

# Chemistry Reference Tables

Name	Value
Avogadro's number	$6.022 \times 10^{23}$ particles/mole
Gas constant ( $R$ )	$0.0821 \frac{\text{L atm}}{\text{mole K}}$ $62.4 \frac{\text{L mmHg}}{\text{mole K}}$ $8.314 \frac{\text{L kPa}}{\text{mole K}}$
Standard pressure	1.00 atm = 101.3 kPa = 760. mmHg = 760. torr
Standard temperature	0°C or 273K
Volume of 1 mole of any gas at STP	22.4 L

Thermodynamic Constants	Symbol	Value (4.18 J = 1 cal)
Heat of fusion of water	$H_f$ (water)	334 J/g
Heat of vaporization of water	$H_v$ (water)	2,260 J/g
Specific heat of water	$C_p$ (water)	$2.05 \frac{\text{J}}{\text{g}^\circ\text{C}}$ for ice, $2.02 \frac{\text{J}}{\text{g}^\circ\text{C}}$ for steam, $4.18 \frac{\text{J}}{\text{g}^\circ\text{C}}$ for liquid

Metal	Specific Heat $\frac{\text{J}}{\text{g}^\circ\text{C}}$	Density (g/cm <sup>3</sup> )	Melting Point (°C)
Aluminum	0.897	2.702	660
Copper	0.385	8.92	1083
Gold	0.129	19.31	1064
Iron	0.449	7.86	1535
Lead	0.129	11.3437	328
Magnesium	1.023	1.74	649
Mercury	0.140	13.5939	-39
Nickel	0.444	8.90	1455
Titanium	0.523	4.5	1660
Zinc	0.388	7.14	420

<b>Organic Substances</b>			
<b>Name</b>	<b>Density</b>	<b>Melting Point (°C)</b>	<b>Boiling Point (°C)</b>
Ethanol (CH <sub>3</sub> CH <sub>2</sub> OH)	0.7893 g/cm <sup>3</sup>	-119	79
Glucose (C <sub>6</sub> H <sub>12</sub> O <sub>6</sub> )	1.54 g/cm <sup>3</sup>	86	Decompose
Hexane (C <sub>6</sub> H <sub>14</sub> )	0.6603 g/cm <sup>3</sup>	-95	69
Methane (CH <sub>4</sub> )	0.716 g/L	-182	-164
Methanol (CH <sub>3</sub> OH)	0.7914 g/cm <sup>3</sup>	-94	65
Sucrose (C <sub>12</sub> H <sub>22</sub> O <sub>11</sub> )	1.27 g/cm <sup>3</sup>	86	Decompose

<b>Inorganic Substances</b>			
<b>Name</b>	<b>*Density @ STP</b>	<b>Melting Point (°C)</b>	<b>Boiling Point (°C)</b>
Chlorine	3.21 g/L	-101	-35
Hydrogen	0.0899 g/L	-259	-253
Hydrogen chloride	1.640 g/L	-115	-85
Hydrogen sulfide	1.54 g/L	-85	-61
Nitrogen	1.25 g/L	-210	-196
Nitrogen monoxide	1.34 g/L	-164	-152
Oxygen	1.43 g/L	-218	-183
Sodium carbonate	2.532 g/cm <sup>3</sup>	851	Decomposes
Sodium chloride	2.165 g/cm <sup>3</sup>	801	1413
Sulfur dioxide	2.92 g/L	-73	-10
*Water (at 4°C)	1.00 g/cm <sup>3</sup>	0	100

## Formulas

$$D = \frac{m}{V}$$

$D$  = density

$$K = ^\circ C + 273$$

$m$  = mass

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

$V$  = volume

$$P_t = P_1 + P_2 + P_3 + \dots$$

$K$  = Kelvin

$$M_1V_1 = M_2V_2$$

$P$  = pressure

$$PV = nRT$$

$R$  = gas constant

$$M = \frac{\text{moles of solute}}{\text{liters of solution}}$$

$T$  = temperature

$$q = mC_p\Delta T$$

$M$  = molarity

$$q = mH_v$$

$n$  = number of moles

$$q = mH_f$$

$q$  = quantity of heat energy

$$pH + pOH = 14$$

$C_p$  = specific heat

$$pH = -\log[H^+]$$

$H_v$  = heat of vaporization

$$pOH = -\log[OH^-]$$

$H_f$  = heat of fusion

$$K_w = [H^+][OH^-] = 1 \times 10^{-14}$$

$K_w$  = equilibrium constant for the ionization of water

$$[H^+] = 10^{-pH}$$

$E$  = energy of a photon

$$[OH^-] = 10^{-pOH}$$

$h$  = Planck's constant =  $6.626 \times 10^{-34}$  Js

$$E = h\nu$$

$\nu$  = frequency of light

$$c = \lambda\nu$$

$c$  = speed of light =  $3.00 \times 10^8$  m/s

$$\frac{\text{rate}_B}{\text{rate}_A} = \sqrt{\frac{M_A}{M_B}}$$

$\lambda$  = wavelength of light

$$1 \text{ m} = 10^9 \text{ nm}$$

# PERIODIC TABLE

1 IA								
1 <b>H</b> Hydrogen 1.008	2 IIA							
3 <b>Li</b> Lithium 6.941	4 <b>Be</b> Beryllium 9.012							
11 <b>Na</b> Sodium 22.99	12 <b>Mg</b> Magnesium 24.31	3 IIIB	4 IVB	5 VB	6 VIB	7 VIIB	8 VIIIB	9 VIIIB
19 <b>K</b> Potassium 39.10	20 <b>Ca</b> Calcium 40.08	21 <b>Sc</b> Scandium 44.96	22 <b>Ti</b> Titanium 47.88	23 <b>V</b> Vanadium 50.94	24 <b>Cr</b> Chromium 51.99	25 <b>Mn</b> Manganese 54.94	26 <b>Fe</b> Iron 55.85	27 <b>Co</b> Cobalt 58.93
37 <b>Rb</b> Rubidium 85.47	38 <b>Sr</b> Strontium 87.62	39 <b>Y</b> Yttrium 88.91	40 <b>Zr</b> Zirconium 91.22	41 <b>Nb</b> Niobium 92.91	42 <b>Mo</b> Molybdenum 95.94	43 <b>Tc</b> Technetium (98)	44 <b>Ru</b> Ruthenium 101.07	45 <b>Rh</b> Rhodium 102.91
55 <b>Cs</b> Cesium 132.91	56 <b>Ba</b> Barium 137.38	57 <b>La</b> Lanthanum 138.91	72 <b>Hf</b> Hafnium 178.49	73 <b>Ta</b> Tantalum 180.95	74 <b>W</b> Tungsten 183.84	75 <b>Re</b> Rhenium 186.21	76 <b>Os</b> Osmium 190.23	77 <b>Ir</b> Iridium 192.22
87 <b>Fr</b> Francium (223)	88 <b>Ra</b> Radium (226)	89 <b>Ac</b> Actinium (227)	104 <b>Rf</b> Rutherfordium (261)	105 <b>Db</b> Dubnium (262)	106 <b>Sg</b> Seaborgium (263)	107 <b>Bh</b> Bohrium (264)	108 <b>Hs</b> Hassium (269)	109 <b>Mt</b> Meitnerium (268)

