Ms. Randall
Regents Chemistry
Lab activity Composition of a Hydrate

Background: A ***HYDRATED CRYSTAL*** or hydrate occurs when water becomes tightly attracted to a metal salt. The water molecules maintain integrity as molecules, however they are considered to be part of the formula of the hydrate. When the hydrated metal salt crystal is heated, the attractions to the water are broken by the heat energy and the water escapes from the crystal. After heating the salt crystal is called ***ANHYDROUS***, meaning without water. Many of the salts contain transition metals such as copper or cobalt and therefore are colorful. Often the color of a transition metal hydrate will change as a function of how many waters it is attracted to. Hydrates are one of the few formulas to have a coefficient within. Hydrates are ionic compounds (salts) that have a definite amount of water (water of hydration) as part of their structure. The water is chemically combined with the salt in a definite ratio. Ratios vary in different hydrates but are specific for any given hydrate. The formula of a hydrate is represented in a special manner. The hydrate of copper sulfate in this experiment has the formula $CuSO_4 \cdot xH_2O$. The unit formula for the salt appears first, and the water formula is last. The raised dot means that the water is loosely bonded to the salt. The coefficient x stands for the number of molecules of water bonded to one unit of salt. This special formula, like all other formulas, illustrates the law of definite composition. When hydrates are heated, the "water of hydration" is released as vapor. The remaining solid is known as the anhydrous salt. The general reaction for heating a hydrate is:

Hydrate → Anhydrous Salt + Water

The percent of water in a hydrate can be found experimentally by accurately determining the mass of the hydrate and the mass of the anhydrous salt. The difference in mass is due to the water lost by the hydrate. The percentage of water in the original hydrate can easily be calculated:

Percent H_2O = (mass H_2O / mass hydrate) x 100

In this experiment, as was mentioned, a hydrate of copper sulfate will be studied

$(CuSO_4 \cdot xH_2O)$.

The change from hydrate to anhydrous salt is accompanied by a change in color:

$CuSO_4 \cdot xH_2O$ (this is blue) → $CuSO_4 + xH_2O$ (this is white)

Pre-lab:
1. What two things make up hydrates?

2. In order to determine the percent composition and the empirical formula of a hydrate, you must know how much water is in the hydrate. How can you determine this? Hint: Re-read the background information!

Objective: To determine the percent water in a hydrated compound of Copper (II) sulfate. To determine the molar ratio of anhydride to water in hydrated Copper (II) sulfate.

Materials:
Ring stand, iron ring, wire gauze, Bunsen burner, foil, evaporating dish, crucible tongs, hydrate, scale, plastic pipettes

Safety:

1. Do not touch a hot evaporating dish with your hands. Use tongs
2. Tie back long hair and secure loose clothing when working around an open flame. Be sure to wear a lab apron or coat and safety goggles when working in the lab.
3. Be careful to avoid BURNS as a hot ring stand looks like a cool one! If your dish drops off of the ring stand during heating DO NOT TRY TO CATCH IT, let it fall. I would rather you break a dish than have you burn your hand.
4. Do not wear gloves; they will melt from the heat. Should skin contact occur, flush thoroughly with water.
5. Wear aprons and goggles and do not sit during the lab.

Procedure:

1. Prepare the setup shown below:

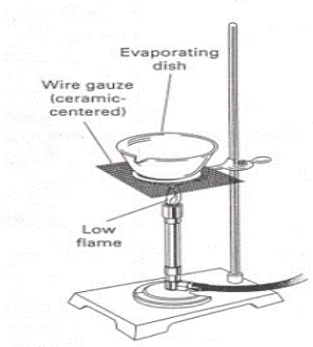

FIGURE L

2. Heat the dish with the hottest part of the flame for 3 minutes.

3. Using crucible tongs, remove the evaporating dish from the apparatus. Place it on an insulated pad and allow it to cool for several minutes.

4. Find the mass of the evaporating dish. Record the mass in the Observations and Data section.

5. With the evaporating dish on the balance, measure into it exactly 2.00 g of copper sulfate hydrate. Record the data below.

6. Place the evaporating dish + hydrate on the wire gauze. Gently heat the dish Avoid any popping and spattering.

7. Heat strongly for 5 minutes or until the blue color has disappeared. If the edges of the solid appear to be turning brown, remove the heat momentarily and resume heating at a gentler rate.

8. Allow the evaporating dish to cool for about a minute. *Immediately* find the mass of the dish + anhydrous salt, and record the data below.

Data

Mass of evaporating dish	
Mass of hydrated salt	
Mass of evaporating dish + anhydrous salt	
Mass of anhydrous salt remaining after heating	
Mass of water (lost from hydrated salt)	

* Gram molecular weight of anhydrous salt $CuSO_4$ =159.5 g/mole

** Gram molecular weight of water H_2O= 18.0 g/mole

Analysis:

1. How many moles of copper (II) sulfate (CuSO4) and how many moles of water did you have in your original sample? Hint: Convert each mass using molar mass (g/mol).

2. Examine the formula for the hydrate: CuSO4 • n H2O. Notice that "n" is "the molar ratio of water to copper sulfate." Find the numerical value for n in this sample (use your numbers from part a above). Hint: what does "molar ratio of water to copper sulfate" mean? Write it as a fraction – then solve it, since n = "the molar ratio of water to copper sulfate."

3. The actual mass percent of water in the hydrated copper (II) sulfate compound should have been 36.1%. Compare this value to the experimental percentage you obtained. Hint: how do you quantitatively compare an experimental value to an "actual" value?

Ms. Randall
Regents Chemistry
Lab conclusion: Composition of a Hydrate

1. **Write a paragraph summarizing what you have learned about the scientific concept of the lab from doing the lab. Back up your statement with details from your lab experience.**

2. **A hydrated salt is a solid that includes water molecules within its crystal structure. A student heated a 9.10-gram sample of a hydrated salt to a constant mass of 5.41 grams. What percent by mass of water did the salt contain?**

   a. 3.69% b. 16.8% c. 40.5% d. 59.5%

3. **A 1.20-gram sample of a hydrated salt is heated to a constant mass of 0.80 gram. What was the percent by mass of water contained in the original sample?**

   a. 20. b. 33 c. 50. d. 67

4. **A student determining the percent by mass of water in a hydrated crystal obtained the following data.**

   Mass of crystal before heating.....5.0 g
   Mass of crystal after 1st heating..... 4.0 g
   Mass of crystal after 2nd heating.....4.0 g
   what is the percent by mass of water in the hydrate?

   a. 0.80% b. 0.20% c. 80. % d. 20. %

5. **A student obtained the following data to determine the percent by mass of water in a hydrate**

Mass of empty crucible + cover	11.70 g
Mass of crucible + cover + hydrated salt before heating	14.90 g
Mass of crucible + cover + anhydrous salt after thorough heating	14.53 g

   What is the approximate percent by mass of the water in the hydrated salt?

   a. 2.5% b. 12% c. 88 % d. 98 %