Composition of Hydrates

Introduction:

Scientists investigate cycles of matter in order to make claims about patterns in nature. Questions about the way atoms combine to form compounds have intrigued chemists throughout time. Careful measurements can help scientists understand mathematical patterns in the structure of matter. In this lab, you will analyze data to calculate the percent water in an unknown hydrate.

The compound you will investigate in this lab is called a hydrate. When certain ionic compounds crystallize out of water, the resulting crystals contain water molecules. These solids are known as hydrates. The water molecules present in a hydrate can be released by heating, leaving behind the anhydrous form of the ionic compound. This product is called anhydrous salt.

In this lab, you will heat an unknown hydrate of copper sulfate, a blue solid. When the hydrate is heated, water is released, and a white solid (anhydrous copper sulfate) remains.

$$\underbrace{CuSO_4 \cdot {}^{x}H_2O(s)}_{\text{Deep Blue}} \xrightarrow{\Delta} \underbrace{CuSO_4(s)}_{\text{Ashy White}} + {}^{x}H_2O(g)$$

$$\underbrace{CuSO_4(s)}_{\text{Ashy White}} \xrightarrow{H_2O(l)} \underbrace{CuSO_4(aq)}_{\text{Deep Blue}}$$

You will take careful measurements of the mass of the hydrate and the mass of the anhydrous salt to determine the percentage of water in this hydrate. By combining your measurements with data from other groups, you can calculate the amount of hydrate in the original sample

Objective:

To qualitatively determine the mass percent of hydrate in an unknown hydrated salt using the chemical analysis technique gravimetric analysis.

Materials:

- indirectly vented chemical splash goggles, non latex apron, and nitrile gloves
- balance
- Bunsen burner
- Unknown Hydrate of Copper sulfate
- Evaporating dish

- Crucible tongs
- Ring stand with ring and wire gauze
- spatula/spoon

Safety Information:

- Wear indirectly vented chemical splash goggles, a non latex apron, and nitrile gloves during the setup, hands-on, and takedown segments of the activity.
- Use caution when working with Bunsen burners, because this heat source can seriously burn skin and clothing.
- Secure loose clothing, wear closed-toe shoes, and tie back hair.
- Keep liquids away from electrical equipment to prevent shock.
- Immediately wipe up spilled liquids so they do not become a slip/fall hazard
- Use caution when working with glassware, which can shatter if dropped and cut skin.
- Wash your hands with soap and water immediately after completing this activity.

Prelab:

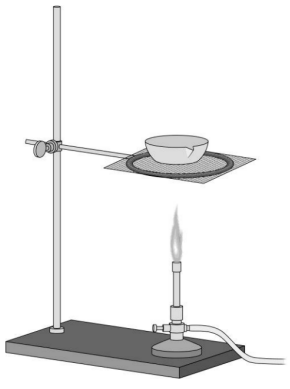
1. **Calculate the molar mass of $MgSO_4 \cdot 7\ H_2O$**
   MgSO4: 120.4 g/mol and 7H2O: 126.1 g/mol

2. **What is the percent by mass of water in $MgSO_4 \cdot 7\ H_2O$**
   51.17%

3. **You weight out a 0.470 g sample of hydrated nickel(II) chloride, $NiCl_2 \cdot X\ H_2O$. Upon heating, the mass of the anhydrous salt that remains is 0.256 grams. What is the formula of the hydrate?**
   NiCl2 4.27H2O

Procedure:

1. Your teacher will assign your group a mass of hydrate to analyze.
2. Weigh a clean, dry evaporating dish to the nearest 0.001 g.Record its mass in the data section of the table below.
3. Add enough copper sulfate to the evaporating dish to approximate the mass assigned to you. Note that it is not important that you measure exactly your assigned mass. Rather, it is important that you measure a mass close to your assigned mass and that you record the actual mass to the nearest 0.001 g.
4. Record the combined mass of the hydrate and evaporating dish in the data section of the table.
5. Adjust the ring on the ring stand so that it is positioned about 2 to 3 cm above the top of the Bunsen burner. Place the wire gauze on



the ring and the evaporating dish containing the hydrate on the wire gauze. Use the diagram as a guide for your setup.

6. Light the Bunsen burner and adjust the airflow using the vent at the base of the burner so that the flame is blue, not yellow. Place the lit burner under the evaporating dish on the ring stand.
7. Observe and record your observations as the hydrate is heated. If the hydrate begins splattering, move the burner away from the evaporating dish for a short time to allow it to cool. Then replace it to resume heating.
8. Continue heating until you observe no more changes. Heat for an additional two minutes after changes have ceased. Turn off the Bunsen burner and allow the dish to cool on the ring stand.
9. After five minutes of cooling time, use the crucible tongs or finger cots to carefully move the evaporating dish and its contents to the lab bench. Allow the dish to continue cooling until it reaches room temperature. At this point, you can safely carry the dish and sample to the balance to weigh it. Record the mass in the data section of the table.
10. Discard the anhydrous salt in the chemical waste container provided by your teacher. Wash the evaporating dish to remove any traces of the salt, and dry it using a paper towel. Wash your hands thoroughly with soap and water.
11. Collect data from six other groups and record these data in the data section of your table.

Collect Data:

	Group 1	**Group 2**	**Group 3**	**Group 4**	**Group 5**	**Group 6**	**Group 7**
Mass of empty dish	x	x	20.3 g	18.4 g	15.15 g	59.36 g	x
Mass of dish + hydrate	x	x	1.7 g	2 g	17.4 g	2.5 g	x
Mass of dish + anhydrous salt	x	x	21.5 g	19.8 g			x

Observations while burning: Since our flame is huge, it took longer for any big noticeable changes in color to occur, but it eventually took 5 or so minutes to start turning white and the blue did not fully disappear, there were still remains of a grayish light blue

Calculate:

Use data from your investigation to determine the mass of the hydrate, the mass of the anhydrous salt, and the mass of the water present in the hydrate. Then use this information to calculate the percentage of water in the hydrate using the equation below:

$$\%H_2O = \frac{\text{mass of water}}{\text{mass of hydrate}} \times 100$$

Repeat these calculations using data collected from each of the six other groups. Show your work below and record all results in the table.

	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	Group 7
Mass of hydrate	x	x					x
Mass of anhydrous salt	x	x					x
Mass of water	x	x					x
% Water in Hydrate	x	x					x

Analyze:

1. Calculate and average the moles of both water and anhydrous salt in the table below:

	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	Group 7
Moles of anhydrous salt							
Moles of water							

2. Using the average of each, calculate the ratio of anhydrous salt to water. Use this to determine the formula for the unknown hydrate.

3. How did the calculated values for percentage of water compare for the seven sets of data? Did the results show any particular trend with respect to the quantity of hydrate analyzed?

4. **What were possible sources of experimental error in this investigation? Name at least two. How would each of these have affected the calculated percentage value?**
   Possible sources of experimental error in this investigation could be measuring out the wrong amount of anhydrous salt and/or leaving the anhydrous salt in the Bunsen burner for way too long. Measuring the wrong amount of anhydrous salt can affect the calculated percentage because then you would get the wrong answer when trying to figure out the hydrate. Leaving the salt in the Bunsen burner can affect calculation of the hydrate to be lower than normal.

5. **Why was it important to continue heating for several minutes after you observed no more color change in the sample? What did this step help ensure?**

Extend:

1. **Say you were tasked to rehydrate this salt by leaving it in a moisture chamber so it can accumulate water. Design an experiment that would ensure a way to produce the exact hydrate: $CuSO_4 \cdot 5\ H_2O$.**