

## Appendix: Chemistry Reference Tables

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Table A. Standard Temperature and Pressure			
Name	Values		
"Standard" Pressure	1 atm	760 torr	101.3 kPa
Standard Temperature	0 °C	32°F	273.15K
atm =	atmosphere		
Torr =	millimeter of mercury (mm Hg)		
kPa =	kilopascal		
°C =	degree Celsius		
°F =	degree Fahrenheit		
K =	kelvin		

Table C. Selected Prefixes			
Factor	Number of Units	Prefix	Symbol
$10^6$	1,000,000	mega-	M
$10^3$	1,000	kilo-	k
$10^{-1}$	0.1	deci-	d
$10^{-2}$	0.01	centi-	c
$10^{-3}$	0.001	milli-	m
$10^{-6}$	0.000 001	micro-	$\mu$ (or u)

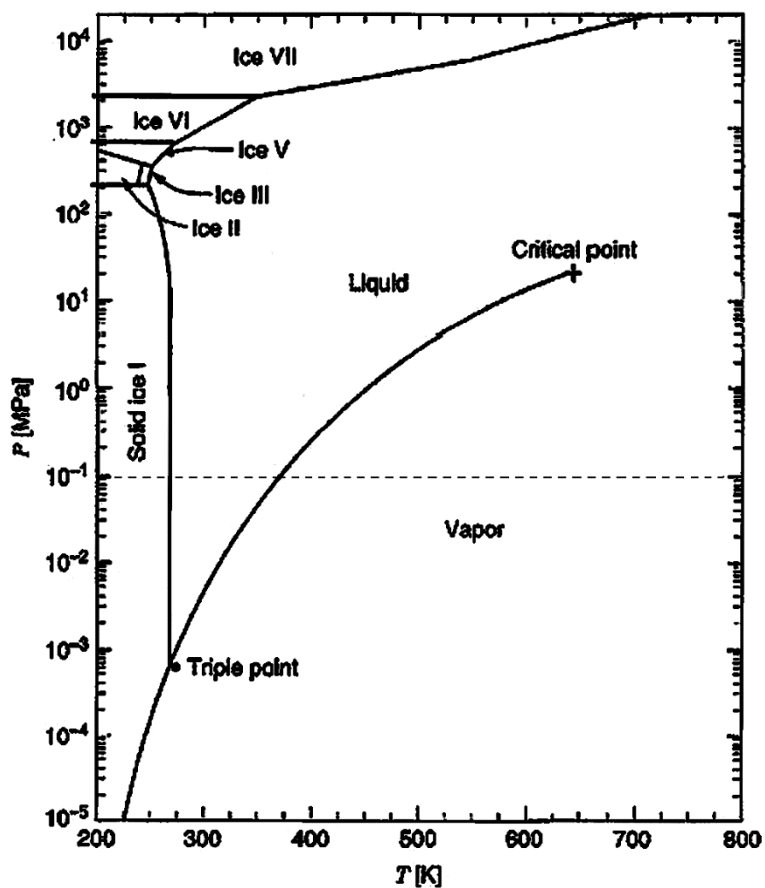
Table B. Selected Units		
Name	Symbol	Quantity
meter (SI)	m	length
centimeter	cm	
kilogram (SI)	kg	mass
gram	g	
Pascal (SI derived)	Pa	pressure
atmosphere	atm	
mm of mercury	mm Hg	
Torr	Torr	
Kelvin (SI)	K	temperature
degree Celsius	°C	
amt of substance (SI)	mol	mole
Joule (SI derived)	J	energy
kilocalorie	kcal	
second (SI)	s	time
liter	L, $\ell$	volume
part per million	ppm	concentration
molarity	$M, \frac{\text{mol}}{\ell}$	concentration

**Table D. Physical Constants for Water**

Freezing Point @ 1 atm	0 °C = 273.15 K
Boiling Point @ 1 atm	100 °C = 373.15 K
Heat of Fusion	333.6 J/g
Heat of Vaporization	2270 J/g
Specific Heat Capacity ( $C_p$ )	4.184 J/g·°C
Freezing Point Depression Constant ( $K_f$ )	0.52 °C/m
Boiling Point Elevation Constant ( $K_b$ )	1.86 °C/m

**Table E. Vapor Pressure and Density of Water**

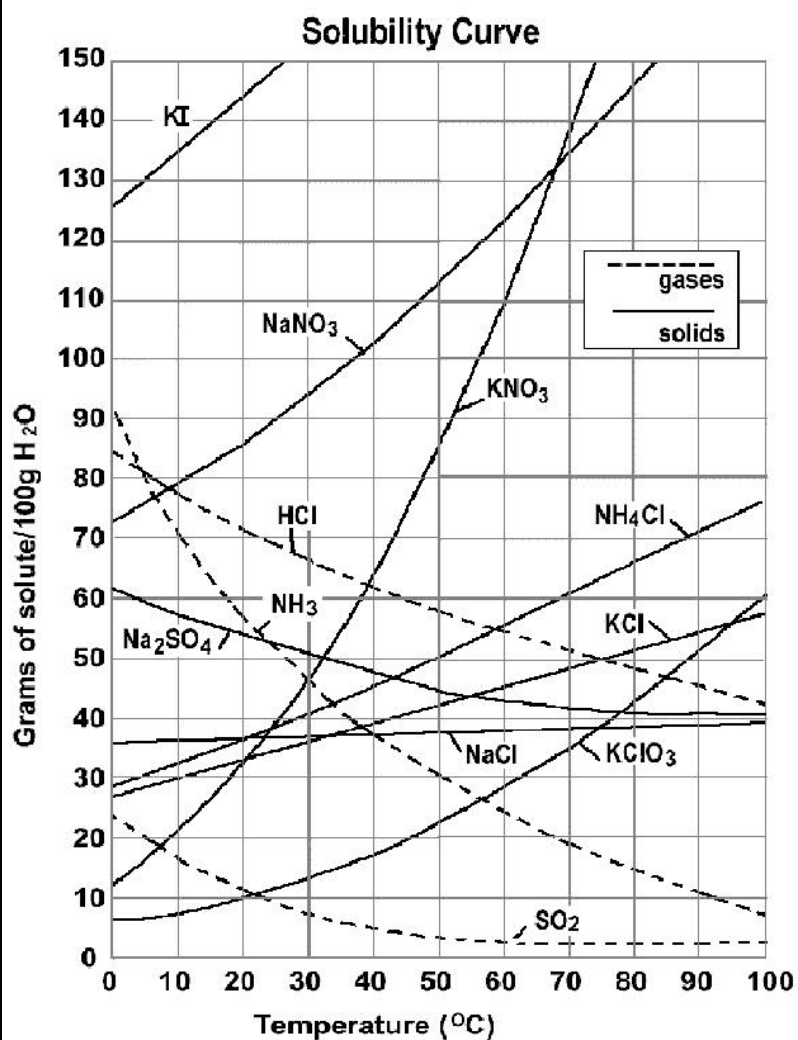
Temp (°C)	$P_{\text{vap}}$ (kPa)	density (g/cm <sup>3</sup> )
0.01	0.61173	0.99978
1	0.65716	0.99985
4	0.81359	0.99995
5	0.87260	0.99994
10	1.2281	0.99969
15	1.7056	0.99909
20	2.3388	0.99819
25	3.1691	0.99702
30	4.2455	0.99561
35	5.6267	0.99399
40	7.3814	0.99217
45	9.5898	0.99017
50	12.344	0.98799
55	15.752	0.98565
60	19.932	0.98316
65	25.022	0.98053
70	31.176	0.97775
75	38.563	0.97484
80	47.373	0.97179
85	57.815	0.96991
90	70.117	0.96533
95	84.529	0.96192
100	101.32	0.95475
105	120.79	0.95475

