Module 8: Thermochemistry

Topic 5 Content: Standard Thermodynamic Values Table

Formula	ΔH°f (kJ/mol)	ΔG°f (kJ/mol)	S (J/K·mol)
Ag	0	0	42.55
Ag	284.55	245.65	172.997
$Ag(NH_3)2^+$	-111.29	-17.12	245.2
$Ag(S_2O_3)2^{3-}$	-1285.7	-1033.65	98.92
Ag^+	105.579	77.107	72.68
Ag^+	1021.73	-	-
Ag_2CO_3	-505.8	-436.8	167.4
Ag_2CrO_4	-731.74	-641.76	217.6
Ag_2O	-31.05	-11.2	121.3
Ag_2S	-32.59	-40.67	144.01
Ag_2SO_4	-715.88	-618.41	200.4
Ag_3PO_4	-	-879	-
AgBr	-100.37	-96.9	107.1
AgCl	-127.068	-109.789	96.2
$AgCl2^-$	-245.2	-215.4	231.4
AgCN	146	156.9	107.19
AgCNS	87.9	101.39	131
AgI	-61.83	-66.19	115.5
$AgNO_3$	-124.39	-33.47	140.92
Al	0	0	28.33
Al	326.4	285.7	164.54
$Al(OH)_3$	-1276	-	-
Al_2O_3	-1675.7	-1582.3	50.92
Al^{3+}	-531	-485	-321.7
Al^{3+}	5483.17	-	-
$AlCl_3$	-704.2	-628.8	110.67
$AlCl_3$	-583.2	-	-
Ar	0	0	154.843
As	0	0	35.1
B	0	0	5.86
Ba	0	0	62.8
Ba^{2+}	-537.64	-560.77	9.6
BaC_2O_4	-1368.6	-	-
BaCO3	-1216.3	-1137.6	112.1
$BaCrO_4$	-1446	-1345.22	158.6
BaF_2	-1207.1	-1156.8	96.36
$BaSO_4$	-1473.2	-1362.2	132.2
Be	0	0	9.5
BeO	-609.6	-580.3	14.14
BF_3	-1137	-1120.35	254.01
Bi	0	0	56.74
Bi_2S_3	-143.1	-140.6	200.4
Bi^{3+}	-	82.8	-
Br^-	-121.55	-103.96	82.4

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Br	111.88	82.429	174.91
Br^-	-219.07	-	-
Br_2	30.907	3.11	245.463
Br_2	0	0	152.231
Br_3^-	-130.42	-107.05	215.5
BrO_3^-	-67.07	18.6	161.71
C(diamond)	1.895	2.9	2.377
C (graphite)	0	0	5.74
C	716.682	671.257	158.096
$(CH_3)_2O$	-184.05	-112.59	266.38
C_2H_2	226.73	209.2	200.94
C_2H_4	52.25	68.12	219.45
C_2H_5OH	-235.1	-168.49	282.7
C_2H_5OH	-277.69	-174.78	160.7
C_2H_6	-84.68	-32.82	229.6
$C_2O_4^{2-}$	-825.1	-673.9	45.6
C_3H_6	20.2	62.72	266.9
C_3H_8	-104.5	-23.4	269.9
C_4H_{10}	-126.5	-17.15	310.1
C_5H_{12}	-146.5	-8.37	348.9
C_6H_{12}	-156.3	26.7	204.4
C_6H_6	82.9	129.7	269.2
C_6H_6	49.0	124.7	172.
C_8H_{18}	-208.5	16.40	466.7
CH_3CHO	-192.3	-128.2	160.2
CH_3Cl	-80.83	-57.37	234.58
CH_3COO^-	-486.01	-369.31	-6.3
CH_3COOH	-485.76	-396.46	178.7
CH_3COOH	-484.51	-389.9	159.8
CH_3NH_2	-70.17	20.77	123.4
$CH_3NH_3^+$	-124.93	-39.86	142.7
CH_3OCH_3	-184.05	-112.59	266.38
CH_3OH	-200.66	-162	239.7
CH_3OH	-238.66	-166.36	126.8
CH_4	-74.81	-50.72	186.264
$CHCl_3$	-103.14	-70.34	295.71
CCl_4	-135.44	-65.27	216.4
CN^-	150.6	172.4	94.1
CNS^-	76.44	92.71	144.3
CO	-110.525	-137.168	197.674
CO_2	-413.8	-385.98	117.6
CO_2	-393.509	-394.359	213.74
CO_3^{2-}	-677.14	-527.81	-56.9
$COCl_2$	-218.8	-204.6	283.53
$Ca(OH)_2$	-986.09	-898.49	83.39
Ca^{2+}	-542.83	-553.58	-53.1
$Ca_3(PO_4)_2$	-4109.9	-3884.7	240.91

