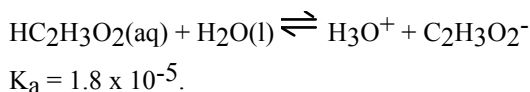


CHEM 113L EXP# 7: Buffer Preparation and pH Measurements

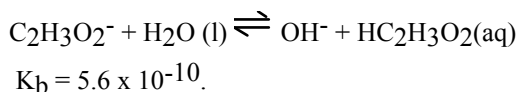
Revised . AMB 7-2005

Introduction:

Even in quite dilute aqueous solutions, acetic acid is very slightly ionized (it would approach 99% ionization only as the concentration approaches 0.0 M):



On the other hand, the salt, sodium acetate ($\text{NaC}_2\text{H}_3\text{O}_2$), is essentially 100% dissociated into the constituent hydrated ions in a dilute aqueous solution. Sodium acetate solutions are basic because the acetate ion (the conjugate base of acetic acid) behaves as a proton acceptor with respect to water:



Consequently, in solutions of acetic acid alone, the molar concentration of the $\text{HC}_2\text{H}_3\text{O}_2$ is much larger than the $\text{C}_2\text{H}_3\text{O}_2^-$ ion concentration, but in solutions of sodium acetate alone, the reverse is true. Neither solute alone can provide "comparable" concentrations in solutions of both the weak acid and its conjugate base; thus neither an acetic acid solution nor a sodium acetate solution is a buffer solution, i.e. a buffer solution, by definition, must contain moderate concentrations of both species!

In general, if the acid is not extremely weak, the pH of a solution of a weak acid is governed by the concentration of the acid and K_a . Under similar conditions, the pH of a solution of a weak base is determined by the concentration of the weak base and K_b . In solutions containing both a weak acid and a strong acid, both acids play a role in determining the pH of the solution; however, if the concentration of the strong acid is relatively large, it will inhibit the dissociation of the weak acid (the common-ion effect). The pH of this solution would then be calculated as if the weak acid were not present! (Likewise, in a solution containing both a strong base and a weak base, the strong base concentration would be used to calculate pH.)

Buffer solutions contain both a weak acid and its conjugate weak base in appreciable concentrations. Within limits, these solutions tend to resist changes in pH upon addition of either H_3O^+ or OH^- (because these species are largely consumed by the acidic and basic components of the buffer mixture). In buffer systems like $\text{NaC}_2\text{H}_3\text{O}_2$ - $\text{HC}_2\text{H}_3\text{O}_2$ mixtures, the principal source of the acetic acid molecule is from the acid; the principal source of the acetate ion is from the salt. Therefore, the $[\text{H}_3\text{O}^+]$ is determined by the salt/acid (or equivalently, the base/acid) mole ratio. For a conjugate acid/base pair:

$$\text{pH} = \text{p}K_a + \log_{10} \frac{[\text{nconjugate base}]}{[\text{nacid}]}$$

where n stands for moles (or millimoles). and the symbol, p , to indicate $-\log_{10}$ of". For acetic acid at 25°C , $pK_a = 4.74$.

This experiment deals with the pH of a solution of acetic acid alone and with a solution of sodium acetate alone (Part A); of "direct" buffer solutions prepared by mixing solutions of acetic acid with solutions of sodium acetate (Part B); of "indirect" buffers prepared by partially "neutralizing" an acetic acid solution with NaOH (Part C), and with the comparison of the pH-changes observed when strong acid (HCl) solutions are added to equal volumes of buffered and unbuffered solutions.

Experimental (work in pairs).

You will use the same pH probes as in the previous experiment. Please remember that the probe must be thoroughly rinsed and recalibrated using the pH =7 buffer periodically.

In general, volume measurement will be made with 25 or 50 mL graduated cylinders. Remember to label these and the beakers to avoid contamination.

50 mL beaker are required for there to be sufficient depth for the pH electrodes.

Part A. pH-Measurements on Solutions of Acetic Acid and Sodium Acetate. Acquire, rinse, label two 250 mL plastic bottles. Prepare 250 mL of 0.25 M acetic acid by dilution of an appropriate stock solution provided by your instructor, usually 1.0 M – 4.0M (check the label). Also, prepare 250 mL of 0.25 M sodium acetate by dissolving the solid salt provided and likewise record all pertinent data.

Transfer 10-20 mL of these solutions to separate clean 50 mL beakers; measure and record the pH of each solution - these data will be used to compare the observed pH with that calculated using the K_a and K_b values provided.

Part B. pH Measurements on Buffer Mixtures of Acetic Acid and Sodium Acetate. Using the 0.25 M solutions prepared in Part A, prepare in clean 50 mL beakers the following ("direct") buffer solutions:

Beaker #	mL of 0.250 M $\text{HC}_2\text{H}_3\text{O}_2$ (aq)	mL of 0.250 M $\text{NaC}_2\text{H}_3\text{O}_2$ (aq)
B1	16.0	4.0
B2	12.0	8.0
*B3	10.0	10.0
B4	6.0	14.0
B5	2.0	18.0

Measure the pH and record the results for each solution. These will be used to compare with those calculated using pK_a . ***KEEP BEAKER (B3)**

FOR PART D!

Notes:

Part C. pH Measurements on Solutions Prepared by Reaction of Acetic Acid with Sodium Hydroxide.

