MISCELLANEOUS CHEMICAL INFORMATION. (updated 4/21)

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1 Conversion information:

System	Pressure:	LENGTH:	VOLUME	MASS	Temperature
English:	760 mmHg = 14.7 psi 1 atm = 101.3 KPa	1 ft = 12 in 1 mile = 5280 ft	1 gal = 4 qt 1 qt = 57.75 in^3	1 lb = 16 oz 1 ton = 2000lb	$T_{\circ F} = 1.8T_{\circ C} + 32$
SI-English:	1 atm = 760 torr 1atm = 760 mmHg	1 in = 2.54 cm 1 mi = 1.609 km	1 L = 1.057 qt 1 qt = 0.946 L 1 fl oz = 20.57 ml	1 lb = 453.6 g 1 oz = 28.35 g	$T_{\circ C} = \frac{(T_{\circ F} - 32)}{1.8}$
Misc. info	1cal = 4.184 J = 4.184 kg m^2 / s^2		1 mole = $6.02 \cdot 10^{23}$	Density H_2O: 1.0 g/ml	

2 Quantum Equations

Electromagnetic Radiation	$E = h \cdot n = \frac{h\,c}{l}$, $h = 6.63 \cdot 10^{-34}\ J \cdot s$, $c = 3.0 \cdot 10^{8}\ m/s$
Energy for H-like atom	$E = Z^2 R_h \left[\frac{1}{n^2}\right]$
Rydberg Equation	$\Delta E = R_H \left[\frac{1}{n_i^2} - \frac{1}{n_f^2}\right]$ $\quad \frac{1}{l} = R_{H(l)} \left[\frac{1}{n_i^2} - \frac{1}{n_f^2}\right]$ $R_{H(E)} = 2.18 \cdot 10^{-18}\ J$ $\quad R_H\ (\lambda) = 1.097 \cdot 10^{7}\ m^{-1}$

3 Gas law equations:

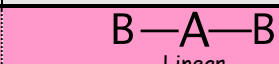
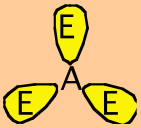
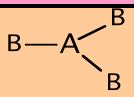
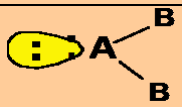
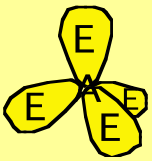
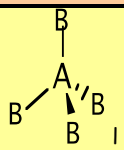
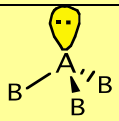
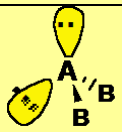
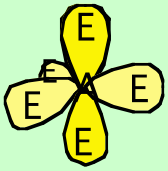
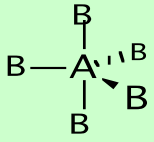
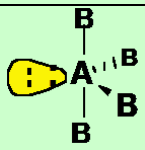
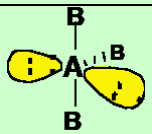
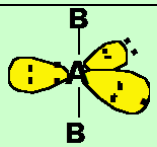
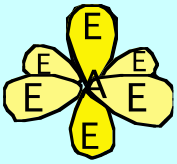
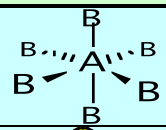
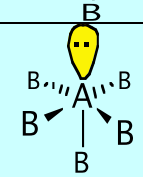
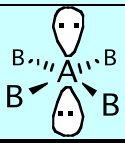
Ideal Gas Law	$PV = nRT$ $\quad Denstiy(D) = \frac{m \cdot P}{n\,R\,T}$, m = mass $\quad R = 0.08206\ \frac{L \cdot atm}{mol \cdot K}$
Real Gas Vander Waal Equation	$\left(P + \frac{a \cdot n^2}{V^2}\right)(V - n \cdot b) = nRT$
STP	P = 1 atm, T = 0°C, 1mole = 22.4 L
Dalton's Law of Partial Pressure	$P_T = P_a + P_b + P_c + \ldots$ $\quad P_T = \frac{(n_a + n_b + n_c + \ldots)R \cdot T}{V_T}$. $Pa = \chi_a \cdot P_T$ $\quad Pb = \chi_b \cdot P_T$ $\quad \chi_a = n_a / n_T$ $\quad \chi_b = n_b / n_T$
Speed of Gas particles	$\overline{KE} = \frac{1}{2} m \overline{u^2}$ $\quad u_{rms} = \sqrt{\frac{3RT}{M}}$ $\quad R = 8.314\ \frac{J}{mol \cdot K}$
Graham's Law of effusion	$\frac{rate_a}{rate_b} = \frac{time_b}{time_a} = \sqrt{\frac{M_b}{M_a}}$
Calorimetry	$q_p = \Delta H = m\,C_s\,\Delta T$ where $\Delta T = T_f - T_i$, C_s (H2O) = 4.184 J/g·K = 1.00 cal/g·K

4 Boiling Points of Liquids

	Liquid	Boiling Point (°C)
1	Acetone	56.5
2	Carbon disulfide	46.3
3	Carbon tetrachloride	76.8
4	Chloroform	61.3

	Liquid	Boiling Point (°C)
5	Ethanol	78.5
6	Ether	34.6
7	Methanol	64.6
8	Water	100.0

5 Valence Shell Electron-Pair Repulsion Theory (VSEPR) :

# e- Domain or region	AE_n	Electronic Geometry	Bond Pr [Cord #]	non-bond	AE_nB_m	Molecular Geometry	Bond angle, Hybrid	Examples
2	AE_2	 Linear	2	0	AB_2	 Linear	180° sp	BeH_2 CO_2
3	AE_3	 Trigonal	3	0	AB_3	 Trigonal Planar	120° sp^2	BF_3 BCl_3
			2	1	AB_2E	 (Trigonal) Bent	< 120° sp^2	NO_2
4	AE_4	 Tetrahedral	4	0	AB_4	 Tetrahedra	109.5° sp^3	CH_4 NH_4^+
			3	1	AB_3E	 Trigonal Pyramidal	< 109.5° sp^3	NH_3 H_3O^+ PH_3
			2	2	AB_2E_2	 (Tetrahedral) Bent	< 109.5° sp^3	H_2O H_2S F_2O
5	AE_5	 Trigonal Bipyriamidal	5	0	AB_5	 Trigonal Bipyramidal	180° 120° 90° sp^3d	$P I_5$
			4	1	AB_4E	 See-saw	180° 90° <120° sp^3d	$S F_4$
			3	2	AB_3E_2	 T-shape	180° 90° sp^3d	$Cl F_3$
			2	3	AB_2E_3	 Linear	180° sp^3d	$Xe F_2$
6	AE_6	 Octahedral	6	0	AB_6	 Octahedral	90° sp^3d^2	$S F_6$
			5	1	AB_5E	 Square Pyramidal	90° < 90° sp^3d^2	$Br F_5$
			4	2	AB_4E_2	 Square planar	90° sp^3d^2	$Xe F_4$

6 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

7 Solubility rules:

Soluble substances with -	Exceptions
(NO_3^-) (ClO_3-) (ClO_4^-) (CH_3COO^-)	None
X^- = Cl^-, Br^-, I^-	Ag, Hg, Pb
(SO_4^{2-})	Sr, Ca, Ba, Hg, Pb
Alkali & NH_4^+	None