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Topic 5 Content: Standard Thermodynamic Values Table

CaC_2O_4	-1360.6	-	-
$CaCO_3$	-1207.13	-1127.75	88.7
$CaCO_3$	-1206.92	-1128.79	92.9
CaF_2	-1219.6	-1167.3	68.87
CaO	-635.09	-604.03	39.75
$CaSO_4$	-1434.11	-1321.79	106.7
Cd	0	0	51.76
$Cd(CN)_4^{2-}$	428	507.6	322
Cd	2623.54	-	-
$Cd(NH_3)_4^{2+}$	-450.2	-226.1	336.4
$Cd(OH)_2$	-560.7	-473.6	96
Cd^{2+}	-75.9	-77.612	-73.2
Cd^{2+}	112.01	77.41	167.746
CdS	-161.9	-156.5	64.9
Ce	0	0	72
Ce^{3+}	-696.2	-672	-205
Ce^{4+}	-537.2	-503.8	-301
Cl^-	-167.159	-131.228	56.5
Cl	121.679	105.68	165.198
Cl^-	-233.13	-	-
Cl_2	0	0	223.066
Cl_3^-	-	-120.4	-
ClO_2	102.5	120.5	256.84
ClO_4^-	-129.33	-8.52	182
Co	0	0	30.04
$Co(NH_3)_6^{3+}$	-584.9	-157	146
Co2+	-58.2	-54.4	-113
Co^{3+}	92	134	-305
$Cr_2O_7^{2-}$	-149.03	-1301.1	261.9
CrO_4^{2-}	-881.15	-727.75	50.21
Cs	0	0	85.23
Cu	0	0	33.15
$Cu(CN)_3^{2-}$	-	403.8	-
$Cu(CN)_4^{3-}$	-	566.6	-
Cu	338.32	298.58	166.38
$Cu(NH_3)_4^{2+}$	-348.5	-111.07	273.6
$Cu(OH)_2$	-449.8	-	-
Cu^+	71.67	49.98	40.6
Cu^{2+}	64.77	65.49	-99.6
Cu_2O	-168.6	-146	93.14
Cu_2S	-79.5	-86.2	120.9
CuC_2O_4	-	-661.8	-
$CuCO_3$	-1051.4	-893.6	186.2
CuO	-157.3	-129.7	42.63
CuS	-53.1	-53.6	66.5
F^-	-332.63	-278.79	-13.8
F	78.99	61.91	158.754

F^-	-255.39	-	-
F_2	0	0	202.78
Fe	0	0	27.28
$Fe(CN)_6^{3-}$	561.9	729.4	270.3
$Fe(CN)_6^{4-}$	455.6	695.08	95
$Fe(CNS)^{2+}$	23.4	71.1	-130
Fe	416.3	370.7	180.49
$Fe(OH)_3$	-823	-696.5	106.7
$Fe_2(SO_4)_3$	-2581.5	-	-
Fe^{2+}	-89.1	-78.9	-137.7
Fe^{2+}	2749.93	-	-
Fe_2O_3	-824.2	-742.2	87.4
Fe^{3+}	-48.5	-4.7	-315.9
Fe^{3+}	5712.8	-	-
Fe_3C	25.1	20.1	104.6
Fe_3O_4	-1118.4	-1015.4	146.4
$FeCO_3$	-740.57	-666.67	92.9
FeO	-266.27	-245.12	57.49
FeS	-100	-100.4	60.29
FeS_2	-178.2	-166.9	52.93
$FeSO_4$	-928.4	-820.8	107.5
Ga	0	0	40.88
Ge	0	0	31.09
H	217.965	203.247	114.713
H^+	0	0	0
H^+	1536.202	-	-
H_2	-4.2	17.6	57.7
H_2	0	0	130.684
H_2O	-241.818	-228.572	188.825
H_2O	-285.83	-237.129	69.91
H_2O_2	-191.17	-134.03	143.9
H_2O_2	-136.31	-105.57	232.7
H_2O_2	-187.78	-120.35	109.6
H_2S	-20.63	-33.56	205.79
H_2SO_3	-608.81	-537.81	232.2
H_2SO_4	-813.989	-690.003	156.904
H_3AsO_3	-742.2	-639.8	195
H_3AsO_4	-902.5	-766	184
HBr	-36.4	-53.45	198.695
HCl	-92.307	-95.299	186.908
HCN	135.1	124.7	201.78
He	-1.7	19.7	54.4
He	0	0	126.15
HF	-271.1	-273.2	173.779
HI	26.48	1.7	206.594
HNO_2	-119.2	-50.6	135.6
HS^-	-17.6	12.08	62.8

