

Battle of the Acids



Introduction

Not all acids are created equal. This demonstration examines the “frothing and foaming” activity of different acids with calcium carbonate and also their properties in the presence of their conjugate bases to distinguish strong versus weak acids. The use of a “rainbow acid” universal indicator produces a rainbow spectrum of color changes as the mixtures react.

Concepts

- Strong acid
- Weak acid
- Conjugate base
- pH

Materials

Acetic acid, CH_3COOH , 1 M, 400 mL

Calcium carbonate, CaCO_3 , 40 g

Hydrochloric acid, HCl , 1 M, 400 mL

“Rainbow acid” universal indicator, 5 mL
(includes accompanying color chart)

Sodium acetate, NaCH_3CO_2 , 16 g

Sodium chloride, NaCl , 12 g

Demonstration tray, large

Hydrometer cylinders, 600-mL, 4

Graduated cylinder, 250-mL

Pipet, Beral-type

Water, distilled or deionized

Weighing dishes or small beakers, 6

Safety Precautions

Hydrochloric acid and acetic acid solutions are toxic and corrosive. Avoid contact with skin and eyes. “Rainbow-acid” universal indicator solution is an alcohol-based solution and is flammable. Avoid contact with flames or other ignition sources. 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.

Procedure

1. Obtain 4 large hydrometer cylinders, tall-form beakers, or 500-mL graduated cylinders and place them on a large demonstration tray. Label the cylinders #1–4.
2. Using a graduated cylinder, add 200 mL of 1 M hydrochloric acid to cylinders #1 and 2. Rinse the graduated cylinder, then add 200 mL of 1 M acetic acid to cylinders #3 and 4.
3. Add about 20 drops (1 mL) of “rainbow acid” universal indicator to cylinders #1 and 3. Compare the color and pH of hydrochloric acid versus acetic acid.
4. Write equations for the ion-forming reactions of hydrochloric acid and acetic acid in water to give H_3O^+ ions. Identify the “common ion” or conjugate base of each acid (chloride ion and acetate ion, respectively).
5. Add 12 g of sodium chloride, followed by about 20 drops of “rainbow acid” universal indicator, to cylinder #2. Mix thoroughly to dissolve.
6. Compare the color and pH of cylinder #2 with that in cylinder #1. What effect does adding chloride ion (its “common ion” or conjugate base) have on the pH of hydrochloric acid?
7. Add 16 g of sodium acetate, followed by about 20 drops of “rainbow acid” universal indicator, to cylinder #4. Mix thoroughly to dissolve.
8. Compare the color and pH of cylinder #4 with that in cylinder #3. What effect does adding acetate ion (its “common ion” or conjugate base) have on the pH of acetic acid?
9. Add 10 g of calcium carbonate to each cylinder #1–4. Compare the amount of frothing and foaming and observe the rainbow of indicator color changes in the four cylinders as the reactions proceed.
10. Relate the activity of the solutions to pH, the difference between strong and weak acids, and the “common ion” effect.

Disposal

Please consult your current *Flinn Scientific Catalog/Reference Manual* for general guidelines and specific procedures governing the disposal of laboratory waste. The waste solutions may be disposed 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

Content Standards: Grades 9–12

Content Standard A: Science as Inquiry

Content Standard B: Physical Science, structure and properties of matter, chemical reactions

Tips

- The use of a demonstration tray to catch any spillover is strongly recommended. The reaction mixtures bubble and froth and a solid wall of foam may erupt out of the hydrometer cylinders.
- “Rainbow acid” universal indicator (Flinn Catalog No. U0012) contains a combination of indicators to give a rainbow spectrum of colors for acid solutions having pH values between 1 and 7. Use the color chart that accompanies the indicator to estimate the pH of acidic solutions.
- For best results, use powdered calcium carbonate.

Discussion

The following table summarizes the observations and conclusions in this demonstration.

	Strong Acid	Weak Acid
Example	Hydrochloric acid	Acetic acid
“Rainbow Acid” Color	Red	Yellow-Orange
pH	≤ 1	2–3
Rate of Reaction with CaCO₃	Extremely fast	Moderate
Concentration of H⁺ ions	High	Low
Extent of Ionization	100%	1–10%
Effect of Common Ion		
pH	≤ 1 (No change)	4–5
Rate of Reaction with CaCO₃	Extremely fast	Slow

Reference

Flinn ChemTopic™ Labs, Vol. 13 Acids and Bases; Flinn Scientific: Batavia, IL, 2002.

***Battle of the Acids* is available as a chemical demonstration kit from Flinn Scientific, Inc.**

Catalog No.	Description
AP6287	Battle of the Acids—Strong vs. Weak Acids Kit
AP8599	Hydrometer Cylinder, 600-mL
AP5429	Demonstration Tray, Large

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