PERCENTAGE COMPOSITION OF HYDRATES

Reminder – Goggles must be worn at all times in the lab!

PRE-LAB DISCUSSION:

Hydrates are ionic compounds (salts) that have a definite amount of water as part of their structure. This "water of hydration" is released as vapor when the hydrate is heated. The remaining solid is known as the **anhydrous salt**. The general reaction for heating a hydrate is:

$$\text{Hydrate} \xrightarrow{\Delta} \text{Anhydrous salt} + \text{water}$$

The Δ sign means that heat is applied. 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 percent of water in the original hydrate can be calculated easily:

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

In this experiment, a hydrate of copper (II) sulfate ($CuSO_4 \cdot 5H_2O$) will be studied. The change from copper (II) sulfate pentahydrate to anhydrous copper (II) sulfate is accompanied by a change in color.

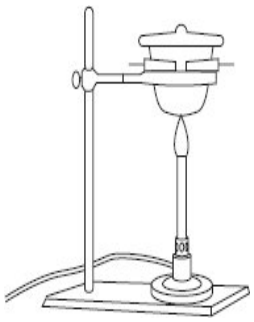
$$\underset{\text{Blue}}{CuSO_4 \cdot 5H_2O} \xrightarrow{\Delta} \underset{\text{white}}{CuSO_4} + 5H_2O$$

This investigation should aid in the understanding of the composition of hydrates, simple decomposition reactions, and the Law of Definite Composition.

PURPOSE:

Determine the percent of water in a hydrate.

PROCEDURE:



1. Clean and dry your crucible and lid.
2. Prepare your ring stand set-up as shown in the diagram at the right.
3. Place your empty crucible on the clay triangle and heat the dish with the hottest flame for 1-2 minutes. This is done to be sure that the crucible is absolutely dry.
4. Using crucible tongs, remove the crucible from the apparatus. Place it on the base of the bunsen burner stand and allow it to cool for several minutes.
5. Using a balance, find the mass of the cooled crucible with the lid. Record mass in the Observations and Data section. Never weigh an object when it is hot because heat waves tend to be circular and upward (convective), which tends to make objects appear to weigh less.
6. Measure the mass of the full sample bottle. Transfer about 2 grams of copper(II) sulfate penta-hydrate into the crucible. Record the mass of the sample bottle again in the Data table.
7. Place the crucible, lid and hydrate on the balance and record the mass in the Data table.
8. Place the crucible, lid and hydrate on the clay triangle. Gently heat the crucible by moving the burner back and forth around the base. Increase the heat gradually. Avoid any popping and spattering.
9. Heat strongly for 5 minutes or until all of the blue color has disappeared. During the heating, a glass stirring rod may be used to "spread" the solid and break up larger portions of the hydrate. Be sure not to pick up any of the solid on the stirring rod. If the edges of the solid appear to be turning brown, remove the heat momentarily and resume heating with a cooler flame.
10. Allow the crucible to cool for five minutes by covering with a lid and putting it onto the base of the ring stand. Then, find the mass of the crucible plus the anhydrous salt and lid, and record the mass in the data section before the compound reabsorbs water from the air.
11. Repeat steps 8-9 two more times until constant mass is achieved (mass changes by less than 0.02 grams).
12. When you have finished weighing the crucible, lid and salt, place the dish back on the counter and squirt some distilled water onto the anhydrous salt. Record any change in appearance in the Data section.
13. When you have finished, the anhydrous salt can be thrown into the beaker in the fume hood, and your crucible can be washed, dried and returned to the front counter.

RESULTS:

Data (set up for 3 heatings)

1. Mass of clean, dry crucible with the lid _____g
2. Mass of sample bottle with hydrate _____g
3. Mass of sample bottle after removing 2 grams hydrate _____g
4. Mass of crucible, lid and hydrate before heat _____g
5. Mass of crucible, lid and anhydrous salt after heat 1 _____g
6. Mass of crucible, lid and anhydrous salt after heat 2 _____g
7. Mass of crucible, lid and anhydrous salt after heat 3 _____g
8. Appearance before and after adding water:

CALCULATIONS Remember to show all of your work.

1. Calculate the mass of only the hydrate used before heating. (#4 - #1 above)
2. Calculate the mass of water lost from the hydrate. (#4 - #7 above)
3. Find the percent of water lost from the original hydrate (remember that percentage is "the part divided by the whole, multiplied by 100").
4. Calculate the Theoretical yield: This is where we find out how well you did. Theoretical yield is the yield you should have gotten if you had done everything perfect.
    a. Using the periodic table, add up the weight of the five water molecules
    b. Next, add up the weight of the entire compound, including the five water molecules.
    c. Theoretical percent of water ("the part that is water, divided by the weight of the whole compound, multiplied by 100"):
5. Error Calculation: To find your error, Absolute Error: E = xi - xt where xi is your Individual value and xt is the Theoretical true yield. This error is Absolute Error and can be both positive or negative.
6. Percent Error: To find your percentage error, follow the formula below. For high school, anything under 10% error is great. In college, you will be graded on the % error, and they expect it be within 2 – 3%.

Percent error = | absolute error/theoretical yield | x 100.