WKS 3-8 – Honors
Stoichiometry 2: Gases & Yield

NAME Answer Key
Period _______ **Date** __________________

I. Gas Stoichiometry

1. What volume of oxygen gas at 20.0°C and 102.6 kPa is required to produce 640. L of CO_2, also at 20.0°C and 102.6 kPa? Balance the equation first.

$$\_\_\ C_3H_8\ (g) + \underline{5}\ O_2\ (g) \rightarrow \underline{3}\ CO_2\ (g) + \underline{4}\ H_2O\ (g)$$

$$?\ L\ O_2 = 640\ \cancel{L\ CO_2} \times \frac{5\ L\ O_2}{3\ \cancel{L\ CO_2}} = \boxed{1070\ L\ O_2\ \left(1.07\times10^3\ L\ O_2\right)}$$

2. What volume of oxygen gas at 20.0°C and 0.953 atm is needed to react with 3.500×10^3 L of CO, also at 20.0°C and 0.953 atm? First balance the equation.

$$\underline{2}\ CO\ (g) + \_\_\ O_2\ (g) \rightarrow \underline{2}\ CO_2\ (g)$$

$$?\ L\ O_2 = 3.500\times10^3\ \cancel{L\ CO} \times \frac{1\ L\ O_2}{2\ \cancel{L\ CO}} = \boxed{1.750\times10^3\ L\ O_2}$$

3. What volume of hydrogen gas can be produced at STP by the reaction of 6.28 g of Fe according to the following equation? Balance the equation first.

$$\underline{3}\ Fe\ (s) + \underline{4}\ H_2O\ (l) \rightarrow \_\_\ Fe_3O_4\ (s) + \underline{4}\ H_2\ (g)$$

$$?\ L\ H_2 = \underbrace{6.28\ \cancel{g\ Fe} \times \frac{1\ \cancel{mol\ Fe}}{55.85\ \cancel{g\ Fe}}}_{0.1124\ mol\ Fe} \times \underbrace{\frac{4\ \cancel{mol\ H_2}}{3\ \cancel{mol\ Fe}}}_{0.1499\ mol\ H_2} \times \frac{22.4\ L\ H_2}{1\ \cancel{mol\ H_2}} = 3.358\ L\ H_2 = \boxed{3.36\ L\ H_2}$$

4. If 0.270 g of sodium reacts with excess water according to the following equation, what volume of hydrogen gas at STP will be produced? First write and balance the equation.

$$2\ Na\ (s) + 2\ H_2O\ (l) \rightarrow 2\ NaOH\ (aq) + H_2\ (g)$$

$$?\ L\ H_2 = \underbrace{0.270\ \cancel{g\ Na} \times \frac{1\ \cancel{mol\ Na}}{22.99\ \cancel{g\ Na}}}_{0.01174\ mol\ Na} \times \underbrace{\frac{1\ \cancel{mol\ H_2}}{2\ \cancel{mol\ Na}}}_{0.005872\ mol\ H_2} \times \frac{22.4\ L\ H_2}{1\ \cancel{mol\ H_2}} = 0.1315\ L\ H_2 = \boxed{0.132\ L\ H_2}$$

II. Theoretical & Percent Yield

5. Certain race cars can use methanol (CH_3OH) as a fuel. Liquid methanol burns in air (oxygen gas) according to the following equation. Balance the equation first.

$$\underline{2}\ CH_3OH\ (\ell) + \underline{3}\ O_2\ (g) \rightarrow \underline{2}\ CO_2\ (g) + \underline{4}\ H_2O\ (g)$$

a. What is the theoretical yield of CO_2 (in g) when 35.4 mol CH_3OH reacts with excess O_2?

$$?\ g\ CO_2 = \underbrace{35.4\ \cancel{mol\ CH_3OH} \times \frac{2\ \cancel{mol\ CO_2}}{2\ \cancel{mol\ CH_3OH}}}_{35.4\ mol\ CO_2} \times \frac{44.01\ g\ CO_2}{1\ \cancel{mol\ CO_2}} = \boxed{1560\ g\ CO_2}$$

b. If 1430 g CO_2 are actually obtained, what is the percent yield (equation on Chart B)?

$$\%\ Yield = \frac{1430\ g\ CO_2}{1560\ g\ CO_2} \times 100\% = \boxed{91.7\%}$$

6. When bleach (aqueous sodium hypochlorite) is mixed with ammonia (also aqueous), it forms aqueous sodium hydroxide and the noxious gas nitrogen trichloride. Write and balance the equation first.

$$3\ NaClO\ (aq) + NH_3\ (aq) \rightarrow 3\ NaOH\ (aq) + NCl_3\ (g)$$

a. What is the theoretical yield of nitrogen trichloride (in g) from 2.94 g of bleach and excess ammonia?

$$?\ g\ NCl_3 = 2.94\ g\ NaClO \times \frac{1\ mol\ NaClO}{74.44\ g\ NaClO} \times \frac{1\ mol\ NCl_3}{3\ mol\ NaClO} \times \frac{120.36\ g\ NCl_3}{1\ mol\ NCl_3} = 1.5845\ g\ NCl_3 = \boxed{1.58\ g\ NCl_3}$$

0.03949 mol NaClO; 0.01316 mol NCl_3

b. What is the percent yield if 1.35 g of nitrogen trichloride are actually isolated?

$$\%\ Yield = \frac{1.35\ g\ NCl_3}{1.58\ g\ NCl_3} \times 100\% = \boxed{85.4\ \%}$$

7. Disulfur dichloride (S_2Cl_2) is a liquid that plays an important role in rubber production. It is produced by reacting liquid sulfur (S_8) with chlorine gas. Balance the equation first.

$$\_\_\_\ S_8\ (\ell) + \underline{\ 4\ }\ Cl_2\ (g) \rightarrow \underline{\ 4\ }\ S_2Cl_2\ (\ell)$$

If the percent yield for this reaction is 92.7%, what mass of S_8 would you need to start with to obtain an actual yield of 10.0 kg S_2Cl_2?

Determine the theoretical yield of S_2Cl_2 needed:

$$?\ g\ S_2Cl_2 = 10.0\ kg\ S_2Cl_2 \times \frac{1\times10^3\ g}{1\ kg} = 1.00\times10^4\ g\ S_2Cl_2$$

$$92.7\% = \frac{1.00\times10^4\ g\ S_2Cl_2}{\text{Theoretical Yield}} \times 100\% \Rightarrow \text{Theoretical Yield} = 1.00\times10^4\ g\ S_2Cl_2 \times \frac{100\%}{92.7\%} = 1.079\times10^4\ g\ S_2Cl_2$$

$$?\ g\ S_8 = 1.079\times10^4\ g\ S_2Cl_2 \times \frac{1\ mol\ S_2Cl_2}{135.04\ g\ S_2Cl_2} \times \frac{1\ mol\ S_8}{4\ mol\ S_2Cl_2} \times \frac{256.6\ g\ S_8}{1\ mol\ S_8} = 5125\ g\ S_8 = \boxed{5130\ g\ S_8}$$

79.88 mol S_2Cl_2; 19.97 mol S_8

8. List the factors that can cause the percent yield to be less than 100%. What can cause the *apparent* percent yield to be greater than 100%?

Loss of/inability to collect all of product; impure reactant (less of expected substance), side reactions can all lead to lower % yield. Impurities in the product (such as water) or failure to completely separate two products can lead to an apparent (because the measured mass is too high) higher % yield.