Introduction

Many ionic compounds strongly attract water and thus include water in their crystalline structure. These materials are known as *hydrates*. In a hydrate, water is considered part of the structure of the compound. When a hydrate is heated strongly, it loses the water (becomes "dehydrated" or "anhydrous"). A given ionic compound usually will complex with a specific amount of water. For example, one mole of magnesium sulfate generally complexes with seven moles of water. This magnesium sulfate hydrate, known as magnesium sulfate heptahydrate, has the chemical formula $MgSO_4 \cdot 7H_2O$ and has the common name of epsom salts. When magnesium sulfate heptahydrate is heated it releases water to yield anhydrous magnesium sulfate and water vapor:

$$MgSO_4 \cdot 7H_2O\ (s) + \text{heat} \rightarrow MgSO_4\ (s) + 7\ H_2O\ (g)$$

In this lab you will investigate the effects of heating hydrates (both qualitatively and quantitatively). In the qualitative part, you will investigate and observe what happens when two different hydrates are heated. In the quantitative part, you will experimentally determine the exact chemical composition of an unknown hydrate, copper (II) sulfate • xH_2O.

Procedure

QUALITATIVE

A: Place a small amount (just enough to cover the bottom of the test tube) of each hydrate (copper (II) sulfate • xH_2O and cobalt (II) chloride •xH_2O) into separate Pyrex test tubes. Heat each test tube with a bunsen burner (hold with clamps and point the mouth of the test tube away from yourself and others!) In your notebook, describe: the appearance of each hydrate before heating and the effects of heating on each hydrate.

B: Add a few drops of water to each of the cooled anhydrous salts. What do you observe? Describe the similarities and differences in the behavior of the two substances.

QUANTITATIVE

A: Clean and dry a crucible (wash with distilled water and heat for about two minutes over the bunsen burner). Do not allow the crucible to become red hot at any time. After the crucible has cooled, place the crucible on a zeroed (tared) balance. Record the exact mass of the crucible (with 0.01 g precision) in the data table of your notebook.

B: Tare (zero) the balance and weigh about one to four grams of copper (II) sulfate hydrate into the crucible. Record the exact mass of copper (II) sulfate hydrate (with 0.01 g precision) in the data table in your notebook.

C: Place the crucible on a screen or triangle attached to a ring stand support. Cover the crucible, leaving the lid partially cocked in order to allow the water vapor to escape. Heat slowly at first, then increase the heat. Do not allow the crucible to become red hot at any time. Check the material periodically to determine when the dehydration is complete. After dehydration appears to be complete, continue heating for about five minutes, before turning off the bunsen burner.

D: After allowing the crucible and contents to cool completely, weigh the crucible and its contents. Record this mass value in your notebook. Do a second trial using a different mass of copper (II) sulfate hydrate.

E: Calculate the mass of the anhydrous copper (II) sulfate salt and the mass of water lost. Repeat this calculation with the supplied data. Determine the formula weights of water and copper (II) sulfate and use these values to calculate the moles of water lost and moles of anhydrous copper (II) sulfate. You must obtain your lab assistant's or instructor's initials before leaving the lab.

Safety

CAUTION: POINT THE TEST TUBE AWAY FROM YOURSELF AND OTHERS WHEN HEATING! Use caution around the flame of the bunsen burner--be aware that baggy clothing and long hair may catch on fire if brought too near the flame! Turn off the burner when it is not supervised (when you leave your lab station). Use a metal paper clip to form a hook to remove or reposition the lid. USE TONGS TO HANDLE THE HOT CRUCIBLE!

Chemical Disposal & Cleanup

Thoroughly wash the test tubes used in the first part of the experiment. The small amounts of hydrates used in the qualitative part of the experiment may be washed down the drain. The anhydrous copper (II) sulfate prepared in the quantitative part of the experiment should be disposed of in a beaker provided for this purpose.

Results & Discussion

- In your notebook, plot the mass of water lost (dependent variable) as a function of the mass of anhydrous copper (II) sulfate (independent variable). Plot the moles of water lost as a function of moles of anhydrous copper (II) sulfate. For each graph, determine the equation for the best fit line through the data points, making sure to use the correct units for values of the slope and the y-intercept. Would you expect to find a similar relationship if cobalt (II) chloride hydrate had been used instead of copper (II) sulfate hydrate in this experiment? Why or why not?

- Using information obtained from the slope of the appropriate graph, find the empirical formula of the copper (II) sulfate (i. e. the value of x in formula for the hydrate $CuSO_4 \cdot xH_2O$). Explain how you performed your calculation.

- Write a balanced chemical equation (including the physical states of each compound) for the reaction that occurred when the copper (II) sulfate hydrate was heated.

Prelab Exercise (to be done in your notebook--due at the beginning of lab)

1. Complete the Title and Purpose for this laboratory experiment.

2. Draw a data table in the data section of your notebook. Use the following row headings, and leave 5 columns available for data.

Table 1: Mass and Mole Data for the Dehydration of Copper (II) Sulfate Hydrate

		Trial # 1	Trial # 2	previous year's data		
before heating	mass of crucible (g)			11.48	10.90	11.83
	mass of hydrate (g)			3.00	2.04	3.79
after heating	mass of crucible and anhydrous salt (g)			13.37	12.18	14.22
	mass of anhydrous salt (g)					
	mass of water lost (g)					
	moles of anhydrous salt					
	moles of water lost					