**Figure F. Phase Diagram for Water**

Ions That Form SOLUBLE Compounds	EXCEPT with	Ions That Form INSOLUBLE Compounds	EXCEPT with
Group I ions ( $\text{Li}^+$ , $\text{Na}^+$ , etc.) ammonium ( $\text{NH}_4^+$ ) nitrate ( $\text{NO}_3^-$ ) hydrogen carbonate ( $\text{HCO}_3^-$ ) chlorate ( $\text{ClO}_3^-$ ) perchlorate ( $\text{ClO}_4^-$ )		carbonate ( $\text{CO}_3^{2-}$ ) chromate ( $\text{CrO}_4^{2-}$ ) phosphate ( $\text{PO}_4^{3-}$ ) sulfite ( $\text{SO}_3^{2-}$ )	Group I ions, ammonium ( $\text{NH}_4^+$ )
acetate ( $\text{C}_2\text{H}_3\text{O}_2^-$ or $\text{CH}_3\text{COO}^-$ )	$\text{Ag}^+$	sulfide ( $\text{S}^{2-}$ )	Group I ions, Group II ions, $\text{NH}_4^+$
halides ( $\text{Cl}^-$ , $\text{Br}^-$ , $\text{I}^-$ )	$\text{Ag}^+$ , $\text{Cu}^+$ , $\text{Pb}^{2+}$ , $\text{Hg}_2^{2+}$	hydroxide ( $\text{OH}^-$ )	Group I ions, $\text{NH}_4^+$ , $\text{Ba}^{2+}$ , $\text{Sr}^{2+}$ , $\text{Tl}^+$
sulfates ( $\text{SO}_4^{2-}$ )	$\text{Ca}^{2+}$ , $\text{Sr}^{2+}$ , $\text{Ba}^{2+}$ , $\text{Ag}^+$ , $\text{Pb}^{2+}$	oxide ( $\text{O}^{2-}$ )	

Compound	$K_{sp}$
$\text{MgCO}_3$	$1.0 \times 10^{-5}$
$\text{PbCl}_2$	$1.7 \times 10^{-5}$
$\text{BaF}_2$	$2.0 \times 10^{-6}$
$\text{CuCl}$	$1.0 \times 10^{-6}$
$\text{PbI}_2$	$1.6 \times 10^{-8}$
$\text{AgOH}$	$1.0 \times 10^{-8}$
$\text{BaCO}_3$	$8.1 \times 10^{-9}$
$\text{CaCO}_3$	$3.8 \times 10^{-9}$
$\text{SrCO}_3$	$9.4 \times 10^{-10}$
$\text{AgCl}$	$1.8 \times 10^{-10}$
$\text{BaSO}_4$	$1.1 \times 10^{-10}$
$\text{CaF}_2$	$3.9 \times 10^{-11}$
$\text{Mg(OH)}_2$	$1.0 \times 10^{-11}$
$\text{Ag}_2\text{CrO}_4$	$9.0 \times 10^{-12}$
$\text{CuI}$	$5.0 \times 10^{-12}$
$\text{AgBr}$	$3.3 \times 10^{-13}$
$\text{PbSO}_4$	$2.5 \times 10^{-13}$
$\text{PbCO}_3$	$1.6 \times 10^{-13}$
$\text{Mn(OH)}_2$	$4.0 \times 10^{-14}$
$\text{PbCrO}_4$	$1.8 \times 10^{-14}$
$\text{Fe(OH)}_2$	$1.6 \times 10^{-14}$
$\text{AgI}$	$1.5 \times 10^{-16}$
$\text{Zn(OH)}_2$	$7.9 \times 10^{-18}$
$\text{FeS}$	$4.0 \times 10^{-18}$
$\text{HgCl}$	$2.0 \times 10^{-18}$
$\text{ZnS}$	$1.0 \times 10^{-23}$
$\text{PbS}$	$8.4 \times 10^{-28}$
$\text{CdS}$	$3.6 \times 10^{-29}$
$\text{Al(OH)}_3$	$1.6 \times 10^{-34}$
$\text{CuS}$	$8.7 \times 10^{-36}$
$\text{Fe(OH)}_3$	$1.3 \times 10^{-36}$
$\text{Ag}_2\text{S}$	$2.0 \times 10^{-50}$
$\text{HgS}$	$3.0 \times 10^{-53}$

Figure I. Solubilities of Selected Compounds



Number	Inorganic	Organic	Number	Inorganic	Organic
1	mono-	meth-	6	hexa-	hex-
2	di-	eth-	7	hepta-	hept-
3	tri-	prop-	8	octa-	oct-
4	tetra-	but-	9	nona-	non-
5	penta-	pent-	10	deca-	dec-

ion	formula	ion	formula	ion	formula	ion	formula
americium	$\text{AmO}_2^{2+}$	ammonium	$\text{NH}_4^+$	cyanate	$\text{OCN}^-$	dichromate	$\text{Cr}_2\text{O}_7^{2-}$
carbonyl	$\text{CO}_2^+$	hydronium	$\text{H}_3\text{O}^+$	thiocyanate	$\text{SCN}^-$	imide	$\text{NH}_2^-$
thiocarbonyl	$\text{CS}_2^+$	iodyl	$\text{IO}_2^+$	selenocyanate	$\text{SeCN}^-$	molybdate	$\text{MoO}_4^{2-}$
chromyl	$\text{CrO}_2^{2+}$	nitrosyl	$\text{NO}^+$	tellurocyanate	$\text{TeCN}^-$	peroxide	$\text{O}_2^{2-}$
neptunyl	$\text{NpO}_2^{2+}$	thionitrosyl	$\text{NS}^+$	hydroxide	$\text{OH}^-$	oxalate	$\text{C}_2\text{O}_4^{2-}$
plutonyl	$\text{PuO}_2^{2+}$	phosphoryl	$\text{PO}^+$	iodate	$\text{IO}_3^-$	phthalate	$\text{C}_8\text{H}_4\text{O}_4^{2-}$
selinyl	$\text{SeO}_2^+$	thiophosphoryl	$\text{PS}^+$	methanolate	$\text{CH}_3\text{O}^-$	selenate	$\text{SeO}_4^{2-}$
selenoyl	$\text{SeO}_2^{2+}$	phospho	$\text{PO}_2^+$	methanethiolate	$\text{CH}_3\text{S}^-$	disulfide	$\text{S}_2^{2-}$
thionyl / sulfinyl	$\text{SO}_2^+$	acetate	$\text{CH}_3\text{COO}^-$	ethanolate	$\text{C}_2\text{H}_5\text{O}^-$	sulfate	$\text{SO}_4^{2-}$
sulfonyl / sulfuryl	$\text{SO}_2^{2+}$	amide	$\text{NH}_2^-$	permanganate	$\text{MnO}_4^-$	thiosulfate	$\text{S}_2\text{O}_3^{2-}$
uranyl	$\text{UO}_2^+$	hydroxylamide	$\text{NHOH}^-$	nitrate	$\text{NO}_3^-$	dithionate	$\text{S}_2\text{O}_4^{2-}$
vanadyl	$\text{VO}_2^+$	azide	$\text{N}_3^-$	superoxide	$\text{O}_2^-$	silicate	$\text{SiO}_3^{2-}$
mercury (II)	$\text{Hg}^{2+}$	hydrazide	$\text{N}_2\text{H}_3^-$	tetraborate	$\text{B}_4\text{O}_7^{2-}$	borate	$\text{BO}_3^{3-}$
mercury (I)	$\text{Hg}_2^{2+}$	bromate	$\text{BrO}_3^-$	carbide	$\text{C}_2^{2-}$	arsenate	$\text{AsO}_4^{3-}$
		chlorate	$\text{ClO}_3^-$	carbonate	$\text{CO}_3^{2-}$	phosphate	$\text{PO}_4^{3-}$
		cyanide	$\text{CN}^-$	chromate	$\text{CrO}_4^{2-}$	orthosilicate	$\text{SiO}_4^{4-}$

Element	Color	Element	Color	Element	Color
Ba	yellow-green	K	pink	Pb	blue
Ca	orange-red	Li	fuchsia	Sb	pale green
Cu	blue-green	Mg	bright white	Sr	red
Fe	gold	Na	yellow	Zn	blue-green

Ion	Color	Ion	Color
$\text{Cu}^+$	green	$\text{V}^{2+}$	violet
$\text{Cu}^{2+}$	blue	$\text{V}^{3+}$	blue-green
$\text{Fe}^{2+}$	yellow-green	$\text{CrO}_4^{2-}$	yellow
$\text{Fe}^{3+}$	orange-red	$\text{Cr}_2\text{O}_7^{2-}$	orange
$\text{Cr}^{3+}$	violet [ $\text{Cr}(\text{NO}_3)_3$ ] to green [ $\text{CrCl}_3$ ]	$\text{Cu}(\text{NH}_3)_4^{2+}$	dark blue
$\text{Ni}^{2+}$	green	$\text{FeSCN}^{2+}$	red-brown (wine-red to dark orange)
$\text{Mn}^{2+}$	pink	$\text{Co}^{2+}$	pink
$\text{Mn}^{7+}$	purple (e.g., the $\text{MnO}_4^-$ ion)	$\text{CoCl}_4^{2-}$	blue
$\text{Pb}^{3+}$	blue-green ( $\text{Pb}^{2+}$ and $\text{Pb}^{4+}$ are clear)	$\text{Ti}(\text{H}_2\text{O})_6^{3+}$	purple

