ULTIMATE KCET

CRASH COURSE 2026

Chemistry | Lecture - 01

Ionic Equilibrium

By – Arunkumar Sir

Topics *to be covered*

1. Theory + PYQ.
2. [redacted]
3. [redacted]
4. [redacted]

Ionic equilibrium

* the equilibrium in which ions are involved is called ionic equilibrium.

eg:- $CH_3COOH \rightleftharpoons CH_3COO^- + H^+$

* Arhenius Acid-Base Theory:-

Acid:- produces H^+ ion in aq. Medium

$$HCl \xrightarrow{H_2O} H^+ + Cl^-$$

Base:- produces OH^- ion in aq Medium

$$NaOH \xrightarrow{H_2O} Na^+ + OH^-$$

* Brownsted-Lowry Acid-Base theory :-

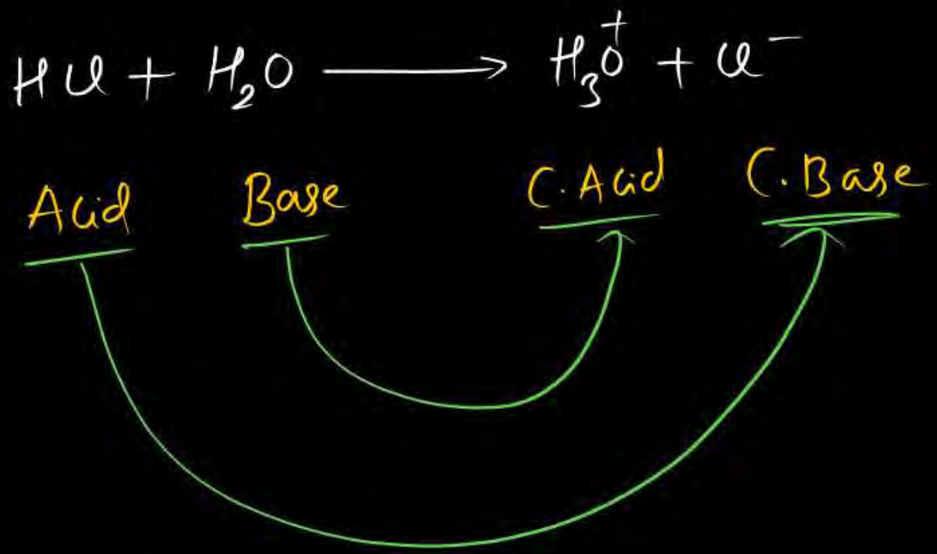
* Acid :- H^+ donor

eg :- HCl, HF, HBr, HNO_3, H_2SO_4 - - - -

* Base :- H^+ acceptor

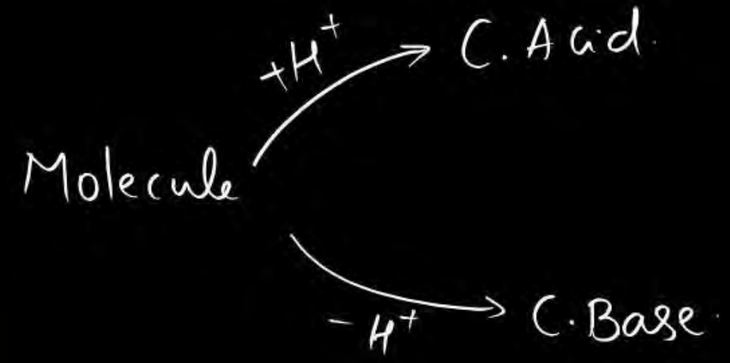
eg :- OH^-, Cl^-, NH_3 - ——-

* Conjugate - Acid - Base pair :-



* H_2O & H_3O^+

* HCl & Cl^-



* Lewis Acid-Base Theory:-

Acid:- e⁻ pair Acceptor

eg:- BF_3, $AlCl_3$ . . . . .

