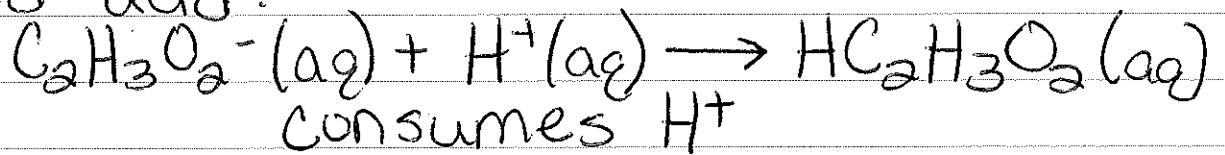


# Buffers

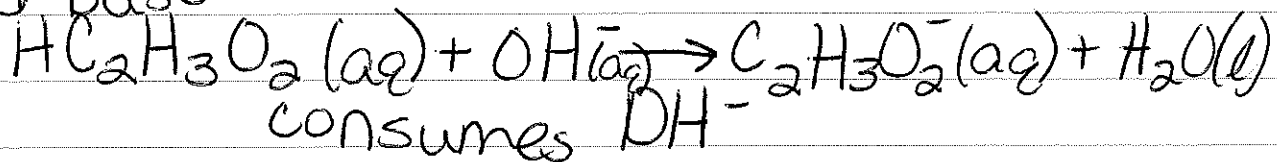
- Consists of weak acid or weak base and its salt; resists changes in pH upon addition of small amounts of acid or base

ex. Acetic acid and sodium acetate

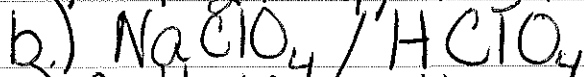
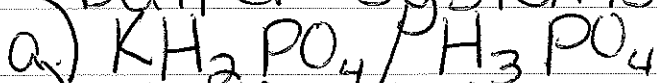
Add acid:



Add base:



ex. Which of the following are buffer systems?



weak base pyridine cation

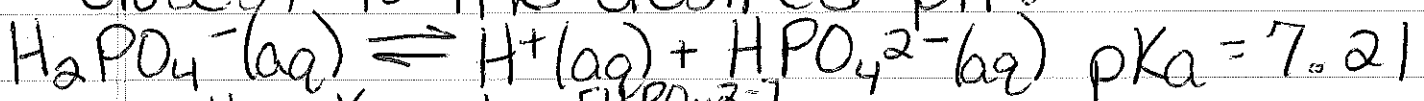
yes!

no- $\text{HClO}_4$  strong

yes

ex. How would you prepare a phosphate buffer with a pH of 7.40?

Choose a buffer system with a  $\text{pK}_a$  closest to the desired pH:



$$\text{pH} = \text{pK}_a + \log \frac{[\text{HPO}_4^{2-}]}{[\text{H}_2\text{PO}_4^-]}$$
$$7.40 = 7.21 + \log \frac{[\text{base}]}{[\text{acid}]}$$

$$\log \frac{[\text{HPO}_4^{2-}]}{[\text{H}_2\text{PO}_4^-]} = 0.19$$

$$10^{0.19} = 1.5$$

$$\frac{[\text{HPO}_4^{2-}]}{[\text{H}_2\text{PO}_4^-]} = \boxed{1.5} \text{ mole ratio}$$

## Buffer Example:

A buffer is formed by adding 1.00 mol lactic acid ( $K_a = 1.4 \times 10^{-4}$ ) and 1.00 mol sodium lactate in enough water to make 550 mL of solution.

a) Calculate  $H^+$  and pH:



$$K_a = \frac{[H^+][Lac^-]}{[HLac]}$$

$$1.4 \times 10^{-4} = \frac{[H^+][1.00]}{1.00} \quad H^+ = 1.4 \times 10^{-4}$$

$$pH = -\log(1.4 \times 10^{-4}) = \cancel{3.85} \cancel{3.85} 3.85$$

b) Calculate pH after addition of 0.08 mol HCl:



