

Matter and Minerals
Fall 2005

Chemistry Lab
Week 4

We will meet in Lab II, 1234 on Thursday of Week 4, from 9 a.m. – 12 noon

**This lab is adapted from
Gordon T. Yee, Jeannine E. Eddleton, and Cris E. Johnson, Journal of Chemical
Education, Volume 81, Page 1777, (2004)**

**Presented by
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Experiment 1

Copper Metal from Malachite Circa 4000 BCE

Introduction

The smelting of copper ore to obtain copper metal probably represents one of the big steps man made in his quest to utilize the natural resources in his environment for his benefit. In this experiment, we will mimic the steps the Copper Age Man might have used to produce copper metal from its ore. Our starting material will be malachite. Another copper containing mineral is azurite. Today however, azurite and malachite are more important as semiprecious stones used in jewelry than as sources of copper metal.

The procedure for isolating copper metal from malachite involves two steps:

Step 1: Roasting malachite to drive off carbon dioxide and water to produce copper(II) oxide.

Step 2: Reduction of the copper(II) oxide using carbon to produce copper metal.

Carbon (charcoal) is used in the second step to reduce copper(II) oxide to metallic copper. Charcoal is hardwood that has been heated in the absence of oxygen to drive off volatile organic compounds. As a result, it burns hotter and faster than wood. When charcoal is burned, a mixture of carbon monoxide and carbon dioxide are produced. Therefore it is very dangerous to burn charcoal indoors.

Pre-Lab Questions (answers to be submitted at the START of Lab)

Read the entire lab write-up three times.

Please show all work when doing calculations.

1. What is the chemical formula of malachite?
2. What is the color of malachite?
3. State two other physical properties of malachite.
4. What is the percentage by mass of copper in malachite?
5. What is the chemical formula of azurite?
6. What is the color of azurite?
7. State two other physical properties of azurite.
8. What is the percentage by mass of copper in azurite?
9. Write a balanced equation for the first step of the reaction (roasting malachite to form copper(II) oxide, carbon dioxide and water)
10. Write a balanced equation for the second step of the reaction (reaction of copper(II) oxide with charcoal to produce copper metal, carbon monoxide and carbon dioxide)

Experimental Procedure (work in pairs)

Use the analytical balance only for weighing in all steps.

Step 1: Roasting malachite to drive off carbon dioxide and water to produce copper(II) oxide

Obtain one malachite bead from your instructor. Clean and accurately weigh the sample to the nearest milligram in a weighing boat. Transfer the sample to a crucible and cover the crucible with its lid. Save the weighing boat to use again in the next step. In the hood, assemble a Bunsen burner and an iron ring on a ring stand and place an iron triangle on the ring (as demonstrated in class). Place the crucible in the triangle and adjust the height of the ring such that the tip of the inner blue

cone of the Bunsen burner is touching the bottom of the crucible. **Using the blue flame of the burner**, heat the crucible for about 15 minutes to transform malachite to copper(II) oxide. **OBVIOUSLY, THE CRUCIBLE, THE METAL RING AND STAND GET VERY HOT.** Also, the flame sometimes can go out, so check on your burner. If the flame goes out, relight it, but remember that all surfaces will be hot. After the heating period, remove the heat and allow the crucible to cool for 15 minutes. Use tongs to handle the crucible. Remove the crucible from the stand and determine the mass of the copper(II) oxide product. Record the physical properties of your product.

Step 2: Reduction of the copper(II) oxide using carbon to produce copper metal

Add a little bit of charcoal powder to your crucible and then carefully transfer the copper(II) oxide you made into the crucible. Add enough charcoal powder to cover the copper(II) oxide. Gently tap the crucible once on the bench to help settle the contents. Cover the crucible and heat it on the Bunsen burner (same setup as before) for 90 minutes. Make sure that you are using the blue flame of the burner. Otherwise the reaction will not produce what you desire. **(While this is heating, start on Experiment 2).** Remove the flame and allow the covered crucible to cool for 15 minutes. Pour out the contents onto a clean, watch glass and isolate the copper metal using a spatula. Use a soft brush/clean paper towel to remove any charcoal stuck to your product. If it isn't shiny, try wiping it on a paper towel to remove the thin layer of carbon attached to the surface. When you have cleaned your piece of copper, weigh it and record the weight.

