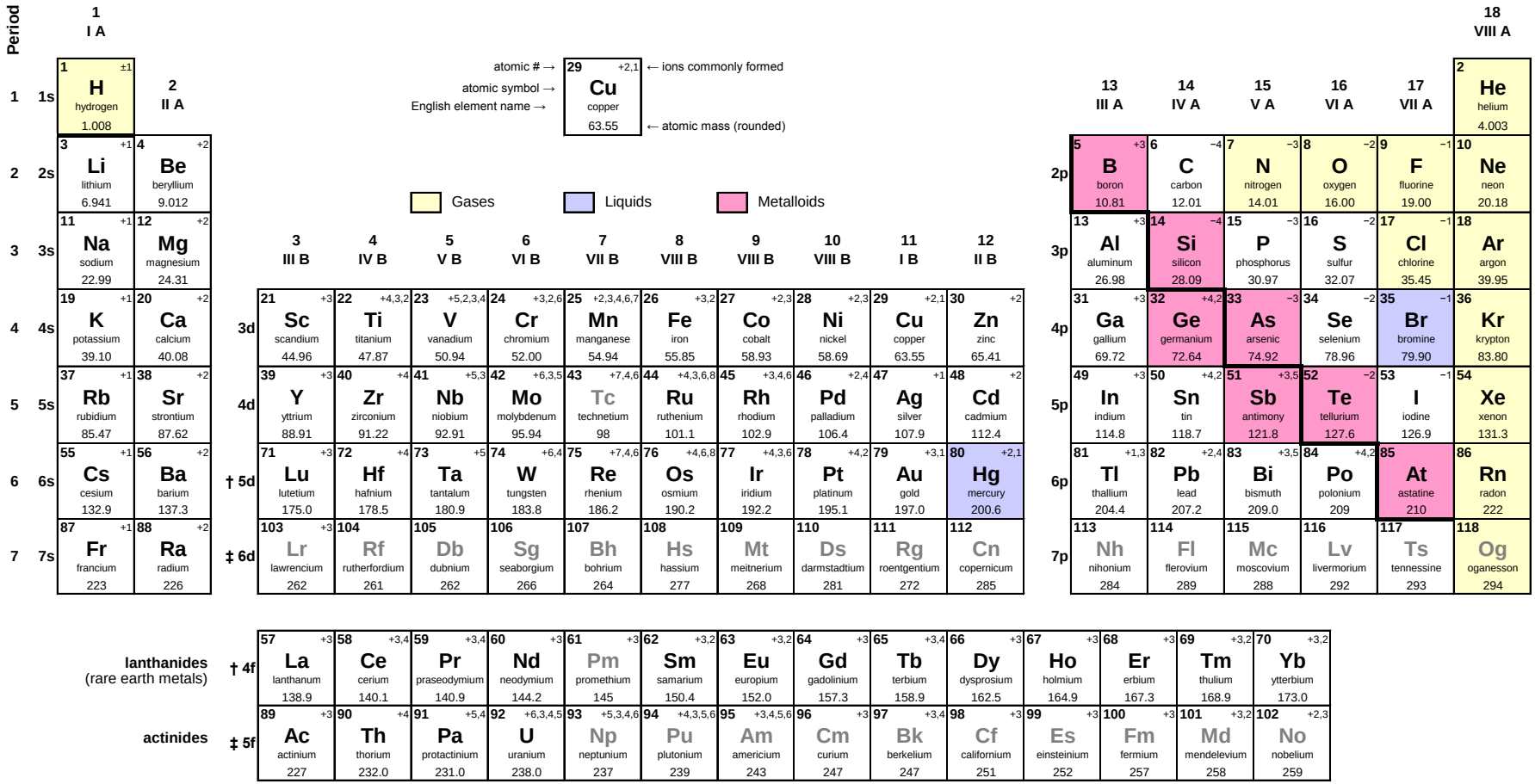
Periodic Table of the Elements



Common Polyatomic Ions

ammonium	NH_4^{+1}	perchlorate	ClO_4^{-1}	hydrogen sulfate	HSO_4^{-1}	sulfate	SO_4^{-2}	oxalate	$C_2O_4^{-2}$
hydronium	H_3O^{+1}	chlorate	ClO_3^{-1}			sulfite	SO_3^{-2}	silicate	SiO_3^{-2}
acetate	$C_2H_3O_2^{-1}$ CH_3COO^{-1}	chlorite	ClO_2^{-1}	permanganate	MnO_4^{-1}	phthalate	$C_8H_4O_4^{-2}$	peroxide	O_2^{-2}
		hypochlorite	ClO^{-1}	periodate	IO_4^{-1}	chromate	CrO_4^{-2}	tetraborate	$B_4O_7^{-2}$
hydroxide	OH^{-1}	nitrate	NO_3^{-1}	hydrogen carbonate	HCO_3^{-1}	dichromate	$Cr_2O_7^{-2}$	borate	BO_3^{-3}
cyanide	CN^{-1}	nitrite	NO_2^{-1}			carbonate	CO_3^{-2}	arsenate	AsO_4^{-3}
cyanate	OCN^{-1}	bromate	BrO_3^{-1}	dihydrogen phosphate	$H_2PO_4^{-1}$	hydrogen phosphate	HPO_4^{-2}	phosphate	PO_4^{-3}
thiocyanate	SCN^{-1}	iodate	IO_3^{-1}					orthosilicate	SiO_4^{-4}

Chemistry Reference Tables[1]

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 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, ℓ	volume
part per million	ppm	concentration
molarity	M, $\frac{\text{mol}}{\ell}$	concentration