Base:- e⁻ pair donor

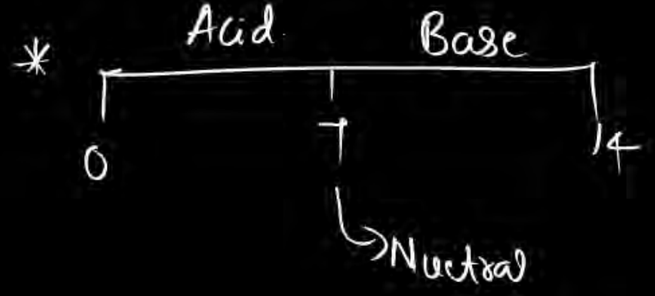
eg:- NH_3, H_2O . —

P^H Scale :-

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

$$P^{OH} = -\log [OH^-]$$

S. Acid	$P^H \rightarrow$ Small
W. Acid	$P^H \rightarrow$ Large
S. Base	$P^H \rightarrow$ large
W. Base	$P^H \rightarrow$ Small



Ionic product of water:-

at 25°C

$$H_2O \rightleftharpoons H^+ + OH^-$$

I $\quad 10^{-7} \quad 10^{-7}$

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

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

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

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

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

$-\log$ on both side

$$-\log\{(H^+)(OH^-)\} = -\log 10^{-14}$$

$$-\{\log(H^+) + \log(OH^-)\} = -\{-14 \log 10\}$$

$$= -\log(H^+) - \log(OH^-) = 14$$

$$= \boxed{pH + pOH = 14}$$

Degree of dissociation :- (α) :-

$$\alpha = \frac{\text{No. of molecule dissociated}}{\text{Total molecule}}$$

* for strong Electrolyte

$$\alpha = 1$$

* for weak Electrolyte

$$\alpha <<< 1$$

Ostwald's dilution law:-

$$HA \rightleftharpoons H^+ + A^-$$

	HA	H^+	A^-
$t=0$	C	0	0
$t=eq$	$C-C\alpha$	$C\alpha$	$C\alpha$

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

$$= \frac{(C\alpha)(C\alpha)}{C-C\alpha}$$

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

$$K_a = \frac{C\alpha^2}{1-\alpha} \quad \{\text{for weak electrolyte } 1-\alpha \simeq 1\}$$

$$K_a = C\alpha^2$$

$$\alpha^2 = \frac{K_a}{C}$$

$$\alpha = \sqrt{\frac{K_a}{C}} \quad \left\{\because \alpha \propto \frac{1}{\sqrt{C}}\right\}$$

$\Rightarrow$ at more dilution weak electrolyte behave as strong electrolyte.

