClO_4)_3$	122	128	133						182
sulfate	$Al_2(SO_4)_3$	31.2	33.5	36.4	40.4	45.8	59.2	73.0	80.8	89.0
thallium(l) sulfate	$Al_2Tl_2(SO_4)_4$	3.15	4.60	6.39	9.37	14.39	35.35			
Ammonium aluminum sulfate	$NH_4Al(SO_4)_2$	2.10	5.00	7.74	10.9	14.9	26.7			
azide	NH_4N_3	16.0		25.3		37.1				
bromide	NH_4Br	60.5	68.1	76.4	83.2	91.2	108	125	135	145
chloride	NH_4Cl	29.4	33.2	37.2	41.4	45.8	55.3	65.6	71.2	77.3
chloroiridate(IV)	$(NH_4)_2TrCl_6$	0.56	0.71	0.95	1.20	1.56	2.45	4.38		
chloroplatinate(IV)	$(NH_4)_2PtCl_6$	0.289	0.374	0.499	0.637	0.815	1.44	2.16	2.61	3.36
chromate	$(NH_4)_2CrO_4$	25.0	29.2	34.0	39.3	45.3	59.0	76.1		
chromium(III) sulfate	$(NH_4)Cr(SO_4)_2$	3.95			18.8	32.6				
cobalt(II) sulfate	$(NH_4)_2Co(SO_4)_2$	6.0	9.5	13.0	17.0	22.0	33.5	49.0	58.0	75.1
dichromate	$(NH_4)_2Cr_2O_7$	18.2	25.5	35.6	46.5	58.5	86.0	115		156
dihydrogen arsenate	$NH_4H_2AsO_4$	33.7		48.7		63.8	83.0	107	122	
dihydrogen phosphate	$NH_4H_2PO_4$	22.7	29.5	37.4	46.4	56.7	82.5	118		173
dithionate	$(NH_4)_2S_2O_6$	133	151	166	179					
formate	NH_4CHO_2	102		143		204	311	533		
hydrogen carbonate	NH_4HCO_3	11.9	16.1	21.7	28.4	36.6	59.2	109	170	354
hydrogen phosphate	$(NH_4)_2HPO_4$	42.9	62.9	68.9	75.1	81.8	97.2			
hydrogen tartrate	$NH_4C_4H_5O_6$	1.00	1.88	2.70						
iodide	NH_4I	155	163	172	182	191	209	229		250
iron(II) sulfate	$(NH_4)_2Fe(SO_4)_2$	12.5	17.2	26.4	33	46				

TABLE 5.2 Solubilities of Inorganic Compounds and Metal Salts of Organic Acids in Water at Various Temperatures (*Continued*)

Substance	Formula	0°	10°	20°	30°	40°	60°	80°	90°	100°
Ammonium magnesium sulfate	$(NH_4)_2Mg(SO_4)_2$	11.8	14.6	18.0	21.7	25.8	35.1	48.3		65.7
nickel sulfate	$(NH_4)_2Ni(SO_4)_2$	1.00	4.00	6.50	9.20	12.0	17.0			
nitrate	NH_4NO_3	118	150	192	242	297	421	580	740	871
oxalate	$(NH_4)_2C_2O_4$	2.2	3.21	4.45	6.09	8.18	14.0	22.4	27.9	34.7
perchlorate	NH_4ClO_4	12.0	16.4	21.7	27.7	34.6	49.9	68.9		
selenite	$(NH_4)_2SeO_3$	96	105	115	126	143	192			
sulfate	$(NH_4)_2SO_4$	70.6	73.0	75.4	78.0	81	88	95		103
sulfite	$(NH_4)_2SO_3$	47.9	54.0	60.8	68.8	78.4	104	144	150	153
tartrate	$(NH_4)_2C_4H_4O_6$	45.0	55.0	63.0	70.5	76.5	86.9			
thioantimonate(V)	$(NH_4)_3SbS_4$	71.2		91.2	120					
thiocyanate	NH_4SCN	120	144	170	208	234	346			
vanadate	NH_4VO_3			0.48	0.84	1.32	2.42			
zinc sulfate	$(NH_4)_2Zn(SO_4)_2$	7.0	9.5	12.5	16.0	20.0	30.0	46.6	58.0	72.4
Antimony(III) chloride	$SbCl_3$	602		910	1087	1368	[completely miscible at 72°]			
fluoride	SbF_3	385		444	562					
Arsenic hydride (760 mm), cc	AsH_3	42	30	28						
oxide (pent-)	As_2O_5	59.5	62.1	65.8	69.8	71.2	73.0	75.1		76.7
oxide (tri-)	As_2O_3	1.20	1.49	1.82	2.31	2.93	4.31	6.11		8.2
Barium acetate	$Ba(C_2H_3O_2)_2 \cdot 3H_2O$	58.8	62	72	75	78.5	75.0	74.0		74.8
azide	$Ba(N_3)_2$	12.5	16.1	$17.4^{17°}$						
bromate	$Ba(BrO_3)_2 \cdot H_2O$	0.29	0.44	0.65	0.95	1.31	2.27	3.52	4.26	5.39
bromide	$BaBr_2 \cdot 2H_2O$	98	101	104	109	114	123	135		149
n-butyrate	$Ba(C_4H_7O_2)_2$	37.0	36.1	35.4	34.9	35.2	37.2	41.7	45.5	$48.1^{95°}$
caproate	$Ba(C_6H_{11}O_2)_2 \cdot 3.5H_2O$	11.71	8.38	6.89	5.87	5.79	8.39	14.71	19.28	
chlorate	$Ba(ClO_3)_2 \cdot H_2O$	20.3	26.9	33.9	41.6	49.7	66.7	84.8		105
chloride	$BaCl_2 \cdot 2H_2O$	31.2	33.5	35.8	38.1	40.8	46.2	52.5	55.8	59.4
chlorite	$Ba(ClO_2)_2$	43.9	44.6	45.4		47.9	53.8	66.6		80.8
fluoride	BaF_2		0.159	0.160	0.162					

formate	$Ba(CHO_2)_2$	26.2	28.0	29.9	31.9	34.0	38.6	44.2	47.6	51.3
hydroxide	$Ba(OH)_2$	1.67	2.48	3.89	5.59	8.22	20.94	101.4		
iodate	$Ba(IO_3)_2$			0.035	0.046	0.057				
iodide	$BaI_2 \cdot 2H_2O$	182	201	223	250		264		291	301
nitrate	$Ba(NO_3)_2$	4.95	6.67	9.02	11.48	14.1	20.4	27.2		34.4
nitrite	$Ba(NO_2)_2 \cdot H_2O$	50.3	60	72.8		102	151	222	261	325
perchlorate	$Ba(ClO_4)_2 \cdot 3H_2O$	239		336		416	495	575		653
propionate	$Ba(C_3H_5O_2)_2 \cdot H_2O$	57.2	56.8		57.5	59.0	62.0	67.8	73.0	82.7
*iso*succinate	$BaC_4H_4O_4$	0.421	0.432	0.418	0.393	0.366	0.306	0.237		
sulfamate	$Ba(SO_3NH_2)_2$	18.3	22.3	26.8	32.5	38.5	49.6	61.5		73.5
sulfide	BaS	2.88	4.89	7.86	10.38	14.89	27.69	49.91	67.34	60.29
tartrate	$Ba(C_2H_2O_3)_2$	0.021	0.024	0.028	0.032	0.035	0.044	0.053		
Beryllium nitrate	$Be(NO_3)_2$	97	102	108	113	125	178			
sulfate	$BeSO_4$	37.0	37.6	39.1	41.4	45.8	53.1	67.2		82.8
Boric acid	H_3BO_3	2.67	3.73	5.04	6.72	8.72	14.81	23.62	30.38	40.25
Cadmium bromide	$CdBr_2$	56.3	75.4	98.8	129	152	153	156		160
chlorate	$Cd(ClO_3)_2$	299	308	322	348	376	455			
chloride	$CdCl_2 \cdot 2.5H_2O$	90	100	113	132					
	$CdCl_2 \cdot H_2O$		135	135	135	135	136	140		147
formate	$Cd(CHO_2)_2$	8.3	11.1	14.4	18.6	25.3	59.5	80.5	85.2	94.6
iodide	CdI_2	78.7		84.7	87.9	92.1	100	111		125
nitrate	$Cd(NO_3)_2$	122	136	150	167	194	310	713		
perchlorate	$Cd(ClO_4)_2 \cdot 6H_2O$		180	188	195	203	221	243		272
selenate	$CdSeO_4$	72.5	68.4	64.0	58.9	55.0	44.2	32.5	27.2	22.0
sulfate	$CdSO_4$	75.4	76.0	76.6		78.5	81.8	66.7	63.1	60.8
Calcium acetate	$Ca(OAc)_2 \cdot 2H_2O$	37.4	36.0	34.7	33.8	33.2	32.7	33.5	31.1	29.7
benzoate	$Ca(OBz)_2 \cdot 3H_2O$	2.32	2.45	2.72	3.02	3.42	4.71	6.87	8.55	8.70
bromide	$CaBr_2 \cdot 6H_2O$	125	132	143	$185^{34°}$	213	278	295		$312^{105°}$
butyrate	$Ca(C_4H_7O_2)_2$	20.31	19.15	18.20	17.25	16.40	15.15	14.95		15.85
cacodylate	$Ca(C_2H_6AsO_2)_2 \cdot 9H_2O$	48	52	59	71					
chloride	$CaCl_2 \cdot 6H_2O$	59.5	64.7	74.5	100	128	137	147	154	159
chromate	$CaCrO_4$	4.5		2.25	1.83	1.49	0.83			
(mn)	$CaCrO_4 \cdot 2H_2O$	17.3		16.6	16.1					
formate	$Ca(CHO_2)_2$	16.15		16.60		17.05	17.50	17.95		18.40
gluconate	$Ca(C_6H_{11}O_7)_2 \cdot H_2O$			3.72		5.29		12.11	36.80	$57.2^{96°}$
hydrogen carbonate	$Ca(HCO_3)_2$	16.15		16.60		17.05	17.50	17.95		18.40
hydroxide	$Ca(OH)_2$	0.189	0.182	0.173	0.160	0.141	0.121		0.086	0.076

TABLE 5.2 Solubilities of Inorganic Compounds and Metal Salts of Organic Acids in Water at Various Temperatures (*Continued*)

Substance	Formula	0°	10°	20°	30°	40°	60°	80°	90°	100°
Calcium iodate	$Ca(IO_3)_2 \cdot 6H_2O$	0.090		0.24	0.38	0.52	0.65	0.66	0.67	
iodide	CaI_2	64.6	66.0	67.6	69.0	70.8	74	78		81
lactate	$Ca(C_3H_5O_3)_2 \cdot 5H_2O$	3.1		$5.4^{15°}$	7.9					
levulinate	$Ca(C_{10}H_{14}O_6) \cdot 2H_2O$	38.1		$45.1^{16°}$	55.0	$70.3^{45°}$	$88.7^{55°}$			
malonate	$Ca(C_3H_2O_4)$	0.29	0.33	0.36	0.40	0.42	0.46	0.48		
nitrate	$Ca(NO_3)_2 \cdot 4H_2O$	102	115	129	152	191		358		363
nitrite	$Ca(NO_2)_2 \cdot 4H_2O$	63.9		$84.5^{18°}$	104		134	151	166	178
propionate	$Ca(C_3H_5O_2)_2 \cdot H_2O$	42.80		39.85			38.25	39.85	42.15	48.44
selenate	$CaSeO_4 \cdot 2H_2O$	9.73	9.77	9.22	8.79	7.14				
succinate	$Ca(C_3H_2O_2)_2 \cdot 3H_2O$	1.127	1.22	1.28		1.18	0.89	0.68		0.66
sulfamate	$Ca(SO_3NH_2)_2$	56.5	62.8	72.3	84.5	100.1	150.0	215.2	$242^{95°}$	
sulfate	$CaSO_4 \cdot ½H_2O$			0.32	$0.29^{25°}$	$0.26^{35°}$	$0.21^{45°}$	$0.145^{65°}$	$0.12^{75°}$	0.071
	$CaSO_4 \cdot 2H_2O$	0.223	0.244	$0.255^{18°}$	0.264	0.265	$0.244^{65°}$	$0.234^{75°}$		0.205
tartrate	$CaC_4H_4O_6 \cdot 4H_2O$	0.026	0.029	0.034	0.046	0.063	0.091	0.130		
uranyl carbonate	$Ca_2UO_2(CO_3)_3 \cdot 10H_2O$	0.1		0.4^{23}		0.8	$1.5^{55°}$			
valerate	$Ca(C_5H_9O_2)_2$	9.82	9.25	8.80	8.40	8.05	7.78	7.95	8.20	8.78
*iso*valerate	$Ca(C_5H_9O_2)_2 \cdot 3H_2O$	26.05	22.70	21.80	21.68	22.00	18.38	16.88	16.65	16.55
Carbon disulfide	CS_2	0.204	0.194	0.179	0.155	0.111				
oxide sulfide (STP)										
mL/100 mL	COS	133.3	83.6	56.1	40.3					
tetrafluoride (STP)										
mL/100 g	CF_4		0.595	0.490	0.415	0.366				
Cerium(III) ammonium										
nitrate	$Ce(NH_4)_2(NO_3)_5$		242	276	318	376	681			
(IV) ammonium										
nitrate	$Ce(NH_4)_2(NO_3)_6$			135	150	169	213			
(III) ammonium										
sulfate	$Ce(NH_4)(SO_4)_2$			5.53	4.49	3.48	2.02	1.33		
(III) selenate	$Ce_2(SeO_3)_3$	39.5	37.2	35.2	33.2	32.6	13.7	4.6	2.1	

(III) sulfate	$Ce_2(SO_4)_3 \cdot 9H_2O$	21.4		9.84	7.24	5.63	3.87			
	$Ce_2(SO_4)_3 \cdot 8H_2O$			9.43	7.10	5.70	4.04			
Cesium aluminum sulfate	$Cs_2Al_2(SO_4)_4$	18.8	0.30	0.40	0.61	0.85	2.00	5.40	10.5	22.7
bromate	$CsBrO_3$	0.21		$3.66^{25°}$	4.53	$5.30^{35°}$				
chlorate	$CsClO_3$		3.8	6.2	9.5	13.8	26.2	45.0	58.0	79.0
chloride	CsCl	2.46	175	187	197	208	230	250	260	271
chloroaurate(III)	$CsAuCl_4$	161	0.5	0.8	1.7	3.3	8.9	19.5	27.7	37.9
chloroplatinate(IV)	Cs_2PtCl_6	0.0047	0.0064	0.0087	0.0119	0.0158	0.0290	0.0525	0.0675	0.0914
formate	$CsCHO_2$	335	381	450	533	694				
iodide	CsI	44.1	58.5	76.5	96	$124^{45°}$	150	190	205	
nitrate	$CsNO_3$	9.33	14.9	23.0	33.9	47.2	83.8	134	163	197
perchlorate	$CsClO_4$	0.8	1.0	1.6	2.6	4.0	7.3	14.4	20.5	30.0
sulfate	Cs_2SO_4	167	173	179	184	190	200	210	215	220
Chlorine dioxide	ClO_2	2.76	6.00	$8.70^{15°}$						
Chromium(III) nitrate	$Cr(NO_3)_3$	$108^{5°}$	$124^{15°}$	$130^{25°}$	$152^{35°}$					
(VI) oxide	CrO_3	164.8		167.2		172.5	183.9	191.6		206.8
(III) perchlorate	$Cr(ClO_4)_3$	104	123	130						
Cobalt(II) bromide	$CoBr_2$	91.9		112	128	163	227	241		257
chlorate	$Co(ClO_3)_2$	135	162	180	195	214	316			
chloride	$CoCl_2$	43.5	47.7	52.9	59.7	69.5	93.8	97.6	101	106
iodate	$Co(IO_3)_2$			1.02	0.90	0.88	0.82	0.73		0.70
nitrate	$Co(NO_3)_2$	84.0	89.6	97.4	111	125	174	204	300	
nitrite	$Co(NO_2)_2$	0.076	0.24	0.40	0.61	0.85				
sulfate	$CoSO_4$	25.5	30.5	36.1	42.0	48.8	55.0	53.8	45.3	38.9
	$CoSO_4 \cdot 7H_2O$	44.8	56.3	65.4	73.0	88.1	101			
Copper(II) ammonium chloride	$CuCl_2 \cdot 2NH_4Cl$	28.2	$32.0^{12°}$	35.0	38.3	43.8	56.6	76.5	76.5	
ammonium sulfate	$CuSO_4 \cdot (NH_4)_2SO_4$	11.5	15.1	19.4	24.4	30.5	46.3	69.7	86.1	107
bromide	$CuBr_2$	107	116	126	128	$131^{50°}$				
chloride	$CuCl_2$	68.6	70.9	73.0	77.3	87.6	96.5	104	108	120
fluorosilicate	$CuSiF_6$	73.5	76.5	81.6	$84.1^{25°}$	$91.2^{50°}$		$93.2^{75°}$		
nitrate	$Cu(NO_3)_2$	83.5	100	125	156	163	182	208	222	247
potassium sulfate	$CuSO_4 \cdot K_2SO_4$	5.1	7.2	10.0	13.6	18.2				
selenate	$CuSeO_4$	12.04	14.53	17.51	21.04	25.22	36.50	53.68		
sulfate	$CuSO_4 \cdot 5H_2O$	23.1	27.5	32.0	37.8	44.6	61.8	83.8		114
tartrate	$CuC_4H_4O_6 \cdot 3H_2O$		$0.020^{15°}$	0.042	0.089	0.142	0.197	0.144		
Gadolinium bromate	$Gd(BrO_3)_3 \cdot 9H_2O$	50.2	70.1	95.6	126	166				
sulfate	$Gd_2(SO_4)_3$	3.98	3.30	2.60	2.32					

TABLE 5.2 Solubilities of Inorganic Compounds and Metal Salts of Organic Acids in Water at Various Temperatures (*Continued*)

Substance	Formula	0°	10°	20°	30°	40°	60°	80°	90°	100°
Germanium(IV) oxide	GeO_2		0.49	0.43	0.50	0.61				
Holmium sulfate	$Ho_2(SO_4)_3 \cdot 8H_2O$			8.18	$6.71^{25°}$	4.52				
Hydrazinium (1+) nitrate	$N_2H_5NO_3$		175	266	402	607	2127			
(2+) sulfate	$N_2H_6SO_4$			2.87	3.89	4.15	9.08	14.39		
(1+) sulfate	$(N_2H_5)_2SO_4$				221	300	554			
Hydrogen bromide	HBr	221.2	210.3	$204.0^{15°}$		$171.5^{50°}$		$150.5^{75°}$		130.0
chloride	HCl	82.3	77.2	72.1	67.3	63.3	56.1			
selenide, mL at STP	H_2Se	386	351	289						
Iodine	I_2	0.014	0.020	0.029	0.039	0.052	0.100	0.225	0.315	0.445
Iridium(IV) ammonium chloride	$(NH_4)_2IrCl_6$	0.556	0.706	0.77	1.21	1.57	2.46	4.38	dec	
sodium chloride	Na_2IrCl_6		$34.46^{15°}$		56.17	96.00	191.2	279.3		
Iron(II) ammonium sulfate	$FeSO_4 \cdot (NH_4)_2SO_4 \cdot 6H_2O$	17.23	31.0	36.47	45.0					
(II) bromide	$FeBr_2$	101	109	117	124	133	144	168	176	184
(II) chloride	$FeCl_2$	49.7	59.0	62.5	66.7	70.0	78.3	88.7	92.3	94.9
(III) chloride	$FeCl_3 \cdot 6H_2O$	74.4		91.8	106.8					
(II) fluoro-silicate	$FeSiF_6 \cdot 6H_2O$	72.1	74.4		$77.0^{25°}$		$83.7^{50°}$	$88.1^{75°}$		$100.1^{106°}$
(II) nitrate	$Fe(NO_3)_2 \cdot 6H_2O$	113	134				266			
(III) nitrate	$Fe(NO_3)_3 \cdot 9H_2O$	112.0		137.7		175.0				
(III) perchlorate	$Fe(ClO_4)_3$	289		368	422	478	772			
(II) sulfate	$FeSO_4 \cdot 7H_2O$	28.8	40.0	48.0	60.0	73.3	100.7	79.9	68.3	57.8
Lanthanum bromate	$La(BrO_3)_3$	98	120	149	200					
nitrate	$La(NO_3)_3$	100		136		168	247			
selenate	$La_2(SeO_3)_3$	50.5	45	45	45	45	18.5	5.4	2.2	
sulfate	$La_2(SO_4)_3$	3.00	2.72	2.33	1.90	1.67	1.26	0.91	0.79	0.68
Lead(II) acetate	$Pb(C_2H_3O_2)_2$	19.8	29.5	44.3	69.8	116				
bromide	$PbBr_2$	0.45	0.63	0.86	1.12	1.50	2.29	3.23	3.86	4.55
chloride	$PbCl_2$	0.67	0.82	1.00	1.20	1.42	1.94	2.54	2.88	3.20
fluorosilicate	$PbSiF_6$	190		222			403	428		463

iodide	PbI_2	0.044	0.056	0.069	0.090	0.124	0.193	0.294		0.42
nitrate	$Pb(NO_3)_2$	37.5	46.2	54.3	63.4	72.1	91.6	111		133
Lithium acetate	$LiC_2H_3O_2$	31.2	35.1	40.8	50.6	68.6				
ammonium sulfate	$LiNH_4SO_4$		55.2		55.9	56.1	56.5			
azide	LiN_3	61.3	64.2	67.2	71.2	75.4	86.6			100
benzoate	$LiC_7H_5O_2$	38.9	41.6	44.7	53.8					
borate (meta-)	$LiBO_2$	0.90	1.3	2.7	5.7	10.9				
bromate	$LiBrO_3$	154	166	179	198	221	269	308	329	355
bromide	LiBr	143	147	160	183	211	223	245		266
carbonate	Li_2CO_3	1.54	1.43	1.33	1.26	1.17	1.01	0.85		0.72
chlorate	$LiClO_3$	241	283	372	488	604	777			
chloride	LiCl	69.2	74.5	83.5	86.2	89.8	98.4	112	121	128
chloroaurate(III)	$LiAuCl_4$		113	136	167	206	324	599		
cyanoplatinate(II)	$Li_2Pt(CN)_4$	105		141	153	160	178	216	239	
formate	$LiCHO_2$	32.3	35.7	39.3	44.1	49.5	64.7	92.7	116	138
hydrogen phosphite	Li_2HPO_3	9.97			7.61	7.11	6.03			4.43
hydroxide	LiOH	11.91	12.11	12.35	12.70	13.22	14.63	16.56		19.12
iodide	LiI	151	157	165	171	179	202	435	440	481
molybdate	Li_2MoO_4	82.6		79.5	79.4	78.0				73.9
nitrate	$LiNO_3$	53.4	60.8	70.1	138	152	175			
nitrite	$LiNO_2$	70.9	82.5	96.8	114	133	177	233	272	324
perchlorate	$LiClO_4$	42.7	49.0	56.1	63.6	72.3	92.3	128	151	
phosphate (meta-)	$LiPO_3$	0.101		$0.058^{25°}$		0.048				
selenite	Li_2SeO_3	25.0	23.3	21.5	19.6	17.9	14.7	11.9	11.1	9.9
sulfate	Li_2SO_4	36.1	35.5	34.8	34.2	33.7	32.6	31.4	30.9	
tartrate (*d*-)	$Li_2C_4H_4O_6$	42.0	31.8	27.1	26.6	27.2	29.5			
thiocyanate	LiSCN			114	131	153				
vanadate	Li_3VO_4	2.50		4.82	6.28	4.38	2.67			
Magnesium acetate	$Mg(C_2H_3O_2)_2$	56.7	59.7	53.4	68.6	75.7	118			
bromide	$MgBr_2$	98	99	101	104	106	112			125
chlorate	$Mg(ClO_3)_2$	114	123	135	155	178	242		268	
chloride	$MgCl_2$	52.9	53.6	54.6	55.8	57.5	61.0	66.1	69.5	73.3
fluorosilicate	$MgSiF_6$	26.3		30.8		34.9	44.4			
formate	$Mg(CHO_2)_2$	14.0	14.2	14.4	14.9	15.9	17.9	20.5	22.2	23.9
iodate	$Mg(IO_3)_2$		7.2	8.6	10.0	11.7	15.2	15.5	15.6	
iodide	MgI_2	120		140		173		186		

TABLE 5.2 Solubilities of Inorganic Compounds and Metal Salts of Organic Acids in Water at Various Temperatures (*Continued*)

Substance	Formula	0°	10°	20°	30°	40°	60°	80°	90°	100°
Magnesium nitrate	$Mg(NO_3)_2$	62.1	66.0	69.5	73.6	78.9	78.9	91.6	106	
selenate	$MgSeO_4$	20.0	30.4	38.3	44.3	48.6	55.8			
sulfate	$MgSO_4$	22.0	28.2	33.7	38.9	44.5	54.6	55.8	52.9	50.4
sulfite	$MgSO_3$	0.339	0.446	0.573	0.751	0.959	0.779	0.642	0.622	
tartrate	$MgC_4H_4O_6$	0.54	0.78	1.06		1.02				
Manganese bromide	$MnBr_2$	127	136	147	157	169	197	225	226	228
chloride	$MnCl_2$	63.4	68.1	73.9	80.8	88.5	109	113	114	115
fluoride	MnF_2			1.06		0.67	0.44			0.48
nitrate	$Mn(NO_3)_2$	102	118	139	206					
oxalate	MnC_2O_4	0.020	0.024	0.028	0.033					
sulfate	$MnSO_4$	52.9	59.7	62.9	62.9	60.0	53.6	45.6	40.9	35.3
Mercury(II) bromide	$HgBr_2$	0.30	0.40	0.56	0.66	0.91	1.68	2.77		4.9
(II) chloride	$HgCl_2$	3.63	4.82	6.57	8.34	10.2	16.3	30.0		61.3
(I) perchlorate	$Hg_2(ClO_4)_2$	282	325	367	407	455	499	541		580
Molybdenum trioxide	MoO_3			0.134	0.285	0.454	1.08	1.74		
Neodymium bromate	$Nd(BrO_3)_3$	43.9	59.2	75.6	95.2	116				
chloride	$NdCl_3$		96.7	98.0	99.6	102	105			
nitrate	$Nd(NO_3)_3$	127	133	142	145	159	211			
selenate	$Nd_2(SeO_3)_3$	46.2	44.6	41.8	39.9	39.9	43.9	7.0	3.3	
sulfate	$Nd_2(SO_4)_3$	13.0	9.7	7.1	5.3	4.1	2.8	2.2	1.2	
Nickel bromide	$NiBr_2$	113	122	131	138	144	153	154		155
chlorate	$Ni(ClO_3)_2$	111	120	133	155	181	221	308		
chloride	$NiCl_2$	53.4	56.3	60.8	70.6	73.2	81.2	86.6		87.6
fluoride	NiF_2		2.55	2.56			2.56		2.59	
iodate	$Ni(IO_3)_2$				1.15		1.06		1.00	
	$Ni(IO_3)_2 \cdot 4H_2O$	0.74		1.09	1.43					
iodide	NiI_2	124	135	148	161	174	184	187	188	
nitrate	$Ni(NO_3)_2$	79.2		94.2	105	119	158	187	188	
perchlorate	$Ni(ClO_4)_2$	105	107	110	113	117				

Nickel sulfate	$NiSO_4 \cdot 6H_2O$	(pale blue)		40.1	43.6	47.6				
		(green)		44.4	46.6	49.2	55.6	64.5	70.1	76.7
	$NiSO_4 \cdot 7H_2O$	26.2	32.4	37.7	43.4	50.4				
Osmium tetroxide	OsO_4	5.26	5.75	6.43						
Oxalic acid	$H_2C_2O_4$	3.54	6.08	9.52	14.23	21.52	44.32	84.5	120	
Potassium acetate	$KC_2H_3O_2$	216	233	256	283	324	350	381	398	
aluminum sulfate	$KAl(SO_4)_2$	3.00	3.99	5.90	8.39	11.7	24.8	71.0	109	
azide	KN_3	41.4	46.2	50.8	55.8	61.0				106
benzoate	$KC_7H_5O_2$		65.8	70.7	76.7	82.1				
bromate	$KBrO_3$	3.09	4.72	6.91	9.64	13.1	22.7	34.1		49.9
bromide	KBr	53.6	59.5	65.3	70.7	75.4	85.5	94.9	99.2	104
cadmium bromide	$KCdBr_3$	116	133	150	170	191	233	276	298	325
cadmium chloride	$KCdCl_3$	26.6	32.3	38.9	45.6	53.1	67.5	83.5		101
carbonate	K_2CO_3	105	108	111	114	117	127	140	148	156
chlorate	$KClO_3$	3.3	5.2	7.3	10.1	13.9	23.8	37.6	46.0	56.3
chloride	KCl	28.0	31.2	34.2	37.2	40.1	45.8	51.3	53.9	56.3
chloroaurate(III)	$KAuCl_4$		38.3	61.8	94.9	145	405			
chloroplatinate(IV)	K_2PtCl_6	0.48	0.60	0.78	1.00	1.36	2.45	3.71		5.03
chromate	K_2CrO_4	56.3	60.0	63.7	66.7	67.8	70.1		74.5	
citrate	$K_3C_6H_5O_7$		153	172	194					
cobalt(II) sulfate	$K_2Co(SO_4)_2$	8.5	11.7	15.5	19.3	23.3	32.5	47.7		
copper(II) sulfate	$K_2Cu(SO_4)_2$	5.1	7.2	10.0	13.6	18.2				
cyanoplatinate(II)	$K_2Pt(CN)_4$	11.6	19.8	33.9	52.0	78.3	139	177	194	
dichromate	$K_2Cr_2O_7$	4.7	7.0	12.3	18.1	26.3	45.6	73.0		
dihydrogen phosphate	KH_2PO_4	14.8	18.3	22.6	28.0	33.5	50.2	70.4	83.5	
dithionate	$K_2S_2O_6$	2.6	4.2	6.6	9.3					
ferricyanide	$K_3Fe(CN)_6$	30.2	38	46	53	59.3	70			91
ferrocyanide	$K_4Fe(CN)_6$	14.3	21.1	28.2	35.1	41.4	54.8	66.9	71.5	74.2
fluoride	KF	44.7	53.5	94.9	108	138	142	150		
fluorogermanate(IV)	K_2GeF_6	0.25	0.36	0.50	0.66	0.96				
fluorosilicate	K_2SiF_6	0.077	0.102	0.151	0.202	0.253				
fluorotitanate(IV)	K_2TiF_6	0.55	0.91	1.28						
formate	$KCHO_2$		313	337	361	398	471	580	658	
hydrogen carbonate	$KHCO_3$	22.5	27.4	33.7	39.9	47.5	65.6			

TABLE 5.2 Solubilities of Inorganic Compounds and Metal Salts of Organic Acids in Water at Various Temperatures (*Continued*)

Substance	Formula	0°	10°	20°	30°	40°	60°	80°	90°	100°
Potassium hydrogen fluoride	KHF_2	24.5	30.1	39.2	46.8	56.5	78.8	114		
hydrogen selenite	$KH_3(SeO_3)_2$	115	162	215	300	408	900			
hydrogen sulfate	$KHSO_4$	36.2		48.6	54.3	61.0	76.4	96.1		122
hydrogen tartrate	$KC_4H_5O_6$	0.231	0.358	0.523	0.762					
hydroxide	KOH	95.7	103	112	126	134	154			178
iodate	KIO_3	4.60	6.27	8.08	10.3	12.6	18.3	24.8		32.3
iodide	KI	128	136	144	153	162	176	192	198	206
iron(II) sulfate	$K_2Fe(SO_4)_2$	19.6	24.5	32.1	39.1	44.9	57.2			
magnesium sulfate	$K_2Mg(SO_4)_2$	14.0	19.5	25.0	30.4	36.6	50.2	63.4		
nickel sulfate	$K_2Ni(SO_4)_2$	3.37	4.50	5.94	7.72	9.85	15.4	23.0	27.8	33.4
nitrate	KNO_3	13.9	21.2	31.6	45.3	61.3	106	167	203	245
nitrite	KNO_2	279	292	306	320	329	348	376	390	410
oxalate	$K_2C_2O_4$	25.5	31.9	36.4	39.9	43.8	53.2	63.6	69.2	75.3
perchlorate	$KClO_4$	0.76	1.06	1.68	2.56	3.73	7.3	13.4	17.7	22.3
periodate	KIO_4	0.17	0.28	0.42	0.65	1.0	2.1	4.4	5.9	
permanganate	$KMnO_4$	2.83	4.31	6.34	9.03	12.6	22.1			
peroxodisulfate	$K_2S_2O_8$	1.65	2.67	4.70	7.75	11.0				
perrhenate	$KReO_4$	0.34	0.63	0.99	1.47	2.2	4.58	8.7		
phosphate	K_3PO_4		81.5	92.3	108	133				
salicylate	$KC_7H_5O_3$	21.2	32.4	47.1	61.3	78.6	116	156		
selenate	K_2SeO_4	107	109	111	113	115	119	121		122
selenite	K_2SeO_3	169	186	203	217	217	220			217
sulfate	K_2SO_4	7.4	9.3	11.1	13.0	14.8	18.2	21.4	22.9	24.1
sulfite	K_2SO_3	106		106	107	107	108			112
tellurate	K_2TeO_4	8.8		27.5	50.4					
thioantimonate(V)	K_3SbS_4	306	320		302	315		381		
thiocyanate	KSCN	177	198	224	255	289	372	492	571	675
thiosulfate	$K_2S_2O_3$	96		155	175	205	238	293	312	
zinc sulfate	$K_2Zn(SO_4)_2 \cdot 6H_2O$	13.0	18.9	25.9	35.0	44.9	72.1			

Praseodymium bromate	$Pr(BrO_3)_3$	55.9	73.0	91.8	114	144				
nitrate	$Pr(NO_3)_3$			112	162	178				
selenate	$Pr_2(SeO_3)_3$	36.2			32.4	31.2	30.4	5.43	3.6	
sulfate	$Pr_2(SO_4)_3$	19.8	15.6	12.6	9.89	2.56	5.04	3.5	1.1	0.91
Rubidium aluminum sulfate	$Rb_2Al_2(SO_4)_4$	0.72	1.05	1.50	2.20	3.25	7.40	21.6		
bromate	$RbBrO_3$				3.6	5.1				
bromide	RbBr	90	99	108	119	132	158			
chlorate	$RbClO_3$	2.1	3.4	5.4	8.0	11.6	22	38	49	63
chloride	RbCl	77	84	91	98	104	115	127	133	143
chloroaurate(III)	$RbAuCl_4$		4.8	9.9	15.5	21.5	36.2	54.6	65.8	79.2
chloroplatinate(IV)	Rb_2PtCl_6	0.014	0.020	0.028	0.040	0.056	0.090	0.182	0.247	0.333
chromate	Rb_2CrO_4	62.0	67.5	73.6	78.9	85.6	95.7			
cobalt sulfate	$Rb_2Co(SO_4)_2$	5.10	7.47	10.8	14.5	18.2	30.2	44.9	55.0	70.1
dichromate (mn)	$Rb_2Cr_2O_7$			5.9	10.0	15.2	32.3			
(tric)				5.8	9.5	14.8	32.4			
formate	$RbCHO_2$		443	554	614	694	900			
iron(III) sulfate	$RbFe(SO_4)_2 \cdot 12H_2O$		8.0	20	35	52				
nitrate	$RbNO_3$	19.5	33.0	52.9	81.2	117	200	310	374	452
perchlorate	$RbClO_4$	1.09	1.19	1.55	2.20	3.26	6.27	11.0	15.5	22.0
salicylate	$RbC_7H_5O_3$		187	212	238	268	324			
sulfate	Rb_2SO_4	37.5	42.6	48.1	53.6	58.5	67.5	75.1	78.6	81.8
Samarium bromate	$Sm(BrO_3)_3$	34.2	47.6	62.5	79.0	98.5				
chloride	$SmCl_3$		92.4	93.4	94.6	96.9				
Selenic acid	H_2SeO_4	426		567	1328					
Selenious acid	H_2SeO_3	90.1	122.2	166.7	235.6	344.4	383.1	383.1	385.4	
Selenium dioxide	SeO_2		222	257	291	335	440			
Silver acetate	$AgC_2H_3O_2$	0.73	0.89	1.05	1.23	1.43	1.93	2.59		
bromate	$AgBrO_3$		0.11	0.16	0.23	0.32	0.57	0.94	1.33	
chlorate	$AgClO_3$		10.4	15.3	20.9	26.8				
fluoride	AgF	85.9	120	172	190	203				
nitrate	$AgNO_3$	122	167	216	265	311	440	585	652	733
nitrite	$AgNO_2$	0.16	0.22	0.34	0.51	0.73	1.39			
perchlorate	$AgClO_4$	455	484	525	594	635				793
sulfamate	$AgNH_2SO_3$	2.30	4.82	7.53	10.3	15.3	28.5			
sulfate	Ag_2SO_4	0.57	0.70	0.80	0.89	0.98	1.15	1.30	1.36	1.41

TABLE 5.2 Solubilities of Inorganic Compounds and Metal Salts of Organic Acids in Water at Various Temperatures (*Continued*)

Substance	Formula	0°	10°	20°	30°	40°	60°	80°	90°	100°
Sodium acetate	$NaC_2H_3O_2$	36.2	40.8	46.4	54.6	65.6	139	153	161	170
aluminum sulfate	$Na_2Al_2(SO_4)_4$	37.4	39.3	39.7	41.7	43.8				
azide	NaN_3	38.9	39.9	40.8						55.3
benzoate	$NaC_7H_5O_2$	62.6	62.8	62.8	62.9	63.1	64.5	68.6	70.6	73.3
borate (penta-)	$Na_2B_{10}O_{16}$	6.4	8.6	12.0	16.4	22.0	37.9	63.4	83.5	108
borate (tetra-)	$Na_2B_4O_7$	1.11	1.60	2.56	3.86	6.67	19.0	31.4	41.0	52.5
bromate	$NaBrO_3$	24.2	30.3	36.4	42.6	48.8	62.6	75.7		90.8
bromide	NaBr	80.2	85.2	90.8	98.4	107	118	120	121	121
carbonate	Na_2CO_3	7.00	12.5	21.5	39.7	49.0	46.0	43.9	43.9	
chlorate	$NaClO_3$	79.6	87.6	95.9	105	115	137	167	184	204
chloride	NaCl	35.7	35.8	35.9	36.1	36.4	37.1	38.0	38.5	39.2
chloroaurate(III)	$NaAuCl_4$		139	151	178	227	900			
chloroiridate(IV)	Na_2IrCl_6		31.6	39.3	56.2	96.1	192	279		
chromate	Na_2CrO_4	31.7	50.1	84.0	88.0	96.0	115	125		126
cyanide	NaCN	40.8	48.1	58.7	71.2					
dichromate	$Na_2Cr_2O_7$	163	172	183	198	215	269	376	405	415
diethyl barbiturate	$NaC_8H_{11}N_2O_3$		12.7	21.5	24.7				48.0	
dihydrogen phosphate (ortho-)	NaH_2PO_4	56.5	69.8	86.9	107	133	172	211	234	
dihydrogen phosphate (pyro-)	$Na_2H_2P_2O_7$	4.47	6.95	12.0	17.1	18.4				
dithionate	$Na_2S_2O_6$	6.3	11.1	15.1	19.6	24.7	36.1	49.3	56.3	64.7
dodecanesulfonate	$NaC_{12}H_{25}SO_3$			0.13	0.25	6.54				
dodecanoate	$NaC_{12}H_{23}O_2$				4.58	22.7	105	170		
EDTA (Y)*	$Na_2H_2Y \cdot 2H_2O$	10.6		11.1	12.8	14.2	17.0	22.2	24.3	$27.0^{98°}$
ferrocyanide	$Na_4Fe(CN)_6$	11.2	14.8	18.8	23.8	29.9	43.7	62.1		
fluoride	NaF	3.66		4.06	4.22	4.40	4.68	4.89		5.08
fluoroberyllate	Na_2BeF_4	1.33		1.44		1.92	2.24	2.62	2.73	
fluorogermanate	Na_2GeF	1.52	1.68		2.25	2.83		3.36		
fluorosilicate	Na_2SiF_6	4.35	5.7	7.2	8.6	10.3	14.3	18.7	21.5	24.5

formate	$NaCHO_2$	43.9	62.5	81.2	102	108	122	138	147	160
germanate	Na_2GeO_3	14.4	18.8	23.8	28.7	37.2	65.0	116		
hydrogen arsenate	Na_2HAsO_4	5.9	13.0	33.9	49.3	69.5	144	186	188	198
hydrogen carbonate	$NaHCO_3$	7.0	8.1	9.6	11.1	12.7	16.0			
hydrogen phosphate	Na_2HPO_4	1.68	3.53	7.83	22.0	55.3	82.8	92.3	102	104
hydrogen phosphite	Na_2HPO_3	418	424	429	566					
hydrogen succinate	$NaC_4H_5O_4$	17.5	25.3	34.8	47.7	61.6	74.5	90.1		
hydroxide	NaOH		98	109	119	129	174			
hydroxostannate(IV)	$Na_2Sn(OH)_6$	46.0		43.7	42.7	38.9				
hypochlorite	NaClO	29.4	36.4	53.4	100	110				
iodate	$NaIO_3$	2.48	4.59	8.08	10.7	13.3	19.8	26.6	29.5	33.0
iodide	NaI	159	167	178	191	205	257	295		302
molybdate	Na_2MoO_4	44.1	64.7	65.3	66.9	68.6	71.8			
nitrate	$NaNO_3$	73.0	80.8	87.6	94.9	102	122	148		180
nitrite	$NaNO_2$	71.2	75.1	80.8	87.6	94.9	111	133		160
oxalate	$Na_2C_2O_4$	2.69	3.05	3.41	3.81	4.18	4.93	5.71		6.50
perchlorate	$NaClO_4$	167	183	201	222	245	288	306		329
periodate	$NaIO_4$	1.83	5.6	10.3	19.9	30.4				
phosphate	Na_3PO_4	4.5	8.2	12.1	16.3	20.2	29.9	60.0	68.1	77.0
potassium tartrate	$NaKC_4H_4O_6$	31.9	46.6	67.8	102					
salicylate	$NaC_7H_5O_3$		44.7	95.3	111	117	130	144		
selenate	Na_2SeO_4	13.3	25.2	26.9	77.0	81.8	78.6	74.8	73.0	72.7
selenite	Na_2SeO_3	78.6	81.2	86.2	94.2	96.5	91.6	86.6	84.5	82.5
sulfate	Na_2SO_4	4.9	9.1	19.5	40.8	48.8	45.3	43.7	42.7	42.5
	$Na_2SO_4 \cdot 7H_2O$	19.5	30.0	44.1						
sulfide	Na_2S	9.6	12.1	15.7	20.5	26.6	39.1	55.0	65.3	
sulfite	Na_2SO_3	14.4	19.5	26.3	35.5	37.2	32.6	29.4	27.9	
thioantimonate(V)	Na_3SbS_4	13.4	20.0	27.9	37.2	49.3	53.8	88.3		
thiocyanate	NaSCN		111	134	164	176	192	210	218	
thiosulfate	$Na_2S_2O_3 \cdot 5H_2O$	50.2	59.7	70.1	83.2	104				
tungstate	Na_2WO_4	71.5		73.0		77.6		90.8		97.2
vanadate	$NaVO_3$			19.3	22.5	26.3	33.0	40.8		
Strontium acetate	$Sr(C_2H_3O_2)_2$	37.0	42.9	41.1	39.5	38.3	36.8	36.1	36.2	36.4
bromide	$SrBr_2$	85.2	93.4	102	112	123	150	182		223
chloride	$SrCl_2$	43.5	47.7	52.9	58.7	65.3	81.8	90.5		101
chromate	$SrCrO_4$		0.085	0.090				0.058		

*Properly called dihydrogen ethylenediaminetetraacetate ($Na_2H_2EDTA \cdot 2H_2O$).

TABLE 5.2 Solubilities of Inorganic Compounds and Metal Salts of Organic Acids in Water at Various Temperatures (*Continued*)

Substance	Formula	0°	10°	20°	30°	40°	60°	80°	90°	100°
Strontium fluoride	SrF_2	0.0113		0.0117	0.0119					
formate	$Sr(CHO_2)_2$	9.1	10.6	12.7	15.2	17.8	25.0	31.9	32.9	34.4
hydroxide	$Sr(OH)_2$	0.91	1.25	1.77	2.64	3.95	8.42	20.2	44.5	91.2
iodide	SrI_2	165		178		192	218	270	365	383
nitrate	$Sr(NO_3)_2$	39.5	52.9	69.5	88.7	89.4	93.4	96.9	98.4	
nitrite	$Sr(NO_2)_2$			65	72	79	97	130	134	
oxide	SrO				1.03	1.05	3.40	9.15	13.13	12.15
sulfate	$SrSO_4$	0.0113	0.0129	0.0132	0.0138	0.0141	0.0131	0.0116	0.0115	
Sulfamic acid	H_2NSO_3H	14.7	18.6	21.3	26.1	29.5	37.1	47.1		
Telluric acid	H_2TeO_4	16.2	33.8	41.6	50.0	57.2	77.5	106		155
Terbium bromate	$Tb(BrO_3)_3 \cdot 9H_2O$	66.4	89.7	117	152	198				
Thallium(I) azide	TlN_3	0.171	0.236	0.364						
bromide	TlBr	0.022	0.032	0.048	0.068	0.097	0.177			
carbonate	Tl_2CO_3			5.3			12.2			27.2
chlorate	$TlClO_3$	2.00		3.92		$12.7^{50°}$		36.6		57.3
chloride	TlCl	0.21	0.25	0.33	0.42	0.52	0.80	1.20		1.80
hydroxide	TlOH	25.4	29.6	35.0	40.4	49.4	73.3	106	126	150
iodide	TlI	0.002		0.006		0.015	0.035	0.070		0.120
nitrate	$TlNO_3$	3.90	6.22	9.55	14.3	21.0	46.1	110	200	414
nitrite	$TlNO_2$	17.9	28.9	40.3	53.2	83.6	216	1150	750	
perchlorate	$TlClO_4$	6.00	8.04	13.1	19.7	28.3	50.8	81.5		
picrate	$TlOC_6H_2(NO_2)_3$	0.135		0.40	0.57	0.83	1.73			
selenate	Tl_2SeO_4		2.17	2.80				8.50		10.8
sulfate	Tl_2SO_4	2.73	3.70	4.87	6.16	7.53	11.0	14.6	16.5	18.4
Thorium nitrate	$Th(NO_3)_4$	186	187	191						
sulfate	$Th(SO_4)_2 \cdot 4H_2O$					4.04	1.63			
	$Th(SO_4)_2 \cdot 9H_2O$	0.74	0.99	1.38	1.99	3.00				
Tin(II) iodide	SnI_2			0.99	1.17	1.42	2.11	3.04	3.58	4.20
Uranium(IV) sulfate	$U(SO_4)_2 \cdot 4H_2O$				10.1	9.0	7.7			
	$U(SO_4)_2 \cdot 8H_2O$			11.9	17.9	29.2	55.8			

Uranyl nitrate	$UO_2(NO_3)_2$	98	107	122	141	167	317	388	426	474
oxalate	$UO_2C_2O_4$		0.45	0.50	0.61	0.80	1.22	1.94		3.16
Ytterbium sulfate	$Yb_2(SO_4)_3$	44.2	37.5		22.2	17.2	10.4	6.4	5.8	4.7
Yttrium bromide	YBr_3	63.9		75.1		87.3	101	116	123	
chloride	YCl_3	77.3	78.1	78.8	79.6	80.8				
nitrate	$Y(NO_3)_3$	93.1	106	123	143	163	200			
sulfate	$Y_2(SO_4)_3$	8.05	7.67	7.30	6.78	6.09	4.44	2.89	2.2	
Zinc bromide	$ZnBr_2$	389		446	528	591	618	645		672
chlorate	$Zn(ClO_3)_2$	145	152	200	209	223				
chloride	$ZnCl_2$	342	363	395	437	452	488	541		614
formate	$Zn(CHO_2)_2$	3.70	4.30	5.20	6.10	7.40	11.8	21.2	28.8	38.0
iodide	ZnI_2	430		432		445	467	490		510
nitrate	$Zn(NO_3)_2$	98			138	211				
sulfate (rh)	$ZnSO_4$	41.6	47.2	53.8	61.3	70.5	75.4	71.1		60.5
sulfate (mn)			54.4	60.0	65.5					
tartrate	$ZnC_4H_4O_6$			0.022	0.041	0.060	0.104	0.059		

5.2 VAPOR PRESSURES

TABLE 5.3 Vapor Pressure of Mercury

Temp. °C	mm of Hg	Temp. °C	mm of Hg	Temp. °C	mm of Hg
0	0.000 185	92	0.1769	184	10.116
2	0.000 228	94	0.1976	186	10.839
4	0.000 276	96	0.2202	188	11.607
6	0.000 335	98	0.2453	190	12.423
8	0.000 406	100	0.2729	192	13.287
10	0.000 490	102	0.3032	194	14.203
12	0.000 588	104	0.3366	196	15.173
14	0.000 706	106	0.3731	198	16.200
16	0.000 846	108	0.4132	200	17.287
18	0.001 009	110	0.4572	202	18.437
20	0.001 201	112	0.5052	204	19.652
22	0.001 426	114	0.5576	206	20.936
24	0.001 691	116	0.6150	208	22.292
26	0.002 000	118	0.6776	210	23.723
28	0.002 359	120	0.7457	212	25.233
30	0.002 777	122	0.8198	214	26.826
32	0.003 261	124	0.9004	216	28.504
34	0.003 823	126	0.9882	218	30.271
36	0.004 471	128	1.084	220	32.133
38	0.005 219	130	1.186	222	34.092
40	0.006 079	132	1.298	224	36.153
42	0.007 067	134	1.419	226	38.318
44	0.008 200	136	1.551	228	40.595
46	0.009 497	138	1.692	230	42.989
48	0.010 98	140	1.845	232	45.503
50	0.012 67	142	2.010	234	48.141
52	0.014 59	144	2.188	236	50.909
54	0.016 77	146	2.379	238	53.812
56	0.019 25	148	2.585	240	56.855
58	0.022 06	150	2.807	242	60.044
60	0.025 24	152	3.046	244	63.384
62	0.028 83	154	3.303	246	66.882
64	0.032 87	156	3.578	248	70.543
66	0.037 40	158	3.873	250	74.375
68	0.042 51	160	4.189	252	78.381
70	0.048 25	162	4.528	254	82.568
72	0.054 69	164	4.890	256	86.944
74	0.061 89	166	5.277	258	91.518
76	0.069 93	168	5.689	260	96.296
78	0.078 89	170	6.128	262	101.28
80	0.088 80	172	6.596	264	106.48
82	0.100 0	174	7.095	266	111.91
84	0.112 4	176	7.626	268	117.57
86	0.126 1	178	8.193	270	123.47
88	0.1413	180	8.796	272	129.62
90	0.1582	182	9.436	274	136.02

TABLE 5.3 Vapor Pressure of Mercury (*Continued*)

Temp. °C	mm of Hg	Temp. °C	mm of Hg	Temp. °C	mm of Hg
276	142.69	332	478.13	388	1299.1
278	149.64	334	497.12	390	1341.9
280	156.87	336	516.74	392	1386.1
282	164.39	338	537.00	394	1431.3
284	172.21	340	557.90	396	1477.7
286	180.34	342	579.45	398	1525.2
288	188.79	344	601.69	400	1574.1
290	197.57	346	624.64	430	2464
292	206.70	348	648.30	460	3715
294	216.17	350	672.69	490	5420
296	226.00	352	697.83	520	7691
298	236.21	354	723.73	550	10650
300	246.80	356	750.43	600	22.87 atm
302	257.78	358	777.92	650	35.49 atm
304	269.17	360	806.23	700	52.51 atm
306	280.98	362	835.38	750	74.86 atm
308	293.21	364	865.36	800	103.31 atm
310	305.89	366	896.23	850	138.42 atm
312	319.02	368	928.02	900*	180.92 atm
314	332.62	370	960.66	950	226.58 atm
316	346.70	372	994.34	1000	290.5 atm
318	361.26	374	1028.9	1050	358.1 atm
320	376.33	376	1064.4	1100	437.3 atm
322	391.92	378	1100.9	1150	521.3 atm
324	408.04	380	1138.4	1200	616.8 atm
326	424.71	382	1177.0	1250	721.4 atm
328	441.94	384	1216.6	1300	835.9 atm
330	459.74	386	1257.3		

* Critical point.

TABLE 5.4 Vapor Pressure of Ice in Millimeters of Mercury

For temperatures from −99 to 0°C.

The values in the table are for ice in contact with its own vapor. Where the ice is in contact with air at a temperature t°C, this correction must be added: Correction = $20p/(100)(t + 273)$.

t, °C	*p*, mm Hg	*t*, °C	*p*, mm Hg	*t*, °C	*p*, mm Hg
−99	0.000 012	−51	0.026 1	−16.5	1.080
−98	0.000 015	−50	0.029 6	−16.0	1.132
−97	0.000 018	−49	0.033 4	−15.5	1.186
−96	0.000 022	−48	0.037 8	−15.0	0.241
−95	0.000 027	−47	0.042 6	−14.5	1.300
−94	0.000 033	−46	0.048 1	−14.0	1.361
−93	0.000 040	−45	0.054 1	−13.5	1.424
−92	0.000 048	−44	0.060 9	−13.0	1.490
−91	0.000 058	−43	0.068 4	−12.5	1.559
−90	0.000 070	−42	0.076 8	−12.0	1.632
−89	0.000 084	−41	0.086 2	−11.5	1.707
−88	0.000 10	−40	0.096 6	−11.0	1.785
−87	0.000 12	−39	0.108 1	−10.5	1.866
−86	0.000 14	−38	0.120 9	−10.0	1.950
−85	0.000 17	−37	0.135 1	−9.8	1.985
−84	0.000 20	−36	0.150 7	−9.6	2.021
−83	0.000 24	−35	0.168 1	−9.4	2.057
−82	0.000 29	−34	0.187 3	−9.2	2.093
−81	0.000 34	−33	0.208 4	−9.0	2.131
−80	0.000 40	−32	0.231 8	−8.8	2.168
−79	0.000 47	−31	0.257 5	−8.6	2.207
−78	0.000 56	−30.0	0.285 9	−8.4	2.246
−77	0.000 66	−29.5	0.301	−8.2	2.285
−76	0.000 77	−29.0	0.317	−8.0	2.326
−75	0.000 90	−28.5	0.334	−7.8	2.367
−74	0.001 05	−28.0	0.351	−7.6	2.408
−73	0.001 23	−27.5	0.370	−7.4	2.450
−72	0.001 43	−27.0	0.389	−7.2	2.493
−71	0.001 67	−26.5	0.409	−7.0	2.537
−70	0.001 94	−26.0	0.430	−6.8	2.581
−69	0.002 25	−25.5	0.453	−6.6	2.626
−68	0.002 61	−25.0	0.476	−6.4	2.672
−67	0.003 02	−24.5	0.500	−6.2	2.718
−66	0.003 49	−24.0	0.526	−6.0	2.765
−65	0.004 03	−23.5	0.552	−5.8	2.813
−64	0.004 64	−23.0	0.580	−5.6	2.862
−63	0.005 34	−22.5	0.609	−5.4	2.912
−62	0.006 14	−22.0	0.640	−5.2	2.962
−61	0.007 03	−21.5	0.672	−5.0	3.013
−60	0.008 08	−21.0	0.705	−4.8	3.065
−59	0.009 25	−20.5	0.740	−4.6	3.117
−58	0.010 6	−20.0	0.776	−4.4	3.171
−57	0.012 1	−19.5	0.814	−4.2	3.225
−56	0.013 8	−19.0	0.854	−4.0	3.280
−55	0.015 7	−18.5	0.895	−3.8	3.336
−54	0.017 8	−18.0	0.939	−3.6	3.393
−53	0.020 3	−17.5	0.984	−3.4	3.451
−52	0.023 0	−17.0	1.031	−3.2	3.509

TABLE 5.4 Vapor Pressure of Ice in Millimeters of Mercury (*Continued*)

t, °C	*p*, mm Hg	*t*, °C	*p*, mm Hg	*t*, °C	*p*, mm Hg
−3.0	3.568	−1.8	3.946	−0.8	4.287
−2.8	3.360	−1.6	4.012	−0.6	4.359
−2.6	3.691	−1.4	4.079	−0.4	4.431
−2.4	3.753	−1.2	4.147	−0.2	4.504
−2.2	3.816	−1.0	4.217	0.0	4.579
−2.0	3.880				

TABLE 5.5 Vapor Pressure of Liquid Ammonia, NH_3

t°C.	*p* in atm	*t*°C.	*p* in atm	*t*°C.	*p* in atm
−78	0.0582	−6	3.3677	66	29.784
−76	0.0683	−4	3.6405	68	31.211
−74	0.0797	−2	3.9303	70	32.687
−72	0.0929	0	4.2380	72	34.227
−70	0.1078	+2	4.5640	74	35.813
−68	0.1246	4	4.9090	76	37.453
−66	0.1437	6	5.2750	78	39.149
−64	0.1651	8	5.6610	80	40.902
−62	0.1891	10	6.0685	82	42.712
−60	0.2161	12	6.4985	84	44.582
−58	0.2461	14	6.9520	86	46.511
−56	0.2796	16	7.4290	88	48.503
−54	0.3167	18	7.9310	90	50.558
−52	0.3578	20	8.4585	92	52.677
−50	0.4034	22	9.0125	94	54.860
−48	0.4536	24	9.5940	96	57.111
−46	0.5087	26	10.2040	98	59.429
−44	0.5693	28	10.8430	100	61.816
−42	0.6357	30	11.512	102	64.274
−40	0.7083	32	12.212	104	66.804
−38	0.7875	34	12.943	106	69.406
−36	0.8738	36	13.708	108	72.084
−34	0.9676	38	14.507	110	74.837
−32	1.0695	40	15.339	112	77.668
−30	1.1799	42	16.209	114	80.578
−28	1.2992	44	17.113	116	83.570
−26	1.4281	46	18.056	118	86.644
−24	1.5671	48	19.038	120	89.802
−22	1.7166	50	20.059	122	93.045
−20	1.8774	52	21.121	124	96.376
−18	2.0499	54	22.224	126	99.796
−16	2.2349	56	23.372	128	103.309
−14	2.4328	58	24.562	130	106.913
−12	2.6443	60	25.797	132	110.613
−10	2.8703	62	27.079	132.3	111.3(c.p.)
−8	3.1112	64	28.407		

TABLE 5.6 Vapor Pressure of Water

For temperatures from −10 to 120°C.

