Name _____ Class _____ Date _____

Core Skill Lab

# Water of Hydration

Many ionic compounds, when crystallized from an aqueous solution, will take up definite amounts of water as an integral part of their crystal structures. You can drive off this water of crystallization by heating the hydrated substance to convert it to its anhydrous form. Because the law of definite composition holds for crystalline hydrates, the number of moles of water driven off per mole of the anhydrous compound is a simple whole number. If the formula of the anhydrous compound is known, you can use your data to determine the formula of the hydrate.

## OBJECTIVES

**Determine** that all the water has been driven from a hydrate by heating a sample to constant mass.

**Use** experimental data to calculate the number of moles of water released by a hydrate.

**Infer** the empirical formula of the hydrate from the formula of the anhydrous compound and experimental data.

## MATERIALS

- balance, centigram
- Bunsen burner and related equipment
- crucible and cover
- desiccator
- iron ring
- copper (II) sulfate hydrated crystals, $CuSO_4 \cdot nH_2O$
- pipe-stem triangle
- ring stand
- sparker
- spatula
- crucible tongs

 **Always wear safety goggles and a lab apron to protect your eyes and clothing.** If you get a chemical in your eyes, immediately flush the chemical out at the eyewash station while calling to your teacher. Know the locations of the emergency lab shower and the eyewash station and the procedures for using them.

 **Do not touch any chemicals.** If you get a chemical on your skin or clothing, wash the chemical off at the sink while calling to your teacher. Make sure you carefully read the labels and follow the precautions on all containers of chemicals that you use. If there are no precautions stated on the label, ask your teacher what precautions you should follow. Do not taste any chemicals or items used in the laboratory. **Never return leftovers to their original containers; take only small amounts to avoid wasting supplies.**

 **Call your teacher in the event of a spill.** Spills should be cleaned up promptly, according to your teacher's directions.

 **When using a Bunsen burner, confine long hair and loose clothing.** If your clothing catches on fire, WALK to the emergency lab shower and use it to put out the fire. Do not heat glassware that is broken, chipped, or cracked. Use tongs or a hot mitt to handle heated glassware and other equipment because hot glassware does not look hot.

## Procedure

**1.** Throughout the experiment, handle the crucible and cover with clean crucible tongs only. Place the crucible and cover on the triangle as shown in **Figure A.** Position the cover slightly tipped, leaving only a small opening for any gases to escape. Preheat the crucible and its cover until the bottom of the crucible turns red.

**CAUTION The crucible and cover are very hot after each heating. Remember to handle them only with tongs.**

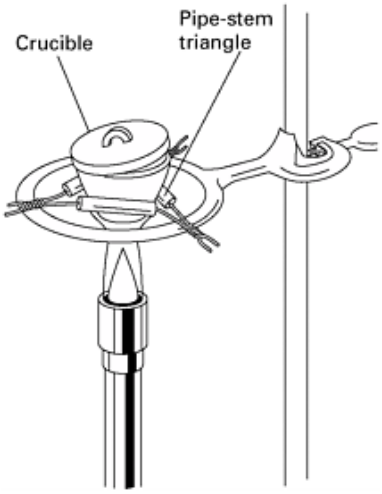


**Figure A**

**2.** Using tongs, transfer the crucible and cover to a desiccator. Allow them to cool 5 min in the desiccator. Never place a hot crucible on a balance. When the crucible and cover are cool, determine their mass to the nearest 0.001 g. Record this mass in **Data Table.**

**3.** Using a spatula, add approximately 5 g of copper (II) sulfate hydrate crystals to the crucible. Determine the mass of the covered crucible and crystals to the nearest 0.01 g. Record this mass in the **Data Table.**

**4.** Place the crucible with the copper (II) sulfate hydrate on the triangle, and again position the cover so that there is a small opening. Too large an opening may allow the hydrate to spatter out of the crucible. Heat the crucible very gently with a low flame to avoid spattering any of the hydrate. Increase the temperature gradually for 2 or 3 min. Then, heat strongly for at least 5 min. Be very careful not to raise the temperature of the crucible and its contents too suddenly. You will observe a color change, which is normal, but if the substance remains yellow after cooling, it was overheated and has begun to decompose.

