Part I: Review of Calculations Based on Chemical Reactions

For Part I we will review how to write chemical reactions and how to use mole to mole ratios for calculations.

1. Ammonium nitrate is a common fertilizer and has been the cause of multiple disasters due to improper handling. When heat is applied to ammonium nitrate, it decomposes into nitrogen gas, oxygen gas, and water vapor.

    a. Write the balanced chemical reaction for the decomposition of solid ammonium nitrate. Be sure to include the states of the reactant and products.

    b. Based on your balanced reaction, what is the conversion factor that allows you to relate the moles of ammonium nitrate to total moles of gas produced?

    c. Use this conversion factor to find how many moles of gas are produced from the decomposition of 95 grams of ammonium nitrate.

    d. What is the total number of gas molecules produced from the 95 grams of ammonium nitrate?

    e. Calculate the amount of nitrogen gas produced from the 95 grams of ammonium nitrate.

    f. Calculate the amount of oxygen gas produced from the 95 grams of ammonium nitrate.

2. Copper metal reacts with aqueous nitric acid to produce aqueous copper (II) nitrate, nitrogen monoxide gas, and water.

a. Write the balanced chemical reaction.

$$\_\_\_\_Cu_{(s)} + \_\_\_\_HNO_{3\,(aq)} \rightarrow \_\_\_\_\_Cu(NO_3)_{2\,(aq)} + \_\_\_\_NO_{2\,(g)} + \_\_\_\_H_2O_{(l)}$$

b. Based on the balanced reaction, what is the conversion factor that allows you to relate moles of copper to moles of nitrogen monoxide?

c. Calculate the number of moles in 11.8 grams of copper metal.

d. Calculate the amount of nitrogen monoxide gas produced in moles from 11.8 grams of copper metal with an excess of nitric acid.

e. Now calculate the amount of copper (II) nitrate produced in moles from 11.8 grams of copper metal with an excess of nitric acid.

f. Finally calculate the amount of water produced from the reaction with 11.8 grams of copper metal with an excess of nitric acid.

g. Determine the mole to mole ratio of each product to the number of moles of copper metal used in the reaction. Do they match the ratios seen in our balanced chemical reaction?

h. Talk with your group and think about what might happen if we were limited to 0.247 moles of aqueous nitric acid. Do you think this would change the amount of each product that was made? What is the mole to mole ratio of copper metal to aqueous nitric acid?

Part II: Limiting Reactants

3. Now that we've reviewed how to do calculations based on chemical reactions, we can turn to calculating limiting reactants. We can think of limiting reactants like making pancakes. We know if a recipe can make 6 pancakes using 1.5 cups of flour, 1 egg and ½ tsp of baking powder (*Author's note: this is actually a horrible pancake recipe… It is not suggested you use this to make pancakes)*. We can think of this pancake recipe as a chemical reaction (which it actually is!)

1.5 Cup of flour + 1 egg + ½ tsp → 6 pancakes

You need to make as many pancakes as you possible can and have the following ingredients available:

3.1 cups of flour

3 eggs

7 tsp baking powder

We can use stoichiometry to figure out how many pancakes we can make with the quantity of ingredients we have on hand.

Ex:

$$3.1 \text{ cups of flour} \times \frac{6 \text{ pancakes}}{1.5 \text{ cups of flour}} = 12.4 \text{ pancakes}$$

a. How many pancakes you can make with 3 eggs?

b. How many pancakes can you make with 7 tsp of baking powder?

c. Which produces the least number of pancakes? This is our limiting ingredient (reactant)!

Part III: Determining limiting reactants of chemical reactions

4. Scrap aluminum metal can react with chlorine gas to produce solid aluminum chloride, an inexpensive chemical used in many industrial processes.

a. Write the balanced equation for the synthesis of aluminum chloride.

You want to figure out how much aluminum chloride you can make if you have 150.0 grams of aluminum and 150.0 grams of chlorine gas. Let's break it down into steps.

b. Based on your balanced reaction, what is the conversion factor that allows you to relate moles of aluminum to moles of aluminum chloride?

c. Assuming that the 150.0 g of aluminum metal is the limiting reactant, how many grams of aluminum chloride can be made?

d. Based on your balanced reaction, what is the conversion factor that allows you to relate moles of chlorine gas to moles of aluminum chloride?

e. Assuming that the 150.0 g of chlorine gas is the limiting reactant, how many grams of aluminum chloride can be made?

f. Given your answers to questions 3c) and 3e), what is the actual limiting reactant and how much aluminum chloride can you actually make? Briefly explain your choice.

5. Iron(III) oxide is also called hematite and is a common ore of iron. Iron metal can be made by reacting the hematite with carbon monoxide. In addition to the desired iron metal, the process also produces carbon dioxide gas.

a. Write the balanced equation for the reaction of hematite and carbon monoxide to produce iron and carbon dioxide. If you start with 2.00 kg of each reactant, what is the maximum amount of iron you can produce?

b. Based on your balanced reaction, what is the conversion factor that allows you to relate moles of iron to moles of hematite?

c. Assuming that the 2.00 kg of hematite is the limiting reactant, how many grams of iron can be made?

d. Based on your balanced reaction, what is the conversion factor that allows you to relate moles of iron to moles of carbon monoxide?

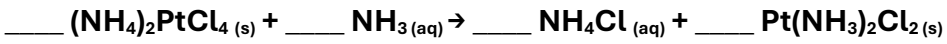
e. Assuming that the 2.00 kg of carbon monoxide is the limiting reactant, how many grams of iron can be made?

f. Given your answers to questions 4c) and 4e), what is the actual limiting reactant and how much iron can you actually make? Briefly explain your choice.

Part IV: Extra Practice Problems

These problems have not been broken down into steps for you, so look back at the two previous questions if you get stuck.

6. The cancer chemotherapy agent, cisplatin, Pt(NH3)2Cl2, is produced by the following unbalanced reaction:



What is the maximum mass, in g, of cisplatin that can be made from 0.85 g of $(NH_4)_2PtCl_4$ and 0.15 g of NH_3?

7. Sulfur dioxide is a toxic gas that contributes to acid rain. It is produced as an unwanted product during the burning of sulfur containing coal. The gaseous sulfur dioxide can be removed from the smokestacks of coal burning power plants by reacting it with limestone (calcium carbonate) and oxygen. The products are solid calcium sulfate and carbon dioxide gas. What is the maximum mass, in kg, of sulfur dioxide that can be treated if you have 85.0 lbs. of limestone and 650.0 L of oxygen? Assume each mole of oxygen has a volume of 22.4 L.