The values in the table are for water in contact with its own vapor. Where the water is in contact with air at a temperature t in degrees Celsius, the following correction must be added: Correction (when $t \leq 40°C$) = $p(0.775 - 0.000\ 313t)/100$; correction (when $t > 50°C$) = $p(0.0652 - 0.000\ 087\ 5t)/100$.

t, °C	p, mm Hg	t, °C	p, mm Hg	t, °C	p, mm Hg	t, °C	p, mm Hg
−10.0	2.149	13.0	11.231	23.4	21.583	32.6	36.891
−9.5	2.236	13.5	11.604	23.6	21.845	32.8	37.308
−9.0	2.326	14.0	11.987	23.8	22.110	33.0	37.729
−8.5	2.418	14.5	12.382	24.0	22.387	33.2	38.155
−8.0	2.514	15.0	12.788	24.2	22.648	33.4	38.584
−7.5	2.613	15.2	12.953	24.4	22.922	33.6	39.018
−7.0	2.715	15.4	13.121	24.6	23.198	33.8	39.457
−6.5	2.822	15.6	13.290	24.8	23.476	34.0	39.898
−6.0	2.931	15.8	13.461	25.0	23.756	34.2	40.344
−5.5	3.046	16.0	13.634	25.2	24.039	34.4	40.796
−5.0	3.163	16.2	13.809	25.4	24.326	34.6	41.251
−4.5	3.284	16.4	13.987	25.6	24.617	34.8	41.710
−4.0	3.410	16.6	14.166	25.8	24.912	35.0	42.175
−3.5	3.540	16.8	13.347	26.0	25.209	35.2	42.644
−3.0	3.673	17.0	14.530	26.2	25.509	35.4	43.117
−2.5	3.813	17.2	14.715	26.4	25.812	35.6	43.595
−2.0	3.956	17.4	14.903	26.6	26.117	35.8	44.078
−1.5	4.105	17.6	15.092	26.8	26.426	36.0	44.563
−1.0	4.258	17.8	15.284	27.0	26.739	36.2	45.054
−0.5	4.416	18.0	15.477	27.2	27.055	36.4	45.549
0.0	4.579	18.2	15.673	27.4	27.374	36.6	46.050
0.5	4.750	18.4	15.871	27.6	27.696	36.8	46.556
1.0	4.926	18.6	16.071	27.8	28.021	37.0	47.067
1.5	5.107	18.8	16.272	28.0	28.349	37.2	47.582
2.0	5.294	19.0	16.477	28.2	28.680	37.4	48.102
2.5	5.486	19.2	16.685	28.4	29.015	37.6	48.627
3.0	5.685	19.4	16.894	28.6	29.354	37.8	49.157
3.5	5.889	19.6	17.105	28.8	29.697	38.0	49.692
4.0	6.101	19.8	17.319	29.0	30.043	38.2	50.231
4.5	6.318	20.0	17.535	29.2	30.392	38.4	50.774
5.0	6.543	20.2	17.753	29.4	30.745	38.6	51.323
5.5	6.775	20.4	17.974	29.6	31.102	38.8	51.879
6.0	7.013	20.6	18.197	29.8	31.461	39.0	52.442
6.5	7.259	20.8	18.422	30.0	31.824	39.2	53.009
7.0	7.513	21.0	18.650	30.2	32.191	39.4	54.580
7.5	7.775	21.2	18.880	30.4	32.561	39.6	54.156
8.0	8.045	21.4	19.113	30.6	32.934	39.8	54.737
8.5	8.323	21.6	19.349	30.8	33.312	40.0	55.324
9.0	8.609	21.8	19.587	31.0	33.695	40.5	56.81
9.5	8.905	22.0	19.827	31.2	34.082	41.0	58.34
10.0	9.209	22.2	20.070	31.4	34.471	41.5	59.90
10.5	9.521	22.4	20.316	31.6	34.864	42.0	61.50
11.0	9.844	22.6	20.565	31.8	35.261	42.5	63.13
11.5	10.176	22.8	20.815	32.0	35.663	43.0	64.80
12.0	10.518	23.0	21.068	32.2	36.068	43.5	66.51
12.5	10.870	23.2	21.324	32.4	36.477	44.0	68.26

TABLE 5.6 Vapor Pressure of Water (*Continued*)

t, °C	*p*, mm Hg	*t*, °C	*p*, mm Hg	*t*, °C	*p*, mm Hg	*t*, °C	*p*, mm Hg
44.5	70.05	63.0	171.38	81.5	377.3	97.0	682.07
45.0	71.88	63.5	175.35	82.0	384.9	97.2	687.04
45.5	73.74	64.0	179.31	82.5	392.8	97.4	692.05
46.0	75.65	64.5	183.43	83.0	400.6	97.6	697.10
46.5	77.61	65.0	187.54	83.5	408.7	97.8	702.17
47.0	79.60	65.5	191.82	84.0	416.8	98.0	707.27
47.5	81.64	66.0	196.09	84.5	425.2	98.2	712.40
48.0	83.71	66.5	200.53	85.0	433.6	98.4	717.56
48.5	85.85	67.0	204.96	85.5	442.3	98.6	722.75
49.0	88.02	67.5	209.57	86.0	450.9	98.8	727.98
49.5	90.24	68.0	214.17	86.5	459.8	99.0	733.24
50.0	92.51	68.5	218.95	87.0	468.7	99.2	738.53
50.5	94.86	69.0	223.73	87.5	477.9	99.4	743.85
51.0	97.20	69.5	228.72	88.0	487.1	99.6	749.20
51.5	99.65	70.0	233.7	88.5	496.6	99.8	754.58
52.0	102.09	70.5	238.8	89.0	506.1	100.0	760.00
52.5	104.65	71.0	243.9	89.5	515.9	101.0	787.57
53.0	107.20	71.5	249.3	90.0	525.76	102.0	815.86
53.5	109.86	72.0	254.6	90.5	535.83	103.0	845.12
54.0	112.51	72.5	260.2	91.0	546.05	104.0	875.06
54.5	115.28	73.0	265.7	91.5	556.44	105.0	906.07
55.0	118.04	73.5	271.5	92.0	566.99	106.0	937.92
55.5	120.92	74.0	277.2	92.5	577.71	107.0	970.60
56.0	123.80	74.5	283.2	93.0	588.60	108.0	1004.42
56.5	126.81	75.0	289.1	93.5	599.66	109.0	1038.92
57.0	129.82	75.5	295.3	94.0	610.90	110.0	1074.56
57.5	132.95	76.0	301.4	94.5	622.31	111.0	1111.20
58.0	136.08	76.5	307.7	95.0	633.90	112.0	1148.74
58.5	139.34	77.0	314.1	95.2	638.59	113.0	1187.42
59.0	142.60	77.5	320.7	95.4	643.30	114.0	1227.25
59.5	145.99	78.0	327.3	95.6	648.05	115.0	1267.98
60.0	149.38	78.5	334.2	95.8	652.82	116.0	1309.94
60.5	152.91	79.0	341.0	96.0	657.62	117.0	1352.95
61.0	156.43	79.5	348.1	96.2	662.45	118.0	1397.18
61.5	160.10	80.0	355.1	96.4	667.31	119.0	1442.63
62.0	163.77	80.5	362.4	96.6	672.20	120.0	1489.14
62.5	167.58	81.0	369.7	96.8	677.12		

TABLE 5.7 Vapor Pressure of Deuterium Oxide

t, °C	*p*, mm Hg	*t*, °C	*p*, mm Hg	*t*, °C	*p*, mm Hg
0	3.65	20	15.2	80	331.6
1	3.93	30	28.0	90	495.5
2	4.29	40	49.3	100	722.2
3	4.65	50	83.6	101.43	760.0
3.8	5.05	60	136.6		
10	7.79	70	216.1		

5.2.1 Vapor-Pressure Equations

Numerous mathematical formulas relating the temperature and pressure of the gas phase in equilibrium with the condensed phase have been proposed. The Antoine equation (Eq. 1) gives good correlation with experimental values. Equation 2 is simpler and is often suitable over restricted temperature ranges. In these equations, and the derived differential coefficients for use in the Haggenmacher and Clausius-Clapeyron equations, the p term is the vapor pressure of the compound in pounds per square inch (psi), the t term is the temperature in degrees Celsius, and the T term is the absolute temperature in kelvins (t°C + 273.15).

Eq.	Vapor-pressure equation	dp/dT	$-[d(\ln p)/d(1/T)]$
1	$\log p = A - \frac{B}{t + C}$	$\frac{2.303pB}{(t + C)^2}$	$\frac{2.303BT^2}{(t + C)^2}$
2	$\log p = A - \frac{B}{T}$	$\frac{2.303pB}{T^2}$	$2.303B$
3	$\log p = A - \frac{B}{T} - C \log T$	$p\left(\frac{2.303B}{T^2} - \frac{C}{T}\right)$	$2.303B - CT$

Equations 1 and 2 are easily rearranged to calculate the temperature of the normal boiling point:

$$t = \frac{B}{A - \log p} - C \tag{5.1}$$

$$T = \frac{B}{A - \log p} \tag{5.2}$$

The constants in the Antoine equation may be estimated by selecting three widely spaced data points and substituting in the following equations in sequence:

$$\left(\frac{y_3 - y_2}{y_2 - y_1}\right)\left(\frac{t_2 - t_1}{t_3 - t_2}\right) = 1 - \left(\frac{t_3 - t_1}{t_3 + C}\right)$$

$$B = \left(\frac{y_3 - y_1}{t_3 - t_1}\right)(t_1 + C)(t_3 + C)$$

$$A = y_2 + \left(\frac{B}{t_2 + C}\right)$$

In these equations, $y_i = \log p_i$.

TABLE 5.8 Vapor Pressures of Various Inorganic Compounds

Substance	State	Eq.	Range, °C	*A*	*B*	*C*
Aluminum						
$AlCl_3$		2	70–190	16.24	6 006	
Al_2O_3		2	1840–2000	14.22	28 200	
Ammonium						
NH_3	c*	1		9.963 82	1 617.907	272.55
	liq	1		7.360 50	926.132	240.17
NH_4Br	subl c	1		9.220 0	3 947	227.0
NH_4Cl	subl c	1		9.355 7	3 703.7	232.0
NH_4I	subl c	1		9.147 0	3 858	226.0
NH_4N_3	c	1		10.433 4	2 821.0	240.0
Antimony						
Sb	c	2	1070–1325	9.051	9 871	
$SbBr_3$		2	235–324	8.005	2 873	
$SbCl_3$		2	170–253	8.090	2 582.3	
SbI_3		2	330–445	7.831	3 350.55	
Sb_2Se_3	subl c	2		8.790 6	6 432.3	
Argon						
Ar	c	1		7.505 81	399.085	272.63
	liq	1		6.616 51	304.227	267.32
Arsenic						
As		2	440–815	10.800	6 947	
		2	800–860	6.692	2 460	
$AsCl_3$		2	50–100	7.953	2 042.7	
As_2O_3		2	100–310	12.127	5 815.81	
		2	315–490	6.513	2 722.2	
Barium						
Ba		2	930–1130	15.765	18 280	
BaH_2 [97% pure]		2	500–1000	6.86	4 000	
Bismuth						
Bi		2	1210–1420	8.876	10 446	
$BiCl_3$		2	91–213	2.681	685.519	
Boron						
BBr_3		2	−40 to 90	7.655	1 740.3	
BCl_3		1		6.188 11	756.89	214.0
$B(CH_3)_3$		2	−118 to −20	7.459 5	1 157.99	
B_2H_6	liq	1		6.366 38	521.490	241.98
B_5H_{11}	liq	2	−43 to 8.4	7.901	1 690.3	
Bromine						
Br_2	c	1		9.7209	2 041.3	260.1
	liq	1		6.877 80	1 119.68	221.38
BrF_3	liq	1		7.729 74	1 673.95	219.48
BrF_5	liq	1		7.273 68	1 219.28	236.40
BrO_2F	liq	1		7.436 51	1 195.8	260.1
Cadmium						
Cd		2	150–321	8.564	5 693	
		2	500–840	7.897	5 218	
CdI_2		2	385–450	9.269	6 383	
Calcium						
Ca		2	500–700	9.697	10 185	
		2	960–1100	16.240	19 325	

* Crystalline solid.

TABLE 5.8 Vapor Pressures of Various Inorganic Compounds (*Continued*)

Substance	State	Eq.	Range, °C	*A*	*B*	*C*
Carbon						
C [as C(g)]	liq	1		11.042 8	37 736	302.2
[as C_2(g)]	liq	1		12.583 2	43 281	318.3
[all species]	liq	1		9.381 3	27 240	264.0
Carbon						
CNBr	subl c	1		9.488 9	2 041.8	251.70
CNF		1	−76 to −47	6.778 9	697.61	224.95
CO	c I	1		7.414 8	342.50	269.0
	liq	1		6.694 22	291.743	267.99
CO_2	c	1		9.810 66	1 347.786	273.00
C_3O_2	liq	1	−71 to 7	7.188 99	1 100.94	249.15
$COCl_2$	liq	1		6.971 33	998.770	236.68
COF_2		1	−109 to −84	6.885 5	576.70	228.58
COS		1	−111 to −49	6.907 23	804.48	250.0
CS_2		1	3–80	6.942 79	1 169.11	241.59
CSe_2		1	0–50	6.776 73	1 353.20	219.95
CSeS		1	−16 to 84	6.699 6	1 161.97	219.59
Cesium						
Cs		2	200–350	6.949	3 833.7	
CsBr		2	978–1305	7.990	8 022.53	
CsCl		2	986–1295	8.340	8 523.94	
CsF		2	1033–1255	7.703	7 359.21	
CsH		2	245–378	11.79	5 900	
		2	340–440	9.25	4 410	
CsI		2	1052–1280	9.124	9 699.11	
Chlorine						
Cl_2	c	1		9.705 12	1 444.19	267.13
	liq	1		6.937 90	861.34	246.33
ClF	liq	1		6.989	682.1	256
ClF_3	liq	1		7.366 85	1 096.28	232.63
ClF_5		1		6.269 33	653.06	206.6
ClO_2	liq	1		6.036 11	590.09	176.15
Cl_2O	liq	1		7.132 68	1 021.56	238.16
$ClOClO_3$	liq	1		7.538 67	1 404.18	257.00
Cl_2O_7	liq	1		6.869 29	1 214.00	220.79
ClO_2F	liq	1		6.677 15	809.78	218.96
ClO_3F	liq	1		6.895 19	791.73	243.88
Copper						
CuBr		2	997–1351	5.460	4 173.2	
CuCl		2	878–1369	5.454	4 215.0	
CuI		2	991–1154	5.570	4 215.0	
Fluorine						
F_2	liq	1		6.765 88	304.35	266.54
FNO_3	liq	1		6.658 6	769.5	248.0
Germanium						
$GeCl_4$		2	10.4–86	7.340	2 010.9	
Helium						
^{3}He	liq	1	−271.13 to −270.86	4.272 7	5.594	273.840
	liq	1	−271.13 to −269.92	5.100 0	11.062	274.950
^{4}He		1	−271.4 to −270.1	4.558 7	8.1548	273.710
		1	−271.4 to −268.9	5.320 75	14.6515	274.950
		1	−271.4 to −268.1	6.004 60	24.0668	276.650

TABLE 5.8 Vapor Pressures of Various Inorganic Compounds (*Continued*)

Substance	State	Eq.	Range, °C	*A*	*B*	*C*
Hydrogen						
$^1H_2$ normal, 25% para	c	1		6.043 86	66.507	274.630
	liq	1		5.824 38	67.5078	275.700
equilibrium	c	1		6.042 07	65.961	274.60
	liq	1		5.814 64	66.7945	275.650
$^1H^2H$ (DH)	c	1		6.960 08	99.968	276.590
	liq	1		6.016 12	77.1349	275.620
$^2H_2$ (D_2) normal,	c	1		7.726 05	135.461	278.550
66.7% ortho	liq	1		6.128 25	83.5251	275.216
$^2H_2$ equilibrium,	c	1		7.751 10	135.58	278.50
97.8% ortho	liq	1		6.044 68	79.5888	274.680
$^3H_2$ (T_2) normal, 25%	c	1		6.184 03	76.7445	271.850
para	liq	1		6.089 21	81.8971	273.650
^{1}HBr	c	1		7.667 61	878.57	253.2
	liq	1		6.287 53	540.82	225.44
^{2}HBr (DBr)	c	1		7.500 93	820.68	247.3
	liq	1		6.162 38	505.68	220.6
^{1}HCl	c	1		8.134 73	941.57	268.06
	liq	1		7.170 00	745.80	258.88
^{2}HCl (DCl)	c	1		7.850 47	843.32	258.32
	liq	1		6.935 96	668.20	249.50
HCN	liq	1	−16 to 46	7.528 2	1329.5	260.4
^{1}HF	liq	1		7.680 98	1475.60	287.88
^{2}HF (DF)	liq	1		7.217 04	1268.37	273.87
^{1}HI	c	1		7.315 6	894.32	239.6
	liq	1		5.608 9	416.04	188.1
^{2}HI (DI)	c	1		7.314 9	889.52	238.8
	liq	1		5.601 8	413.98	187.8
HN_3	liq	1		6.857	1 066	232
HNO_3	liq	1		7.511 9	1 406	221.0
^1H_2O			[See Tables 5.4 and 5.6]			
^2H_2O (D_2O)			[See Table 5.7]			
$H_2{}^{18}O$		1	0–60	8.133 2	1 762.39	235.660
		1	60–120	7.972 08	1 668.84	227.700
H_2O_2	liq	1		7.969 17	1 886.76	220.6
HPO_2F	liq	1		6.735 3	1 342.9	232.0
H_2S	c	1		7.614 18	885.319	250.25
	liq	1		6.993 92	768.130	249.09
H_2S_2	liq	1		6.974	1 232	225
H_2S_3	liq	1		6.807	1 488	209
H_2S_4	liq	1		6.945	1 772	196
H_2S_5	liq	1		7.320	2 104	189
HSO_3Cl	liq	1		7.049	1 480	201
HSO_3F	liq	1		7.399 5	1 521	174.0
H_2Se	c	1		7.635 4	927.6	240.0
	liq	1		6.966 0	787.67	235.0
H_2Te	liq	1		7.000	935	229
Iodine						
I_2	c	1		9.810 9	2 901.0	256.00
	liq	1		7.018 1	1 610.9	205.0
ICl	liq	1		7.702 1	1 517.9	217.0
IF_5	c	1		10.964	2 538	245
	liq	1		7.464 8	1 460	216.0
IF_7	c	1		7.998	1 340	256

TABLE 5.8 Vapor Pressures of Various Inorganic Compounds (*Continued*)

Substance	State	Eq.	Range, °C	*A*	*B*	*C*
Iridium						
IrF_6	c	2	0.4–44	8.618	1 868	
	liq	2	44–54	7.952	1 657	
Iron						
$FeCl_2$	liq	2	708–834	9.794	7 455	
	liq	2	700–930	8.33	7 061	
$FeCl_3$	c	2	160–304	15.11	7 142	
FeI_2		2	517–577	13.183	10 778	
		2	601–686	9.674	7 716	
Krypton						
Kr	c	1		7.539 55	539.48	269.8
	liq	1		6.630 70	416.38	264.45
Lead						
Pb		2	525–1325	7.827	9 845.4	
$PbBr_2$		2	735–918	8.064	6 163.1	
$PbCl_2$		2	500–950	8.961	7 411.4	
PbF_2		2	1078–1289	8.391	8 623.2	
Lithium						
LiBr		2	1010–1265	8.068	7 975.5	
LiCl		2	1045–1325	7.939	8 142.7	
LiF		2	1398–1666	8.753	11 407	
LiH		2	500–650	11.227	9 600	
		2	700–800	9.926	8 204	
LiI		2	940–1140	8.011	7 500	
Magnesium						
Mg		2	900–1070	12.993	13 579.8	
MgH_2		2	337–415	9.78	3 857	
Mercury						
Hg			[See Table 5.3]			
$HgBr_2$		2	130–270	10.094	4 168.0	
$HgCl_2$		2	130–270	10.094	4 118.34	
		2	275–309	8.409	3 187.1	
Hg_2Cl_2		1		8.521 51	3 110.96	168.0
HgI_2		2	266–360	8.115	3 278.5	
Neon						
Ne	c	1		7.065 16	110.61	272.00
	liq	1		6.084 44	78.380	270.550
Neptunium						
NpF_6	liq	3	55.1–76.8	0.010 23	1 191.1	−2.582 5
Nickel						
$Ni(CO)_4$		2	2–40	7.780	1 556.5	
Niobium						
$NbBr_5$	liq	2		8.92	3 850	
$NbCl_5$	liq	2	210–254	8.37	2 827	
NbF_5	liq	2		8.439	2 824	
Nitrogen						
N_2 natural	c	1		7.345 12	322.222	269.980
	liq	1		6.494 57	255.680	266.550
$^{15}N_2$	c	1		7.363 96	323.17	269.88
	liq	1		6.494 14	255.535	266.451
NCl_3		1		6.956	1 190	221
NF_3	liq	1		6.779 66	501.913	257.79
NH_3			[See Table 5.5]			

TABLE 5.8 Vapor Pressures of Various Inorganic Compounds (*Continued*)

Substance	State	Eq.	Range, °C	*A*	*B*	*C*
Nitrogen (*continued*)						
N_2H_4	liq	1		7.801 9	1 679.07	227.7
NO natural	c	1		9.628 26	758.736	266.00
	liq	1		8.743 00	682.938	268.27
N_2O	c	1		9.437 00	1 174.020	268.22
	liq	1		7.003 94	654.260	247.16
N_2O_4 equilibrium	c	1		10.736 31	2 075.53	252.80
mixture	liq	1		8.917 12	1 798.54	276.80
N_2O_5	c	1		11.644 5	2 510	253.0
NOCl	c	1		8.540 8	1 397.3	261.0
	liq	1		7.361 54	1 094.73	249.70
N_2O_3		2	−25 to 0	10.30	2 057.9	
NOF	liq	1		6.443 5	556.13	216.0
NO_2Cl	liq	1		5.372 3	395.40	174.0
NO_2F	liq	1		6.833 4	654.55	238.0
Osmium						
OsF_5		2	75–180	9.75	3 429	
OsF_6		2	34–48	7.470	1 473	
OsF_8		2	38–47	7.650	1 525	
OsO_4		2	−38 to 40	10.710 0	2 951.00	
OsO_3F_2		2	59–105	7.994	1 911	
Oxygen						
O_2	liq	1		6.691 44	319.013	266.697
O_3	liq	1		6.837	552.5	251.0
OF_2	liq	1		7.236 19	545.05	269.91
O_2F_2	liq	1		6.779 02	756.39	250.16
O_3F_2		2	79–114	6.134 3	675.57	
Palladium						
$PdCl_2$		2	680–857	6.32	5 032	
Phosphorus						
P red, V	subl c	1		11.060	5 323	220
white	subl c	1		6.936 9	1 907.6	190.0
P_4 black, o-rh		1		12.405	6 671	247
PBr_3	liq	1	−40 to 173	6.915 5	1 590.5	221.0
PBr_5	liq	1	to 104	6.948	1 320	214
$PBrF_2$	liq	1	−133 to −16	6.904 2	885.12	236.0
PBr_2F	liq	1	−115 to 78	6.858 0	1 210.3	226.0
PCl_3	liq	1	−92 to 76	6.826 7	1 196	227.0
PCl_5	c	1	to 160	10.206 8	2 903.1	237.0
	liq	1		7.033	1 490	200.0
$PClF_2$	liq	1	−165 to −47	6.639 6	780.88	255.0
PCl_2F	liq	1	−144 to 14	6.796 56	982.332	237.00
$P(OCN)_3$	liq	2	−2 to 169	8.745 5	2 595	
PF_3	liq	1	−152 to −101	6.860 4	620.22	257.0
PF_5	liq	1	−93.8 to −84.5	6.914 4	647.21	245.0
PH_3	c	1		7.482 35	794.496	265.20
	liq	1		6.715 59	645.512	256.066
P_2H_4	liq	1		6.862 8	1 137	227.0
P_4O_6	liq	1	24–175	6.716 37	1 412.8	193.0
P_4O_{10}	c III	1		9.707 0	3 822	201.0
	c I	1		10.843 2	6 424	213
	liq	1		6.935 2	3 069	152
$POBr_3$	liq	1	51–192	7.007 8	1 609.2	198.0

TABLE 5.8 Vapor Pressures of Various Inorganic Compounds (*Continued*)

Substance	State	Eq.	Range, °C	*A*	*B*	*C*
Phosphorus (*continued*)						
$POBrCl_2$	liq	1	31–165	6.924	1 411	213
POBrClF	liq	1		6.914	1 214	222
$POBrF_2$	liq	1	−85 to 32	7.101 9	1 118.9	233.0
$POBr_2F$	liq	1	−117 to 110	6.721 2	1 328.9	236.0
$POCl_3$	liq	1	1.2–105	6.865 8	1 297.2	220.0
$POClF_2$	liq	1	−96 to 3	6.926 6	946.96	231.0
$POCl_2F$	liq	1	−80 to 53	7.084 65	1 201.86	233.00
POF_3	c	1		10.930 5	1 783	261.0
	liq	1		7.115 5	810.1	231.0
$PO(OCN)_3$		2	5–193	9.168 2	2 931	
$PO(SCN)_3$		2	14–300	8.533 0	3 240	
P_4S_{10}		2		9.17	4 940	
$PSBr_3$	c	2		10.105	3 196.2	
	liq	2		8.338 3	2 641.9	
$PS(OCN)_3$		2		10.032	3 492	
Platinum						
Pt		2	1425–1765	7.786	25 384	
PtF_6	liq	1	61.3–81.7	89.15	5 686	27.49
Polonium						
Po	liq	1		7.041 4	5 017.6	241.0
$PoCl_4$	liq	1		7.554	2 360	115
Potassium						
K		2	260–760	7.183	4 434.33	
KBr		2	1095–1375	7.936	8 555.3	
KCl		2	1116–1418	8.130	8 863.4	
KF		2	1278–1500	9.000	10 838	
KOH		2	1170–1327	7.330	7 103.3	
KI		2	1063–1333	7.949	8 132.2	
Protactinium	liq	2		17.27	7 377	
Radon						
Rn	c	1		7.495 5	884.41	255.0
	liq	1		6.701 5	718.25	250.0
Rhenium						
ReF_5	c	2		9.024	3 037	
ReF_6	c	3	−3.45 to 18.5	9.123 0	1 765.4	0.1790
	liq	3	18.5–48	18.208 1	1 956.7	3.599
ReF_7	c	3	−14.5 to 48.3	13.043 2	2 205.8	1.470 3
	liq	3	48.3–74.6	−21.583 5	244.28	−9.908 3
ReO_2	c	2	650–785	11.65	14 437	
	liq	2	480–660	5.345	4 742	
ReO_3	c	2	325–420	15.16	10 882	
	liq	2	300–480	7.745	4 966	
Re_2O_7	liq	2	230–360	8.98	3 868	
$ReOF_4$	liq	2	108–172	10.09	3 206	
$ReOF_5$	liq	2	41–73	7.727	1 679	
ReS_2	c	2	500–700	3.214	4 976	
Re_2S_7	c	2	260–410	8.86	4 800	
Rubidium						
Rb		2	250–370	6.976	3 969.5	
RbCl		2	1142–1395	9.111	10 373	
RbF		2	1142–1400	8.570	9 568.4	

TABLE 5.8 Vapor Pressures of Various Inorganic Compounds (*Continued*)

Substance	State	Eq.	Range, °C	*A*	*B*	*C*
Ruthenium						
$RuOF_4$		2	120–160	8.60	2 616	
Selenium						
Se	liq	1		7.631 6	4 213.0	202.0
$SeCl_4$	c	1		10.250 9	3 068.8	225.0
SeF_4	liq	1		7.888 7	1 603.0	215.0
SeF_6	c	1		8.385 4	1 121.4	250.0
SeO_2		1		6.577 81	1 879.81	179.0
$SeOCl_2$	liq	1		6.257 3	970.87	112.0
$SeOF_2$	liq	1		7.420	1 380	178
Silicon						
$SiCl_4$	liq	1	0–53	6.857 26	1 138.92	228.88
SiH_4		2	−160 to −112	6.881	645.9	
Si_2H_6		2	−115 to −14.6	7.258	1 133.4	
Si_3H_8		2	−70 to 52	7.676	1 559.1	
Silver						
AgCl		2	1255–1442	8.179	9 688.7	
Sodium						
Na		2	180–883	7.553	5 395.4	
NaCl		2	976–1155	8.329 7	9 417.07	
NaCI		2	1156–1430	8.548	9 704.3	
NaCN		2	800–1360	7.472	8 122.81	
NaF		2	1562–1701	8.640	11 396.6	
NaI		2	1063–1307	8.371	8 623.2	
NaOH		2	1010–1402	7.030	6 894	
Strontium						
Sr		2	940–1140	16.056	18 802.8	
Sulfur						
S equilibrium	liq	1		6.843 59	2 500.12	186.30
S_2Br_2	liq	1		7.177	1 660	185
SCl_2	liq	1		8.454	1 594	227
S_2Cl_2	liq	1		6.783 6	1 341	206.0
S_2F_2	liq	1		6.684	628	256
SF_4	liq	1		6.839 5	823.4	248.0
SF_6	c	1		8.416 0	1 096.5	262.0
S_2F_{10}	liq	1		7.067 6	1 100.6	234.0
SO_2	c	1		9.754 3	1 553.8	225.0
	liq	1		7.282 28	999.900	237.190
SO_3 “icelike”	c III	1		10.565 7	2 273.8	255.0
“woollike”	c II	1		11.590 1	2 665.6	264.0
	c I	1		14.255 9	3 692.1	273.0
	liq	1		9.050 85	1 735.31	236.50
$SOBr_2$	liq	1		7.056	1 445	206
$SOCl_2$	liq	1		7.287 45	1 446.7	252.7
SOClF	liq	1		7.173 1	1 100.1	244.00
SOF_2	liq	1		6.959 06	775.48	234.00
SOF_4	liq	1		7.071 8	840.3	249.0
$S_2O_2F_{10}$	liq	1		6.874	1 110	229
$S_2O_5Cl_2$	liq	1		7.019	1 460	202
S_2O_5ClF	liq	1		7.015 6	1 257.4	204.0
$S_2O_5F_2$	liq	1		6.881	1 120	229
$S_2O_5F_4$	liq	1		6.885	1 140	227

TABLE 5.8 Vapor Pressures of Various Inorganic Compounds (*Continued*)

Substance	State	Eq.	Range, °C	*A*	*B*	*C*
Sulfur (*continued*)						
SO_2BrF	liq	1		7.142 8	1 155	231.0
SO_2Cl_2	liq	1		7.001 7	1 209	224.0
SO_2ClF	liq	1		6.521 5	793.73	210.70
SO_2F_2	liq	1		6.907 0	784.3	250
Tantalum						
$TaBr_5$	liq	2		8.11	3 260	
$TaCl_5$	liq	2	220–240	8.68	2 970	
TaF_5	liq	2		8.524	2 834	
TaI_5	liq	2		7.67	3 950	
Technetium						
TcF_6	liq	3	37.4–51.7	24.808 7	2 405	5.803 6
TcO_3F	liq	2	18.3–51.8	8.417	2 065	
Tc_2O_7	c	2		18.279	7 205	
	liq	2		8.999	3 571	
Tellurium						
Te	liq	1		7.301 0	5 370.6	221
$TeCl_4$	liq	1		7.558 6	2 355	115
TeF_6	liq	1		6.748 8	807.0	247.0
Te_2F_{10}	liq	1		6.901 8	1 150	227.0
TeO_2		2	450–733	12.328 4	13 222	
Thallium						
Tl		2	950–1200	6.1240	6 268	
TlF		2	282–298	12.52	5 484	
Thorium						
ThF_4	liq	2		10.821	15 270	
ThH_2		2	up to 883	9.50	7 650	
Tin						
$SnCl_4$		2	−52 to −38	9.824	2 441.23	
SnH_4		2	−148 to −49	7.400	999.68	
Titanium						
$TiCl_2$	subl c	2		9.30	8 500	
$TiCl_3$	subl c	2	455–550	10.401	8 296	
$TiCl_4$	liq	2	−23 to 136	7.683	1 964	
TiI_4	liq	2	160–360	7.577	3 054	
Tungsten						
W		2	2230–2770	9.920	46 850	
Uranium						
UF_6	liq	1	64–116	6.994 64	1 126.288	221.963
	liq	1	116–230	7.690 69	1 683.165	302.148
UH_3 dissociation		2	200–430	9.39	4 590	
U^2H_3 (UD_3)		2		9.43	4 500	
U^3H_3 (UT_3)		2		9.46	4 471	
Vanadium						
VBr_2	c	2	541–716	9.08	10 460	
	subl c	2	800–905	5.9	9 830	
VBr_3		2	314–427	11.12	7 470	
VCl_2	subl c	2	910–1100	5.725	9 721	
VCl_3		2	352–567	11.20	9 777	
VCl_4	liq	2	30–153	7.62	2 020	
VF_3	subl c	2	650–920	12.357	15 603	
VF_5	subl c	2	−20 to 19.5	8.168	2 608	
	liq	2	19.5–45.5	7.549	2 423	

TABLE 5.8 Vapor Pressures of Various Inorganic Compounds (*Continued*)

Substance	State	Eq.	Range, °C	*A*	*B*	*C*
Vanadium (*continued*)						
VI_2	subl c	2	850–1016	2.56	5 600	
$VOCl_3$	liq	2	15.4–125	7.69	1 920	
Xenon						
Xe	c	1		7.484 5	714.896	264.0
	liq	1		6.642 89	566.282	258.660
XeF_2	subl c	1		10.019 47	2 683.96	261.68
XeF_4	subl c	1		10.913 87	3 095.06	269.56
Zinc						
Zn	c	2	250–419	9.200	6 946.6	

TABLE 5.9 Vapor Pressures of Various Organic Compounds

Substance	Eq.	Range, °C	*A*	*B*	*C*
Acenaphthene	1	147–187	7.728 19	2 534.234	245.576
	2	147–288	8.033	2 834.99	
Acetaldehyde	1	liq	8.005 52	1 600.017	291.809
Acetic acid	1	liq	7.387 82	1 533.313	222.309
Acetic anhydride	1	liq	7.149 48	1 444.718	199.817
Acetone	1	liq	7.117 14	1 210.595	229.664
Acetonitrile	1	liq	7.119 88	1 314.4	230
Acetophenone	2	30–100	9.135 2	2 878.8	
Acetyl bromide	1	liq	5.197 02	545.784	150.396
Acetyl chloride	1	liq	6.948 87	1 115.954	223.554
Acetylene	1	−130 to −83	9.140 2	1 232.6	280.9
	1	−82 to −72	7.099 9	711.0	253.4
Acetyl iodide	1	liq	4.181 44	355.452	108.160
Acrylic acid	1	20–70	8.538 67	2305.843	266.547
Acrylonitrile	1	−20 to 140	7.038 55	1 232.53	222.47
Allyl isothiocyanate	1	10–50	5.126 58	791.434	154.019
m-Aminobenzotrifluoride	1	0–96	7.651 86	1 940.6	218.0
		96–300	7.170 30	1 650.21	193.58
p-Aminophenol	1	130–185	−3.357 50	699.157	−331.343
Aniline	1	102–185	7.320 10	1 731.515	206.049
Anthracene	2	100–160	8.91	3 761	
	1	176–380	7.674 01	2 819.63	247.02
9,10-Anthracenedione	2	224–286	12.305	5 747.9	
	2	285–370	8.002	3 341.94	
Benzene	1	−12 to 3	9.106 4	1 885.9	244.2
	1	8–103	6.905 65	1 211.033	220.790
Benzenethiol	1	52–198	6.990 19	1 529.454	203.048
Benzoic acid	2	60–110	9.033	3 333.3	
Benzonitrile	1	liq	6.746 31	1 436.72	181.0
Benzophenone	1	48–202	7.349 66	2 331.4	195.0
	1	200–306	7.162 94	2 051.855	173.074
Benzotrifluoride	1	−20 to 180	7.007 08	1 331.30	220.58
Benzoyl chloride	2	140–200	7.924 5	2 372.1	
Benzyl acetate	1	46–156	8.457 05	2 623.206	259.067
Benzyl alcohol	1	122–205	7.198 17	1 632.593	172.790

TABLE 5.9 Vapor Pressures of Various Organic Compounds *(Continued)*

Substance	Eq.	Range, °C	*A*	*B*	*C*
Biphenyl	1	69–271	7.245 41	1 998.725	202.733
2-(2-Biphenylyloxy)ethanol	1	240–300	8.005 87	2 776.761	206.914
Bromobenzene	1	56–154	6.860 64	1 438.817	205.441
2-Bromobenzyl cyanide	1	85–152	5.044 59	734.821	59.273
1-Bromobutane	1	−78 to 23	5.281 38	685.001	160.880
Bromochloromethane	1	16–68	6.496 06	942.267	192.587
Bromochlorodifluoromethane	1	−95 to 10	6.839 98	935.632	240.330
2-Bromo-2-chloro-1,1,1-trifluoro-ethane	1	−51 to 55	6.945 02	1 127.856	227.341
Bromocyclohexane	1	68–260	6.979 80	1 572.19	217.38
p-Bromodiphenyl ether	1	25–190	7.009 3	1 902.7	153.3
	1	190–400	6.681 43	1 683.84	132.90
Bromoethane	1	28–75	6.988 6	1 121.9	234.7
Bromoethene	1	−88 to 16	6.997 4	1 009.9	251.6
2-Bromoethylbenzene	1	127–217	7.800	2 235.4	238.7
4-Bromoethylbenzene	1	liq	6.982 09	1 632.60	193
2-Bromo-2-methylpropane	1	0–72.8	7.395 9	1 512.7	262.2
1-Bromonaphthalene	1	liq	7.003 50	1 927.05	186.0
o-Bromostyrene	1	liq	6.910 38	1 631.2	195
p-Bromostyrene	1		7.228 38	1 743.67	218.0
4-Bromotoluene	1	85–280	7.007 62	1 612.35	206.36
2-Bromovinylbenzene	1	110–129	0.564 97	82.913	−191.71
4-Bromovinylbenzene	1	119–147	12.504 2	7 349.00	559.02
1,2-Butadiene	1	−69 to −34	7.398 22	1 219.877	259.776
	1	−26 to 30	6.993 83	1 041.117	242.274
1,3-Butadiene	1	−80 to −62	7.035 55	998.106	245.233
	1	−58 to 15	6.849 99	930.546	238.854
n-Butane	1	−77 to 19	6.808 96	935.86	238.73
1-Butanethiol	1	−2 to 123	6.927 54	1 281.018	218.100
2-Butanethiol	1	−13 to 110	6.886 98	1 229.904	222.021
1-Butanol	1	15–131	7.476 80	1 362.39	178.77
2-Butanol	1	25–120	7.474 31	1 314.19	186.55
2-Butanone	1	43–88	7.063 56	1 261.34	221.97
1-Butene	1	−82 to 13	6.792 90	908.80	238.54
2-Butene *cis*	1	−73 to 23	6.884 68	967.32	237.87
trans	1	−76 to 20	6.883 37	967.50	240.84
Butyl acetate	1	60–126	7.127 12	1 430.418	210.745
n-Butylamine trimethylboron	1	0–99	8.465 21	1 980.98	193.60
n-Butylbenzene	1	62–213	6.983 17	1 577.965	201.378
sec-Butylbenzene	1	87–174	6.942 19	1 533.95	204.39
t-Butylbenzene	1	84–170	6.922 55	1 505.987	203.490
n-Butyl borate	1	117–218	7.406 87	1 905.035	186.134
n-Butyl-*t*-butyl ether	1	83–124	6.955 56	1 348.702	206.303
Butyl carbitol	1	50–153	7.741 14	2 056.904	195.655
Butyl cellosolve	1	93–170	6.956 59	1 399.903	172.154
sec-Butyl chloroacetate	1	30–172	7.933 38	2 103.30	249.29
n-Butylcyclohexane	1	60–211	6.910 30	1 538.518	200.833
sec-Butylcyclohexane	1	91–180	6.890 96	1 530.70	202.373
t-Butylcyclohexane	1	84–173	6.856 80	1 501.724	206.108
n-Butylcyclopentane	1	41–185	6.899 35	1 457.08	205.99
n-Butyl formate	1	29–112	7.693 6	1 698.7	247.4
sec-Butyl formate	1	30–100	6.493	972.9	176.0
n-Butyl-α-hydroxyisobutyrate	1	112–185	8.421 7	2 617.32	287.09

TABLE 5.9 Vapor Pressures of Various Organic Compounds *(Continued)*

Substance	Eq.	Range, °C	*A*	*B*	*C*
1-*n*-Butylnaphthalene	1	25–170	7.434 47	2 227.7	202.2
	1	170–345	7.081 4	1 971.5	180
2-*n*-Butylnaphthalene	1	25–170	7.438 08	2 242.2	202.3
	1	170–345	7.084 8	1 984.3	180
n-Butyl nitrate	1	0–70	8.054 27	1 992.83	254.30
1-Butyl pentafluoropropionate	1	82–116	6.651 00	1 108.02	177.04
2-*sec*-Butylphenol	1	179–240	6.951 93	1 593.74	163.79
2-*t*-Butylphenol	1	135–225	7.217 56	1 822.81	196.23
4-*t*-Butylphenol	1	198–252	7.000 38	1 627.51	155.24
Butyl phenyl ether	1	119–210	7.299 7	1 882.70	215.82
n-Butyl propionate	1	32–93	9.484 89	2 852.58	296.98
n-Butyl trifluoroacetate	1	71–104	8.567 94	2 305.22	301.06
1-Butyl trimethylsilyl ether	1	71–124	7.763 00	1 884.68	261.31
1-Butyne	1	−68 to 27	6.981 98	988.75	233.01
2-Butyne	1	−51 to −34	7.037 91	896.91	199.06
	1	−31 to 47	7.073 38	1 101.71	235.81
n-Butyraldehyde	1	31–74	6.385 44	913.59	185.48
Butyric acid	1	90–163	7.739 9	1 764.7	199.9
Camphor	2	0–180	8.799	2 797.39	
	1	178–232	6.106	1 043.6	116.4
Capric acid	1	153–187	6.255 3	1 106.3	57.96
Caproic acid	1	98–179	6.924 9	1 340.8	126.6
Capronitrile	1	92–164	7.123 1	1 597.2	212.8
Caprylic acid	1	130–206	7.770 64	1 933.05	159.36
Carbazole	1	253–358	7.086 3	2 179.4	163.5
Carbitol	1	40–151	7.640 81	1 801.31	183.97
Chloroacetic acid	1	104–190	7.550 16	1 723.365	179.98
4-Chloroacetophenone	1	122–212	7.084 57	1 693.63	190.95
Chloroacetyl chloride	1	28–107	7.149 77	1 340.79	208.70
N-Chloroaniline	1	61–125	3.037 67	171.35	−14.99
2-Chloroaniline	1	20–108	7.562 65	1 998.6	220.0
	1	108–300	7.192 40	1 762.74	200.0
3-Chloroaniline	1	15–125	7.559 39	2 073.75	215
	1	125–310	7.236 03	1 857.75	196.64
o-Chloroanisole	1	115–186	7.121 36	1 655.80	188.77
Chlorobenzene	1	62–131.7	6.978 08	1 431.05	217.55
o-Chlorobenzotrichloride	1	30–150	7.504 30	2 228.07	220.0
	1	150–350	7.117 94	1 951.37	196.27
1-Chloro-4-bromobenzene	2	23–63	11.629	3 643.30	
1-Chlorobutane	1	−17 to 78.6	6.836 94	1 173.79	218.13
2-Chlorobutane	1	0–40	6.799 23	1 149.12	224.68
1-Chlorodecane	1	86–225.9	6.939 86	1 639.06	177.94
1-Chlorododecane	1	116–246	6.834 08	1 654.82	155.09
Chloroethane	1	−56 to 12.2	6.986 47	1 030.01	238.61
2-Chloroethylbenzene	1		6.981 69	1 556.0	201.0
3-Chloroethylbenzene	1		6.990 82	1 577.3	200
4-Chloroethylbenzene	1		6.983 09	1 577.0	200
Chloroethylene	1	−65 to −13	6.891 17	905.01	239.48
Chloroform	1	−35 to 61	6.493 4	929.44	196.03
1-Chloroheptane	1	34–160	6.916 70	1 453.96	199.83
1-Chlorohexadecane	1	166–327	7.282 03	2 152.61	162.73
1-Chlorohexane	1	15–136	7.051 36	1 461.72	215.57
Chlorohexylisocyanate	1	90–180	7.740 95	2 340.50	241.90

TABLE 5.9 Vapor Pressures of Various Organic Compounds *(Continued)*

Substance	Eq.	Range, °C	*A*	*B*	*C*
Chloromethane	1	−75 to −5	7.093 49	948.58	249.34
Chloromethoxytrichlorosilane	1	0–50	7.312 92	1 545.71	226.10
2-Chloro-2-methylpropane	1	22–47	4.896	334.99	114.0
1-Chlorononane	1	69–205	7.046 54	1 655.57	192.26
1-Chlorooctane	1	54–184	7.051 52	1 600.24	200.28
Chloropentafluorobenzene	1	36–140	7.068 83	1 389.19	213.75
p-Chlorophenetole	1	122–212	7.084 57	1 693.63	190.95
2-Chlorophenol	1	80–200	6.877 31	1 471.61	193.17
β-Chloro-β-phenylethyl alcohol	1	166–259	6.917 33	1 635.63	145.87
1-Chlorophenylisocyanate	1	50–160	12.265 9	6 532.55	499.59
m-Chlorophenylisocyanate	1	71–158	6.797 29	1 512.43	180.90
Chloroprene	1	20–60	6.161 50	783.45	179.7
1-Chloropropane	1	−25 to 47	6.926 48	1 110.19	227.94
2-Chloropropane	1	0–30	7.771	1 582	288
3-Chloro-1-propene	1	13–44	5.297 16	418.375	128.168
2-Chloropropionitrile	1	0–84	7.329 73	1 732.55	211.79
	1	84–240	7.200 85	1 657.25	205.3
γ-Chloropropyltrichlorosilane	1	87–179	7.156 4	1 679.07	210.38
1-Chlorotetradecane	1	142–296.8	7.200 7	2 018.9	170.6
o-Chlorotoluene	1	0–65	7.367 97	1 735.8	230.0
	1	65–220	6.947 63	1 497.2	209.0
1-Chloro-2,4,6-trinitrobenzene	1	200–270	3.080 9	184.93	−117.9
1-Chloroundecane	1	101–245	6.967 6	1 709.4	172.9
o-Chlorovinylbenzene	1	98–155	6.956 6	1 602.2	204.5
p-Chlorovinylbenzene	1	100–127	9.969 1	4 093.5	392.4
2-Chlorovinyldichloroarsine *cis*	1	68–109	5.487 9	785.09	115.61
trans	1	50–150	6.814 0	1 465.07	178.53
3-Chlorovinyldichloroarsine	1	66–110	2.810 5	97.17	−27.51
o-Cresol	1	120–191	6.911 7	1 435.50	165.16
m-Cresol	1	150–201	7.508 0	1 856.36	199.07
p-Cresol	1	128–202	7.035 08	1 511.08	161.85
Cyanic acid	1	−76 to −6	7.568 59	1 251.86	243.79
Cyclobutane	1	−60 to 12	6.916 31	1 054.54	241.37
Cyclobutanone	1	−24 to 25	6.116 68	933.95	183.19
Cyclobutene	1	−77 to 2	7.305 7	1 166.0	261.06
Cycloheptane	1	68–159	6.853 95	1 331.57	216.35
1,3,5-Cycloheptatriene	1	0–65	6.974 33	1 376.84	220.75
Cyclohexane	1	20–81	6.841 30	1 201.53	222.65
Cyclohexanethiol	1	84–203	6.886 73	1 476.70	209.83
Cyclohexanol	1	94–161	6.255 3	912.87	109.13
Cyclohexene	1		6.886 17	1 229.973	224.10
Cyclohexyl acetate	1	95–172	7.975 86	2 167.99	252.30
Cyclohexylamine	1	61–128	6.689 54	1 229.42	188.80
1-Cyclohexylamino-2-propanol	1	150–238	7.011 56	1 655.02	162.59
Cyclohexylpentafluoropropionate	1	82–155	7.725 5	1 844.73	224.89
Cyclohexyltrifluoroacetate	1	72–147	7.802 35	1 954.66	249.33
Cyclohexyltrimethylsilyl ether	1	91–168	8.090 52	2 276.62	267.94
Cyclooctane	1	97–194	6.861 87	1 437.79	210.02
1,3,5,7-Cyclooctatetraene	1	0–75	7.006 69	1 472.11	215.84
Cyclopentane	1	−40 to 72	6.886 76	1 124.162	231.36
Cyclopentanethiol	1	81–173	6.914 97	1 388.63	212.05
Cyclopentanone	1	0–26	2.902 47	162.90	63.22
Cyclopentene	1		6.920 66	1 121.818	223.45

TABLE 5.9 Vapor Pressures of Various Organic Compounds *(Continued)*

Substance	Eq.	Range, °C	*A*	*B*	*C*
Cyclopentyl-1-thiaethane	1	83–199	6.940 83	1 480.70	208.47
Cyclopropane	1	−90 to −32	6.887 88	856.01	246.50
o-Cymene	1	81–180	7.266 10	1 768.45	224.95
m-Cymene	1	79–176	7.123 74	1 644.95	212.76
p-Cymene	1	107–178	7.050 74	1 608.91	208.72
Decahydronaphthalene *cis*	1	68–228	6.875 29	1 594.460	203.39
trans	1	61–219	6.856 81	1 564.683	206.26
Decane	1	58–203	6.943 65	1 495.17	193.86
1-Decanethiol	1	109–271	6.998 1	1 713.6	177.0
1-Decanol	1	25–52	11.560	4 055	273.2
	1	103–230	6.922 44	1 472.01	133.98
1-Decene	1	54–199	6.934 77	1 484.98	195.707
Decylbenzene	1	203–298	7.035 96	1 903.98	160.33
Decylcyclohexane	1	197–298	7.019 37	1 899.33	161.35
Decylcyclopentane	1	182–279	6.999 12	1 822.05	163.05
Deuterodiborane	1	−155 to −94	6.480 83	545.20	244.73
Diacetone alcohol	1	28–115	8.502 42	2 400.56	263.79
1,3-Diacetylbenzene	1	50–145	0.056 24	64.188	−196.97
1,4-Diacetylbenzene	1	116–157	2.803 71	177.25	−46.43
Diacetylene	1	−78 to 0	4.990 79	356.36	143.22
Diallyl sulfide	1	10–40	4.829 30	643.18	142.34
4,4′-Diaminodiphenylmethane	1	198–272	3.172 31	210.49	−137.41
Diamyl ether	1	105–187	7.067 10	1 604.77	196.58
Dibenzyl ketone	2	285–325	8.257	3 244.42	
1,2-Dibromobenzene	1	20–117	7.501 28	2 093.7	230
	1	117–300	7.102 65	1 825.77	207.0
Dibromodichloroethane	1	25–130	5.197 53	763.44	110.81
Dibromodifluoromethane	1	−26 to 23	7.152 22	1 181.612	253.85
1,2-Dibromoethane	1	52–131	6.721 48	1 280.82	201.75
1,2-Dibromoethylene *cis*	1	26–78	7.038 74	1 349.84	209.26
trans	1	4–71	4.581 11	393.641	103.56
1,2-Dibromopropane	1	0–50	7.303 98	1 644.4	232.0
	1	50–250	6.891 05	1 419.60	212.0
1,3-Dibromopropane	1	0–71	7.549 84	1 890.56	240.0
	1	71–275	7.198 74	1 678.26	222.0
Di-*n*-butyl ether	1	89–140	6.796 3	1 297.29	191.03
Di-*t*-butyl ether	1	4–109	6.932 9	1 348.53	233.79
Di-*n*-butyl phthalate	1	126–202	6.639 80	1 744.20	113.69
Di-*n*-butyl sebacate	1	128–208	7.587 66	2 364.89	147.54
Di-*n*-butyl sulfide	1	10–40	6.769 3	1 208.80	217.51
1,2-Dichlorobenzene	1	131–181	7.143 78	1 704.49	219.42
1,3-Dichlorobenzene	1	91–173	7.040 1	1 607.05	213.38
1,4-Dichlorobenzene	1	95–174	7.020 8	1 590.9	210.2
Dichlorobenzotrichloride	1	20–167	7.439 54	2 190.0	200
	1	167–340	6.985 24	1 868.91	172.00
Dichlorobenzyl chloride	1	20–138	7.504 57	2 125.9	213.8
	1	138–350	7.147 35	1 881.38	192.93
1,1-Dichloroethane	1	−39 to 18	6.977 0	1 174.02	229.06
1,2-Dichloroethane	1	−31 to 99	7.025 3	1 271.3	222.9
1,1-Dichloroethylene	1	−28 to 32	6.972 2	1 099.4	237.2
1,2-Dichloroethylene *cis*	1	0–84	7.022 3	1 205.4	230.6
trans	1	−38 to 85	6.965 1	1 141.9	231.9
2,2′-Dichloroethyl sulfide	1	15–76	8.587 41	2 588.23	246.06

TABLE 5.9 Vapor Pressures of Various Organic Compounds *(Continued)*

Substance	Eq.	Range, °C	*A*	*B*	*C*
1,2-Dichloroethyltrichlorosilane	1	102–181	7.826	2 144.9	253.1
Dichloromethane	1	−40 to 40	7.409 2	1 325.9	252.6
2-(2,4-Dichlorophenoxy)-ethanol	1	212–286	7.240 09	2 004.31	157.25
3,4-Dichlorophenylisocyanate	1	60–190	8.679 3	3 312.3	333.9
1,2-Dichloropropane	1	45–96	6.980 7	1 308.1	222.8
3,4-Dichlorotoluene	1	0–105	7.343 94	1 882.5	215.0
	1	105–330	6.979 25	1 655.44	195.0
Diethanolamine	1	194–241	8.138 8	2 327.9	174.4
1,1-Diethoxyethane	1	0–70	6.757 63	1 191.60	203.12
Diethoxymethane	1	0–75	6.908 41	1 229.52	217.01
Diethylaluminum chloride	1	44–125	8.229 70	2 484.53	255.45
Diethylamine	1	31–61	5.801 6	583.30	144.1
N,*N*-Diethylaniline	1	50–218	7.466 0	1 993.57	218.5
1,2-Diethylbenzene	1	liq	6.987 80	1 576.940	200.51
1,3-Diethylbenzene	1	liq	7.003 60	1 575.310	200.96
1,4-Diethylbenzene	1	liq	6.998 20	1 588.310	201.97
Diethyldichlorosilane	1	48–128	6.862 9	1 346.3	207.7
Diethyl disulfide	1	15–61	7.349 89	1 695.00	227.29
	1	61–230	6.975 07	1 485.970	208.96
Diethylene glycol	1	130–243	7.636 7	1 939.4	162.7
Diethyl ether	1	−61 to 20	6.920 32	1 064.07	228.80
Diethyl ethylphosphate	1	76–134	4.101 6	315.17	15.50
N,*N*-Diethylformamide	1	30–90	6.395 4	1 203.8	165.6
Diethyl ketone	1		6.857 91	1 216.3	204
3,3-Diethylpentane	1	63–147	6.896 03	1 453.48	215.83
3,5-Diethylphenol	1	114–248	7.651 3	2 228	218.5
Diethylpropylphosphonate	1	87–134	4.558 1	446.50	26.17
Diethyl sulfide	1	0–150	6.928 36	1 257.83	218.66
1,2-*bis*-Difluoroamino-4-methyl-pentane	1	−20 to 20	8.009 11	1 944.92	245.44
Difluoromethane	1	−82 to −32	7.138 9	821.7	244.7
1,2-Dihydroxybenzene	1	118–246	7.577	2 054	187
1,3-Dihydroxybenzene	1	151–276	7.889	2 231	169
1,2-Diiodoethylene *cis*	1	29–152	5.522	797.8	106.4
trans	1	77–130	6.093 1	1 197.0	172.3
Diisoamyl sulfide	1	10–80	−1.959 8	390.61	−219.33
p-Diisopropylbenzene	1	120–211	6.993 3	1 663.88	194.41
Diisopropyl ether	1	23–67	6.849 5	1 139.34	218.7
2,4-Diisopropylphenol	1	122–255	6.714	1 506	138
1,2-Dimethoxyethane	1	0–60	6.718 9	1 050.5	209.2
N,*N*-Dimethylacetamide	1	30–90	9.720 9	3 273.8	334.5
Dimethylamine	1	−72 to 6.9	7.082 12	960.242	221.67
bis-Dimethylaminoborane	1	−25 to 62.5	5.584 52	774.371	170.64
N-Dimethylaminodiborane	1	−38 to 14	8.340 1	1 917.35	302.73
bis-Dimethylaminodifluorosilane	1	24–88	5.952	748.7	146.9
N,*N*-Dimethylaniline	1	71–197	7.367 7	1 857.08	220.36
Dimethyl beryllium	1	100–180	19.089 9	11 535.45	496.64
1,4-Dimethyl-bicyclo(2,2,1)-heptane	1	56–119	6.761 96	1 342.66	213.53
2,3-Dimethyl-bicyclo(2,2,1)-heptane *trans*	1	72–138	6.868 15	1 420.32	212.94
2,3-Dimethyl-1,3-butadiene	1	0–68.5	7.119 7	1 299.69	238.09
2,2-Dimethylbutane	1	−42 to 73	6.754 83	1 081.176	229.34

TABLE 5.9 Vapor Pressures of Various Organic Compounds *(Continued)*

Substance	Eq.	Range, °C	*A*	*B*	*C*
2,3-Dimethylbutane	1	−35 to 81	6.809 83	1 127.187	228.90
2,3-Dimethyl-2-butanethiol	1	56–167	6.839 56	1 354.24	215.96
2,3-Dimethyl-1-butene	1	−36 to 78	6.862 36	1 134.675	229.37
2,3-Dimethyl-2-butene	1	−21 to 97	6.950 58	1 215.428	225.44
3,3-Dimethyl-1-butene	1	−47 to 64	6.677 51	1 010.516	224.91
Dimethyl cadmium	1	−2 to 23	6.490 55	1 126.36	201.07
1,1-Dimethylcyclohexane	1	10–147	6.798 21	1 321.705	217.85
1,2-Dimethylcyclohexane *cis*	1	18–158	6.837 46	1 367.311	215.84
trans	1	13–151	6.833 08	1 353.881	219.13
1,3-Dimethylcyclohexane *cis*	1	11–147	6.838 83	1 338.473	218.07
trans	1	15–152	6.834 55	1 343.687	215.39
1,4-Dimethylcyclohexane *cis*	1	15–152	6.832 87	1 345.613	216.15
trans	1	10–147	6.817 73	1 330.437	218.58
1,1-Dimethylcyclopentane	1	−12 to 113	6.817 24	1 219.474	221.95
1,2-Dimethylcyclopentane *cis*	1	−3 to 125	6.850 08	1 269.140	220.21
trans	1	−9 to 117	6.844 22	1 242.748	221.69
1,3-Dimethylcyclopentane *cis*	1	−10–116	6.837 15	1 237.456	222.01
trans	1	−9 to 117	6.838 17	1 240.023	221.62
Dimethyldichlorosilane	1	28–72	7.062 1	1 280.29	235.65
1,2-Dimethyldisilane	1	−46 to 0	4.024 3	255.4	129.2
Dimethyl ether	1	−71 to −25	6.976 03	889.264	241.96
N,*N*-Dimethylformamide	1	30–90	6.928 0	1 400.87	196.43
2,2-Dimethylhexane	1		6.837 15	1 273.59	215.07
2,3-Dimethylhexane	1		6.870 04	1 315.50	214.16
2,4-Dimethylhexane	1		6.853 05	1 287.88	214.79
2,5-Dimethylhexane	1		6.859 84	1 287.27	214.41
3,3-Dimethylhexane	1		6.851 21	1 307.88	217.44
3,4-Dimethylhexane	1		6.879 86	1 330.04	214.86
1,1-Dimethylhydrazine	1	−35 to 20	7.408 13	1 305.91	225.53
1,2-Dimethylhydrazine	1	1–25	5.611 9	633.59	143.17
N,*N*-Dimethylhydroxylamine	1	17–90	7.565 8	1 415.96	201.93
O,*N*-Dimethylhydroxylamine	1	−45 to 42.2	7.405 4	1 245.58	233.06
Dimethylmalononitrile	1	49–140	7.035 5	1 546.99	202.00
1,3-Dimethylnaphthalene	1	20–148	7.634 7	2 295.4	232.4
	1	148–310	7.269 8	2 076.0	210
1,4-Dimethylnaphthalene	1	20–148	7.634 7	2 345.8	232.6
(same for 1,6- and 1,7-)	1	148–310	7.269 8	2 076.0	210
1,8-Dimethylnaphthalene	1	25–150	7.407 89	2 123.2	201.2
	1	150–320	7.056 4	1 879	180
2,3-Dimethylnaphthalene	1	20–155	7.403 96	2 111.9	201.1
	1	155–315	7.052 7	1 869	180
2,6-Dimethylnaphthalene	1	20–150	7.396 8	2 080.3	200.8
	1	150–310	7.046 0	1 841	180
2,7-Dimethylnaphthalene	1	25–150	7.398 75	2 085.9	200.9
	1	150–310	7.047 8	1 846	180
2,2-Dimethylpentane	1	−19 to 103	6.814 80	1 190.033	223.30
2,3-Dimethylpentane	1	−10 to 115	6.853 82	1 238.017	221.82
2,4-Dimethylpentane	1	−17 to 105	6.826 21	1 192.04	225.32
3,3-Dimethylpentane	1	−14 to 112	6.826 67	1 228.663	225.32
2,4-Dimethyl-3-pentanone	1	48–125	6.968 53	1 382.84	213.06
Dimethyl-*o*-phthalate	1	82–151	4.522 32	700.31	51.42
2,2-Dimethylpropane	1	−14 to 29	6.604 27	883.42	227.78
2,2-Dimethyl-1-propanol	1	55–115	7.875 3	1 604.7	208.2

TABLE 5.9 Vapor Pressures of Various Organic Compounds *(Continued)*

Substance	Eq.	Range, °C	*A*	*B*	*C*
2,5-Dimethylpyrrole	1	100–199	7.203 06	1 509.60	181.76
2,4-Dimethylquinoline	1	185–269	7.025 4	1 830.29	174.44
2,6-Dimethylquinoline	1	188–267	6.931 12	1 748.73	166.37
Dimethyl sulfide	1	−22 to 20	7.150 9	1 195.58	242.68
3,3-Dimethyl-2-thiabutane	1	liq	6.847 09	1 259.648	218.69
2,2-Dimethyl-3-thiapentane	1	liq	6.850 86	1 323.24	212.89
2,4-Dimethyl-3-thiapentane	1	liq	6.871 18	1 327.12	212.55
2,3-Dimethylthiophene	1	50–205	6.924 9	1 430.0	212
2,4-Dimethylthiophene	1	50–205	6.993 9	1 450.7	212.0
2,5-Dimethylthiophene	1	47–200	6.961 1	1 427.7	213.2
3,4-Dimethylthiophene	1	54–205	6.996 1	1 467.1	211.5
1,3-Dinitrobenzene	1	252–292	4.337	229.2	−137
2,4-Dinitrotoluene	1	200–299	5.798	1 118	61.8
2,6-Dinitrotoluene	1	150–260	4.372	380	−43.6
3,5-Dinitrotoluene	1	220–270	1.556	30.59	−302
1,4-Dioxane	1	20–105	7.431 55	1 554.68	240.34
Dipentene	1	21–170	7.111 6	1 613.42	207.8
2,2′-Diphenol	1	171–325	8.193 5	3 067.6	253.1
Diphenyldichlorosilane	1	192–281	6.999 03	1 918.20	161.41
Diphenyl ether	1	204–271	7.011 04	1 799.71	177.74
Diphenylmethane	1	217–282	6.291	1 261	105
Di-*n*-propyl ether	1	26–89	6.947 6	1 256.5	219.0
Disilanyl chloride	1	−46 to 18	7.104 8	1 211.8	245.2
2,3-Dithiabutane	1	6–135	6.977 92	1 346.342	218.86
5,6-Dithiadecane	1	101–263	6.963 8	1 684.1	181.3
3,4-Dithiahexane	1	40–182	6.975 07	1 485.970	208.96
4,5-Dithiaoctane	1	72–226	6.975 29	1 603.793	195.85
Dodecane	1	91–247	6.997 95	1 639.27	181.84
1-Dodecanethiol	1		7.024 4	1 817.8	164.1
Dodecanoic acid	1	106–176	7.860 8	2 159.1	143.2
1-Dodecanol	1	138–214	7.539 86	2 003.29	168.13
1-Dodecene	1	89–244	6.976 07	1 621.11	182.45
Durenol	1	108–249	7.758	2 432	250
Eicosane	1	198–379	7.152 2	2 032.7	132.1
1-Eicosanethiol	1		7.114	2 125	119
1-Eicosene	1	liq	7.135 1	2 043.0	137.9
Ethane	1	−142 to −75	6.829 15	663.72	256.68
Ethanethiol	1	−49 to 56	6.952 06	1 084.531	231.39
Ethanol	1	−2 to 100	8.321 09	1 718.10	237.52
Ethanolamine	1	65–171	7.456 8	1 577.67	173.37
Ethyl acetate	1	15–76	7.101 79	1 244.95	217.88
m-Ethylacetophenone	1	19–143	3.767 2	708.05	182.6
p-Ethylacetophenone	1	21–94	4.274 6	629.34	120.9
Ethylamine	1	−20 to 90	7.054 13	987.31	220.0
N-Ethylaniline	1	50–207	7.422 8	1 903.4	214.3
Ethylbenzene	1	26–164	6.957 19	1 424.255	213.21
2-Ethyl-1-butene	1	−28 to 88	6.997 12	1 218.352	231.30
Ethyl butyl ether	1	38–92	6.944 4	1 256.4	216.9
Ethyl chloroacetate	1	25–146	6.967	1 355.9	188.2
p-Ethylchlorobenzene	1	109–184	6.951 1	1 557.1	198.1
Ethylcyclohexane	1	20–160	6.867 28	1 382.466	214.99
Ethylcyclopentane	1	−0.1 to 129	6.887 09	1 298.599	220.68
Ethylene	1	−153 to −91	6.744 19	594.99	256.16

