Experiment: Solutions & Solubility

Objectives:

- Produce and collect $Cu(OH)_2$ precipitate from a simple double displacement reaction
- Determine mass and number of moles of the insoluble product
- Compare the predicted mass of the precipitate with the obtained mass

Supplies:

- Dry $CuSO_4 \cdot 5H_2O$
- Small bottle of de-ionized water
- 1.0 M NaOH solution
- Weigh paper
- Small measuring spatula
- Digital gram scale
- 20 mL graduated pipette and pump
- 1 small beaker
- Vacuum Filtration set-up:
  - 1 filter flask
  - 1 Buchner filter w/hose
  - Filter paper
  - Ring stand w/clamp
- Methanol in a squeeze bottle

Introduction:

In this experiment you will perform the following chemical reaction and observe the formation of the copper(II) hydroxide precipitate:

$$\mathbf{NaOH(aq) + CuSO_4(aq) \rightarrow Na_2SO_4(aq) + Cu(OH)_2(s)}$$

The precipitate will be collected by physical separation, using filtration, and its mass will be measured and compared to the predicted value.

i) Write out the balanced chemical equation for the above reaction:

Preliminary Questions:

1. Copper(II) Sulfate

a) Write out the chemical formula for the pre-hydrated copper(II) sulfate (i.e. copper(II) sulfate pentahydrate):

Chemical Formula: _____

b) Calculate the formula (molar) mass for this substance: *{Note: the formula mass is the equivalent of molar mass when there is more than one substance combined in a mixture}*

Formula (Molar) Mass: _____

c) If you had a sample of 0.5 grams of copper(II) sulfate pentahydrate, how many moles of copper(II) sulfate would you have?

2. Sodium Hydroxide

a) Write out the chemical formula for sodium hydroxide:

Chemical Formula: _____

b) Calculate the molar mass for this substance:

Molar Mass: _____

c) If you had a 20.0 mL sample of sodium hydroxide solution (1.0 mol/L) how many moles of sodium hydroxide would you have?

d) When the two above samples are combined together in the same test tube, a chemical reaction will occur. Identify the substance with the least amount of quantity (in moles).

Note: This substance is called the limiting reactant in this particular chemical reaction.

Main Activity:

1) Using a digital gram scale, measure approximately 0.5 grams of hydrated copper(II) sulfate. Record the actual mass of the sample.

Mass of sample: _____

2) Add the dry sample to a beaker containing approximately 10 mL de-ionized water. Gently stir until completely dissolved. Record your observations:

3) Using a graduated pipette and pump, measure out approximately 20 mL of sodium hydroxide solution and dispense it in the small test beaker containing aqueous copper (II) sulfate. Gently stir. Record the measured volume of the solution.

Concentration of NaOH solution: _____

Volume of NaOH solution: _____

4) Using your recorded measurements in steps 1 and 3, calculate the number of moles of each reactant in this reaction.

 # Moles of copper(II) sulfate: _____

 # Moles of sodium hydroxide: _____

5) Based on these molar values and the balanced chemical equation for this reaction, how many moles of copper(II) hydroxide would you expect to produce?

Predicted # Moles of copper(II) hydroxide: _____

6) How much, in grams, should this sample of copper(II) hydroxide weigh?

Predicted Mass (in grams) of copper(II) hydroxide: _____

7) Set-up a filtration system, according to your instructor's directions. *Please be careful not to flood the sinks and try to avoid water splashes around the computer equipment.*

8) Obtain a piece of dry filter paper and measure the mass. Record the measurement.

Mass of filter paper: _____

9) With the vacuum going, place the filter paper into the Buchner funnel and wet it down with de-ionized water (to "seal" the filter). Slowly pour the beaker contents (precipitate and liquid) into the funnel. The precipitate will separate from the solution as the vacuum quickly draws the liquid through the filter paper.

10) Rinse the precipitate several times with de-ionized water (vacuum permitting). Add a small amount of de-ionized water to reaction beaker, swirl, and pour into the Buchner funnel. Be careful not to flood the funnel or spill the precipitate.

11) Gently rinse the precipitate several times with methanol and allow it to completely filter through. This step will more quickly and effectively remove the excess water from the filter and the precipitate.

12) Let the filter and solid sit (under vacuum) and air dry for several minutes to evaporate most of the remaining alcohol.

13) To better remove the moisture from the product, place it on a low heat hot plate for several minutes, until the sample looks cracked and "spider webbed". *It may turn a greenish color.*

14) ***Determine the mass of the final solid product:*** First, measure the mass of the filter and product. Second, carefully remove all of the copper(II) hydroxide from the filter

paper into a small beaker. Measure and record the mass of the filter paper by itself. Finally, subtract the two masses to determine the mass of the obtained product.

Measured Mass (in grams) of filter paper & solid: _____

Measured Mass (in grams) of filter paper-only: _____

Measured Mass (in grams) of copper(II) hydroxide: _____

15) Calculate the % Error between your measured and predicted mass values.

% Error = _____

16) Enter all of the above values in the summary data table.

Summary Data Table:		
Concentration of NaOH		in mol/L
Volume of NaOH		mL
# moles of NaOH		
Mass of $CuSO_4$		g
# moles of $CuSO_4$		
# moles of $Cu(OH)_2$ (predicted)		
Mass of $Cu(OH)_2$ (predicted)		***g***
Mass of filter paper & solid		g
Mass of filter paper only		g
Mass of $Cu(OH)_2$ (measured)		***g***
% Error		***%***

Summary Questions:

1) How close is your prediction with the measured amount of copper(II) hydroxide? Based on this answer, do you consider this experiment a success?

2) What might account for any discrepancy between your predicted and measured results?

3) List 2 assumptions that are made in predicting how much copper(II) hydroxide product will be produced.

4) How has this experiment helped clarify your understanding of the role of the mole unit in the chemistry lab and its importance in the science of chemistry in general?

5) Suppose you wanted to produce 100. grams of $Cu(OH)_2$ using the reaction described in this experiment.
   a. How many moles of $Cu(OH)_2$ are in 100. grams?

   b. How many molecules of $Cu(OH)_2$ are in 100. grams?

   c. How much $CuSO_4$ (in grams) would you need as initial reactant to produce 100. grams of product?

   d. How much NaOH solution (of the same concentration used above) would you need to start with to maintain the same reaction ratio (in moles) of NaOH:$CuSO_4$?