THE UNIVERSITY OF TENNESSEE KNOXVILLE

Empirical Formula of Copper Compounds

Objectives

Investigate properties of hydrates

Determine the empirical formula of unknown copper hydrates

Perform a RedOx reaction to precipitate a metal from solution

Introduction

- **Empirical Formula**: the simplest ratio of elements present in a compound
- Could match the exact molecular formula for the compound.
- Could be something more different than the molecular formula:
    - Glucose ***molecular*** formula : $C_6H_{12}O_6$
    - Glucose ***empirical*** formula : CH_2O

Today's Experimental Hydrates

Today's experimental hydrates are copper chloride and copper sulfate:

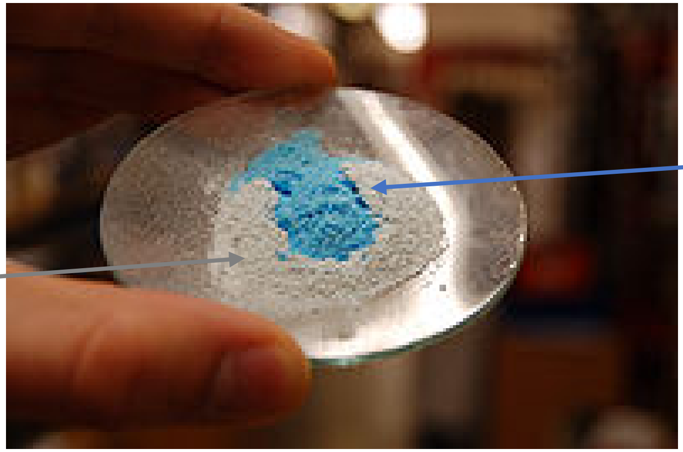
$$Cu_{a}Cl_{b}\cdot xH_2O \quad \text{and} \quad Cu_{a}(SO_4)_{b}\cdot xH_2O$$

Where a, b and x are integers.

1) Determine mass of each element.
2) Calculate number of moles of each element.
3) Express the ratio of moles of each element as smallest whole number.

What is a Hydrate?

- A hydrate is any salt that has water chemically bound to the crystal structure.
- Hydrates are typically colorful.
- When heated, they lose the bound water and the color.



Copper Sulfate (hydrate)

Copper Sulfate (anhydrous)

Hydrate: An Example

$CoCl_2 \bullet 6H_2O$ cobalt(II)chloride hexahydrate

$$CoCl_2 \bullet 6H_2O_{(s)} \xrightarrow{\Delta} CoCl_{2(s)} + 6\,H_2O_{(g)}$$

>> >> Turns from pink to **blue** when heated.

<< << Turns from **blue** to pink when water is added

Calculations

- Since water can be driven off from the hydrate, you will heat your sample [$Cu_aCl_b \,.\, x\, H_2O$] to remove water.
  - By recording the mass before and after heating, you can determine grams of ***water***. This will find ***x***.

$$x\ moles = mass\ H_2O\ (g) \times \frac{1\ mole}{18.015\ g}$$

- A chemical reaction between the anhydrous product and aluminum will result in elemental copper.

$$\mathbf{Cu_aCl_b + Al \longrightarrow Cu(s) + Al\,Cl_3}$$

- By comparing the mass before and after the chemical reaction, you can determine the moles of ***copper***. This will help to find ***a***.

$$\text{a}\ moles = mass\ Cu(g) \times \frac{1\ mole}{63.546\ g}$$

- By difference you can determine the remaining moles of *chlorine*. This will help to find *b*.

$$\text{b}\ moles = mass\ Cl(g) \times \frac{1\ mole}{35.45\ g}$$

Calculations

- Express the ratio of the moles of each component as their small, whole number ratios

  - If you find you have 5 moles of Cu, 11 moles of Cl, and 14 moles of H_2O, divide by the lowest value of moles.

    Cu: 5/5 = 1 (a) Cl: 11/5 = 2.2 ≈ 2 (b) H_2O: 14/5 = 2.8 ≈ 3 (x)

