Ornament-Making Kit

Student Laboratory Kit

Introduction

Holiday fun—combine chemistry and art to design a holiday ornament!

Chemical Concepts

- Redox reactions

Background

Oxidation–reduction, or *redox*, reactions are reactions in which electrons are transferred from one element to another. There are two key parts present in every redox reaction—an element that is oxidized and an element that is reduced. *Oxidation* of an element occurs when the element donates electrons. The net result is that the charge on an oxidized substance increases (e.g., 0 to +2) during a chemical reaction. *Reduction* of an element occurs when an element accepts electrons. As a result, the charge on a reduced substance decreases (e.g., –1 to –2) during a chemical reaction. Because it is the *reduced* substance's charge that is *reduced*, this is often a convenient way to remember which is the oxidized and which is the reduced species.

Another way to look at a redox reaction is in terms of oxidizing and reducing agents. The substance that accepts electrons in a chemical reaction is the *oxidizing agent*, while the *reducing agent* is the substance that donates electrons. An easy way to identify the oxidizing and reducing agents in a chemical reaction is to look at the difference in charge on each species between the reactants and the products. The charge on the reducing agent increases during a chemical reaction—the reducing agent is oxidized. On the other hand, the charge on the oxidizing agent decreases during a chemical reaction—the oxidizing agent is reduced. In general, the reducing agent is oxidized by the oxidizing agent, and the oxidizing agent is reduced by the reducing agent.

Two redox reactions will be performed in this activity. In each case, the transfer of electrons may be followed by looking at the charges. The first reaction involves the oxidation of zinc metal by hydrogen ions.

$$Zn(s) + 2H^{+}(aq) \rightarrow Zn^{2+}(aq) + H_2(g)$$

In this reaction, the charge on Zn increases from 0 to +2, while the charge on H is reduced from +1 to 0. Therefore, Zn is oxidized and H is reduced. Since Zn is oxidized, it must have been oxidized by the oxidizing agent which must be H. Since H is reduced, it must have been reduced by the reducing agent which must be Zn. So, in this reaction, Zn is the reducing agent, and H is the oxidizing agent.

The second reaction to be performed in this activity occurs between iron and copper (II) ions. Can you identify the oxidizing agent and the reducing agent in this reaction?

$$Fe(s) + Cu^{2+}(aq) \rightarrow Fe^{2+}(aq) + Cu(s)$$

In this activity, a piece of galvanized iron is used to make an ornament. Galvanized iron is iron coated with a layer of zinc. The zinc protects the iron from rusting. The zinc layer is removed by submerging the galvanized iron in hydrochloric acid. The reaction between zinc and hydrochloric acid generates lots of bubbles from the formation of hydrogen gas.

$$Zn(s) + 2HCl(aq) \rightarrow ZnCl_2(aq) + H_2(g)$$

Once the zinc layer is removed, the iron surface then reacts with cupric nitrate. As the reaction occurs, copper is plated onto the surface of the iron.

$$Fe(s) + Cu(NO_3)_2(aq) \rightarrow Fe(NO_3)_2(aq) + Cu(s)$$

Therefore, everywhere that the zinc layer was first removed and then the iron layer was reacted with cupric ions, the color of the ornament is copper-colored. Everywhere the galvanized iron did not undergo the reaction, it remains the original silver color. By designing a pattern and only allowing part of the pattern to be exposed and undergo the reactions, the exposed part of the pattern will turn copper-colored, while the unexposed part will remain silver-colored. This redox concept can thus be used to create an ornament of creative and original design.

Materials

Chemicals

Acidified cupric nitrate solution, 0.05 M, $Cu(NO_3)_2$, 25 mL

Galvanized (zinc-coated) iron, 2½″ × 2½″ piece

Hydrochloric acid solution, 6 M, HCl, 50 mL

Equipment

Beaker, 250-mL

Beaker, 1-L

Cotton swab

Eraser

Graduated cylinder, 50-mL

Hanger

Masking tape

Paper towels

Pencil

Scalpel

Tongs

Acrylic sealer (optional)

Safety Precautions

Hydrochloric acid solution is corrosive to skin and eyes and is moderately toxic by ingestion and inhalation. Acidified cupric nitrate solution is slightly toxic by ingestion and is a skin, eye, and mucous membrane irritant. The edges of the galvanized iron are sharp; be careful of cuts and scratches. Wear chemical splash goggles, chemical-resistant gloves, and a chemical-resistant apron. Wash hands thoroughly with soap and water before leaving the laboratory.

Procedure

1. Completely cover both sides of a 2½″ × 2½″ piece of galvanized iron with masking tape. Mark where the hole is—this is the top of the ornament. Make sure that the edges of the galvanized iron are also covered.
2. Draw a simple design (such as your initials or name) on the masking tape with a pencil. Designs may be drawn on both sides of the piece of galvanized iron if desired. The design that is drawn will be the part of the ornament that is copper-colored. See Figure 1.
3. Use a scalpel to cut along the pencil marks. Remove the masking tape inside the drawing so that the design is uncovered. See Figure 1.

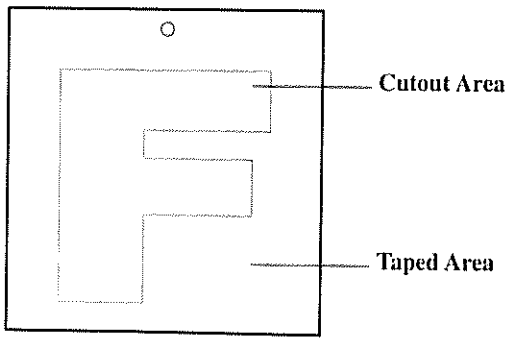

Figure 1.

4. *Caution:* 6 M hydrochloric acid solution is corrosive to skin and eyes; avoid all body tissue contact. Pour about 50 mL of 6 M hydrochloric acid solution into a 1-L beaker. Share this beaker of hydrochloric acid solution with three other students. Obtain four stacks of paper towels with about 5–6 towels in each stack. Set these next to the beaker.
5. Submerge the ornament in the hydrochloric acid solution using a pair of tongs. Lay it flat on the bottom of the beaker so that it is completely submerged. Observe the reaction between the galvanized iron and the hydrochloric acid solution.
6. As soon as the rapid bubbling stops, remove the ornament from the hydrochloric acid with the tongs. Be careful not to drip any hydrochloric acid on your hands. Rinse the ornament in the sink. Place the ornament on the paper towels next to the beaker. Dry the ornament with the paper towels.

7. Carefully clean the exposed area of the design by rubbing it with an eraser. Clean both sides if a design was created on both sides. Do not remove the masking tape.
8. Pour about 25 mL of cupric nitrate solution into a 250-mL beaker. Share this beaker of cupric nitrate solution with three other students.
9. Dip a cotton swab into the acidified cupric nitrate solution and gently rub it over the exposed parts of the design. Rub the swab on both sides if a design was created on both sides. Observe the reaction between the cupric nitrate and the iron.
10. Once the entire area is coated with copper, rinse it with tap water and dry it with a paper towel.
11. Remove the masking tape from both sides of the piece of iron.
12. Attach a hanger to the hole in the top of the ornament.

Optional

13. Coat both sides of the ornament with acrylic sealer. Hang the ornament as instructed by your teacher so that it can dry completely.