

chapter two

Determination of the formula of a copper supplement

Green chemistry principles investigated:

Prevention

Catalysis

At times, a hazardous heavy metal or substance must be used. Even if this is necessary, often the product or process can be made greener by reducing the quantity of hazardous material used or using a less hazardous substance that contains a required heavy metal. In this experiment, while students determine the formula of copper gluconate, they are introduced to the green chemistry principles of *prevention* and *catalysis*. *Prevention* is achieved since copper gluconate is less hazardous and contains a smaller percentage of copper than copper compounds traditionally used in formula determination labs. *Catalysis* is discussed since catalysts often use hazardous heavy metals. Although converting a stoichiometric method to a catalytic one is usually greener, often the method can be further improved by using a catalyst that contains a lower percentage of a hazardous substance.

Experiment considerations

In this experiment, the quantity of copper gluconate used was minimized. Students will need to be cautioned that it will be important for them to be careful and precise. The copper metal obtained can be collected and recycled.

The main safety concerns are burns from a hot plate and hot glassware and cuts from broken glass. Be sure students wear their safety goggles and use beaker tongs or oven mitts to remove the hot beaker from the hot plate.

Materials and reagents: (per student or lab group)

Quantity	Material/Reagent	Teacher preparation (<i>and alternatives</i>)
1	150 mL beaker	
2	50 mL beakers	
1	Glass stirring rod	
2	Lab scoops	
1	Balance	
1	Wash bottle	
0.5 g	Copper gluconate	
3	Aluminum washers	3/8 th inch washer with 1/8 th inch (3 mm) hole works well
	Sand paper	
10 mL	1.0% wt/v NaCl solution	Dissolve 1.0 g NaCl in 100 mL of DI water; makes enough solution for 10 groups
50 mL	DI water	
	Oven (120°C)	
	Hot plate	
	Beaker tongs	Make sure they work well before using

Notes

Name _____

Prelab questions

1. Why is it important in this experiment to be accurate in all your measurements?

Since these measurements will determine the chemical formula, if the numbers are inaccurate, then the formula will also be inaccurate.

2. List the measurements you will be taking in this experiment:

1. Mass of copper gluconate
2. Volume of 1.0% wt/v NaCl
3. Mass of 50 mL recovery beaker
4. Mass of copper and beaker

3. What wastes are produced in this reaction?

Aluminum gluconate, sodium chloride solution, copper metal

4. Copper gluconate is the copper salt of D-gluconic acid. D-Gluconic acid loses one H to form the gluconate ion that bonds to copper. The gluconate ion has the molecular formula $C_6H_{11}O_7$. What is the molar mass of the gluconate ion?

Carbon: $6 \times 12.011 = 72.066$ amu
Hydrogen: 11×1.008 amu = 11.088 amu
Oxygen: $7 \times 15.999 = 111.993$ amu
Gluconate ion = 195.147 g/mol

5. Research and evaluate the hazards for all chemicals you will be using. Study the procedure and look for other possible hazards that exist. List all hazards including ones from chemicals. What protective equipment will you need to use?

Protective equipment needed:

Safety goggles, oven mitts, tongs, hood

Equipment hazards:

Oven and hot plate: Burns

Glassware: Cuts from broken glass

Chemical hazards:

Copper gluconate: May cause eye, skin, respiratory or gastrointestinal irritation.

NaCl: May cause eye, skin, respiratory or gastrointestinal irritation.

Name _____

Data

Mass of copper gluconate: 0.501g

Mass of beaker: 28.674g

Mass of beaker + copper: 28.746g

Mass of copper: 0.072g

Observations

Students should observe bubbling and a color change as the reaction progresses. Other recorded observations should include any abnormalities or notes of recovery process.

