Standand Enthalpies of Formation & Standard Entropies of Common Compounds

Substance	*State*	ΔH_f° $(\frac{\text{kJ}}{\text{mol}})$	S° $(\frac{\text{J}}{\text{mol·K}})$
Ag	s	0	42.6
Ag^+	aq	105.79	72.7
AgCl	s	−127.01	96.2
AgBr	s	−100.4	107.1
$AgNO_3$	s	−124.4	140.9
Al	s	0	28.3
Al^{+3}	aq	−538.4	−321.7
$AlCl_3$	s	−704	110.7
Al_2O_3	s	−1675.7	50.9
Ba	s	0	62.8
$BaCl_2$	s	−858.6	123.7
$BaCO_3$	s	−1216.3	112.1
$Ba(NO_3)_2$	s	−992	214
BaO	s	−553.5	70.4
$Ba(OH)_2$	s	−998.2	112
$BaSO_4$	s	−1473.2	132.2
Br_2	ℓ	0	152.2
C	s	0	5.7
CCl_4	ℓ	−135.4	216.4
$CHCl_3$	ℓ	−134.5	201.7
CH_4	g	−74.8	186.2
C_2H_2	g	+226.7	200.8
C_2H_4	g	+52.3	219.5
C_2H_6	g	−84.7	229.5
C_3H_8	g	−103.8	269.9
CH_3OH	ℓ	−238.7	126.8
C_2H_5OH	ℓ	−277.7	160.7
CO	g	−110.53	197.6
CO_2	g	−393.51	213.6
CO_3^{-2}	aq	−675.23	−56.9
Ca	s	0	41.4
Ca^{+2}	aq	−543.0	−53.1
$CaCl_2$	s	−795.8	104.6
$CaCO_3$	s	−1206.9	92.9
CaO	s	−634.92	39.8
$Ca(OH)_2$	s	−986.1	83.4
$CaSO_4$	s	−1434.1	106.7
Cd	s	0	51.8
Cd^{+2}	aq	−75.92	−73.2
$CdCl_2$	s	−391.5	115.3
CdO	s	−258.35	54.8

Substance	*State*	ΔH_f° $(\frac{\text{kJ}}{\text{mol}})$	S° $(\frac{\text{J}}{\text{mol·K}})$
Cl_2	g	0	223.0
Cl^-	aq	−167.080	56.5
ClO_4^-	aq	−128.10	182.0
Cr	s	0	23.8
Cr_2O_3	g	−1139.7	81.2
Cu	s	0	33.2
Cu^+	aq	+71.7	40.6
Cu^{+2}	aq	+64.8	−99.6
CuO	s	−157.3	42.6
Cu_2O	s	−168.6	93.1
CuS	s	−53.1	66.5
Cu_2S	s	−79.5	120.9
$CuSO_4$	s	−771.4	107.6
F^-	aq	−335.35	−13.8
F_2	g	0	202.7
Fe	s	0	27.3
$Fe(OH)_3$	s	−823.0	106.7
Fe_2O_3	s	−824.2	87.4
Fe_3O_4	s	−1118.4	146.4
H_2	g	0	130.6
H^+	aq	0	0.0*
HBr	g	−36.29	198.6
HCO_3^-	aq	−689.93	91.2
HCl	g	−92.31	186.8
HF	g	−273.30	173.7
HI	g	26.50	206.5
HNO_3	ℓ	−174.1	155.6
HPO_4^{-2}	aq	−1299.0	−33.5
HSO_4^-	aq	−886.9	131.8
H_2O	ℓ	−285.830	69.9
H_2O	g	−241.826	188.7
$H_2PO_4^-$	aq	−1302.6	90.4
H_2S	g	−20.6	205.7
Hg	ℓ	0	76.0
Hg^{+2}	aq	170.21	−32.2
HgO	cr,red	−90.79	70.3

*The standard entropy of the $H^+(aq)$ ion is defined to be 0.

