

# Cycle of Copper Reactions

Minneapolis Community and Technical College

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**Objectives:** To observe and document copper's chemical changes in five different reactions and verify that copper is conserved throughout.

To identify and classify various types of chemical reactions.

**Prelab Questions:** Read through this lab handout and answer the following questions before coming to lab. There will be a quiz at the beginning

1. What are the oxidation numbers for nitrogen and hydrogen in  $\text{NH}_4^+$ ?
2. For each of the five reactions below, identify it as precipitation, single replacement, double replacement, acid-base neutralization, oxidation/reduction, decomposition, gas formation, or combustion. If a reaction falls into more than one category, list all possibilities.
3. What color is a solution that contains  $\text{Cu}(\text{NO}_3)_2(\text{aq})$ ?
4. What color is a solution that contains  $\text{CuSO}_4(\text{aq})$ ?
5. What important conservation principle do we hope to prove by weighing the copper before and after the reactions occur?
6. What two waste products must be collected separately?
7. What is "bumping" and how do we avoid it in this experiment?

## Introduction

To a beginning student of chemistry, one of the most fascinating aspects of the laboratory is the dazzling array of sights, sounds, odors (Don't breathe any fumes in this experiment!), and textures that are encountered there. You will carry out a series of reactions involving the element copper and carefully observe and record your observations. The sequence of reactions begins and ends with copper metal, so it is called a *cycle of copper reactions*. Because no copper is added or removed between the initial and final steps, and because each reaction goes approximately to completion, you should be able to recover almost all of the copper you started with... if you are careful.

This cycle of reactions consists of the following 5 reactions:



## Experiment: Cycle of Copper

### Safety Notes:

- **You will be working in the fume hood for all parts of today's experiment.**
- A squeeze pipette can be useful for transferring the HNO<sub>3</sub> from a small beaker to your 10-ml graduated cylinder. Wash your hands after handling HNO<sub>3</sub>.
- Reaction 1, must be carried out in a fume hood. The brown NO<sub>2</sub> gas that is evolved is **TOXIC**.
- NaOH solutions are corrosive to the skin and especially dangerous if splashed into the eyes—*wear your safety glasses*.
- Methanol is flammable and its vapors are toxic. Use in the hood to avoid breathing the vapor, and *keep away from all open flames*.
- **WASTE COLLECTION:** It is both better for the environment and less expensive to MCTC if we collect waste products in separate containers. Please note the following two waste products require special attention.
  - *The solution you pour off after reaction 5 contains zinc sulfate and will be collected in a separate waste container.*
  - *The used methanol used to rinse the reaction 5 product is also collected separately.*



1. Obtain a pure copper wire ball that weighs about 0.5 g.
2. Weigh the copper wire ball to the nearest 0.1 milligram using an analytical balance.
3. Place the pre-weighed copper in the bottom of a 250-mL beaker.
4. Add ~4.0 mL of concentrated (16 M) nitric acid, HNO<sub>3</sub>.
5. Continue working in the hood and gently swirl the solution in the beaker until the copper has completely dissolved.
6. After the copper has dissolved, carefully add distilled water until the beaker is approximately half full.



1. While stirring the solution with a glass rod, add 30 mL of 3.0 M NaOH. (No Heat)
2. Stir well.



1. Preheat ~ 200 mL of distilled water in a separate beaker using the corner of your hotplate (350 degrees).
2. Warm your reaction mixture using the center of the hotplate. **Stir at all times** to avoid "bumping" (formation of large, uncontrollable boiling bubbles). Do not allow the solution to boil. If it is necessary to cool the mixture, move it to the corner of the hotplate where its cooler.
3. When the reaction is complete, remove the beaker from the hot plate, continue stirring for a minute or so, and then allow the CuO to settle.

If the CuO doesn't settle significantly, re-heat and stir the mixture for 3-5 more minutes and try again.

4. Decant (pour off) the supernatant liquid using another beaker. Avoid transferring CuO solid as you decant.
5. ADD ABOUT 200mL of the preheated distilled water to the CuO.
6. Allow the solid to settle and decant again.



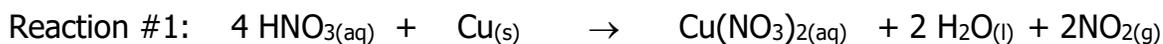
1. While stirring, add 15 mL of 6 M H<sub>2</sub>SO<sub>4</sub>, to the CuO.
2. Transfer the resulting solution into a 100 or 150 mL beaker.



1. In the fume hood, add 2.0 - 2.1 g of granulated zinc metal all at once to your reaction mixture. Stir until the supernatant liquid is colorless and all of the Zn is consumed.
2. Pre-weigh a dry evaporating dish (figure at right) on the analytical balance.
3. Decant the supernatant liquid into **the waste container** provided and transfer the copper to the evaporating dish. A spatula or rubber policeman is helpful when making this material transfer.
4. Wash the copper product with about 5 mL of distilled water, allow it to settle, and decant the wash water into the Zn solution waste container provided.
5. Repeat washing /decanting at least two more times.
6. Now wash the solid with approximately 5 mL of methanol from a squirt bottle. Allow the solid to settle, and decant. *Dispose of the methanol in the methanol recovery container.*
7. *Repeat the methanol washing step a second time and dispose of it properly.*
8. Place the evaporating dish on your hot plate (150 degrees). The methanol will quickly evaporate leaving you with dry copper metal. Hint: Position the hotplate at the rear of the hood to keep drafts from cooling the dish/product during the drying process.
9. When the copper has properly dried (...think dry beach sand), let the evaporating dish cool and re-weigh it on the analytical balance. Avoid excess heating as it produces undesirable copper oxides.



Observations: Record at least two observations in the spaces below.



Initial Copper Mass = \_\_\_\_\_

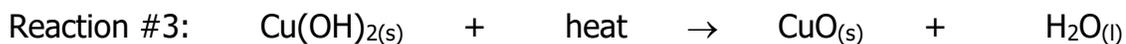
Observations:

1. \_\_\_\_\_
2. \_\_\_\_\_



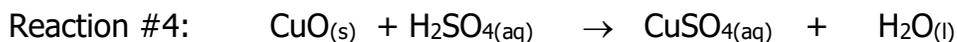
Observations:

1. \_\_\_\_\_
2. \_\_\_\_\_



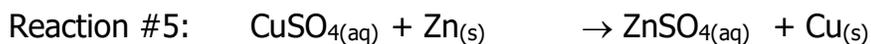
Observations:

1. \_\_\_\_\_
2. \_\_\_\_\_



Observations:

1. \_\_\_\_\_
2. \_\_\_\_\_



Empty Evaporating Dish Mass = \_\_\_\_\_

Evaporating Dish + Product Mass = \_\_\_\_\_

Final Copper Mass = \_\_\_\_\_

Observations:

1. \_\_\_\_\_
2. \_\_\_\_\_



Answers to pre-lab questions:

1. Oxidation numbers: H ... +1    N ... -3
2. Reactions:
  - Reaction #1: Oxidation/reduction & gas formation
  - Reaction #2: Precipitation & double replacement
  - Reaction #3: Precipitation & decomposition
  - Reaction #4: Double replacement
  - Reaction #5: Oxidation/reduction, single replacement & precipitation
3. Blue
4. Blue
5. Conservation of Mass. The mass of the copper should not change throughout the experiment.
6. Zinc sulfate (reaction #5) solution and methanol (used for product drying)
7. "Bumping" is sudden, almost explosive boiling that can propel liquid out of its container.  
You will stir constantly to avoid a superheated solution that could bump.