

Buffer Systems

PROCEDURE

System #1 – Deionized water – NO buffer.

1. Place 10.0 mL of deionized water into each of two sample cups.
2. Measure the pH. (Should be the same in both cups – if not, they were likely not properly cleaned.)
3. Into one cup, add one drop (assume 1 drop ~ 0.05 mL) of 0.10 M HCl. Measure the pH.
4. Add an additional 9 drops of the HCl. Measure the pH.
5. Into one cup, add one drop of 0.10 M NaOH. Measure the pH.
6. Add an additional 9 drops of the NaOH. Measure the pH.

Solution	Calculated pH	Observed pH
DI water		
DI water + 1 drop 0.1 M HCl		
DI water + 10 drops 0.1 M HCl		
DI water + 1 drop 0.1 M NaOH		
DI water + 10 drops 0.1 M NaOH		

System #2 – pH of Acetate Buffer solutions

7. Obtain ~ 40.0 mL each of acetic acid ($\text{CH}_3\text{CO}_2\text{H} = \text{HOAc}$) and sodium acetate ($\text{NaCH}_3\text{CO}_2 = \text{NaOAc}$) and put into separate burettes.
8. Deliver 10.0 mL of each solution to separate sample cups. Measure the pH of both solutions
9. Prepare Buffer A by mixing these two solutions. Measure the pH of the buffer solution. Save this solution.
10. Prepare Buffers B and C as indicated in the table below. Measure their pH's. Save the solutions.

pH of acetic acid: _____ **pH of acetate:** _____

Buffer	Volume (mL) 0.10 M HOAc	Volume (mL) 0.10 M NaOAc	NaOAc/ HOAc	$\log(\text{NaOAc}/\text{HOAc})$	Calculated pH	Observed pH
A	10.0	10.0				
B	5.0	15.0				
C	15.0	5.0				

11. Divide each of the 3 buffers into two equal parts (10.0 mL each).
12. For one sample of each buffer:
 - a. Add one drop 0.10 M HCl and measure the pH.
 - b. Add 9 additional drops and measure the pH.
 - c. Add enough to change the pH by one unit from the start. Record the volume.
 - d. Add enough to change the pH by two units (or more) from the start. Record the volume.
 - e. Add enough to change the pH by three units (or more) from the start. Record the volume.

Buffer	Observed pH	Predicted Resistance: More to acid, base, or the same?	pH after 1 drop 0.10 M HCl	pH after 10 drops 0.10 M HCl	TOTAL volume HCl to change pH by one unit	TOTAL volume HCl to change pH by two units	TOTAL volume HCl to change pH by three units
A							
B							
C							

13. For one sample of each buffer:
 - a. Add one drop 0.10 M NaOH and measure the pH.
 - b. Add 9 additional drops and measure the pH.
 - c. Add enough to change the pH by one unit from the start. Record the *total* volume added at that point.
 - d. Add enough to change the pH by two units (or more) from the start. Record the *total* volume added at that point.
 - e. Add enough to change the pH by four units (or more) from the start. Record the *total* volume added at that point.

Buffer	Observed pH	Predicted Resistance: More to acid, base, or the same?	pH after 1 drop 0.10 M NaOH	pH after 10 drops 0.10 M NaOH	TOTAL volume NaOH to change pH by one unit	TOTAL volume NaOH to change pH by two units	TOTAL volume to change pH by four units
A							
B							
C							

Diluting a buffer:

14. Prepare an additional sample of "Buffer A" by mixing 5.0 mL of sodium acetate and 5.0 mL of acetic acid. These volumes can be approximate. (You may use your 10-mL graduated cylinder to measure.)
15. Measure the pH of the buffer.
16. Dilute the buffer by adding 90.0 mL of DI water. The total volume is now 100. mL (therefore the concentrations of the buffer ions have decreased by a factor of ten.)
17. Measure the pH of the resulting solution.

pH of buffer before dilution: _____ **pH of buffer after dilution:** _____

System #3 – Sorensen's Phosphate buffer

Buffer preparation:

- Using a volumetric pipette, dispense 20.0 mL of a 0.10 M sodium dihydrogen phosphate (NaH_2PO_4) solution into a clean, dry beaker.
- Using a volumetric pipette, dispense 20.0 mL of 0.10 M NaOH solution into the same beaker.
(This produces 40.0 mL of a 0.050 M solution of hydrogen phosphate ion, HPO_4^{2-} .)
- Dispense a second 20.0 mL volume of potassium dihydrogen phosphate buffer into a second clean, dry beaker.
- Add 20.0 mL of deionized water to the beaker.
(This produces 40.0 mL of a 0.050 M solution of dihydrogen phosphate ion, H_2PO_4^- .)
- Mix the two solutions.
(This will produce 80.0 mL of a buffer solution with $[\text{HPO}_4^{2-}] = [\text{H}_2\text{PO}_4^-] = 0.0250 \text{ M}$.)
- Calculate the expected pH of the buffer.
- Measure the pH using the pH meter.

Determination of Buffer Capacity:

Adding Acid:

- Transfer 25.0 mL of the buffer to a clean, dry beaker.
- From a burette, add 0.10 M HCl solution dropwise, with constant light stirring. Record the pH at increments of **approximately** 0.20 pH units and the total volume added (from the start) until the pH has changed by a total of approximately 2 pH units.

Note: Always record the precise pH from the meter for each interval. After you pass about 1.2 pH unit change, it will be difficult to get the 0.2 pH unit interval – that is expected.

- Calculate the buffer capacity based on the moles of acid added to result in ~ 1.2 pH unit change.

Adding Base:

- Transfer another 25.0 mL of the buffer to a clean, dry beaker.
- From a burette, add 0.10 M NaOH solution dropwise, with constant light stirring. Record the total volume added (from the start) and the pH at increments of **approximately** 0.20 pH units until the pH has changed by a total of approximately 2 pH units.

Note: Always record the precise pH from the meter for each interval. After you pass about 1.2 pH unit change, it will be difficult to get the 0.2 pH unit interval – that is expected.

- Calculate the buffer capacity based on the moles of base added to result in ~ 1.2 pH unit change.

$$\text{buffer capacity} = \frac{\text{mol of H}_3\text{O}^+ \text{ or OH}^- \text{ consumed}}{[\text{pH change}][\text{volume of buffer (L)}]}$$

Analysis:

- Plot pH of the solution on the y-axis vs. volume of acid added to the left on the x-axis and volume of base added to the right on the x-axis. (If using MS Excel, treat acid volumes as negative numbers (-) in order to get the auto-scaling to work properly.)

