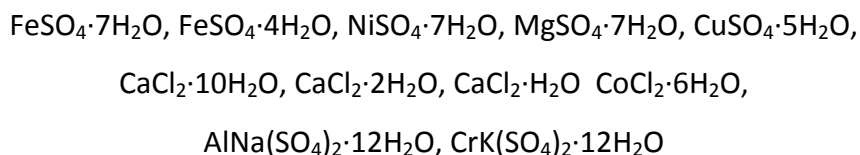


HYDRATES

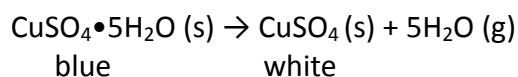
INTRODUCTION

Some ionic compounds form crystals that incorporate a definite proportion of molecules of water as well as the ions of the compound itself. These compounds are called hydrates. A hydrate is a chemical compound that contains water as part of its crystal structure. The water is tightly bound to the compound, but it is still a separate and unique compound. The water in a hydrated compound is called the **water of hydration**.



The chemical formula of a typical hydrated compound, such as copper(II) sulfate pentahydrate, is written as $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$. The dot in the formula indicates that the two compounds are bound together.

Upon heating, the water can be evaporated leaving an anhydrous salt. When $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ is heated, the water of hydration is lost and the blue crystal crumble to a white powder - CuSO_4 itself. When we wish to emphasize that the compound has lost its water of hydration, we call it **anhydrous**. Thus, CuSO_4 is anhydrous copper (II) sulfate.



This process is reversible. By adding water to the anhydrous salt, the hydrate will reform.

Some anhydrous salts can absorb moisture from the air to become hydrated. These salts are as said to be **hygroscopic**. Some hygroscopic salts are useful as drying agents. A common example is silica gel, made from sodium silicate, Na_2SiO_3 , which is usually packaged with optical or electronic devices shipped by boat. The silica gel protects the devices from high humidity. There are some hygroscopic compounds that can absorb so much moisture from their surroundings that they eventually dissolve in the absorbed water. An example of this type of compound is calcium chloride, CaCl_2 . This type of compound is said to be **deliquescent**.

In the first part of this experiment, you will observe some properties of a hydrate. In the second part, you will determine the percent water in a hydrated compound and the formula of the compound.

OBJECTIVE

In this experiment, the properties of a hydrated compound will be investigated. The percent of water in a hydrated compound will be determined and the formula of the hydrate will be calculated.

EXPERIMENTAL PROCEDURE

1. Properties of a Hydrate

SAFETY PRECAUTIONS AND DISPOSAL

Goggles or safety glasses must be worn at all times in the laboratory.

Allow the test tube, in part A of the procedure, to cool to room temperature before handling it.

Dispose of all chemical wastes in the proper waste container for solid chemicals.

Materials needed:

Cobalt(II) chloride hexahydrate, $\text{CoCl}_2 \cdot 6\text{H}_2\text{O}$

Calcium chloride, CaCl_2 , anhydrous

Test tube,

Test tube holder

Spatula or scoopula

Small watch glass

Glass stirring rod

20-mL or 50-mL beaker

600-mL or 1000-mL beaker

Procedure:

A. Behavior of a Hydrate

1. Place a few crystals of cobalt(II) chloride hexahydrate into a clean, dry test tube. Hold the test tube at an angle, heat the bottom of test tube gently in a Bunsen burner flame for about 1 to 2 minutes. Record your observations.

2. Allow the test tube to cool to room temperature. Hold the bottom of the test tube with your hand. Add two or three drops of water to the test tube. Record your observations.

B. Properties of Anhydrous CaCl_2

1. Place a few beads of anhydrous calcium chloride on a watch glass. Observe the compound's appearance.

2. Set the watch glass aside until the end of the remainder of experiment. **NOTE:** For dry environments, where the relative humidity is less than 20%, follow the procedure below: Fill a small beaker, 20-mL or 50-mL, approximately half-way with water. Place it next to the watch glass containing the calcium chloride. Cover the watch glass and the beaker

with a large, inverted, 600-mL or 1000-mL beaker. Allow the material to stand, undisturbed until the end of the experiment.