Insoluble substances with -	Exceptions
(S^{2-}), (CO_3^{2-}), (CrO_4^{2-}), (PO_4^{3-})	Grp1A, NH_4^+
(OH^-)	Grp1A, NH_4^+, Sr, Ba, Ca

Soluble - dissolve, no precipitate (aq -phase)

insoluble (or slightly soluble) - does not dissolve, precipitate forms. (s-phase)

Solubility Table

	$C_2H_3O_2^-$	AsO_4^{3-}	Br^-	CO_3^{2-}	Cl^-	CrO_4^{2-}	OH^-	I^-	NO_3^-	$C_2O_4^{2-}$	O^{2-}	PO_4^{3-}	$SO4^{2-}$	S^{2-}	SO_3^{2-}
Al^{+3}	S	I	S	-	S	-	I	S	S	-	I	I	S	d	-
NH_4^+	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
Ba^{2+}	S	I	S	I	S	I	s	S	S	I	s	S	S	S	S
Bi^{3+}	-	s	d	I	d	-	I	I	d	I	I	s	d	I	-
Ca^{2+}	S	I	S	I	S	S	I	S	S	I	I	I	I	d	I
Co^{2+}	S	I	S	I	S	I	I	S	S	I	I	I	S	I	I
Cu^{2+}	S	I	S	I	S	I	I	-	S	I	I	I	S	I	-
Fe^{2+}	S	I	S	s	S	-	I	S	S	I	I	I	S	I	s
Fe^{3+}	I	I	S	I	S	-	I	-	S	S	I	I	S	I	-
Pb^{2+}	S	I	I	I	I	I	I	I	S	I	I	I	I	I	I
Mg^{2+}	S	d	S	I	S	S	I	S	S	I	I	I	S	d	s
Hg^{2+}	S	I	I	I	S	s	I	I	S	I	I	I	d	I	-
K^+	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
Ag^+	s	I	I	I	I	I	-	I	S	I	I	I	I	I	I
Na^+	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
Zn^{2+}	S	I	S	I	S	I	I	S	S	I	I	I	S	I	I

S = Soluble in water I = Insoluble in water (less than 1g/100g H_2O) s = slightly soluble in water d = Decomposes in water

8 Solution and Concentration equations:

Concentrations	M, molarity = moles solute / liter solution N , normality = eq solute / liter solution m , molality = moles solute / Kg solvent % m, percent by mass = (mass solute / mass solution)*100 χ → mole fraction → moles a / moles a + moles b ...
Solution Dilution	$C_1V_1 = C_2V_2$ (moles before dilution = moles after dilution)

9 Solubility and Colligative Properties

Pressure effects: Henry's Law	P	= c / k where c = solubility
Raoult's Law	P_{solv}	= $\Delta\chi_{solvent} \cdot P^o_{solvent}$
	ΔP_{solv}	= $P^o_{solv} - P_{solv} = \chi_{solute} \cdot P^o_{solv}$
Boiling Point Elevation	ΔT_b	= m K_b
Freezing Point Depression	ΔT_f	= m K_f
Osmotic Pressure	Π	= MRT (R = 0.08206 L·atm / mol·K)
Van't Hoff Factor	i	$i = \frac{\text{moles particles solution (expt)}}{\text{moles solute dissolved (calculated conc)}}$

10 Equilibrium

Equilibrium constant	K_p & K_c	$K_p = K_c(RT)^{\Delta n}$ $K_c = K_p(RT)^{-\Delta n}$
Quadratic Eqn $ax^2+bx+c=0$		$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

11 Acid Base:

pX and [X] Relationship	pH = -log $[H_3O^+]$ pOH = -log $[OH^-]$ pK_a = -log $[K_a]$ $[H_3O^+] = 10^{-pH}$ $[OH^-] = 10^{-pOH}$ $[K_a] = 10^{-pKa}$
K_w	$K_w = 1 \cdot 10^{-14}$ @ 25°C $K_w = K_a \cdot K_b$ 14 = pH + pOH
Henderson - Hasselbach Equation	pH = pKa + log $[C_b/C_a]$ pOH = pKb + log $[C_a/C_b]$
Quadratic Equation $ax^2+bx+c=0$	$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

12 Kinetics

Rates of Reaction	rate = $\Delta[A]/\Delta t = -\Delta[react]/\Delta t = \Delta[prod]/\Delta t$	
Rate laws (Order of reaction)	initial rate = $k[A]^x[B]^y[C]^z$ ...	Overall order = x + y + z + ...
Conc. vs. Time dependence		
Zeroth Order rate = k	$[A] = [A]_o - kt$	Conc. vs. Time →straight line. Half life; $t_{1/2} = [A]_o / 2k$
First Order rate = k [A]	$[A] = [A]o \exp\{-kt\}$ $\ln[A] = \ln[A]_o - kt$	ln[Conc.] vs. Time →straight line Half life; $t_{1/2} = 0.693 / k$
Second Order rate = $k[A]^2$ or k [A] [B]	$1/[A] = 1/[A]_o + kt$	1/[Conc.] vs. Time →straight line Half life; $t_{1/2} = 1 / k[A]_o$
Temperature vs. Rate dependence	$k = A \exp\{-Ea/RT\}$ $\ln k = \ln A - (Ea/R) \cdot 1/T$	ln(k) vs. 1/T →straight line.

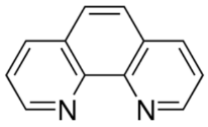
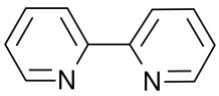
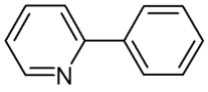
13 Inorganic:

Spectrochemical Series:

$I^- < Br^- < Cl^- < NO_3^- < F^- < CO_3^{2-} < OH^- < C_2O_4^{2-} < H_2O < NH_3 = en < NO_2^- < phen < bpy < SCN^- < CN^- < CO < ppy^-$

ϕ **Weak Field Ligands** **Strong Field Ligands** γ

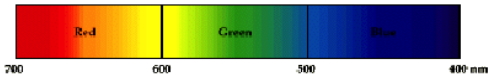
Bidentate Ligands:

phen  bpy  ppy 

Abbreviation

Ox^{2-} (oxalato), en (ethylenediamine), phen (1,10-phenathroline),

ppy^- (2-phenylpyridine), bpy (2,2'-bipyridine), EDTA (Ethylenediaminetrisacetate)



Color Wheel

14 Thermo Electro Chemistry Equations

Thermodynamics

Standard Conditions: 1 atm, 25°C

Universe = surroundings + system

State Function (X) where X = E, H, S or G

$\Delta X_{rxn} = \Sigma n \Delta X^\circ_{prod} - \Sigma n \Delta X^\circ_{react}$

