Chemistry 112

Learning Opportunities

May 18 – 22

<u>Limiting Reagents</u>

This is a recipe for chocolate chip cookies:

1/3 cup margarine

½ cup white sugar

¼ cup brown sugar

1 egg

1 teaspoon baking soda

1 cup flour

½ cup chocolate chips

If I have lots of all other ingredients but only 2 eggs, I can only make 2 batches of cookies. In this case, eggs would be my limiting reagent. I run out of eggs first and that controls how many cookies I can make.

In a chemical reaction, an insufficient quantity of any of the reactants will limit the amount of product that forms. The limiting reagent is the reactant in the chemical equation that determines the amount of product that can be formed by the reaction. The reaction occurs only until the limiting reagent is all used.

The reactants that are not completely used in the reaction are called excess reagent.

Stoichiometry can be used to determine which reactant is the limiting reagent. All the other reactants are excess reagents.

Follow these steps:

1. Start with a balance chemical equation
2. Choose one reactant (we will call it reactant A) to start with - there is no wrong choice
3. Start with the amount (usually grams) of reactant A and calculate how much (usually grams) of the other reactant (we will call it reactant B) is needed. You will be given amounts for both reactants but only use the one for reactant A and ignore the amount given for reactant B for now.
4. Compare the amount of reactant B calculated to the amount of reactant B given in the question.
   a. If the calculate amount of reactant B is less than the amount given in the question – reactant B is in excess and reactant A is the limiting reagent
   b. If the calculated amount of reactant B is greater than the amount given in the question – reactant B is the limiting reagent and reactant A is in excess

See Limiting Reagents – Sample Problem

<u>Practice Problems</u>

1. What is the limiting reagent when 60.0g NH_3 reacts with 40.0g of O_2?
   $NH_3 + O_2 \rightarrow NO + H_2O$

2. What is the limiting reagent when 6.00g of HCl react with 5.00g of Mg?
   $Mg + 2HCl \rightarrow MgCl_2 + H_2$

3. If 5.00g of CS_2 reacts with 7.50g of O_2, what is the limiting reagent?

$$CS_2 + 3O_2 \rightarrow CO_2 + 2SO_2$$
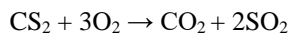
Percent Yield

When performing an experiment in the lab, the amount of product formed is often less than what was expected. The theoretical yield is the maximum amount of product that could be formed based on the given reactants. The actual yield is the amount of product that forms when the lab is carried out in the lab.

Percent yield is the ratio of the actual yield compared to the theoretical yield expressed as a percent.

$$\% \, Yield = \frac{actual \, yield}{theoretical \, yield} \, x \, 100\%$$

Factors that could cause a percent yield less than 100% are:

- Impure reactants
- Competing side reactions
- Reaction does not go to completion
- Lose some product during filtration or when transferring
- If reactants or products are not carefully measured

To complete percent yield questions, frequently three things must be done:

1. Find the limiting reagent.
2. Use the limiting reagent to calculate the theoretical yield for the product in question
3. Calculate the percent yield for the product

See Percent yield – Sample problem

Practice problems

1. When 5.00g of Cu reacts with 32.6g of $AgNO_3$, 12.4g of Ag is produced. What is the percent yield of Ag?
   $Cu + 2AgNO_3 \rightarrow 2Ag + Cu(NO_3)_2$

2. When 15.0g of N_2 reacts with 2.5g of H_2, 10.5g of NH_3 is produced. What is the percent yield of NH_3?
   $N_2 + 3H_2 \rightarrow 2NH_3$