Italo Bongioanni

Speed of light: 3×10^8 m/s

$\lambda \cdot \nu$ = C = speed of light

Planck's Constant: 6.626×10^{-34} J·s = h

$E_{photon} = h\nu$

Periodic Table of Elements

Honors Chemistry

Type I Elements
Type II Elements
Type III Elements
Acids

Diatomic Elements

H_2 N_2 O_2 F_2 Cl_2 Br_2 I_2

Electronegativity

Atomic Number — Atomic Symbol — Name — Atomic Mass

Example: 30 Zn 1.7 — Zinc — 65.38

S orbital

P orbital

D orbital

F orbital

Non-metal

Metal

	+1												+3		-3	-2	-1	
1	1 H 2.1 Hydrogen 1.008	+2																2 He 4.003 Helium
2	3 Li 1.0 Lithium 6.941	4 Be 1.5 Beryllium 9.012											5 B 2.0 Boron 10.811	6 C 2.5 Carbon 12.011	7 N 3.0 Nitrogen 14.007	8 O 3.5 Oxygen 15.999	9 F 4.0 Fluorine 18.998	10 Ne Neon 20.180
3	11 Na 0.9 Sodium 22.990	12 Mg 1.2 Magnesium 24.305											13 Al 1.5 Aluminum 26.982	14 Si 1.8 Silicon 28.086	15 P 2.1 Phosphorus 30.974	16 S 2.5 Sulfur 32.066	17 Cl 3.0 Chlorine 35.453	18 Ar Argon 39.948
4	19 K 0.8 Potassium 39.098	20 Ca 1.0 Calcium 40.078	21 Sc 1.3 Scandium 44.956	22 Ti 1.5 Titanium 47.867	23 V 1.6 Vanadium 50.942	24 Cr 1.6 Chromium 51.996	25 Mn 1.5 Manganese 54.938	26 Fe 1.8 Iron 55.845	27 Co 1.8 Cobalt 58.933	28 Ni 1.8 Nickel 58.693	29 Cu 1.9 Copper 63.546	30 Zn 1.6 Zinc 65.38	31 Ga 1.6 Gallium 69.723	32 Ge 1.8 Germanium 72.631	33 As 2.0 Arsenic 74.922	34 Se 2.4 Selenium 78.971	35 Br 2.8 Bromine 79.904	36 Kr 3.0 Krypton 84.798
5	37 Rb 0.8 Rubidium 84.468	38 Sr 1.0 Strontium 87.62	39 Y 1.2 Yttrium 88.906	40 Zr 1.4 Zirconium 91.224	41 Nb 1.6 Niobium 92.906	42 Mo 1.8 Molybdenum 95.95	43 Tc 1.9 Technetium 98.907	44 Ru 2.2 Ruthenium 101.07	45 Rh 2.2 Rhodium 102.906	46 Pd 2.2 Palladium 106.42	47 Ag 1.9 Silver 107.868	48 Cd 1.7 Cadmium 112.414	49 In 1.7 Indium 114.818	50 Sn 1.8 Tin 118.711	51 Sb 1.9 Antimony 121.760	52 Te 2.1 Tellurium 127.6	53 I 2.5 Iodine 126.904	54 Xe 2.6 Xenon 131.294
6	55 Cs 0.7 Cesium 132.905	56 Ba 0.9 Barium 137.328	57-71 71 Lu 1.2 Lutetium 174.967	72 Hf 1.3 Hafnium 178.49	73 Ta 1.5 Tantalum 180.948	74 W 1.7 Tungsten 183.84	75 Re 1.9 Rhenium 186.207	76 Os 2.2 Osmium 190.23	77 Ir 2.2 Iridium 192.217	78 Pt 2.2 Platinum 195.085	79 Au 2.4 Gold 196.967	80 Hg 1.9 Mercury 200.592	81 Tl 1.8 Thallium 204.383	82 Pb 1.8 Lead 207.2	83 Bi 1.9 Bismuth 208.980	84 Po 2.0 Polonium [208.982]	85 At 2.2 Astatine 209.987	86 Rn 2.4 Radon 222.018
7	87 Fr 0.7 Francium 223.020	88 Ra 0.7 Radium 226.025	89-103 103 Lr 1.2 Lawrencium [262]	104 Rf Rutherfordium [261]	105 Db Dubnium [262]	106 Sg Seaborgium [266]	107 Bh Bohrium [264]	108 Hs Hassium [269]	109 Mt Meitnerium [268]	110 Ds Darmstadtium [269]	111 Rg Roentgenium [272]	112 Cn Copernicium [277]	113 Uut Ununtrium unknown	114 Fl Flerovium [289]	115 Uup Ununpentium unknown	116 Lv Livermorium [298]	117 Uus Ununseptium unknown	118 Uuo Ununoctium unknown

