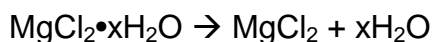


## Determination of the Formula of a Hydrate

### 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 formula for this substance is  $\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$ . 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  $\text{CdSO}_4$ . This hydrate is best represented as  $(\text{CdSO}_4)_3 \cdot 8\text{H}_2\text{O}$ . 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.



### 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 +<br>anhydrous 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  $\text{MgCl}_2$
2. Calculate the mass of water evaporated
  - a. Convert this quantity to its equivalent number of moles of  $\text{H}_2\text{O}$
3. Divide the number of moles of water by the number of moles of  $\text{MgCl}_2$  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  $\text{MgCl}_2$  is 1
4. You should now be able to write an empirical formula for the hydrate in the form:  
$$\text{MgCl}_2 \cdot x\text{H}_2\text{O}$$
in which x is some whole number