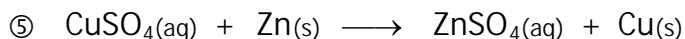
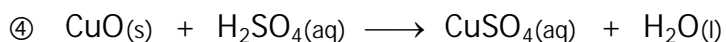
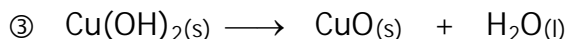
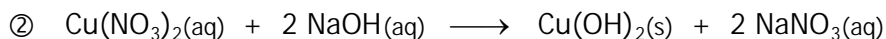
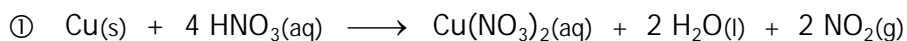
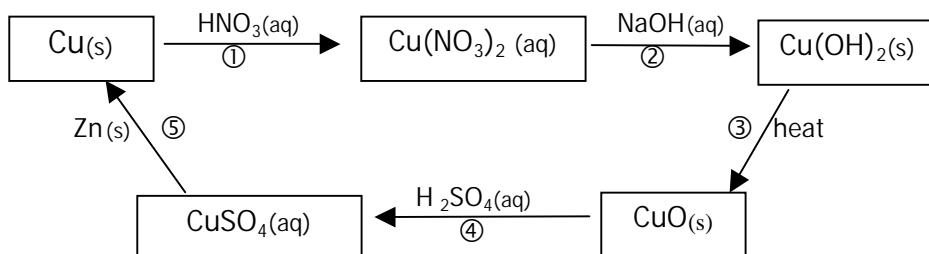


# EXPERIMENT 8: REACTIONS OF COPPER

## INTRODUCTION

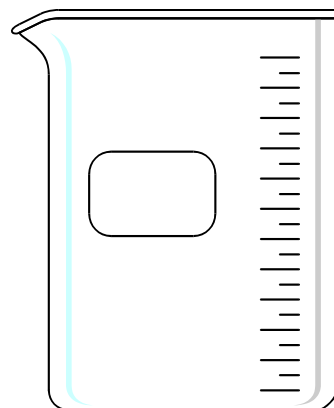
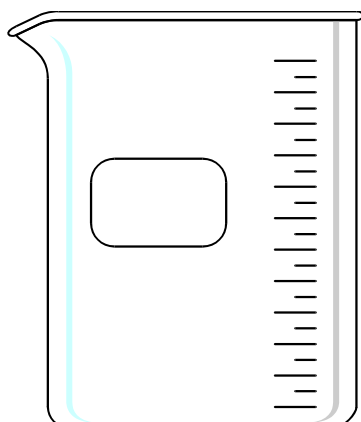
In this experiment you will observe a sequence of copper reactions. The sequence begins with copper metal and ends with copper metal, so it is called a cycle of copper reactions. The diagram below shows (in an abbreviated form) the cycle of copper reactions.



As you carry out each reaction in the cycle you will work carefully to avoid loss of Cu in the process so that you recover the same amount of copper that you began with. The success of your copper metal recovery will be reflected in your percent recovery (percent yield). At each step you will identify possible sources of error in your recovered copper.

You will also classify the reactions as combination, decomposition, single replacement or double replacement.

Throughout the experiment you will make careful observations that you will record in detail on your Report Sheet. You will note such things as a solid going into solution and report the color of the solid and the resulting color of its solution. If a reaction mixture becomes cloudy, you will allow the solid to settle and then observe the color of the precipitate as well as the solution above it. You will also need to identify what ions are present in each solution. If you see bubbles forming in your reaction mixture, you will record the color and identity of the gas that has formed.



## **CAUTION**

**CONCENTRATED (16 M) NITRIC ACID SOLUTION:** DANGER! CORROSIVE! STRONG OXIDIZER! Contact with other material may cause a fire. Vapors are irritating and may cause permanent eye damage. May cause severe respiratory tract OR severe digestive tract irritation with possible burns. Can cause redness, pain, and severe skin burns. Concentrated solutions cause deep ulcers and stain skin a yellow or yellow-brown color.