S orbital

Lanthanide Series	57 La 1.1 Lanthanum 138.905	58 Ce 1.1 Cerium 140.116	59 Pr 1.1 Praseodymium 140.908	60 Nd 1.1 Neodymium 144.243	61 Pm 1.1 Promethium 144.913	62 Sm 1.1 Samarium 150.36	63 Eu 1.1 Europium 151.964	64 Gd 1.1 Gadolinium 157.25	65 Tb 1.1 Terbium 158.925	66 Dy 1.1 Dysprosium 162.500	67 Ho 1.1 Holmium 164.930	68 Er 1.1 Erbium 167.259	69 Tm 1.1 Thulium 168.934	70 Yb 1.1 Ytterbium 173.055
Actinide Series	89 Ac 1.1 Actinium 227.028	90 Th 1.3 Thorium 232.038	91 Pa 1.5 Protactinium 231.036	92 U 1.7 Uranium 238.029	93 Np 1.3 Neptunium 237.048	94 Pu 1.3 Plutonium 244.064	95 Am 1.3 Americium 243.061	96 Cm 1.3 Curium 247.070	97 Bk 1.3 Berkelium 247.070	98 Cf 1.3 Californium 251.080	99 Es 1.3 Einsteinium [254]	100 Fm 1.3 Fermium 257.095	101 Md 1.3 Mendelevium 258.1	102 No 1.3 Nobelium 259.101

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

Common Polyatomic Ions

Acetate	$C_2H_3O_2^-$	Bromite	BrO_2^-	Fluorite	FO_2^-	Permanganate	MnO_4^-
★ Ammonium	NH_4^+	Perchlorate	ClO_4^-	Hydroxide	OH^-	Phosphate	PO_4^{3-}
Arsenate	AsO_4^{3-}	Chlorate	ClO_3^-	Iodate	IO_3^-	Phosphite	PO_3^{3-}
Carbonate	CO_3^{2-}	Chlorite	ClO_2^-	Nitrate	NO_3^-	Silicate	SiO_3^{2-}
Bicarbonate	HCO_3^-	Hypochlorite	ClO^-	Nitrite	NO_2^-	Sulfate	SO_4^{2-}
Bisulfate	HSO_4^-	Chromate	CrO_4^{2-}	Oxalate	$C_2O_4^{2-}$	Sulfite	SO_3^{2-}
Bisulfite	HSO_3^-	Cyanide	CN^-	Perchlorate	ClO_4^-	Thiocyanate	SCN^-
Bromate	BrO_3^-	Chromate	CrO_4^{2-}	Peroxide	O_2^{2-}	Thiosulfate	$S_2O_3^{2-}$
		Dichromate	$Cr_2O_7^{2-}$				

Roman Numerals			
1	I	6	VI
2	II	7	VII
3	III	8	VIII
4	IV	9	IX
5	V	10	X

$4\,Fe + 3O_2 \rightarrow 2\,Fe_2O_3$

$Ba(NO_3)_2 + (NH_4)_2SO_4 \rightarrow BaSO_4 + 2NH_4NO_3$

$Cu(NO_3)_2$

$Zn(NO_3)_2 + 2LiOH$

$Zn(OH)_2 + 2LiNO_3$

Metric Conversions

1 G_ (giga) = 1,000,000,000 (10^9) **SI units**
1 M_ (mega) = 1,000,000 (10^6) **SI units**
1 k_ (kilo) = 1,000 (10^3) **SI units**
1 h_ (hector) = 100 (10^2) **SI units**
1 da_ (deka) = 10 (10^1) **SI units**