58 <b>Ce</b> Cerium 140.12	59 <b>Pr</b> Praseodymium 140.91	60 <b>Nd</b> Neodymium 144.24	61 <b>Pm</b> Promethium (145)	62 <b>Sm</b> Samarium 150.36	63 <b>Eu</b> Europium 151.96	64 <b>Gd</b> Gadolinium 157.25
90 <b>Th</b> Thorium 232.04	91 <b>Pa</b> Protactinium 231.04	92 <b>U</b> Uranium 238.04	93 <b>Np</b> Neptunium (237)	94 <b>Pu</b> Plutonium (244)	95 <b>Am</b> Americium (243)	96 <b>Cm</b> Curium (247)

# OF THE ELEMENTS

									18 VIIIA
			13 IIIA	14 IVA	15 VA	16 VIA	17 VIIA		2 <b>He</b> Helium 4.003
			5 <b>B</b> Boron 10.81	6 <b>C</b> Carbon 12.01	7 <b>N</b> Nitrogen 14.01	8 <b>O</b> Oxygen 16.00	9 <b>F</b> Fluorine 19.00		10 <b>Ne</b> Neon 20.18
10 VIII B	11 IB	12 IIB	13 <b>Al</b> Aluminum 26.98	14 <b>Si</b> Silicon 28.09	15 <b>P</b> Phosphorus 30.97	16 <b>S</b> Sulfur 32.07	17 <b>Cl</b> Chlorine 35.45		18 <b>Ar</b> Argon 39.95
28 <b>Ni</b> Nickel 58.69	29 <b>Cu</b> Copper 63.55	30 <b>Zn</b> Zinc 65.39	31 <b>Ga</b> Gallium 69.72	32 <b>Ge</b> Germanium 72.61	33 <b>As</b> Arsenic 74.92	34 <b>Se</b> Selenium 78.96	35 <b>Br</b> Bromine 79.90		36 <b>Kr</b> Krypton 83.80
46 <b>Pd</b> Palladium 106.42	47 <b>Ag</b> Silver 107.87	48 <b>Cd</b> Cadmium 112.41	49 <b>In</b> Indium 114.82	50 <b>Sn</b> Tin 118.71	51 <b>Sb</b> Antimony 121.76	52 <b>Te</b> Tellurium 127.60	53 <b>I</b> Iodine 126.90		54 <b>Xe</b> Xenon 131.29
78 <b>Pt</b> Platinum 195.08	79 <b>Au</b> Gold 196.97	80 <b>Hg</b> Mercury 200.59	81 <b>Tl</b> Thallium 204.38	82 <b>Pb</b> Lead 207.2	83 <b>Bi</b> Bismuth 208.98	84 <b>Po</b> Polonium (209)	85 <b>At</b> Astatine (210)		86 <b>Rn</b> Radon (222)
110 <b>Ds</b> Darmstadtium (271)	111 <b>Rg</b> Roentgenium (272)	112 <b>Uub</b> Ununbium (277)							

65 <b>Tb</b> Terbium 158.93	66 <b>Dy</b> Dysprosium 162.50	67 <b>Ho</b> Holmium 164.93	68 <b>Er</b> Erbium 167.26	69 <b>Tm</b> Thulium 168.93	70 <b>Yb</b> Ytterbium 173.04	71 <b>Lu</b> Lutetium 174.97
97 <b>Bk</b> Berkelium (247)	98 <b>Cf</b> Californium (251)	99 <b>Es</b> Einsteinium (252)	100 <b>Fm</b> Fermium (257)	101 <b>Md</b> Mendelevium (258)	102 <b>No</b> Nobelium (254)	103 <b>Lr</b> Lawrencium (262)

## SOLUBILITY RULES

### Soluble:

- All Nitrates, Acetates, Ammonium, and Group 1 (IA) salts
- All Chlorides, Bromides, and Iodides, except Silver, Lead, and Mercury(I)
- All Fluorides except Group 2 (IIA), Lead(II), and Iron(III)
- All Sulfates except Calcium, Strontium, Barium, Mercury, Lead(II), and Silver

### Insoluble (0.10 M or greater):

- All Carbonates and Phosphates except Group 1 (IA) and Ammonium
- All Hydroxides except Group 1 (IA), Strontium, Barium, and Ammonium
- All Sulfides except Group 1 (IA), 2 (IIA), and Ammonium
- All Oxides except Group 1 (IA)

## Guidelines for Predicting the Products of Selected Types of Chemical Reaction

Key: **M** = Metal  
**NM** = Nonmetal

### 1. SYNTHESIS:

- a. Formation of binary compound:  $A + B \rightarrow AB$
- b. Metal oxide-water reactions:  $MO + H_2O \rightarrow \text{base}$
- c. Nonmetal oxide-water reactions:  $(NM)O + H_2O \rightarrow \text{acid}$

### 2. DECOMPOSITION:

- a. Binary compounds:  $AB \rightarrow A + B$
- b. Metallic carbonates:  $MCO_3 \rightarrow MO + CO_2$
- c. Metallic hydrogen carbonates:  $MHCO_3 \rightarrow MO + H_2O_{(l)} + CO_{2(g)}$
- d. Metallic hydroxides:  $MOH \rightarrow MO + H_2O$
- e. Metallic chlorates:  $MClO_3 \rightarrow MCl + O_2$
- f. Oxyacids decompose to nonmetal oxides and water:  $\text{acid} \rightarrow (NM)O + H_2O$

### 3. SINGLE REPLACEMENT:

- a. Metal-metal replacement:  $A + BC \rightarrow AC + B$
- b. Active metal replaces H from water:  $M + H_2O \rightarrow MOH + H_2$
- c. Active metal replaces H from acid:  $M + HX \rightarrow MX + H_2$
- d. Halide-Halide replacement:  $D + BC \rightarrow BD + C$

### 4. DOUBLE REPLACEMENT: $AB + CD \rightarrow AD + CB$

- a. Formation of a precipitate from solution
- b. Acid-Base neutralization reaction

