

Universal Indicator Rainbow *Preparer's Version*

Introduction

Acid-base reactions are fundamental to many chemical processes, and their principles can be effectively demonstrated using a saturated sodium carbonate solution and acidic water containing a universal indicator. In this demonstration, the addition of the basic sodium carbonate solution to the acidic water results in a visually striking rainbow gradient. This effect is due to the interaction of acid and base, density differences between the solutions, and the gradual diffusion of ions. Density and diffusion are key factors in this demonstration. The saturated sodium carbonate solution is denser than the acidic water, causing it to sink to the bottom when first added. As it slowly diffuses upward, a gradient is established due to the slower movement of ions compared to water molecules. This gradient allows for a smooth transition in pH levels, producing the rainbow effect. The interplay of density and diffusion not only creates a visually appealing demonstration but also provides a tangible example of how substances mix and react over time.

Safety Hazards

- Personal Protective Equipment
 - Safety glasses/goggles
 - Nitrile gloves
 - Chemical & flame retardant lab coat
- Physical Hazards
 - Universal indicator is a highly flammable liquid and vapor.
- Chemical Hazards
 - Hydrochloric acid is corrosive, may cause eye and skin damage; irritant, may cause severe respiratory irritation.
 - Sodium carbonate may cause eye irritation.

Materials

- 1 L Graduated Cylinder
- Universal Indicator
- 700 mL 0.1M HCl
- 100 mL Saturated (~ 2.0M) Sodium carbonate solution
- Optional: Pipette

Safety Data Sheet(s)

- [Universal indicator](#)
- [Hydrochloric acid](#)
- [Sodium carbonate](#)

Procedure

1. Measure 5.83 mL of concentrated (12M) hydrochloric acid and add it to 694.17 mL of deionized water (total volume should be 700 mL). Stir well until fully mixed.
2. Measure 21.1978 g of sodium carbonate and add it 100 mL deionized water. Stir thoroughly until fully dissolved.
3. Fill the graduated cylinder with 700 mL with 0.1M HCl.
4. Add approximately 6 mL universal Indicator and swirl gently to mix.
5. Minimizing the disruption of the solution, slowly pour the sodium carbonate solution into the cylinder, pouring slowly down the side of the cylinder. Optional: use a pipette to aid in undistruptive addition. Gently set down the cylinder. Do NOT stir.
6. Allow the carbonate (purple color) to sink to the bottom, and slowly diffuse to the top (rainbow). The universal indicator is found in 2 forms: 2 pH paper (dip paper to see color) or solution (drop in solution to see pH).

Tips & Tricks

- Keep the cylinder on the table at all times. Carefully tilt it to rest on an edge of its base, still stabilized on the table, to approximately a 30° angle. Begin slowly pouring the sodium carbonate, aiming for it to contact the glass above the liquid level of the acidic solution to minimize disruptive.

Clean-Up Procedures

1. Neutralize the solution using weak acid/weak base.
 - a. For universal indicator, aim for a neutral green for a pH of approximately 7.
 - b. When the solution is acidic, you can use either dilute sodium hydroxide (0.01M or 0.1M works well, but be careful not to overshoot) or baking soda. When the solution is basic, you can use dilute acetic acid (0.5M or 1M works well).
2. Pour into an acid/base waste stream with other compatible substances.
3. Rinse the labware thoroughly with deionized water at least three times, emptying the runoff into the waste stream.
4. Clean thoroughly with laboratory detergent.