ARJUNA

JEE AIR 2024

GURUKUL

Physical Chemistry

Ionic Equilibrium

Lecture No. - 07

By- Dr. Gopal Chaturvedi Sir
(GC Sir)

Topics to be Covered

GURUKUL

- Topic — Buffer Action
- Topic — Titration
- Topic — Indicator Theory
- Topic — Solubility and Solubility Product

Recap of Previous Lecture

GURUKUL

Topic pH of amphiprotic salt

Topic Buffer Solution

ATDB.uno

Buffer Action

GURUKUL

1. Acidic Buffer :

SA.

H^+ addition (HCl/HNO_3)

GURUKUL

GURUKUL

before addition : $\boxed{p_1H = pK_a + \log\left(\frac{s}{a}\right)}$; $\left(K_{eq} = \frac{1}{K_a}\right)$; $s = [CH_3COO^-]$, $a = [CH_3COOH]$

If we add small amount of SA. e.g HCl

Now $CH_3COO^-(aq) + H^+(aq) \rightleftharpoons CH_3COOH(aq)$

S (s−x) ; x (L.R.) ; a (a+x)

after addition of H^+ $\boxed{(P^H)_2 = pK_a + \log\frac{(s-x)}{(a+x)}}$, P_2^H is slightly lesser than P_1^H

or

$$K_a = \frac{[H^+][CH_3COO^-]}{[CH_3COOH]} = \frac{[H^+](s-x)}{(a+x)} \quad \text{— (2)}$$

OH^- addition:

GURUKUL

$$\underset{a}{CH_3COOH}(aq) + \underset{z(L,R)}{OH^-}(aq) \rightleftharpoons \underset{S}{CH_3COO^-}(aq) + H_2O(\ell); \left(K_{eq} = \frac{1}{K_h} \right)$$

$$(a-z) \qquad - \qquad (s+z)$$

$$= \frac{K_a}{K_w} = \frac{1.8 \times 10^{-5}}{10^{-14}}$$

$$= 1.8 \times 10^{9}$$

$$(P^H)_2 = pK_a + \log \frac{(s+z)}{(a-z)}$$

P_2^H is slightly ↑

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

$$K_a = \frac{(H^+)(S+z)}{(a-z)}$$

Addition of Small Amount of Strong Acid in Basic Buffer

GURUKUL

(Buffer Action of Basic Buffer)

ATDB.uno

K_{RNH_2}

Before addition $\boxed{pOH = pK_b + \log\left(\frac{s}{b}\right)}$; $s = [RNH_3^+]$

$b = [RNH_2(aq)]$

GURUKUL

H_3O^+ addition :-

Base

$RNH_2(aq) + H_3O^+(aq) \rightleftharpoons RNH_3^+(aq) + H_2O(\ell)$; $K_{eq} = \frac{1}{K_h} = \frac{K_b}{K_w}$ ↑

b	x(L.R.)	s
(b-x)	—	(s + x)

$\boxed{p_2^{OH} = pK_b + \log\left(\frac{s+x}{b-x}\right)}$ ↑ ; p_2^{OH} is slightly ↓

Reaction mainly shift to Forward direction

$\therefore$ p^{OH} is slightly ↑

p^H is slightly ↓

OH^- addition:

$$RNH_3^{\oplus}(aq) + \underline{OH^{\ominus}}(aq) \rightleftharpoons RNH_2(aq) + H_2O(\ell)$$

($RNH_3OH(aq)$ or)

	s	y(L.R.)	b
	$(s-y)$	–	$(b+y)$

$$\downarrow \boxed{pOH = pK_b + \log\left(\frac{s-y}{b+y}\right)}$$

$\therefore$ pH ↑ (slightly)

