Thinking like a Chemist Day 6

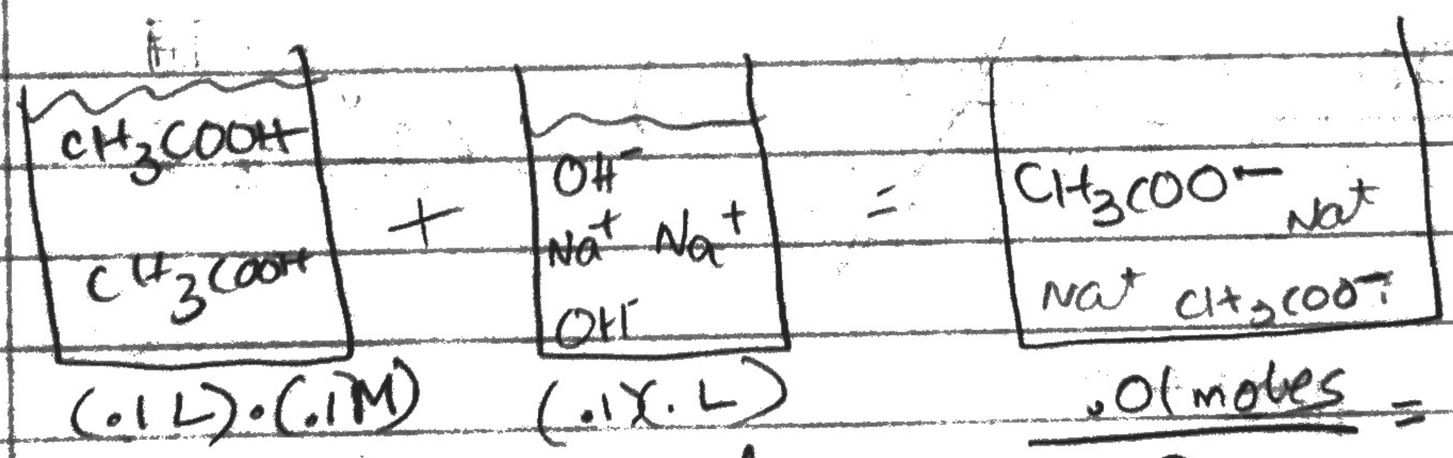
- Apply the principles of chemical equilibrium to mixtures of conjugate acid base pairs.
- Predict the pH of such solutions predict

Clicker Question

- The pH of 0.1 M aqueous solutions of salts $NaCH_3COO$, NH_4Cl, KCl will be:
  - Basic, Acidic, Neutral

- $CH_3COOH + NaOH \rightarrow NaCH_3COO_{(aq)} + H_2O_{(l)}$

100 ml 100 ml
.1 M .1 M



$(.1L)\cdot(.1M)$ $(.1L\cdot L)$ $\frac{.01 \text{ moles}}{.2} = .05M$

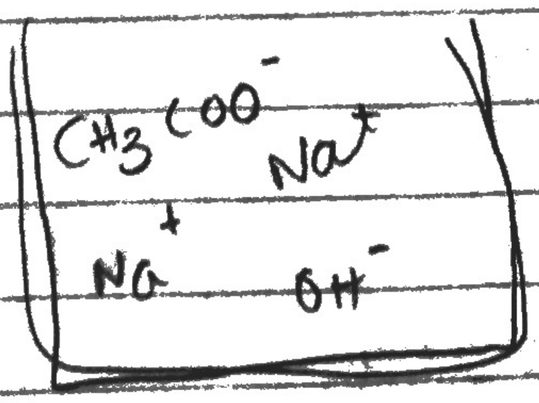
$= .01$ mols $= .01$ mol

$\rightarrow H^+$

- 100 ml of 0.1 M CH_3COOH + 200ml 0.1 M NaOH

$(1)(.1)$ $(.2L)(.02) = .02$ moles OH^-

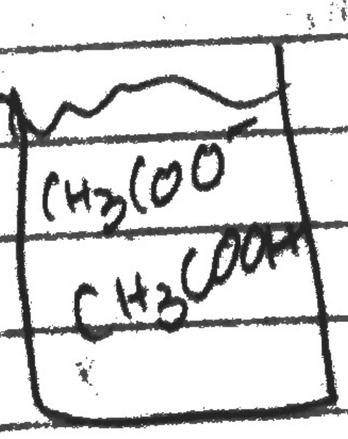
$= .01$ moles CH_3COOH



- 200ml 0.1 M CH_3COOH + 100ml 0.1 M NaOH

$(.2)(.1) = .02$ mol $(.1L)(.1M) = .01$ moles OH^-

CH_3COOH



· How would you determine the pH?

$CH_3COOH + NaOH \rightleftharpoons Na^+CH_3COO^- + H_2O$

	.02 mol	.01 mol	0	—
	-.01	-.01	+.01	
	.01	0	.01	

	$CH_3COOH_{(aq)}$	+ $H_2O_{(l)}$	$\leftrightarrow$ CH_3COO^-	+ H_3O^+
I	.01	—	.01	x
C	-x		+x	x
E	.01 - x		.01 + x	x

one
one
v

$$K_a = \frac{[CH_3COO^-][H_3O^+]}{[CH_3COOH]} = \frac{(.01+x)(\frac{x}{.3})}{(\frac{.01-x}{.3})} = (1)(\frac{x}{.3})$$

$K_a = 1.8 \times 10^{-5}$

$pH = 4.74$

Demo

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

3 moles .1 moles 3 moles

2.9 3.1

$$K_a = \frac{[CH_3COO^-]}{[CH_3COOH]}[H_3O^+]$$

Ratio

· buffers go against change

· Buffer – a solution in which the pH resists change when a strong acid or base is added

· Buffers can be basic or acidic

$NH_3 + HCl \rightarrow NH_4^+ + H_2O + Cl^-$

	NH_3	+ HCl	NH_4^+	H_2O	Cl^-
I	.02	.01	0	—	
C	-.01	-.01	+.01		
E	.01	0	.01		

$K_b = \frac{[NH_4^+]}{[NH_3]}[OH^-]$ $\quad 1K_b = [OH^-]$

$OH = 1.8 \times 10^{-5}$

$pOH = 4.74$

$pH = 9.26$, basic

• 1 mol CH_3COOH and 1 mole $NaCH_3COO$ in 1 L solution

$$K_a = \frac{[NaCH_3COO^-]}{[CH_3COOH]}[H_3O^+]$$

	$CH_3COOH + H_2O \rightleftharpoons$	$CH_3COO^- + H_3O^+$
	1 —	1 0
	$-x$	$+x \quad +x$
	$1-x$	$x \quad x$

$$K_a = \frac{[x][x]}{[1-x]} = \frac{x^2}{1}$$

$x = [H_3O^+] = K_a$

Shortcut

• $K_a = \frac{[A^-][H_3O^+]}{[HA]}$

$-\log K_a = -\log \frac{[A^-]}{[HA]} - \log [H_3O^+]$ ($\log [H_3O^+] \rightarrow pH$)

$pK_a = -\log \frac{[A^-]}{[HA]} + pH$

$pH = pK_a + \log \frac{[A^-]_0}{[HA]_0}$ ← initial conjugate base / initial weak acid

• Buffer capacity
  - difference in number of moles
  - keep ratios