Substance	*State*	ΔH_f° $(\frac{\text{kJ}}{\text{mol}})$	S° $(\frac{\text{J}}{\text{mol·K}})$
I^-	aq	−56.78	111.3
I_2	s	0	116.1
K	s	0	64.2
K^+	aq	−252.14	102.5
KBr	s	−393.8	95.9
KCl	s	−436.7	82.6
$KClO_3$	s	−397.7	143.1
$KClO_4$	s	−432.8	151.0
KNO_3	s	−494.6	133.0
Mg	s	0	32.7
Mg^{+2}	aq	−467.0	−138.1
$MgCl_2$	s	−641.3	89.6
$MgCO_3$	s	−1095.8	65.7
MgO	s	−601.60	26.9
$Mg(OH)_2$	s	−924.5	63.2
$MgSO_4$	s	−1284.9	91.6
Mn	s	0	32.0
Mn^{+2}	aq	−220.8	−73.6
MnO	s	−385.2	59.7
MnO_2	s	−520.0	53.0
N_2	g	0	191.5
NH_3	g	−45.94	192.3
NH_4^+	aq	−133.26	113.4
NO_2^-	aq	−104.6	123.0
NO_3^-	aq	−206.85	146.4
N_2H_4	ℓ	+50.6	121.2
NH_4Cl	s	−314.4	94.6
NH_4NO_3	s	−365.6	151.1
NO	g	+90.2	210.7
NO_2	g	+33.2	240.0
N_2O_4	g	+9.2	304.2
Na	s	0	51.2
Na^+	aq	−240.34	59.0
NaCl	s	−411.2	72.1
NaF	s	−573.6	51.5
NaOH	s	425.6	64.5

Substance	*State*	ΔH_f° $(\frac{\text{kJ}}{\text{mol}})$	S° $\frac{\text{J}}{\text{mol K}}$
Ni	s	0	29.9
NiO	s	−239.7	38.0
OH^-	aq	−230.015	−10.8
O_2	g	0	205.0
P_4	s	0	164.4
PCl_3	g	−287.0	311.7
PCl_5	g	−374.9	364.5
PO_4^{-3}	aq	−1277.4	−222
Pb	s	0	64.8
Pb^{+2}	aq	0.92	10.5
$PbBr_2$	s	−278.7	161.5
$PbCl_2$	s	−359.4	136.0
PbO	s	−219.0	66.5
PbO_2	s	−277.4	68.6
S	s	0	31.8
SO_2	g	−296.81	248.1
SO_3	g	−395.7	256.7
SO_4^{-2}	aq	−909.34	20.1
S_2^-	aq	+33.1	−14.6
Si	s	0	18.8
SiO_2	s	−910.7	41.8
Sn	s	0	51.6
Sn^{+2}	aq	−8.9	−17.4
SnO_2	s	−577.63	52.3
Zn	s	0	41.6
Zn^{+2}	aq	−153.39	−112.1
ZnI_2	s	−208.0	161.1
ZnO	s	−350.46	43.6
ZnS	s	−206.0	57.7

TABLE 9.3 Average Bond Energies

Bond	Bond Energy (kJ/mol)	Bond	Bond Energy (kJ/mol)	Bond	Bond Energy (kJ/mol)
H—H	436	N—N	163	Br—F	237
H—C	414	N=N	418	Br—Cl	218
H—N	389	N≡N	946	Br—Br	193
H—O	464	N—O	222	I—Cl	208
H—S	368	N=O	590	I—Br	175
H—F	565	N—F	272	I—I	151
H—Cl	431	N—Cl	200	Si—H	323
H—Br	364	N—Br	243	Si—Si	226
H—I	297	N—I	159	Si—C	301
C—C	347	O—O	142	S—O	265
C=C	611	O=O	498	Si=O	368
C≡C	837	O—F	190	S=O	523
C—N	305	O—Cl	203	Si—Cl	464
C=N	615	O—I	234	S=S	418
C≡N	891	F—F	159	S—F	327
C—O	360	Cl—F	253	S—Cl	253
C=O	736*	Cl—Cl	243	S—Br	218
C≡O	1072			S—S	266
C—Cl	339				

