

WATER OF HYDRATION

ALL THE DATA YOU WOULD COLLECT IN THE LABORATORY TO COMPLETE THIS LABORATORY REPORT IS IN THIS DOCUMENT HIGHLIGHTED IN YELLOW

ENTER YOUR ANSWERS AND INFORMATION IN THE LIGHT BLUE FIELDS

Purpose

The purpose of this experiment is to learn about hydrates and to determine the percentage of water in an unknown hydrate sample.

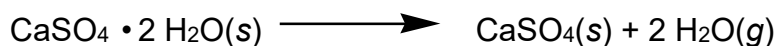
Theory

Hydrates are compounds that have a specific number of water molecules attached to them. For example, each unit of hydrated calcium sulfate has two water molecules per one unit of calcium sulfate (CaSO_4). The formula of this hydrate is $\text{CaSO}_4 \cdot 2 \text{H}_2\text{O}$.

- The “2” in front of the formula for water indicates that there are two water molecules per one unit of CaSO_4 .
- The dot (•) between the formula for calcium sulfate and the formula for water indicates that this is the formula of a hydrate.

The water molecules in this hydrate are chemically bonded to the units of calcium sulfate. Hydrates are dry solids, they are not “wet”.

Anhydrous calcium sulfate is the form of the compound that does not contain water. The term “anhydrous” means without water. If a sample of the hydrated calcium sulfate is heated the chemical bonds connecting the water molecules to the units of calcium sulfate will break. The heat will cause the water to boil away resulting in the formation of the anhydrous compound. The equation for this reaction is shown below.



The solid anhydrous compound will be in the container at the end of the reaction. You can determine the mass of the water that is produced during the reaction by subtracting the mass of the anhydrous compound from the mass of the hydrated compound.

$$(\text{Mass of hydrated compound}) - (\text{Mass of anhydrous compound}) = \text{Mass of water produced}$$

You can calculate the percentage of water in the hydrated sample as follows.

$$\frac{\text{Mass of water produced}}{\text{Mass of hydrated compound}} \times 100 = \text{Percentage of water in the hydrated sample}$$

The number of moles of water absorbed or released from a sample can be calculated from the mass in grams of the water and the molar mass of water.

$$\frac{\text{Mass of water}}{\text{Molar mass of water}} = \text{Number of moles of water}$$

The molar mass of water is 18.02 grams per mole.

$$\frac{\text{Mass of water}}{18.02 \text{ g/mol}} = \text{Number of moles of water}$$

In this experiment you will determine the amount of water a sample of anhydrous calcium chloride can absorb from the air. You will also heat an unknown hydrate to determine the amount of water that it contains.

Materials Needed

- Anhydrous calcium chloride (1 gram per student)
- Unknown hydrate samples (5 grams per student)

Procedure

A. Absorption of water from the air

1. Put on your chemical-splash safety goggles. Your goggles must be worn at all times while in the laboratory. Don't take off your goggles until you leave the laboratory.

2. Weigh a dry watch glass and record the mass on your data sheet. Add about one tablespoon of anhydrous calcium chloride to the watch glass and reweigh. Determine the mass of calcium chloride on the watch glass.

3. Allow the sample to remain on your laboratory table until the end of the laboratory period. Then reweigh the calcium chloride sample and record your observations of the sample on your data sheet.

B. Dehydration by heating

1. Place a crucible with its lid on a clay triangle mounted on an iron ring. Heat the empty crucible for 2 minutes. The bottom of the crucible should turn a dull-red color if you are heating the crucible properly. Allow the crucible and lid to cool after the 2-minute heating period. Cooling will take five to ten minutes. The top part of the Bunsen burner, the crucible, ring stand, iron ring and clay triangle will be very hot after heating. Do not touch these items with your hands until they have cooled.

2. Carefully transfer the crucible and lid to a balance when the crucible is cool. Record the mass on your data sheet. Don't place a hot crucible on the balance.

3. Obtain an unknown hydrate and record its code on your data sheet. Fill your crucible approximately one-third with the unknown hydrate using a clean scoop. Put the lid back on the crucible and weigh.