$$K_{eq} = \left(\frac{1}{K_b}\right)\uparrow\uparrow$$

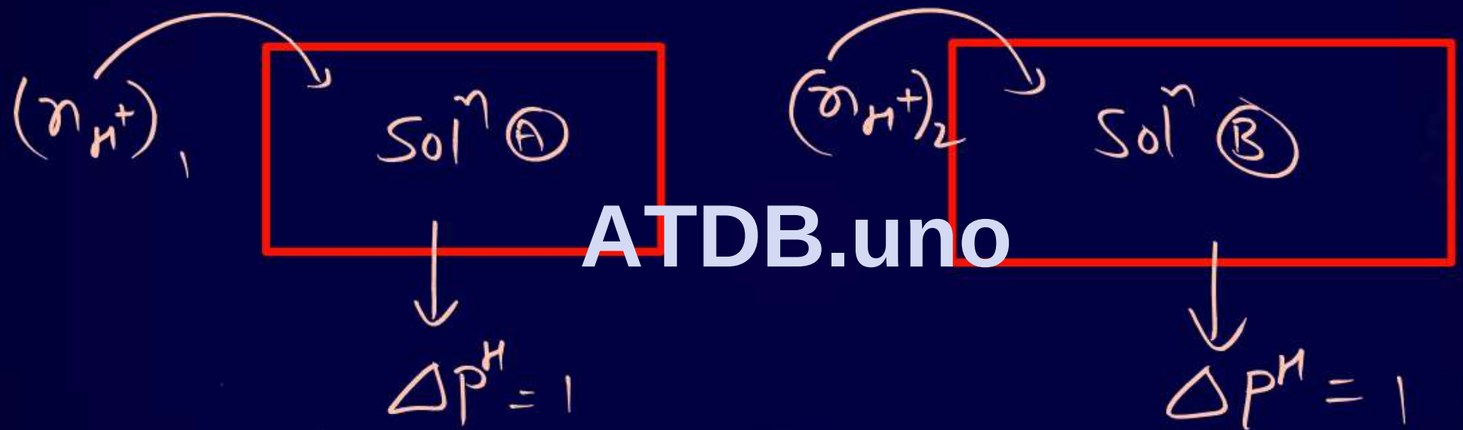
Reaction mainly shift in forward

(OH^-) slightly ↑

P^{OH} slightly ↓

Buffer Capacity

GURUKUL



If $(n_{H^+})_1 > (n_{H^+})_2$, Buffer Capacity of Soln (A) > Buffer Capacity of Soln (B)

