Percent water in a hydrate

Purpose

The purpose of the lab is to calculate the theoretical percent water in a known hydrate and determine the experimental percent water and number of water molecules (n) in the formula then compare the experimental results to the theoretical values.

Introduction

A hydrate is a compound that incorporates water as part of its crystalline structure. This water is held by hydrogen bonds, attraction of the oxygen of water to a metallic ion, or several other interactions. The water is not held as strongly as the bonds holding the rest of the compound together and may be driven off under simple heating. A typical formula for a hydrate is:

$$Na_2CO_3 \bullet 2H_2O$$

This hydrate has 2 water molecules attached to one Na_2CO_3 group. Hydrates have the water of crystallization denoted as • nH_2O, where n typically is a whole number from 1 to 10. If a hydrate is heated, the water is released and the structure of the compound is changed leaving the anhydrous salt behind, in this case **Na_2CO_3**. The reaction can be thought of as:

$$Na_2CO_3 \bullet 2H_2O(s) \xrightarrow[\Delta]{} Na_2CO_3\,(s) + 2H_2O(g)$$

Δ means heat

If the anhydrous salt is dissolved in water and recrystallized, the hydrate will reform.

A common hydrate is Epsom salts, magnesium sulfate heptahydrate $MgSO_4 \bullet 7H_2O$. In this lab, $MgSO_4 \bullet 7H_2O$ will be heated to remove the water. The anhydrous salt, $MgSO_4$, will remain after heating.

$$MgSO_4 \bullet 7H_2O\,(s) \xrightarrow[\Delta]{} MgSO_4(s) + 7H_2O\,(g)$$

Procedure

1) Wear goggles.

2) Clean an evaporating dish and watch glass.

3) Attach a small iron ring to a ring stand. Place the evaporating dish in the small iron ring. Light a Bunsen burner making sure to have the correct blue flame with the inner core. Position the bottom of the evaporating dish about 2 inches from the top of the inner core. Heat for 2 minutes. This first heating is to drive off any impurities such as oil or water that may remain on the evaporating dish.

4)Cool the evaporating dish (place it on the metal electrical outlet tower to speed cooling). Put the watch glass with the cooled evaporating dish on top on the balance.Record as mass of empty evaporating dish and watch glass in table 1.

5) With the evaporating dish and watch glass still on the balance, put approximately 2.0 gof$MgSO_4 \bullet 7H_2O$ into the dish. Record the mass of the evaporating dish, watch glass and hydrate in table 1.

6) Return the evaporating dish, watch glass and hydrate to the iron ring and carefully heat for 3 minutes by moving flame back and forth under the dish. This gradual heating ensures that the compound will not foam up and spill out (termed splattering) of the evaporating dish.

7) Place flame under the dish without moving it. Make sure that the bottom of the evaporating dish is at least 2 inches above the inner cone of the flame.Continue to heat until the dish and watch glass are completely dry. Remove the dish and watch glass from the metal tripod and let cool.

8) Place the evaporating dish, watch glass and anhydrous salt on the balance. Record mass in table 1 as mass evaporating dish, watch glass and anhydrous salt after heating.

9) Calculate the theoretical percent water in $MgSO_4 \bullet 7H_2O$, the mass of the hydrate before heating, the mass of anhydrous salt remaining in the evaporating dish after heating and the mass of water driven off. Calculate the number of water molecules per formula. All answers are reported under results in table 2.

Data

Table 1

Mass empty evaporating dishand watch glass (g)	
Mass evaporating dish. watch glass and hydrate$MgSO_4 \bullet 7H_2O$(g)	
Mass evaporating dish, watch glass and anhydrous salt$MgSO_4$ after heating (g)	

Calculations (Show all work with units. Record all answers in table 2)

1. Calculate the theoretical % water in $MgSO_4 \bullet 7H_2O$

$$\text{Theoretical \% } H_2O = \frac{7 \times \text{ molar mass* } H_2O}{\text{molar mass* } MgSO_4 \bullet 7H_2O \text{ g}} \times 100$$

* Use formula and Periodic Table to calculate

2. Calculate **mass of hydrate**$MgSO_4 \bullet 7H_2O$ before heating

mass evaporating dish, watch glass and hydrate (g) – mass empty evaporating dish and watch glass (g)

3. Calculate **mass of anhydrous salt** $MgSO_4$ after heating.

mass evaporating dish, watch glass and anhydrous saltafter heating (g) – mass empty dish and watch glass (g).

4. Calculate **mass of water lost** during heating.

Mass water lost = mass hydrate (from #2) – mass anhydrous salt (from #3)

5. Calculate the **experimental percent water in hydrate**$MgSO_4 \bullet 7H_2O$

$$\text{Experimental \%Water} = \frac{\text{mass water lost (from \# 4)}}{\text{mass hydrate} MgSO_4 \bullet 7H_2O \text{ (from \# 2)}} \times 100$$

6. Calculate the **moles anhydrous salt** $MgSO_4$after heating

$$\text{Moles anhydrous salt} = \text{mass anhydrous salt } MgSO_4 \text{ after heating (from \# 3)} \times \frac{1 \text{ mol}}{\text{molar mass } MgSO_4 \text{ g}}$$

7. Calculate the **moles of water lost** from the compound, record the value.

$$\text{Moles water lost} = \text{mass water lost (g) (from 4)} \times \frac{1 \text{ mol}}{\text{molar mass** water}}$$

** use Periodic Table to calculate

8. Calculate **n**, thenumberofmolecules of waterofper formula.

$$n^* = \frac{\text{moles water lost (from \#7)}}{\text{moles anhydrous salt } MgSO_4 \text{ (from \#6)}}$$

***round to the nearest whole number**

Results

Table 2

Theoretical % water in $MgSO_4 \cdot 7H_2O$	
Mass of hydrate$MgSO_4 \cdot 7H_2O$ before heating (g)	
Mass of anhydrous compound$MgSO_4$after heating (g)	
Mass of water lost during heating (g)	
experimental % water in hydrate $MgSO_4 \cdot 7H_2O$	
Moles of anhydrous salt$MgSO_4$	
Moles of water lost	
n (roundest to nearest whole number)	

Conclusion

Summarize the results of the experiment from Table 2 in paragraph form. Compare the theoretical % water in$MgSO_4 \cdot 7H_2O$ to the experimental % water.

Questions

1. Why is it important to heat the empty evaporating dish at the beginning of the lab procedure?

2.Howwould the experimental percent water in the hydrate change (increase, decrease, or remain the same)if: (Explain your thinking).

a) the sample was not heated long enough to remove all of the water?

b) some of the sample splattered out of the evaporating dish during heating?

3.Is the decomposition of the hydrate a physical or a chemical change? Why?

4.Calculate the theoretical percentage of water in calcium nitrate tetrahydrate $Ca(NO_3)_2 \cdot 4\ H_2O$.