$w = -P \Delta V$

$\Delta E = q + w$

$\Delta H = \Delta E + P \Delta V$

$\Delta H = q_p$

$\Delta S^\circ_{univ} = \Delta S^\circ_{surr} + \Delta S^\circ_{sys}$

$\Delta S^\circ_{surr} = - \Delta H^\circ_{sys} / T$

$\Delta G = \Delta H - T\Delta S$

$\Delta G = \Delta G^\circ + RT \ln Q$

$\Delta G^\circ = - RT \ln K_{eq}$

$K_{eq} = \exp \{-\Delta G^\circ / RT\}$

$\ln K_{eq} = (\Delta S^\circ / R) - (\Delta H^\circ / RT)$

Cell Potential, ΔG and Keq

$\Delta G = - nFE$

$\Delta G^\circ = - nFE^\circ$

$E^\circ_{cell} = E^\circ_{red}(cathode) - E^\circ_{red}(anode)$

$E^\circ_{cell} = E^\circ_{red} + E^\circ_{ox}$

$E^\circ = (RT/ nF) \ln K_{eq}$

$E^\circ = (0.0591 / n) \log K_{eq}$

$E = E^\circ - (0.0592 / n) \log Q$

$2H_2O_{(l)} + 2e^- \gamma H_{2(g)} + 2OH^-_{(aq)}$ $E^\circ = - 0.83$ V

$O_{2(g)} + 4H^+_{(aq)} + 2e^- \gamma 2H_2O_{(l)}$ $E^\circ = +1.23$V

Constants

R = 8.314 J / mol•K

F = 96,485 C / mol e-

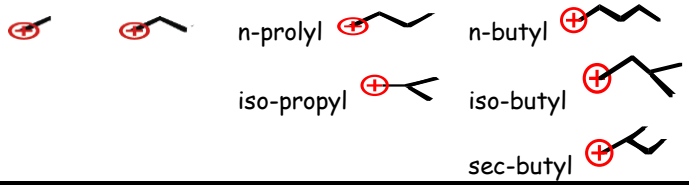
15 Organic: Nomenclature:

Group	Structural Feature	Suffix
Alk**ane**	single bond	-ane
Alk**ene**	double bond	-ene
Alkyne	triple bond	-yne
Alcoh**ol**	-OH group	-ol
Ether	R-**O**-R	ether
Aldehyde	R**CHO**	-al
Ket**one**	R-**CO**-R	-one
carboxyl**ic acid**	R-**COO**H	-oic acid
ester	R**COO**R'	-ate
amine	R R'R"**N**	-amine
amide	R-**CON**HR'	-amide

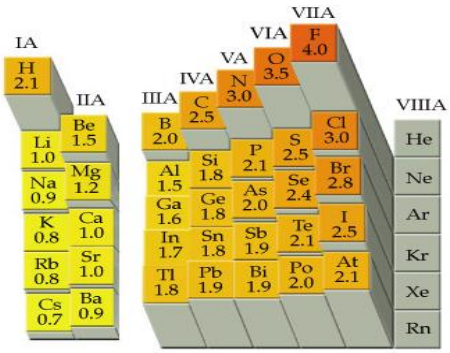
#C	prefix	C_nH_{2n+2} Alkane	C_nH_{2n} Alkene	C_nH_{2n-2} Alkyne
1	meth-	methane		
2	eth-	ethane	ethene	ethyne
3	prop-	propane	propene	propyne
4	but-	butane	butene	butyne
5	pent-	pentane	pentene	pentyne
6	hex-	hexane	hexene	hexyne
7	hept-	heptane	heptene	heptyne
8	oct-	octane	octene	octyne
9	non-	nonane	nonene	nonyne
10	dec-	decane	decene	decyne

Alkyl groups:

Methyl Ethyl Propyl Butyl



Reactivity	Alkene & Alkynes
1	Halogenation (+ X_2)
2	Hydrogenation (+ H_2)
3	Hydrohalogenation (+ HX)
4	Polymerization



←Electronegativity Values

	1 IA												13 IIIA	14 IVA	15 VA	16 VIA	17 VIIA	18 VIIIA
1	1 **H** 1.00797	2 IIA																2 **He** 4.0026
2	3 **Li** 6.939	4 **Be** 9.0122											5 **B** 10.811	6 **C** 12.0112	7 **N** 14.0067	8 **O** 15.9994	9 **F** 18.9984	10 **Ne** 20.179
3	11 **Na** 22.9898	12 **Mg** 24.305	3 IIIB	4 IVB	5 VB	6 VIB	7 VIIB	8	9 VIIIB	10	11 IB	12 IIB	13 **Al** 26.9815	14 **Si** 28.086	15 **P** 30.9738	16 **S** 32.064	17 **Cl** 35.453	18 **Ar** 39.948
4	19 **K** 39.102	20 **Ca** 40.08	21 **Sc** 44.956	22 **Ti** 47.90	23 **V** 50.942	24 **Cr** 51.996	25 **Mn** 54.9380	26 **Fe** 55.847	27 **Co** 58.9332	28 **Ni** 58.71	29 **Cu** 63.54	30 **Zn** 65.37	31 **Ga** 69.72	32 **Ge** 72.59	33 **As** 74.9216	34 **Se** 78.96	35 **Br** 79.909	36 **Kr** 83.80
5	37 **Rb** 85.47	38 **Sr** 87.62	39 **Y** 88.905	40 **Zr** 91.22	41 **Nb** 92.906	42 **Mo** 95.94	43 **Tc** [99]	44 **Ru** 101.07	45 **Rh** 102.905	46 **Pd** 106.4	47 **Ag** 107.870	48 **Cd** 112.40	49 **In** 114.82	50 **Sn** 118.69	51 **Sb** 121.75	52 **Te** 127.60	53 **I** 126.904	54 **Xe** 131.30
6	55 **Cs** 132.905	56 **Ba** 137.34	71* **Lu** 174.967	72 **Hf** 178.49	73 **Ta** 180.948	74 **W** 183.85	75 **Re** 186.2	76 **Os** 190.2	77 **Ir** 192.2	78 **Pt** 195.09	79 **Au** 197.0	80 **Hg** 200.59	81 **Tl** 204.37	82 **Pb** 207.19	83 **Bi** 208.980	84 **Po** [210]	85 **At** [210]	86 **Rn** [222]
7	87 **Fr** [223.02]	88 **Ra** [226.03]	103‡ **Lr** [260]	104 **Rf** [261.11]	105 **Db** [262.11]	106 **Sg** [266.12]	107 **Bh** [264.12]	108 **Hs** [269.13]	109 **Mt** [268.14]	110 **Ds** [271]	111 **Rg** [272]	112 [277]		114 [289]		116 [292]		

* Lanthanide Series	57 **La** 138.91	58 **Ce** 140.115	59 **Pr** 140.9077	60 **Nd** 144.24	61 **Pm** (145)	62 **Sm** 150.368	63 **Eu** 151.965	64 **Gd** 157.25	65 **Tb** 158.9254	66 **Dy** 162.50	67 **Ho** 164.9303	68 **Er** 167.26	69 **Tm** 168.9342	70 **Yb** 173.04
‡ Actinide Series	89 **Ac** [227.03]	90 **Th** 232.0381	91 **Pa** 231.0359	92 **U** 238.0289	93 **Np** 237.048	94 **Pu** [244]	95 **Am** [260]	96 **Cm** [247]	97 **Bk** [247]	98 **Cf** [251]	99 **Es** [252]	100 **Fm** [257]	101 **Md** [258]	102 **No** [259]

