AP Stoichiometry Practice

Name Key

Block ___ Date ___

Write out the balanced chemical equation to answer the following:

1) In a single displacement reaction between 43.6g of aluminum and concentrated hydrochloric acid, how many grams of hydrogen gas can be produced?

$$2Al(s) + 6HCl(aq) \longrightarrow 3H_2(g) + 2AlCl_3(aq)$$

$$43.6\text{ g Al}\left(\frac{1\text{ mol Al}}{26.98\text{ g}}\right)\left(\frac{3\text{ mol }H_2}{2\text{ mol Al}}\right)\left(\frac{2.016\text{ g}}{1\text{ mol }H_2}\right) = \boxed{4.89\text{ g }H_2}$$

2) In a decomposition reaction, ammonium nitrate decomposes into nitrogen, oxygen, and water. How many mL of water can be produced if you begin with 1205.7g of ammonium nitrate?

$$2NH_4NO_3(s) \longrightarrow 2N_2(g) + O_2(g) + 4H_2O(l)$$

$$1205.7\text{ g }NH_4NO_3\left(\frac{1\text{ mol }NH_4NO_3}{80.05\text{ g}}\right)\left(\frac{4\text{ mol }H_2O}{2\text{ mol }NH_4NO_3}\right)\left(\frac{18.02\text{ g}}{1\text{ mol }H_2O}\right)\left(\frac{1\text{ mL}}{1\text{ g }H_2O}\right) = \boxed{542.83\text{ mL }H_2O}$$

3) How many grams of carbon dioxide are produced from the combustion of 43.7g of propane (C_3H_8) in your space heater?

$$C_3H_8(g) + 5O_2(g) \longrightarrow 3CO_2(g) + 4H_2O(g)$$

$$43.7\text{ g }C_3H_8\left(\frac{1\text{ mol }C_3H_8}{44.09\text{ g}}\right)\left(\frac{3\text{ mol }CO_2}{1\text{ mol }C_3H_8}\right)\left(\frac{44.01\text{ g}}{1\text{ mol }CO_2}\right) = \boxed{131\text{ g }CO_2}$$

4) How many grams of sodium hydroxide would be required to produce 75.0g of precipitate from a double displacement reaction between sodium hydroxide and excess magnesium nitrate?

$$2NaOH(aq) + Mg(NO_3)_2(aq) \rightarrow 2NaNO_3(aq) + Mg(OH)_2(s$$

$$75.0\ g\ Mg(OH)_2 \left(\frac{1\ mol\ Mg(OH)_2}{58.33\ g}\right)\left(\frac{2\ mol\ NaOH}{1\ mol\ Mg(OH)_2}\right)\left(\frac{39.99\ g}{1\ mol\ NaOH}\right) = 102.8 = \boxed{103\ g\ NaOH}$$

5) If you have 13.5g of aluminum and 46.8g of oxygen, how much aluminum oxide could you theoretically produce in a synthesis reaction?

limiting reagent

$$4Al(s) + 3O_2(g) \rightarrow 2Al_2O_3(s)$$

① $13.5\ g\ Al \left(\frac{1\ mol\ Al}{26.98\ g}\right) = \boxed{0.500\ mol\ Al}$

$46.8\ g\ O_2 \left(\frac{1\ mol\ O_2}{32.00\ g}\right) = \boxed{1.46\ mol\ O_2}$

How much you HAVE

② $0.500\ mol\ Al \left(\frac{3\ mol\ O_2}{4\ mol\ Al}\right) = \boxed{0.375\ mol\ O_2}$

How much O_2 you need to use all of the Al

③ O_2 is in excess (have more than you need)
Al is limiting

④ $0.500\ mol\ Al \left(\frac{2\ mol\ Al_2O_3}{4\ mol\ Al}\right)\left(\frac{101.96\ g}{1\ mol\ Al_2O_3}\right) = \boxed{25.5\ g\ Al_2O_3}$

limiting reagent 6) How many grams of hydrochloric acid could be produced from a reaction between 219.5g of chlorine and 300.9g of hydrobromic acid?

$$Cl_2(g) + 2HBr(aq) \rightarrow 2HCl(aq) + Br_2(l)$$

$219.5\ g\ Cl_2 \left(\frac{1\ mol\ Cl_2}{70.90\ g}\right) = 3.096\ mol\ Cl_2$ HAVE

