Name ________________________ **Honors Chemistry** **___/___/___**

Composition of Hydrates Lab

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 $CuSO_4 * xH_2O$. 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 + heat → 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:

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

In this experiment a hydrate of copper sulfate will be studied ($CuSO_4 * xH_2O$). The change from hydrate to anhydrous salt is accompanied by a change in color:

$$\underset{\text{blue}}{CuSO_4 * xH_2O} \rightarrow \underset{\text{white}}{CuSO_4} + xH_2O$$

Objective: To determine the percentage of water in a hydrate.

Equipment

evaporating dish	iron ring	ring stand
wire gauze	spatula	laboratory burner
laboratory balance	test tube	test tube holder

Chemicals: copper sulfate hydrate, $CuSO_4 * xH_2O$

Safety

- Do not touch a hot evaporating dish with you hands.
- Tie back long hair and secure loose clothing when working around an open flame.
- Lab aprons and goggles must be worn during the lab.

Procedure

Part A: Reaction of Copper(II) Sulfate

☐ 1. Heat the evaporating dish with the hottest part of the flame for three minutes.
☐ 2. Once it is cool enough to handle, remove the evaporating dish from the apparatus.
☐ 3. Use the balance to find the mass of the evaporating dish to the 0.01 g. Record the mass.
☐ 4. With the evaporating dish on the balance, measure **approximately** 2.00 grams of copper sulfate hydrate. Record the mass of the evaporating dish and the hydrate.
☐ 5. Place the evaporating dish & hydrate on the wire gauze. **Gently** heat the dish by moving the burner back and forth around the base. Increase the heat gradually. **Avoid any popping and spattering**.
☐ 6. Heat strongly for five minutes or until the blue color has disappeared. During heating, a spatula should be used to "spread" the solid and break up any "caked" portions of the hydrate. Be careful not to pick up any of the solid on the spatula. If the edges of the solid appear to be turning brown, remove the heat momentarily and resume heating at a gentler rate.
☐ 7. Allow the evaporating dish to cool enough so that it can be handled. Immediately find the mass of the dish & anhydrous salt and record your data (first heating).
☐ 8. Place the evaporating dish & hydrate back on the wire gauze. Heat the dish strongly for three minutes.
☐ 9. Allow the evaporating dish to cool enough so that it can be handled. Immediately find the mass of the dish & anhydrous salt and record your data (second heating). If the mass of the first heating and the second heating differ by 0.10 or more, do a third heating.

☐ 10. Once your evaporating dish has cooled to room temperature, add a few drops of water and note the color change.
☐ 11. Discard the copper(II) sulfate in the waste container. Record the mass of dry copper sulfate on the waste data sheet.
☐ 12. Clean and put away all equipment.

Part B: Reactions of Other Hydrates
☐ 1. Obtain a small sample of nickel(II) sulfate hexahydrate, cobalt(II) chloride hexahydrate or manganese(II) chloride tetrahydrate
☐ 2. Add the sample to your test tube.
☐ 3. Make observations of your hydrate.
☐ 4. Heat the sample in a low Bunsen burner flame.
☐ 5. Make observations of what happens to the hydrate during heating.
☐ 6. **Allow the test tube to cool completely to room temperature**.
☐ 7. Add a few drops of water to the test tube and note any changes.
☐ 8. Clean your test tube.

Data Table:
Part A: Reaction of Copper(II) Sulfate

Mass of evaporating dish __________________ grams.

Mass of evaporating dish & hydrate __________________ grams.

Mass of evaporating dish & anhydrous salt (first heating) __________________ grams.

Mass of evaporating dish & anhydrous salt (second heating) __________________ grams.

Observations:

Color of hydrate before heating: ____

Color of anhydrous salt: ____

Color of re-hydrated salt: ____

Calculations:
Find the total mass of the hydrate used: ____

Find the mass of the water in the hydrate: ____

Find the mass of the anhydrous salt: ____

Find the percentage of water in the hydrate: ____

Find the percentage of anhydrous salt in the hydrate: ____

Determine the formula of the hydrate using the percentages from above: ______________________________

Part B: Reactions of Other Hydrates
Chemical Chosen: ______________________________

Observations before heating: ____

Observations after heating:____

Observations after adding water:____

Post- Lab Questions:

1. What is a hydrate?

2. Why was the empty evaporating dish heated for three minutes at the start of the lab?

3. Why must you measure the mass of the anhydrous salt immediately upon cooling?

4. What does the term "anhydrous" mean?

5. How would the predicted formula be different (more water or less water) if the evaporating dish was not heated to dryness? Why?

6. How would the predicted formula be different (more water or less water) if some of the hydrate got stuck on your spatula? Why?

7. Use the information from below to make calculations and determine the formula of the hydrate.

Situation 1:
Hydrate Used: $Na_2CO_3 \cdot xH_2O$
Data:

a. Mass of evaporating dish: 47.35 grams.
b. Mass of evaporating dish & hydrate: 54.87 grams.
c. Mass of evaporating dish & anhydrous salt: 50.14 grams.

Calculations:

a. Find the total mass of the hydrate used.

b. Find the mass of the water.

c. Find the mass of the anhydrous salt.

d. Find the percentage of water in the hydrate.

e. Find the percentage of anhydrous salt in the hydrate.

f. Determine the formula of the hydrate using the percentages from above.

8. Use the information from below to make calculations and determine the formula of the hydrate.

Situation II:
Hydrate Used: $CaSO_3 \cdot xH_2O$
Data:

a. Mass of evaporating dish: 42.98 grams.
b. Mass of evaporating dish & hydrate: 47.28 grams.
c. Mass of evaporating dish & anhydrous salt: 46.29 grams.

Calculations:
a. Find the total mass of the hydrate used.

b. Find the mass of the water.

c. Find the mass of the anhydrous salt.

d. Find the percentage of water in the hydrate.

e. Find the percentage of anhydrous salt in the hydrate.

f. Determine the formula of the hydrate using the percentages from above.

9. When heated to 220.°C, $BeC_2O_4 * 3H_2O(s)$ dehydrates completely as represented below.

$$BeC_2O_4 * 3H_2O(s) \rightarrow BeC_2O_4(s) + 3\ H_2O(g)$$

If 3.21 g of $BeC_2O_4 * 3\ H_2O(s)$ is heated to 220.°C, calculate the mass of $BeC_2O_4(s)$ formed.

10. A student is assigned the task of determining the number of moles of water in one mole of $MgCl_2 * nH_2O$. The student collects the data shown in the following table.

Mass of empty container	22.347 g
Initial mass of sample and container	25.825 g
Mass of sample and container after first heating	23.982 g
Mass of sample and container after second heating	23.976 g
Mass of sample and container after third heating	23.977 g

(a) Explain why the student can correctly conclude that the hydrate was heated a sufficient number of times in the experiment.

(b) Use the data above to determine the formula of the hydrated compound.