**5.** Using tongs, transfer the crucible, cover, and contents to the desiccator, and allow them to cool for 5 min. Then, using the same balance you used in Step **2,** determine their mass. Be sure the crucible is sufficiently cool, because heat can affect your measurement. Record the mass in the **Data Table.**

**6.** Again heat the covered crucible and contents strongly for 5 min. Allow the crucible, cover, and contents to cool in the desiccator, and then use the same balance as before to determine their mass. If the last two mass measurements differ by no more than 0.01 g, you may assume that all the water has been driven off. Otherwise, repeat the heating process until the mass no longer changes. Record this constant mass in your **Data Table.**

**7.** Clean all apparatus and your lab station. Return equipment to its proper place. Dispose of the $CuSO_4$ in your crucible as your teacher directs. Wash your hands thoroughly after all work is finished and before you leave the lab.

## Observations

| **Data Table** | |
|---|---|
| Mass of empty crucible and cover | |
| Mass of crucible, cover, and copper (II) sulfate hydrate | |
| Mass of crucible, cover, and anhydrous copper (II) sulfate after 1st heating | |
| Mass of crucible, cover, and anhydrous copper (II) sulfate after last heating | |

| **Calculations Table (Show ALL calculations below.)** | |
|---|---|
| Mass of anhydrous copper (II) sulfate | |
| Moles of anhydrous copper (II) sulfate | |
| Mass of water driven off from hydrate | |
| Moles of water driven off from hydrate | |
| Mole ratio of anhydrous copper (II) sulfate to water | |
| Empirical formula of the hydrate | |

## Calculations (Show all calculations below.)

**1.** Calculate the mass of anhydrous copper (II) sulfate (the residue that remained after driving off the water). Record the mass in the **Calculations Table.**

**2.** Calculate the number of moles of anhydrous copper sulfate. Record the number of moles in the **Calculations Table.**

**3.** Calculate the mass of water driven off from the hydrate. Record the mass in the **Calculations Table.**

**4.** Calculate the number of moles of water driven off from the hydrate. Record the number of moles in the **Calculations Table.**

**5.** **Organizing Conclusions** Using your answers to Calculations Items **2** and **4,** determine the mole ratio of $CuSO_4$ to $H_2O$ to the nearest whole number. Record the ratio in the **Calculations Table.**

**6.** **Organizing Conclusions** Use your answer to Calculations Item **5** to write the formula for the copper (II) sulfate hydrate. Record the formula in the **Calculations Table.**

## Questions

**1.** The following results were obtained when a solid was heated by three different lab groups. In each case, the students observed that when they began to heat the solid, drops of a liquid formed on the sides of the test tube.

| Lab group | Mass before heating | Mass after heating |
|---|---|---|
| 1 | 1.48 g | 1.26 g |
| 2 | 1.64 g | 1.40 g |
| 3 | 2.08 g | 1.78 g |

**a.** Could the solid be a hydrate? What evidence supports your answer?

**b.** If, after heating, the solid has a molar mass of 208 g/mol and a formula of XY, what is the formula of the hydrate? Use **Lab group 1**'s results.

**2.** Some cracker tins include a glass vial of drying material in the lid to keep the crackers crisp. In many cases, the material is a mixture of magnesium sulfate and cobalt chloride indicator. As the magnesium sulfate absorbs moisture $(MgSO_4 \cdot H_2O + 6H_2O \rightarrow MgSO_4 \cdot 7H_2O)$, the indicator changes color from blue to pink$(CoCl_2 \cdot 4H_2O + 2H_2O \rightarrow CoCl_2 \cdot 6H_2O)$. When this drying mixture becomes totally pink, it can be restored if it is heated in an oven. What two changes are caused by the heating?

**3.** How does the experiment you performed exemplify the law of definite composition?

**4.** **Analyzing Methods** Why did you use the same balance each time you measured the mass of the crucible and its contents?