* dissociation constant for weak acid & Base :-

$$HA \rightleftharpoons H^+ + A^-$$

$t=0$	C	0	0
$t=t$	$C-C\alpha$	$C\alpha$	$C\alpha$

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

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

$$K_a = C\alpha^2$$

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

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

$$= -\log\{C\alpha\}$$

$$= -\log\left\{C\sqrt{\frac{K_a}{C}}\right\}$$

$$= -\log\left\{\sqrt{\frac{C^2 K_a}{C}}\right\}$$

$$= -\log\{K_a \times C\}^{\frac{1}{2}}$$

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

$$\boxed{pH = -\frac{1}{2}\{\log K_a + \log C\}}$$

$$\boxed{pK_a = -\log K_a}$$

for weak base :-

$$BOH \rightleftharpoons B^+ + OH^-$$

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

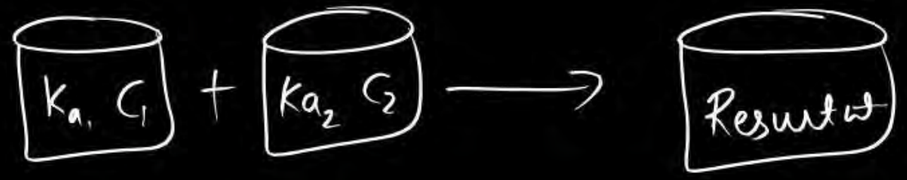
$$pK_b = -\log [K_b]$$

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

C = Conc^n

K_b = dissociation Constant

pH of mixture of two weak Acids :-



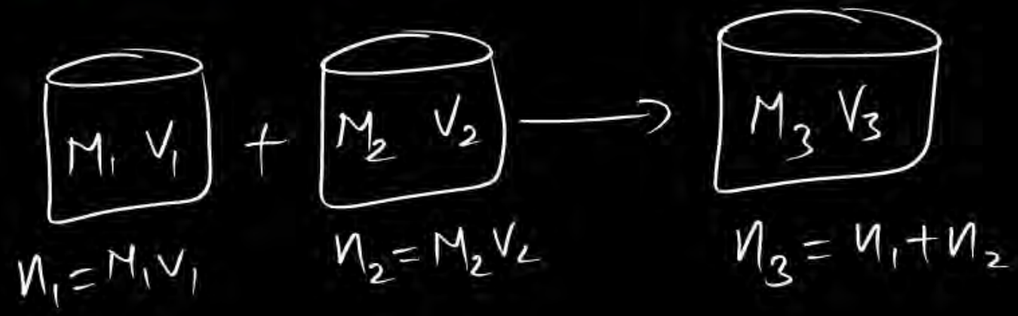
$$pH = -\frac{1}{2}\log\{K_{a_1} \times C_1 + K_{a_2} \times C_2\}$$

pH of mixture of Strong Acid & weak Acid :-

HA & HB
W.A S.A

$$pH = -\log(H^+)$$
↳ Strong Acid

pH of two strong Acids



$$M_3V_3 = M_1V_1 + M_2V_2$$

$$M_3 = \frac{M_1V_1 + M_2V_2}{V_3}$$

$$M_3 = \frac{M_1V_1 + M_2V_2}{V_1 + V_2}$$

Salt hydrolysis:-

$AB_{(s)} \longrightarrow AB_{(aq)} \longrightarrow A^{+}_{(aq)} + B^{-}_{(aq)}$

01. S.Acid & S.Base $\Rightarrow$ $pH = 7$

02. S.Acid & W.Base $=$ $pH < 7$

03. W.Acid & S.Base $=$ $pH > 7$

04. W.Acid & W.Base $=$ $pH \gtrless 7$

Buffer Soln:- the Soln which Resist change in pH of the Soln when Small Amount of Acid (or) Base added

Buffer soln — W. Acid + Salt of Strong Base

Types:-

01. Acidic Buffer:- $CH_3COOH + CH_3COONa$

02. Basic Buffer:- $NH_4OH + NH_4Cl$

Mechanism of Buffer Soln — Common ion effect

$$HCl \longrightarrow Cl^- + H^+$$

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

$$CH_3COONa \longrightarrow CH_3COO^- + Na^+$$

$$10\,H^+ + 8\,CH_3COO^- \longrightarrow 8\,CH_3COOH$$

$\hookrightarrow_2$

Solubility Product :-

$$AgCl_{(s)} \longrightarrow \underset{s}{AgCl_{(aq)}} \rightleftharpoons \underset{s}{Ag^+_{(aq)}} + \underset{s}{Cl^-_{(aq)}}$$

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

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

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

$$\boxed{s = \sqrt{K_{sp}}}$$

$$A_2B_3(s) \longrightarrow A_2B_3(aq) \longrightarrow \underset{2s}{\underline{2}}A^{+3} + \underset{3s}{\underline{3}}B^{-2}$$

$$s$$

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

$$K_{sp} = 4s^2 \cdot 27s^3$$

$$= 108\, s^5$$

$$s^5 = \frac{K_{sp}}{108}$$

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

Relation b/w K_{IP} & K_{SP} :-

Case i) $K_{IP} = K_{SP} \Rightarrow$ Saturated soln

Case ii) $K_{IP} > K_{SP} \Rightarrow$ Supersaturated soln

Case iii) $K_{IP} < K_{SP} \Rightarrow$ Unsaturated soln

* factors affect Solubility :-

* Common ion Effect :-

$AgCl \rightleftharpoons Ag^+ + Cl^-$

S ↓ S

$HCl \longrightarrow H^+ + Cl^-$

→ due to Common ion effect

Question

Solubility product of CaC_2O_4 at a given temperature in pure water is $4 \times 10^{-9}(\text{ mol L}^{-1})^2$. Solubility of CaC_2O_4 at the same temperature is (KCET 2024)

A 6.3×10^{-5} mol L^{-1}

B 2×10^{-5} mol L^{-1}

C 2×10^{-4} mol L^{-1}

D 6.3×10^{-4} mol L^{-1}

$$CaC_2O_4 \rightleftharpoons Ca^{+2} + C_2O_4^{-2}$$
$$S \qquad S \qquad S$$

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

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

$$S = \sqrt{4 \times 10^{-9}}$$

$$S = \sqrt{40 \times 10^{-10}}$$

$$= \sqrt{40} \times 10^{-5}$$

Question

A weak acid with pK_a 5.9 and weak base with pK_b 5.8 are mixed in equal proportions. pH of the resulting solution is

