

## Periodic Table of the Elements

1 H 1.008																2 He 4.003	
3 Li 6.941	4 Be 9.012											5 B 10.811	6 C 12.011	7 N 14.007	8 O 15.999	9 F 18.998	10 Ne 20.180
11 Na 22.990	12 Mg 24.305											13 Al 26.982	14 Si 28.086	15 P 30.974	16 S 32.066	17 Cl 35.453	18 Ar 39.948
19 K 39.098	20 Ca 40.078	21 Sc 44.956	22 Ti 47.88	23 V 50.942	24 Cr 51.996	25 Mn 54.938	26 Fe 55.847	27 Co 58.933	28 Ni 58.69	29 Cu 63.546	30 Zn 65.39	31 Ga 69.723	32 Ge 72.61	33 As 74.922	34 Se 78.96	35 Br 79.904	36 Kr 83.80
37 Rb 85.468	38 Sr 87.62	39 Y 88.906	40 Zr 91.224	41 Nb 92.906	42 Mo 95.94	43 Tc (98)	44 Ru 101.07	45 Rh 102.91	46 Pd 106.42	47 Ag 107.87	48 Cd 112.41	49 In 114.82	50 Sn 118.71	51 Sb 121.75	52 Te 127.60	53 I 126.90	54 Xe 131.29
55 Cs 132.91	56 Ba 137.33	57 La* 138.91	72 Hf 178.49	73 Ta 180.95	74 W 183.85	75 Re 186.21	76 Os 190.23	77 Ir 192.22	78 Pt 195.08	79 Au 196.97	80 Hg 200.59	81 Tl 204.38	82 Pb 207.2	83 Bi 208.98	84 Po (209)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra (226)	89 Ac** (227)	104 Rf (267)	105 Db (268)	106 Sg (269)	107 Bh (270)	108 Hs (277)	109 Mt (278)	110 Ds (281)	111 Rg (282)	112 Cn (285)	113 Nh (286)	114 Fl (289)	115 Mc (289)	116 Lv (293)	117 Ts (294)	118 Og (294)

* 58 Ce 140.12	59 Pr 140.91	60 Nd 144.24	61 Pm (145)	62 Sm 150.36	63 Eu 151.96	64 Gd 157.25	65 Tb 158.92	66 Dy 162.50	67 Ho 164.93	68 Er 167.26	69 Tm 168.93	70 Yb 173.04	71 Lu 174.97
** 90 Th 232.04	91 Pa 231.04	92 U 238.03	93 Np 237.05	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (252)	100 Fm (257)	101 Md (258)	102 No (259)	103 Lr (260)

## Potentially Useful Information

$$PV = nRT \quad R = 8.314 \frac{\text{J}}{\text{mol}\cdot\text{K}} \quad K = ^\circ\text{C} + 273.15$$

$$1 \text{ mole} = 6.022 \times 10^{23} \quad R = 0.08206 \frac{\text{L}\cdot\text{atm}}{\text{mol}\cdot\text{K}} \quad 760 \text{ torr} \equiv 1 \text{ atm}$$

$$\text{Molarity (M)} = \frac{\text{moles solute}}{\text{liters solution}} \quad \text{molality (m)} = \frac{\text{moles solute}}{\text{kg solvent}} \quad (\text{w/w}) \% = \frac{\text{mass solute}}{\text{mass solution}} \times 100\%$$

$$M_1 V_1 = M_2 V_2 \text{ (dilution)} \quad M_{\text{acid}} V_{\text{acid}} = M_{\text{base}} V_{\text{base}} \text{ (at equivalence point)}$$

$$\Delta T = i K m \quad \Pi = i MRT \quad \text{Mole fraction } (\chi_A) = \frac{\text{moles A}}{\text{total moles}}$$

$$q = s m \Delta T \quad q = m \Delta H \quad P_{\text{solvent}} = \chi_{\text{solvent}} P_{\text{solvent}}^\circ$$

$$\text{pH} = -\log_{10}([\text{H}^+]) \quad K_w = [\text{H}^+][\text{OH}^-] = 1.0 \times 10^{-14} \quad x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

$$\text{pOH} = -\log_{10}([\text{OH}^-]) \quad [\text{H}^+] \approx \sqrt{K_a \cdot [\text{weak acid}]} \quad [\text{OH}^-] \approx \sqrt{K_b \cdot [\text{weak base}]}$$

