Chemistry 103, Dr. Hamers
Help Sheet #3; Chapter 2 (Part II)
Tony Jacob

Nuggets: *Ionic vs molecular compounds; Naming chemicals; Writing formulas from names; Polyatomic Ions; Mole and mole calculations; Mass percent; Empirical and Molecular formulas*

TYPES OF COMPOUNDS

Ionic Compounds: contain metal (or polyatomic ion) and a nonmetal (or polyatomic ion); ionic compounds are extended solids, not molecules; Examples: NaCl, $Ca(NO_3)_2$, NH_4NO_3

Ions: atoms that have lost or gained electrons (atoms **never** receive a charge by gaining or losing protons!)

Cations: positively charged atoms (electrons have been lost)
Anions: negatively charged atoms (electrons have been gained)

Polyatomic Ions: many atom ions; these compounds should **never** be broken up;

Memorize: NH_4^+, NO_3^-, SO_4^{-2}, OH^-, PO_4^{-3}, CO_3^{-2}, HCO_3^-, $C_2H_3O_2^-$, etc. (see handout for complete list)

Molecular Compounds: contain 2 nonmetal elements; Examples: CO, CO_2, N_2O_4

NAMING COMPOUNDS

Ionic Compounds

- Metal & Nonmetal: Metal name & Nonmetal stem+"ide"; Example: $CaCl_2$; calcium chloride
- Metal & Polyatomic Ion: Metal name & Polyatomic ion name; Example: $Mg(NO_3)_2$; magnesium nitrate
- If Metal is a transition metal, the charge is written in Roman numerals in parentheses after the metal Example: $FeCl_2$; since Fe is a transition metal, it most likely has a variable charge; since Cl has a -1 charge, then the Fe must have a +2 charge which is written as II in Roman numerals; iron(II) chloride

Molecular Compounds

- Prefix (only when greater than 1)+1st nonmetal name & Prefix (always)+2nd nonmetal stem+"ide" Examples: CO: carbon monoxide; CO_2: carbon dixoide; N_2O: dinitrogen monoxide

Prefixes: mono (1), di (2), tri (3), tetra (4), penta (5)

WRITING FORMULAS FROM NAMES

Ionic Compounds

1. Take metal name or polyatomic ion and write formula including charge
   - If metal has a Roman numeral, then charge is determined from that numeral (e.g., iron(III) = Fe^{+3})
   - If it does not have a Roman numeral, it is a memorized polyatomic ion (e.g., ammonium = NH_4^+) or determined from column in Periodic Table it resides in (e.g., magnesium = Mg^{+2} since IIA column)
2. Take nonmetal name or polyatomic ion and write formula including charge
   - If nonmetal name ends with "ide" it is a single ion with a negative charge (e.g., chloride = Cl^-) except for hydroxide (OH^-) and cyanide (CN^-)
   - If it ends with "ite" or "ate" or starts with "hypo" or "per" it's a memorized polyatomic ion (e.g., chlorite = ClO_2^-)
3. Balance charges within formula (e.g., iron(III) chorite → Fe^{+3} and ClO_2^- → $Fe(ClO_2)_3$)

Memorize charges on elements in IONIC compounds based on the column of Periodic Table it resides in

Group IA: +1 (H^+, Li^+, ...)	Group IIA: +2 (Be^{+2}, Mg^{+2}, ...)	Group IIIA: +3
Group IV A: ±4	Group VA: -3	Group VIA: -2
Group VIIA: -1 (F^-, Cl^-, ...)	Group VIIIA : no charge (He, Ne, ...)	

Molecular Compounds: translate name with prefixes; e.g., dinitrogen trioxide → 2N and 3O → N_2O_3

MOLE

a number equal to 6.022×10^{23} units (can treat a mole like a dozen; i.e., just like a number)
Average atomic mass on the periodic table (the number below the chemical symbol) reflects the average weight in grams of one mole of that element taking into account all the different isotopes that exist

MOLAR MASS (also called molecular weight, MW) = sum of the individual atomic weights

MW of $Ca(NO_3)_2$ = 1(40.08)+2(14.01)+6(16.00) = 164.10 g $Ca(NO_3)_2$/1 mole $Ca(NO_3)_2$

MASS PERCENT of elements within a compound (e.g., $Ca(NO_3)_2$: 24.4% Ca, 17.1% N, 58.5% O)

$$\textbf{mass\%A} = \frac{\textbf{massA}}{\textbf{total mass}} \textbf{ x 100\%} \quad \text{and} \quad \textbf{mass\%A} = \frac{\textbf{\#molA x AW}_\textbf{A}}{\textbf{molar mass compound}} \textbf{ x 100\%}$$

