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Buffer Balancing Acts

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Introduction

Buffers provide an essential acid–base balancing act—in consumer products, foods, lakes and streams, even living cells. What are buffers made of and how do they work?

Concepts

- Acids and bases
- pH
- Buffer

Materials (for each demonstration)

Alka-Seltzer® tablets, 2
Bromthymol blue indicator, 0.04%, 8 mL
Hydrochloric acid, HCl, 1 M, 50 mL
Sodium hydroxide, NaOH, 1 M, 50 mL
Sodium phosphate monobasic, NaH_2PO_4, 0.2 M, 200 mL
Sodium phosphate dibasic, Na_2HPO_4, 0.2 M, 200 mL
Universal indicator, 5 mL (includes accompanying color chart)
Beakers, 400-mL, 4
Beral-type pipets, graduated, 2
Graduated cylinders, 10- and 250-mL
Stirring rod
Water, distilled or deionized

Safety Precautions

Hydrochloric acid and sodium hydroxide are corrosive liquids. Avoid exposure to eyes and skin. Universal indicator is an alcohol-based solution and is flammable. Avoid exposure to flames and other ignition sources. Wear chemical splash goggles and chemical-resistant gloves and apron. Consult current Material Safety Data Sheets for additional safety information.

Procedure

Part A. What Is a Buffer?

1. Mix together 200 mL each of 0.2 M NaH_2PO_4 and 0.2 M Na_2HPO_4 to prepare 400 mL of a pH 7 phosphate buffer.
2. Set up four 400-mL beakers and label them #1–4.
3. Add 200 mL of distilled or deionized water to beakers #1 and 3, followed by 200 mL of the phosphate buffer to beakers #2 and 4.
4. Add about 2 mL of bromthymol blue indicator to each beaker. *(The solutions should all be green. This is the "neutral" color of the indicator, corresponding to pH values between 6 and 7.6.)*
5. Add 10 drops of 1 M HCl to beaker #1. *(Note the color change to yellow. This is the "acidic" color of the indicator.)*
6. Add 10 drops of 1 M HCl to beaker #2. *(No color change—solution stays green.)*

7. Add an extra 10 drops of 1 M HCl to beaker #2. *(Still no color change. Look frustrated!)*
8. Use a graduated cylinder to add 5 mL of 1 M HCl to beaker #2. *(The frustration mounts as the solution remains green.)*
9. Continue adding 1 M HCl in 5-mL increments until the color changes to yellow. *(This will probably take 2–3 more 5-mL portions of HCl, for a total of 15–20 mL.)*
10. Discuss the behavior of the buffer with respect to excess strong acid. What will happen if strong base is added?
11. Add 10 drops of 1 M NaOH to beaker #3. *(Note the color change to blue. This is the "basic" color of the indicator.)*
12. Repeat steps 6–9 with 1 M NaOH and the buffer solution in beaker #4. *(A total of 15–20 mL of NaOH will be needed to change the buffer to blue.)*
13. Discuss the composition and properties of a buffer. *(A buffer is a solution prepared from a weak acid and its conjugate base that resists pH changes upon addition of strong acid or base.)*

Part B. Buffer Action in a Consumer Product

1. Set up four clean beakers and relabel them #1–4, if necessary.
2. Add 200 mL of distilled or deionized water to each beaker. Dissolve one Alka-Seltzer tablet in each beaker #2 and 4.
3. Read the label on the Alka-Seltzer tablet and note the principal ingredients listed. Are there any weak acids and weak bases present that are capable of forming a buffer? *(The active buffer ingredients are citric acid and sodium bicarbonate.)*
4. Add about 20 drops (1 mL) of universal indicator solution to each beaker #1–4. Note the color of each solution and use the color chart to estimate the initial pH of each solution. *(The solutions should all be yellow-green, pH 6–7)*
5. Add 1 mL of 1 M HCl to beakers #1 and 2. Compare the indicator color and pH of each solution. *(Water will turn red, indicating a pH ≤ 4. The Alka-Seltzer solution should stay green, pH 6–7, suggesting that it is acting as a buffer.)*
6. Continue adding 1 M HCl in 1-mL increments to the Alka-Seltzer solution in beaker #2 until the indicator color is the same as that in beaker #1. How much acid must be added to overwhelm the buffer capacity of one Alka-Seltzer tablet? *(This will probably take about 20 mL of 1 M HCl.)*
7. Add 1 mL of 1 M NaOH to beakers #3 and 4. Compare the indicator color and pH of each solution. *(Water will turn purple, indicating a pH ≥ 10. The Alka-Seltzer solution should stay green, pH 6-7, suggesting that it acts as a buffer against both acid and base.)*
8. Continue adding 1 M NaOH in 1-mL increments to the Alka-Seltzer solution in beaker #4 until the indicator color is the same as that in beaker #3. How much base must be added to overwhelm the buffer capacity of one Alka-Seltzer tablet? *(This will take about 20 mL of 1 M NaOH. The buffer capacity of Alka-Seltzer is similar against both acids and bases.)*

Disposal

All final solutions may be disposed of down the drain with plenty of excess water according to Flinn Scientific Disposal Method #26b. Please consult your current *Flinn Scientific Catalog/Reference Manual* for general guidelines and specific procedures governing the disposal of laboratory waste.

Tip

- For best results, use either freshly distilled water, boiled distilled water, or bottled water as the control in Parts A and B. Distilled water may absorb large quantities of carbon dioxide from the air during storage. The presence of dissolved CO_2 may make the water acidic enough to turn yellow with bromthymol blue. In areas of the country where the water is not hard, tap water may be a suitable control.

Reference

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

Buffer Balancing Acts is available as a chemical demonstration kit from Flinn Scientific, Inc.

Catalog No.	Description	Price/Each
AP6288	Buffer Balancing Acts—Chemical Demonstration Kit	Consult Your Current *Flinn Catalog/Reference Manual.*