

LOGIC EQUILIBRIUM

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$$\log_e x$$

$x \rightarrow \text{no.}$

$e \rightarrow \text{base}$

$$\ln x = \log_e x = 2.303 \log_{10} x$$

$$\log xy = \log x + \log y$$

$$\log \frac{x}{y} = \log x - \log y$$

$$\log x^n = n \log x$$

$$\log_{10} 1 = 0$$

$$\log_{10} 2 = 0.3010$$

$$\log_{10} 3 = 0.4771$$

$$\log 5 = 0.699 = 0.7$$

$$\log 7 = 0.8451 = 0.85$$

$$\log_{10} 10 = 1$$

$$\log_{10} 11 = 1.04$$

eg ① $\log 4 = \log 2^2 = 2 \log 2 = 2 \times 0.30 = 0.60$

② $\log 6 = \log 3 \times 2 = \log 3 + \log 2 = 0.48 + 0.30 = 0.78$

③ $\log 8 = \log 2^3 = 3 \log 2 = 3 \times 0.30 = 0.90$

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$$\log 9 = \log 3^2 = 2 \log 3 = 2 \times 0.47 = 0.94$$

$$\log 12 = \log 2^2 \times 3 = 2 \log 2 + \log 3 = 2 \times 0.30 + 0.47 = 0.60 + 0.47 = 1.07$$

$$\log 18 = \log 3^2 \times 2 = 2 \log 3 + \log 2 = 2 \times 0.47 + 0.30 = 0.94 + 0.30 = 1.24$$

$$\log 64 = \log 2^6 = 6 \log 2 = 6 \times 0.30 = 1.80$$

$$\log 100 = \log 10^2 = 2 \log 10 = 2$$

$$\log 1000 = \log 10^3 = 3 \log 10 = 3$$

$$\log 10^{-3} = -3 \log 10 = -3$$

$$\log 0.0001 = \log 10^{-4} = -4 \log 10 = -4$$

$$\log 1.28 = \log 128 \times 10^{-2} = \log 2^7 \times 10^{-2} = \log 2^7 + \log 10^{-2} = 7 \log 2 - 2 \log 10 = 7 \times 0.30 - 2 = 2.10 - 2 = 0.10$$

$$\log 3.4 \times 10^{-3} = \log 3.4 + \log 10^{-3} = 0.54 - 3 \log 10 = 0.54 - 3 = -2.46$$

$$\log 7.3 \times 10^{-3} = \log 72 \times 10^{-4} = \log 2^3 \times 3^2 = 3 \log 2 + 2 \log 3 = 3 \times 0.30 + 2 \times 0.47 = 0.90 + 0.94 = 1.84$$

$$\log 2.2 \times 10^5$$

$$\log 0.625 = \log 10^{-3} \times 625 = -3 + 4 \times 0.7 = -0.2$$

$$\log 1.728 = \log 10^{-3} \times (12)^3$$

$$\log 0.0576$$

Antilog :

$$\log 2 = 0.3010$$

$$\text{Antilog } (0.3010) = 2$$

$$\text{Antilog } x = e^x$$

$$\text{Antilog } x = 10^x$$

$$\text{Antilog } 0.30 = 10^{0.30} = 2$$

$$\text{Antilog } 0.48 = 10^{0.48} = 3$$

$$\text{Antilog } 0.699 = 10^{0.699} = 5$$

$$\text{Antilog } 2 = 10^2$$

$$\text{Antilog } 4 = 10^4$$

$$\text{Antilog } -3 = 10^{-3}$$

$$\text{Antilog } -5 = 10^{-5}$$

$$\text{Antilog } 1.3 = 10^{1.3} = 10^1 \times 10^{0.3} = 10 \times 2 = 20$$

$$\text{Antilog } 3.48 = 10^{3.48} = 10^3 \times 10^{0.48} = 3000$$

$$\text{Antilog } 2.95 = 10^2 \times 10^{0.95} = 10^2 \times 9$$

$$\text{Antilog } -1.3 = 10^{-1.3} = 10^{-2+0.7} = 10^{-2} \times 10^{0.7} = 5 \times 10^{-2}$$

or

$$= \frac{1}{10^{1.3}} = \frac{1}{10^1 \times 10^{0.3}} = \frac{10^{-1}}{2} = 0.5 \times 10^{-1} = 5 \times 10^{-2}$$

$$\text{Antilog } -4.52 = 10^{-4.52} = 10^{-5+0.48} = 10^{-5} \times 3$$

$$\text{Antilog } -3.3 = 10^{-4} \times 10^{0.7} = 5 \times 10^{-4}$$

$$\text{Antilog } -4.05 = 10^{-5} \times 10^{0.95} = 9 \times 10^{-5}$$

$$\text{Antilog } -5.15 = 10^{-6} \times 10^{0.85} = 7 \times 10^{-6}$$

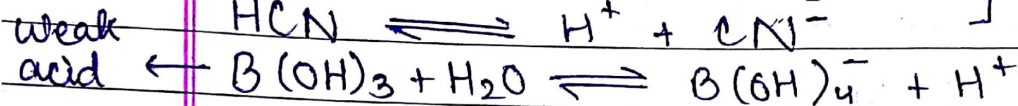
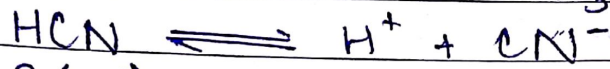
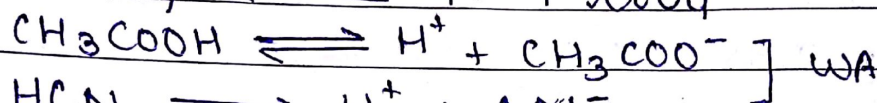
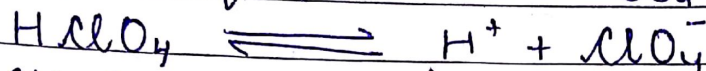
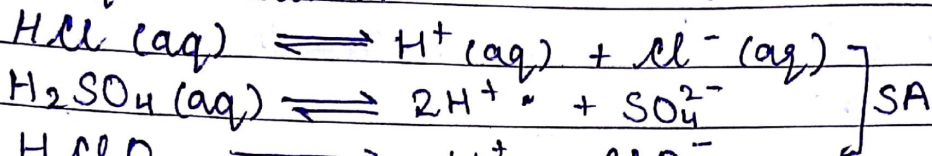
$$\text{Antilog } -3.48 = 10^{-3} \times 10^{-0.48}$$

$$= \frac{10^{-3}}{10^{0.48}} = \frac{10^{-3}}{3}$$

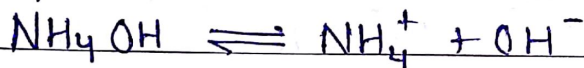
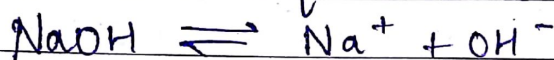
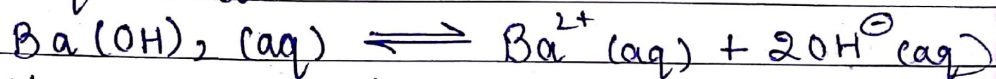
$$\text{Antilog } -4.85 = 10^{-4} \times 10^{-0.85} = \frac{10^{-4}}{10^{0.85}} = \frac{10^{-4}}{7}$$

Acid and Base :-

Arrhenius Acid :- which give H^+ ion in aq. medium.



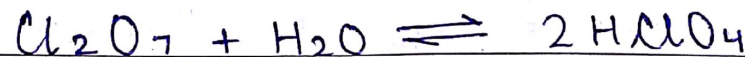
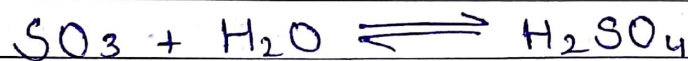
Arrhenius Base :- which give OH^- ions in aq. medium.



Application :-

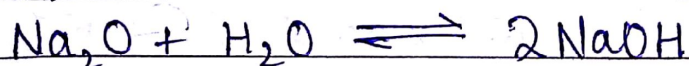
- It explain acidic nature of non-metallic oxides in aq. medium.

$CO_2, NO_2, P_4O_{10}, SO_3, SO_2, Cl_2O_7$ etc.



- It explains basic nature of metallic oxides

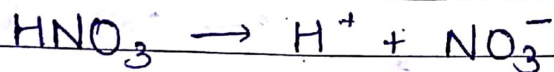
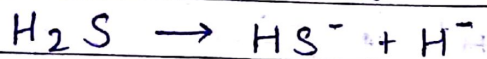
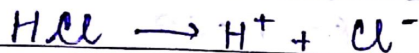
eg: CaO, Na_2O, BaO etc.



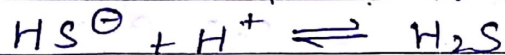
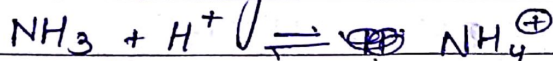
Accⁿ to Arrhenius, H_2O is neutral.

Bronsted - Lowry Concept :-

Acid :- which donate H^+ in any medium



Base : which gain H^+ ion in any medium

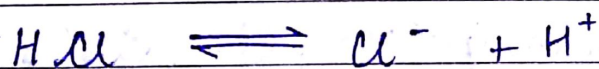


Conjugate acid - base pair :-

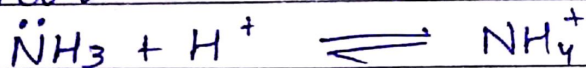
acid - base pair which is differ by H^+ ion.

conjugate acid : Conj. acid of a base is formed by taking H^+ ion.

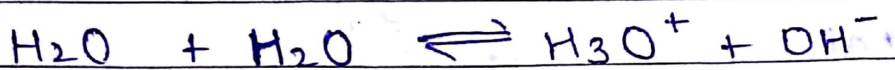
conjugate base : Conj. base of an acid is formed by releasing H^+ ion.



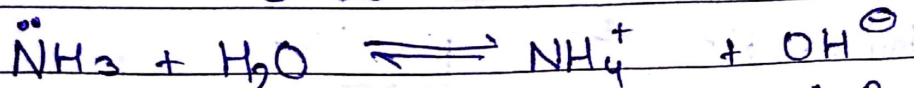
Acid C.B.



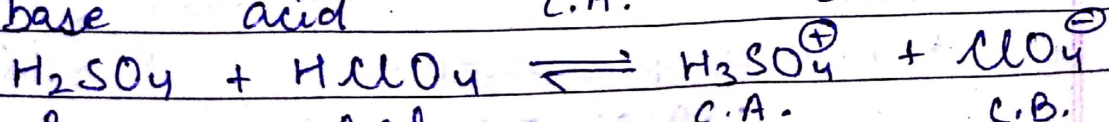
Base C.A.



acid Base C.A. C.B.



base acid C.A. C.B.



Base Acid C.A. C.B.

Strong Acid $\div$ HClO_4 , HCl , HBr , HI , H_2SO_4 , HNO_3

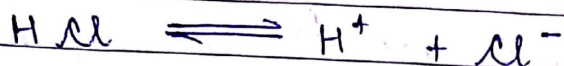
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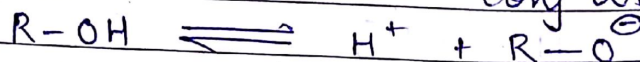
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Strong acid give weak c.B. & vice-versa
Strong base give weak c.A. & vice-versa



SA

Conj WB



WA

Conj S.B



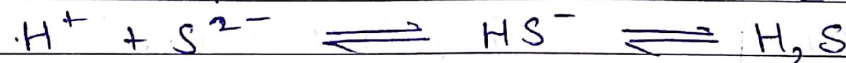
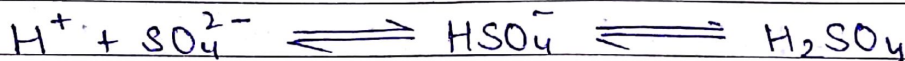
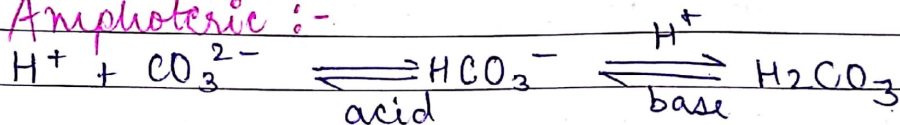
WB

S.C.A.



S.C.B.

Amphoteric :-



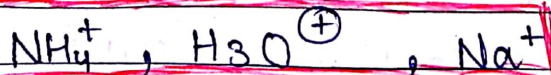
Lewis acid - base

Lewis Acid : which accept lone pair.
 e^- deficient

→ Vacant orbital & incomplete octet SiCl_4 , SnCl_2 ,
 SnCl_4 , BF_3 , AlCl_3 , PCl_5 , XeF_6 ,
 SbF_5

→ Polar π bond $\rightarrow \text{SO}_2$, SO_3 , CO_2 etc

→ Bare cations $\rightarrow \text{H}^+$, CH_3^+



→ L.A. x complete octet

• vacant orbital x

→ cation of IA

L.A. x

Lewis Base : which donate lp are Lewis base

eg anions $\rightarrow F^{\ominus}, Cl^{\ominus}, Br^{\ominus}, H^{\ominus}, OH^{\ominus}, N^{3-}$
lp containing species $\rightarrow \ddot{N}H_3, H_2\ddot{O}, \ddot{P}H_3$

non-polar π -bond $\rightarrow CH_2=CH_2$

Poly-basic acid :-

Basicity :- no. of H^+ ion donated by acid

$HCl \rightarrow 1$

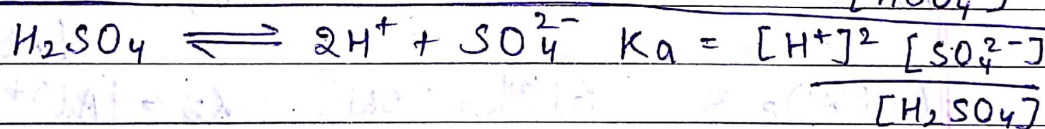
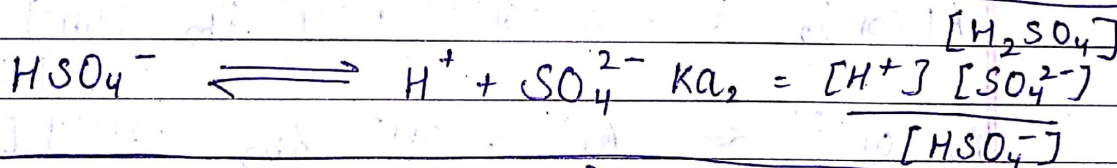
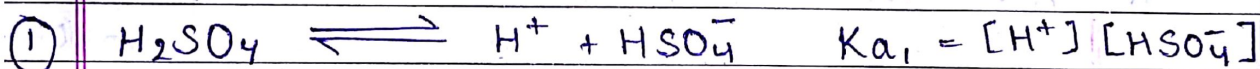
$HNO_3 \rightarrow 1$

$H_2SO_4 \rightarrow 2$

$H_3PO_4 \rightarrow 3$

$H_2PO_3 \rightarrow 2$

$H_3PO_2 \rightarrow 1$



$$K_a = K_{a1} \times K_{a2}$$

$$K_{a1} > K_{a2}$$

$$pK_{a1} < pK_{a2}$$

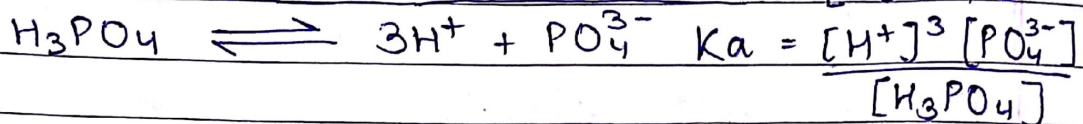
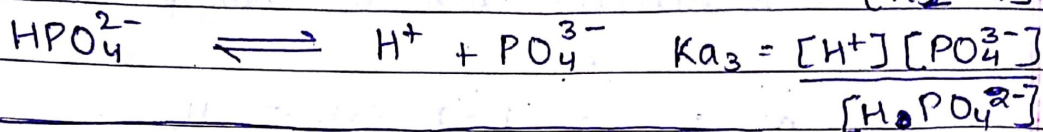
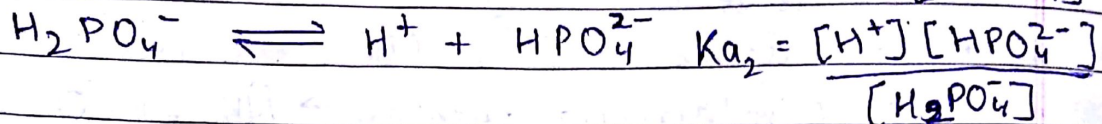
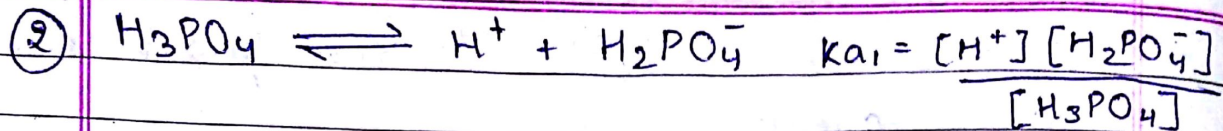
$$[H^+] \uparrow \quad K_a \uparrow \quad pK_a \downarrow \quad A.S. \uparrow$$

$$pK_a = pK_{a1} + pK_{a2}$$

H₃PO₄

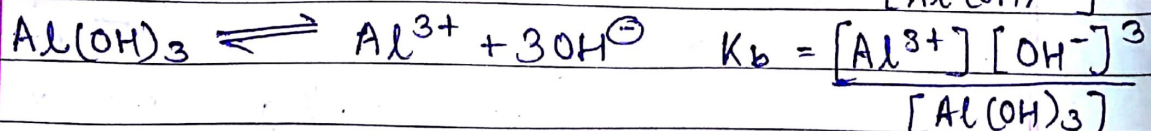
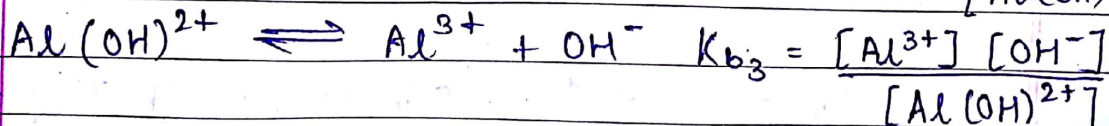
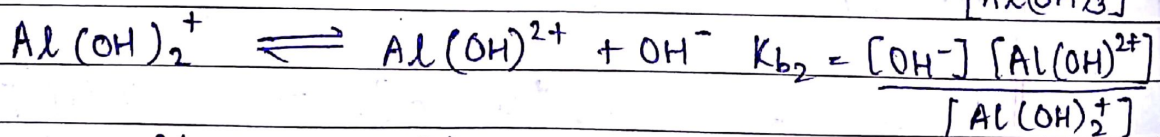
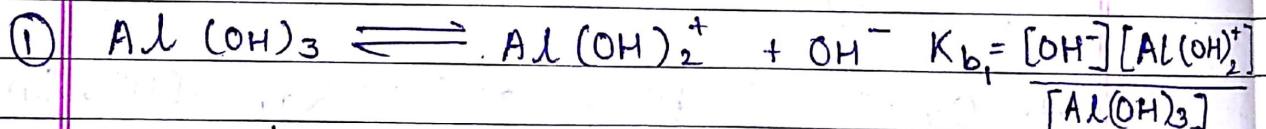
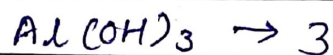
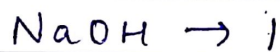
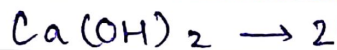
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$$K_{a_f} = K_{a1} \times K_{a2} \times K_{a3}$$

Base $\rightarrow$ Acidity : no. of OH⁻ given



$$[\text{OH}^-] \uparrow K_b \uparrow pK_b \downarrow \text{B.S.} \uparrow \quad K_b = K_{b1} \times K_{b2} \times K_{b3}$$

$$pK_b = pK_{b1} + pK_{b2} + pK_{b3}$$

ex ② Ca(OH)_2

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Non Conductor

which do not conduct electricity.

eg: Plastic, wood, glass & non-metals

↓

Exception :- graphite

Conductors

which conduct electricity

• 2 factors are responsible for conductivity

→ free e^-

→ free ions

Metallic conductor :- Conduct electricity due to +ve of free e^- .

eg: Al, Fe, Cu, --

Electrolytes : Conduct electricity due to +ve of free ions.