(KCET 2023)

A 7.005

B 7.5

C 7

D 7.05

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

$$= 7 + \frac{1}{2}\{5.9 - 5.8\}$$

$$= 7 + \frac{1}{2}(0.1)$$

$$= 7 + 0.05$$

$$= 7.05$$

Question

Which among the following has highest pH? (KCET 2022)

A. 1 M NaOH

B. 1 M H_2SO_4

C. 0.1 M NaOH

D. 1M HCl

Question

K_a values for acids H_2SO_3, HNO_2, CH_3COOH and HCN are respectively 13×10^{-2}, 4×10^{-4}, 1.8×10^{-5} and 4×10^{-10}, which of the above acids produces stronger conjugate base in aqueous solution?

(KCET 2021)

A H_2SO_3

B HNO_2

C CH_3COOH

D HCN

$HA \rightleftharpoons H^+ + A^-$

$\uparrow K_a = (H^+)\uparrow(A^-)$

$pK_a \downarrow$

$K_a \downarrow$ W. Acid ↓ C. Base ↑

$K_a \uparrow$ S. Acid ↑

Question

The conjugate base of NH_3 is

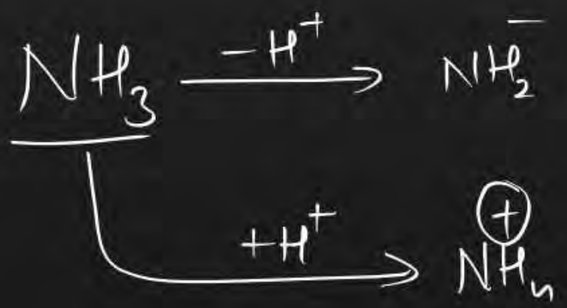
(KCET 2020)

A NH_4^+

B NH_4OH

C NH_2OH

D NH_2^-



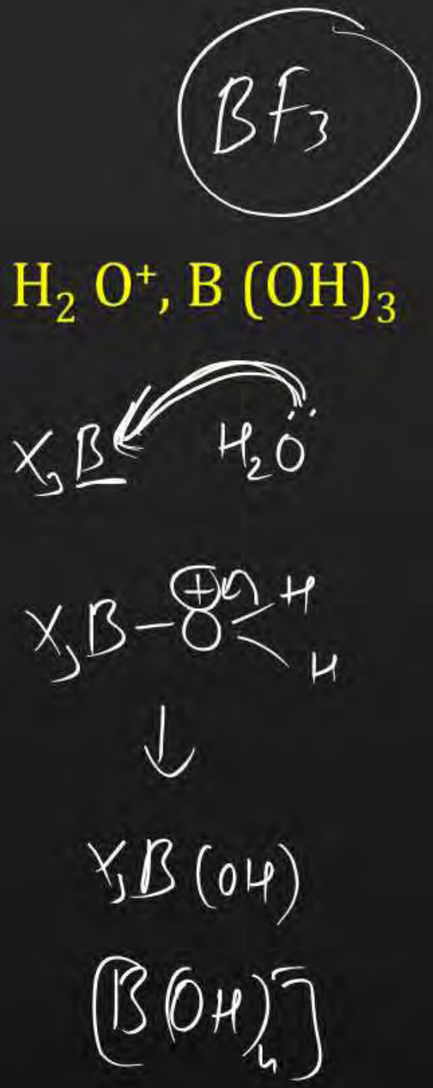
Question

In the reaction

$B(OH)_3 + 2H_2O \rightarrow 2H_2O \rightarrow [B(OH)_4]^- + H_2O^+, B(OH)_3$

Functions as

(KCET 2019)



A Protonic acid

B Lewis base

C Bronsted acid

D Lewis acid

Question

Solubility of AgCl is least in

(KCET 2019)

A 0.1 M NaCl

B pure water

C 0.1 M $BaCl_2$

D 0.1 M $AlCl_3$

Question

Identify conjugate acid and conjugate base for HCO_3^- ion respectively

(A) CO_3^{2-} and H_2CO_3

(B) H_2CO_3 and CO_2

(C) CO_2 and H_2CO_3

(D) H_2CO_3 and CO_3^{2-}

Question

Find the concentration of sodium acetate when added to 0.1 M solution of acetic acid to form a buffer solution of $\mathrm{pH} = 5.5$?

