

## #18 Notes Unit 3: Stoichiometry

### Ch. continued

### III. Percent Composition

Ex. 1) Find the % composition of  $(\text{NH}_4)_2\text{C}_4\text{H}_4\text{O}_4$

$$\begin{aligned}2 \text{ N} &= 2 (14.007 \text{ g}) &= 28.014 \text{ g N} \\8+4= 12 \text{ H} &= 12 (1.0080 \text{ g}) &= 12.096 \text{ g H} \\4 \text{ C} &= 4 (12.011 \text{ g}) &= 48.044 \text{ g C} \\4 \text{ O} &= 4 (15.999 \text{ g}) &= \underline{63.996 \text{ g O}} \\ &&152.15 \text{ g (molar mass)}\end{aligned}$$

$$\% \text{ N} = \frac{\text{mass of N}}{\text{molar mass}} \times 100 = \frac{28.014 \text{ g}}{152.15 \text{ g}} \times 100 = \mathbf{18.4 \% \text{ N}} \quad \text{Keep 3 or 4 digits!}$$

$$\% \text{ H} = \frac{\text{mass of H}}{\text{molar mass}} \times 100 = \frac{12.096 \text{ g}}{152.15 \text{ g}} \times 100 = \mathbf{7.95 \% \text{ H}}$$

$$\% \text{ C} = \frac{\text{mass of C}}{\text{molar mass}} \times 100 = \frac{48.044}{152.15 \text{ g}} \times 100 = \mathbf{31.6 \% \text{ C}}$$

$$\begin{aligned}\% \text{ O} &= \frac{\text{mass of O}}{\text{molar mass}} \times 100 = \frac{63.996}{152.15 \text{ g}} \times 100 = \underline{\mathbf{42.1 \% \text{ O}}} \\ &= 100.05\% \approx 100\%\end{aligned}$$

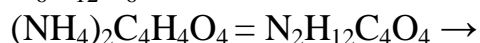
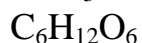
Ex. 2) Find the molar mass of a compound, if it is 23.9% oxygen. The compound contains 3 oxygen atoms in each molecule.

$$\begin{aligned}\% \text{ O} &= \frac{\text{mass O}}{\text{molar mass}} \times 100 & 23.9\% &= \frac{3 (15.999\text{g})}{\text{(mm)}} \times 100 \\ & & & \\ & & 23.9 \text{ (mm)} &= 4799.7 \\ & & \text{mm} &= 2.01 \times 10^2 \text{ g/mol}\end{aligned}$$

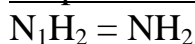
### IV. Empirical Formula

-is the simplest whole # ratio of atoms in a compound.

#### Molecular Formula (Real Formula)



#### Empirical Formula



#19 notes IV. Empirical Formula (continued)

Ex. 1a) Find the empirical formula of a compound containing 3.57 g Sc and 1.91 g O.

$$\text{i) Find mols: } \frac{3.57 \text{ g Sc}}{44.956 \text{ g}} \left| \frac{1 \text{ mol}}{44.956 \text{ g}} \right. = 7.94109 \times 10^{-2} \text{ mol Sc} \quad \begin{array}{c} \text{Sc}_\# \text{O}_\# \\ \uparrow \uparrow \\ \text{mols} \end{array}$$

$$\frac{1.91 \text{ g O}}{15.999 \text{ g}} \left| \frac{1 \text{ mol}}{15.999 \text{ g}} \right. = 1.193824 \times 10^{-1} \text{ mol O}$$

$$\text{ii) Divide by the smallest: } \frac{7.94109 \times 10^{-2} \text{ mol Sc}}{7.94109 \times 10^{-2}} = 1.00$$

$$\frac{1.193824 \times 10^{-1} \text{ mol O}}{7.94109 \times 10^{-2}} = 1.50335 = 1.50$$

$$\text{iii) If necessary, multiply to make whole #'s: } \begin{array}{c} \text{Sc}_{1.00} \text{O}_{1.50} \\ \times 2 \quad \times 2 \end{array} \rightarrow \text{Sc}_2\text{O}_3$$

Ex. 1b) What is the molecular formula, if the molar mass is 413.7 g/mol?

$$\text{Sc}_2\text{O}_3 = 2 \text{ Sc} + 3 \text{ O} = 137.909 \text{ g/mol}$$

$$\frac{\text{molar mass}}{\text{empirical mass}} = \frac{413.7 \text{ g/mol}}{137.909 \text{ g/mol}} = 3 \quad \text{3 times bigger, so } \text{Sc}_2\text{O}_3 \times 3 = \text{Sc}_6\text{O}_9$$

Ex. 2a) Find the empirical formula of a compound containing 37.7 % Na, 23.0 % Si and ? % O.