**NITROGEN DIOXIDE GAS:** DANGER! POISON! CORROSIVE! Highly toxic by inhalation. Inhalation may be fatal. Causes severe eye damage. Contact lenses should not be worn if you may be exposed to nitrogen dioxide.

**6 M SODIUM HYDROXIDE SOLUTION:** DANGER! POISON! CORROSIVE! May be fatal if swallowed. Harmful if inhaled. Causes burns to any area of contact.

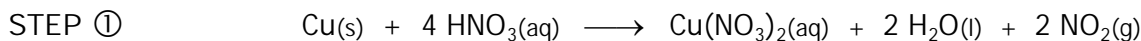
**6 M HYDROCHLORIC ACID SOLUTION :** DANGER! POISON! CORROSIVE! Liquid and mist cause severe burns to all body tissue. Inhalation of vapors can cause coughing, choking, inflammation of the nose, throat, and upper respiratory tract, and in severe cases, pulmonary edema, circulatory failure, and death.

**3 M SULFURIC ACID SOLUTION :** DANGER! POISON! CORROSIVE! Extremely corrosive, causes serious burns. Highly toxic. Harmful by inhalation, ingestion and through skin contact. Ingestion may be fatal. Skin contact can lead to extensive and severe burns. Chronic exposure may result in lung damage and possibly cancer.

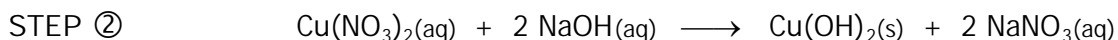
## PROCEDURE

[Reminder: NEVER RETURN EXCESS REAGENTS TO REAGENT BOTTLE S!]

### Reactions of Copper



1. Weigh a clean, dry evaporating dish accurately. Record the mass on your Report Sheet.
2. Obtain a piece of copper wire. Place the copper into the evaporating dish and weigh the copper plus evaporating dish accurately, recording the mass on your Report Sheet.
3. Transfer the copper wire to a labeled (with your name or initials) 250 mL beaker and place it under the FUME HOOD. Your instructor will put on a pair of rubber gloves and carefully add 4.0 mL of concentrated (16 M) nitric acid,  $\text{HNO}_3$ , solution to your copper. Swirl the solution to remove the brown  $\text{NO}_2$  gas. Record your observations on your Report Sheet. (Include identities of all of the solutes in the solution.)
4. After the copper has dissolved, carefully (slowly!) add approximately 100 mL deionized water to your copper solution to dilute it. (Note: You are adding water to acid!)



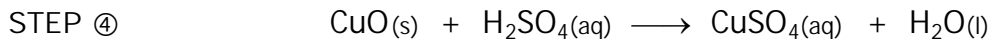
1. Return to your lab bench and VERY SLOWLY add 15 mL of dilute (6 M) NaOH solution to the mixture from step 1 while stirring the mixture with a glass stirring rod. It is important to add the NaOH slowly, because the reaction between NaOH and the  $\text{HNO}_3$  is exothermic. (If your mixture warms up too much, it may cause the reaction in step 3 to occur and you will not be able to observe the step 2 reaction.)
2. Allow the precipitate (which is a gelatinous solid) to settle, then test the solution with litmus to be sure it is basic. If it is not, add 5 mL of the 6 M NaOH solution.
3. Wait until the precipitate settles before you make your observations. Be sure to note the color of the precipitate as well as the color of the solution. (There should be no blue color in the solution.)