17 Acid Dissociation Constant, K_a @ RT

Acid	Formula	K_{a1}	K_{a2}	K_{a3}
Acetic	CH_3COOH	$1.75x10^{-5}$		
Ammonium Ion	NH_4^+	$5.70x10^{-10}$		
Anilinium Ion	$C_6H_5NH_3^+$	$2.51x10^{-5}$		
Arsenic	H_3AsO_4	$5.8x10^{-3}$	$1.1x10^{-7}$	$3.2x10^{-12}$
Arsenous	H_3AsO_3	$5.1x10^{-10}$		
Benzoic	C_6H_5COOH	$6.28x10^{-5}$		
Boric	H_3BO_3	$5.81x10^{-10}$		
1-Butanoic (butric acid)	$CH_3CH_2CH_2COOH$	$1.52x10^{-5}$		
Carbonic	H_2CO_3	$4.45x10^{-7}$	$4.69x10^{-11}$	
Chloroacetic	$ClCH_2COOH$	$1.36x10^{-3}$		
Citric	$HOOC(OH)C(CH_2COOH)_2$	$7.45x10^{-4}$	$1.73x10^{-5}$	$4.02x10^{-7}$
Crotonic acid (cis)	$HC_4H_5O_2$	$3.89\ x10^{-5}$		
Crotonic acid (trans)	$HC_4H_5O_2$	$2.04\ x10^{-5}$		
Formic	$HCOOH$	$1.80x10^{-4}$		
Fumaric	*trans*-$HOOCCH{:}CHCOOH$	$8.85x10^{-4}$	$3.21x10^{-5}$	
Glycolic	$HOCH_2COOH$	$1.47x10^{-4}$		
Hydrazinium Ion	$H_2NNH_3^+$	$1.05x10^{-8}$		
Hydrazoic	HN_3	$2.2x10^{-5}$		
Hydrogen Cyanide	HCN	$6.2x10^{-10}$		
Hydrofluoric	HF	$3.2x10^{-4}$		
Hydrogen Peroxide	H_2O_2	$2.2x10^{-12}$		
Hydrogen Sulfide	H_2S	$9.6x10^{-8}$	$1.3x10^{-14}$	
Hydroxyl Ammonium Ion	$HONH_3^+$	$1.10x10^{-6}$		
Hypochlorous	$HOCl$	$3.0x10^{-8}$		
Iodic	HIO_3	$1.7x10^{-1}$		
Lactic	$CH_3CHOHCOOH$	$1.38x10^{-4}$		
Maleic	*cis*-$HOOCCH{:}CHCOOH$	$1.3x10^{-2}$	$5.9x10^{-7}$	
Malic	$HOOCCHOHCH_2COOH$	$3.48x10^{-4}$	$8.00x10^{-6}$	
Malonic	$HOOCCH_2COOH$	$1.42x10^{-3}$	$2.01x10^{-6}$	
Mandelic	$C_6H_5CHOHCOOH$	$4.0x10^{-4}$		
Methyl Ammonium Ion	$CH_3NH_3^+$	$2.3x10^{-11}$		
Nitric	HNO_3	Strong		
Nitrous	HNO_2	$4.6x10^{-4}$		
Oxalic	$HOOCCOOH$	$5.60x10^{-2}$	$5.42x10^{-5}$	
Periodic	H_5IO_6	$2x10^{-2}$	$5x10^{-9}$	
Phenol	C_6H_5OH	$1.00x10^{-10}$		
Phosphoric	H_3PO_4	$7.11x10^{-3}$	$6.32x10^{-8}$	$4.5x10^{-13}$
Phosphorous	H_3PO_3	$3x10^{-2}$	$1.62x10^{-7}$	
o-Phthalic	$C_6H_4(COOH)_2$	$1.12x10^{-3}$	$3.91x10^{-6}$	
Picric	$(NO_2)_3C_6H_2OH$	$4.3x10^{-1}$		
Piperidinium	C_5H11NH^+	$7.50x10^{-12}$		
Propanoic	CH_3CH_2COOH	$1.34x10^{-5}$		
Pyridinium	$C_5H_5NH^+$	$5.90x10^{-6}$		
Salicylic	$C_6H_4(OH)COOH$	$1.06x10^{-3}$		
Sulfamic	H_2NSO_3H	$1.03x10^{-1}$		
Succinic	$HOOCCH_2CH_2COOH$	$6.21x10^{-5}$	$2.31x10^{-6}$	
Sulfuric	H_2SO_4	Strong	$1.02x10^{-2}$	
Sulfurous	H_2SO_3	$1.23x10^{-2}$	$6.16x10^{-8}$	
Tartaric	$HOOC(CHOH)_2COOH$	$9.20x10^{-4}$	$4.31x10^{-5}$	
Thiocyanic	$HSCN$	0.13		
Thiosulfuric	$H_2S_2O_3$	0.3	$2.5x10^{-2}$	
Trichloroacetic	Cl_3CCOOH	3		
Trimethyl Ammonium Ion	$(CH_3)_3NH^+$	$1.58x10^{-10}$		