TABLE 5.9 Vapor Pressures of Various Organic Compounds *(Continued)*

Substance	Eq.	Range, °C	*A*	*B*	*C*
Ethylene glycol	1	50–200	8.090 8	2 088.9	203.5
Ethylene glycol monoethyl ether	1	63–134	7.874 6	1 843.5	234.2
Ethylene glycol monomethyl ether	1	56–124	7.849 8	1 793.9	236.9
Ethylene oxide	1	−49 to 12	7.128 43	1 054.54	237.76
Ethyl formate	1	4–54	7.009 0	1 123.94	218.2
3-Ethylhexane	1		6.890 98	1 327.88	212.60
2-Ethyl-1-hexanol	1	74–184	6.914 7	1 339.7	147.8
2-Ethyl-2-hexenal	1	54–175	6.861 3	1 457.4	190.6
Ethyl iodoacetate	1	29–89	4.073 7	374.64	54.8
Ethyl isothiocyanate	1	10–50	7.106 0	1 567.5	234.2
Ethyl methyl ether	1	5–7.7	5.518	434.5	158
Ethyl methyl ketone	1		6.974 21	1 209.6	216
3-Ethyl-5-methylphenol	1	195–247	7.040 83	1 615.44	152.6
2-Ethyl-4-methyl-1-pentanol	1	70–176	6.582 6	1 134.6	129.2
Ethyl nitrate	1	0–60	7.163 7	1 338.8	224.9
3-Ethylpentane	1	−7 to 119	6.875 64	1 251.827	219.89
2-Ethylphenol	1	86–208	7.800 3	2 140.4	227
3-Ethylphenol	1	97–218	7.468	1 856	187
4-Ethylphenol	1	101–218	8.291	2 423	229
Ethyl phenyl ether	1	117–181	7.021 38	1 508.39	194.49
Ethyl *n*-propanoate	1	34–98	6.994 9	1 260.6	207.4
Ethyl *n*-propyl ether	1	20–63	6.985 1	1 188.5	226.4
Ethyl *n*-propyl ketone	1	75–133	7.000 82	1 365.79	208.01
m-Ethylstyrene	1		7.039 28	1 614.0	198
p-Ethylstyrene	1		6.900 71	1 570.9	198
Ethyl trichloroacetate	1	44–95	7.725 4	1 927.0	233.7
Ethyl trichlorosilane	1	28–96	6.606	1 118	201
Ethyl triexthoxysilane	1	64–153	6.886 8	1 377.9	183.0
Ethyl vinyldichlorosilane	1	45–122	6.859	1 331	210.8
Fenchyl alcohol	1	59–200	5.693	797.6	84.6
Fluoranthene	1	197–384	6.373	1 756	118
Fluorene	1	161–300	7.761 8	2 637.1	243.2
Fluorobenzene	1	−18 to 84	7.187 0	1 381.8	235.6
m-Fluorobenzotrifluoride	1	40–137	7.006 59	1 304.35	215.67
bis-(Fluorocarbonyl)-peroxide	1	−47 to −7	9.608 4	2 247.64	319.83
p-Fluorotoluene	1	68–155	6.994 26	1 374.055	217.40
Formaldehyde	1	−109 to −22	7.195 8	970.6	244.1
Formic acid	1	37–101	7.581 8	1 699.2	260.7
Formyl fluoride	1	−95 to −61	5.270	362	175
Furan	1	2–61	6.975 27	1 060.87	227.74
2-Furfuraldehyde	1	56–161	6.575 9	1 198.7	162.8
Glycerol	1	183–260	6.165	1 036	28
Glyceryl-1,3-diacetate	1	100–190	6.407 3	1 092.0	119.3
Guaiacol	1	82–205	6.161	1 051	116
Hemellitenol	1	123–248	6.972	1 563	134
Heptadecane	1	161–337	7.014 3	1 865.1	149.20
1-Heptadecene	1		7.008 67	1 868.9	152.50
Heptane	1	−2 to 124	6.896 77	1 264.90	216.54
1-Heptanethiol	1	58–206	6.952 49	1 525.311	197.70
Heptanoic acid	1	112–150	5.287 4	665.54	42.07
1-Heptanol	1	60–176	6.647 67	1 140.64	126.56
1-Heptene	1	−6 to 118	6.901 87	1 258.345	219.30
Hexadecane	1	149–321	7.028 67	1 830.51	154.45

TABLE 5.9 Vapor Pressures of Various Organic Compounds *(Continued)*

Substance	Eq.	Range, °C	*A*	*B*	*C*
1-Hexadecanethiol	1		7.075	1 990	140
1-Hexadecanol	1	50–103	7.281 7	1 909.7	128.1
	1	145–190	6.158 6	1 380.0	91
1-Hexadecene	1		7.040 11	1 840.52	157.57
1,5-Hexadiene	1	0–59	6.574 1	1 013.5	214.8
Hexafluoroacetone	1	−79 to −27	6.650 2	725.90	219.9
Hexafluorobenzene	1	5–114	7.032 95	1 227.98	215.49
Hexafluorodisiloxane	1	−39 to −23	7.471 2	1 169.3	278.1
Hexafluoroethane	1	−93 to −78	6.793 35	657.06	246.2
Hexahydroindane *cis*	1	77–168	6.868 22	1 497.33	207.67
trans	1	71–161	6.861 19	1 475.70	209.66
Hexamethyldisiloxane	1	36–138	6.773 79	1 202.03	208.25
Hexane	1	−25 to 92	6.876 01	1 171.17	224.41
1-Hexanethiol	1	40–181	6.946 64	1 454.004	204.95
1-Hexanol	1	35–157	7.860 45	1 761.26	196.66
2-Hexanol	1	25–142	7.261 0	1 371.7	173.2
3-Hexanol	1	25–138	7.689	1 670.0	211.8
1-Hexene	1	16–64	6.857 70	1 148.62	225.35
3-Hexyne	1	−20 to 24	5.895	863.3	194
Hydroquinone	1	159–286	8.137	2 461	183
3-Hydroxy-3-methyl-2-butanone	1	45–146	7.340 9	1 653.6	227.5
Iodobenzene	1	20–188	7.011 9	1 640.1	208.8
Iodoethane	1	30–60	6.959	1 232	229
Isoamyl acetate	1	41–95	7.436	1 606.6	216
Isobutylbenzene	1	86–174	6.935 56	1 530.05	204.59
Isobutyl borate	1	99–200	7.197	1 745.8	193
Isobutyl cellosolve	1	71–159	7.694 8	1 825.9	219.6
Isobutylcyclohexane	1	85–172	6.867 97	1 493.10	203.16
Isobutyl nitrate	1	0–70	8.164 3	2 022.7	262.4
Isobutyraldehyde	1	13–63	6.735 1	1 053.2	209.1
Isobutyric acid	1	58–152	4.894	382.6	38
Isocaproic acid	1	96–133	6.258	1 038.6	130
Isopropylbenzene	1	39–181	6.936 66	1 460.793	207.78
Isopropyl borate	1	65–139	8.070	2 120	269
o-Isopropylbromobenzene	1	132–210	6.717 8	1 462.7	170.9
Isopropyl caprate	1	90–178	9.959	4 013.9	326.5
Isopropyl caprylate	1	65–146	8.032 2	2 213.6	220.9
Isopropyl cellosolve	1	67–140	7.500 0	1 639.2	213.3
Isopropyl chloroacetate	1	35–153	8.382	2 328	275
Isopropylcyclohexane	1	71–155	6.873 14	1 453.20	209.44
Isopropylcyclopentane	1	47–127	6.887 36	1 380.12	218.05
Isopropyl laurate	1	117–196	8.532 6	2 951.6	240.7
Isopropyl myristate	1	140–193	10.418 0	4 866.48	314.17
Isopropyl nitrate	1	0–70	7.266 6	1 434.4	255.2
Isopropyl palmitate	1	160–197	10.916 4	5 572.0	364.8
o-Isopropylphenol	1	97–215	8.167	2 343	229
p-Isopropylphenol	1	108–228	8.666	2 810	258
Isopropyl phenyl ether	1	72–175	6.517 6	1 238.0	163.0
Isopropyl stearate	1	182–207	0.079 3	10.41	−221
Isopseudocumenol	1	106–233	5.602	768	49
Isoquinoline	1	167–244	6.912 2	1 723.4	184.3
Isovaleric acid	1	86–104	3.946 55	255.41	11.3
Ketene	1	−88 to −49	7.615	1 036	269

TABLE 5.9 Vapor Pressures of Various Organic Compounds *(Continued)*

Substance	Eq.	Range, °C	*A*	*B*	*C*
Lauric acid	1	106–176	7.860 8	2 159.1	143.2
Lepidine	1	199–266	7.271 2	1 946.14	177.64
2,3-Lutidine	1	155–162	7.447 8	1 832.6	240.1
2,4-Lutidine	1	150–160	7.339 0	1 733.4	230.4
2,5-Lutidine	1	85–157	7.081 0	1 539.6	209.6
2,6-Lutidine	1	79–144	7.056 7	1 470.2	208.0
3,4-Lutidine	1	172–180	7.362 0	1 840.1	231.5
3,5-Lutidine	1	163–173	7.333 1	1 783.6	228.7
Mesitol	1	94–221	6.659	1 392	148
Mesityl oxide	1	14–130	6.635 8	1 186.1	186.0
Methacrylonitrile	1		6.980 2	1 274.96	220.7
Methane c	1	−195 to −183	7.193 09	451.64	268.49
liq	1	−181 to −152	6.695 61	405.42	267.78
Methanol	1	−14 to 65	7.897 50	1 474.08	229.13
	1	64–110	7.973 28	1 515.14	232.85
Methoxybenzene	1	110–164	7.052 69	1 489.99	203.57
N-Methylacetamide	1	40–90	2.631 1	121.7	−9.3
Methyl acetate	1	1–56	7.065 2	1 157.63	219.73
Methylal	1	0–35	6.872 2	1 049.2	220.6
Methylamine	1	−83 to −6	7.336 9	1 011.5	233.3
N-Methylaniline	1	50–200	7.081 9	1 631.3	192.4
Methyl benzoate	1	111–199	7.273	1 847	221
Methyl borate	1	31–68	7.646 0	1 491.5	245.5
Methyl boric anhydride	1	0–55	8.004 1	1 726.1	257.9
2-Methyl-1,3-butadiene	1	−52 to −24	7.011 87	1 126.159	238.88
	1	−19 to 55	6.885 64	1 071.578	233.51
3-Methyl-1,2-butadiene	1	−45 to −20	7.151 95	1 194.537	239.47
	1	−20 to 62	6.943 50	1 103.901	230.89
2-Methylbutane	1	−57 to 49	6.833 15	1 040.73	235.45
2-Methyl-1-butanethiol	1	liq	6.913 85	1 347.317	215.07
3-Methyl-1-butanethiol	1	liq	6.914 91	1 342.509	214.45
2-Methyl-2-butanethiol	1	liq	6.828 37	1 254.885	218.76
2-Methyl-1-butanol	1	34–129	7.067 30	1 195.26	156.83
3-Methyl-1-butanol	1	25–153	7.258 21	1 314.36	169.36
2-Methyl-2-butanol	1	25–102	6.519 3	863.4	135.3
3-Methyl-2-butanol	1	25–111	6.942 1	1 090.9	157.2
2-Methyl-1-butene	1	−53 to 52	6.846 37	1 039.69	236.65
3-Methyl-1-butene	1	−63 to 41	6.824 55	1 012.37	236.65
2-Methyl-2-butene	1	−48 to 60	6.966 59	1 124.33	236.63
Methyl butyl ether	1	23–69	6.887 1	1 162.1	219.9
3-Methyl-1-butyne	1	−55 to 47	6.884 80	1 014.81	227.11
2-Methyl-3-butyn-2-ol	1	21–106	6.657 5	976.5	154.1
Methyl *n*-butyrate	1		6.972 11	1 272.73	208.5
Methyl caprate	1	107–188	7.190 0	1 783.8	181.6
Methyl caproate	1	44–105	7.409 3	1 672.74	218.98
Methyl caprylate	1	100–146	6.916 5	1 496.3	176.5
Methyl carbitol	1	112–193	7.424	1 751	192
Methyl cellosolve acetate	1	70–144	7.125 1	1 447.0	196.1
Methyl chloroacetate	1	45–130	7.004 4	1 306.3	187.3
Methylcyclohexane	1	−3 to 127	6.823 00	1 270.763	221.42
Methylcyclopentane	1	−24 to 96	6.862 83	1 186.059	226.04
Methyldichlorosilane	1	1–41	7.027 8	1 167.8	240.7
1-Methyl-2-ethylbenzene	1	48–194	7.003 14	1 535.374	207.30

TABLE 5.9 Vapor Pressures of Various Organic Compounds *(Continued)*

Substance	Eq.	Range, °C	*A*	*B*	*C*
1-Methyl-3-ethylbenzene	1	46–190	7.015 82	1 529.184	208.51
1-Methyl-4-ethylbenzene	1	46–191	6.998 02	1 527.113	208.92
1-Methyl-1-ethylcyclopentane	1	43–122	6.859 20	1 347.602	217.21
1-Methyl-2-ethylcyclopentane *cis*	1	49–129	6.905 88	1 388.412	216.89
2-Methyl-3-ethylpentane	1		6.867 31	1 318.12	215.31
3-Methyl-3-ethylpentane	1		6.867 31	1 347	219.68
3-Methyl-5-ethylphenol	1	111–233	7.958	2 236	208
2-Methyl-5-ethylpyridine	1	52–177	5.050	517	59
N-Methylformamide	1	96–200	7.497 4	1 849.4	201.1
Methyl formate	1	21–32	3.027	3.02	−11.9
2-Methylheptane	1	42–119	6.917 35	1 337.47	213.69
3-Methylheptane	1	43–120	6.899 44	1 331.53	212.41
4-Methylheptane	1		6.900 65	1 327.66	212.57
2-Methylhexane	1	−9 to 115	6.873 18	1 236.026	219.55
3-Methylhexane	1	−8 to 117	6.867 64	1 240.196	219.22
Methylhydrazine	1	2–25	6.576 2	1 007.5	181.4
N-Methylhydroxylamine	1	40–65	7.045 6	1 223.3	172.1
O-Methylhydroxylamine	1	−63 to 48	7.363 9	1 225.3	225.2
Methyl isobutyl ketone	1	22–116	6.672 7	1 168.4	191.9
1-Methyl-2-isopropylbenzene	1	liq	6.940 4	1 548.05	203.15
1-Methyl-3-isopropylbenzene	1	liq	6.940 5	1 539.05	203.93
1-Methyl-4-isopropylbenzene	1	liq	6.923 7	1 537.06	203.05
3-Methylisoquinoline	1	176–225	6.969 2	1 717.3	166.9
Methyl isothiocyanate	1	10–50	2.896 8	103.6	45.4
Methyl laurate	1	158–212	6.767 1	1 589.72	140.5
Methyl linolate	1	166–206	6.111 1	1 660.1	118.8
Methyl methacrylate	1	39–89	8.409 2	2 050.5	274.4
Methyl myristate	1	166–238	7.622 3	2 283.93	184.8
1-Methylnaphthalene	1	108–278	7.035 92	1 826.948	195.00
2-Methylnaphthalene	1	105–274	7.068 50	1 840.268	198.40
Methyl oleate	1	166–205	7.544 1	2 656.9	200.7
Methyl palmitate	1	148–202	9.594 4	4 146.43	297.76
2-Methylpentane	1	−32 to 83	6.839 10	1 135.410	226.57
3-Methylpentane	1	−30 to 87	6.848 87	1 152.368	227.13
2-Methyl-2-pentanethiol	1	56–165	6.858 5	1 343.79	212.8
2-Methyl-1-pentanol	1	25–150	7.520 1	1 564.7	189.2
2-Methyl-4-pentanol	1	25–133	8.467 1	2 174.9	257.8
2-Methyl-1-pentene	1	−30 to 85	6.850 30	1 138.516	224.70
3-Methyl-1-pentene	1	−38 to 77	6.755 23	1 086.316	226.20
4-Methyl-1-pentene	1	−38 to 77	6.835 29	1 121.302	229.687
2-Methyl-2-pentene	1	−26 to 90	6.923 67	1 183.837	225.51
3-Methyl-2-pentene *cis*	1	−26 to 91	6.910 73	1 186.402	226.70
trans	1	−23 to 94	6.926 34	1 194.527	224.83
4-Methyl-2-pentene *cis*	1	−35 to 79	6.841 29	1 120.707	226.59
trans	1	−33 to 81	6.880 30	1 142.874	227.14
Methyl phenyl ether	1	110–164	7.052 69	1 489.99	203.57
2-Methylpiperidine	1	51–158	6.818 59	1 274.61	205.40
2-Methylpropane	1	−87 to 7	6.910 48	946.35	246.68
2-Methyl-1-propanethiol	1	−10 to 113	6.887 46	1 237.282	220.31
2-Methyl-2-propanethiol	1	1–88	6.787 81	1 115.565	221.31
2-Methyl-1-propanol	1	20–115	7.327 05	1 248.48	172.92
2-Methyl-2-propanol	1	26–83	9.170 6	2 206.4	267.9
2-Methylpropene	1	−82 to 12	6.684 66	866.25	234.64

TABLE 5.9 Vapor Pressures of Various Organic Compounds *(Continued)*

Substance	Eq.	Range, °C	*A*	*B*	*C*
N-Methylpropionamide	1	30–90	−0.9103	119.4	−148.0
Methyl propionate	1	21–79	6.942 4	1 170.2	208.8
2-Methyl-2-propylamine	1	19–75	6.783 2	993.33	210.50
Methyl propyl ether	1	0–39	6.118 6	708.69	179.9
2-Methylpyridine	1	80–168	7.032 4	1 415.73	211.63
3-Methylpyridine	1	74–185	7.050 21	1 481.78	211.25
4-Methylpyridine	1	75–186	7.041 77	1 480.68	210.50
1-Methylpyrrole	1	49–149	7.085 0	1 368.66	212.80
6-Methylquinoline	1	187–266	6.927 2	1 746.08	166.46
7-Methylquinoline	1	238–258	7.597 7	2 229.4	214.9
Methyl salicylate	1	79–220	7.083 3	1 712.8	187.1
Methyl stearate	1	204–240	2.357 0	68.92	−156.5
o-Methylstyrene	1	32–112	7.212 9	1 664.08	214.59
	1	75–255	6.884 61	1 485.41	200.0
m-Methylstyrene	1	10–72	7.275 34	1 695.4	220.0
	1	72–250	6.879 28	1 471.44	200.0
p-Methylstyrene	1	68–170	7.011 2	1 535.1	200.7
α-Methylstyrene	1		6.923 66	1 486.88	202.4
β-Methylstyrene	1		6.923 39	1 499.80	201.0
Methyl sulfoxide	1	20–50	7.763 7	2 048.7	231.6
3-Methyl-2-thiabutane	1	−13 to 109	6.901 96	1 232.170	221.67
2-Methylthiacyclopentane	1	liq	6.944 12	1 409.503	214.41
3-Methylthiacyclopentane	1	67–179	6.949 1	1 431.8	213.6
2-Methyl-3-thiapentane	1	liq	6.891 30	1 293.05	215.04
Methyl-2-thiazole	1	80–128	7.042 1	1 407.05	209.33
2-Methylthiophene	1	9–138	6.938 97	1 326.48	214.31
3-Methylthiophene	1	11–141	6.986 11	1 363.83	216.78
Methyl trichlorosilane	1	13–64	7.088 2	1 289.2	239.9
2-Methyl-5-vinylpyridine	1	69–183	6.156	1 023	129
Morpholine	1	0–44	7.718 13	1 745.8	235.0
	1	44–170	7.160 30	1 447.70	210.0
Naphthalene c	1	86–250	7.010 65	1 733.71	201.86
liq	1	125–218	6.818 1	1 585.86	184.82
1-Naphthol	1	141–282	7.284 21	2 077.56	184.0
2-Naphthol	1	144–288	7.347 14	2 135.00	183.0
Nicotine	1	134–246	6.789	1 650	176
o-Nitroaniline	2	150–260	8.868 4	3 336.50	
m-Nitroaniline	2	170–260	8.818 8	3 440.9	
p-Nitroaniline	2	190–260	9.559 5	4 039.73	
Nitrobenzene	1	134–211	7.115 6	1 746.6	201.8
m-Nitrobenzotrifluoride	1	10–105	7.653 15	2 006.1	220.0
	1	104–280	7.180 25	1 710.60	195.12
Nitromethane	1	56–136	7.281 66	1 446.94	227.60
1-Nitropropane	1	59–131	7.114 6	1 467.45	215.23
o-Nitrotoluene	1	129–222	5.851	946	96
p-Nitrotoluene	1	148–233	6.994 8	1 720.39	184.9
Nonadecane	1	184–366	7.015 3	1 932.8	137.6
1-Nonadecene	1	liq	7.115 1	1 997.4	142.7
Nonafluorocyclopentane	1	17–75	6.945 3	1 051.7	220.1
Nonane	1	39–179	6.938 93	1 431.82	202.01
1-Nonanethiol	1	93–251	6.983 9	1 655.6	183.7
Nonanoic acid	1	137–177	3.235 9	143.97	−75.6
1-Nonanol	1	94–214	7.827 8	1 953.8	181.9

TABLE 5.9 Vapor Pressures of Various Organic Compounds *(Continued)*

Substance	Eq.	Range, °C	*A*	*B*	*C*
1-Nonene	1	35–175	6.954 30	1 436.20	205.69
Octadecane	1	172–352	7.002 2	1 894.3	143.30
1-Octadecanethiol	1	liq	7.096	2 061	129
1-Octadecanol	1	120–218	6.461 6	1 599	90
1-Octadecene	1		7.060 65	1 997.4	147.50
Octane	1	19–152	6.918 68	1 351.99	209.15
1-Octanethiol	1	76–229	6.969 09	1 593.0	190.61
1-Octanol	1	0–80	12.070 1	4 506.8	319.9
	1	70–195	6.837 90	1 310.62	136.05
2-Octanol	1	72–180	6.388 8	1 060.4	122.5
3-Octanol	1	76–176	5.221 5	560.3	64.7
4-Octanol	1	71–176	5.739 6	760.5	89.5
1-Octene	1	15–147	6.934 95	1 355.46	213.05
5-Oxyhydrindene	1	120–251	9.213 7	3 665.8	326.4
Pentachloroethane	1	25–162	6.740	1 378	197
Pentadecane	1	136–304	7.023 59	1 789.95	161.38
1-Pentadecene	1		7.022 91	1 788.58	163.347
1,2-Pentadiene	1	−42 to −26	7.259 90	1 250.293	241.96
	1	−21 to 67	6.918 20	1 104.991	228.85
1,3-Pentadiene *cis*	1	−43 to −22	7.193 87	1 223.602	240.62
	1	−18 to 66	6.910 89	1 101.923	229.37
trans	1	−45 to −20	7.102 12	1 185.389	239.41
	1	−18 to 64	6.913 17	1 103.840	231.72
1,4-Pentadiene	1	−57 to −37	7.174 01	1 155.378	244.30
	1	−33 to 47	6.835 43	1 017.995	231.46
2,3-Pentadiene	1	−39 to −18	7.202 53	1 231.768	237.56
	1	−14 to 70	6.962 16	1 126.837	227.84
Pentafluorobenzene	1	49–94	7.036 65	1 254.07	216.02
Pentafluorochloroacetone	1	−40 to 32	6.848 4	925.3	225.4
Pentafluorochlorethane	1	−95 to −39	6.833 34	802.97	242.27
Pentafluorophenol	1	105–155	7.066 0	1 379.15	183.91
2,2,3,3,3-Pentafluoropropanol	1	0–23	6.308 7	830.56	153.8
Pentafluorotoluene	1	39–138	7.084 78	1 392.20	213.67
bis-Pentamethyldisilanoxydisilane	1	169–201	8.556 64	3 051.316	258.85
bis-Pentamethyldisilanyl ether	1	88–183	8.161 44	2 575.250	273.32
Pentane	1	−50 to 58	6.852 96	1 064.84	233.01
Pentanenitrile	1	69–141	7.104 9	1 519.4	218.4
1-Pentanethiol	1	19–153	6.933 11	1 369.479	211.31
Pentanoic acid	1	72–174	5.412	591	60
1-Pentanol	1	37–138	7.177 58	1 314.56	168.11
2-Pentanol	1	25–120	7.275 75	1 271.92	170.37
3-Pentanol	1	21–116	7.414 93	1 354.42	183.41
2-Pentanone	1	56–111	7.021 93	1 313.85	215.01
3-Pentanone	1	56–111	7.025 29	1 310.28	214.19
1-Pentene	1	−55 to 51	6.844 24	1 044.01	233.50
2-Pentene *cis*	1	−49 to 58	6.843 08	1 052.44	228.69
trans	1	−49 to 58	6.899 83	1 080.76	232.57
1-Pentyne	1	−44 to 61	6.967 34	1 092.52	227.18
2-Pentyne	1	−33 to 78	7.046 14	1 189.87	229.60
Perdeuterobenzene	1	10–82	6.892 35	1 198.39	219.43
Perdeuterocyclohexane	1	10–80	6.837 86	1 190.38	222.40
Perfluorobutane	1	−39 to −4	7.035 1	990.27	240.4
Perfluorobutene	1	−28 to 20	9.222	2 401.6	382

TABLE 5.9 Vapor Pressures of Various Organic Compounds *(Continued)*

Substance	Eq.	Range, °C	*A*	*B*	*C*
Perfluorocyclobutane	1	−32 to 0	6.815 29	862.49	225.19
Perfluorocyclohexane	1	19–65	6.04	597	136
Perfluorocyclopentane	1	17–56	7.039 6	1 069.3	234.6
Perfluoroheptane	1	−2 to 106	6.937 72	1 181.14	208.66
Perfluorohexane	1	30–57	6.875 2	1 080.8	213.4
Perfluoromethylcyclohexane	1	33–111	6.824 06	1 133.76	211.22
Perfluorooctane	1	37–105	5.902 5	1 225.93	198.99
Perfluoropentane	1	9–65	7.017 9	1 072.9	230.0
Perfluoropiperidine	1	29–81	6.853 4	1 059.95	217.2
Perfluoropropane	1	−79 to −36	6.919 4	825.8	241.2
Perfluoropropene	1	−41 to 20	7.355	1 012.1	257
Phenanthrene	1	176–379	7.260 82	2 379.04	203.76
Phenol	1	107–182	7.133 0	1 516.79	174.95
β-Phenylethyl acetate	1	149–233	6.834 3	1 555.2	160.8
α-Phenylethyl alcohol	1	82–190	1.508	91	−263
o-Phenylethylphenol	1	169–250	4.506 0	516.8	−32.1
p-Phenylethylphenol	1	174–251	4.304 1	459.3	−52.4
Phenylisocyanate	1	10–80	−0.708 0	106.4	−146.6
4-Phenylphenol	1	177–308	8.657 5	3 022.8	216.1
Phosgene	1	−68 to 68	6.842 97	941.25	230
Phthalic anhydride	2	160–285	8.022	2 868.5	
α-Pinene	1	19–156	6.852 5	1 446.4	208.0
β-Pinene	1	19–166	6.898 4	1 511.7	210.2
Piperidine	1	42–144	6.855 69	1 238.80	205.43
Propadiene	1	−99 to −16	5.713 7	458.06	196.07
Propane	1	−108 to −25	6.803 38	804.00	247.04
1-Propanethiol	1	−25 to 91	6.928 46	1 183.307	224.62
2-Propanethiol	1	−37 to 75	6.877 34	1 113.895	226.16
1-Propanol	1	2–120	7.847 67	1 499.21	204.64
2-Propanol	1	0–101	8.117 78	1 580.92	219.61
2-Propen-1-ol	1	21–97	11.187 0	4 068.5	392.7
Propionic acid	1	56–139.5	6.403	950.2	130.3
Propionic anhydride	1	67–167	5.819 5	810.3	108.7
Propionitrile	1	−84 to 22	5.278 2	665.52	159.10
Propiophenone	1	132–201	7.370	1 894	205
Propyl acetate	1	39–101	7.016 15	1 282.28	208.60
1-Propylamine	1	23–77	6.926 51	1 044.05	210.84
2-Propylamine	1	4–61	6.890 25	985.69	214.07
n-Propylbenzene	1	43–188	6.951 42	1 491.297	207.14
n-Propyl borate	1	85–179	7.399 8	1 741	206
n-Propyl caprate	1	97–186	8.701 22	2 945.99	253.63
n-Propyl caproate	1	43–120	8.667 1	2 556.0	262.9
n-Propyl caprylate	1	70–153	8.516 7	2 599.5	246.2
n-Propyl cellosolve	1	77–149	7.146 4	1 440.6	187.7
n-Propylcyclohexane	1	40–186	6.886 46	1 460.800	207.94
n-Propylcyclopentane	1	21–158	6.903 92	1 384.386	213.16
Propylene	1	−112 to −32	6.778 11	770.85	245.51
1,2-Propylene oxide	1	−35 to 130	7.064 92	1 113.6	232
n-Propyl formate	1	26–82	6.848	1 127	203
n-Propyl laurate	1	124–205	8.068 9	2 692.4	222.5
n-Propyl myristate	1	147–200	9.216 8	3 744.68	272.87
n-Propyl nitrate	1	0–70	6.954 9	1 294.4	206.7
n-Propyl palmitate	1	166–204	14.129 2	9 759.2	539.7

TABLE 5.9 Vapor Pressures of Various Organic Compounds *(Continued)*

Substance	Eq.	Range, °C	*A*	*B*	*C*
o-(*n*-Propyl)phenol	1	104–222	9.215	3 254	292
p-(*n*-Propyl)phenol	1	0–234	8.329 6	2 661	254
n-Propyl phenyl ether	1	101–190	7.734 3	2 146.2	252.3
Propyne	1	−90 to −6	6.784 85	803.73	229.08
Pseudocumenol	1	107–232	6.915	1 547	152
Pyrene	1	200–395	5.618 4	1 122.0	15.2
Pyridine	1	67–153	7.041 15	1 373.80	214.98
Pyrogallol	1	177–309	6.092	1 031	12
Pyrrole	1	66–166	7.294 70	1 501.56	210.42
Quinaldine	1	178–248	7.179 00	1 857.84	184.50
Quinoline	1	164–238	6.817 59	1 668.73	186.26
Spiropentane	1	3–71	6.917 00	1 090.08	231.10
Styrene	1	32–82	7.140 16	1 574.51	224.09
Terpenyl acetate	1	37–150	6.443 46	1 377.27	143.85
α-Terpineol	1	84–217	8.141 2	2 479.4	253.7
Terpinolene	1	40–179	7.169	1 706	211
Tetrabutyl tin	1	100–300	6.545	1 649	148
1,1,2,2-Tetrachloro-1,2-difluoro-ethane	1	10–91.5	10.995	4 437.1	455.2
1,1,1,2-Tetrachloroethane	1	59–130	6.898 75	1 365.88	209.74
1,1,2,2-Tetrachloroethane	1	25–130	6.631 7	1 228.1	179.9
Tetrachloroethylene	1	37–120	6.976 83	1 386.92	217.53
Tetrachloromethane	1		6.879 26	1 212.021	226.41
Tetradecane	1	122–286	7.013 00	1 740.88	167.72
1-Tetradecanethiol	1		7.048 5	1 909.2	151.9
1-Tetradecanol	1	130–264	6.674 1	1 204.5	54.0
1-Tetradecene	1	119–283	7.030 65	1 754.09	171.52
1,2,3,4-Tetrafluorobenzene	1	6–50	7.084 6	1 339.23	223.49
1,2,3,5-Tetrafluorobenzene	1	6–50	6.986 17	1 245.20	218.35
Tetrafluoroethylene	1	−131 to −65	6.896 59	683.84	245.93
Tetrafluoromethane	1		6.972 31	540.50	260.10
Tetrahydrofuran	1	23–100	6.995 15	1 202.29	226.25
Tetraiodothiophene	1	−65 to 24	5.585 44	871.25	175.59
Tetralin	1	94–206	7.070 55	1 741.30	208.26
1,2,3,4-Tetramethylbenzene	1	80–217	7.059 4	1 690.54	199.48
1,2,3,5-Tetramethylbenzene	1	75–228	7.077 9	1 675.43	201.14
1,2,4,5-Tetramethylbenzene	1	74–227	7.080 0	1 672.43	201.43
2,2,3,3-Tetramethylbutane	1	0–65	6.876 65	1 329.93	226.36
Tetramethyl lead	1	0–60	6.937 7	1 335.3	219.1
2,2,3,3-Tetramethylpentane	1	57–141	6.830 60	1 398.67	213.84
2,2,3,4-Tetramethylpentane	1	52–134	6.834 18	1 375.59	214.94
2,2,4,4-Tetramethylpentane	1	43–123	6.796 20	1 324.59	216.02
Tetramethylsilane	1	−64 to 21	6.822 39	1 033.72	235.62
2-Thiabutane	1	−26 to 90	6.938 49	1 182.562	224.78
Thiacyclobutane	1	−5 to 120	7.016 67	1 321.331	224.51
Thiacyclohexane	1	29–170	6.905 18	1 422.47	211.72
Thiacyclopentane	1	14–148	6.995 40	1 401.939	219.61
Thiacyclopropane	1	−35 to 77	7.037 25	1 194.37	232.42
3-Thiaheptane	1	33–172	6.941 02	1 421.32	205.81
4-Thiaheptane	1	32–170	6.935 77	1 413.44	205.73
2-Thiahexane	1	17–150	6.945 83	1 363.808	212.07
3-Thiahexane	1	14–144	6.933 80	1 341.57	212.51

TABLE 5.9 Vapor Pressures of Various Organic Compounds *(Continued)*

Substance	Eq.	Range, °C	*A*	*B*	*C*
2-Thiapentane	1	−4 to 120	6.955 45	1 284.32	219.66
3-Thiapentane	1	−13 to 109	6.928 36	1 257.833	218.66
2-Thiapropane	1	−47 to 58	6.948 79	1 090.755	230.80
Thiazole	1	63–118	7.142 01	1 425.35	216.26
Thiophene	1	−12 to 108	6.959 26	1 246.02	221.35
Toluene	1	6–137	6.954 64	1 344.800	219.48
o-Toluidine	1	118–200	7.082 03	1 627.72	187.13
m-Toluidine	1	122–203	7.093 67	1 631.43	183.91
p-Toluidine	1		7.260 22	1 758.55	201.0
m-Tolyl pentafluoropropionate	1	98–174	7.427 20	1 707.59	201.70
p-Tolyl pentafluoropropionate	1	99–176	8.078 6	2 223.8	252.1
m-Tolyl trifluoroacetate	1	91–166	7.681 0	1 874.84	223.48
p-Tolyl trifluoroacetate	1	92–169	7.913 8	2 055.41	238.99
Tribromomethane	1	30–101	6.821 8	1 376.7	201.0
1,2,3-Tribromopropane	1	128–205	7.037 2	1 735.32	195.42
Trichloroacetic acid	1	112–198	7.273 0	1 594.3	165.4
Trichloroacetonitrile	1	17–83	7.183 5	1 368.3	232.5
Trichloroacetyl chloride	1	32–119	6.990 75	1 390.47	220.11
1,1,1-Trichloroethane	1	−6 to 17	8.643 4	2 136.6	302.8
1,1,2-Trichloroethane	1	50–114	6.951 85	1 314.41	209.20
Trichloroethylene	1	18–86	6.518 3	1 018.6	192.7
Trichlorofluoromethane	1		6.884 28	1 043.004	236.88
Trichlorosilane	1	2–32	6.773 9	1 009.0	227.2
bis-Trichlorosilylethane	1	91–160	7.835 11	2 241.769	249.84
1,1,1-Trichloro-2,2,2-trifluoro-ethane	1	14–36	4.437 3	204.1	83.9
1,1,2-Trichloro-1,2,2-trifluoro-ethane	1	−25 to 83	6.880 3	1 099.9	227.5
Tridecane	1	107–267	7.007 56	1 690.67	174.22
1-Tridecene	1	105–264	6.981 02	1 672.00	174.95
Triethanolamine	1	252–305	10.067 5	4 542.78	297.76
Triethyl aluminum	1	57–126	11.646 1	4 466.59	322.87
Triethylamine	1	50–95	5.858 8	695.7	144.8
Triethyl borate	1	29–109	7.511 1	1 641.7	236.3
Triethylsilanol	1	24–140	7.793 7	1 756.1	202.4
Trifluoroacetic acid	1	12–72	8.389	1 895	273
Trifluoroacetic anhydride	1	−2 to 39	6.135 8	1 026.1	202.0
Trifluoroacetonitrile	1	−132 to −68	7.127 6	773.82	249.9
1,3,5-Trifluorobenzene	1	6–50	6.919 8	1 197.13	219.12
Trifluorochloroethylene	1	−67 to −11	6.896 16	848.33	293.64
1,1,1-Trifluoroethane	1	−110 to −48	6.903 78	788.20	243.23
2,2,2-Trifluoroethanol	1	−0.5 to 25	6.788 2	978.13	173.06
Trifluoromethane	1	−128 to −82	7.088 6	705.33	249.78
bis-(Trifluoromethyl)-acetoxyphos-phine	1	0–40	7.391 31	1 426.254	220.37
2,2,2-Trifluoro-1-methylbenzene	1	55–139	6.970 45	1 306.35	217.38
bis-(Trifluoromethyl)-chlorophos-phine	1	−80 to 0	7.661 06	1 386.652	267.14
Trifluoromethylhypofluorite	1	145–189	6.950 6	650.1	−18.4
bis-(Trifluoromethyl)-iodophos-phine	1	0–47	6.901 39	1 180.723	222.95
Triisobutylene	1	56–179	7.002 1	1 613.47	212.5

TABLE 5.9 Vapor Pressures of Various Organic Compounds *(Continued)*

Substance	Eq.	Range, °C	*A*	*B*	*C*
Trimethyl aluminum	1	64–127	7.570 29	1 734.72	242.78
Trimethylamine	1	−80 to 3	6.857 55	955.94	237.52
1,2,3-Trimethylbenzene	1	57–205	7.040 82	1 593.958	207.08
1,2,4-Trimethylbenzene	1	52–198	7.043 83	1 573.257	208.56
1,3,5-Trimethylbenzene	1	49–193	7.074 36	1 569.622	209.58
2,2,3-Trimethylbutane	1	−19 to 106	6.792 30	1 200.563	226.05
Trimethylchlorosilane	1	2–55	7.055 8	1 245.5	240.7
1,1,3-Trimethylcyclohexane	1	55–137	6.839 51	1 394.88	215.73
1,1,2-Trimethylcyclopentane	1	36–115	6.822 38	1 309.81	218.58
1,1,3-Trimethylcyclopentane	1	29–106	6.809 31	1 275.92	219.89
1,2,4-Trimethylcyclopentane					
cis, cis, trans	1	39–118	6.857 38	1 335.69	219.16
cis, trans, cis	1	33–110	6.851 3	1 307.10	219.92
1,3,5-Trimethyl-2-ethylbenzene	1	88–210	6.790 8	1 505.8	174.7
1,4,5-Trimethyl-2-ethylbenzene	1	87–132	3.029 3	116.4	−34.6
2,2,5-Trimethylhexane	1	46–125	6.837 75	1 325.54	210.91
2,4,4-Trimethylhexane	1	51–131	6.856 54	1 371.81	214.40
Trimethylhydrazine	1	−16 to 14	7.106 80	1 189.88	222.06
O,N,N-Trimethylhydroxylamine	1	−79 to 23	6.765 8	979.55	222.2
2,2,3-Trimethylpentane	1		6.825 46	1 294.88	218.42
2,2,4-Trimethylpentane	1	24–100	6.811 89	1 257.84	220.74
2,3,3-Trimethylpentane	1		6.843 53	1 328.05	220.38
2,3,4-Trimethylpentane	1	36–114	6.853 96	1 315.08	217.53
2,4,4-Trimethyl-1-pentene	1	−3 to 128	6.834 57	1 273.416	220.62
2,4,4-Trimethyl-2-pentene	1	2–131	6.859 22	1 272.717	214.99
2,3,5-Trimethylphenol	1	186–247	7.080 12	1 685.90	166.14
Trimethylsilanol	1	18–85	8.126 6	1 657.6	219.2
2,4,5-Trimethylstyrene	1	79–216	7.331 5	1 880.7	205.7
2,4,6-Trimethylstyrene	1	90–208	7.089 1	1 702.61	195.93
1,2,4-Trinitrobenzene	1	250–300	3.194	87	−199
1,3,5-Trinitrobenzene	1	202–312	5.534 5	993.6	11.2
2,4,6-Trinitrobenzene	1	249–342	9.621 1	4 987.9	329.9
2,4,6-Trinitrotoluene	1	230–250	7.671 52	2 669.4	205.6
α-Trioxane	1	56–114	7.818 6	1 783.3	247.1
Trivinylarsine	1	22–66	7.894 1	2 115.6	293.9
Trivinyl bismuth	1	20–74	7.237 2	1 667.0	215.1
Trivinylphosphine	1	16–61	7.928 4	2 102.0	301.3
Trivinylstibine	1	20–70	8.322 1	2 446.3	303.8
Undecane	1	75–226	6.972 20	1 569.57	187.70
1-Undecanethiol	1		7.012 2	1 767.4	170.4
1-Undecene	1	72–222	6.966 77	1 563.21	189.87
Urethane	1		7.421 64	1 758.21	205.0
Vinyl acetate	1	22–72	7.210 1	1 296.13	226.66
o-Xylene	1	32–172	6.998 91	1 474.679	213.69
m-Xylene	1	28–166	7.009 08	1 462.266	215.11
p-Xylene	1	27–166	6.990 52	1 453.430	215.31
2,3-Xylenol	1	149–218	7.053 97	1 617.57	170.74
2,4-Xylenol	1	144–212	7.055 39	1 587.46	169.34
2,5-Xylenol	1	144–212	7.051 56	1 592.70	170.74
2,6-Xylenol	1	145–204	7.070 70	1 628.32	187.60
3,4-Xylenol	1	172–229	7.079 19	1 621.45	159.26
3,5-Xylenol	1	155–223	7.130 76	1 639.86	164.16

5.3 BOILING POINTS

TABLE 5.10 Boiling Points of Water

A. Barometric Pressures at Various Temperatures

Temp. °C.	0.0°	0.2°	0.4°	0.6°	0.8°
	mm of Hg	mm of Hg	mm of Hg	mm of Hg	mm of Hg
80	355.40	358.28	361.19	364.11	367.06
81	370.03	373.01	376.02	379.05	382.09
82	385.16	388.25	391.36	394.49	397.64
83	400.81	404.00	407.22	410.45	413.71
84	416.99	420.29	423.61	426.95	430.32
85	433.71	437.12	440.55	444.01	447.49
86	450.99	454.51	458.06	461.63	465.22
87	468.84	472.48	476.14	479.83	483.54
88	487.28	491.04	494.82	498.63	502.46
89	506.32	510.20	514.11	518.04	521.99
90	525.97	529.98	534.01	538.07	542.15
91	546.26	550.40	554.56	558.75	562.96
92	567.20	571.47	575.76	580.08	584.43
93	588.80	593.20	597.63	602.09	606.57
94	611.08	615.62	620.19	624.79	629.41
95	634.06	638.74	643.45	648.19	652.96
96	657.75	662.58	667.43	672.32	677.23
97	682.18	687.15	692.15	697.19	702.25
98	707.35	712.47	717.63	722.81	728.03
99	733.28	738.56	743.87	749.22	754.59
100	760.00	765.44	770.91	776.42	781.95

B. Boiling Points of Water at Various Pressures

Pressure, atm.	Boiling Point, °C.	Pressure, atm.	Boiling Point, °C.	Pressure, atm.	Boiling Point, °C.	Pressure, atm.	Boiling Point, °C.
0.5	80.9	7	164.2	14	194.1	21	213.9
1	100.0	8	169.6	15	197.4	22	216.2
2	119.6	9	174.5	16	200.4	23	218.5
3	132.9	10	179.0	17	203.4	24	220.8
4	142.9	11	183.2	18	206.1	25	222.9
5	151.1	12	187.1	19	208.8	26	225.0
6	158.1	13	190.7	20	211.4	27	227.0

TABLE 5.11 Binary Azeotropic (Constant-Boiling) Mixtures

An azeotrope is a mixture that cannot be separated by distillation.

A. Binary azeotropes containing water

System	BP of azeotrope, °C	Composition, wt %	
		Water	Other component
Inorganic acids			
Hydrogen bromide	126	52.5	47.5
Hydrogen chloride	108.58	79.78	20.22
Hydrogen fluoride	111.35	64.4	35.6
Hydrogen iodide	127	43	57
Hydrogen peroxide	zeotrope		
Nitric acid	120.7	32.6	67.4
Perchloric acid	203	28.4	71.6
Organic acids			
Formic acid	107.2	22.6	77.4
Acetic acid	zeotrope		
Propionic acid	99.9	82.3	17.7
Isobutyric acid	99.3	79	21
Butyric acid	99.4	81.6	18.4
Pentanoic acid	99.8	89	11
Isopentanoic acid	99.5	81.6	18.4
Perfluorobutyric acid	97	71	29
Crotonic acid	99.9	97.8	2.2
Alcohols			
Ethanol	78.17	4	96
Allyl alcohol	88.9	27.7	72.3
1-Propanol	71.7	71.7	28.3
2-Propanol	80.3	12.6	87.4
1-Butanol	92.7	42.5	57.5
2-Butanol	87.0	26.8	73.2
2-Methyl-2-propanol	79.9	11.7	88.3
1-Pentanol	95.8	54.4	45.6
2-Pentanol	91.7	36.5	63.5
3-Pentanol	91.7	36.0	64.0
2,2-Dimethyl-2-propanol	87.35	27.5	72.5
1-Hexanol	97.8	67.2	32.8
1-Octanol	99.4	90	10
Cyclopentanol	96.25	58	42
1-Heptanol	98.7	83	17
Phenol	99.52	90.8	9.2
2-Methoxyphenol	99.5	87.5	12.5
1-Phenylphenol	99.95	98.75	1.25
Benzyl alcohol	99.9	91	9
2,3-Dimethyl-2,3-butanediol	zeotrope		
Furfuryl alcohol	98.5	80	20

TABLE 5.11 Binary Azeotropic (Constant-Boiling) Mixtures (*Continued*)

System	BP of azeotrope, °C	Composition, wt %	
		Water	Other component
Aldehydes			
Propionaldehyde	47.5	2	98
Butyraldehyde	68	6	94
Pentanal	83	19	81
Paraldehyde	90	28.5	71.5
Furaldehyde	97.5	65	35
Amines			
N-Methylbutylamine	82.7	15	85
Furfurylamine	99	74	26
Piperidine	92.8	35	65
Pyridine	93.6	41.3	58.7
2-Methylpyridine	93.5	48	52
3-Methylpyridine	97	60	40
4-Methylpyridine	97.35	62.8	37.2
2,6-Dimethylpyridine	96.02	51.8	48.2
Dibutylamine	97	50.5	49.5
Dihexylamine	99.8	92.8	7.2
Triallylamine	95	38	62
Tributylamine	99.65	79.7	20.3
Aniline	98.6	80.8	19.2
N-Ethylaniline	99.2	83.9	16.1
1-Methyl-2-(2-pyridyl)pyrrolidine	99.85	97.5	2.5
Halogenated hydrocarbons			
Chloroform	56.1	2.8	97.2
Carbon tetrachloride	42.6	2.8	97.2
Trichloroethylene	73.4	17	83
Tetrachloroethylene	88.5	17.2	82.8
1,2-Dichloroethane	72	8.3	91.7
1-Chloropropane	44	2.2	97.8
1,2-Dichloropropane	78	12	88
Chlorobenzene	90.2	28.4	71.6
Esters			
Ethyl formate	52.6	5	95
Isopropyl formate	65.0	3	97
Propyl formate	71.6	2.3	97.7
Isobutyl formate	80.4	7.8	92.2
Butyl formate	83.8	14.5	85.5
Isopentyl formate	90.2	21	79
Pentyl formate	91.6	28.4	71.6
Benzyl formate	99.2	80	20
Ethyl acetate	70.38	8.47	91.53
Allyl acetate	83	14.7	85.3

TABLE 5.11 Binary Azeotropic (Constant-Boiling) Mixtures (*Continued*)

System	BP of azeotrope, °C	Composition, wt %	
		Water	Other component
Esters (*continued*)			
Isopropyl acetate	76.6	10.6	89.4
Propyl acetate	82.4	14	86
Isobutyl acetate	87.4	16.5	83.5
Butyl acetate	90.2	28.7	71.3
Isopentyl acetate	93.8	36.3	63.7
Pentyl acetate	95.2	41	59
Hexyl acetate	97.4	61	39
Phenyl acetate	98.9	75.1	24.9
Benzyl acetate	99.6	87.5	12.5
Methyl propionate	71.4	3.9	96.1
Ethyl propionate	81.2	10	90
Isopropyl propionate	85.2	19.9	80.1
Propyl propionate	88.9	23	77
Isobutyl propionate	92.75	52.2	47.8
Isopentyl propionate	96.55	48.5	51.5
Methyl butyrate	82.7	11.5	88.5
Ethyl butyrate	87.9	21.5	78.5
Propyl butyrate	94.1	36.4	63.6
Isobutyl butyrate	96.3	46	54
Butyl butyrate	97.2	53	47
Isopentyl butyrate	98.05	63.5	36.5
Methyl isobutyrate	77.7	6.8	93.2
Ethyl isobutyrate	85.2	15.2	84.8
Propyl isobutyrate	92.2	30.8	69.2
Isobutyl isobutyrate	95.5	39.4	60.6
Isopentyl isobutyrate	97.4	56.0	44.0
Methyl isopentanoate	87.2	19.2	80.8
Ethyl isopentanoate	92.2	30.2	69.8
Propyl isopentanoate	96.2	45.2	54.8
Isobutyl isopentanoate	97.4	55.8	44.2
Isopentyl isopentanoate	98.8	74.1	25.9
Ethyl pentanoate	94.5	40	60
Ethyl hexanoate	97.2	54	46
Methyl benzoate	99.08	79.2	20.8
Ethyl benzoate	99.4	84.0	16.0
Propyl benzoate	99.7	90.9	9.1
Butyl benzoate	99.9	94	6
Isopentyl benzoate	99.9	95.6	4.4
Ethyl phenylacetate	99.7	91.3	8.7
Methyl cinnamate	99.9	95.5	4.5
Methyl phthalate	99.95	97.5	2.5
Diethyl *o*-phthalate	99.98	98.0	2.0
Ethyl chloroacetate	95.2	45.1	54.9
Butyl chloroacetate	98.12	75.5	24.5
Methyl acrylate	71	7.2	92.8
Isobutyl carbonate	98.6	74	26
Ethyl crotonate	93.5	38	62
Methyl lactate	99	80	20

TABLE 5.11 Binary Azeotropic (Constant-Boiling) Mixtures (*Continued*)

System	BP of azeotrope, °C	Composition, wt %	
		Water	Other component
Esters (*continued*)			
1,2-Ethanediol diacetate	99.7	84.6	15.4
Ethyl nitrate	74.35	22	78
Propyl nitrate	84.8	20	80
Isobutyl nitrate	89.0	25	75
Methyl sulfate	98.6	73	27
Ethers			
Ethyl vinyl ether	34.6	1.5	98.5
Diethyl ether	34.2	1.3	98.7
Ethyl propyl ether	59.5	4	96
Diisopropyl ether	62.2	4.5	95.5
Butyl ethyl ether	76.6	11.9	88.1
Diisobutyl ether	88.6	23	77
Dibutyl ether	92.9	33	67
Diisopentyl ether	97.4	54	46
1,1-Diethoxyethane	82.6	14.5	85.5
Diphenyl ether	99.33	96.75	3.25
Methoxybenzene	95.5	40.5	59.5
Hydrocarbons			
Pentane	34.6	1.4	98.6
Hexane	61.6	5.6	94.4
Heptane	79.2	12.9	87.1
2,2,4-Trimethylpentane	78.8	11.1	88.9
Nonane	94.8	82	18
Undecane	98.85	96.0	4.0
Dodecane	99.45	98	2
Acrolein	52.4	2.6	97.4
Cyclohexene	70.8	8.93	91.07
Cyclohexane	69.5	8.4	91.6
1-Octene	88.0	28.7	71.3
Benzene	69.25	8.83	91.17
Toluene	84.1	13.5	86.5
Ethylbenzene	92.0	33.0	67.0
m-Xylene	92	35.8	64.2
Isopropylbenzene	95	43.8	56.2
Naphthalene	98.8	84	16
Ketones			
Acetone	zeotrope		
2-Butanone	73.5	11	89
2-Pentanone	83.3	19.5	80.5
Cyclopentanone	94.6	42.4	57.6
4-Methyl-2-pentanone	87.9	24.3	75.7

TABLE 5.11 Binary Azeotropic (Constant-Boiling) Mixtures (*Continued*)

System	BP of azeotrope, °C	Composition, wt %	
		Water	Other component
Ketones (*continued*)			
2-Heptanone	95	48	52
3-Heptanone	94.6	42.2	57.8
4-Heptanone	94.3	40.5	59.5
4-Hydroxy-4-methyl-2-pentanone	98.8	87.3	12.7
4-Methyl-3-penten-2-one	91.8	34.8	65.2
Nitriles			
Acetonitrile	76.5	16.3	83.7
Isobutyronitrile	82.5	23	l77
Butyronitrile	88.7	32.5	67.5
Acrylonitrile	70.6	14.3	85.7
Miscellaneous			
Hydrazine	120	32.3	67.7
Acetamide	zeotrope		
Nitromethane	83.59	23.6	76.4
Nitroethane	87.22	28.5	71.5
2,5-Dimethylfuran	77.0	11.7	88.3
Trioxane	91.4	30	70
Carbon disulfide	42.6	2.8	97.2

B. Binary azeotropes containing organic acids

System	BP of azeotrope, °C	Composition, wt %	
		Acid	Other component
Formic acid			
2-Methylbutane	27.2	4	96
Pentane	34.2	20	80
Hexane	60.6	28	72
Methylcyclopentane	63.3	29	71
Cyclohexane	70.7	70	30
Methylcyclohexane	80.2	46.5	53.5
Heptane	78.2	56.5	43.5
Octane	90.5	63	37
Benzene	71.05	31	69
Toluene	85.8	50	50
o-Xylene	95.5	74	26
m-Xylene	92.8	71.8	28.2
Styrene	97.8	73	27

TABLE 5.11 Binary Azeotropic (Constant-Boiling) Mixtures (*Continued*)

System	BP of azeotrope, °C	Composition, wt %	
		Acid	Other component
Formic acid (*continued*)			
Iodomethane	42.1	6	94
Chloroform	59.15	15	85
Carbon tetrachloride	66.65	18.5	81.5
Trichloroethylene	74.1	25	75
Tetrachloroethylene	88.2	50	50
Bromoethane	38.2	3	97
1,2-Dibromoethane	94.7	51.5	48.5
1,2-Dichloroethane	77.4	14	86
1-Bromopropane	64.7	27	73
2-Bromopropane	56.0	14	86
1-Chloropropane	45.6	8	92
2-Chloropropane	34.7	1.5	98.5
1-Chloro-2-methylpropane	63.0	19	81
Bromobenzene	98.1	68	32
Chlorobenzene	93.7	59	41
Fluorobenzene	73.0	27	73
o-Chlorotoluene	100.2	83	17
Pyridine	127.43	61.4	38.6
2-Methylpyridine	158.0	25	75
2-Pentanone	105.3	32	68
3-Pentanone	105.4	33	67
Nitromethane	97.07	45.5	54.5
Diethyl sulfide	82.2	35	65
Diisopropyl sulfide	93.5	62	38
Dipropyl sulfide	98.0	83	17
Carbon disulfide	42.55	17	83
Acetic acid			
Hexane	68.3	6.0	94.0
Heptane	91.7	23	67
Octane	105.7	53.7	46.3
Nonane	112.9	69	31
Decane	116.75	79.5	20.5
Undecane	117.9	95	5
Cyclohexane	78.8	9.6	90.4
Methylcyclohexane	96.3	31	69
Benzene	80.05	2.0	98.0
Toluene	100.6	28.1	71.9
o-Xylene	116.6	78	22
m-Xylene	115.35	72.5	27.5
p-Xylene	115.25	72	28
Ethylbenzene	114.65	66	34
Styrene	116.8	85.7	14.3
Isopropylbenzene	116.0	84	16
Triethylamine	163	67	33
Nitromethane	101.2	96	4

TABLE 5.11 Binary Azeotropic (Constant-Boiling) Mixtures (*Continued*)

System	BP of azeotrope, °C	Composition, wt %	
		Acid	Other component
Acetic acid (*continued*)			
Nitroethane	112.4	30	70
Pyridine	138.1	51.1	48.9
2-Methylpyridine	144.1	40.4	59.6
3-Methylpyridine	152.5	30.4	69.6
4-Methylpyridine	154.3	30.3	69.7
2,6-Dimethylpyridine	148.1	22.9	77.1
Carbon tetrachloride	76	98.46	1.54
Trichloroethylene	86.5	96.2	3.8
Tetrachloroethylene	107.4	61.5	38.5
1,2-Dibromoethane	114.4	55	45
2-Iodopropane	88.3	9	91
1-Bromobutane	97.6	18	82
1-Bromo-2-methylpropane	90.2	12	88
Chlorobenzene	114.7	58.5	41.5
Trichloronitromethane	107.65	80.5	19.5
1,4-Dioxane	119.5	77	23
Diisopropyl sulfide	111.5	48	52
Propionic acid			
Heptane	97.8	2	98
Octane	120.9	21.5	78.5
Nonane	134.3	54.0	46.0
Decane	139.8	80.5	19.5
o-Xylene	135.4	43	57
p-Xylene	132.5	34	66
1,3,5-Trimethylbenzene	139.3	77	23
Isopropylbenzene	139.0	65	35
Propylbenzene	139.5	75	25
Camphene	138.0	65	35
α-Pinene	136.4	58.5	41.5
Methoxybenzene	140.8	96	4
Pyridine	148.6	67.2	32.8
2-Methylpyridine	154.5	55.0	45.0
1,2-Dibromoethane	127.8	17.5	82.5
1-Iodo-2-methylpropane	119.5	9	91
Chlorobenzene	128.9	18	82
Dipropyl sulfide	136.5	45	55
Butyric acid			
Undecane	162.4	84.4	15.5
o-Xylene	143.0	10	90
m-Xylene	138.5	6	94
p-Xylene	137.8	5.5	94.5
Ethylbenzene	135.8	4	96

TABLE 5.11 Binary Azeotropic (Constant-Boiling) Mixtures (*Continued*)

