Student's Card 2 **Copper, never ending recycling**

Module 2

Objective: Lab experiment - Recovery of copper from printed circuited board

Introduction

Electronics waste, commonly known as e-scrap and e-waste, is the trash we generate from surplus, broken and obsolete electronic devices.

Electronics are full of valuable materials including copper, tin, iron, aluminum, fossil fuels, titanium, gold, and silver. Many of the materials used in making these electronic devices can be recovered, reused and recycled, including plastics, metals, and glass.

Here, we explore the role of copper products in meeting present and future societal needs such as renewable energy, healthcare, more energy efficient transportation and modern communications.

It's hard to imagine a world without copper. We rely on copper for power, lighting, heating, communications, water supply and transport. Copper makes our homes, schools and businesses efficient, comfortable and decorative and it lasts for many years.

You are going to explore Copper's life cycle, why Copper is considered a circular material and how Recycling saves CO_2.

Necessities

Reagents	Formula		Quantity (g) or Concentration (M)
Nitric Acid	HNO_3		12M
Sodium Hydroxide	NaOH		6M
Sulfuric Acid	H_2SO_4		6M,3M
Zinc solid	Zn		
Deionized water			

List of materials/tools

- 4 beakers
- Glass-rod stirrer
- Glass stirring rod
- Ring stand, wire gauze
- Bunsen burner
- Graduated cylinder
- Funnel, filter
- Balance

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Lab Procedure

Step I: Oxidizing Cu with concentrated nitric acid, $HNO3_{(aq)}$

CAUTION: Concentrated nitric acid reacts with copper metal to form brown *toxic* NO2 gas. Leave the reaction beaker in the fume hood until all of the brown gas is vented in the hood.

1. Remove the thin layer green over the PCB (printed circuit board) using a piece of sand-paper
2. Mass the electronic circuit.
3. In a fume hood, use a graduated cylinder to carefully measure about 5 mL of concentrated nitric acid 12M, $HNO3_{(aq)}$. Slowly pour the nitric acid onto the electronic circuit in the beaker, swirling the beaker to maximize contact between the Cu and nitric acid until all of the solid Cu has dissolved and the NO2 gas has escaped.

Keep the reaction beaker in the hood until all the toxic brown NO_2 gas is gone, and keep your face away from the hood to avoid inhaling nitric acid fumes and NO_2 gas.

Describe the reaction between HNO_3 and the Cu metal in your lab report.

4. Dilute the resulting solution with about 10 mL of deionized water. Describe the appearance of the resulting solution containing Cu^{2+} in your data table.

Step II: Precipitating $Cu(OH)_{2(s)}$ with $NaOH_{(aq)}$

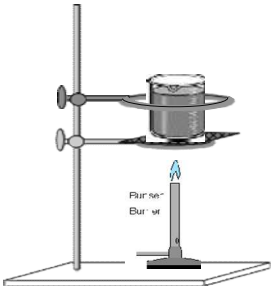
CAUTION: Sodium hydroxide (NaOH) can easily damage eyes. It is corrosive and can cause chemical burns and damage clothing. Any NaOH splashed into eyes or spilled on skin must be rinsed immediately with water for 15 minutes. Any base spilled on your work area must be neutralized then the entire area should be washed and dried.

1. While constantly stirring the Cu solution, slowly add 6M $NaOH_{(aq)}$ from the dropper bottles. First, the OH^- from the NaOH added will neutralize the excess acid left over from step I.
2. Once all the acid is neutralized, additional OH^- ions react with the Cu^{2+} to form $Cu(OH)_{2(s)}$, a blue precipitate.

Record what you observe in your lab report.

When adding more NaOH does not produce more precipitate, the solution can be tested to determine if all the Cu^{2+} has been precipitated and additional OH^- has made the solution basic. Use red litmus paper to test if the solution is basic as follows. *Without disturbing any precipitate*, use a glass stir rod to place a drop of **solution** (NOT the precipitate) on a piece of red litmus paper. If it turns blue, the solution is basic. Stop adding NaOH when the solution turns red litmus paper blue. Describe your litmus test in your lab report.

Step III: Converting $Cu(OH)_{2(s)}$ to $CuO_{(s)}$



1. Set up a ring stand as shown in the figure at the right. Set up a ring clamp, and put a wire gauze on top of it. Above it, attach another ring clamp with a diameter large enough to go around a 250-mL beaker. You are going to set your 250 mL beaker on the lower ring and gauze. The upper clamp will hold the beaker in place so it does not fall.