SI Units
Length – Meter (m)
Volume – Liter (L)
Mass – Gram (g)
Time – Seconds (s)
Amount – Mole (mol)

1 SI unit = 10 (10^1) d_ (deci)
1 SI unit = 100 (10^2) c_ (centi)
1 SI unit = 1000 (10^3) m_ (milli)
1 SI unit = 1,000,000 (10^6) μ_ (micro)
1 SI unit = 1,000,000,000 (10^9) n_ (nano)

Temperature Conversions

$^\circ C \rightarrow K = {}^\circ C + 273$
$K \rightarrow {}^\circ C = K - 273$
$^\circ F \rightarrow {}^\circ C = \frac{^\circ F - 32}{1.80}$
$^\circ C \rightarrow {}^\circ F = (^\circ C \times 1.80) + 32$

Thermochemistry

$q = m \cdot C \cdot \Delta T$

(q is heat, m is mass, C is specific heat, and T is temperature)

$\Delta T = T_{Final} - T_{Inital}$

$\Delta H^\circ_{rxn} = \Sigma \Delta H^\circ_f (products) - \Sigma \Delta H^\circ_f (reactants)$

$\Delta S^\circ_{rxn} = \Sigma \Delta S^\circ_f (products) - \Sigma \Delta S^\circ_f (reactants)$

$\Delta G_{system} = \Delta H_{system} - T\,\Delta S_{system}$ (T is in Kelvin)

Other Conversions

1 yr = 365.4 days	1 lb = 452.8 g	1 gal = 3.78 L
1 day = 24 hr	1 kg = 2.2 lb	1 oz = 29.57 mL
1 hr = 60 min	1 oz = 28.3 g	1 gal = 231 in^3
1 min = 60 sec	1 ft = 12 in	1 gal = 4 qt
1 in = 2.54 cm	1 m = 1.094 yd	1 L = 1.06 qt
1 mile = 1.61 km = 1760 yds = 5280 ft		1 cm^3 = 1 mL

Molecular Geometry Chart

# of Bonds	# of Lone Pairs	Molecular Shape	Shape
1	0	Linear	
2	0	Linear	
	1	Bent	
	2	Bent	
	3	Linear	
3	0	Trigonal Planar	
	1	Trigonal Pyramidal	
	2	T-structure	
4	0	Tetrahedral	
	1	See-saw	
	2	Square Planar	
5	0	Trigonal Bipyramidal	
	1	Square Pyramidal	
6	0	Octahedral	

Avogadro's

6.02×10^{23} = 1 mole

Activity Series

Metals		Non-metals
Li	Most	F_2
Rb		Cl_2
K		Br_2
Cs		I_2
Ba		
Sr		
Ca		
Na		
Mg		
Al		
Ti		
Mn		
Zn		
Cr		
Fe		
Co		
Ni		
Sn		
Pb		
H_2*		
Cu		
Ag		
Pt		
Au	Least	

Gas Laws Summary

Boyles	$P_1V_1 = P_2V_2$
Charles	$V_1T_2 = V_2T_1$
Gay-Lussac	$P_1/T_1 = P_2/T_2$
Combined	$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$
Ideal	PV=nRT

Remember:

- Temperature MUST be in KELVIN
- Any other units MUST CANCEL
  - Watch for mL and L in same problem, or atm and mmHg in same problem. YOU MUST CONVERT!
    - 1 L = 1000 mL
    - 1 atm = 760 mmHg = 760 torr = 101.3 kPa
- Ideal Gas Law
  - n = moles
  - R = 0.0821 $\frac{L \cdot atm}{mol \cdot K}$ or 8.314 $\frac{L \cdot kPa}{mol \cdot K}$ or 62.4 $\frac{L \cdot mmHg}{mol \cdot K}$
- STP = 273 K and 1 atm