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-	μ (or u)

[1] adapted from: The University of the State of New York. The State Education Department. Albany, NY. 12234. 2002 Edition. Reference Tables for Physical Setting/Chemistry. http://www.nysedregents.org/testing/reftable/chemref2002.pdf

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_{vap} (kPa)	density (g/cm^3)
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

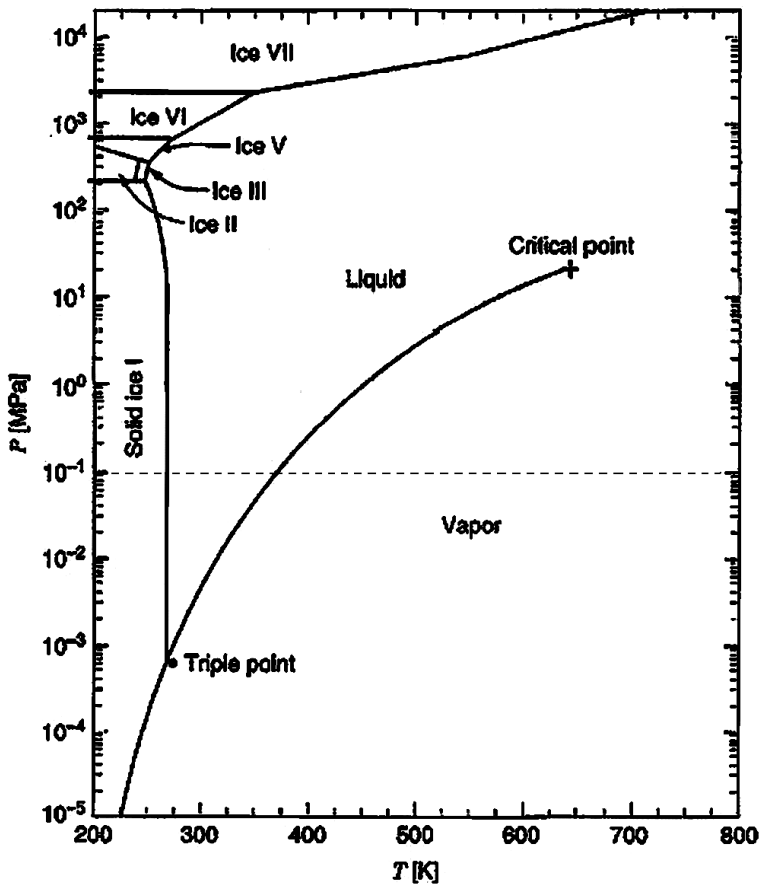


Table G. Solubility Guidelines

Ions That Form SOLUBLE Compounds	EXCEPT with	Ions That Form INSOLUBLE Compounds	EXCEPT with
Group I ions (Li^+, Na^+, *etc.*) ammonium (NH_4^+) nitrate (NO_3^-) hydrogen carbonate (HCO_3^-) chlorate (ClO_3^-) perchlorate (ClO_4^-)		carbonate (CO_3^{2-}) chromate (CrO_4^{2-}) phosphate (PO_4^{3-}) sulfite (SO_3^{2-})	Group I ions, ammonium (NH_4^+)
		sulfide (S^{2-})	Group I ions, Group II ions, NH_4^+
acetate ($C_2H_3O_2^-$ or CH_3COO^-)	Ag^+	hydroxide (OH^-)	Group I ions, NH_4^+, Ba^{2+}, Sr^{2+}, Tl^+
halides (Cl^-, Br^-, I^-)	Ag^+, Cu^+, Pb^{2+}, Hg_2^{2+}	oxide (O^{2-})	
sulfates (SO_4^{2-})	Ca^{2+}, Sr^{2+}, Ba^{2+}, Ag^+, Pb^{2+}		