4. Place the covered crucible on the clay triangle and heat with a Bunsen burner for ten minutes. **Heat the crucible gently. You are heating your sample too strongly if your sample begins to produce smoke. Lower the flame on your Bunsen burner if this occurs.** Allow the crucible to cool after the ten-minute heating period. It will take five to ten minutes for the crucible to cool. When the crucible is cool, carefully transfer the crucible and lid to the same balance that you used previously and determine the mass. **Be careful when transferring your crucible to the balance. Your crucible is fragile and will probably break if you drop it.**

5. Gently heat the crucible and lid for three additional minutes to make certain that all the water is driven off. Cool and weigh the crucible and lid as described above. Consult your instructor about further heating and weighing if this mass does not agree within 0.05 grams of the mass obtained after the first heating.

6. **Clean all glassware and equipment that you used during this experiment and return it to its proper location. Clean your workstation and wash your hands with soap and water before you leave the laboratory.**

Name _____

Date _____

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Prelaboratory Assignment

1. What safety precautions should you take while using a Bunsen burner during this experiment? (See Part B in the Procedure.)

The top part of the Bunsen burner, the crucible, ring stand, iron ring and clay triangle will be very hot after heating. Do not touch these items with your hands until they have cooled

2. Anhydrous strontium nitrate, $\text{Sr}(\text{NO}_3)_2$, is a compound that will absorb water to form a hydrate. Read the description of an experiment below involving strontium nitrate and complete the table below.

Five (5.00) grams of anhydrous strontium nitrate is added to a beaker and exposed to the air. After several hours the beaker and the contents are weighed. It was found that the mass increased by 1.70 grams. Assume that the increase in mass is totally due to the absorption of water by the anhydrous compound.

a) Complete the table below.

How many grams of water were absorbed by the strontium nitrate?	How many moles of water were absorbed by the strontium nitrate?	What is the percentage of water in the strontium nitrate hydrate?
1.70 grams	0.09433 moles	25.37%

3. Barium chloride, BaCl_2 , is an example of a compound that can absorb water to form a hydrate. Read the description of an experiment below involving hydrated barium chloride and complete the table below.

Five (5.00) grams of hydrated barium chloride is heated in a crucible until the mass of the sample no longer changes. The mass of the sample after heating is 4.26 grams. Assume that the mass lost during heating is solely due to the loss of water from the sample.

a) Complete the table below.

How many grams of water were removed from the barium chloride?	How many moles of water were removed from the barium chloride?	What is the percentage of water in the barium chloride hydrate?
0.74 grams	0.04106 moles	14.8%

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Data Sheet

A. Absorption of water from the air

Mass of watch glass and anhydrous calcium chloride

25.84 g

Mass of watch glass

23.39 g

Mass of anhydrous calcium chloride

2.39g

Mass of watch glass and calcium chloride at end of lab period

26.42 g

Mass of calcium chloride at end of lab period

3.03g

Mass of water that calcium chloride absorbed

0.64g

Describe the appearance of the anhydrous calcium chloride and compare this with the appearance of the hydrated calcium chloride below.

The anhydrous calcium chloride was a white solid containing small crystals. The hydrated calcium chloride had colorless crystals which were larger than the crystals in the anhydrous sample.

B. Dehydration by heating

Code of unknown hydrate

#1

Amount of time that you heated the empty crucible and lid

2 minutes

Mass of empty crucible and lid

15.34 g

Mass of crucible, lid, and hydrate

17.19 g

Mass of hydrate

1.85g

Amount of time for first heating of hydrate

10 minutes

Mass of crucible, lid, and sample after first heating

16.72 g

Mass of anhydrous sample after first heating

1.34g

Amount of time for second heating of hydrate

3 minutes

Mass of crucible, lid, and sample after second heating

16.59 g

Mass of anhydrous sample after second heating

1.25g

Describe the appearance of the anhydrous unknown sample and compare this with the appearance of the hydrated sample below.

The hydrated unknown sample was a blue solid containing small crystals. The anhydrous sample was a white solid containing small crystals.

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Questions

a) Complete the table below based on your results from **Part A** of this experiment.

How many grams of water were absorbed by the calcium chloride?	How many moles of water were absorbed by the calcium chloride?	What is the percentage of water in the calcium chloride hydrate?
0.64g	0.03552 moles	21.12%

b) Complete the table below based on your results from **Part B** of this experiment.

How many grams of water were removed from your hydrated unknown sample?	How many moles of water were removed from your hydrated unknown sample?	What is the percentage of water in your unknown hydrated sample?
0.60g	0.033296 moles	32.43%