EMPIRICAL FORMULA: the simplest formula that shows the ratio between atoms

Determining empirical formula from mass percents:

1. Assume 100g
2. % → g
3. g → mol (if g originally given and not mass% → start at step 3!)
4. Write chemical formula; divide by smallest number of moles
5. fractions: $^1/_2$ (0.5) → x2; $^1/_3$ or $^2/_3$ (0.33, 0.66) → x 3; $^1/_4$ or $^3/_4$ (0.25, 0.75) → x 4; need MW and mass% to determine molecular formula

MOLECULAR FORMULA: the exact formula of a compound

For N_2O_4, the molecular formula is N_2O_4 and the empirical formula is NO_2

You can not determine the molecular formula from mass percent, only the empirical formula

Determine Molecular formula from Empirical formula and Molecular Weight

Take ratio: $\frac{\text{molar mass of molecular formula}}{\text{molar mass of empirical formula}}$

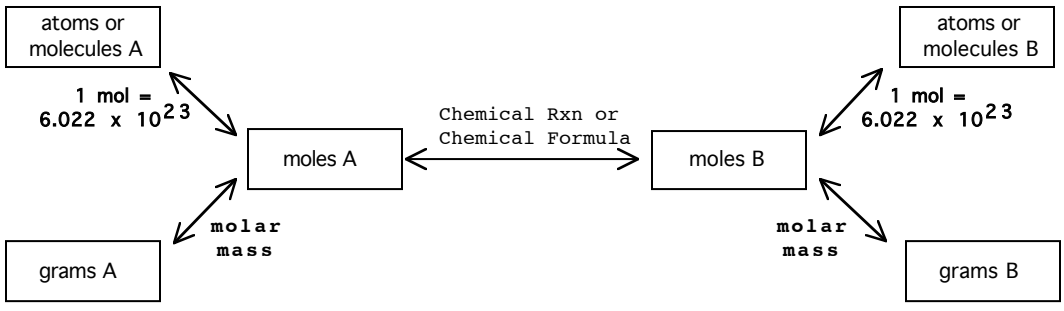
Take empirical formula and multiply each subscript by the number from above ratio

HYDRATED COMPOUNDS: compounds that have waters attached to their chemical formulas but the structure of water is maintained; this is represented in the formula with a "dot" followed by the number of waters attached, e.g., $CuSO_4 \cdot 5H_2O$; *when determining molar mass of hydrated compound, add the water to the total*

$$\textbf{\#H}_\textbf{2}\textbf{O} = \frac{\textbf{mol H}_\textbf{2}\textbf{O}}{\textbf{mol compd}_{\textbf{no H}_\textbf{2}\textbf{O}}}$$

$$\textbf{mol H}_\textbf{2}\textbf{O} = \frac{\textbf{mass}_{\textbf{hydrated compd}} - \textbf{mass}_{\textbf{anhydrous compd}}}{\textbf{molar mass H}_\textbf{2}\textbf{O}} \quad \text{and} \quad \textbf{mol compd}_{\textbf{no H}_\textbf{2}\textbf{O}} = \frac{\textbf{mass compd}_{\textbf{no H}_\textbf{2}\textbf{O}}}{\textbf{molar mass compd}_{\textbf{no H}_\textbf{2}\textbf{O}}}$$

CONVERTING BETWEEN MOLES, GRAMS AND ATOMS/MOLECULES:



1. Name the following molecules.
a. NO b. PCl_3 c. KBr d. Na_2CO_3 e. N_2O_4 f. K_2SO_4 g. HNO_3 h. $Ca_3(PO_4)_2$ i. $Al_2(HPO_4)_3$

2. Write the chemical formula for the following names.
a. sulfur trioxide b. calcium fluoride c. chlorine monobromide d. sulfuric acid e. sodium sulfate
f. ammonium nitrite g. lithium carbonate h. calcium nitrate i. magnesium sulfite
j. calcium hydrogen carbonate

3. Answer each statement as True or False.
a. Chlorine is an example of a halogen.
b. Chlorine is a non-metal.
c. Fluorine is an example of an element in the third period.
d. The mass percent of N in NO is less than the mass percent of N in N_2O.
e. Two different molecules each with a different molecular formula can have the same empirical formula.
f. The molecular formula can have the same molar mass as the empirical formula.

4. Magnesium has naturally occurring isotopes with the following masses and abundances:

Isotope	Atomic Mass	Fractional Abundance
^{24}Mg	23.985	0.7870
^{25}Mg	24.986	0.1013
^{26}Mg	25.983	0.1117

What is the atomic mass of magnesium calculated from these data?