System	BP of azeotrope, °C	Composition, wt %	
		Acid	Other component
Butyric acid (*continued*)			
Styrene	143.5	15	85
1,2,4-Trimethylbenzene	159.5	45	55
1,3,5-Trimethylbenzene	158.0	38	62
Isopropylbenzene	149.5	20	80
Propylbenzene	154.5	28	72
Butylbenzene	162.5	75	25
Naphthalene	zeotrope		
Indene	163.7	84	16
Camphene	152.3	2.8	97.2
Methoxybenzene	152.9	12	88
Pyridine	163.2	92.0	8.0
2-Furaldehyde	159.4	42.5	57.5
1,2-Dibromoethane	131.1	3.5	96.5
1-Iodobutane	129.8	2.5	97.5
Chlorobenzene	131.75	2.8	97.2
1,4-Dichlorobenzene	162.0	57	43
o-Bromotoluene	163.0	72	28
m-Bromotoluene	163.6	79.5	20.5
p-Bromotoluene	161.5	75	25
α-Chlorotoluene	160.8	65	35
Ethyl bromoacetate	157.4	84	16
Propyl chloroacetate	160.5	40	60
Isobutyric acid			
2,7-Dimethyloctane	148.6	48	52
o-Xylene	141.0	22	78
m-Xylene	139.9	15	85
p-Xylene	136.4	13	87
Styrene	142.0	27	73
1,2,4-Trimethylbenzene	152.3	63	37
Isopropylbenzene	146.8	35	65
Propylbenzene	149.3	49	51
Camphene	148.1	45	55
D-Limonene	152.5	78	22
Methoxybenzene	149.0	42	58
Ethyl bromoacetate	153.0	40	60
Ethyl 2-oxopropionate	153.0	60	40
1,2-Dibromoethane	130.5	6.5	93.5
1-Iodobutane	128.8	7	93
1-Bromohexane	148.0	35	65
Bromobenzene	148.6	35	65
Chlorobenzene	131.5	8	92
o-Bromotoluene	153.9	85	15
α-Chlorotoluene	153.5	80	20
Diisopentyl ether	154.2	93	7
Ethyl bromoacetate	153.0	40	60

TABLE 5.11 Binary Azeotropic (Constant-Boiling) Mixtures (*Continued*)

C. Binary azeotropes containing alcohol

System	BP of azeotrope, °C	Composition, wt %	
		Alcohol	Other component
Methanol			
Pentane	30.9	7	93
Cyclopentane	38.8	14	86
Cyclohexane	53.9	36.4	63.6
Methylcyclohexane	59.2	54	46
Heptane	59.1	51.5	48.5
Octane	62.8	67.5	32.5
Nonane	64.1	83.4	16.6
Benzene	57.5	39.1	60.9
Fluorobenzene	59.7	32	68
Toluene	63.5	72.5	27.5
Bromomethane	3.55	99.55	0.45
Iodomethane	37.8	95.5	4.5
Bromodichloromethane	63.8	60	40
Chloroform	53.4	87.4	12.6
Carbon tetrachloride	55.7	79.44	20.56
Bromoethane	34.9	5.3	94.7
1,2-Dichloroethane	61.0	32	68
Trichloroethylene	59.3	38	62
1-Bromopropane	54.5	21	79
2-Bromopropane	48.6	15.0	85.0
1-Chloropropane	40.5	9.5	90.5
2-Chloropropane	33.4	6	94
2-Iodopropane	61.0	38	62
1-Chlorobutane	57.0	27	73
Isobutyl formate	64.6	95	5
Methyl acetate	53.5	19	81
Methyl acrylate	62.5	54	46
Methyl nitrate	52.5	73	27
Acetone	55.5	12.1	87.9
1,4-Dioxane	zeotrope		
Dipropyl ether	63.8	72	28
Methyl *tert*-butyl ether	51.3	14.3	85.7
Diethyl sulfide	61.2	62	38
Carbon disulfide	39.8	71	29
Thiophene	59.7	16.4	83.6
Nitromethane	64.4	9.1	90.9
Ethanol			
Pentane	34.3	5	95
Cyclopentane	44.7	7.5	92.5
Hexane	58.7	21	79
Cyclohexane	64.8	29.2	70.8
Heptane	70.9	49	51

TABLE 5.11 Binary Azeotropic (Constant-Boiling) Mixtures (*Continued*)

System	BP of azeotrope, °C	Composition, wt %	
		Alcohol	Other component
Ethanol (*continued*)			
Octane	77.0	78	22
Benzene	67.9	31.7	68.3
Fluorobenzene	70.0	75	25
Toluene	76.7	68	32
Bromodichloromethane	75.5	72	28
Iodomethane	41.2	96.8	3.2
Chloroform	59.3	93	7
Trichloronitromethane	77.5	34	66
Carbon tetrachloride	65.0	84.2	15.8
1,2-Dichloroethane	70.5	37	63
3-Chloro-1-propene	44	5	95
1-Bromopropane	62.8	20.5	79.5
2-Bromopropane	55.6	10.5	89.5
1-Chloropropane	45.0	6	94
2-Chloropropane	35.6	2.8	97.2
1-Iodopropane	75.4	44	56
2-Iodopropane	71.5	27	73
1-Bromobutane	75.0	43	57
1-Chlorobutane	65.7	20.3	79.7
2-Butanone	74.8	40	60
1,1-Diethoxyethane	78.0	76	24
Dipropyl ether	74.5	44	56
Acetronitrile	72.5	44	56
Acrylonitrile	70.8	41	59
Nitromethane	76.1	29	71
Carbon disulfide	42.6	91	9
Diethyl sulfide	72.6	56	44
1-Propanol			
Hexane	65.7	4	96
Cyclohexane	74.7	18.5	81.5
Methylcyclohexane	87.0	34.7	65.3
Heptane	84.6	34.7	65.3
Octane	93.9	70	30
Benzene	77.1	16.9	83.1
Toluene	92.5	51.2	48.8
o-Xylene	zeotrope		
m-Xylene	97.1	94	6
p-Xylene	96.9	92.2	7.8
Styrene	97.0	8	92
Propyl formate	80.7	3	97
Butyl formate	95.5	64	36
Propyl acetate	94.7	51	49
Ethyl propionate	93.4	48	52
Methyl butyrate	94.4	49	51
Dipropyl ether	85.7	30	70

TABLE 5.11 Binary Azeotropic (Constant-Boiling) Mixtures (*Continued*)

System	BP of azeotrope, °C	Composition, wt %	
		Alcohol	Other component
1-Propanol (*continued*)			
1,1-Diethoxyethane	92.4	37	63
1,4-Dioxane	95.3	55	45
Chloroform	zeotrope		
Carbon tetrachloride	73.4	92.1	7.9
Trichloronitromethane	94.1	58.5	41.5
Iodethane	70	93	7
1,2-Dichloroethane	80.7	19	81
Tetrachloroethylene	94.0	52	48
1-Bromopropane	69.7	9	91
1-Chlorobutane	74.8	18	82
Chlorobenzene	96.5	80	20
Fluorobenzene	80.2	18	82
Nitromethane	89.1	48.4	51.6
1-Nitropropane	97.0	8.8	91.2
Carbon disulfide	45.7	94.5	5.5
2-Propanol			
Pentane	35.5	6	94
Hexane	62.7	23	77
Cyclohexane	69.4	32	68
Heptane	76.4	50.5	49.5
Octane	81.6	84	16
Benzene	71.7	33.7	66.3
Fluorobenzene	74.5	30	70
Toluene	80.6	69	31
Chloroform	60.8	4.2	95.8
Trichloronitromethane	81.9	35	65
Carbon tetrachloride	69.0	18	82
1,2-Dichloroethane	74.7	43.5	56.5
Iodoethane	67.1	15	85
3-Bromo-1-propene	66.5	20	80
1-Chloropropane	46.4	2.8	97.2
1-Bromopropane	66.8	20.5	79.5
2-Bromopropane	57.8	12	88
1-Iodopropane	79.8	42	58
2-Iodopropane	76.0	32	68
1-Chlorobutane	70.8	23	77
Ethyl acetate	75.3	25	75
Isopropyl acetate	81.3	60	40
Methyl propionate	76.4	37	63
Acrylonitrile	71.7	56	44
Butylamine	74.7	60	40
2-Butanone	77.5	32	68
1,1-Diethoxyethane	81.3	63	37
Ethyl propyl ether	62.0	10	90
Diisopropyl ether	66.2	14.1	85.9

TABLE 5.11 Binary Azeotropic (Constant-Boiling) Mixtures (*Continued*)

System	BP of azeotrope, °C	Composition, wt %	
		Alcohol	Other component
1-Butanol			
Cyclohexane	79.8	9.5	90.5
Cyclohexene	82.0	5	95
Hexane	68.2	3.2	96.8
Methylcyclohexane	95.3	20	80
Heptane	93.9	18	82
Octane	108.5	45.2	54.8
Nonane	115.9	71.5	28.5
Toluene	105.5	27.8	72.2
o-Xylene	116.8	75	25
m-Xylene	116.5	71.5	28.5
p-Xylene	115.7	68	32
Ethylbenzene	115.9	65.1	34.9
Butyl formate	105.8	23.6	76.4
Isopentyl formate	115.9	69	31
Butyl acetate	117.2	47	53
Isobutyl acetate	114.5	50	50
Ethyl butyrate	115.7	64	36
Ethyl isobutyrate	109.2	17	83
Methyl isopentanoate	113.5	40	60
Ethyl borate	113.0	52	48
Ethyl carbonate	116.5	63	37
Isobutyl nitrate	112.8	45	55
Dibutyl ether	117.8	82.5	17.5
Diisobutyl ether	113.5	48	52
1,1-Diethoxyethane	101.0	13	87
Carbon tetrachloride	76.6	97.6	2.4
Tetrachloroethylene	110.0	68	32
2-Bromo-2-methylpropane	90.2	7	93
2-Iodo-2-methylpropane	110.5	30	70
Chlorobenzene	115.3	56	44
Paraldehyde	115.8	52	48
Hexaldehyde	116.8	77.1	22.9
Ethylenediamine	124.7	35.7	64.3
Pyridine	118.6	69	31
1-Nitropropane	115.3	32.2	67.8
Butyronitrile	113.0	50	50
Diisopropyl sulfide	112.0	45	55
2-Methyl-2-propanol			
Cyclohexene	80.5	14.2	85.8
Cyclohexane	78.3	14	86
Methylcyclopentane	71.0	5	95
Hexane	68.3	2.5	97.5
Methylcyclohexane	92.6	32	68
Heptane	90.8	27	73
2,5-Dimethylhexane	98.7	42	58
1,3-Dimethylcyclohexane	102.2	56	44
2,2,4-Trimethylpentane	92.0	27	73
Benzene	79.3	7.4	92.6
Chlorobenzene	107.1	63	37
Fluorobenzene	84.0	9	91

TABLE 5.11 Binary Azeotropic (Constant-Boiling) Mixtures (*Continued*)

System	BP of azeotrope, °C	Composition, wt %	
		Alcohol	Other component
2-Methyl-2-propanol (*continued*)			
Toluene	101.2	45	55
Ethylbenzene	107.2	80	20
p-Xylene	107.1	88.6	11.4
Butyl formate	103.0	40	60
Isobutyl formate	97.4	12	88
Propyl acetate	101.0	17	83
Isobutyl acetate	107.6	92	8
Methyl butyrate	101.3	25	75
Ethyl isobutyrate	105.5	52	48
Methyl chloroacetate	107.6	12	88
Dipropyl ether	89.5	10	90
Isobutyl vinyl ether	82.7	6.2	93.8
1,1-Diethoxyethane	98.2	20	80
2-Pentanone	101.8	19	81
3-Pentanone	101.7	20	80
1,2-Dichloroethane	83.5	6.5	93.5
1-Bromobutane	95.0	21	79
1-Chlorobutane	77.7	4	96
2-Bromo-2-methylpropane	88.8	12	88
2-Iodo-2-methylpropane	104.0	36	64
1-Nitropropane	105.3	15.2	84.8
Isobutyl nitrate	105.6	36	64
Diisopropyl sulfide	105.8	73	27
3-Methyl-1-butanol			
Heptane	97.7	7	93
Octane	117.0	30	70
Toluene	109.7	10	90
Ethylbenzene	125.7	49	51
Isopropylbenzene	131.6	94	6
Camphene	130.9	24	76
Bromobenzene	131.7	85	15
o-Fluorotoluene	112.1	14.0	86.0
Butyl acetate	125.9	16.5	83.5
Paraldehyde	123.5	22.0	78.0
Dibutyl ether	129.8	65	35
Cyclohexanol			
o-Xylene	143.0	14	86
m-Xylene	138.9	5	95
Propylbenzene	153.8	40	60
Indene	160.0	75	25
Camphene	151.9	41	59
Cineole	160.6	92	8

TABLE 5.11 Binary Azeotropic (Constant-Boiling) Mixtures (*Continued*)

System	BP of azeotrope, °C	Composition, wt %	
		Alcohol	Other component
Allyl alcohol			
Methylcyclohexane	85.0	42	58
Hexane	65.5	4.5	95.5
Cyclohexane	74.0	58	42
2,5-Dimethylhexane	89.3	50	50
Octane	93.4	68	32
Benzene	76.75	17.36	82.64
Toluene	92.4	50	50
Propyl acetate	94.2	53	47
Methyl butyrate	93.8	55	45
1,2-Dichloroethane	79.9	18	82
3-Iodo-1-propene	89.4	28	72
Chlorobenzene	96.2	85	15
Diethyl sulfide	85.1	45	55
Phenol			
2,7-Dimethyloctane	159.5	6	94
Decane	168.0	35	65
Tridecane	180.6	83.1	16.9
Butylbenzene	175.0	46	54
1,2,4-Trimethylbenzene	166.0	25	75
1,3,5-Trimethylbenzene	163.5	21	79
Indene	177.8	47	53
Camphene	156.1	22	78
Benzaldehyde	175.6	51.0	49.0
1-Octanol	195.4	13	87
2-Octanol	184.5	50	50
Dipentyl ether	180.2	78	22
Diisopentyl ether	172.2	15	85
2-Methylpyridine	185.5	75.4	24.6
3-Methylpyridine	188.9	71.2	29.8
4-Methylpyridine	190.0	67.5	32.5
2,4-Dimethylpyridine	193.4	57.0	43.0
2,6-Dimethylpyridine	185.5	72.5	27.5
2,4,6-Trimethylpyridine	195.2	52.3	47.7
Aniline	185.8	41.9	58.1
Ethylene diacetate	195.5	39.2	60.8
Iodobenzene	177.7	53	47
Benzyl alcohol			
Naphthalene	204.1	60	40
D-Limonene	176.4	11	89
1,3,5-Triethylbenzene	203.2	57	43
o-Cresol	zeotrope		
m-Cresol	207.1	61	39

TABLE 5.11 Binary Azeotropic (Constant-Boiling) Mixtures (*Continued*)

System	BP of azeotrope, °C	Composition, wt %	
		Alcohol	Other component
Benzyl alcohol (*continued*)			
p-Cresol	206.8	62	38
N-Methylaniline	195.8	30	70
N,*N*-Dimethylaniline	193.9	6.5	93.5
N-Ethylaniline	202.8	50	50
N,*N*-Diethylaniline	204.2	72	28
Iodobenzene	187.8	12	88
Nitrobenzene	204.0	58	42
o-Bromotoluene	181.3	7	93
Borneol	205.1	85.8	14.2
2-Ethoxyethanol			
Methylcyclohexane	98.6	15	85
Heptane	96.5	14	86
Octane	116.0	38	62
Toluene	110.2	10.8	89.2
Ethylbenzene	127.8	48	52
p-Xylene	128.6	50	50
Styrene	130.0	55	45
Propylbenzene	134.6	80	20
Isopropylbenzene	133.2	67	33
Camphene	131.0	65	35
Propyl butyrate	133.5	72	28
2-Butoxyethanol			
Dipentene	164.0	53	47
1,3,5-Trimethylbenzene	162.0	32	68
Butylbenzene	169.6	73.4	26.6
Camphene	154.5	30	70
o-Cresol	191.6	15	85
Phenetole	167.1	52	48
Cineole	168.9	58.5	41.5
Benzaldehyde	171.0	91	9
Diisobutyl sulfide	163.8	42	58
1,2-Ethanediol			
Heptane	97.9	3	97
Decane	161.0	23	77
Tridecane	188.0	55	45
Toluene	110.1	2.3	97.7
Styrene	139.5	16.5	83.5
Stilbene	196.8	87	13
m-Xylene	135.1	6.55	93.45
p-Xylene	134.5	6.4	93.6
1,3,5-Trimethylbenzene	156	13	87
Propylbenzene	152	19	81

TABLE 5.11 Binary Azeotropic (Constant-Boiling) Mixtures (*Continued*)

System	BP of azeotrope, °C	Composition, wt %	
		Alcohol	Other component
1,2-Ethanediol (*continued*)			
Isopropylbenzene	147.0	18	82
Naphthalene	183.9	51	49
1-Methylnaphthalene	190.3	60.0	40.0
2-Methylnaphthalene	189.1	57.2	42.8
Anthracene	197	98.3	1.7
Indene	168.4	26	74
Acenaphthene	194.65	74.2	25.8
Fluorene	196.0	82	18
Camphene	152.5	20	80
Camphor	186.2	40	60
Biphenyl	192.3	66.5	33.5
Diphenylmethane	193.3	68.5	31.5
Benzyl alcohol	193.1	56	44
2-Phenylethanol	194.4	69	31
o-Cresol	189.6	27	73
m-Cresol	195.2	60	40
3,4-Dimethylphenol	197.2	89	11
Menthol	188.6	51.5	48.5
Ethyl benzoate	186.1	46.5	53.5
o-Bromotoluene	166.8	25	75
Dibutyl ether	139.5	6.4	93.6
Methoxybenzene	150.5	10.5	89.5
Diphenyl ether	193.1	60	40
Benzyl phenyl ether	195.5	87	13
Acetophenone	185.7	52	48
2,4-Dimethylaniline	188.6	47	53
N,*N*-Dimethylaniline	175.9	33.5	66.5
m-Toluidine	188.6	42	58
2,4,6-Trimethylpyridine	170.5	9.7	90.3
Quinoline	196.4	79.5	20.5
Tetrachloroethylene	119.1	94	6
1,2-Dibromoethane	129.8	4	96
Chlorobenzene	130.1	94.4	5.6
α-Chlorotoluene	167.0	30	70
Nitrobenzene	185.9	59	41
o-Nitrotoluene	188.5	48.5	51.5
1,2-Ethanediol monoacetate			
Indene	180.0	20	80
1-Octanol	189.5	71	29
Phenol	197.5	65	35
o-Cresol	199.5	51	49
m-Cresol	206.5	31	69
p-Cresol	206.0	33	67
Dipentyl ether	180.8	42	58
Diisopentyl ether	170.2	28	72
m-Bromotoluene	182.0	32	68

TABLE 5.11 Binary Azeotropic (Constant-Boiling) Mixtures (*Continued*)

D. Binary azeotropes containing ketones

System	BP of azeotrope, °C	Composition, wt %	
		Ketone	Other component
Acetone			
Cyclopentane	41.0	36	64
Pentane	32.5	20	80
Cyclohexane	53.0	67.5	32.5
Hexane	49.8	59	41
Heptane	55.9	89.5	10.5
Diethylamine	51.4	38.2	61.8
Methyl acetate	55.8	48.3	51.7
Diisopropyl ether	54.2	61	39
Chloroform	64.4	78.1	21.9
Carbon tetrachloride	56.1	11.5	88.5
Carbon disulfide	39.3	67	33
Ethylene sulfide	51.5	57	43
2-Butanone			
Cyclohexane	71.8	40	60
Hexane	64.2	28.6	71.4
Heptane	77.0	70	30
2,5-Dimethylhexane	79.0	95	5
Benzene	78.33	44	56
2-Methyl-2-propanol	78.7	69	31
Butylamine	74.0	35	65
Ethyl acetate	77.1	11.8	88.2
Methyl propionate	79.0	60	40
Butyl nitrite	76.7	30	70
1-Chlorobutane	77.0	38	62
Fluorobenzene	79.3	75	25

E. Miscellaneous binary azeotropes

System	BP of azeotrope, °C	Composition, wt %	
		Solvent	Other component
Solvent: acetamide			
Dipentene	169.2	18	82
Biphenyl	213.0	50.5	49.5
Diphenylmethane	215.2	56.5	43.5
1,2-Diphenylethane	218.2	68	32
o-Xylene	142.6	11	89

TABLE 5.11 Binary Azeotropic (Constant-Boiling) Mixtures (*Continued*)

System	BP of azeotrope, °C	Composition, wt %	
		Solvent	Other component
Solvent: acetamide (*continued*)			
m-Xylene	138.4	10	90
p-Xylene	137.8	8	92
Styrene	144	12	88
4-Isopropyl-1-methylbenzene	170.5	19	81
Naphthalene	199.6	27	73
1-Methylnaphthalene	209.8	43.8	56.2
2-Methylnaphthalene	208.3	40	60
Indene	177.2	17.5	82.5
Acenaphthene	217.1	64.2	35.8
Camphene	155.5	12	88
Camphor	199.8	23	77
Benzaldehyde	178.6	6.5	93.5
3,4-Dimethylphenol	221.1	96	4
2-Methoxy-4-(2-propenyl)phenol	220.8	88	12
N-Methylaniline	193.8	14	86
N-Ethylaniline	199.0	18	82
N,*N*-Diethylaniline	198.1	24	76
Diphenyl ether	214.6	52	48
Safrole	208.8	32	68
Tetrachloroethylene	120.5	97.4	2.6
Solvent: aniline			
Nonane	149.2	13.5	86.5
Decane	167.3	36	64
Undecane	175.3	57.5	42.5
Dodecane	180.4	71.5	28.5
Tridecane	182.9	86.2	13.8
Tetradecane	183.9	95.2	4.8
Butylbenzene	177.8	46	54
1,2,4-Trimethylbenzene	168.6	13.5	86.5
1,3,5-Trimethylbenzene	164.3	12.0	88.0
Indene	179.8	41.5	58.5
1-Octanol	183.9	83	17
o-Cresol	191.3	8	92
Dipentyl ether	177.5	55	45
Diisopentyl ether	169.3	28	72
Hexachloroethane	176.8	66	34
Solvent: pyridine			
Heptane	95.6	25.3	74.7
Octane	109.5	56.1	43.9
Nonane	115.1	89.9	10.1
Toluene	110.1	22.2	77.8
Phenol	183.1	13.1	86.9
Piperidine	106.1	8	92

TABLE 5.11 Binary Azeotropic (Constant-Boiling) Mixtures (*Continued*)

System	BP of azeotrope, °C	Composition, wt %	
		Solvent	Other component
Solvent: thiophene			
Methylcyclopentane	71.5	14	86
Cyclohexane	77.9	41.2	58.8
Hexane	68.5	11.2	88.8
Heptane	83.1	83.2	16.8
2,3-Dimethylpentane	80.9	64	36
2,4-Dimethylpentane	76.6	42.7	57.3
Solvent: benzene			
Methylcyclopentane	71.7	16	84
Cyclohexene	78.9	64.7	35.3
Cyclohexane	77.6	51.9	48.1
Hexane	68.5	4.7	95.3
Heptane	80.1	99.3	0.7
2,2-Dimethylpentane	75.9	46.3	53.7
2,3-Dimethylpentane	79.4	78.8	21.2
2,4-Dimethylpentane	75.2	48.3	51.7
2,2,4-Trimethylpentane	80.1	97.7	2.3
Solvent: bis(2-hydroxyethyl) ether			
Biphenyl	232.7	48	52
Diphenylmethane	236.0	52	48
1,3,5-Trimethylbenzene	210.0	22	78
Naphthalene	212.6	22	78
1-Methylnaphthalene	277.0	45	55
2-Methylnaphthalene	225.5	39	61
Acenaphthene	239.6	62	38
Fluorene	243.0	80	20
Benzyl acetate	214.9	7	93
Bornyl acetate	223.0	18	82
Ethyl fumarate	217.1	10	90
Dimethyl *o*-phthalate	245.4	96.3	3.7
Methyl salicylate	220.6	15	85
2-Hydroxy-1-isopropyl-4-methylbenzene	232.3	13	87
1,2-Dihydroxybenzene	259.5	46	54
Safrole	225.5	33	67
Isosafrole	233.5	46	54
Benzyl phenyl ether	241.5	80	20
Nitrobenzene	210.0	10	90
m-Nitrotoluene	224.2	25	75
o-Nitrophenol	216.0	10.5	89.5
Quinoline	233.6	29	71
p-Dibromobenzene	212.9	13	87

TABLE 5.12 Ternary Azeotropic Mixtures

A. Ternary azeotropes containing water and alcohols

System	BP of azeotrope, °C	Composition, wt %		
		Water	Alcohol	Other component
Methanol				
Chloroform	52.3	1.3	8.2	90.5
2-Methyl-1,3-butadiene	30.2	0.6	5.4	94.0
Methyl chloroacetate	67.9	6.3	81.2	13.5
Ethanol				
Acetonitrile	72.9	1	55	44
Acrylonitrile	69.5	8.7	20.3	71.0
Benzene	64.9	7.4	18.5	74.1
Butylamine	81.8	7.5	42.5	50.0
Butyl methyl ether	62	6.3	8.6	85.1
Carbon disulfide	41.3	1.6	5.0	93.4
Carbon tetrachloride	62	4.5	10.0	85.5
Chloroform	55.3	2.3	3.5	94.2
Crotonaldehyde	78.0	4.8	87.9	7.3
Cyclohexane	62.6	4.8	19.7	75.5
1,2-Dichloroethane	66.7	5	17	78
1,1-Diethoxyethane	77.8	11.4	27.6	61.0
Diethoxymethane	73.2	12.1	18.4	69.5
Ethyl acetate	70.2	9.0	8.4	82.6
Heptane	68.8	6.1	33.0	60.9
Hexane	56.0	3	12	85
Toluene	74.4	12	37	51
Trichloroethylene	67.0	5.5	16.1	78.4
Triethylamine	74.7	9	13	78
1-Propanol				
Benzene	67	7.6	10.1	82.3
Carbon tetrachloride	65.4	5	11	84
Cyclohexane	66.6	8.5	10.0	81.5
1,1-Dipropoxyethane	87.6	27.4	51.6	21.0
Dipropoxymethane	86.4	8.0	44.8	47.2
Dipropyl ether	74.8	11.7	20.2	68.1
3-Pentanone	81.2	20	20	60
Propyl acetate	82.5	17.0	10.0	73.0
Propyl formate	70.8	13	5	82
Tetrachloroethylene	81.2	12.5	20.7	66.8
2-Propanol				
Benzene	66.5	7.5	18.7	73.8
Butylamine	83	12.5	40.5	47.0

TABLE 5.12 Ternary Azeotropic Mixtures (*Continued*)

System	BP of azeotrope, °C	Composition, wt %		
		Water	Alcohol	Other component
2-Propanol (*continued*)				
Cyclohexane	64.3	7.5	18.5	74.0
Toluene	76.3	13.1	38.2	48.7
Trichloroethylene	69.4	7	20	73
1-Butanol				
Butyl acetate	89.4	37.3	27.4	35.3
Butyl formate	83.6	21.3	10.0	68.7
Dibutyl ether	90.6	29.9	34.6	35.5
Heptane	78.1	41.4	7.6	51.0
Hexane	61.5	19.2	2.9	77.9
Nonane	90.0	69.9	18.3	11.8
Octane	86.1	60.0	14.6	25.4
2-Butanol				
Carbon tetrachloride	65	4.05	4.95	91.00
Cyclohexane	69.7	8.9	10.8	80.3
Isooctane	76.3	9	19	72
2-Methyl-1-propanol				
Isobutyl acetate	86.8	30.4	23.1	46.5
Isobutyl formate	80.2	17.3	6.7	76.0
Toluene	81.3	17.9	16.4	65.7
2-Methyl-2-propanol				
Benzene	67.3	8.1	21.4	70.5
Carbon tetrachloride	64.7	3.1	11.9	85.0
Cyclohexane	65.0	8	21	71
3-Methyl-1-butanol				
Isopentyl acetate	93.6	44.8	31.2	24.0
Isopentyl formate	89.8	32.4	19.6	48.0
Allyl alcohol				
Benzene	68.2	8.6	9.2	82.2
Carbon tetrachloride	65.2	5	11	84
Cyclohexane	66.2	8	11	81
Hexane	59.7	8.5	5.1	86.4

TABLE 5.12 Ternary Azeotropic Mixtures (*Continued*)

B. Other ternary azeotropes

System	BP of azeotrope, °C	Composition, wt %	System	BP of azeotrope, °C	Composition, wt %
Water	32.5	0.4	Water	71.4	7.9
Acetone		7.6	Nitromethane		29.7
2-Methyl-1,3-butadiene		92.0	Heptane		62.4
Water	66	8.2	Water	80.7	17.4
Acetonitrile		23.3	Nitromethane		58.3
Benzene		68.5	Nonane		24.3
Water	67	6.4	Water	77.4	12.4
Acetonitrile		20.5	Nitromethane		44.3
Trichloroethylene		73.1	Octane		43.3
Water	68.6	3.5	Water	33.1	2.1
Acetonitrile		9.6	Nitromethane		6.5
Triethylamine		86.9	Pentane		91.4
Water	63.6	5	Water	82.8	20.6
2-Butanone		35	Nitromethane		73.3
Cyclohexane		60	Undecane		6.1
Water	55.0	4	Water	93.5	40.5
Butyraldehyde		21	Pyridine		54.5
Hexane		75	Dodecane		5.0
Water	107.6	21.3	Water	93.1	38.5
Formic acid		76.3	Pyridine		51.0
Isopentanoic acid		2.4	Undecane		10.5
Water	107.0	15.5	Water	92.3	35.5
Formic acid		66.8	Pyridine		45.5
Isobutyric acid		17.7	Decane		19.0

TABLE 5.12 Ternary Azeotropic Mixtures (*Continued*)

System	BP of azeotrope, °C	Composition, wt %	System	BP of azeotrope, °C	Composition, wt %
Water	107.6	19.5	Water	90.5	30.5
Formic acid		75.9	Pyridine		37.0
Butyric acid		4.6	Nonane		32.5
Water	107.2	18.6	Water	86.7	22.4
Formic acid		71.9	Pyridine		25.5
Propionic acid		9.5	Octane		52.0
Water	105	11.0	Water	78.6	14.0
Hydrogen bromide		10.4	Pyridine		15.5
Chlorobenzene		78.6	Heptane		70.5
Water	96.9	20.2	Acetic acid	134.4	23
Hydrogen chloride		5.3	Pyridine		55
Chlorobenzene		74.5	Acetic anhydride		22
Water	107.3	64.8	Acetic acid	134.1	31.4
Hydrogen chloride		15.8	Pyridine		38.2
Phenol		19.4	Decane		30.4
Water	116.1	54	Acetic acid	129.1	13.5
Hydrogen fluoride		10	Pyridine		25.2
Fluorosilic acid		36	Ethylbenzene		61.3
Water	75.1	11.5	Acetic acid	98.5	3.4
Nitroethane		75.1	Pyridine		10.6
Heptane		64.0	Heptane		86.0
Water	59.5	8.4	Acetic acid	128.0	20.7
Nitroethane		9.3	Pyridine		29.4
Hexane		82.3	Nonane		49.9
Water	82.4	19.1	Acetic acid	115.7	10.4
Nitromethane		68.1	Pyridine		20.1
Decane		12.8	Octane		69.5

Water	83.1	21.5
Nitromethane		75.3
Dodecane		3.2
Acetic acid	129.2	10.2
Pyridine		22.5
p-Xylene		67.3
Acetic acid	163.0	75.0
2,6-Dimethylpyridine		13.8
Undecane		11.2
Acetic acid	147.0	12.6
2,6-Dimethylpyridine		74.3
Decane		13.1
Acetic acid	141.3	19.9
2-Methylpyridine		46.8
Decane		33.3
Acetic acid	135.0	12.8
2-Methylpyridine		38.4
Nonane		48.8
Acetic acid	121.3	3.6
2-Methylpyridine		24.8
Octane		71.6
Acetic acid	77.2	7.6
Benzene		34.4
Cyclohexane		58.0
Acetic acid	132	15
2-Methyl-1-butanol		54
Isopentyl acetate		31
Propionic acid	149.3	29.5
2-Methylpyridine		32.0
Decane		38.5
Acetic acid	132.2	17.7
Pyridine		30.5
o-Xylene		51.8
Methanol	47.4	14.6
Methyl acetate		36.8
Hexane		48.6
Ethanol	63.2	10.4
Acetone		24.3
Chloroform		65.3
Ethanol	70.1	8
Acetonitrile		34
Triethylamine		58
Ethanol	64.7	29.6
Benzene		12.8
Cyclohexane		57.6
Ethanol	57.3	9.5
Chloroform		56.1
Hexane		34.4
1-Propanol	73.8	15.5
Benzene		30.4
Cyclohexane		54.2
2-Propanol	69.1	31.1
Benzene		15.0
Cyclohexane		53.9
1-Butanol	77.4	4
Benzene		48
Cyclohexane		48
1-Butanol	108.7	11.9
Pyridine		20.7
Toluene		76.4

TABLE 5.12 Ternary Azeotropic Mixtures (*Continued*)

System	BP of azeotrope, °C	Composition, wt %	System	BP of azeotrope, °C	Composition, wt %
Propionic acid	140.1	16.5	1,2-Ethanediol	185.0	8.7
2-Methylpyridine		21.5	Phenol		74.6
Nonane		42.0	2,6-Dimethylpyridine		16.7
Propionic acid	123.7	4.5	1,2-Ethanediol	185.1	5.9
2-Methylpyridine		10.5	Phenol		79.1
Octane		85.0	2-Methylpyridine		15.0
Propionic acid	153.4	43.0	1,2,-Ethanediol	186.4	15.9
2-Methylpyridine		40.0	Phenol		67.7
Undecane		17.0	3-Methylpyridine		16.4
Propionic acid	147.1	55.5	1,2-Ethanediol	188.6	29.5
Pyridine		26.4	Phenol		54.8
Undecane		18.1	2,4,6-Trimethylpyridine		15.7
Methanol	57.5	23	Acetone	60.8	3.6
Acetone		30	Chloroform		68.8
Chloroform		47	Hexane		27.6
Methanol	47	14.6	Acetone	49.7	51.1
Acetone		30.8	Methyl acetate		5.6
Hexane		59.6	Hexane		43.3
Methanol	53.7	17.4	Chloroform	62.0	79.7
Acetone		5.8	Ethyl formate		5.3
Methyl acetate		76.8	2-Bromopropane		15.7
Methanol	50.8	17.8	1,4-Dioxane	101.8	44.3
Methyl acetate		48.6	2-Methyl-1-propanol		26.7
Cyclohexane		33.6	Toluene		29.0

5.4 FREEZING MIXTURES

TABLE 5.13 Compositions of Aqueous Antifreeze Solutions

Freezing point of ethyl alcohol-water mixtures*

Specific gravity 20°/4°C. (68°F.)	% alcohol by weight	% alcohol by volume	Freezing point °C.	Freezing point °F.
0.99363	2.5	3.13	−1.0	30.2
0.98971	4.8	6.00	−2.0	28.4
0.98658	6.8	8.47	−3.0	26.6
0.98006	11.3	14.0	−5.0	23.0
0.97670	13.8	17.0	−6.1	21.0
0.97336	16.4	20.2	−7.5	18.5
0.97194	17.5	21.5	−8.7	16.3
0.97024	18.8	23.1	−9.4	15.1
0.96823	20.3	24.8	−10.6	12.9
0.96578	22.1	27.0	−12.2	10.0
0.96283	24.2	29.5	−14.0	6.8
0.95914	26.7	32.4	−16.0	3.2
0.95400	29.9	36.1	−18.9	−2.0
0.94715	33.8	40.5	−23.6	−10.5
0.93720	39.0	46.3	−28.7	−19.7
0.92193	46.3	53.8	−33.9	−29.0
0.90008	56.1	63.6	−41.0	−41.8
0.86311	71.9	78.2	−51.3	−60.3

Freezing point of methyl (wood) alcohol-water mixtures*

Specific gravity 15.6°C. (60°F.)	% alcohol by weight	% alcohol by volume	Freezing point °C.	Freezing point °F.
0.993	3.9	5	−2.2	28
0.986	8.1	10	−5.0	23
0.980	12.2	15	−8.3	17
0.974	16.4	20	−11.7	11
0.968	20.6	25	−15.6	4
0.963	24.9	30	−20.0	−4
0.956	29.2	35	−25.0	−13
0.949	33.6	40	−30.0	−22
0.942	38.0	45	−35.6	−32

* Values are for pure alcohol. Since some commercial antifreezes contain small amounts of water, slightly higher volume concentrations than those given in the table may be required. Antifreezes also contain corrosion inhibitors and other additives to make them function properly as cooling liquids. These affect freezing point slightly and specific gravity to a greater degree. If a protection table is furnished by the manufacturer it should be used in preference to the values given above for the pure substance.

TABLE 5.13 Compositions of Aqueous Antifreeze Solutions (*Continued*)

Freezing point of Prestone-water mixtures†

% Prestone		Specific gravity	Freezing point	
By weight	By volume	15°/15C. (59°F.)	°C.	°F.
10	9.2	1.013	−3.6	25.6
15	13.8	1.019	−5.6	22.0
20	18.3	1.026	−7.9	17.8
25	23.0	1.033	−10.7	12.8
30	28.0	1.040	−14.0	6.8
40	37.8	1.053	−22.3	−8.2
50	47.8	1.067	−33.8	−28.8
60	58.1	1.079	−49.3	−56.7

Freezing point of ethyl alcohol-water mixtures

Specific gravity 15.6°C. (60°F.)	% alcohol by volume	Freezing point	
		°C.	°F.
0.990	5	−1.7	29
0.984	10	−3.3	26
0.978	15	−6.1	21
0.972	20	−8.3	17
0.964	25	−11.1	12
0.955	30	−14.4	6
0.945	35	−17.8	0
0.933	40	−18.3	−1
0.922	45	−18.9	−2
0.910	50	−20.0	−4
0.899	55	−21.7	−7
0.887	60	−23.3	−10
0.875	65	−24.4	−12
0.864	70	−26.7	−16
0.852	75	−32.2	−26
0.840	80	−41.7	−43

† Eveready Prestone marketed for antifreeze purposes, is 97% ethylene glycol containing fractional percentages of soluble and insoluble ingredients to prevent foaming, creepage and water corrosion in automobile cooling systems.

TABLE 5.13 Compositions of Aqueous Antifreeze Solutions (*Continued*)

Freezing point of propylene glycol-water mixtures*

Specific gravity 15.6°C. (60°F.)	% glycol by volume	Freezing point °C.	Freezing point °F.
1.004	5	−1.1	30
1.006	10	−2.2	28
1.012	15	−3.9	25
1.017	20	−6.7	20
1.020	25	−8.9	16
1.024	30	−12.8	9
1.028	35	−16.1	3
1.032	40	−20.6	−5
1.037	45	−26.7	−16
1.040	50	−33.3	−28

Freezing point of glycerol-water mixtures†

% Glycerol by weight	Specific gravity 15°/15°C. (59°F.)	Specific gravity 20°/20°C. (68°F.)	Freezing point °C.	Freezing point °F.
10	1.02415	1.02395	−1.6	29.1
20	1.04935	1.04880	−4.8	23.4
30	1.07560	1.07470	−9.5	14.9
40	1.10255	1.10135	−15.5	4.3
50	1.12985	1.12845	−22.0	−7.4
60	1.15770	1.15605	−33.6	−28.5
70	1.18540	1.18355	−37.8	−36.0
80	1.21290	1.21090	−19.2	−2.3
90	1.23950	1.23755	−1.6	29.1
100	1.26557	1.26362	17.0	62.6

* Values are for pure alcohol. Since some commercial antifreezes contain small amounts of water, slightly higher volume concentrations than those given in the table may be required. Antifreezes also contain corrosion inhibitors and other additives to make them function properly as cooling liquids. These affect freezing point slightly and specific gravity to a greater degree. If a protection table is furnished by the manufacturer it should be used in preference to the values given above for the pure substance.

† The values are those reported by Bosart and Snoddy (*Jour. Ind. Eng. Chem.,* **19,** 506 (1927)), and Lane (*Jour. Ind. Eng. Chem.,* **17,** 924 (1925)) but modified by adding 2°F to all temperatures below 0°F in accordance with the suggestion of the Procter and Gamble Co.

TABLE 5.13 Compositions of Aqueous Antifreeze Solutions (*Continued*)

Freezing point of magnesium chloride brines

% $MgCl_2$ by weight	Spec. grav. 15.6°C. (60°F.)	Freezing point °C.	Freezing point °F.
5	1.043	−3.11	26.4
6	1.051	−3.89	25.0
7	1.060	−4.72	23.5
8	1.069	−5.67	21.8
9	1.078	−6.67	20.0
10	1.086	−7.83	17.9
11	1.096	−9.05	15.7
12	1.105	−10.5	13.1
13	1.114	−12.1	10.3
14	1.123	−13.7	7.3
15	1.132	−15.6	4.0
16	1.142	−17.6	0.4
17	1.151	−19.7	−3.5
18	1.161	−22.1	−7.7
19	1.170	−25.6	−12.2
20	1.180	−27.4	−17.3
21	1.190	−30.6	−23.0
22	1.200	−32.8	−27.0
23	1.210	−28.9	−20.0
24	1.220	−25.6	−14.0
25	1.230	−23.3	−10.0
26	1.241	−21.1	−6.0
27	1.251	−19.4	−3.0
28	1.262	−18.3	−1.0
29	1.273	−17.2	+1.0
30	1.283	−16.7	2.0

Freezing point of sodium chloride brines
Compiled in collaboration with C. D. Looker, Ph.D., International Salt Co., Inc.

% NaCl by weight	Spec. grav. 15°C. (59°F.)	Freezing point °C.	Freezing point °F.
0	1.000	0.00	32.0
1	1.007	−0.58	31.0
2	1.014	−1.13	30.0
3	1.021	−1.72	28.9
4	1.028	−2.35	27.8
5	1.036	−2.97	26.7
6	1.043	−3.63	25.5
7	1.051	−4.32	24.2
8	1.059	−5.03	22.9
9	1.067	−5.77	21.6
10	1.074	−6.54	20.2
11	1.082	−7.34	18.8
12	1.089	−8.17	17.3
13	1.097	−9.03	15.7
14	1.104	−9.94	14.1
15	1.112	−10.88	12.4
16	1.119	−11.90	10.6
17	1.127	−12.93	8.7
18	1.135	−14.03	6.7
19	1.143	−15.21	4.6
20	1.152	−16.46	2.4
21	1.159	−17.78	+0.0
22	1.168	−19.19	−2.5
23	1.176	−20.69	−5.2
23.3 (*E*)	1.179	−21.13	−6.0
24	1.184	−17.0*	+1.4*
25	1.193	−10.4*	13.3*
26	1.201	−2.3*	27.9*
26.3	1.203	0.0*	32.0*

* Saturation temperatures of sodium chloride dihydrate; at these temperatures $NaCl \cdot 2H_2O$ separates leaving the brine of the eutectic composition (*E*).

5.4.1 Propylene Glycol–Glycerol

Propylene glycol, a satisfactory antifreeze with the advantage of being nontoxic, can be combined with glycerol, also an efficient nontoxic antifreeze, to give a mixture that can be tested for freezing point with an ethylene glycol (Prestone) hydrometer. A mixture of 70% propylene glycol and 30% glycerol (% by weight of water-free materials), when diluted, can be tested on the standard instrument used for ethylene glycol solutions.

5.5 DENSITY AND SPECIFIC GRAVITY

TABLE 5.14 Density of Mercury and Water

The density of mercury and pure air-free water under a pressure of 101 325 Pa(1 atm) is given in units of grams per cubic centimeter ($g \cdot cm^{-3}$). For mercury, the values are based on the density at 20°C being 13.545 884 $g \cdot cm^{-3}$. Water attains its maximum density of 0.999 973 $g \cdot cm^{-3}$ at 3.98°C. For water, the temperature (t_m, °C) of maximum density at different pressures (p) in atmospheres is given by

$$t_m = 3.98 - 0.0225(p - 1)$$

Density of water	Temp., °C	Density of mercury	Density of water	Temp., °C	Density of mercury
	−20	13.644 59	0.987 12	52	13.467 68
	−18	13.639 62	0.986 18	54	13.462 82
	−16	13.634 66	0.985 21	56	13.457 96
	−14	13.629 70	0.984 22	58	13.453 09
	−12	13.624 75	0.983 20	60	13.448 23
	−10	13.619 79	0.982 16	62	13.443 37
	−8	13.614 85	0.981 09	64	13.438 52
	−6	13.609 90	0.980 01	66	13.433 67
	−4	13.604 96	0.978 90	68	13.428 82
	−2	13.600 02	0.977 77	70	13.423 97
0.999 84	0	13.595 08	0.976 61	72	13.419 13
0.999 94	2	13.590 15	0.975 44	74	13.414 28
0.999 97	4	13.585 22	0.974 24	76	13.409 43
0.999 94	6	13.580 29	0.973 03	78	13.404 60
0.999 85	8	13.575 36	0.971 79	80	13.399 77
0.999 70	10	13.570 44	0.970 53	82	13.394 92
0.999 50	12	13.565 52	0.969 26	84	13.390 09
0.999 24	14	13.560 60	0.967 96	86	13.385 26
0.998 94	16	13.555 70	0.966 65	88	13.380 42
0.998 60	18	13.550 79	0.965 31	90	13.375 60
0.998 20	20	13.545 88	0.963 96	92	13.370 77
0.997 77	22	13.540 97	0.962 59	94	13.365 94
0.997 30	24	13.536 06	0.961 20	96	13.361 12
0.996 78	26	13.531 17	0.959 79	98	13.356 30
0.996 23	28	13.526 26	0.958 36	100	13.351 48
0.995 65	30	13.521 37		120	13.303 4
0.995 03	32	13.516 47		140	13.255 4
0.994 37	34	13.511 58		160	13.207 6
0.993 69	36	13.506 70		180	13.159 8
0.992 97	38	13.501 82		200	13.112 0
0.992 22	40	13.496 93		220	13.064 5
0.991 44	42	13.492 07		240	13.016 9
0.990 63	44	13.487 18		260	12.969 2
0.989 79	46	13.482 29		280	12.921 5
0.988 93	48	13.477 42		300	12.873 7
0.988 04	50	13.472 56			

TABLE 5.15 Specific Gravity of Air at Various Temperatures

The table below gives the weight in grams × 10^4 of 1 mL of air at 760 mm of mercury pressure and at the temperature indicated. Density in grams per milliliter is the same as the specific gravity referred to water at 4°C as unity. To convert to density referred to air at 70°F as unity, divide the values below by 12.00.

t°C.	Sp.Gr. × 10^4	t°C.	Sp.Gr. × 10^4	t°C.	Sp.Gr. × 10^4	t°C.	Sp.Gr. × 10^4
−25	14.240	15	12.255	60	10.596	140	8.541
−24	14.182	16	12.213	62	10.532	142	8.500
−23	14.125	17	12.170	64	10.470	144	8.459
−22	14.069	18	12.129	66	10.408	146	8.419
−21	14.013	19	12.087	68	10.347	148	8.379
−20	13.957	20	12.046	70	10.286	150	8.339
−19	13.902	21	12.004	72	10.227	155	8.242
−18	13.847	22	11.964	74	10.168	160	8.147
−17	13.793	23	11.923	76	10.109	165	8.054
−16	13.739	24	11.883	78	10.052	170	7.963
−15	13.685	25	11.843	80	9.995	175	7.874
−14	13.632	26	11.803	82	9.938	180	7.787
−13	13.580	27	11.764	84	9.882	185	7.702
−12	13.527	28	11.725	86	9.828	190	7.619
−11	13.476	29	11.686	88	9.773	195	7.537
−10	13.424	30	11.647	90	9.719	200	7.457
−9	13.373	31	11.609	92	9.666	205	7.379
−8	13.322	32	11.570	94	9.613	210	7.303
−7	13.272	33	11.533	96	9.561	215	7.228
−6	13.222	34	11.495	98	9.509	220	7.155
−5	13.173	35	11.458	100	9.458	230	7.013
−4	13.124	36	11.420	102	9.408	240	6.881
−3	13.075	37	11.383	104	9.358	250	6.753
−2	13.026	38	11.347	106	9.308	260	6.624
−1	12.978	39	11.310	108	9.259	270	6.504
0	12.931	40	11.274	110	9.211	280	6.389
+1	12.883	41	11.238	112	9.163	290	6.277
2	12.836	42	11.202	114	9.116	300	6.166
3	12.790	43	11.167	116	9.069	310	6.062
4	12.743	44	11.132	118	9.022	320	5.942
5	12.697	45	11.097	120	8.976	330	5.847
6	12.652	46	11.062	122	8.931	340	5.755
7	12.606	47	11.027	124	8.886	350	5.664
8	12.561	48	10.993	126	8.841	360	5.578
9	12.517	49	10.958	128	8.797	370	5.493
10	12.472	50	10.924	130	8.753	380	5.407
11	12.428	52	10.857	132	8.710	400	5.248
12	12.385	54	10.791	134	8.667	420	5.101
13	12.341	56	10.725	136	8.625	440	4.952
14	12.298	58	10.660	138	8.583	460	4.812

5.5.1 Density of Moist Air

The density of moist air depends upon the temperature, the humidity, and the barometric pressure. It is expressed by the equation

$$d_t = D_t \times \frac{P - 0.3783e}{760}$$

where d_t is the density of the moist air at the temperature t; D_t is the density of dry air at the temperature t (see Table 5.15, Specific Gravity of Air at Various Temperatures); P is the height of the barometer after correction and reduction to standard conditions, and is expressed in millimeters of mercury (see Sec. 2.1.3, Barometry and Barometric Corrections); e is the vapor pressure of water at the temperature of the dew point and is expressed in millimeters of mercury (see Table 5.6, Vapor Pressure of Water).

Example. To find the density of moist air at a temperature of 20°C, with a dew point of 10°C, and a corrected barometric pressure of 750 mm.

Reference to Table 5.15 shows that D at 20°C is equal to 0.001 204 6 g/mL. Reference to Table 5.6 shows that at 10°C (the temperature of the dew point) e is equal to 9.209 mm. Therefore,

$$d = 0.001\ 204\ 6 \times \frac{750 - (0.3783 \times 9.209)}{760}$$

$$= 0.001\ 183\ 2 \text{ g/mL} = 1.1832 \text{ g/L}$$

5.5.2 Specific Gravity Corrections for the Buoyant Effect of Air

5.5.2.1 Determinations Made with a Pyknometer

$$D_{\text{vac}} = \frac{W_2}{W_1} d - 0.0012\left(\frac{W_2 d}{W_1} - 1\right)$$

$$S_{\text{vac}} = \frac{W_2}{W_1} - 0.0012\left(\frac{W_2}{W_1} - 1\right)$$

where D_{vac} = density of the liquid in grams per milliliter at t°C corrected for the buoyant effect of air
W_1 = weight in air of the water required to fill the pyknometer at t°C
W_2 = weight in air of the liquid required to fill the pyknometer at t°C
d = density of water in grams per milliliter at t°C
S_{vac} = specific gravity of the liquid at t°C referred to water at t°C corrected for the buoyant effect of air

When the weight of the water is determined at a temperature of t°C, and that of the liquid at a different temperature t', the equations above are modified as follows:

$$D_{\text{vac}} = \frac{W_2}{W_1} d - 0.0012\left(\frac{W_2}{W_1} d - 1\right) + 0.000\ 026\ (t' - t^\circ)\left(\frac{W_2}{W_1} d\right)$$

$$S_{\text{vac}} = \frac{W_2}{W_1} - 0.0012\left(\frac{W_2}{W_1} - 1\right) + 0.000\ 026\ (t' - t^\circ)\left(\frac{W_2}{W_1} d\right)$$

5.5.2.2 Determinations Made with a Plummet or Sinker. The equations above may also be used when the density is determined with plummet or sinker, but in this case

W_1 = weight of the plummet in air minus its weight in water

W_2 = weight of the plummet in air minus its weight in the liquid

5.6 VISCOSITY, SURFACE TENSION, DIELECTRIC CONSTANT, DIPOLE MOMENT, AND REFRACTIVE INDEX

TABLE 5.16 Viscosity and Surface Tension of Various Organic Substances

For the majority of substances the dependence of the surface tension γ on the temperature can be given as:

$$\gamma = a - bt$$

where a and b are constants and t is the temperature in degrees Celsius. In the SI system the surface tensions are expressed in $mN \cdot m^{-1}$ ($= dyn \cdot cm^{-1}$).

A compilation of some 2200 liquid compounds has been prepared by J. J. Jasper, *J. Phys. Chem. Reference Data* **1:**841 (1972).

The SI unit of viscosity is pascal-second ($Pa \cdot s$) or newton-second per meter squared ($N \cdot s \cdot m^{-2}$). Values tabulated are $mN \cdot s \cdot m^{-2}$ ($=$ centipoise, cP). The temperature in degrees Celsius at which the viscosity of a substance was measured is shown in parentheses after the value.

Substance	Surface tension, $mN \cdot m^{-1}$		Liquid range, °C	Viscosity, $mN \cdot s \cdot m^{-2}$
	a	b		
Acetaldehyde	23.90	0.1360	−123 to 21	0.2797(0), 0.2557(10), 0.22(20)
Acetaldoxime	34.23	0.1134	12(β) or 46.5(α) to 114.5	
Acetamide	47.66	0.1021	81 to 222	1.63(94), 1.32(105), 1.06(120)
Acetanilide	46.21	0.0912	114 to 304	2.22(120), 1.90(130)
Acetic acid	29.58	0.0994	16.7 to 118	1.056(25), 0.786(50), 0.424(110)
Acetic anhydride	35.52	0.1436	−73 to 139	1.241(0), 0.907(20), 0.699(40)
Acetone	26.26	0.112	−94 to 56	0.395(0), 0.306(25), 0.256(50)
Acetonitrile	29.58	0.1178	−44 to 81.6	0.397(10), 0.329(30), 0.2753(50)
Acetophenone	41.92	0.1154	20 to 202	1.511(30), 1.192(45), 0.634(100)
Acetyl chloride	26.7(15)		−113 to 51	0.368(25), 0.294(50)
Acrylic acid	28.1(30)		14 to 141	
Acrylonitrile	29.58	0.1178	−83.5 to 77.3	
Allyl acetate	28.73	0.1186	up to 104	
Allyl alcohol	27.53	0.0902	−129 to 97	1.218(25), 0.759(50), 0.553(70)
Allylamine	27.49	0.1287	−88 to 55	
Allyl isothiocyanate	36.76	0.1074	−80 to 152	
2-Aminoethanol	51.11	0.1117	10.3 to 171	
Aniline	44.83	0.1085	−6 to 186	3.847(25), 2.029(50), 1.247(75)
Benzaldehyde	40.72	0.1090	−26 to 179	
Benzamide	47.26	0.0705	129 to 290	
Benzene	28.88(20)	27.56(30)	5.5 to 80	0.649(20), 0.566(30), 0.395(60)
Benzenesulfonyl chloride	45.48	0.1117	14.5 to 251	
Benzenethiol	41.41	0.1202	−14.9 to 169	
Benzonitrile	41.69	0.1159	−12.7 to 191	1.447(15), 1.111(30), 0.883(50)
Benzophenone	46.31	0.1128	48 to 305	
Benzoyl bromide	45.85	0.1397	−24 to 219	
Benzoyl chloride	41.34	0.1084	−1 to 197	
Benzyl alcohol	38.25	0.1381	−15.2 to 205	5.474(25), 2.760(50), 1.618(75)
Benzylamine	42.33	0.1213	10 to 180	1.624(25), 1.080(50), 0.769(75)
Benzyl benzoate	48.07	0.1065	21 to 323	8.454(25)
Benzyl chloride	39.92	0.1227	−43 to 179	

TABLE 5.16 Viscosity and Surface Tension of Various Organic Substances (*Continued*)

Substance	Surface tension, $mN \cdot m^{-1}$		Liquid range, °C	Viscosity, $mN \cdot s \cdot m^{-2}$
	a	*b*		
Benzyl ethyl ether	32.82(20)	29.97(40)	up to 186	
Biphenyl	41.52	0.0931	69 to 256	
Bis(2-ethoxyethyl) ether	29.74	0.1176	−45 to 188	
Bis(2-hydroxyethyl) ether	46.97	0.0880	−10.4 to 246	
Bis(2-methoxyethyl) ether	32.47	0.1164	−68 to 162	
Bromobenzene	38.14	0.1160	−30.6 to 156	1.196(15), 0.985(30), 0.385(1423)
1-Bromobutane	28.71	0.1126	−112.4 to 101.6	0.633(20), 0.606(25), 0.471(50)
(±)-2-Bromobutane	27.48	0.1107	−112.7 to 91.4	
Bromochloromethane	33.32(20)		−88 to 68	
Bromocyclohexane	36.13	0.1117	up to 165.8	
1-Bromodecane	31.26	0.0856	−30 to 240	
Bromodichloromethane	35.11	0.1294	−55 to 87	
1-Bromododecane	32.58	0.0882	−11 to bp	
Bromoethane	26.52	0.1159	−119 to 38.2	0.477(10), 0.374(25)
Bromoform	48.14	0.1308	8 to 149	
1-Bromoheptane	30.74	0.0982	−58 to 180	
1-Bromohexadecane	33.37	0.0861	17.8 to 336	
1-Bromohexane	29.81	0.0967	−85 to 158	
Bromomethane	26.52	0.1159	−94 to 3.56	
1-Bromo-3-methylbutane	28.10	0.0996	−112 to 119.7	
1-Bromo-2-methylpropane	26.96	0.1059	−119 to 91.5	
1-Bromonaphthalene	46.44	0.1018	−1.8 to 281	
1-Bromononane	31.36	0.0894	ca. −55 to 201	
1-Bromooctane	31.00	0.0928	−55 to 201	
1-Bromopentane	29.51	0.1049	−88 to 129.6	
p-Bromophenol	48.88	0.1070	64 to 238	
1-Bromopropane	28.30	0.1218	−110.1 to 71	0.539(15), 0.459(30), 0.338(70)
2-Bromopropane	26.21	0.1183	−89 to 59.5	0.536(15), 0.437(30), 0.359(50)
3-Bromopropene	29.45	0.1257	−119 to 70	0.620(0), 0.471(25), 0.373(50)
1-Bromotetradecane	32.93	0.0878	6 to >178	
o-Bromotoluene	36.62	0.0998	−26 to 181	
p-Bromotoluene	36.40	0.0997	28.5 to 184	
1-Bromoundecane	31.94	0.0861	−9 to >138	
Butanal	26.67	0.0925	−99 to 74.8	
Butane	14.87	0.1206	−138.3 to −0.5	
1,3-Butanediol	37.8(25)		<−50 to 207.5	
2,3-Butanediol	36(25)		25 to 182	
Butanenitrile			−112 to 117.6	0.553(25), 0.418(50), 0.330(75)
Butanesulfonyl chloride	37.33	0.0977		
1-Butanethiol	28.07	0.1142	−116 to 98.5	
Butanoic acid	28.35	0.0920	−6 to 163.5	1.540(20), 0.980(40), 0.323(60)
Butanoic anhydride	28.93(20)	28.44(25)	−66 to 199.5	
1-Butanol	27.18	0.0898	−89.5 to 117.7	5.185(0), 2.948(20), 1.782(40)
(±)-2-Butanol	23.47(20)	22.62(30)	−114.7 to 99.5	3.907(20), 1.332(50), 0.698(75)
2-Butanone	26.77	0.1122	−86.7 to 79.6	0.428(20), 0.349(40), 0.249(75)
1-Butene	15.19	0.1323	−185 to −6.5	
2-Butene	16.11	0.1289	−106 to 0.9	
3-Butenenitrile	31.40	0.1085	−87 to 119	
2-Butoxyethanol	28.18	0.0816	−75 to 168	

TABLE 5.16 Viscosity and Surface Tension of Various Organic Substances (*Continued*)

Substance	Surface tension, $mN \cdot m^{-1}$		Liquid range, °C	Viscosity, $mN \cdot s \cdot m^{-2}$
	a	*b*		
2-(2-Butoxyethoxy)ethanol	30.0(25)		−68.1 to 230.4	
Butyl acetate	27.55	0.1068	−77 to 126	0.734(20), 0.688(25), 0.500(50)
(±)-*sec*-Butyl acetate	23.33(22)	21.24(42)	−99 to 112	0.676(25), 0.493(50), 0.370(75)
tert-Butyl acetate	24.69	0.1102	up to 98	
Butylamine	26.24	0.1122	−50 to 77	0.830(0), 0.574(25), 0.409(50)
sec-Butylamine	23.75	0.1057	−104 to 63	0.770(0), 0.571(25), 0.367(50)
tert-Butylamine	19.44	0.1028	−66 to 44	
Butylbenzene	31.28	0.1025	−88 to 183	1.035(20), 0.683(50), 0.515(75)
sec-Butylbenzene	30.48	0.0979	−82.7 to 173	
tert-Butylbenzene	30.10	0.0985	−58.1 to 168.5	
Butyl butanoate	27.65	0.0965	−91.5 to 166	
Butyl ethyl ether	22.75	0.1049	−124 to 92	
Butyl formate	27.08	0.1026	−91.5 to 106	0.940(0), 0.691(20), 0.472(50)
Butyl methyl ether	22.17	0.1057	−115.5 to 70	
Butyl nitrate	30.35	0.1126	up to 133	
Butyl propanoate	27.37	0.0993	−89 to 146.8	
4-*tert*-Butylpyridine	35.48	0.0951	ca. −44 to 197	
Butyl stearate	33.0(25)	32.7(30)	26 to 343	
Butyl vinyl ether	21.99(20)		−92 to 94.2	
Carbon disulfide	35.29	0.1484	−111.6 to 46.5	0.429(0), 0.363(20), 0.352(25)
Carbon tetrachloride	29.49	0.1224	−23 to 76.7	1.321(0), 0.908(25), 0.656(50)
D-(+)-Carvone	36.54	0.0920	<15 to 230	
Chloroacetic acid	43.27	0.1117	61 to 189	3.15(50), 1.92(75)
o-Chloroaniline	43.41	0.0904	−14 to 208.8	3.316(25), 1.913(50), 1.248(75)
p-Chloroaniline	48.69	0.1099	72.5 to 232	
Chlorobenzene	35.97	0.1191	−45.3 to 131.7	0.799(20), 0.631(40), 0.512(60)
1-Chlorobutane	25.97	0.1117	−123.1 to 78.4	0.556(0), 0.422(25), 0.329(50)
2-Chlorobutane	24.40	0.1118	−131.3 to 68.2	0.439(15)
Chlorocyclohexane	33.90	0.1101	−44 to 142	
1-Chlorododecane	31.56	0.0904	−9 to 116	
1-Chloro-2,3-epoxypropane	39.76	0.1360	−57.2 to 116.1	1.03(25)
Chloroethane	21.18(5)	20.58(10)	−139 to 12.3	0.416(−25), 0.319(0), 0.279(10)
2-Chloroethanol	38.9(20)		−67.5 to 128.6	3.913(15)
Chloroform	29.91	0.1295	−63.6 to 61.1	0.706(0), 0.596(15), 0.514(30)
1-Chloroheptane	28.94	0.0961	−69 to 161	
1-Chlorohexane	28.32	0.1038		
1-Chloro-3-methylbutane	25.51	0.1076	−104 to 99	
1-Chloro-2-methylpropane	24.40	0.1099	−130.3 to 68.9	0.462(20), 0.373(40)
2-Chloro-2-methylpropane	20.06(15)	18.35(30)	−26 to 50.8	0.543(15)
1-Chloronaphthalene	44.12	0.1035	−2.3 to 259	2.940(25)
o-Chloronitrobenzene	48.10	0.1171	33 to 246	
m-Chloronitrobenzene	49.71	0.1417	44 to 236	
p-Chloronitrobenzene	45.84	0.1046	84 to 242	
1-Chlorooctane	29.64	0.0961	−58 to 182	
1-Chloropentane	27.09	0.1076	−99 to 108	0.580(20)
o-Chlorophenol	42.5	0.1122	9.8 to 175	3.589(25), 1.835(50), 1.131(75)
m-Chlorophenol	43.7	0.1009	33 to 214	11.55(25), 4.725(45), 4.041(50)
p-Chlorophenol	46.0	0.1049	43 to 220	4.99(50)
1-Chloropropane	24.41	0.1246	−122.8 to 47	0.436(0), 0.372(15), 0.318(30)