Compound	Color	Compound	Color
$\text{F}_2$	pale yellow gas	NO	colorless gas
$\text{Cl}_2$	green-yellow gas	$\text{NO}_2$	brown gas
$\text{Br}_2$	red-brown liquid	metallic	sulfides of transition metals
$\text{I}_2$	dark metallic solid; dark violet vapor	sulfides	tend to be black
$\text{S}_8$	yellow odorous solid	metallic	oxides of colored transition metals
$\text{PbI}_2$	bright yellow precipitate	oxides	tend to be colored
$\text{Fe}_2\text{O}_3$	reddish-brown (rust)		

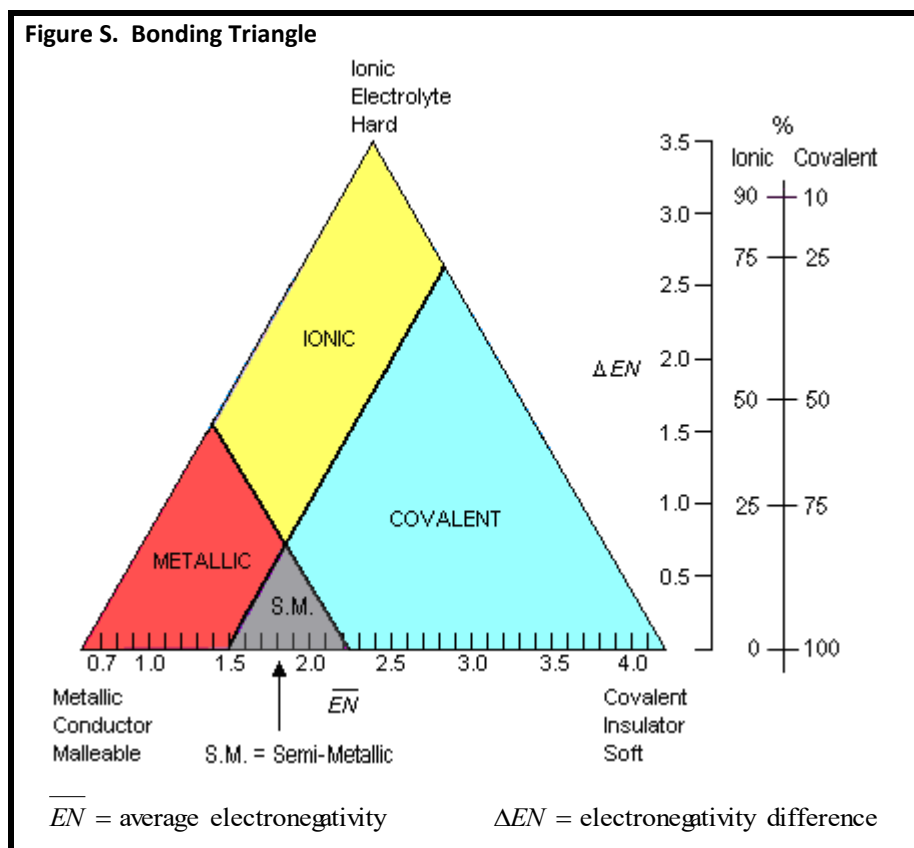
Formula	Name
HCl ( <i>aq</i> )	hydrochloric acid
HNO <sub>3</sub> ( <i>aq</i> )	nitric acid
H <sub>2</sub> SO <sub>4</sub> ( <i>aq</i> )	sulfuric acid
H <sub>3</sub> PO <sub>4</sub> ( <i>aq</i> )	phosphoric acid
H <sub>2</sub> CO <sub>3</sub> ( <i>aq</i> )	carbonic acid
HC <sub>2</sub> H <sub>3</sub> O <sub>2</sub> ( <i>aq</i> ) or CH <sub>3</sub> COOH ( <i>aq</i> )	ethanoic acid (acetic acid)

Formula	Name
NaOH ( <i>aq</i> )	sodium hydroxide
KOH ( <i>aq</i> )	potassium hydroxide
Ca(OH) <sub>2</sub> ( <i>aq</i> )	calcium hydroxide
NH <sub>3</sub> ( <i>aq</i> )	aqueous ammonia

Indicator	pH Range of Color Change	Color Change
bromophenol blue	3.0 – 4.6	yellow–purple
methyl orange	3.2 – 4.4	red–yellow
bromocresol green	3.8 – 5.4	yellow–blue
methyl red	4.4 – 6.2	red–yellow
litmus	5.5 – 8.2	red–blue
bromothymol blue	6.0 – 7.6	yellow–blue
phenol red	6.8 – 8.4	yellow–red
thymol blue	8.0 – 9.6	yellow–blue
phenolphthalein	8.2 – 10	clear–pink

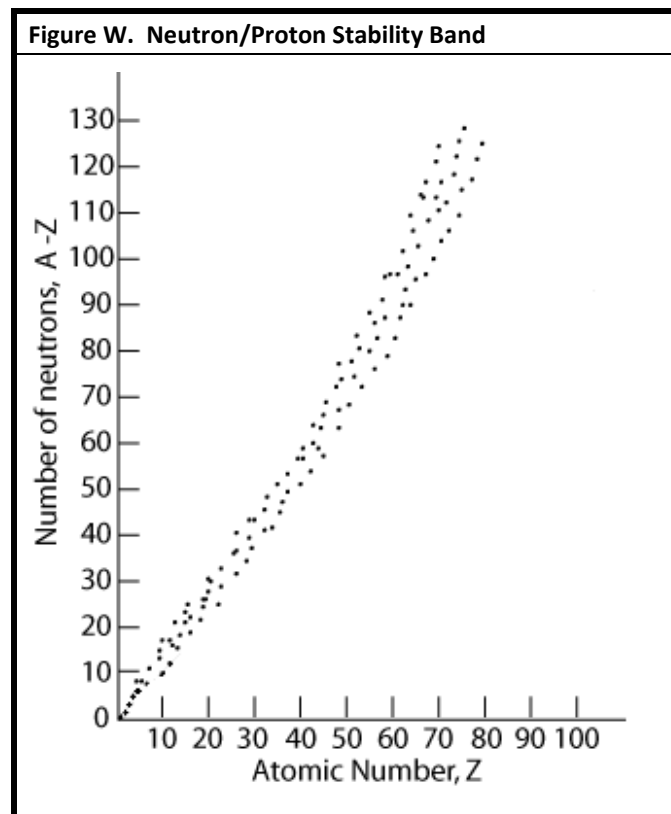
Acid	$pK_a$	Conj. Base
H <sub>2</sub> O	15.7	OH <sup>-</sup>
HPO <sub>4</sub> <sup>2-</sup>	12.6	PO <sub>4</sub> <sup>3-</sup>
HCO <sub>3</sub> <sup>-</sup>	10.2	CO <sub>3</sub> <sup>2-</sup>
NH <sub>4</sub> <sup>+</sup>	9.2	NH <sub>3</sub>
HCN	9.1	CN <sup>-</sup>
H <sub>2</sub> PO <sub>4</sub> <sup>-</sup>	7.2	HPO <sub>4</sub> <sup>2-</sup>
H <sub>2</sub> S	7.0	HS <sup>-</sup>
H <sub>2</sub> CO <sub>3</sub>	6.4	HCO <sub>3</sub> <sup>-</sup>
CH <sub>3</sub> COOH	4.8	CH <sub>3</sub> COO <sup>-</sup>
HCOOH	3.7	HCOO <sup>-</sup>
HNO <sub>2</sub>	3.3	NO <sub>2</sub> <sup>-</sup>
HF	3.2	F <sup>-</sup>
C <sub>6</sub> H <sub>8</sub> O <sub>7</sub> (citric acid)	3.1	C <sub>6</sub> H <sub>7</sub> O <sub>7</sub> <sup>-</sup>
H <sub>3</sub> PO <sub>4</sub>	2.2	H <sub>2</sub> PO <sub>4</sub> <sup>-</sup>
HSO <sub>4</sub> <sup>-</sup>	2.0	SO <sub>4</sub> <sup>2-</sup>
HNO <sub>3</sub>	-1.4	NO <sub>3</sub> <sup>-</sup>
H <sub>3</sub> O <sup>+</sup>	-1.7	H <sub>2</sub> O
HCl	-7.0	Cl <sup>-</sup>
HBr	-9.0	Br <sup>-</sup>
HI	-10	I <sup>-</sup>
HClO <sub>4</sub>	-10	ClO <sub>4</sub> <sup>-</sup>
H <sub>2</sub> SO <sub>4</sub>	-12	HSO <sub>4</sub> <sup>-</sup>

Any acid with a  $pK_a$  value less than 1 is a strong acid; any base whose conjugate acid has a  $pK_a$  value greater than 14 is a strong base.