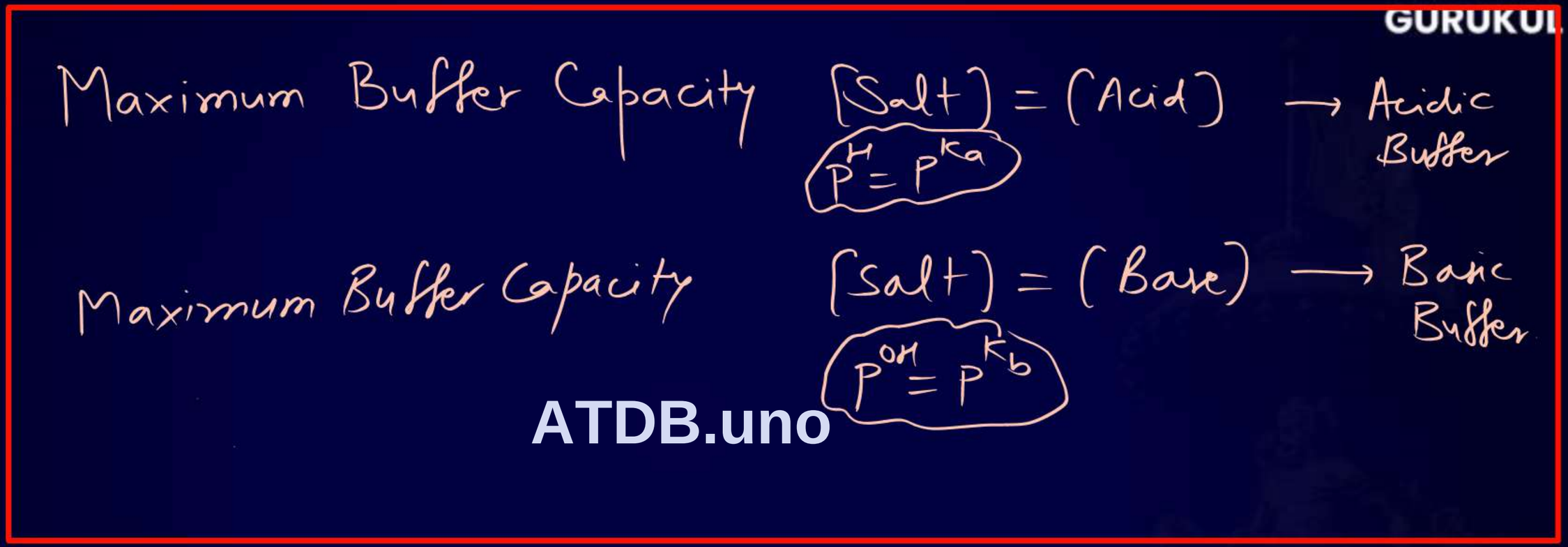
GURUKUL

$$\text{Buffer capacity} = \frac{\text{no. of moles of } H^+ / OH^- \text{ added per litre of buffer solution}}{\text{Change in pH}}$$

* More concentrate buffer solution; more pH resisting power; better buffer solution.

$0.01\ H^+/OH^-$

acid : 0.1 base : 0.1	acid : 0.05 base : 0.05
small change in pH	



Buffer solution at its maximum capacity: [Salt] = [Acid]

GURUKUL

ATDB.uno

$$\boxed{pH = pK_a}$$

GURUKUL

Basic buffer: $\frac{[salt]}{[base]} = \frac{1}{10}$ to $\frac{10}{1}$

$$pOH = pK_b \pm 1$$

Maximum capacity: [Salt] = [Base] ; $\boxed{pOH = pK_b}$

$$p_1H = pK_a + \log\left(\frac{s}{a}\right)$$

$\begin{cases} s = [CH_3COO^-] \\ a = [CH_3COOH] \end{cases}$ ≡

GURUKUL

b : small amount of strong base

$$p_2H = pK_a + \log\left(\frac{s+b}{a-b}\right)$$

$[CH_3COO^-] = s + b$

$[CH_3COOH] = a - b$

$[CH_3COO^-] + [CH_3COOH] = a + s = X$

↓

Const-ant.

Change in pH ; $\Delta pH = p_2H - p_1H = \log\left(\frac{(s+b)}{(a-b)} \times \frac{a}{s}\right)$

$$\Delta pH = \log\left(\frac{1+\left(\frac{b}{s}\right)}{1-\left(\frac{b}{a}\right)}\right)$$ ✓

GURUKUL

$$\Delta pH = \frac{1}{2.303} \ln \left[\frac{1 + \frac{b}{s}}{1 - \frac{b}{a}} \right] = \frac{1}{2.303} \left[\frac{b}{s} + \frac{b}{a} \right] = \frac{b}{2.303} \left[\frac{a+s}{a.s} \right]$$

buffer capacity in terms of buffer index: $\boxed{\frac{b}{\Delta pH} = 2.303 \left[\frac{a.s}{a+s} \right]}$

where $\boxed{a+s=x}$ constant $s = (x - a)$

$$\text{Buffer capacity} = 2.303 \left[\frac{a}{x}(x-a) \right]$$

For maximum buffer capacity

$$\frac{d(BC)}{da} = 0$$

$$x - a + a(-1) = 0 \quad ; \quad x = 2a \quad , \quad s + a = 2a \quad , \quad \boxed{s = a}$$

$$x - 2a = 0$$

$$x - 2a = 0 \Rightarrow a = \frac{x}{2} \qquad \because s = \frac{x}{2}$$

where solution at its maximum capacity

[Salt] = [Acid]

pH = pKa

$$pH = pK_a + \log\left(\frac{s}{a}\right)$$

$$= pK_a$$

(1)

Home Work

GURUKUL

A.W

Practice Sheet HW

1,3,7,12,13,14,19,21,22,23,24,37,38,39,40,41,45,53,55,56,
58,59,62,63,65,66,71,72,73,74,75,76,88,89,90,91,92,93,94

ATDB.uno