EXPERIMENT 4B

Moles of Iron and Copper

The mole is a convenient unit for analyzing chemical reactions. The mole is equal to 6.02×10^{23} particles, or Avogadro's number of particles. More importantly, however, the mass of a mole of any compound or element is the mass in grams that corresponds to the molecular formula, or atomic mass. Simply stated, the atomic mass of copper is 63.5 amu, which means that the mass of one mole of copper atoms is equal to 63.5 g. Likewise, the molecular mass of water is equal to 18.0 amu, and the mass of one mole of water molecules is equal to 18.0 g.

The mole is the common language in chemical reactions. In this experiment, you will observe the reaction of iron nails with a solution of copper(II) chloride and determine the number of moles involved in the reaction.

OBJECTIVES

1. to determine the number of moles of copper produced in the reaction of iron and copper(II) chloride
2. to determine the number of moles of iron used up in the reaction of iron and copper(II) chloride
3. to determine the ratio of moles of iron to moles of copper
4. to determine the number of atoms and formula units involved in the reaction.

MATERIALS

Apparatus

beakers (250-mL)
wash bottle
stirring rod
crucible tongs
centigram balance
drying oven
safety goggles
lab apron
plastic gloves
sandpaper or emery cloth

Reagents

copper(II) chloride
2 iron nails (sixpenny size)
1*M* hydrochloric acid
distilled water

PRELAB

Answer questions 1-5 on the Report Sheet.

PROCEDURE

CAUTION: Copper(II) chloride is very poisonous and can kill you. Do not get it in your mouth. Do not swallow any.

1. Put on your lab apron, safety goggles and plastic gloves.
2. Find the mass of a clean, empty, dry 250-mL beaker. Record the mass to the nearest 0.01 g.
3. Add approximately 8 g of copper(II) chloride crystals to the beaker. Find the mass and record it on the Report Sheet.
4. Add 50 mL of distilled water to the beaker. Swirl the beaker around to dissolve all of the copper(II) chloride crystals.
5. Obtain two clean, dry nails. If the nails are not clean, use a piece of sandpaper to make the surface of the nail shiny. Find the mass of the nails and record it on the Report Sheet.
6. Place the nails into the copper(II) chloride solution, as shown in Figure 4B-1. Leave them undisturbed for approximately 20 min. During that time, you should see the formation of copper in the beaker. At the same time, some of the iron will be used up.
7. Use the tongs to carefully pick up the nails, one at a time. Use distilled water

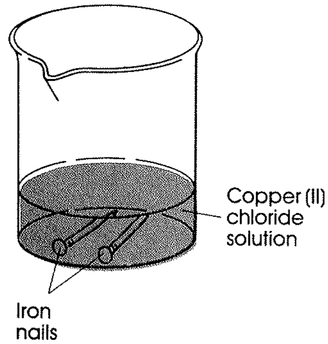

Figure 4B-1

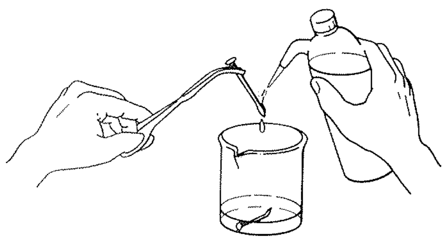

Figure 4B-2 *Any copper remaining on the nails may be washed back into the beaker with the use of distilled water from a wash bottle.*

CAUTION: Hydrochloric acid is corrosive to skin, eyes, and clothing. When handling 1M hydrochloric acid, wear safety goggles and a lab apron. Wash spills and splashes off your skin and clothing immediately using plenty of water. Call your teacher.

