Ch. 5 Notes: TYPES OF COMPOUNDS

I. Compounds in General
- A. **compound** ("cmpd.")—*a substance formed from more than one element*
  - 1) has more than one different capital letter… Al_2S_3, NaBr, $Ca(OH)_2$
  - 2) can be separated by chemical means
- B. **molecule**—*a group of atoms with no net charge*
- C. two general types of compounds
  - 1) **molecular compound**—*composed of atoms*
    - usually liquids or gases at room temp.
    - usually have a low melting point (m.p.) and boiling point (b.p.)
    - *composed of nonmetals*… like CO_2
  - 2) **ionic compounds**—*composed of positive/negative ions*
    - usually crystalline solids at room temp.
    - usually have a high melting point (m.p.) and boiling point (b.p.)
    - *composed of metals and nonmetals*… like NaCl

II. Chemical formulas
- **A. chemical formula**
  - 1) symbols representing the composition of the smallest unit of a substance
  - 2) *shows which elements are present and how many there are*
    H_2SO_4 = hydrogen, sulfur, oxygen = 7 atoms total
- B. **molecular formula**—symbols representing the composition of a *molecular compound*
- C. **formula unit**— the lowest whole-number ratio of ions in an *ionic compound*
  - 1) It is improper to use the term "molecule" to describe an ionic compound.
  - 2) Ionic compounds occur in repeating units in their crystals (BCC, FCC, etc.).
- D. number codes
  - 1) **subscript**—a number written slightly *below* the symbol Br_2
  - 2) **superscript**—a number written slightly *above* the symbol Sr^{2+}

(In chem., a superscript is not called an exponent. Nothing is being multiplied.)

III. Common vs. Systematic Names: Why use naming rules at all?
- A. common names do not discuss chemical composition
- B. systematic names are a standardized way of naming compounds
- C. some common names for chemicals:

asbestos = magnesium silicate
aspirin = acetylsalicylic acid
baking soda = sodium bicarbonate
black lead = graphite
borax = sodium borate
brine = strong sodium chloride solution
chalk = calcium carbonate
drinking alcohol = ethanol
Epsom salts = magnesium sulfate
laughing gas = dinitrogen monoxide
lime = calcium oxide
lime, slaked = calcium hydroxide
limewater = calcium hydroxide solution
table salt = sodium chloride
quicksilver = mercury
silica = silicon dioxide
soda ash, dry = dry sodium carbonate
soda lye = sodium hydroxide
soluble glass = sodium silicate
talc or talcum = magnesium silicate
vinegar = dilute acetic acid
Vitamin C = ascorbic acid
water = H_2O
water glass = sodium silicate

IV. Ionic Compounds

A. *metals form cations (+)* *nonmetals form anions (--)*

B. ionic charges of the elements

"Charge Chant": +1 +2 +3 mixed -3 -2 -1 0
+2 in the middle, unless they tell you otherwise

Group number:	**IA**	**IIA**	**IIIA**	**IVA**	**VA***	**VIA***	**VIIA***	**VIIIA**
	1	**2**	**13**	**14**	**15**	**16**	**17**	**18**
Main ionic charge:	**1+**	**2+**	**3+**	**M**	**3-**	**2-**	**1-**	**none**

M most of the Group IVA don't usually form ions; when they do, there are mixed charges possible
* when applicable

C. charge is also called **<u>oxidation number</u>**

D. multiple charges (transition metals and others) – *if an atom forms more than one charge, you must say which one it is:*

1) Stock system uses number clues – this is the most common way to do it
2) Classical (Latin root) system

LOWER CHARGED ION: suffix "–OUS" Cu^{+} *= cuprous ion*
HIGHER CHARGED ION: suffix "–IC" Cu^{2+} *= cupric ion*

IMPORTANT REFERENCE TABLE FOR IONS WITH MULTIPLE CHARGES:

<u>ION FORMULA</u>	**<u>STOCK NAME</u>**	<u>(CLASSICAL NAME)</u>
Cu^{+}	**copper(I) ion**	cuprous ion
Cu^{2+}	**copper(II) ion**	cupric ion
Fe^{2+}	**iron(II) ion**	ferrous ion
Fe^{3+}	**iron(III) ion**	ferric ion
Pb^{2+}	**lead(II) ion**	plumbous ion
Pb^{4+}	**lead(IV) ion**	plumbic ion
Sn^{2+}	**tin(II) ion**	stannous ion
Sn^{4+}	**tin(IV) ion**	stannic ion
Cr^{2+}	**chromium(II) ion**	chromous ion
Cr^{3+}	**chromium(III) ion**	chromic ion
Mn^{2+}	**manganese(II) ion**	manganous ion
Mn^{3+}	**manganese(III) ion**	manganic ion
Co^{2+}	**cobalt(II) ion**	cobaltous ion
Co^{3+}	**cobalt(III) ion**	cobaltic ion
Hg^{2+}	mercury(I) ion	mercurous ion
Hg_2^{2+}	mercury(II) ion	mercuric ion

3) **one-charge transition metal ions: Ag^{+}, Cd^{2+}, Zn^{2+}**

VI. Binary compounds: binary ionic and binary molecular

A. **<u>binary compound</u>**—*composed of two elements*

B. **<u>binary ionic compound</u>**—("BI")—*metal cation / nonmetal anion combination*

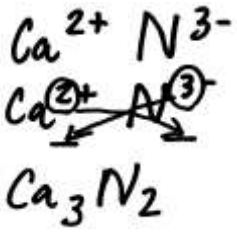
1) compound composed of **<u>monatomic</u>** (*one symbol*) ions
2) crisscross formula method is used
3) name the cation first, then the anion (*-IDE* ending)

4) use Roman numerals if/when needed for the cation
5) examples:

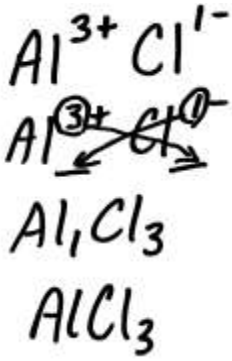
$CaBr_2$ = calcium bromide KI = potassium iodide $FeCl_3$ = iron(III) chloride

C. *"crisscross" formula method for ionic compounds*
1) *write the symbols of the two ions next to each other*
2) *write the charges as superscripts*
3) *balance the formula by crisscrossing the numbers (net charge = 0)*
4) *the numbers are now subscripts, telling you how many of each symbol is in the formula*
5) *if the charges are the same, they cancel out*
6) *if the charges are multiples of each other, reduce them*

EXAMPLE 1: calcium nitride
Ca^{2+} and N^{3-}



EXAMPLE 2: aluminum chloride
Al^{3+} and Cl^{1-}



D. **<u>binary molecular compound</u>**—("BM")— *nonmetal / nonmetal combination*
1) no ionic charges involved (no crisscross)
2) ending in *-IDE*
3) since there are no charges to determine the ration of symbols, *mandatory prefixes are used in naming:*

MONO-,	DI-,	TRI-,	TETRA-,	PENTA-,	HEXA-,	HEPTA-,	OCTA-,	NONA-,	DECA-
1	2	3	4	5	6	7	8	9	10

(mono- is not used on the first element)

4) examples:

CCl_4 = carbon tetrachloride BF_3 = boron trifluoride CO = carbon monoxide

VII. Polyatomic ions
A. **<u>polyatomic ion</u>**—*a group of charged atoms*
B. most end in *–ATE* or *–ITE*
C. To avoid confusion, you may keep the parentheses around the polyatomic ion if there is only one polyatomic ion in the formula, but be aware that textbooks do not do this.

Example: sodium hydroxide may be written Na(OH) but will be shown in textbooks and by the teacher as NaOH.

POLYATOMIC IONS

Students must memorize these 20 ions.

1⁺ CHARGE:
ammonium $(NH_4)^+$

1⁻ CHARGE:
acetate $(C_2H_3O_2)^-$ or $(CH_3COO)^-$
chlorate $(ClO_3)^-$
chlorite $(ClO_2)^-$
cyanide $(CN)^-$
hydrogen carbonate or bicarbonate $(HCO_3)^-$
hydroxide $(OH)^-$
hypochlorite $(ClO)^-$
nitrate $(NO_3)^-$

MORE 1- CHARGE:
nitrite $(NO_2)^-$
perchlorate $(ClO_4)^-$
permanganate $(MnO_4)^-$