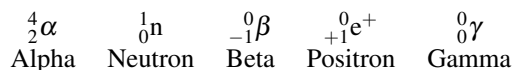
$$\text{pH} + \text{pOH} = 14 \quad K_w = K_a \cdot K_b \quad \text{pH} = \text{p}K_a + \log_{10} \left( \frac{[\text{base}]}{[\text{acid}]} \right)$$

$$\Delta G^\circ = \Delta H^\circ - T\Delta S^\circ \quad \Delta G = \Delta G^\circ + RT \ln(Q) \quad \Delta G^\circ = -RT \ln(K_{eq})$$

$$F = 96485 \frac{\text{Coulombs}}{\text{mol e}^-} \quad \Delta G^\circ = -nFE^\circ \quad E_{\text{cell}} = E_{\text{cell}}^\circ - \frac{RT}{nF} \ln(Q)$$

$$\text{Amp} = \frac{\text{Coulombs}}{\text{sec}} \quad \text{Volt} = \frac{\text{Joules}}{\text{Coulomb}} \quad E_{\text{cell}} = E_{\text{cell}}^\circ - \frac{0.0592}{n} \log_{10}(Q) \text{ (at } 25^\circ\text{C)}$$

### Subatomic Particles



### Kinetics

$$\text{rate} = \frac{\Delta \text{Concentration}}{\Delta \text{time}}$$

$$t_{\frac{1}{2}} = \frac{\ln(2)}{k} = \frac{0.693}{k} \text{ (1st order only)} \qquad \ln\left(\frac{k_1}{k_2}\right) = \frac{E_a}{R} \left(\frac{1}{T_2} - \frac{1}{T_1}\right)$$

