Foiled Again — Aluminum Loses to Copper

A Redox Reaction

Introduction

Watch aluminum foil disappear as it is added to a green-blue solution of copper(II) chloride. Observe color changes, production of a gas, formation of solid metallic copper, and a drastic change in temperature. Learn the crucial role of a catalyst as the single-replacement, oxidation–reduction reaction proceeds.

Concepts

- Oxidation–reduction
- Catalysis
- Single replacement reaction

Materials (for each demonstration)

Aluminum foil, 6″ × 12″, 1 piece

Copper(II) chloride solution, $CuCl_2$, 0.5 M, 300 mL

Graduated cylinder, 250-mL

Beaker, Pyrex®, 600-mL
or Graduated cylinder, Pyrex®, 500-mL

Stirring rod

Safety Precautions

Copper(II) chloride solution is toxic by ingestion. Small volumes of hydrogen gas are produced from the reaction. Hydrogen is a highly flammable gas; keep flammable materials away from the reaction mixture. Wear chemical splash goggles, chemical-resistant gloves, and a chemical-resistant apron. This activity requires the use of hazardous components and/or has the potential for hazardous reactions. Please review current Material Safety Data Sheets for additional safety, handling, and disposal information. Wash hands thoroughly with soap and water before leaving the laboratory.

Procedure

1. Place a 600-mL Pyrex® beaker (or a 500-mL graduated cylinder) on the demonstration table.
2. Use a graduated cylinder to measure 300 mL of 0.5 M $CuCl_2$ solution. Pour this into the beaker.
3. Cut a piece of aluminum foil approximately 6″ × 12″. Loosely crumple the foil enough to fit into the beaker. *Note:* Do not wad up the foil tightly in a ball as this decreases the surface area and slows any reaction that may occur.
4. Place the piece of crumpled foil into the beaker, using a stirring rod to push it down completely into the solution. Notice the increase in temperature, indicating a very exothermic reaction.
5. Have students make detailed observations of the reaction occurring in the beaker. Have students generate hypotheses as to the reaction(s) that are occurring and have them write an equation for the reaction(s) they observe.
6. Test the various hypotheses by performing additional reactions. Some examples may include combining aluminum foil with: 0.5 M copper(II) sulfate solution (no reaction), 0.5 M sodium chloride solution (no reaction), or both copper(II) sulfate and sodium chloride solutions (reaction occurs).

Extensions

Test for hydrogen gas with a burning splint — Light a wood splint and hold it in the beaker over the bubbles that are released from the reaction. A positive test is indicated if a pop or a barking sound is heard.

Test for oxygen gas with a glowing splint — Light a wood splint and blow it out so that it is glowing. Hold the glowing splint over the bubbles that are released from the reaction. A positive test is indicated if the glowing splint re-ignites.

Results — Notice that hydrogen gas is released from the reaction. Discuss the origin of the gas. Write the chemical equation for the production of hydrogen gas. No oxygen is produced.

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Disposal

Please consult your current *Flinn Scientific Catalog/Reference Manual* for general guidelines and specific procedures governing the disposal of laboratory waste. Allow the solid material in the beakers to settle. Decant the copper(II) chloride solution down the drain according to Flinn Suggested Disposal Method #26b. Dispose of the solid copper and leftover aluminum foil in the solid waste according to Flinn Suggested Disposal Method #26a.

Discussion

In the demonstration, aluminum foil is added to an aqueous solution of copper(II) chloride causing a single replacement oxidation–reduction reaction to take place (see *Equation 1*).

$$2Al(s) + 3CuCl_2(aq) \rightarrow 2AlCl_3(aq) + 3Cu(s) \qquad \textit{Equation 1}$$

silver *green-blue* *colorless* *reddish*

The oxidation of aluminum metal to aluminum(III) (Al^0 to Al^{3+}) is visible by the dissolving of the aluminum foil to form aluminum chloride. The simultaneous reduction of copper(II) ions to copper metal (Cu^{2+} to Cu^0) will occur and solid copper metal precipitates from solution. As the copper(II) ions are reduced to copper, the green-blue solution color will fade until the solution is completely colorless—the indication that the reaction is complete and all of the copper(II) ions have been reduced.

It can be observed that hydrogen gas is simultaneously released from the reaction when aluminum metal foil is added to copper(II) chloride solution. If the pH of the copper(II) chloride solution is measured, it is found to be slightly acidic. Hence there are free hydrogen ions in solution, which cause the side reaction of hydrogen ions with the aluminum surface to form hydrogen gas and aluminum ions (See *Equation 2*). Due to the limited concentration of hydrogen ions, this reaction only consumes a small amount of the aluminum.

$$2Al(s) + 6\,H^+(aq) \rightarrow 2Al^{3+}(aq) + 3H_2(g) \qquad \textit{Equation 2}$$

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 of atoms, structure and properties of matter, chemical reactions

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Materials for *Foiled Again—Aluminum Loses to Copper* are available from Flinn Scientific, Inc.

Catalog No.	Description
A0019	Aluminum Foil
C0381	Copper(II) chloride solution, 0.5 M, 500 mL
AP5936	Foiled Again—Aluminum Loses to Copper—Chemical Demonstration Kit

Consult your *Flinn Scientific Catalog/Reference Manual* for current prices.