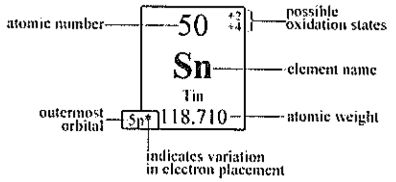
THE PERIODIC TABLE OF ELEMENTS



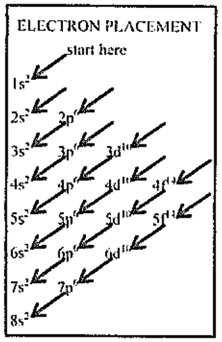
Pb solid
Br liquid
F gas

NONMETALS

TRANSITION METALS

+1 Alkali Metals	+2 Alkaline Earth Metals											+3	-4 +4	-3	-2 Chalcogens	-1 Halogens	Noble Gases
1 +1 -1 H Hydrogen 1.008 1s																	2 0 He Helium 1s 4.003
3 +1 **Li** Lithium 6.941 2s	4 +2 **Be** Beryllium 9.012											5 +3 **B** Boron 10.811 2p	6 +2 +4 -4 **C** Carbon 12.011	7 +1 +2 +3 +4 +5 -1 -2 -3 **N** Nitrogen 14.007 2p	8 -2 O Oxygen 15.999	9 -1 F Fluorine 18.998 2p	10 0 Ne Neon 20.180
11 +1 **Na** Sodium 22.990 3s	12 +2 **Mg** Magnesium 24.305											13 +3 **Al** Aluminum 26.982 3p	14 +2 +4 -4 **Si** Silicon 28.086	15 +3 +5 -3 **P** Phosphorus 30.974 3p	16 +4 +6 -2 **S** Sulfur 32.066	17 +1 +5 +7 -1 Cl Chlorine 35.453 3p	18 0 Ar Argon 39.948
19 +1 **K** Potassium 39.098 4s	20 +2 **Ca** Calcium 40.078	21 +3 **Sc** Scandium 44.956 3d	22 +2 +3 +4 **Ti** Titanium 47.867	23 +2 +3 +4 +5 **V** Vanadium 50.942 3d*	24 +2 +3 +6 **Cr** Chromium 51.996	25 +2 +3 +4 +7 **Mn** Manganese 54.938 3d	26 +2 +3 **Fe** Iron 55.845	27 +2 +3 **Co** Cobalt 58.933 3d	28 +2 +3 **Ni** Nickel 58.693	29 +1 +2 **Cu** Copper 63.546 *3d*	30 +2 **Zn** Zinc 65.39	31 +3 *Ga* Gallium 69.723 4p	32 +2 +4 **Ge** Germanium 72.61	33 +3 +5 -3 **As** Arsenic 74.922 4p	34 +4 +6 -2 **Se** Selenium 78.96	35 +1 +5 -1 *Br* Bromine 79.904 4p	36 0 Kr Krypton 83.80
37 +1 **Rb** Rubidium 85.468 5s	38 +2 **Sr** Strontium 87.62	39 +3 **Y** Yttrium 88.906 4d	40 +4 **Zr** Zirconium 91.224	41 +3 +5 **Nb** Niobium 92.906 *4d*	42 +6 **Mo** Molybdenum 95.94	43 +4 +6 +7 **Tc** Technetium (98) *4d*	44 +3 **Ru** Ruthenium 101.07	45 +3 **Rh** Rhodium 102.906 *4d*	46 +2 +4 **Pd** Palladium 106.42	47 +1 **Ag** Silver 107.868 *4d*	48 +2 **Cd** Cadmium 112.411	49 +3 **In** Indium 114.818 5p	50 +2 +4 **Sn** Tin 118.710	51 +3 +5 -3 **Sb** Antimony 121.760 5p	52 +4 +6 -2 **Te** Tellurium 127.60	53 +1 +5 +7 -1 **I** Iodine 126.904 5p	54 0 Xe Xenon 131.29
55 +1 *Cs* Cesium 132.906 6s	56 +2 **Ba** Barium 137.327	57 +3 **La** Lanthanum 138.906 5d	72 +4 **Hf** Hafnium 178.49	73 +5 **Ta** Tantalum 180.948 *5d	74 +6 **W** Tungsten 183.84	75 +4 +6 +7 **Re** Rhenium 186.207 5d*	76 +3 +4 **Os** Osmium 190.23	77 +3 +4 **Ir** Iridium 192.217 5d*	78 +2 +4 **Pt** Platinum 195.078	79 +1 +3 **Au** Gold 196.967 *5d*	80 +1 +2 *Hg* Mercury 200.59	81 +1 +3 **Tl** Thallium 204.383 6p	82 +2 +4 **Pb** Lead 207.2	83 +3 +5 **Bi** Bismuth 208.980 6p	84 +2 +4 **Po** Polonium (209)	85 **At** Astatine (210) 6s	86 0 Rn Radon (222)
87 +1 *Fr* Francium (223) 7s	88 +2 **Ra** Radium (226)	89 +3 **Ac** Actinium (227) 6d	104 +4 **Rf** Rutherfordium (261)	105 **Db** Dubnium (262) 6d	106 **Sg** Seaborgium (263)	107 **Bh** Bohrium (262) 6d	108 **Hs** Hassium (265)	109 **Mt** Meitnerium (266) 6d									