↓

Strong Electrolyte
which dissociate completely
 $\alpha = 1$ or $\alpha = 100\%$

eg SA: HCl, HBr, HI, HNO₃, H₂SO₄, HClO₄

SB: NaOH, KOH, RbOH, CsOH, Ba(OH)₂

Salt: NaCl, KCl, Na₂SO₄, Na₂CO₃

↓

Weak Electrolyte
which dissociate partially
 $\alpha < 1$ or $\alpha < 100\%$

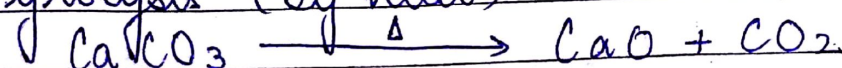
eg WA: HCN $\rightleftharpoons$ HCOOH, HF, H₂S, CH₃COOH,

H₂CO₃

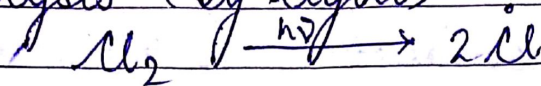
eg WB: NH₄OH, Mg(OH)₂, Ca(OH)₂, Zn(OH)₂, Fe(OH)₂

Decomposition :- Breaking of molecule by applying some energy.

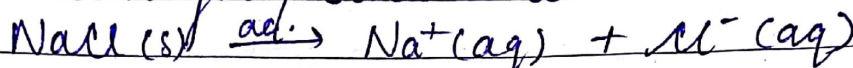
Pyrolysis (by heat)



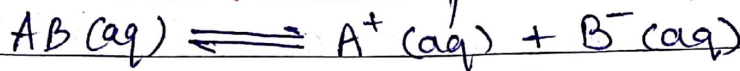
Photolysis (by light)



Ionisation : separation of ions when an electrolyte / substance is dissolved in water



Dissociation : It is partial ^{decomposition} dissociation



→ when a weak electrolyte is dissolved in water then its ions remains in eq. with undissociated then the process is c/a dissociation.

DOD (α)

$$\alpha = \frac{\text{no. of moles dissociated}}{\text{initial moles}}$$

Factors affecting D.O.D:-

1. Nature of Electrolyte:

Strong electrolyte $\text{dod} \uparrow \alpha = 1$

Weak electrolyte $\text{dod} \downarrow \alpha < 1$

2. Nature of solvent:

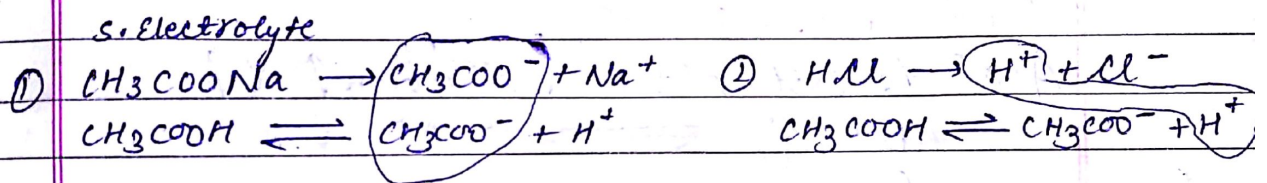
$\text{dod} \propto \text{dielectric const. of solvent}$

Solvent	H ₂ O	CH ₃ OH	C ₂ H ₅ OH	Acetone
dielectric const. (K)	81	32	24.6	20

3. dilution as dilution $\uparrow \alpha \uparrow$
at infinite dilution $\alpha \approx 1$

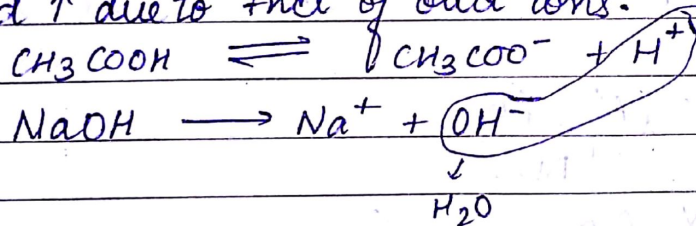
4. Temperature :
dissociation of electrolyte is an endothermic process
as $T \uparrow \alpha \uparrow$

5. Common ion effect :- $dod \propto \frac{1}{C.I.E.}$
dod of $CH_3COOH \downarrow$ in +ve of CH_3COONa or HCl
becoz CH_3COO^- or H^+ ions are already +ve
in solⁿ



6. Odd ion effect :- $dod \propto O.I.E.$

dod $\uparrow$ due to +ve of odd ions.



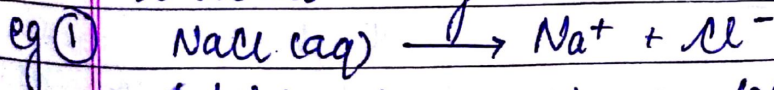
Arrhenius Theory of electrolytes :-

1. When an electrolyte is dissolved in water then it dissociate into ions.

2. After dissociation,

total +ve charge = total -ve charge

but total no. of cations may or may not be equal to total no. of anions

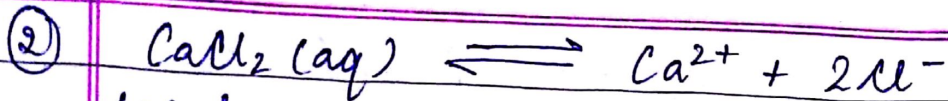


total +ve charge = +1

total cation = 1

total -ve charge = -1

total anion = 1



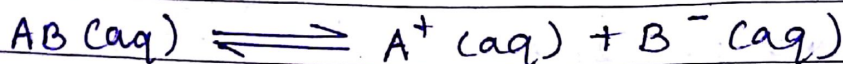
total +ve charge = +2

Total cations = 1

total -ve charge = -2

Total anions = 2

3. when a weak electrolyte is dissolved in water then it ions remains in eq^m with undissociate part.



$$K = \frac{[\text{A}^+][\text{B}^-]}{[\text{AB}]}$$

Ostwald Law :-

Accⁿ to Ostwald, as dilution $\uparrow$ $\alpha \uparrow$



to

C

$C - x$

x

x

$C - C\alpha$

$C\alpha$

$C\alpha$

$$K = \frac{[\text{A}^+][\text{B}^-]}{[\text{AB}]}$$

$$K = \frac{C\alpha \cdot C\alpha}{C - C\alpha} = \frac{C\alpha \cdot C\alpha}{C(1 - \alpha)}$$

$$K = \frac{C\alpha^2}{1 - \alpha}$$

for weak electrolytes $\alpha \ll 1$

$$1 - \alpha \approx 1$$

$$K = C\alpha^2$$

$$\alpha = \sqrt{\frac{K}{C}}$$

$\alpha \rightarrow \text{dod}$

$C \rightarrow \text{initial conc}^n$

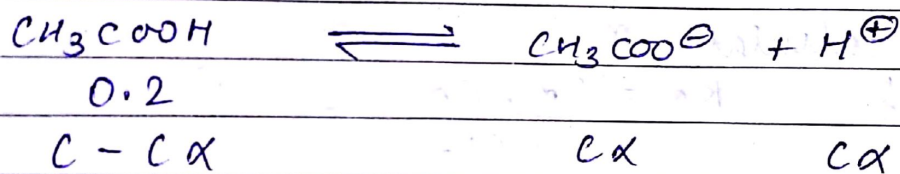
$$\alpha \propto \frac{1}{\sqrt{C}} \quad C = \frac{n}{V}$$

$$\alpha \propto \sqrt{V}$$

as dilution $\uparrow$ $\alpha \uparrow$

Application of Ostwald Law:-
Calculation of α , K , C

Ques Calculate concⁿ of H^+ ion in a solⁿ of 0.2 M acetic acid & calculate α . If dissociation const. $K_a = 1.8 \times 10^{-4}$



$$K = \frac{[C\alpha][C\alpha]}{C(1-\alpha)}$$

$$1.8 \times 10^{-4} = C\alpha^2$$

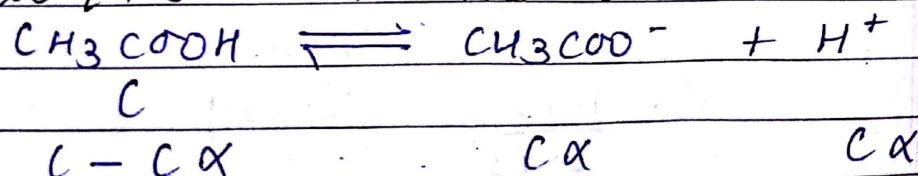
$$\frac{1.8 \times 10^{-4}}{0.2} = \alpha^2$$

$$\alpha = \sqrt{\frac{1.8 \times 10^{-4}}{0.2}} = \sqrt{9 \times 10^{-4}} = 3 \times 10^{-2}$$

$$[H^+] = C\alpha$$

$$= 0.2 \times 3 \times 10^{-2} = 0.6 \times 10^{-2}$$

Ques (i) Calculate the concⁿ of solⁿ of acetic acid in which $[H^+] = 1.5 \times 10^{-3} M$ & $K_a = 2.6 \times 10^{-3}$



$$\frac{[H^+]}{1.5 \times 10^{-3}} = \alpha$$

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

$$2.6 \times 10^{-3} = \frac{1.5 \times 10^{-3} \times 1.5 \times 10^{-3}}{[CH_3COOH]}$$

$$[CH_3COOH] = \frac{1.5 \times 10^{-3} \times 1.5 \times 10^{-3}}{2.6 \times 10^{-3}}$$

$$= \frac{1.5 \times 10^{-3}}{2.6}$$

(ii)

Calculate α

1st method

$$K_a = \frac{C\alpha \cdot C\alpha}{C(1-\alpha)} = C\alpha^2$$

$$K_a = C\alpha^2 = (C\alpha)\alpha = [H^+]\alpha$$

$$\alpha = \frac{K_a}{[H^+]} = \frac{2.6 \times 10^{-3}}{1.5 \times 10^{-3}} = 1.73$$

$\alpha > 1$ ✗

2nd method

$$K_a = \frac{C\alpha \cdot C\alpha}{C(1-\alpha)} = \frac{C\alpha^2}{1-\alpha}$$

$$K_a = \frac{C\alpha \cdot \alpha}{1-\alpha} = [H^+] \frac{\alpha}{1-\alpha}$$

$$2.6 \times 10^{-3} = \frac{1.5 \times 10^{-3} \alpha}{1-\alpha}$$

$$\frac{\alpha}{1-\alpha} = 1.73$$

$$\alpha = 1.73 - 1.73\alpha$$

$$\alpha = \frac{1.73}{2.73} = 0.634$$

pH scale :- Sorenson

$$pH = -\log [H^+]$$

$$pOH = -\log [OH^-]$$

$$\text{at } 25^\circ C \quad [H^+] [OH^-] = 10^{-14}$$

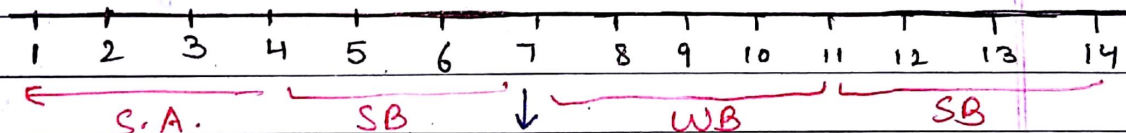
$$-\log [H^+] - \log [OH^-] = -\log 10^{-14}$$

$$pH + pOH = 14$$

$[H^+] \uparrow$ $pH \downarrow$ A.S. $\uparrow$

$[OH^-] \uparrow$ $pOH \downarrow$ $pH \uparrow$ B.S. $\uparrow$

pH Scale at $25^\circ C$



$pH = 7$ neutral

$pH < 7$ acidic

$pH > 7$ basic

Ques Find pH of following :-

1. $[H^+] = 10^{-3}$

$$pH = 3$$

2. $[OH^-] = 10^{-4}$

$$pOH = 4$$

$$pH = 10$$

3. $[H^+] = 3 \times 10^{-4}$

$$\begin{aligned} -\log [H^+] &= -\log 3 \times 10^{-4} \\ &= 4 - \log 3 \\ &= 4 - 0.477 \\ &= 3.523 \end{aligned}$$

4. $[\text{OH}^-] = 3.6 \times 10^{-5}$ $\text{pOH} = 5 - \log 3.6$

5. $[\text{H}^+] = 8.1 \times 10^{-3}$ $\text{pH} = 3 - \log 8.1$

6. $[\text{OH}^-] = 2.16 \times 10^{-5}$ $\text{pOH} = 5 - \log 2.16$

7. $[\text{H}^+] = 1.28 \times 10^{-2}$ $\text{pH} = 2 - \log 1.28$

8. $[\text{OH}^-] = 3.43 \times 10^{-5}$ $\text{pOH} = 5 - \log 3.43$

Calculation of H^+ & OH^-

$\text{pH} = -\log_{10} [\text{H}^+]$ $\text{pOH} = -\log [\text{OH}^-]$

$[\text{H}^+] = 10^{-\text{pH}}$ $[\text{OH}^-] = 10^{-\text{pOH}}$

Ques Find $[\text{H}^+]$ & $[\text{OH}^-]$

1. $\text{pH} = 3$ $[\text{H}^+] = 10^{-3}$
 $\text{pOH} = 11$ $[\text{OH}^-] = 10^{-11}$

2. $\text{pOH} = 12$ $[\text{OH}^-] = 10^{-12}$
 $\text{pH} = 2$ $[\text{H}^+] = 10^{-2}$

3. $\text{pH} = 6$ $[\text{H}^+] = 10^{-6}$
 $\text{pOH} = 8$ $[\text{OH}^-] = 10^{-8}$

4. $\text{pOH} = 5$ $[\text{OH}^-] = 10^{-5}$
 $\text{pH} = 9$ $[\text{H}^+] = 10^{-9}$

5. $pH = 3.15$ $[H^+] = ?$
 $[H^+] = 10^{-3.15} = 10^{-4} \times 10^{0.85} = 7 \times 10^{-4}$
$$\begin{array}{cc} 10^{-3-1} & 10^{1-0.15} \\ 10^{-4} & 10^{0.85} \end{array}$$

6. $pOH = 10.85$ $[H^+]$
 $pH = \cancel{10.85} 3.15$
 $[H^+] = 10^{-3.15} = 10^{-4} \times 10^{0.85}$
 $= 7 \times 10^{-4}$

7. $pH = 2.52$ $[H^+]$
 $[H^+] = 10^{-2.52}$
 $= 10^{-3} \times 10^{0.48}$
 $= 10^{-3} \times 3$
 $= 3 \times 10^{-3}$

8. $pOH = 11.95$ $[H^+]$
 $pH = 2.05$
 $[H^+] = 10^{-2.05}$
 $= 10^{-3} \times 10^{0.95}$
 $= 9 \times 10^{-3}$

9. $pH = 3.3$ $[OH^-]$
 $pOH = 10.7$
 $[OH^-] = 10^{-10.7} = 10^{-11} \times 10^{0.3}$
 $= 2 \times 10^{-11}$

10. $pH = 2.95$ $[OH^-]$
 $pOH = 11.05$
 $[OH^-] = 10^{-11.05} = 10^{-12} \times 10^{0.95}$
 $= 9 \times 10^{-12}$

Application of Ostwald Dilution Law :-

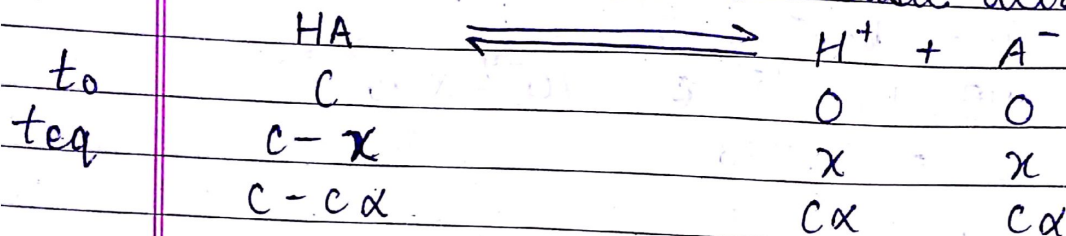
PH of weak monobasic acid :-

monobasic acid $\rightarrow$ which give $[H^+]$

bi- dibasic acid $\rightarrow$ $2[H^+]$

tribasic acid $\rightarrow$ $3[H^+]$

Let HA is a weak monobasic acid



$$K_a = \frac{[H^+][A^-]}{[HA]}$$

$$1 - x \approx 1$$

$$K_a = \frac{Cx \cdot Cx}{C(1-x)} = \frac{Cx^2}{1-x} \approx Cx^2$$

$$K_a = Cx^2$$

$$x = \sqrt{\frac{K_a}{C}}$$

$$[H^+] = Cx = C \sqrt{\frac{K_a}{C}}$$

$$[H^+] = \sqrt{K_a \times C}$$

$$[H^+] = (K_a \times C)^{1/2}$$

$$pH = -\log [H^+] = -\log (K_a \times C)^{1/2}$$

$$pH = \frac{1}{2} [-\log K_a - \log C]$$

$$pH = \frac{1}{2} pK_a - \frac{1}{2} \log C$$

ionisation const.
of acid

initial concⁿ. in terms
of NORMALITY

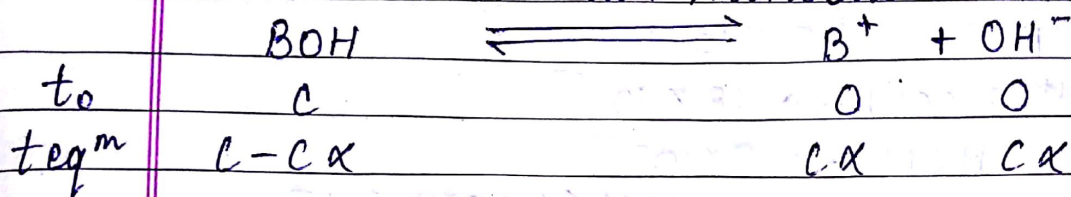
pH of weak monoacidic base :-

monoacidic base $\longrightarrow$ 1 $[\text{OH}^-]$

bi $\longrightarrow$ 2 $[\text{OH}^-]$

tri $\longrightarrow$ 3 $[\text{OH}^-]$

Let BOH is a weak ^{acidic} monobasic base



$$K_b = \frac{C\alpha \cdot C\alpha}{C(1-\alpha)} = \frac{C\alpha^2}{1-\alpha}$$

$$K_b = C\alpha^2$$

$$\alpha = \sqrt{\frac{K_b}{C}}$$

$$[\text{OH}^-] = C\alpha = C \times \sqrt{\frac{K_b}{C}}$$

$$[\text{OH}^-] = \sqrt{K_b \times C}$$

$$\text{pOH} = -\log [\text{OH}^-] = -\log (K_b \times C)^{1/2}$$

$$\text{pOH} = \frac{1}{2} [-\log K_b - \log C]$$

$$\text{pOH} = \frac{1}{2} \text{p}K_b - \frac{1}{2} \log C$$

$$\text{pH} = 14 - \text{pOH}$$

$K_b \rightarrow$ ionisation const base

$C \rightarrow$ initial concⁿ of base in NORMALITY

$[\text{H}^+] \uparrow$ A.S. $\uparrow$ $K_a \uparrow$ $\text{p}K_a \downarrow$ $\text{pH} \downarrow$

$[\text{OH}^-] \uparrow$ B.S. $\uparrow$ $K_b \uparrow$ $\text{p}K_b \downarrow$ $\text{pOH} \downarrow$ $\text{pH} \uparrow$

Ques Equimolar solⁿ of HF, HCOOH & HCN at 298 K have values of K_a of 6.8×10^{-4} , 1.8×10^{-4} , 9×10^{-5} resp. what will be $\uparrow$ order of their acidic strength?

$K_a \uparrow$ A.S. $\uparrow$

HF $\rightarrow 68 \times 10^{-5}$

HCOOH $\rightarrow 18 \times 10^{-5}$

HCN $\rightarrow 9 \times 10^{-5}$

HCN < HCOOH < HF

Ques Calculate pH of 0.02 M CH₃COOH aq. solⁿ also calculate α if K_a for CH₃COOH is 1.8×10^{-5}

$$\begin{aligned} \text{pH} &= -\log (K_a \times C)^{1/2} \\ &= -\log (0.02 \times 1.8 \times 10^{-5})^{1/2} \\ &= -\log (2 \times 18 \times 10^{-8})^{1/2} \\ &= -\log (36 \times 10^{-8})^{1/2} \\ &= -\log (6 \times 10^{-4}) \\ &= 4 - \log 6 \\ &= 4 - 0.77 = 3.23 \end{aligned}$$

30 $\rightarrow$ 2
47 $\rightarrow$ 3
60 $\rightarrow$ 4
699 $\rightarrow$ 5
30 + 47
6.77

$$\alpha = \sqrt{\frac{K_a}{C}} = \sqrt{\frac{1.8 \times 10^{-5}}{0.02}} = \sqrt{\frac{189 \times 10^{-5} \times 10^2}{2 \times 10}} = \sqrt{9 \times 10^{-4}} = 3 \times 10^{-2}$$

Ques At 25°C, dissociation const. of a base BOH is 1.0×10^{-12} . Find concⁿ of hydroxyl ions in 0.01 M aq. solⁿ of base. also pH of solⁿ.

