

Monday, October 7, 2019 – Stoichiometry Part 1 (Chapter 3)

I. **Warm-Up** – Compound  $X_2Y$  is 60% X by mass. Calculate the percent Y by mass of the compound  $XY_3$ ?

Assume 100g of  $X_2Y$ , therefore 60g in  $X_2Y$  and 40g of Y. If one unit of X is 30g, and one unit of Y is 40g in  $X_2Y$ , then the percent of Y in  $XY_3$  is given by  $\frac{40+40+40}{30+40+40+40} \times 100\% = 80\% \text{ Y in } XY_3$ .

II. **What is a mole?** A mole is a number; it is  $6.022 \times 10^{23}$  of something.

(Hint: You will need your periodic table for these problems.)

1. How many moles in  $5.23 \times 10^{23}$  atoms?

$$5.23 \times 10^{23} \text{ atoms} \left( \frac{1 \text{ mol}}{6.0224 \times 10^{23} \text{ atoms}} \right) = 0.868 \text{ mol}$$

2. How many moles of copper in 3.20 g?

$$3.20 \text{ g Cu} \left( \frac{1 \text{ mol Cu}}{63.55 \text{ g Cu}} \right) = 0.0504 \text{ mol Cu}$$

3. How many moles of O in 3.4 mol of  $CuSO_4$ ?

$$3.4 \text{ g } CuSO_4 \left( \frac{4 \text{ mol O}}{1 \text{ mol } CuSO_4} \right) = 14 \text{ mol O}$$

4. **Average Atomic Mass Values** - Three naturally occurring isotopes of potassium are  $^{39}\text{K}$ , 38.963707 amu,  $^{40}\text{K}$ , 39.963999 amu, and  $^{41}\text{K}$ . The natural abundances of  $^{39}\text{K}$  and  $^{41}\text{K}$  are 93.2581% and 6.7302%, respectively. Determine the atomic mass of  $^{41}\text{K}$ .

$$^{39}\text{K} \Rightarrow 93.2581\% \Rightarrow 38.963707 \text{ amu}$$

$$^{40}\text{K} \Rightarrow 100\% - 93.2581\% - 6.7302\% = 0.0117\% \Rightarrow 39.963999 \text{ amu}$$

$$^{41}\text{K} \Rightarrow 6.7302\% \Rightarrow ? \text{ amu}$$

Average Atomic Mass = (fraction of isotope A)(mass of isotope A) + (fraction of isotope B)(mass of isotope B) + etc.

$$39.098 \text{ amu} = (0.932581)(38.963707 \text{ amu}) + (0.000117)(39.963999 \text{ amu}) + (0.067302)(X \text{ amu})$$

$$\text{Atomic Mass of } ^{41}\text{K} \Rightarrow 40.957 \text{ amu}$$

5. In a sample of 200 chlorine atoms, it is found that 151 are  $^{35}\text{Cl}$  (34.969 amu), and 49 are another isotope. What is the other naturally occurring isotope of chlorine?

Average Atomic Mass = (fraction of Cl-35)(mass of Cl-35) + (fraction of Cl-X)(mass of isotope Cl-X) + etc.

$$35.453 \text{ amu} = (151/200)(34.969 \text{ amu}) + (49/200)(\text{mass of Cl-X})$$

$$\text{Mass of Cl-X} = 36.945 \text{ amu}$$

Therefore the other isotope is Cl-37

6. For which of the following compounds does 1.00 g represent  $3.32 \times 10^{-2}$  mol?

- a.  $\text{NO}_2$       b.  $\text{H}_2\text{O}$       c.  $\text{C}_2\text{H}_6$       d.  $\text{NH}_3$       e.  $\text{CO}$

$$1.00 \text{ g} / 3.32 \times 10^{-2} \text{ mol} = 30.12 \text{ g/mol} = \text{molar mass of ethane}$$

*Molar Mass/Atomic Mass* = The mass of a mole of objects (g/mol = amu)  
1 mole of C weighs 12.011 grams

*Average Atomic Mass* = The sum of the masses of an atoms isotopes, each multiplied by its natural abundance

*Percent by mass* = mass X/total Mass

7. A single atom of an element weighs  $5.81 \times 10^{-23}$  g. Identify the isotope.

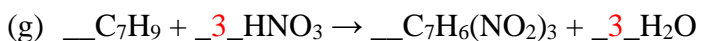
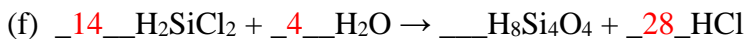
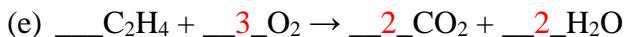
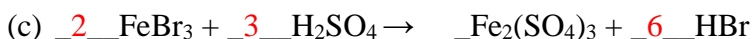
$$\frac{5.81 \times 10^{-23} \text{ g}}{1 \text{ atom}} \times \frac{6.022 \times 10^{23} \text{ atoms}}{1 \text{ mol}} = 34.9 \text{ g/mol} \Rightarrow {}^{35}\text{Cl}$$

8. How many hydrogen atoms are in 6.3 mg sample of methane? (Methane is  $\text{CH}_4$ ).

$$6.3 \text{ mg CH}_4 \times \frac{1 \text{ g}}{1000 \text{ mg}} \times \frac{1 \text{ mole CH}_4}{16.042 \text{ g}} \times \frac{4 \text{ mole H}}{1 \text{ mole CH}_4} \times \frac{6.022 \times 10^{23} \text{ atoms}}{1 \text{ mole H}} = 9.5 \times 10^{20} \text{ atoms}$$

### Chemical Equations

9. Balance the following equations:



### Methodology for Reaction Stoichiometry Problems

1. Write a balanced chemical reaction
2. Convert given value(s) into moles (you may have to ID the limiting reagent)
3. Use reaction coefficients as a molar ratio
4. Convert moles of your unknown into the desired units

Limiting Reagent ⇒ Limits the amount of product that is produced due to running out  
1st - The limiting reagent is used to determine the maximum yield of product/s aka the theoretical yield and the maximum consumption of reactants aka the theoretical consumption

### Identifying Limiting Reagents:

1. Convert all given values of reactants into moles
2. Divide each mole value by the coefficient
3. The smallest number identifies the LR