LANTHANIDES	58 **Ce** Cerium 140.116	59 **Pr** Praseodymium 140.908	60 **Nd** Neodymium 144.24	61 **Pm** Promethium (145)	62 **Sm** Samarium 150.36	63 **Eu** Europium 151.964	64 **Gd** Gadolinium 157.25	65 **Tb** Terbium 158.925	66 **Dy** Dysprosium 162.50	67 **Ho** Holmium 164.930	68 **Er** Erbium 167.26	69 **Tm** Thulium 168.934	70 **Yb** Ytterbium 173.04	71 **Lu** Lutetium 174.967
ACTINIDES	90 **Th** Thorium 232.038	91 **Pa** Protactinium 231.036	92 **U** Uranium 238.029	93 **Np** Neptunium (237)	94 **Pu** Plutonium (244)	95 **Am** Americium (243)	96 **Cm** Curium (247)	97 **Bk** Berkelium (247)	98 **Cf** Californium (251)	99 **Es** Einsteinium (252)	100 **Fm** Fermium (257)	101 **Md** Mendelevium (258)	102 **No** Nobelium (259)	103 **Lr** Lawrencium (262)



DIATOMIC ELEMENTS
Bromine
Chlorine
Fluorine
Hydrogen
Iodine
Nitrogen
Oxygen

PREFIXES
1. mono
2. di
3. tri
4. tetra
5. penta
6. hexa
7. hepta
8. octa
9. nona
10. deca

1 MOLE
=atomic weight in grams for an element
=molecular weight in grams for a compound
=6.02x1023 atoms for an element
=6.02x1023 molecules for a compound
=22.4 liters for a gas at STP
=24.4 liters for a gas at S.C.