Name	Notation	Symbol
alpha particle	${}^4_2\text{He}$ or ${}^4_2\alpha$	$\alpha$
beta particle (electron)	${}^0_{-1}e$ or ${}^0_{-1}\beta$	$\beta^-$
gamma radiation	${}^0_0\gamma$	$\gamma$
neutron	${}^1_0n$	$n$
proton	${}^1_1\text{H}$ or ${}^1_1p$	$p$
positron	${}^0_{+1}e$ or ${}^0_{+1}\beta$	$\beta^+$

Constant	Value
mass of an electron ( $m_e$ )	0.00055 amu
mass of a proton ( $m_p$ )	1.00728 amu
mass of a neutron ( $m_n$ )	1.00867 amu
Becquerel (Bq)	1 disintegration/second
Curie (Ci)	$3.7 \times 10^{10}$ Bq



Nuclide	Half-Life	Decay Mode
${}^3\text{H}$	12.26 y	$\beta^-$
${}^{14}\text{C}$	5730 y	$\beta^-$
${}^{16}\text{N}$	7.2 s	$\beta^-$
${}^{19}\text{Ne}$	17.2 s	$\beta^+$
${}^{24}\text{Na}$	15 h	$\beta^-$
${}^{27}\text{Mg}$	9.5 min	$\beta^-$
${}^{32}\text{P}$	14.3 d	$\beta^-$
${}^{36}\text{Cl}$	$3.01 \times 10^5$ y	$\beta^-$
${}^{37}\text{K}$	1.23 s	$\beta^+$
${}^{40}\text{K}$	$1.26 \times 10^9$ y	$\beta^+$
${}^{42}\text{K}$	12.4 h	$\beta^-$
${}^{37}\text{Ca}$	0.175 s	$\beta^-$
${}^{51}\text{Cr}$	27.7 d	$\alpha$
${}^{53}\text{Fe}$	8.51 min	$\beta^-$
${}^{59}\text{Fe}$	46.3 d	$\beta^-$
${}^{60}\text{Co}$	5.26 y	$\beta^-$
${}^{85}\text{Kr}$	10.76 y	$\beta^-$
${}^{87}\text{Rb}$	$4.8 \times 10^{10}$ y	$\beta^-$
${}^{90}\text{Sr}$	28.1 y	$\beta^-$
${}^{99}\text{Tc}$	$2.13 \times 10^5$ y	$\beta^-$
${}^{131}\text{I}$	8.07 d	$\beta^-$
${}^{137}\text{Cs}$	30.23 y	$\beta^-$
${}^{153}\text{Sm}$	1.93 d	$\beta^-$
${}^{198}\text{Au}$	2.69 d	$\beta^-$
${}^{222}\text{Rn}$	3.82 d	$\alpha$
${}^{220}\text{Fr}$	27.5 s	$\alpha$
${}^{226}\text{Ra}$	1600 y	$\alpha$
${}^{232}\text{Th}$	$1.4 \times 10^{10}$ y	$\alpha$
${}^{233}\text{U}$	$1.62 \times 10^5$ y	$\alpha$
${}^{235}\text{U}$	$7.1 \times 10^8$ y	$\alpha$
${}^{238}\text{U}$	$4.51 \times 10^9$ y	$\alpha$
${}^{239}\text{Pu}$	$2.44 \times 10^4$ y	$\alpha$
${}^{241}\text{Am}$	432 y	$\alpha$

Metals	Non-metals
Reacts with cold H <sub>2</sub> O and acids, replacing hydrogen. Reacts with O <sub>2</sub> , forming oxides.	↑ Cs
	Rb
	K
	Na
	Li
Reacts with steam (not cold H <sub>2</sub> O) and acids, replacing hydrogen. Reacts with O <sub>2</sub> , forming oxides.	Ba
	Sr
	Ca
	Mg
	Be
	Al
	Mn
Does not react with H <sub>2</sub> O. Reacts with acids, replacing hydrogen. Reacts with O <sub>2</sub> , forming oxides.	Zn
	Cr
	Fe
	Cd
	Co
Reacts with O <sub>2</sub> , forming oxides.	Ni
	Sn
	Pb
Fairly unreactive, forming oxides only indirectly.	H <sub>2</sub>
	Sb
	Bi
	Cu
	Ag
	Hg
	Au
	Pt

Arrows indicate direction from LEAST to MOST active elements. An element can replace any element below itself on the activity series.

Note that the order of elements in the activity series is similar to, though not quite identical with, the order of elements/ions in the table of Std. Reduction Potentials (Table Y).

Half-Reaction	E <sup>0</sup> (V)
Li <sup>+</sup> + e <sup>-</sup> ⇌ Li(s)	-3.040
Cs <sup>+</sup> + e <sup>-</sup> ⇌ Cs(s)	-3.026
Rb <sup>+</sup> + e <sup>-</sup> ⇌ Rb(s)	-2.98
K <sup>+</sup> + e <sup>-</sup> ⇌ K(s)	-2.931
Ba <sup>2+</sup> + 2 e <sup>-</sup> ⇌ Ba(s)	-2.912
Sr <sup>2+</sup> + 2 e <sup>-</sup> ⇌ Sr(s)	-2.899
Ca <sup>2+</sup> + 2 e <sup>-</sup> ⇌ Ca(s)	-2.868
Na <sup>+</sup> + e <sup>-</sup> ⇌ Na(s)	-2.71
Mg <sup>2+</sup> + 2 e <sup>-</sup> ⇌ Mg(s)	-2.372
Be <sup>2+</sup> + 2 e <sup>-</sup> ⇌ Be(s)	-1.85
Al <sup>3+</sup> + 3 e <sup>-</sup> ⇌ Al(s)	-1.66
Mn <sup>2+</sup> + 2 e <sup>-</sup> ⇌ Mn(s)	-1.029
2 H <sub>2</sub> O + 2 e <sup>-</sup> ⇌ H <sub>2</sub> (g) + 2 OH <sup>-</sup>	-0.828
Zn <sup>2+</sup> + 2 e <sup>-</sup> ⇌ Zn(s)	-0.762
Cr <sup>3+</sup> + 3 e <sup>-</sup> ⇌ Cr(s)	-0.74
Fe <sup>2+</sup> + 2 e <sup>-</sup> ⇌ Fe(s)	-0.44
Cr <sup>3+</sup> + e <sup>-</sup> ⇌ Cr <sup>2+</sup>	-0.42
Cd <sup>2+</sup> + 2 e <sup>-</sup> ⇌ Cd(s)	-0.40
Co <sup>2+</sup> + 2 e <sup>-</sup> ⇌ Co(s)	-0.28
Ni <sup>2+</sup> + 2 e <sup>-</sup> ⇌ Ni(s)	-0.25
Sn <sup>2+</sup> + 2 e <sup>-</sup> ⇌ Sn(s)	-0.13
Pb <sup>2+</sup> + 2 e <sup>-</sup> ⇌ Pb(s)	-0.13
2 H <sup>+</sup> + 2 e <sup>-</sup> ⇌ H <sub>2</sub> (g)	0.000
S(s) + 2 H <sup>+</sup> + 2 e <sup>-</sup> ⇌ H <sub>2</sub> S(g)	+0.14
Sn <sup>4+</sup> + 2 e <sup>-</sup> ⇌ Sn <sup>2+</sup>	+0.15
Cu <sup>2+</sup> + e <sup>-</sup> ⇌ Cu <sup>+</sup>	+0.159
Cu <sup>2+</sup> + 2 e <sup>-</sup> ⇌ Cu(s)	+0.340
Cu <sup>+</sup> + e <sup>-</sup> ⇌ Cu(s)	+0.520
I <sub>2</sub> (s) + 2 e <sup>-</sup> ⇌ 2 I <sup>-</sup>	+0.54
Fe <sup>3+</sup> + e <sup>-</sup> ⇌ Fe <sup>2+</sup>	+0.77
Ag <sup>+</sup> + e <sup>-</sup> ⇌ Ag(s)	+0.800
Hg <sub>2</sub> <sup>2+</sup> + 2 e <sup>-</sup> ⇌ 2 Hg(l)	+0.80
Hg <sup>2+</sup> + 2 e <sup>-</sup> ⇌ Hg(l)	+0.85
2 Hg <sup>2+</sup> + 2 e <sup>-</sup> ⇌ Hg <sub>2</sub> <sup>2+</sup>	+0.91
Br <sub>2</sub> (l) + 2 e <sup>-</sup> ⇌ 2 Br <sup>-</sup>	+1.07
Pt <sup>2+</sup> + 2 e <sup>-</sup> ⇌ Pt(s)	+1.188
O <sub>2</sub> (g) + 4 H <sup>+</sup> + 4 e <sup>-</sup> ⇌ 2 H <sub>2</sub> O	+1.23
Cl <sub>2</sub> (g) + 2 e <sup>-</sup> ⇌ 2 Cl <sup>-</sup>	+1.36
Au <sup>3+</sup> + 3 e <sup>-</sup> ⇌ Au(s)	+1.52
Co <sup>3+</sup> + e <sup>-</sup> ⇌ Co <sup>2+</sup>	+1.82
F <sub>2</sub> (g) + 2 e <sup>-</sup> ⇌ 2 F <sup>-</sup>	+2.87