2⁻ CHARGE:
carbonate $(CO_3)^{2-}$
chromate $(CrO_4)^{2-}$
dichromate $(Cr_2O_7)^{2-}$
silicate $(SiO_3)^{2-}$
sulfate $(SO_4)^{2-}$
sulfite $(SO_3)^{2-}$

3⁻ CHARGE:
phosphate $(PO_4)^{3-}$
phosphite $(PO_3)^{3-}$

VIII. Ternary Compounds

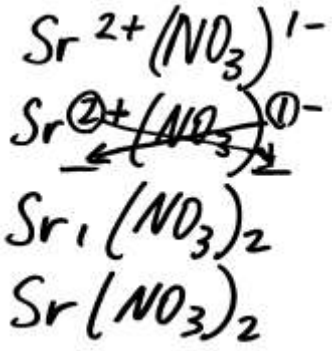
A. **ternary compound**—compound made up of *three different elements*

B. **ternary ionic compound**—("TI")— *metal cation / nonmetal anion combination of three symbols, involving polyatomic ions*

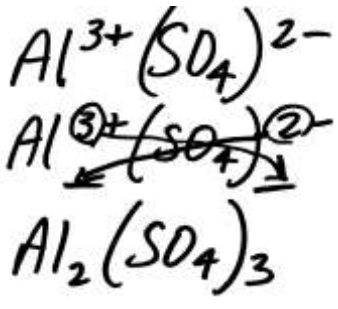
1) *crisscross* formula method is used

- *write the symbols of the two ions next to each other*
- *be careful to keep the parentheses around the polyatomic ion*
- *write the charges as superscripts*
- *balance the formula by crisscrossing the numbers (net charge = 0)*
- *the numbers are now subscripts, telling you how many of each symbol is in the formula*
- *if the charges are the same, they cancel out*
- *if the charges are multiples of each other, reduce them*

EXAMPLE 1: strontium nitrate
Sr^{2+} and $(NO_3)^{1-}$



EXAMPLE 2: aluminum sulfate
Al^{3+} and $(SO_4)^{2-}$



2) name the cation first, then the anion (-*IDE* ending)

3) use Roman numerals if/when needed for the cation

C. examples:
Na_2SO_4 = sodium sulfate $KMnO_4$ = potassium permanganate $Fe(OH)_3$ = iron(III) hydroxide

D. **ternary molecular compound**—("TM")— *three nonmetals, involving polyatomic ions*
1) acids are TM compounds
2) acids donate H+ ions when in solution $HX \rightarrow H^+ + X^-$
3) examples:
H_2SO_4 = sulfuric acid $HC_2H_3O_2$ = acetic acid

IX. Molecular Elements
A. diatomic elements

THE SEVEN DIATOMIC MOLECULES ("Super Seven"):
H_2 F_2 O_2 N_2 Cl_2 Br_2 I_2

B. **allotropes**—*molecules of a single element that differ in crystalline or molecular structure*
1) oxygen (O_2) and ozone (O_3)
2) C: graphite, diamond, charcoal, carbon black, linear, buckyballs (C_{60})
3) P: white, red, black phosphorus
4) sulfur (S_8, S_3, S_4)
5) Sn: white and gray tin

X. Hydrates
A. **water of hydration**—*water molecules chemically integrated into a crystalline structure*
B. **hydrate**—*a compound with water in its structure*
1) *general formula: [compound]$\cdot H_2O$*
2) *naming: [compound name] (prefix)hydrate*
$CuSO_4 \cdot 5H_2O$ copper(II) sulfate pentahydrate
$CaCl_2 \cdot 2H_2O$ calcium chloride dehydrate

C. **anhydrous**—*a hydrate without its water of hydration*
$Na_2SO_4 \cdot 2H_2O \rightarrow Na_2SO_4 + 2H_2O$
sodium sulfate dihydrate anhydrous sodium sulfate + water

D. **efflorescence**—the release of water by a hydrate (heating not needed)
E. **hygroscopic**—*removing water from the atmosphere*
F. **deliquescence**
1) absorbing excess water from the atmosphere to form a liquid substance
2) this is an extreme hygroscopic condition
G. **desiccant**
1) a *drying agent* which is hygroscopic
2) examples: Damp Rid; packets of silica powder in shoe boxes