Formulas

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

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

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

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

$M_1V_1 = M_2V_2$

$PV = nRT$

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

$q = mC_p\Delta T$

$q = mH_v$

$q = mH_f$

$\text{pH} + \text{pOH} = 14$

$\text{pH} = -\log[\text{H}^+]$

$\text{pOH} = -\log[\text{OH}^-]$

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

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

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

D = density

m = mass

V = volume

K = Kelvin

P = pressure

R = gas constant

T = temperature

M = molarity

n = number of moles

q = quantity of heat energy

C_p = specific heat

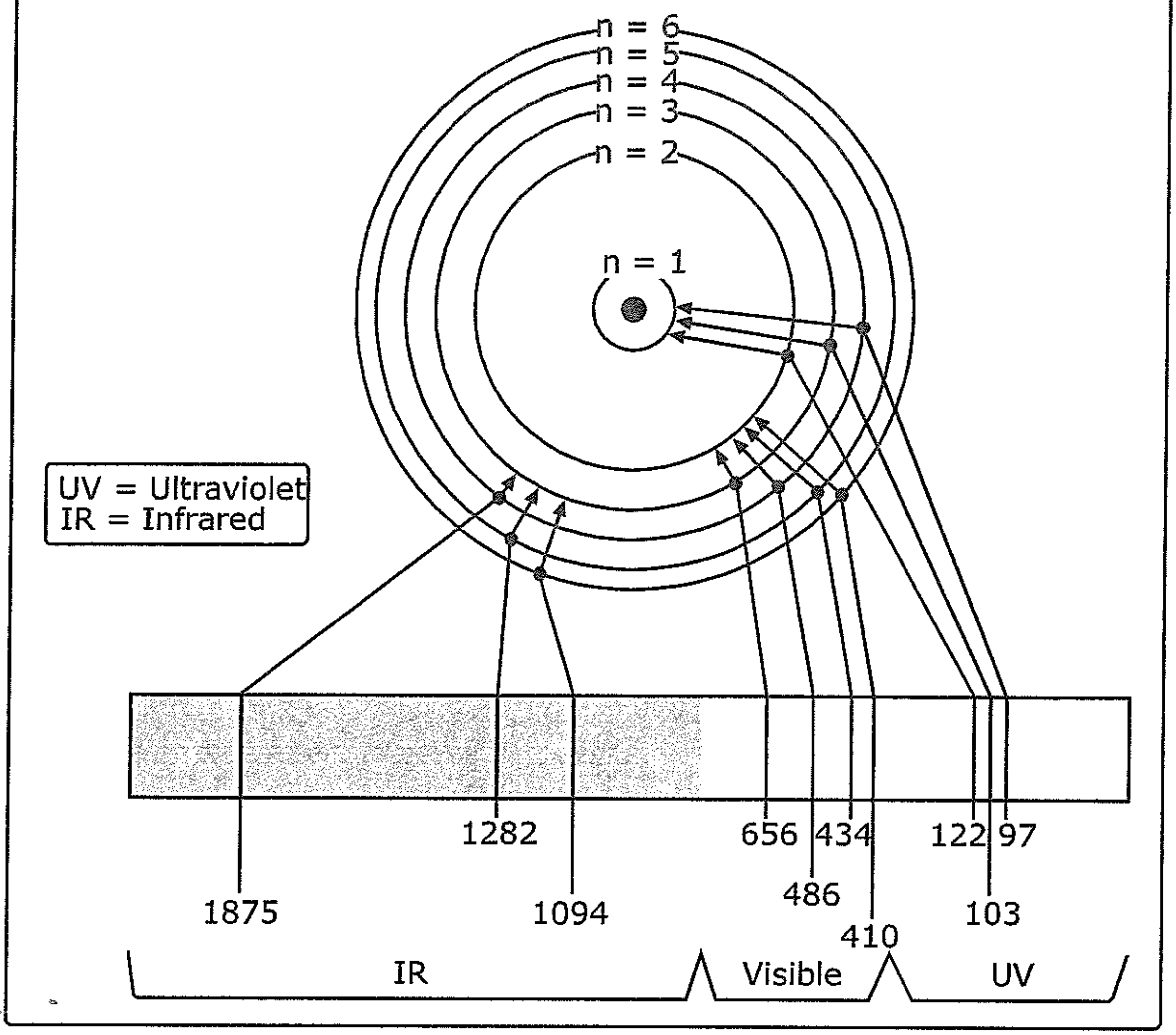
H_v = heat of vaporization

H_f = heat of fusion

K_w = equilibrium constant for the ionization of water

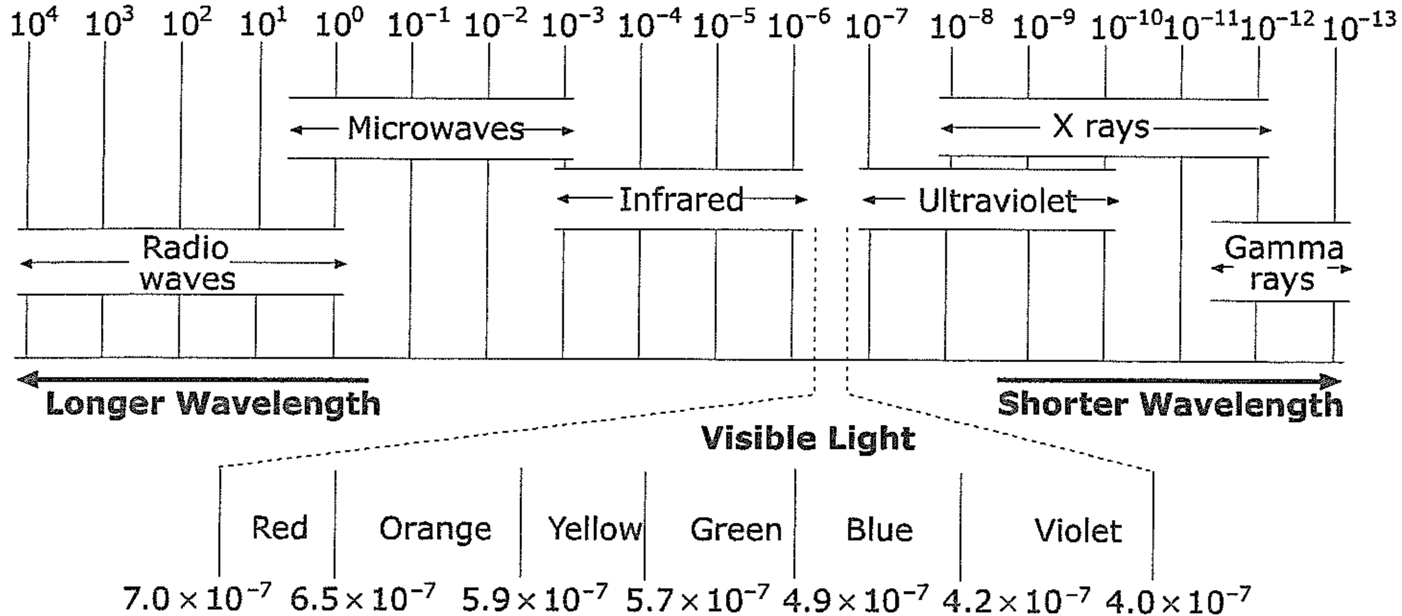
Bohr Model for Hydrogen Atom

(measurement in nanometers)



Electromagnetic Spectrum

(measurement in meters)



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 Reactions

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

1. **SYNTHESIS:**
   a. Formation of binary compound: $\mathbf{A + B \rightarrow AB}$
   b. Metal oxide and water: $\mathbf{MO + H_2O \rightarrow base}$
   c. Nonmetal oxide and water: $\mathbf{(NM)O + H_2O \rightarrow acid}$

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

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

4. **DOUBLE REPLACEMENT:** $\mathbf{AB + CD \rightarrow AD + CB}$
   a. Formation of a precipitate from solution
   b. Acid-Base neutralization

5. **COMBUSTION REACTION**
   Hydrocarbon + oxygen → carbon dioxide + water

General Chemistry Nomenclature

Anions

Monoatomic

Cl^-	chloride
F^-	fluoride
Br^-	bromide
I^-	iodide
O^{-2}	oxide
S^{-2}	sulfide
H^-	hydride
N^{-3}	nitride
C^{-4}	carbide