0.08 mol  $H^+$  added so,

$$HLac = 1.00 + 0.08 = 1.08 \text{ mol}$$

$$Lac = 1.00 - 0.08 = 0.92 \text{ mol}$$

$$pH = -\log 1.4 \times 10^{-4} + \log \frac{0.92}{1.08} = \cancel{3.78} 3.78$$

c) Calculate pH after addition of 0.08 mol NaOH:



0.08 mol  $OH^-$  added so,

$$HLac = 1.00 - 0.08 = 0.92 \text{ mol}$$

$$Lac = 1.00 + 0.08 = 1.08 \text{ mol}$$

$$pH = -\log 1.4 \times 10^{-4} + \log \frac{1.08}{0.92} = \cancel{3.92} 3.92$$

## Buffer Example:

ex. A 100.0 mL buffer sample is made of 0.120 M benzoic acid ( $C_6H_5COOH$ ) and 0.105 M sodium benzoate ( $NaC_6H_5COO^-$ ) ( $K_a$  for benzoic acid is  $6.5 \times 10^{-5}$ )

a) Calculate pH of the buffer soln:

$$pH = pK_a + \log \frac{[Bz^-]}{[HBz]}$$

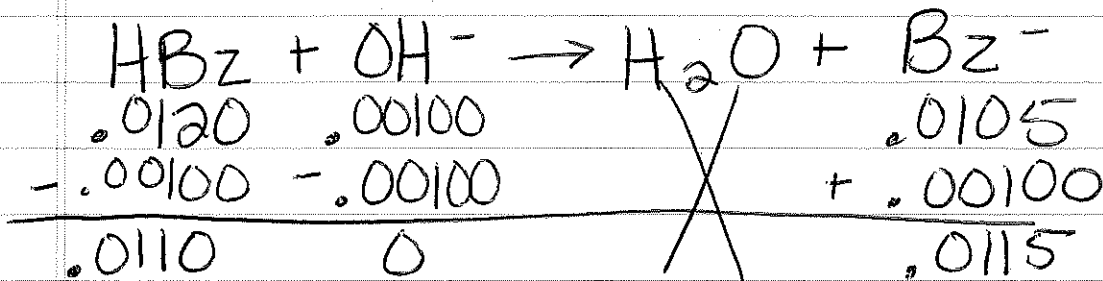
$$= -\log 6.5 \times 10^{-5} + \log \frac{0.105 M}{0.120 M} = \boxed{4.13}$$

b) Calculate pH of the buffer soln after adding 0.100 M NaOH 10 mL

$$(0.0100 L)(0.100 M OH^-) = 0.00100 \text{ mol } OH^-$$

$$(0.1000 L)(0.120 M HBz) = 0.0120 \text{ mol } HBz$$

$$(0.1000 L)(0.105 M Bz^-) = 0.0105 \text{ mol } Bz^-$$



$$pH = -\log 6.5 \times 10^{-5} + \log \frac{0.0115}{0.0110} = \boxed{4.21}$$

Calculate pH of the solution when 20.0 mL of 0.100 M NaOH is added to 0.100 M HNO<sub>3</sub>.

$$\text{NaOH: } (20.0 \text{ mL}) (.100 \text{ M}) = 2.00 \text{ mmol OH}^-$$

$$\text{HNO}_3: (30.0 \text{ mL}) (.100 \text{ M}) = 3.00 \text{ mmol H}^+$$



$$3.00 \quad 2.00$$

$$-2.00 \quad -2.00$$

$$\hline 1.00 \quad 0$$

$$[\text{H}^+] = \frac{1.00 \text{ mmol}}{50 \text{ mL}} = .0200 \text{ M H}^+$$

$$\text{pH} = -\log .0200 = \boxed{1.70}$$