Pre-AP Chemistry – Unit 8, Stoichiometry

Objective 1:   Students will use Avogadro's number and the concept of the mole to convert chemical quantities, including the determination of empirical and molecular formulas. [S.12.C.2, S.13.C.1, S.13.C.2, GL.16.C.2]

Objective 2:   Students will use stoichiometry to determine quantities formed and consumed in chemical reactions including limiting reactants, excess reactants, theoretical yields, and percent yields. [S.12.C.3, S.12.C.4, S.15.C.1, S.15.C.3, S.15.C.4]

Objective 1

1. Answer the following questions concerning moles and mass: (a) How many grams are in 0.275 mol of $UOCl_2$? (b) How many grams are in 3.01×10^{24} molecules of $(NH_4)_2SO_4$? (c) How many grams of lithium are there in 4.5mol of Li_3P?
2. Answer the following questions concerning moles and volume at STP: (a) Find the number of nitrogen molecules in 45.2L of nitrogen gas. (b) What volume will 65.3g of helium occupy? (c) Determine the number of oxygen atoms in 450L of air if O_2 comprises approximately 21% of normal atmospheric air.
3. (a) Fumaric acid, $C_4H_4O_4$, is a molecule found in most organisms. The percent composition of C, H and O in fumaric acid by mass is? (b) Write the empirical formula for fumaric acid. (c) If I have 13.5g of fumaric acid, then what mass of carbon do I have?
4. A compound was found to be comprised of 36.763% iron, 21.108% sulfur and 42.128% oxygen by mass. What is its empirical formula?
5. A compound was found to be comprised of 21.955% sulfur and 78.045% fluorine by mass. What is its molecular formula?

Objective 2

1. Given the equation: $2 HClO + Na_2SO_4 \rightarrow 2 NaClO + H_2SO_4$
   If you start with 77 grams of hypochlorous acid (HClO), how many grams of sulfuric acid (H_2SO_4) will be produced?
2. 1-propene (C_3H_6) reacts with oxygen gas according to the reaction below. If you start with 45 grams of 1-propene, how many grams of carbon dioxide will be produced?
   $2 C_3H_6 + 9 O_2 \rightarrow 6 CO_2 + 6 H_2O$
3. How many moles of H_2 and N_2 can be formed by the decomposition of 0.145mol of ammonia, NH_3?
4. How many liters of 0.100 M HCl would be required to react completely with 5.00 grams of calcium hydroxide?
   $Ca(OH)_2 + HCl \rightarrow CaCl_2 + H_2O$
5. What volume of oxygen gas, at STP, is needed to fully combust 150.5g of methamphetamine ($C_{10}H_{15}N$) according to the following equation: $4 C_{10}H_{15}N + 59 O_2 \rightarrow 40 CO_2 + 30 H_2O + 4 NO_2$. What mass of NO_2 would be produced?
6. If 75g of iron(III) oxide reacts with a slight excess of aluminum powder according to the reaction below, how many aluminum oxide formula units are formed? $Fe_2O_3 + 2 Al \rightarrow Al_2O_3 + 2 Fe$
7. The reaction of iron with silver ions is shown below. This reaction can be used to recover silver ions from solution. How many moles of silver could be recovered if a 5.0g piece of iron is placed in a tank of excess spent silver solution? $Fe (s) + 3 Ag^+ (aq) \rightarrow Fe^{3+} (aq) + 3 Ag (s)$
8. $2 Al + 6 HCl \rightarrow 2 AlCl_3 + 3 H_2$. If 25 g of aluminum was added to 90 g of HCl, what mass of H_2 will be produced?
9. $N_2 + 3 H_2 \rightarrow 2 NH_3$: If you have 20 g of N_2 and 5.0 g of H_2, which is the limiting reagent?
10. What mass of aluminum oxide is formed when 10.0 g of Al is burned in 20.0 g of O_2?
    $4 Al + 3 O_2 \rightarrow 2 Al_2O_3$

11. When C_3H_8 burns in oxygen, CO_2 and H_2O are produced. If 15.0 g of C_3H_8 reacts with 60.0g of O_2, how much CO_2 is produced?