The percents must add up to 100%, so  
 $100\% - 37.7\% \text{ Na} - 23.0\% \text{ Si} = 39.3\% \text{ O}$

Assume we have a 100 g sample of the compound: 37.7 % of 100 g = 37.7 g Na  
23.0 % of 100 g = 23.0 g Si and 39.3 % of 100 g = 39.3 g O

$$\frac{37.7 \text{ g Na}}{22.990 \text{ g}} \left| \frac{1 \text{ mol}}{22.990 \text{ g}} \right. = 1.6398434 \text{ mol Na} \quad / 8.189133 \times 10^{-1} = 2$$

$$\frac{23.0 \text{ g Si}}{28.086 \text{ g}} \left| \frac{1 \text{ mol}}{28.086 \text{ g}} \right. = 8.189133 \times 10^{-1} \text{ mol Si} \quad / 8.189133 \times 10^{-1} = 1$$

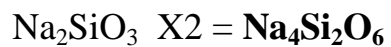
$$\frac{39.3 \text{ g O}}{15.999 \text{ g}} \left| \frac{1 \text{ mol}}{15.999 \text{ g}} \right. = 2.4564035 \text{ mol O} \quad / 8.189133 \times 10^{-1} = 3$$



Ex. 2b) What is the molecular formula, if the molar mass is 244 g?

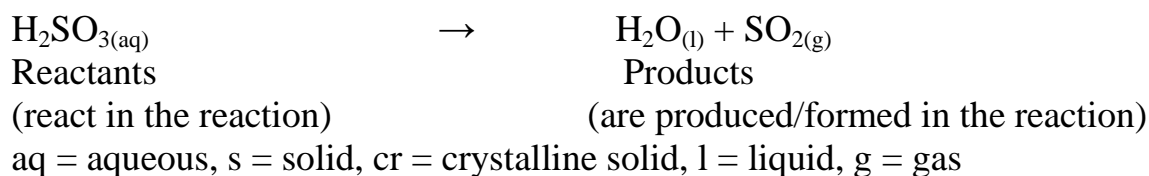
$$\text{Na}_2\text{SiO}_3 = 122.062 \text{ g/mol}$$

$$\frac{244 \text{ g}}{122.062 \text{ g/mol}} = 2$$





## #21 Notes VI. Balancing Chemical Reactions

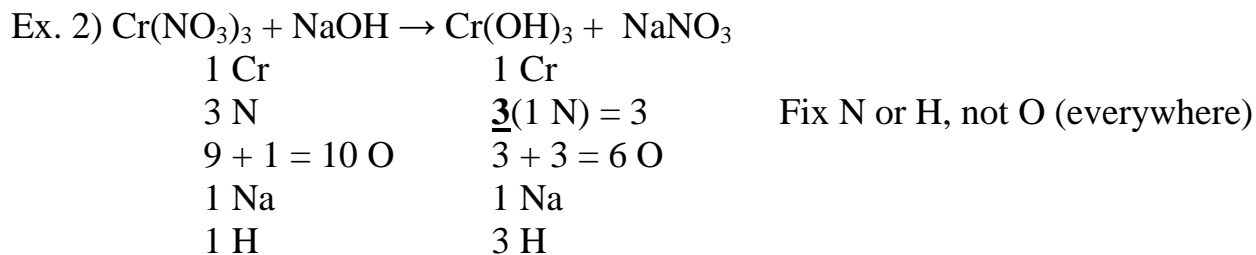
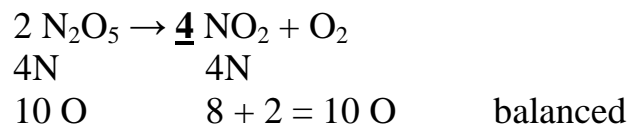
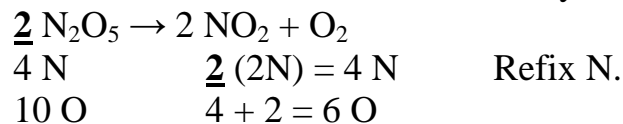
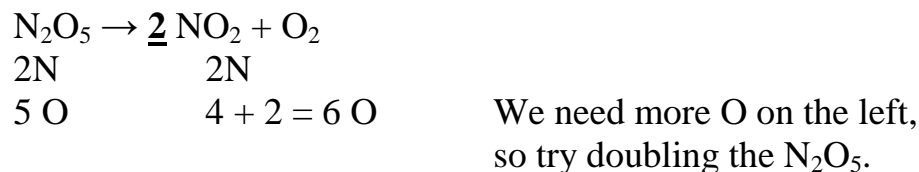


