Name: ____ Period: ______ Assigned on Wednesday, August 27, 2025

2.3 Lab: Experimental Determination of the Formula of a Hydrate **Due Tuesday, September 02, 2025**

Background

Epsom salt (aka magnesium sulfate) is a combination of $MgSO_4$ and H_2O. Many ionic compounds incorporate a fixed number of water molecules into their crystal structures. These are called hydrates. Heat can be used to dehydrate a hydrated salt causing the H_2O molecules to evaporate and produce an anhydrous salt which often will appear different than its hydrate. When expressing the formula for a hydrate, it is necessary to notate the fixed number of H_2O molecules. A large dot is placed between the formula and the H_2O molecules following the formula for the ionic compound.

For example: $CuSO_4 \bullet 5\ H_2O$ is the formula for hydrated copper sulfate. This formula indicates that for every 1 mole of $CuSO_4$ there are 5 moles of H_2O present.

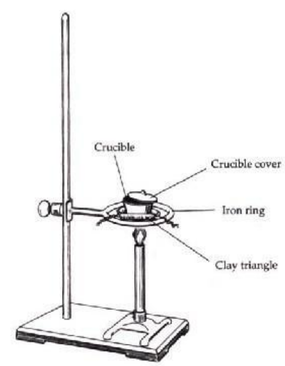
Objectives

1. Dehydrate Epsom salt using appropriate laboratory techniques to determine the molecular formula and percent water of the hydrated magnesium sulfate.
2. Calculate the percent error of your percent water to the actual percentage of water for hydrated magnesium sulfate.

Materials

- electronic balance
- crucible tongs
- Bunsen burner
- ring stand with iron ring
- clay triangle
- Epsom salt (hydrated $MgSO_4$)
- crucible with cover
- matches
- stirring rod
- scoopula
- test tube brush

Procedure



1. Put on your goggles. Secure the iron ring on the ring stand a couple of inches above the height of the burner. Place the wire gauze on the ring. (See figure to the right.)
2. Place a clean crucible on the set-up. Light the burner and heat for a couple of minutes to make certain crucible is thoroughly dry. Turn off burner and cool the crucible for several minutes until it is comfortable to touch. Record the mass of the dry crucible and cover together.
3. Add about 5 grams of Epsom salt to the crucible. Record the mass of the crucible, cover, and Epsom salt.
4. Place the crucible back on the set-up. Cover with the cover slightly ajar so that steam can escape and heat gently until the water has been released from the hydrate. This will require about 5 minutes. Note: If you heat the hydrate too quickly, some of the crystal might spatter out.
5. When no more H_2O appears to be coming from the hydrate, turn off the burner and cool for several minutes until crucible is comfortable to the touch. Record the mass of the crucible and salt.
6. If time allows, reheat the crucible containing the salt, cool, and find the mass again. If the two final masses agree, you can be confident that you have indeed released all of the H_2O. If not, continue the heating and cooling as directed in this lab to make sure all the water is released.
7. Put your excess Epsom salt into the trash can and carefully clean out your crucible. All other lab materials need to be ready for the next class.

Data

Mass of empty crucible and cover	
Mass of crucible, cover, and hydrated salt before heating	
Mass of crucible, cover, and salt after 1st heating	
Mass of crucible, cover, and salt after 2nd heating	

Mass of crucible, cover, and salt after 3rd heating	

Calculations (Show all work for all calculations)

1. a) Determine the mass of H_2O lost from your salt during the process of heating.

   b) Calculate how many moles of H_2O were lost from your salt during the process of heating.

2. a) Determine the mass of the anhydrous $MgSO_4$ present in the Epsom salt sample.

   b) Calculate how many moles of anhydrous $MgSO_4$ were present in the Epsom salt sample.

3. Calculate the mole ratio of H_2O molecules to $MgSO_4$ particles. To do this, divide the mole of water by the moles of anhydrous $MgSO_4$. Your value should be very close to a whole number. Round your answer to the nearest whole number.

4. Write the correct formula for the hydrate using the ratio calculated in problem three. $MgSO_4$ • ______ H_2O

5. Calculate the percent of water by mass in the Epsom salt. (Hint: $\% = \frac{part}{whole} x100$, so in this case $\%_{water} = \frac{mass\ water\ in\ hydrate}{mass\ hydrated\ epsom\ salt}\ x\ 100$). This is your experimental value of the percent of water in the Epsom salt.

Analysis

1. Why might you need to reheat the salt several times before getting the final mass of the anhydrous salt?

2. Using the internet, what should be the formula for hydrated magnesium sulfate (Epsom salt). ________________________

   a) Calculate the theoretical percent of water by mass (what it should be according to the internet) using the following formula:

$$\%_{water} = \frac{molar\ mass\ water\ x\ coefficient}{molar\ mass\ of\ entire\ hydrate}\ x\ 100$$

   b) Calculate the percent error of the % water of your experiment:

$$\%_{error} = \frac{experimental\ value\ of\ \%\ water - theoretical\ value\ of\ \%\ water}{theoretical\ value\ of\ \%\ water}\ x\ 100$$

3. Copper(II) nitrate, $Cu(NO_3)_2$, is commonly found as a hydrate. If you heat up 4.25 g of $Cu(NO_3)_2$ • X H_2O and release 0.95 g of water, what is formula for the hydrate? (Hint: first determine the moles of water and moles of anhydrous $Cu(NO_3)_2$ present in the sample!)

4. How would the following common experimental errors affect the your calculated experimental percent water value for the Epsom salt? Be specific on why it would affect the formula in the way you predict it would raise or lower the experimental percent water.

   a) You didn't heat the crucible (container) to remove extra water molecules before getting the mass of the container and hydrate sample.

   b) Strong initial heating caused some of the hydrate sample to spatter out of the crucible.