### 5. COMBUSTION REACTION

Hydrocarbon + oxygen  $\rightarrow$  carbon dioxide + water

### ACTIVITY SERIES of Halogens:

F<sub>2</sub>  
Cl<sub>2</sub>  
Br<sub>2</sub>  
I<sub>2</sub>

### ACTIVITY SERIES of Metals

Li	↑		
Rb	↑		
K	↑		
Ba	↑		
Sr	↑		
Ca	↑		
Na	↑		
Mg	↓		
Al			
Mn			
Zn			
Cr			
Fe			
Cd			
Co			
Ni			
Sn			
Pb			
[H <sub>2</sub> ]			
Sb			
Bi			
Cu			
Hg			
Ag			
Pt			
Au			

Replace hydrogen from cold water

Replace hydrogen from steam

Replace hydrogen from acids

React with oxygen to form oxides

Polyatomic Ions	
NH <sub>4</sub> <sup>+</sup>	Ammonium
BrO <sub>3</sub> <sup>-</sup>	Bromate
CN <sup>-</sup>	Cyanide
C <sub>2</sub> H <sub>3</sub> O <sub>2</sub> <sup>-</sup>	Acetate
(CH <sub>3</sub> COO <sup>-</sup> )	
ClO <sub>4</sub> <sup>-</sup>	Perchlorate
ClO <sub>3</sub> <sup>-</sup>	Chlorate
ClO <sub>2</sub> <sup>-</sup>	Chlorite
ClO <sup>-</sup>	Hypochlorite
IO <sub>3</sub> <sup>-</sup>	Iodate
MnO <sub>4</sub> <sup>-</sup>	Permanganate
NO <sub>3</sub> <sup>-</sup>	Nitrate
NO <sub>2</sub> <sup>-</sup>	Nitrite
OH <sup>-</sup>	Hydroxide
HCO <sub>3</sub> <sup>-</sup>	Hydrogen carbonate
HSO <sub>4</sub> <sup>-</sup>	Hydrogen sulfate
SCN <sup>-</sup>	Thiocyanate
CO <sub>3</sub> <sup>2-</sup>	Carbonate
Cr <sub>2</sub> O <sub>7</sub> <sup>2-</sup>	Dichromate
CrO <sub>4</sub> <sup>2-</sup>	Chromate
SO <sub>4</sub> <sup>2-</sup>	Sulfate
SO <sub>3</sub> <sup>2-</sup>	Sulfite
PO <sub>4</sub> <sup>3-</sup>	Phosphate

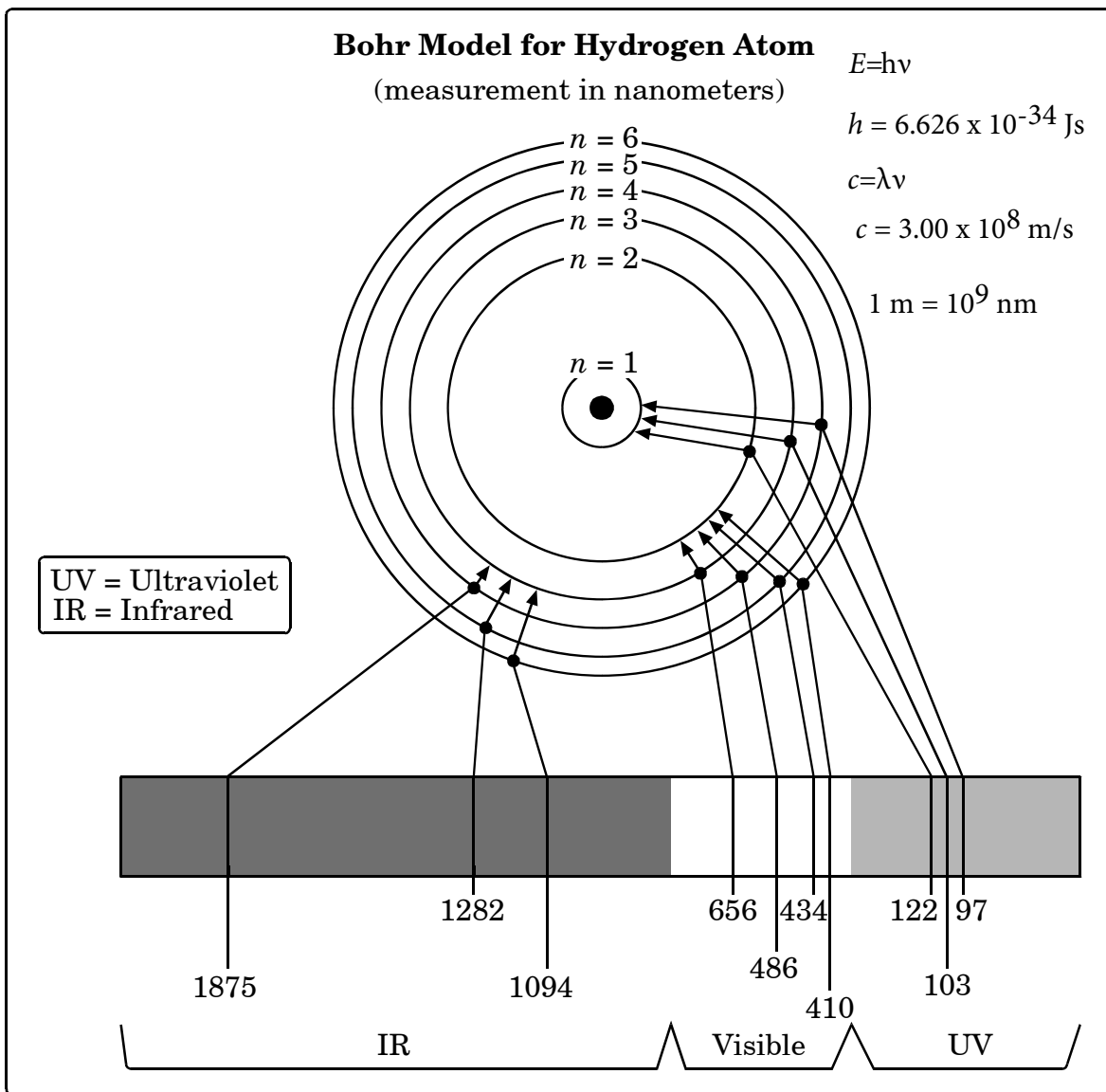
### Boling Point Elevation and Freezing Point Depression

