① Mixed Buffer

(a) WA/WB + conjugate Base/acid

$CH_3COOH + CH_3COO^-$

$NH_4OH + NH_4^+$

(b) Salt formed by WA + WB — Simple Buffer

CH_3COONH_4 ⟶ $CH_3COO^- + H^+ \rightarrow CH_3COOH$

$NH_4^+ + OH^- \rightarrow NH_4OH$

$pH = \frac{1}{2}(pK_w + pK_a - pK_b)$

(c) Amphiprotic soln

$NaHCO_3$

$\frac{1}{2}(pK_{a_2} + pK_{a_1})$

(11) Buffer mechanism

e.g $CH_3COOH + CH_3COO^-$

add^n of H^+

$$CH_3COO^- + H^+ \longrightarrow CH_3COOH \quad K = 10^5$$

add^n of OH^-

$$CH_3COOH + OH^- \longrightarrow CH_3COO^- + H_2O \quad K = 10^9$$

$\Rightarrow$ ~~X~~ $HCl + Cl^-$

add^n of OH^-

$$\underline{HCl} + OH^- \longrightarrow Cl^- + H_2O$$

add^n of H^+

$$H^+ + Cl^- \not\longrightarrow HCl$$

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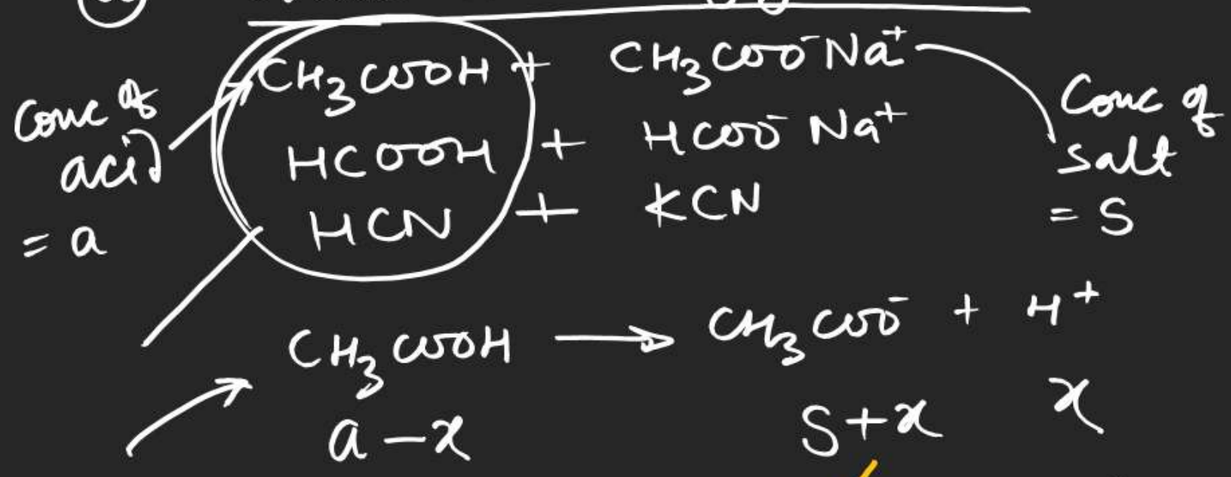
③ pH Calculation

