**For Teachers** **Copper, never ending recycling**

# Module 2

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

## Necessities

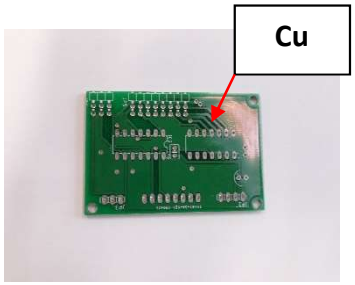
**List of materials/tools**

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

| Reagents | Formula | ! | Quant. (g) or Concentr.(M) |
|---|---|---|---|
| **Nitric acid** | HNO3 | | 12 M |
| **Sodium Idroxide** | NaO H | | 6 M |
| **Sulfuric acid** | $H_2SO_4$ | | 6 M, 3M |
| **Zinc** | Zn | - | metal |
| **Deionized water** | $H_2O$ | - | - |

## Lab Procedure

Disassemble all the electronic parts.




Remove the green layer over the PCB (printed circuit board) using a piece of sand-paper.

**Step 1** - Oxidizing Cu with concentrated nitric acid $HNO_3$

$$3\,Cu_{(s)} + 8\,HNO_{3\,(aq)} \rightarrow 3\,Cu(NO_3)_{2\,(aq)} + 2NO_{(g)} + 4H_2O_{(l)}$$

The first step involves transforming Cu metal to copper (II) ions, $Cu^{2+}$, using concentrated nitric acid, $HNO3_{(aq)}$. At the same time, the nitrate ions ($NO_3^-$) undergo a series of reactions to form nitrogen monoxide, NO. This product rapidly reacts with oxygen in the air to form NO2, a brown gas. The presence of $Cu^{2+}_{(aq)}$ makes the solution blue.

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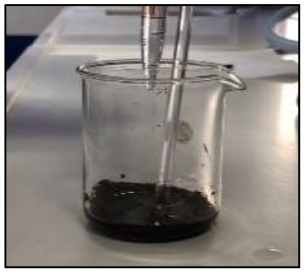
## **Step 2 -** Precipitating $Cu(OH)_2$ with NaOH

$$Cu(NO_3)_{2(aq)} + 2\ NaOH_{(aq)} \rightarrow Cu(OH)_{2(aq)} + 2NaNO_{3(aq)}$$

Two reactions are carried out by adding $NaOH_{(aq)}$ 6M. In the first reaction, the hydroxide ions ($OH^-$) from the $NaOH_{(aq)}$ neutralize the excess hydronium ions ($H_3O^+$), once all the $H_3O^+$ ions are neutralized, additional $OH^-$ ions react with the $Cu^{2+}$ ions to form $Cu(OH)_2$ precipitate. When all the $Cu^{2+}$ ions have reacted, no more precipitate forms. Adding more $OH^-$ ions makes the solution basic, so it can turn red litmus paper blue.

## **Step 3 -** Converting solid $Cu(OH)_2$ to solid CuO

$$Cu(OH)_{2(aq)} \rightarrow CuO_{(s)} + H_2O_{(l)}$$



Heat the solution on bunsen. The CuO precipitate is separated from the solution, called the **supernatant liquid**, using a method called **gravity filtration**. The mixture is filtered using a filter funnel, and the solid is collected on filter paper. The supernatant liquid runs through the filter paper and collects in a beaker. This resulting filtered solution is called the **filtrate**.

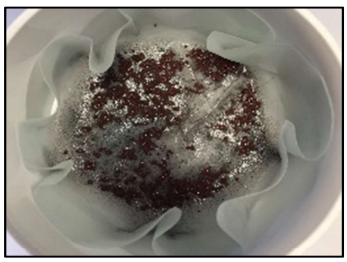
## **Step 4** - Dissolving CuO with sulfuric acid, $H_2SO_4$

$$CuO_{(s)} + H_2SO_{4(aq)} \rightarrow CuSO_{4(aq)} + H_2O_{(l)}$$

CuO precipitate is dissolved using sulfuric acid, $H_2SO_{4(aq)}$. This redox reaction returns copper to its aqueous phase.

## **Step 5** - Reducing $Cu^{2+}$ ions with Zinc metal

$$CuSO_{4(aq)} + Zn_{(s)} \rightarrow ZnSO_{4(aq)} + Cu_{(s)}$$



Zinc metal (Zn) is added to the copper solution to convert the copper ions back to copper metal, $Cu_{(s)}$. The resulting solution will contain colorless zinc ions, $Zn^{2+}_{(aq)}$ and copper solid. Visible evidence of this reaction is observed as bubbles of gas being released form the solution. (Since the H3O+ ions do not dissolve the Cu metal, the amount of copper yielded is not affected by excess acid.)
Identify the gas displaced from the acid in this reaction.
When the solution becomes colorless, all of the $Cu^{2+}$ ions have been converted to Cu metal.
All of the excess Zn metal is also converted to $Zn^{2+}$ ion by the excess $H_3O^+$ ions from the sulfuric acid, $H_2SO_{4(aq)}$, used to dissolve the CuO precipitate in step 4.
Once all the Zn metal is dissolved, the Cu metal can be isolated by **filtration**. The Cu will then be rinsed, dried, and weighed as described in the procedure.

## **Step 5** - Realize a lab report of your experience.

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## Additional Safety Notes

***Step I***

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.

*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.*

***Step II***

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.

***Step IV***

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.

## 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.