# The Two-Cent Colorful Demonstration

## Introduction

A myriad of colors is produced by several reactions occurring in one apparatus, and it all starts with two pennies.

## Concepts

- Oxidation/reduction
- Acids and bases
- Indicators
- Reactions of metals and acids

## Materials

Nitric acid, $HNO_3$, 15.8 M, 50 mL
Sodium hydroxide solution, NaOH, 0.1 M, 2 mL
Universal indicator solution, 10 to 12 drops
Water, distilled, 800 mL
Boiling flask (Florence flask), 1000-mL
Erlenmeyer flask, 500-mL
Glass tubing elbows, 5 mm O.D., 3
Stopper, 1-hole, #7
Stopper, 2-hole, #8
Medicine dropper
Pre-1982 pennies, 2
Plastic tubing, 3⁄16″ I.D., 1⁄16″ wall thickness, 12″ length

## *Safety Precautions*

*Nitric acid solution is corrosive to eyes, skin, and other tissue; strong oxidant; toxic by inhalation; avoid contact with readily oxidized substances. Sodium hydroxide solutions are corrosive to eyes, skin, and other tissue. Universal indicator solution is an alcohol-based solution and therefore flammable. Cupric nitrate solution is toxic. It is very important that this demonstration be done in a hood or well-ventilated area. Although the flasks are stoppered tightly and the $NO_2$ gas is dissolved in water, leaks can occur in the system. Nitrogen dioxide is an irritant and toxic by inhalation. If any $NO_2$ gas escapes, it should be allowed to dissipate before anyone approaches the apparatus. 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.*

## Preparation

Assemble the tubing/stopper/glass elbows apparatus as shown in Figure 1. Lubrication of the holes of the stoppers with mineral oil will help with the insertion of the glass tubing elbows. Insert slowly and carefully, with a twisting motion. Wear heavy cloth gloves to help avoid cuts should the glass elbows break. The 0.1 M sodium hydroxide can be prepared (4.0 g/1 L $H_2O$) or can be purchased readymade.

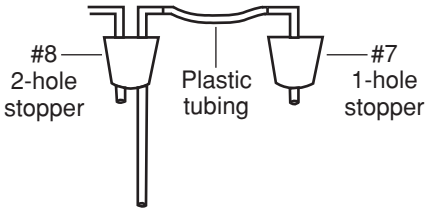


**Figure 1.**

## Procedure

(This reaction should be done only in an operating fume hood or well-ventilated area.)

1. Fill the 1000-mL boiling flask with approximately 800 mL distilled water and add 10 to 12 drops of universal indicator solution.
2. Using the medicine dropper, add the 0.1 M NaOH solution dropwise to the flask until the solution is a deep blue color.
3. Tightly stopper the boiling flask with the #8 2-hole stopper of the assembled apparatus.
4. Add approximately 50 mL of concentrated (15.8 M) nitric acid to the 500-mL Erlenmeyer flask.
5. Holding the 1-hole stopper in one hand, drop the two pennies into the nitric acid and *immediately* stopper the Erlenmeyer flask (see Figure 2). The red-brown gas given off is nitrogen dioxide and is toxic. Therefore, the stoppers


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*must* be inserted quickly and tightly.

6. Observe the color changes. The indicator solution will change from blue to pink, and the nitric acid solution will become green, and later a light blue/green (see the *Discussion* below). The reaction will last approximately 10 minutes.
7. When the reaction is finished, shake the Erlenmeyer flask to dissolve all of the red-brown $NO_2$ gas in solution before unstoppering the Erlenmeyer flask.

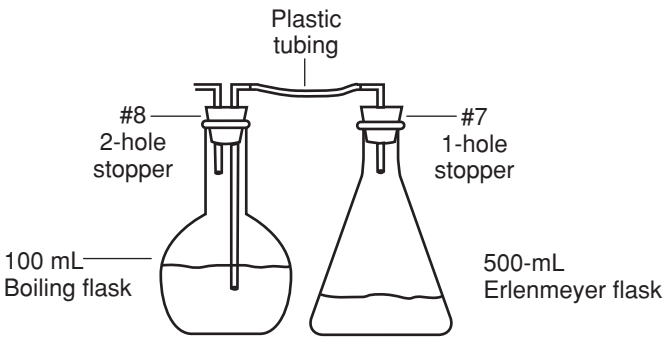


**Figure 2.**

## Disposal

Please consult your current *Flinn Scientific Catalog/Reference Manual* for general guidelines and specific procedures governing the disposal of laboratory waste. The resulting product is an acidic solution of cupric nitrate. It can be disposed of according to Flinn Suggested Disposal Method #24b.

## Connecting to the National Standards

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

***Unifying Concepts and Processes: Grades K–12***
Constancy, change, and measurement
***Content Standards: Grades 9–12***
Content Standard B: Physical Science, structure and properties of matter, chemical reactions

## Tips

- Be sure to use pre-1982 pennies. Pennies minted before 1982 are made entirely of copper. Pennies minted after 1982 have a core of zinc that is plated with a very thin film of copper.
- Pieces or strips of elemental copper may be used rather than pennies. Use a total of approximately 6 g of copper.

## Discussion

The copper pennies react with the nitric acid to produce nitrogen(II) oxide.

$$3Cu(s) + 2NO_3^-(aq) + 8H^+(aq) \rightarrow 3Cu^{2+}(aq) + 4H_2O(l) + 2NO(g) \qquad \textit{Equation 1}$$

The nitrogen(II) oxide quickly reacts with oxygen to form nitrogen dioxide, a red-brown gas.

$$2NO(g) + O_2(g) \rightarrow 2NO_2(g) \qquad \textit{Equation 2}$$

As the $NO_2$ gas pressure increases, it bubbles through the basic (blue) solution in the boiling flask. Nitrogen dioxide is very soluble in water. As it dissolves, it reacts with the water to form nitric acid. The nitric acid reacts with the sodium hydroxide lowering the pH of the solution.

$$2NO_2(g) + H_2O(aq) \rightarrow 2HNO_3(aq) \qquad \textit{Equation 3}$$

As the solution changes from basic to acidic, the color of the universal indicator changes from blue to pink/yellow.

When the copper pennies are completely dissolved, the reaction stops. As the Erlenmeyer flask cools, the pressure inside the flask decreases. This lower pressure draws the solution from the boiling flask into the Erlenmeyer flask. As the liquid flows into the Erlenmeyer flask, it dilutes the cupric nitrate solution that was formed by the initial reaction of copper with nitric acid. The $Cu^{2+}$ ions color this solution a bright blue.

## Acknowledgment

Special thanks to Pat Funk of Watkins Memorial High School in Pataskala, OH for bringing this demo to our attention.

## Reference

Shakhashiri, B. Z. *Chemical Demonstrations: A Handbook for Teachers in Chemistry;* University of Wisconsin: Madison, WI; Vol. 2, pp 165–166, Vol. 3, pp 83–91.

## Materials for *The Two-Cent Colorful Demonstration* are available from Flinn Scientific, Inc.

| Catalog No. | Description |
|---|---|
| N0043 | Nitric Acid, $HNO_3$, 15.8 M, 100 mL |
| U0001 | Universal Indicator Solution, 100 mL |
| S0149 | Sodium Hydroxide Solution, NaOH, 0.1 M, 500 mL |
| GP3095 | Flask, Boiling, Flat-bottom, Florence, Pyrex®, 1000-mL |
| AP2307 | Stopper, Rubber, Black, 1-hole, #7, 1 lb. |
| AP2318 | Stopper, Rubber, Black, 2-hole,#8, 1 lb. |

Consult the Flinn Scientific website for current prices.