Table H. K_{sp} Values for Some Insoluble Salts at 25°C

Compound	K_{sp}
$MgCO_3$	1.0×10^{-5}
$PbCl_2$	1.7×10^{-5}
BaF_2	2.0×10^{-6}
CuCl	1.0×10^{-6}
PbI_2	1.6×10^{-8}
AgOH	1.0×10^{-8}
$BaCO_3$	8.1×10^{-9}
$CaCO_3$	3.8×10^{-9}
$SrCO_3$	9.4×10^{-10}
AgCl	1.8×10^{-10}
$BaSO_4$	1.1×10^{-10}
CaF_2	3.9×10^{-11}
$Mg(OH)_2$	1.0×10^{-11}
Ag_2CrO_4	9.0×10^{-12}
CuI	5.0×10^{-12}
AgBr	3.3×10^{-13}
$PbSO_4$	2.5×10^{-13}
$PbCO_3$	1.6×10^{-13}
$Mn(OH)_2$	4.0×10^{-14}
$PbCrO_4$	1.8×10^{-14}
$Fe(OH)_2$	1.6×10^{-14}
AgI	1.5×10^{-16}
$Zn(OH)_2$	7.9×10^{-18}
FeS	4.0×10^{-18}
HgCl	2.0×10^{-18}
ZnS	1.0×10^{-23}
PbS	8.4×10^{-28}
CdS	3.6×10^{-29}
$Al(OH)_3$	1.6×10^{-34}
CuS	8.7×10^{-36}
$Fe(OH)_3$	1.3×10^{-36}
Ag_2S	2.0×10^{-50}
HgS	3.0×10^{-53}