*799 in CO_2

TABLE 10.4 Van der Waals Constants for Common Gases

Gas	a ($L^2 \cdot atm/mol^2$)	b (L/mol)
He	0.0342	0.02370
Ne	0.211	0.0171
Ar	1.35	0.0322
Kr	2.32	0.0398
Xe	4.19	0.0511
H_2	0.244	0.0266
N_2	1.39	0.0391
O_2	1.36	0.0318
Cl_2	6.49	0.0562
H_2O	5.46	0.0305
CH_4	2.25	0.0428
CO_2	3.59	0.0427
CCl_4	20.4	0.1383

Values of Grubbs Statistic (G)

Number of Observations n	Confidence Level (%)					
	99.9	99.5	99	97.5	95	90
3	1.155	1.155	1.155	1.155	1.153	1.148
4	1.499	1.496	1.492	1.481	1.463	1.425
5	1.780	1.764	1.749	1.715	1.672	1.602
6	2.011	1.973	1.944	1.887	1.822	1.729
7	2.201	2.139	2.097	2.020	1.938	1.828
8	2.358	2.274	2.221	2.126	2.032	1.909
9	2.492	2.387	2.323	2.215	2.110	1.977
10	2.606	2.482	2.410	2.290	2.176	2.036
11	2.705	2.564	2.485	2.355	2.234	2.088
12	2.791	2.636	2.550	2.412	2.285	2.134
13	2.867	2.699	2.607	2.462	2.331	2.175
14	2.935	2.755	2.659	2.507	2.371	2.213
15	2.997	2.806	2.705	2.549	2.409	2.247
16	3.052	2.852	2.747	2.585	2.443	2.279
17	3.103	2.894	2.785	2.620	2.475	2.309
18	3.149	2.932	2.821	2.651	2.504	2.335
19	3.191	2.968	2.854	2.681	2.532	2.361
20	3.230	3.001	2.884	2.709	2.557	2.385
30	3.507	3.236	3.103	2.908	2.745	2.563
40	3.673	3.381	3.240	3.036	2.866	2.682
50	3.789	3.483	3.336	3.128	2.956	2.768
60	3.874	3.560	3.411	3.199	3.025	2.837
70	3.942	3.622	3.471	3.257	3.082	2.893
80	3.998	3.673	3.521	3.305	3.130	2.940
90	4.044	3.716	3.563	3.347	3.171	2.981
100	4.084	3.754	3.600	3.383	3.207	3.017

Source: ASTM E178-00, “Standard Practice for Dealing with Outlying Observations”

Values of Student's t

Degrees of Freedom	Confidence Level (%)						
	50	90	95	97.5	99	99.5	99.9
1	1.000	6.314	12.706	25.452	63.657	127.321	636.619
2	0.816	2.920	4.303	6.205	9.925	14.089	31.599
3	0.765	2.353	3.182	4.177	5.841	7.453	12.924
4	0.741	2.132	2.776	3.495	4.604	5.598	8.610
5	0.727	2.015	2.571	3.163	4.032	4.773	6.869
6	0.718	1.943	2.447	2.969	3.707	4.317	5.959
7	0.711	1.895	2.365	2.841	3.499	4.029	5.408
8	0.706	1.860	2.306	2.752	3.355	3.833	5.041
9	0.703	1.833	2.262	2.685	3.250	3.690	4.781
10	0.700	1.812	2.228	2.634	3.169	3.581	4.587
11	0.697	1.796	2.201	2.593	3.106	3.497	4.437
12	0.695	1.782	2.179	2.560	3.055	3.428	4.318
13	0.694	1.771	2.160	2.533	3.012	3.372	4.221
14	0.692	1.761	2.145	2.510	2.977	3.326	4.140
15	0.691	1.753	2.131	2.490	2.947	3.286	4.073
16	0.690	1.746	2.120	2.473	2.921	3.252	4.015
17	0.689	1.740	2.110	2.458	2.898	3.222	3.965
18	0.688	1.734	2.101	2.445	2.878	3.197	3.922
19	0.688	1.729	2.093	2.433	2.861	3.174	3.883
20	0.687	1.725	2.086	2.423	2.845	3.153	3.850
30	0.683	1.697	2.042	2.360	2.750	3.030	3.646
40	0.681	1.684	2.021	2.329	2.704	2.971	3.551
50	0.679	1.676	2.009	2.311	2.678	2.937	3.496
60	0.679	1.671	2.000	2.299	2.660	2.915	3.460
70	0.678	1.667	1.994	2.291	2.648	2.899	3.435
80	0.678	1.664	1.990	2.284	2.639	2.887	3.416
90	0.677	1.662	1.987	2.280	2.632	2.878	3.402
100	0.677	1.660	1.984	2.276	2.626	2.871	3.390
∞	0.674	1.645	1.960	2.241	2.576	2.807	3.291