Equilibrium Constant (K) Expression

For the equation $aA + bB \rightarrow cC + dD$ the **equilibrium constant expression** is

$$K = \frac{[C]^c[D]^d}{[A]^a[B]^b}$$

$K_w = [H^+][OH^-] = 1.0 \times 10^{-14}$

$pH = -\log[H^+]$ $\quad pOH = -\log[OH^-]$

$pH + pOH = 14$

Percent Error

$$\left\{\frac{Experimental - Theoretical}{Theoretical} \times 100\right\}$$

Percent Yield

$$\frac{Experimental}{Theoretical} \times 100$$

Strong Acids:

HCl, HBr, HI, HNO_3, $HClO_3$, $HClO_4$, H_2SO_4

Strong Bases:

$LiOH$, $NaOH$, KOH, $RbOH$, $CsOH$, $Ca(OH)_2$, $Sr(OH)_2$, $Ba(OH)_2$

Table of Solubility in Water

	Acetate	Bromate	Carbonate	Chlorate	Chloride	Chromate	Fluoride	Hydroxide	Iodide	Nitrate	Oxalate	Oxide	Perchlorate	Phosphate	Silicate	Sulfate	Sulfide	Sulfite
Aluminum	S	Aq	-	Aq	Aq	-	S	S	Aq	Aq	S	S	Aq	S	S	Aq	-	-
Ammonium	Aq	Aq	Aq	Aq	Aq	Aq	Aq	Aq	Aq	Aq	Aq	-	Aq	Aq	-	Aq	Aq	Aq
Antimony	-	P	-	-	P	-	-	P	P	-	-	S	-	-	-	-	S	-
Arsenic (III)	-	Aq	-	-	Aq	-	-	Aq	Aq	Aq	S	Aq	-	S	S	Aq	Aq	S
Barium	Aq	Aq	S	Aq	Aq	S	S	Aq	Aq	Aq	S	Aq	Aq	S	S	S	Aq	S
Bismuth	-	P	S	-	P	S	S	S	Aq	Aq	S	S	-	S	-	Aq	S	-
Cadmium	Aq	Aq	S	Aq	Aq	-	P	S	Aq	Aq	S	P	Aq	S	-	Aq	S	Aq
Calcium	Aq	Aq	S	Aq	Aq	S	S	P	Aq	Aq	S	P	Aq	S	S	P	Aq	P
Chromium	Aq	Aq	-	Aq	Aq	-	P	S	S	Aq	P	S	Aq	S	S	Aq	S	Aq
Cobalt (II)	Aq	Aq	S	Aq	Aq	S	-	S	Aq	Aq	S	S	Aq	S	S	Aq	S	Aq
Copper (II)	Aq	Aq	S	Aq	Aq	S	Aq	S	-	Aq	S	S	Aq	S	S	Aq	S	Aq
Hydrogen	Aq	Aq	-	Aq	Aq	Aq	Aq	-	Aq	Aq	Aq	-	Aq	Aq	Aq	Aq	Aq	-
Iron (III)	-	Aq	-	-	Aq	-	S	S	Aq	Aq	S	S	Aq	S	S	Aq	S	-
Iron (II)	Aq	Aq	S	-	Aq	-	S	S	Aq	Aq	S	S	Aq	S	S	Aq	S	P
Lead (II)	Aq	S	P	Aq	S	S	S	S	P	P	Aq	S	Aq	S	S	S	S	S
Lithium	Aq	Aq	Aq	Aq	Aq	-	Aq	Aq	Aq	Aq	S	Aq	Aq	P	Aq	Aq	Aq	Aq
Magnesium	-	Aq	S	Aq	Aq	Aq	S	S	Aq	Aq	S	P	Aq	S	S	Aq	S	P
Manganese (II)	Aq	Aq	S	-	Aq	-	-	S	Aq	Aq	P	S	Aq	P	S	Aq	S	-
Mercury (II)	Aq	Aq	S	Aq	Aq	P	-	-	P	Aq	S	S	Aq	S	-	P	S	-
Mercury (I)	P	S	S	Aq	S	P	-	-	S	Aq	S	S	Aq	S	-	P	S	-
Nickel	Aq	Aq	S	-	Aq	-	Aq	S	Aq	Aq	-	S	Aq	S	-	Aq	S	S
Potassium	Aq	Aq	Aq	Aq	Aq	Aq	Aq	Aq	Aq	Aq	Aq	Aq	Aq	Aq	Aq	Aq	Aq	Aq
Silver	S	S	S	Aq	S	S	Aq	S	S	Aq	S	S	Aq	S	-	P	S	Aq
Sodium	Aq	Aq	Aq	Aq	Aq	Aq	Aq	Aq	Aq	Aq	Aq	Aq	Aq	Aq	Aq	Aq	Aq	Aq
Strontium	Aq	Aq	S	Aq	Aq	P	S	P	Aq	Aq	P	S	Aq	S	S	P	Aq	-
Tin (II)	-	Aq	S	Aq	Aq	-	-	S	Aq	Aq	-	S	Aq	S	-	Aq	S	P
Tin (IV)	Aq	Aq	-	-	Aq	Aq	-	-	-	-	S	S	Aq	-	S	Aq	S	-
Zinc	Aq	Aq	S	Aq	Aq	-	Aq	S	Aq	Aq	S	S	Aq	S	S	Aq	S	P