Figure I. Solubilities of Selected Compounds

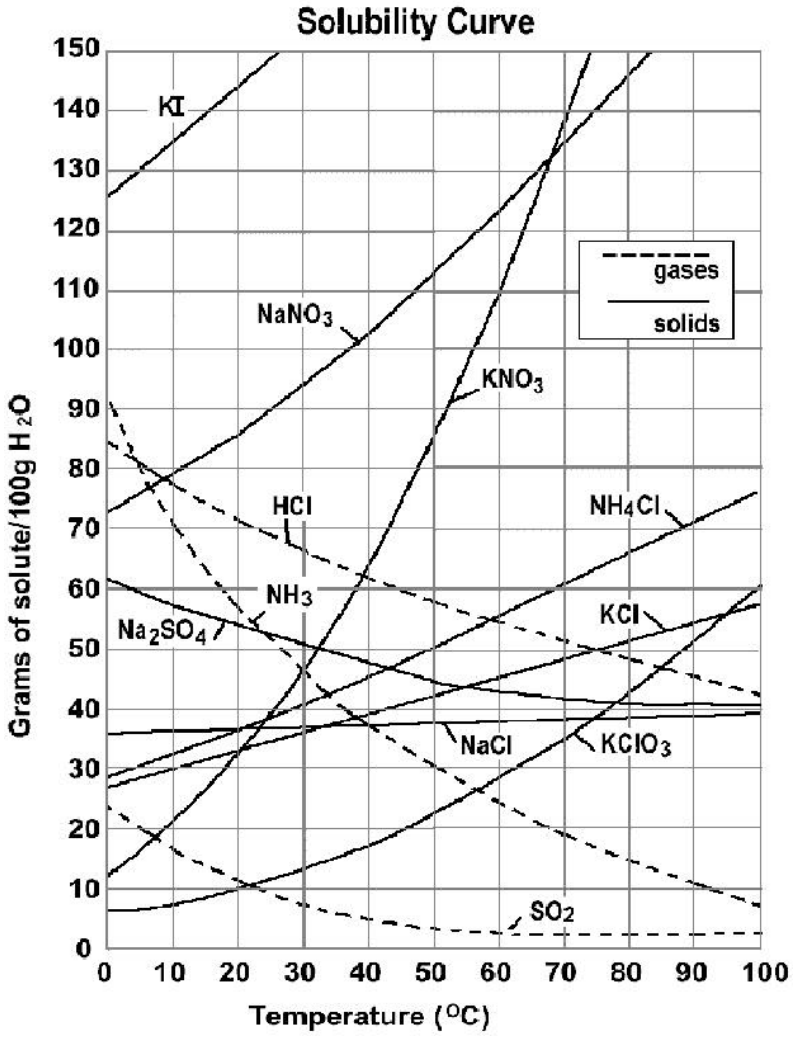


Table J. Number Prefixes

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-

Table K. Polyatomic Ions

ion	formula	ion	formula	ion	formula	ion	formula
americyl	AmO_2^{2+}	ammonium	NH_4^+	cyanate	OCN^-	dichromate	$Cr_2O_7^{2-}$
carbonyl	CO^{2+}	hydronium	H_3O^+	thiocyanate	SCN^-	imide	NH^{2-}
thiocarbonyl	CS^{2+}	iodyl	IO_2^+	selenocyanate	$SeCN^-$	molybdate	MoO_4^{2-}
neptunyl	NpO_2^{2+}	nitrosyl	NO^+	tellurocyanate	$TeCN^-$	peroxide	O_2^{2-}
plutoryl	PuO_2^{2+}	thionitrosyl	NS^+	hydroxide	OH^-	oxalate	$C_2O_4^{2-}$
selinyl	SeO^{2+}	phosphoryl	PO^+	iodate	IO_3^-	phthalate	$C_8H_4O_4^{2-}$
selenoyl	SeO_2^{2+}	thiophosphoryl	PS^+	methanolate	CH_3O^-	selenate	SeO_4^{2-}
thionyl / sulfinyl	SO^{2+}	phospho	PO_2^+	methanethiolate	CH_3S^-	disulfide	S_2^{2-}
		acetate	CH_3COO^-	ethanolate	$C_2H_5O^-$	sulfate	SO_4^{2-}
sulfonyl / sulfuryl	SO_2^{2+}	amide	NH_2^-	permanganate	MnO_4^-	thiosulfate	$S_2O_3^{2-}$
		hydroxylamide	$NHOH^-$	nitrate	NO_3^-	dithionate	$S_2O_4^{2-}$
uranyl	UO^{2+}	azide	N_3^-	superoxide	O_2^-	silicate	SiO_3^{2-}
vanadyl	VO^{2+}	hydrazide	$N_2H_3^-$	tetraborate	$B_4O_7^{2-}$	borate	BO_3^{3-}
mercury (II)	Hg^{2+}	bromate	BrO_3^-	carbide	C_2^{2-}	arsenate	AsO_4^{3-}
mercury (I)	Hg_2^{2+}	chlorate	ClO_3^-	carbonate	CO_2^{2-}	phosphate	PO_4^{3-}
		cyanide	CN^-	chromate	CrO_4^{2-}	orthosilicate	SiO_4^{4-}

Table L. Flame Test Colors

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

Table M. Aqueous Ion Colors

Ion	Color	Ion	Color
Cu^+	green	V^{2+}	violet
Cu^{2+}	blue	V^{3+}	blue-green
Fe^{2+}	yellow-green	CrO_4^{2-}	yellow
Fe^{3+}	orange-red	$Cr_2O_7^{2-}$	orange
Cr^{3+}	violet [$Cr(NO_3)_3$] to green [$CrCl_3$]	$Cu(NH_3)_4^{2+}$	dark blue
Ni^{2+}	green	$FeSCN^{2+}$	red-brown (wine-red to dark orange)
Mn^{2+}	pink	Co^{2+}	pink
Mn^{7+}	purple (*e.g.*, the MnO_4^- ion)	$CoCl_4^{2-}$	blue
Pb^{3+}	blue-green (Pb^{2+} and Pb^{4+} are clear)	$Ti(H_2O)_6^{3+}$	purple

Table N. Colors of Assorted Compounds

Compound	Color	Compound	Color
F_2	pale yellow gas	NO	colorless gas
Cl_2	green-yellow gas	NO_2	brown gas
Br_2	red-brown liquid	metallic sulfides	of transition metals tend to be black
I_2	dark metallic solid; dark violet vapor	metallic oxides	of colored transition metals tend to be colored
S_8	yellow odorous solid		
PbI_2	bright yellow precipitate		
Fe_2O_3	reddish-brown (rust)		

Table O. Common Acids	
Formula	**Name**
HCl *(aq)*	hydrochloric acid
HNO_3 *(aq)*	nitric acid
H_2SO_4 *(aq)*	sulfuric acid
H_3PO_4 *(aq)*	phosphoric acid
H_2CO_3 *(aq)*	carbonic acid
$HC_2H_3O_2$ *(aq)* or CH_3COOH *(aq)*	ethanoic acid (acetic acid)

Table Q. Common Bases	
Formula	**Name**
NaOH *(aq)*	sodium hydroxide
KOH *(aq)*	potassium hydroxide
$Ca(OH)_2$ *(aq)*	calcium hydroxide
NH_3 *(aq)*	aqueous ammonia