$\alpha = 10^{-5}$
pH = 7
pOH = 7

~~$K_a = 1.0 \times 10^{-12}$~~

$C = 0.01 \text{ M}$

$[\text{OH}^-] = \sqrt{K_b \times C}$

$[\text{OH}^-] = ?$

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$$[\text{OH}^-] = \sqrt{1 \times 10^{-12} \times 10^{-2}}$$

$$[\text{OH}^-] = 10^{-7}$$

$$\text{pOH} = 7$$

$$\text{pH} = 14 - 7$$

$$\text{pH} = 7$$

Ques Ionisation const. of CH_3COOH is 1.7×10^{-5} & concⁿ of H^+ is $3.4 \times 10^{-4} \text{ M}$ then find out initial concⁿ of CH_3COOH molecules. & also find pH, α .

$$[\text{H}^+] = \sqrt{K_a \times c}$$

$$\frac{[\text{H}^+]^2}{K_a} = c = \frac{(3.4 \times 10^{-4})^2}{1.7 \times 10^{-5}} = \frac{3.4 \times 3.4 \times 10^{-8}}{1.7 \times 10^{-5}}$$

$$c = 6.8 \times 10^{-3}$$

$$\alpha = \sqrt{\frac{K_a}{c}} = \sqrt{\frac{1.7 \times 10^{-5}}{6.8 \times 10^{-3}}} = \sqrt{\frac{17}{684} \times 10^{-2}} = \sqrt{\frac{1}{4} \times \frac{1}{10^2}}$$

$$\alpha = \frac{1}{2 \times 10} = \frac{1}{20}$$

$$[\text{H}^+] = c \alpha = \frac{6.8 \times 10^{-3} \times 1}{20} = \frac{17}{5} \times 10^{-4} = 3.4 \times 10^{-4}$$

$$\text{pH} = 4 - \log 3.4 = 4 - 0.5 = 3.5$$

Ques
AIPMT

A weak acid HA has a K_a of 1.00×10^{-5} if 0.100 mole of this acid is dissolved in 1 L of water, then find % dissociation of acid at eqm.

$$c = \frac{n}{V}$$

$$c = \frac{0.1}{1} = 0.1 \text{ M}$$

$$c = 0.1 \times 1 = 0.1 \text{ N}$$

$$\alpha \% = ?$$

$$\alpha \% = \sqrt{\frac{K_a}{c}} \times 100$$

$$= \sqrt{\frac{1 \times 10^{-5}}{10^{-1}}} \times 100$$

$$= \sqrt{10^{-4}} \times 100$$

$$= 10^{-2} \times 100$$

$$\alpha \% = 1 \%$$

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Ques Find pH of following assuming complete ionisation or at ~~at~~ infinite dilution?

1. 0.001 M HCl

$$\alpha = \sqrt{\frac{K_a}{C}}$$

$$K_a = C\alpha^2 \\ = 1 \times 10^{-3} \times 1 \\ = 10^{-3}$$

$$[H^+] = \sqrt{K_a \times C}$$

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

$$pH = 3$$

2. 0.0001 M H₂S
10⁻⁴

$$[H^+] = C\alpha \\ = 2 \times 10^{-4}$$

$$pH = 4 - \log 2 = 4 - 0.30 \\ = 3.70$$

3. 0.002 M H₃PO₄
2 × 10⁻³

$$[H^+] = C\alpha \\ = 3 \times 2 \times 10^{-3} \times 1 = 6 \times 10^{-3}$$

$$pH = 3 - \log 6 =$$

4. 0.01 N ~~Ca~~ Ca(OH)₂

$$[OH^-] = C\alpha \\ = 1 \times 10^{-2}$$

$$pOH = 2$$

$$pH = 14 - 2 = 12$$

5. 0.005 M Mg(OH)₂
5 × 10⁻³

$$[OH^-] = C\alpha \\ = 2 \times 5 \times 10^{-3} = 10^{-2}$$

$$pOH = 2$$

$$pH = 12$$

6. 0.0001 N H₃PO₄
1 × 10⁻⁴

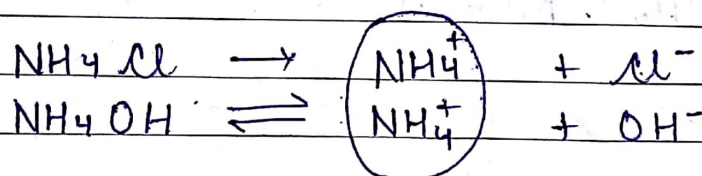
$$[H^+] = C\alpha \\ = 10^{-4}$$

$$pH = 4$$

7. $0.0005 \text{ N Al(OH)}_3$ $[\text{OH}^-] = c\alpha$
 5×10^{-4} $= 5 \times 10^{-4}$
 $\text{pOH} = 4 - \log 5$
 $= 4 - 0.69 = 3.3$
 $\text{pH} = 14 - 3.3$
 $= 10.7$

Common Ion Effect:-

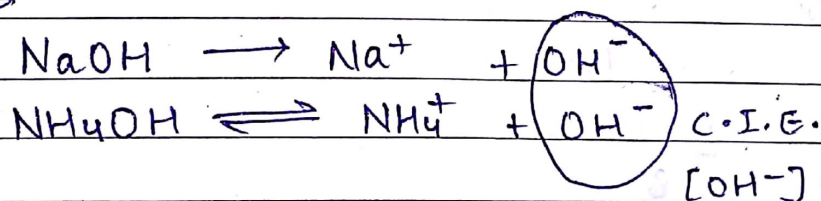
When strong electrolyte having common ion is put in weak electrolyte then eq^m shift backward & α ↓



C.I.E. $[\text{NH}_4^+] \uparrow$

accⁿ to Le Chatelier, eq^m shift backward
 $\alpha \downarrow$

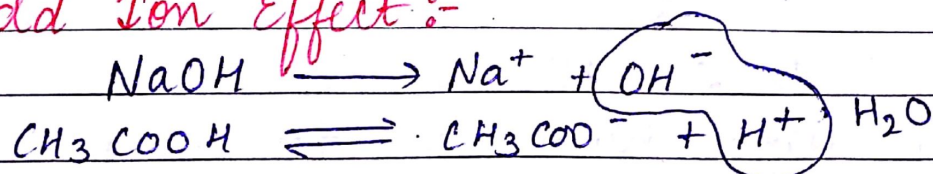
~~NaOH~~



$[\text{OH}^-] \uparrow$

eq^m shift backward
 $\alpha \downarrow$

Odd Ion Effect:-



$[\text{H}^+] \downarrow$

eq^m shift forward $\alpha \uparrow$

Que Which of the following show common ion effect? W.E. + S.E.

1. $\text{NH}_4\text{OH} + \text{HNO}_3$ W.B + S.A
2. $\text{NaCl} + \text{HCl}$ S.E. + S.E
3. $\text{NH}_4\text{OH} + \text{Ba}(\text{OH})_2$ W.E. + S.E
4. $\text{HCN} + \text{NaCN}$ W.E. + S.E.
5. $\text{NH}_4\text{NO}_3 + \text{NH}_4\text{OH}$ S.E. + W.E.
6. $\text{NaCl} + \text{NH}_4\text{Cl}$ S.E. + S.E.
7. $\text{Ca}(\text{OH})_2 + \text{Ba}(\text{OH})_2$ W.E + S.E
8. $\text{CH}_3\text{COOH} + \text{HCl}$ W.E + S.E.
9. $\text{HCN} + \text{NH}_4\text{Cl}$ W.E + S.E.
10. $\text{CH}_3\text{COONH}_4 + \text{NH}_4\text{OH}$ S.E. + W.E

Explanation of water :-

H_2O is neutral

$$\text{pH} = 7$$

$$\text{pOH} = 7$$

$$[\text{H}^+] = 10^{-7} \text{ mol L}^{-1}$$

$$[\text{OH}^-] = 10^{-7} \text{ mol L}^{-1}$$

$$d_{\text{H}_2\text{O}} = 1 \text{ g/ml}$$

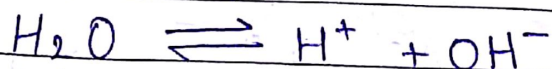
$$1000 \text{ g} \rightarrow 1 \text{ L}$$

$$1 \text{ L H}_2\text{O} \Rightarrow 1000 \text{ g}$$

$$n = \frac{1000}{18} = 55.55$$

$$V = 1 \text{ L}$$

$$[\text{H}_2\text{O}] = \frac{n}{V} = 55.55 \text{ mol/L}$$



1 L water have = 55.55 moles

1 L " " = 55.55 NA molecules of H_2O

$$[\text{H}^+] = 10^{-7} \text{ mol/L}$$

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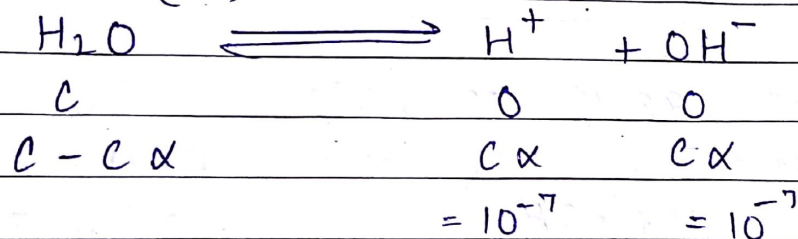
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$$1 \text{ L water home} = 10^{-7} \text{ mol of } H^+ \\ = 10^{-7} \text{ NA } H^+ \text{ ions}$$

$$\begin{array}{ccc} \text{no. of molecules of water} & : & \text{no. of } H^+ \text{ ions in} \\ \text{in 1L} & & \text{1L water} \\ 55.55 \text{ NA} & : & 10^{-7} \text{ NA} \\ 55.55 \times 10^7 & : & 1 \end{array}$$

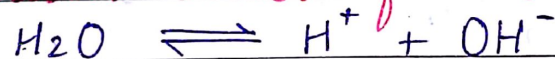
So water is a weak electrolyte

d o d (α)



$$\alpha = \frac{10^{-7} \times 1000}{55.55 \times 1000} = 1.8 \times 10^{-9}$$

Ionisation Const. for water :-



$$K = \frac{[H^+][OH^-]}{[H_2O]}$$

$$K = \frac{10^{-7} \times 10^{-7}}{55.55}$$

$$K = 1.8 \times 10^{-16}$$

Ionic products of water (K_w)

$$K = \frac{[H^+][OH^-]}{[H_2O]}$$

$$K [H_2O] = [H^+] [OH^-]$$

$$K_w = 10^{-7} \times 10^{-7}$$

$$K_w = 10^{-14}$$

$$pK_w = -\log K_w$$

$$pK_w = 14$$

Relation b/w pH, pOH & pK_w

$$K_w = [H^+] [OH^-]$$

$$-\log K_w = -\log [H^+] - \log [OH^-]$$

$$pK_w = pH + pOH$$

$$pH + pOH = 14$$

At ~~298~~ 298 K or 25°C

$$pH = 7$$

$$pOH = 7$$

$$pK_w = pH + pOH$$

$$pK_w = 2 pOH$$

$$14 = pK_w = pH + pH$$

$$pOH = \frac{14}{2} = 7$$

$$pH = \frac{14}{2} = 7$$

pH, pK_w & pOH of water at different Temperature

	0°C	25°C	90°C
K _w	0.114×10^{-14}	10^{-14}	10^{-12}
pK _w	14.94	14	12
pH	7.47	7	6
pOH	7.47	7	6
[H ⁺]	$10^{-7.47}$	10^{-7}	10^{-6}
[OH ⁻]	$10^{-7.47}$	10^{-7}	10^{-6}

On ↑sing Temp, water remains neutral but
ionisation of water ↑
K_w ↑

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Ques pH of water at 298 K
1. > 7 2. < 7 3. 7 4. Can't be determined

Ques pH of water at 273 K
1. > 7 2. < 7 3. 7 4. Can't be determined

Ques pH of water at 328 K
1. > 7 2. < 7 3. 7 4. Can't be determined

Ques Find no. of H^+ ions in 1ml water at $25^\circ C$.
 $[H^+] = 10^{-7} \text{ mol/L}$
 $10^{-7} \text{ mol of } H^+ \text{ in 1L}$
 $10^{-7} \text{ NA } H^+ \text{ ions in 1000ml}$
 $10^{-10} \text{ NA } \leftarrow \text{ 1ml}$

Ques If ionic product of water at a particular temp. is given 10^{-16} . then find $[H^+]$, $[OH^-]$, pH, pOH, $pH + pOH$, $[H^+] + [OH^-]$
 $[H^+] = 10^{-8}$
 $[OH^-] = 10^{-8}$
 $pH = 8$
 $pOH = 8$
 $pH + pOH = 8 + 8 = 16$
 $[H^+] + [OH^-] = 10^{-8} + 10^{-8} = 2 \times 10^{-8}$

Ques Find $[H^+]$ & $[OH^-]$ of a 0.1 M aq. solⁿ of 5% ionised acid (given $K_w = 10^{-14} \text{ M}$)
 $H_2O \rightleftharpoons H^+ + OH^-$
 $C = 0.1$
 $C - C\alpha \quad C\alpha \quad C\alpha$

$$\alpha = 5\% = 0.05$$

$$[H^+] = C\alpha = 0.1 \times 0.05 = 5 \times 10^{-3}$$

$$[H^+][OH^-] = 10^{-14}$$

$$[OH^-] = \frac{10^{-14}}{5 \times 10^{-3}}$$

pH of mixtures :-

Mixture Strong Acids :-

$$\left[\begin{array}{c} M_1, \\ V_1 \end{array} \right] + \left[\begin{array}{c} M_2, \\ V_2 \end{array} \right] = \left[\begin{array}{c} V = V_1 + V_2 \end{array} \right]$$

$$\text{no. of eq} = N_1 V_1 \quad N_2 V_2 \quad N_1 V_1 + N_2 V_2$$

$$[H^+] = \frac{N_1 V_1 + N_2 V_2}{V_1 + V_2}$$

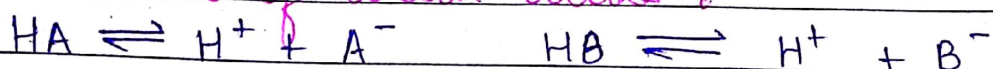
Mixture of strong base :

$$\left[\begin{array}{c} M_1, \\ V_1 \end{array} \right] + \left[\begin{array}{c} M_2, \\ V_2 \end{array} \right] = \left[\begin{array}{c} V = V_1 + V_2 \end{array} \right]$$

$$N_1 V_1 \quad N_2 V_2 \quad N_1 V_1 + N_2 V_2$$

$$[OH^-] = \frac{N_1 V_1 + N_2 V_2}{V_1 + V_2}$$

Mixture of weak acids :-



C_1

C_2

O

O

$$C_1 - C_1\alpha, C_1\alpha, C_1\alpha, C_2 - C_2\alpha, C_2\alpha, C_2\alpha$$

$$[H^+] = C_1\alpha_1 + C_2\alpha_2$$

$$= \sqrt{K_{a1}C_1} + \sqrt{K_{a2}C_2}$$

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Ques If pH of HCl & HNO₃ is 2 & 3 resp. 200 ml of HCl & 300 ml HNO₃ is mixed find pH of resulting solⁿ?

$$[H^+] = \frac{10^{-2} \times 200 + 10^{-3} \times 300}{500}$$

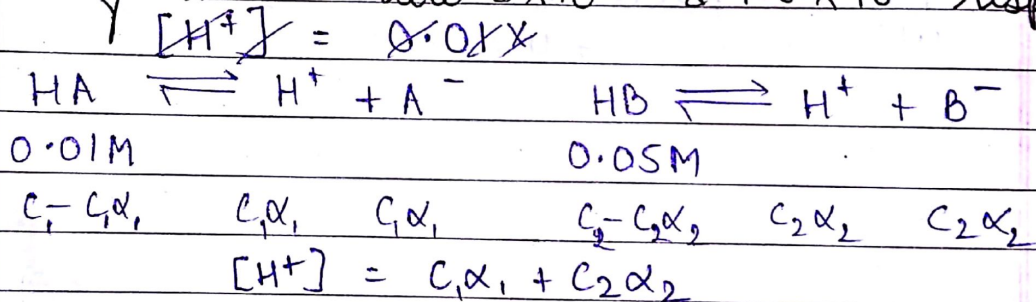
$$= \frac{2 + 3/10}{500} = \frac{20+3}{500} = \frac{23}{500} = 4.6 \times 10^{-3}$$

$$pH = 3 - \log 4.6$$

$$= 3 - 0.66$$

$$= 2.34$$

Ques Two weak monobasic acid, HA & HB having 0.01 M & 0.05 M resp. are mixed. Find pH of resulting mixture if dissociation const. of HA & HB are 8×10^{-4} & 1.6×10^{-4} resp.



$$= \sqrt{K_{a1}C_1} + \sqrt{K_{a2}C_2}$$

$$= \sqrt{8 \times 10^{-4} \times 1 \times 10^{-2}} + \sqrt{1.6 \times 10^{-4} \times 5 \times 10^{-2}}$$

$$= 2 \times 10^{-3} \sqrt{2} + \frac{2 \times 10^{-3} \sqrt{8}}{2 \times 10} \times 5$$

$$= 2 \times 10^{-3} \sqrt{2} + 2 \sqrt{2} \times 10^{-3}$$

$$= 2 \times 2 \sqrt{2} \times 10^{-3}$$

$$= 4 \sqrt{2} \times 10^{-3} = 5.6 \times 10^{-3}$$

$$pH = 3 - \log 5.6$$

$$= 3 - 0.7 = 2.3$$

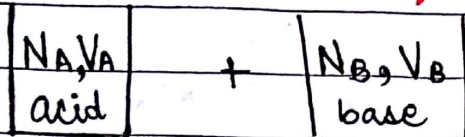
$$\frac{5.6}{5.6} = 1$$

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pH of mixture of SA & SB :-



Case-I $N_A V_A > N_B V_B \rightarrow \text{sol}^n \text{ is acidic}$

$$[H^+] = \frac{N_A V_A - N_B V_B}{V_A + V_B}$$

Case-II $N_A V_A < N_B V_B \rightarrow \text{sol}^n \text{ is basic}$

$$[OH^-] = \frac{N_B V_B - N_A V_A}{V_A + V_B}$$

Case III $N_A V_A = N_B V_B$ $\text{sol}^n \text{ is neutral}$
 $pH = 7$

① $0.1 \text{ M HCl}, 300 \text{ ml} + 0.1 \text{ M NaOH}, 200 \text{ ml}$

$$N_A V_A = 0.1 \times 300 = 30$$

$$N_B V_B = 0.1 \times 200 = 20$$

$$\frac{N_A V_A - N_B V_B}{V_A + V_B} = \frac{30 - 20}{500} = \frac{10}{500}$$

$$[H^+] = \frac{1}{50}$$

$$= 0.2 \times 10^{-1}$$

$$= 2 \times 10^{-2}$$

$$pH = 2 - \log 2$$

$$= 2 - 0.30 = 1.70$$

(2)

0.5 M HCl, 200 ml + 0.05 M Ba(OH)₂, 300 ml

12.6

$$[H^+] = \frac{100 - 30}{500}$$

$$N_A V_A = 0.5 \times 200 = 100$$

$$= \frac{70}{500} = \frac{7}{50} = 0.14 = 1.4 \times 10^{-2}$$

$$N_B V_B = 2 \times 0.05 \times 300 = 30$$

$$\begin{aligned} pH &= 2 - \log 1.4 = 2 - (\log 7 \times 2) = 2 - (\log 7 + \log 2) \\ &= 2 - (0.8 + 0.3) = 2 - 1.1 \\ &= 0.9 \end{aligned}$$

(3)

0.1 M NaOH, 100 ml + 0.05 M H₂SO₄, 100 ml

neutral

$$N_A V_A = 0.1 \times 100 = 10$$

$$N_B V_B = 0.05 \times 2 \times 100 = 10$$

$$N_A V_A = N_B V_B$$

then pH = 7
neutral

(4)

0.1 N H₂SO₄, 200 ml + 0.2 N KOH, 100 ml

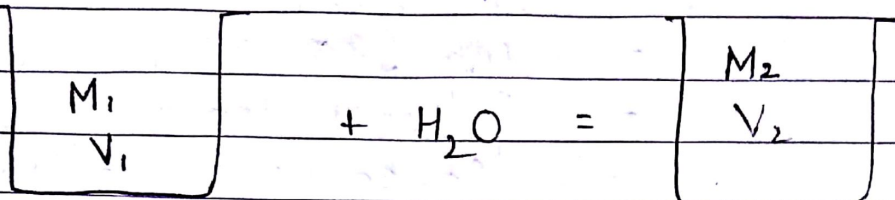
$$N_A V_A = 0.1 \times 200 = 20$$

$$N_B V_B = 0.2 \times 100 = 20$$

$$N_A V_A = N_B V_B$$

then pH = 7
neutral

Dilution $\div$ SA or SB



n_{solute}

n_{solute}

$$M = \frac{n}{V}$$

no. of moles = const.
 $M_1 V_1 = M_2 V_2$

$$n = MV = \text{const}$$

$$N = \frac{\text{no. of eq.}}{V}$$

no. of eq. = $n \times n\text{-factor}$
no. of eq. = const.