($\mathrm{pK_a}$ of $\mathrm{CH_3COOH} = 4.5$)

A 0.1 M

B 0.01M

C 1.0 M

D 10.0 M

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

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

$$5.5 = 4.5 + \log \frac{x}{0.1}$$

$$\log \frac{x}{0.1} = 1$$

$$\frac{x}{0.1} = \text{Antilog } 1$$

$$\frac{x}{0.1} = 10 \Rightarrow x = 1$$

Question

Calculate the ionisation constant of $0.08\ \mathrm{moldm^{-3}}$ of a monobasic acid having $\mathrm{pH} = 2$.

(A) 3531×10^{-7}

(B) 2.081×10^{-6}

(C) 3.456×10^{-8}

(D) 1.25×10^{-3}

$HA \rightleftharpoons H^+ + A^-$

0.08

$pH = 2.$ K_a

$pH = -\frac{1}{2}\log(K_a \times C)$

$2 = -\frac{1}{2}\log(x \times 0.08)$

$-\log(x \times 0.08) = 4.$

Question

The solubility product of salt B_2A is 3.2×10^{-11} at 298 K. What is solubility of the salt at same temperature?

(A) $5.52 \times 10^{-5}\ \text{moldm}^{-3}$

(B) $4.92 \times 10^{-4}\ \text{moldm}^{-3}$

(C) $2.00 \times 10^{-4}\ \text{moldm}^{-3}$

(D) $3.52 \times 10^{-5}\ \text{moldm}^{-3}$

$B_2A \longrightarrow 2B^{+} + A^{-2}$

$2s \quad s$

$K_{sp} = (2s)^2 (s)^1$

$= 4s^2 \cdot s$

$= 4s^3$

$s = \sqrt[3]{\frac{K_{sp}}{4}}$

Question

Which among the following salts turns red litmus blue in its aqueous solution?

A $CH_3 - COONa$

B $CuCl_2$

C KCl

D KCl

Question

$HA \longrightarrow H^+ + A^-$

$C-C\alpha \quad 2\times C\alpha \quad C\alpha$

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

$= -\log(2\times C\alpha)$

What is pH of weak dibasic acid, that is 2% dissociated in its M/100 solution at 298 K ?

A 1.6990

B 2.3979

C 3.3970

D 4.6990

Question

The solubility product of AgBr is 4.9×10^{-13} at a certain temperature. Calculate the solubility.

A $4 \times 10^{-6}\,\text{moldm}^{-3}$

B $4 \times 10^{-7}\,\text{moldm}^{-3}$

C $7 \times 10^{-7}\,\text{moldm}^{-3}$

D $3 \times 10^{-8}\,\text{moldm}^{-3}$

Question

Dissociation constant of 0.01 M weak acid is 10^{-4}. What is percent dissociation of acid?

A 2%

B 6%

C 10%

D 1.5%

Question

Which among the following salts forms basic solution when dissolved in water?

A $NaNO_3$

B CH_3COONH_4

C KCN

D NH_4F

Question

Calculate the pH of centimolar solution of monoacidic weak base. Which is 10% dissociated in its aqueous solution?

A 9

B 10

C 11

D 12

Question

A monobasic weak acid dissociates 2% in its 0.002 M solution. Calculate the dissociation constant of weak acid.

A 2×10^{-9}

B 8×10^{-7}

C 6×10^{-7}

D 4×10^{-6}

Question

Which among the following salts turns blue litmus red in its aqueous solution?

A KCN

B Na_2CO_3

C $NaNO_3$

D $CuCl_2$

Question

The solubility product of the sparingly soluble salt AB_2 is 2.56×10^{-10} at 298 K. Calculate its solubility in $\mathrm{mol dm^{-3}}$ at the same temperature?

A 1×10^{-4}

B 2×10^{-4}

C 4×10^{-4}

D 3×10^{-2}

Question

Calculate the value of dissociation constant of weak acid, which dissociates to 0.01% in its 0.1 M solution?

A 10^{-3}

B 10^{-4}

C 10^{-5}

D 10^{-9}

Question

The pH of monoacidic base is 10 . Calculate its percentage dissociation in 0.01 M solution at 298 K ?

A 10%

B 5%

C 2%

D 1%

Question

Which amlong the following salts forms basic solution when dissolved in water?