TABLE 5.16 Viscosity and Surface Tension of Various Organic Substances (*Continued*)

Substance	Surface tension, $mN \cdot m^{-1}$		Liquid range, °C	Viscosity, $mN \cdot s \cdot m^{-2}$
	a	*b*		
2-Chloropropane	21.37	0.0883	−117 to 36	0.401(0), 0.335(15), 0.299(30)
3-Chloro-1-propene	25.50	0.0946	−134.5 to 45	0.347(15)
o-Chlorotoluene			−35.6 to 159	1.267(25), 0.883(50), 0.662(75)
m-Chlorotoluene			−47.8 to 161.8	0.964(25), 0.710(50), 0.547(75)
p-Chlorotoluene	34.93	0.1082	7.5 to 162.4	0.837(25), 0.621(50), 0.483(75)
Chlorotrimethylsilane	19.51	0.0875	−40 to 57	
o-Cresol	39.43	0.1011	30 to 191	3.035(50), 1.562(75), 0.961(100)
m-Cresol	38.00	0.0924	12 to 202	12.9(25), 4.417(50), 2.093(75)
p-Cresol	38.58	0.0962	34.8 to 202	5.607(45)
Cycloheptanol	35.02	0.0923	2 to 185	
Cyclohexane	27.62	0.1188	6.6 to 80.7	0.980(20), 0.912(25), 0.650(50)
Cyclohexanol	35.33	0.0966	25.4 to 161	57.5(25), 41.07(30), 12.3(50)
Cyclohexanone	37.67	0.1242	−31 to 155.7	2.453(15), 1.803(30), 1.321(50)
Cyclohexene	29.23	0.1223	−103.5 to 83	0.882(0), 0.625(25), 0.467(50)
Cyclohexylamine	34.19	0.1188	−18 to 134	1.079(25), 0.692(50), 0.485(75)
Cyclooctane	32.02	0.1090	14.8 to 151.1	
Cyclopentane	25.53	0.1462	−94 to 50	0.555(0), 0.413(25), 0.321(50)
Cyclopentanol	35.04	0.1011	−19 to 140	0.439(20)
Cyclopentanone	35.55	0.1100	−51 to 130.6	
Cyclopentene	25.94	0.1495	−135.1 to 44.2	
cis-Decahydronaphthalene	32.18(20)	31.01(30)	−43 to 195.8	3.042(25), 1.875(50), 1.271(75)
trans-Decahydronaphthalene	29.89(20)	28.87(30)	−30.4 to 187.3	1.948(25), 1.289(50), 0.917(75)
Decamethylcyclopentasiloxane	19.56	0.0565	−38 to >101	
Decamethyltetrasiloxane	86.20(25)		−68 to 194	1.28(20)
Decane	25.67	0.0920	−29.7 to 174.1	1.277(0), 0.838(25), 0.598(50)
1-Decanol	30.34	0.0732	6.9 to 232	10.9(25), 4.590(50)
1-Decene	25.84	0.0919	−66 to 170.6	0.805(20)
Dibenzylamine	43.27	0.1086	−26 to 300	
Dibenzyl ether	38.2(35)		2 to 298	3.711(25)
p-Dibromobenzene	41.84	0.1007	87.3 to 220	
1,4-Dibromobutane	48.24	0.1190	−20 to 198	
1,2-Dibromoethane	42.85	0.1320	10 to 131.7	1.721(20), 1.286(40), 0.648(100)
1,2-Dibromopropane	36.81	0.1155	−55.5 to 142	1.5(25)
Dibromotetrafluoroethane	18.9(20)	18.1(25)	−110.5 to 47	0.72(25)
Dibutylamine	26.50	0.0952	−62 to 159.6	0.918(25), 0.619(50), 0.449(75)
Dibutyl decanedioate			−10 to 345	9.03(25)
Dibutyl ether	24.78	0.0934	−95 to 140	0.637(25), 0.466(50), 0.356(75)
Dibutyl maleate	32.46	0.0865	< −80 to 281	5.62(20), 4.76(25)
Dibutyl *o*-phthalate	33.40(20)		−35 to 340	19.91(20), 11.17(35), 7.85(45)
Dichloroacetic acid	37.8	0.0927	9 to 194	3.23(50), 1.92(75)
o-Dichlorobenzene	35.55(30)		−17 to 180.4	1.324(25), 0.962(50), 0.739(75)
m-Dichlorobenzene	38.30	0.1147	−24.8 to 173.1	1.044(25), 0.783(50), 0.628(75)
p-Dichlorobenzene	34.66	0.0879	53 to 174.1	0.839(55), 0.668(79)
1,4-Dichlorobutane	37.79	0.1174	−38 to 163	
1,1-Dichloroethane	27.03	0.1186	−97 to 57.3	0.505(15), 0.464(25), 0.362(50)
1,2-Dichloroethane	35.43	0.1428	−35.7 to 83.5	1.125(0), 0.779(25), 0.576(50)
1,1-Dichloroethylene			−122.6 to 31.6	0.442(0), 0.358(20)
cis-1,2-Dichloroethylene	28(20)		−80.1 to 60	0.785(−25), 0.575(0), 0.444(25)
trans-1,2-Dichloroethylene	25(20)		−49.8 to 48.7	0.522(−25), 0.398(0), 0.317(25)
2,2′-Dichloroethyl ether	40.57	0.1306	up to 178.5	2.41(20), 2.065(25)

TABLE 5.16 Viscosity and Surface Tension of Various Organic Substances (*Continued*)

Substance	Surface tension, $mN \cdot m^{-1}$		Liquid range, °C	Viscosity, $mN \cdot s \cdot m^{-2}$
	a	*b*		
Dichloromethane	30.41	0.1284	−95 to 40	0.533(0), 0.449(15), 0.393(30)
2,4-Dichlorophenol	46.59	0.1221	42 to 210	
1,2-Dichloropropane	31.42	0.1240	−100 to 96	0.865(20), 0.700(25)
1,3-Dichloropropane	36.40	0.1233	−99.5 to 122	
2,2-Dichloropropane	23.60(20)	22.53(30)	−35 to 69	0.769(15), 0.619(30)
α,α-Dichlorotoluene	41.26	0.1035	−16 to 205	
Diethanolamine			28 to 269	368(30), 109.5(50), 28.7(75)
1,1-Diethoxyethane	23.46	0.1030	−100 to 102.2	
1,2-Diethoxyethane			−74 to 121.4	0.65(20)
Dimethoxymethane	23.87	0.1291	up to 88	
Diethylamine	22.71	0.1143	−50 to 55.5	
N,*N*-Diethylaniline	36.59	0.1040	−38 to 217	3.838(0), 1.15(50), 0.750(75)
Diethyl carbonate	28.62	0.1100	−43 to 126	0.868(15), 0.748(25)
Diethyl decanedioate	34.68	0.0959		
Diethyl ether	18.92	0.0908	−116 to 34.6	0.283(0), 0.224(25)
Diethyl ethyl phosphonate	30.63	0.0975	up to 198	1.627(15), 0.969(45), 0.743(65)
Di(2-ethylhexyl) *o*-phthalate			−50 to 384	33.67(35), 21.40(45)
Diethyl maleate	34.67	0.1039	−8.8 to 225.3	3.57(20), 3.14(25)
Diethyl 1,3-propanedioate (malonate)	33.91	0.1042	−49.9 to 199.3	2.15(20), 1.94(25)
Diethyl oxalate	34.32	0.1119	−40.6 to 185.4	2.311(15), 1.618(30)
Diethyl *o*-phthalate	38.47	0.0963	−40 to 295	9.18(35), 6.41(45)
Diethyl succinate	33.97	0.1041	−21 to 217.7	
Diethyl sulfate	35.47	0.0976	−25 to 208	
Diethyl sulfide	27.33	0.1106	−104 to 92.1	0.558(0), 0.422(25)
1,2-Dihydroxybenzene	47.6	0.0849	104 to 245.5	
1,3-Dihydroxybenzene	54.8	0.0717	110 to 276	
Diiodomethane	70.21	0.1613	6 to 181	
Diisobutylamine	24.00	0.0912	−77 to 139	
Diisopentyl ether	24.76	0.0871	up to 172.5	1.40(11), 1.012(20)
Diisopropylamine	21.03	0.1077	−61 to 83.5	0.393(25), 0.300(50), 0.237(75)
Diisopropyl ether	19.89	0.1048	−87 to 68	0.379(25)
1,2-Dimethoxybenzene	34.4	0.0642	22.5 to 206	3.281(25), 2.184(40)
1,1-Dimethoxyethane	23.90	0.1159	−113 to 64.5	
1,2-Dimethoxyethane	48.0(25)		−68 to 85	0.670(−10), 0.530(10), 0.455(25)
Dimethoxymethane	23.59	0.1199	−104.8 to 42	0.340(15), 0.325(20)
N,*N*-Dimethylacetamide	32.40(30)	29.50(50)	−20 to 165.5	1.956(25), 1.279(50), 0.896(75)
Dimethylamine	29.50	0.1265	−92 to 6.9	0.300(−25), 0.232(0)
N,*N*-Dimethylaniline	38.14	0.1049	2.5 to 194	1.300(25), 0.911(50), 0.675(75)
2,4-Dimethylaniline	39.34	0.0996	−14 to 214	
2,2-Dimethylbutane	18.29	0.0990	−100 to 49.7	0.351(25), 0.330(30)
2,3-Dimethylbutane	19.38	0.1000	−128 to 58	0.361(25), 0.342(30)
2,3-Dimethyl-1-butanol	26.22	0.0992	−14 to 118	
Dimethyl carbonate	31.94	0.1343	0.5 to 91	
1,1-Dimethylcyclopentane	23.78	0.1016	−70 to 87.5	
Dimethyl ether	14.97	0.1478	−141 to −24.9	
N,*N*-Dimethylformamide	36.76(20)	34.40(40)	−60 to 153	1.176(0), 0.794(25), 0.624(50)
2,4-Dimethylheptane	23.21	0.0929	< −100 to 133	
2,5-Dimethylheptane	23.21	0.0929	< −100 to 136	

TABLE 5.16 Viscosity and Surface Tension of Various Organic Substances (*Continued*)

Substance	Surface tension, $mN \cdot m^{-1}$		Liquid range, °C	Viscosity, $mN \cdot s \cdot m^{-2}$
	a	*b*		
2,6-Dimethylheptane	22.17	0.0887	−103 to 135	
Dimethyl hexanedioate	38.26	0.1138	8 to >112	14(20)
Dimethyl maleate	40.73	0.1220	−19 to 202	3.54(20), 3.21(25)
Dimethyl malonate	39.72	0.1208	−62 to 181	
2,2-Dimethylpentane	19.94	0.0957	−124 to 79	
2,3-Dimethylpentane	21.96	0.0995	up to 90	0.406(20)
2,4-Dimethylpentane	20.09	0.0972	−120 to 80.4	0.361(20)
3,3-Dimethylpentane	21.59	0.0996	−135 to 86	
2,4-Dimethylphenol	34.57	0.0869	24.5 to 211	
2,5-Dimethylphenol	36.72	0.0850	74.5 to 211.5	1.55(80)
3,4-Dimethylphenol	35.75	0.0910	61 to 227	3.00(80)
3,5-Dimethylphenol	34.09	0.0807	64 to 222	2.42(80)
Dimethyl *o*-phthalate			5.5 to 284	14.4(25), 5.309(50), 2.824(75)
2,2-Dimethylpropane	12.05(20)	10.98(30)	−16.6 to 9.5	0.328(0), 0.303(5)
Dimethyl succinate	39.00	0.1191	19 to 196.4	
Dimethyl sulfate	41.26	0.1163	−31.8 to 188	
Dimethyl sulfide	26.07	0.0805	−98 to 37	0.356(0), 0.289(20), 0.265(36)
Dimethyl sulfite	36.48	0.1253	up to 127	0.715(30), 0.436(80)
Dimethyl sulfoxide	43.54(20)	42.41(30)	18.5 to 189	2.47(20), 1.192(55), 0.849(80)
1,4-Dioxane	36.23	0.1391	11.8 to 101.2	1.439(15), 1.087(30), 0.787(50)
Dipentyl ether	26.66	0.0925	−69 to 190	1.188(15), 0.922(30)
Dipentyl *o*-phthalate	32.56	0.0739		17.03(35), 11.51(45)
Dipentyl sulfide	29.55	0.0876		
Dipentylamine	45.36	0.1017	53 to 302	4.66 (55), 1.04(130)
Diphenyl ether	28.70	0.0780	27 to 258	2.130(50), 1.407(75), 1.023(100)
1,2-Dipropoxyethane	25.03	0.0972		
Dipropoxymethane	25.17	0.0953		
Dipropylamine	24.86	0.1022	−63 to 109	0.517(25), 0.377(50), 0.288(75)
Dipropyl carbonate	28.94	0.1015	up to 168	
Dipropylene glycol butyl ether	28.2(25)		up to >103	4.23(25)
Dipropylene glycol ethyl ether	27.7(25)			3.11(25)
Dipropylene glycol isopropyl ether	25.9(25)		up to 80	386(25)
Dipropylene glycol methyl ether	28.8(25)		−117 to 188	3.1(25)
Dipropyl ether	22.60	0.1047	−126 to 89.6	0.542(0), 0.396(25), 0.304(50)
Dodecane	27.12	0.0884	−10 to 216	2.277(0), 1.378(25), 0.930(50)
1-Dodecanol	31.25	0.0748	24 to 259	
Epichlorohydrin	39.76	0.1360	−26 to 117	1.20(25)
1,2-Epoxybutane	23.9(20)		−150 to 63	0.419(15), 0.358(30)
1,2-Ethanediamine	44.77	0.1398	11 to 117.3	1.54(20), 1.226(30)
1,2-Ethanediol	50.21	0.0890	−12.6 to 197.3	26.09(15), 13.55(30)
Ethanesulfonic acid	45.74	0.0824	−17 to >123	
Ethanesulfonyl chloride	43.43	0.1177	up to 177	
Ethanethiol	25.06	0.0793	−148 to 35	0.364(0), 0.287(25)
Ethanol	24.05	0.0832	−114 to 78	1.786(0), 1.074(25), 0.694(50)
Ethanolamine	51.11	0.1117	10.5 to 171	21.1(25), 8.560(50), 3.935(75)
Ethoxybenzene (phenetol)	35.17	0.1104	−29.5 to 170	1.364(15), 1.197(25), 0.817(50)
2-Ethoxyethanol	30.59	0.0897	−70 to 135	2.04(20), 1.85(25)
Ethyl acetate	26.29	0.1161	−84 to 77	0.578(0), 0.423(25), 0.325(50)

TABLE 5.16 Viscosity and Surface Tension of Various Organic Substances (*Continued*)

Substance	Surface tension, $mN \cdot m^{-1}$		Liquid range, °C	Viscosity, $mN \cdot s \cdot m^{-2}$
	a	*b*		
Ethyl acetoacetate	34.42	0.1015	−45 to 181	1.419(20), 1.508(25)
Ethylamine	22.63	0.1372	−81 to 16.6	
N-Ethylaniline	39.00	0.1070	−63.5 to 203	2.047(25), 1.231(50), 0.825(75)
Ethylbenzene	31.48	0.1094	−95 to 136	1360.631(25), 0.482(50), 0.380(75)
Ethyl benzoate	37.16	0.1059	−35 to 212	2.407(15), 1.751(30)
Ethyl butanoate	26.55	0.1045	−98 to 121	0.771(15), 0.613(25)
2-Ethylbutanoic acid	26.3(20)		−14 to 194	3.3(20)
2-Ethyl-1-butanol	25.06(15)	24.32(25)	< −15 to 146	8.021(15), 5.892(25)
Ethyl carbamate			50 to 184	0.916(105), 0.715(120)
Ethyl chloroacetate	34.18	0.1177	−21 to 144	
Ethyl chloroformate	28.90	0.1084	−81 to 93	
Ethyl *trans*-cinnamate	39.99	0.1045	10 to 271	8.7(20)
Ethyl crotonate	29.31	0.1066	up to 138	
Ethyl cyanoacetate	38.80	0.1092	−22 to 206	3.256(15), 2.148(30)
Ethylcyclohexane	27.78	0.1054	−111 to 132	1.139(0), 0.784(25), 0.579(50)
Ethyl dichloroacetate	34.89	0.1158	up to 155	
Ethyl dodecanoate	30.05	0.0863	−10 to 271	
Ethylene carbonate			36 to 248	1.85(40)
Ethylenediamine	44.77	0.1398	11 to 117	1.540(18)
Ethylene glycol	50.21	0.0890	up to 198	26.09(15), 13.35(30), 6.554(50)
Ethyleneimine	7.9(20)		−78 to 56	0.418(25)
Ethylene oxide	27.66	0.1664	−111 to 10.6	0.3(0)
Ethyl formate	26.47	0.1315	−80 to 54	0.419(15), 0.358(30), 0.300(50)
Ethyl fumarate	33.90	0.1056	68 to >148	
Ethylhexadecanoate	32.86	0.0859	22 to >191	
Ethyl hexanoate	27.73	0.0960	up to 168	
2-Ethyl-1-hexanol	30.0(22)		−70 to 185	6.271(25), 2.631(50), 1.360(75)
Ethyl isobutanoate	25.33	0.1046	−88 to 110	
Ethyl isothiocyanate	38.69	0.1326	−6 to 132	
Ethyl lactate	30.72	0.0983	−26 to 155	2.44(25)
Ethyl 3-methylbutanoate	25.79	0.1006	−99 to 135	
Ethyl methyl ether	18.56	0.1317	−113 to 7.4	
Ethyl methyl sulfide	27.63	0.1286	−106 to 67	0.373(20), 0.354(25)
Ethyl nitrate	30.81	0.1345	−95 to 88	
3-Ethylpentane	22.52	0.1032	−119 to 93.5	
Ethyl pentanoate	27.15	0.0999	−91 to 145	0.847(20)
Ethyl propanoate	26.72	0.1168	−74 to 99	0.564(15), 0.473(30), 0.380(50)
Ethyl propyl ether	21.92	0.1054	−79 to 63	0.401(0), 0.323(20), 0.225(60)
Ethyl salicylate	31.00	0.1091	2 to 234	1.772(45)
Ethyl thiocyanate	37.28	0.1226	up to 145	
o-Ethyltoluene	32.33	0.1060	−81 to 165	
p-Ethyltoluene	30.98	0.1075	−62 to 162	
Ethyl trichloroacetate	32.97	0.1073	up to 168	
Fluorobenzene	29.67	0.1204	−42 to 85	0.620(15), 0.517(30), 0.423(50)
1-Fluorohexane	23.41	0.1001	−103 to 93	
1-Fluoropentane	22.81	0.1315	−120 to 63	
o-Fluorotoluene			−62 to 115	0.680(20), 0.601(30)
m-Fluorotoluene	32.31	0.1257	−87 to 115	0.608(20), 0.534(30)
p-Fluorotoluene	30.44	0.1109	−56 to 117	0.622(20), 0.522(30)

TABLE 5.16 Viscosity and Surface Tension of Various Organic Substances (*Continued*)

Substance	Surface tension, $mN \cdot m^{-1}$		Liquid range, °C	Viscosity, $mN \cdot s \cdot m^{-2}$
	a	*b*		
Formamide	59.13	0.0842	2.6 to 220	4.320(15), 2.296(30), 1.833(50)
Formanilide	44.30	0.0875	47 to 271	1.65(120)
Formic acid	39.87	0.1098	8 to 101	1.966(15), 1.607(25), 1.030(50)
Furan	24.10(20)	23.38(25)	−86 to 31	0.380(20), 0.361(25)
2-Furancarboxaldehyde	46.41	0.1327	−36.5 to 162	2.501(0), 1.587(25), 1.143(50)
2-Furanmethanol	ca. 38(20)		−31 to 171	4.62(25)
Glycerol	63.14(17)	62.5(25)	18 to 290	934(25), 152(50), 39.8(75)
Glycerol tris(acetate)	37.88	0.081		
Glycerol tris(nitrate)	55.74	0.2504	13 to >160	36.0(20), 13.6(40)
Glycerol tris(oleate)	36.03	0.0699	−5 to >233	
Glycerol tris(palmitate)	32.26	0.0672	65 to 320	
Glycerol tris(sterate)	32.73	0.0685		
Heptanal	28.64	0.0920	−43 to 153	0.977(15)
Heptane	22.10	0.0980	−91 to 98	0.523(0), 0.416(20), 0.341(40)
Heptanoic acid	29.88	0.0848	−8 to 222	3.84(25), 2.282(50), 1.488(75)
1-Heptanol			−34 to 176	8.53(15), 5.810(25), 2.603(50)
2-Heptanol			up to 159	3.955(25), 1.799(50), 0.987(75)
3-Heptanol			−70 to 157	1.957(50), 0.976(75), 0.584(100)
4-Heptanol				4.207(25), 1.695(50), 0.882(75)
2-Heptanone	28.76	0.1056	−35 to 151	0.854(15), 0.686(30), 0.407(50)
4-Heptanone	28.11	0.1060	−32 to 143.7	0.736(20)
1-Heptene	22.28	0.0991	−120 to 93.6	0.441(0), 0.340(25), 0.273(50)
Heptylamine	25.96	0.0783	−23 to 156	1.314(25), 0.865(50), 0.600(75)
Hexadecane	29.18	0.0854	18.2 to 286.8	3.032(25), 1.879(50), 1.260(75)
1,5-Hexadiene	20.93	0.1028	−140.7 to 59.5	0.275(20), 0.244(36)
Hexafluorobenzene	22.6(20)		5.1 to 80.3	2.789(25), 1.730(50), 1.151(75)
Hexamethyldisiloxane	17.01	0.0763	−67 to 101	
Hexamethylphosphoramide	33.8(20)		7 to 232	3.47(20)
Hexane	20.44	0.1022	−95.4 to 68.7	0.405(0), 0.313(20), 0.271(40)
Hexanenitrile	29.64	0.0907	−80 to 163.6	1.041(15), 0.830(30), 0.650(50)
Hexanoic acid	28.05(20)	27.55(25)	−3 to 205	3.525(15), 2.511(30)
1-Hexanol	27.81	0.0801	−44.6 to 157.5	6.203(15), 3.872(30), 2.271(50)
2-Hexanone	28.18	0.1092	−55.5 to 127.6	0.584(25), 0.429(50), 0.329(75)
1-Hexene	20.47	0.1027	−140 to 63.5	0.326(0), 0.252(25), 0.202(50)
Hexyl acetate	28.44	0.0970	−81 to 171	
4-Hydroxy-4-methyl-2-pentanone	31.0(20)		−44 to 168	6.621(0), 2.798(25), 1.829(50)
Iodobenzene	41.52	0.1123	−31 to 188	1.554(25), 1.117(50), 0.854(75)
1-Iodobutane	30.82	0.1031	−103.5 to 131	
2-Iodobutane	30.32	0.1056	−104 to 120	
Iodoethane	31.67	0.1286	−111 to 72.4	0.617(15), 0.540(30), 0.444(50)
1-Iodoheptane	32.18	0.0887	−48 to 204	
1-Iodohexadecane	34.49	0.0880	23 to >207	
1-Iodohexane	31.63	0.0845	up to 180	
Iodomethane	33.42	0.1234	−66.5 to 42.5	0.594(0), 0.500(20), 0.424(40)
1-Iodo-2-methylpropane	30.26	0.1072	−93.5 to 121	0.875(20), 0.697(40)
1-Iodooctane	32.51	0.0915	−46 to 226	
1-Iodopentane	31.41	0.1014	−85 to 155	
1-Iodopropane	31.64	0.1136	−101 to 102.6	0.837(15), 0.670(30), 0.541(50)

TABLE 5.16 Viscosity and Surface Tension of Various Organic Substances (*Continued*)

Substance	Surface tension, $mN \cdot m^{-1}$		Liquid range, °C	Viscosity, $mN \cdot s \cdot m^{-2}$
	a	*b*		
2-Iodopropane	29.35	0.1107	−90 to 89.5	0.732(15), 0.620(30), 0.506(50)
p-Iodotoluene	39.23	0.0965	up to 211	
α-Ionone	34.10	0.0949	>124	
β-Ionone	35.36	0.0950	>128	
Isobutanenitrile	24.93(20)	23.84(30)	−71.5 to 104	0.551(15), 0.456(30)
Isobutyl acetate	25.59	0.1013	−99 to 116.5	0.676(25), 0.493(50), 0.370(75)
Isobutylamine	24.48	0.1092	−86.6 to 68	0.770(0), 0.571(25), 0.367(50)
Isobutylbenzene	29.39	0.0961	−51.5 to 172.8	
Isobutyl formate	26.14	0.1122	−95.5 to 98.4	0.680(20)
Isobutyl propanoate	30.92	0.1270	−71 to 137	
Isopentyl acetate	26.75	0.0989	−78.5 to 142	0.872(20), 0.790(25)
Isophorone			−8.1 to 215.2	4.201(0), 2.329(25), 1.415(50)
Isopropyl acetate	24.44	0.1072	−73 to 89	0.559(20)
Isopropylamine	19.91	0.0972	−95 to 31.7	0.454(0), 0.325(25)
Isopropylbenzene	30.32	0.1054	−96 to 154	1.075(0), 0.737(25), 0.547(50)
Isopropyl formate	24.56	0.1147		0.512(20)
Lactonitrile	38.31	0.0960	−40 to >103	2.01(30)
D-Limonene	29.50	0.0929	−96.5 to 178	
(±)-Mandelonitrile	45.90	0.0988	−10 to 170	
Methacrylic acid	26.5(25)		16 to 163	1.32(20)
Methacrylonitrile	24.4(20)		−35.8 to 90.3	0.392(20)
Methanesulfonic acid	52.28	0.0893	20 to >167	
Methanethiol	28.09	0.1696	−123 to 6.0	
Methanol	24.00	0.0773	−97.7 to 64.7	0.793(0), 0.676(10), 0.544(25)
o-Methoxybenzaldehyde	45.34	0.1105	37 to 238	
p-Methoxybenzaldehyde	44.69	0.1047	−1 to 248	
Methoxybenzene	38.11	0.1204	−37.5 to 153.8	1.152(15), 1.056(25), 0.747(50)
2-Methoxyethanol	33.30	0.0984	−85.1 to 124	1.71(20), 1.60(25)
2-(2-Methoxyethoxy)ethanol	34.8(25)	29.9(75)	−50 to 194	3.48(25), 1.61(60)
1-Methoxy-2-nitrobenzene	48.62	0.1185	10.5 to 277	
o-Methoxyphenol	41.2	0.0943	28 to 205	
p-Methoxytoluene	36.20	0.1071	up to 174	
N-Methylacetamide	33.67(30)	30.62(50)	30.6 to 206	3.88(30), 2.54(45)
Methyl acetate	27.95	0.1289	−98 to 57	0.477(0), 0.364(25), 0.284(50)
Methyl acetoacetate	34.98	0.0944	27.5 to 171.7	
Methyl acrylate			−76.5 to 80.2	1.398(20)
Methylamine	22.87	0.1488	−93.5 to −6.3	0.319(−25)
N-Methylaniline	39.32	0.0970	−57 to 196	2.042(25), 1.222(50), 0.825(75)
o-Methylaniline				3.823(25), 1.936(50), 1.198(75)
m-Methylaniline				3.306(25), 1.679(50), 1.014(75)
Methyl benzoate	40.10	0.1171	−15 to 199.5	2.298(15), 0.206(20), 1.673(30)
2-Methyl-1,2-butadiene				0.266(0.3), 0.233(20)
2-Methylbutane	17.20	0.1103	up to 30	0.376(−25), 0.277(0), 0.214(25)
Methyl butanoate	27.48	0.1145	−85.8 to 103	0.580(20), 0.459(40), 0.406(50)
3-Methylbutanoic acid	27.28	0.0886	−29.3 to 176.5	2.731(15), 2.411(20)
2-Methyl-1-butanol	21.5(25)		< −70 to 128	5.50(20), 4.453(25), 1.963(50)
2-Methyl-2-butanol	24.18	0.0748	−9.0 to 102.0	5.48(15), 2.81(30)
3-Methyl-1-butanol	25.76	0.0820	−117 to 131	4.81(15), 2.96(30), 1.842(50)
3-Methyl-2-butanol	23.0(25)		up to 112.9	3.51(25)

TABLE 5.16 Viscosity and Surface Tension of Various Organic Substances (*Continued*)

Substance	Surface tension, $mN \cdot m^{-1}$		Liquid range, °C	Viscosity, $mN \cdot s \cdot m^{-2}$
	a	*b*		
2-Methyl-1-butene	18.81	0.1148	−137.6 to 31	
2-Methyl-2-butene	19.70	0.1271	−133.8 to 38.6	
3-Methyl-1-butene	16.42	0.1031	−168 to 20	
2-Methylbutyl acetate	26.75	0.0989	−99 to 117	0.872(20)
3-Methylbutyronitrile	27.58	0.0827	−101 to 129	
Methyl chloroacetate	37.90	0.1304	−32 to 130	
Methyl cyanoacetate	41.32	0.1074	−22.5 to 201	3.824(50), 3.398(55), 2.687(65)
Methylcyclohexane	26.11	0.1130	−126.6 to 100.9	0.679(25), 0.501(50), 0.390(75)
cis-2-Methylcyclohexanol	32.45	0.0770 (mixed isomers)	7 to 165	18.08(25), 13.60(30)
trans-2-Methylcyclohexanol			−2 to 167.5	37.13(25), 25.14(30)
cis-3-Methylcyclohexanol	29.08	0.0629 (mixed isomers)	−6 to 168	19.7(25), 17.23(30)
trans-3-Methylcyclohexanol	28.80(30)		−0.5 to 167	25.62(16), 15.60(30)
cis-4-Methylcyclohexanol	29.07	0.0690 (mixed isomers)	−9.2 to 173	
2-Methylcyclohexanone	34.06	0.1027	up to 162	
3-Methylcyclohexanone	33.06	0.0925	up to 169	
4-Methylcyclohexanone	32.83	0.0935	up to 171	
Methylcyclopentane	24.63	0.1163	−142.2 to 71.8	0.653(0), 0.478(25), 0.364(50)
Methyl decanoate	30.33	0.0912	−18 to 223	
Methyl dichloroacetate	37.00	0.1219	−52 to 143	
Methyl dodecanoate	31.37	0.0893	4.8 to 262	
N-Methylformamide	37.96(30)	35.02(50)	−4 to 199.5	1.678(25), 1.155(50), 0.824(75)
Methyl formate	28.29	0.1572	−99 to 31.7	0.424(0), 0.360(15), 0.325(25)
Methyl heptanoate	28.95	0.0987	−55.8 to 173.5	
4-Methyl-3-heptanol			−123 to 170	1.085(25), 0.702(50), 0.497(75)
5-Methyl-3-heptanol			−91 to 172	1.178(25), 0.762(50), 0.536(75)
Methyl hexadecanoate (palmitate)	31.50	0.0775	32 to >196	
2-Methylhexane	21.22	0.0966	−118 to 90	0.378(20)
3-Methylhexane	21.73	0.0970	−119 to 92	0.372(20), 0.350(25)
Methyl hexanoate	28.47	0.1045	−71 to 151	
Methyl isobutanoate	25.99	0.1131	−84.7 to 92.5	0.672(0), 0.523(20), 0.419(40)
1-Methyl-4-isopropylbenzene (*p*-cymene)	28.83	0.0877		3.402(20)
Methyl methacrylate	28-29(30)		−48 to 100	0.632(20)
1-Methylnaphthalene	39.96	0.0934	−30.4 to 245	
Methyl octadecanoate	32.20	0.0775	38 to >215	
2-Methyloctane	23.76	0.0940	−80.3 to 143.2	
4-Methyloctane	24.22	0.0940	−113 to 142	
Methyl octanoate	29.93	0.1002	−40 to 192.9	
Methyl oleate	31.3(25)	25.4(100)	−19.9 to >218	4.88(20)
2-Methylpentane	19.37	0.0997	−154 to 60.3	0.372(0), 0.286(25), 0.226(50)
3-Methylpentane	20.26	0.1060	−163 to 63	0.395(0), 0.307(25), 0.292(30)

TABLE 5.16 Viscosity and Surface Tension of Various Organic Substances (*Continued*)

Substance	Surface tension, mN · m^{-1}		Liquid range, °C	Viscosity, mN · s · m^{-2}
	a	*b*		
4-Methylpentanenitrile	28.89	0.0917	−51.1 to 156.5	0.980(20), 0.843(30)
Methyl pentanoate	27.85	0.1044	up to 128	0.713(20)
2-Methyl-1-pentanol	26.98	0.0819	up to 148	
3-Methyl-1-pentanol	26.92	0.0789	up to 153	
4-Methyl-1-pentanol	25.93	0.0743	up to 152	
2-Methyl-2-pentanol	25.07	0.0861	−103 to 121	
3-Methyl-2-pentanol	27.14	0.0919	up to 134	
4-Methyl-2-pentanol	24.67	0.0821	−90 to 122	4.074(25)
2-Methyl-3-pentanol	26.43	0.0914	up to 126	
3-Methyl-3-pentanol	25.48	0.0888	−23.6 to 123	
4-Methyl-2-pentanone	23.64(20)	19.62(60)	−84 to 116.5	0.585(20), 0.522(30), 0.406(50)
Methyl phenyl sulfide	42.81	0.1238	−15 to 188	
N-Methyl propanamide	31.29(20)	29.12(50)	−43 to >146	6.06(20), 4.58(30), 3.56(40)
2-Methylpropanenitrile			−72 to 108	0.551(15), 0.456(30)
Methyl propanoate	27.58	0.1258	−88 to 80	0.581(0), 0.431(25), 0.333(50)
2-Methylpropanoic acid	25.55(20)	25.13(25)	−47 to 154	1.857(0), 1.226(25), 0.863(50)
2-Methyl-1-propanol	24.53	0.0795	−108 to 108	4.70(15), 2.876(30)
2-Methyl-2-propanol	20.02(15)	19.10(30)	25.8 to 82.4	1.421(50), 0.678(75)
2-Methylpropene	14.84	0.1319	−140 to −6.9	
1-Methylpropyl acetate	25.72	0.1054		
2-Methyl-1-propylamine	24.48	0.1092	−87 to 68	21.7(25)
2-Methylpropyl formate	26.14	0.1122	−96 to 98	0.680(20)
2-Methylpyridine	36.11	0.1243	−66.7 to 129	0.805(20), 0.710(30)
3-Methylpyridine	37.35	0.1153	−18.3 to 144	
4-Methylpyridine	37.71	0.1141	3.8 to 145	
N-Methyl-2-pyrrolidinone			−24.4 to 202	1.666(25)
Methyl salicylate	42.15	0.1174	−8 to 223	1.102(75), 0.815(100)
Methyl tetradecanoate	31.00	0.0800	18.4 to 323	
2-Methyltetrahydrofuran			< −75 to 78	0.777(−20), 0.601(0), 0.536(10)
Methyl thiocyanate	40.66	0.1305	−5 to 133	64.3(0)
Morpholine	37.63(20)	36.24(30)	−4.9 to 128	2.53(15), 1.79(30), 1.247(50)
Naphthalene			80 to 217.7	0.967(80), 0.780(100)
p-Nitroaniline	60.62	0.0923	147 to 332	
Nitrobenzene	48.62	0.1185	5.8 to 210.8	2.165(15), 1.863(25), 1.262(50)
Nitroethane	35.27	0.1255	−90 to 114	0.940(0), 0.688(25), 0.526(50)
Nitromethane	40.72	0.1678	−28.4 to 101.2	0.692(15), 0.596(30), 0.481(50)
1-Nitro-2-methoxybenzene	48.62	0.1185	95 to 273	
o-Nitrophenol	47.35	0.1174	45 to 216	2.343(45)
1-Nitropropane	32.62	0.1009	−108 to 131.1	0.798(25), 0.589(50), 0.460(75)
2-Nitropropane	32.18	0.1158	−91.3 to 120.3	0.750(25)
o-Nitrotoluene	44.10	0.1174	−10 to 222	2.37(20), 1.63(40)
m-Nitrotoluene	43.54	0.1118	15.5 to 231.9	0.233(20), 1.60(40)
p-Nitrotoluene	42.26	0.0974	52 to 238	1.20(60)
Nonane	24.72	0.0935	−53.5 to 150.8	0.964(0), 0.666(25), 0.488(50)
Nonanoic acid			12.5 to 254.5	7.011(25), 3.712(50), 2.234(75)
1-Nonanol	29.79	0.0789	−5.5 to 215	14.3(20), 9.123(25), 4.032(50)
5-Nonanone	28.72	0.0975	−50 to 187	1.199(25), 0.834(50), 0.619(75)
1-Nonene	24.90	0.0938	−81 to 146	0.620(20), 0.586(25)
Octadecane	29.98	0.0843	28.1 to 316.3	2.487(50), 1.609(75), 1.132(100)

TABLE 5.16 Viscosity and Surface Tension of Various Organic Substances (*Continued*)

Substance	Surface tension, $mN \cdot m^{-1}$		Liquid range, °C	Viscosity, $mN \cdot s \cdot m^{-2}$
	a	*b*		
Octamethylcyclotetrasiloxane	20.19	0.0811	17 to 176	2.20(20)
Octane	23.52	0.0951	−56.8 to 125.7	0.546(20), 0.433(40), 0.355(60)
Octanenitrile	29.61	0.0802	−45.6 to 205	1.811(15), 1.356(30)
Octanoic acid	29.21(20)	28.7(25)	16.6 to 239	5.020(25), 2.656(50), 1.654(75)
1-Octanol	29.09	0.0795	−15.5 to 195	10.64(15), 6.125(30), 3.232(50)
2-Octanol	27.96	0.0820	−31.6 to 180	
1-Octene	23.68	0.0958	−102 to 121	0.470(20), 0.447(25)
Oleic acid	32.80(20)	27.94(90)	13.4 to 360	38.80(20), 27.64(25)
4-Oxopentanoic acid	41.69	0.0763	33 to 246	
Paraldehyde	28.28	0.1062	12.6 to 124	1.079(25), 0.692(50), 0.485(75)
Parathion	39.2(25)		6 to 375	15.30(25)
Pentachloroethane	37.09	0.1178	−29.9 to 160	2.741(15), 2.070(30), 1.491(50)
Pentadecane	28.78	0.0857	9.9 to 270	2.814(22)
Pentanal	27.96	0.1010	−92 to 103	
Pentane	18.25	0.1121	−129.7 to 36.0	0.351(−25), 0.274(0), 0.224(25)
1,5-Pentanediol	43.2(20)		−18 to 239	128(20)
2,4-Pentanedione	33.28	0.1144	−23.1 to 138	0.6(20)
Pentanenitrile	27.44(20)	26.33(30)	−92 to 141.3	0.779(15), 0.637(30)
Pentanoic acid	28.90	0.0887	−33.7 to 186	2.359(15), 1.774(30), 0.979(70)
1-Pentanol	27.54	0.0874	−79 to 137.5	4.650(15), 3.619(25), 1.820(50)
2-Pentanol	25.96	0.1004	−73 to 119.3	5.130(15), 2.780(30), 1.447(50)
3-Pentanol	24.60(20)	23.76(30)	−69 to 116	7.337(15), 3.306(30), 1.473(50)
2-Pentanone	24.89	0.0655	−76.8 to 102	0.641(0), 0.473(25), 0.362(50)
3-Pentanone	27.36	0.1047	−39.0 to 102	0.592(0), 0.444(25), 0.345(50)
1-Pentene	18.20	0.1099	−165 to 30.1	0.313(−25), 0.241(0), 0.195(25)
cis-2-Pentene	19.71	0.1172	−151 to 37.0	
trans-2-Pentene	18.90	0.0997	−140 to 36.3	
Pentyl acetate	27.66	0.0994	−70.8 to 149.2	0.924(20), 0.862(25)
Pentylamine	24.4(13)		−55 to 104	1.030(0), 0.702(25), 0.493(50)
Phenol	43.54	0.1069	41 to 182	3.437(50), 1.784(75), 1.099(100)
2-Phenylacetamide	46.26	0.0788	157 to bp	
Phenyl acetate			<45 to 196	1.799(45)
Phenylacetonitrile	44.57	0.1155	−23.8 to 233.5	1.93(25)
1-Phenylethanol	42.88	0.1038	20 to 204	
Phenylhydrazine	48.14	0.1292	19.5 to 243	13.0(25), 4.553(50), 1.850(75)
Phenyl isothiocyanate	42.73	0.1086	−30 to 163	
Phenyl salicylate	45.20	0.0976	44 to >173	
(±)-α-Pinene	28.35	0.0944	−64 to 156	1.61(25)
L-β-Pinene	28.26	0.0934	−61 to 166	1.70(20), 1.41(25)
Piperidine	31.79	0.1153	−11 to 106	1.573(25), 0.958(50), 0.649(75)
1,2-Propanediol (see propylene glycol)				
1,3-Propanediol	47.43	0.0903	−27 to 214	56.0(20), 18.0(40)
Propanenitrile (propionitrile)	29.63	0.1153	−92.8 to 97.2	0.294(25), 0.240(50), 0.202(75)
1-Propanethiol	27.38	0.1272	−113 to 68	0.503(0), 0.385(25)
2-Propanethiol	24.26	0.1174	−131 to 52.6	0.477(0), 0.357(25), 0.280(50)
Propanoic acid	28.68	0.0993	−20.5 to 141.1	1.030(25), 0.749(50), 0.569(75)
Propanoic anhydride	30.30(20)	29.70(25)	−45 to 170	1.144(20), 1.061(25)
1-Propanol	25.26	0.0777	−127 to 97.2	2.522(15), 1.722(30), 1.107(50)

TABLE 5.16 Viscosity and Surface Tension of Various Organic Substances (*Continued*)

Substance	Surface tension, $mN \cdot m^{-1}$		Liquid range, °C	Viscosity, $mN \cdot s \cdot m^{-2}$
	a	*b*		
2-Propanol	22.90	0.0789	−89.5 to 82.4	2.859(15), 1.765(30), 1.028(50)
2-Propen-1-ol (allyl alcohol)	27.53	0.0902	−129 to 98	1.363(20), 0.914(40)
Propionaldehyde (propanal)			−81 to 48	0.357(15), 0.321(25)
Propionamide	39.05	0.0909	79 to 222.2	
Propyl acetate	26.60	0.1120	−93 to 101.6	0.768(0), 0.544(25), 0.406(50)
Propylamine	24.86	0.1243	−83 to 42.2	0.376(25)
Propylbenzene	31.13	0.1075	−99.2 to 159.2	
Propyl benzoate	36.55	0.1069	−51.6 to 98	
Propyl butanoate	27.06	0.1000	−95 to 143	0.831(20)
1,2-Propylene glycol			−60 to 188	40.4(0), 11.3(25), 4.770(50)
Propyleneimine			up to 66	0.491(25)
1,2-Propylene oxide			−112 to 34	0.327(20), 0.28(25)
Propyl formate	26.77	0.1119	−92.9 to 80.9	0.669(0), 0.574(20), 0.417(40)
Propyl isobutanoate	25.83	0.1015	up to 135	0.831(20)
Propyl nitrate	29.67	0.1237	−100 to 110.1	
Propyl pentanoate	27.72	0.0984	−75.9 to 122.5	1.053(20)
Propyl propanoate	26.85	0.1059	−76 to 122.5	0.673(20)
Propyne	14.51	0.1482	−102.8 to −23.2	
2-Propyn-1-ol	38.59	0.1270	−51.8 to 114	1.68(20)
Pyridazine	50.55	0.1036	−8 to 208	
Pyridine	39.82	0.1306	−41.6 to 115.2	1.361(0), 0.879(25), 0.637(50)
Pyrimidine	32.85	0.1010	22 to 124	
Pyrrole	39.81	0.1100	−23.4 to 130	2.085(0), 1.225(25), 0.828(50)
Pyrrolidine	31.48	0.0900	−58 to 86.5	1.071(0), 0.704(25), 0.512(50)
2-Pyrrolidone			25 to 251	13.3(25)
Quinoline	45.25	0.1063	−15 to 237	3.337(25), 1.892(50), 1.201(75)
Salicylaldehyde	45.38	0.1242	−7 to 197	2.90(20), 1.71(30), 1.669(45)
Squalane			−38 to 350	6.08(20)
Squalene			−75 to >285	12(25)
Stearic acid			67 to >184	11.6(70)
Styrene	32.0(20)	30.98(30)	−31 to 145	1.050(0), 0.696(25), 0.507(50)
Succinonitrile	53.26	0.1079	54.5 to 266	2.591(60), 2.008(75)
1,1,2,2-Tetrabromoethane	52.37	0.1463	0 to 243.5	13.50(11), 9.797(20)
1,1,2,2-Tetrachlorodifluoroethane	26.13	0.1133	26.0 to 92.8	1.21(25), 1.208(30)
1,1,2,2-Tetrachloroethane	38.75	0.1268	−70.2 to 130.5	1.844(15), 1.456(30)
Tetrachloroethylene	32.86(15)	31.27(30)	−22 to 121	1.932(15), 0.798(30), 0.654(53)
Tetradecane	28.30	0.0869	5.5 to 253.6	2.128(25), 1.376(50), 0.953(75)
Tetradecanoic acid	33.90	0.0932	54 to >250	
1-Tetradecanol	32.72	0.0703	39.5 to 289	
Tetraethylene glycol	45(25)		−6 to 328	44.9(25)
Tetraethyl lead	30.50	0.0969	−136 to >85	
Tetraethylsilane	25.22	0.1079	−82 to 154.7	
Tetraethyl silicate	23.63	0.0979	−82.5 to 169	
Tetrahydrofuran	26.5(25)		−108.5 to 65	0.605(0), 0.460(25), 0.359(50)
2,5-Tetrahydrofurandimethanol			< −50 to 265	225(25)
Tetrahydro-2-furanmethanol	39.96	0.1008	< −80 to 178	6.24(20)
1,2,3,4-Tetrahydronaphthalene	35.55	0.0954	−35.8 to 207.6	2.202(20), 2.003(25)
Tetrahydropyran			−45 to 88	0.826(20), 0.764(25)

TABLE 5.16 Viscosity and Surface Tension of Various Organic Substances (*Continued*)

Substance	Surface tension, $mN \cdot m^{-1}$		Liquid range, °C	Viscosity, $mN \cdot s \cdot m^{-2}$
	a	*b*		
Tetrahydropyran-2-methanol	34.1(25)		−70 to 187	11.0(20)
Tetrahydrothiophene-1,1-dioxide (sulfolane)	35.5(30)		27.6 to 287.3	9.87(30), 6.280(50), 3.818(75)
Tetrahydrothiophene oxide				52(30), 19(80)
Thiacyclohexane	36.06(20)	33.74(40)		
Thiacyclopentane	38.44	0.1342		1.042(20), 0.971(25)
2,2′-Thiodiethanol	53.8(20)		−10.2 to 282	65.2(20)
Thiophene	34.00	0.1328	−39.4 to 84	0.871(0), 0.662(20), 0.353(82)
Thymol	33.95	0.0821	49 to 232	
Toluene	30.90	0.1189	−94.9 to 110.6	0.623(15), 0.523(30), 0.424(50)
p-Toluenesulfonyl chloride	42.41	0.0903	67 to >134	
o-Toluidine	42.87	0.1094	−16.5 to 200	5.195(15), 4.39(20)
m-Toluidine	40.33	0.0979	−31 to 203	4.418(15), 2.741(30)
p-Toluidine	39.58	0.0957	43.8 to 200	1.945(45), 1.557(60)
m-Tolunitrile	38.85	0.1013	−23 to 210	
p-Tolunitrile	39.79	0.1100	29.5 to 85	
Tribenzylamine	42.41	0.0953	91-94 to bp	
Tribromomethane	48.14	0.1308	8.1 to 149.6	2.152(15), 1.741(30), 1.367(50)
1,2,3-Tribromopropane	47.99	0.1267	16.5 to 220	
Tributylamine	26.47	0.0831	−70 to 216	1.35(25)
Tributyl borate	26.2(20)	25.8(25)	< −70 to 234	1.776(20), 1.601(25)
Tributyl phosphite	27.57	0.0865	up to >125	1.9(25)
Tributyl phosphate	28.71	0.0666	−79 to 289	11.1(15), 3.39(25)
Trichloroacetaldehyde	27.66	0.1197	−57.5 to 97.8	
Trichloroacetic acid	35.4	0.0895	57.5 to 196.5	
1,1,1-Trichloroethane	28.28	0.1242	−30.4 to 74	0.903(15), 0.725(30), 0.578(50)
1,1,2-Trichloroethane	37.40	0.1351	−37 to 114	0.119(20), 0.110(25)
Trichloroethylene	29.5(20)	28.8(25)	−84.8 to 87	0.703(0), 0.545(25), 0.444(50)
Trichlorofluoromethane	18(25)		−111 to 23.8	0.740(−25), 0.539(0)
2,4,6-Trichlorophenol	43.13	0.0955	69 to 246	
1,2,3-Trichloropropane	37.8(20)	37.05(25)	−14.7 to 157	
Trichlorosilane	20.43	0.1076	−127 to 32	0.332(20), 0.316(25)
α,α,α-Trichlorotoluene			−5 to 223	3.07(10), 2.55(17)
1,1,2-Trichloro-1,2,2-trifluoroethane	17.75(20)	16.56(30)	−35 to 47.7	0.711(20), 0.627(30)
Tridecane	27.73	0.0872	−5 to 235	2.909(0), 1.724(25), 1.129(50)
1-Tridecene	28.01	0.0884	−13 to 232.8	
Triethanolamine			20.5 to 335.4	609(25), 114(50), 31.5(75)
Triethylamine	22.70	0.0992	−114.7 to 88.8	0.455(0), 0.347(25), 0.273(50)
Triethylene glycol	47.33	0.0880	−7 to 285	49.0(20), 8.5(60)
Triethyl phosphate	31.81	0.0928	−56 to 215	1.684(40), 1.376(55)
Triethyl phosphite	25.73	0.0878	up to 156	0.72(25)
Trifluoroacetic acid	15.64	0.1844	−15.3 to 73	0.926(20), 0.808(25), 0.571(50)
2,2,2-Trifluoroethanol	20.6(33)		−43.5 to 74	1.996(20)
Trimethylamine	16.24	0.1133	−117 to 2.9	0.321(−33.5)
1,2,3-Trimethylbenzene	30.91	0.1040	−25.4 to 176.1	
1,2,4-Trimethylbenzene	31.76	0.1025	−43.9 to 169	0.894(15), 0.730(30)
1,3,5-Trimethylbenzene	29.79	0.0897	−44.7 to 165	1.154(20)
2,2,3-Trimethylbutane	20.70	0.0973	−24.9 to 80.9	0.579(20)

TABLE 5.16 Viscosity and Surface Tension of Various Organic Substances (*Continued*)

Substance	Surface tension, mN · m^{-1}		Liquid range, °C	Viscosity, mN · s · m^{-2}
	a	*b*		
cis,*cis*-1,3,5-Trimethylcyclohexane				0.632(20), 0.558(30)
trans-1,3,5-Trimethylcyclohexane			−107.4 to 140.5	0.714(20), 0.624(30)
Trimethylene sulfide	36.3(20)	35.0(30)	−73.2 to 95	0.638(20), 0.607(25)
3,5,5-Trimethyl-1-hexanol			< −70 to 194	11.06(25)
2,2,3-Trimethylpentane	22.46	0.0895	−112.3 to 110	0.598(20)
2,2,4-Trimethylpentane	20.55	0.0888	−107.4 to 99.2	0.502(20)
Trimethyl phosphite	27.18(20)	24.88(40)	−78 to 112	0.61(20)
2,4,6-Trimethylpyridine			−46 to 171	1.498(20)
Triphenylamine	46.2	0.0955	125 to 348	
Triphenyl phosphite			22 to 360	6.95(45)
Tripropylamine	24.58	0.0878	−93.5 to 158	
Tripropylene glycol	34(25)		up to 273	56.1(25)
Tripropylene glycol butyl ether	28.8(25)		up to 276	6.58(25)
Tripropylene glycol ethyl ether	28.2(25)			5.17(25)
Tripropylene glycol isopropyl ether	27.4(25)			7.7(25)
Tripropylene glycol methyl ether	30.0(25)		−42 to 242.4	5.96(25)
Tris(*m*-tolyl) phosphite				37.55(15), 9.132(45), 5.075(65)
Tris(*p*-tolyl) phosphite				35.52(15), 8.794(45), 5.017(65)
Tri-*o*-tolyl phosphate	40.9(20)		11 to 410	38.8(35), 16.8(55)
Undecane	26.26	0.0901	−25.6 to 196	1.707(0), 1.098(25), 0.761(50)
Vinyl acetate	23.95(20)	22.54(30)	−93 to 73	0.421(20)
o-Xylene	32.51	0.1101	−25.2 to 145	1.084(0), 0.760(25), 0.561(50)
m-Xylene	31.23	0.1104	−47.9 to 139	0.795(0), 0.581(25), 0.445(50)
p-Xylene	30.69	0.1074	13 to 138	0.603(25), 0.457(50), 0.359(75)

TABLE 5.17 Dielectric Constant (Permittivity) and Dipole Moment of Various Organic Substances

The temperature in degrees Celsius at which the dielectric constant and dipole moment were measured is shown in this table in parentheses after the value. In some cases, the dipole moment was determined with the substance dissolved in a solvent, and the solvent used is also shown in parentheses after the temperature.

The dielectric constant (permittivity) tabulated is the relative dielectric constant, which is the ratio of the actual electric displacement to the electric field strength when an external field is applied to the substance, which is the ratio of the actual dielectric constant to the dielectric constant of a vacuum. The table gives the static dielectric constant ϵ, measured in static fields or at relatively low frequencies where no relaxation effects occur.

The dipole moment is given in debye units D. The conversion factor to SI units is 1 D = 3.33564×10^{-30} C · m.

Alternative names for entries are listed in Table 1.15 at the bottom of each double page.