5. Give the number of moles of *each element* present in 1.0 mol of each of the following compounds:
a. NH_3 b. $Ca_3(PO_4)_2$ c. $(NH_4)_2Cr_2O_7$

6. How many moles are represented by each of these samples? a. 100.0 g H_2O b. 500.0 g Fe c. 150.0 g Fe_2O_3

7. a. How many atoms of each element are present in 1.0 mol $Ca_3(PO_4)_2$?
b. How many grams of each element are present in 1.0 $Ca_3(PO_4)_2$?
c. How many moles of each element are present in 1.0 g $Ca_3(PO_4)_2$?
d. How many grams of each element are present in 1.0 g $Ca_3(PO_4)_2$?

8. a. How many molecules of N_2O are there in 20.5 grams of N_2O?

b. How many atoms of H are there in 44.0grams of $Ca(H_2PO_4)_2$?

c. How much does 9.3×10^{26} molecules of SO_2 weigh?

9. a. What is the mass percent of nitrogen in ammonium carbonate, $(NH_4)_2CO_3$?

b. What is the mass percentage of S in $Fe_2(SO_4)_3$?

10. a. A compound of nitrogen and oxygen exists and contains 36.36% oxygen. What is the empirical formula?
b. A compound contains 28.18% manganese, 30.80% carbon, and 41.03% oxygen. What is the empirical formula for this compound? If the molar mass of this compound is 389.98g/mol, what is the molecular formula for this compound?
c. Adipic acid is used in the manufacture of nylon. The composition of the acid is 49.3% C, 6.9% H, and 43.8% O and the molecular weight is 146 g/mol. What is the molecular formula of adipic acid?

11. Which compound has the greatest mass percent of oxygen?
a. NO b. CO c. CO_2 d. H_2O e. N_2O

12. a. A compound is 52.2% by mass carbon and contains 2 carbon atoms per molecule. What is the molar mass of this compound?
b. A compound is 46.7% by mass nitrogen and has a molar mass of 60g/mol. How many atoms of nitrogen are there in each molecule of this compound?

13. a. A hydrated compound of Cr(III), $Cr(ClO_4)_3 \cdot xH_2O$ is analyzed. It is found that when 2.1254g of the hydrate was heated for 6 hours all the water was removed and the mass of the sample dropped to 1.6243g. How many waters of hydration were in the original compound?

b. Glauber's salt, a hydrated compound of $Na_2SO_4 \cdot xH_2O$ is analyzed. It is found that when 0.7459g of the hydrate was heated and it's waters of hydration were removed and the mass dropped to 0.3289g. How many waters of hydration were in the original compound? What mass percent of the hydrate, $Na_2SO_4 \cdot xH_2O$, is water?

14. How many molecules of water will be found in 5 ml of water? The density of water is 0.997 g/ml.

ANSWERS

1. a. nitrogen monoxide b. phosphorus trichloride c. potassium bromide d. sodium carbonate e. dinitrogen tetroxide f. potassium sulfate g. nitric acid h. calcium phosphate i. aluminum hydrogen phosphate
2. a. SO_3 b. CaF_2 c. ClBr d. H_2SO_4 e. Na_2SO_4 f. NH_4NO_2 g. Li_2CO_3 h. $Ca(NO_3)_2$ i. $MgSO_3$ j. $Ca(HCO_3)_2$ 3. a. T b. T c. F d. T e. T f. T 4. 24.310
5. a. 1 mol of N, 3 mol of H b. 3 mol Ca, 2 mol P, 8 mol O c. 2 mol N, 8 mol H, 2 mol Cr, 7 mol O
6. a. 5.56 mol H_2O b. 8.95 mol Fe c. 0.939 mol Fe_2O_3
7. a. $Ca_3(PO_4)_2$: 1.8×10^{24} atoms Ca, 1.2×10^{24} atoms P, 4.8×10^{24} atoms O
b. $Ca_3(PO_4)_2$: 120 g Ca, 62 g P, 128 g O
c. $Ca_3(PO_4)_2$: 9.7×10^{-3} mol Ca, 6.5×10^{-3} mol P, 2.6×10^{-2} mol O
d. $Ca_3(PO_4)_2$: 0.39 g Ca, 0.20 g P, 0.41 g O
8. a. 2.81×10^{23} molecules N_2O b. 4.53×10^{23} atoms of H c. 9.9×10^4 grams
9. a. 29.2% b. 24.1% 10. a. N_2O b. MnC_5O_5; $Mn_2C_{10}O_{10}$ c. $C_3H_5O_2$; $C_6H_{10}O_4$
11. d 12. a. 46.0g/mol b. 2 13. a .6 b. 10 waters; 55.9% 14. 1.67×10^{23} molecules of water