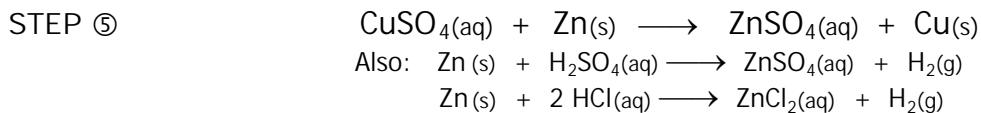
1. Using a Bunsen burner, heat the mixture from step 2 until it has just barely reached boiling, while stirring continuously and gently with a glass stirring rod to prevent "bumping" (a phenomenon caused by the formation of a large bubble in a locally overheated area of the liquid in the beaker)
2. Continue to heat gently while stirring. When the transformation is complete (the color change of the precipitate is complete) remove the burner, continue stirring for a minute or two, and then allow the solid to settle.
4. Record all observations on your Report Sheet.
5. Decant the supernatant liquid into a clean beaker (being careful not to lose any CuO).
6. Wash the solid two or three times, each time adding about 50 mL of hot deionized water and swirling the mixture, then allowing the solid to settle and decanting off the supernatant (the wash water) into a clean beaker. (If the precipitate is not washed well, the ions in remaining solution will prevent the reaction in Step 4 from taking place.)
7. Cover the beaker containing the washed CuO precipitate with a watch glass and store it in the designated cabinet under the Fume Hood. The designated cabinet is labeled "CuO/Cu solution".



Do not begin step 4 unless there is at least 1 hour left in the lab period .



1. Add 15 mL of 3 M  $\text{H}_2\text{SO}_4$  solution to the CuO precipitate, while stirring. All of the black solid must dissolve.
2. Record all of your observations on your Report Sheet.



1. Weigh out about 1.3 g of granular zinc. Take the Zn and the reaction mixture from step 4 to the FUME HOOD where you will add the Zn to the mixture all at once. The reaction is complete when the solution is colorless. If the Zn is completely dissolved but the solution is still blue, add more zinc.
2. When the solution is colorless (the evolution of gas should be slow), decant the supernatant liquid into a clean beaker.
3. If any silvery grains of unreacted zinc are present, add 10 mL of Dil (6 M) HCl. Complete dissolving of zinc is indicated when bubbles of hydrogen gas cease to be evolved.
4. Record all of your observations on your Report Sheet.
5. Allow the copper to settle, then decant the supernatant solution into a clean beaker.
6. Wash the solid twice, each time adding about 50 mL of deionized water and swirling the mixture, then allowing the solid to settle and decanting off the supernatant (the wash water) into a clean beaker.
7. Transfer all the copper to the evaporating dish using a little deionized water to wash all the copper from the beaker. Decant the water used in transferring.

## DRYING THE COPPER

1. Place the evaporating dish with the copper on a steam bath (250 mL beaker filled 2/3 with water heated to boiling) to dry to constant mass—to within 0.0050 g.
2. Record your observations and the mass of the dish plus copper on your Report Sheet.
3. Show your instructor your copper sample to get it approved.

# REPORT SHEET - EXPERIMENT 8

Name \_\_\_\_\_  
(last) (first)

Instructor's initials \_\_\_\_\_

## DATA

Mass of Evaporating Dish			
Mass of Dish + Copper Wire			
Mass of Dish + Recovered Copper			

Instructor Approval of Recovered Copper (initials/stamp) \_\_\_\_\_

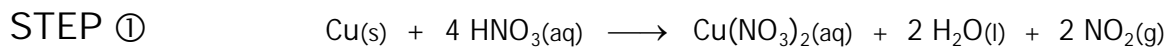
## CALCULATIONS

1. Mass of Cu Wire

2. Mass of Recovered Copper

3. Percent Recovery

## OBSERVATIONS



Observations:

a. \_\_\_\_\_

b. \_\_\_\_\_

c. \_\_\_\_\_

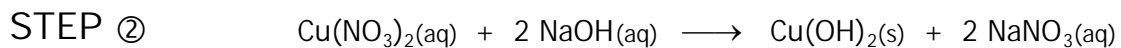
What solute particles are present in the solution when the reaction is complete? \_\_\_\_\_

Which ion in the solution gives it the blue color? \_\_\_\_\_

Possible sources of error in the procedure at this step:

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

Instructor Approval of Observations \_\_\_\_\_



Reaction Type: \_\_\_\_\_

Observations:

a. \_\_\_\_\_

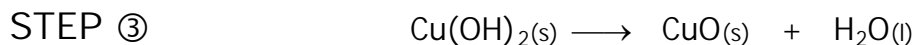
b. \_\_\_\_\_

What solute particles are present in the solution when the reaction is complete? \_\_\_\_\_

Possible sources of error in the procedure at this step:

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

Instructor Approval of Observations \_\_\_\_\_



Reaction Type: \_\_\_\_\_

Observations:

\_\_\_\_\_

What solute particles are present in the solution when the reaction is complete? \_\_\_\_\_

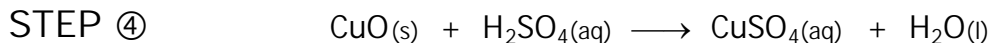
What would happen if the precipitate was not washed well to remove these solutes?

