Lab
Moles/ Stoichiometry
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Name:_____ Lab Partner:_____ Date:_____ Class:_____

Percent Composition

Pre-Lab Discussion

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 $CuSO_4 \cdot 5H_2O$, read as copper(II) sulfate pentahydrate. The formula for the salt appears first, and the water formula is last. The raised dot (it is read as "dot") means that the water is loosely bonded to the salt. The coefficient 5 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 constant 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:

$$\text{hydrate} \xrightarrow{\text{heat}} \text{anhydrous salt} + \text{water}$$

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 using the formula for percent composition found in Reference Table T.

In this experiment, as was mentioned, a hydrate of copper sulfate will be studied ($CuSO_4 \cdot 5H_2O$). The change from hydrate to anhydrous salt is accompanied by a change in color:

$$CuSO_4 \cdot 5H_2O \text{ (blue)} \rightarrow CuSO_4 \text{ (white)} + 5\ H_2O$$

This investigation should aid in the understanding of the formulas and composition of hydrates and the law of constant composition.

Purpose

Determine the percentage of water in a hydrate.

Equipment

evaporating dish
iron ring
crucible tongs
wire gauze
microspatula
laboratory burner
laboratory balance
ring stand

Materials

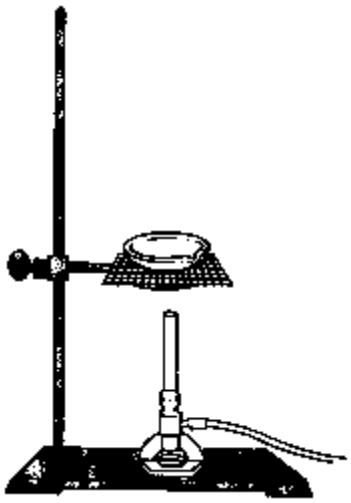
Copper(II) sulfate pentahydrate, $CuSO_4 \cdot 5H_2O$

Safety

Do not touch a hot evaporating dish with your hands. Tie back long hair and secure loose clothing when working around an open flame. Be sure to wear safety goggles when working in the lab.

Procedure

1. Prepare the setup shown in Figure below.



2. Heat the evaporating dish with the hottest part of the flame for 3 minutes.
3. Turn off the burner, and allow the dish to cool for several minutes. Hot items weigh less than when cool because they heat the air around them, causing the air to rise and make the item appear lighter.
4. Using crucible tongs, transfer the dish to the balance. Record the mass in the *Data and Observations* section.
5. With the evaporating dish on the balance, measure into it approximately 2 g of copper(II) sulfate pentahydrate. Record mass of the dish and hydrate in the data table below.
6. Place the evaporating dish and 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 of the 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. Turn off the burner, and allow the evaporating dish to cool for about two minutes. *Immediately* find the mass of the dish + anhydrous salt, and record the data. Allowing the dish to cool for a longer period of time would let the anhydrous crystals reabsorb water from the air.

Data and Observations

a. Mass of evaporating dish _____ g

b. Mass of evaporating dish + hydrate _____ g

c. Mass of evaporating dish + anhydrous salt _____ g

Calculations

1. Find the mass of the hydrate used.

2. Find the mass of the water lost.

3. Using the masses of water and hydrate above, find the percentage of water in the hydrate using the formula for percent composition found in *Reference Table T*.

Conclusions and Questions

1. The accepted value for the percentage of water in this hydrate is 36.0%. What is your experimental error? (measured value minus accepted value) Note that this is different from percent error.

2. Why must you allow the evaporating dish to cool before measuring its mass?

_____

_____

_____

3. Why must you measure the mass of the anhydrous salt immediately upon cooling?

_____

_____

_____

4. Define the law of constant composition and explain how your class's results in this experiment support the law.

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1. A sample of a hydrate is heated to dryness. The data collected is below. Determine the percent of water in the crystal.

Mass Before Heating	5.00 grams
Mass After Heating	3.41 grams

2. An 8.00 gram sample of a hydrate is heated to dryness and 5.68 grams remain. Calculate the percent by mass of water in the original hydrate.

3. Sodium carbonate, $Na_2CO_3 \cdot H_2O$, is the main ingredient in baking powder.

   a How many water molecules are in the hydrate? _____

   b What is the formula mass of the hydrate? _____

   c What is the percent by mass of water in the hydrate? _____

4. Sodium phosphate, $Na_3PO_4 \cdot 12H_2O$, is the chemical in Spic ‘n Span, a common household cleaner.

   a How many water molecules are in the hydrate? _____

   b What is the formula mass of the hydrate? _____

   c What is the percent by mass of water in the hydrate? _____