ⓐ Weak acid + conjugate Base



	CH_3COOH	$\rightarrow$	CH_3COO^-	+	H^+
	$a-x$		$S+x$		x

$$K_a = \frac{(S+x)(x)}{a-x} = \frac{S}{a} \times [H^+]$$

$$-\log K_a = -\log\frac{S}{a} - \log[H^+]$$

$$\boxed{pH = pK_a + \log\frac{[Salt]}{[Acid]}}$$

Henderson eqn

$$CH_3COO^- + H_2O \longrightarrow CH_3COOH + OH^-$$

(5) WB + conjugate acid

$NH_4OH + NH_4^+Cl^-$

$C_5H_5N + C_5H_5NH^+Cl^-$

$C_6H_5NH_2 + C_6H_5NH_3^+Cl^-$

$$pOH = pK_b + \log \frac{[Salt]}{[Base]}$$

$$NH_4OH \longrightarrow NH_4^+ + OH^-$$

$$b - x \qquad S + x \qquad x$$

$$K_b = \frac{(S+x)(x)}{b-x}$$

H_2CO_3 + $NaHCO_3$

a s

$H_2CO_3 \longrightarrow H^+ + HCO_3^-$ Ka_1

$HCO_3^- \longrightarrow X$

$a-x$ x $s+x$

$$pH = pKa_1 + \log \frac{[NaHCO_3]}{[H_2CO_3]}$$

$NaHCO_3$ + Na_2CO_3

acid salt

$$pH = pKa_2 + \log \frac{[Na_2CO_3]}{[NaHCO_3]}$$

$\Longrightarrow$ Na_2HPO_4 + NaH_2PO_4

s a

$$pH = pKa_2 + \log \frac{[Na_2HPO_4]}{[NaH_2PO_4]}$$

✓, ✓, ✓

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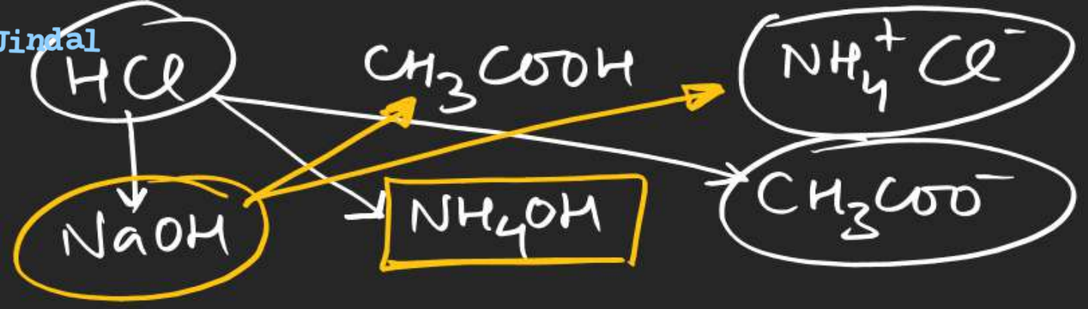
- $pH = pK_a + \log \frac{S}{a}$
- $pOH = pK_b + \log \frac{S}{b}$
- $H_2CO_3 + NaHCO_3$
- $NaH_2PO_4 + Na_2HPO_4$



① $HCl + NaOH \longrightarrow$

② $HCl + CH_3COOH$

$C_1 \qquad C_2$

$CH_3COOH \rightarrow CH_3COO^- + H^+ \qquad K_a$

$C_2 - x \qquad x \qquad C_1 + x$

③ $HCl + NH_4^+Cl^-$

$NH_4^+ + H_2O \longrightarrow NH_3 + H_3O^+ \qquad \frac{K_w}{K_b}$

$C_2 - x \qquad x \qquad C_1 + x$

④

$HCl + NH_4OH \longrightarrow NH_4Cl + H_2O$

① 1 1 0 1 salt

0 0 1

$NH_4^+ + H_2O \longrightarrow NH_3 + H_3O^+ \qquad \frac{K_w}{K_b}$

$\Rightarrow$

② 1 2 0 Buffer

0 1 1

$pOH = pK_b + \log s/b$

③ 2 1 0

1 0 1

$HCl + NH_4^+$

SA WA

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$HCl + CH_3COO^- \rightarrow CH_3COOH + Cl^-$

①	1	1	0	W acid
	0	0	1	$K_a = \frac{x^2}{C-x}$
②	1	2	0	Buffer
	0	1	1	
③	2	1	0	
	1	0	1	

$HCl + CH_3COOH$ (CIE)

① 100 ml 0.2M CH_3COOH + 100 ml 0.2M NaOH ($K_a = 10^{-5}$)

$\frac{100 \times 0.2}{200 \times 2} = 0.1$

② 100 ml 0.2M CH_3COONa + 100 ml 0.1M HCl

③ 100 ml 0.002 M NaOH + 100 ml 0.2M CH_3COONa

④ 100 ml 0.202 M HCl + 100 ml 0.2M CH_3COONa

① $CH_3COOH + NaOH \rightarrow CH_3COONa + H_2O$

0.1	0.1	0
0	0	0.1
20	20	0
0	0	$\frac{20 \text{ mmoles}}{200} = 0.1$

$CH_3COO^- + H_2O \rightarrow CH_3COOH + OH^-$

$0.1 - x \quad x \quad x$

$\frac{x^2}{0.1 - x} = 10^{-9}$

$x = 10^{-5}$

$pOH = 5$

② $CH_3COONa + HCl \rightarrow CH_3COOH + NaCl$

20	10	0
10	0	10 mmoles

$pH = 5 + \log \frac{10/200}{10/200} = 5$

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$CH_3COO^- + H_2O \rightarrow CH_3COOH + OH^-$

$0.1 - x \qquad x \qquad 10^{-3} + x$

$pOH = 3$

$pH = 11$

$$\frac{(10^{-3} + x)(x)}{0.1 - x} = 10^{-9}$$

$$x = 10^{-7}$$

$HCl + CH_3COONa \rightarrow CH_3COOH + NaCl$

$0.101 \qquad 0.1 \qquad\qquad 0.1$

$10^{-3} \qquad 0$

$CH_3COOH \rightarrow CH_3COO^- + H^+$

$0.1 - x \qquad x \qquad 10^{-3} + x$

$$K_a = \frac{(10^{-3} + x)\,x}{0.1 - x}$$

$$x = 0.62 \times 10^{-3}$$

$$[H^+] = 1.62 \times 10^{-3}$$

$$pH = 3 - \log 1.62$$

$$= 2.78$$

O-I	39 – 51
	56 – 64
S-I	43 – 50

100 ml 0.1M CH_3COOH is titrated with 0.1 NaOH. find (100 ml)

pH at eq. point.

10