E<sup>0</sup> values at 1 M concentration and 1 atm.

atomic #	atomic symbol	element name	atomic mass (IUPAC 2005)	melting point °C	boiling point °C	specific heat capacity (J/g·K)	density (g/mL)	electro-negativity (Pauling)	1 <sup>st</sup> ionization potential (kJ/mol)	common oxidation states
89	Ac	actinium	227	1050	3200	—	10.1	1.1	499	+3
13	Al	aluminum	26.98	660	2467	0.9	2.7	1.61	578	+3
95	Am	americium	243	994	2607	0.11	13.7	1.3	578	+3,4,5,6
51	Sb	antimony	121.8	631	1950	0.21	6.69	2.05	834	+3,5
18	Ar	argon	39.95	-189.2	-185.7	0.52	0.00178	—	1521	0
33	As	arsenic	74.92	817	617	0.33	5.73	2.18	947	±3,+5
85	At	astatine	210	302	337	—	—	2.2	917	—
56	Ba	barium	137.3	725	1640	0.204	3.5	0.89	503	+2
97	Bk	berkelium	247	986	—	—	14	1.3	601	+3,4
4	Be	beryllium	9.012	1278	2970	1.82	1.85	1.57	899	+2
83	Bi	bismuth	209.0	271	1560	0.12	9.75	2.02	703	+3,5
107	Bh	bohrium	272	—	—	—	—	—	—	—
5	B	boron	10.81	2079	2550	1.02	2.34	2.04	801	+3
35	Br	bromine	79.90	-7.2	58.8	0.473	3.12	2.96	1140	±1,+5
48	Cd	cadmium	112.4	320.9	765	0.23	8.65	1.69	868	+2
20	Ca	calcium	40.08	839	1484	0.63	1.55	1	590	+2
98	Cf	californium	251	—	—	—	—	1.3	608	+3
6	C	carbon	12.01	3367	4827	0.71	2.25	2.55	1086	±4
58	Ce	cerium	140.1	798	3257	0.19	6.66	1.12	534	+3,4
55	Cs	cesium	132.9	28.4	669	0.24	1.87	0.79	376	+1
17	Cl	chlorine	35.45	-101	-34.6	0.48	0.00321	3.16	1251	-1
24	Cr	chromium	52.00	1857	2672	0.45	7.19	1.66	653	+3,2,6
27	Co	cobalt	58.93	1495	2870	0.42	8.9	1.88	760	+2,3
112	Cn	copernicium	285	—	—	—	—	—	—	—
29	Cu	copper	63.55	1083	2567	0.38	8.96	1.9	745	+2,1
96	Cm	curium	247	1340	—	—	13.5	1.3	581	+3
110	Ds	darmstadtium	281	—	—	—	—	—	—	—
105	Db	dubnium	268	—	—	—	—	—	—	—
66	Dy	dysprosium	162.5	1412	2567	0.17	8.55	1.22	573	+3
99	Es	einsteinium	252	—	—	—	—	1.3	619	+3
68	Er	erbium	167.3	1529	2868	0.17	9.07	1.24	589	+3
63	Eu	europium	152.0	822	1529	0.18	5.24	—	547	+3,2
100	Fm	fermium	257	—	—	—	—	1.3	627	+3
114	Fl	flerovium	289	—	—	—	—	—	—	—
9	F	fluorine	19.00	-219.8	-188.1	0.82	0.0017	3.98	1681	-1
87	Fr	francium	223	27	677	—	—	0.7	380	+1
64	Gd	gadolinium	157.3	1313	3273	0.23	7.9	1.2	593	+3
31	Ga	gallium	69.72	29.8	2403	0.37	5.9	1.81	579	+3
32	Ge	germanium	72.63	947.4	2830	0.32	5.32	2.01	762	+4,2
79	Au	gold	197.0	1064	3080	0.128	19.3	2.54	890	+3,1
72	Hf	hafnium	178.5	2227	4600	0.14	13.3	1.3	659	+4
108	Hs	hassium	270	—	—	—	—	—	—	—
2	He	helium	4.003	-272.2	-268.9	5.193	0.000179	—	2372	0
67	Ho	holmium	164.9	1474	2700	0.16	8.8	1.23	581	+3
1	H	hydrogen	1.008	-259.1	-252.9	14.304	0.0000699	2.2	1312	±1
49	In	indium	114.8	156.6	2080	0.23	7.31	1.78	558	+3
53	I	iodine	126.9	113.5	184	0.214	4.93	2.66	1008	-1,+5,7
77	Ir	iridium	192.2	2410	4130	0.13	22.4	2.2	878	+4,3,6
26	Fe	iron	55.85	1535	2750	0.44	7.86	1.83	762	+3,2
36	Kr	krypton	83.80	-157	-152	0.248	0.00374	3	1351	0
57	La	lanthanum	138.9	920	3454	0.19	6.15	1.1	538	+3
103	Lr	lawrencium	262	—	—	—	—	—	—	+3
82	Pb	lead	207.2	327.5	1740	0.13	11.4	2.33	716	+2,4
3	Li	lithium	6.968	180.5	1342	3.6	0.543	0.98	520	+1
116	Lv	livermorium	293	—	—	—	—	—	—	—
71	Lu	lutetium	175.0	1663	3402	0.15	9.84	1.27	524	+3
12	Mg	magnesium	24.31	649	1090	1.02	1.74	1.31	738	+2
25	Mn	manganese	54.94	1244	1962	0.48	7.43	1.55	717	+2,3,4,6,7



