Module 6: Percent Yield of NaCl

Introduction

Reaction stoichiometry is used to relate the amounts of reactants and products in a chemical reaction. For example, consider the combustion of propane:

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

This equation tells you that for every 1 mol C_3H_8 combusted, 5 mol O_2 must react and 3 mol of CO_2 and 4 mol H_2O must be produced. No matter how much propane is consumed, these ratios must always be the same. Thus, it is possible to predict the number of moles of CO_2 that would be produced if 40.0 mol O_2 is reacted:

$$40.0 \text{ mol } O_2 * \frac{3 \text{ mol } CO_2}{5 \text{ mol } O_2} = 24.0 \text{ mol } CO_2$$

It is also possible to predict the mass of CO_2 that would be produced from the combustion of 61.0 g of propane:

$$61.0 \text{ g } C_3H_8 * \frac{1 \text{ mol } C_3H_8}{44.11 \text{ g } C_3H_8} \frac{3 \text{ mol } CO_2}{1 \text{ mol } C_3H_8} \frac{44.01 \text{ g } CO_2}{1 \text{ mol } CO_2} = 183 \text{ g } CO_2$$

183 g is the theoretical yield of CO_2. The amount that SHOULD be made according to theory. The actual amount of CO_2 collected will almost always be less. There are a variety of reasons why the actual yield is less than the percent yield. Sometimes the reaction is not allowed to finish. Sometimes a different reaction occurs, causing byproducts. Sometimes you cannot collect all of the product generated. To account for these difficulties, it is common to report the percent yield:

$$\text{percent yield} = \frac{\text{actual yield}}{\text{theoretical yield}} * 100\%$$

If 125 g of CO_2 were actually collected from the above reaction, the percent yield would be:

$$68.3\% = \frac{125 \text{ g } CO_2}{183 \text{ g } CO_2} * 100\%$$

Pre-Lab Questions

You will be observing a reaction in this lab. As with most reactions, this reaction occurs by the breaking of some bonds in the reactants and the formation of new bonds in the products. During the reaction, the gas that is produced will fizz away. After the reaction is complete, one of the products can be removed. Then you will determine the mass of the other product – this will be your actual (or experimental) yield. You will compare this value to what you should have got (theoretical yield) to calculate your % yield.

1. Balance the following equation: $\mathbf{NaHCO_3 + HCl \rightarrow NaCl + H_2O + CO_2}$

2. List the reactants that will be put into the beaker:
   -
   -

3. List the products that will be formed in this reaction:
   -
   -
   -

4. Which product will fizz away?

5. How can you get rid of another one of the products so that there is only one left?

6. How many grams of NaCl should be produced if you start with **1.0 g** of sodium bicarbonate. This conversion will require three conversion factors. *(Ref: Example 8.3 and 8.6, chapter 8 of textbook*).

7. How many molecules of CO2 should be produced if you start with **1.0 g** of sodium bicarbonate. This conversion will require three conversion factors. *(Ref: Example 8.3, chapter 8 and Example 6.1, chapter 6 of textbook*).

% Yield of NaCl

Procedures and Data

Watch the following video and answer the following questions. I suggest you use a split screen so that you can watch the experiment as you collect the data.
https://www.youtube.com/watch?v=vjVrIFScsls

STEP 1: Determine the mass of $NaHCO_3$.
Record what the data should be for the second measurement in the table below and then do the subtraction to show that you have 2.00 g of $NaHCO_3$ in the beaker.

Mass of Beaker	**145.55 g**
Mass of Beaker and $NaHCO_3$	
Mass of $NaHCO_3$ (show calculation)	

STEP 2: Add chemicals.
Write down the next two reagents added and the rationale (reason) for them.
-
-

Notice that the color of the solution is blue.
What does this mean?
What would it mean if it were yellow?

STEP 3: Run the reaction to completion
Record your observations in the table below. Explain what the observations indicate (inferences).

Observations upon addition of first four drops of HCl	Inferences

How will you know when the reaction is complete (three indications).
-
-
-

FINAL STEPS: List the last two steps needed to isolate NaCl.
-
-

FINAL PRODUCT: The video does not show the result after evaporation. If it had, you would see salt (NaCl) alone in the beaker. The following data table provides the data you need to calculate the amount of salt you produced:

Mass of beaker alone (see data table above)	
Mass of NaCl and beaker	**146.83 g**
Mass of NaCl (show subtraction)	

% Yield of NaCl

Data Analysis

1. What was the mass of $NaHCO_3$ you started with (see first data table)? _____

2. The mass of NaCl that should be produced is called the _____ yield because it is the amount that should be produced according to theory. What is the mass of NaCl that should be produced in theory? (Show your calculation. Start with the mass of $NaHCO_3$ from above and use conversion factors like you did in the pre-lab worksheet).

3. The mass of NaCl that you ended up with is called the _____ yield because it is the amount of product that you actually got in the experiment. What was the mass of NaCl that was actually produced (see second data table)?_____

4. Calculate your % yield **(actual yield / theoretical yield) X 100**.

5. Did you get what you were supposed to? Explain one thing that might account for the difference.