Aq = Soluble in water S = Solid (Insoluble) in water P = Partially soluble in water

- = compounds do not exist or decomposes in water

Redox Rules

Elemental form	**Zero (0).** Only one kind of atom present, no charge
Atomic Ions	**= the charge on the atom** (monatomic ion)
Group 1A	**+1** Unless in elemental form
Group 2A	**+2** Unless in elemental form
Hydrogen (H)	**+1** when bonded to a nonmetal, **-1** when bonded to a metal
Oxygen (O)	**-1** in peroxides O_2^-, **-2** in all other compounds (most common)
Fluorine (F)	**-1**, always
Neutral Compounds	The sum of all oxidation numbers of atoms or ions in a neutral compound is **zero.**
Ionic Compounds	The sum of all oxidation numbers of atoms in an ionic compound is the **charge** on the polyatomic ion.

Class of Compound	Functional Group	General Formula	Example
halide (halocarbon)	—F (fluoro-) —Cl (chloro-) —Br (bromo-) —I (iodo-)	*R*—*X* (*X* represents any halogen)	$CH_3CHClCH_3$ 2-chloropropane
alcohol	—OH	*R*—OH	$CH_3CH_2CH_2OH$ 1-propanol
ether	—O—	*R*—O—*R′*	$CH_3OCH_2CH_3$ methyl ethyl ether
aldehyde	$-\overset{\overset{O}{\|\|}}{C}-H$	$R-\overset{\overset{O}{\|\|}}{C}-H$	$CH_3CH_2\overset{\overset{O}{\|\|}}{C}-H$ propanal
ketone	$-\overset{\overset{O}{\|\|}}{C}-$	$R-\overset{\overset{O}{\|\|}}{C}-R'$	$CH_3\overset{\overset{O}{\|\|}}{C}CH_2CH_2CH_3$ 2-pentanone
organic acid	$-\overset{\overset{O}{\|\|}}{C}-OH$	$R-\overset{\overset{O}{\|\|}}{C}-OH$	$CH_3CH_2\overset{\overset{O}{\|\|}}{C}-OH$ propanoic acid
ester	$-\overset{\overset{O}{\|\|}}{C}-O-$	$R-\overset{\overset{O}{\|\|}}{C}-O-R'$	$CH_3CH_2\overset{\overset{O}{\|\|}}{C}OCH_3$ methyl propanoate
amine	$-\overset{\|}{N}-$	$R-\overset{\overset{R'}{\|}}{N}-R''$	$CH_3CH_2CH_2NH_2$ 1-propanamine
amide	$-\overset{\overset{O}{\|\|}}{C}-\overset{\|}{N}H$	$R-\overset{\overset{O}{\|\|}}{C}-\overset{\|}{N}H$	$CH_3CH_2\overset{\overset{O}{\|\|}}{C}-NH_2$ propanamide

Note: *R* represents a bonded atom or group of atoms.