$$\Delta T = i K_b m$$

$$\Delta T = i K_f m$$

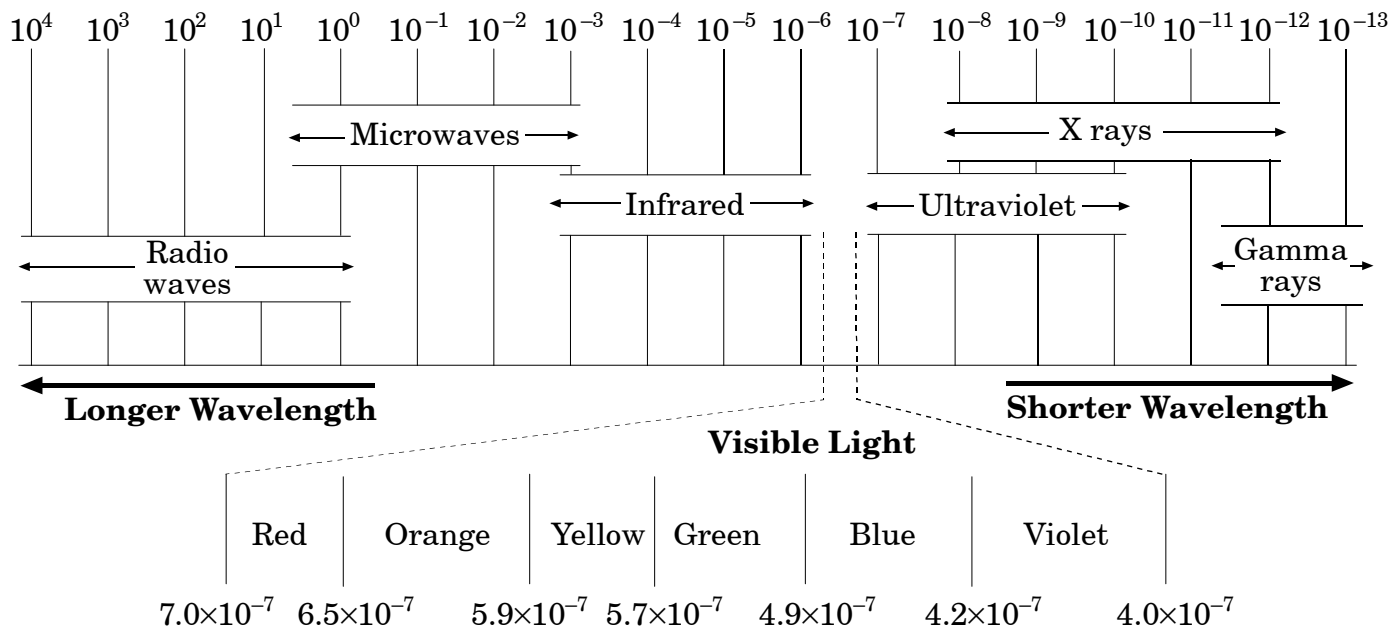
i = van't Hoff factor

Substance	K <sub>b</sub> (°C/m)	K <sub>f</sub> (°C/m)
benzene	2.53	5.12
camphor	5.95	40
carbon tetrachloride	5.03	30
ethyl ether	2.02	1.79
water	0.52	1.86



### Electromagnetic Spectrum

(measurement in meters)





Common Polyatomic Ions							
+1		-1		-2		-3	
$\text{NH}_4^+$	ammonium	$\text{C}_2\text{H}_3\text{O}_2^-$	acetate	$\text{CO}_3^{2-}$	carbonate	$\text{PO}_4^{3-}$	phosphate
$\text{H}_3\text{O}^+$	hydronium	$\text{ClO}^-$	hypochlorite	$\text{CrO}_4^{2-}$	chromate	$\text{PO}_3^{3-}$	phosphite
		$\text{ClO}_2^-$	chlorite	$\text{Cr}_2\text{O}_7^{2-}$	dichromate		
		$\text{ClO}_3^-$	chlorate	$\text{SO}_4^{2-}$	sulfate		
		$\text{ClO}_4^-$	perchlorate	$\text{SO}_3^{2-}$	sulfite		
		$\text{CN}^-$	cyanide	$\text{O}_2^{2-}$	peroxide		
		$\text{NO}_3^-$	nitrate	$\text{C}_2\text{O}_4^{2-}$	oxalate		
		$\text{NO}_2^-$	nitrite				
		$\text{HCO}_3^-$	hydrogen carbonate (bicarbonate)				
		$\text{OH}^-$	hydroxide				
		$\text{MnO}_4^-$	permanganate				

Common Metal Ions			Prefixes Used in Naming Binary Molecular Compounds	
Ion	Systematic Name	Common Name	Prefix	Number
$\text{Fe}^{2+}$	iron (II)	ferrous	mono	1
$\text{Fe}^{3+}$	iron (III)	ferric	di	2
$\text{Cu}^+$	copper (I)	cuprous	tri	3
$\text{Cu}^{2+}$	copper (II)	cupric	tetra	4
$\text{Pb}^{2+}$	lead (II)	plumbous	penta	5
$\text{Pb}^{4+}$	lead (IV)	plumbic	hexa	6
$\text{Cr}^{2+}$	chromium (II)	chromous	hepta	7
$\text{Cr}^{3+}$	chromium (III)	chromic	octa	8
$\text{Sn}^{2+}$	tin (II)	stannous	nona	9
$\text{Sn}^{4+}$	tin (IV)	stannic	deca	10
$\text{Co}^{2+}$	cobalt (II)	cobaltous		
$\text{Co}^{3+}$	cobalt (III)	cobaltic		
$\text{Hg}_2^{2+}$	mercury (I)	mercurous		
$\text{Hg}^{2+}$	mercury (II)	mercuric		

