Spirit of Lincoln

Introduction

Three flasks containing colorless solutions are arranged in a row. The first contains a small amount of liquid. The second is full and the third is half full. After the demonstration reaction is complete, the three flasks will be equally filled, one with a blue solution, one with a colorless solution and one with a red solution.

Concepts

- Oxidation–reduction reaction
- Acid–base indicators
- Ideal gas law

Materials

Copper, Cu, 3 g or pre-1982 penny
Nitric acid solution, HNO_3, conc., 15 mL
Nitric acid solution, HNO_3, 0.1 M, 600 mL
Phenolphthalein indicator solution, 1%, 1 mL
Sodium hydroxide solution, NaOH, 0.35 M, 200 mL
Erlenmeyer flasks, 500 mL, 3
Glass tubing, 6 mm O.D., 7″ length, 3
Glass tubing, 6 mm O.D., 2½″ length
Plastic tubing, ⅜″ O.D., 5⁄16″ I.D., 10″ length, 2
Rubber stopper, size #7, 1-hole
Rubber stopper, size #7, 2-hole, 2

Safety Precautions

Nitric acid is extremely corrosive; toxic by inhalation and absorption. Avoid contact with acetic acid and oxidizers. Sodium hydroxide solution is corrosive; skin contact causes severe blisters; very dangerous to eyes; wear chemical-splash goggles, chemical-resistant gloves. Phenolphthalein solutions are flammable liquids and a fire risk. Keep from sources of heat and open flames. Please review current Material Safety Data Sheets for additional safety, handling, and disposal information.

Preparation

- Prepare 0.1 M nitric acid solution: Dissolve 6.3 mL of concentrated nitric acid to 1 L of distilled or deionized water. Stir to dissolve. *Caution:* Always add acid to water.
- Prepare 0.35 M sodium hydroxide solution: Add 7 g of sodium hydroxide pellets to 500 mL of distilled or deionized water. Stir to dissolve.
- Cut three pieces of glass tubing, each seven inches in length. Cut another piece two and one-half inches in length. When inserted into the stoppers the three longer pieces should extend half-way down into the Erlenmeyer flasks—to the 250 mL mark. It is critical that the three longer tubes extend exactly the same distance into the flasks. The other piece should only extend approximately one-half inch into the flask. Connect the glass tubing with the pieces of plastic tubing as in Figure 1.

Procedure

1. Assemble the apparatus as in Figure 1.
2. Add 15 mL of concentrated nitric acid to Flask 1.
3. Add 1 mL of phenolphthalein to Flask 2 and fill with 0.10 M nitric acid. Leave enough space to replace the stopper.
4. Add 200 mL of 0.35 M sodium hydroxide to Flask 3.
5. Replace stoppers onto Flasks 2 and 3.
6. Place one copper penny into flask 1 and quickly replace the stopper. The reaction will begin immediately and the solutions will begin to move through the flasks. After about five minutes all action in the flasks will stop and the first flask

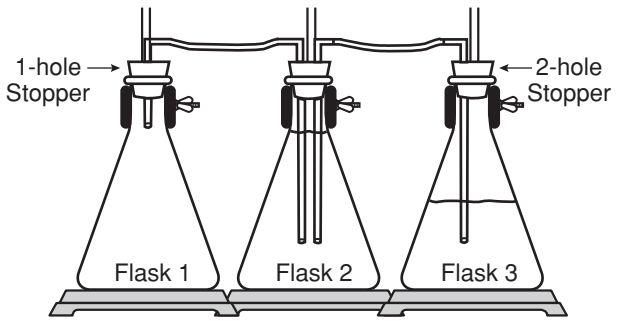

Figure 1.

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will begin to cool. This would be an excellent time to present a discussion or lecture on the chemical reactions and subjects of temperature, pressure and volume. After the first flask completely cools the solutions will begin to move again. The whole demonstration will take 20–25 minutes to complete.

Disposal

Please consult your current *Flinn Scientific Catalog/Reference Manual* for general guidelines and specific procedures, and review all federal, state and local regulations that may apply, before proceeding. Remaining copper may be rinsed and reused. All solutions should be combined and treated according to Flinn Suggested Disposal Method #26b.

Connecting to the National Standards

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

Unifying Concepts and Processes: Grades K–12

Systems, order, and organization
Constancy, change, and measurement Content Standards: Grades 9–12
Content Standard A: Science as Inquiry
Content Standard B: Physical Science, structure and properties of matter, chemical reactions, interactions of energy and matterTips

- *Caution:* Only use pennies dated prior to 1982. Pennies minted in 1982 and later are copper-plated zinc that reacts vio lently with nitric acid.
- The cooling process will take at least 15 minutes.
- Make sure the tubing apparatus is set up properly and the stoppers are tightly in place. Nitrogen dioxide gas is highly toxic. Keep it contained in Flask 1 until it dissolves completely in the aqueous solution. Wrap stoppers with Parafilm® or use petroleum jelly to provide an air-tight seal. Conduct the demonstration in an operating fume hood.
- Nitrogen dioxide fumes will eventually corrode the stopper in Flask 1 and in time it will need to be replaced.

Discussion

In this demonstration the copper penny reacts with nitric acid, generating heat and a red-brown gas called nitrogen dioxide—beginning a series of chemical and physical processes. The gas forming in Flask 1 is forced through the tubing into Flask 2. This increases the pressure in Flask 2 and forces some of the dilute nitric acid solution from Flask 2 into Flask 3. The dilute nitric acid solution contains a small amount of phenolphthalein that causes the sodium hydroxide solution in Flask 3 to turn a red-pink color. Flask 3 has a 2-hole stopper that allows the excess gas to escape. As the reaction in Flask 1 nears completion, the reaction begins to slow and Flask 1 begins to cool. The cooling process takes about 15 minutes. During this time the highly soluble nitrogen dioxide gas in Flask 1 cools and is absorbed into the solution. The cooling gas decreases pressure in Flask 1, forming a partial vacuum. This partial vacuum acts on Flasks 2 and 3—drawing the solutions back through the system. As the dilute nitric acid solution from Flask 2 enters Flask 1, it forms a brilliant blue copper(II) nitrate solution. As the red-colored sodium hydroxide solution in Flask 3 is drawn into Flask 2 it is neutralized by the dilute nitric acid solution and becomes colorless. Flask 3 is left with a red-colored sodium hydroxide solution. The penny should be completely dissolved and the red, white and blue flasks are filled with the Spirit of Lincoln.

References

Perkins, R. I. *J. Chem. Educ.* 63:781, 1986.

Cotton, F. A. and G. Wilkinson, *Advanced Inorganic Chemistry, 3rd Edition.* John Wiley and Sons: New York, 1972

Shakhashiri, B., *Chemical Demonstrations, Volume 3, A Handbook for Teachers of Chemistry.* Madison: The University of Wisconsin Press. 1989, p. 83.

Materials for *Spirit of Lincoln* are available from Flinn Scientific, Inc.

Catalog No.	Description
N0043	Nitric Acid, 100 mL, 15.8 M
N0052	Nitric Acid, 0.1 M, 500 mL
S0243	Sodium Hydroxide Solution, 0.5 M, 500 mL

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