$Hg(CN)_4^{2-}$	526.3	618.5	305
$Hg(CNS)_4^{2-}$	326.4	411.4	456
Hg	0	0	76.02
Hg^{2+}	171.1	164.4	-32.2
Hg_2^{2+}	172.4	153.52	84.5
Hg_2Br_2	-206.9	-181.075	218
Hg_2Cl_2	-265.22	-210.745	192.5
Hg_2SO_4	-743.12	-625.815	200.66
$HgCl_2$	-224.3	-178.6	146
$HgCl_4^{2-}$	-554	-446.8	293
HgI_4^{2-}	-235.1	-211.7	360
HgS	-53.6	-47.7	88.3
HgS	-58.2	-50.6	82.4
I^-	-55.19	-51.57	111.3
I	106.838	70.25	180.791
I^-	-197	-	-
I_2	22.6	16.4	137.2
I_2	0	0	116.135
I_2	62.438	19.327	260.69
I_3^-	-51.5	-51.4	239.3
ICl	17.78	-5.46	247.551
IO^{3-}	-221.3	-128	118.4
In	0	0	57.82
Ir	0	0	35.48
K	0	0	64.18
K	89.24	60.59	160.336
K^+	-252.38	-283.27	102.5
K^+	514.26	-	-
K_2O_2	-494.1	-425.1	102.1
KBr	-393.798	-380.66	95.9
KCl	-436.747	-409.14	82.59
$KClO_4$	-432.75	-303.09	151
KF	-567.27	-537.75	66.57
KI	-327.9	-324.892	106.32
KNO_3	-494.63	-394.86	133.05
KO_2	-284.93	-239.4	116.7
KOH	-424.764	-379.08	78.7
Kr	0	0	164.082
Mg	0	0	32.68
$Mg(OH)_2$	-924.54	-833.51	63.18
Mg^{2+}	-466.85	-454.8	-138.1
Mg^{2+}	2348.504	-	-
$MgCO_3$	-1095.8	-1012.1	65.7
MgF_2	-1123.4	-1070.2	57.24
MgO	-601.7	-569.43	26.94
Mn	0	0	32.01
Mn^{2+}	-220.75	-228.1	-73.6

MnO_2	-520.03	-465.14	53.05
MnO_4^-	-541.4	-447.2	191.2
MnS	-214.2	-218.4	78.2
Mo	0	0	28.66
Na	0	0	51.21
Na	107.32	76.761	153.712
Na^+	-240.12	-261.905	59
Na^+	609.358	-	-
Na_2CO_3	-1130.68	-1044.44	134.98
Na_2O	-414.22	-375.46	75.06
NaBr	-361.062	-348.983	86.82
NaCl	-411.153	-384.138	72.13
NaF	-573.647	-543.494	51.46
NaI	-287.78	-286.06	98.53
$NaNO_2$	-358.65	-284.55	103.8
$NaNO_3$	-467.85	-367	116.52
Ne	0	0	146.328
N	472.704	455.563	153.298
N_2	0	0	191.61
N_2O	82.05	104.2	219.85
N_2O_4	9.16	97.89	304.29
N_2O_4	-19.5	97.54	209.2
N_2O_5	-43.1	113.9	178.2
N_2O_5	11.3	115.1	355.7
NH_3	-80.29	-26.5	111.3
NH_3	-46.11	-16.45	192.45
NH_4^+	-132.51	-79.31	113.4
NH_4Cl	-314.43	-202.87	94.6
NO	90.25	86.55	210.761
NO_2	33.18	51.31	240.06
NO_3^-	-205	-108.74	146.4
NOBr	82.17	82.42	273.66
NOCl	51.71	66.08	261.69
Ni	0	0	29.87
$Ni(CN)_4^{2-}$	367.8	472.1	218
$Ni(NH_3)_4^{2+}$	-438.9	-	258.6
$Ni(NH_3)_6^{2+}$	-630.1	-255.7	394.6
Ni^{2+}	-54	-45.6	-128.9
NiS	-82	-79.5	52.97
O	249.17	231.731	161.055
O_2	-11.7	16.4	110.9
O_2	0	0	205.138
O_3	142.7	163.2	238.93
OH^-	-229.994	-157.244	-10.75
Os	0	0	32.6
P	0	0	41.09
P	314.64	278.25	163.193