\*\* ALWAYS:  $\text{Zn}^{2+}$ ,  $\text{Ag}^+$ ,  $\text{Cd}^{2+}$  \*\*

# Periodic Table with Electronegativities

## Type of bond

Nonpolar covalent bond

Polar covalent bond

Ionic bond

## Electronegativity difference

0 to 0.4

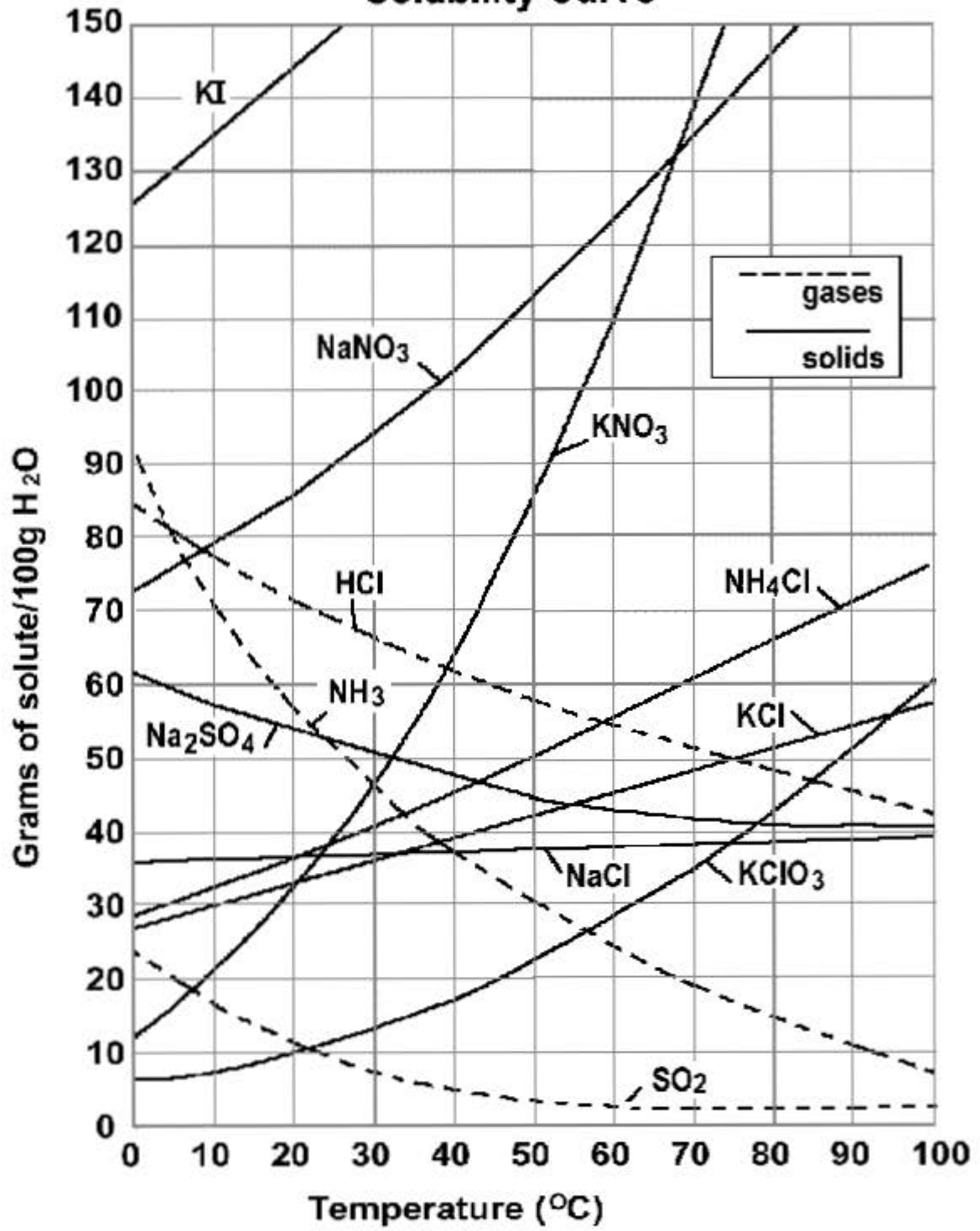
0.5 to 1.7

1.8 and above

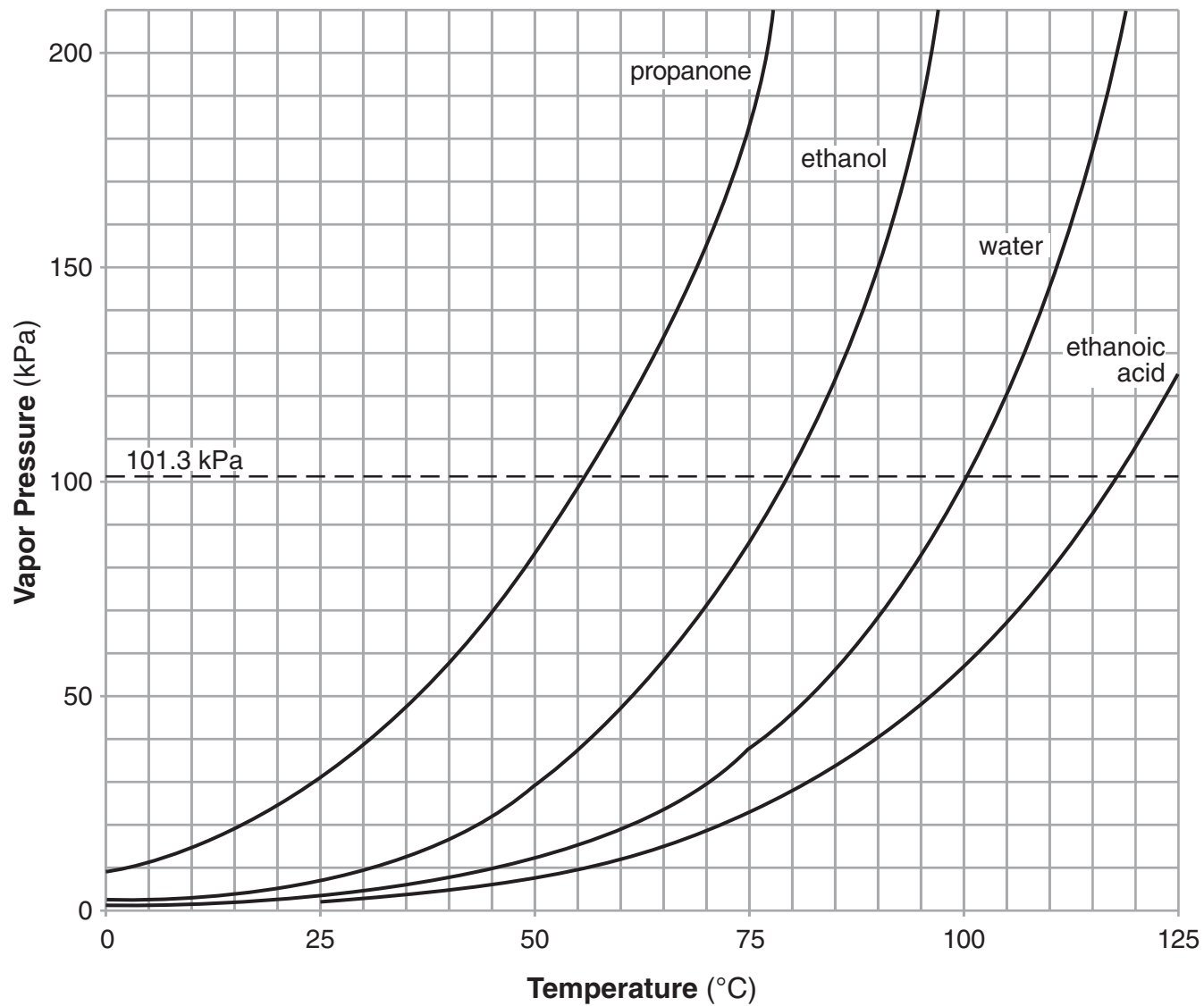
1A	2A	3B	4B	5B	6B	7B	8B			1B	2B	3A	4A	5A	6A	7A	8A
1 <b>H</b> 2.1																	2 <b>He</b>
3 <b>Li</b> 1.0	4 <b>Be</b> 1.5											5 <b>B</b> 2.0	6 <b>C</b> 2.5	7 <b>N</b> 3.0	8 <b>O</b> 3.5	9 <b>F</b> 4.0	10 <b>Ne</b>
11 <b>Na</b> 0.9	12 <b>Mg</b> 1.2											13 <b>Al</b> 1.5	14 <b>Si</b> 1.8	15 <b>P</b> 2.1	16 <b>S</b> 2.5	17 <b>Cl</b> 3.0	18 <b>Ar</b>
19 <b>K</b> 0.8	20 <b>Ca</b> 1.0	21 <b>Sc</b> 1.3	22 <b>Ti</b> 1.5	23 <b>V</b> 1.6	24 <b>Cr</b> 1.6	25 <b>Mn</b> 1.5	26 <b>Fe</b> 1.8	27 <b>Co</b> 1.9	28 <b>Ni</b> 1.9	29 <b>Cu</b> 1.9	30 <b>Zn</b> 1.6	31 <b>Ga</b> 1.6	32 <b>Ge</b> 1.8	33 <b>As</b> 2.0	34 <b>Se</b> 2.4	35 <b>Br</b> 2.8	36 <b>Kr</b>
37 <b>Rb</b> 0.8	38 <b>Sr</b> 1.0	39 <b>Y</b> 1.2	40 <b>Zr</b> 1.4	41 <b>Nb</b> 1.6	42 <b>Mo</b> 1.8	43 <b>Tc</b> 1.9	44 <b>Ru</b> 2.2	45 <b>Rh</b> 2.2	46 <b>Pd</b> 2.2	47 <b>Ag</b> 1.9	48 <b>Cd</b> 1.7	49 <b>In</b> 1.7	50 <b>Sn</b> 1.8	51 <b>Sb</b> 1.9	52 <b>Te</b> 2.1	53 <b>I</b> 2.5	54 <b>Xe</b>
55 <b>Cs</b> 0.7	56 <b>Ba</b> 0.9	57 <b>La</b> 1.1	72 <b>Hf</b> 1.3	73 <b>Ta</b> 1.5	74 <b>W</b> 1.7	75 <b>Re</b> 1.9	76 <b>Os</b> 2.2	77 <b>Ir</b> 2.2	78 <b>Pt</b> 2.2	79 <b>Au</b> 2.4	80 <b>Hg</b> 1.9	81 <b>Tl</b> 1.8	82 <b>Pb</b> 1.9	83 <b>Bi</b> 1.9	84 <b>Po</b> 2.0	85 <b>At</b> 2.2	86 <b>Rn</b>
87 <b>Fr</b> 0.7	88 <b>Ra</b> 0.9	89 <b>Ac</b> 1.1	104 <b>Rf</b>	105 <b>Db</b>	106 <b>Sg</b>	107 <b>Bh</b>	108 <b>Hs</b>	109 <b>Mt</b>	110 <b>Ds</b>	111 <b>Uuu</b>	112 <b>Uub</b>	113 <b>Uut</b>	114 <b>Uuq</b>	115 <b>Uup</b>	116 <b>Uuh</b>		