Polyatomic

OH^-	hydroxide
PO_4^{-3}	phosphate
CN^-	cyanide
PO_3^{-3}	phosphite
HCO_3^-	bicarbonate
HSO_4^-	bisulfate
NO_3^-	nitrate
NO_2^-	nitrite
MnO_4^-	permanganate
$C_2H_3O_2^-$	acetate
O_2^{-2}	peroxide
$C_2O_4^{-2}$	oxalate
CO_3^{-2}	carbonate
SO_4^{-2}	sulfate
SO_3^{-2}	sulfite
CrO_4^{-2}	chromate
$Cr_2O_7^{-2}$	dichromate

BrO^-	hypobromite	ClO^-	hypochlorite	IO^-	hypoiodite
BrO_2^-	bromite	ClO_2^-	chlorite	IO_2^-	iodite
BrO_3^-	bromate	ClO_3^-	chlorate	IO_3^-	iodate
BrO_4^-	perbromate	ClO_4^-	perchlorate	IO_4^-	periodate

Cations

+1 Cations

H^+	hydrogen
Li^+	lithium
Na^+	sodium
K^+	potassium
Rb^+	rubidium
Cs^+	cesium
Ag^+	silver
NH_4^+	ammonium

+2 Cations

Be^{+2}	beryllium
Mg^{+2}	magnesium
Ca^{+2}	calcium
Sr^{+2}	strontium
Ba^{+2}	barium
Zn^{+2}	zinc
Cd^{+2}	cadmium

+3 Cations

Al^{+3}	aluminum

Cations with multiple oxidation states

Fe^{+2}	iron (II) or ferrous	Pb^{+2}	lead (II) or plumbous
Fe^{+3}	iron (III) or ferric	Pb^{+4}	lead (IV) or plumbic
Cr^{+2}	chromium (II) or chromous	Cu^{+1}	copper (I) or cuprous
Cr^{+3}	chromium (III) or chromic	Cu^{+2}	copper (II) or cupric
Sn^{+2}	tin (II) or stannous	Hg^{+2}	mercury (II) or mercuric
Sn^{+4}	tin (IV) or stannic	Hg_2^{+2}	mercury (I) or mercurous

Acids

HF	hydrofluoric acid	HNO_2	nitrous acid
HCl	hydrochloric acid	HNO_3	nitric acid
HBr	hydrobromic acid	H_3PO_4	phosphoric acid
HI	hydroiodic acid	H_2SO_3	sulfurous acid
HCN	hydrocyanic acid	H_2SO_4	sulfuric acid
H_2S	hydrosulfuric acid	$HC_2H_3O_2$	acetic acid
H_2CO_3	carbonic acid	$H_2C_2O_4$	oxalic acid
		HClO	hypochlorous acid
		$HClO_2$	chlorous acid
		$HClO_3$	chloric acid
		$HClO_4$	perchloric acid

Rules for Naming Compounds

A. Binary Compounds Containing a Metal and a Nonmetal (ionic compounds)
   1. Name of cation is given first (same as name of element)
   2. Name of anion is given second
      i. Monoatomic anions end in *–ide*
      ii. Polyatomic ion names do not change

B. Binary Compounds between Two Nonmetals (molecular compounds)
   1. Prefixes are used to specify the number of each atom present
      i.e. 1=mono, 2=di, 3=tri, 4=tetra, 5=penta, 6=hexa, 7=hepta, 8=octa
   2. If first atom is a single atom then prefix "mono' is omitted

Rules for Writing Formulas

A. Ionic Compounds
   1. Sum of charges of all ions must equal zero i.e. total negative charge of all anions must cancel the total positive charge of all cations
   2. Use subscripts to indicate the presence of more than one ion
   3. Polyatomic ions must be in parentheses if subscripts are used.

SCIENTIFIC NOTATION RULES

RULE #1: **Standard Scientific Notation** is a number from 1 to 9 followed by a decimal and the remaining significant figures and an exponent of 10 to hold place value.

Example:

$5.43 \text{ x } 10^2 = 5.43 \text{ x } 100 = 543$
$8.65 \text{ x } 10^{-3} = 8.65 \text{ x } .001 = 0.00865$
****$54.3 \text{ x } 10^1$ **is not** Standard Scientific Notation!!!