12. How can you tell if a question is a limiting reagent question vs. typical stoichiometry?

13. Nitrogen can be burned in air to produce nitrous oxide (dinitrogen monoxide), also known as laughing gas. 17.3L of oxygen gas is placed in a container with 45.3g of nitrogen gas. $N_2 + O_2 \rightarrow N_2O$
    a. Determine the limiting reactant in the above equation.
    b. If 5g of nitrous oxide is formed what is the percent yield of the process?
    c. What mass of excess reactant remains after the reaction?

14. If 85mL of a 0.25M solution of hydrochloric acid is mixed with 0.84g of lithium carbonate the following reaction takes place: Li_2CO_3 (s) +2 HCl (aq) $\rightarrow$ 2 LiCl (aq) + H_2O (l) + CO_2 (g).
    a. Identify the limiting reactant in this process.
    b. Determine what mass of excess reactant remains.
    c. Calculate the theoretical yield of the carbon dioxide gas.
    d. If 150mL of CO_2 is produced at STP, then what is the percent yield of the process?

Name_____Period_____Date_____

PreAP Chemistry Homework: Percent Composition & Empirical Formulas

1. What is the percent composition of oxygen in potassium permanganate?

2. What is the percent composition of hydrogen in calcium acetate

3. A 138 g sample of a compound is analyzed and found to contain 25.8 g of lithium, 22.5 g of carbon, and the remainder to be oxygen. Calculate the percent composition.

4. A sample contains 52.94% aluminum and 47.06% oxygen. What is the empirical formula of the substance?

5. A sample contains 17.96 grams of potassium, 7.35 gram of sulfur, and 14.70 grams of oxygen. What is the empirical formula of the sample?

6. 50.0 grams of sulfur are mixed with 100.0 grams of iron and then the mixture is heated. When the reaction is completed, 12.7 grams of iron remain. What is the empirical formula of the compound that was formed?

7. A 165 g sample of a compound to contain only arsenic and sulfur was analyzed and found to contain 101 g of arsenic. Calculate the empirical formula

8. A 145 g sample of a compound to contain only phosphorus and oxygen was analyzed and found to contain 63.28 g of phosphorus. Calculate the empirical formula.

9. Find the molecular formula of ethylene glycol. The molar mass is 62 g/mol and the empirical formula is CH_3O.

10. A compound is composed of 7.20 g of carbon, 1.20 g of hydrogen, and 9.60 grams oxygen. The molecular mass of the compound is 180 grams. What are the empirical and molecular formulas for this compound?

4 • Chemical Equations and Stoichiometry

General Stoichiometry

1. Several brands of antacid tablets use aluminum hydroxide to neutralize excess acid.

    $$Al(OH)_3(s) + 3\ HCl(aq) \rightarrow AlCl_3(aq) + 3\ H_2O(l)$$
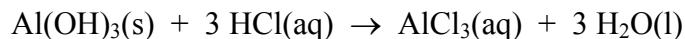
    [Molar masses: 78.01   36.46   133.4   18.02]

    What quantity of HCl, in grams, can a tablet with 0.750 g of $Al(OH)_3$ consume? What quantity of water is produced?

2. If 10.0 g of carbon is combined with an exact, stoichiometric amount of oxygen (26.6 g) to produce carbon dioxide, what mass, in grams, of CO_2 can be obtained? That is, what is the theoretical yield of CO_2? [Molar masses: C: 12.011 O_2: 32.00 CO_2: 44.01]

3. The equation for one of the reactions in the process of reducing iron ore to the metal is

    $$Fe_2O_3(s) + 3\ CO(g) \rightarrow 2\ Fe(s) + 3\ CO_2(g)$$
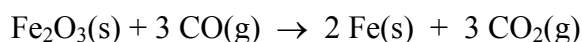
    [Molar masses: 159.7   28.01   55.85   44.01]

    (a) What is the maximum mass of iron, in grams, that can be obtained from 454 g (1.00 lb) of iron(III) oxide?