$[H^+] \rightarrow \text{NORMALITY}$

$$V_2 = V_1 + H_2O \quad \text{water added}$$

Ques

0.1 M HCl having vol. 500 ml is diluted by adding 500 ml water. Calculate pH?

$$N_1 V_1 = N_2 V_2$$

$$0.1 \times 500 = N_2 \times 1000$$

$$[H^+] = N_2 = \frac{0.1}{2} = 0.05 = 5 \times 10^{-2}$$

$$pH = 2 - \log 5 = 2 - 0.69 = 1.3$$

Ques

0.2 M, 200 ml of H_2SO_4 solⁿ is diluted upto 2L by adding water. Calculate pH of resulting solⁿ?

$$N_1 V_1 = N_2 V_2$$

$$0.2 \times 200 = N_2 \times 2000$$

$$[H^+] = N_2 = 0.02$$

$$\begin{aligned} \text{pH} &= -\log [\text{H}^+] \\ &= -\log [40] \\ &= -\log [4 \times 10] \\ &= -[\log 4 + \log 10] \\ &= -[0.60 + 1] = -1.60 \end{aligned}$$

Ques HCl solⁿ of pH = 2 is diluted upto 10 times by adding water. & Calculate change in pH?

pH = 3

$$10^{-2} \times V = N_2 \times 10V$$

$$N_2 = 10^{-3}$$

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

$$\text{pH} = 3$$

$$\begin{aligned} \Delta \text{pH} &= 3 - 2 \\ &= 1 \end{aligned}$$

Ques pH of NaOH is 13. Solⁿ is diluted upto 100 times calculate change in pH?

$$[\text{H}^+] = 10^{-13}$$

$$[\text{OH}^-] = 10^{-1}$$

$$10^{-1} \times V = N_2 \times 100V$$

$$[\text{OH}^-] = N_2 = \frac{10^{-1}}{10^2} = 10^{-3}$$

$$\begin{aligned} \text{pOH} &= 3 - \log 1 = 3 \\ \text{pH} &= 11 \end{aligned}$$

$$\Delta \text{pH} = 11 - 13 = -2$$

Tab concⁿ Tyada ho :-

Note :- * If an acid is diluted upto 10 times then pH ↑ by 1 & If a base is diluted upto 10 times then pH ↓ by 1.

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* If an acid is diluted upto 100 times then pH is $\uparrow$ by 2 & if a base is diluted upto 100 times then pH $\downarrow$ by 2.

If an acid is diluted upto 1000 times then pH is $\uparrow$ by 3 & if a base is diluted upto 1000 times pH $\downarrow$ by 3

pH of very dilute solⁿ :-

$10^{-7} \text{ M}, 10^{-8} \text{ M}, 10^{-9} \text{ M}$

Ques Find pH of $10^{-7} \text{ M HCl sol}^n$?

$$[\text{H}^+]_{\text{acid}} = 10^{-7} \text{ M} \times 1 = 10^{-7} \text{ M}$$

$$[\text{H}^+]_{\text{H}_2\text{O}} = 10^{-7}$$

$$[\text{H}^+]_{\text{total}} = 10^{-7} + 10^{-7} = 2 \times 10^{-7}$$

$$\text{pH} = -\log 2 \times 10^{-7} = 7 - 0.3 = 6.7$$

Ques Find pH of $10^{-8} \text{ M HCl sol}^n$

$$[\text{H}^+]_{\text{acid}} = 10^{-8}$$

$$[\text{H}^+]_{\text{total}} = 10^{-8} + 10^{-7}$$

$$= 10^{-8} (1 + 10)$$

$$= 10^{-8} \times 11$$

$$\text{pH} = 8 - \log 11 = 8 - 1.04 = 6.96$$

Ques Find pH of $10^{-9} \text{ M HNO}_3 \text{ sol}^n$

$$[\text{H}^+]_{\text{total}} = 10^{-9} + 10^{-7}$$

$$= 10^{-9} [1 + 100] = 10^{-9} \times 101 = 1.01 \times 10^{-7}$$

$$\text{pH} = 7 - \log 1.01 = 7 - 0.001 = 6.999$$

Ques Find pH of 10^{-9} M NaOH solⁿ

$$[\text{OH}^-] = 10^{-9}$$

$$[\text{OH}^-]_{\text{H}_2\text{O}} = 10^{-7}$$

$$\begin{aligned} [\text{OH}^-]_{\text{Total}} &= 10^{-9} + 10^{-7} \\ &= 10^{-7} \left(\frac{10^{-9}}{10^{-7}} + 1 \right) \\ &= 10^{-7} \left(\frac{1 + 100}{100} \right) \end{aligned}$$

$$= 10^{-7} \times \frac{101}{100}$$

$$= 10^{-7} \times 1.01$$

$$\begin{aligned} \text{pOH} &= 7 - \log 1.01 = 7 - 0.001 \\ &= 6.999 \end{aligned}$$

$$\text{pH} = 7.001$$

Ques pH of solⁿ is 6 it is diluted 1000 times
calculate pH of resultant solⁿ

$$\text{pH} = 6 \quad [\text{H}^+] = 10^{-6}$$

$$[\text{H}^+] = 10^{-9}$$

$$\begin{aligned} 10^{-6} \times &= N_2 \times 1000 \\ N_2 &= 10^{-9} \end{aligned}$$

$$[\text{H}^+] = 10^{-9} + 10^{-7}$$

$$= 10^{-9} (1 + 100)$$

$$= 10^{-9} \times 101 = 1.01 \times 10^{-7}$$

$$\begin{aligned} \text{pH} &= 7 - 0.001 \\ &= 6.999 \end{aligned}$$

Ques 10^{-5} M HNO_3 solⁿ is diluted 100 times Find
pH of resulting solⁿ?

$$10^{-5} \times &= N_2 \times 100$$

$$[\text{H}^+] = N_2 = 10^{-7}$$

$$[\text{H}^+]_{\text{Total}} = 10^{-7} + 10^{-7} = 2 \times 10^{-7}$$

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$$pH = 7 - \log 2 = 7 - 0.30 = 6.70$$

Que How much moles of HCl should be removed from 1 L solⁿ to change pH 2 to 3

$$N = M \times n_{\text{factor}} \quad n_{\text{factor}} = 1$$

$$N = M$$

$$V = 1 \text{ L}$$

$$n_1 - n_2 = \frac{1}{100} - \frac{1}{1000}$$

$$= \frac{9}{1000}$$

$$M = \frac{n}{V}$$

$$pH = 2$$

$$[H^+] = 10^{-2}$$

$$V = 1 \text{ L}$$

$$n_1 = 10^{-2}$$

$$pH = 3$$

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

$$V = 1 \text{ L}$$

↓

$$n_2 = 10^{-3}$$

Que How much volⁿ of water should be added to change the pH of HCl solⁿ from 2 to 3. If mixture volⁿ is 1 L

$$N = M \times n_{\text{factor}}$$

$$N = M$$

$$N_1 = [H^+] = 10^{-2}$$

$$N_2 = [H^+] = 10^{-3}$$

$$V_1 = 1 \text{ L}$$

$$V_2 = ?$$

$$N_1 V_1 = N_2 V_2$$

$$10^{-2} \times 1 = 10^{-3} V_2$$

$$10 \text{ L} = V_2$$

*

→ Volume of water added = 10 - 1
= 9 L

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Conjugate acid - base pair :-

Acid & Base which differ by one H^+ or one OH^- ion is c/a conj. acid - base pair

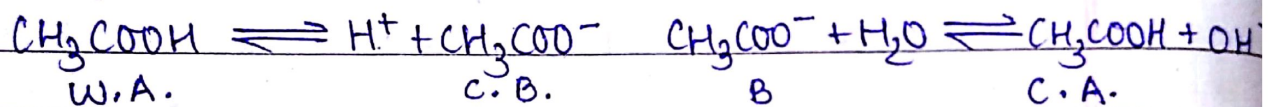
Conj. base of SA is a WB

Conj. base of WA is a SB

Conj. acid of SB is a WA

Conj. acid of WB is a SA

Relation b/w pK_a , pK_b and pK_w :-



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

$$K_b = \frac{[CH_3COOH][OH^-]}{[CH_3COO^-]}$$

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

$$K_a \times K_b = [H^+][OH^-]$$

$$K_a \times K_b = K_w$$

$$-\log K_a - \log K_b = -\log K_w$$

$$pK_a + pK_b = pK_w$$

$$pK_a + pK_b = 14$$

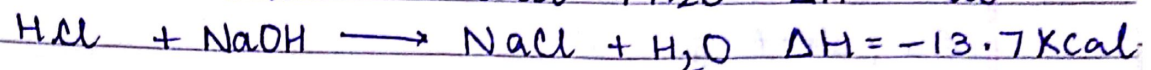
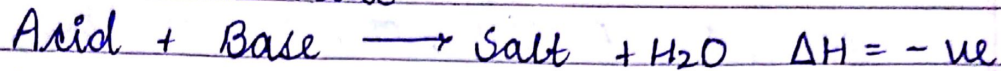
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Salt :-

→ Acid & base gives neutralisation reacⁿ to form salt.

→ Exothermic reacⁿ

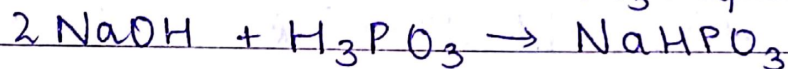
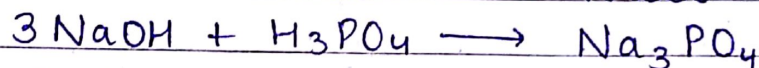
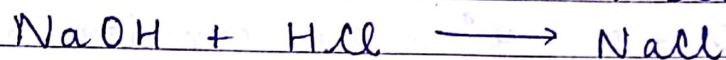
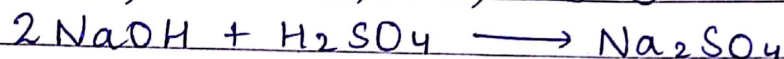
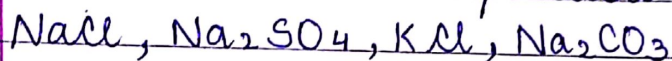


Type of Salt :-

1. Normal salt :- complete neutralisation

↓

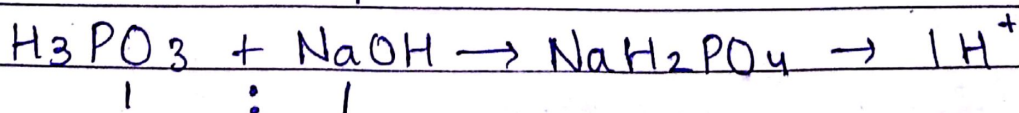
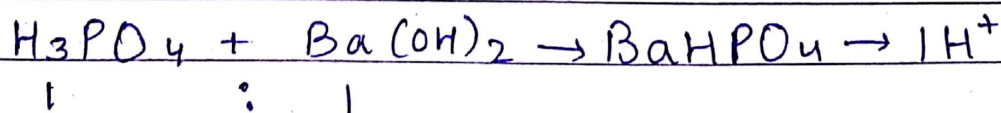
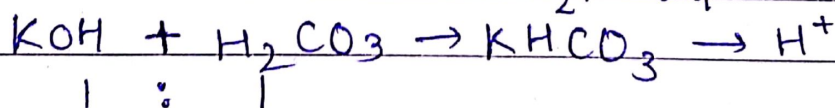
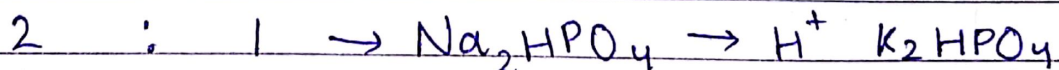
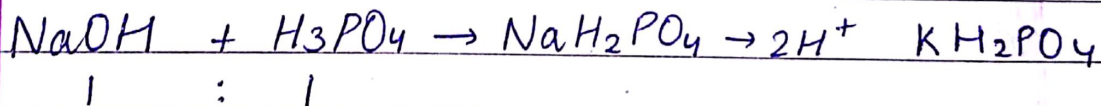
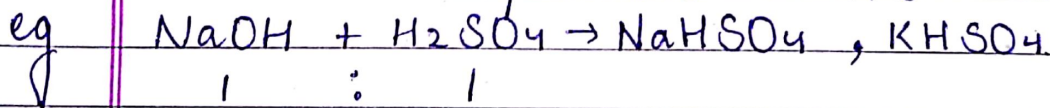
there is no replacable H^+ & OH^- ion



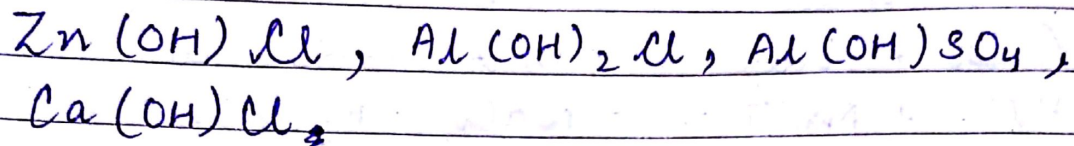
2. Acidic Salt incomplete neutralisation

↓

There is replacable H^+ ions



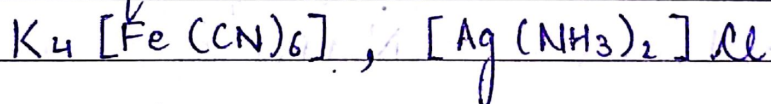
3. Basic salt : incomplete neutralisation
↓
which have replaceable OH^- ions



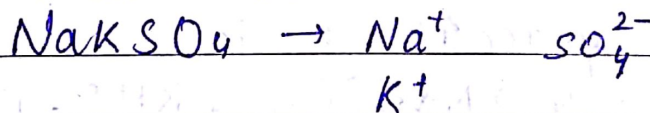
4. Double Salt :- Those addition comp. which is formed by addition of 2 salts.

eg Potash Alum $\text{K}_2\text{SO}_4 \cdot \text{Al}_2(\text{SO}_4)_3 \cdot 24\text{H}_2\text{O}$
Ferrous Ammonium Salt $\text{FeSO}_4 \cdot (\text{NH}_4)_2\text{SO}_4 \cdot 6\text{H}_2\text{O}$

5. Complex Salt :- which give complex ions in aq. medium.



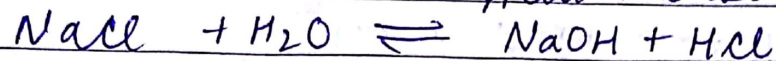
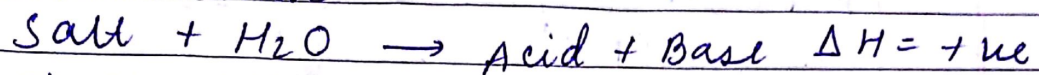
6. Mixed Salt :- which give more than one type of cations or anions.



~~10~~

Hydrolysis of salt :- It is reversed process of neutralisation.

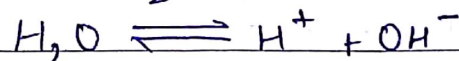
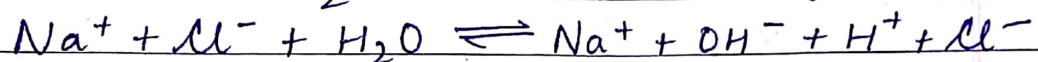
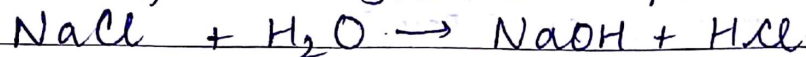
• Endothermic



Types of Hydrolysis :

1. **Hydrolysis of SA-SB salt :-**

NaCl , KCl , Na_2SO_4 , K_2SO_4 , NaClO_4 , NaI , KBr ,
 NaNO_3 , $\text{Ba}(\text{NO}_3)_2$, BaSO_4



Weak Electrolyte

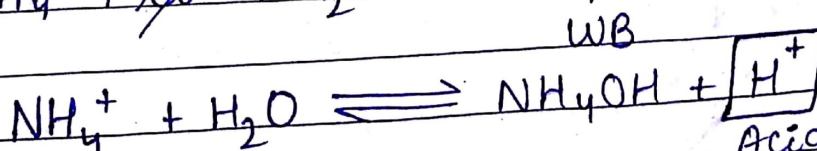
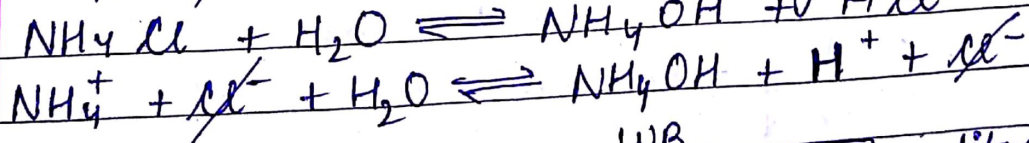
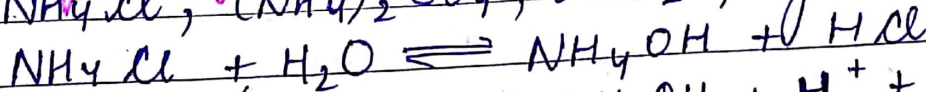
Note :- It is not a hydrolysis reacⁿ becoz cation & anion are not active

- $\text{pH} = 7 \rightarrow$ neutral
- no effect toward litmus paper

Ques pH of NaCl solⁿ at 90°C
 ① 7 ② > 7 ③ < 7 ④ Can't be said

2. **Hydrolysis of SA-WB salt :- / Cationic hydrolysis**

eg NH_4Cl , $(\text{NH}_4)_2\text{SO}_4$, CaCl_2 , MgSO_4

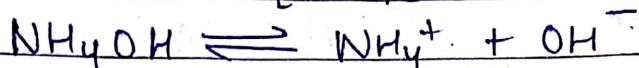


litmus paper $\rightarrow$
 Blue to Red
 Acidic
 $\text{pH} < 7$

Calculation of K_h , K_a , h , $[H^+]$, pH

$K_h \rightarrow$ hydrolysis const

$$K_h = \frac{[NH_4OH][H^+]}{[NH_4^+]}$$



$$K_b = \frac{[NH_4^+][OH^-]}{[NH_4OH]}$$

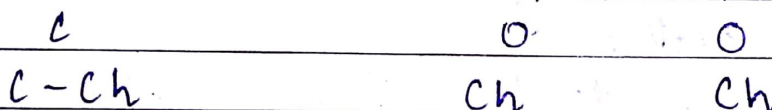
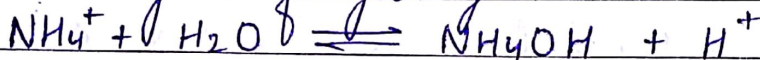
$$K_h \times K_b = \frac{[NH_4OH][H^+]}{[NH_4^+]} \times \frac{[NH_4^+][OH^-]}{[NH_4OH]}$$

$$K_h \times K_b = [H^+][OH^-]$$

$$K_h \times K_b = K_w$$

$$K_h = \frac{K_w}{K_b}$$

$h \rightarrow$ degree of hydrolysis



$$K_h = \frac{ch \cdot ch}{c(1-h)} = ch^2$$

$$h = \sqrt{\frac{K_h}{c}} = \sqrt{\frac{K_w}{K_b \times c}}$$

$$h = \sqrt{\frac{K_w}{K_b \times c}}$$

$$[H^+] = ch = c \times \sqrt{\frac{K_w}{K_b \times c}} = \sqrt{\frac{K_w \times c}{K_b}}$$

$$pH = -\log [H^+] = -\log \left(\frac{K_w \times c}{K_b} \right)^{1/2}$$

$$= \frac{1}{2} \left[-\log K_w - \log c - (-\log K_b) \right]$$

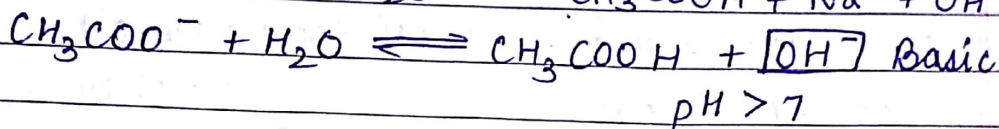
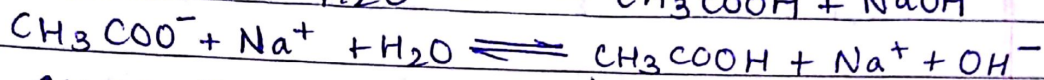
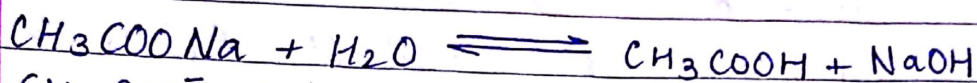
$$= \frac{1}{2} pK_w - \frac{1}{2} \log c - \frac{1}{2} pK_b$$