RULE #2: When the decimal is moved to the Left the exponent gets Larger, but the value of the number stays the same. Each place the decimal moves Changes the exponent by one (1). If you move the decimal to the Right it makes the exponent smaller by one (1) for each place it is moved.

Example:

$6000. \text{ x } 10^0 = 600.0 \text{ x } 10^1 = 60.00 \text{ x } 10^2 = 6.000 \text{ x } 10^3 = 6000$
(Note: $10^0 = 1$)

All the previous numbers are equal, but only $6.000 \text{ x } 10^3$ is in proper Scientific Notation.

RULE #3: To add/subtract in scientific notation, the exponents must first be the same.

Example:

$(3.0 \text{ x } 10^2) + (6.4 \text{ x } 10^3)$; since $6.4 \text{ x } 10^3$ is equal to $64. \text{ x } 10^2$. Now add.

$$\begin{array}{r} (3.0 \text{ x } 10^2) \\ \underline{+\,(64. \text{ x } 10^2)} \\ 67.0 \text{ x } 10^2 \end{array} = 6.70 \text{ x } 10^3 = \underline{\mathbf{6.7 \text{ x } 10^3}}$$

- $67.0 \text{ x } 10^2$ is mathematically correct, but a number in standard scientific notation can only have one number to the left of the decimal, so the decimal is moved to the left one place and one is added to the exponent.
- Following the rules for significant figures, the answer becomes $6.7 \text{ x } 10^3$.

RULE #4: To multiply, find the product of the numbers, then add the exponents.

Example:

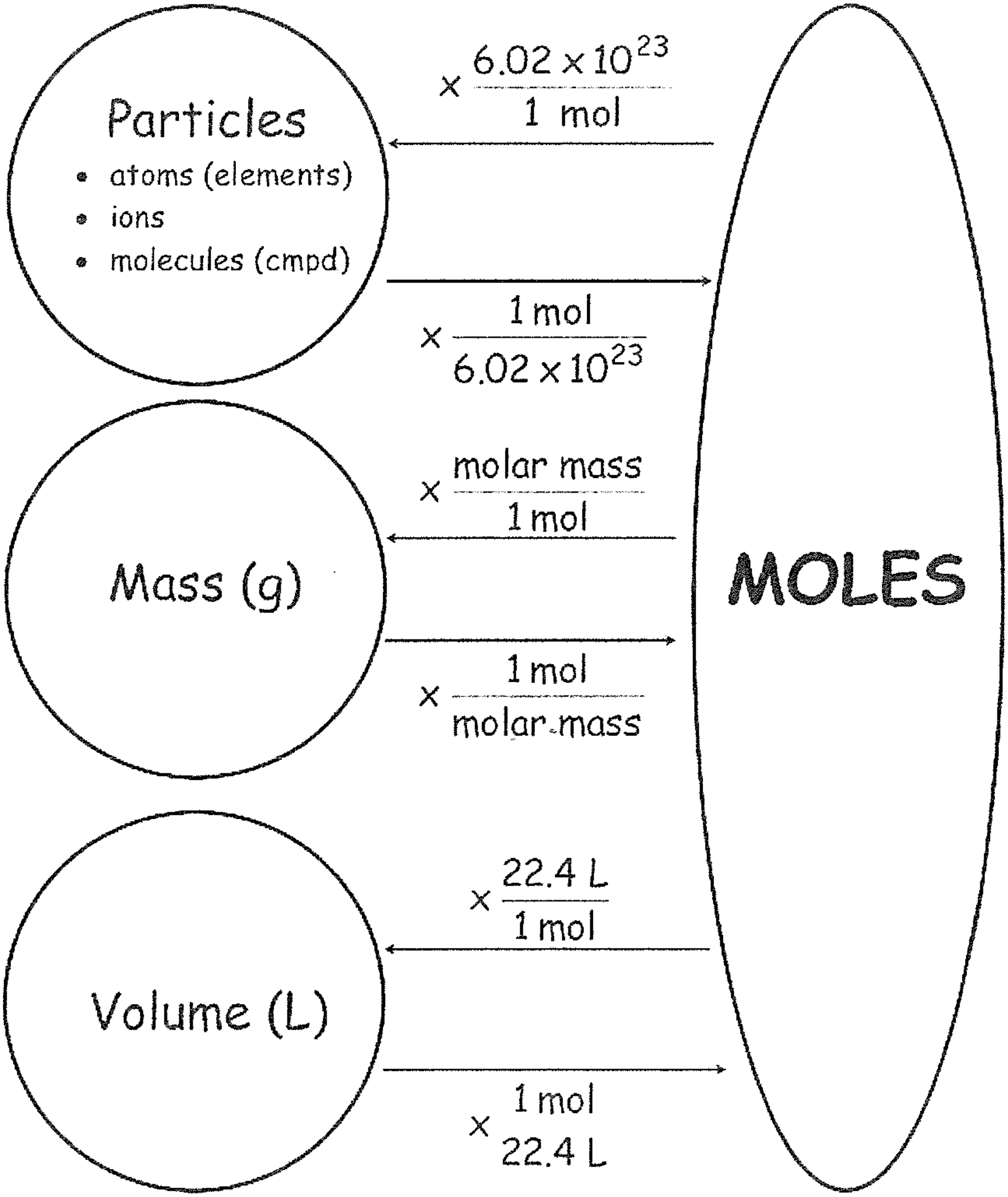
$(2.4 \text{ x } 10^2)(5.5 \text{ x } 10^{-4}) = ?$ $[2.4 \text{ x } 5.5 = 13.2]$; $[2 + -4 = -2]$, so
$(2.4 \text{ x } 10^2)(5.5 \text{ x } 10^{-4}) = 13.2 \text{ x } 10^{-2} = \underline{\mathbf{1.3 \text{ x } 10^{-1}}}$