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2. Add about 30-40 mL of deionized water to your reaction beaker from Part II. Carefully place the beaker on the ring stand inside the upper ring.

CAUTION: Gently heat the beaker over a medium flame. Constantly stir the solution with the glass end of the stirring rod until all the blue precipitate turns black, and the solution is clear. If the solution starts to bump or boil, immediately remove the beaker from the heat and let the solution cool slightly.

Describe what happens to the $Cu(OH)_2$ precipitate upon heating in your lab report.

3. Filtrate

Step IV: Dissolving $CuO_{(s)}$ with sulfuric acid, $H_2SO_{4(aq)}$

CAUTION: Sulfuric acid, $H_2SO_{4(aq)}$, is corrosive, so it can cause severe chemical burns and damage clothing. Handle with care and avoid breathing the fumes. Any sulfuric acid spilled on skin must be rinsed immediately with water for 15 minutes. Any acid spilled on your work area must be neutralized, and the entire area should be washed and dried.

Add about 16 mL of 6M sulfuric acid, H_2SO_4 (check the label before pouring), to the funnel to dissolve the CuO precipitate. Allow the solution to drain through the funnel to the rinsed 250 mL beaker. Repeat the procedure until all of the CuO solid dissolves to Cu^{2+} ions. Use as little of the sulfuric acid as possible in this step.
Describe the reaction between the CuO precipitate and the H_2SO_4 in your lab report.

Step V: Reducing Cu^{2+} ions with Zn Metal

a. Use a weighing boat to measure and transfer about 1 g of Zn mesh to the Cu^{2+} solution in the 250 mL beaker. Constantly stir the mixture with a *glass stirring rod*. Do not use any metal object that will react with the acid to stir the solution. Continue stirring until all the Cu^{2+} ions have been reduced to Cu metal as indicated by the solution becoming colorless. Dissolve any excess Zn by adding a few drops of 3M $H_2SO_{4(aq)}$.
   Describe your observations of the reduction of Cu^{2+} to Cu metal.
b. Filter the solution.
c. Dry the filter containing copper in the oven (between the hoods) to let the Cu completely dry. Check it after about 10 minutes. If the copper pieces are loose then it is dry. If it appears black in color, then the copper has been heated too much and has turned to copper (II) oxide.
d. When the Cu appears completely dry, let the evaporating dish cool to room temperature, and weigh the evaporating dish with the Cu.
   Record the final mass in your lab report.

Wash and dry all of your glassware, equipment, and your lab area to prevent chemical contamination and potential hazards.

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Additional Safety Notes

Look at each step the red safety notes

Calculations

Calculating Percent Copper Recovered

Theoretically, the mass of Cu recovered should be equal to the mass of the original Cu sample. The overall efficiency of the experiment is measured by calculating the percentage of copper recovered:

$$\textbf{Percent recovered} = \frac{\textbf{Mass of final product}}{\textbf{Mass of initial sample}} \times 100$$

Ideally, the percent recovered should be close to 100%, which indicates that most (if not all) of the copper was successfully transformed through all five parts of the experiment.

Questions/Quiz

For each equation shown below (1 for each step of the copper cycle), indicate

a. the products of the equation, include phases of all products,
b. balance the equations, and tell what type of equation it is: combination, decomposition, single replacement, double replacement (precipitation), or acid/base neutralization (**Hint:** Many metal oxides can function as bases in aqueous solutions).

Step I

$$__\ Cu_{(s)} + __\ HNO_{3(aq)} \rightarrow __Cu(NO_3)_{2\,(aq)} + __NO_{(g)} + __H_2O_{(l)}$$

Observations: _____

Type of reaction: _____

Step II

$$__Cu(NO_3)_{2(aq)} + __\ NaOH_{(aq)} \rightarrow _____ + _____$$

Observations: _____

Type of reaction: _____

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Step III

___$Cu(OH)_{2(aq)}$ → _____ + ____$H_2O_{(l)}$

Observations: _____

Type of reaction: _____

Step IV

__ $CuO_{(s)}$ + ___$H_2SO_{4(aq)}$ → _____ + _____

Observations: _____

Type of reaction: _____

Step V

____ $CuSO_{4(aq)}$ + ___$Zn_{(s)}$ → _____ + _____

Observations: _____

Type of reaction: _____