Table R. Common Acid-Base Indicators		
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

Table P. pK_a Values for Common Acids		
Acid	**pK_a**	**Conj. Base**
H_2O	15.7	OH^-
HPO_4^{2-}	12.6	PO_4^{3-}
HCO_3^-	10.2	CO_3^{2-}
NH_4^+	9.2	NH_3
HCN	9.1	CN^-
$H_2PO_4^-$	7.2	HPO_4^{2-}
H_2S	7.0	HS^-
H_2CO_3	6.4	HCO_3^-
CH_3COOH	4.8	CH_3COO^-
HCOOH	3.7	$HCOO^-$
HNO_2	3.3	NO_2^-
HF	3.2	F^-
$C_6H_8O_7$ (citric acid)	3.1	$C_6H_7O_7^-$
H_3PO_4	2.2	$H_2PO_4^-$
HSO_4^-	2.0	SO_4^{2-}
HNO_3	−1.4	NO_3^-
H_3O^+	−1.7	H_2O
HCl	−7.0	Cl^-
HBr	−9.0	Br^-
HI	−10	I^-
$HClO_4$	−10	ClO_4^-
H_2SO_4	−12	HSO_4^-

Any acid with a pK_a value less than 0 is a strong acid; any base with a pK_a value greater than 14 is a strong base.

Table S. Symbols Used in Nuclear Chemistry		
Name	**Notation**	**Symbol**
alpha particle	${}^{4}_{2}\text{He}$ or ${}^{4}_{2}\alpha$	α
beta particle (electron)	${}^{0}_{-1}e$ or ${}^{0}_{-1}\beta$	β^-
gamma radiation	${}^{0}_{0}\gamma$	γ
neutron	${}^{1}_{0}n$	n
proton	${}^{1}_{1}\text{H}$ or ${}^{1}_{1}p$	p
positron	${}^{0}_{+1}e$ or ${}^{0}_{+1}\beta$	β^+

Table U. Constants Used in Nuclear Chemistry	
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
Bequerel (Bq)	1 disintegration/second
Curie (Ci)	3.7×10^{10} Bq

Figure V. Neutron/Proton Stability Band

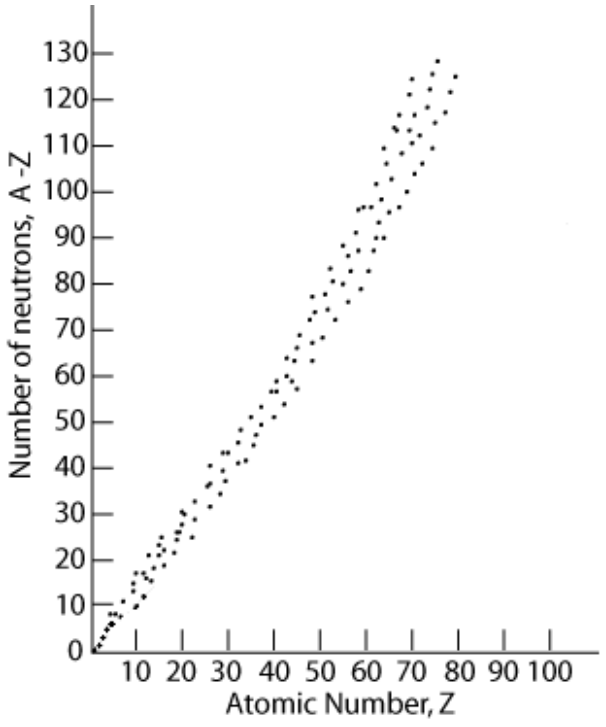


Table T. Selected Radioisotopes		
Nuclide	**Half-Life**	**Decay Mode**
${}^{3}\text{H}$	12.26 y	β^-
${}^{14}\text{C}$	5730 y	β^-
${}^{16}\text{N}$	7.2 s	β^-
${}^{19}\text{Ne}$	17.2 s	β^+
${}^{24}\text{Na}$	15 h	β^-
${}^{27}\text{Mg}$	9.5 min	β^-
${}^{32}\text{P}$	14.3 d	β^-
${}^{36}\text{Cl}$	3.01×10^5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

Table W. Activity Series

Metals		Nonmetals
Reacts with cold H_2O and acids, replacing hydrogen. Reacts with O_2, forming oxides.	Cs Rb K Na Li Ba Sr Ca	F_2 Cl_2 Br_2 I_2
Reacts with steam (not cold H_2O) and acids, replacing hydrogen. Reacts with O_2, forming oxides.	Mg Be Al Mn Zn Cr Fe Cd	
Does not react with H_2O. Reacts with acids, replacing hydrogen. Reacts with O_2, forming oxides.	Co Ni Sn Pb H_2	
Reacts with O_2, forming oxides.	Sb Bi Cu	
Fairly unreactive, forming oxides only indirectly.	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 X).