RULE #5: To divide, find the quotient of the number and subtract the exponents.

Example:

$(3.3 \text{ x } 10^{-6}) / (9.1 \text{ x } 10^{-8}) = ?$ $[3.3 / 9.1 = .36]$; $[-6 - (-8) = 2]$, so
$(3.3 \text{ x } 10^{-6}) / (9.1 \text{ x } 10^{-8}) = .36 \text{ x } 10^2 = \underline{\mathbf{3.6 \text{ x } 10^1}}$

Mole Conversion Diagram



CONSTANTS AND VALUES

Name	**Value**
Avogadro's number	6.022×10^{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**
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)	$2.05 \frac{\text{J}}{\text{g°C}}$ for ice, $2.02 \frac{\text{J}}{\text{g°C}}$ for steam, $4.18 \frac{\text{J}}{\text{g°C}}$ for liquid

Metal	**Specific Heat** $\frac{\text{J}}{\text{g°C}}$	**Density** (g/cm^3)	**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

Organic Substances

Name	**Density**	**Melting Point** (°C)	**Boiling Point** (°C)
Ethanol (CH_3CH_2OH)	0.7893 g/cm^3	–114	79
Glucose ($C_6H_{12}O_6$)	1.56 g/cm^3	146	Decomposes
Hexane (C_6H_{14})	0.6603 g/cm^3	–95	69
Methane (CH_4)	0.716 g/L	–182	–161
Methanol (CH_3OH)	0.7914 g/cm^3	–98	65
Sucrose ($C_{12}H_{22}O_{11}$)	1.58 g/cm^3	86	Decomposes

Inorganic Substances

Name	***Density @ STP**	**Melting Point** (°C)	**Boiling Point** (°C)
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^3	851	Decomposes
Sodium chloride	2.165 g/cm^3	801	1413
Sulfur dioxide	2.92 g/L	–73	–10
*Water (at 4°C)	1.00 g/cm^3	0	100