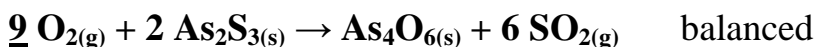
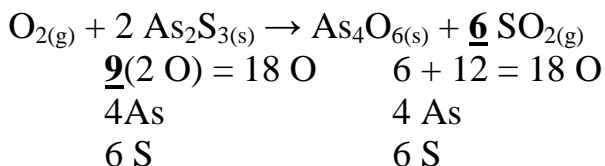
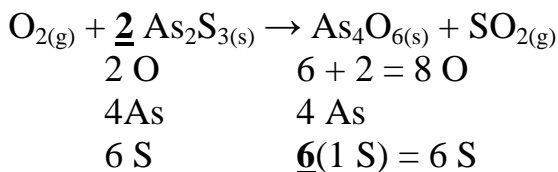
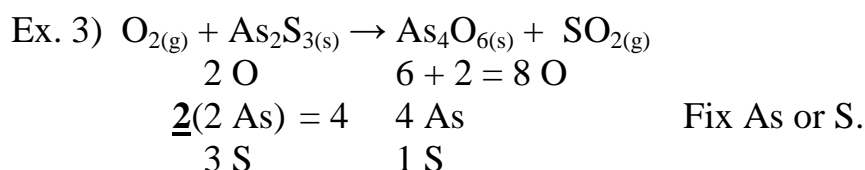
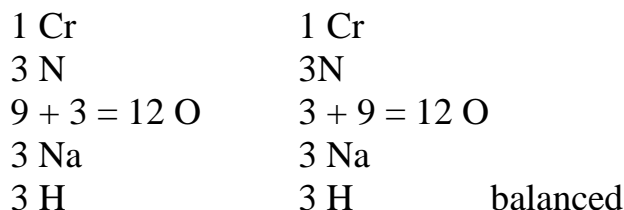
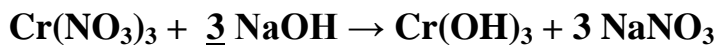
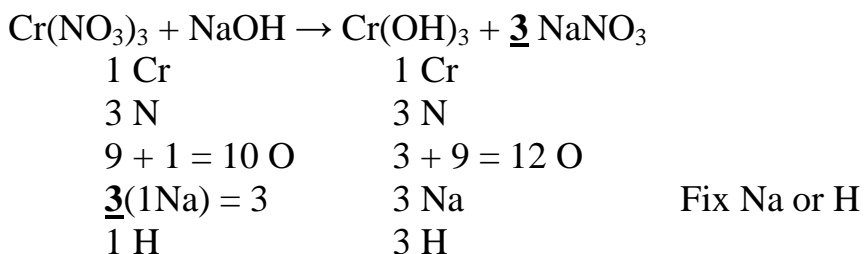
### Steps:

- 1) Put reactants on the left side of the arrow and the products on the right.
- 2) Balance the elements by changing the coefficients at the front of the compounds, until both sides are equivalent. (Do not change subscripts or put numbers into the compound!!)



- a) Balance metals first {(+) part of the compounds}.
- b) Balance N or S.
- c) Balance H or O.
- d) Save for last whatever element is all over.



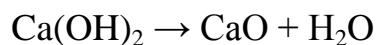


\*\* if odd/even problem, multiply everything by 2

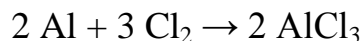
\*\* if no clue, try adding a 2 somewhere, then a 3, then a 4 (trial and error)

## #22 Notes VII. 5 Types of Chemical Reactions

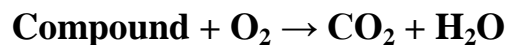
1) Decomposition ( one compound falls apart to 2 or more compounds)



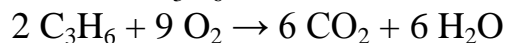
2) Synthesis ( 2 or more compounds combine to form one compound)



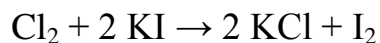
3) Combustion (burning)



Combustion of  $\text{C}_3\text{H}_6$ :

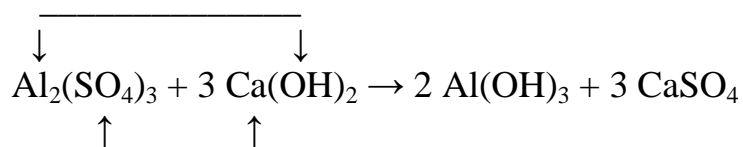


4) Single Displacement (elements and compounds, one element replaces another)



K moves over to the Cl, leaving I alone

5) Double Displacement (all compounds, 2 elements/groups replace each other)



Al moves to OH

Ca moves to  $\text{SO}_4$

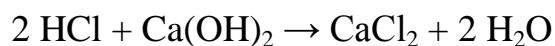
## #23 Notes VIII. Stoichiometry

### Steps:

- 1) Write the balanced chemical reaction.
- 2) Write a conversion equation.
  - a) Find the mols of the compound with known mass.
  - b) Use the mol ratio (in the balanced reaction) between the 2 compounds you are interested in.
  - c) Find the grams of the compound you are looking for.