58 <b>Ce</b> 1.1	59 <b>Pr</b> 1.1	60 <b>Nd</b> 1.1	61 <b>Pm</b> 1.2	62 <b>Sm</b> 1.2	63 <b>Eu</b> 1.1	64 <b>Gd</b> 1.2	65 <b>Tb</b> 1.2	66 <b>Dy</b> 1.2	67 <b>Ho</b> 1.2	68 <b>Er</b> 1.2	69 <b>Tm</b> 1.2	70 <b>Yb</b> 1.2	71 <b>Lu</b> 1.3
90 <b>Th</b> 1.3	91 <b>Pa</b> 1.5	92 <b>U</b> 1.7	93 <b>Np</b> 1.3	94 <b>Pu</b> 1.3	95 <b>Am</b> 1.3	96 <b>Cm</b> 1.3	97 <b>Bk</b> 1.3	98 <b>Cf</b> 1.3	99 <b>Es</b> 1.3	100 <b>Fm</b> 1.3	101 <b>Md</b> 1.3	102 <b>No</b> 1.5	103 <b>Lr</b>

# Solubility Curve



**Table H**  
**Vapor Pressure of Four Liquids**



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

Substance	$\Delta H_f^\circ$ (kJ/mol)	$\Delta G_f^\circ$ (kJ/mol)	$S^\circ$ (J/mol-K)	Substance	$\Delta H_f^\circ$ (kJ/mol)	$\Delta G_f^\circ$ (kJ/mol)	$S^\circ$ (J/mol-K)
<b>Aluminum</b>				<b>CF<sub>4</sub>(g)</b>	-679.9	-635.1	262.3
Al(s)	0	0	28.32	CH <sub>4</sub> (g)	-74.8	-50.8	186.3
AlCl <sub>3</sub> (s)	-705.6	-630.0	109.3	C <sub>2</sub> H <sub>2</sub> (g)	226.7	209.2	200.8
Al <sub>2</sub> O <sub>3</sub> (s)	-1669.8	-1576.5	51.00	C <sub>2</sub> H <sub>4</sub> (g)	52.30	68.11	219.4
				C <sub>2</sub> H <sub>6</sub> (g)	-84.68	-32.89	229.5
<b>Barium</b>				C <sub>3</sub> H <sub>8</sub> (g)	-103.85	-23.47	269.9
Ba(s)	0	0	63.2	C <sub>4</sub> H <sub>10</sub> (g)	-124.73	-15.71	310.0
BaCO <sub>3</sub> (s)	-1216.3	-1137.6	112.1	C <sub>4</sub> H <sub>10</sub> (l)	-147.6	-15.0	231.0
BaO(s)	-553.5	-525.1	70.42	C <sub>6</sub> H <sub>6</sub> (g)	82.9	129.7	269.2
				C <sub>6</sub> H <sub>6</sub> (l)	49.0	124.5	172.8
<b>Beryllium</b>				CH <sub>3</sub> OH(g)	-201.2	-161.9	237.6
Be(s)	0	0	9.44	CH <sub>3</sub> OH(l)	-238.6	-166.23	126.8
BeO(s)	-608.4	-579.1	13.77	C <sub>2</sub> H <sub>5</sub> OH(g)	-235.1	-168.5	282.7
Be(OH) <sub>2</sub> (s)	-905.8	-817.9	50.21	C <sub>2</sub> H <sub>5</sub> OH(l)	-277.7	-174.76	160.7
				C <sub>6</sub> H <sub>12</sub> O <sub>6</sub> (s)	-1273.02	-910.4	212.1
<b>Bromine</b>				CO(g)	-110.5	-137.2	197.9
Br(g)	111.8	82.38	174.9	CO <sub>2</sub> (g)	-393.5	-394.4	213.6
Br <sup>-</sup> (aq)	-120.9	-102.8	80.71	HC <sub>2</sub> H <sub>3</sub> O <sub>2</sub> (l)	-487.0	-392.4	159.8
Br <sub>2</sub> (g)	30.71	3.14	245.3				
Br <sub>2</sub> (l)	0	0	152.3	<b>Cesium</b>			
HBr(g)	-36.23	-53.22	198.49	Cs(g)	76.50	49.53	175.6
				Cs(s)	0	0	85.15
<b>Calcium</b>				CsCl(s)	-442.8	-414.4	101.2
Ca(g)	179.3	145.5	154.8	<b>Chlorine</b>			
Ca(s)	0	0	41.4	Cl(g)	121.7	105.7	165.2
CaCO <sub>3</sub>				Cl <sup>-</sup> (aq)	-167.2	-131.2	56.5
(s, calcite)	-1207.1	-1128.76	92.88	Cl <sub>2</sub> (g)	0	0	222.96
CaCl <sub>2</sub> (s)	-795.8	-748.1	104.6	HCl(aq)	-167.2	-131.2	56.5
CaF <sub>2</sub> (s)	-1219.6	-1167.3	68.87	HCl(g)	-92.30	-95.27	186.69
CaO(s)	-635.5	-604.17	39.75				
Ca(OH) <sub>2</sub> (s)	-986.2	-898.5	83.4	<b>Chromium</b>			
CaSO <sub>4</sub> (s)	-1434.0	-1321.8	106.7	Cr(g)	397.5	352.6	174.2
				Cr(s)	0	0	23.6
<b>Carbon</b>				Cr <sub>2</sub> O <sub>3</sub> (s)	-1139.7	-1058.1	81.2
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 <sub>4</sub> (g)	-106.7	-64.0	309.4				
CCl <sub>4</sub> (l)	-139.3	-68.6	214.4				