Using the 0.25 M solutions prepared in A, prepare in clean 50 mL beakers the following ("indirect") buffer solutions:

Beaker #	mL of 0.250 M HC ₂ H ₃ O ₂ (aq)	mL of 0.250 M NaOH (aq)
C1	18.0	2.0
C2	16.0	4.0
**C3	14.0	6.0
C4	12.0	8.0
C5	10.0	10.0

Measure the pH and record the results for each solution. These will be used to compare with those calculated using pK_a. ****KEEP BEAKER (C3)**

FOR PART D!

Notes:

Part D. pH Changes Caused by Adding Strong Acid and Base to Buffered and Unbuffered Solutions.

1. In clean 50-mL beakers, prepare the following solutions, and:

Tests with 2.0 M HCl (aq)

Beaker	Contents
#1 Acid	10 mL 0.25 M HA, 10 mL 0.25 M NaA -* B3
#2Acid	14 mL 0.25 M HA, 6 mL 0.25 M NaA -**C3
#3Acid	20 mL 0.25 M NaCl
#4Acid	20 mL H ₂ O

- Record the initial pH of each beaker
- Now add 3 drops (only!) of 2.0 M HCl to each beaker above, stir, and remeasure (record) the pH.
- Explain these results (pH changes) in terms of the buffered and unbuffered solutions in #1-#4

Notes:

2. In clean 50-mL beakers, prepare the following solutions(duplicates of step 1), and:

Tests with 2.0 M NaOH (aq)

Beaker	Contents
#1Base w	10 mL 0.25 M HA, 10 mL 0.25 M NaA -* B3
#2Base	14 mL 0.25 M HA '6 mL 0.25 M NaA -**C3
#3Base	20 mL 0.25 M NaCl
#4Base	20 mL H ₂ O

- Record the initial pH of each beaker
- Now add 3 drops (only!) of 2.0 M HCl to each beaker above, stir, and remeasure (record) the pH.
- Explain these results (pH changes) in terms of the buffered and unbuffered solutions in #1-#4

Notes:

Caution: 2.0 M HCl and NaOH can cause burns. Rinse your hands with water and wipe up spills if they occur! All solutions may be washed down the sink with large volumes of water.

EXPERIMENT 6: Buffer Preparation and pH Measurements

DATA SHEET 1

Name _____ Lab Section _____

PARTNER _____

PART A Initial Solutions

	<u>pH measured</u>	<u>pH calculated</u>
0.25 M Acetic Acid	_____	_____
0.25 M Sodium Acetate	_____	_____

_____ g $\text{NaC}_2\text{H}_3\text{O}_2$ weighed

PART B. Buffers Direct Method

<u>Beaker#</u>	<u>mL $\text{HC}_2\text{H}_3\text{O}_2$</u>	<u>mL $\text{NaC}_2\text{H}_3\text{O}_2$</u>	<u>pH measured</u>	<u>pH calculated</u>
B1	16	4	_____	_____
B2	12	8	_____	_____
B3	10	10	_____	_____
B4	6	14	_____	_____
B5	2	18	_____	_____

Notes:

PART C. Buffers Indirect Method

<u>Beaker#</u>	<u>mL $\text{HC}_2\text{H}_3\text{O}_2$</u>	<u>mL NaOH</u>	<u>pH measured</u>	<u>pH calculated</u>
C1	18	2	_____	_____
C2	16	4	_____	_____
C3	14	6	_____	_____
C4	12	8	_____	_____
C5	10	10	_____	_____

Notes:

EXPERIMENT 6: Buffer Preparation and pH Measurements

DATA SHEET 2

Name _____ Lab Section _____

PARTNER _____

PART D. pH Changes

1. Addition of 3 drops of 2M HCl

<u>Beaker#</u>	<u>Contents</u>	<u>pH initial</u>	<u>pH final</u>	<u>ΔpH</u>
1Acid	Solution B3	_____	_____	_____
2Acid	Solution C3	_____	_____	_____
3Acid	0.25 M NaCl	_____	_____	_____
4Acid	H ₂ O	_____	_____	_____

2. Addition of 3 drops of 2M NaOH

<u>Beaker#</u>	<u>Contents</u>	<u>pH initial</u>	<u>pH final</u>	<u>ΔpH</u>
1Base	Solution B3	_____	_____	_____
2Base	Solution C3	_____	_____	_____
3Base	0.25 M NaCl	_____	_____	_____
4Base	H ₂ O	_____	_____	_____

Which Solutions are Buffers? Elaborate.

EXPERIMENT 6: Buffer Preparation and pH Measurements

POSTLAB QUESTIONS

Name _____ Lab Section _____

1. Calculate the pH of a solution prepared by mixing 25.0 mL of 0.60 M $\text{HC}_2\text{H}_3\text{O}_2$ and 15.0 mL of 0.60 M $\text{NaC}_2\text{H}_3\text{O}_2$?
2. Calculate the pH of a solution prepared by mixing 25.0 mL of 0.60 M $\text{HC}_2\text{H}_3\text{O}_2$ and 15.0 mL of 0.60 M NaOH ?
3. Write the Net Ionic Equation for Question 2.
4. Write the Net Ionic Equation for mixing acetic acid with water.