Quantitative Analysis Percent Yield

# **Purpose**: To practice the reality of chemical reactions using percent yield for an actual double displacement reaction.

**Discussion**: Our goal at the beginning of this unit was to be able to determine exact quantities of a substance in a reaction [analytical or quantitative analysis].

Using a balanced equation, one can determine what quantity of one substance is needed to react with a given quantity of another substance. Using a balanced equation, one can determine how much product of one substance we expect from a specified amount of reactant (vice versa). Specifically, using a balanced equation, one can determine how many grams of one substance is needed to react with a given mass of another substance OR one can determine how much product of one substance we expect from a specified mass of reactant (vice versa).

Quantitative analysis gives us “**theoretical yield**”, not **actual yield** (*how much product could be expected from the reactants used*). In this lab you will calculate theoretical yield and test it by actually performing the chemical reaction. Your final “actual yield” divided by the calculated “theoretical yield” times 100% gives a “percent yield.”

EXAMPLE *How much water is converted to sodium hydroxide and hydrogen gas when 11.5 g of sodium is added?*

Step 1 🡪 Make sure of a **balanced equation**

*2 Na + 2 H2O 🡪 2 Na(OH) + H2 (g)*

Step 2 🡪 determine the **moles**

*11.5 g x 1 mole / 23 g = 0.50 moles Na*

Step 3 🡪 determine the **mole ratio** of sodium to water

* *According to the equation the mole ratio is 2:2*
* *Therefore, 0.50 moles of water will be produced*

Step 4 🡪 convert **moles**

*0.50 mole x 18 g / mole =* ***9.0 g of water***

H 1 x 2 = 2.0 g/mole

O 16 x 1 = 16 g/mole

**18 g/mole**

Assume that only 8.1 g of water is actually produced. What is the Percent Yield?

% yield = actual yield / theoretical yield x 100 % = 8.1 g/9.0 g x 100 % = 90% yield**Calculations & Data**

1. Write a balanced chemical equation for the reaction between solutions of sodium sulfate and barium nitrate. [ <http://somup.com/cFX13bn17X> ]

2. Determine the molar mass of each reactant in the reaction above (Show work):

Na2SO4 (aq) 🡪 \_\_\_\_\_\_\_\_\_\_ Ba(NO3)2 (aq) 🡪 \_\_\_\_\_\_\_\_\_\_

3. Determine the molar mass of the precipitate formed in the reaction above (Show work):

4. Assume that 0.01 mol of sodium sulfate reacted with 0.01 mol of barium nitrate and 2.20 grams of precipitate formed. Calculate the **percent yield**.

*Actual Total Product / Theoretical Yield x 100%*

**Conclusions and Questions**

1. List several sources of error in this laboratory (why was your percent yield not equal to the theoretical yield?).

2. Using the balanced chemical equation, determine the “limiting reagent” for this reaction.

ANSWER KEY

1. Write a balanced chemical equation for the reactants given.

**Na2SO4 (aq) + Ba(NO3)2 (aq) 🡪 Ba(SO4) (s) + 2 NaNO3 (aq)**

2. Determine the molar mass of each reactant in the reaction above (Show work):

Na2SO4 (aq) 🡪 **142 g** Ba(NO3)2 (aq) 🡪 **261 g**

Na 2 x 23 = 46.0 g/mole Ba 1 x 137 = 137 g/mole

S 1 x 32 = 32.0 g/mole N 2 x 14 = 28.0 g/mole

O 4 x 16 = 64.0 g/mole O 6 x 16 = 96.0 g/mole

**142 g/mole** **261 g/mole**

3. Determine the molar mass of the precipitate formed in the reaction above (Show work):

BaSO4 (s) 🡪 **233 g** Ba 1 x 1 = 137 g/mole

S 1 x 32 = 32.0 g/mole

O 4 x 16 = 64.0 g/mole

**233 g/mole**

4. Assume that 0.0100 mol of sodium sulfate reacted with 0.0100 mol of barium nitrate and 2.20 grams of precipitate formed. Calculate the **percent yield**.

*Actual Total Product / Theoretical Yield x 100%*

Step 1 🡪 Based on the balanced equation, the mole ratio of either reactant to the precipitate (barium sulfate) is 1:1. Therefore, since 0.0100 mol of reactant is used, 0.0100 mole of product is formed.

Na2SO4 (aq) + Ba(NO3)2 (aq) 🡪 Ba(SO4) (s) + **2** NaNO3 (aq)

Step 2 🡪 Use the number of moles to find theoretical yield of product

*0.100 moles x 233 g / mole =* ***2.33 g*** *of Barium Sulfate [theoretical yield]*

Step 3 🡪 Calculate the percent yield.

*Actual Total Product / Theoretical Yield x 100%*

2.20 g/2.33 g x 100% = **94%** yield

**Conclusions and Questions**

1. Assuming you performed this experiment using the laboratory. List several sources of error in this laboratory (why was the percent yield not equal to the theoretical yield?).

*Poor skills (measuring, calculating, filtering, decanting)*

2. Using the balanced chemical equation, determine the “limiting reagent” for this reaction.

*Based on this reaction, there is no limiting reagent. Both reactants would produce the same amount of theoretical product (2.33 g) since the number of moles matched the mole ratio of the balanced equation.*