Experiment 7

Analysis of Hydrates

Pre-lab Assignment

Before coming to lab:

- Read the lab thoroughly.
- Answer the pre-lab questions that appear at the end of this lab exercise.

Purpose

To determine the percentage of water in an unknown hydrate

Background

Sometimes salts combine chemically with water and from hydrates in which a definite number of water molecules combine with ions of a salt to form a crystal. Although chemically bound, this water of hydration maintains its characteristic composition in much the same manner as ions do. The formulas for a hydrate would look something like: $Na_2SO_4 \bullet 10H_2O$. The dot means that each Na_2SO_4 are associated with 10 molecules of water. Some salts have form more than one hydrate; i.e., sodium sulfate forms $Na_2SO_4 \bullet 10H_2O$ and $Na_2SO_4 \bullet 7H_2O$. Hydrates are usually not very stable and all the water may be removed from the hydrated crystal by heating, leaving an anhydrous salt behind.

Many hydrates lose their water of hydration with heating when they are exposed to dry air. These substances are said to be efflorescent. Some salts absorb water from the air until a concentrated solution of the salt is formed. Salts that absorb water from the air are called deliquescent and can be used as drying agents.

In this experiment, a hydrated salt will be heated to constant weight, removing the water of hydration. The loss of mass will be the mass of water present in the original salt. Using the mass of the water in the sample, the molar mass of water, the mass of the anhydrous salt, and the formula of the anhydrous salt (which your instructor will give to you), the percent of water in the hydrate and the number of moles of water associated with one mole of the anhydrous salt will be calculated.

hydrated salt *(solid)* + heat → anhydrous salt(*solid)* + water of hydration *(gas)*

EXAMPLE 1: When a 2.200 g sample of $CuSO_4 \cdot 5\ H_2O(s)$ was heated so that the waters of hydration were driven off, the mass of the anhydrous salt remaining was found to be 0.6390 g. What is the experimental value of the percent water of hydration?

$$CuSO_4 \cdot 5H_2O_{(s)} + \text{heat} \rightarrow CuSO_{4(s)} + 5\ H_2O(g)$$
$$2.200\ g \qquad\qquad 0.6390\ g$$

1. Find the difference between the mass of hydrate before heating and the mass of the anhydrate after heating. The difference is the mass of water last.

$$2.200\ g - 0.6390\ g = 1.561\ g$$

2. Dividing the mass of the water lost by the mass of hydrate used is equal to the fraction of water in the compound. Multiplying this fraction by 100 gives the percent water in the hydrate.

$$(1.561\ g / 2.200\ g)(100) = 70.95\%$$

Procedure

Safety: Be sure to wear your googles at all times. Take care when using the Bunsen burner.

Waste: Dispose of all waste in the waste container in the fume hood.

1. Obtain a sample of an unknown from your instructor.

2. Weigh a clean, dry 250 mL beaker covered with a watch glass.

3. Add about 1.0 gram of your unknown into the beaker and weight again.

4. Determine the mass of your unknown,

5. Place the beaker and watch glass on a wire gauze above a Bunsen Burner using a ring stand.

6. Gently heat the hydrate. When you no longer observe moisture in the beaker, turn off the burner and let the beaker cool back to room temperature.

7. Weigh the remaining solid, beaker and watch glass. Determine the mass of the remaining anhydrous salt.

8. Discard the solid in the waste container and repeat the experiment for a second time.

9. Calculate the percent of water in the hydrate.

10. Check your results with your instructor and obtain the correct percent of water and the formula of the anhydrous salt.

11. Calculate the formula of the hydrated salt.

Name _____

Experiment 7-Formula of a Hydrated Salt

Data and Report

	Trial 1	Trial 2
1. Sample number		
2.Mass of beaker, watch glass and sample		
3.Mass of empty beaker and watch glass		
4.Mass of sample (before heating)		
5.Mass of beaker, watch glass and sample after heating		
6.Mass of anhydrous salt (after heating)		
7.Mass of water in sample		
8.Experimental percent of water in sample		
9.Correct percent of water in sample (from instructor)		
10.Percent error		
11.Formula of anhydrous salt (from instructor)		
12.Calculated molar mass of anhydrous salt		
13.Moles of water in sample (use data above)		
14.Moles of anhydrous salt in sample (use data above)		
15. Formula of hydrated salt		

Calculations- show work below for Trial 1

Post- Lab Questions

1. What is the percent of oxygen in $Al_2(SO_4)_3$?

2. What is the percent of water in $Na_2SO_4 \bullet 10H_2O$?

3. 5.00 grams of a sample of hydrated $PtCl_4$ are heated and lose 1.5 grams of water. How many moles of water are combined with each mole of $PtCl_4$?

4. A student records the following data in the laboratory when determining the percentage water in an unknown hydrate. What is the percentage water in this student's unknown?

Mass of container	47.952 g
Mass of container and hydrate	49.837 g
Mass of container and contents after heating	49.500 g

4. You watch another student perform the experiment on and notice that several errors are made. For each error below determine how it would influence the reported percent of water and circle the appropriate letter.
H - means the reported percent of water is Higher because of the error.
L - means the reported percent of water is Lower because of the error.
N - means the reported percent of water is Not affected by the error.

In analyzing each error consider its effect, if any, on each weighing and then its ultimate effect on the calculated percent of water.

Example: Analysis of error "1" from the table below.

1. Some solid material spattered out of the open crucible during the heating.

……Mass of empty crucible is not affected by the error.

……Mass of crucible and hydrate before heating is not affected by error.

….. Mass of crucible and anhydrous solid after heating is low because of error.

…..The above factors cause the calculated mass of water to be high.

…….Calculated percent water (equation 1) is therefore high due to the error.

…… Letter H must be circled.

Observed Experimental Error Influence on the Calculated Percent of Water

1. Some solid material spattered out of the open crucible during the heating. H L N

2. The crucible was wet before its mass was originally determined. H L N

3. The crucible and anhydrous solid were carried in wet hands over to the balance for the final weighing. H L N

4. The substance was heated so strongly that some of anhydrous salt was vaporized. H L N

5. There was a mechanical defect in the balance so that all masses reading were actually 1.0 g too high. H L N

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Pre-Lab Assignment for Analysis of Hydrates

1. Define these terms:

   a. Hydrate

   b. Anhydrous solid

   c. Deliquescent

2. How can you tell when to stop heating your sample in this experiment?

3. A 4.68 g of a hydrate is heated to remove its water content, and the residue solid weighs 3.54 g. Determine the percent water in the hydrate.