

Copper Sulfate Lab

Determining the % hydration of a compound

The time is six years in the future. You've just completed college, and accepted your first job as a medical crime scene investigator. Your first case is at the Shadydale Nursing Home. You've been called to the facility to investigate a possible arson.

The supply shed at the edge of Shadydale's scenic "nature garden" burned down less than 24 hours ago. The supply shed was used to house a variety of chemicals, including copper sulfate, a common weed killer and fungicide. Copper sulfate is easily recognizable as a blue green powder, sold in a variety of package sizes. A quantity of copper sulfate has been spilled in and around the shed, and was exposed to high heat during the fire.

The gardener himself is the most likely suspect. He has keys to the shed. His boot prints are found all around the shed. And police have found a pair of boots at his house which appear to be partly melted (as if he stepped through the fire or over some coals). The boots are also coated with fine copper sulfate dust.

Yet this evidence is inconclusive. The gardener claims he burned his boots more than a year ago, putting them too close to a campfire. He works in the garden daily, and seems unsurprised that his boot prints could be found near the shed. Also, he says that the copper sulfate has been on his boots since he opened the bag more than a week ago. Indeed, he says he was not at the shed the night of the fire, and has not visited it since the fire occurred.

There is a way for you to determine if the gardener is really telling the truth. Copper Sulfate absorbs water easily, forming a weak bond between the copper sulfate and five water molecules. This is written $\text{CuSO}_4 \cdot 5 \text{H}_2\text{O}$. The name of this compound is "copper sulfate pentahydrate". But when copper sulfate is heated (as in a fire), these weak bonds are broken and the water evaporates. Copper sulfate without water is named "anhydrous copper sulfate" and written just " CuSO_4 ". Over time anhydrous copper sulfate reabsorbs moisture from the air to revert to the hydrated form.

If you can prove that the copper sulfate on the gardeners boots is the anhydrous form, that would place him at the scene of the fire, and soon after the fire began (certainly before the firefighters arrived and doused the place with their hoses). The purpose of this lab is to determine the amount of water present in a sample of copper sulfate scraped from the bottom of the gardener's boot.

Many compounds form hydrates, when they crystallize out of aqueous solution. Analyze the following data to determine the mole ratio of compound to water for the following hydrated compounds. For each set of data, determine the empirical formula for the hydrate. Finally write the correct name of the hydrate (using prefixes mono- di- tri- tetra- penta- hexa- or hepta-, as appropriate) and write a balanced chemical equation describing the decomposition of hydrated compound to form anhydrous compound.

1. 5.00 grams of Barium chloride hydrate is heated gently to produce 4.27 grams of Barium chloride anhydride.

- a) Write a formula for anhydrous Barium Chloride
- b) Calculate the molecular weight of anhydrous Barium Chloride
- c) Determine the empirical formula of the hydrated Barium Chloride. Write the name and formula of the hydrated compound
- d) Write a balanced equation for decomposition of hydrated Barium Chloride. Correctly name the hydrate

2. 10.00 grams of Iron (III) chloride hydrate decompose, when heated, to produce 6.00 grams of anhydrous product.

- a) Write a formula for anhydrous Iron (III) chloride
- b) Calculate the molecular weight of anhydrous Iron (III) Chloride

c) Determine the empirical formula of the hydrated Barium Chloride. Write the name and formula of the hydrated compound

d) Write a balanced equation for decomposition of hydrated Iron(III) Chloride. Correctly name the hydrate

3. 12.00 grams of iron (II) sulfate hydrate decompose, when heated, to produce 6.55 grams of anhydrous product.

a) Write a formula for anhydrous Iron (III) chloride

b) Calculate the molecular weight of anhydrous Iron (III) Chloride

c) Determine the empirical formula of the hydrated Barium Chloride. Write the name and formula of the hydrated compound

d) Write a balanced equation for decomposition of hydrated Iron(III) Chloride. Correctly name the hydrate

4. 12.00 grams of magnesium sulfate hydrate decompose, when heated, to produce 5.86 grams of anhydrous product. On your own, attached piece of paper, repeat the steps in the problems above, showing all work required to determine the empirical formula (and full name) of hydrated magnesium sulfate.