Values for the F Statistic at the 95% Confidence Level

Degrees of Freedom (denominator)	Degrees of Freedom (numerator)										
	2	3	4	5	6	7	8	9	10	20	∞
2	19.00	19.16	19.25	19.30	19.33	19.35	19.37	19.38	19.40	19.45	19.50
3	9.55	9.28	9.12	9.01	8.94	8.89	8.85	8.81	8.79	8.66	8.53
4	6.94	6.59	6.39	6.26	6.16	6.09	6.04	6.00	5.96	5.80	5.63
5	5.79	5.41	5.19	5.05	4.95	4.88	4.82	4.77	4.74	4.56	4.36
6	5.14	4.76	4.53	4.39	4.28	4.21	4.15	4.10	4.06	3.87	3.67
7	4.74	4.35	4.12	3.97	3.87	3.79	3.73	3.68	3.64	3.44	3.23
8	4.46	4.07	3.84	3.69	3.58	3.50	3.44	3.39	3.35	3.15	2.93
9	4.26	3.86	3.63	3.48	3.37	3.29	3.23	3.18	3.14	2.94	2.71
10	4.10	3.71	3.48	3.33	3.22	3.14	3.07	3.02	2.98	2.77	2.54
20	3.49	3.10	2.87	2.71	2.60	2.51	2.45	2.39	2.35	2.12	1.84
∞	3.00	2.60	2.37	2.21	2.10	2.01	1.94	1.88	1.83	1.57	1.00

Values for the F Statistic at the 90% Confidence Level

Degrees of Freedom (denominator)	Degrees of Freedom (numerator)										
	2	3	4	5	6	7	8	9	10	20	∞
2	9.00	9.16	9.24	9.29	9.33	9.35	9.37	9.38	9.39	9.44	9.49
3	5.46	5.39	5.34	5.31	5.28	5.27	5.25	5.24	5.23	5.18	5.13
4	4.32	4.19	4.11	4.05	4.01	3.98	3.95	3.94	3.92	3.84	3.76
5	3.78	3.62	3.52	3.45	3.40	3.37	3.34	3.32	3.30	3.21	3.10
6	3.46	3.29	3.18	3.11	3.05	3.01	2.98	2.96	2.94	2.84	2.72
7	3.26	3.07	2.96	2.88	2.83	2.78	2.75	2.72	2.70	2.59	2.47
8	3.11	2.92	2.81	2.73	2.67	2.62	2.59	2.56	2.54	2.42	2.29
9	3.01	2.81	2.69	2.61	2.55	2.51	2.47	2.44	2.42	2.30	2.16
10	2.92	2.73	2.61	2.52	2.46	2.41	2.38	2.35	2.32	2.20	2.06
20	2.59	2.38	2.25	2.16	2.09	2.04	2.00	1.96	1.94	1.79	1.61
∞	2.30	2.08	1.94	1.85	1.77	1.72	1.67	1.63	1.60	1.42	1.00