

Bet on Buffers

Buffers



Introduction

One of the most important applications of acids and bases in chemistry and biology is that of buffers. A buffer solution resists rapid changes in pH when acids and bases are added to it.

Concepts

- Buffer
- LeChâtelier's principle
- Conjugate acid–base pair
- Weak acid–weak base

Materials

Acetic acid solution, CH_3COOH , 0.1 M, 25 mL	Beaker, 100-mL
Hydrochloric acid, HCl , 0.1 M, 10 mL	Graduated cylinders, 25-mL, 4
Sodium acetate solution, NaCH_3COO , 0.1 M, 25 mL	Petri dishes, 2
Sodium hydroxide, NaOH , 0.1 M, 10 mL	Pipets, Beral-type, graduated, 3
Thymol blue indicator solution, 0.04%, 5 mL	Stirring rods, 4
Water, distilled or deionized	

Safety Precautions

The acetic acid solution is slightly corrosive. The hydrochloric acid solution is toxic by ingestion and inhalation and is corrosive to skin and eyes. The sodium hydroxide solution is corrosive to eyes, skin, and other tissue. The buffer solution is strongly basic and is corrosive to skin, eyes, and other tissue. Avoid contact of all chemicals with eyes and skin. 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.

Preparation

1. Obtain 25.0 mL of the 0.1 M acetic acid solution in a 25-mL graduated cylinder.
2. Transfer the acetic acid solution to a clean 100-mL beaker.
3. Obtain 25.0 mL of the 0.1 M sodium acetate solution in a clean 25-mL graduated cylinder.
4. Transfer the sodium acetate solution to the 100-mL beaker containing 25 mL of the acetic acid solution.
5. Use a clean stirring rod to mix the solution.

Procedure

1. Use a clean 25-mL graduated cylinder to transfer 25.0 mL of distilled water to the bottom half of a Petri dish.
2. Use a clean 25-mL graduated cylinder to transfer 25.0 mL of the buffer solution to the lid of the Petri dish.
3. Add several drops of 0.04% Thymol blue indicator solution to each dish. Mix well.
4. Add 0.1 M hydrochloric acid drop-wise to the water. Stir well after each addition. Note the number of drops added to produce a color change.
5. Repeat steps 1–3 using fresh water and buffer solutions.
6. Repeat step 4 using the 0.1 M sodium hydroxide solution.

Disposal

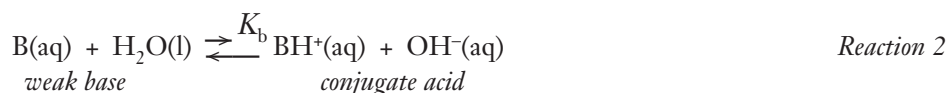
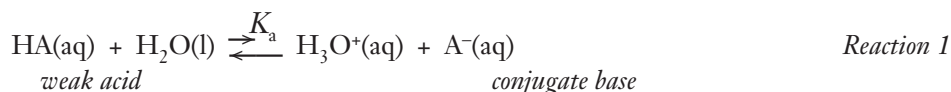
Please consult your current *Flinn Scientific Catalog/Reference Manual* for general guidelines and specific procedures governing the disposal of laboratory waste. The sodium hydroxide solution may be disposed of according to Flinn Suggested Disposal Method #10. The hydrochloric acid solution may be disposed of according to Flinn Suggested Disposal Method #24b. The acetic acid solution may be disposed of according to Flinn Suggested Disposal Method #24a. The buffer solution and the sodium acetate solution may be disposed of according to Flinn Suggested Disposal Method #26b.

Tips

- Repeat the same procedure using a phosphate buffer with methyl orange as the indicator for the 0.1 M hydrochloric acid or phenolphthalein as the indicator for the 0.1 M sodium hydroxide experiment.
- Buffers Keep the Balance—Properties of Biological Buffers (Catalog No. AP1767) available from Flinn Scientific is a good student laboratory kit in which students explore buffers.

Discussion

The ability of buffers to resist changes in pH when an acid or a base is added is a result of their chemical composition. All buffers contain a mixture of a conjugate acid–base pair; either a weak acid (HA) and its conjugate base (A^-), or a weak base (B), and its conjugate acid (BH^+). Weak acids and weak bases both dissociate slightly in water (Reactions 1 and 2).

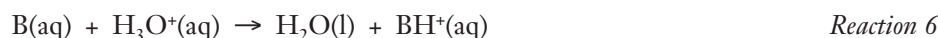
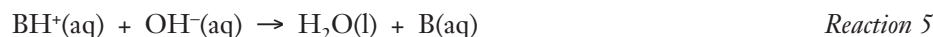
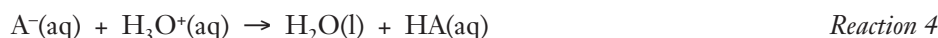
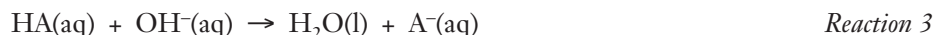


These reactions are reversible and both the weak acid and its conjugate base or the weak base and its conjugate acid are present in solution. The equilibrium constant expressions for these dissociation reactions are:

$$K_a = [H_3O^+][A^-]/[HA] \quad \text{Equation 1}$$

$$K_b = [OH^-][BH^+]/[B] \quad \text{Equation 2}$$

Buffers control pH because the two buffering components, either HA and A^- or B and BH^+ , are able to neutralize both acids and bases added to the solution.



The actual pH of a buffer solution depends on the concentration of the conjugate acid–base pair in solution. If Equation 1 is rearranged, the concentration of hydronium ions in solution is:

$$[H_3O^+] = K_a \times \frac{[HA]}{[A^-]} \quad \text{Equation 3}$$

and the pH is:

$$\text{pH} = -\log[\text{H}_3\text{O}^+] = \text{p}K_a - \log \frac{[\text{HA}]}{[\text{A}^-]} \quad \text{Equation 4}$$

if the concentrations of the acid–base pair are equal, $[\text{HA}] = [\text{A}^-]$.

The $-\log \frac{[\text{HA}]}{[\text{A}^-]}$ is equal to zero, and the pH of the buffer is equal to $\text{p}K_a$.

By varying the amounts of HA and A^- in solution, the pH of the buffer solution can be changed. For a buffer made up of a weak base (B) and its conjugate acid (BH^+), the solution pH calculations are similar.

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
Evolution and equilibrium

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 and properties of matter, chemical reactions

Flinn Scientific—Teaching Chemistry™ eLearning Video Series

A video of the *Bet on Buffers* activity, presented by Penney Sconzo, is available in *Buffers*, part of the Flinn Scientific—Teaching Chemistry eLearning Video Series.

Materials for *Bet on Buffers* are available from Flinn Scientific, Inc.

Materials required to perform this activity are available in the *Properties of Buffers—Student Laboratory Kit* available from Flinn Scientific. Materials may also be purchased separately.

Catalog No.	Description
AP1767	Properties of Buffers—Student Laboratory Kit
A0096	Acetic Acid Solution, 0.1 M, 1 L
H0014	Hydrochloric Acid, 0.1 M, 500 mL
S0452	Sodium Acetate Solution, 1 M, 500 mL
S0149	Sodium Hydroxide, 0.1M, 500 mL
T0045	Thymol Blue Indicator Solution, 0.04%, 100 mL
AP1447	Reaction Plate, 24-well
AP8673	Checker™ pH Meter

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