\_\_\_\_\_

Possible sources of error in the procedure at this step:

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

Instructor Approval of Observations \_\_\_\_\_



Reaction Type: \_\_\_\_\_

Observations:

- a. \_\_\_\_\_
- b. \_\_\_\_\_

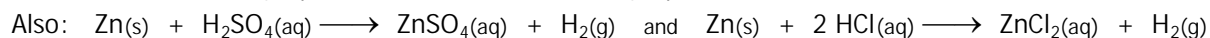
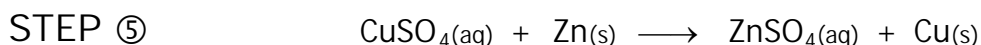
What solute particles are present in the solution when the reaction is complete? \_\_\_\_\_

Which ion in the solution gives it the blue color? \_\_\_\_\_

Possible sources of error in the procedure at this step:

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

Instructor Approval of Observations \_\_\_\_\_



Reaction Type: \_\_\_\_\_

Observations:

- a. \_\_\_\_\_
- b. \_\_\_\_\_
- c. \_\_\_\_\_
- d. \_\_\_\_\_

What gas is produced in the reactions? \_\_\_\_\_

What solute particles are present in the solution when the reaction is complete? (The solutes that are removed by decanting and washing the Cu)

\_\_\_\_\_

What color is the washed copper? \_\_\_\_\_

What color is the recovered (dry) copper? \_\_\_\_\_

Possible sources of error in the procedure at this step:

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

Instructor Approval of Observations \_\_\_\_\_

## QUESTIONS

1. What are three possible reasons why the percent recovery might be less than 100%?

a. \_\_\_\_\_

b. \_\_\_\_\_

c. \_\_\_\_\_

2. What are three possible reasons why the percent recovery might be greater than 100%?

a. \_\_\_\_\_

b. \_\_\_\_\_

c. \_\_\_\_\_

FOR THE FOLLOWING PROBLEMS, GIVE COMPLETE SETUPS WITH ALL UNITS AND LABELS. BE SURE SIGNIFICANT FIGURES ARE CORRECT.

3. What volume, in mL, of 3.00 M NaOH are required to react with 5.00 mL of 16.0 M H<sub>2</sub>SO<sub>4</sub>?

(molar masses: NaOH = 40.00 g/mole, HNO<sub>3</sub> = 63.01 g/mole)

4. What volume, in mL, of 6.00 M NaOH are required to react with 0.785 g Cu<sup>2+</sup> to produce Cu(OH)<sub>2</sub>?

(molar masses: NaOH = 40.00 g/mole, Cu = 63.546 g/mole, Cu(OH)<sub>2</sub> = 97.56 g/mole)

5. What is the theoretical mass of CuO that can be produced from 4.831 g Cu?  
(molar masses: Cu = 63.546 g/mole, CuO = 79.55 g/mole)

6. Iron may be obtained from Fe<sub>2</sub>O<sub>3</sub> according to the following reaction:



- a. Assuming a 90.0% recovery, what mass of iron, in grams, would actually be produced by 927 g Fe<sub>2</sub>O<sub>3</sub>? (molar masses: Fe<sub>2</sub>O<sub>3</sub> = 159.69 g/mole, CO = 28.01 g/mole, Fe = 55.85 g/mole, CO<sub>2</sub> = 44.01 g/mole)
- b. What is the theoretical mass, in grams, of Fe produced when 250.0 g Fe<sub>2</sub>O<sub>3</sub> reacts with 126.0 g CO?