atomic #	atomic symbol	element name	atomic mass (IUPAC 2005)	melting point °C	boiling point °C	specific heat capacity (J/g·K)	density (g/mL)	electro-negativity (Pauling)	1 <sup>st</sup> ionization potential (kJ/mol)	common oxidation states
109	Mt	meitnerium	276	—	—	—	—	—	—	—
101	Md	mendelevium	258	—	—	—	—	1.3	635	+3,2
80	Hg	mercury	200.6	-38.9	357	0.139	13.5	2	1007	+2,1
42	Mo	molybdenum	95.95	2617	4612	0.25	10.2	2.16	684	+6,3,5
115	Mc	moscovium	288	—	—	—	—	—	—	—
60	Nd	neodymium	144.2	1016	3127	0.19	7	1.14	533	+3
10	Ne	neon	20.18	-248	-248.7	0.904	0.0009	—	2081	0
93	Np	neptunium	237	640	3900	0.12	20.2	1.36	605	+5,3,4,6
28	Ni	nickel	58.69	1453	2730	0.44	8.9	1.91	737	+2,3
113	Nh	nihonium	284	—	—	—	—	—	—	—
41	Nb	niobium	92.91	2468	4742	0.26	8.57	1.6	652	+5,3
7	N	nitrogen	14.01	-209.9	-195.8	1.04	0.00125	3.04	1402	-3
102	No	nobelium	259	—	—	—	—	1.3	642	+2,3
118	Og	oganesson	294	—	—	—	—	—	—	—
76	Os	osmium	190.2	3045	5030	0.13	22.6	2.2	839	+4,6,8
8	O	oxygen	16.00	-218.4	-183	0.92	0.00143	3.44	1314	-2
46	Pd	palladium	106.4	1554	3140	0.24	12	2.2	804	+2,4
15	P	phosphorus	30.97	44.1	280	0.77	1.82	2.19	1012	-3
78	Pt	platinum	195.1	1772	3827	0.13	21.4	2.28	868	+4,2
94	Pu	plutonium	244	641	3232	0.13	19.8	1.28	585	+4,3,5,6
84	Po	polonium	209	254	962	0.12	9.32	2	812	+4,2
19	K	potassium	39.10	63.25	760	0.75	0.86	0.82	419	+1
59	Pr	praseodymium	140.9	931	3017	0.19	6.77	1.13	527	+3,4
61	Pm	promethium	145	1042	3000	0.18	7.26	—	535	+3
91	Pa	protactinium	231.0	1570	4000	0.12	15.4	1.5	568	+5,4
88	Ra	radium	226	700	1140	0.12	5	0.9	509	+2
86	Rn	radon	222	-71	-61.8	0.09	0.00973	—	1037	0
75	Re	rhenium	186.2	3180	5600	0.13	21	1.9	760	+7,4,6
45	Rh	rhodium	102.9	1966	3727	0.242	12.4	2.28	720	+3,4,6
111	Rg	roentgenium	280	—	—	—	—	—	—	—
37	Rb	rubidium	85.47	38.9	686	0.363	1.53	0.82	403	+1
44	Ru	ruthenium	101.1	2310	3900	0.238	12.4	2.2	710	+4,3,6,8
104	Rf	rutherfordium	267	—	—	—	—	—	—	—
62	Sm	samarium	150.4	1074	1794	0.2	7.52	1.17	545	+3,2
21	Sc	scandium	44.96	1541	2832	0.6	2.99	1.36	633	+3
106	Sg	seaborgium	271	—	—	—	—	—	—	—
34	Se	selenium	78.97	217	685	0.32	4.79	2.55	941	+4,-2,+6
14	Si	silicon	28.09	1410	2355	0.71	2.33	1.9	787	+4
47	Ag	silver	107.9	962	2212	0.235	10.5	1.93	731	+1
11	Na	sodium	22.99	97.8	883	1.23	0.971	0.93	496	+1
38	Sr	strontium	87.62	769	1384	0.3	2.54	0.95	549	+2
16	S	sulfur	32.07	112.8	444.7	0.71	2.07	2.58	1000	-2
73	Ta	tantalum	180.9	2996	5425	0.14	16.6	1.5	761	+5
43	Tc	technetium	98	2172	4877	0.21	11.5	1.9	702	+7,4,6
52	Te	tellurium	127.6	449.5	989.8	0.2	6.24	2.1	869	+4,6,-2
117	Ts	tennessine	292	—	—	—	—	—	—	—
65	Tb	terbium	158.9	1365	3230	0.18	8.23	—	569	+3,4
81	Tl	thallium	204.4	303	1457	0.13	11.9	1.62	589	+1,3
90	Th	thorium	232.0	1750	4790	0.12	11.7	1.3	587	+4
69	Tm	thulium	168.9	1545	1950	0.16	9.32	1.25	597	+3,2
50	Sn	tin	118.7	232	2270	0.227	7.31	1.96	709	+4,2
22	Ti	titanium	47.87	1660	3287	0.52	4.54	1.54	659	+4,3,2
74	W	tungsten	183.8	3410	5660	0.13	19.3	2.36	770	+6,4
92	U	uranium	238.0	1132	3818	0.12	19	1.38	598	+6,3,4,5
23	V	vanadium	50.94	1890	3380	0.49	6.11	1.63	651	+5,2,3,4
54	Xe	xenon	131.3	-111.8	-107.1	0.158	0.00589	2.6	1170	0
70	Yb	ytterbium	173.1	819	1196	0.15	6.97	—	603	+3,2
39	Y	yttrium	88.91	1523	3337	0.3	4.47	1.22	600	+3
30	Zn	zinc	65.38	419.6	906	0.39	7.13	1.65	906	+2
40	Zr	zirconium	91.22	1852	4377	0.27	6.51	1.33	640	+4

**Table AA. Bond Dissociation Energies & Bond Lengths**

Values given are *homolytic* bond dissociation energies, meaning that the electrons are divided equally between the two atoms.

Hydrogen Compounds		
Bond	<i>D</i> (kJ/mol)	<i>r</i> (pm)
H – H	432	74
H – B	389	119
H – C	411	109
H – Si	318	148
H – Ge	288	153
H – Sn	251	170
H – N	386	101
H – P	322	144
H – As	247	152
H – O	459	96
H – S	363	134
H – Se	276	146
H – Te	238	170
H – F	565	92
H – Cl	428	127
H – Br	362	141
H – I	295	161

Group VIIA Compounds		
Bond	<i>D</i> (kJ/mol)	<i>r</i> (pm)
F – F	155	142
Cl – Cl	240	199
Br – Br	190	228
I – I	148	267
At – At	116	?
I – O	201	?
I – F	273	191
I – Cl	208	232
I – Br	175	?

Group IIIA Compounds		
Bond	<i>D</i> (kJ/mol)	<i>r</i> (pm)
B – B	293	?
B – O	536	?
B – F	613	?
B – Cl	456	175
B – Br	377	?

Group IVA Compounds		
Bond	<i>D</i> (kJ/mol)	<i>r</i> (pm)
C – C	346	154
C = C	602	134
C ≡ C	835	120
C – Si	318	185
C – Ge	238	195
C – Sn	192	216
C – Pb	130	230
C – N	305	147
C = N	615	129
C ≡ N	887	116
C – P	264	184
C – O	358	143
C = O	799	120
C ≡ O	1072	113
C – B	356	?
C – S	272	182
C = S	573	160
C – F	485	135
C – Cl	327	177
C – Br	285	194
C – I	213	214
Si – Si	222	233
Si – N	355	?
Si – O	452	163
Si – S	293	200
Si – F	565	160
Si – Cl	381	202
Si – Br	310	215
Si – I	234	243
Ge – Ge	188	241
Ge – N	257	?
Ge – F	470	168
Ge – Cl	349	210
Ge – Br	276	230
Ge – I	212	?
Sn – F	414	?
Sn – Cl	323	233
Sn – Br	273	250
Sn – I	205	270
Pb – F	331	?
Pb – Cl	243	242
Pb – Br	201	?
Pb – I	142	279

Group VA Compounds		
Bond	<i>D</i> (kJ/mol)	<i>r</i> (pm)
N – N	167	145
N = N	418	125
N ≡ N	942	110
N – O	201	140
N = O	607	121
N – F	283	136
N – Cl	313	175
P – P	201	221
P – O	335	163
P = O	544	150
P = S	335	186
P – F	490	154
P – Cl	326	203
P – Br	264	?
P – I	184	?
As – As	146	243
As – O	301	178
As – F	484	171
As – Cl	322	216
As – Br	458	233
As – I	200	254
Sb – Sb	121	?
Sb – F	440	?
Sb – Cl <sub>(5)</sub>	248	?
Sb – Cl <sub>(3)</sub>	315	232

Group VIA Compounds		
Bond	<i>D</i> (kJ/mol)	<i>r</i> (pm)
O – O	142	148
O = O	494	121
O – F	190	142
S = O	522	143
S – S <sub>(8)</sub>	226	205
S = S	425	149
S – F	284	156
S – Cl	255	207
Se – Se	172	?
Se = Se	272	215

Table BB. Thermodynamic Data

Standard enthalpy of formation ( $\Delta H_f^\circ$ ) & standard entropy ( $S^\circ$ ) for selected compounds. Note that standard enthalpy values are in kilojoules per mole, whereas entropy values are in joules per mole-Kelvin.