Table X. Std. Reduction Potentials

Half-Reaction	E^0 (V)
$Li^+ + e^- \leftrightarrows Li(s)$	−3.040
$Cs^+ + e^- \leftrightarrows Cs(s)$	−3.026
$Rb^+ + e^- \leftrightarrows Rb(s)$	−2.98
$K^+ + e^- \leftrightarrows K(s)$	−2.931
$Ba^{2+} + 2e^- \leftrightarrows Ba(s)$	−2.912
$Sr^{2+} + 2e^- \leftrightarrows Sr(s)$	−2.899
$Ca^{2+} + 2e^- \leftrightarrows Ca(s)$	−2.868
$Na^+ + e^- \leftrightarrows Na(s)$	−2.71
$Mg^{2+} + 2e^- \leftrightarrows Mg(s)$	−2.372
$Be^{2+} + 2e^- \leftrightarrows Be(s)$	−1.85
$Al^{3+} + 3e^- \leftrightarrows Al(s)$	−1.66
$Mn^{2+} + 2e^- \leftrightarrows Mn(s)$	−1.029
$2H_2O + 2e^- \leftrightarrows H_2(g) + 2OH^-$	−0.828
$Zn^{2+} + 2e^- \leftrightarrows Zn(s)$	−0.762
$Cr^{3+} + 3e^- \leftrightarrows Cr(s)$	−0.74
$Fe^{2+} + 2e^- \leftrightarrows Fe(s)$	−0.44
$Cr^{3+} + e^- \leftrightarrows Cr^{2+}$	−0.42
$Cd^{2+} + 2e^- \leftrightarrows Cd(s)$	−0.40
$Co^{2+} + 2e^- \leftrightarrows Co(s)$	−0.28
$Ni^{2+} + 2e^- \leftrightarrows Ni(s)$	−0.25
$Sn^{2+} + 2e^- \leftrightarrows Sn(s)$	−0.13
$Pb^{2+} + 2e^- \leftrightarrows Pb(s)$	−0.13
$2H^+ + 2e^- \leftrightarrows H_2(g)$	0.000
$S(s) + 2H^+ + 2e^- \leftrightarrows H_2S(g)$	+0.14
$Sn^{4+} + 2e^- \leftrightarrows Sn^{2+}$	+0.15
$Cu^{2+} + e^- \leftrightarrows Cu^+$	+0.159
$Cu^{2+} + 2e^- \leftrightarrows Cu(s)$	+0.340
$Cu^+ + e^- \leftrightarrows Cu(s)$	+0.520
$I_2(s) + 2e^- \leftrightarrows 2I^-$	+0.54
$Fe^{3+} + e^- \leftrightarrows Fe^{2+}$	+0.77
$Ag^+ + e^- \leftrightarrows Ag(s)$	+0.800
$Hg_2^{2+} + 2e^- \leftrightarrows 2Hg(l)$	+0.80
$Hg^{2+} + 2e^- \leftrightarrows Hg(l)$	+0.85
$2Hg^{2+} + 2e^- \leftrightarrows Hg_2^{2+}$	+0.91
$Br_2(l) + 2e^- \leftrightarrows 2Br^-$	+1.07
$Pt^{2+} + 2e^- \leftrightarrows Pt(s)$	+1.188
$O_2(g) + 4H^+ + 4e^- \leftrightarrows 2H_2O$	+1.23
$Cl_2(g) + 2e^- \leftrightarrows 2Cl^-$	+1.36
$Au^{3+} + 3e^- \leftrightarrows Au(s)$	+1.52
$Co^{3+} + e^- \leftrightarrows Co^{2+}$	+1.82
$F_2(g) + 2e^- \leftrightarrows 2F^-$	+2.87

E^o values at 1*M* concentration and 1 atm.