(A) NH_4NO_3

(B) Na_2CO_3

(C) $NaNO_3$

(D) $CuSO_4$

Question

Calculate the equilibrium concentration of Pb^{++} ions in a solution of PbS containing $1 \times 10^{-11}\ moldm^{-3}$ of sulphide ions.

(Given K_{sp} for $PbS = 8.0 \times 10^{-28}$)

A 4×10^{-14}

B 4×10^{-17}

C 8×10^{-17}

D 8×10^{-11}

Question

Which among the following salts forms basic solution in water?

A NH_4NO_3

B NH_4Cl

C Na_2CO_3

D Na_2SO_4

Question

A weak base is 5% dissociated in its 0.01 M solution. Calculate the dissociation constant.

A 3.5×10^{-6}

B 2.0×10^{-5}

C 2.3×10^{-4}

D 2.5×10^{-5}

Question

Solubility of binary sparingly soluble salt is $1.12 \times 10^{-4}\ \mathrm{g/dm^3}$. Calculate its solubility product (molar mass of salt $= 112\ \mathrm{g\ mol^{-1}}$)

A 1×10^{-3}

B 1×10^{-6}

C 1×10^{-9}

D 1×10^{-12}

Question

Identify conjugate acid-base pair from following equilibrium reaction.

$$HSO^{-}_{3(aq)} + H_3O^{+}_{(aq)} \rightleftharpoons H_2SO_3 + H_2O$$

A H_2SO_3 and HSO_3^-

B HSO_3^- and H_3O^+

C H_2SO_3 and H_2O

D H_3O^+ and H_2SO_3

Question

A weak monoacidic base dissociates to 1.5% in 0.001 M solution at 298 K. Calculate the dissociation constant of weak base.

(A) 2.25×10^{-7}

(B) 3.05×10^{-7}

(C) 2.5×10^{-5}

(D) 3.725×10^{-6}

Question

The solubility product of NiS is 4.9×10^{-5} at 298 K . Calculate its solubility in moldm^{-3} at the same temperature?

A 1.69×10^{-3}

B 7.0×10^{-3}

C 2.45×10^{-3}

D 6.18×10^{-3}

Question

Identify the conjugate acid-base pair respectively from following equilibrium reaction.

$$HPO_{4(aq)}^{2-} + H_2O_{(\ell)} \rightleftharpoons PO_{4(aq)}^{3-} + H_3O_{(eq)}^{+}$$

(A) H_3O^+ and H_2O

(B) H_2O and HPO_4^{2-}

(C) PO_4^{3-} and H_3O^+

(D) H_3O^+ and HPO_4^{2-}

Question

The solubility of sparingly soluble salt AX_2 is $1 \times 10^{-4}\ moldm^{-3}$ at 298 K. Calculate its solubility product.

(A) 2×10^{-12}

(B) 4×10^{-12}

(C) 2×10^{-10}

(D) 4×10^{-10}

Question

Calculate the value of dissociation constant of weak monoacidic base if it dissociates to 2% in 0.1 M solution?

A 6×10^{-5}

B 4×10^{-5}

C 2×10^{-5}

D 1×10^{-5}

Question

Which from following formulae is used to find the $[OH^-]$ ion concentration of a weak monoacidic base?

A $K_b . c$

B $\sqrt{K_b \cdot c}$

C $\sqrt{\frac{K_b}{c}}$

D $\sqrt{K_b}$

Question

A monobasic weak acid dissociates to 1.2% in its 0.01 M solution at 298 K. Calculate dissociation constant of it.

(A) 1.04×10^{-8}

(B) 1.44×10^{-6}

(C) 1.30×10^{-6}

(D) 1.18×10^{-5}

Question

The solubility of calcium carbonate at 298 K is $6.4 \times 10^{-5}\ \mathrm{moldm^{-3}}$. Calculate the value of solubility product at the same temperature?

A 5.06×10^{-10}

B 4.096×10^{-9}

C 3.05×10^{-10}

D 2.8×10^{-9}

Question

The solubility product of PbI_2 is 1.08×10^{-7}.

Calculate its solubility in $moldm^{-3}$ at 298 K.

(A) 2.018×10^{-3}

(B) 2.011×10^{-9}

(C) 1.259×10^{-9}

(D) 3.0×10^{-3}

Summary

Theory + MCQ

Homework

Remaining Questions


Thank
You