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$$pH = 7 - \frac{1}{2} pK_b - \frac{1}{2} \log C$$

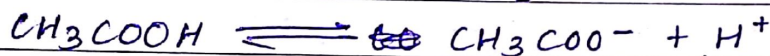
3. Hydrolysis of WA⁻SB Salt / anionic hydrolysis
eg CH_3COONa , $HCOONa$, $HCOOK$, $NaCN$, KCN , Na_2CO_3 , $BaCO_3$



$pH > 7$

litmus $\rightarrow$ Red to blue

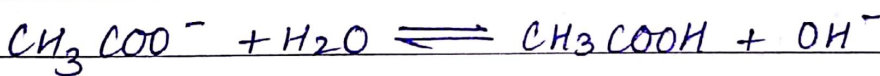
$$K_h = \frac{[CH_3COOH][OH^-]}{[CH_3COO^-]}$$



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

$$K_h \times K_a = K_w$$

$$K_h = \frac{K_w}{K_a}$$



C

C - ch

Ch

ch

$$K_h = \frac{Ch \cdot ch}{C(1-h)} = Ch^2$$

$$h = \sqrt{\frac{K_h}{C}}$$

$$h = \sqrt{\frac{K_w}{K_a \times C}}$$

$$[OH^-] = Ch = \sqrt{\frac{K_w \times C}{K_a}}$$

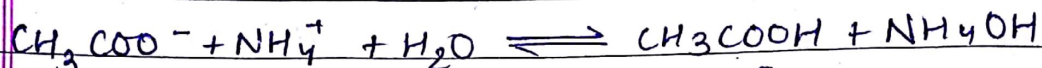
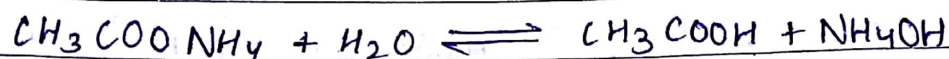
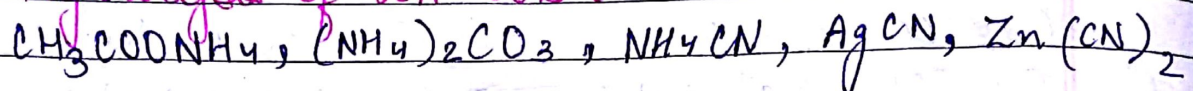
$$pOH = -\log \left(\frac{K_w \times C}{K_a} \right)^{1/2} = \frac{1}{2} [-\log K_w - \log C + \log K_a]$$

$$pOH = 7 - \frac{1}{2} \log C - \frac{1}{2} pK_a$$

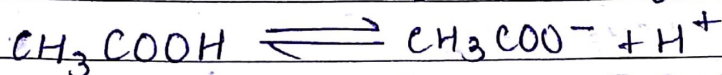
$$pH = 14 - pOH$$

$$pH = 7 + \frac{1}{2} pK_a + \frac{1}{2} \log C$$

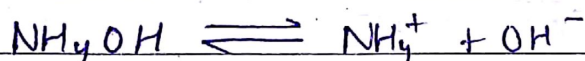
4. Hydrolysis of WA-WB :-



$$K_h = \frac{[CH_3COOH][NH_4OH]}{[CH_3COO^-][NH_4^+]}$$



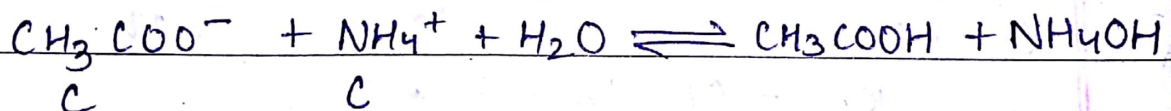
$$K_a = \frac{[CH_3COO^-][H^+]}{[CH_3COOH]}$$



$$K_b = \frac{[NH_4^+][OH^-]}{[NH_4OH]}$$

$$K_h \times K_a \times K_b \times \cancel{K_w} = K_w$$

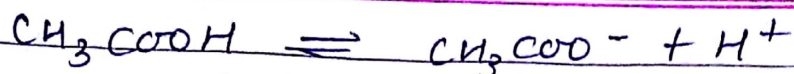
$$K_h = \frac{K_w}{K_a \times K_b}$$



$$K_h = \frac{C-h}{C} \cdot \frac{C-h}{C} = \frac{h^2}{(1-h)^2} = h^2$$

$$h = \sqrt{K_h}$$

$$h = \sqrt{\frac{K_w}{K_a \times K_b}}$$



$$K_a = \frac{[\text{H}^+][\text{CH}_3\text{COO}^-]}{[\text{CH}_3\text{COOH}]}$$

Ch

C-CH

$$K_a = \frac{[\text{H}^+][x(1-h)]}{xh}$$

$$h \times K_a = [\text{H}^+]$$

$$[\text{H}^+] = K_a \times \sqrt{\frac{K_w}{K_a \times K_b}}$$

$$[\text{H}^+] = K_a \times \left(\frac{K_w}{K_a \times K_b} \right)^{1/2}$$

$$[\text{H}^+] = \left(\frac{K_w \times K_a}{K_b} \right)^{1/2}$$

$$\text{pH} = -\log \left(\frac{K_w \times K_a}{K_b} \right)^{1/2}$$

$$= \frac{1}{2} (-\log K_w - \log K_a + \log K_b)$$

$$\text{pH} = 7 + \frac{1}{2} \text{p}K_a - \frac{1}{2} \text{p}K_b$$

SA SB	SAWB	WASB	WAWB
1. Neutral	Acidic	Basic	Almost neutral
2. -	$K_h = \frac{K_w}{K_b}$	$K_h = \frac{K_w}{K_a}$	$K_h = \frac{K_w}{K_a \times K_b}$
3.	$h = \sqrt{\frac{K_w}{K_b \cdot C}}$	$h = \sqrt{\frac{K_w}{K_a \cdot C}}$	$h = \sqrt{\frac{K_w}{K_a \cdot K_b}}$
4.	$[\text{H}^+] = Ch = \sqrt{\frac{K_w \cdot C}{K_b}}$	$[\text{H}^+] = \sqrt{\frac{K_w \times K_a}{C}}$	$[\text{H}^+] = Kah = \sqrt{\frac{K_w K_a}{K_b}}$
		$[\text{OH}^-] = Ch = \sqrt{\frac{K_w \cdot C}{K_a}}$	
5.	$\text{pH} = 7 - \frac{1}{2} \text{p}K_b - \frac{1}{2} \log C$	$\text{pH} = 7 + \frac{1}{2} \text{p}K_a + \frac{1}{2} \log C$	$\text{pH} = 7 + \frac{1}{2} \text{p}K_a - \frac{1}{2} \text{p}K_b$

WA - WB

- may be neutral, acidic or basic.
- depend upon strength of Acid or Base.
- *** h , $[H^+]$ & pH does not depend upon initial concⁿ.

Ques Which of the following salt does not show hydrolysis

- ① AgBr ~~WB~~ ② ZnSO₄ SAWB ③ Na₂SO₄ SASB ④ ~~HCOOK~~ HCOOK WASB

SASB → NaOH H₂SO₄

Ques Which of the following salt solⁿ have pH = 7?

- ① (NH₄)₂SO₄ WB SA ② NaCN ~~WASB~~ ③ MgSO₄ WB SA ④ NaNO₃ SASB

Ques For which of the following salt degree of hydrolysis does not depend upon initial concⁿ? ~~WA - WB~~

- ① NH₄Cl WB SA ② FeCl₃ SAWB ③ CH₃COONa WASB ④ (NH₄)₂S WA & WB

- ② HCOOK WA SB ③ NH₄CN WA WB ④ KCN WASB ⑤ NaCl SASB

- ① Na₂S WASB ② NaBr SASB ③ AgCN WA WB ④ ZnCl₂ SA WB

Ques The comp. whose aq. solⁿ has highest pH? ~~WASB~~

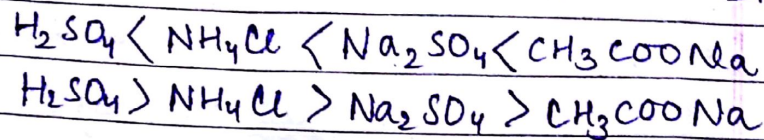
- ① NaCl SASB ② NaHCO₃ ~~WASB~~ ③ Na₂CO₃ WASB ④ NH₄Cl SAWB

- ① CH₃COOK WASB ② Na₂CO₃ WASB ③ NH₄Cl SAWB ④ NaNO₃ SASB

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Ques Arrange following in ↑ order of pH & H^+ ?
 ① NH_4Cl ② Na_2SO_4 ③ CH_3COONa ④ H_2SO_4
 SA WB SA SB WA SB SA



Ques Which of the following salt will give acidic soln when dissolved in water? SAWB
 ① NH_4Cl ② $KHSO_4$ ③ $NaCN$ ④ KNO_3
 SA WB SB WA SB SA

Ques Which of the following salt will give basic soln when dissolved in water? WASB
 ① KNO_3 ② $NaNO_2$ ③ $(NH_4)_2SO_4$ ④ KCl
 SA SB SB WA WB SA WASB
 a) 1 & 3 b) only 3 c) only 2 d) only 2 & 3

Ques 0.1 M of each soln is given. Arrange them in ↓ order of pH ?
 ① $HCOOK$ ② NH_4Cl ③ CH_3COONH_4 ④ $NaCl$ ⑤ KCl
 1 > 3 > 5 > 4 > 2

Ques Calculate hydrolysis const. & degree of hydrolysis & pH of 0.1 M $NaNO_2$ soln? $K_{HNO_2} = 4.5 \times 10^{-10}$
 $NaNO_2 + H_2O \rightleftharpoons NaOH + HNO_2$ WA SB
 $Na^+ + NO_2^- + H_2O \rightleftharpoons Na^+ + OH^- + HNO_2$
 $K_h = K_w = 10^{-14}$
 $K_a = 4.5 \times 10^{-10}$
 $K_h = \frac{K_w}{K_a} = \frac{10^{-14}}{4.5 \times 10^{-10}} = 2.2 \times 10^{-5}$

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$$4.5 \times 10^{-10}$$

$$10 - \log 4.5 = 10 - 0.65$$

$$= 9.35$$

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$$h = \sqrt{\frac{K_w}{C}} = \sqrt{\frac{2 \times 10^{-5}}{10 \times 1}} = \sqrt{2 \times 10^{-4}}$$

$$1.414 \times 10^{-2} = 10^{-2} \times \sqrt{2}$$

$$pH = 7 + \frac{1}{2} pK_a + \frac{1}{2} \log C = 11.67 + \frac{1}{2} (-1) = 11.67 - 0.5$$

$$= 11.17$$

$$7 + \frac{1}{2} \times 9.35 + \frac{1}{2} \log 10^{-1} = 7 + 4.67 + \frac{1}{2} (-1 \log 10)$$

Ques calculate degree of hydrolysis, hydrolysis const. & pH of 0.2 M $HCOONH_4$ soln WAWB

$K_{HCOOH} = 1.8 \times 10^{-4}$; $K_{NH_3} = 1.8 \times 10^{-5}$

$$pH = 7 + \frac{1}{2} pK_a - \frac{1}{2} pK_b$$

$$7 + \frac{1}{2} \times 3.74 - \frac{1}{2} \times 4.74$$

$$7 + 1.87 - 2.37$$

$$8.87 - 2.37 = 6.50$$

$$K_h = \frac{K_w}{K_a \times K_b} = \frac{10^{-14}}{1.8 \times 10^{-4} \times 1.8 \times 10^{-5}}$$

$$= 3.1 \times 10^{-74} \times 10^2 \times 10^6$$

$$= 3.1 \times 10^{-6}$$

$$K_a = 1.8 \times 10^{-4}$$

$$pK_a = 4 - \log 1.8$$

$$= 4 - 0.26$$

$$= 3.74$$

$$pK_b = 5 - \log 1.8$$

$$= 5 - 0.26$$

$$= 4.74$$

$$= \frac{10^{-14}}{3.24 \times 10^{-9}}$$

But

Buffer Solution

Solⁿ which resist change in pH on dilution or with addition of small amt. of acid or base, c/a buffer solⁿ.

eg: Blood

pH range $\Rightarrow$ 7.35 - 7.45

~~simple~~

Simple Buffer solⁿ & Mixed Buffer

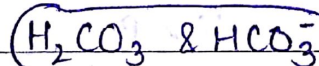
Acidic Buffer

Basic Buffer

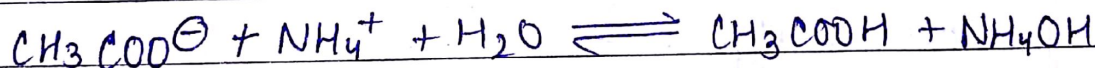
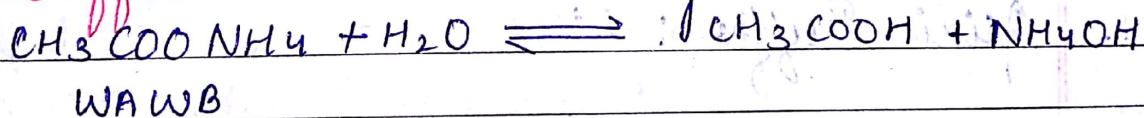
Simple Buffer : WA & WB solⁿ

eg $\text{CH}_3\text{COONH}_4(\text{aq})$, $\text{HCOOAg}(\text{aq})$, $\text{AgCN}(\text{aq})$, $\text{NH}_4\text{CN}(\text{aq})$

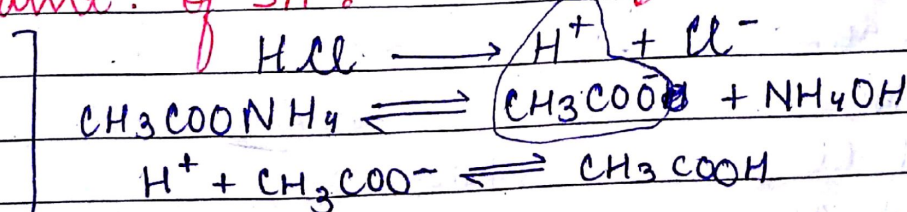
Blood is simple ~~to~~ buffer becoz it contains H_2CO_3 & NaHCO_3 .



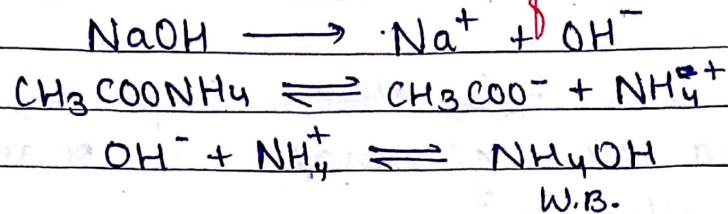
Buffer Action :- During dilution



Buffer Action on adding addition of small amt. of SA :-



Buffer Action on addition of small amt. of SB



On addition of small amt. of SB due to form of WB change in pH is negligible.

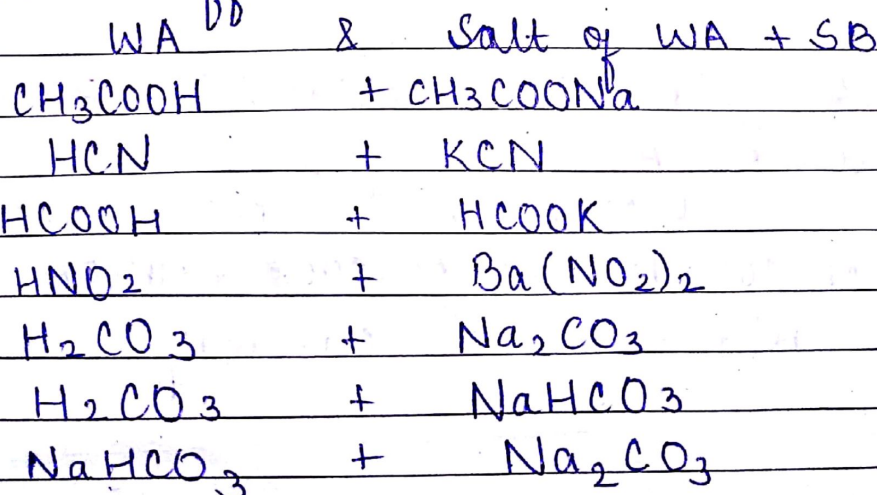
Ques Which of the following is simple buffer?

- | | | |
|----|--------------------------------------|-------|
| 1. | CH_3COONa | WASB |
| 2. | NaCl | SASB |
| 3. | CH_3COOAg | WASWB |
| 4. | NH_4Cl | SAWB |
| 5. | NH_4CN | WAWB |
| 6. | K_2SO_4 | SASB |
| 7. | Ag_2SO_4 | SAWB |
| 8. | $\text{Mg}(\text{CH}_3\text{COO})_2$ | WAWB |

Mixed Buffer :

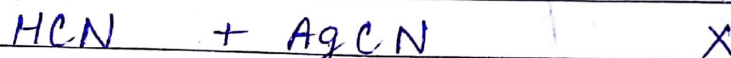
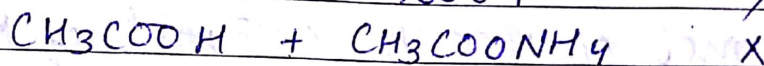
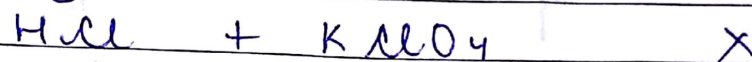
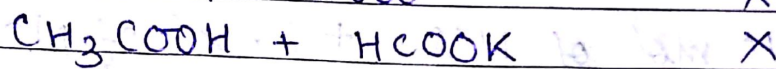
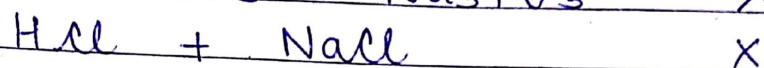
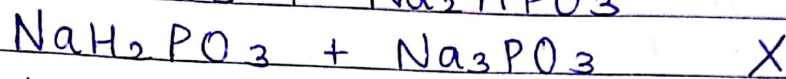
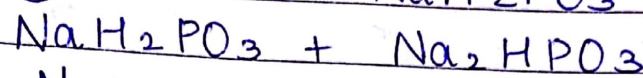
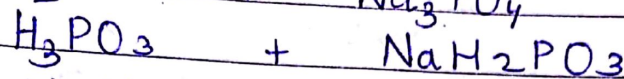
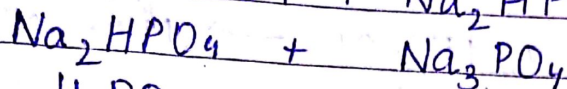
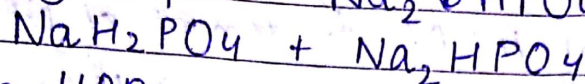
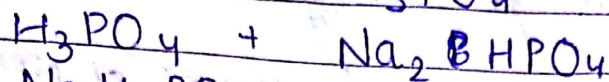
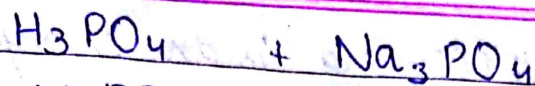
1. Acidic Buffer : Mixture of weak acid & salt of the same WA & SB is c/a
Acidic Buffer.

