CHM 130: Stoichiometry Practice Problems

1. The fertilizer ammonium sulfate, $(NH_4)_2SO_4$, is prepared by the reaction of ammonia, NH_3, with sulfuric acid:

$$2\ NH_3\ (g)\ +\ H_2SO_4\ (aq)\ \Rightarrow\ (NH_4)_2SO_4\ (aq)$$

   a. What mass of ammonium sulfate is produced if 50.0 L of ammonia gas reacts completely at STP?

$$50.0\ L\ NH_3 \times \frac{mol\ NH_3}{22.4\ L\ NH_3} \times \frac{1\ mol\ (NH_4)_2SO_4}{2\ mol\ NH_3} \times \frac{132.17\ g\ (NH_4)_2SO_4}{mol\ (NH_4)_2SO_4} = 148\ g\ (NH_4)_2SO_4$$

   b. What mass of sulfuric acid is required to react completely with 50.0 L of ammonia?

$$50.0\ L\ NH_3 \times \frac{mol\ NH_3}{22.4\ L\ NH_3} \times \frac{1\ mol\ H_2SO_4}{2\ mol\ NH_3} \times \frac{98.09\ g\ H_2SO_4}{mol\ H_2SO_4} = 109\ g\ H_2SO_4$$

2. Propane, C_3H_8 (g), burns in oxygen to produce carbon dioxide gas and steam.

   a. Write the equation for this reaction, then balance the equation.

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

   b. If 5.000 g of propane burn completely in excess oxygen, what volume of carbon dioxide gas is produced at STP?

$$5.000\ g\ C_3H_8 \times \frac{mol\ C_3H_8}{44.11\ g\ C_3H_8} \times \frac{3\ mol\ CO_2}{1\ mol\ C_3H_8} \times \frac{22.4\ L\ CO_2}{mol\ CO_2} = 7.62\ L\ CO_2$$

   c. If 75.0 L of steam are produced at STP, what mass of propane must have burned completely in oxygen?

$$75.0\ L\ H_2O \times \frac{mol\ H_2O}{22.4\ L\ H_2O} \times \frac{1\ mol\ C_3H_8}{4\ mol\ H_2O} \times \frac{44.11\ g\ C_3H_8}{mol\ C_3H_8} = 36.9\ g\ C_3H_8$$

3. Fermentation is a complex chemical process of making wine by converting glucose into ethanol and carbon dioxide:

$$C_6H_{12}O_6\ (s)\ \Rightarrow\ 2\ C_2H_5OH\ (l)\ +\ 2\ CO_2\ (g)$$

a. Calculate the mass of ethanol produced if 5.00 kg of glucose decomposes completely.

$$5.00\ \text{kg}\ C_6H_{12}O_6 \times \frac{1000\ g}{1\ \text{kg}} \times \frac{\text{mol}\ C_6H_{12}O_6}{180.18\ g\ C_6H_{12}O_6} \times \frac{2\ \text{mol}\ C_2H_5OH}{1\ \text{mol}\ C_6H_{12}O_6} \times \frac{46.08\ g\ C_2H_5OH}{\text{mol}\ C_2H_5OH} =$$

$$2.56 \times 10^3\ g\ C_2H_5OH$$

b. Calculate the volume of carbon dioxide gas produced at STP if 100.0 g of glucose react completely.

$$100.0\ g\ C_6H_{12}O_6 \times \frac{\text{mol}\ C_6H_{12}O_6}{180.18\ g\ C_6H_{12}O_6} \times \frac{2\ \text{mol}\ CO_2}{1\ \text{mol}\ C_6H_{12}O_6} \times \frac{22.4\ L\ CO_2}{\text{mol}\ CO_2} = 24.9\ L\ CO_2$$

4. Consider the reaction of zinc metal with hydrochloric acid.

a. Write the equation for this reaction, then balance the equation.

$$Zn\ (s) + 2\ HCl\ (aq) \Rightarrow H_2\ (g) + ZnCl_2\ (aq)$$

b. Calculate the volume of hydrogen gas produced at STP if 25.00 g of zinc react with 25.00 g of hydrochloric acid.

$$25.00\ g\ Zn \times \frac{\text{mol}\ Zn}{65.39\ g\ Zn} \times \frac{1\ \text{mol}\ H_2}{1\ \text{mol}\ Zn} \times \frac{22.4\ L\ H_2}{\text{mol}\ H_2} = 8.56\ L\ H_2$$

so $7.68\ L\ H_2$ produced

$$25.00\ g\ HCl \times \frac{\text{mol}\ HCl}{36.46\ g\ HCl} \times \frac{1\ \text{mol}\ H_2}{2\ \text{mol}\ HCl} \times \frac{22.4\ L\ H_2}{\text{mol}\ H_2} = 7.68\ L\ H_2$$

c. Identify the limiting reagent and the reactant in excess.

