

A pH Study of Acids, Salt Solutions, and Buffers

Cautions

Acetic acid and hydrochloric acid are toxic, irritants and corrosive. Ionic salts may be irritants and toxic. Avoid skin contact from all chemicals and rinse thoroughly with running water if contact occurs.

Purpose

To compare calculated and measured pH values of a buffer solution and investigate buffer action.

Introduction

Buffers are solutions that resist large changes in pH when small quantities of strong acid or strong base are added to them. These solutions contain a weak acid and its conjugate base in nearly equal quantities. When small amounts of strong acid are added, it reacts with the conjugate base present to produce weak acid; small additions of strong base react with weak acid to form conjugate base. Changes in pH of buffer solutions can be determined using the Henderson-Hasselbalch equation:

$$pH = pK_a + \log \frac{[A^-]}{[HA]} \quad (12)$$

where pK_a is $-\log(K_a)$, $[A^-]$ is the concentration of conjugate base and $[HA]$ is the concentration of weak acid present in the buffer. Human blood is a buffer solution, with a normal pH range of 7.35 – 7.45. Variations in blood $pH \pm 0.1$ can cause serious health problems.

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Procedure

NOTE: Distilled water (not deionized) will be used for all experimental procedures.

A. Acetic Acid-Acetate Buffer

C1. In a clean beaker, mix together 25.0 mL of acetic acid solution and 25 mL of sodium acetate solution provided to make Buffer Solution **A**

C2. Use the pH meter to measure the pH of the solution

C3. Using the same acetic acid and sodium acetate solutions,

prepare Buffer Solutions **B** and **C** using the volumes of acid and conjugate base indicated in the table above.

C4. Measure the pH of each solution, making sure to rinse the electrode with distilled water between measurements.

Buffer	Acetic Acid (mL)	Sodium Acetate (mL)
A	25.0	25.0
B	5.0	45.0
C	45.0	5.0

B. Observing pH Change in a Buffer

B1. Label 4 clean, dry 50 mL beakers "1," "2," "3," and "4."

B2. Add 25 mL of buffer solution **A** from part **C** into beakers **1** and **3**.

B3. Add 25 mL distilled water to beakers **2** and **4**.

B4. Measure the pH of the four solutions in beakers **1-4**.

B5. Transfer 1.0 mL 1 M HCl to beakers **1** and **2**. **Thoroughly mix** each solution with a clean glass stirring rod.

B6. Transfer 1.0 mL 1 M NaOH to beakers **3** and **4**. **Thoroughly mix** each solution with a clean glass stirring rod.

B7. Measure the **new** pH of the four solutions in beakers **1-4**.

Disposal

Dispose of all solutions into the appropriate waste containers.

Clean-Up

Wash all glassware with soap then rinse 3 times with tap water, and once with distilled water.

Clean your work area with water and dry with paper towels. Wash your hands before leaving the laboratory.

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Calculations and Helpful Hints

Perform the following calculations, record the results on the Data Sheets, and **show all work CLEARLY on page 5.**

A. Acetic Acid/ Acetate Buffer Solution and pH

- Calculate the concentration of acetic acid in the buffers by dilution (see equation above)
- Calculate the concentration of sodium acetate in the buffers by dilution
- Calculate the theoretical pH of each acetic acid–acetate buffer solution.

B. Observing pH Change in a Buffer

- Determine the number of moles of acid and conjugate base present in the buffer
- Calculate the number of moles of strong acid or strong base added to the buffer and use this value to determine its effect on the buffer components
- Use the Henderson-Hasselbach equation to calculate the theoretical pH of the buffer solution after addition of strong acid or strong base
- Calculate the change in pH (ΔpH) for the buffer solution a) when strong acid was added; b) when strong base was added. Use the pH of the pure buffer solution (beakers **1** and **3**) or the distilled water (beakers **2** and **4**) as the initial pH and the pH of the mixture of strong acid or strong base with buffer (or with distilled water) as the final pH.
- Calculate the change in pH (ΔpH) for the distilled water a) when strong acid was added; b) when strong base was added.

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Data Sheet

Name: _____ Lab Partner _____

A. Acetic Acid – Acetate Buffer Solution and pH

	Molarity
Acetic Acid	
Sodium Acetate	

Buffer Solution	Volume Acid (mL)	Volume Base (mL)	[Acid]	[Base]	Measured pH	Theoretical pH
A	25.0	25.0				
B	5.0	45.0				
C	45.0	5.0				

B. Observing pH Change in Buffer Solution A

Beaker	Solution	Measured pH (without HCl or NaOH)	Measured pH (with HCl or NaOH)	Theoretical pH (with HCl or NaOH)	DpH
1	Buffer A + HCl				
2	Water + HCl				
3	Buffer A + NaOH				
4	Water + NaOH				

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Calculations:

A pH Study of Acids, Salt Solutions, and Buffers**Pre-lab Assignment****Name:** _____

1. Calculate each of the following values for a solution whose $[\text{H}_3\text{O}^+] = 2.1 \times 10^{-4} \text{ M}$

pH = _____

pOH = _____

 $[\text{OH}^-] =$ _____

2. Calculate each of the following values for a solution having a pH = 6.21

 $[\text{H}_3\text{O}^+] =$ _____

pOH = _____

 $[\text{OH}^-] =$ _____

3. A buffered solution contains 0.45 M acetic acid ($K_a = 1.80 \times 10^{-5}$) and 0.60 M sodium acetate. Calculate the pH of this solution.

4. Predict whether the following salts are acidic, neutral or basic when dissolved in water. Write balanced chemical equations that support your answer.

Salt	NaCH_3CO_2	NH_4Cl	NaCl	NaHCO_3
Nature				