Appendix 11 Standard Reduction Potentials in Aqueous Solution at 25° C

Acidic Solution	Std Red Potential E_0 (volts)
$S_2O_8^{2-}{}_{(aq)} + 2e \rightarrow 2SO_4^{2-}$	2.0
$Co^{3+}{}_{(aq)} + e^- \rightarrow Co2+{}_{(aq)}$	1.82
$Pb^{4+}{}_{(aq)} + 2e^- \rightarrow Pb^{2+}{}_{(aq)}$	1.8
$H_2O_2{}_{(aq)} + 2H^+{}_{(aq)} + 2e^- \rightarrow 2H_2O$	1.77
$NiO_{2(s)} + 4H^+{}_{(aq)} + 2e^- \rightarrow Ni^{2+}{}_{(aq)} + 2H_2O$	1.7
$PbO_{2(s)} + HSO_4^-{}_{(aq)} + 3H^+{}_{(aq)} + 2e \rightarrow PbSO_4{}_{(s)} + 2H_2O$	1.685
$Au^+{}_{(aq)} + e^- \rightarrow Au_{(s)}$	1.68
$2HClO{}_{(aq)} + 2H^+{}_{(aq)} + 2e^- \rightarrow Cl_2{}_{(g)} + 2H_2O$	1.63
$Ce^{4+}{}_{(aq)} + e^- \rightarrow Ce^{3+}{}_{(aq)}$	1.61
$NaBiO_{3(s)} + 6H^+{}_{(aq)} + 2e^- \rightarrow Bi^{3+}{}_{(aq)} + Na^+{}_{(aq)} + 3H_2O$	1.6
$MnO_4^-{}_{(aq)} + 8H^+{}_{(aq)} + 5e^- \rightarrow Mn^{2+}{}_{(aq)} + 4H_2O$	1.51
$Au^{3+}{}_{(aq)} + 3e^- \rightarrow Au_{(s)}$	1.50
$HO_2 + H^+ + e^- \rightarrow H_2O_2$	1.495
$ClO_3^-{}_{(aq)} + 6H^+{}_{(aq)} + 5e^- \rightarrow Cl_2{}_{(g)} + 3H_2O$	1.47
$BrO3^-{}_{(aq)} + 6H^+{}_{(aq)} + 6e^- \rightarrow Br^-{}_{(aq)} + 3H_2O$	1.44
$Cl_2{}_{(g)} + 2e^- \rightarrow 2Cl^-{}_{(aq)}$	1.358
$Cr_2O_7^{2-}{}_{(aq)} + 14H^+{}_{(aq)} + 6e^- \rightarrow 2Cr^{3+}{}_{(aq)} + 7H_2O$	1.33
$N_2H_5^+{}_{(aq)} + 3H^+{}_{(aq)} + 2e^- \rightarrow 2NH_4^+{}_{(aq)}$	1.24
$MnO_2{}_{(s)} + 4H^+{}_{(aq)} + 2e^- \rightarrow Mn^{2+}{}_{(aq)} + 2H_2O$	1.23
$O_{2(g)} + 4H^+{}_{(aq)} + 4e^- \rightarrow 2H_2O$	1.229
$Pt^{2+}{}_{(aq)} + 2e^- \rightarrow Pt_{(s)}$	1.2
$IO_3^-{}_{(aq)} + 6H^+{}_{(aq)} + 5e^- \rightarrow I_2{}_{(aq)} + 3H_2O$	1.195
$Br_{2(l)} + 2e^- \rightarrow 2Br^-{}_{(aq)}$	1.19
$AuCl_4^-{}_{(aq)} + 3e^- \rightarrow Au_{(s)} + 4Cl^-{}_{(aq)}$	1.066
$Pd^{2+}{}_{(aq)} + 2e^- \rightarrow Pd_{(s)}$	1.00
$NO_3^-{}_{(aq)} + 4H^+{}_{(aq)} + 3e^- \rightarrow NO_{(g)} + 2H_2O$	0.987
$ClO_4^-{}_{(aq)} + 2H^+{}_{(aq)} + 2e^- \rightarrow ClO_3^-{}_{(aq)} + H_2O$	0.96
$NO_3^-{}_{(aq)} + 3H^+{}_{(aq)} + 2e^- \rightarrow HNO_2{}_{(aq)} + H_2O$	0.94
$2Hg^{2+}{}_{(aq)} + 2e^- \rightarrow Hg_2^{2+}{}_{(aq)}$	0.920
$Hg^{2+}{}_{(aq)} + 2e^- \rightarrow Hg_{(l)}$	0.855
$Ag^+{}_{(aq)} + e^- \rightarrow Ag_{(s)}$	0.7994
$Hg_2^{2+}{}_{(aq)} + 2e^- \rightarrow 2Hg_{(l)}$	0.789
$Fe^{3+}{}_{(aq)} + e^- \rightarrow Fe^{2+}{}_{(aq)}$	0.771
$SbCl_6^-{}_{(aq)} + 2e^- \rightarrow SbCl_4^-{}_{(aq)} + 2Cl^-{}_{(aq)}$	0.75
$[PtCl_4]^{2-}{}_{(aq)} + 2e^- \rightarrow Pt_{(s)} + 4Cl^-{}_{(aq)}$	0.73
$O_2{}_{(g)} + 2H^+{}_{(aq)} + 2e^- \rightarrow H_2O_2{}_{(aq)}$	0.682
$[PtCl_6]^{2-}{}_{(aq)} + 2e^- \rightarrow [PtCl_4]^{2-}{}_{(aq)} + 2Cl^-{}_{(aq)}$	0.68
$S_2O_6^{2-}{}_{(aq)} + 4H^+{}_{(aq)} + 2e \rightarrow 2H_2SO_3$	0.6
$H_3AsO_4{}_{(aq)} + 2H^+{}_{(aq)} + 2e^- \rightarrow H_3AsO_3{}_{(aq)} + H_2O$	0.58
$I_3^-{}_{(aq)} + 2e^- \rightarrow 3I^-{}_{(aq)}$	0.536
$I_{2(s)} + 2e^- \rightarrow 2I^-{}_{(aq)}$	0.5355
$TeO_2{}_{(s)} + 4H^+{}_{(aq)} + 4e^- \rightarrow Te_{(s)} + 2H_2O$	0.529
$Cu^+{}_{(aq)} + e^- \rightarrow Cu_{(s)}$	0.521
$[RhCl_6]^{3-}{}_{(aq)} + 3e^- \rightarrow Rh_{(s)} + 6Cl^-{}_{(aq)}$	0.44
$Cu^{2+}{}_{(aq)} + 2e^- \rightarrow Cu_{(s)}$	0.337
$HgCl_2{}_{(s)} + 2e^- \rightarrow 2Hg_{(l)} + 2Cl^-{}_{(aq)}$	0.27
$AgCl_{(s)} + e^- \rightarrow Ag_{(s)} + Cl^-{}_{(aq)}$	0.222
$SO_4^{2-}{}_{(aq)} + 4H^+{}_{(aq)} + 2e^- \rightarrow SO_2{}_{(g)} + 2H_2O$	0.20
$SO_4^{2-}{}_{(aq)} + 4H^+{}_{(aq)} + 2e^- \rightarrow H_2SO_3{}_{(aq)} + H_2O$	0.17
$Cu^{2+}{}_{(aq)} + e^- \rightarrow Cu^+{}_{(aq)}$	0.153
$Sn^{4+}{}_{(aq)} + 2e^- \rightarrow Sn^{2+}{}_{(aq)}$	0.15
$S_{(s)} + 2H^+{}_{(aq)} + 2e^- \rightarrow H_2S_{(aq)}$	0.14
$AgBr_{(s)} + e^- \rightarrow Ag_{(s)} + Br^-{}_{(aq)}$	0.0713
$2H^+{}_{(aq)} + 2e^- \rightarrow H_2{}_{(g)}$ (reference electrode)	**0.0000**
$N_2O_{(g)} + 6H^+{}_{(aq)} + H_2O + 4e^- \rightarrow 2NH_3OH^+{}_{(aq)}$	-0.05
$Pb^{2+}{}_{(aq)} + 2e^- \rightarrow Pb_{(s)}$	-0.126
$Sn^{2+}{}_{(aq)} + 2e^- \rightarrow Sn_{(s)}$	-0.14
$AgI_{(s)} + e^- \rightarrow Ag_{(s)} + I^-{}_{(aq)}$	-0.15
$[SnF_6]^{2-}{}_{(aq)} + 4e^- \rightarrow Sn_{(s)} + 6F^-{}_{(aq)}$	-0.25
$Ni_{2+}{}_{(aq)} + 2e^- \rightarrow Ni_{(s)}$	-0.25
$Co^{2+}{}_{(aq)} + 2e^- \rightarrow Co_{(s)}$	-0.28
$Tl^+{}_{(aq)} + e^- \rightarrow Tl_{(s)}$	-0.34
$PbSO_4{}_{(s)} + H^+{}_{(aq)} + 2e^- \rightarrow Pb_{(s)} + HSO_4^-{}_{(aq)}$	-0.356
$PbI_2{}_{(s)} + 2e^- \rightarrow Pb_{(s)} + 2I^-{}_{(aq)}$	-0.365
$Se_{(s)} + 2H^+{}_{(aq)} + 2e^- \rightarrow H_2Se_{(aq)}$	-0.40
$Cd^{2+}{}_{(aq)} + 2e^- \rightarrow Cd_{(s)}$	-0.403
$Cr^{3+}{}_{(aq)} + e^- \rightarrow Cr^{2+}{}_{(aq)}$	-0.41
$Fe^{2+}{}_{(aq)} + 2e^- \rightarrow Fe_{(s)}$	-0.44
$2CO_2{}_{(g)} + 2H^+{}_{(aq)} + 2e^- \rightarrow (COOH)_2{}_{(aq)}$	-0.49
$Ga^{3+}{}_{(aq)} + 3e^- \rightarrow Ga_{(s)}$	-0.53
$HgS_{(s)} + 2H^+{}_{(aq)} + 2e^- \rightarrow Hg_{(l)} + H_2S_{(g)}$	-0.72
$Cr^{3+}{}_{(aq)} + 3e^- \rightarrow Cr_{(s)}$	-0.74
$Zn^{2+}{}_{(aq)} + 2e^- \rightarrow Zn_{(s)}$	-0.763
$Cr^{2+}{}_{(aq)} + 2e^- \rightarrow Cr_{(s)}$	-0.91
$FeS_{(s)} + 2e^- \rightarrow Fe_{(s)} + S^{2-}{}_{(aq)}$	-1.01
$Mn^{2+}{}_{(aq)} + 2e^- \rightarrow Mn_{(s)}$	-1.18
$V^{2+}{}_{(aq)} + 2e^- \rightarrow V_{(s)}$	-1.18
$CdS_{(s)} + 2e^- \rightarrow Cd_{(s)} + S^{2-}{}_{(aq)}$	-1.21
$ZnS_{(s)} + 2e^- \rightarrow Zn_{(s)} + S^{2-}{}_{(aq)}$	-1.44
$Zr^{4+}{}_{(aq)} + 4e^- \rightarrow Zr_{(s)}$	-1.53
$Al^{3+}{}_{(aq)} + 3e^- \rightarrow Al_{(s)}$	-1.66
$H_{2(g)} + 2e^- \rightarrow 2H^-{}_{(aq)}$	-2.25
$La^{3+}{}_{(aq)} + 3e^- \rightarrow La_{(s)}$	-2.37
$Mg^{2+}{}_{(aq)} + 2e^- \rightarrow Mg_{(s)}$	-2.375
$Na^+{}_{(aq)} + e^- \rightarrow Na_{(s)}$	-2.714
$Ca^{2+}{}_{(aq)} + 2e^- \rightarrow Ca_{(s)}$	-2.87
$Sr^{2+}{}_{(aq)} + 2e^- \rightarrow Sr_{(s)}$	-2.89
$Ba^{2+}{}_{(aq)} + 2e^- \rightarrow Ba_{(s)}$	-2.90
$Rb^+{}_{(aq)} + e^- \rightarrow Rb_{(s)}$	-2.925
$K^+{}_{(aq)} + e^- \rightarrow K_{(s)}$	-2.925
$Li^+{}_{(aq)} + e^- \rightarrow Li_{(s)}$	-3.045