PCl_3	-287	-267.8	311.78
PCl_5	-374.9	-305	364.58
PH_3	5.4	13.4	210.23
$PO4^{3-}$	-1277.4	-1018.7	-222
Pa	0	0	51.9
Pb	0	0	64.81
Pb	195	161.9	175.373
$Pb(OH)_2$	-	-452.2	-
$Pb(OH)_3^-$	-	-575.6	-
Pb^{2+}	-1.7	-24.43	10.5
Pb_3O_4	-718.4	-601.2	211.3
$PbBr_2$	-278.9	-261.92	161.5
$PbCl_2$	-359.41	-314.1	-136
PbO	-218.99	-189.93	66.5
PbO	-217.32	-187.89	68.7
PbO_2	-277.4	-217.33	68.6
PbS	-100.4	-98.7	91.2
$PbSO_4$	-919.94	-813.14	148.57
Pd	0	0	37.57
Pt	0	0	41.63
Ra	0	0	71
Rb	0	0	76.78
Re	0	0	36.86
Rh	0	0	31.51
Rn	0	0	176.21
Ru	0	0	28.53
S	0.33	-	-
S	0	0	31.8
S	278.805	238.25	167.821
S^{2-}	33.1	85.8	-14.6
$S_2O_3^{2-}$	-648.5	-522.5	67
$S_4O_6^{2-}$	-1224.2	-1040.4	257.3
SO_2	-296.83	-300.194	248.22
SO_2Cl_2	-364	-320	311.94
SO_3	-395.72	-371.06	256.76
SO_3	-441.04	-373.75	113.8
SO_4^{2-}	-909.27	-744.53	20.1
SF_6	-1209	-1105.3	291.82
Sb	0	0	45.69
Sc	0	0	34.64
Se	0	0	42.442
Si	0	0	18.83
SiO_2	-910.94	-856.64	41.84
Sn	-2.09	0.13	44.14
Sn	0	0	51.55
Sn^{2+}	-8.8	-27.2	-17
Sn^{4+}	30.5	2.5	-117

SnO	-285.8	-256.9	56.5
SnO_2	-580.7	-519.6	52.3
SnS	-100	-98.3	77
Sr	0	0	52.3
Sr^{2+}	-545.8	-559.48	-32.6
Ta	0	0	41.51
Tc	0	0	-
Te	0	0	49.71
Th	0	0	53.39
ThO_2	-1226.4	-1168.77	65.23
Ti	0	0	30.63
Tl	0	0	64.18
Tl^{+}	5.36	-32.4	125.5
Tl^{+}	777.764	-	-
Tl^{3+}	196.6	214.6	-192
Tl^{3+}	5639.2	-	-
U	0	0	50.21
U_4+	-591.2	-531	-410
UO_2	-1084.9	-1031.7	77.08
UO_2^{2+}	-1019.6	-953.5	-97.5
V	0	0	28.91
VO^{2+}	-486.6	-446.4	-133.9
VO_2^{+}	-649.8	-587	-42.3
W	0	0	32.64
WO_2	-589.69	-533.89	50.54
WO_3	-842.87	-764.03	75.9
Xe	0	0	169.683
Zn	0	0	41.63
$Zn(CN)_4^{2-}$	342.3	446.9	226
$Zn(NH3)_4^{2+}$	-533.5	-301.9	301
$Zn(OH)_4^{2-}$	-	-858.52	-
Zn^{2+}	-153.89	-147.06	-112.1
Zn^{2+}	2782.78	-	-
ZnO	-348.28	-318.3	43.64
ZnS	-205.98	-201.29	57.7
ZnS	-192.63	-	-
Zr	0	0	53.39