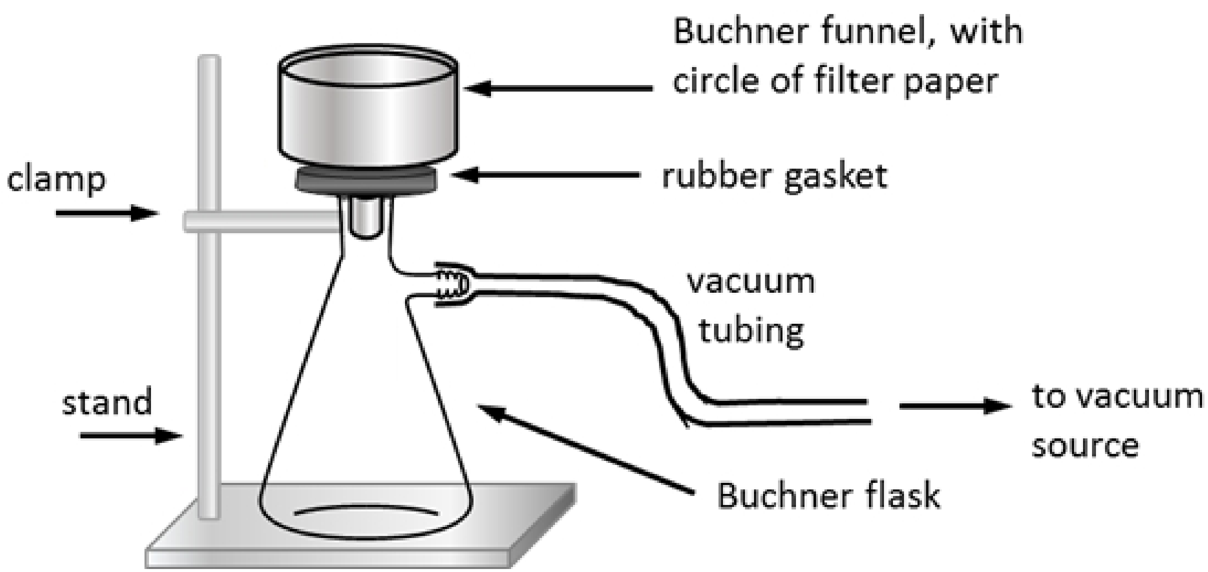
  - Empirical Formula: $CuCl_2 \cdot 3H_2O$

Experimental Notes

Step 3	• **Don’t look too closely. The material may occasionally pop.**
Step 4	• **After cooling, make sure you weigh your evaporation dish + dehydrated sample**
Step 7	• **Don’t add the full amount of Al. Add small pieces one at a time but make sure the pieces are large enough that they can be removed easily.**
Step 10	• **Remove excess Al and rinse with DI water into funnel** • **Clean the funnel between uses and use a new piece of filter paper**
All	• **Use the same balance throughout the experiment**

Vacuum Filtration

- Set up vacuum flask.
- Clamp Down Flask
- Turn vacuum FULLY ON.



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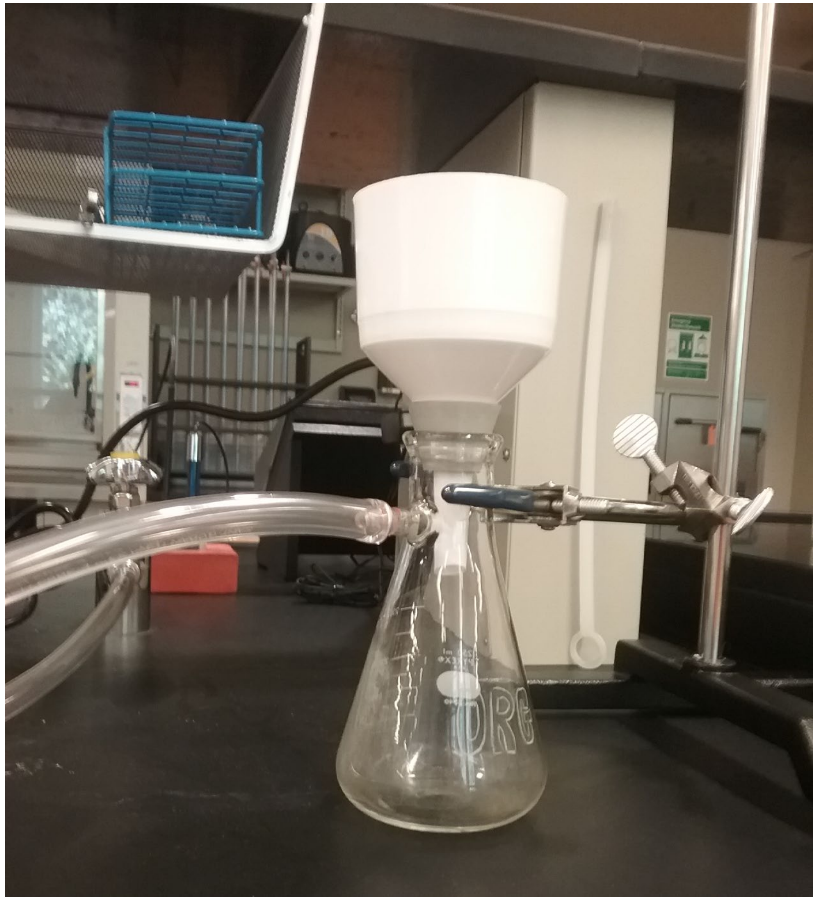

Vacuum Filtration Video

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Hazards and Waste Disposal

Hazards

- Using strong acid. Be careful with spills
- Use thermal gloves or tongs to pick up heated evaporating dish.

Waste Disposal

- Discard solid copper in the Trash Can.
- Discard liquids in Aqueous Waste container in fume hood.

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