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Naming Compounds

What type of element is the first one in the compound?

Metal – Ionic Compound

Is the metal (cation) in the s block or Ag, An, Cd, Al, Ga, or In?

Yes – Type I

Write the element name for the cation

No – Type II

Write the element name for that cation WITH a **roman numeral** after it to indicate the charge.

Anion

Is the anion a polyatomic ion?

Yes

Write the name of the polyatomic ion

Example

- *Type I – $CaSO_4$*
  Calcium sulfate
- *Type II – $Cu(OH)_2$*
  Copper (II) hydroxide

No

Write the root name of the anion and add the suffix **–ide**.

Example

- *Type I – Na_3P*
  Sodium phosphide
- *Type II – PbS*
  Lead (II) sulfide

Hydrogen - Acid

Is the anion a polyatomic ion?

Yes

Is the suffix of the polyatomic ion –ate or –ite?

-ate

Replace the **–ate** with **–ic**. The second word is acid.

Example

H_2CO_3
(carbonate)
Carbonic acid

-ite

Replace the **–ite** with **–ous**. The second word is acid.

Example

HNO_2
(nitrite)
Nitrous acid

No

The name starts with **hydro-**, then the root name of the nonmetal, and the suffix –ic. The second word is acid.

Example

HCl
***Hydro**chloric*
acid

Nonmetal – Molecule Type III

The first element in the formula is named first using the entire element. The second element is named using the element root name plus the suffix –ide. **Prefixes** are used to indicate the number of atoms present for each element (never use mono on the first element).

Don't use on first element

Prefixes

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

Example

CO_2 - Carbon **di**oxide
B_2Br_4 - **Di**boron **tetra**bromide

1. Is the first element in the compound a metal?
    - Yes, it is an ionic compound. Go to #2.
    - No, go to #8
2. Is the metal (cation) in the s block or Ag, Zn, Cd, Al, Ga, or In?
    - Yes, it is a type I compound. Go to #3
    - No, it is a type II compound. Go to #4
3. Write the element name for the cation.
    - Go to #5
4. Write the element name for the cation **WITH** a roman numeral after it to indicate the charge. (determine by doing the backward criss-cross from the chemical compound)
    - Go to #5
5. Is the anion a polyatomic ion?
    - Yes, go to #6
    - No, go to #7
6. Write the name of the polyatomic ion.
    - *Type I – $CaSO_4$ Calcium sulfate*
    - *Type II – $Cu(OH)_2$ Copper (II) hydroxide*
7. Write the root name of the anion and add the suffix –ide.
    - *Type I – Na_3P Sodium phosphide*
    - *Type II – PbS Lead (II) sulfide*
8. Is the first element of the compound hydrogen?
    - Yes, it's an acid. Go to #9
    - No, it's a molecule. Go to #12
9. Is the anion a polyatomic ion?
    - Yes, go to #10
    - No, go to #11
10. Is the suffix of the polyatomic ion –ate?
    - Yes, replace the –ate with –ic. The second word is acid.
        - *H_2CO_3 Carbonic acid* (carbonate polyatomic ion)
    - No, replace the –ite with –ous. The second word is acid.
        - *HNO_2 Nitrous acid* (nitrite polyatomic ion)
11. The name starts with hydro-, then the root name of the nonmetal, and the suffix –ic. The second word is acid.
    - *HCl Hydrochloric acid*
12. The first element in the formula is named first using the entire element. The second element is named using the element root name plus the suffix –ide. Prefixes are used to indicate the number of atoms present for each element (never use mono on the first element).
    - *CO_2 Carbon dioxide*
    - *B_2Br_4 Diboron tetrabromide*
        - 1 = mono
        - 2 = di
        - 3 = tri
        - 4 = tetra
        - 5 = penta
        - 6 = hexa
        - 7 = hepta
        - 8 = octa
        - 9 = nona
        - 10 = deca