Large pH Tube

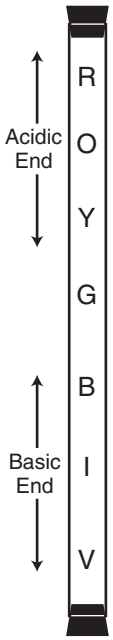
Neutralization Reactions

Concepts

- Scientific method
- Diffusion
- Acid–base indicators

Background

Universal indicator can be used to illustrate an entire range of pH conditions because it is made up of a mixture of different indicators that change color at different pH values. As an acid is diluted with water, its pH increases— but never above pH 7. Likewise, as a base is diluted, its pH decreases—but, again, never below pH 7.



The half-color spectrum that you see after adding just the hydrochloric acid solution and inverting the tube is comparable to what one would see after performing a series dilution of hydrochloric acid. Although the hydrochloric acid solution
concentration may range from 10–1 M at the bottom of the tube to 10–13 M at the top of the tube, the corresponding pH values will be approximately 1, 2, 3, 4, 5, 6, 7, 7, 7, 7. . . . It is the $1 \cdot 10^{-7}$ M H_3O^+ already present in the water that is
ultimately responsible for the pH reaching this plateau of 7 and for the color not changing beyond the neutral (green) point. This is important to point out to students who might think that they can use the log of the hydrochloric acid
solution concentration, no matter how dilute, to derive the pH of the solution. Certainly you can never add hydrochloric acid solution to neutral water and expect to get a pH greater than 7! Likewise, you cannot expect dilute base solutions to have pH values of less than 7. Therefore, to derive the entire pH scale by series dilutions, you must use both an acid and a base—starting, of course, at opposite ends. This is exactly what is accomplished in the pH rainbow tube.

Materials

Hydrochloric acid, 3 M, 1-mL
Sodium hydroxide, 3 M, 1-mL
Universal indicator solution, < 1-mL
Water, distilled or deionized
Beaker, 600-mL
Demonstration tube, 24″
Rubber stoppers, size 2, 2

Safety Precautions

Hydrochloric acid is toxic by ingestion and by inhalation. It is also severely corrosive to eyes and skin. Sodium hydroxide solution is a corrosive liquid; skin burns are possible; very dangerous to eyes. Universal indicator is an alcohol based solution and a flammable liquid. Wear chemical splash goggles, chemical-resistant gloves and a chemical-resistant apron. Wash hands thoroughly with soap and water before leaving the laboratory. Follow all laboratory safety guidelines. Please review current Material Safety Data Sheets for additional safety, handling and disposal information.

Procedure

1. Obtain a 600-mL beaker and fill it with 400 mL of distilled or deionized water.
2. Add 15–20 drops of universal indicator to the water and stir. The solution should be green in color. *Note:* If the solution is not green add a very small amount of dilute acid or base until the solution is green.
3. Securely place a size 2 stopper in one end of the demonstration tube.
4. Turn the tube over and fill the open end with distilled water that contains universal indicator.
5. Add 15–20 drops of 3 M sodium hydroxide to the solution in the tube and insert the second stopper.

Publication No. 91216
061616

6. Turn over the tube and remove stopper. Add 15–20 drops of 3 *M* hydrochloric acid to the solution and stopper.
7. Gently turn the tube back and forth until the different colors become visible.
8. Set the tube horizontally on a table and allow students to observe the colors.

Disposal

Please consult your current *Flinn Scientific Catalog/Reference Manual* for general guidelines and specific procedures governing the disposal of laboratory waste. The contents of the tube may be flushed down the drain with excess water 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
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

Flinn Scientific—Teaching Chemistry™ eLearning Video Series

A video of the *Large pH Tube* activity, presented by John Little, is available in *Neutralization Reactions*, part of the Flinn Scientific—Teaching Chemistry eLearning Video Series.

Materials for *Large pH Tube* are available from Flinn Scientific, Inc.

Materials required to perform this activity are available in the *pH Rainbow Tube* available from Flinn Scientific. Materials may also be purchased separately.

Catalog No.	Description
GP9146	Demonstration Tube
AP2224	Rubber Stopper, Size 2
U0009	Universal Indicator Solution, 35 mL
H0034	Hydrochloric Acid Solution, 3 M, 500 mL
S0447	Sodium Hydroxide, 3 M, 500 mL

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