Basic Solution	Std Red Potential E_0 (volts)
$ClO^-{}_{(aq)} + H_2O + 2e^- \rightarrow Cl^-{}_{(aq)} + 2OH^-{}_{(aq)}$	0.89
$OOH^-{}_{(aq)} + H_2O + 2e^- \rightarrow 3OH^-{}_{(aq)}$	0.88
$2NH_2OH{}_{(aq)} + 2e^- \rightarrow N_2H_4{}_{(aq)} + 2OH^-{}_{(aq)}$	0.74
$ClO_3^-{}_{(aq)} + 3H_2O + 6e^- \rightarrow Cl^-{}_{(aq)} + 6OH^-{}_{(aq)}$	0.62
$MnO_4^-{}_{(aq)} + 2H_2O + 3e^- \rightarrow MnO_{2(s)} + 4OH^-{}_{(aq)}$	0.588
$MnO_4^-{}_{(aq)} + e^- \rightarrow MnO_4^{2-}{}_{(aq)}$	0.564
$NiO_2{}_{(s)} + 2H_2O + 2e^- \rightarrow Ni(OH)_2{}_{(s)} + 2OH^-{}_{(aq)}$	0.49
$Ag_2CrO4{}_{(s)} + 2e^- \rightarrow 2Ag_{(s)} + CrO_4^{2-}{}_{(aq)}$	0.446
$O_2{}_{(g)} + 2H_2O + 4e^- \rightarrow 4OH^-{}_{(aq)}$	0.40
$ClO_4^-{}_{(aq)} + H_2O + 2e^- \rightarrow ClO_3^-{}_{(aq)} + 2OH^-{}_{(aq)}$	0.36
$Ag_2O{}_{(s)} + H_2O + 2e^- \rightarrow 2Ag_{(s)} + 2OH^-{}_{(aq)}$	0.34
$2NO_2^-{}_{(aq)} + 3H_2O + 4e^- \rightarrow N_2O{}_{(g)} + 6OH^-{}_{(aq)}$	0.15
$N_2H_4{}_{(aq)} + 2H_2O + 2e^- \rightarrow 2NH_3{}_{(aq)} + 2OH^-{}_{(aq)}$	0.10
$[Co(NH_3)_6]^{3+}{}_{(aq)} + e^- \rightarrow [Co(NH_3)_6]^{2+}{}_{(aq)}$	0.10
$HgO{}_{(s)} + H_2O + 2e^- \rightarrow Hg_{(l)} + 2OH^-{}_{(aq)}$	0.0984
$O_2{}_{(g)} + H_2O + 2e^- \rightarrow OOH^-{}_{(aq)} + OH^-{}_{(aq)}$	0.076
$NO_3^-{}_{(aq)} + H_2O + 2e^- \rightarrow NO_2^-{}_{(aq)} + 2OH^-{}_{(aq)}$	0.01
$MnO_{2(s)} + 2H_2O + 2e^- \rightarrow Mn(OH)_{2(s)} + 2OH^-{}_{(aq)}$	-0.05
$CrO_4^{2-}{}_{(aq)} + 4H_2O + 3e^- \rightarrow Cr(OH)_3{}_{(s)} + 5OH^-{}_{(aq)}$	-0.12
$Cu(OH)_2{}_{(s)} + 2e^- \rightarrow Cu_{(s)} + 2OH^-{}_{(aq)}$	-0.36
$S_{(s)} + 2e^- \rightarrow S^{2-}{}_{(aq)}$	-0.48
$Fe(OH)_3{}_{(s)} + e^- \rightarrow Fe(OH)_2{}_{(s)} + OH^-{}_{(aq)}$	-0.56
$2H_2O + 2e^- \rightarrow H_2{}_{(g)} + 2OH^-{}_{(aq)}$	-0.8277
$2NO_3^-{}_{(aq)} + 2H_2O + 2e^- \rightarrow N_2O_4{}_{(g)} + 4OH^-{}_{(aq)}$	-0.85
$Fe(OH)_2{}_{(s)} + 2e^- \rightarrow Fe_{(s)} + 2OH^-{}_{(aq)}$	-0.877
$SO_4^{2-}{}_{(aq)} + H_2O + 2e^- \rightarrow SO_3^{2-}{}_{(aq)} + 2OH^-{}_{(aq)}$	-0.93
$N_2{}_{(g)} + 4H_2O + 4e^- \rightarrow N_2H_4{}_{(aq)} + 4OH^-{}_{(aq)}$	-1.15
$[Zn(OH)_4]^{2-}{}_{(aq)} + 2e^- \rightarrow Zn_{(s)} + 4OH^-{}_{(aq)}$	-1.22
$Zn(OH)_2{}_{(s)} + 2e^- \rightarrow Zn_{(s)} + 2OH^-{}_{(aq)}$	-1.245
$[Zn(CN)_4]^{2-}{}_{(aq)} + 2e^- \rightarrow Zn_{(s)} + 4CN^-{}_{(aq)}$	-1.26
$Cr(OH)_3{}_{(s)} + 3e^- \rightarrow Cr_{(s)} + 3OH^-{}_{(aq)}$	-1.30
$SiO_3^{2-}{}_{(aq)} + 3H_2O + 4e^- \rightarrow Si_{(s)} + 6OH^-{}_{(aq)}$	-1.70