Substance	$\Delta H_f^\circ$ (kJ/mol)	$\Delta G_f^\circ$ (kJ/mol)	$S^\circ$ (J/mol-K)	Substance	$\Delta H_f^\circ$ (kJ/mol)	$\Delta G_f^\circ$ (kJ/mol)	$S^\circ$ (J/mol-K)
<b>Cobalt</b>				<b>Magnesium</b>			
Co(g)	439	393	179	Mg(g)	147.1	112.5	148.6
Co(s)	0	0	28.4	Mg(s)	0	0	32.51
<b>Copper</b>				MgCl <sub>2</sub> (s)	-641.6	-592.1	89.6
Cu(g)	338.4	298.6	166.3	MgO(s)	-601.8	-569.6	26.8
Cu(s)	0	0	33.30	Mg(OH) <sub>2</sub> (s)	-924.7	-833.7	63.24
CuCl <sub>2</sub> (s)	-205.9	-161.7	108.1	<b>Manganese</b>			
CuO(s)	-156.1	-128.3	42.59	Mn(g)	280.7	238.5	173.6
Cu <sub>2</sub> O(s)	-170.7	-147.9	92.36	Mn(s)	0	0	32.0
<b>Fluorine</b>				MnO(s)	-385.2	-362.9	59.7
F(g)	80.0	61.9	158.7	MnO <sub>2</sub> (s)	-519.6	-464.8	53.14
F <sup>-</sup> (aq)	-332.6	-278.8	-13.8	MnO <sub>4</sub> <sup>-</sup> (aq)	-541.4	-447.2	191.2
F <sub>2</sub> (g)	0	0	202.7	<b>Mercury</b>			
HF(g)	-268.61	-270.70	173.51	Hg(g)	60.83	31.76	174.89
<b>Hydrogen</b>				Hg(l)	0	0	77.40
H(g)	217.94	203.26	114.60	HgCl <sub>2</sub> (s)	-230.1	-184.0	144.5
H <sup>+</sup> (aq)	0	0	0	Hg <sub>2</sub> Cl <sub>2</sub> (s)	-264.9	-210.5	192.5
H <sup>+</sup> (g)	1536.2	1517.0	108.9	<b>Nickel</b>			
H <sub>2</sub> (g)	0	0	130.58	Ni(g)	429.7	384.5	182.1
<b>Iodine</b>				Ni(s)	0	0	29.9
I(g)	106.60	70.16	180.66	NiCl <sub>2</sub> (s)	-305.3	-259.0	97.65
I <sup>-</sup> (aq)	-55.19	-51.57	111.3	NiO(s)	-239.7	-211.7	37.99
I <sub>2</sub> (g)	62.25	19.37	260.57	<b>Nitrogen</b>			
I <sub>2</sub> (s)	0	0	116.73	N(g)	472.7	455.5	153.3
HI(g)	25.94	1.30	206.3	N <sub>2</sub> (g)	0	0	191.50
<b>Iron</b>				NH <sub>3</sub> (aq)	-80.29	-26.50	111.3
Fe(g)	415.5	369.8	180.5	NH <sub>3</sub> (g)	-46.19	-16.66	192.5
Fe(s)	0	0	27.15	NH <sub>4</sub> <sup>+</sup> (aq)	-132.5	-79.31	113.4
Fe <sup>2+</sup> (aq)	-87.86	-84.93	113.4	N <sub>2</sub> H <sub>4</sub> (g)	95.40	159.4	238.5
Fe <sup>3+</sup> (aq)	-47.69	-10.54	293.3	NH <sub>4</sub> CN(s)	0.0	—	—
FeCl <sub>2</sub> (s)	-341.8	-302.3	117.9	NH <sub>4</sub> Cl(s)	-314.4	-203.0	94.6
FeCl <sub>3</sub> (s)	-400	-334	142.3	NH <sub>4</sub> NO <sub>3</sub> (s)	-365.6	-184.0	151
FeO(s)	-271.9	-255.2	60.75	NO(g)	90.37	86.71	210.62
Fe <sub>2</sub> O <sub>3</sub> (s)	-822.16	-740.98	89.96	NO <sub>2</sub> (g)	33.84	51.84	240.45
Fe <sub>3</sub> O <sub>4</sub> (s)	-1117.1	-1014.2	146.4	N <sub>2</sub> O(g)	81.6	103.59	220.0
FeS <sub>2</sub> (s)	-171.5	-160.1	52.92	N <sub>2</sub> O <sub>4</sub> (g)	9.66	98.28	304.3
<b>Lead</b>				NOCl(g)	52.6	66.3	264
Pb(s)	0	0	68.85	HNO <sub>3</sub> (aq)	-206.6	-110.5	146
PbBr <sub>2</sub> (s)	-277.4	-260.7	161	HNO <sub>3</sub> (g)	-134.3	-73.94	266.4
PbCO <sub>3</sub> (s)	-699.1	-625.5	131.0	<b>Oxygen</b>			
Pb(NO <sub>3</sub> ) <sub>2</sub> (aq)	-421.3	-246.9	303.3	O(g)	247.5	230.1	161.0
Pb(NO <sub>3</sub> ) <sub>2</sub> (s)	-451.9	—	—	O <sub>2</sub> (g)	0	0	205.0
PbO(s)	-217.3	-187.9	68.70	O <sub>3</sub> (g)	142.3	163.4	237.6
<b>Lithium</b>				OH <sup>-</sup> (aq)	-230.0	-157.3	-10.7
Li(g)	159.3	126.6	138.8	H <sub>2</sub> O(g)	-241.82	-228.57	188.83
Li(s)	0	0	29.09	H <sub>2</sub> O(l)	-285.83	-237.13	69.91
Li <sup>+</sup> (aq)	-278.5	-273.4	12.2	H <sub>2</sub> O <sub>2</sub> (g)	-136.10	-105.48	232.9
Li <sup>+</sup> (g)	685.7	648.5	133.0	H <sub>2</sub> O <sub>2</sub> (l)	-187.8	-120.4	109.6
LiCl(s)	-408.3	-384.0	59.30				

