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Disappearing Rainbow

Introduction

A rainbow of solution colors appears and disappears as acids and bases are added to a series of indicators.

Concepts

- Acids and bases
- pH indicators

Materials

Hydrochloric acid solution, HCl, 0.01 M, 1 L

Beakers, 400-mL, 6

Sodium hydroxide solution, NaOH, 0.01 M, 800 mL

Beakers, 1000-mL, 2

Sodium hydroxide solution, NaOH, 3 M, 50 mL

Dropping bottles, 6

Indicator solutions, 30 mL each:

Violet—0.45 g of phenolphthalein and 0.2 g thymolphthalein in 30 mL of 95% ethyl alcohol.

Blue—0.2 g of thymolphthalein in 30 mL of 95% ethyl alcohol.

Green—0.2 g of thymolphthalein and 2 g of *p*-nitrophenol in 30 mL of 95% ethyl alcohol. Add 5 drops of 1 M HCl to acidify.

Yellow—1 g of *p*-nitrophenol in 30 mL of 95% ethyl alcohol. Add 5 drops of 1 M HCl to acidify.

Orange—2 g of *p*-nitrophenol and 0.15 g phenolphthalein in 30 mL of 95% ethyl alcohol. Add 5 drops of 1 M HCl to acidify.

Red—1.5 g of *p*-nitrophenol and 0.75 g phenolphthalein in 30 mL of 95% ethyl alcohol. Add 5 drops of 1 M HCl to acidify.

Safety Precautions

p-Nitrophenol is toxic by ingestion. Dilute hydrochloric acid solution is corrosive to eyes, skin, and other tissue. Dilute sodium hydroxide solution is corrosive; skin burns are possible. Indicator solutions contain ethyl alcohol, a flammable liquid and a fire risk; keep away from flames and heat. 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

1. Set up six 400-mL beakers on an overhead projector or in front of the class.
2. Add 3 drops of "violet" indicator solution to the first beaker. Add 3 drops of "blue" indicator solution to the second beaker. Continue adding three drops of the appropriate indicator solution to each beaker.

Procedure

1. Fill each 400-mL beaker with approximately 50 mL of the 0.01 M hydrochloric acid solution. All six resulting solutions should be clear and colorless.
2. Add approximately 75 mL of 0.01 M sodium hydroxide solution to each beaker. Each solution will change from colorless to a bright, vivid color of the rainbow!
3. Add approximately 100 mL of the 0.01 M hydrochloric acid solution to each beaker. The solutions will once again be colorless.
4. Add 3 M sodium hydroxide solution dropwise to each beaker until the color reappears.

Disposal

The final solution may be flushed down the drain with excess water according to Flinn Suggested Disposal Method #26b. Consult your current *Flinn Scientific Catalog/Reference Manual* for general guidelines and specific procedures governing the disposal of laboratory wastes.

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
Evidence, models, and explanation

Content Standards: Grades 5–8

Content Standard A: Science as Inquiry
Content Standard B: Physical Science, properties and changes of properties in matter

Content Standards: Grades 9–12

Content Standard A: Science as Inquiry
Content Standard B: Physical Science, chemical reactions

Tips

- This demonstration kit contains enough materials to perform this demonstration seven times.
- The indicators are dissolved in 95% ethyl alcohol. The alcohol will readily evaporate, leaving the indicator powder in the beaker—unseen to the observers of the demonstration. Save the indicator solutions for future demonstrations.
- At the end of the demonstration (step 4), pour all of the colored solutions together into a large glass pitcher or beaker containing a few drops of concentrated acid. The combined solution will be clear and colorless.
- The specific amounts of acid and base solutions are not important. Each addition of acid or base solution must neutralize the solution in the beaker and drive the pH in the opposite direction. This process may be repeated many times using increasingly more concentrated acid and base solutions.
- For brighter yellows, *m*-nitrophenol can be used in place of *p*-nitrophenol.

Discussion

The three indicators used in this demonstration—phenolphthalein, thymolphthalein and *p*-nitrophenol—are colorless in acidic solution. In basic solution phenolphthalein is red, thymolphthalein is blue, and *p*-nitrophenol is yellow. Any color in the spectrum may be prepared by combining these primary colors in different amounts. The indicator solutions added to each beaker readily evaporate, leaving the exact, minute proportions of the appropriate dry indicators on the bottom of each beaker. Students will not see this step of the procedure. They will only see the pouring of the acid and base solutions and the color changes. This demonstration is a wonderful “magic show” demonstration, especially when performed to music, such as “The Rainbow Connection.”

Reference

Shakhashiri, B. Z. *Chemical Demonstrations*, Volume 3; University of Wisconsin: Madison (1989).

Materials for *Disappearing Rainbow* are available from Flinn Scientific, Inc.

This activity is also available as a Flinn Chemical Demonstration Kit that contains all the materials to perform this demonstration seven times.

Catalog No.	Description
AP8979	Disappearing Rainbow Demonstration Kit
P0017	Phenolphthalein, 25 g
T0073	Thymolphthalein, 5 g
N0073	<i>p</i> -Nitrophenol, 25 g
N0088	<i>m</i> -Nitrophenol, 25 g

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