List of Abbreviations

B, benzene	g, gas
C, CCl_4	Hx, hexane
cHex, cyclohexane	lq, liquid
D, 1,4-dioxane	

Substance	Dielectric constant, ϵ	Dipole moment, D
Acetaldehyde	21.8 (10), 21.0 (18)	2.75
Acetaldehyde oxime	4.70 (25)	0.830 (20, lq), 0.90 (25, B)
Acetamide	67.6 (91)	3.76
Acetanilide		3.65 (25, B)
Acetic acid	6.20 (20)	1.70
Acetic anhydride	23.3 (0), 22.45 (20)	2.8
Acetone	21.0 (20), 20.7 (25), 17.6 (56)	2.88
Acetonitrile	36.64 (20), 26.6 (82)	3.924
Acetophenone	17.44 (25), 8.64 (202)	3.02
(±)-*erythro*-2-Acetoxy-2-bromobutane	7.268 (25)	
(±)-*threo*-2-Acetoxy-2-bromobutane	7.414 (25)	
Acetyl bromide	16.2 (20)	2.43 (20, B)
Acetyl chloride	16.9 (2), 15.8 (22)	2.72
Acetylene	2.484 (−77)	
Acrylonitrile	33.0 (20)	3.87
Allene	2.025 (−4)	
Allylamine		1.2
Allyl alcohol	19.7 (20)	1.61
Allyl isocyanate	15.15 (15)	
Allyl isothiocyanate	17.2 (18)	3.2 (20, B)
Allyl nitrite	9.12 (25)	
2-Aminoethanol	31.94 (20), 37.72 (25)	2.59 (25, D)
2-(2-Aminoethylamino)ethanol	21.81 (20)	
N-(2-Aminoethyl)-1,2-ethanediamine	12.62 (20)	1.9
Aniline	7.06 (20), 5.93 (70)	1.13
Benzaldehyde	19.7 (0), 17.85 (20)	3.0
Benzaldehyde oxime (mp 30)	3.8 (20)	1.2 (25, B)
(mp 128)		1.5 (25, B)
Benzamide		3.42 (25, B)
Benzene	2.292(15), 2.283 (20), 2.274 (25)	0
Benzeneacetonitrile	17.87 (26)	3.5
Benzenesulfonyl chloride	28.90 (50)	4.50 (20, B)
Benzenethiol	4.38 (25), 4.26 (30)	1.13 (25, lq), 1.19 (20, B)
Benzonitrile	25.9 (20), 24.0 (40)	4.18
Benzophenone	14.60 (18), 11.4 (50)	3.09 (50, lq), 2.98 (25, B)

TABLE 5.17 Dielectric Constant (Permittivity) and Dipole Moment of Various Organic Substances (*Continued*)

Substance	Dielectric constant, ϵ	Dipole moment, D
Benzoyl bromide	21.33 (20), 20.74 (25)	3.40 (20, B)
Benzoyl chloride	29.0 (0), 23 (23)	3.16 (25, B)
Benzoyl fluoride	22.7 (20)	
Benzyl acetate	5.1 (21), 5.34 (930)	1.80 (25, B)
Benzyl alcohol	13.0 (20), 11.92 (30), 9.5 (70)	1.71
Benzylamine	5.5 (1), 5.18 (20)	1.15 (20, lq), 1.38 (25, B)
Benzyl benzoate	5.26 (30)	2.06 (30, B)
Benzyl chloride	7.0 (13), 6.85 (25)	1.83 (20, B)
Benzylethylamine	4.3 (20)	
Benzyl ethyl ether	3.90 (25)	
Benzyl formate	6.34 (30)	
N-Benzylmethylamine	4.4 (19)	
Biphenyl	2.53 (75)	0
Bis(2-aminoethyl)amine	12.62 (20)	
Bis(2-chloroethyl) ether	21.20 (20)	2.6
Bis(3-chloropropyl) ether	10.10 (20)	
Bis(2-ethoxyethyl) ether		1.92 (25, B)
Bis(2-hydroxyethyl) ether	31.69 (20)	2.31 (20, B)
Bis(2-hydroxyethyl)sulfide	28.61 (20)	
Bis(2-hydroxypropyl) ether	20.38 (20)	
Bis(2-methoxyethyl) ether	7.23 (25)	
(±)-Bornyl acetate	4.6 (21)	1.89 (22)
3-Bromoaniline	13.0 (20)	2.67 (20, B)
4-Bromoaniline	7.06 (30)	2.88 (25, B)
2-Bromoanisole	8.96 (30)	
4-Bromoanisole	7.40 (30)	
Bromobenzene	5.45 (20), 5.40 (25)	1.70
1-Bromobutane	7.88 (−10), 7.32 (10), 7.07 (20)	2.08
(±)-2-Bromobutane	8.64 (25)	2.23
2-Bromobutanoic acid	7.2 (20)	
cis-2-Bromo-2-butene	5.38 (20)	
trans-2-Bromo-2-butene	6.76 (20)	
1-Bromo-2-chlorobenzene	6.80 (20)	2.15 (20, B)
1-Bromo-3-chlorobenzene	4.58 (20)	1.52 (22, B)
1-Bromo-4-chlorobenzene		0.1 (25, B)
1-Bromo-2-chloroethane	7.41 (10)	1.09
cis-1-Bromo-2-chloroethene	7.31 (17)	
trans-1-Bromo-2-chloroethene	2.50 (17)	
Bromochlorodifluoromethane	3.92 (−150)	
Bromochloromethane	7.79	1.66 (25, B)
3-Bromo-1-chloro-2-methylpropane	8.90 (30)	
Bromocyclohexane	11 (−65), 8.003(30)	1.08 (25, lq), 2.3 (25, B)
1-Bromodecane	4.75 (1), 4.44 (25)	2.08 (20, lq), 1.90 (25, lq)
Bromodichloromethane		1.31 (25, B)
1-Bromododecane	4.07 (25)	2.01 (25, lq), 1.89 (25, B)
Bromoethane	13.6 (−60), 9.39 (20), 9.01 (25)	2.03 (g), 2.04 (20, lq)
1-Bromo-2-ethoxypentane	6.45 (25)	2.32 (25, B)
2-Bromo-3-ethoxypentane	6.40 (25)	2.07 (25, B)
3-Bromo-2-ethoxypentane	8.24 (25)	2.15 (25, B)
1-Bromo-2-ethylbenzene	5.55 (25)	
1-Bromo-3-ethylbenzene	5.56 (25)	
1-Bromo-4-ethylbenzene	5.42 (25)	

TABLE 5.17 Dielectric Constant (Permittivity) and Dipole Moment of Various Organic Substances (*Continued*)

Substance	Dielectric constant, ϵ	Dipole moment, D
Bromoethylene	5.63 (5), 4.78 (25)	1.42
1-Bromo-2-fluorobenzene	4.72 (25)	
1-Bromo-3-fluorobenzene	4.85 (25)	
1-Bromo-4-fluorobenzene	2.60 (25)	
Bromoform	4.39 (20)	1.00, 0.92 (25, lq)
1-Bromoheptane	5.33 (25), 4.48 (90)	2.17, 2.02 (20, lq)
2-Bromoheptane	6.46 (22)	2.08 (20, B)
3-Bromoheptane	6.93 (22)	2.06 (20, B)
4-Bromoheptane	6.81 (22)	2.06 (20, B)
1-Bromohexadecane	3.71 (25)	1.98 (20, lq), 1.96 (25, C)
1-Bromohexane	6.30 (1), 5.82 (25)	2.06 (20, lq)
Bromomethane	9.82 (0), 9.71 (3), 1.0068 (100, g)	1.82
(Bromomethyl)benzene	6.658 (20)	
1-Bromo-3-methylbutane	8.04 (−56), 6.33 (18)	1.95 (20, B)
2-Bromo-2-methylbutane	9.21 (25)	
2-Bromo-3-methylbutanoic acid	6.5 (20)	
1-Bromo-2-methylpropane	10.98 (20), 7.2 (25)	1.92 (25, lq), 1.99 (20, B)
2-Bromo-2-methylpropane	10.98 (20)	
1-Bromonaphthalene	5.83 (25), 5.12 (20)	1.29 (25, lq)
3-Bromonitrobenzene	20.2 (55)	
1-Bromononane	5.42 (−20), 4.74 (25)	1.95 (25, lq)
1-Bromooctane	6.35 (−50)	1.99 (20, lq), 1.88 (25, lq)
1-Bromopentadecane	3.9 (20)	
1-Bromopentane	9.9 (−90), 6.32 (25)	2.20
3-Bromopentane	8.37 (25)	
1-Bromopropane	8.09 (20)	2.18
2-Bromopropane	9.46 (20)	2.21
2-Bromopropanoic acid	11.0 (21)	
3-Bromopropene	7.0 (20)	1.9
2-Bromopyridine	23.18 (25)	
1-Bromotetradecane	3.84 (25)	1.92 (20, lq), 1.83 (25, lq)
o-Bromotoluene	4.64 (20), 4.28 (58)	1.45 (20, B)
m-Bromotoluene	5.566 (20), 5.36 (58)	1.77 (20, B)
p-Bromotoluene	5.503 (20), 5.49 (58)	1.95 (20, B)
Bromotrichloromethane	2.40 (20)	
Bromotrifluoromethane	3.73 (−150)	0.65
1-Bromoundecane	4.73 (−9)	
1,3-Butadiene	2.050 (−8)	0.403
Butanal	13.45 (25)	2.72
Butane	1.7697 (22)	0
1,2-Butanediol	22.4 (25)	
1,3-Butanediol	28.8 (25)	
1,4-Butanediol	33 (15), 31.9 (25), 30 (38)	4.07
1,3-Butanediol dinitrate	18.85 (20)	
2,3-Butanediol dinitrate	28.85 (20)	
1,3-Butanedione	4.04 (25)	
Butanenitrile	24.83 (20)	4.07
Butanesulfonyl chloride		3.94 (25, D)
1,2,3,4-Butanetetrol	28.2 (120)	
1-Butanethiol	5.20 (15), 5.07 (25), 4.59 (50)	1.54 (25, lq or B)
2-Butanethiol	5.645 (15)	
Butanoic acid	2.97 (20)	1.65 (30, B)

TABLE 5.17 Dielectric Constant (Permittivity) and Dipole Moment of Various Organic Substances (*Continued*)

Substance	Dielectric constant, ϵ	Dipole moment, D
Butanoic anhydride	12.8 (20)	
1-Butanol	17.84 (20), 8.2 (118)	1.66
(±)-2-Butanol	17.26 (20), 16.6 (25)	1.66 (30, B)
2-Butanone	18.56 (20), 15.3 (60)	2.78
2-Butanone oxime	3.4 (20)	
trans-2-Butenal		3.67
1-Butene	2.2195 (−53), 1.0032 (20, g)	0.438
cis-2-Butene	1.960 (23)	0.253
trans-2-Butene		0
3-Butenenitrile	28.1 (20)	4.53
2-Butoxyethanol	9.43 (25)	2.08 (25, B)
Butoxyethyne	6.62 (25)	2.05 (25, lq)
N-Butylacetamide	104.0 (20)	
N-*sec*-Butylacetamide	100.0 (100)	
Butyl acetate	6.85 (−73), 5.07 (20)	1.86 (22, B)
sec-Butyl acetate	5.135 (20)	1.9
tert-Butyl acetate	5.672 (20)	1.91 (25, B)
tert-Butylacetic acid	2.85 (23)	
Butyl acrylate	5.25 (28)	
Butylamine	4.71 (20)	1.00
sec-Butylamine	4.4 (21)	1.28 (25, B)
tert-Butylamine		1.29 (25, B)
Butylbenzene	2.36 (20)	0
sec-Butylbenzene	2.36 (20)	0
tert-Butylbenzene	2.36 (20)	0.83
Butyl butanoate	4.39 (25)	
Butyl ethyl ether		1.24
Butyl formate	6.10 (30), 2.43 (80)	2.08 (26, lq), 2.03 (25, B)
Butyl isocyanate	12.29 (20)	
Butyl methyl ether		1.25 (25, B)
2-*tert*-Butyl-4-methylphenol		1.31 (20, B)
Butyl nitrate	13.10 (20)	2.99 (20, B)
tert-Butyl nitrite	11.47 (25)	
Butyl oleate	4.00 (25)	
N-Butylpropanamide	100.6 (25)	
Butyl propanoate	4.838 (20)	1.79 (23, B)
4-*tert*-Butylpyridine		2.87 (25, C)
Butylsilane	2.537 (20)	
Butyl stearate	3.11 (30)	1.88 (24, B)
Butyl trichloroacetate	7.480 (20)	
Butyl vinyl ether		1.25 (25, Hx)
4-Butyrolactone	39.0 (20)	4.27
Camphor	11.35 (20)	2.91 (20, B), 3.10 (25, B)
Carbon disulfide	3.0 (−112), 2.64 (20)	0
Carbon tetrachloride	2.24 (20), 2.228 (25)	0
Carbon tetrafluoride	1.0006 (25, g)	0
D-(+)-Carvone	11 (22)	2.8 (15, B)
Chloroacetic acid	20 (20), 12.35 (65)	2.31 (30, B)
o-Chloroaniline	13.40 (20)	1.78 (20, B)
m-Chloroaniline	13.3 (20)	2.68 (20, B)
p-Chloroaniline		2.99 (25, B)
Chlorobenzene	5.69 (20), 4.2 (120)	1.69

TABLE 5.17 Dielectric Constant (Permittivity) and Dipole Moment of Various Organic Substances (*Continued*)

Substance	Dielectric constant, ϵ	Dipole moment, D
2-Chloro-1,3-butadiene	4.914 (20)	
1-Chlorobutane	9.07 (−30), 7.276 (20)	2.05 (g), 2.0 (20, B)
2-Chlorobutane	8.564 (20), 7.09 (30)	2.04 (g), 2.1 (20, B)
Chlorocyclohexane	10.9 (−47), 7.951 (30)	2.2 (25, B)
Chlorodifluoromethane	6.11 (24)	1.42 (g)
2-Chloro-*N*,*N*-dimethylacetamide	39.2 (25)	
1-Chlorododecane	4.2 (20)	2.11 (25, lq), 1.94 (20, B)
1-Chloro-2,3-epoxypropane	25.6 (1), 22.6 (22)	1.8 (25, C)
Chloroethane	1.013 (19, g), 9.45 (20)	2.05
2-Chloroethanol	25.80 (20), 13 (132)	1.78
(2-Chloro)ethylbenzene	4.36 (25)	
(3-Chloro)ethylbenzene	5.18 (25)	
(4-Chloro)ethylbenzene	5.16 (25)	
2-Chlorofluorobenzene	6.10 (25)	
3-Chlorofluorobenzene	4.96 (25)	
4-Chlorofluorobenzene	3.34 (25)	
Chloroform	4.807 (25), 4.31 (50)	1.04
1-Chloroheptane	5.52 (20)	1.86 (22, B)
2-Chloroheptane	6.52 (22)	2.05 (22, B)
3-Chloroheptane	6.70 (22)	2.06 (22, B)
4-Chloroheptane	6.54 (22)	2.06 (22, B)
1-Chlorohexane	6.104 (20)	1.94 (20, B)
6-Chloro-1-hexanol	21.6 (−31)	
1-Chloro-2-isocyanatoethane	29.1 (15)	
Chloromethane	1.0069 (g), 12.6 (−20), 10.0 (22)	1.892
1-Chloro-3-methylbutane	7.63 (−70), 6.05 (20)	1.94 (20, B)
2-Chloro-2-methylbutane	12.31 (−50)	
4-Chloromethyl-1,3-dioxolan-2-one	97.5 (40)	
Chloromethyl methyl ether		1.88 (C)
(Chloromethyl)oxirane	22.6 (20)	1.8
1-Chloro-2-methylpropane	7.87 (−38), 7.027 (20)	2.00
2-Chloro-2-methylpropane	10.95 (0), 9.66 (20)	2.13
1-Chloronaphthalene	5.04 (25)	1.33 (25, lq), 1.52 (25, B)
o-Chloronitrobenzene	37.7 (50), 32 (80)	4.64
m-Chloronitrobenzene	20.9 (50), 18 (80)	3.73
p-Chloronitrobenzene	8.09 (120)	2.83
2-Chloro-2-nitropropane	31.9 (−23)	
4-Chloro-3-nitrotoluene	28.07 (28)	
1-Chlorooctane	5.05 (25)	2.14 (25, lq)
Chloropentafluoroethane		0.52
1-Chloropentane	6.654 (20)	2.16
o-Chlorophenol	7.40 (21), 6.31 (25)	2.19
m-Chlorophenol	6.255 (20)	2.19 (25, B)
p-Chlorophenol	11.18 (41)	2.11
1-Chloropropane	8.59 (20)	2.05
2-Chloropropane	9.82 (20)	2.17
3-Chloro-1,2-propanediol	31.0 (20)	
3-Chloro-1,2-propanediol dinitrate	17.50 (20)	
3-Chloro-1-propanol	36.0 (−58)	
1-Chloro-2-propanol	59.0 (−120)	
1-Chloro-2-propanone	30 (19)	2.22 (g), 2.37 (20, Hx)
2-Chloro-1-propene	8.92 (26)	1.647

TABLE 5.17 Dielectric Constant (Permittivity) and Dipole Moment of Various Organic Substances (*Continued*)

Substance	Dielectric constant, ϵ	Dipole moment, D
3-Chloro-1-propene	8.2 (20)	1.94
2-Chloropyridine	27.32 (20)	
4-Chlorothiophenol	3.59 (65)	
o-Chlorotoluene	4.72 (20), 4.2 (55)	1.56
m-Chlorotoluene	5.76 (20), 5.0 (60)	1.77 (20, lq), 1.8 (22, B)
p-Chlorotoluene	6.25 (20), 5.6 (55)	2.21
Chlorotrifluoromethane	1.0013 (29, g), 3.01 (−150)	0.50
2-Chloro-1-trifluoromethyl-5-nitrobenzene	9.8 (30)	
4-Chloro-1-trifluoromethyl-3-nitrobenzene	12.8 (30)	
3-Chloro-1,1,1-trifluoropropane	7.32 (22)	
Chlorotrimethylsilane		2.09 (20, B)
Cineole	4.57 (25)	
Cinnamaldehyde	17 (20), 16.9 (24)	3.74
o-Cresol	6.76 (25)	1.45 (25, B)
m-Cresol	12.44 (25)	1.61 (25, B)
p-Cresol	13.05 (25)	1.54 (20, B)
Crotonic acid		2.13 (30, B)
Cyanoacetic acid	33.4 (4)	
Cyanoacetylene	72.3 (19)	3.724
2-Cyanopyridine	93.77 (30)	
3-Cyanopyridine	20.54 (50)	
4-Cyanopyridine	5.23 (80)	
Cyclobutanone	14.27 (25)	2.89
Cycloheptane	2.078 (30)	
Cycloheptanone	13.16 (25)	
1,3-Cyclohexadiene	2.68 (−89)	0.38 (20, B)
1,4-Cyclohexadiene	2.211 (23)	
Cyclohexane	2.05 (15), 2.02 (25)	0
Cyclohexanecarboxylic acid	2.6 (31)	
1,4-Cyclohexanedione	15.0 (25), 4.40 (78)	1.41
Cyclohexanethiol	5.420 (25)	
Cyclohexanol	16.40 (20), 15.0 (25), 7.24 (100)	1.86 (25, C)
Cyclohexanone	20 (−40), 16.1 (20)	2.87
Cyclohexanone oxime	3.04 (89)	0.83 (25, B)
Cyclohexene	2.6 (−105), 2.218 (20)	0.332
Cyclohexylamine	4.55 (20)	1.22 (20, lq), 1.26 (20, B)
Cyclohexylbenzene		0
Cyclohexylmethanol	9.7 (60), 8.1 (80)	1.68 (20, B)
Cyclohexyl nitrite	9.33 (25)	
o-Cyclohexylphenol	3.97 (55)	
p-Cyclohexylphenol	4.42 (131)	
Cyclooctane	2.116 (22)	0
cis-Cyclooctene	2.306 (23)	
Cyclopentane	1.9687 (20)	0
Cyclopentanecarbonitrile	22.68 (20)	
Cyclopentanol	25 (−20), 18.5 (10)	1.72 (25, C)
Cyclopentanone	16 (−51), 13.58 (25)	3.30
Cyclopentene	2.083 (22)	0.20
p-Cymene	2.243 (20), 2.23 (25)	0
cis-Decahydronaphthalene	2.22 (20)	0

TABLE 5.17 Dielectric Constant (Permittivity) and Dipole Moment of Various Organic Substances (*Continued*)

Substance	Dielectric constant, ϵ	Dipole moment, D
trans-Decahydronaphthalene	2.18 (20)	0
Decamethylcyclopentasiloxane	2.5 (20)	
Decamethyltetrasiloxane	2.4 (20)	0.79 (25, lq)
Decane	1.991 (20), 1.844 (130)	0
1-Decanol	8.1 (20)	1.71 (20, B), 1.62 (25, B)
1-Decene	2.14 (20)	0
meso-2,3-Diacetoxybutane	6.644 (25)	
Diallyl sulfide	4.9 (20)	1.33 (25, B)
Dibenzofuran	3.0 (100)	0.88 (25, B)
Dibenzylamine	3.6 (20)	0.97 (20, lq), 1.02 (20, B)
Dibenzyl decanedioate	4.6 (25)	
Dibenzyl ether	3.82 (20)	1.39 (21, B)
o-Dibromobenzene	7.86 (20)	2.13 (20, B)
m-Dibromobenzene	4.21 (20)	1.5 (20, B)
p-Dibromobenzene	2.57 (95)	0
1,2-Dibromobutane	4.74 (20)	
1,3-Dibromobutane	9.14 (20)	
1,4-Dibromobutane	8.68 (30)	2.16 (20, lq), 2.06 (20, B)
2,3-Dibromobutane	6.36 (20), 5.75 (25)	2.20
meso-2,3-Dibromobutane	6.245 (25)	
(±)-2,3-Dibromobutane	5.758 (25)	
1,2-Dibromodichloromethane	2.54 (25)	
1,2-Dibromodifluoromethane	2.94 (0)	0.66
1,2-Dibromoethane	4.96 (20), 4.78 (25), 4.09 (131)	1.11
cis-1,2-Dibromoethylene	7.08 (25)	
trans-1,2-Dibromoethylene	2.88 (25)	
Dibromomethane	7.77 (10)	1.43
cis-1,2-Dibromoethylene	7.7 (0), 7.08 (25)	1.35 (B)
trans-1,2-Dibromoethylene	2.9 (0), 2.88 (25)	0
1,2-Dibromoheptane	3.8 (25)	1.78 (25, D)
2,3-Dibromoheptane	5.1 (25)	2.15 (25, B)
3,4-Dibromoheptane	4.7 (25)	2.15 (25, B)
meso-3,4-Dibromohexane	4.67 (25)	
(±)-3,4-Dibromohexane	6.732 (25)	
1,6-Dibromohexane	8.52 (25)	
Dibromomethane	7.77 (10), 6.7 (40)	1.43
1,2-Dibromo-2-methylpropane	4.1 (20)	
1,2-Dibromopentane	4.39 (25)	
(±)-*erythro*-2,3-Dibromopentane	5.43 (25)	
(±)-*threo*-2,3-Dibromopentane	6.507 (25)	
1,4-Dibromopentane	9.05 (20)	
1,5-Dibromopentane	9.14 (30)	
1,2-Dibromopropane	4.60 (10), 4.3 (20)	1.13
1,3-Dibromopropane	9.48 (20)	
Dibromotetrafluoroethane	2.34 (25)	
Dibutylamine	2.78 (20)	1.06 (20, lq), 1.05 (20, B)
Dibutyl decanedioate	4.54 (20)	2.64 (25, B)
Dibutyl ether	3.08 (20)	1.18
Dibutyl maleate		2.70 (25, B)
Dibutyl *o*-phthalate	6.58 (20), 6.436 (30), 5.99 (45)	2.97 (20, lq), 2.85 (30, B)
Dibutyl sulfide	4.29 (25)	1.6
Dichloroacetic acid	8.33 (20), 7.8 (61)	

TABLE 5.17 Dielectric Constant (Permittivity) and Dipole Moment of Various Organic Substances (*Continued*)

Substance	Dielectric constant, ϵ	Dipole moment, D
Dichloroacetic anhydride	15.8 (25)	
1,1,-Dichloroacetone	14.6 (20)	
o-Dichlorobenzene	10.12 (20), 9.93 (25), 7.10 (90)	2.50
m-Dichlorobenzene	5.02 (20), 5.04 (25), 4.22 (90)	1.72
p-Dichlorobenzene	2.394 (55)	0
1,2-Dichlorobutane	7.74 (25)	
1,4-Dichlorobutane	9.30 (35)	2.22
Dichlorodifluoromethane	3.50 (−150), 2.13 (29)	0.51
4-Chloro-1,3-dioxalan-2-one	62.0 (40)	
4,5-Dichloro-1,3-dioxalan-2-one	31.8 (40)	
1,1-Dichloroethane	10.10 (20)	2.06
1,2-Dichloroethane	12.7 (−10), 10.42 (20)	1.48
1,1-Dichloroethylene	4.60 (20), 4.60 (25)	1.34
cis-1,2-Dichloroethylene	9.20 (25)	1.90
trans-1,2-Dichloroethylene	2.14 (20)	0
2,2′-Dichloroethyl ether	21.2 (20)	2.61 (20, B)
Dichlorofluoromethane	5.34 (28)	1.29 (g)
1,6-Dichlorohexane	8.60 (35)	
Dichloromethane	9.14 (20), 8.93 (25), 1.0065 (100, g)	1.60
1,3-Dichloroisopropyl nitrate	13.28 (20)	
(Dichloromethyl)benzene	6.9 (20)	2.1
Dichloromethyl isocyanate	7.36 (15)	
1,2-Dichloro-2-methylpropane	7.15 (23)	
2,4-Dichloro-1-nitrobenzene	13.06 (28)	
1,1-Dichloro-1-nitroethane	16.3 (30)	
1,2-Dichloropentane	6.89 (20)	
1,5-Dichloropentane	9.92 (25)	
2,4-Dichlorophenol		1.60 (25, B)
1,2-Dichloropropane	8.37 (20), 8.93 (26), 7.90 (35)	1.87 (25, B)
1,3-Dichloropropane	10.27 (30)	2.08
2,2-Dichloropropane	11.37 (20)	2.62
1,1-Dichloro-2-propanone	14 (20)	
1,2-Dichlorotetrafluoroethane	2.48 (0), 2.26 (25)	0.53
2,4-Dichlorotoluene	5.68 (28)	1.7
2,6-Dichlorotoluene	3.36 (28)	
3,4-Dichlorotoluene	9.39 (28)	3.0
Diethanolamine	25.75 (20)	2.84 (25, B)
1,1-Diethoxyethane	3.80 (25)	1.08
1,2-Diethoxyethane	3.90 (20)	1.99 (20, B), 1.65 (25, B)
Diethoxymethane	2.527 (20)	
N,*N*-Diethylacetamide	32.1 (20)	
N,*N*-Diethylacetoacetamide	40.8 (25)	
Diethylamine	3.680 (20)	0.92
N,*N*-Diethylaniline	5.5 (19)	1.40 (20, lq), 1.80 (20, B)
Diethyl carbonate	2.82 (24)	1.10
N,*N*-Diethyl-*N*′,*N*′-dimethylurea	17.89 (25)	
Diethyl decanedioate	5.0 (30)	2.38 (20, lq), 2.52 (20, B)
Diethylene glycol	3.182 (20)	2.3
Diethylene glycol diethyl ether	5.70	
Diethyl ether	4.267 (20), 3.97 (40)	1.15
Diethyl ethyl phosphonate	11.00 (15), 9.86 (45)	2.95 (32, lq), 2.91 (20, C)
N,*N*-Diethylformamide	29.6 (20)	

TABLE 5.17 Dielectric Constant (Permittivity) and Dipole Moment of Various Organic Substances (*Continued*)

Substance	Dielectric constant, ϵ	Dipole moment, D
Diethyl fumarate	6.56 (23)	2.40 (20, B)
Diethyl glutarate	6.7 (30)	2.46 (30, lq)
Diethyl glycol	31.82 (20)	
Di(2-ethylhexyl) *o*-phthalate	5.3 (20), 4.91 (35), 4.77 (45)	2.8
Diethyl maleate	8.58 (23), 7.56 (25)	2.56 (25, B)
Diethyl methanephosphate	13.405 (40)	
Diethyl 1,3-propanedioate (malonate)	8.03 (25), 7.55 (31)	2.49 (20, lq), 2.54 (25, B)
Diethyl nonanedioate	5.13 (30)	
Diethyl oxalate	8.266 (20)	2.49 (20, D)
Diethyl *o*-phthalate	7.34 (35), 7.13 (45)	2.8 (25, B)
Diethylsilane	2.544 (20)	
Diethyl succinate	6.098 (20)	2.3
Diethyl sulfate	29.2 (20)	4.46 (25, D)
Diethyl sulfide	5.72 (25), 5.24 (50)	1.54
Diethyl sulfite	15.6 (20), 14 (50)	
Diethylzinc	2.55 (20)	0.62 (25, B)
o-Difluorobenzene	13.38 (28)	2.46
m-Difluorobenzene	5.01 (28)	1.51
1,1-Difluoroethane		2.27
Difluoromethane	53.74 (−121)	1.978
2,3-Dihydropyran	5.136 (35)	
1,2-Dihydroxybenzene	17.57 (115)	2.60 (25, B)
1,3-Dihydroxybenzene	13.55 (120)	2.09 (44, B)
1,4-Dihydroxybenzene		1.4 (44, B)
1,2-Diiodobenzene	5.7 (20), 5.41 (50)	1.70 (20, B)
1,3-Diiodobenzene	4.3 (25), 4.11 (50)	1.22 (20, B)
1,4-Diodobenzene	2.88 (120)	0.19 (20, B)
cis-1,2-Diiodoethylene	4.46 (72)	0.71 (B)
trans-1,2-Diiodoethylene	3.19 (77)	0
Diiodomethane	5.316 (25)	1.08 (25, B)
Diisobutylamine	2.7 (22)	1.10 (25, B)
1,6-Diisocyanatohexane	14.41 (15)	
Diisopentylamine	2.5 (18)	1.48 (30, B)
Diisopentyl ether	2.82 (20)	0.98 (20, lq), 1.23 (25, B)
Diisopropylamine		1.26 (25, B)
Diisopropyl ether	3.88 (25), 3.805 (30)	1.13
1,2-Dimethoxybenzene	4.45 (20), 4.09 (25)	1.32 (25, B)
Dimethoxydimethylsilane	3.663 (25)	
1,2-Dimethoxyethane	7.60 (10), 7.30 (23.5)	1.71 (25, B)
Dimethoxymethane	2.644 (20)	0.74
N,*N*-Dimethylacetamide	38.85 (21), 37.78 (25)	3.80
2-Dimethylamino-2-methyl-1-propanol	12.36 (25)	
Dimethylamine	6.32 (0), 5.26 (25)	1.01
N,*N*-Dimethylaniline	4.90 (25), 4.4 (70)	1.68
2,4-Dimethylaniline	4.9 (20)	1.40 (25, B)
2,3-Dimethyl-1,3-butadiene	2.102 (20)	
N,*N*-Dimethylbutanamide	29.7 (20)	
2,2-Dimethylbutane	1.869 (20)	0
2,3-Dimethylbutane	1.889 (20)	0
3,3-Dimethyl-2-butanone	12.73 (20)	

TABLE 5.17 Dielectric Constant (Permittivity) and Dipole Moment of Various Organic Substances (*Continued*)

Substance	Dielectric constant, ϵ	Dipole moment, D
2,2-Dimethyl-1-butanol	10.5 (20)	
Dimethyl carbonate	3.087 (25)	0.90
cis-1,2-Dimethylcyclohexane	2.06 (25)	0
trans-1,2-Dimethylcyclohexane	2.04 (25)	0
1,1-Dimethylcyclopentane		0
Dimethyl disulfide	9.6 (25)	1.8
Dimethyl ether	6.18 (−15), 5.02 (25), 2.97 (110)	1.30
N,*N*-Dimethylformamide	38.25 (20), 36.71 (25)	3.82 (25, B)
2,4-Dimethylheptane	1.9 (20)	0
2,5-Dimethylheptane	1.9 (20)	0
2,6-Dimethylheptane	2 (20)	0
2,6-Dimethyl-4-heptanone	9.91 (20)	2.66 (25, C)
2,2-Dimethylhexane	1.95 (20)	0
2,5-Dimethylhexane	1.96 (21)	0
3,3-Dimethylhexane	1.96 (20)	0
3,4-Dimethylhexane	1.98 (19)	0
Dimethyl hexanedioate	6.84 (20)	2.28 (20, B)
1,3-Dimethylimidazolidin-2-one	37.60 (25)	
Dimethyl maleate		2.48 (25, C)
Dimethyl malonate	9.82 (20)	2.41 (20, B)
Dimethyl methanephosphate	22.3 (20)	
N,*N*-Dimethyl methanesulfonamide	80.4 (50)	
1,2-Dimethylnaphthalene	2.61 (25)	0
1,6-Dimethylnaphthalene	2.73 (20)	0
4,4-Dimethyloxazolidine-2-one	39.2 (60)	
N,*N*-Dimethylpentanamide	26.4 (20)	
2,2-Dimethylpentane	1.915 (20)	0
2,3-Dimethylpentane	1.929 (20)	0
2,4-Dimethylpentane	1.902 (20)	0
3,3-Dimethylpentane	1.942 (20)	0
Dimethyl pentanedioate	7.87 (20)	
2,4-Dimethyl-3-pentanone		2.7
2,3-Dimethylphenol	4.81 (70)	
2,4-Dimethylphenol	5.06 (30)	1.48 (20, B), 1.98 (60, B)
2,5-Dimethylphenol	5.36 (65)	1.43 (20, B), 1.52 (60, B)
2,6-Dimethylphenol	4.90 (40)	1.4
3,4-Dimethylphenol	9.02 (60)	1.77 (20, B)
3,5-Dimethylphenol	9.06 (50)	1.76 (20, B)
Dimethyl *o*-phthalate	8.66 (20), 8.25 (25), 8.11 (45)	2.8 (25, B)
2,2-Dimethylpropanal	9.051 (20)	2.66
N,*N*-Dimethylpropanamide	34.6 (20)	
2,2-Dimethylpropanamide	20.13 (25)	
2,2-Dimethylpropane	1.769 (23), 1.678 (98)	0
2,2-Dimethylpropane nitrile	21.1 (20)	3.95
N,*N*-Dimethylpropanamide	33.1	
2,2-Dimethyl-1-propanol	8.35 (60)	
2,5-Dimethylpyrazine	2.436 (20)	0
2,6-Dimethylpyrazine	2.653 (35)	
2,4-Dimethylpyridine	9.60 (20)	2.3
2,6-Dimethylpyridine	7.33 (20)	1.7
2,6-Dimethylpyridine-1-oxide	46.11 (25)	
2,3-Dimethylquinoxaline	2.3 (25)	0

TABLE 5.17 Dielectric Constant (Permittivity) and Dipole Moment of Various Organic Substances (*Continued*)

Substance	Dielectric constant, ϵ	Dipole moment, D
Dimethyl succinate	7.19 (20)	2.09 (20, B)
Dimethyl sulfate	55.0 (25)	4.31 (25, D)
Dimethyl sulfide	6.70 (21)	1.554
Dimethyl sulfite	22.5 (23)	2.93 (20, B)
Dimethyl sulfone	47.39 (110)	
Dimethyl sulfoxide	47.24 (20), 41.9 (55)	3.96 (25, B)
cis-2,5-Dimethyltetrahydrofuran	5.03 (23)	
N,*N*-Dimethylthioformamide	47.5 (25)	
N,*N*-Dimethyl-*o*-toluidine	3.4 (20)	0.88 (25, B)
N,*N*-Dimethyl-*p*-toluidine	3.9(20)	1.29 (25, B)
m-Dinitrobenzene	22.9 (92)	
2,2-Dinitropropane	42.4 (52)	
Dinonyl hexanedioate		2.53 (25, B)
Dinonyl *o*-phthalate	4.65 (35), 4.52 (45)	
Dioctyl decanedioate	4.0 (27)	
Dioctyl *o*-phthalate	5.1 (25)	3.06 (25, C)
1,4-Dioxane	2.219 (20), 2.21 (25)	0
1,3-Dioxolane		1.19
1,3-Dioxolan-2-one	89.78 (40)	
Dipentene	2.38 (25)	
Dipentyl ether	2.80 (25)	0.98 (20, lq), 1.24 (25, B)
Dipentyl *o*-phthalate	5.79 (35), 5.62 (45)	2.71 (20, lq)
Dipentyl sulfide	3.83 (25)	1.59 (25, B)
Dipentylamine	3.3 (52)	1.31 (20, C), 1.01 (25, B)
1,2-Diphenylethane	2.4 (110)	0 (110, lq), 0.45 (25, B)
Diphenyl ether	3.73 (10), 3.63 (30)	1.3
Diphenylmethane	2.7 (18), 2.57 (26)	0.26 (30, lq), 0.3 (25, B)
Dipropylamine	2.923 (20)	1.01 (20, lq), 1.03 (20, B)
Dipropyl ether	3.38 (24)	1.21
N,*N*-Dipropylformamaide	23.5 (20)	
Dipropyl sulfone	32.62 (30)	
Dipropyl sulfoxide	30.37 (30)	
Divinyl ether	3.94 (15)	0.78
Dodecamethylcyclohexasiloxane	2.6 (20)	
Dodecamethylpentasiloxane	2.5 (20)	
Dodecane	2.05 (−10), 2.01 (20)	0
1-Dodecanol	5.15 (20), 6.5 (25)	1.52 (20, B)
1-Dodecene	2.15 (20)	0
6-Dodecyne	2.17 (25)	
1,2-Epoxybutane		2.01 (20, B)
Erythritol	28 (128)	
Ethane	1.936 (−178), 1.0015 (0)	0
1,2-Ethanediamine	16.8 (18), 13.82 (20)	1.96
1,2-Ethanediol	41.4 (20), 37.7 (25)	2.28
1,2-Ethanediol diacetate	7.7 (17)	2.34 (30, B)
1,2-Ethanediol dinitrate	28.26 (20)	
1,2-Ethanediol monoacetate	12.95 (30)	
1,2-Ethanedithiol	7.26 (20)	
Ethanesulfonyl chloride		3.89 (25, B)
Ethanethiol	6.9 (15), 6.667 (25)	1.58
Ethanol	25.3 (20), 20.21 (55)	1.69
Ethanolamine	31.94 (20)	

TABLE 5.17 Dielectric Constant (Permittivity) and Dipole Moment of Various Organic Substances (*Continued*)

Substance	Dielectric constant, ϵ	Dipole moment, D
Ethoxyacetylene	8.05 (25)	
4-Ethoxyaniline	7.43 (25)	
Ethoxybenzene (phenetol)	4.216 (20)	1.45
2-Ethoxyethanol	13.38 (25)	2.24 (30, B)
2-Ethoxyethyl acetate	7.567 (30)	2.25 (30, B)
1-Ethoxy-2-methylbutane	3.96 (20)	
1-Ethoxynaphthalene	3.3 (19)	
1-Ethoxypentane	3.6 (23)	
α-Ethoxytoluene	3.9 (20)	
Ethoxytrimethylsilane	3.013 (25)	
N-Ethylacetamide	135.0 (20)	
Ethyl acetate	6.081 (20), 5.30 (77)	1.78
Ethyl acetoacetate	14.0 (20)	3.22 (18, B, keto form) 2.04 (-80, CS_2, enol form)
Ethyl acrylate	6.05 (30)	2.0
Ethylamine	8.7 (0), 6.94 (10)	1.22
N-Ethylaniline	5.87 (20)	
4-Ethylaniline	4.84 (25)	
Ethylbenzene	2.446 (20)	0.59
Ethyl benzoate	6.20 (20)	2.00
Ethyl 2-bromoacetate	8.75 (30)	
Ethyl α-bromobutanoate	8 (20)	2.40 (25, B)
Ethyl 2-bromo-2-methylpropanoate	8.55 (30)	
Ethyl 2-bromopropanoate	9.4 (20), 8.57 (30)	
N-Ethylbutanamide	107.0 (25)	
Ethyl butanoate	5.18 (28)	1.74 (22, B)
2-Ethylbutanoic acid	2.72 (23)	
2-Ethyl-1-butanol	6.19 (90)	
Ethyl *tert*-butyl ether	7.07 (25)	
Ethyl carbamate	14.2 (50), 14.14 (55)	2.59 (30, D)
Ethyl chloroacetate	11.4 (21)	2.65 (25, B)
Ethyl chlorocarbonate	9.736 (36)	
Ethyl *cis*-3-chlorocrotonate	7.67 (76)	
Ethyl *trans*-3-chlorocrotonate	4.70 (54)	
Ethyl chloroformate	11 (20)	2.56 (35, B)
Ethyl 2-chloropropanoate	11.95 (30)	
Ethyl 3-chloropropanoate	10.19 (30)	
Ethyl *trans*-cinnamate	6.1 (18), 5.83 (20)	1.86 (20, B)
Ethyl crotonate	5.4 (20)	1.95 (24, B)
Ethyl cyanoacetate	31.62 (-10), 26.9 (20)	2.2
Ethylcyclobutane	1.965 (20)	
Ethylcyclohexane	2.054 (20)	0
Ethylcyclopropane	1.933 (20)	
Ethyl dichloroacetate	12 (2), 10 (22)	2.63 (25, B)
Ethyl dodecanoate	3.4 (20), 2.7 (143)	1.3 (20, lq)
Ethylene	1.001 44 (0, g), 1.483 (-3)	0
Ethylene carbonate	89.78 (40), 69.4 (91)	4.87 (25, B)
Ethylenediamine	13.82 (20)	1.98
Ethylene dinitrate	28.3 (20)	3.58 (25, B)
2,2′-(Ethylenedioxy)diethanol	23.69 (20)	5.58 (lq)
Ethylene glycol	41.4 (20), 37.7 (25)	2.28
Ethylene glycol diacetate	7.7 (17)	

TABLE 5.17 Dielectric Constant (Permittivity) and Dipole Moment of Various Organic Substances (*Continued*)

Substance	Dielectric constant, ϵ	Dipole moment, D
Ethyleneimine	18.3 (25)	1.90
Ethylene oxide	14 (−1), 12.42 (20)	1.89
Ethylene sulfite	39.6 (25)	
N-Ethylformamide	102.7 (25)	
Ethyl formate	8.57 (15), 7.16 (25)	1.94
Ethyl fumarate	6.5 (23)	
Ethyl furan-2-carboxylate	9.02 (20)	
Ethylhexadecanoate	3.2 (20), 2.71 (104)	1.2 (lq)
3-Ethylhexane	1.96 (20)	0
2-Ethyl-1,2-hexanediol	18.73 (20)	
Ethyl hexanoate	4.45 (20)	1.80 (20, B)
2-Ethyl-1-hexanol	7.58 (25), 4.41 (90)	1.74 (25, B)
2-Ethylhexyl acetate		1.8
Ethyl 2-iodopropanoate	8.6 (20)	
Ethyl isocyanate	19.7 (20)	
Ethyl isopentyl ether	3.96 (20)	
Ethyl isothiocyanate	19.6 (20)	3.67 (20, B)
Ethyl lactate	15.4 (30)	2.4 (20, B)
Ethyl maleate	8.6 (23)	
Ethyl methacrylate	5.68 (30)	
Ethyl 3-methylbutanoate	4.71 (20)	
Ethyl-*N*-methyl carbamate	21.10 (25)	
Ethyl methyl carbonate	2.985 (20)	
Ethyl methyl ether		1.17
3-Ethyl-2-methylpentane	1.99 (18)	0
Ethyl nitrate	19.7 (20)	2.93 (20, B)
Ethyl 9-octadecanoate	3.2 (25)	1.83 (20, lq)
3-Ethyloxazolidine-2-one	66.8 (25)	
4-Ethyloxazolidine-2-one	42.6 (25)	
Ethyl 4-oxopentanoate	12 (21)	
3-Ethylpentane	1.942 (20)	0
Ethyl pentanoate	4.71 (18)	1.76 (28, B)
3-Ethyl-3-pentanol	3.158 (20)	
Ethyl pentyl ether	3.6 (23)	1.2 (20, B)
Ethyl phenylacetate	5.3 (21)	1.82 (30)
Ethyl phenyl sulfide		4.08 (25, B)
N-Ethyl propanamide	126.8 (25)	
Ethyl propanoate	5.76 (20)	1.75 (22, B)
Ethyl propyl ether		1.16 (25, B)
2-Ethylpyridine	8.33 (20)	
4-Ethylpyridine	10.98 (20)	
Ethyl salicylate	7.99 (30)	2.85 (25, B)
Ethyl stearate	2.98 (40), 2.69 (100)	1.65 (40, lq)
Ethyl thiocyanate	29.3 (21)	3.33 (20, B)
p-Ethyltoluene	2.24 (25)	0
Ethyl trichloroacetate	8.428 (20)	2.56 (25, B)
Ethyltrimethylsilazine	2.275 (30)	
Ethyl vinyl ether		1.26 (20, B)
Fluorobenzene	5.465 (20), 5.42 (25), 4.7 (60)	1.60
4-Fluorobenzene sulfonylchloride	12.65 (40)	
2-Fluoroiodobenzene	8.22 (25)	
3-Fluoroiodobenzene	4.62 (25)	

TABLE 5.17 Dielectric Constant (Permittivity) and Dipole Moment of Various Organic Substances (*Continued*)

Substance	Dielectric constant, ϵ	Dipole moment, D
4-Fluoroiodobenzene	3.12 (25)	
Fluoromethane	51.0 (−142)	1.858
2-Fluoro-2-methylbutane	5.89 (20)	1.92 (25, B)
1-Fluoropentane	3.93 (20)	1.85 (25, B)
o-Fluorotoluene	4.23 (25), 4.22 (30), 3.9 (60)	1.37
m-Fluorotoluene	5.41 (25), 4.9 (60)	1.82
p-Fluorotoluene	5.88 (25), 5.86 (30), 5.3 (60)	2.00
Formamide	111.0 (20), 103.5 (40)	3.73
Formanilide		3.37 (25, C)
Formic acid	58.5 (15), 57.0 (21), 51.1 (25)	1.41
2-Furaldehyde	42.1 (20), 34.9 (50)	3.63 (25, B)
Furan	2.88 (4)	0.66
2-Furfuryl acetate	5.85 (20)	
Furfuryl alcohol	16.85 (25)	1.92 (25, lq)
Glycerol	46.5 (20), 42.5 (25)	2.68 (25, D)
Glycerol tris(acetate)	7.2 (20)	2.73 (25, B)
Glycerol tris(nitrate)	19.25 (20)	3.38 (25, B)
Glycerol tris(oleate)	3.2 (26)	3.11 (23, B)
Glycerol tris(palmitate)	2.9 (65)	2.80 (23, B)
Glycerol tris(sterate)	2.8 (70)	2.86 (23, B)
1,6-Heptadiene	2.161 (20)	
Heptacosafluorotributylamine	2.15 (20)	
2,2,3,3,4,4,4-Heptafluoro-1-butanol	14.4 (25)	
Heptanal	9.1 (20)	2.26 (40, lq), 2.58 (22, B)
Heptane	1.921 (20), 1.85 (70)	0
1-Heptanethiol	4.194 (20)	
Heptanoic acid	3.04 (15), 2.6 (71)	
1-Heptanol	11.75 (20)	1.73 (20, B)
(±)-2-Heptanol	9.72 (21)	1.73 (20, B)
(±)-3-Heptanol	7.07 (23)	1.73 (20, B)
4-Heptanol	6.18 (23)	1.72 (20, B)
2-Heptanone	11.95 (20), 8.27 (100)	2.61 (22, B)
3-Heptanone	12.7 (20)	2.81 (22, B)
4-Heptanone	12.60 (20), 9.46 (80)	2.74 (20, B)
1-Heptene	2.09 (20)	0
Heptylamine	3.81 (20)	
Hexachloroacetone	3.93 (19)	
Hexachloro-1,3-butadiene	2.55 (20)	
Hexadecamethylcyclooctasiloxane	2.7 (20)	
Hexadecane	2.046 (30)	0
1-Hexadecanol	3.8 (50)	1.67 (25, B)
1,5-Hexadiene	2.125 (26)	
2,4-Hexadiene	2.207 (25)	0.31 (25, B)
cis,*cis*-2,4-Hexadiene	2.163 (24)	
trans,*trans*-2,4-Hexadiene	2.123 (24)	
Hexafluoroacetone	2.104 (−71)	
Hexafluorobenzene	2.029 (25)	0
1,1,1,3,3,3-Hexafluoro-2-propanol	16.70 (20)	
Hexamethyldisiloxane	2.2 (20)	0.37 (25, lq)
Hexamethylphosphorotriamide	31.3 (20)	5.5, 4.31 (25, lq)
Hexane	1.904 (15), 1.890 (20)	0
Hexanedinitrile	32.45 (25)	3.8 (25, B)

TABLE 5.17 Dielectric Constant (Permittivity) and Dipole Moment of Various Organic Substances (*Continued*)

Substance	Dielectric constant, ϵ	Dipole moment, D
Hexanenitrile	17.26 (25)	
1-Hexanethiol	4.436 (20)	
1,2,6-Hexanetriol	31.5 (12)	
Hexanoic acid	2.600 (25)	1.13 (25, lq)
1-Hexanol	13.03 (20), 8.5 (75)	1.55 (20, B)
(±)-2-Hexanol	11.06 (25)	
3-Hexanol	9.66 (25)	
2-Hexanone	14.6 (15), 14.56 (20)	2.68 (22, B)
1-Hexene	2.051 (20)	0
cis-2-Hexene		0
trans-2-Hexene	1.978 (22)	0
cis-3-Hexene	2.069 (23)	0
trans-3-Hexene	1.954 (20)	0
Hexyl acetate	4.42 (20)	
Hexylamine	4.08 (20)	
1-Hexyne	2.621 (23)	0.83
2-Hydroxyacetophenone	21.33 (25)	
2-Hydroxybutanoic acid	37.7 (23)	
3-Hydroxybutanoic acid	31.5 (23)	
N-(2-Hydroxyethyl)acetamide	96.6 (25)	
4-Hydroxy-4-methyl-2-pentanone	18.2 (25)	3.24 (20, B)
3-Hydroxypropanoic acid	30.0 (23)	
Iodobenzene	4.59 (20)	1.70
1-Iodobutane	6.27 (20), 4.52 (130)	2.10
2-Iodobutane	7.873 (20)	2.12
1-Iodododecane	3.9 (20)	1.87 (20, C)
Iodoethane	10.2 (−50), 7.82 (20)	1.91
1-Iodoheptane	4.92 (22)	1.86 (22, B)
3-Iodoheptane	6.39 (22)	1.95 (22, B)
1-Iodohexadecane	3.5 (20)	
1-Iodohexane	5.37 (20)	1.94 (20, C)
Iodomethane	6.97 (20)	1.62
1-Iodo-3-methylbutane	5.6 (19)	1.85 (20, B)
2-Iodo-2-methylbutane	8.19 (20)	2.20 (20, B)
1-Iodo-2-methylpropane	6.47 (20)	1.89 (20, B)
2-Iodo-2-methylpropane	6.65 (10)	
1-Iodooctane	4.6 (25)	1.80 (25, lq), 1.90 (20, C)
2-Iodooctane	5.8 (20)	2.07 (20, C)
1-Iodopentane	5.78 (20)	1.90 (20, B)
3-Iodopentane	7.432 (20)	
1-Iodopropane	7.07 (20)	2.03
2-Iodopropane	8.19 (25)	2.01 (20, B)
3-Iodopropene	6.1 (19)	
p-Iodotoluene	4.4 (35)	1.72 (22, B)
α-Ionone	11 (18)	
β-Ionone	12 (20)	
Iron pentacarbonyl	2.602 (20)	
Isobutanenitrile	20.4 (24)	3.61 (25, B)
Isobutene	2.1225 (15)	0.503
N-Isobutylacetamide	111.0 (20)	
Isobutyl acetate	5.068 (20)	1.87 (22, B)
Isobutylamine	4.43 (21)	1.27 (25, B)

TABLE 5.17 Dielectric Constant (Permittivity) and Dipole Moment of Various Organic Substances (*Continued*)

Substance	Dielectric constant, ϵ	Dipole moment, D
Isobutylbenzene	2.319 (20), 2.298 (30)	0.31 (20, lq)
Isobutyl butanoate	4.1 (20)	1.9
Isobutyl chlorocarbonate	9.1 (20)	
Isobutyl formate	6.41 (20)	1.89 (20, B)
Isobutyl isocyanate	11.64 (20)	
Isobutyl nitrate	2.7 (20)	
Isobutyl pentanoate	3.8 (19)	
Isobutylsilane	2.497 (20)	
Isobutyl trichloroacetate	7.667 (20)	
Isobutyl vinyl ether	3.34 (20)	
Isobutyronitrile	20.4 (24)	3.61 (25, B)
Isopentyl acetate	4.72 (20), 4.63 (30)	1.84 (22, B), 1.76 (30, lq)
Isopentyl butanoate	4.0 (20)	
Isopentyl pentanoate	3.6 (19)	1.8 (28, B)
Isopentyl propanoate	4.2 (20)	
Isopropyl acetate		1.86 (22, B)
Isopropylamine	5.627 (20)	1.19
Isopropylbenzene	2.38 (20)	0.79
Isopropyl carborane	45.0 (20)	
N-Isopropylformamide	65.7 (25)	
1-Isopropyl-4-methylbenzene	2.24 (20)	0
Isopropyl nitrite	13.92 (−13)	
Isoquinoline	11.0 (25)	2.73
Lactic acid	22 (17)	
Lactonitrile	38 (20)	
D-Limonene	2.4 (20), 2.37 (25)	1.57 (25, B)
(±)-Limonene	2.3 (20)	0.63 (25, B)
Maleic anhydride	52.75 (53)	
(±)-Mandelonitrile	17.8 (23)	
D-Mannitol	24.6 (170)	
Menthol		1.55 (20, B)
Methacrylic acid		1.65
Methacrylonitrile		3.69
Methane	1.676 (−182), 1.000 94 (0)	0
Methanesulfonyl chloride	34.0 (20)	
Methanethiol		1.52 (g)
Methanol	41.8 (−20), 33.0 (20)	1.70
2-Methoxyaniline	5.230 (30)	
3-Methoxyaniline	8.76 (25)	
4-Methoxyaniline	7.85 (60)	
o-Methoxybenzaldehyde		4.34 (20, B)
p-Methoxybenzaldehyde	22.3 (22), 22.0 (30), 10.4 (248)	3.26 (35, B)
Methoxybenzene	4.30 (21), 3.9 (70)	1.38
2-Methoxyethanol	17.2 (25), 16.0 (30)	2.36
N-(2-Methoxyethyl)acetamide	80.7 (25)	
2-Methoxyethyl acetate	8.25 (20)	2.13 (30, B)
1-Methoxy-2-nitrobenzene	45.75 (20)	4.83
o-Methoxyphenol	11.95 (25)	
m-Methoxyphenol	11.59 (25)	
p-Methoxyphenol	11.05 (60)	
2-Methoxy-4-(2-propenyl)phenol		2.46 (25, B)
o-Methoxytoluene	3.5 (20)	

TABLE 5.17 Dielectric Constant (Permittivity) and Dipole Moment of Various Organic Substances (*Continued*)

Substance	Dielectric constant, ϵ	Dipole moment, D
m-Methoxytoluene	3.5 (20)	
p-Methoxytoluene	4.0 (20)	
Methoxytrimethylsilane	3.248 (25)	
N-Methylacetamide	178.9 (30), 138.6 (60)	4.39 (20, D)
Methyl acetate	7.07 (15), 7.03 (20), 6.68 (25)	1.72
Methyl acrylate	7.03 (30)	1.77 (25, B)
Methylamine	16.7 (−58), 11.4 (−10), 10.0 (18)	1.31
Methyl 2-aminobenzoate	21.9 (25)	
N-Methylaniline	5.96 (20)	1.67 (25, B)
2-Methylaniline	6.138 (25)	
3-Methylaniline	5.816 (25)	
4-Methylaniline	5.058 (25)	
N-Methylbenzenesulfonamide	67.1 (30)	
Methyl benzoate	6.64 (30)	1.86 (25, B)
2-Methyl-1,2-butadiene	2.1 (25)	0.15
2-Methyl-1,3-butadiene	2.098 (20)	0.25
2-Methylbutane	1.871 (0), 1.845 (20)	0.13
2-Methyl-2-butanethiol	5.083 (20)	
Methyl butanoate	5.6 (20), 5.48 (29)	1.72 (22, B)
3-Methylbutanoic acid	2.64 (20)	0.63 (25)
2-Methyl-1-butanol	15.63 (25)	1.9
2-Methyl-2-butanol	5.78 (25)	1.72 (20, B)
3-Methyl-1-butanol	15.63 (20), 14.7 (25), 5.82 (130)	1.82 (25, B)
3-Methyl-2-butanol	12.1 (25)	
3-Methyl-2-butanone	10.37 (20)	
2-Methyl-1-butene	2.180 (20)	0.52 (20, lq)
2-Methyl-2-butene	1.979 (23)	0.11 (25, lq), 0.34 (25, B)
3-Methyl-1-butene	1.0028 (100, g)	0.320
2-Methyl-1-butene-2-one	10.39 (30)	
2-Methylbutyl acetate	4.63 (30)	1.82 (22)
3-Methylbutyl 3-methylbutanoate	4.39 (15)	
3-Methylbutyronitrile	18 (220)	3.62 (25, C)
Methyl carbamate	18.48 (55)	
Methyl chloroacetate	12.0 (20)	
N-Methyl-2-chloroacetamide	92.3 (50)	
Methyl 4-chlorobutanoate	9.51 (30)	
Methyl crotonate	6.664 (20)	
Methyl cyanoacetate	29.3 (20), 19.23 (50), 17.57 (65)	
Methylcyclohexane	2.024 (20)	0
2-Methylcyclohexanol		1.95 (25, B)
cis-3-Methylcyclohexanol	16.05 (20)	1.91
trans-3-Methylcyclohexanol	8.05 (20)	1.75
4-Methylcyclohexanol		1.9 (25, B)
2-Methylcyclohexanone	16 (−15), 14.0 (20)	2.98 (25, B)
3-Methylcyclohexanone	18 (−80), 12.4 (20)	3.06 (25, B)
4-Methylcyclohexanone	15 (−41), 12.35 (20)	3.07 (25, B)
Methylcyclopentane	1.985 (20)	0
1-Methylcyclopentanol	7.11 (37)	
Methyl decanoate		1.65 (20, Hx)
Methyl dodecanoate		1.70 (20, Hx)
N-Methylformamide	200.1 (15), 189.0 (20), 182.4 (25)	3.83
Methyl formate	9.20 (15), 8.5 (20)	1.77

TABLE 5.17 Dielectric Constant (Permittivity) and Dipole Moment of Various Organic Substances (*Continued*)

Substance	Dielectric constant, ϵ	Dipole moment, D
2-Methylfuran	2.76 (20)	0.65
Methyl furan-2-carboxylate	11.01 (20)	
(mono)Methyl glutarate	8.37 (20)	
2-Methylheptane	1.95 (20)	0
2-Methyl-2-heptanol	3.38 (−7), 2.46 (25)	
2-Methyl-3-heptanol	3.37 (20), 3.75 (60)	1.63 (20, B)
2-Methyl-4-heptanol	3.30 (20), 3.65 (60)	
3-Methyl-3-heptanol	3.74 (20), 2.89 (60)	
3-Methyl-4-heptanol	9.1 (−20), 7.4 (20)	
4-Methyl-3-heptanol	5.25 (20), 4.62 (55)	
4-Methyl-4-heptanol	2.87 (20), 3.27 (60)	
2-Methylhexane	1.922 (20)	0
3-Methylhexane	1.920 (20)	0
Methyl hexanoate	4.615 (20)	1.70 (20, Hx)
2-Methyl-2-hexanol	3.257 (24)	
3-Methyl-2-hexanol	4.990 (24)	
3-Methyl-3-hexanol	3.248 (25)	
5-Methyl-2-hexanone	13.53 (20)	
Methyl isobutanoate		1.98 (20, B)
Methylisocyanate	21.75 (16)	2.8
Methyl methacrylate	6.32 (30)	1.68 (25, B)
N-Methyl methanesulfonamide	104.4 (25)	
Methyl *o*-methoxybenzene	7.7 (21)	
Methyl *p*-methoxybenzoate	4.3 (33)	
N-Methyl-2-methylbutanamide	123.0 (34)	
N-Methyl-3-methylbutanamide	114.0 (26)	
Methyl 3-(methylthio)propanoate	8.66 (30)	
1-Methylnaphthalene	2.92 (20)	0
Methyl nitrate	23.9 (20)	
Methyl nitrite	20.77 (−73)	
Methyl *o*-nitrobenzoate	28 (25)	3.67 (30, B)
2-Methyloctane	1.97 (20)	0
3-Methyloctane		0
4-Methyloctane	1.97 (20)	0
Methyl oleate	3.211 (20)	
2-Methyl-1,3-pentadiene	2.422 (25)	
3-Methyl-1,3-pentadiene	2.426 (25)	
4-Methyl-1,3-pentadiene	2.599 (20)	
N-Methylpentanamide	131.0 (13)	
2-Methylpentane	1.886 (20)	0
3-Methylpentane	1.886 (20)	0
2-Methyl-2,4-pentanediol	23.4 (20)	2.9
4-Methylpentanenitrile	17.5 (22)	3.53 (25, B)
Methyl pentanoate	4.992 (20)	1.62 (22, B)
3-Methyl-1-pentanol	15.2 (25)	
3-Methyl-3-pentanol	4.322 (20)	
4-Methyl-2-pentanone	15.6 (0), 15.1 (20), 11.78 (40)	
4-Methylpentenenitrile	17.5 (22)	3.5
4-Methyl-3-penten-2-one	15.6 (0)	2.8
1-Methyl-1-phenylhydrazine	7.3 (19)	1.84 (15, B)
Methyl phenyl sulfide		1.38 (20, B)
Methyl phenyl sulfone	37.9 (100)	

TABLE 5.17 Dielectric Constant (Permittivity) and Dipole Moment of Various Organic Substances (*Continued*)

Substance	Dielectric constant, ϵ	Dipole moment, D
2-Methylpropanal		2.6
N-Methylpropanamide	170.0 (20), 151 (40)	3.59
2-Methyl-1-propanamine	4.43 (21)	1.3
2-Methylpropane	1.752 (25)	0.132
2-Methylpropanenitrile	24.42 (20)	4.29
2-Methyl-1-propanethiol	4.961 (25)	
2-Methyl-2-propanethiol	5.475 (20)	1.66
Methyl propanoate	6.200 (20)	1.70 (22, B)
2-Methylpropanoic acid	2.58 (20)	1.08 (25, lq)
2-Methylpropanoic anhydride	13.6 (19)	
2-Methyl-1-propanol	26 (−34), 17.93 (20)	1.64
2-Methyl-2-propanol	12.47 (25), 10.9 (30), 8.49 (50)	1.67 (22, B)
2-Methylpropene		0.50
2-Methyl-2-propenenitrile		3.69
2-Methylpropenoic acid		1.6
2-Methylpropyl acetate	5.07 (20)	1.87 (22, B)
2-Methyl-1-propylamine	4.43 (21)	1.27 (27)
(2-Methylpropyl)benzene	2.32 (20)	0
2-Methylpropyl formate	6.41 (20)	1.88 (22)
2-Methylpyridine	10.18 (20)	1.85
3-Methylpyridine	11.10 (30)	2.41 (25, B)
4-Methylpyridine	12.2 (20)	2.70
2-Methylpyridine-1-oxide	36.4 (50)	
3-Methylpyridine-1-oxide	28.26 (45)	
N-Methylpyrrolidine	32.2 (25)	
N-Methyl-2-pyrrolidinone	32.55 (20), 32.2 (25)	4.09 (30, B)
Methyl salicylate	9.41 (30), 8.80 (41)	2.47 (25, B)
3-Methyl sulfolane	29.4 (25)	
Methyl tetradecanoate		1.62 (25, B)
2-Methyltetrahydrofuran	6.97 (25)	
Methyl tetrahydrothiophene-2-carboxylate	7.30 (20)	
Methyl thiocyanate	4.3 (19)	3.34 (20, B)
2-Methylthiophene		0.674
3-Methylthiophene		0.95
Methyl thiophene-2-carboxylate	8.81 (20)	
Methyl trifluoromethyl sulfone	32.0 (20)	
Morpholine	7.42 (25)	1.55
β-Myrcene	2.3 (25)	
Naphthalene	2.54 (90)	0
1-Naphthonitrile	16 (70)	
2-Naphthonitrile	17 (70)	
o-Nitroaniline	47.3 (80), 34.5 (90)	4.28 (20, B)
m-Nitroaniline	35.6 (125)	
p-Nitroaniline	78.5 (155), 56.3 (160)	6.3 (25, B)
o-Nitroanisole	45.75 (20)	4.83
m-Nitroanisole	25.7 (45)	
p-Nitroanisole	26.95 (65)	
Nitrobenzene	35.6 (20), 34.82 (25), 24.9 (90)	4.22
m-Nitrobenzyl alcohol	22 (20)	
2-Nitrobiphenyl		3.83 (20, B)
Nitroethane	29.11 (15), 28.06 (30), 27.4 (35)	3.23

TABLE 5.17 Dielectric Constant (Permittivity) and Dipole Moment of Various Organic Substances (*Continued*)

Substance	Dielectric constant, ϵ	Dipole moment, D
2-Nitro-ethylbenzene	21.9 (0)	
Nitromethane	37.27 (20), 35.87 (30), 35.1 (35)	3.46
1-Nitro-2-methoxybenzene		4.83
o-Nitrophenol	16.50 (50)	3.14 (25, B)
m-Nitrophenol	35.45 (100)	
p-Nitrophenol	42.20 (120)	
1-Nitropropane	24.70 (15), 23.24 (30), 22.7 (35)	3.66
2-Nitropropane	26.74 (15), 25.52 (30)	3.73
N-Nitrosodimethylamine	53 (20)	4.01 (20, B)
o-Nitrotoluene	26.36 (20), 22.0 (58)	3.72 (20, B)
m-Nitrotoluene	24.95 (30), 22 (58)	4.20 (20, B)
p-Nitrotoluene	22.2 (58)	4.47 (25, B)
Nonane	1.972 (20), 1.85 (110)	0
Nonanoic acid	2.48 (22)	0.8
1-Nonanol		1.72 (20, B)
1-Nonene	2.18 (20)	0
(*trans, trans*)-9,12-Octadecadienoic acid	2.70 (70), 2.60 (120)	1.40 (18, Hx)
Octamethylcyclotetrasiloxane	2.4 (20)	0.42 (25, lq), 0.67 (25, B)
Octamethyltrisiloxane	2.3 (20)	0.64 (25, lq)
Octane	1.948 (20), 1.83 (110)	0
Octanenitrile	13.90 (20)	
Octanoic acid	2.85 (15), 2.45 (20)	1.15 (25, lq)
1-Octanol	11.3 (10), 10.30 (20)	1.72 (20, B)
2-Octanol	8.13 (20), 6.52 (40)	1.65 (20, B)
2-Octanone	9.51 (20), 7.42 (100)	2.72 (15, B)
1-Octene	2.113 (20)	0
cis-2-Octene	2.06 (25)	0
trans-2-Octene	2.00 (25)	0
Oleic acid	2.34 (20)	1.2
Oxalyl chloride	3.470 (21)	0.93 (20, B)
Palmitic acid	2.3 (70)	
Paraldehyde	13.9 (25)	1.43
Parathion		4.98 (25, B)
Pentachloroethane	3.73 (20), 3.716 (25)	0.92
2,3,4,5,6-Pentachlorotoluene	4.8 (20)	
Pentadecane		0
cis-1,3-Pentadiene	2.32 (25)	0.50 (25, B)
1,4-Pentadiene	2.054 (24)	
Pentanal	10.1 (17), 10.00 (20)	2.59 (20, B)
Pentane	2.011 (−90), 1.837 (20)	0
1,2-Pentanediol	17.31 (24)	
1,4-Pentanediol	26.74 (23)	
1,5-Pentanediol	26.2 (20)	2.45 (20, D)
2,3-Pentanediol	17.37 (24)	
2,4-Pentanediol	24.69 (21)	
2,4-Pentanedione	26.52 (30)	3.03
Pentanenitrile	20.04 (20)	4.12, 3.57 (25, B)
1-Pentanethiol	4.85 (20), 4.55 (25), 4.23 (50)	1.54 (25, lq)
Pentanoic acid	2.66 (21)	1.61 (20, D)
1-Pentanol	16.9 (20), 15.13 (25)	1.71 (20, B)
2-Pentanol	13.71 (25)	1.66 (22, B)