Subst.	State	$\Delta H_f^\circ$ ( $\frac{\text{kJ}}{\text{mol}}$ )	$S^\circ$ ( $\frac{\text{J}}{\text{mol}\cdot\text{K}}$ )
Ag	s	0	42.6
Ag <sup>+</sup>	aq	105.79	72.7
AgCl	s	-127.01	96.2
AgBr	s	-100.4	107.1
AgNO <sub>3</sub>	s	-124.4	140.9
Al	s	0	28.3
Al <sup>3+</sup>	aq	-538.4	-321.7
AlCl <sub>3</sub>	s	-704	110.7
Al <sub>2</sub> O <sub>3</sub>	s	-1675.7	50.9
Al(OH) <sub>3</sub>	s	-1277	
Ba	s	0	62.8
BaCl <sub>2</sub>	s	-858.6	123.7
BaCO <sub>3</sub>	s	-1216.3	112.1
Ba(NO <sub>3</sub> ) <sub>2</sub>	s	-992	214
BaO	s	-553.5	70.4
Ba(OH) <sub>2</sub>	s	-998.2	112
BaSO <sub>4</sub>	s	-1473.2	132.2
Be	s	0	10
BeO	s	-599	14
Br <sub>2</sub>	l	0	152.2
Br <sup>-</sup>	aq	-121	82
C	s	0	5.7
CCl <sub>4</sub>	l	-135.4	216.4
CHCl <sub>3</sub>	l	-134.5	201.7
CH <sub>4</sub>	g	-74.8	186.2
C <sub>2</sub> H <sub>2</sub>	g	+226.7	200.8
C <sub>2</sub> H <sub>4</sub>	g	+52.3	219.5
C <sub>2</sub> H <sub>6</sub>	g	-84.7	229.5
C <sub>3</sub> H <sub>8</sub>	g	-103.8	269.9
CH <sub>3</sub> OH	l	-238.7	126.8
C <sub>2</sub> H <sub>5</sub> OH	l	-277.7	160.7
C <sub>6</sub> H <sub>12</sub> O <sub>6</sub>	s	-1275	212
CO	g	-110.53	197.6
CO <sub>2</sub>	g	-393.51	213.6
CO <sub>3</sub> <sup>2-</sup>	aq	-675.23	-56.9
Ca	s	0	41.4
Ca <sup>2+</sup>	aq	-543.0	-53.1
CaCl <sub>2</sub>	s	-795.8	104.6
CaCO <sub>3</sub>	s	-1206.9	92.9
CaO	s	-634.92	39.8
Ca(OH) <sub>2</sub>	s	-986.1	83.4
Ca <sub>3</sub> (PO <sub>4</sub> ) <sub>2</sub>	s	-4126	241
CaSO <sub>4</sub>	s	-1434.1	106.7
Cd	s	0	51.8
Cd <sup>2+</sup>	aq	-75.92	-73.2
CdCl <sub>2</sub>	s	-391.5	115.3
CdO	s	-258.35	54.8
Cd(OH) <sub>2</sub>	s	-561	96
CdS	s	-162	65
CdSO <sub>4</sub>	s	-935	123
Cl <sub>2</sub>	g	0	223.0
Cl <sup>-</sup>	aq	-167.080	56.5
ClO <sub>4</sub> <sup>-</sup>	aq	-128.10	182.0
Cr	s	0	23.8
Cr <sub>2</sub> O <sub>3</sub>	g	-1139.7	81.2
Cu	s	0	33.2
Cu <sup>+</sup>	aq	+71.7	40.6
Cu <sup>2+</sup>	aq	+64.8	-99.6
CuO	s	-157.3	42.6
Cu <sub>2</sub> O	s	-168.6	93.1
Cu(OH) <sub>2</sub>	s	-450	108
CuS	s	-53.1	66.5
Cu <sub>2</sub> S	s	-79.5	120.9
CuSO <sub>4</sub>	s	-771.4	107.6
F <sup>-</sup>	aq	-335.35	-13.8
F <sub>2</sub>	g	0	202.7
Fe	s	0	27.3
Fe(OH) <sub>3</sub>	s	-823.0	106.7
FeO	s	-272	61
Fe <sub>2</sub> O <sub>3</sub>	s	-824.2	87.4
Fe <sub>3</sub> O <sub>4</sub>	s	-1118.4	146.4
FeSO <sub>4</sub>	s	-929	121
H <sub>2</sub>	g	0	130.6
H <sup>+</sup>	aq	0	0.0
HBr	g	-36.29	198.6
HCO <sub>3</sub> <sup>-</sup>	aq	-689.93	91.2
HCl	g	-92.31	186.8
HF	g	-273.30	173.7
HI	g	26.50	206.5
HNO <sub>3</sub>	aq	-174.1	155.6
HPO <sub>4</sub> <sup>2-</sup>	aq	-1299.0	-33.5
HSO <sub>4</sub> <sup>-</sup>	aq	-886.9	131.8
H <sub>2</sub> O	l	-285.830	69.9
H <sub>2</sub> O	g	-241.826	188.7
H <sub>2</sub> PO <sub>4</sub> <sup>-</sup>	aq	-1302.6	90.4
H <sub>2</sub> S	g	-20.6	205.7
Hg	l	0	76.0
Hg <sup>2+</sup>	aq	170.21	-32.2
HgO	cr	-90.79	70.3
I <sup>-</sup>	aq	-56.78	111.3
I <sub>2</sub>	s	0	116.1
K	s	0	64.2
K <sup>+</sup>	aq	-252.14	102.5
KBr	s	-393.8	95.9
KCl	s	-436.7	82.6
KClO <sub>3</sub>	s	-397.7	143.1
KClO <sub>4</sub>	s	-432.8	151.0
KNO <sub>3</sub>	s	-494.6	133.0
Mg	s	0	32.7
Mg <sup>2+</sup>	aq	-467.0	-138.1
MgCl <sub>2</sub>	s	-641.3	89.6
MgCO <sub>3</sub>	s	-1095.8	65.7
MgO	s	-601.60	26.9
Mg(OH) <sub>2</sub>	s	-924.5	63.2
MgSO <sub>4</sub>	s	-1284.9	91.6
Mn	s	0	32.0
Mn <sup>2+</sup>	aq	-220.8	-73.6
MnO	s	-385.2	59.7
MnO <sub>2</sub>	s	-520.0	53.0
N <sub>2</sub>	g	0	191.5
NH <sub>3</sub>	g	-45.94	192.3
NH <sub>4</sub> <sup>+</sup>	aq	-133.26	113.4
NO <sub>2</sub> <sup>-</sup>	aq	-104.6	123.0
NO <sub>3</sub> <sup>-</sup>	aq	-206.85	146.4
N <sub>2</sub> H <sub>4</sub>	l	+50.6	121.2
NH <sub>4</sub> Cl	s	-314.4	94.6
NH <sub>4</sub> NO <sub>3</sub>	s	-365.6	151.1
NO	g	+90.2	210.7
NO <sub>2</sub>	g	+33.2	240.0
N <sub>2</sub> O	g	+82	220
N <sub>2</sub> O <sub>4</sub>	g	+9.2	304.2
Na	s	0	51.2
Na <sup>+</sup>	aq	-240.34	59.0
Na <sub>2</sub> CO <sub>3</sub>	s	-1131	136
NaHCO <sub>3</sub>	s	-948	102
NaCl	s	-411.2	72.1
NaF	s	-573.6	51.5
NaNO <sub>3</sub>	s	-467	116
NaOH	s	425.6	64.5
Ni	s	0	29.9
NiCl <sub>2</sub>	s	-316	107
NiO	s	-239.7	38.0
OH <sup>-</sup>	aq	-230.015	-10.8
O <sub>2</sub>	g	0	205.0
P <sub>4</sub>	s	0	164.4
PCl <sub>3</sub>	g	-287.0	311.7
PCl <sub>5</sub>	g	-374.9	364.5
PH <sub>3</sub>	g	+5	210
PO <sub>4</sub> <sup>3-</sup>	aq	-1277.4	-222
Pb	s	0	64.8
Pb <sup>2+</sup>	aq	0.92	10.5
PbBr <sub>2</sub>	s	-278.7	161.5
PbCl <sub>2</sub>	s	-359.4	136.0
PbO	s	-219.0	66.5
PbO <sub>2</sub>	s	-277.4	68.6
PbS	s	-100	91
PbSO <sub>4</sub>	s	-920	149
S	s	0	31.8
SO <sub>2</sub>	g	-296.81	248.1
SO <sub>3</sub>	g	-395.7	256.7
SO <sub>4</sub> <sup>2-</sup>	aq	-909.34	20.1
S	-	2	18.8
Si	s	0	18.8
SiO <sub>2</sub>	s	-910.7	41.8
Sn	s	0	51.6
Sn <sup>2+</sup>	aq	-8.9	-17.4
SnO <sub>2</sub>	s	-577.63	52.3
Zn	s	0	41.6
Zn <sup>2+</sup>	aq	-153.39	-112.1
ZnI <sub>2</sub>	s	-208.0	161.1
ZnO	s	-350.46	43.6
ZnS	s	-206.0	57.7