Modified 05/10

Thermodynamic Quantities for Selected Substances at 298.15 K (25°C)

Substance	ΔH_f° (kJ/mol)	ΔG_f° (kJ/mol)	ΔS° (J/mol-K)
Aluminum			
Al (s)	0	0	28.32
$AlCl_3$ (s)	- 705.6	- 630.0	109.3
Al_2O_3 (s)	- 1669.8	1576.5	51.00
Barium			
Ba(s)	0	0	63.2
$BaCO_3$(s)	- 1216.3	- 1137.6	112.1
BaO(s)	- 553.5	- 525.1	70.42
Beryllium			
Be(s)	0	0	9.44
BeO(s)	- 608.4	- 579.1	13.77
$Be(OH)_2$(s)	- 905.8	- 817.9	50.21
Bromine			
Br(g)	111.8	82.38	174.9
Br-(aq)	- 120.9	- 102.8	80.71
Br_2(g)	30.71	3.14	245.3
Br_2(l)	0	0	152.3
HBr(g)	-36.23	-53.22	198.49
Calcium			
Ca(g)	179.3	145.5	154.8
Ca(s)	0	0	41.4
$CaCO_3$ (s, calcite)	- 1207.1	-1128.76	92.88
$CaCl_2$(s)	- 795.8	- 7484	104.6
CaF_2(s)	- 1219.6	- 1167.3	68.87
CaO(s)	- 635.5	-604.17	39.75
$Ca(OH)_2$(s)	- 986.2	- 898.5	83.4
$CaSO_4$(s)	- 1434.0	- 1321.8	106.7
Carbon			
C(g)	718.4	672.9	158.0
C(s, diamond)	1.88	2.84	2.43
C(s, graphite)	0	0	5.69
CCl_4 (g)	- 106.7	- 64.0	309.4
CCl_4 (l)	- 139.3	- 68.6	214.4
CF_4 (g)	- 679.9	- 635.1	262.3
CH_4 (g)	- 74.8	- 50.8	186.3
C_2H_2 (g)	226.7	209.2	200.8
C_2H_4 (g)	52.30	68.11	219.4
C_2H_6 (g)	-84.68	-32.89	229.5
C_2H_5 (g)	-103.85	-23.47	269.9
C_4H_{10} (g)	-124.73	- 15.0	310.0
C_4H_{10} (l)	- 147.6	- 15.0	231.0
C_6H_6 (g)	82.9	129.7	269.2
C_6H_6 (l)	49.0	124.5	172.8
CH_3OH (g)	- 201.2	- 161.9	237.6
CH_3OH (l)	- 238.6	-166.23	126.8
C_2H_5OH (g)	- 235.1	- 168.5	282.7
C_5H_5OH (l)	- 277.7	-174.76	160.7
$C_6H_{12}O_6$ (s)	-1273.02	- 910.4	212.1
CO (g)	- 110.5	- 137.2	197.9
CO_2 (g)	- 393.5	- 394.4	213.6
$HC_2H_3O_2$ (l)	- 487.0	- 392.4	159.8
H_2CO (g)	-116.	-110	219
H_3CCHO (g)	-166	-133.7	266
Cesium			
Cs (g)	76.50	49.53	175.6
Cs (s)	0	0	85.15
CsCl (s)	- 442.8	- 414.4	101.2

Substance	ΔH_f° (kJ/mol)	ΔG_f° (kJ/mol)	ΔS° (J/mol-K)
Chlorine			
Cl (g)	121.7	105.7	165.2
Cl- (aq)	- 167.2	- 131.2	56.5
Cl_2 (g)	0	0	222.96
HCl (aq)	- 167.2	- 131.2	56.5
HCl (g)	-92.30	-95.27	186.69
Chromium			
Cr (g)	397.5	352.6	174.2
Cr (s)	0	0	23.6
Cr_2O_3 (s)	- 1139.7	- 1058.1	81.2
Cobalt			
Co (g)	439	393	179
Copper			
Cu (s)	0	0	33.30
$CuCl_2$ (s)	- 205.9	- 167.7	108.1
CuO (s)	- 156.1	- 128.3	42.59
Cu_2O (s)	- 170.7	- 147.9	92.36
Fluorine			
F (g)	80.0	61.9	158.7
F- (aq)	- 332.6	- 278.8	- 13.8
F_2 (g)	0	0	202.7
HF (g)	- 268.61	-270.70	173.51
Hydrogen			
H (g)	217.94	203.26	114.60
H+(aq)	0	0	0
H+ (g)	1536.2	1517.0	108.9
H_2 (g)	0	0	130.58
Iodine			
I (g)	106.60	70.16	180.66
I^- (aq)	-55.19	-51.57	111.3
I_2 (g)	62.25	19.37	260.57
I_2 (s)	0	0	116.73
HI (g)	25.94	1.30	206.3
Iron			
Fe (g)	415.5	369.8	180.5
Fe (s)	0	0	27.15
Fe^{2+} (aq)	-87.86	-84.93	113.4
Fe^{3+} (aq)	-47.69	-10.54	293.3
$FeCl_2$ (s)	- 341.8	- 302.3	1179
$FeCl_3$ (s)	- 400	- 334	142.3
FeO (s)	- 271.9	- 255.2	60.75
Fe_2O_3 (s)	-822.16	-740.98	89.96
Fe_3O_4 (s)	- 1117.1	- 1014.2	146.4
FeS_2 (s)	- 171.5	- 160.1	52.92
Lead			
Pb (s)	0	0	68.85
$PbBr_2$ (s)	- 277.4	- 260.7	161
$PbCO_3$ (s)	- 6994	- 625.5	131.0
$Pb(NO_3)_2$ (aq)	-421.3	-246.9	303.3
$Pb(NO_3)_2$ (s)	- 451.9	-	-
PbO (s)	- 217.3	- 187.9	68.70
Lithium			
Li (g)	159.3	126.6	138.8
Li (s)	0	0	29.09
Li^+ (g)	685.7	648.5	133.0
LiCl (s)	- 408.3	- 384.0	59.30