Type-1

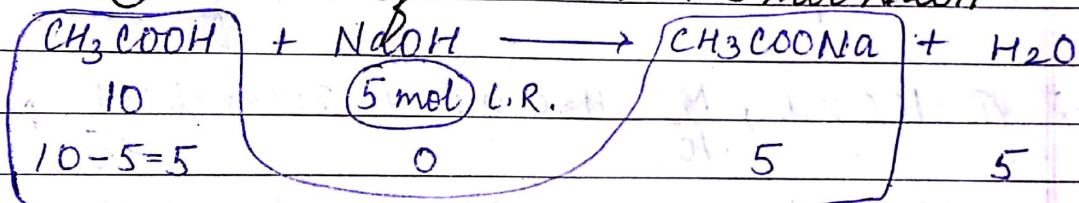


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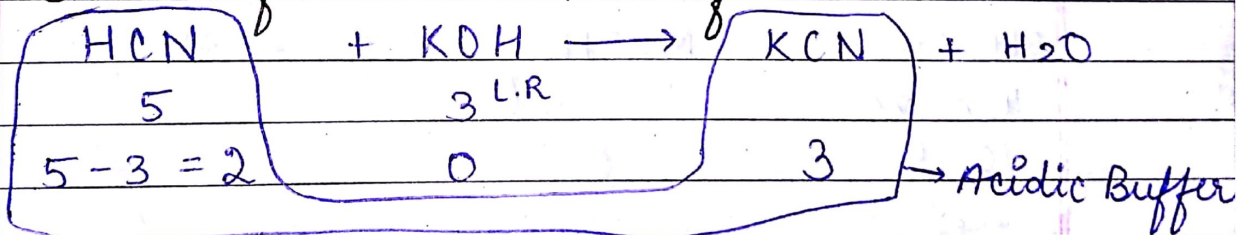
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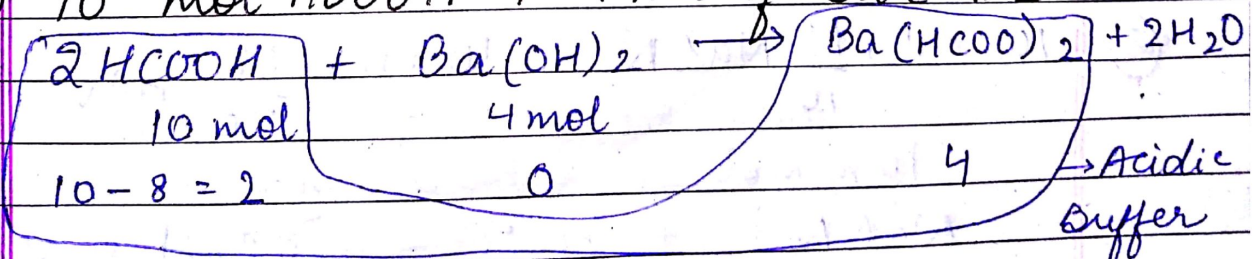
Type-2 ① 10 mol of CH_3COOH + 5 mol NaOH



② 5 mol of HCN + 3 mol of KOH



③ 10 mol HCOOH + 4 mol of $\text{Ba}(\text{OH})_2$



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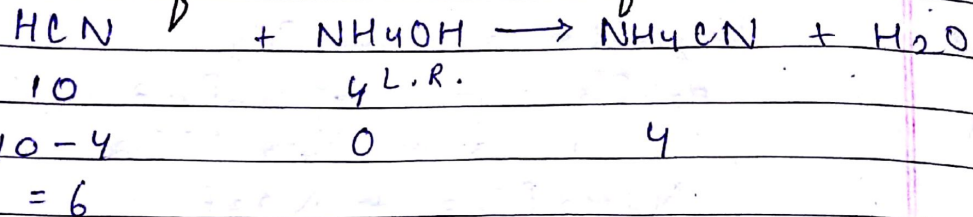
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Ques Which of the following is an example of Acidic Buffer?

① 10 mol of HCN + 4 mol of NH_4OH



② 10 mol of HCl + 6 mol of NaOH

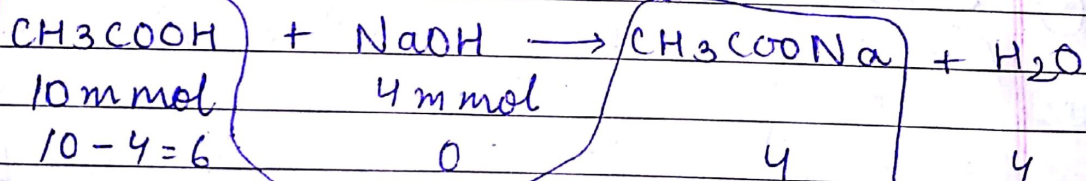
③ 8 mol of HCOOH + 3 mol of KOH

④ 5 mol of CH_3COOH + 2 mol of NaCl

Type-3 ① 100 ml, $\frac{M}{10}$ CH_3COOH + 200 ml $\frac{M}{50}$ NaOH

$$100 \times \frac{1}{10} = 10 \text{ mmol}$$

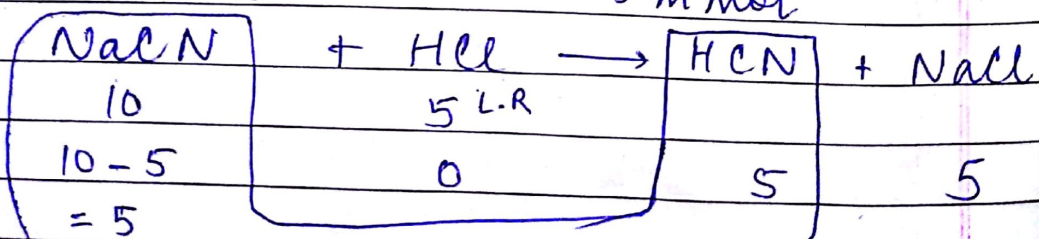
$$200 \times \frac{1}{50} = 4 \text{ mmol}$$



② 100 ml, $\frac{M}{10}$ NaCN + 100 ml $\frac{M}{20}$ HCl

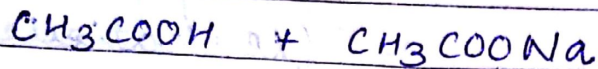
10 mmol

5 mmol

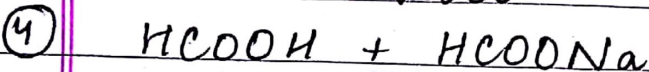
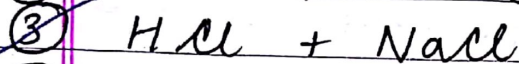
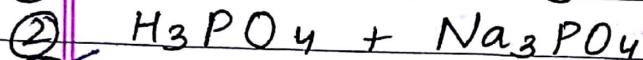
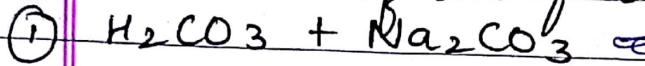


Ques Which of the following will make a buffer with acetic acid?

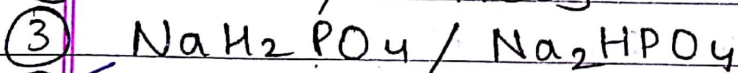
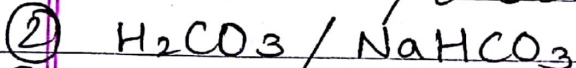
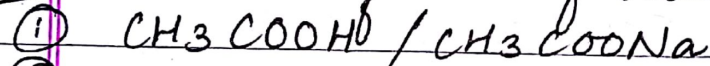
- ① CH_3COONa ② NaOH ③ KOH ④ ~~all the~~ ^{of} above



Ques Which of the following can ^{not} act as acid buffer



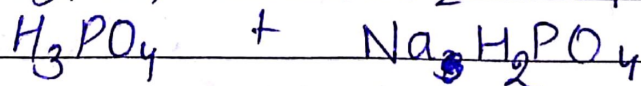
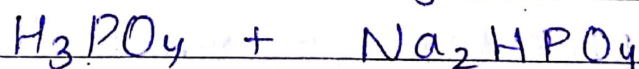
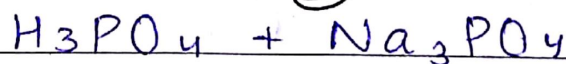
Ques Which of the following is not a buffer?



④ all of these are buffer

Ques How many types of buffer are obtained during titration H_3PO_4 & NaOH ?

- ① 0 ② 1 ③ 2 ④ 3



Buffer Action of acidic Buffer

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$$\text{CH}_3\text{COOH} \rightleftharpoons \text{CH}_3\text{COO}^- + \text{H}^+$$

$$\text{CH}_3\text{COONa} \rightarrow \text{CH}_3\text{COO}^- + \text{Na}^+$$

S.A. $\xrightarrow{\text{H}^+}$

S.B. $\xrightarrow{\text{OH}^-} \text{H}_2\text{O}$

- C.I.E.
- So form $\text{CH}_3\text{COOH} \downarrow$
- again there is negligible change in pH
- $[\text{H}^+] \downarrow$
- but maintained by forward reaction (Le Chatelier Principle)
- So there is negligible change in pH.

pH of Acidic Buffer :-

$$\text{CH}_3\text{COOH} + \text{CH}_3\text{COONa}$$

$$\underset{\text{C}}{\text{CH}_3\text{COONa}} \longrightarrow \underset{\text{C}}{\text{CH}_3\text{COO}^-} + \underset{\text{C}}{\text{Na}^+}$$

$$\underset{\text{O}}{\text{CH}_3\text{COOH}} \rightleftharpoons \underset{\text{C}}{\text{CH}_3\text{COO}^-} + \underset{\text{C}}{\text{H}^+}$$

$$K_a = \frac{[\text{H}^+][\text{CH}_3\text{COO}^-]}{[\text{CH}_3\text{COOH}]}$$

$$[\text{H}^+] = K_a \times \frac{[\text{CH}_3\text{COO}^-]}{[\text{CH}_3\text{COOH}]}$$

$$[\text{CH}_3\text{COO}^-]_{\text{acid}} \approx [\text{CH}_3\text{COO}^-]_{\text{salt}}$$

$$[\text{H}^+] = K_a \times \frac{[\text{Salt}]}{[\text{Acid}]}$$

$$\text{pH} = -\log \left(K_a \times \frac{[\text{Acid}]}{[\text{Salt}]} \right)$$

$$\text{pH} = \text{p}K_a - \log \frac{[\text{Acid}]}{[\text{Salt}]}$$

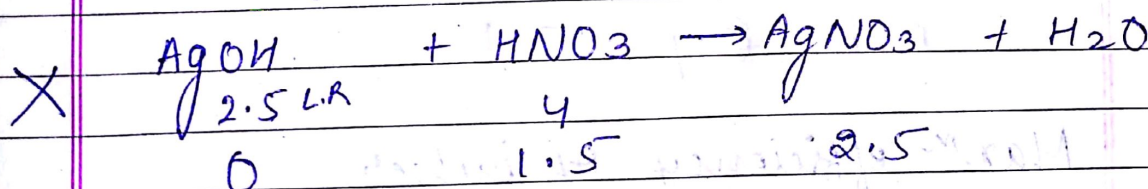
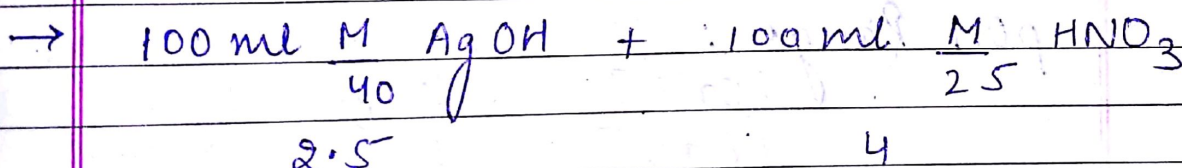
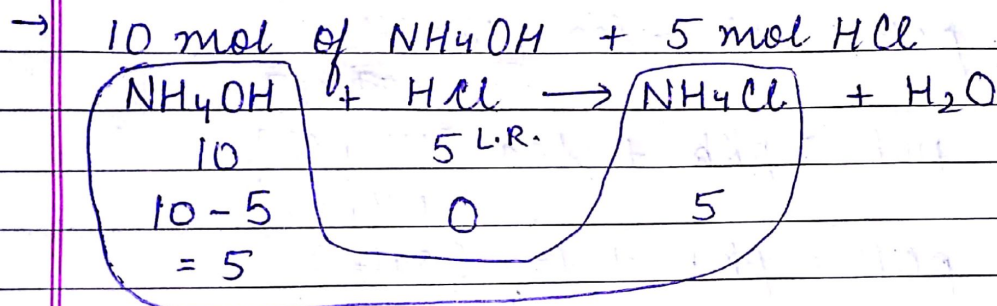
$$\text{pH} = \text{p}K_a + \log \frac{[\text{Salt}]}{[\text{Acid}]}$$

pH Range :-

$$\frac{[\text{Salt}]}{[\text{Acid}]} = \frac{10}{1} \text{ or } \frac{1}{10}$$

Max^m efficiency of buffer :-
when $[salt] = [Acid]$
~~pH~~ $pH = pKa$

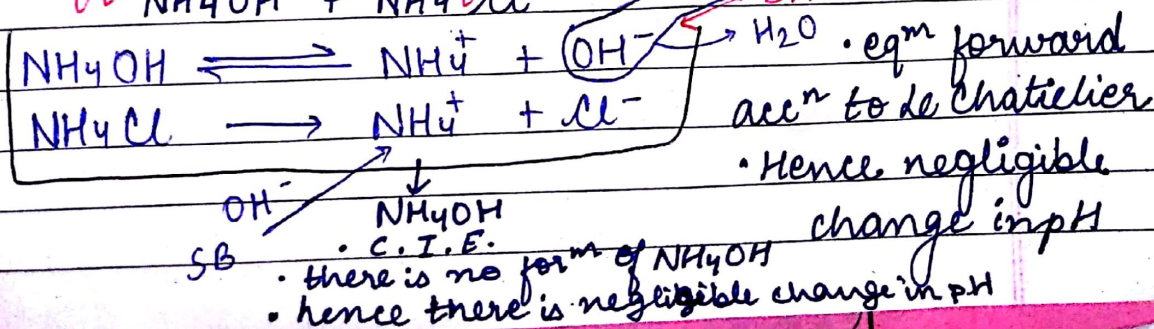
(mixture of WB) + (salt of this WB + SA)



Buffer Action of Basic Buffer :-

$$\text{NH}_4\text{OH} + \text{NH}_4^+ \rightleftharpoons \text{NH}_4^+ + \text{OH}^-$$

SA SA



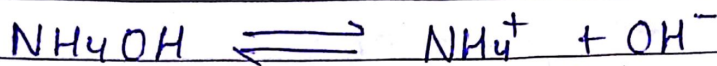
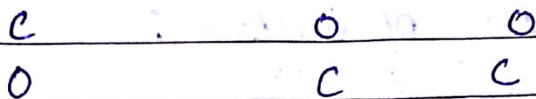
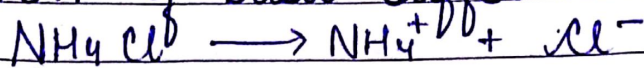
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pOH of basic buffer :-



$$K_b = \frac{[\text{NH}_4^+][\text{OH}^-]}{[\text{NH}_4\text{OH}]}$$

$$[\text{OH}^-] = K_b \times \frac{[\text{NH}_4\text{OH}]}{[\text{NH}_4^+]}$$

$$[\text{NH}_4^+]_{\text{base}} \approx [\text{NH}_4^+]_{\text{salt}}$$

$$\text{pOH} = -\log K_b \times \frac{[\text{NH}_4\text{OH}]}{[\text{NH}_4\text{Cl}]}$$

$$\text{pOH} = \text{p}K_b - \log \frac{[\text{NH}_4\text{OH}]}{[\text{NH}_4\text{Cl}]}$$

$$\text{pOH} = \text{p}K_b + \log \frac{[\text{NH}_4\text{Cl}]}{[\text{NH}_4\text{OH}]}$$

$$\text{pOH} = \text{p}K_b + \log \frac{[\text{salt}]}{[\text{Base}]}$$

pOH Range :

$$\frac{[\text{salt}]}{[\text{Base}]} = \frac{10}{1} \text{ or } \frac{1}{10}$$

$$\text{pOH} = \text{p}K_b \pm 1$$

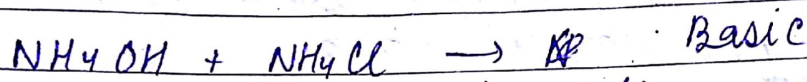
Max^m efficiency of buffer
when $[\text{salt}] = [\text{Base}]$

$$\text{pOH} = \text{p}K_b$$

Buffer Capacity :

$$\frac{\text{no. of moles of SA in 1L}}{\text{change in pH}} \quad \text{OR} \quad \frac{\text{no. of moles of SB in 1L}}{\text{change in pH}}$$

Ques Find pH of solⁿ having equimolar amt. of NH_4OH & NH_4Cl . Given $pK_b = 4.74$



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

$$pH = 14 - pK_b - \log \frac{\text{Salt}}{\text{Base}}$$

$$= 4.74 + \log \frac{1}{1}$$

$$pOH = 4.74$$

$$pH = 14 - 4.74 = 9.26$$

Ques 500 ml, $\frac{M}{50}$ CH_3COOH is added to 50 ml 0.3 M

CH_3COONa . Find pH of resulting solⁿ if K_a for acetic acid is 1.5×10^{-5}

→ Acidic

$$\text{no. of eq. of } \text{CH}_3\text{COOH} = \frac{500 \times \frac{1}{50} \times 1}{50} = 10$$

$$\text{CH}_3\text{COONa} = 50 \times 0.3 = 15.0$$

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

$$= 5 - \log 1.5 + \log \frac{15}{10}$$

$$\begin{aligned}
 &= 5 - 0.40 + \log 3 - \log 2 \\
 &= 4.60 + 0.47 - 0.30 \\
 &= 4.60 + 0.17 \\
 &= 4.77
 \end{aligned}$$

Ques For a given volⁿ, 50 ml of 0.05 M HCOOH. How much vol. of 0.1 M HCOONa must be added to get a buffer solⁿ of pH = 4
pKa for HCOOH = 3.8

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

$$4 = 3.8 + \log \frac{[0.1 \times V] \times \cancel{10^2}}{0.05 \times \cancel{50} \times \cancel{10^2}}$$

$$0.2 = \log \frac{V}{25}$$

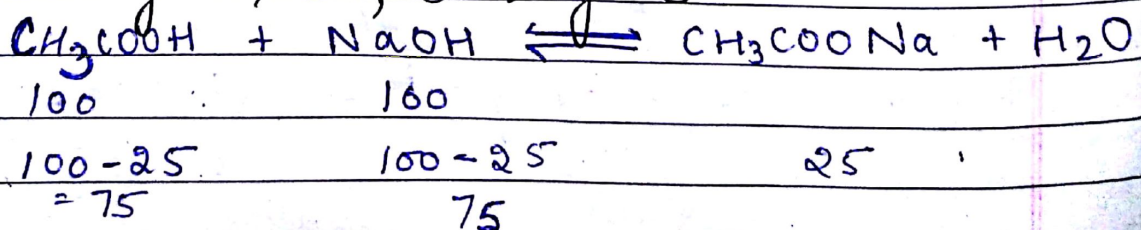
Ques N/10 CH₃COOH was neutralised with N/10 NaOH 25%, 50% & 75% neutralisation is over then pH of resulting solⁿ take Ka = 10⁻⁵

① 5 + log 1/3, 5, 5 + log 3

② 5 + log 3, 5, 5 + log 1/3

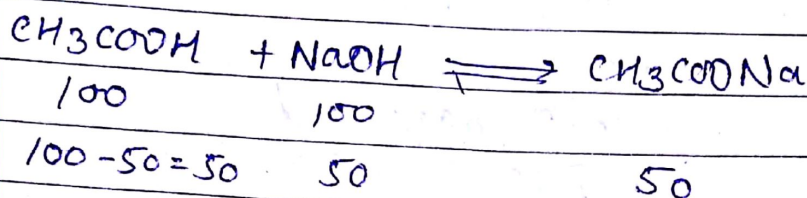
③ 5 - log 1/3, 5, 5 - log 3

④ 5 - log 3, 5, 5 - log 1/3



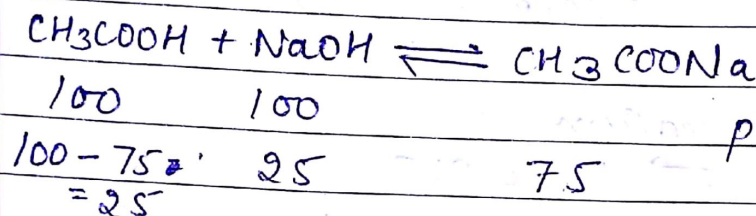
$$pH = pK_a + \log \frac{[salt]}{[Acid]} = 5 + \log \frac{25}{75}$$

$$= 5 + \log \frac{1}{3}$$



$$pH = 5 + \log \frac{50}{50}$$

$$pH = 5$$



$$pH = 5 + \log \frac{75}{25}$$

$$= 5 + \log 3$$

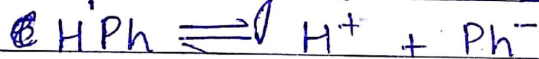
Indicator :- The substance which indicate change in pH by changing its own colour.
2 type

Acidic Indicator

eg

Phenolphthalein

pH range 8.3-10.2

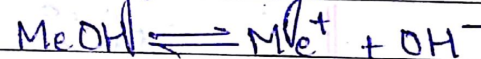


Colourless

Pink

Basic Indicator

Methyl Orange 3.3-4.5



Orange

Yellow

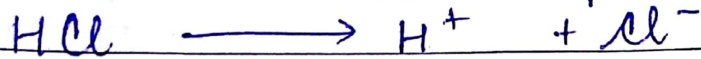
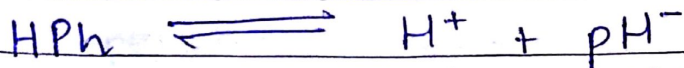
Ostwald Theory :-

- Indicators are weak electrolyte i.e. WA or WB
- Indicator may be present in form of molecule or ions (unionised) (ionised)

3. If molecules are more than color of solⁿ will be same as that of molecular form of indicator.
If ~~molecules~~ ions are more than colour of solⁿ will be same as that of ionic form of indicator.