Calculations

Mass of copper recovered:

$$(\text{Mass of beaker + copper}) - (\text{Mass of beaker})$$

$$28.746 \text{ g} - 28.674 \text{ g} = 0.072 \text{ g Cu}$$

Moles of copper recovered:

$$(\text{mass of copper recovered}) \left(\frac{1 \text{ mol Cu}}{\text{MW Cu}} \right)$$

$$0.072 \text{ g} \times \frac{1 \text{ mol Cu}}{63.55 \text{ g Cu}} = 0.00113 \text{ mol Cu}$$

Mass of gluconate:

$$\text{Mass of copper gluconate} - \text{Mass of copper}$$

$$0.501 \text{ g} - 0.072 \text{ g} = 0.429 \text{ g}$$

Moles of gluconate:

$$\text{Mass of gluconate} \times \left(\frac{1 \text{ mol gluconate}}{\text{MW Gluconate}} \right)$$

$$0.429 \text{ g} \times \left(\frac{1 \text{ mol gluconate}}{195.15 \text{ g Gluconate}} \right) = 0.00220 \text{ mole gluconate}$$

Chemical formula:

$$\text{Cu}_{\text{mol copper}} \text{Gluconate}_{\text{mol gluconate}}$$

$$\text{Cu}_{(\text{mol copper}/\text{mol copper})} \text{Gluconate}_{(\text{mol gluconate}/\text{mol copper})}$$

$$\text{Cu}_{0.00113/0.00113} \text{Gluconate}_{0.00220/0.00113} = \text{Cu}_1 \text{Gluconate}_2$$

$$\text{Formula} = \text{Cu}(\text{C}_6\text{H}_{11}\text{O}_7)_2$$

Analysis

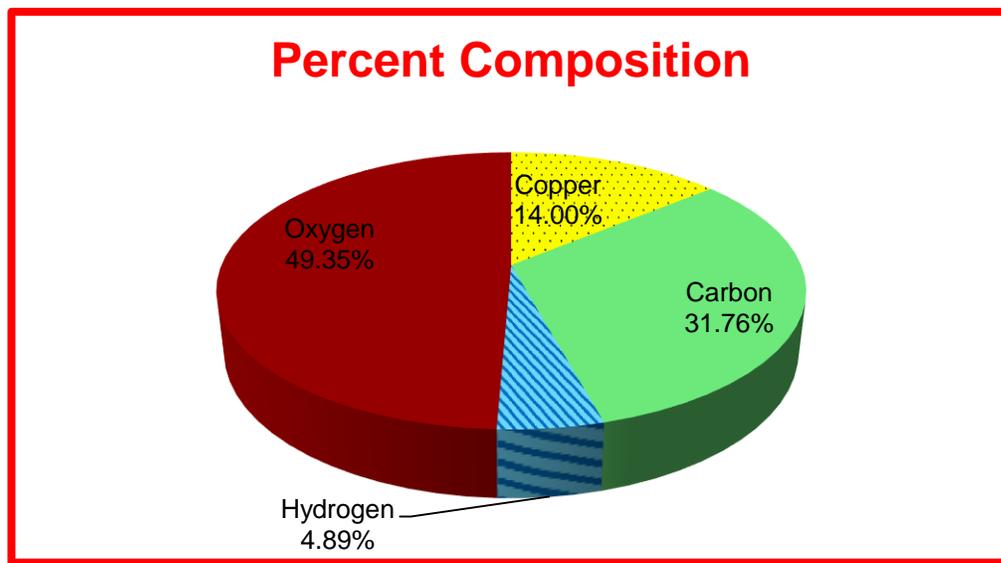
1. What is the formula of your compound?



2. List two sources of error in your experiment and explain the impact they had on your results.

Answers will vary.

3. Create a pie chart showing the percentage composition for each element in the compound copper gluconate; clearly label each element and the percentage.



Think green

1. Copper (II) chloride can be used as a source of copper for this experiment, but copper gluconate is preferred due the fact that it is a greener compound. Compare the percent copper in both compounds. Look up the (Material) Safety Data Sheet or (M)SDS for both compounds. In terms of green chemistry, discuss the advantages of using copper gluconate instead of copper chloride in this experiment.

$\% \text{ Cu in CuCl}_2 = \frac{63.55}{134.45} \times 100 = 47.27\%$ compared to 14.00% shown above for copper gluconate. Copper gluconate is also a lower health risk. The rest of the discussion will vary.

2. Copper (II) sulfate pentahydrate can also be used as a source of copper. Why would the procedure you did not work as it is written? How would you change the procedure so that you could determine its chemical formula? If time and resources permit, test your hypothesis. Determine which of the 12 principles of green chemistry would be negatively impacted by changing to copper (II) sulfate pentahydrate and discuss the reasons for your answer.

Since it is a hydrate, the water molecules would have to be removed by heating first at a high temperature and the number of water molecules calculated. This would negatively impact energy efficiency and safety.