

thymol blue $\begin{cases} \text{red: pH 1-3} \\ \text{yellow: pH 3-8} \\ \text{blue: 8-14} \end{cases}$

Buffers Exploration

$$K_a(\text{HC}_2\text{H}_3\text{O}_2) = 1.8 \times 10^{-5}$$

$$\Rightarrow \text{p}K_a = -\log(1.8 \times 10^{-5}) = 4.74$$

Procedure (Teacher Demo):

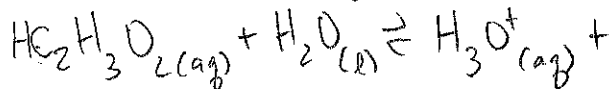
- Obtain two beakers] 50 mL, using ~20 mL sol'n
- Add water to one and the 0.10 M $\text{HC}_2\text{H}_3\text{O}_2/\text{C}_2\text{H}_3\text{O}_2^-$ buffer system to the other
- Add thymol blue indicator to each. (2 drops)
- Add 0.10 M HCl dropwise to the water.
 - Students: Predict how many drops of acid it will take to change the color of the water solution
- Add 0.10 M HCl dropwise to the buffer.
 - Students: Predict how many drops of acid it will take to change the color of the buffer solution
- Repeat Steps 1-5 with the same solutions, but adding 0.10 M NaOH dropwise

Data Table:

Water color = yellow } 1:1 buffer color = yellow

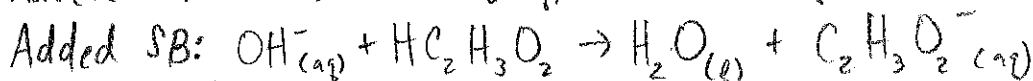
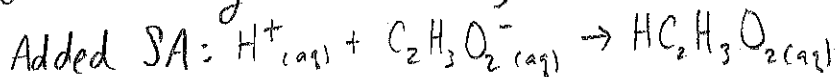
Solution	# of drops predicted to change color	# of drops actually to change color	Relevant Reaction
Water + HCl		5-10	$\text{H}^+_{(aq)} + \text{H}_2\text{O}_{(l)} \rightarrow \text{H}_3\text{O}^+_{(aq)}$
Buffer + HCl		50+	$\text{H}^+_{(aq)} + \text{C}_2\text{H}_3\text{O}_2^-_{(aq)} \rightarrow \text{HC}_2\text{H}_3\text{O}_2_{(aq)}$
Water + NaOH		1	$\text{OH}^-_{(aq)} + \text{H}_2\text{O}_{(l)} \rightleftharpoons \text{H}_2\text{O}_{(l)} + \text{OH}^-_{(aq)}$
Buffer + NaOH		50+	$\text{OH}^-_{(aq)} + \text{HC}_2\text{H}_3\text{O}_2_{(aq)} \rightarrow \text{H}_2\text{O}_{(l)} + \text{C}_2\text{H}_3\text{O}_2^-_{(aq)}$

Analysis:



- Describe how a buffer system is effective at maintaining a constant pH when strong acid/base is added (use relevant chemical reactions as part of your explanation).

A buffer contains both a weak acid + its conjugate base, so if a strong acid is added, the conjugate base will neutralize the acid, maintaining the pH. And if a strong base is added, the weak acid will neutralize it.



- Describe buffer capacity. (What does it mean to exceed the buffer capacity? How can we increase the buffer capacity?)

↑ how much weak acid/conjugate base are present in the buffer + able to neutralize added base/acid

→ Exceeding the capacity means adding more strong base than the amount of acid present in the buffer (or vice versa, adding more strong acid than base present).

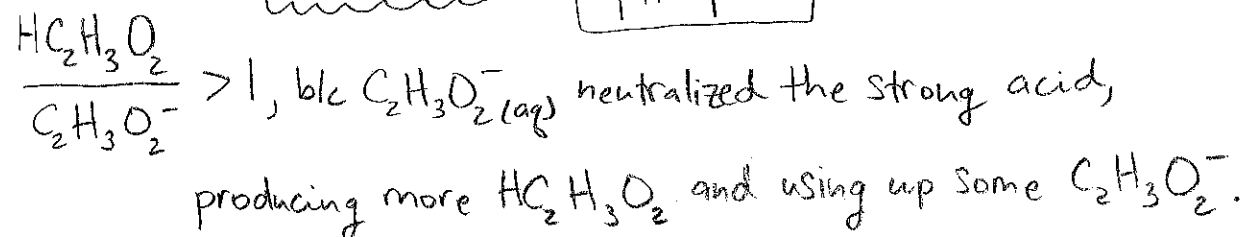
→ To increase buffer capacity, add more of the weak acid and/or conjugate base to your buffer system!

3. The buffer is made from equal volumes 0.10 M acetic acid and 0.10 M sodium acetate. Given this, the $\text{HC}_2\text{H}_3\text{O}_2/\text{C}_2\text{H}_3\text{O}_2^-$ ratio is equal to 1. What color was the solution at this point in time?

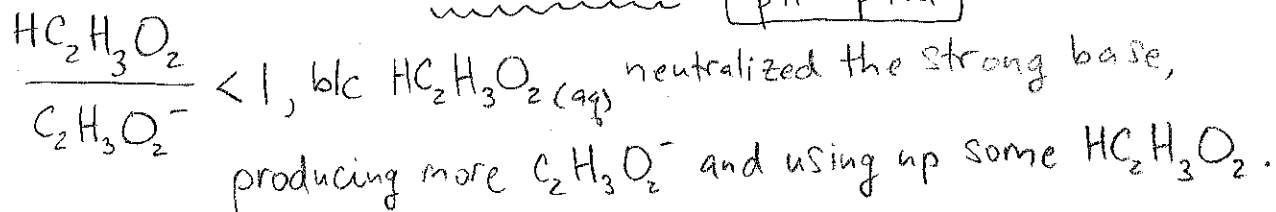
$$\frac{\text{HC}_2\text{H}_3\text{O}_2}{\text{C}_2\text{H}_3\text{O}_2^-} = 1 \Rightarrow \text{pH} = \text{pK}_a = -\log(1.8 \times 10^{-5}) = 4.74$$

color = yellow

4. When strong acid is added to the buffer, is the $\text{HC}_2\text{H}_3\text{O}_2/\text{C}_2\text{H}_3\text{O}_2^-$ ratio greater than, less than, or equal to 1? What color is the solution? \rightarrow color = red pH < pK_a



5. When strong base is added to the buffer, is the $\text{HC}_2\text{H}_3\text{O}_2/\text{C}_2\text{H}_3\text{O}_2^-$ ratio greater than, less than, or equal to 1? What color is the solution? \rightarrow color = blue pH > pK_a



6. Given a solution of only acetic acid ($K_a = 1.8 \times 10^{-5}$), is the $\text{HC}_2\text{H}_3\text{O}_2/\text{C}_2\text{H}_3\text{O}_2^-$ ratio greater than, less than, or equal to 1? What color is the solution? \rightarrow color = red!

