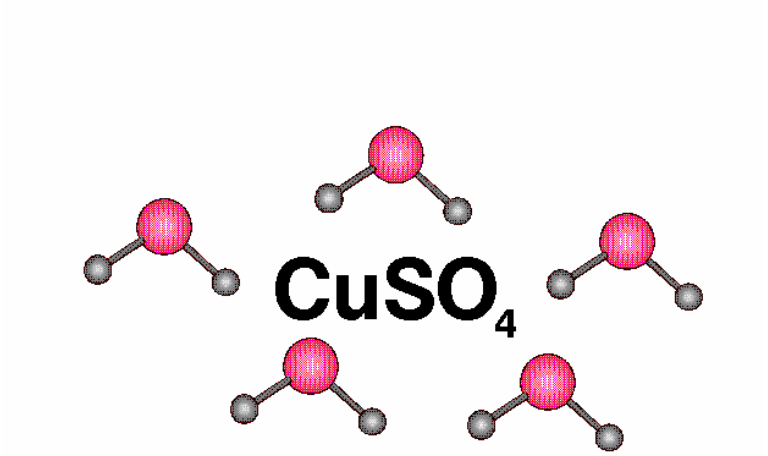
HYDRATES:
An Investigation of Ionic Compounds Containing Water Molecules in Their Structure



Copper Sulfate Pentahydrate

INTRODUCTION

Controlling the amount of water moisture present in the air is very important. Skin becomes too dry during the winter when humidity levels are too low due to heating a sealed home. Many people choose to use humidifiers in order to replenish moisture to help alleviate sore throats, cracked furniture and static electricity. By contrast, during the summer months dehumidifiers can be very useful. VCRs won't work when there is too much humidity (dew indicator) in the machine. Dehydrated foods are also very important.

Sometimes chemicals are used to control the moisture level. Have you ever heard of putting rice in a salt shaker to minimize the clumping caused by humidity? Ever wondered about that little packet of "rocks" that is commonly found in the carton of a new VCR, TV, stereo or other electronic equipment? The "rocks" are a calcium or magnesium salt material that acts as a desiccant and absorbs the moisture. Other chemicals, such as cobalt chloride, are used as humidity indicators, changing colors according to hydration.

For instance, the copper sulfate used earlier in the semester was stated to be $CuSO_4$, but it actually had absorbed 5 moles of water for every 1 mole of $CuSO_4$ and should have been correctly labeled as $CuSO_4 \bullet 5H_2O$, copper (II) sulfate pentahydrate.

The water in these compounds can be removed quantitatively by heating the compound with a bunsen burner. The loss in mass of the compound after losing the water can be used to calculate the amount of water originally in the hydrated sample. When all the water has been removed, the ionic compound is said to be anyhydrous. Once a true hydrate had been heated and the water is driven off, one can regenerate the original compound by adding water (i.e. the process is reversible).

Hydrates are often shown as •H_2O (after the formula for the ionic compound; means + H_2O) to indicate the connection of the water to the anhydrous material. Hydrates are named by the Greek prefixes attached to the word hydrate (as in the naming of nonmetallic compounds):

•H_2O monohydrate	•$6H_2O$ hexahydrate
•$2H_2O$ dihydrate	•$7H_2O$ heptahydrate
•$3H_2O$ trihydrate	•$8H_2O$ octahydrate
•$4H_2O$ tetrahydrate	•$9H_2O$ nonahydrate
•$5H_2O$ pentahydrate	•$10H_2O$ decahydrate

Magnesium sulfate (epsom salts) can be a hydrated salt. Upon heating, the water is separated from the salt, leaving only anhydrous magnesium sulfate. By comparing the mass of the hydrate and the anhydrous form, the number of moles of water combined with one mole of anhydrous magnesium sulfate can be determined and ultimately the formula for the hydrate. How can one tell if a chemical is hydrated? How can the amount of water absorbed be determined? What is the correct formula for the hydrate? What chemical would be a "better" desiccant? This experiment will help in answering these questions.

TECHNIQUES

Using a crucible

1. To clean: place a few drops of 1M ammonia (NH_3) in the empty crucible and scrub with a paper towel. Wear gloves during the process.