TABLE 5.17 Dielectric Constant (Permittivity) and Dipole Moment of Various Organic Substances (*Continued*)

Substance	Dielectric constant, ϵ	Dipole moment, D
3-Pentanol	13.35 (25)	1.64 (22, B)
2-Pentanone	15.45 (20), 11.73 (80)	2.72 (22, B)
3-Pentanone	19.4 (−20), 17.00 (20)	2.72 (20, B)
2-Pentanone oxime	3.3 (25)	
1-Pentene	2.011 (20)	0.5
cis-2-Pentene		0
trans-2-Pentene		0
Pentyl acetate	4.79 (20)	1.75
Pentylamine	4.27 (20)	1.55 (30, B)
Pentyl formate	5.7 (19)	1.90
Pentyl nitrate	9.0 (18)	
Pentyl nitrite	7.21 (25)	
tert-Pentyl nitrite	10.88 (25)	
Phenanthrene	2.8 (20)	0
Phenol	12.40 (30), 9.78 (60)	1.224
Phenoxyacetylene	4.76 (25)	1.42 (25, lq)
Phenyl acetate	5.40 (25)	1.54 (22, B)
Phenylacetic acid	3.47 (80)	
Phenylacetonitrile	17.87 (26), 8.5 (234)	3.47 (27, B)
Phenylacetylene	2.98 (20)	0.72 (20, B)
1-Phenylethanol	8.77 (20), 7.6 (90)	1.51 (20, B)
2-Phenylethanol	12.31 (20)	
Phenylhydrazine	7.15 (20)	1.67 (25, B)
Phenyl isocyanate	8.94 (20)	
Phenyl isothiocyanate	10 (20)	
1-Phenylpropene	2.7 (20)	
2-Phenylpropene	2.3 (20)	
3-Phenylpropene	2.6 (20)	
Phenyl salicylate	6.3 (50)	
Phosgene	4.7 (0), 4.3 (22)	
Phthalide	36 (75)	
(±)-α-Pinene	2.64 (25), 2.26 (30)	0.60 (25, B)
L-β-Pinene	2.76 (20)	
Piperidine	4.33 (20)	1.19 (25, B)
Propanal	18.5 (17)	2.52
Propane	1.668 (20)	0.084
1,2-Propanediamine	10.2	
1,3-Propanediamine	9.55	1.96 (25, B)
1,2-Propanediol	32.0 (20), 27.5 (30)	2.27 (25, D)
1,3-Propanediol	35.1 (20)	2.52 (25, D)
1,2-Propanediol dinitrate	26.80 (20)	
1,3-Propanediol dinitrate	18.97 (20)	
1,2-Propanedithiol	7.24 (20)	
1,3-Propanedithiol	8.11 (30)	
Propanenitrile	29.7 (20)	4.05
1-Propanethiol	5.94 (15), 1.55 (25)	1.68
2-Propanethiol	5.95 (25)	1.61
1,2,3-Propanetriol 1-acetate	38.57 (−31), 7.11 (20)	
Propanoic acid	3.30 (10), 3.44 (25)	1.76
Propanoic anhydride	18.30 (20)	
1-Propanol	20.8 (20), 20.33 (25)	1.55
2-Propanol	20.18 (20), 18.3 (25), 16.2 (40)	1.58

TABLE 5.17 Dielectric Constant (Permittivity) and Dipole Moment of Various Organic Substances (*Continued*)

Substance	Dielectric constant, ϵ	Dipole moment, D
2-Propenal		3.12
Propene	2.137 (−53), 1.88 (20), 1.44 (90)	0.366
Propenenitrile	33.0 (20)	3.87
2-Propen-1-ol	21.6 (15), 19.7 (20)	1.60
Propionaldehyde (propanal)	18.5 (17)	2.75
Propionamide		3.4 (30, B)
Propyl acetate	5.62 (20)	1.86 (25, B)
N-Propylacetamide	117.8 (25)	
Propylamine	5.31 (20), 5.08 (26)	1.17
Propylbenzene	2.37 (20), 2.351 (30)	0
Propyl benzoate	5.78 (30)	
Propyl butanoate	4.3 (20)	
Propyl carbamate	12.06 (65)	
Propylene carbonate	66.14 (20)	4.9
Propyleneimine		1.77 (*cis*), 1.60 (*trans*)
1,2-Propylene oxide		2.00
Propyl formate	7.72 (19), 6.92 (30)	1.91 (22, B)
Propyl nitrate	14 (18)	3.01 (20, B)
Propyl nitrite	12.35 (−23)	
Propyl pentanoate	4 (19)	
N-Propylpropanamide	118.1 (25)	
Propyl propanoate	5.25 (20)	1.79 (22, B)
Propyl trichloroacetate	8.32 (25)	
Propyne	3.218 (−27)	0.784
2-Propyn-1-ol	20.8 (20)	1.13
Pulegone	9.5 (20)	2.00 (25, B)
Pyridazine		4.22
Pyrazine	2.80 (50)	0
Pyridine	13.26 (20), 12.3 (25), 9.4 (116)	2.215
Pyridine-1-oxide	35.94 (70)	
Pyrimidine		2.33
1*H*-Pyrrole	8.00 (20), 8.13 (25)	1.74
Pyrrolidine	8.30 (20)	1.58 (20, B)
2-Pyrrolidone		3.55 (25, B)
Quinoline	9.16 (20), 9.00 (25)	2.29
Safrole	3.1 (21)	
Salicylaldehyde	18.35 (20)	2.86 (20, B)
D-Sorbitol	35.5 (80)	
Squalane	1.911 (100)	0
Squalene		0.68 (25, B)
Stearic acid	2.29 (70), 2.26 (100)	1.76 (25, D)
Styrene	2.47 (20), 2.43 (25), 2.32 (75)	0.13 (25, lq)
Succinonitrile	62.6 (25), 56.5 (57), 54 (68)	3.68 (30, toluene)
α-Terpinene	2.45 (25)	
Terpinolene	2.29 (25)	
1,1,2,2-Tetrabromoethane	8.6 (3), 7.0 (22), 6.72 (30)	1.41
1,1,2,2-Tetrachlorodifluoroethane	2.52 (35)	
1,1,1,2-Tetrachloroethane	9.22 (−66)	
1,1,2,2-Tetrachloroethane	8.50 (20)	1.32
Tetrachloroethylene	2.30 (25), 2.268 (30)	0
1,1,3,4-Tetrachlorohexafluoro-butane	2.86 (20)	

TABLE 5.17 Dielectric Constant (Permittivity) and Dipole Moment of Various Organic Substances (*Continued*)

Substance	Dielectric constant, ϵ	Dipole moment, D
Tetradecafluorohexane	1.76 (25)	
Tetradecamethylhexasiloxane	2.5 (20)	1.58 (20, lq)
Tetradecane		0
Tetradecanoic acid		0.76 (25, B)
1-Tetradecanol	4.72 (38), 4.40 (48)	1.69 (25, C)
Tetraethylene glycol	20.44 (20)	5.84 (20, lq)
Tetraethyl lead		0.3 (20, B)
Tetraethylsilane	2.09 (20)	0
Tetraethyl silicate	4.1 (20)	1.72 (32, B)
Tetrafluoromethane	1.685 (−147)	
2,2,3,3-Tetrafluoro-1-propanol	21.03 (25)	
Tetrahydrofuran	11.6 (−70), 7.52 (22)	1.75 (25, B)
Tetrahydro-2-furanmethanol	13.61 (23), 13.48 (30)	2.12 (35, lq)
2-Tetrahydrofurfuryl acetate	9.65 (20)	
1,2,3,4-Tetrahydronaphthalene	2.77 (25)	0
1,2,3,4-Tetrahydro-2-naphthol	11.7 (20), 6.7 (90)	
Tetrahydropyran	5.66 (20), 5.61 (25)	1.74
Tetrahydrothiophene		1.9
Tetrahydrothiophene-1,1-dioxide (sulfolane)	43.26 (30)	4.81 (25, B)
Tetrahydrothiophene-*S*-oxide	42.96 (25), 42.5 (30)	
Tetrakis(methylthio)methane	2.818 (70)	
Tetramethoxymethane	2.40 (20)	
Tetramethyl germanium	1.817 (24)	
1,1,3,3-Tetramethylguanidine	11.5 (25)	
Tetramethylsilane	1.921 (20)	0
Tetramethyl silicate	6.0 (20)	
1,1,2,2-Tetramethylurea	23.10 (20)	3.47 (25, B)
Tetranitromethane	2.317 (25)	0
Tetrathiomethylmethane	2.82 (70)	
Thiacyclopentane		1.90 (25, B)
Thioacetic acid	14.30 (25)	
Thiophene	2.74 (20), 2.57 (25)	0.55
Thymol		1.55 (25, B)
Toluene	2.385 (20), 2.364 (30)	0.375
o-Toluidine	6.34 (18), 6.14 (25), 5.71 (58)	1.60 (25, B)
m-Toluidine	5.95 (18), 5.82 (25), 5.45 (58)	1.45 (25, B)
p-Toluidine	5.06 (60)	1.52 (25, B)
m-Tolunitrile		4.21 (22, B)
p-Tolunitrile		4.47 (20, B)
Tribenzylamine		0.65 (20, B)
2,2,2-Tribromoacetaldehyde	7.6 (20)	1.70 (20, C)
Tribromochloromethane	2.60 (60)	
Tribromofluoromethane	3.00 (20)	
Tribromomethane	4.404 (10), 4.39 (20)	0.99
Tribromonitromethane	9.03 (25)	
1,2,3-Tribromopropane	6.45 (20), 6.00 (30)	1.59 (25, B)
Tributylamine	2.34 (20)	0.78 (25, B)
Tributyl borate	2.23 (20)	0.78 (25, C)
Tributyl phosphate	8.34 (20), 7.96 (30)	3.07 (25, B)
Tributyl phosphite		1.92 (20, C)
Trichloroacetaldehyde	7.6 (−40), 6.9 (20), 6.8 (25)	1.96 (25, B)

TABLE 5.17 Dielectric Constant (Permittivity) and Dipole Moment of Various Organic Substances (*Continued*)

Substance	Dielectric constant, ϵ	Dipole moment, D
Trichloroacetic acid	4.34 (60)	1.1 (25, B, dimer)
Trichloroacetic anhydride	5.0 (25)	
Trichloroacetonitrile	7.85 (19)	1.93 (19, lq)
4,4,4-Trichlorobutanal	10.0 (18)	
1,2,2-Trichloro-1,1-difluoroethane	4.01 (30)	
1,1,1-Trichloroethane	7.1 (7), 7.24 (20)	1.755
1,1,2-Trichloroethane	7.19 (25)	1.45
Trichloroethylene	3.42 (16), 3.39 (28)	0.77 (30, lq), 0.95 (30, B)
Trichloroethylsilane		2.0
Trichlorofluoromethane	3.00 (25), 2.28 (29)	0.45
(Trichloromethyl)benzene	6.9 (21)	2.0
Trichloromethylsilane		1.87 (25, B)
Trichloronitromethane	7.32 (25)	
2,4,6-Trichlorophenol		1.88 (25, D)
1,2,3-Trichloropropane	7.5 (20)	1.61
Trichlorosilane		0.86
α,α,α-Trichlorotoluene	6.9 (21)	2.17 (20, B)
1,1,2-Trichloro-1,2,2-trifluoroethane	2.41 (25)	
Tridecane	2.02 (20)	0
1-Tridecene	2.14 (20)	0
Triethanolamine	29.36 (25)	3.57 (25, B)
Triethoxymethane	4.779 (20)	
Triethylaluminum	2.9 (20)	
Triethylamine	2.418 (20)	0.66
Triethylborane	1.874 (20)	
Triethylene glycol	23.69 (20)	5.58 (20, lq)
Triethylenetetramine	10.76 (20)	
Triethyl orthovanadate	3.333 (25)	
Triethyl phosphate	13.43 (15), 13.20 (25), 10.93 (65)	3.08 (25, B)
Triethylphosphine oxide	35.5 (50)	
Triethylphosphine sulfide	39.0 (98)	
Triethyl phosphite	5.0	1.82 (25, D)
Trifluoroacetic acid	8.42 (20), 5.76 (50)	2.28
Trifluoroacetic anhydride	2.7 (25)	
1,1,1-Trifluoroethane		2.347
2,2,2-Trifluoroethanol	27.68 (20)	2.03 (25, cHex)
Trifluoromethane	5.2 (26)	1.651
(Trifluoromethyl)benzene	9.22 (25)	2.86
1-Trifluoromethyl-3-nitrobenzene	17.0 (30)	
α,α,α-Trifluorotoluene	9.2 (30), 8.1 (60)	
Trimethoxymethylsilane	4.9 (25)	
Trimethylamine	2.44 (25)	0.612
1,2,3-Trimethylbenzene	2.66 (20), 2.609 (30)	0
1,2,4-Trimethylbenzene	2.38 (20), 2.36 (30)	0
1,3,5-Trimethylbenzene	2.28 (20)	0
Trimethyl borate	2.276 (20)	0.82 (25, C)
2,2,3-Trimethylbutane	1.930 (20)	0
Trimethylchlorosilane	10.21 (0)	
Trimethylene sulfide		1.85
2,2,5-Trimethylhexane		0
2,3,5-Trimethylhexane		0
2,2,3-Trimethylpentane	1.962 (20)	0

TABLE 5.17 Dielectric Constant (Permittivity) and Dipole Moment of Various Organic Substances (*Continued*)

Substance	Dielectric constant, ϵ	Dipole moment, D
2,2,4-Trimethylpentane	1.940 (20)	0
2,3,3-Trimethylpentane	1.98 (20)	0
2,3,4-Trimethylpentane	1.97 (20)	0
Trimethyl phosphate	20.6 (20)	3.2
Trimethylphosphine sulfide		71.6 (20)
Trimethyl phosphite		1.83 (20, C)
2,4,6-Trimethylpyridine	7.807 (25)	1.95 (25, B)
2,4,6-Trinitrophenol	4.0 (21)	
1,3,5-Trioxane	15.55 (65)	2.08
Triphenyl phosphite	3.67 (45), 3.57 (65)	2.04 (25, B)
Tris(4-ethylphenyl) phosphite	3.74 (15), 3.61 (45)	2.08 (25, B)
Tris(2-methylphenyl) phosphate	6.7 (25)	2.9
Tris(3-methylphenyl) phosphate		3.0
Tris(4-methylphenyl) phosphate		3.2
Tris(*m*-tolyl) phosphite	3.67 (15), 3.53 (45)	1.62 (25, B)
Tris(*p*-tolyl) phosphite	3.88 (15), 3.74 (45)	1.77 (25, B)
Tri-*o*-tolyl phosphate	6.92 (40)	2.84 (40, C)
Undecane	2.00 (20), 1.84 (150)	0
2-Undecanone		2.71 (15, B)
1-Undecene	2.14 (20)	0
Urea		4.59 (25, D)
Vinyl acetate		1.79 (25, B)
Vinyl chloride	6.26 (17)	1.45
Vinyl isocyanate	10.62 (25)	
2-Vinylpyridine	9.126 (20)	
4-Vinylpyridine	10.50 (20)	
o-Xylene	2.562 (20), 2.54 (30)	0.62
m-Xylene	2.359 (20), 2.35 (30)	0.33 (20, lq), 0.37 (20, B)
p-Xylene	2.273 (20), 2.22 (50)	0
Xylitol	40.0 (20)	

TABLE 5.18 Viscosity, Dielectric Constant, Dipole Moment, and Surface Tension of Selected Inorganic Substances

For the majority of compounds the dependence of the surface tension γ on the temperature can be given as:

$$\gamma = a - bt$$

where a and b are constants and t is the temperature in degrees Celsius.
The values of the dipole moment are for the gas phase.

Substance	Viscosity, $mN \cdot s \cdot m^{-2}$	Dielectric constant, ϵ	Dipole moment, D	Surface tension, $mN \cdot m^{-1}$	
				a	b
Air	0.0182^{20}, 0.0231^{127}	1.000 536 4			
$AlBr_3$		3.38^{100}	5.2		
Ar					
(g)	0.0233^{20}, 0.0288^{127}	1.000 517 2			
(lq)		1.538^{-191}, 1.325^{-132}	0	34.28	0.2493
$AsBr_3$		8.83^{35}	1.61	54.41	0.1043
$AsCl_3$		12.6^{20}	1.59	41.67	0.097 81
AsH_3 (arsine)		2.40^{-72}, 2.05^{20}	0.20		
BBr_3		2.58^{0}	0	31.90	0.1280
BCl_3			0		
BF_3	0.0171^{27}, 0.0217^{127}		0	−2.92	0.2030
B_2H_6 (diborane)		$1.872^{-92.5}$	0	−3.13	0.1783
B_4H_{10}			0.486		
B_5H_9		21.1^{25}	2.13		
B_6H_{10}			2.50		
$B_3H_6N_3$			0		
Br_2 (g)		1.0128^{20}			
(lq)	1.252^{0}, 1.03^{16}, 0.744^{25}	3.1484^{25}	0	45.5	0.1820
BrF_3	2.22^{20}	106.8^{25}	1.1	38.30	0.0999
BrF_5	0.62^{24}	$7.91^{24.5}$	1.51	25.24	0.1098
Cl_2 (g)	0.0132^{20}		0		
(lq)		2.147^{-65}, 1.91^{14}		19.87	0.1897
ClF_3	0.48^{12}	4.394^{20}, 4.29^{25}	0.554	26.9	0.1660
ClF_5		4.28^{-80}			
ClO_3F		2.194^{-123}	0.023	12.24	0.1576
CO (g)	0.0175^{20}, 0.0221^{127}	$1.000\ 70^{0}$	0.112		
(lq)				−30.20	0.2073
CO_2 (g)	0.0147^{20}, 0.0197^{127}	1.000 922	0		
(lq)	0.071^{20}	$1.60^{0°C,\ 50\ atm}$, 1.449^{23}		6.14^{-10}	2.67^{10}
$COCl_2$		4.34^{22}	1.17	22.59	0.1456
COF_2			0.95		
COS		4.47^{-88}	0.712	12.12	0.1779
COSe		3.47^{10}	0.73		
CS			1.98		

TABLE 5.18 Viscosity, Dielectric Constant, Dipole Moment, and Surface Tension of Selected Inorganic Substances (*Continued*)

Substance	Viscosity, $mN \cdot s \cdot m^{-2}$	Dielectric constant, ϵ	Dipole moment, D	Surface tension, $mN \cdot m^{-1}$	
				a	*b*
CS_2 (g)		1.0029^{0}	0		
(lq)	0.429^{0}, 0.375^{20}, 0.352^{25}	2.632^{20}		35.29	0.1484
CrO_2Cl_2		2.6^{20}	0.47		
D_2 (deuterium)	0.0126^{27}, 0.0154^{127}	1.290^{-255}, 1.277^{-253}			
DH		$1.269^{16.78\ K}$		6.537	0.1883
D_2O	0.0111^{25} (g), 1.098^{25} (lq)	79.75^{20}, 78.25^{25}	1.87	71.72^{20}	68.38^{40}
F_2		1.491^{-220}, 1.54^{-202}		−16.10	0.1646
$GaCl_3$			0.85	35.0	0.1000
$GeBr_4$				35.51^{30}	33.70^{50}
$GeBr_4$		2.955^{26}		35.51^{30}	33.70^{50}
$GeCl_4$		2.463^{0}, 2.430^{25}	0	22.44^{30}	
$GeClH_3$			2.13		
H_2 (g)	0.0088^{20}, 0.109^{127}	1.000 253 8	0		
t					
(lq)		$1.279^{13.5\ K}$, $1.228^{20.4\ K}$		2.80^{-258}	2.12^{-254}
HBr (g)		$1.003\ 13^{0}$	0.827		
(lq)	0.83^{-67}	8.23^{-86}, 3.82^{25}		13.10	0.2079
He (g)	0.0196^{27}, 0.0244^{27}	1.000 065 0	0		
(lq) (II)		$1.0555^{2.055\ K}$		$0.351^{0.50\ K}$	$0.317^{2.00\ K}$
(III)				$0.151^{3.61\ K}$	$0.131^{1.13\ K}$
(IV)				$0.372^{0.50\ K}$	$0.354^{1.40\ K}$
HCl (g)	0.0146^{27}, 0.0197^{127}	1.0046^{0}	1.109		
(lq)	0.51^{-95}	14.3^{-114}, 4.60^{28}			
HClO			1.3		
HCN	0.235^{0}, 0.206^{18}, 0.183^{25}	114.9^{20}	2.98	19.45^{10}	18.33^{20}
HCNO (isocyanate)			1.6		
HCNS			1.7		
HF	0.256^{0}	83.6^{0}	1.826	10.41	0.078 67
HFO			2.23		
HI (g)		$1.002\ 34^{0}$	0.448		
(lq)		3.87^{-53}, 2.90^{22}			
HN_3 (azide)			1.70		
H_2O (see Table 5.19)					
H_2O_2	1.25^{20}	84.2^{0}, 74.6^{17}	1.573	78.97	0.1549
HNO_3			2.17		
H_2S (g)		1.0040^{0}	0.97		
(lq)	0.412^{0}	5.93^{10}		48.95	0.1758
H_2Se			0.24	22.32	0.1482

TABLE 5.18 Viscosity, Dielectric Constant, Dipole Moment, and Surface Tension of Selected Inorganic Substances (*Continued*)

Substance	Viscosity, $mN \cdot s \cdot m^{-2}$	Dielectric constant, ϵ	Dipole moment, D	Surface tension, $mN \cdot m^{-1}$	
				a	*b*
HSO_3Cl	2.43^{20}	60^{60}			
HSO_3F	1.56^{25}	ca. 120^{25}			
H_2SO_4	24.54^{25}	100^{25}			
H_2Te			<0.2	29.03	0.2619
Hg	1.552^{20}, 1.526^{25}, 1.402^{50}		0	490.6	0.2049
I_2	1.98^{116}	11.1^{118}	0		
IBr			0.726		
IF			1.95		
IF_5		37.13^{20}	2.18	33.16	0.1318
IF_7		1.97^{23}			
IOF_5		1.75^{25}			
Kr (g)	0.0250^{20}, 0.0331^{127}		<0.05		
(lq)		$1.644^{-153.4}$		40.576 (in K)	0.2890 (in K)
Mn_2O_7		3.28^{20}			
Ne (g)	0.0303^{20}, 0.0389^{127}	$1.000\ 063\ 9^{20}$	0		
(lq)		$1.1907^{-247.1}$			
N_2 (g)	0.0176^{20}, 0.0222^{127}	$1.000\ 548\ 0^{20}$	0		
(lq)		1.468^{-210}, 1.454^{-203}		26.42 (in K)	0.2265 (in K)
NH_3 (g)		1.0072^{0}	1.471		
(lq)	$0.254^{-33.5}$	$22.4^{-33.5}$, 16.61^{20}		37.91^{-50}	35.38^{-40}
N_2H_4 (hydrazine)	0.97^{20}, 0.876^{25}, 0.628^{50}	52.9^{20}, 51.7^{25}	1.75	72.41	0.2407
$Ni(CO)_4$				18.11	0.1117
NO	0.0192^{27}, 0.0238^{127}		0.159	−67.48	0.5853
N_2O (g)	0.0146^{20}, 0.0194^{127}	$1.001\ 13^{0}$	0.161		
(lq)		1.52^{15}		5.09	0.2032
NO_2	0.532^{0}, 0.402^{25}		0.316		
N_2O_4		2.56^{25}, 2.44^{20}	0.5		
N_2O_3			2.122		
NOBr		13.4^{15}	1.8		
NOCl		18.2^{12}	1.9	29.49	0.1493
NO_2Cl			0.53		
NOF			1.73	14.00	0.1165
NO_2F			0.47	8.26	0.1854
NO_3		31.13^{-70}			
O_2 (g)	0.0204^{20}, 0.0261^{127}	$1.000\ 494\ 7^{20}$	0		
(lq)		$1.568^{-218.7}$, 1.507^{-193}		−33.72	0.2561
O_3		4.75^{-183}	0.534	38.1^{-183}	

TABLE 5.18 Viscosity, Dielectric Constant, Dipole Moment, and Surface Tension of Selected Inorganic Substances (*Continued*)

Substance	Viscosity, $mN \cdot s \cdot m^{-2}$	Dielectric constant, ϵ	Dipole moment, D	Surface tension, $mN \cdot m^{-1}$	
				a	*b*
OF_2			0.297		
O_2F_2 (FOOF)			1.44		
OsO_4			0		
P (lq)		4.096[34]			
PBr_3		3.9[20]	0.56	45.34	0.1283
PCl_3	0.662[0], 0.529[25], 0.439[50]	3.43[25], 3.50[17]	0.78	31.14	0.1266
PCl_5		2.85[160], 2.7[165]	0.9		
PCl_2F_3		2.813[−45]			
PCl_3F_2		2.375[−5]			
PCl_4F		2.65[0.5]			
PF_3			1.03		
PF_5			0		
PH_3		2.9[15]	0.574		
PI_3		4.12[65]	0	61.66	0.067 71
PO_3				40.44	0.1158
$POCl_3$	1.065[25]	13.7[25]	2.54	35.22	0.1275
POF_3			1.868		
$PSCl_3$		5.8[22]	1.42	37.00	0.1272
PSF_3			0.64		
$PbCl_4$		2.78[20]			
ReO_2Cl_3				57.00	0.2485
ReO_3Cl				54.05	0.1979
S		3.499[134]			
SCl_2		2.915[25]	0.36		
S_2Cl_2 dimer		4.79[15]	1.0	46.23	0.1464
S_2F_2					
FSSF isomer			1.45		
$S{=}SF_2$ isomer			1.03		
SF_4			0.632	12.87	0.1734
SF_6	0.0153[27], 0.0198[127]	1.81[−50]	0	5.66	0.1190
S_2F_{10}		2.020[20]	0		
SO_2 (g)	0.0129[27], 0.0175[127]	1.0093[0]	1.63		
(lq)		16.3[25]		26.58	0.1948
SO_3		3.11[18]	0		
$SOBr_2$		9.06[20]	9.11	46.28	0.0750
$SOCl_2$		9.25[20], 8.675[25]	1.45	36.10	0.1416
SOF_2			1.63		
SO_2Cl_2		9.15[20]	1.81	32.10	0.1328
SO_2F_2			1.12		
$SbCl_3$		33.2[75]	3.93	47.87	0.1238
$SbCl_5$		3.22[20]	0		
SbF_5				49.07	0.1937
SbH_3			0.12		
Se (lq)		5.44[237.5]			
SeF_4			1.78	38.61	0.1274

TABLE 5.18 Viscosity, Dielectric Constant, Dipole Moment, and Surface Tension of Selected Inorganic Substances (*Continued*)

Substance	Viscosity, $mN \cdot s \cdot m^{-2}$	Dielectric constant, ϵ	Dipole moment, D	Surface tension, $mN \cdot m^{-1}$	
				a	*b*
SeF_6			0		
$SeOCl_2$		46.2^{20}	2.64		
SeO_2			2.62		
$SiCl_4$	99.4^{25}, 96.2^{50}	2.248^{0}	0	20.78	0.099 62
SiF_4			0		
SiH_4			0		
$SiHCl_3$	0.415^{0}, 0.326^{25}		0.86	20.43	0.1076
SiH_3Cl			1.31		
$SnBr_4$		3.169^{30}	0		
$SnCl_4$		3.014^{0}, 2.89^{20}	0	29.92	0.1134
TeF_6			0		
$TiCl_4$		2.843^{14}, 2.80^{20}	0	33.54^{20}	31.06^{40}
UF_6 (g)		1.002 92^{67}	0		
(lq)		2.18^{65}		25.5	0.1240
VCl_4		3.05^{25}	0		
$VOBr_3$		3.6^{25}			
$VOCl_3$		3.4^{25}	0.3	36.36^{20}	33.60^{40}
Xe (g)	0.0228^{20}, 0.030^{127}	1.001 23	0		
(lq, II)		$1.880^{-111.9}$		$0.345^{1.00\ K}$	$0.317^{2.00\ K}$
XeF_6		4.10^{125}			

TABLE 5.19 Refractive Index, Viscosity, Dielectric Constant, and Surface Tension of Water at Various Temperatures

Temp., °C	Refractive index, n_D	Viscosity, $mN \cdot s \cdot m^{-2}$	Dielectric constant, ϵ	Surface tension, $mN \cdot s \cdot m^{-2}$
0	1.333 95	1.793	87.90	75.83
5	1.333 88	1.521	85.84	75.09
10	1.333 69	1.307	83.96	74.36
15	1.333 39	1.135	82.00	73.62
20	1.333 00	1.002	80.20	72.88
25	1.332 50	0.890 3	78.35	72.14
30	1.331 94	0.797 7	76.60	71.40
35	1.331 31	0.719 0	74.83	70.66
40	1.330 61	0.653 2	73.17	69.92
50	1.329 04	0.547 0	69.58	68.45
60	1.327 25	0.466 5	66.73	66.97
70	1.325 11	0.404 0	63.73	65.49
80		0.354 4	60.86	64.01
90		0.314 5	58.12	62.54
100		0.281 8	55.51	61.07

5.6.1 Refractive Index

The refractive index n is the ratio of the velocity of light in a particular substance to the velocity of light in vacuum. Values reported refer to the ratio of the velocity in air to that in the substance saturated with air. Usually the yellow sodium doublet lines are used; they have a weighted mean of 589.26 nm and are symbolized by **D**. When only a single refractive index is available, approximate values over a small temperature range may be calculated using a mean value of 0.000 45 per degree for dn/dt, and remembering that n_D decreases with an increase in temperature. If a transition point lies within the temperature range, extrapolation is not reliable.

The *specific refraction* r_D is given by the Lorentz and Lorenz equation,

$$R_D = \frac{n_D^2 - 1}{n_D^2 + 2} \cdot \frac{1}{\rho}$$

where ρ is the density at the same temperature as the refractive index, and is independent of temperature and pressure. The molar refraction is equal to the specific refraction multiplied by the molecular weight. It is a more or less additive property of the groups or elements comprising the compound. A set of atomic refractions is given in Table 5.19; an extensive discussion will be found in Bauer, Fajans, and Lewin, in *Physical Methods of Organic Chemistry*, 3d ed., A. Weissberger (ed.), vol. 1, part II, chap. 28, Wiley-Interscience, New York, 1960.

The empirical Eykman equation

$$\frac{n_D^2 - 1}{n_D + 0.4} \cdot \frac{1}{\rho} = \text{constant}$$

offers a more accurate means for checking the accuracy of experimental densities and refractive indices, and for calculating one from the other, than does the Lorentz and Lorenz equation.

The refractive index of moist air can be calculated from the expression

$$(n - 1) \times 10^6 = \frac{103.49}{T} p_1 + \frac{177.4}{T} p_2 + \frac{86.26}{T} \left(1 + \frac{5748}{T}\right) p_3$$

where p_1 is the partial pressure of dry air (in mmHg), p_2 is the partial pressure of carbon dioxide (in mmHg), p_3 is the partial pressure of water vapor (in mmHg), and T is the temperature (in kelvins).

Example: 1-Propynyl acetate has $n_D = 1.4187$ and density = 0.9982 at 20°C; the molecular weight is 98.102. From the Lorentz and Lorenz equation,

$$r_D = \frac{(1.4187)^2 + 1}{(1.4187)^2 + 2} \cdot \frac{1}{0.9982} = 0.2528$$

The molar refraction is

$$Mr_D = (98.102)(0.2528) = 24.80$$

From the atomic and group refractions in Table 5.19, the molar refraction is computed as follows:

6 H	6.600
5 C	12.090
1 C≡C	2.398
1 O(ether)	1.643
1 O(carbonyl)	2.211
	$Mr_D = 24.942$

TABLE 5.20 Atomic and Group Refractions

Group	Mr_D	Group	Mr_D
H	1.100	N (primary aliphatic amine)	2.322
C	2.418	N (*sec*-aliphatic amine)	2.499
Double bond (C═C)	1.733	N (*tert*-aliphatic amine)	2.840
Triple bond (C≡C)	2.398	N (primary aromatic amine)	3.21
Phenyl (C_6H_5)	25.463	N (*sec*-aromatic amine)	3.59
Naphthyl ($C_{10}H_7$)	43.00	N (*tert*-aromatic amine)	4.36
O (carbonyl) (C═O)	2.211	N (primary amide)	2.65
O (hydroxyl) (O—H)	1.525	N (*sec* amide)	2.27
O (ether, ester) (C—O—)	1.643	N (*tert* amide)	2.71
F (one fluoride)	0.95	N (imidine)	3.776
(polyfluorides)	1.1	N (oximido)	3.901
Cl	5.967	N (carbimido)	4.10
Br	8.865	N (hydrazone)	3.46
I	13.900	N (hydroxylamine)	2.48
S (thiocarbonyl) (C═S)	7.97	N (hydrazine)	2.47
S (thiol) (S—H)	7.69	N (aliphatic cyanide) (C≡N)	3.05
S (dithia) (—S—S—)	8.11	N (aromatic cyanide)	3.79
Se (alkyl selenides)	11.17	N (aliphatic oxime)	3.93
3-membered ring	0.71	NO (nitroso)	5.91
4-membered ring	0.48	NO (nitrosoamine)	5.37
		NO_2 (alkyl nitrate)	7.59
		(alkyl nitrite)	7.44
		(aliphatic nitro)	6.72
		(aromatic nitro)	7.30
		(nitramine)	7.51

5.6.2 Surface Tension

The surface tension of a liquid, γ, is the force per unit length on the surface that opposes the expansion of the surface area. In the literature the surface tensions are expressed in dyn · cm^{-1}; 1 dyn · cm^{-1} = 1 mN · m^{-1} in the SI system. For the large majority of compounds the dependence of the surface tension on the temperature can be given as

$$\gamma = a - bt$$

where a and b are constants and t is the temperature in degrees Celsius. The values of a and b given in Tables 5.16 and 5.18 can be used to calculate the values of surface tension for the particular compound within its liquid range. For example, the least-squares constants for acetic anhydride (liquid from −73 to 140°C) are 35.52 and 0.1436, respectively. At 20°C, $\gamma = 35.52 - 0.1436(20) = 32.64$ dyn · cm^{-1}.

A compilation of data of some 2200 pure liquid compounds has been prepared by Jasper, *J. Phys. Chem. Reference Data* **1:**841 (1972).

5.6.3 Dipole Moments

The permanent dipole moment of an isolated molecule depends on the magnitude of the charge and on the distance separating the positive and negative charges. It is defined as

$$\mu = \left(\sum_i q_i r_i \right)$$

where the summation extends over all charges (electrons and nuclei) in the molecule. The numerical values of the dipole moment, expressed in the c.g.s. system of units, are in debye units, D, where 1 D = 10^{-18} esu of charge × centimeters. The conversion factor to SI units is

$$1\ \text{D} = 3.335\ 64 \times 10^{-30}\ \text{C} \cdot \text{m} \quad \text{[coulomb-meter]}$$

Tables 5.17 and 5.18 contain a selected group of compounds for which the dipole moment is given. An extensive collection of dipole moments (approximately 7000 entries) is contained in A. L. McClellan, *Tables of Experimental Dipole Moments,* W. H. Freeman, San Francisco, 1963. A critical survey of 500 compounds in the gas phase is given by Nelson, Lide, and Maryott, NSRDS-NBS 10, Washington, D.C., 1967.

5.6.4 Dielectric Constants

If two oppositely charged plates exist in a vacuum, there is a certain force of attraction between them, as stated by Coulomb's law:

$$\boldsymbol{F} = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q_1 q_2}{\varepsilon r^2}$$

where $\boldsymbol{F}$ is the force, in newtons, acting on each of the charges q_1 and q_2, r is the distance between the charges, ε is the dielectric constant of the medium between the plates, and ε_0 is the permittivity of free space. q_1, q_2 are expressed in coulombs and r in meters. If another substance, such as a solvent, is in the space separating these charges (or ions in a solution), their attraction for each other is less. The dielectric constant is a measure of the relative effect a solvent has on the force with which two oppositely charged plates attract each other. The dielectric constant is a unitless number.

Dielectric constants for a selected group of inorganic and organic compounds are included in Tables 5.17 and 5.18. An extensive list has been compiled by Maryott and Smith, *National Bureau Standards Circular 514,* Washington, D.C., 1951.

For gases the values of the dielectric constant can be adjusted to somewhat different conditions of temperature and pressure by means of the equation

$$\frac{(\varepsilon - 1)_{t,p}}{(\varepsilon - 1)_{20°,1\ \text{atm}}} = \frac{p}{760[1 + 0.003\ 411(t - 20)]}$$

where p is the pressure (in mmHg) and t is the temperature (in °C). The errors associated with this equation probably do not exceed 0.02% for gases between 10 and 30°C and for pressures between 700 and 800 mm. The dielectric constants of selected gases will be found in Table. 5.18.

5.6.5 Viscosity

The *dynamic viscosity,* or coefficient of viscosity, η of a Newtonian fluid is defined as the force per unit area necessary to maintain a unit velocity gradient at right angles to the direction of flow between two parallel planes a unit distance apart. The SI unit is pascal-second or newton-second per meter squared [$\text{N} \cdot \text{s} \cdot \text{m}^{-2}$].The c.g.s. unit of viscosity is the poise [P]; 1 cP ≡ 1 $\text{mN} \cdot \text{s} \cdot \text{m}^{-2}$.The dynamic viscosity decreases with the temperature approximately according to the equation: $\log \eta = A + B/T$. Values of A and B for a large number of liquids are given by Barrer, *Trans. Faraday Soc.* **39:**48 (1943).

TABLE 5.21 Aqueous Glycerol Solutions

% Weight glycerol	Grams per liter	Relative density 25°/25°C	Viscosity, mN · s · m^{-2}		
			20°C	25°C	30°C
100	1261	1.262 01	1 495	942	622
99	1246	1.259 45	1 194	772	509
98	1231	1.256 85	971	627	423
97	1216	1.254 25	802	521	353
96	1201	1.251 65	659	434	296
95	1186	1.249 10	543.5	365	248
80	966.8	1.209 25	61.8	45.72	34.81
50	563.2	1.127 20	6.032	5.024	4.233
25	265.0	1.061 15	2.089	1.805	1.586
10	102.2	1.023 70	1.307	1.149	1.021

Kinematic viscosity v is the ratio of the dynamic viscosity to the density of a fluid. The SI unit is meter squared per second [$m^2 \cdot s^{-1}$]. The c.g.s. units are called stokes [$cm^2 \cdot s^{-1}$]; poises = stokes × density.

Fluidity ϕ is the reciprocal of the dynamic viscosity.

The primary reference liquid for viscosity measurements is water. The absolute viscosity of water at 20°C is 1.0019 (±0.0003) mN · s · m^{-2} (or centipoise), as determined by Swindells, Coe, and Godfrey, *J. Research Natl. Bur. Standards* **48:**1 (1952). The relative viscosity of water, $\eta/\eta_{20°}$, is 0.8885 at 25°C, 0.7960 at 30°C, and 0.6518 at 40°C. Values at temperatures between 15 and 60°C are best represented by Cragoe's equation:

$$\log \frac{\eta}{\eta_{20°}} = \frac{1.2348(20 - t) - 0.001\,467(t - 20)^2}{t + 96}$$

The *Reynolds number* for flow in a tube is defined by $d\bar{v}\rho/\eta$, where d is the diameter of the tube, $\bar{v}$ is the average velocity of the fluid along the tube, ρ is the density of the fluid, and η is its dynamic viscosity. At flow velocities corresponding with values of the Reynolds number of greater than 2000, turbulence is encountered.

TABLE 5.22 Aqueous Sucrose Solutions

% Weight sucrose	Grams per liter	Relative density 20°/4°C	Viscosity, mN · s · m^{-2}		
			15°C	20°C	25°C
75	1034	1.379 0	4 039	2 328	1 405
70	943.0	1.347 2	746.9	481.6	321.6
65	855.6	1.316 3	211.3	147.2	105.4
60	771.9	1.286 5	79.49	58.49	40.03
50	614.8	1.299 6	19.53	15.43	12.40
40	470.6	1.176 4	7.463	6.167	5.164
30	338.1	1.127 0	3.757	3.187	2.735

5.7 COMBUSTIBLE MIXTURES

TABLE 5.23 Properties of Combustible Mixtures in Air

The *autoignition temperature* is the minimum temperature required for self-sustained combustion in the absence of an external ignition source. The value depends on specified test conditions. The *flammable (explosive) limits* specify the range of concentration of the vapor in air (in percent by volume) for which a flame can propagate. Below the lower flammable limit, the gas mixture is too lean to burn; above the flammable limit, the mixture is too rich. Additional compounds can be found in National Fire Protection Association, National Fire Protection Handbook, 14th ed., 1991.

For alternative nomenclature, see Table 1.15.

Substance	Autoignition temperature, °C	Flammable (explosive) limits, percent by volume of fuel (25°C, 760 mm)	
		Lower	Upper
Acetaldehyde	175	4.0	60
Acetanilide	540		
Acetic acid, glacial	463	4.0	19.9
Acetic anhydride	316	2.7	10.3
Acetone	465	2.5	12.8
Acetonitrile	524	3.0	16.0
Acetophenone	570		
Acetylacetone	340		
Acetylene	305	3.0	65
Acetyl chloride	390		
Acrolein	220	2.8	31.0
Acrylic acid (2-propenoic acid)	438	2.4	8.0
Acrylonitrile	481	3.0	17.0
Adiponitrile	550	2	5
Allyl acetate	374		
Allyl alcohol	378	2.5	18.0
Allylamine	374	2.2	22
Ammonia, anhydrous	651	16	25
Aniline	615	1.3	11
Asphalt	485		
Benzaldehyde	192		
Benzene	498	1.2	7.8
Benzoyl peroxide	80		
Benzyl acetate	460		
Benzyl alcohol	436		
Benzyl benzoate	480		
Benzyl chloride	585	1.1	
Bis(2-aminoethyl)amine	399		
Bis(2-chloroethyl) ether	369	2.7	
Biscyclohexyl	245	0.7	5.1
Bis(2-hydroethyl) ether	229		
Bromobenzene	565		
1-Bromobutane	265	2.6	6.6
Bromoethane	511	6.8	8.0
Bromomethane	537	10	16.0
1-Bromopropane	490		

TABLE 5.23 Properties of Combustible Mixtures in Air (*Continued*)

Substance	Autoignition temperature, °C	Flammable (explosive) limits, percent by volume of fuel (25°C, 760 mm)	
		Lower	Upper
3-Bromopropene	295	4.4	7.3
1,3-Butadiene	420	2.0	11.5
Butanal (butyraldehyde)	218	1.9	12.5
Butane	287	1.9	8.5
1,3-Butanediol	395		
2,3-Butanediol	402		
Butanenitrile	501	1.65	
Butanoic acid (butyric acid)	443	2.0	10.0
Butanoic anhydride (butyric anhydride)	279	0.9	5.8
1-Butanol	343	1.4	11.2
2-Butanol	415	1.7	11
2-Butanone	404	1.4	11.4
trans-2-Butenal (crotonaldehyde)	232	2.1	15.9
1-Butene	384	1.6	9.3
cis-2-Butene	324	1.7	
trans-2-Butene	324	1.8	9.7
1-Butene oxide		1.5	18.3
3-Buten-1-ol		4.7	34
2-Butoxyethanol	238	4	13
2-(2-Butoxyethoxy)ethyl acetate	299		
Butyl acetate	425	1.7	7.6
sec-Butyl acetate		1.7	9.8
Butylamine	312	1.7	9.8
tert-Butylamine	380	1.7	8.9
Butylbenzene	410	0.8	5.8
sec-Butylbenzene	418	0.8	6.9
tert-Butylbenzene	450	0.7	5.7
Butyl formate	322	1.7	8.2
Butyl methyl ketone	423	1	8
Butyl 2-methyl-2-propenoate	294	2	8
Butyl propanoate	427		
Butyl stearate	355		
Butyl vinyl ether	255		
2-Butyne		1.4	
Camphor	466	0.6	3.5
Carbon disulfide	90	1.3	50.0
Carbon monoxide	609	12.5	74.2
Carbonyl sulfide		12	28.5
Chlorobenzene	593	1.3	9.6
1-Chloro-1,3-butadiene		4.0	20.0
1-Chlorobutane	240	1.8	10.1
2-Chloro-2-butene		2.3	9.3
1-Chloro-2,3-epoxypropane	411	4	21
1-Chloro-1,1-difluoroethane		6.2	17.9
1-Chloro-2,4-dinitrobenzene		2.0	22
1-Chloro-2,3-epoxypropane	411	3.8	21
Chloroethane	519	3.8	15.4
2-Chloroethanol	425	4.9	15.9
Chloromethane	632	8.1	17.4
1-Chloro-3-methylbutane		1.5	7.4
1-Chloro-2-methylpropane		2.0	8.8

TABLE 5.23 Properties of Combustible Mixtures in Air (*Continued*)

Substance	Autoignition temperature, °C	Flammable (explosive) limits, percent by volume of fuel (25°C, 760 mm)	
		Lower	Upper
3-Chloro-2-methyl-1-propene		2.3	9.3
1-Chloronaphthalene	>588		
1-Chloropentane	260	1.6	8.6
1-Chloropropane	520	2.6	11.1
2-Chloropropane	593	2.8	10.7
1-Chloro-1-propene		4.5	16
2-Chloro-1-propene		4.5	16
3-Chloro-1-propene	485	2.9	11.1
Chlorotrifluoroethylene		24	40.3
m-Cresol	558	1.1	
o-Cresol	599	1.4	
p-Cresol	558	1.1	
Cumene	424	0.9	6.5
Cyanogen		6.6	32
Cyclobutane		1.8	
Cyclohexane	245	1.3	8
Cyclohexanol	300	1	9
Cyclohexanone	420	1.1	9.4
Cyclohexene	244	1.2	
Cyclohexyl acetate	334		
Cyclohexylamine	293	1	9
Cyclopentane	361	1.5	
Cyclopentene	395		
Cyclopropane	500	2.4	10.4
p-Cymene	436	0.7	5.6
trans-Decahydronaphthalene	255	0.7	5.4
Decane	210	0.8	5.4
Decene	235		
Diborane(6)	38 to 52	0.8	88
Dibutylamine		1.1	6
Dibutyl decanedioate (dibutyl sebacate)	365	0.44	
Dibutyl ether	194	1.5	7.6
Dibutyl *o*-phthalate	402	0.5	
1,2-Dichlorobenzene	648	2.2	9.2
1,1-Dichloroethane	458	5.4	11.4
1,2-Dichloroethane	413	6.2	16
1,1-Dichloroethylene	570	6.5	15.5
cis-1,2-Dichloroethylene	460	3	15
trans-1,2-Dichloroethylene	460	6	13
Dichloromethane	556	13	23
1,2-Dichloropropane	557	3.4	14.5
Diethanolamine [2,2′-iminobis(ethanol)]	662	2	13
1,1-Diethoxyethane (acetal)	230	1.6	10.4
Diethylamine	312	1.8	10.1
Diethylene glycol [bis(2-hydroxyethyl) ether]	224	2	17
Diethylene glycol dibutyl ether	310		
Diethylene glycol monoethyl ether acetate	425		
Diethylene glycol monomethyl ether	240	1.4	22.7
Diethylenetriamine	358	2	6.7
Diethyl ether	180	1.9	36.0
3,3-Diethylpentane	290	0.7	5.7

TABLE 5.23 Properties of Combustible Mixtures in Air (*Continued*)

Substance	Autoignition temperature, °C	Flammable (explosive) limits, percent by volume of fuel (25°C, 760 mm)	
		Lower	Upper
Diethyl peroxide		2.3	15.9
Diethyl sulfate	436		
1,1-Difluoroethylene		5.5	21.3
1,3-Dihydroxybenzene (resorcinol)	664		
1,4-Dihydroxybenzene	516		
Diisopropylamine	316	1.1	7.1
Diisopropyl ether	443	1.4	7.9
Dimethoxymethane	237	2.2	13.8
N,*N*-Dimethylacetamide	490	2.0	11.5
Dimethylamine (anhydrous)	400	2.8	14.4
N,*N*-Dimethylaniline	371		
2,3-Dimethylaniline		1.0	
2,2-Dimethylbutane	405	1.2	7.0
2,3-Dimethylbutane	405	1.2	7.0
3,3-Dimethyl-2-butanone	423	1	8
cis-1,2-Dimethylcyclohexane	304		
trans-1,2-Dimethylcyclohexane	304		
Dimethyl ether	350	3.4	27.0
N,*N*-Dimethylformamide	445	2.2	15.2
2,6-Dimethyl-4-heptanol		0.8	6.1
2,6-Dimethyl-4-heptanone	396	0.8	6.2
2,3-Dimethylhexane	438		
1,1-Dimethylhydrazine	249	2	95
2,3-Dimethylpentane	335	1.1	6.7
Dimethyl 1,2-phthalate	490	0.9	
2,2-Dimethylpropane	450	1.4	7.5
Dimethyl sulfate	188		
Dimethyl sulfide	206	2.2	19.7
Dimethyl sulfoxide	215	2.6	42
1,4-Dioxane	180	2.0	22
Dipentene	237		
Dipentyl ether	170		
Diphenylamine	634		
Diphenyl ether	618	0.8	1.5
Dipropylamine	299		
Dipropyl ether	188	1.3	7.0
Divinyl ether	360	1.7	27.0
Dodecane	203	0.6	
1-Dodecanol	275		
1,2-Epoxybutane	439	1.7	19
Ethane	515	3.0	12.5
1,2-Ethanediamine	385	2.5	12.0
1,2-Ethanediol	398	3.2	22
Ethanethiol	299	2.8	18.2
Ethanol	363	3.3	19
Ethanolamine	410	3.0	23.5
2-Ethoxyethanol	235	3	18
2-Ethoxyethyl acetate	379	2	8
1-Ethoxypropane		1.7	9.0
Ethyl acetate	426	2	11.5
Ethyl acetoacetate	295	1.4	9.5

TABLE 5.23 Properties of Combustible Mixtures in Air (*Continued*)

Substance	Autoignition temperature, °C	Flammable (explosive) limits, percent by volume of fuel (25°C, 760 mm)	
		Lower	Upper
Ethyl acrylate	372	1.4	14
Ethylamine	385	3.5	14.0
Ethylbenzene	432	0.8	6.7
Ethyl benzoate	490		
Ethyl butanoate	463		
2-Ethylbutanoic acid	463		
Ethyl chloroformate	500		
Ethylcyclobutane	210	1.2	7.7
Ethylcyclohexane	238	0.9	6.6
Ethylene	490	2.7	36.0
Ethylene glycol diacetate	482	1.6	8.4
Ethylene glycol dimethyl ether	202		
Ethylene glycol ethyl ether acetate	379	2	8
Ethylene glycol monobutyl ether	238	4	13
Ethylene glycol methyl ether acetate	392	2	12
Ethylene glycol monoethyl ether	235	3	18
Ethyleneimine	320	3.3	54.8
Ethylene oxide	429	3.0	100
Ethyl formate	455	2.8	16.0
2-Ethylhexanal	197		
2-Ethyl-1,3-hexanediol	360		
2-Ethyl-1-hexanol	231	0.88	9.7
2-Ethylhexyl acetate	268	0.76	8.14
Ethyl lactate	400	1.5	
Ethyl methyl ether		2.0	10.0
3-Ethyl-2-methylpentane	460		
Ethyl nitrate	85 explodes	3.8	
Ethyl nitrite	90 explodes	3.0	50.0
Ethyl propanoate	440	1.9	11
Ethyl vinyl ether	202	1.7	28
Formaldehyde	430	7.0	73.0
Formic acid, 90%	434	18	57
2-Furaldehyde (furfural)	316	2.1	19.3
Furan		2.3	14.3
Furfuryl alcohol	491	1.8	16.3
Gasoline, 50-100 octane	280 to 456	1.4	7.6
Glycerol	370	3	19
Heptane	204	1.05	6.7
2-Heptanone (methyl pentyl ketone)	393	1.1	7.9
4-Heptanone (diisobutyl ketone)	396	0.8	7.1
1-Heptene	260		
1,1,2,3,4,4-Hexachlorobutadiene	610		
Hexane	225	1.1	7.5
1,6-Hexanedioic acid	420		
Hexanoic acid	380		
2-Hexanone	423	1	8
1-Hexene	253		
Hydrazine	23 to 270	4.7	100
Hydrogen	400	4.1	74.2
Hydrogen cyanide, 96%	538	5.6	40.0
Hydrogen sulfide	260	4	46

TABLE 5.23 Properties of Combustible Mixtures in Air (*Continued*)

Substance	Autoignition temperature, °C	Flammable (explosive) limits, percent by volume of fuel (25°C, 760 mm)	
		Lower	Upper
N-Hydroxyethyl-1,2-ethanediamine	368		
1-Hydroxy-2-methylbenzene	599	1.4	
1-Hydroxy-3-methylbenzene	559	1.1	
1-Hydroxy-4-methylbenzene (see *p*-cresol)			
4-Hydroxy-4-methyl-2-pentanone	643	1.8	6.9
Isobutanal	196	1.6	10.6
Isobutyl acetate	421	1	10.5
Isobutylamine	378	2	12
Isobutylbenzene	427	0.8	6.0
Isobutyl isobutyrate	432	0.96	7.59
Isopentane	420	1.4	7.6
Isopentyl acetate	360	1.0	7.5
Isoprene	220	2	9
Isopropyl acetate	460	1.8	8
Isopropyl alcohol	399	2.5	12.7
Isopropylamine	402	2.3	10.4
Isopropylbenzene (cumene)	424	0.8	6.5
Isopropyl formate	485		
4-Isopropyl-1-methylbenzene	436		
Kerosene	210	0.7	5.0
Maleic anhydride	477	1.4	7.1
Methacrylic acid	68	1.6	8.8
Methacrylonitrile		2	6.8
Methane	650	5.3	15.0
Methanethiol		3.9	21.8
Methanol	464	6.0	36
Methoxybenzene (anisole)	475		
2-Methoxyethanol	285	1.8	14
2-Methoxyethyl acetate	392	1.5	12.3
Methyl acetate	454	3.1	16
Methyl acetoacetate	280		
Methyl acetylacetate	280		
Methyl acrylate	468	2.8	25
Methylamine	430	4.9	20.7
2-Methylbutane		1.4	7.6
2-Methyl-1-butanol	385	1.4	9.0
2-Methyl-2-butanol	437	1.2	9.0
3-Methyl-1-butanol	350	1.2	9.0
3-Methylbutyl acetate	360	1.0	7.5
2-Methyl-2-butene	275	1.6	8.7
3-Methyl-1-butene	365	1.5	9.1
2-Methyl-1-buten-3-one		1.8	9.0
Methyl chloroformate	504		
Methylcyclohexane	250	1.2	6.7
cis-2-Methylcyclohexanol	296		
trans-2-Methylcyclohexanol	296		
cis-4-Methylcyclohexanol	295		
trans-4-Methylcyclohexanol	295		
Methylcyclopentane	258	1.0	8.35
Methyl formate	449	4.5	23
2-Methylhexane	280	1.0	6.0

TABLE 5.23 Properties of Combustible Mixtures in Air (*Continued*)

Substance	Autoignition temperature, °C	Flammable (explosive) limits, percent by volume of fuel (25°C, 760 mm)	
		Lower	Upper
3-Methylhexane	280		
5-Methyl-2-hexanone	191	1.0	8.2
Methylhydrazine	196	2.5	97.±2
Methyl isobutyl ketone (MIBK)	448	1	8
2-Methyllactonitrile	688		
Methyl methacrylate		1.7	8.2
1-Methyl-4-(1-methylethenyl)-cyclohexene (dipentene)	237		
1-Methylnaphthalene	529		
2-Methylpentane	264	1.0	7.0
3-Methylpentane	278	1.2	7.0
2-Methyl-2,4-pentanediol	306	1	9
2-Methyl-1-pentanol	310	1.1	9.65
4-Methyl-2-pentanol		1.0	5.5
4-Methyl-2-pentanone	452	2	8.0
4-Methyl-3-penten-2-one	344	1.4	7.2
2-Methylpropanal	223	1.6	10.6
2-Methyl-1-propanamine	378	2	12
2-Methylpropane	460	1.8	8.4
2-Methylpropanenitrile	482		
Methyl propanoate	469	2.5	13
2-Methylpropanoic acid	481	2.0	9.2
2-Methyl-1-propanol	415	1.7	10.6
2-Methyl-2-propanol (*t*-butyl alcohol)	478	2.4	8.0
2-Methyl-1-propene	465	1.8	9.6
2-Methylpropyl acetate	421	1.3	10.5
2-Methylpropyl formate	320	1.7	8
2-Methylpyridine	538		
N-Methyl-2-pyrrolidone	346	1	10
Methyl salicylate	454		
α-Methylstyrene	574	1.9	6.1
Methyl vinyl ether		2.6	39
Morpholine	290	1	11
Naphtha, coal tar	277		
Naphthalene	526	0.9	5.9
Neoprene		4.0	20
Nicotine	244	0.75	4.0
Nitrobenzene	482	1.8	9
2-Nitrobiphenyl	179		
Nitroethane	414	3.4	17
Nitroglycerine	270		
Nitromethane	418	7.3	22
1-Nitropropane	421	2.2	
2-Nitropropane	428	2.6	11
Nonane	205	0.8	2.9
Octadecanoic acid (stearic acid)	395		
cis-9-Octadecenoic acid (oleic acid)	362		
Octane	206	1.0	6.5
1-Octene	230		
Paraldehyde	238	1.3	
Pentaborane(9)		0.42	
Pentanamine		2.2	22

TABLE 5.23 Properties of Combustible Mixtures in Air (*Continued*)

Substance	Autoignition temperature, °C	Flammable (explosive) limits, percent by volume of fuel (25°C, 760 mm)	
		Lower	Upper
Pentane	260	1.5	7.8
1,5-Pentanediol	335		
Pentanoic acid	400		
1-Pentanol	300	1.2	10.0
2-Pentanol	343		
3-Pentanol	435	1.2	9.0
2-Pentanone (methyl propyl ketone)	452	1.5	8.2
3-Pentanone (diethyl ketone)	450	1.6	
1-Pentene	275	1.5	8.7
Pentyl acetate	360	1.1	7.5
Pentylamine		2.2	22
Petroleum ether (solvent naphtha)	288	1.1	5.9
Phenol	715	1.8	8.6
Phosphorus, red	260		
Phosphorus, white	30		
Phosphorus pentasulfide	142		
o-Phthalic anhydride	570	1.7	10.4
Picric acid	300 (explodes)		
α-Pinene	275		
β-Pinene	275		
Piperidine		1	10
1-Propanal	207	2.6	17
1-Propanamine (propylamine)	318	2.0	10.4
Propane	450	2.1	9.5
1,2-Propanediol	371	2.6	12.5
1,3-Propanediol	400		
Propanenitrile	512	3.1	14
1,2,3-Propanetriol (glycerol)	370	3	19
1,2,3-Propanetriol triacetate (triacetin)	433	1.0	
Propanoic acid	465	2.9	12.1
Propanoic anhydride	285	1.3	9.5
1-Propanol	412	2.2	13.7
2-Propanol	399	2.0	12.7
Propene	460	2.4	10.1
Propyl acetate	450	1.7	8
Propylbenzene	450	0.8	6.0
Propyl formate	455		
Propyl nitrate	175	2	100
Propyne		1.7	
Pyridine	482	1.8	12.4
Quinoline	480		
Sodium	115 (dry air)		
Styrene	490	0.9	6.8
Sulfur (di-) dichloride	233		
1,1,2,2-Tetrabromoethane	335		
Tetrabromoethylene	335		
1,1,1,2-Tetrachloroethane		5	12

TABLE 5.23 Properties of Combustible Mixtures in Air (*Continued*)

Substance	Autoignition temperature, °C	Flammable (explosive) limits, percent by volume of fuel (25°C, 760 mm)	
		Lower	Upper
1,1,2,2-Tetrachloroethane		20	54
Tetrahydrofuran	321	2	11.8
Tetrahydrofurfuryl alcohol	282	1.5	9.7
1,2,3,4-Tetrahydronaphthalene	385	0.8	5.0
2,2,3,3-Tetramethylpentane	430	0.8	4.9
2,2-Thiodiethanol	298		
Titanium, powder	250		
Toluene	480	1.1	7.1
Toluene diisocyanate		0.9	9.5
o-Toluidine (also *p*-)	482		
Tributylamine		1	5
1,1,1-Trichloroethane	537	7.5	12.5
1,1,2-Trichloroethane	460	6	28
Trichloroethylene	420	8	10.5
(Trichloromethyl)benzene	211		
Trichloromethylsilane	>404	7.6	>20
1,2,3-Trichloropropane		3.2	12.6
Trichlorosilane	104		
1,1,2-Trichloro-1,2,2-trifluoroethane (Freon 113)	680		
Tri-*o*-cresyl phosphate	385		
Triethanolamine		1	10
Triethylamine	249	1.2	8.0
Triethylene glycol	371	0.9	9.2
Triethyl phosphate	454		
Trimethylamine	190	2.0	11.6
1,2,3-Trimethylbenzene (hemimellitene)	470	0.8	6.6
1,2,4-Trimethylbenzene (pseudocumene)	500	0.9	6.4
1,3,5-Trimethylbenzene	559	1	5
2,2,3-Trimethylbutane	412		
1,1,3-Trimethyl-3-cyclohexen-5-one	462	0.8	3.8
3,5,5-Trimethylcyclohex-2-ene-1-one	460	0.8	3.8
2,2,3-Trimethylpentane	346		
2,2,4-Trimethylpentane	418	1.1	6.0
2,3,3-Trimethylpentane	425		
Trioxane	414	3.6	28.7
Tri-*o*-tolyl phosphate	385		
Turpentine		0.8	
Vinyl acetate	402	2.6	13.4
Vinyl bromide	530	9	15
Vinyl butanoate		1.4	8.8
Vinyl chloride	472	3.6	33.0
4-Vinyl-1-cyclohexene	269		
Vinyl fluoride		2.6	21.7
Vinylidene	573	5.6	16.0
m-Xylene	527	1.1	7.0
o-Xylene	463	0.9	6.7
p-Xylene	528	1.1	7.0

TABLE 5.24 Thermal Conductivities of Gases as a Function of Temperature

The coefficient k, expressed in $J \cdot sec^{-1} \cdot cm^{-1} \cdot K^{-1}$, is the quantity of heat in joules, transmitted per second through a sample one centimeter in thickness and one square centimeter in area when the temperature difference between the two sides is one degree kelvin (or Celsius). The tabulated values are in microjoules. To convert to microcalories, divide values by 4.184. To convert to $mW \cdot m^{-1} \cdot K^{-1}$, divide values by 10.