    (b) What mass of CO is required to reduce the iron(III) oxide to iron metal?

4. Burning coal and oil in a power plant produces pollutants such as sulfur dioxide, SO_2. The sulfur-containing compound can be removed from other waste gases, however, by the following reaction:

    $$2\ SO_2(g) + 2\ CaCO_3(s) + O_2(g) \rightarrow 2\ CaSO_4(s) + 2\ CO_2(g)$$
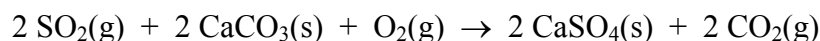
    [Molar masses: 64.07   100.1   32.00   136.2   44.01]

    (a)   Name the compounds involved in the reaction.

    (b)   What mass of $CaCO_3$ is required to remove 155 g of SO_2?

    (c)   What mass of $CaSO_4$ is formed when 155 g SO_2 is consumed completely?

5. Your body deals with excess nitrogen by excreting it in the form of urea, NH_2CONH_2. The reaction producing it is the combination of arginine ($C_6H_{14}N_4O_2$) with water to give urea and ornithine ($C_5H_{12}N_2O_2$).

    $$C_6H_{14}N_4O_2 + H_2O \rightarrow NH_2CONH_2 + C_5H_{12}N_2O_2$$

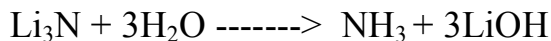   [Molar masses: 174.2   18.02   60.06   132.2]

    If you excrete 95 mg of urea, what quantity of arginine must have been used? What quantity of ornithine must have been produced?

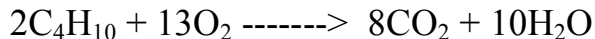# STOICHIOMETRY/LIMITING REAGENT PRACTICE   AP CHEMISTRY

1. Determine the mass of lithium hydroxide produced when 0.38 g of lithium nitride reacts with water according to the following equation:
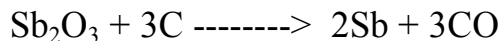
$Li_3N + 3H_2O \text{-------}> NH_3 + 3LiOH$

8. Identify the limiting reactant when 4.687 g of SF_4 reacts with 6.281 g of I_2O_5 to produce IF_5 and SO_2.

2. What mass of sodium chloride is produced when chlorine reacts with 0.29 g of sodium iodide?

9. If 4.1 g of Cr is heated with 9.3 g of Cl_2, what mass of $CrCl_3$ will be produced?

3. Determine the mass of carbon dioxide produced when 0.85 g of butane reacts with oxygen according to the following equation:

$2C_4H_{10} + 13O_2 \text{-------}> 8CO_2 + 10H_2O$

10. What mass of SO_2 is produced from the reaction between 31.5 g of S_8 and 8.65 g of O_2?

4. Determine the mass of antimony produced when 0.46 g of antimony(III)oxide reacts with carbon according to the following equation:

$Sb_2O_3 + 3C \text{--------}> 2Sb + 3CO$

11. What mass of SO_3 is produced from the reaction of 12.4 g of SO_2 and 3.45 g of O_2?

5. What mass of hydrogen peroxide (H_2O_2) must decompose to produce 0.77 g of water?

12. What mass of H_2SO_4 is produced from the reaction of 6.58 g of SO_3 and 1.64 g of H_2O?

6. What mass of carbon monoxide must react with oxygen to produce 0.69 g of carbon dioxide?

13. What mass of CdS is produced if 8.47 g of cadmium reacts with 2.51 g of sulfur?

7. Identify the limiting reagent when 65.14 g of $CaCl_2$ reacts with 74.68 g of Na_2CO_3 to produce $CaCO_3$ and NaCl (show work!)