### Integrated Rate Laws

$$0^{th}: [A]_t = -kt + [A]_0$$

$$1^{st}: \ln([A]_t) = -kt + \ln([A]_0)$$

$$[A]_t = [A]_0 \cdot e^{-kt}$$

$$2^{nd}: \frac{1}{[A]_t} = kt + \frac{1}{[A]_0}$$

### Thermodynamic Properties of Water (H<sub>2</sub>O)

$$\Delta H_{\text{fusion}} = 6.02 \frac{\text{kJ}}{\text{mol}}$$

$$\Delta H_{\text{vaporization}} = 40.7 \frac{\text{kJ}}{\text{mol}}$$

$$K_f = 1.862 \frac{C^\circ}{m}$$

$$K_b = 0.512 \frac{C^\circ}{m}$$

$$H_2O = 18.02 \frac{\text{grams}}{\text{mole}}$$

### Standard Thermodynamic Values

Compound	$\Delta G_f^\circ \left(\frac{\text{kJ}}{\text{mole}}\right)$	$\Delta H_f^\circ \left(\frac{\text{kJ}}{\text{mole}}\right)$	$S^\circ \left(\frac{\text{J}}{\text{mol} \cdot \text{circK}}\right)$
H <sub>2</sub> (gas)	0	0	130.6
O <sub>2</sub> (gas)	0	0	205.0
Cl <sub>2</sub> (gas)	0	0	223.0
Br <sub>2</sub> (liquid)	0	0	152.2
Br <sub>2</sub> (gas)	3.1	30.9	245.4
CH <sub>4</sub> (gas)	-50.7	-74.8	186.3
CO(gas)	-137.3	-110.5	197.9
CO <sub>2</sub> (gas)	-394.4	-393.5	213.6
CH <sub>3</sub> OH(gas)	-162.0	-200.7	239.8
CH <sub>3</sub> OH(liquid)	-166.3	-238.7	126.8
C <sub>2</sub> H <sub>5</sub> OH(gas)	-168.3	-235.3	283.0
C <sub>2</sub> H <sub>5</sub> OH(liquid)	-174.1	-277.4	159.9
C <sub>6</sub> H <sub>6</sub> (gas)	129.7	+82.9	269.0
C <sub>6</sub> H <sub>6</sub> (liquid)	124.3	+48.7	173.3
CCl <sub>4</sub> (liquid)	-65.3	-135.4	216.2
H <sub>2</sub> O(gas)	-228.6	-241.8	188.7
H <sub>2</sub> O(liquid)	-237.2	-285.8	69.9
Ni(solid)	0	0	30.0
Ni(CO) <sub>4</sub> (gas)	-589.6	-632.0	320.0
SO <sub>4</sub> <sup>-2</sup> (aq)	-744.5	-909.3	20.1
Li <sup>+1</sup> (aq)	-293.3	-278.5	13.4
Li <sub>2</sub> SO <sub>4</sub> (solid)	-1320.9	-1436.4	113.0

## Acid Dissociation Constants

Acid	$K_a$	$pK_a$
H <sub>3</sub> PO <sub>4</sub>	$7.5 \times 10^{-3}$	2.12
HF	$7.1 \times 10^{-4}$	3.15
HNO <sub>2</sub>	$4.5 \times 10^{-4}$	3.35
HCOOH	$1.7 \times 10^{-4}$	3.77
CH <sub>3</sub> COOH	$1.8 \times 10^{-5}$	4.74
H <sub>2</sub> CO <sub>3</sub>	$4.2 \times 10^{-7}$	6.38

Acid	$K_a$	$pK_a$
H <sub>2</sub> PO <sub>4</sub> <sup>-1</sup>	$6.2 \times 10^{-8}$	7.21
HBrO	$2.0 \times 10^{-9}$	8.70
HCN	$6.17 \times 10^{-10}$	9.21
NH <sub>4</sub> <sup>+</sup>	$5.6 \times 10^{-10}$	9.25
C <sub>6</sub> H <sub>5</sub> OH	$1.3 \times 10^{-10}$	9.89
HCO <sub>3</sub> <sup>-1</sup>	$5.6 \times 10^{-11}$	10.25

## Standard Reduction Potentials

Half Reaction	$E^\circ$ (Volts)
$F_2 + 2 e^- \rightarrow 2 F^-$	+2.87
$PbO_2 + H_2SO_4 + 2 H^+ + 2 e^- \rightarrow PbSO_4 + 2 H_2O$	+1.685
$MnO_4^- + 8 H^+ + 5 e^- \rightarrow Mn^{+2} + 4 H_2O$	+1.51
$Cl_2 + 2 e^- \rightarrow 2 Cl^-$	+1.36
$Ag^+ + e^- \rightarrow Ag$	+0.80
$O_2 + 2 H_2O + 4 e^- \rightarrow 4 OH^-$	+0.40
$Cu^{+2} + 2 e^- \rightarrow Cu$	+0.34
$2 H^+ + 2 e^- \rightarrow H_2$	+0.00
$PbSO_4 + 2 H^+ + 2 e^- \rightarrow Pb + H_2SO_4$	-0.356
$Fe^{+2} + 2 e^- \rightarrow Fe$	-0.44
$Zn^{+2} + 2 e^- \rightarrow Zn$	-0.76
$2 H_2O + 2 e^- \rightarrow H_2 + 2 OH^-$	-0.83
$Al^{+3} + 3 e^- \rightarrow Al$	-2.37
$Na^+ + e^- \rightarrow Na$	-2.71
$Li^+ + e^- \rightarrow Li$	-3.05