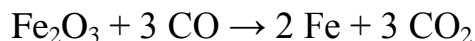
**\*\*The only time you look at the balanced reaction is for step 2b!!\*\***

Ex. 1) How many grams of HCl will react with 44.7 g Ca(OH)<sub>2</sub>?



$$\frac{44.7 \text{ g Ca(OH)}_2}{74.094 \text{ g Ca(OH)}_2} \left| \frac{1 \text{ mol Ca(OH)}_2}{1 \text{ mol Ca(OH)}_2} \right| \left| \frac{2 \text{ mol HCl}}{1 \text{ mol Ca(OH)}_2} \right| \left| \frac{36.461 \text{ g HCl}}{1 \text{ mol HCl}} \right| = \mathbf{44.0 \text{ g HCl}}$$

Ex. 2) What would be the minimum amount of carbon monoxide used, if 80.3 g iron were produced?



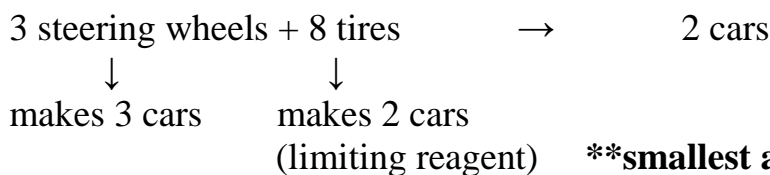
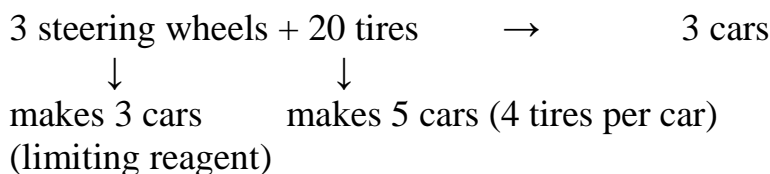
$$\frac{80.3 \text{ g Fe}}{55.847 \text{ g Fe}} \left| \frac{1 \text{ mol Fe}}{2 \text{ mol Fe}} \right| \left| \frac{3 \text{ mol CO}}{1 \text{ mol CO}} \right| \left| \frac{28.01015 \text{ g CO}}{1 \text{ mol CO}} \right| = \mathbf{60.4 \text{ g CO}}$$



## #24 Notes IX. Limiting Reagent

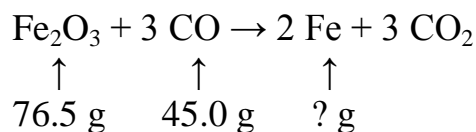
-is the reactant that makes the least amount of product.

How many cars?



**\*\*smallest amount will be the answer due to the limiting reagent.**

Ex. 1a) Given 76.5 g iron III oxide and 45.0 g carbon monoxide, find the mass of iron produced.



$$\frac{76.5 \text{ g Fe}_2\text{O}_3}{159.691 \text{ g Fe}_2\text{O}_3} \left| \frac{1 \text{ mol Fe}_2\text{O}_3}{1 \text{ mol Fe}_2\text{O}_3} \right| \left| \frac{2 \text{ mol Fe}}{1 \text{ mol Fe}_2\text{O}_3} \right| \left| \frac{55.847 \text{ g Fe}}{1 \text{ mol Fe}} \right| = 53.5 \text{ g Fe}$$

$$\frac{45.0 \text{ g CO}}{28.01015 \text{ g CO}} \left| \frac{1 \text{ mol CO}}{3 \text{ mol CO}} \right| \left| \frac{2 \text{ mol Fe}}{3 \text{ mol CO}} \right| \left| \frac{55.847 \text{ g Fe}}{1 \text{ mol Fe}} \right| = 59.8 \text{ g Fe}$$

**53.5 g Fe** (the answer will be the least.)

## X. Percent Yield

-shows the efficiency of a reaction.

The limiting reagent problems allow a calculation to give the amount of product that **should** be produced (the **theoretical** yield).

$$\% \text{ yield} = \frac{\text{actual yield}}{\text{theoretical yield}} \times 100$$

Ex. 1b) What is the % yield, if only 47.4 g Fe was produced in an experiment.

$$\% \text{ yield} = \frac{47.4 \text{ g}}{53.5 \text{ g}} \times 100 = 88.6 \%$$

↑  
Theoretical yield is found from doing the stoichiometry (above in part a)

\*\* Don't forget:  $D = m/v$  (if have density and volume, find mass)

\*\*100% yield means all will react (actual = theoretical), so ignore the % part, just do stoichiometry

**\*End of Notes\*** (Assignments #25-26 are Review Assignments. There are no notes for these assignments.)