AP Chemistry
Stoichiometry Practice   Name ____________________

Stoichiometry – From the Greek words "stoicheion" (meaning element) and "metron" (meaning measure) is the branch of chemistry that deals with the quantitative relationships in chemical reactions.

1) Nitroglycerin is the active ingredient in dynamite. It explosively decomposes into several gases.

$4C_3H_5N_3O_9(l) \rightarrow 12CO_2(g) + 6N_2(g) + O_2(g) + 10H_2O(g)$ reaction type? D

How many *total liters of gases at STP* will be produced by *25g of nitroglycerin*?
(add the coefficients of all the products to determine the total number of moles of gases produced)

$$\frac{25\text{ g }C_3H_5N_3O_9}{} \left| \frac{1\text{ mol }C_3H_5N_3O_9}{227.08\text{ g }C_3H_5N_3O_9} \right| \frac{29\text{ mol gas}}{4\text{ mol }C_3H_5N_3O_9} \left| \frac{22.4\text{ L gas}}{1\text{ mol gas}} \right.$$

$= \boxed{18.L\text{ gases @ STP}}$

2) The Haber process is an important industrial process used to produce ammonia gas. Balance the equation:

___ $N_2(g)$ + 3 $H_2(g)$ → 2 $NH_3(g)$ reaction type? S

a) Calculate the *liters of ammonia* gas at *STP* that can be produced from *350kg of nitrogen gas* when it reacts with excess hydrogen gas. (Excess means there is more than enough to react with the nitrogen.)

$$\frac{350\text{ Kg }N_2}{} \left| \frac{1000\text{ g }N_2}{1\text{ Kg }N_2} \right| \frac{1\text{ mol }N_2}{28.02\text{ g }N_2} \left| \frac{2\text{ mol }NH_3}{1\text{ mol }N_2} \right| \frac{22.4\text{ L }NH_3}{1\text{ mol }NH_3} = \boxed{560000\text{ L }NH_3}$$

b) Calculate the *kilograms of hydrogen gas* needed to react with the *350kg of nitrogen gas.*

$$\frac{350\text{ Kg }N_2}{} \left| \frac{1000\text{ g }N_2}{1\text{ Kg }N_2} \right| \frac{1\text{ mol }N_2}{28.02\text{ g }N_2} \left| \frac{3\text{ mol }H_2}{1\text{ mol }N_2} \right| \frac{2.02\text{ g }H_2}{1\text{ mol }H_2} \left| \frac{1\text{ Kg }H_2}{1000\text{ g }H_2} \right.$$

$= \boxed{76\text{ Kg }H_2}$

3) Pure sodium can be produced through the electrolysis of molten sodium chloride. Balance the equation:

2 $NaCl(l) - e^- \rightarrow$ 2 $Na(l)$ + ___ $Cl_2(g)$ reaction type? D

a) Calculate the *pounds of NaCl* needed to produce *25lbs of sodium.*

$$\frac{25\text{ lbs Na}}{} \left| \frac{454\text{ g Na}}{1\text{ lb Na}} \right| \frac{1\text{ mol Na}}{22.99\text{ g Na}} \left| \frac{2\text{ mol NaCl}}{2\text{ mol Na}} \right| \frac{58.44\text{ g NaCl}}{1\text{ mol NaCl}} \left| \frac{1\text{ lb NaCl}}{454\text{ g NaCl}} \right|$$

$= \boxed{64\text{ lb NaCl}}$

b) Calculate the liters of *chlorine gas at STP* that will be produced. (you may start with either Na or NaCl)

$$\frac{25\text{ lbs Na}}{} \left| \frac{454\text{ g Na}}{1\text{ lb Na}} \right| \frac{1\text{ mol Na}}{22.99\text{ g Na}} \left| \frac{1\text{ mol }Cl_2}{2\text{ mol Na}} \right| \frac{22.4\text{ L }Cl_2}{1\text{ mol }Cl_2} \right|$$

$= \boxed{5500\text{ L }Cl_2}$

4) Aspirin, $C_9H_8O_4$, is synthesized by the reaction of salicylic acid, $C_7H_6O_3$, with acetic anhydride, $C_4H_6O_3$.

$$2C_7H_6O_3 + C_4H_6O_3 \rightarrow 2\ C_9H_8O_4 + H_2O$$

a) Calculate the grams of aspirin ($C_9H_8O_4$) that can be produced (theoretical yield) when 450g of $C_7H_6O_3$ are reacted with excess $C_4H_6O_3$.

$$\frac{450\text{ g } C_7H_6O_3}{} \cdot \frac{1\text{ mol } C_7H_6O_3}{138.13\text{ g } C_7H_6O_3} \cdot \frac{2\text{ mol } C_9H_8O_4}{2\text{ mol } C_7H_6O_3} \cdot \frac{180.17\text{ g } C_9H_8O_4}{1\text{ mol } C_9H_8O_4} =$$

$$\boxed{590\text{ g } C_9H_8O_4}$$

b) Calculate the percent yield of this process if the actual yield of aspirin is only 520g.

$$\%\text{ Yield} = \frac{520\text{ g}}{590\text{ g}} = \boxed{88\ \%}$$

5) Diidodine pentoxide is used in respirators to change harmful carbon monoxide into carbon dioxide:

$$I_2O_5\ (s)\ +\ 5CO\ (g)\ \rightarrow I_2(s)\ +\ 5\ CO_2\ (g)$$

a) In a test of the respirator, 4.5 L of CO gas at STP are reacted with 11 g of I_2O_5. Determine which reactant is *limiting* and which one is in *excess* by calculating the number of grams of I_2 produced (theoretical) by each reactant. Label one reactant as LR and the other as ER.

ER

$$\frac{4.5\text{ L CO}}{} \cdot \frac{1\text{ mol CO}}{22.4\text{ L CO}} \cdot \frac{1\text{ mol } I_2}{5\text{ mol CO}} \cdot \frac{253.80\text{ g } I_2}{1\text{ mol } I_2} = 10.\text{ g } I_2$$

LR

$$\frac{11\text{ g } I_2O_5}{} \cdot \frac{1\text{ mol } I_2O_5}{333.80\text{ g } I_2O_5} \cdot \frac{1\text{ mol } I_2}{1\text{ mol } I_2O_5} \cdot \frac{253.80\text{ g } I_2}{1\text{ mol } I_2} = \boxed{8.4\text{ g } I_2}$$

b) Can the respirator absorb all 4.5L of CO? Explain your answer based on the LR and ER calculation.

No, the CO is the excess reactant. There is no I_2O_5 left to react.

c) The percent yield of the reaction is found to be 85%. How many grams of I_2 would actually be produced? How would this affect the design of the respirator?

$$0.85 = \frac{x}{8.4} \qquad x = 7.1\text{ g } I_2$$

Extra I_2O_5 would be needed.