Table Y. Selected Properties of the Elements

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)	1st ioni-zation 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	copernicum	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

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)	1st ioni-zation potential (kJ/mol)	common oxidation states
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
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	roentgentium	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

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)	1st ioni-zation potential (kJ/mol)	common oxidation states
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

Figure Z. Bonding Triangle

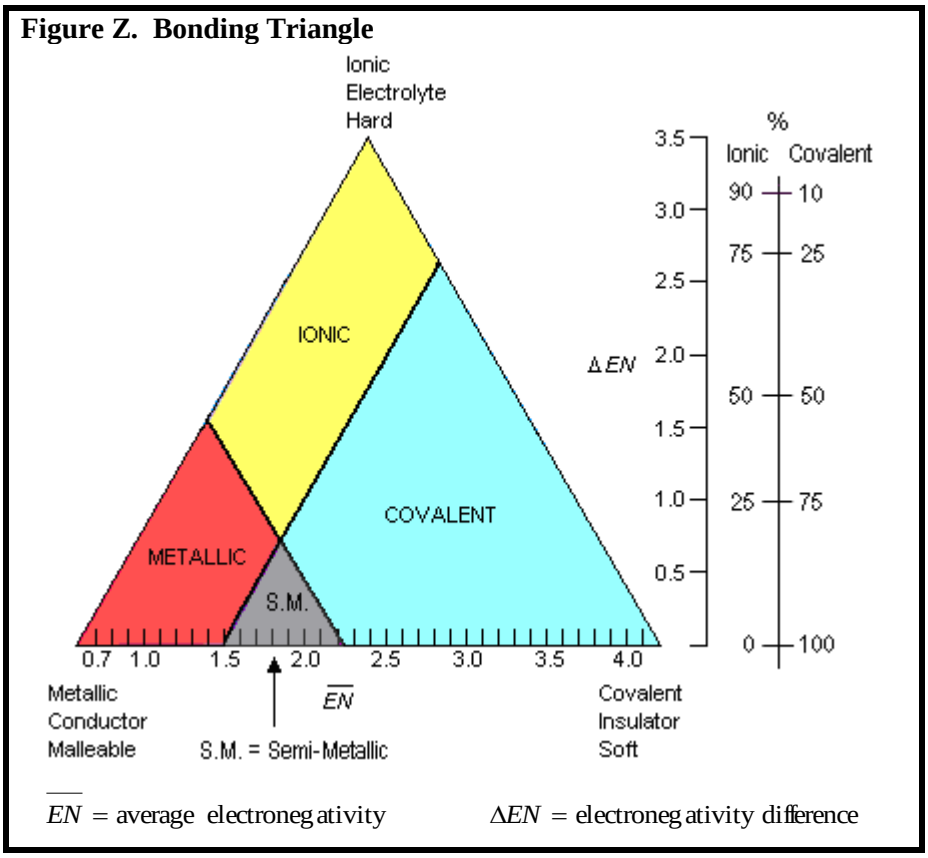


Table AA. Bond Dissociation Energies & Bond Lengths

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

Hydrogen Compounds		
Bond	*D* (kJ/mol)	*r* (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	*D* (kJ/mol)	*r* (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	*D* (kJ/mol)	*r* (pm)
B − B	293	?
B − O	536	?
B − F	613	?
B − Cl	456	175
B − Br	377	?

Group IVA Compounds		
Bond	*D* (kJ/mol)	*r* (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	*D* (kJ/mol)	*r* (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 − $Cl_{(5)}$	248	?
Sb − $Cl_{(3)}$	315	232

Group VIA Compounds		
Bond	*D* (kJ/mol)	*r* (pm)
O − O	142	148
O = O	494	121
O − F	190	142
S = O	522	143
S − $S_{(8)}$	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 (ΔH_f°) & standard entropy (S°) for selected compounds. Note that standard enthalpy values are in kilojoules per mole, whereas entropy values are in joules per mole·Kelvin.

Substance	State	ΔH_f° $(\frac{kJ}{mol})$	S° $(\frac{J}{mol \cdot K})$
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
$Al(OH)_3$	*s*	−1277	
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
Be	*s*	0	10
BeO	*s*	−599	14
Br_2	*ℓ*	0	152.2
Br−	*aq*	−121	82
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
$C_6H_{12}O_6$	*s*	−1275	212
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
$Ca_3(PO_4)_2$	*s*	−4126	241
$CaSO_4$	*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
$Cd(OH)_2$	*s*	−561	96
CdS	*s*	−162	65
$CdSO_4$	*s*	−935	123
Cl_2	*g*	0	223.0
Cl^-	*aq*	−167.080	56.5
ClO_4^-	*aq*	−128.10	182.0
Cr	*s*	0	23.8

Substance	State	ΔH_f° $(\frac{kJ}{mol})$	S° $(\frac{J}{mol \cdot K})$
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
$Cu(OH)_2$	*s*	−450	108
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
FeO	s	−272	61
Fe_2O_3	*s*	−824.2	87.4
Fe_3O_4	*s*	−1118.4	146.4
$FeSO_4$	*s*	−929	121
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	*aq*	−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*	−90.79	70.3
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

