Name: _____ Period: _____
Date: _____ Physical Setting/Chemistry Lab

Composition of Hydrates

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:

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

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:

$$\underset{\text{Blue}}{CuSO_4 \cdot xH_2O} \rightarrow \underset{\text{white}}{CuSO_4} + x\,H_2O$$

This investigation should aid in the understanding of the formulas and composition of hydrates and the laws of definite composition.

Purpose

Determine the percentage of water in a hydrate

Materials

crucible with cover	iron ring	crucible tongs
pipe-stem triangle	microspatula	laboratory burner
laboratory balance	safety goggles	ring stand
lab apron	copper sulfate hydrate ($CuSO_4 \cdot xH_2O$)	

Procedure

1) Prepare the setup shown in figure 1.

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 insulating pad and allow it to cool for several minutes.

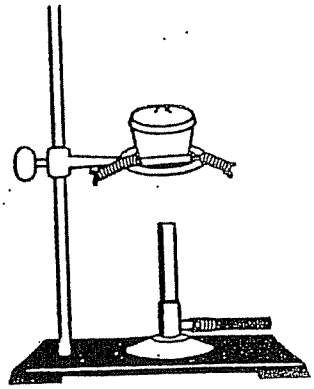
4) Find the mass of the evaporating dish to ± 0.01 g. Record the mass in the Observations and Data section.

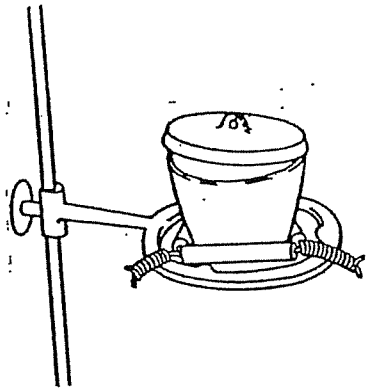
5) With the evaporating dish on the balance, measure into it exactly 2.00 g of copper sulfate hydrate. Record the data below.

6) Place the evaporating dish + hydrate on the wire gauze. *Gently* heat the dish by moving the burner back and forth around the base. Increase the heat gradually. Avoid any popping and spattering.

7) Heat strongly for 5 minutes or until the blue color has disappeared. During heating, a microspatula may be used to "spread" the solid and break up any "caked" portions of the hydrate. Be careful not to pick up any solid on the microspatula. 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 table.





Observations and Data

a) Mass of evaporating dish _____ grams

b) Mass of evaporating dish + hydrate _____ grams

c) Mass of evaporating dish + anhydrous salt _____ grams

Calculations

Find the mass of the hydrate used (b – a)

_____ grams

Find the mass of the water lost (b – c)

_____ grams

Calculate the number of moles of water lost

_____ moles

Find the percentage of water in the hydrate:

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

_____ %

Conclusions and Questions

1) The true value for the percentage of water in this hydrate is 36.0 %. What is your experimental error? (Use the formula from the reference tables)

2) a) Calculate the gram formula mass of the anhydrous salt ($CuSO_4$). b) Then calculate the moles of anhydrous salt. c) Determine the smallest whole number ratio of moles of water to moles of anhydrous salt.

3) Compare your results with other members of your class with the same unknown. Are there differences? What reasons could account for these differences?

3) Explain what effect the following errors would have on the value from the percent water in the hydrate.

a) The hydrate was not heated long enough to drive off all the water.

b) A damp crucible was used, and it was not dried before adding the hydrate.

c) The crucible and contents were allowed to cool overnight before finding their mass.

4) Predict what would happen if you added a few drops of distilled water to the anhydrous salt remaining at the end of this experiment.

_____

_____

_____

2) The data below was obtained by a student in order to determine the percent of water in a hydrate:

Mass of the Hydrate = 5.0 g
Mass of the Anhydrous Compound = 3.2 g

What is the percent of water in the hydrate?

A) 56% B) 36% C) 64% D) 22%

3) An 8.24-gram sample of a hydrated salt is heated until it has a constant mass of 6.20 grams. What was the percent by mass of water contained in the original sample?

A) 24.8% B) 32.9% C) 75.2% D) 14.1%

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 hydrate?

A) 0.80% B) 0.20% C) 20.% D) 80.%

5) A 10.0-gram sample of a hydrate was heated until all the water of hydration was driven off. The mass of anhydrous product remaining was 8.00 grams. What is the percent of water in the hydrate?

A) 20.0% B) 80.0% C) 12.5% D) 25.0%

6) What is the percent by mass of water in the hydrate $Na_2CO_3 \cdot 10H_2O$ (formula mass = 286)?

A) 6.89% B) 26.1% C) 62.9% D) 214.5%

7) Which of the following statements explains why mass is lost when a student heats a sample of $BaCl_2 \cdot 2H_2O$ crystals?

A) Water is given off as a gas.
B) The crystals sublime.
C) Chlorine is given off as a gas.
D) The crystals fuse (melt).