$300.9\ g\ HBr \left(\frac{1\ mol\ HBr}{80.91\ g}\right) = 3.719\ mol\ HBr$ HAVE

$3.096\ mol\ Cl_2 \left(\frac{2\ mol\ HBr}{1\ mol\ Cl_2}\right) = 6.192\ mol\ HBr$ NEED

HBr is limiting

$3.719\ mol\ HBr \left(\frac{2\ mol\ HCl}{2\ mol\ HBr}\right)\left(\frac{36.46\ g}{1\ mol\ HCl}\right) = 135.6\ g\ HCl$

7) If you performed the reaction from #6 and collected 120.1g of HCl, what is your percent yield? Percent error?

$$\%\ Yield = \frac{120.1\ g}{135.6\ g}(100) = 88.6\ \%\ yield$$

$$\%\ Error = \frac{|120.1 - 135.6|}{135.6}(100) = 11.4\ \%\ error$$

8) Tying it all together: You perform a reaction between 15.6 g of ethyl ethanoate ($C_4H_8O_2$) and excess water in the presence of heat. After studying ester hydrolysis (yeah, you're smart) you predict two products were created: ethanol (C_2H_6O) and ethanoic acid ($C_2H_4O_2$).

a) Write a chemical equation for the reaction performed.

$$C_4H_8O_2(\ell) + H_2O(\ell) \longrightarrow C_2H_6O(aq) + C_2H_4O_2(aq)$$

After performing the reaction, you separate the homogenous mixture via distillation & condensation. The separation yields 3 samples that have unique boiling points.

b) Explain this observation and discuss whether or not it agrees with the reaction prediction from part a. Yes, it agrees with (a). Although only 2 products are predicted, H_2O is present in excess and will be left over in the reaction vessel along with the 2 products.

Each individual sample is analyzed for mass and %composition. The results are below.

Sample	Mass (g)	%Composition
1	8.15	52.14% C, 13.13% H, 34.73% O
2	10.63	40.00% C, 6.71% H, 53.29% O
3	45.66	11.19% H, 88.81% O

c) Explain and discuss whether or not both data columns agree with the reaction prediction from part a. Use calculations to support your answer. Yes, the % Comp data produces empirical formulas that match the predicted products & excess water

(1) $\frac{C_{52.14}}{12.01}\frac{H_{13.13}}{1.008}\frac{O_{34.73}}{16}$

$\frac{C_{4.34}}{2.17}\frac{H_{13.03}}{2.17}\frac{O_{2.17}}{2.17}$

C_2H_6O Ethanol

(2) $\frac{C_{40.00}}{12.01}\frac{H_{6.71}}{1.008}\frac{O_{53.29}}{16}$

$\frac{C_{3.33}}{3.33}\frac{H_{6.66}}{3.33}\frac{O_{3.33}}{3.33}$

CH_2O Empirical $\Rightarrow$ $C_2H_4O_2$ Ethanoic Acid

(3) $\frac{H_{11.19}}{1.008}\frac{O_{88.81}}{16}$

$\frac{H_{11.10}}{5.55}\frac{O_{5.55}}{5.55}$

H_2O Water

d) Assuming the predicted products were correct, determine the percent yield of ethanol and ethanoic acid.

$$15.6\text{ g } C_4H_8O_2\left(\frac{1\text{ mol } C_4H_8O_2}{88.10\text{ g}}\right)\left(\frac{1\text{ mol } C_2H_6O}{1\text{ mol } C_4H_8O_2}\right)\left(\frac{46.07\text{ g}}{1\text{ mol } C_2H_6O}\right) = 8.16\text{ g Ethanol}$$

$$15.6\text{ g } C_4H_8O_2\left(\frac{1\text{ mol } C_4H_8O_2}{88.10\text{ g}}\right)\left(\frac{1\text{ mol } C_2H_4O_2}{1\text{ mol } C_4H_8O_2}\right)\left(\frac{60.05\text{ g}}{1\text{ mol } C_2H_4O_2}\right) = 10.63\text{ g}$$

$$\%\text{ Yield}_{\text{Ethanol}} = \frac{8.15\text{ g}}{8.16\text{ g}}(100) = 99.9\%$$

$$\%\text{ Yield}_{\text{Ethanoic Acid}} = \frac{10.63\text{ g}}{10.63\text{ g}}(100) = 100\%$$