Chemistry
Lab - Formula of a Hydrate

Name Key
Period ______ Date ________

Background

Many salts crystallized from water solutions appear to be perfectly dry, yet when heated they liberate large quantities of water. The crystals change form, even color, as the water is driven off. Such compounds are called HYDRATES. The number of moles of water present per mole of anhydrous salt (salt minus water of crystallization) is usually a whole number. One example is the hydrate of copper (II) sulfate. Its blue crystals look and feel dry. Yet, each mole of hydrate contains 5 moles of water. Its formula is $CuSO_4$ $5\ H_2O$. The dot between the $CuSO_4$ and $5\ H_2O$ does not mean multiplication. It indicates that 5 water molecules are bound to the other atoms as ligands. The mass of the 5 water molecules must be accounted for when computing the mass of the hydrated salt.

Purpose

In this experiment, you will do the following:
1. Determine the percent composition of water in a hydrated sample of magnesium sulfate.
2. Calculate the empirical formula of the hydrated magnesium sulfate.

Materials

Pasteur Pipet
ring stand, wire gauze, iron ring, and Bunsen burner
magnesium sulfate and balance.

Procedure

1. Obtain and mass a dry Pasteur pipet. Record the data on the table.

2. Fill the pipet with approximately 0.5 grams of hydrated magnesium sulfate. Try to avoid packing the crystals too tightly.

3. Mass the pipet again and record on the data table.

4. Place the Pasteur pipet on the wire gauze and heat with a Bunsen burner. Keep the flame moving at all times to avoid melting the pipet. You will hear a crackling sound and see water condensing on cooler parts of the pipet as water is driven from the salt. Keep heating the pipet until all visible signs of the water are gone.

5. Allow the pipet to cool to the touch. Remember that HOT GLASS LOOKS JUST LIKE COLD GLASS. Mass the pipet and record in the data table.

6. Repeat steps 4 and 5 two more time or until the mass of the pipet no longer changes.

7. Dispose of the pipet in the appropriate receptacle.

Data

Mass of empty pipet ______ Mass after 1st heating ______

Mass of empty pipet 10.4g

Mass of hydrate & pipet 10.9g

Mass after 1st heating 10.8

Mass after 2nd heating 10.7

Mass after 3rd heating 10.7

Calculations (Show all work!) Sample calculations

A. Mass composition of water in the hydrate

1. Calculate the mass of the hydrated ~~magnesium~~ Copper sulfate.

$10.9 - 10.4 = 0.5g$

2. Calculate the mass of the water driven from the hydrate.

$10.9 - 10.7g = 0.2g$

3. Calculate the % composition of water in the hydrated magnesium sulfate. Record % composition in the results table.

$\frac{0.2g}{0.5g} \cdot 100 = 40\% \ H_2O$

B. Find the empirical formula of the hydrate.

1. Calculate the mass of the anhydrous magnesium sulfate

$0.5 - 0.2 = 0.3g$

$CuSO_4$: $63.55 + 32.06 + 16 \times 4 = 159.61 \ g/mol$

2. Calculate the number of moles of anhydrous ~~magnesium~~ Copper sulfate

$\frac{0.3g}{} \bigg| \frac{1 mol}{159.61g} = 0.0019 \ mol$

3. Calculate the number of moles of water driven from the hydrate. → $16 + 1.01 \times 2 = 18.02 g/mol$

$\frac{0.2g \ H_2O}{} \bigg| \frac{1 mol}{18.02g} = 0.011 \ mol$

4. Divide the moles of water by the moles of anhydrous magnesium sulfate. Round to the nearest whole number. Record the empirical formula in the results table.

Results

$\frac{0.011 \ mol \ H_2O}{0.0019 \ mol \ CuSO_4} = 5.79 \rightarrow \boxed{6}$

Questions

1. Suggest some reasons why this procedure might not be suitable for all hydrates.

- toxic, potentially hazardous materials
- may have too many hydrates

2. The correct formula for the hydrate is ~~Mg~~ Cu $SO_4 \cdot$ ~~?~~ 5 H_2O. Did your results agree? NO. If not, suggest some reasons why you found a different empirical formula.

- measured wrong
- didn't give enough sig figs