**Table CC. Some Common & Equivalent Units and Approximate Conversions**

Some Common & Equivalent Units			
Length	1 in. (inch)	=	2.54 cm
	12 in.	=	1 ft. (foot)
	3 ft.	=	1 yd. (yard)
	5,280 ft.	=	1 mi. (mile) = 1,760 yd
Mass	1 lb. (pound)	=	16 oz. ~ 454 g
	1 ton	=	2000 lb.
	1 tonne	=	1000 kg
Volume	1 pinch	=	$\leq \frac{1}{8}$ teaspoon
	3 teaspoons	=	1 tablespoon (Tbsp)
	2 tablespoons	=	1 ounce
	8 oz. (ounces)	=	1 cup
	2 cups	=	1 pint
	2 pints	=	1 quart
	4 quarts	=	1 gallon

Some APPROXIMATE Conversions			
Length	1 cm	~	width of a small paper clip
	6 in.	~	length of a (US) dollar bill
	1 ft.	~	30 cm
	1 m	~	1 yd.
	1 mi.	~	1.6 km
	0.6 km	~	1 mi.
Volume	1 pinch	~	$\leq \frac{1}{8}$ teaspoon
	1 mL	~	10 drops
	1 teaspoon (tsp)	~	5 mL ~ 60 drops
	1 tablespoon (Tbsp)	=	3 tsp ~ 15 mL
	2 Tbsp.	=	1 fl. oz. ~ 30 mL
	1 C (cup)	=	8 fl. oz. ~ 250 mL
	1 qt. (quart)	~	1 L
Mass	1 small paper clip	~	1 gram (g)
	1 nickel (5¢ coin)	~	5 g
	1 oz.	~	30 g
	1 pound (lb.)	=	16 oz. ~ 0.5 kg
	1 ton	=	2000 lb. ~ 1 tonne
Speed	60 mi./h	~	100 km/h ~ 30 m/s
Density	air	~	1 g/L
	fresh water	~	1 g/mL ~ 8.3 lb./gal.
		~	1 tonne/m <sup>3</sup> ~ 1 ton/yd. <sup>3</sup>

Table DD. Selected Formulas and Equations				
Density	$D = \frac{M}{V}$	$D =$ density	$M =$ mass	$V =$ volume
Mole Conversions	1 mol = [molar mass] g (molar mass = formula weight = gram formula mass) 1 mol = 22.4 L of gas at 0 °C and 1 atm 1 mol = $6.022 \times 10^{23}$ molecules, atoms, or particles			
Percent Error	$\% \text{ error} = \frac{\text{measured value} - \text{accepted value}}{\text{accepted value}} * 100\%$			
Percent Composition	$\% \text{ composition} = \frac{\text{mass of part}}{\text{mass of whole}} * 100\%$			
Concentration	$\text{molarity (M)} = \frac{\text{moles of solute}}{\text{liter of solution}}$		$\text{normality (N)} = \frac{(\text{moles of solute})(\text{dissociation factor})}{\text{liter of solution}}$	
	$\text{molality (m)} = \frac{\text{moles of solute}}{\text{kg of solvent}}$			
	$\text{mole fraction } (\chi_A) = \frac{\text{moles of A}}{\text{total moles}}$		$\text{parts per million (ppm)} = \frac{\text{grams of solute}}{\text{grams of solvent}} \times 1,000,000$	
Gases	$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$  $PV = nRT$	$P =$ pressure $V =$ volume (L)  $R = 0.0821 \frac{\text{L}\cdot\text{atm}}{\text{mol}\cdot\text{K}} = 8.31 \frac{\text{L}\cdot\text{kPa}}{\text{mol}\cdot\text{K}} = 62.4 \frac{\text{L}\cdot\text{torr}}{\text{mol}\cdot\text{K}}$	$n =$ moles $T =$ temperature (K)	
Pressure	1 atm = 101.3 kPa = 760 torr = 760 mm Hg = 29.92 in. Hg = 1.013 bar = 14.7 psi $P_A = \chi_A P_T$ $P_T = P_A + P_B + P_C + \dots$	$P_A =$ partial pressure of A $P_T =$ total pressure	$\chi_A =$ mole fraction of A	
Titration	$N_A V_A = N_B V_B$	$N_A =$ normality of $\text{H}_3\text{O}^+$ $V_A =$ volume of acid	$N_B =$ normality of $\text{OH}^-$ $V_B =$ volume of base	
Colligative Properties	$\Delta T_f = imK_f$  $\Delta T_b = imK_b$  $\pi = iM RT = N RT$	$\Delta T_f =$ freezing point depression (°C) $K_f =$ freezing point depression constant ( $\text{H}_2\text{O} = 0.52 \text{ }^\circ\text{C}/\text{m}$ ) $K_b =$ boiling point elevation constant ( $\text{H}_2\text{O} = 1.86 \text{ }^\circ\text{C}/\text{m}$ ) $i =$ van't Hoff factor (dissociation factor) $m =$ molality $R =$ ideal gas const.	$\Delta T_b =$ boiling point elevation (°C)  $\pi =$ osmotic pressure $M =$ molarity (mol/L) $N =$ normality (mol/L) $T =$ temperature (K)	
Acid-Base	$\text{pH} = -\log[\text{H}_3\text{O}^+]$ $\text{pOH} = -\log[\text{OH}^-]$ $\text{pH} + \text{pOH} = 14$ $K_w = K_a \cdot K_b = 1 \times 10^{-14}$	$K_a = \frac{[\text{H}_3\text{O}^+][\text{A}^-]}{[\text{HA}]}$  $K_b = \frac{[\text{H}^+\text{B}][\text{OH}^-]}{[\text{B}]}$	$\text{p}K_a = -\log(K_a)$  $\text{p}K_b = -\log(K_b)$	$\text{pH} = \text{p}K_a + \log \frac{[\text{base}]}{[\text{acid}]}$
Equilibrium	$K_p = K_c(RT)^{\Delta n}$	$K_p =$ gas press. equil. const.	$K_c =$ molar conc. equil. const.	$\Delta n =$ change in # moles
Heat	$q = m C_p \Delta T$ $q = m \Delta H_f$ $q = m \Delta H_v$	$q =$ heat $m =$ mass $C_p =$ specific heat capacity	$\Delta T =$ change in temperature $\Delta H_f =$ heat of fusion $\Delta H_v =$ heat of vaporization	
Thermodynamics	$\Delta G^\circ = \Delta H^\circ - T\Delta S^\circ$ $\Delta G^\circ = -RT \ln K$	$G^\circ =$ standard free energy $H^\circ =$ standard enthalpy	$S^\circ =$ standard entropy $T =$ temperature (K)	
Electrochemistry	$I = \frac{q}{t}$  $\Delta G^\circ = -nFE^\circ$	$I =$ current (amperes)  $F =$ Faraday's constant = 96,000 Coulomb per mole electrons $n =$ moles of electrons	$q =$ charge (Coulomb s) $t =$ time (seconds)  $E^\circ =$ standard reduction potential	
Temperature	$K = \text{ }^\circ\text{C} + 273.15$ $^\circ\text{C} = (^\circ\text{F} - 32) * 5/9$	$K =$ Kelvin $^\circ\text{C} =$ degrees Celsius	$^\circ\text{F} =$ degrees Fahrenheit	
Radioactive Decay	$A = A_0 \left(\frac{1}{2}\right)^{\frac{t}{\tau_{1/2}}}$	$A =$ amount left $A_0 =$ original amount $\tau_{1/2} =$ half-life	$t =$ total elapsed time $n =$ number of half-lives = $\frac{t}{\tau_{1/2}}$	