Characterization of the copper

- Record physical properties of your copper sample.
- Take a hammer and strike your disk a few times. Record observations. What property of copper is being demonstrated here? Is it a physical or a chemical property?
- Then take a piece of fine sandpaper or steel wool and polish the flattened surface. Record your observations. What property of copper is being demonstrated here? Is it a physical or a chemical property?
- If your sample is deep red, chalky, and falls apart, your sample is not copper metal. What could it be? Why were you unable to obtain pure copper? If this is the case, you need to continue the rest of the experiment with another group that had better luck producing copper from malachite.
- Set up a simple circuit with a battery, a light bulb and some wires. Use your piece of copper as a “switch” in this circuit. See if you could turn the light bulb on and off using your “copper switch”. Draw a block diagram of your circuit in your lab notebook. What property of copper is being demonstrated here? Is it a physical or a chemical property? **Be sure to get your circuit checked by an instructor before you proceed.**

Density Determination

Determine the density of your copper sample. You may want to combine your sample with that of four or five other groups in the lab to get a larger volume change (recall from past labs that small volume changes lead to large errors).

The published value of the density of copper is 8.92 g/cm^3 . Determine your percentage error. If your experimentally determined density for copper differs significantly from the value in the literature (i.e. your percentage error is large), give some reasons for why this might be the case.

Post-lab questions

- One possible side reaction of Step 2 is the reduction of copper(II) oxide to copper(I) oxide. What is the chemical formula of copper(I) oxide?
- Copper(I) oxide is a red, non-metallic solid. Write a balanced equation for the production of Copper(I) oxide from copper(II) oxide and carbon. Another product of this reaction is carbon dioxide.
- How could you deal with the production of Copper(I) oxide if you wanted Cu metal? (You can imagine that Copper Age Man had to address this problem).
- Calculate a percent yield for the roasting step (Step 1).
- Calculate a percent yield for the reduction step (Step 2) and for the overall reaction starting from pure malachite to copper.

Experiment 2**Determination of the amount of copper in “old” and “new” pennies****Pre-Lab Assignment:**

On October 21st, 1982, the Bureau of the Mint changed the composition of pennies. Use the library (**a book, a journal, a magazine, or a newspaper but not the web**) to find the composition of “old” and “new” pennies. You need to find the metals used in the “old” and “new” pennies as well as their composition by mass. Give the reference of your source.

Lab Procedure:

In this experiment, you will determine the composition of a “new” penny and an “old” penny. Obtain a new penny and an old penny from the instructor.

- Record physical observations of the two pennies (the years in which they were minted would be important).
- Using metal cutters, cut each penny in half being careful not to get them mixed up!
- Weigh each penny (both halves) separately with an analytical balance.
- Obtain two 100 mL beakers and label them “old” and “new” and with your name.
- Add about 20 mL of 1M hydrochloric acid to each of the beakers. **Put the beakers in the hood away from any flames.**
- Place the new penny halves in the beaker labeled “new” and the old penny halves in the beaker labeled “old”.
- Write down any observations.
- Leave the pennies in the beakers until you cannot see any reaction in the beaker. Write down observations when you think the reaction is complete.
- Using tongs and gloved hands, remove the pennies from the beaker, being careful to keep the “new” and “old” parts separate. **From now on, be careful to keep the “new” and “old” parts separated from each other.**

- Gently wash under the sink until all trace of acid is gone.
- Wipe with a paper towel until the pieces are completely dry, being careful not to lose any fragile parts.
- Weigh the “new” and “old” parts separately and record them.
- Use your data to determine the amount of copper in the “new” penny and in the “old” penny.
- Determine the amount of zinc in the “new” penny and the “old” penny from your data.
- Use your data to determine the % by mass of copper and zinc in the “new” penny and in the “old” penny.
- Calculate the percentage error for the % by mass of copper and zinc for both types of pennies (using your reference data as the “accurate value”).
- Give reasons for your errors.