5. 15.00 grams of sodium chromate hydrate decompose, when heated, to produce 10.38 grams of anhydrous product (Na_2CrO_4) On your own, attached piece of paper, repeat the steps in the problems above, showing all work required to determine the empirical formula (and full name) of hydrated sodium chromate.

Name: _____

Laboratory Investigation

Percent Composition / Empirical formula.

Complete this section before beginning your lab procedure.

1. (3 pt) Define “pentahydrate”

(3pt) Define “anhydride”

(4pt) Describe at least one commercial use of the chemical “copper sulfate”

3. (5pt) Describe what happens (chemically) when you heat copper sulfate hydrate. Your answer must also explain why the mass of copper sulfate hydrate decreases as it is heated.

4. In the space below, write a balanced chemical formula to represent the reaction “solid copper (II) sulfate pentahydrate decomposes to produce anhydrous copper sulfate (another solid) and water vapor. Be sure to include correct symbols for the states of matter in your formula.

Observations:

1. Prepare a chart for collecting data. As a minimum, your chart should include spaces for recording the mass of the empty crucible, the mass of the starting material in the crucible, the mass of the final product in the crucible, and the calculated mass of the starting and final product without the crucible. Use this chart to record your data as you complete the experiment.

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Record your observations below. For maximum credit, your descriptions should be detailed, thorough, accurate and clearly written in full sentences.

2. Describe the chemicals before grinding it, and after grinding it in the mortar and pestle.

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3. Describe any changes you *observed* while heating the Copper sulfate.

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4. Describe your final product.

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7. Complete the following table of calculations. Each row is worth 5 points, 50 points total. Points deducted for failing to show work, failing to show units, or incorrect calculations.

	You must either show your work, or describe how you obtained your answer.	Final answer:
Mass of copper sulfate hydrate, in your experiment		
Mass of copper sulfate anhydride, in your experiment		
Calculate mass of water in your experiment	$=(\text{mass hydrate}) - (\text{mass anhydride})$	
Calculate the %mass of water in the copper sulfate hydrate	$=100\% * (\text{mass water}) / (\text{mass hydrate})$	
Calculate the molecular weight of water (H ₂ O)	= sum of the atomic masses of 2 H and 1 O	
Calculate the molecular weight of copper sulfate (CuSO ₄)	=sum of the atomic masses of Cu, S and 4 O	
Calculate the number of moles of anhydride from your experiment	$=(\text{mass anhydride})/(\text{molecular weight CuSO}_4)$	
Calculate the number of moles of water from your experiment	$=(\text{mass water})/(\text{molecular weight of water})$	
Calculate the mole ratio of anhydride to water	= (moles of anhydride) : (moles of water)	
Determine the empirical formula of your starting material, and name the compound.	Based on the ratio calculated above.	

Conclusions:

Review your observations notes.

1. Describe one or more points during the experiment when copper sulfate may have been removed from the crucible inadvertently (due to splattering, sloppy procedure, etc.)

2. Describe what effect loss of product (described above) might have on final results. Be specific in describing whether you think this would make your final weight too high or too low, and how this might affect your conclusions.

3. Describe any evidence during the experiment that the copper sulfate may have been heated unevenly, or may have even begun to decompose as a result of overheating. _____

4. Describe what effect overheating, or uneven heating, might have on your interpretation of the results. Again, be very specific.

5. Describe any other possible sources of error during this experiment. Again, how would these affect your conclusions?

6. Reread the story at the beginning of this report. What can you conclude about the gardeners guilt or innocence, based on your results? Support your conclusions very clearly. _____