3. At the end of the experiment, examine the calcium chloride. Touch it with your stirring rod. Record your observations.

2. Determination of the Percentage of Water in a Hydrate

SAFETY PRECAUTIONS AND DISPOSAL

Goggles or safety glasses must be worn at all times in the laboratory.

The crucible will become very hot in this procedure. Allow the crucible to cool before handling. Use crucible tongs to hold the crucible. Dispose of the anhydrous salt in the waste chemical container at the end of the experiment.

Materials needed:

An "unknown" hydrate salt:

$\text{CuSO}_4 \cdot x\text{H}_2\text{O}$

$\text{MgSO}_4 \cdot x\text{H}_2\text{O}$

$\text{Na}_2\text{CrO}_4 \cdot x\text{H}_2\text{O}$

Crucible

Clay triangle

Crucible tongs

Procedure:

1. Prepare the crucible

If necessary, clean and dry the crucible and cover.

Place the crucible and cover on a clay triangle, supported on an iron ring (See Figure 1). Heat the crucible gently for about one minute, then heat strongly for about 5 minutes. Allow the crucible and cover to cool. Handle the hot or cooled crucible and cover using your crucible tongs. (See Figure 2). Weigh the cooled crucible and cover and record the mass to 0.001 g. Weigh the cover of the crucible separately, and record its mass. (This second step will allow you to still determine your final results if the crucible cover falls off the crucible and breaks during the experiment.)



Figure 1. Heating a crucible

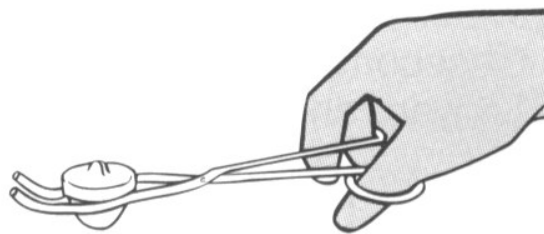


Figure 2. Using crucible tongs to hold a crucible.

2. Weigh 1.00 to 1.500 g of your unknown hydrate. Place the hydrate into the crucible and weigh the crucible, cover, and hydrate together. Record the mass to 0.001 g.
3. Place the crucible and its contents on a clay triangle. Heat gently with a Bunsen burner for one minute. Continue to heat with a moderate flame for 5 minutes. Increase the heat to high and heat for an additional 5 minutes - the bottom of the crucible will glow with a red color. Allow the crucible to cool.
4. When the crucible is cool, close the lid and weigh the crucible, cover, and its contents. Record the mass to 0.001 g. Save the crucible and contents until you have completed your calculations for the experiment.
5. After completing the calculations, inspect the compound inside the crucible. Use your crucible tongs or a glass stirring rod to press down on the compound. How does it differ from the original sample of the hydrate? What happens if you add one or two drops of water to the residue in the crucible?

Reference

Weiner, Susan A. and Edward I. Peters, *Introduction to Chemical Principles, A Laboratory Approach*, 3rd Edition, Saunders College Publishing, 1986.

DATA AND RESULTS

1. Properties of a Hydrate

A. Behavior of a Hydrate

What did you observe upon heating the hydrate in the test tube?

What did you observe when water was added to the anhydrous salt in the test tube?

B. Properties of Anhydrous CaCl₂

Describe the initial appearance of the anhydrous calcium chloride.

Describe the appearance of the calcium chloride at the end of the experiment.

2. Determination of the Percentage of Water in a Hydrate

Which unknown hydrate are you using? _____

Mass of crucible and cover _____ g

Mass of crucible, cover, and hydrate _____ g

Mass of crucible, cover, and anhydrous compound after heating _____ g

Calculations

Mass of hydrate used _____ g

Mass of anhydrous compound (at end of the experiment) _____ g

Mass of the water of hydration _____ g

Calculate the percent of water in your hydrate (show your properly labeled set-up below)

_____ %

Moles of anhydrous compound (show properly labeled set-up below) _____ mole

Moles of water of hydration (show properly labeled set-up below) _____ mole

What is the formula of your hydrated compound? _____

What changes did you observe in your unknown hydrate?