Substance	ΔH_f° (kJ/mol)	ΔG_f° (kJ/mol)	ΔS° (J/mol-K)
Magnesium			
Mg (g)	147.1	112.5	148.6
Mg (s)	0	0	32.51
$MgCl_2$ (s)	- 641.6	- 5924	89.6
MgO (s)	- 601.8	- 569.6	26.8
$Mg(OH)_2$ (s)	- 924.7	- 833.7	63.24
Manganese			
Mn (g)	280.7	238.5	173.6
Mn (s)	0	0	32.0
MnO (s)	- 385.2	- 362.9	59.7
MnO_2 (s)	- 519.6	- 464.8	53.14
MnO_4^- (aq)	-541.4	-447.2	191.2
Mercury			
Hg (g)	60.83	31.76	174.89
Hg (l)	0	0	77.40
$HgCl_2$ (s)	- 230.4	- 184.0	144.5
Hg_2Cl_2 (s)	- 264.9	- 210.5	192.5
Nickel			
Ni (g)	429.7	384.5	182.1
Ni (s)	0	0	29.9
$NiCl_2$ (s)	- 305.3	- 259.0	97.65
NiO (s)	- 239.7	- 211.7	37.99
Nitrogen			
N (g)	472.7	455.5	153.3
N_2 (g)	0	0	191.50
NH_3 (aq)	-80.29	-26.50	111.3
NH3 (g)	-46.19	-16.66	192.5
NH_4^+ (aq)	- 132.5	- 79.31	113.4
N_2H_4 (g)	95.40	159.4	238.5
HCN (g)	135.14	75.00	201.82
NH_4Cl (s)	- 314.4	- 203.0	94.6
NH_4NO_3 (s)	- 365.6	- 184.0	151
NO (g)	90.37	86.71	210.62
NO_2 (g)	33.84	51.84	240.45
N_2O (g)	81.6	103.59	220.0
N_2O_4 (g)	9.66	98.28	304.3
NOCl (g)	52.6	66.3	264
HNO_3 (aq)	- 206.6	- 110.5	146
HNO_3 (g)	- 134.3	-73.94	266.4
Oxygen			
O (g)	247.5	230.1	161.0
O_2 (g)	0	0	205.0
O_3 (g)	142.3	163.4	237.6
OH- (aq)	- 230.0	- 157.3	- 10.7
H_2O (g)	- 241.82	-228.57	188.83
H_2O (1)	-285.83	-237.13	69.91
H_2O_2 (g)	- 136.40	-105.48	232.9
H_2O_2 (l)	- 187.8	- 120.4	109.6
Phosphorus			
P (g)	316.4	280.0	163.2
P_2 (g)	144.3	103.7	218.1
P_4 (g)	58.9	24.4	280
P_4 (s, red)	-17.46	-12.03	22.85
P_4 (s, white)	0	0	41.08
PCl_3 (g)	-288.07	- 269.6	311.7
PCl_3 (l)	- 319.6	- 272.4	217
PF_5(g)	- 1594.4	- 1520.7	300.8
PH_3 (g)	5.4	13.4	210.2
P_4O_6 (s)	- 1640.1	-	-
P_4O_{10} (s)	- 2940.1	- 2675.2	228.9
$POCl_3$ (g)	- 542.2	- 502.5	325
$POCl_3$ (l)	- 597.0	- 520.9	222
H_3PO_4 (aq)	- 1288.3	- 1142.6	158.2
K_2O (s)	- 363.2	- 322.1	94.14
KO_2 (s)	- 284.5	- 240.6	122.5
K_2O_2 (s)	-495.8	-429.8	113.0
KOH (s)	- 424.7	- 378.9	78.91
KOH (aq)	- 482.4	- 440.5	91.6
Rubidium			
Rb (g)	85.8	55.8	170.0
Rb (s)	0	0	76.78
RbCl (s)	- 430.5	- 412.0	92
$RbClO_3$ (s)	- 392.4	- 292.0	152
Scandium			
Sc(g)	377.8	336.1	174.7
Sc(s)	0	0	34.6
Selenium			
H_2Se(g)	29.7	15.9	219.0
Silicon			
Si (g)	368.2	323.9	167.8
Si (s)	0	0	18.7
SiC (s)	-73.22	-70.85	16.61
$SiCl_4$ (l)	- 640.1	- 572.8	239.3
SiO_2 (s, quartz)	-910.9	- 856.5	41.84
Silver			
Ag (s)	0	0	42.55
Ag + (aq)	105.90	77.11	73.93
AgCl (s)	- 127.0	-109.70	96.11
Ag_2O (s)	-31.05	-11.20	121.3
AgNO3 (s)	- 124.4	-33.41	140.9
Sodium			
Na (g)	107.7	77.3	153.7
Na (s)	0	0	51.45
Na+ (aq)	- 240.1	- 261.9	59.0
Na+ (g)	609.3	574.3	148.0
NaBr (aq)	-360.6	- 364.7	141
NaBr (s)	- 361.4	- 349.3	86.82
Na_2CO_3 (s)	- 1130.9	- 1047.7	136.0
NaCl (aq)	- 407.1	- 393.0	115.5
NaCl (g)	- 181.4	- 201.3	229.8
NaCl (s)	-410.9	-384.0	72.33
$NaHCO_3$ (s)	-947.7	-851.8	102.1
$NaNO_3$ (aq)	-446.2	-372.4	207
$NaNO_3$ (s)	- 467.9	- 367.0	116.5
NaOH (aq)	-469.6	-419.2	49.8
NaOH (s)	-425.6	- 379.5	64.46
Strontium			
SrO (s)	- 592.0	- 561.9	54.9
Sr (g)	164.4	110.0	164.6
Sulfur			
S (s, rhombic)	0	0	31.88
SO_2 (g)	- 296.9	- 300.4	248.5
SO_3 (g)	- 395.2	- 370.4	256.2
SO_4^{2-} (aq)	- 909.3	- 744.5	20.1
$SOCl_2$ (l)	- 245.6	-	-
H_2S (g)	-20.17	- 33.01	205.6
H_2SO_4 (aq)	- 909.3	- 744.5	20.1
H_2SO_4 (l)	-814.0	- 689.9	156.1
Titanium			
Ti (g)	468	422	180.3
Ti (s)	0	0	30.76
$TiCl_4$ (g)	- 763.2	- 726.8	354.9
$TiCl_4$ (1)	- 804.2	- 728.1	221.9
TiO_2 (s)	- 944.7	- 889.4	50.29
Vanadium			
V (g)	514.2	453.1	182.2

Potassium			
K (g)	89.99	61.17	160.2
K (s)	0	0	64.67
KCl (s)	- 435.9	-408.3	82.7
$KClO_3$ (s)	- 391.2	- 289.9	143.0
$KClO_3$ (aq)	- 349.5	- 284.9	265.7
KNO_3 (s)	-492.70	-393.13	288.1
V (s)	0	0	28.9
Zinc			
Zn (g)	130.7	95.2	160.9
Zn (s)	0	0	41.63
$ZnCl_2$ (s)	- 415.1	- 369.4	111.5
ZnO (s)	- 348.0	- 318.2	43.9