The following lesson was provided by Janet Bruelhart, a chemistry teacher at Lovington High School in Lovington, NM. An excerpt was printed in the Spring Issue # 35 of Lite Geology.

The Removal of Copper from a Carbonate

Introduction

Malachite is a mineral rich in copper. Its chemical formula is $Cu_2CO_3(OH)_2$. When malachite is heated, carbon dioxide gas and water vapor are released and copper (II) oxide remains along with any impurities found in the mineral. In chemistry class, copper (II) carbonate can be used to model the decomposition of malachite. There are similarities in the formulas of each, copper(II) carbonate is $CuCO_3$, and malachite is a basic form of copper (II) carbonate with OH^- ions attached. The equation for the decomposition of the copper (II) carbonate is:

$$CuCO_{3(s)} \quad CuO_{(s)} + CO_{2(g} \qquad \text{(decomposition)}$$

The equation for the decomposition for malachite is almost the same, except that water vapor is also a product.

$$Cu_2CO_3(OH)_{2(s)} \quad 2CuO_{(s)} + CO_{2(g)} + H_2O_{(g)} \qquad \text{(decomposition)}$$

In this experiment, a bead of malachite will be crushed and heated in a crucible to form the copper(II) oxide. The copper(II) oxide will be treated with sulfuric acid in a double replacement reaction resulting in a deep blue copper (II) sulfate solution as follows:

$$CuO_{(s)} + H_2SO_{4(aq)} \quad CuSO_{4(aq)} + H_2O_{(l)} \qquad \text{(double replacement)}$$

The blue copper(II) solution is collected, and finally, freshly sanded iron nails are added to the copper (II) sulfate and allowed to rest overnight. A single replacement reaction results in copper deposited onto the iron nails as follows:

$$CuSO_{4(aq)} + Fe_{(s)} - FeSO_{4(aq)} + Cu_{(s)} \qquad \text{(single replacement)}$$

Objective

This lab can be adapted to be more quantitative by using the pure copper (II) carbonate and taking precise measurements of mass before heating and after heating to calculate the amount of carbon dioxide released. The amount of copper in the resultant copper (II) oxide can be determined stoichiometrically and compared to the theoretical yield. Those calculations can be used to determine the percent error.

This lab can also be adapted to be more inquiry based for a beginning chemistry class as a lab on types of reactions by removing the equations and having students predict the products when given only reactants. Prior knowledge of polyatomic ions and types of reactions would allow the students to write their own chemical equations as three different types of reactions are done.

Remarks

Supplies are found in general chemistry labs. Malachite beads are easily obtained from online sources or mineral shops. The 8mm beads are placed inside a plastic bag and crushed with a hammer. They are then ground further with a mortar and pestle.

Use caution with sulfuric acid. Goggles and aprons must be worn by all. When heating crucibles with a Bunsen burner, students must realize that very high temperatures are achieved, and there is a risk for burns. Open flames must be respected with caution.

Materials

2-3 malachite beads (approx 1-2 grams), ground

crucible with lid

ring stand with ring

clay triangle

Busen burner

2-400 mL beakers

200 mL 1M H_2SO_4

glass stirring rod

watch glass

sandpaper

small iron nails

tongs

funnel

filter paper

Procedure

1. Obtain a clean crucible with a cover, weigh and record its mass. Add about 1 to 1.5 grams of ground malachite. Weigh and record the mass of the crucible with cover and the ground malachite in the data table. Record your observations.

2. Prepare the ring stand and ring. Place a clay triangle on the ring, and place the crucible with its lid and contents on the clay triangle. Light the Bunsen burner and heat the bottom of the crucible gently for a few minutes, then lower the crucible so that the bottom of the crucible is

the top of the inner blue cone of the flame and heat the crucible vigorously. The bottom of the crucible should glow. Shut off the Bunsen burner after about ten minutes. Remove the crucible with the tongs onto a piece of wire mesh and allow it to cool. Weigh and record the mass of the crucible, lid, and contents. Record any color changes or observations.

3. Remove the contents of the crucible into one of the 400 mL beakers. Slowly add the sulfuric acid to the beaker and stir with the glass stirring rod to dissolve as much of the crucible contents as possible. Record your observations.

4. Set up a funnel with filter paper. Place an empty 400 mL beaker beneath the funnel. Stir the contents of the beaker with the sulfuric acid and crucible contents with the glass stirring rod, and filter the contents of the beaker. Wash the filter paper with a small amount of distilled water. Discard the filter and its contents. Place 2-3 freshly sanded iron nails into the beaker with the filtrate. Record your observations. Cover the beaker with a watch glass, label the beaker, and let it rest overnight. Clean and return all glassware and supplies.

5. On the following day, retrieve your beaker. Record your observations. Remove the nails with the tongs and place them on a paper towel. Record any additional observations. Return the nails to your teacher. Dispose of the contents of your beaker in the proper disposal container. Clean and replace any materials and supplies.

Data

Mass of empty crucible

_____

Mass of crucible with crushed malachite

_____

Mass of malachite

_____

Mass of crucible with CuO (after heating)

_____

Mass of CuO

_____

Observations

Record any observations such as the color and texture of the following:

1. crushed malachite

2. CuO

3. $CuSO_4$

4. nails after one minute in solution

5. nails after one day in solution

Discussion

1. Explain why there was a change in mass after the heating of the crucible and contents. Write a correct and balanced chemical equation.

2. Explain what happened when sulfuric acid was added to the crucible contents in the beaker. Write a correct and balanced chemical equation.

3. What do you think remained on the filter paper after filtration?

4. How do you know that a chemical reaction occurred when the nails were left in the solution for a day? Write a correct and balanced chemical equation.