Substance	Temperature, °C										
	−40	−20	0	20	40	60	80	100	120	140	160
Acetone		80	95	107	124	140	156	173	190	207	
Acetaldehyde				109	126	142	159	176	195		
Acetonitrile						112	124	137	151	166	
Acetylene	118[−75]		184	205	224	248	269	290			
Air			242	256	270	284	299	311	324	336	342[149]
Ammonia	164[−60]		218	238	259	280	301	321			
Argon			166	176	186	196	206	211			
Benzene						126	146	165	184	205	226
Boron trifluoride				186						241	
Bromine			42	45	50	54	59				
Bromomethane					82	94	104	117			
1-Butanamine			135[6.5]					176[110]			
Butane			135	154	174	193	213	233			
Carbon dioxide			144	160	176	192	207	215			
Carbon disulfide			67	76	85						
Carbon monoxide			228	245	262	278					
Carbon tetrachloride			59	64	70	75	80	86			109[184]
Chlorine	64	72	79	85	93	100					
Chlorodifluorimethane		103	110	116	122						
Chloroethane			90	105	120	134	151	167	186	204	
Chloroform					75	84	91	99	107	116	
Chloromethane			84	105	117	130	142	155			
Cyclohexane			77	99	120	141	163	184	206	230	256
Cyclopropane						192	218	243	270		

Deuterium	1150	1222	1297	1372	1448	1523					
Deuterium oxide									263		358[220]
Dibromomethane									74[110]		
Dichlorodifluoromethane		81	84	92	100			138			194[200]
1,1-Dichloroethane			69	81	93	105	117	129	144		
1,2-Dichloroethane								127	140		
Dichlorofluoromethane		91	94	97	100						
Dichloromethane			93					161			
1,2-Dichlorotetrafluoroethane				99					153		211[227]
Diethylamine			118			179	199	218	243	268	
Diethyl ether			113	135	157	178	200	222	244	269	351[213]
1,4-Dioxane								167	187	207	
Ethane	137	159	182	204	228	257	288	316	344		
Ethanol			126	141	155			209			
Ethene					230[49]						
Ethyl acetate					115	133	151	170	191	211	234
Ethylamine			136	153	169	206					
Ethylene	137	158	178	220	241	262	282				
Ethylene oxide								193	256	279	
Ethyl formate			79	100	121	142	164	186	206	226	
Ethyl nitrate								159	178	197	
Fluorine	212	230	247	264	278	294	309	325			
Helium	1276	1343	1423	1481	1540	1598	1661	1720	1778		
Heptane			100	115	130			174			
Hexane			109				178	201	224	247	271
Hydrogen	1494	1607	1724	1828	1925	2025					
Hydrogen bromide	64	70	77	84	90	97	104				
Hydrogen chloride	107	117	128	138	148				191		240[227]
Hydrogen cyanide		99	110	121	132	143					
Hydrogen sulfide		116	129	143	156	169					
Iodomethane			46	53	60	68	75	82	89		
Krypton		79	85		95			110			
Methane	257	280	307	334	361	387	416	445			
Methanol						174	197	221	241	263	284
Methyl acetate			67			150[70]		177	195	215	237
2-Methylbutane			122					215			
2-Methylpropane			141	156	176	196		233[93]	271		421[227]

TABLE 5.24 Thermal Conductivities of Gases as a Function of Temperature (*Continued*)

Substance	Temperature, °C										
	−40	−20	0	20	40	60	80	100	120	140	160
2-Methyl-2-propanol								225			
Neon	410	433	454	476	497	518	537	556			
Nitric oxide	205	221	238	254	269	285	301	317			
Nitrogen	211	226	241	256	270	282	295	307	320	333	385[227]
Nitromethane									139	155	
Nitrous oxide	121	137	152	168	184						
Octafluorocyclobutane				120					190		
Oxygen	211	228	245	261	278	294	311	328			
Pentane			130					218			
Propane	116	132	151	171	192	215	238	262	330	353	379
2-Propanol				151[31]						250[127]	
Sulfur dioxide			83		163			106			
Sulfur hexafluoride				126					201	275[227]	338[327]
Tetrafluoromethane				235					235		
Thiophene								152[110]			
1,1,2-Trichlorotrifluoroethane				87					133		
Triethylamine								195	216	239	
Water		142	159	175	191	207	224	241	257		
Xenon	36[−73]			54					72	89[227]	104[327]

TABLE 5.25 Liquid Thermal Conductivity of Various Substances

All values of thermal conductivity, k, are in millijoules $cm^{-1} \cdot s^{-1} \cdot K^{-1}$. To convert to $mJ \cdot cm^{-1} \cdot s^{-1} \cdot K^{-1}$ into $mW \cdot m^{-1} \cdot K^{-1}$, divide by 10.

Substance	Thermal conductivity in $mJ \cdot cm^{-1} \cdot s^{-1} \cdot K^{-1}$						
	−25°C	0°C	20°C	25°C	50°C	75°C	100°C
Acetaldehyde			1.900				
Acetic acid				1.58	1.53	1.49	1.44
Acetic anhydride			2.209				
Acetone	1.987[−80]	1.69	1.61		1.51[40]		
Acetonitrile	2.08	1.98		1.88	1.78	1.68	
Allyl alcohol				1.80[30]			
Aniline			1.77[17]				
Argon	1.259[−189]						
Benzaldehyde				1.51	1.41	1.31	1.21
Benzene				1.411	1.329	1.247	
Bromobenzene			1.113				
Bromoethane			1.029				
1-Bromo-2-methylpropane		1.163[12]					
1-Bromopentane			0.983				
Bromopropane		1.075[12]					
Butanoic acid		1.506[12]					
1-Butanol		1.538		1.54	1.49		
2-Butanone	1.58	1.51		1.45	1.39	1.33	
Butyl acetate			1.368				
2-Butyne	1.37	1.29		1.21			
Carbon disulfide		1.54		1.49			
Carbon tetrachloride	1.100[−20]	1.071	1.029		0.974		
Chlorobenzene	1.36	1.31		1.27	1.22	1.17	1.12
Chloroethane	1.45	1.32		1.19	1.06	0.93	
Chloroform	1.27	1.22		1.17	1.12	1.07	1.02
(Chloromethyl)oxirane	1.42	1.37		1.31	1.25	1.19	1.14
1-Chloro-2-methylpropane		1.163[12]					
1-Chloropentane		1.184[12]					
Chloropropane		1.184[12]					
4-Chlorotoluene			1.297				
m-Cresol			1.498			1.452[80]	
Cyclohexane			1.243	1.23	1.17	1.11	
Cyclohexene	1.42	1.36		1.30	1.24	1.18	
Cyclohexanol				1.34	1.31		
Cyclopentane	1.40	1.33		1.26			
Cyclopentene	1.43	1.36		1.29			
Decane	1.44	1.38		1.32	1.26	1.19	1.13
1-Decanol				1.62	1.56	1.50	1.45
Dibromomethane	1.20	1.14		1.08	1.03	0.97	
Dibutyl phthalate	1.44	1.40		1.36	1.33	1.29	1.25
1,2-Dichloroethane		1.264					
Dichlorofluoromethane	0.134						
Dichloromethane	1.590[−20]	1.564	1.477				
Diethyl ether	1.50	1.40		1.30	1.20	1.10	1.00
Diisopropyl ether			1.096				
2,3-Dimethylbutane				1.038[32]	0.996		
N,*N*-Dimethylformamide				1.84	1.78	1.71	1.65
Dimethyl phthalate		1.501		1.473	1.443	1.409	1.373

TABLE 5.25 Liquid Thermal Conductivity of Various Substances (*Continued*)

Substance	Thermal conductivity in mJ · cm^{-1} · s^{-1} · K^{-1}						
	−25°C	0°C	20°C	25°C	50°C	75°C	100°C
1,4-Dioxane				1.59	1.47	1.35	1.23
Diphenyl ether					1.39	1.35	1.31
Dodecane		1.57		1.52	1.46	1.40	1.35
1-Dodecanol				1.46	1.42	1.39	1.35
Ethanol		1.76		1.69	1.62		
Ethanolamine				2.99	2.86	2.74	2.61
Ethoxybenzene			1.497				
Ethyl acetate	1.62	1.53		1.44	1.35	1.26	
Ethylbenzene				1.30	1.24	1.18	1.12
Ethylene glycol		2.56		2.56	2.56	2.56	2.56
Ethyl formate		1.581[12]					
Furan	1.42	1.34		1.26			
Glycerol				2.92	2.95	2.97	3.00
Heptane	1.378	1.303	1.259	1.228	1.152	1.077	
1-Heptanol		1.66		1.59	1.53	1.47	1.41
Hexadecane				1.40	1.35	1.30	1.25
Hexane	1.37	1.28	1.218	1.20	1.11	1.92	0.93
1-Hexanol	1.59	1.54		1.50	1.45	1.41	1.37
2-Hexanone	1.51	1.45		1.39	1.33	1.27	1.21
1-Hexene	1.37	1.29		1.21	1.13		
Hydrochloric acid, 38%			4.402[32]				
Hydrogen	1.180^{-253}						
Iodobenzene	1.063^{-20}		1.276			0.937[80]	
Iodoethane				1.109[30]			
1-Iodo-2-methylpropane		0.870[12]					
1-Iodopentane		0.849[12]					
Iodopropane		0.920[12]					
Isopentyl acetate			1.297				
Isopropylbenzene				1.28	1.20	1.12	1.07
Mercury	72.5	77.7		82.5	86.8	90.7	94.3
Methanol	2.14	2.07	2.021	2.00	1.93		
Methoxybenzene	1.70	1.63		1.56	1.50	1.43	1.36
Methyl acetate	1.74	1.64		1.53	1.43	1.33	1.22
Methyl butanoate			1.402				
3-Methylbutanoic acid		1.305					
3-Methyl-1-butanol				1.477[30]			
Methylcyclohexane				1.276[30]			
Methylcyclopentane				1.209	1.151[38]		
N-Methylformamide				2.03	2.01	1.99	1.96
1-Methyl-4-isopropylbenzene	1.32	1.27		1.22	1.17	1.12	1.07
2-Methylpentane				1.084[32]	1.033		
Methyl pentanoate		1.318[12]					
4-Methylpentanoic acid		1.427[12]					
4-Methyl-3-pentene-2-one	1.70	1.63		1.56	1.49	1.42	1.34
2-Methyl-1-propanol		1.423[12]					
2-Methyl-2-propanol				1.159[38]		1.067[77]	
Nitrobenzene			1.510				
Nitromethane				2.151[30]			
Nonane	1.44	1.38		1.31	1.24	1.151[80]	1.11

TABLE 5.25 Liquid Thermal Conductivity of Various Substances (*Continued*)

Substance	Thermal conductivity in mJ · cm^{-1} · s^{-1} · K^{-1}						
	−25°C	0°C	20°C	25°C	50°C	75°C	100°C
1-Nonanol		1.66		1.61	1.55	1.49	1.43
Octadecane					1.46	1.42	1.37
Octane	1.43	1.35		1.28	1.20	1.13	1.06
1-Octanol		1.68	1.657	1.61	1.54	1.47	1.41
Palmitic acid						1.598	
Pentachloroethane			1.251				
Pentane	1.32	1.22	1.138	1.13	1.03	0.95	0.87
Pentanoic acid		1.360[12]					
1-Pentanol		1.57		1.53	1.49	1.45	
1-Pentene	1.31	1.24		1.16			
Pentyl acetate			1.289				
Phenol					1.56	1.53	1.51
Phenylhydrazine				1.724			
1,2-Propanediol		2.02		2.00	1.99	1.98	1.97
Propanoic acid		1.728[12]					
1-Propanol	1.62	1.58		1.54	1.49	1.45	1.41
2-Propanol	1.46	1.41		1.35	1.29	1.24	1.18
1,2-Propylene glycol		2.008					
Propyl formate		1.494[12]					
Pyridine		1.69		1.65	1.61	1.58	
Silicon tetrachloride				0.99	0.96		
Sodium							753.1[300]
Sodium chloride (aq, satd)	5.732						
Stearic acid						1.598	
Styrene	1.48	1.42		1.37	1.31	1.26	1.20
Sulfuric acid, 90%				3.540[32]			
1,1,2,2-Tetrachloroethane		1.138					
Tetrachloroethylene	1.17		1.10	1.04	0.97		
Tetrachloromethane	1.04		0.99	0.93	0.88		
Tetradecane				1.36	1.31	1.26	1.21
1-Tetradecanol					1.67	1.62	1.57
Tetrahydrofuran	1.32	1.26		1.20	1.14		
Thiophene				1.99	1.95	1.91	1.86
Toluene	1.590[−80]	1.386	1.347	1.311	1.236	1.161	
1,1,1-Trichloroethane	1.06		1.01	0.96			
Trichloroethylene	1.359[−60]	1.24		1.160	1.08	1.00	
Trichloromethane	1.27	1.22		1.17	1.12	1.07	
Tridecane				1.37	1.32	1.27	1.22
Triethylamine	1.464[−80]		1.209		1.113[44]		
Trimethylamine	1.43	1.33					
1,3,5-Trimethylbenzene	1.47	1.41		1.36	1.30	1.24	1.18
2,2,4-Trimethylpentane				0.966[38]		0.841[77]	
Undecane				1.40	1.35	1.29	1.23
Water		5.610	5.983	6.071	6.435	6.668	6.791
m-Xylene				1.30	1.24	1.18	1.13
o-Xylene				1.31	1.26	1.20	1.14
p-Xylene				1.30	1.24	1.18	1.12

TABLE 5.26 Thermal Conductivity of Various Solids

All values of thermal conductivity, k, are in millijoules $cm^{-1} \cdot s^{-1} \cdot K^{-1}$. To convert to $mW \cdot m^{-1} \cdot K^{-1}m$, divide values by 10. For values in millicalories, divide by 4.184.

Substance	t, °C	k
Asphalt	20	7.447
Basalt	20	21.76
Bauxite	600	5.56
Boiler scale	66	13.1
Brick, common	20	6.3
Blotting paper	20	0.628
Cardboard	20	2.1
Cement, Portland	90	2.97
Chalk	20	9.2
Chemical elements, *see* Table 4.1		
Coal	0	1.69
Concrete	20	9.2
Cork, sp. grav. = 0.2	30	0.54
Cork meal	100	0.556
Cotton, sp. grav. = 0.081	0	0.569
Diatomaceous earth	20	0.54
Ebonite	0	1.58
Eiderdown	20	0.046
Feathers (with air)	9	0.238
Feldspar	20	23.4
Felt (dark gray)	40	0.623
Fire brick	20	4.6
Flannel	60	0.148
Flint	20	10.0
Glass, crown	12.5	6.82
flint	12.5	5.98
Jena	22	9.50
quartz	0	13.89
	100	19.12
soda	20	7.1
	100	7.5
Granite	20	34.2
Graphite, sp. grav. = 1.58	50	441.4
Graphite powder, sp. grav. = 0.7	40	11.92
Gypsum	0	13.0
Horse hair, sp. grav. = 0.172	20	0.510
Ice		23.8
Leather, cowhide	84	1.76
Linen	20	0.879
Magnesia brick	20	11.3
	1130	30.1
Marble, white		32.6
Mica	41	3.60
Naphthalene	0	3.77
Paper	20	1.3
Paraffin	0	2.88
Plaster of Paris	20	2.93
Porcelain	95	10.38
Quartz, parallel to axis	0	136.0
	100	90.0

TABLE 5.26 Thermal Conductivity of Various Solids (*Continued*)

Substance	*t*, °C	*k*
Quartz, perpendicular to axis	0	72.43
	100	55.77
Plastics, *see* Section 10		
Roofing paper	0	1.90
Rubber, natural and synthetic, *see* Section 10		
Sand, dry	20	3.89
Sandstone, sp. grav. = 2.259	40	18.37
Silk, sp. grav. = 0.101	0	0.510
Slate	20	19.66
Soil, dry	20	1.38
Wax, bees	20	0.866
Wood, maple, parallel to face	20	4.25
perpendicular to face	50	1.82
Wood, oak, parallel to face	15	3.49
perpendicular to face	15	2.09
Wood, pine, parallel to face	20	3.49
perpendicular to face	15	1.51

5.9 MISCELLANY

TABLE 5.27 Compressibility of Water

In the table below are given the relative volumes of water at various temperatures and pressures. The volume at 0°C and one normal atmosphere (760 mm of Hg) is taken as unity.

P, atm	−10°C.	0°C.	10°C.	20°C.	40°C.	60°C.	80°C.
1	1.0017	1.0000	1.0001	1.0016	1.0076	1.0168	1.0287
500	0.9788	0.9767	0.9778	0.9804	0.9867	0.9967	1.0071
1000	0.9581	0.9566	0.9591	0.9619	0.9689	0.9780	0.9884
1500	0.9399	0.9394	0.9424	0.9456	0.9529	0.9617	0.9717
2000	0.9223	0.9241	0.9277	0.9312	0.9386	0.9472	0.9568
2500	0.9083	0.9112	0.9147	0.9183	0.9257	0.9343	0.9437
3000	0.8962	0.8993	0.9028	0.9065	0.9139	0.9225	0.9315
3500	0.8852	0.8884	0.8919	0.8956	0.9030	0.9115	0.9203
4000	0.8751	0.8783	0.8818	0.8855	0.8931	0.9012	0.9097
4500	0.8658	0.8692	0.8725	0.8762	0.8838	0.8919	0.9001
5000	0.8573	0.8606	0.8639	0.8675	0.8752	0.8832	0.8913
6000	.....	0.8452	0.8481	0.8517	0.8595	0.8674	0.8752
7000	.....	.....	0.8340	0.8374	0.8456	0.8534	0.8610
8000	.....	.....	.....	0.8244	0.8330	0.8408	0.8483
9000	.....	.....	.....	0.8128	0.8219	0.8297	0.8371
10000	.....	.....	.....	0.8027	0.8119	0.8196	0.8268
11000	.....	.....	.....	.....	0.8023	0.8101	0.8172
12000	.....	.....	.....	.....	0.7931	0.8009	0.8080

TABLE 5.28 Mass of Water Vapor in Saturated Air

The values in the table are grams of water contained in a cubic meter (m^3) of saturated air at a total pressure 101 325 Pa (1 atm).

°C	$g \cdot m^{-3}$	°C	$g \cdot m^{-3}$	°C	$g \cdot m^{-3}$
−30	0.341	12	10.65	53	95.56
−29	0.375	13	11.35	54	100.0
−28	0.413	14	12.05	55	104.5
−27	0.456	15	12.80	56	109.1
−26	0.504	16	13.60	57	114.1
−25	0.554	17	14.45	58	119.2
−24	0.607	18	15.35	59	124.7
−23	0.667	19	16.30	60	130.2
−22	0.733	20	17.30	61	136.0
−21	0.804	21	18.35	62	142.1
−20	0.883	22	19.40	63	148.4
−19	0.968	23	20.55	64	154.9
−18	1.063	24	21.75	65	161.3
−17	1.164	25	23.05	66	167.9
−16	1.273	26	24.35	67	175.1
−15	1.375	27	25.75	68	182.6
−14	1.510	28	27.20	69	190.3
−13	1.650	29	28.75	70	198.2
−12	1.800	30	30.35	71	206.5
−11	1.965	31	32.05	72	215.1
−10	2.140	32	33.80	73	223.7
−9	2.331	33	35.60	74	233.0
−8	2.539	34	37.55	75	242.0
−7	2.761	35	39.55	76	251.2
−6	3.003	36	41.65	77	261.1
−5	3.250	37	43.90	78	271.6
−4	3.512	38	46.20	79	282.3
−3	3.810	39	48.60	80	293.4
−2	4.131	40	51.21	81	304.8
−1	4.473	41	53.86	82	316.6
0	4.849	42	56.61	83	328.7
1	5.199	43	59.51	84	341.2
2	5.569	44	62.53	85	353.6
3	5.947	45	65.52	86	366.2
4	6.35	46	68.61	87	379.9
5	6.80	47	72.00	88	394.1
6	7.25	48	75.56	89	408.6
7	7.75	49	79.24	90	423.5
8	8.25	50	83.05	91	439.0
9	8.80	51	87.04	92	454.8
10	9.40	52	91.22	93	471.2
11	10.00				

TABLE 5.29 Van der Waals' Constants for Gases

The van der Waals' equation of state for a real gas is:

$$\left(P + \frac{n^2 a}{V^2}\right)(V - nb) = nRT \qquad \text{for } n \text{ moles}$$

where P is the pressure, V the volume (in liters per mole = 0.001 m^3 per mole in the SI system), T the temperature (in degrees Kelvin), n the amount of substance (in moles), and R the gas constant. To use the values of a and b in the table, P must be expressed in the same units as in the gas constant. Thus, the pressure of a standard atmosphere may be expressed in the SI system as follows:

$$1 \text{ atm} = 101{,}325 \text{ N} \cdot \text{m}^{-2} = 101{,}325 \text{ Pa} = 1.01325 \text{ bar}$$

The appropriate value for the gas constant is:

$$0.083\,144\,1 \text{ L} \cdot \text{bar} \cdot \text{K}^{-1} \cdot \text{mol}^{-1} \qquad \text{or} \qquad 0.082\,056 \text{ L} \cdot \text{atm} \cdot \text{K}^{1} \cdot \text{mol}^{1}$$

The van der Waals' constants are related to the critical temperature and pressure, t_c and P_c, in Table 6.5 by:

$$a = \frac{27\,R^2 T_c^2}{64\,P_c} \qquad \text{and} \qquad b = \frac{RT_c}{8\,P_c}$$

Substance	a, $L^2 \cdot bar \cdot mol^{-2}$	b, $L \cdot mol^{-1}$
Acetaldehyde	11.37	0.08695
Acetic acid	17.71	0.1065
Acetic anhydride	26.8	0.157
Acetone	16.02	0.1124
Acetonitrile	17.89	0.1169
Acetyl chloride	12.80	0.08979
Acetylene	4.516	0.05218
Acrylic acid	19.45	0.1127
Acrylonitrile	18.37	0.1222
Allene	8.235	0.07467
Allyl alcohol	15.17	0.1036
Aluminum trichloride	42.63	0.2450
2-Aminoethanol	7.616	0.0431
Ammonia	4.225	0.03713
Ammonium chloride	2.380	0.00734
Aniline	29.14	0.1486
Antimony tribromide	42.08	0.1658
Argon	1.355	0.03201
Arsenic trichloride	17.23	0.1039
Arsine	6.327	0.06048
Benzaldehyde	30.30	0.1553
Benzene	18.82	0.1193
Benzonitrile	33.89	0.1727
Benzyl alcohol	34.7	0.173
Biphenyl	47.16	0.2130
Bismuth trichloride	33.89	0.1025
Boron trichloride	15.60	0.1222
Boron trifluoride	3.98	0.05443
Bromine (Br_2)	9.75	0.0591
Bromobenzene	28.96	0.1541
Bromochlorodifluoromethane	12.79	0.1055
Bromoethane	11.89	0.08406
Bromomethane	6.753	0.05390
Bromotrifluoromethane	8.502	0.0891

TABLE 5.29 Van der Waals' Constants for Gases (*Continued*)

Substance	a, $L^2 \cdot bar \cdot mol^{-2}$	b, $L \cdot mol^{-1}$
1,2-Butadiene	12.76	0.1025
1,3-Butadiene	12.17	0.1020
Butanal	19.48	0.1292
Butane	13.93	0.1168
Butanenitrile	25.76	0.1568
Butanoic acid	28.18	0.1609
1-Butanol	20.90	0.1323
2-Butanol	20.94	0.1326
2-Butanone	19.97	0.1326
1-Butene	12.76	0.1084
cis-2-Butene	12.58	0.1066
trans-2-Butene	12.58	0.1066
3-Butenenitrile	25.76	0.1568
Butyl acetate	31.22	0.1919
1-Butylamine	19.41	0.1301
sec-Butylamine	18.37	0.1273
tert-Butylamine	17.78	0.1310
Butylbenzene	44.071	0.2378
sec-Butylbenzene	43.74	0.2347
tert-Butylbenzene	42.77	0.2310
Butyl benzoate	57.97	0.2857
Butylcyclohexane	41.19	0.2201
sec-Butylcyclohexane	48.89	0.2604
tert-Butylcyclohexane	48.34	0.2614
Butyl ethyl ether	27.05	0.1815
2-Butylhexadecafluorotetrahydrofuran	45.41	0.3235
1-Butyne	13.31	0.1023
2-Butyne	13.68	0.0998
Carbon dioxide	3.658	0.04284
Carbon disulfide	11.25	0.07262
Carbon monoxide	1.472	0.03948
Carbon oxysulfide (COS)	6.975	0.06628
Carbon tetrachloride	20.01	0.1281
Carbon tetrafluoride	4.029	0.06319
Carbonyl chloride	10.65	0.08340
Carbonyl sulfide	3.933	0.05817
Chlorine	6.343	0.05422
Chlorine pentafluoride	9.581	0.08214
Chlorobenzene	25.80	0.1454
1-Chlorobutane	23.22	0.1527
2-Chlorobutane	20.01	0.1370
1-Chloro-1,1-difluoroethane	11.91	0.1035
2-Chloro-1,1-difluoroethylene	10.49	0.09335
Chloroethane	11.7	0.090
Chloroform	15.34	0.1019
Chloromethane	7.566	0.06477
2-Chloro-2-methylpropane	18.98	0.1334
Chloropentafluoroacetone	17.08	0.1482
Chloropentafluorobenzene	29.53	0.1843
Chloropentafluoroethane	11.27	0.1137
1-Chloropropane	16.11	0.1141
2-Chloropropane	14.53	0.1068
Chlorotrifluoromethane	6.873	0.08110

TABLE 5.29 Van der Waals' Constants for Gases (*Continued*)

Substance	a, $L^2 \cdot bar \cdot mol^{-2}$	b, $L \cdot mol^{-1}$
Chlorotrifluorosilane	7.994	0.09240
Chlorotrimethylsilane	22.58	0.1617
m-Cresol	31.86	0.1609
o-Cresol	28.33	0.1447
p-Cresol	28.11	0.1422
Cyanogen	7.803	0.06952
Cyclobutane	12.39	0.0960
Cycloheptane	27.20	0.1645
Cyclohexane	21.95	0.1413
Cyclohexanol	28.93	0.1586
Cyclohexanone	31.1	0.170
Cyclohexene	75.04	0.1339
Cyclopentane	16.94	0.1180
Cyclopentanone	75.84	0.1211
Cyclopentene	15.61	0.1097
Cyclopropane	8.293	0.07420
p-Cymene	43.65	0.2386
Decane	52.88	0.3051
Decanenitrile	34.71	0.1988
1-Decanol	57.45	0.2971
1-Decene	49.96	0.2888
Deuterium (normal)	0.2583	0.02397
Deuterium oxide	5.584	0.03090
Diborane (B_2H_6)	6.048	0.07437
Dibromodifluoromethane	15.69	0.1186
1,2-Dibromoethane	13.98	0.08664
1,2-Dibromotetrafluoroethane	20.45	0.1494
Dibutylamine	34.61	0.2030
Dibutyl ether	33.06	0.2017
Dibutyl sulfide	49.3	0.2702
1,2-Dichlorobenzene	34.59	0.1767
1,3-Dichlorobenzene	35.44	0.1846
1,4-Dichlorobenzene	34.64	0.1802
Dichlorodifluoromethane	10.45	0.09672
Dichlorodifluorosilane	11.34	0.1095
1,1-Dichloroethane	15.73	0.1072
1,2-Dichloroethane	17.0	0.108
1,1-Dichloroethylene	13.74	0.09893
trans-1,2-Dichloroethylene	13.63	0.09573
Dichlorofluoromethane	11.48	0.09060
Dichloromethane	12.44	0.08689
1,2-Dichloropropane	21.62	0.1335
Dichlorosilane	12.59	0.09992
1,1-Dichlorotetrafluoroethane	15.49	0.1318
1,2-Dichlorotetrafluoroethane	15.72	0.1338
Dideuterium oxide	5.535	0.03062
Diethanolamine	45.61	0.2273
Diethylamine	19.40	0.1383
1,4-Diethylbenzene	45.03	0.2439
Diethylene glycol	29.02	0.1519
Diethyl ether	17.46	0.1333
3,3-Diethylhexane	47.69	0.2707
3,4-Diethylhexane	47.93	0.2760

TABLE 5.29 Van der Waals' Constants for Gases (*Continued*)

Substance	a, $L^2 \cdot bar \cdot mol^{-2}$	b, $L \cdot mol^{-1}$
3,3-Diethyl-2-methylpentane	47.20	0.2629
3,3-Diethylpentane	40.64	0.2374
Diethyl sulfide	22.85	0.1462
Difluoroamine	5.028	0.04446
cis-Difluorodiazine	3.043	0.03987
trans-Difluorodiazine	3.539	0.04851
1,1-Difluoroethane	9.691	0.08931
1,1-Difluoroethylene	6.000	0.07058
Difluoromethane	6.184	0.06268
Dihexyl ether	69.17	0.3752
Dihydrogen disulfide	16.15	0.1006
Diisopropyl ether	25.26	0.1836
Dimethoxyethane	21.65	0.1439
Dimethoxymethane	17.28	0.1195
N,N-Dimethoxyacetamide	30.19	0.1689
Dimethylamine	10.44	0.08510
N,N-Dimethylaniline	37.92	0.1967
2,2-Dimethylbutane	22.55	0.1644
2,3-Dimethylbutane	23.29	0.1660
2,3-Dimethyl-1-butene	22.59	0.2566
3,3-Dimethyl-1-butene	21.55	0.1567
2,3-Dimethyl-2-butene	23.83	0.1621
1,1-Dimethylcyclohexane	34.30	0.2068
cis-1,2-Dimethylcyclohexane	36.44	0.2143
trans-1,2-Dimethylcyclohexane	34.89	0.2086
cis-1,3-Dimethylcyclohexane	34.30	0.2068
trans-1,3-Dimethylcyclohexane	35.11	0.2093
cis-1,4-Dimethylcyclohexane	35.47	0.2114
trans-1,4-Dimethylcyclohexane	34.54	0.2086
1,1-Dimethylcyclopentane	25.37	0.1653
cis-1,2-Dimethylcyclopentane	27.04	0.1706
trans-1,2-Dimethylcyclopentane	25.67	0.1663
Dimethyl ether	8.690	0.07742
N,N-Dimethylformamide	23.57	0.1293
2,2-Dimethylheptane	41.29	0.2551
2,2-Dimethylhexane	34.87	0.2260
2,3-Dimethylhexane	35.24	0.2228
2,4-Dimethylhexane	34.97	0.2251
2,5-Dimethylhexane	35.49	0.2299
3,3-Dimethylhexane	34.72	0.2201
3,4-Dimethylhexane	35.06	0.2196
1,1-Dimethylhydrazine	14.69	0.1001
2,4-Dimethyl-3-isopentane	47.05	0.2729
Dimethyl oxalate	28.97	0.1644
2,2-Dimethylpentane	28.49	0.1951
2,3-Dimethylpentane	28.96	0.1921
2,4-Dimethylpentane	28.79	0.1974
3,3-Dimethylpentane	28.48	0.1892
2,3-Dimethylphenol	31.35	0.1545
2,4-Dimethylphenol	33.49	0.1687
2,5-Dimethylphenol	29.99	0.1512
2,6-Dimethylphenol	33.64	0.1710
3,4-Dimethylphenol	31.32	0.1529

TABLE 5.29 Van der Waals' Constants for Gases (*Continued*)

Substance	a, $L^2 \cdot bar \cdot mol^{-2}$	b, $L \cdot mol^{-1}$
3,5-Dimethylphenol	40.92	0.2037
2,2-Dimethylpropane	17.17	0.1410
2,3-Dimethylpropane	23.13	0.1669
2,2-Dimethyl-1-propanol	22.25	0.1444
Dimethyl sulfide	13.34	0.09453
N,*N*-Dimethyl-1,2-toluidine	41.71	0.2225
1,4-Dioxane	19.29	0.1171
Diphenyl ether	54.61	0.2538
Diphenylmethane	60.46	0.2798
Dipropylamine	24.82	0.1591
Dipropyl ether	27.12	0.1821
Dodecafluorocyclohexane	25.09	0.1955
Dodecafluoropentane	25.58	0.2161
Dodecane	69.14	0.3741
1-Dodecanol	72.69	0.3598
1-Dodecene	68.17	0.3694
Ethane	5.570	0.06499
1,2-Ethanediamine	16.30	0.09796
Ethanethiol	13.23	0.09447
Ethanol	12.56	0.08710
Ethoxybenzene	35.70	0.1996
Ethyl acetate	20.57	0.1401
Ethyl acrylate	23.70	0.1530
Ethylamine	10.79	0.08433
Ethylbenzene	30.86	0.1782
Ethyl benzoate	43.73	0.2236
Ethyl butanoate	30.53	0.1922
Ethylcyclohexane	35.70	0.2089
Ethylcyclopentane	27.90	0.1746
3-Ethyl-2,2-dimethylhexane	47.24	0.2752
4-Ethyl-2,2-dimethylhexane	46.45	0.2784
3-Ethyl-2,3-dimethylhexane	47.35	0.2692
4-Ethyl-2,3-dimethylhexane	47.49	0.2742
3-Ethyl-2,4-dimethylhexane	47.31	0.2736
4-Ethyl-2,4-dimethylhexane	45.52	0.2613
3-Ethyl-2,5-dimethylhexane	47.42	0.2800
3-Ethyl-3,4-dimethylhexane	47.00	0.2682
Ethylene	4.612	0.05821
Ethylene glycol dimethyl ether	21.65	0.1439
Ethylene glycol ethyl ether acetate	33.97	0.05594
Ethylene oxide	8.922	0.06779
Ethyl formate	15.91	0.1115
3-Ethylhexane	35.76	0.2253
Ethyl mercaptan	11.24	0.08098
2-Ethyl-1-methylbenzene	40.66	0.2226
3-Ethyl-1-methylbenzene	41.67	0.2331
4-Ethyl-1-methylbenzene	40.63	0.2262
1-Ethyl-1-methylcyclopentane	34.18	0.2058
Ethyl methyl ether	12.70	0.1034
3-Ethyl-2-methylheptane	48.81	0.2847
Ethyl methyl ketone	20.13	0.1340
3-Ethyl-2-methylpentane	34.74	0.2183
3-Ethyl-2-methylpentane	34.53	0.2134

TABLE 5.29 Van der Waals' Constants for Gases (*Continued*)

Substance	a, $L^2 \cdot bar \cdot mol^{-2}$	b, $L \cdot mol^{-1}$
Ethyl 2-methylpropanoate	29.05	0.1872
Ethyl methyl sulfide	19.45	0.1300
3-Ethylpentane	29.49	0.1944
Ethyl phenyl ether	35.16	0.1963
Ethyl propanoate	25.86	0.1688
Ethyl propyl ether	22.45	0.1600
m-Ethyltoluene	41.73	0.2334
o-Ethyltoluene	40.67	0.2226
p-Ethyltoluene	40.63	0.2262
Ethyl vinyl ether	16.17	0.1213
Fluorine	1.171	0.02896
Fluorobenzene	20.10	0.1279
Fluoroethane	8.170	0.07758
Fluoroethylene	5.984	0.06504
Fluoromethane	5.009	0.05617
Formaldehyde	7.356	0.06425
Furan	12.74	0.0926
2-Furaldehyde (furfural)	22.23	0.1182
Germanium tetrachloride	23.12	0.1489
Germanium tetrahydride	5.743	0.06555
Glycerol	22.98	0.07037
Hafnium tetrachloride	26.01	0.1282
Helium (equilibrium)	0.0346	0.02356
Heptane	30.89	0.2038
1-Heptanol	37.22	0.2097
2-Heptanol	35.72	0.2093
2-Heptanone	31.78	0.1850
1-Heptene	28.82	0.09400
Hexadecafluoroheptane	40.58	0.3046
1,5-Hexadiene	21.79	0.1532
Hexafluoraoacetone	12.66	0.1264
Hexafluorobenzene	26.63	0.1641
Hexane	24.97	0.1753
Hexanenitrile	35.50	0.1996
Hexanoic acid	39.94	0.2150
1-Hexanol	31.35	0.1829
2-Hexanol	30.25	0.1840
3-Hexanol	29.44	0.1803
2-Hexanone	30.27	0.1837
3-Hexanone	29.84	0.1824
1-Hexene	23.12	0.1634
cis-2-Hexene	23.86	0.1641
trans-2-Hexene	23.75	0.1640
cis-3-Hexene	23.77	0.1638
trans-3-Hexene	24.25	0.1663
Hexylcyclopentane	59.38	0.3206
Hydrazine	8.46	0.0462
Hydrogen (normal)	0.2484	0.02651
Hydrogen bromide	4.500	0.04415
Hydrogen chloride	3.700	0.04061
Hydrogen cyanide	11.29	0.08806
Hydrogen deuteride	0.2527	0.02516
Hydrogen fluoride	9.565	0.0739

TABLE 5.29 Van der Waals' Constants for Gases (*Continued*)

Substance	a, $L^2 \cdot bar \cdot mol^{-2}$	b, $L \cdot mol^{-1}$
Hydrogen iodide	6.309	0.05303
Hydrogen selenide	5.523	0.0479
Hydrogen sulfide	4.544	0.04339
Indane	34.63	0.1802
Iodobenzene	33.54	0.1658
Iodomethane	12.34	0.08327
Isobutyl acetate	29.05	0.1845
Isobutylamine	19.30	0.1325
Isobutylbenzene	40.40	0.2215
Isobutylcyclohexane	40.39	0.2195
Isobutyl formate	22.82	0.1476
Isopropylamine	14.30	0.1080
Isopropylbenzene	36.20	0.2044
Isopropylcyclohexane	42.06	0.2342
Isopropylcyclopentane	35.11	0.2082
4-Isopropylheptane	48.28	0.2832
2-Isopropyl-1-methylbenzene	45.14	0.2401
3-Isopropyl-1-methylbenzene	44.00	0.2354
4-Isopropyl-1-methylbenzene	43.94	0.2398
3-Isopropyl-2-methylhexane	50.93	0.2870
Ketene	19.1	0.1044
Krypton	2.325	0.0396
Mercury	5.193	0.01057
Methane	2.300	0.04301
Methanethiol	8.911	0.06756
Methanol	9.472	0.06584
Methoxybenzoate	28.60	0.1579
Methyl acetate	15.75	0.1108
Methyl acrylate	19.67	0.1308
Methylamine	7.106	0.05879
2-Methyl-1,3-butadiene	17.74	0.1307
3-Methyl-1,3-butadiene	17.46	0.1245
2-Methylbutane	18.29	0.1415
Methyl butanoate	25.83	0.1661
3-Methylbutanoic acid	33.94	0.1923
2-Methyl-1-butanol	24.51	0.1518
3-Methyl-1-butanol	24.72	0.1526
2-Methyl-2-butanol	23.24	0.1523
3-Methyl-2-butanol	23.30	0.1493
3-Methyl-2-butanone	23.20	0.1494
2-Methyl-1-butene	16.9	0.129
3-Methyl-1-butene	18.08	0.1405
2-Methyl-2-butene	17.26	0.1279
Methylcyclohexane	27.51	0.1713
Methylcyclopentane	21.87	0.1463
N-Methylethylamine	19.39	0.1391
Methyl formate	11.54	0.08406
2-Methylfuran	14.67	0.1160
2-Methylheptane	36.78	0.2342
3-Methylheptane	36.40	0.2301
4-Methylheptane	36.21	0.2297
2-Methylhexane	30.01	0.2016
3-Methylhexane	29.70	0.1977

TABLE 5.29 Van der Waals' Constants for Gases (*Continued*)

Substance	a, $L^2 \cdot bar \cdot mol^{-2}$	b, $L \cdot mol^{-1}$
Methylhydrazine	11.67	0.07334
Methyl isobutanoate	24.87	0.1639
Methyl isocyanate	12.6	0.09161
1-Methyl-2-isopropylbenzene	42.7	0.234
1-Methyl-4-isopropylbenzene	45.27	0.2478
Methyl 2-methylpropanoate	24.50	0.163 7
2-Methyloctane	43.50	0.2641
2-Methylpentane	23.83	0.1707
3-Methylpentane	23.75	0.1677
2-Methyl-2,4-pentanediol	39.05	0.2054
Methyl pentanoate	29.39	0.1847
2-Methyl-3-pentanol	27.96	0.1730
3-Methyl-3-pentanol	27.45	0.1699
4-Methyl-2-pentanol	22.38	0.1388
4-Methyl-2-pentanone	29.08	0.1815
2-Methyl-2-pentene	23.86	0.1641
cis-3-Methyl-2-pentene	23.86	0.1641
trans-3-Methyl-2-pentene	24.60	0.1656
cis-4-Methyl-2-pentene	23.03	0.1675
trans-4-Methyl-2-pentene	23.32	0.1685
2-Methylpropanal	18.49	0.1285
2-Methyl-1-propanamine	19.30	0.1325
2-Methylpropane (isobutane)	13.36	0.1168
Methyl propanoate	20.51	0.1377
2-Methylpropanoic acid	28.9	0.170
2-Methyl-1-propanol	20.35	0.1324
2-Methyl-2-propanol	18.81	0.1324
2-Methylpropene	12.73	0.1086
2-Methylpropyl acetate	29.05	0.1845
2-Methylpropyl formate	22.54	0.1476
2-Methylpyridine	24.45	0.1403
3-Methylpyridine	27.08	0.1496
4-Methylpyridine	25.89	0.1428
1-Methylstyrene	36.69	0.1999
2-Methyltetrahydrofuran	22.37	0.1484
2-Methylthiophene	22.10	0.1299
3-Methylthiophene	21.98	0.1282
Methyl vinyl ether	11.65	0.09520
Morpholine	20.36	0.1174
Naphthalene	40.32	0.1920
Neon	0.208	0.01709
Niobium pentafluoride	25.22	0.1220
Nitric oxide (NO)	1.46	0.0289
Nitroethane	24.13	0.1544
Nitrogen-14	15.18	0.1288
Nitrogen chloride difluoride	6.447	0.06089
Nitrogen dioxide (NO_2)	5.36	0.0443
Nitrogen trifluoride	3.58	0.05364
Nitrous oxide (N_2O)	3.852	0.04435
Nitromethane	17.18	0.1041
Nitrosyl chloride	6.191	0.05014
Nonane	45.11	0.2702
1-Nonanol	50.00	0.2634

TABLE 5.29 Van der Waals' Constants for Gases (*Continued*)

Substance	a, $L^2 \cdot bar \cdot mol^{-2}$	b, $L \cdot mol^{-1}$
1-Nonene	43.68	0.2629
Octadecafluorooctane	44.27	0.3143
Octafluorocyclobutane	15.81	0.1450
Octafluoropropane	12.96	0.1338
Octamethylcyclotetrasiloxane	75.30	0.4579
Octane	37.86	0.2370
1-Octanol	44.71	0.2371
2-Octanol	41.98	0.2376
1-Octene	35.01	0.2227
cis-2-Octene	35.42	0.2176
Osmium tetraoxide	2.79	0.2447
Oxygen	1.382	0.03186
Oxygen difluoride	2.726	0.04516
Ozone	3.570	0.04977
Pentadecane	95.91	0.4834
1-Pentadecene	99.00	0.5011
1,2-Pentadiene	18.13	0.1284
cis-1,3-Pentadiene	17.98	0.1292
1,4-Pentadiene	17.58	0.1311
Pentafluorobenzene	23.45	0.1571
2,2,3,3,4-Pentamethylpentane	46.85	0.2593
2,2,3,4,4-Pentamethylpentane	47.82	0.2716
Pentanal	25.21	0.1622
Pentane	19.13	0.1449
Pentanenitrile	34.16	0.1772
Pentanoic acid	33.68	0.1867
1-Pentanol	25.81	0.1572
2-Pentanol	24.89	0.1585
2-Pentanone	24.85	0.1578
3-Pentanone	24.65	0.1565
1-Pentene	17.86	0.1370
cis-2-Pentene	17.83	0.1338
trans-2-Pentene	18.30	0.1391
Pentylbenzene	51.85	0.2718
Pentyl formate	27.97	0.1730
1-Pentyne	17.53	0.1266
Perchloryl fluoride (ClO_3F)	7.371	0.07130
Phenol	22.93	0.1177
Phosgene	10.65	0.08340
Phosphine	4.693	0.05155
Phosphonium chloride	4.111	0.04545
Phosphorus	53.6	0.157
Phosphorus chloride difluoride	8.47	0.0833
Phosphorus dichloride fluoride	12.50	0.0962
Phosphorus trifluoride	4.954	0.06510
Phosphoryl chloride difluoride	11.90	0.1001
Phosphoryl trifluoride	8.26	0.0849
Piperidine	20.84	0.1250
Propadiene	8.23	0.0747
Propanal	14.08	0.0995
Propane	9.385	0.09044
1,2-Propanediol	18.74	0.1068
1,3-Propanediol	21.11	0.1143

TABLE 5.29 Van der Waals' Constants for Gases (*Continued*)

Substance	a, $L^2 \cdot bar \cdot mol^{-2}$	b, $L \cdot mol^{-1}$
Propanenitrile	21.57	0.1369
Propanoic acid	23.49	0.1386
1-Propanol	16.26	0.1080
2-Propanol	15.82	0.1109
2-Propenal	14.44	0.1017
Propene	8.411	0.08211
Propyl acetate	26.23	0.1700
Propylamine	15.26	0.1095
Propylbenzene	37.14	0.2073
Propylcyclopentane	38.80	0.2189
Propylcyclohexane	38.59	0.2255
Propylene oxide	13.78	0.1019
Propyl formate	20.79	0.1377
Propyne	8.40	0.0744
Pyridine	19.77	0.1136
Pyrrole	18.82	0.1049
Pyrrolidine	16.84	0.1056
Quinoline	36.70	0.1672
Radon	6.601	0.06239
Selenium	33.4	0.0675
Silicon chloride trifluoride	7.95	0.0921
Silicon tetrachloride	20.96	0.1470
Silicon tetrafluoride	5.259	0.072361
Silicon tetrahydride (silane)	4.30	0.0579
Styrene	32.15	0.1799
Sulfur (S)	24.3	0.0660
Sulfur dioxide	6.714	0.05636
Sulfur hexafluoride (SF_6)	7.857	0.08786
Sulfur trioxide	8.57	0.0622
1,1,2,2-Tetrachlorodifluoroethane	25.74	0.1665
Tetrachloroethylene	24.98	0.1435
Tetrachloromethane	20.01	0.1281
Tetradecafluorohexane	30.75	0.2448
Tetradecafluoromethylcyclohexane	29.66	0.2171
1-Tetradecanol	89.91	0.4289
Tetraethylsilane	40.85	0.2411
Tetrafluoroethylene	6.954	0.08085
Tetrafluorohydrazine (N_2F_4)	7.426	0.08564
Tetrafluoromethane	4.040	0.06325
Tetrahydrofuran	16.39	0.1082
Tetrahydropyran	20.02	0.1247
1,2,4,5-Tetramethylbenzene	45.8	0.2422
2,2,3,3-Tetramethylbutane	32.76	0.2056
2,2,3,3-Tetramethylhexane	45.11	0.2580
2,2,3,4-Tetramethylhexane	47.36	0.2721
2,2,3,5-Tetramethylhexane	46.45	0.2753
2,2,4,4-Tetramethylhexane	48.26	0.2819
2,2,4,5-Tetramethylhexane	47.05	0.2802
2,2,5,5-Tetramethylhexane	45.03	0.2760
2,3,3,4-Tetramethylhexane	47.13	0.2653
2,3,3,5-Tetramethylhexane	46.79	0.2733
2,3,4,4-Tetramethylhexane	47.32	0.2691
2,3,4,5-Tetramethylhexane	46.86	0.2723

TABLE 5.29 Van der Waals' Constants for Gases (*Continued*)

Substance	a, $L^2 \cdot bar \cdot mol^{-2}$	b, $L \cdot mol^{-1}$
3,3,4,4-Tetramethylhexane	47.46	0.2615
2,2,3,3-Tetramethylpentane	39.29	0.2304
2,2,3,4-Tetramethylpentane	39.37	0.2367
2,2,4,4-Tetramethylpentane	38.76	0.2403
2,3,3,4-Tetramethylpentane	39.65	0.2325
Tetramethylsilane	20.81	0.1653
Thiophene	17.21	0.1058
Tin(IV) chloride	27.25	0.1641
Titanium(IV) chloride	25.47	0.1423
Toluene	24.89	0.1499
1,2-Toluidine	33.36	0.1681
1,3-Toluidine	34.06	0.1717
1,4-Toluidine	31.74	0.1602
Tributoxyborane	81.34	0.3891
Tributylamine	65.31	0.3645
1,1,1-Trichloroethane	20.14	0.1317
1,1,2-Trichloroethane	25.47	0.1508
Trichloroethylene	17.21	0.1127
Trichlorofluoromethane	14.68	0.1111
Trichlorofluorosilane	15.67	0.1277
Trichloromethane	15.34	0.1019
Trichloromethylsilane	23.77	0.1638
1,2,3-Trichloropropane	31.29	0.1713
1,1,2-Trichlorotrifluoroethane	20.25	0.1481
1,2,2-Trichlorotrifluoroethane	20.25	0.1481
Tridecane	79.09	0.4176
1-Tridecanol	81.20	0.3942
1-Tridecene	77.93	0.4121
Tridecylcyclopentane	139.6	0.6536
Triethanolamine	32.14	0.3340
Triethylamine	27.59	0.1836
Trifluoroacetic acid	21.61	0.1567
1,1,1-Trifluoroethane	9.302	0.09572
Trifluoromethane	5.378	0.06403
Trimethylamine	13.37	0.1101
1,2,3-Trimethylbenzene	37.28	0.1999
1,2,4-Trimethylbenzene	38.03	0.2088
1,3,5-Trimethylbenzene	37.87	0.2118
2,2,3-Trimethylbutane	27.86	0.1869
2,2,3-Trimethyl-1-butene	28.57	0.1910
1,1,2-Trimethylcyclopentane	33.31	0.2048
1,1,3-Trimethylcyclopentane	33.42	0.2091
2,2,3-Trimethylheptane	48.07	0.2801
2,2,4-Trimethylheptane	47.49	0.2847
2,3,4-Trimethylheptane	47.96	0.2785
3,3,4-Trimethylheptane	47.68	0.2730
2,2,3-Trimethylhexane	40.5	0.2452
2,2,4-Trimethylhexane	40.50	0.2516
2,2,5-Trimethylhexane	40.38	0.2533
2,2,3-Trimethylpentane	33.92	0.2145
2,2,4-Trimethylpentane	33.61	0.2202
2,3,3-Trimethylpentane	34.03	0.2114
2,3,4-Trimethylpentane	34.28	0.2157

TABLE 5.29 Van der Waals' Constants for Gases (*Continued*)

Substance	a, $L^2 \cdot bar \cdot mol^{-2}$	b, $L \cdot mol^{-1}$
2,2,4-Trimethyl-1,3-pentanediol	19.96	0.2692
Tungsten(VI) fluoride (WF_6)	13.25	0.1063
Undecane	60.88	0.3396
1-Undecene	59.17	0.3310
Uranium(VI) fluoride (UF_6)	16.01	0.1128
Vinyl acetate	32.31	0.2296
Vinyl chloride	9.62	0.07975
Vinyl fluoride	5.98	0.06502
Vinyl formate	11.38	0.08541
Xenon	4.192	0.05156
Xenon difluoride	12.46	0.7037
Xenon tetrafluoride	15.52	0.09035
m-Xylene	31.41	0.1814
o-Xylene	31.06	0.1756
p-Xylene	31.54	0.1824
Water	5.537	0.03052
Zirconium(IV) chloride	30.59	0.1401

TABLE 5.30 Triple Points of Various Materials

Substance	Triple point, K	Pressure, mmHg
Ammonia	195.46	45.58
Argon	83.78	516
Boron tribromide	226.67	
Bromine	280.4	44.1
Carbon dioxide	216.65	
Cyclopropane	145.59	
Deuterium oxide	276.97	
1-Hexene	133.39	
Hydrogen, normal	13.95	54
Hydrogen, para	13.81	
Hydrogen bromide	186.1	~232
Hydrogen chloride	158.8	
Iodine heptafluoride	279.6	
Krypton	115.95	548
Methane	90.67	87.60
Methane-d_1	90.40	84.52
Methane-d_2	90.14	81.80
Methane-d_3	89.94	80.12
Methane-d_4	89.79	79.13
Molybdenum oxide tetrafluoride	370.3	
Molybdenum pentafluoride	340	
Neon	24.55	324
Neptunium hexafluoride	328.25	758.0
Niobium pentabromide	540.6	
Niobium pentachloride	476.5	
Nitrogen	63.15	94
1-Octene	171.45	
Oxygen	54.34	

TABLE 5.30 Triple Points of Various Materials (*Continued*)

Substance	Triple point, K	Pressure, mmHg
Phosphorus, white	863	32 760
Plutonium hexafluoride	324.74	533.0
Propene	103.95	
Radon	202	~500
Rhenium dioxide trifluoride	363	
Rhenium heptafluoride	321.4	
Rhenium oxide pentafluoride	313.9	
Rhenium pentafluoride	321	
Succinonitrile (NIST standard)	331.23	
Sulfur dioxide	197.68	1.256
Tantalum pentabromide	553	
Tantalum pentachloride	489.0	
Tungsten oxide tetrafluoride	377.8	
Uranium hexafluoride	337.20	1 139.6
Water	273.16	
Xenon	161.37	612

5.9.1 Some Physical Chemistry Equations for Gases

A number of physical chemistry relationships, not enumerated in other sections (*see* Index), will be discussed in this section.

Boyle's law states that the volume of a given quantity of a gas varies inversely as the pressure, the temperature remaining constant. That is,

$$V = \frac{\text{constant}}{P} \qquad \text{or} \qquad PV = \text{constant}$$

A convenient form of the law, true strictly for ideal gases, is

$$P_1V_1 = P_2V_2$$

Charles' law, also known as *Gay-Lussac's law,* states that the volume of a given mass of gas varies directly as the absolute temperature if the pressure remains constant, that is,

$$\frac{V}{T} = \text{constant}$$

Combining the laws of Boyle and Charles into one expression gives

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

In terms of moles, *Avogadro's hypothesis* can be stated: The same volume is occupied by one mole of any gas at a given temperature and pressure. The number of molecules in one mole is known as the *Avogadro number constant* N_A.

The behavior of all gases that obey the laws of Boyle and Charles, and Avogadro's hypothesis, can be expressed by the ideal gas equation:

$$PV = nRT$$

where R is called the *gas constant* and n is the number of moles of gas. If pressure is written as force per unit area and the volume as area times length, then R has the dimensions of energy per degree per mole—8.314 J · K^{-1} · mol^{-1} or 1.987 cal · K^{-1} · mol^{-1}.

Dalton's law of partial pressures states that the total pressure exerted by a mixture of gases is equal to the sum of the pressures which each component would exert if placed separately into the container:

$$P_{\text{total}} = p_1 + p_2 + p_3 + \cdots$$

There are two ways to express the fraction which one gaseous component contributes to the total mixture: (1) the pressure fraction, p_i/P_{total}, and (2) the mole fraction, n_i/n_{total}.

5.9.1.1 Equations of State (PVT *Relations for Real Gases*)

1. *Virial equation* represents the experimental compressibility of a gas by an empirical equation of state:

$$PV = A_p + B_pP + C_pP^2 + \cdots$$

or

$$PV = A_v + B_vV + \frac{C_v}{V^2} + \cdots$$

where A, B, C, . . . are called the virial coefficients and are a function of the nature of the gas and the temperature.

2. *Van der Waals' equation:*

$$\left(P + \frac{an^2}{V^2}\right)(V - nb) = nRT$$

where the term an^2/V^2 is the correction for intermolecular attraction among the gas molecules and the nb term is the correction for the volume occupied by the gas molecules. The constants a and b must be fitted for each gas from experimental data (Table 5.28); consequently the equation is semiempirical. The constants are related to the critical-point constants (Table 6.5) as follows:

$$a = 3P_cV^2$$

$$b = \frac{V_c}{3}$$

$$R = \frac{8P_cV_c}{3T_c}$$

Substitution into van der Waals' equation and rearrangement leads to only the terms P/P_c, V/V_c, and T/T_c, which are called the reduced variables P_R, V_R, and T_R. For 1 mole of gas,

$$\left(P_R + \frac{3}{V_R^2}\right)\left(V_R - \frac{1}{3}\right) = \frac{8}{3}T_R$$

3. *Berthelot's equation of state,* used by many thermodynamicists, is

$$PV = nRT\left[1 + \frac{9}{128}\frac{PT_c}{P_cT}\left(1 - 6\frac{T_c^2}{T^2}\right)\right]$$

This equation requires only knowledge of the critical temperature and pressure for its use and gives accurate results in the vicinity of room temperature for unassociated substances at moderate pressures.

5.9.1.2 Properties of Gas Molecules

Vapor Density. Substitution of the Antoine vapor-pressure equation for its equivalent log P in the ideal gas equation gives

$$\log \rho_{vap} = \log M - \log R - \log (t + 273.15) + A - \frac{B}{t + C}$$

where ρ_{vap} is the vapor density in $g \cdot mL^{-1}$ at t°C, M is the molecular weight, R is the gas constant, and A, B, and C are the constants of the Antoine equation for vapor pressure. Since this equation is based on the ideal gas law, it is accurate only at temperatures at which the vapor of any specific compound follows this law. This condition prevails at reduced temperatures (T_R) of about 0.5 K.

Velocities of Molecules. The mean square velocity of gas molecules is given by

$$\overline{u^2} = \frac{3kT}{m} = \frac{3RT}{M}$$

where k is Boltzmann's constant and m is the mass of the molecule.

The mean velocity is given by

$$\bar{u} = \left(\frac{8\overline{u^2}}{3\pi}\right)^{1/2}$$

Viscosity. On the assumption that molecules interact like hard spheres, the viscosity of a gas is

$$\eta = \left(\frac{5}{16\sigma^2}\right)\left(\frac{mkT}{\pi}\right)^{1/2}$$

where σ is the molecular diameter.

Mean Free Path. The mean free path of a gas molecule l and the mean time between collisions τ are given by

$$l = \frac{m}{\pi\rho\sigma^2\sqrt{2}}$$

$$\tau = \frac{1}{\bar{u}} = \frac{4\eta}{5P}$$

Graham's Law of Diffusion. The rates at which gases diffuse under the same conditions of temperature and pressure are inversely proportional to the square roots of their densities:

$$\frac{r_1}{r_2} = \left(\frac{\rho_2}{\rho_1}\right)^{1/2}$$

Since $\rho = MP/RT$ for an ideal gas, it follows that

$$\frac{r_1}{r_2} = \left(\frac{M_2}{M_1}\right)^{1/2}$$

Henry's Law. The solubility of a gas is directly proportional to the partial pressure exerted by the gas:

$$p_i = kx_i$$

Joule-Thompson Coefficient for Real Gases. This expresses the change in temperature with respect to change in pressure at constant enthalpy:

$$\mu_\pi = \left(\frac{\partial T}{\partial P}\right)_H$$