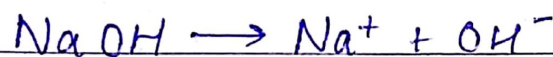
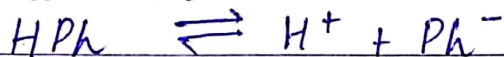
Acidic indicator

in acidic medium :-



- C.I.E.
- eqm backward
- $[\text{HPh}] > [\text{Ph}^-]$
- color $\rightarrow$ colourless

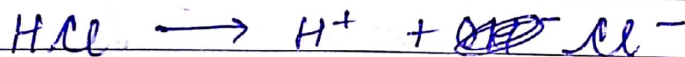
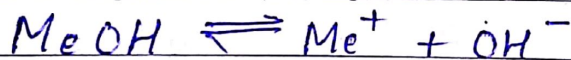
in basic medium



- O.I.E.
- eqm forward
- $[\text{HPh}] < [\text{Ph}^-]$
- Pind

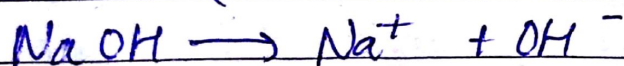
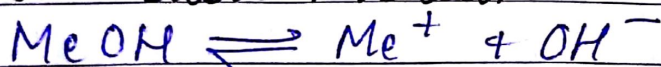
Basic Indicator

in acidic medium :-



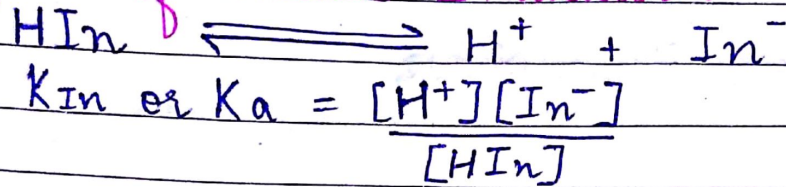
- O.I.E.
- eqm forward
- $[\text{MeOH}] < [\text{Me}^+]$
- Yellow.

In basic Medium



- C.I.E.
- eqm backward
- $[\text{MeOH}] > [\text{Me}^+]$
- Orange

pH of Acidic Indicator :-



$$[\text{H}^+] = K_a \times \frac{[\text{HIn}]}{[\text{In}^-]}$$

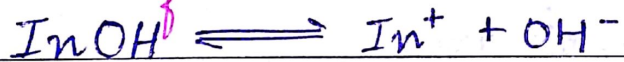
$$-\log [\text{H}^+] = -\log K_a - \log \frac{[\text{HIn}]}{[\text{In}^-]}$$

$$\text{pH} = \text{p}K_a + \log \frac{[\text{In}^-]}{[\text{HIn}]}$$

$$\text{range} \Rightarrow \frac{[\text{In}^-]}{[\text{HIn}]} = \frac{10}{1} \text{ or } \frac{1}{10}$$

$$\text{pH} = \text{p}K_a \pm 1$$

pOH of Basic Indicator :-

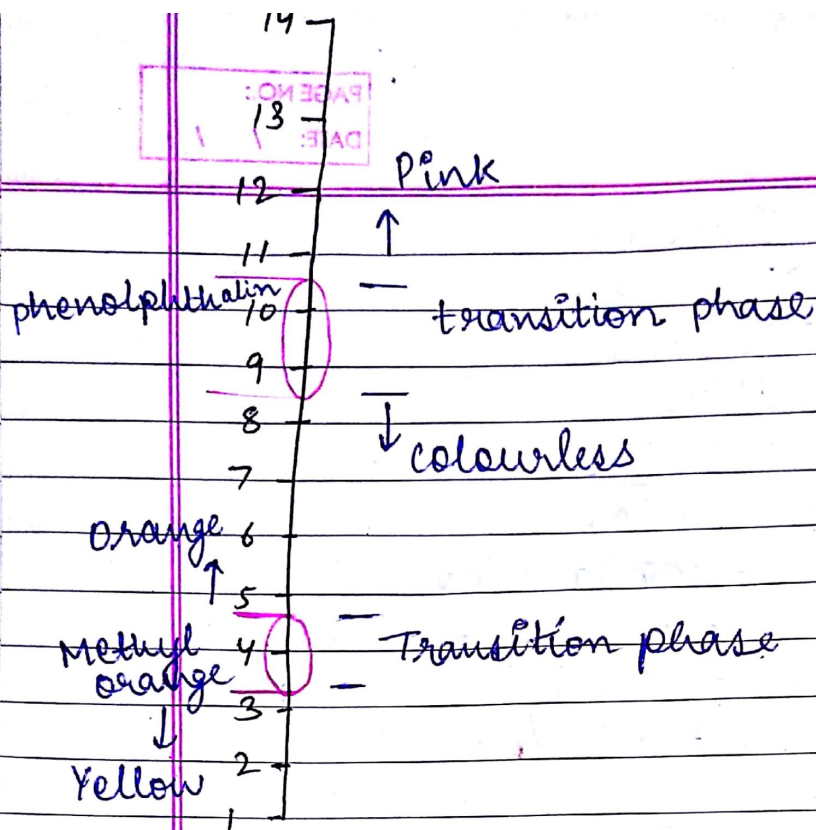


$$K_b = \frac{[\text{In}^+][\text{OH}^-]}{[\text{InOH}]}$$

$$[\text{OH}^-] = K_b \times \frac{[\text{InOH}]}{[\text{In}^+]}$$

$$\text{pOH} = \text{p}K_b + \log \frac{[\text{In}^+]}{[\text{InOH}]}$$

$$\text{pOH range : } \text{pOH} = \text{p}K_b \pm 1$$



Titration

Important Point :-

1. Titration ~~is~~ is done b/w opposite solⁿ i.e acid & base
2. Selection of Indicator
जो Indicator use करना है उसका PH range titration range की range में होना चाहिए।
3. End Point: where colour of solⁿ start changing.
4. Equivalence point: no. of eq. of acid = no. of eq. of base

Ques Phenolphthalein can not be used for which of the following titration?

- ① NaOH & HCl
- ② NaOH & CH₃COOH
- ✓ ③ HCl & (KMnO₄) Salt
- ④ HCl & NH₄OH

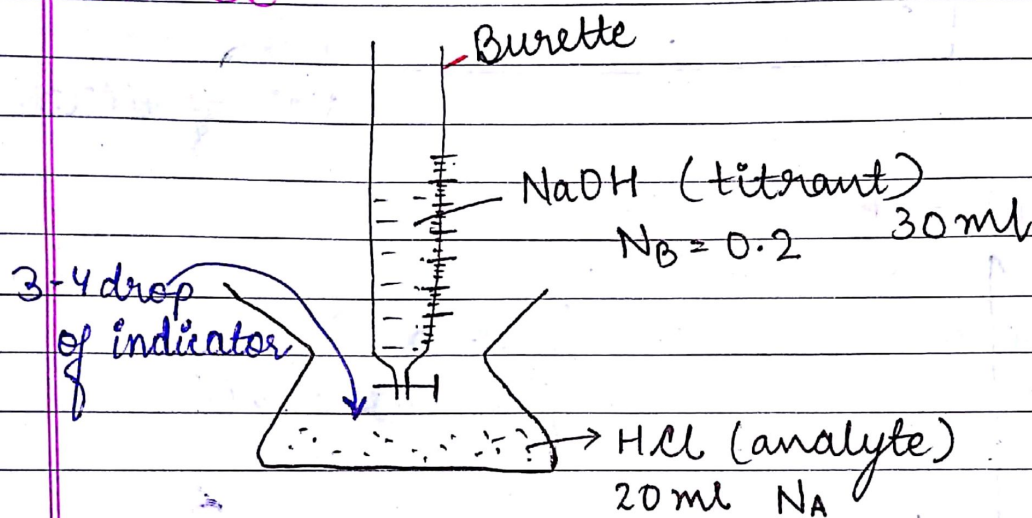
Ques Methyl Orange can work in pH range of

- ① 6-11
- ② 10-14
- ③ 2-10
- ④ 1-3

3.3-4.5

Titration :-

1. SA - SB

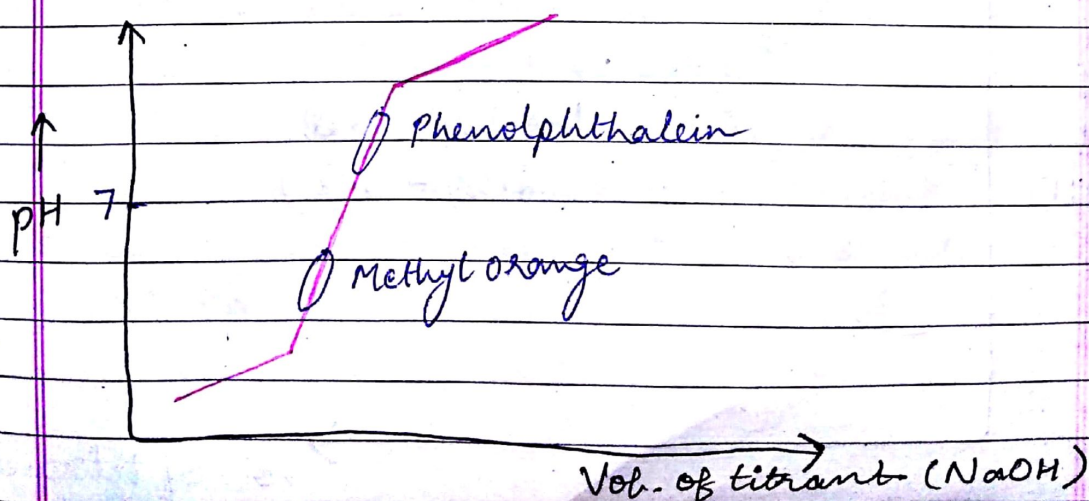


no. of eq. of acid = No. of eq. of base

$$N_A V_A = N_B V_B$$

$$N_A \cdot 20 = 0.2 \times 30$$

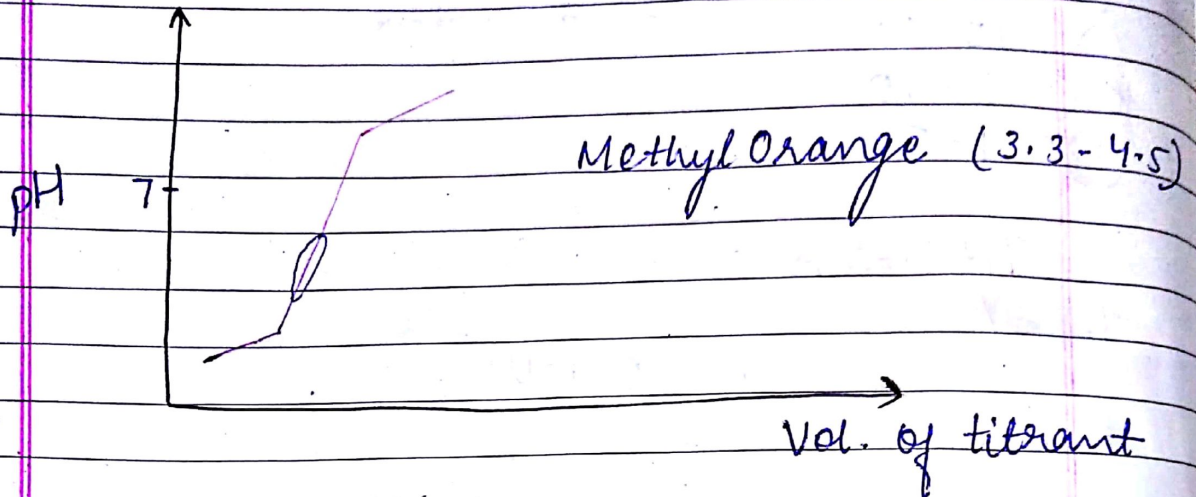
$$N_A = \frac{2 \times 30}{10 \cdot 20 \times 10} = 0.3$$



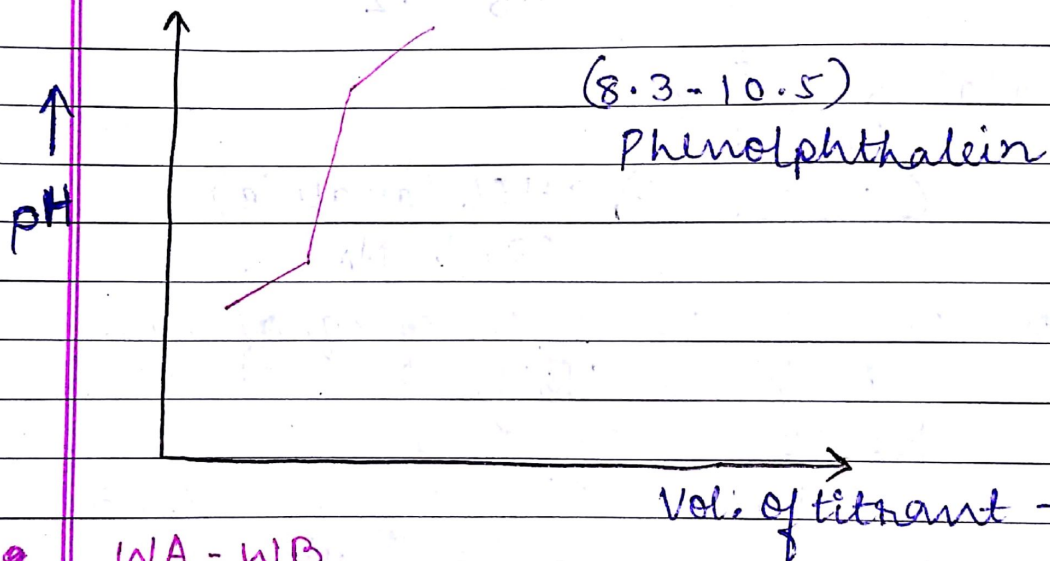
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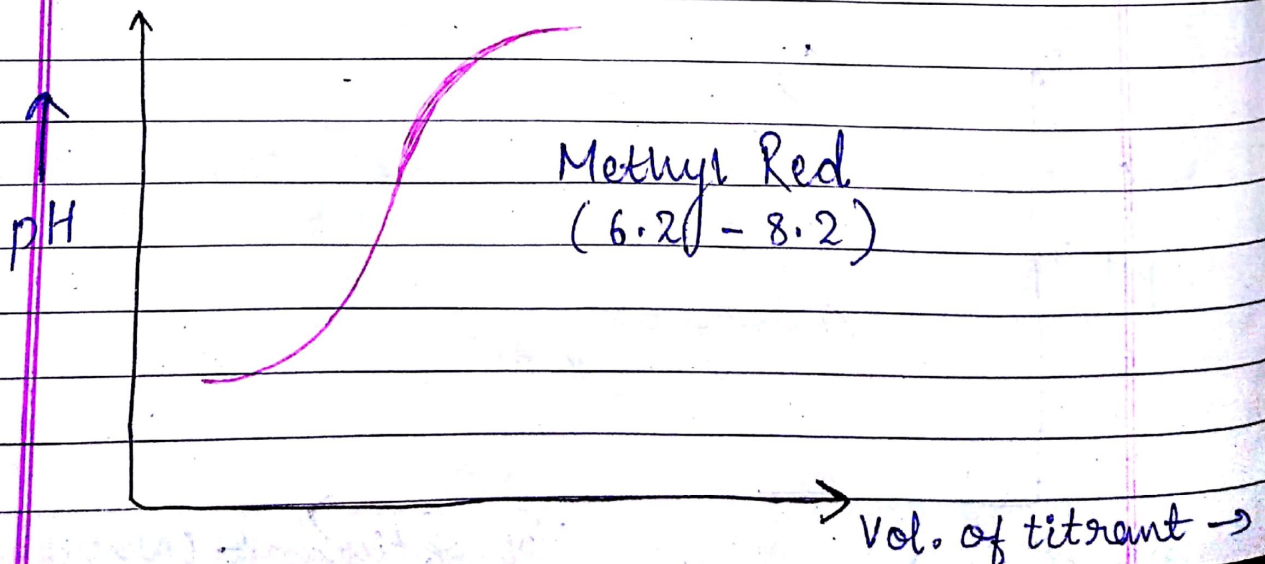
2. SA-WB



3. WA-SB



4. WA-WB



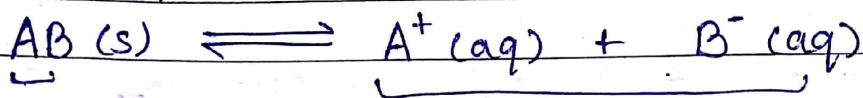
Temp. $\uparrow$ Solubility $\uparrow$ K_{sp} $\uparrow$

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Solubility :- At const temp. ^{max} no. of moles of solute ^{dissolved} in 1L solⁿ to form a saturated solⁿ is c/a solubility.

Unit :- mol L^{-1}

molarity of saturated solⁿ = solubility



Undissolved
Solute

~~*~~ dissolved solute

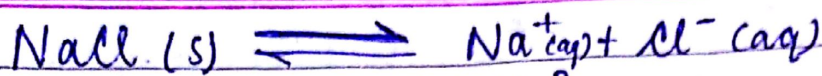
Saturated solⁿ :- The solⁿ in which ^{max} no. of moles of solute dissolved or further solute cannot be dissolved
molarity of solⁿ = solubility

Unsaturated solⁿ :- amt. of solute < solubility
The solⁿ in which further amt. of solute can be dissolved.

Supersaturated solⁿ :- amt. of solute > solubility
it is less stable solⁿ

~~Solⁿ~~ $\bullet$ extra ~~solⁿ~~ amt. of solute is precipitated when solⁿ comes at rest.

Solubility Product :- It is product of concⁿ of ions of solute raised to the power of their stoichiometry coefficient.

