Iron Filings

A Mole Lab That Actually Works!

Introduction

Students will grasp the meaning of a mole and stoichiometry after performing this simple experiment.

Concepts

- Mole relations
- Oxidation–reduction

Background

Iron powder will react with copper(II) sulfate in a one-to-one ratio (1 mole to 1 mole). The students will also be able to more easily visualize the size of a mole of iron and copper. The results obtained in this lab usually have less than a one-percent error.

$Fe(s)$	+	$CuSO_4(aq)$	→	$FeSO_4(aq)$	+	$Cu(s)$
iron powder		copper(II) sulfate		iron(II) sulfate		copper

In the reaction, iron will be the limiting reagent; it will be completely used up in the reaction. Copper(II) sulfate will be in excess; not all of it will be used up in the reaction. The number of moles of iron that react will equal the number of moles of copper produced. The reaction indicates the 1:1 ratio between the iron and copper.

The occurrence of the reaction will be obvious since the blue copper(II) sulfate solution turns green due to the iron going into the solution. Copper metal is noticeably forming on the bottom. If the copper(II) sulfate solution is warm, the reaction occurs almost instantaneously.

This lab can also be used to illustrate a single replacement reaction and oxidation–reduction. As a single replacement reaction, iron replaces the copper in copper(II) sulfate to produce iron(II) sulfate and copper metal. As an oxidation–reduction reaction, the copper in copper(II) sulfate is reduced and the iron powder is oxidized. (Copper goes from a +2 oxidation state to a zero oxidation state while iron goes from a zero oxidation state to a +2 oxidation state.)

Materials

Copper(II) sulfate pentahydrate, $CuSO_4 \cdot 5H_2O$, 12.5 g
Iron powder, Fe, 2.24 g
Water, distilled or deionized, approximately 100 mL
Balance, accurate to 0.01 g
Beaker, 100-mL
Beaker, 250-mL
Graduated cylinder, 50-mL or 100-mL
Glass stirring rod
Hot plate
Oven or heat lamp (optional)
Weighing paper or weighing dish
(a 3″ × 3″ piece of paper will do)

Safety Precautions

Copper(II) sulfate (pentahydrate) is a skin and respiratory irritant. It is toxic by ingestion and inhalation (LD_{50} 300 mg/kg). Students should be warned not to ingest any of the materials, to use them only in the manner for which they are intended, and to wash their hands thoroughly after use. Wear chemical splash goggles, chemical-resistant gloves, and a chemical-resistant apron. Please review current Material Safety Data Sheets for additional safety, handling, and disposal information.

Procedure

1. Mass a clean, dry, 100-mL beaker. Record the mass in a data table.
2. Weigh out 12.5 g of copper(II) sulfate in the previously massed 100-mL beaker.
3. Using the graduated cylinder, measure out 50.0 mL of distilled water, and then add the water to the 100 mL beaker

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containing copper(II) sulfate.

4. On a piece of weighing paper, weigh out 2.24 g of iron powder. Set aside until Step 8.
5. Using a ring stand setup or hot plate, heat the beaker of copper(II) sulfate and water to about 50 °C. Do not boil the solution.
6. To help dissolve the copper(II) sulfate crystals, stir with a glass stirring rod or magnetic stirrer.
7. When all the crystals are dissolved, stop heating and remove the magnetic stirring bar, if used.
8. While stirring, carefully add the iron powder to the hot copper(II) sulfate solution. When all the iron has been added, let the solution sit for ten minutes to allow it to react. Stir it occasionally and record any observations.
9. When the ten-minute reaction time is up, decant the liquid into a 250-mL beaker. Be careful to pour off only the liquid.
10. To wash the solid, add about 10 mL of distilled water to the 100-mL beaker. Stir vigorously then let the solid settle to the bottom. Decant the liquid into the 250-mL beaker. Repeat the washing and decanting two more times.
11. Spread the solid product out on the bottom of the 100-mL beaker and let it dry overnight. An oven or heat lamp will speed up the drying process.
12. Weigh the beaker and dry the copper metal. Record the mass.
13. Answer questions 1–4 to complete calculations.

Disposal

Please consult your current *Flinn Scientific Catalog/Reference Manual* for general guidelines and specific procedures governing the disposal of laboratory waste. Wipe up any spills with wet paper towels and dispose of them in the trash. Solid copper can also be disposed of in the trash. The decanted liquid can be rinsed down the drain. Thoroughly wash equipment, work area, and hands when finished.

Connecting to the National Standards

This laboratory activity relates to the following National Science Education Standards (1996):

Unifying Concepts and Processes: Grades K–12
Evidence, models, and explanation
Constancy, change, and measurement
Content Standards: Grades 5–8
Content Standard B: Physical Science, properties and changes of properties in matter
Content Standards: Grades 9–12
Content Standard B: Physical Science, structure and properties of matter, chemical reactions

Tip

• Even more accurate results may be obtained by filtering the solution instead of decanting the liquid. The filter paper would need to be weighed before its use. The solid on the filter paper will dry much more quickly if opened and placed on a watch glass than by being left in the beaker. Remember, the result obtained by decanting is already less than one-percent error.

Questions

1. What is the mass of the copper produced?
2. Calculate the number of moles of copper produced.
3. What is the number of moles of iron reacted?
4. Find the whole number ratio of moles of iron to moles of copper.

Acknowledgment

Special thanks to Mr. Pat Funk, Chemistry Teacher, Watkins Memorial High School, Pataskala, OH, for supplying us with the procedure for this lab.

Materials for *Iron Filings—A Mole Lab That Actually Works!* are available from Flinn Scientific, Inc.

Catalog No.	Description
C0102	Copper(II) Sulfate, Pentahydrate, 100 g
I0014	Iron, Powder, 500 g
W0001	Water, Distilled, 1 Gallon

Consult the Flinn Scientific website for current prices.