Substance	$\Delta H_f^\circ$ (kJ/mol)	$\Delta G_f^\circ$ (kJ/mol)	$S^\circ$ (J/mol-K)	Substance	$\Delta H_f^\circ$ (kJ/mol)	$\Delta G_f^\circ$ (kJ/mol)	$S^\circ$ (J/mol-K)
<b>Phosphorus</b>				<b>Sodium</b>			
P(g)	316.4	280.0	163.2	Na(g)	107.7	77.3	153.7
P <sub>2</sub> (g)	144.3	103.7	218.1	Na(s)	0	0	51.45
P <sub>4</sub> (g)	58.9	24.4	280	Na <sup>+</sup> (aq)	-240.1	-261.9	59.0
P <sub>4</sub> (s, red)	-17.46	-12.03	22.85	Na <sup>+</sup> (g)	609.3	574.3	148.0
P <sub>4</sub> (s, white)	0	0	41.08	NaBr(aq)	-360.6	-364.7	141
PCl <sub>3</sub> (g)	-288.07	-269.6	311.7	NaBr(s)	-361.4	-349.3	86.82
PCl <sub>3</sub> (l)	-319.6	-272.4	217	Na <sub>2</sub> CO <sub>3</sub> (s)	-1130.9	-1047.7	136.0
PF <sub>5</sub> (g)	-1594.4	-1520.7	300.8	NaCl(aq)	-407.1	-393.0	115.5
PH <sub>3</sub> (g)	5.4	13.4	210.2	NaCl(g)	-181.4	-201.3	229.8
P <sub>4</sub> O <sub>6</sub> (s)	-1640.1	—	—	NaCl(s)	-410.9	-384.0	72.33
P <sub>4</sub> O <sub>10</sub> (s)	-2940.1	-2675.2	228.9	NaHCO <sub>3</sub> (s)	-947.7	-851.8	102.1
POCl <sub>3</sub> (g)	-542.2	-502.5	325	NaNO <sub>3</sub> (aq)	-446.2	-372.4	207
POCl <sub>3</sub> (l)	-597.0	-520.9	222	NaNO <sub>3</sub> (s)	-467.9	-367.0	116.5
H <sub>3</sub> PO <sub>4</sub> (aq)	-1288.3	-1142.6	158.2	NaOH(aq)	-469.6	-419.2	49.8
				NaOH(s)	-425.6	-379.5	64.46
<b>Potassium</b>				<b>Strontium</b>			
K(g)	89.99	61.17	160.2	SrO(s)	-592.0	-561.9	54.9
K(s)	0	0	64.67	Sr(g)	164.4	110.0	164.6
KCl(s)	-435.9	-408.3	82.7				
KClO <sub>3</sub> (s)	-391.2	-289.9	143.0	<b>Sulfur</b>			
KClO <sub>3</sub> (aq)	-349.5	-284.9	265.7	S(s, rhombic)	0	0	31.88
KNO <sub>3</sub> (s)	-492.70	-393.13	288.1	SO <sub>2</sub> (g)	-296.9	-300.4	248.5
K <sub>2</sub> O(s)	-363.2	-322.1	94.14	SO <sub>3</sub> (g)	-395.2	-370.4	256.2
KO <sub>2</sub> (s)	-284.5	-240.6	122.5	SO <sub>4</sub> <sup>2-</sup> (aq)	-909.3	-744.5	20.1
K <sub>2</sub> O <sub>2</sub> (s)	-495.8	-429.8	113.0	SOCl <sub>2</sub> (l)	-245.6	—	—
KOH(s)	-424.7	-378.9	78.91	H <sub>2</sub> S(g)	-20.17	-33.01	205.6
KOH(aq)	-482.4	-440.5	91.6	H <sub>2</sub> SO <sub>4</sub> (aq)	-909.3	-744.5	20.1
				H <sub>2</sub> SO <sub>4</sub> (l)	-814.0	-689.9	156.1
<b>Rubidium</b>				<b>Titanium</b>			
Rb(g)	85.8	55.8	170.0	Ti(g)	468	422	180.3
Rb(s)	0	0	76.78	Ti(s)	0	0	30.76
RbCl(s)	-430.5	-412.0	92	TiCl <sub>4</sub> (g)	-763.2	-726.8	354.9
RbClO <sub>3</sub> (s)	-392.4	-292.0	152	TiCl <sub>4</sub> (l)	-804.2	-728.1	221.9
				TiO <sub>2</sub> (s)	-944.7	-889.4	50.29
<b>Scandium</b>				<b>Vanadium</b>			
Sc(g)	377.8	336.1	174.7	V(g)	514.2	453.1	182.2
Sc(s)	0	0	34.6	V(s)	0	0	28.9
<b>Selenium</b>				<b>Zinc</b>			
H <sub>2</sub> Se(g)	29.7	15.9	219.0	Zn(g)	130.7	95.2	160.9
				Zn(s)	0	0	41.63
				ZnCl <sub>2</sub> (s)	-415.1	-369.4	111.5
				ZnO(s)	-348.0	-318.2	43.9
<b>Silicon</b>							
Si(g)	368.2	323.9	167.8				
Si(s)	0	0	18.7				
SiC(s)	-73.22	-70.85	16.61				
SiCl <sub>4</sub> (l)	-640.1	-572.8	239.3				
SiO <sub>2</sub> (s, quartz)	-910.9	-856.5	41.84				
<b>Silver</b>							
Ag(s)	0	0	42.55				
Ag <sup>+</sup> (aq)	105.90	77.11	73.93				
AgCl(s)	-127.0	-109.70	96.11				
Ag <sub>2</sub> O(s)	-31.05	-11.20	121.3				
AgNO <sub>3</sub> (s)	-124.4	-33.41	140.9				