Copper Reactions and Percent Recovery

# Introduction

In this investigation, a sample of copper metal is taken through several reactions, forming many different aqueous and solid copper compounds, until copper metal is once again reconstituted in the final step. Observations of the chemical changes and the physical properties of the copper-containing products are recorded for each step.

Masses of the original copper sample and final copper product are recorded to determine the percent recovery for the experiment.

In the first step, copper metal (in the form of copper wool) is dissolved in nitric acid, forming copper(II) nitrate, nitrogen dioxide gas, and water. Next, copper(II) nitrate reacts with sodium hydroxide to form a copper(II) hydroxide precipitate.

Upon heating, copper(II) hydroxide decomposes to copper(II) oxide and water. Copper(II) oxide is then converted into copper(II) sulfate.

Finally, when hydrochloric acid and aluminum are added to the solution, the aluminum dissolves, forming aluminum ions and a solid copper precipitate.

Reactants include concentrated nitric acid, sulfu­ric acid, hydrochloric acid, and sodium hydroxide. All these reagents are danger­ous if not handled properly; therefore, it is important to follow directions care­fully and act responsi­bly in the laboratory.

# Materials and Hazards

* Concentrated HNO3 (Nitric Acid) – Corrosive, Oxidizer, Marine Pollutant
* 6.0 M HCl (Hydrochloric Acid) – Corrosive, Poisonous, Toxic
* 3.0 M NaOH (Sodium hydroxide) - Corrosive, Mutagenic, Toxic
* 3.0 M H2SO4 (Sulfuric acid) - Corrosive, Carcinogenic, Poisonous
* Copper Wool – Marine Pollutant
* Medium-sized Test tubes
* Aluminum foil
* Filter paper
* 10 mL graduated cylinder
* 150 mL beaker
* Glass stirring rod
* Filtering flask
* Buchner funnel, hose, and gasket

# Procedure

## Step 1: Copper to copper(II) nitrate

1. Obtain a sample of copper wool. A few strands will be sufficient. Describe its physical characteristics on the Report Sheet.
2. Weigh approximately 0.1 grams of copper on a balance to the closest 0.001 g, roll it up into a ball and drop it into the bottom of a medium-sized test tube.

SAFETY WARNING: Nitric acid is very corrosive. If spilled on the skin, flush the affected area immedi­ately with water.

1. **In a fume hood**, *slowly* add 20 drops of concentrated nitric acid, one drop at a time, to the test tube. Record your observations of the reaction on the Report Sheet.

SAFETY WARNING: The brown fumes produced by the reaction are VERY TOXIC! Perform the reaction in the fume hood.

1. Add 10 mL of deionized water from a wash bottle to the test tube to end the production of brown fumes. Wait until all the fumes have dissipated before removing the test tube from the fume hood and returning to your workstation.
2. Pour the solution into a 150 mL beaker. Rinse the test tube with 10.0 mL of deionized water and add the rinse to the beaker. Describe the physical properties of the product, copper(II) nitrate.

## Step 2: Copper(II) nitrate to copper(II) hydroxide

Add approximately 5.0 mL of 3.0 M NaOH to the copper solution. Record your observations of the reaction and the physical properties of the product, copper(II) hydroxide on the Report Sheet.

SAFETY WARNING: Sodium hydroxide is a very corrosive base. If spilled on the skin, flush the affected area immedi­ately with water.

## Step 3: Copper(II) hydroxide to copper(II) oxide

1. Add approximately 10.0 mL of deionized water from the wash bottle to the beaker to make a total volume around 35 – 40 mL.
2. Heat the solution on a hot plate set to a medium-high temperature. The reaction will occur first where the solution is hottest, at the bottom of the beaker.

Once a change is observed, a glass rod may be used to stir the solution *but leave the rod in the beaker* until the final steps of the activity and do not begin to stir until a change is noted in the solution first. Record your observations of the reaction on the Report Sheet.

1. When the solution is no longer blue, the reaction is complete. Remove the beaker from the hot plate and allow the copper(II) oxide to settle. Describe the physical properties of the product, copper(II) oxide.

## Step 4: Copper(II) oxide copper(II) sulfate

Add approximately 5.0 mL of 3.0 M H2SO4 to the beaker and stir the solution with the stirring rod. Record your observations of the reaction on the Report Sheet and describe the aqueous solution.

SAFETY WARNING: Sulfuric acid is very corrosive. If spilled on the skin, flush the affected area immedi­ately with water.

## Step 5: Copper(II) sulfate to copper metal

1. Submerge a 4.0 cm2 square (2.0 cm by 2.0 cm) piece of aluminum foil into the solution. **In the fume hood**, add 40 drops of 6.0 M HCl solution. Copper will form on the surface of the foil. Stir the solution and press on the foil with the stirring rod to expose the surface of the aluminum foil. The reaction is complete when the copper appears in clumps and none of the metal resembles a sheet of foil.

Record your observations on the Report Sheet. After all bubbling has subsided, take the solution back to your workstation.

1. Set-up a vacuum filtration apparatus as demonstrated by instructor.  Weigh a piece of filter paper and record the mass on the Report Sheet. Label the paper with an identifying mark and place it in the base of the funnel.
2. Turn on the vacuum filtration and pour the contents of the beaker into the funnel. If necessary, add a bit of deionized water from a wash bottle to the beaker, swirl, and add it to funnel to ensure that all the copper has been recovered.
3. Rinse the solid copper on the filter paper with water from the wash bottle until clean. Describe the physical properties of copper metal.
4. Turn off filtration apparatus and place the filter paper and copper on a watch glass. Place the product in a drying oven set to 700 C for 10 minutes.
5. Cool the filter paper and product and weigh it on a balance. Record the mass of the paper and product on the Report Sheet to the closest 0.001 g.

# Data and Results

To calculate the percent recovery, divide the mass of the product by the mass of the original sample and multiply by 100 to make it a percent:

# Clean Up

Put the filtrate and copper product in the labelled waste container. Throw the filter paper in the trash. Wash all glassware and return it to its original location.