AP Chemistry Worksheet 9: *Limiting Reactants & Theoretical Yield*

Zumdahl textbook chapter 3

For each problem below, write the equation and show your work. Always use units and box in your final answer.

1. A manufacturer of bicycles has 50 wheels, 30 frames, and 24 seats.
   a. How many bicycles can be manufactured using these parts?

   b. How many parts of each kind are left over?

   c. Which part is like a limiting reactant in that it limits the production of bicycles?

2. The fizz produced when an Alka-Seltzer tablet is dissolved in water is due to the reaction between sodium bicarbonate, $NaHCO_3$, and citric acid, $H_3C_6H_5O_7$:

$$3\ NaHCO_3\ (aq) + H_3C_6H_5O_7\ (aq) \rightarrow 3\ CO_2\ (g) + 3\ H_2O(l) + Na_3C_6H_5O_7\ (aq)$$

   In a certain experiment 1.00 g of sodium bicarbonate and 1.00 g of citric acid are allowed to react.

   a. Which reactant is the limiting reactant? You must show work to support your answer.

$3\ NaHCO_3$	+ $H_3C_6H_5O_7$	→ $3CO_2$	+ $3H_2O$	+ $Na_3C_6H_5O_7$
.0114 mol	.00521 mol	0	0	0
−.0114	−.00380 mol	+.0115	+.0115	+.00380 mol
0	.00141 mol	.0115	.0115 mol	.00380

   b. How many grams of carbon dioxide form?

$$.0115\ mol \times 40\ g/mol = .46\ g\ CO_2$$

   c. How much of the limiting reactant is left when the reaction is complete?

~~.00141 mol~~ NONE

   d. How much of the excess reactant remains after the reaction is complete?

$$.00141\ mol\ H_3C_6H_5O_7$$

3. When hydrogen sulfide gas is bubbled into a solution of sodium hydroxide, the reaction forms sodium sulfide and water. How many grams of sodium sulfide are formed if 2.50 g of hydrogen sulfide is bubbled into a solution containing 1.85 g of sodium hydroxide, assuming that the limiting reagent is completely consumed?

H_2S

see next page ☺

4. Solutions of sulfuric acid and lead (II) acetate react to form solid lead (II) sulfate and a solution of acetic acid. If 10.0 g of sulfuric acid and 10.0 g of lead (II) acetate are mixed, calculate the number of grams of sulfuric acid, lead (II) acetate, lead (II) sulfate, and acetic acid present in the mixture after the reaction is complete.

$\frac{10.0\text{ g } H_2SO_4}{98.0\text{ g/mol}} = \frac{10.0\text{g } Pb(C_2H_3O_2)_2}{325.29\text{ g/mol}}$

$.102\text{ mol } H_2SO_4$ $\quad .0307\text{ mol } Pb(C_2H_3O_2)_2$

see next page

$C_6H_6 + Br_2 \longrightarrow C_6H_5Br + HBr$

5 A student reacts benzene, C_6H_6, with bromine, Br_2, to prepare bromobenzene, C_6H_5Br, and HBr

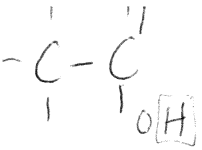
a. What is the theoretical yield of bromobenzene in this reaction when 30.0 g of benzene reacts with 65.0 g of bromine?

$30g\ C_6H_6 \times \frac{1\text{mol}}{78g} = .385\text{ mol } C_6H_6$

$65.0g\ Br_2 \times \frac{1\text{ mol}}{160.8} = .407\text{ mol } Br_2$

b. If the actual yield of bromobenzene was 56.7 g, what was the percent yield?

#5



$C_6H_6 + Br_2 \rightarrow C_6H_5Br + HBr$

	C_6H_6	Br_2	C_6H_5Br	HBr
	.385 mol	.407 mol	0	0
a)	−.385 mol	−.385 mol	+.385 mol	+.385 mol
	0	.022 mol	.385 mol	.385 mol

$$.385 \text{ mol } C_6H_5Br \times \frac{157 \text{ g } C_6H_5Br}{\text{mol}} = 60.445 \text{ g}$$

60.4 g C_6H_5Br

b) $\frac{56.7 \text{ g}}{60.4} \times 100 = 93.9\%$

4) $H_2SO_4 + Pb(C_2H_3O_2)_2 \rightarrow PbSO_4 + 2CH_3COOH$

	H_2SO_4	$Pb(C_2H_3O_2)_2$	$PbSO_4$	CH_3COOH
	.102 mol	.0307 mol	0	0
	−.0307	−.0307	+.0307	+.0614
	.0713 mol	0	.0307 mol	.0614 mol

↓ none left in solution

.0614 mol $CH_3COOH \times \frac{60.1 \text{ g}}{\text{mol}} = 3.69 \text{ g } CH_3COOH$

$.0713 \text{ mol } H_2SO_4 \times \frac{98.0 \text{ g}}{\text{mol}} = 6.99 \text{ g } H_2SO_4$

$.0307 \text{ mol } PbSO_4 \times 303.26 \text{ g} = 9.31 \text{ g } PbSO_4$

3) $H_2S + 2NaOH \rightarrow Na_2S + 2H_2O$ (HOH)

H_2S	$2NaOH$	Na_2S	$2H_2O$
.0735 mol	.0463	0	0
−.02315 mol	−.0463	+.02315	+.0463
.0504 mole H_2S Excess	0	.02315 mol	.0463 mol

$$2.50\text{g } H_2S \times \frac{1\text{mol}}{34\text{g}} = .0735 \text{ mol } H_2S$$

$$1.85\text{g NaOH} \times \frac{1\text{mol}}{40\text{g}} = .0463\text{mol NaOH}$$

$$.02315\text{mol} \times \frac{78.8\text{g}}{1\text{mol}} = \boxed{1.80\text{g } Na_2S \text{ produced}}$$