Chemistry Honors Lab

PSI Chemistry *Name*______________________________

Determination of percent water of hydration and the Empirical Formula for the Hydrate of Copper (II) Sulfate: $Cu(SO_4)$. X H_2O

Purpose:

To calculate the percent of water of hydration and to derive the empirical formula of copper sulfate hydrate, CuSO4. x H2O

Introduction

Hydrates are __________________ ____________________, that have a definite amount of water, called water of hydration, as part of their structure. The water is _________________ combined with the ________________ in a definite ratio for each specific hydrate. Ratios vary for different hydrates.

The formula of a hydrate is represented in a special manner. The hydrate of copper (II) sulfate in this experiment has the formula _________________. The formula unit for the salt appears first, followed by the water formula. The raised dot means that the ________________ is loosely bonded to the _______________. The coefficient x stands for the number of _________________ molecules that are loosely bonded to one formula unit of _________________.

When hydrates are heated, the water of hydration is released as __________________. The remaining solid is referred to as the ___________________ 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 _____________ and the mass of the _____________________ ___________________. The difference in mass is due to the water lost by heating the ____________________ . The percentage of water in the original hydrate can be calculated using the formula:

% of water = (mass of water lost /mass of the hydrate salt) x 100

Pre-Lab Question

Calculate the percentage of water of hydration in calcium chloride dehydrate, $CaCl_2 \bullet 2H_2O$.

Materials: Copper sulfate hydrate, evaporating dish, Bunsen burner, ring stand, wire gauze, electronic scale, tongs, instruction sheet.

Procedure

1. Prepare the set-up of the Bunsen burner, evaporating dish, and ring stand.
2. Heat the evaporating dish with the hottest part of the flame for three minutes to remove impurities.
3. Using crucible tongs, remove the evaporating dish from the apparatus. Place it on an insulated pad and allow it to cool off for a few minutes.
4. Find the mass of the evaporating dish to the nearest 0.01 gram. Record the mass.
5. Keeping the evaporating dish on the balance, measure into it 2.00 grams of copper (II) sulfate hydrate. Record the exact mass of the dish with the hydrate to the nearest 0.01 gram.
6. Record the appearance of the hydrate before it is heated.
7. Return the evaporating dish with the hydrate to the wire gauze. Gently heat the hydrate by moving the burner back and forth around the dish. Try to avoid and popping or splattering.
8. Record observations of the hydrate during and after heating. If any of the solid appears to be turning brown, lower the heat.
9. Turn off the Bunsen burner after you think all of the water of hydration has been driven from the hydrate. The salt will become pale green color. Allow the evaporating dish to cool for about five minutes.
10. Measure and record the mass of the dish with the anhydrous salt.

Results and Calculations

- Observation chart: describe the physical appearance of the hydrate before, during, and after heating
- Data Table: include the following measurements (to the nearest 0.01 gram) *Reproduce the table if necessary.*

Item	**Mass-Trial 1**	**Mass- Trial 2**	**Average Mass**
Evaporating dish, X g			
Evaporating dish + Hydrate, Y g			
Evaporating dish + Anhydrous salt, Z g			
Hydrate (Y-X) g			
Anhydrous salt (Z-X) g			
Water lost from Hydrate, (Y-X)-(Z-X) g			

Show the following six calculations neatly in your lab report.

1. Calculate the percentage of water in your hydrate from Trial 1.
2. Calculate the percentage of water in your hydrate from Trial 2.
3. Using your average mass of water lost, convert grams of water to MOLES of water.
4. Using your average mass of anhydrous salt, convert grams of $CuSO_4$ to MOLES of $CuSO_4$.
5. Look at your answers to #3 and #4 above. Divide by the smaller of the two numbers to obtain the empirical formula for your hydrate. In other words, the ratio you obtain is the "x" in the formula $CuSO_4 \bullet x\ H_2O$.

Ask students to add one drop of water to the dish at the end of the experiment and let them record the observation.

Conclusion Questions

1. What is a hydrate?

2. Why must you let the evaporating dish cool slightly before measuring its mass?

3. Amanda and Max finished heating the hydrate, but wanted to leave for lunch. They asked Mrs. G if they could come in tomorrow to measure the mass of their anhydrous salt. Why do you think Mrs. G said “No”?

ANSWER KEY:

Introduction

Hydrates are crystalline ionic compounds that have a definite amount of water, called water of hydration, as part of their structure. The water is physically combined with the ionic compound in a definite ratio for each specific hydrate. Ratios vary for different hydrates.

The formula of a hydrate is represented in a special manner. The hydrate of copper (II) sulfate in this experiment has the formula $Cu(SO_4) \cdot x H_2O$. The formula unit for the salt appears first, followed by the water formula. The raised dot means that the water is loosely bonded to the Ionic compound or salt. The coefficient x stands for the number of water molecules that are loosely bonded to one formula unit of copper sulfate.

When hydrates are heated, the water of hydration is released as steam. The remaining solid once all the water of crystallization is removed, is referred to 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 salt, the mass of the water and anhydrous salt. The difference in mass is due to the water lost by heating the hydrate. The percentage of water in the original hydrate can be calculated using the formula:

% of water = (mass of water lost /mass of the hydrate salt) x 100

Pre-Lab Question

Calculate the percentage of water of hydration in calcium chloride dehydrate, $CaCl_2 \bullet 2H_2O$.

Molar Mass of $CaCl_2 \bullet 2H_2O$ = 40+(35.45)x2 + 2x 18 = 146.9g

% water = (36g/146.9g)x 100 =25%

Show the following six calculations neatly in your lab report.

1. Calculate the percentage of water in your hydrate from Trial 1.

   = {(Y-X)-(Z-X) g / (Y-X) g} x 100

2. Calculate the percentage of water in your hydrate from Trial 2.

3. Using the mass of water lost, convert grams of water to MOLES of water.
   = Mass of water lost in trial 1/18 g/mol =

4. Using the mass of anhydrous salt, convert grams of $CuSO_4$ to MOLES of $CuSO_4$.
   = mass of the anhydrous salt in trial 1 / 159.55 g/mol

5. Look at your answers to #4 and #5 above. Divide by the smaller of the two numbers to obtain the empirical formula for your hydrate. In other words, the ratio you obtain is the “x” in the formula $CuSO_4 \bullet$ x H_2O.
   Formula = $CuSO_4 \bullet$ ----- H_2O. (Insert x from answer # 5 average)

Ask students to add one drop of water to the dish at the end of the experiment and let them record the observation.
It will turn blue again. *It will absorb moisture from the atmosphere and will turn blue if you keep it open in the lab. It is not good idea to keep it overnight and weigh next day to do the calculation.*