Determination of the Formula of a Hydrate

Introduction

The purpose of this experiment is to determine the empirical formula of a hydrate. Hydrates are inorganic salts which contain a specific number of water molecules loosely attached. An example is sodium carbonate decahydrate (washing soda). The formulas for this substance is $Na_2CO_3 \bullet 10H_2O$. As you may remember, the raised dot does not mean "multiply"; rather, it means that the water molecules are loosely attached. Not all hydrates have simple formulas like this one. For example, a hydrate of cadmium sulfate seems to have 2.66 molecules of water for each molecule of $CdSO_4$. This hydrate is best represented as $(CdSO_4)_3 \bullet 8H_2O$. When determining the formula of a hydrate you must not assume that it is one with a simple formula.

Hydrates can normally be decomposed into the anhydrous ("without water") salt and water by gentle heating according to the equation below. From the data collected the number of molecules of hydrated water will be determined per formula unit of anhydrous salt.

$$MgCl_2 \bullet xH_2O \rightarrow MgCl_2 + xH_2O$$

Purpose

To determine the empirical formula of a hydrated salt.

Materials

Evaporating dish	Wire gauze	Bunsen burner
Magnesium chloride hydrate salt	Stir rod	Pressed fiber pad
Milligram balance	Ring Stand	

Procedure

1. Clean and dry your evaporating dish.
2. Determine the mass of an evaporating dish. Record the mass to the nearest 0.001 g.
3. Add 2.000 g of magnesium chloride hydrate to the evaporating dish and record the combined mass of the salt and evaporating dish.
4. Place the evaporating dish on wire gauze on your ring stand. Begin heating the sample slowly.
5. After about 10 minutes of gentle heating, increase the heat until no further change in the salt is apparent. At this point, the salt will seem to have changed from a crystalline solid to a grainy solid. You may need to use your glass stir rod to gently break up some of the crystals to assist in the evaporation of the water.
6. Use tongs to place the evaporating dish on a piece of pressed fiber pad in order to cool. Cover the salt with a watch glass to slow the possible re-absorption of water by the anhydrous salt.
7. When the evaporating dish has cooled sufficiently to be handled, again determine the mass of the evaporating dish and contents.
8. Return the evaporating dish to the ring stand and re-heat it. Allow it to cool, then determine the mass of the evaporating dish with its contents again.
9. Continue this process until a constant mass is attained.
10. Record the lowest mass of the crucible and anhydrous salt.

Data

Mass of empty evaporating dish ________________________________ g
Mass of hydrate used ________________________________ g
Mass of evaporating dish + hydrate ________________________________ g
Mass of evaporating dish + anyhydrous salt (at constant mass) ________________________________ g

Calculations

Calculations of the coefficient on the water in the formula of a hydrate are done nearly identically to the method you learned for calculating the empirical formula of a compound from its percentage composition.

1. First, calculate the mass of anhydrous salt remaining.
   a. Convert this quantity to its equivalent number of moles of anhydrous $MgCl_2$
2. Calculate the mass of water evaporated
   a. Convert this quantity to its equivalent number of moles of H_2O
3. Divide the number of moles of water by the number of moles of $MgCl_2$ to find the coefficient in front of water in the hydrate
   a. This works because we can assume that the understood coefficient in front of the $MgCl_2$ is 1
4. You should now be able to write an empirical formula for the hydrate in the form:

$$MgCl_2 \bullet xH_2O$$

in which x is some whole number