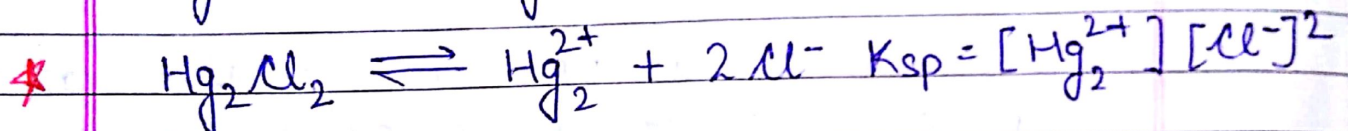
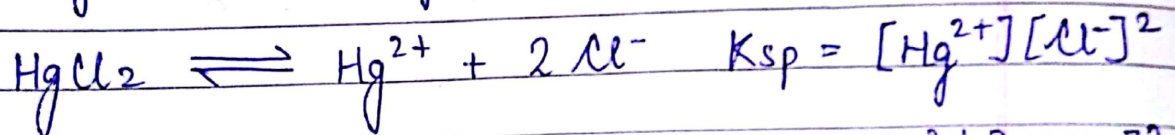
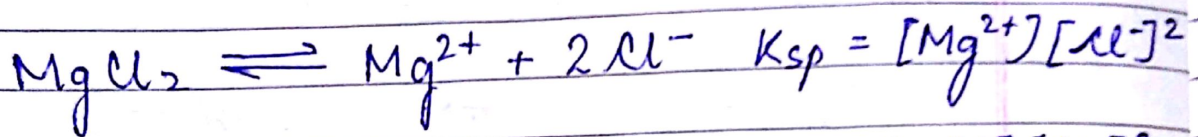


$$K = \frac{[\text{Na}^+][\text{Cl}^-]}{[\text{NaCl}]}$$

$$K[\text{NaCl}] = [\text{Na}^+][\text{Cl}^-]$$

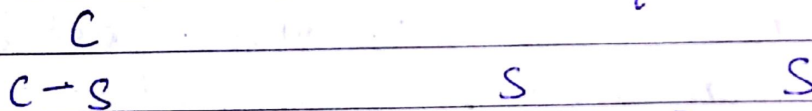
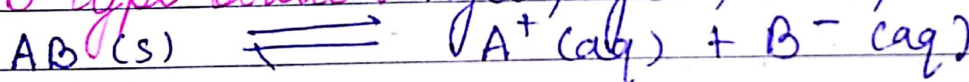
$[\text{NaCl}] \rightarrow \text{const.}$ solid की concⁿ const होता है

$$K_{sp} = [\text{Na}^+][\text{Cl}^-]$$



Relation b/w S & K_{sp}

1. AB type solute : AgCl, AgBr, NaCl, KCl, MgSO₄

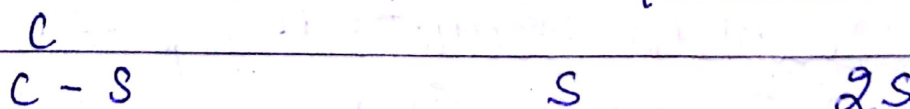
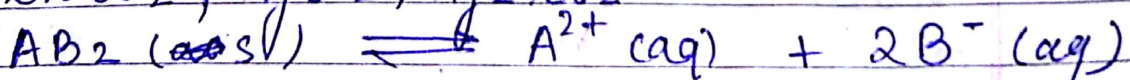


$$K_{sp} = [\text{A}^+][\text{B}^-]$$

$$K_{sp} = S \times S = S^2$$

$$S = \sqrt{K_{sp}}$$

2. AB₂ or A₂B type : MgCl₂, CaCl₂, Na₂SO₄, ZnCl₂, HgCl₂, Hg₂Cl₂

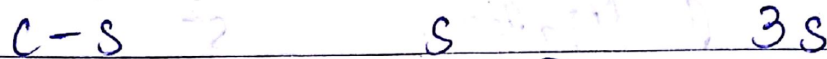
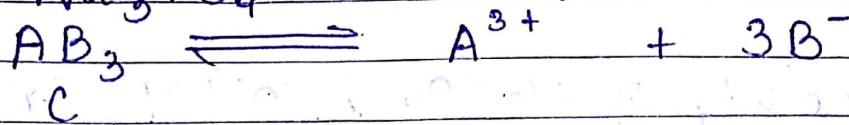


$$K_{sp} = [\text{A}^{2+}]^1 [\text{B}^-]^2 = S(2S)^2$$

$$K_{sp} = 4S^3$$

$$S = \left(\frac{K_{sp}}{4} \right)^{1/3}$$

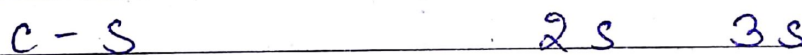
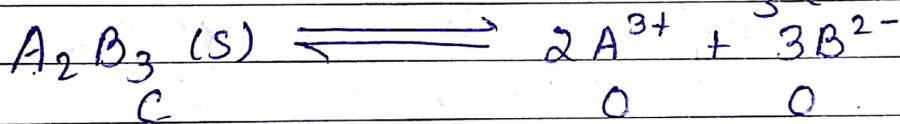
3. AB_3 or A_3B type : ~~$AgCl$~~ $AlCl_3$, $FeCl_3$, Na_3PO_4



$$\begin{aligned} K_{sp} &= [A^{3+}] [B^{-}]^3 \\ &= [S] [3S]^3 \\ &= 27 S^4 \end{aligned}$$

$$S = \left(\frac{K_{sp}}{27} \right)^{1/4}$$

4. A_2B_3 or A_3B_2 type : $Al_2(SO_4)_3$, $Ca_3(PO_4)_2$

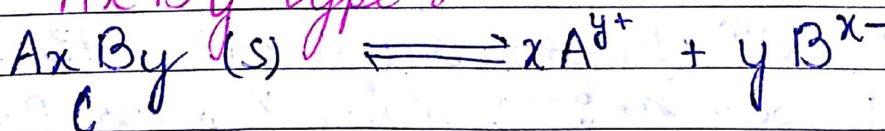


$$\begin{aligned} K_{sp} &= [A^{3+}]^2 [B^{2-}]^3 \\ &= (2S)^2 (3S)^3 \end{aligned}$$

$$K_{sp} = 108 S^5$$

$$S = \left(\frac{K_{sp}}{108} \right)^{1/5}$$

$A_x B_y$ type :-



$$K_{sp} = [A^{y+}]^x [B^{x-}]^y$$

$$= (xS)^x (yS)^y$$

$$= x^x S^x y^y S^y$$

$$K_{sp} = x^x y^y S^{x+y}$$

$$S = \left(\frac{K_{sp}}{x^x y^y} \right)^{1/x+y}$$

Ques Solubility of $MgSO_4$ is $10^{-4} M$. Calculate K_{sp} ?
 $MgSO_4 \rightarrow S^2$
 $K_{sp} = S^2$
 ~~S^2~~ $= (10^{-4})^2 = 10^{-8}$

Ques Calculate solubility of M_2X_3 in pure water, assuming neither kind of ion reacts with water. The solubility product of M_2X_3
 $K_{sp} = 1.1 \times 10^{-23}$

$$M_2X_3$$

$$K_{sp} = 2^2 3^3 S^5 = 4 \times 27 S^5 = 108 S^5$$

$$\frac{1000}{1000} \times \frac{1.1 \times 10^{-23}}{108} = S^5$$

$$(9.2 \times 10^{-26})^{1/5} = S$$

Ques Find vol^m of water required to dissolved 1g $BaSO_4$ at $25^\circ C$ given K_{sp} for $BaSO_4$
 $= 1.1 \times 10^{-10}$ & M_w of $BaSO_4 = 233$
 $BaSO_4 \rightleftharpoons Ba^{2+} + SO_4^{2-}$

$$K_{sp} = [Ba^{2+}] [SO_4^{2-}]$$

$$1.1 \times 10^{-10} = S^2$$

$$s = 10^{-5}$$

$$\frac{n}{V} = 10^{-5}$$

$$\frac{1/233}{V} = 10^{-5}$$

$$V = \frac{1}{233 \times 10^{-5}} = \frac{10^5}{233} = 4.3 \times 10^2 \text{ L}$$

Ques = K_{sp} for a base $M(OH)_3$ is 2.7×10^{-11} calc. concⁿ of $[OH^-]$

$$K_{sp} = 1 \cdot 3^3 s^4 = 27 s^4$$

$$\frac{2.7 \times 10^{-11}}{27 \times 10} = s^4$$

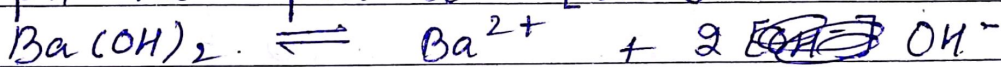
$$10^{-12} = s^4$$

$$s = 10^{-3}$$

$$[OH^-] = 3s = 3 \times 10^{-3}$$

Ques If pH of saturated solⁿ of $Ba(OH)_2$ is 12 Find value its K_{sp}

$$pH = 12 \quad pOH = 2 \quad [OH^-] = 10^{-2}$$



C

C - s

s

2s

$$K_{sp} = 2^2 s^3 = 4s^3$$

$$[OH^-] = 2s$$

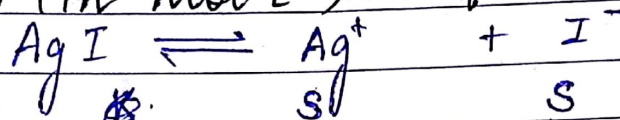
$$5 \times 10^{-3} = \frac{10}{10} \times \frac{10^{-2}}{2} = s$$

$$K_{sp} = s \times (2s)^2$$

$$= 5 \times 10^{-3} (2 \times 5 \times 10^{-3})^2$$

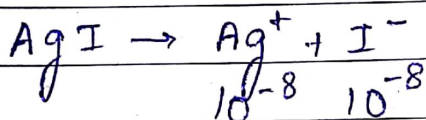
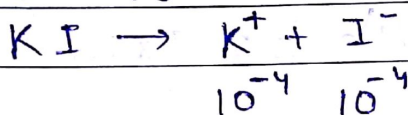
$$= 5 \times 10^{-3} (10^{-2})^2 = 5 \times 10^{-3} \times 10^{-4} = 5 \times 10^{-7}$$

Ques The solubility product of AgI at 25°C is $1 \times 10^{-16} \text{ M}^2$. The solubility product of AgI in 10^{-4} M soln of KI at 25°C is approx (in mol L^{-1})



$$K_{sp} = S^2 = 10^{-16}$$

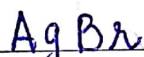
$$S = 10^{-8}$$



$$\begin{aligned} K_{sp} &= [\text{Ag}^+][\text{I}^-] \\ &= 10^{-8} \times [10^{-4} + 10^{-8}] \\ &= 10^{-8} \times 10^{-4} = 10^{-12} \end{aligned}$$

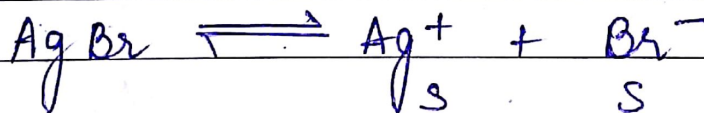
Ques K_{sp} for AgBr $= 10^{-12} \text{ M}^2$ find solubility
① in water ② in 10^{-2} M NaBr.

①

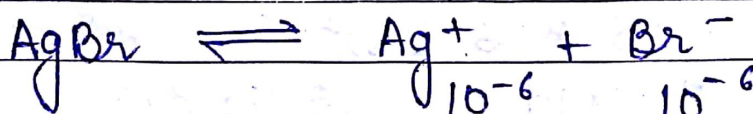
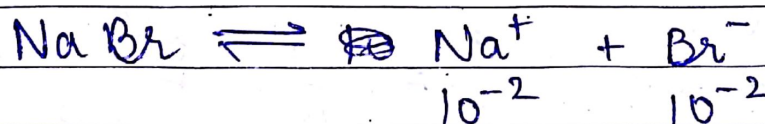


$$K_{sp} = S^2$$

$$\sqrt{10^{-12}} = S = 10^{-6}$$



②



$$\begin{aligned} K_{sp} &= [\text{Ag}^+][\text{Br}^-] \\ &= 10^{-6} \times (10^{-2} + 10^{-6}) \end{aligned}$$

$$= 10^{-6} \times 10^{-2}$$

$$= 10^{-8}$$

Ques Which of the following is most soluble?

- ① MX $K_{sp} = 10^{-8}$ $S = 10^{-4}$
- ② MY $K_{sp} = 10^{-12}$ $S = 10^{-6}$
- ③ MZ $K_{sp} = 10^{-10}$ $S = 10^{-5}$
- ④ MN $K_{sp} = 10^{-16}$ $S = 10^{-8}$

Ques ① XY $K_{sp} = 10^{-12}$

$$K_{sp} = 10^{-12} = S^2$$

$$S = 10^{-6}$$

② X_3Y $K_{sp} = 10^{-20}$

$$K_{sp} = 27 S^4$$

$$\left(\frac{10^{-20}}{27}\right)^{1/4} = S$$

$$S = 10^{-5} \times \left(\frac{1}{27}\right)^{1/4}$$

③ X_2Y_3 $K_{sp} = 10^{-25}$

$$K_{sp} = 10^{-25} = 4 \times 27 S^5$$

$$10^{-25} = 108 S^5$$

$$\left(\frac{1}{108}\right)^{1/5} \times 10^{-5} = \left(\frac{10^{-25}}{108}\right)^{1/5} = S$$

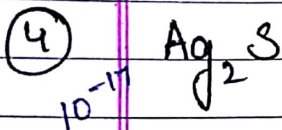
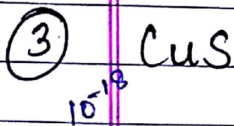
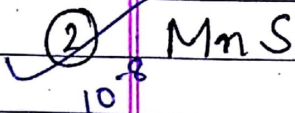
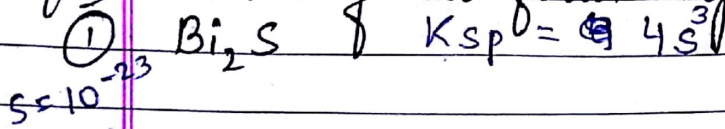
④ X_2Y $K_{sp} = 10^{-9}$

$$K_{sp} = 4 S^3$$

$$\left(\frac{10^{-9}}{4}\right)^{1/3} = S$$

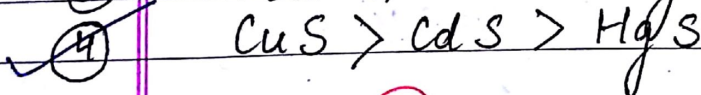
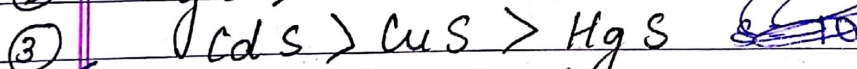
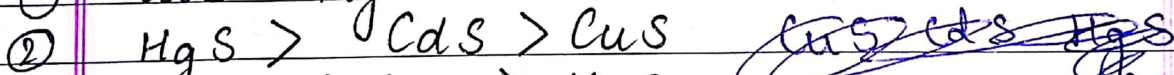
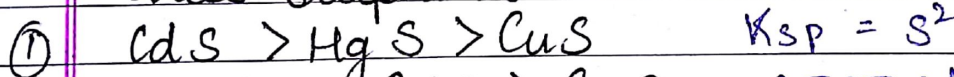
$$10^{-3} \times \left(\frac{1}{4}\right)^{1/3} = S$$

Ques Which of the following is most soluble



AIPMT

Ques The solubility product of CuS , CdS & HgS are 10^{-31} , 10^{-44} , 10^{-54} resp. Then solubility of these sulphides are in order



Ionic Product of water and condition for Precipitation :- I.P. or Q_{sp}

$K_{sp} \rightarrow$ solubility product at eqm

I.P. or $Q_{sp} \rightarrow$ solubility product at any time

1. $K_{sp} = I.P.$ at eqm Saturated soln

2. $K_{sp} > I.P.$ unsaturated soln

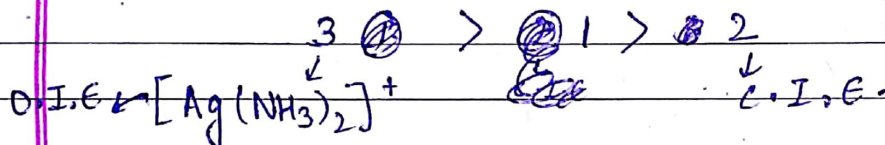
3. $K_{sp} < I.P.$ Supersaturated (condⁿ of ppt)
→ precipitation starts.

Factors affecting Solubility :-

1. Nature of solvent
2. Nature of solute
3. Temp.
4. ~~Set~~ Common Ion effect → decrease the solubility
5. Odd Ion effect → ↑ the solubility.

Ques Arrange the solubility of AgCl in following

(A) ① water ② NaCl ③ NH_3



(B) ① water ② $10^{-1} M$ NaCl ③ $10^{-3} M$ NaCl

① > ③ > ② $C.I.E.$

Ques Arrange the solubility of AgBr in following

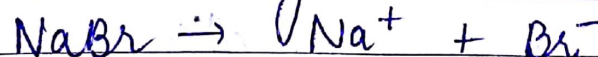
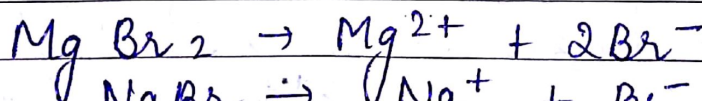
① H_2O ② $0.1 M NH_3$ ③ $0.1 M NaBr$ ④ $0.1 M MgBr_2$

$\downarrow$
O.I.E

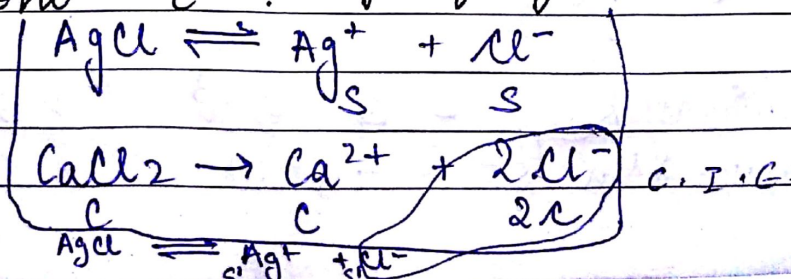
$\downarrow$
C.I.E.

$\downarrow$
C.I.E.

② > ① > ③ > ④



Ques Calculate solubility of AgCl in $CaCl_2$ solⁿ of concⁿ 'C'?



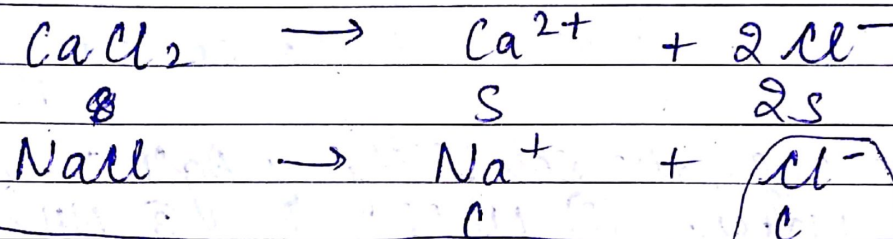
$$K_{sp} = [Ag^+] [Cl^-]$$

$$= s' (s' + 2c)$$

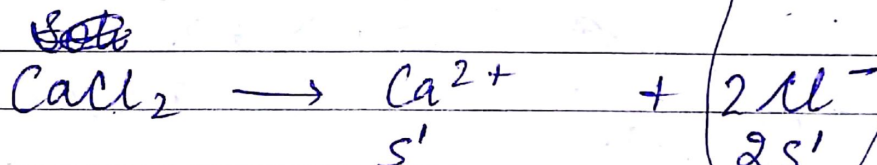
$$= s' \times 2c$$

$$s' = \frac{K_{sp}}{2c}$$

Ques Calculate solubility of $CaCl_2$ in NaCl solⁿ of concⁿ 'c'



New concⁿ



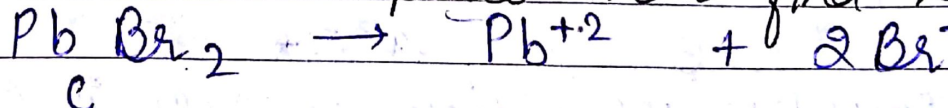
$$K_{sp} = [Ca^{2+}] [Cl^-]^2$$

$$= s' (c + 2s')^2$$

$$= s' \times c^2$$

$$\frac{K_{sp}}{c^2} = s'$$

Ques Solubility of $PbBr_2$ is 's' If 80% dissociation of salt takes place then find K_{sp} .



$$c - \alpha s = c - \frac{4}{5}s \quad \alpha s = \frac{4}{5}s \quad 2 \times \frac{4}{5}s = 2\alpha s$$

$$K_{sp} = [\alpha s] [2\alpha s]^2 = \alpha s \times 4\alpha^2 s^2 = 4\alpha^3 s^3$$

$$= \left(\frac{4}{5}s\right) \left(\frac{4}{5}s\right)^2$$

$$s = \left(\frac{K_{sp}}{4}\right)^{1/3}$$

$$4s^3 = \frac{4}{5} \times \frac{16 \times 4}{25} s^2$$

$$= 4 (0.8)^3 s^3$$

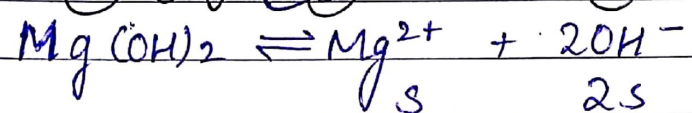
$$= 4 \times 0.512 \times s^3$$

$$K_{sp} = 2 s^3$$

$$s = \left(\frac{K_{sp}}{2}\right)^{1/3}$$

Ques K_{sp} of $Mg(OH)_2$ is 10^{-11} . At what pH precipitation of $Mg(OH)_2$ will begin from 0.1M Mg^{2+} solⁿ?

- ① 5 ② 6 ③ 9 ④ 8

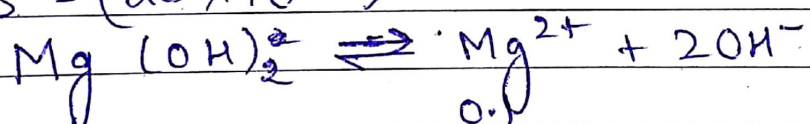


$$K_{sp} = s(2s)^2$$

$$10^{-11} = s \times 4s^2 = 4s^3$$

$$s = \left(\frac{10^{-11}}{4} \times \frac{100}{100}\right)^{1/3}$$

$$s = (25 \times 10^{-13})^{1/3}$$



$$10^{-11} K_{sp} = [0.1 + \dots][OH^-]^2$$

$$10^{-11} \times 10 = [OH^-]^2 = 10^{-10}$$

$$[OH^-] = 10^{-5} \quad pH = 5 \quad pOH = 9$$

Ques what is min^m concⁿ of SO_4^{2-} required to precipitate $BaSO_4$ in a solⁿ containing 1×10^{-4} mol as Ba^{2+} ? K_{sp} for $BaSO_4 = 4 \times 10^{-4}$

$$K_{sp} < I.P.$$

$$4 \times 10^{-4} < [Ba^{2+}][SO_4^{2-}]$$

$$\frac{4 \times 10^{-4}}{10^{-4}} < [SO_4^{2-}] \Rightarrow 4 < [SO_4^{2-}]$$

$$10^{-4}$$