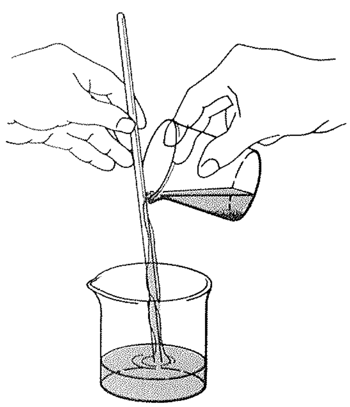

Figure 4B-3 *When decanting, it is helpful to direct the liquid into the second beaker along a stirring rod, as shown here.*

in a wash bottle to rinse off any remaining copper from the nails before removing them completely from the beaker. (See Figure 4B-2). If necessary, use a stirring rod to scrape any excess copper from the nails. Set the nails aside to dry on a paper towel.

8. After the nails are completely dry, find the mass of the nails and record it on the Report Sheet.
9. *Decant* means to pour off only the liquid from a container that is holding both solid and liquid. Carefully decant the liquid from the solid. (See Figure 4B-3.) Pour the liquid into another beaker so that in case you overpour, you can still recover the solid.
10. After decanting, rinse the solid again with about 25 mL of distilled water. Decant again. Repeat this step three or four more times.
11. Next, wash the solid with about 25 mL of 1*M* hydrochloric acid. Decant again; then, once more, clean the solid with 25 mL of distilled water.
12. After the final washing with water, place the copper in a drying oven to dry.
13. Allow the copper to become completely dry, then find the mass of the beaker plus the copper and record it on the Report Sheet.
14. Clean up all of your materials. Before you leave the laboratory, wash your hands thoroughly with soap and water; use a fingernail brush to clean under your fingernails.

POST LAB DISCUSSION

In this experiment, you have reacted some of the iron from the nail at the same time as you have produced some copper. In order to find the moles of each of these substances, you will need to divide the mass of the iron used or the copper produced by the molar mass. You can also determine the moles of copper(II) chloride that you started with by dividing the mass of the copper(II) chloride by the molar mass. By multiplying by Avogadro's number, you will be able to determine the total number of atoms involved in the reaction. Finally, you will determine the ratio of moles of iron used to moles of copper produced.

Moles of Iron and Copper

Name______________________________

Class ____________ Date ________________

EXPERIMENT 4B REPORT SHEET

PRELAB QUESTIONS

1. How many moles are present in a sample of 34.0 g of iron metal? __________________________

2. How many atoms of iron are present in 2 mol of iron? _________________________________

3. What is the formula mass of copper(II) chloride? ______________________________________

4. Why is the washing of the copper necessary in this experiment? __________________________

5. Define *decant.* ____

DATA

Before the reaction:

Mass of empty, dry beaker __________ g

Mass of beaker + copper(II) chloride __________ g

Mass of two iron nails __________ g

After the reaction:

Mass of two iron nails __________ g

Mass of beaker + copper (dry) __________ g

CONCLUSIONS

1. Find the following masses by the appropriate subtractions. Show all of your work.

   a. Mass of iron used in the reaction __________ g

   b. Mass of copper(II) chloride used __________ g

   c. Mass of copper produced __________ g

2. Find the number of moles of the following. (Show all work.)

   a. Moles of iron used _______________ mol

   b. Moles of copper produced _______________ mol

3. Find the number of atoms of each of the substances involved in the reaction. (Show all of your work.)

   a. Atoms of iron used _______________ atoms

   b. Atoms of copper produced _______________ atoms

4. Calculate the ratio of moles of copper produced to moles of iron used. (Show all work.)

   Ratio _______________

5. Was there any evidence that some of the copper(II) chloride was left in the beaker? Explain.

   ____

SYNTHESIS

1. Suppose that you have an unlimited supply of copper(II) chloride to react with iron. How many moles of copper would be produced by reacting 34.0 g of iron with the copper(II) chloride solution?

   Copper produced _______________ mol

2. How many moles of iron would have been used up if 45.0 g of copper were to be produced?

   Iron used up _______________ mol

3. How many atoms of copper would be involved in problem 2?

   Atoms of copper _______________

4. How many atoms of iron would be involved in problem 2?

   Atoms of iron _______________

5. How many grams of copper would be produced if 456 g of iron were reacted?

   Copper produced _______________ g