Substance	State	ΔH_f° $(\frac{kJ}{mol})$	S° $(\frac{J}{mol \cdot K})$
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	*g*	+82	220
N_2O_4	*g*	+9.2	304.2
Na	*s*	0	51.2
Na^+	*aq*	−240.34	59.0
Na_2CO_3	*s*	−1131	136
$NaHCO_3$	*s*	−948	102
NaCl	*s*	−411.2	72.1
NaF	*s*	−573.6	51.5
$NaNO_3$	*s*	−467	116
NaOH	*s*	425.6	64.5
Ni	*s*	0	29.9
$NiCl_2$	*s*	−316	107
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
PH_3	*g*	+5	210
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
PbS	*s*	−100	91
$PbSO_4$	*s*	−920	149
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
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 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 $^{g}/_{L}$	
	water	~ 1 $^{g}/_{mL}$	~ 8 $^{lb}/_{gal}$
		~ 1 $^{tonne}/_{m^3}$	~ 1 $^{ton}/_{yd^3}$

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 = 6.022×10^{23} molecules, atoms, or particles		
Percent Error	$\%\,\text{error} = \frac{\text{measured value - accepted value}}{\text{accepted value}} * 100\%$		
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	$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$	P = pressure V = volume (L)	n = moles T = temperature (K)
	$PV = nRT$	$R = 0.0821 \frac{\text{L·atm}}{\text{mol·K}} = 8.31 \frac{\text{L·kPa}}{\text{mol·K}} = 62.4 \frac{\text{L·torr}}{\text{mol·K}}$	
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_A= partial pressure of A	χ_A = mole fraction of A
	$P_T = P_A + P_B + P_C + \ldots$	P_T = total pressure	
Titration	$N_A V_A = N_B V_B$	N_A = normality of H_3O^+ V_A = volume of acid	N_B = normality of OH^- V_B = volume of base
Colligative Properties	$\Delta T_f = imK_f$	ΔT_f = freezing point depression (°C)	ΔT_b = boiling point elevation (°C)
		K_f = freezing point depression constant (H_2O = 0.52 °C/m)	
	$\Delta T_b = imK_b$	K_b = boiling point elevation constant (H_2O = 1.86 °C/m)	
		i = van't Hoff factor (dissociation factor)	π = osmotic pressure
	$\pi = iM\,RT = N\,RT$	m = molality R = ideal gas constant	M = molarity (mol/L) T = temperature (K) N = normality (mol/L)
Acid-Base	$\text{pH} = -\log[H_3O^+]$	$K_a = \frac{[H_3O^+][A^-]}{[HA]}$	$\text{p}K_a = -\log(K_a)$
	$\text{pOH} = -\log[OH^-]$		$\text{pH} = \text{p}K_a + \log\frac{[base]}{[acid]}$
	$\text{pH} + \text{pOH} = 14$	$K_b = \frac{[H^+B][OH^-]}{[B]}$	$\text{p}K_b = -\log(K_b)$
	$K_w = K_a \cdot K_b = 1 \times 10^{-14}$		
Equilibrium	$K_p = K_c(RT)^{\Delta n}$	K_p = gas press. equil. const.	K_c = molar conc. equil. const. Δn = change in # moles
Heat	$q = m\,C_p\,\Delta T$	q = heat	ΔT = change in temperature
	$q = m\,\Delta H_f$	m = mass	ΔH_f = heat of fusion
	$q = m\,\Delta H_v$	C_p = specific heat capacity	ΔH_v = heat of vaporization
Thermodynamics	$\Delta G° = \Delta H° - T\Delta S°$	$G°$ = standard free energy	$S°$ = standard entropy
	$\Delta G° = -RT \ln K$	$H°$ = standard enthalpy	T = temperature (K)
Electrochemistry	$I = \frac{q}{t}$	I = current (amperes)	q = charge (Coulombs) t = time (seconds)
		$\mathcal{F}$ = Faraday's constant = 96,000 Coulomb per mole electrons	
	$\Delta G° = -n\mathcal{F}E°$	n = moles of electrons	$E°$ = standard reduction potential
Temperature	K = °C + 273.15	K = Kelvin	
	°C= (°F−32) * 5/9	°C = degrees Celsius	°F = degrees Fahrenheit
Radioactive Decay	$A = A_o\left(\frac{1}{2}\right)^{\frac{t}{\tau_{½}}}$	A = amount left A_o = original amount	t = total elapsed time $\tau_{½}$ = half-life number of half-lives = $\frac{t}{\tau_{½}}$