HCl is the limiting reagent, and Zn is in excess.

d. Calculate the percent yield if 6.53 L are actually produced.

$$\frac{6.53\ L\ H_2}{7.68\ L\ H_2} \times 100\% = 85.0\ \%$$

5. Titanium metal can be produced from the reduction of titanium (IV) chloride with magnesium metal:

$$TiCl_4\ (g) + 2\ Mg\ (l) \Rightarrow Ti\ (s) + 2\ MgCl_2\ (l)$$

a. What mass of titanium can be produced from 500.0 g of titanium (IV) chloride and 250.0 g of magnesium?

$$500.0\ g\ TiCl_4 \times \frac{mol\ TiCl_4}{189.68\ g\ TiCl_4} \times \frac{1\ mol\ Ti}{1\ mol\ TiCl_4} \times \frac{47.88\ g\ Ti}{mol\ Ti} = 126.2\ g\ Ti$$

$$250.0\ g\ Mg \times \frac{mol\ Mg}{24.31\ g\ Mg} \times \frac{1\ mol\ Ti}{2\ mol\ Mg} \times \frac{47.88\ g\ Ti}{mol\ Ti} = 246.2\ g\ Ti$$

so *126.2 g Ti* produced

b. Identify the limiting reagent and the reactant in excess.

$TiCl_4$ is the limiting reagent, and Mg is in excess.

c. Calculate the percent yield if 117.0 g of titanium are actually produced.

$$\frac{117.0\ g\ Ti}{126.2\ g\ Ti} \times 100\% = 92.71\ \%$$

6. Nitric oxide, NO (g), reacts with oxygen according to the following equation:

$$2\ NO\ (g) + O_2\ (g) \Rightarrow 2\ NO_2\ (g)$$

a. What volume (in L) of NO_2 is produced when 80.0 L of NO reacts with 35.0 L of oxygen?

$$80.0\ L\ NO \times \frac{2\ L\ NO_2}{2\ L\ NO} = 80.0\ L\ NO_2$$

so 70.0 L NO_2 is produced

$$35.0\ L\ O_2 \times \frac{2\ L\ NO_2}{1\ L\ O_2} = 70.0\ L\ NO_2$$

b. Identify the limiting reagent and the reactant in excess.

O_2 is the limiting reagent, and NO is in excess.

c. Calculate the percent yield of NO_2 if 68.4 L of NO_2 is actually produced.

$$\frac{68.4\ L\ NO_2}{70.0\ L\ NO_2} \times 100\% = 97.7\ \%$$

7. Lead (II) iodide can be produced from the reaction of lead (II) nitrate and potassium iodide:

$$Pb(NO_3)_2\,(aq) + 2\,KI\,(aq) \Rightarrow PbI_2\,(s) + 2\,KNO_3\,(aq)$$

a. What mass of lead (II) iodide can be produced from 100.00 g of lead (II) nitrate and 75.00 g of potassium iodide?

$$100.00\ g\ Pb(NO_3)_2 \times \frac{mol\ Pb(NO_3)_2}{331.22\ g\ Pb(NO_3)_2} \times \frac{1\ mol\ PbI_2}{1\ mol\ Pb(NO_3)_2} \times \frac{461.00\ g\ PbI_2}{mol\ PbI_2} = 139.18\ g\ PbI_2$$

$$75.00\ g\ KI \times \frac{mol\ KI}{166.00\ g\ KI} \times \frac{1\ mol\ PbI_2}{2\ mol\ KI} \times \frac{461.00\ g\ PbI_2}{mol\ PbI_2} = 104.1\ g\ PbI_2$$

so *104.1 g PbI_2* produced

b. Identify the limiting reagent and the reactant in excess.

KI is the limiting reagent, and $Pb(NO_3)_2$ is in excess.

c. Calculate the percent yield if 89.4 g of lead (II) iodide are actually produced.

$$\frac{89.4\ g\ PbI_2}{104.1\ g\ PbI_2} \times 100\% = 85.9\ \%$$