   At 1M, ammonia still has a strong odor and can be corrosive!

2. Rinse the crucible with distilled water and place the empty crucible on a pipestem triangle supported by a ring and ringstand.

3. Heat the crucible until the bottom glows dull red. NOTE: The flame should remain below the bottom of the crucible.

4. After 5 minutes, remove the flame and let the crucible cool to room temperature on the triangle.

   DO NOT TOUCH -- Hot crucibles look the same as cool crucibles.

5. When cooled, use the large tongs to move the crucible to the bench top.

6. To heat the sample: Pour the sample into a cleaned crucible. Using tongs, put the crucible on the triangle. Heat gently for the first few minutes, then heat until the crucible glows red. The tip of the inner blue cone is directly under the

crucible. Continue heating for 10 minutes. If using the cover as well, set it slightly ajar over the crucible so that the water vapor can escape.

7. Remove heat and cool to room temperature while still on the triangle. Setting a hot crucible on a cooler surface, such as a bench could cause it to break.

SAFETY

- Hot crucibles look the same as cool crucibles. Allow the crucible to cool on the ceramic triangle. Handle the crucible and crucible lids with care as they break easily.

MUCH TIME WILL BE SAVED IF PART II IS STARTED AND THEN PART I IS PERFORMED DURING THE WAITING PERIODS.

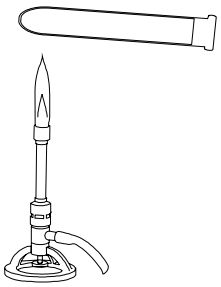
EXPERIMENTAL PROCEDURE

 will appear to indicate helpful hints, additional information, or interesting facts.

I. <u>Hydrate test</u>

A. Copper sulfate

1. Put about ½ inch of hydrated copper sulfate crystals in a dry test tube. Hold it over the flame with a test tube holder and heat it for a few minutes with the mouth of the tube slightly below the base of the tube.



TIP THE TEST TUBE SLIGHTLY DOWNWARD

2. Allow the test tube and its contents to cool.

LEAVE TUBE TIPPED DOWNWARD -- DO NOT TIP UP WHILE COOLING (TUBE WILL BREAK)

3. After the tube is cooled, try to change the crystals back to their original color.
4. Record your observations.

B. Cobalt chloride

1. Put about ½ inch of $CoCl_2 \cdot 6H_2O$ crystals in a test tube. Hold it over the flame with a test tube holder and heat it for a few minutes until it turns blue.
2. Cool for three minutes and add 3-5 mL of water.
3. Record your observations.

II. Percent of water in a hydrate

A. Preparing crucible

1. Clean crucible with 1M NH_3 as directed and rinse well. (See "Techniques" section).
2. After the crucible has cooled to room temperature, weigh the crucible and cover and record the mass. (1)

BE SURE TO USE THE SAME BALANCE FOR EACH WEIGHING!!

B. Dehydration of magnesium sulfate

1. Fill the crucible about half full with hydrated magnesium sulfate.
2. Weigh crucible, cover, and crystals on the same balance and record.
3. Using tongs, move the crucible and contents back to triangle and heat gently for 10 minutes with the cover ajar.
4. Remove the flame and completely cover the crucible with the cover. Allow the crucible to cool on the triangle about 10 minutes.
5. After it reaches room temperature, reweigh the crucible, cover, and its contents.
6. Repeat a 5 minute heating, cooling and reweighing and record the weight. It should be within a few milligrams of the previous weight.

III. Calculations

Initial hydrate weight = W_1
Anhydrous sample mass = W_2
Mass of water lost (W_3) = $W_1 - W_2$
Moles of anhydrous $MgSO_4$ (M_1) = W_2/MM_{MgSO4} where MM_{MgSO4} = the molar mass of $MgSO_4$
Moles of water lost (M_2) = W_3/MM_{H2O} where MM_{H2O} = the molar mass of H_2O
Ratio of moles = $M_2:M_1$ (Do division and report first number with 2 significant digits; report second number as 1.)