PHYSICS WALLAH

IONIC EQUILIBRIUM

01 Which of the following statements is/are incorrect?
I. Aqueous solution of sugar conducts electricity.
II. Conductance of electricity increases with an increase in concentration of common salt in aqueous glucose solution.
III. Aqueous solution of acetic acid mainly contains unionized acetic acid molecules and only some CH_3COO^- and H_3O^+ ions.
(a) III only (b) I only
(c) II and III only (d) I, II and III

ELECTROLYTE

Substance which allow the flow of electricity through their aqueous solution or through their molten form.

01 STRONG ELECTROLYTE
electrolyte which dissociates completely into ions.
eg : HCl, NaOH

02 WEAK ELECTROLYTE
electrolyte which dissociates partially into ions.
eg : CH_3COOH, NH_4OH

IONIC EQUILIBRIUM

Equilibrium established in between ions and unionised Salt in a weak electrolyte.

Eg. In weak electrolytes, equilibrium is established between ions and the unionized molecules. This type of equilibrium
I.involves ions in aqueous solution. II.is called physical equilibrium.
III.is due to complete ionization IV.is called ionic equilibrium.
The correct statement(s) is/are
(A) I and IV only (B) II and III only (C) IV only (D) I, II, III and IV
ANS : (A)

02 Which of the following is conjugate acid of SO_4^{2-}?
(a) HSO_4^- (b) H^+
(c) H_2SO_4 (d) SO_4^{2-}

ACID-BASE CONCEPTS

01 ARRHENIUS CONCEPT
Acids are H^+ ions donors and bases are OH^- ion donors.
▪ $HCl \rightarrow H^+ + Cl^-$ (acid) ▪ $NaOH \rightarrow Na^+ + OH^-$ (base)

02 BRONSTED - LOWRY CONCEPT
Acids are protons (H^+ion) donors and bases are proton acceptors.
Eg : $CH_3COOH + H_2O \rightleftharpoons CH_3COO^- + H_3O^+$
acid base Base acid

base + $H^+ \rightarrow$ Conjugate acid	acid - $H^+ \rightarrow$ Conjugate base

▪ Conjugate acid of $H_20 \rightarrow H_3O^+$ ▪ Conjugate base of $H_20 \rightarrow OH^-$

03 LEWIS CONCEPT
Bases are lone pair e^- donors & acids are lone pair e^- acceptors.
- Lewis acid - Substances having Vacant space in their valence shell to accomodate lone pair of e^-
  Eg : BF_3, $AlCl_3$, H^+, Ag^+
- Lewis base - Substances having lone pair of e^- in their valence shell
  Eg : NH_3, H_2O, Cl^-, OH^-

03 Which of the following species can act both as an acid as well as a base?
(a) SO_4^{2-} (b) HSO_4^-
(c) PO_4^{3-} (d) Cl^-

IONISATION AND IONISATION CONSTANT

In all ionisation reactions concentration of water [H_2O] is taken as constant

01 IONISATION OF WATER
$H_2O + H_2O \rightleftharpoons H_3O^+ + OH^-$
Ionisation constant of water, $K_w = [H_3O^+]\,[OH^-]$
or $K_w = [H^+]\,[OH^-]$

02 IONISATION OF ACID
$CH_3COOH + H_2O \rightleftharpoons CH_3COO^- + H_3O^+$
Ionisation constant, $K_a = \dfrac{[CH_3COO^-]\,[H_3O^+]}{[CH_3COOH]}$
or $K_a = \dfrac{[CH_3COO^-]\,[H^+]}{[CH_3COOH]}$

03 IONISATION OF BASE
Eg : NH_4OH
Ionisation constant of base $K_b = \dfrac{[NH_4^+]\,[OH^-]}{[NH_4OH]}$

04 What will be the pH of a soft drink if hydrogen ion concentration in sample is 3.8×10^{-3} M?
(a) 3.8 (b) 5.04
(c) 2.42 (d) 9.2

VALUE OF IONIC PRODUCT

At 25°C, $K_w = [H_3O^+]\,[OH^-] = 1 \times 10^{-14}$

01 If $[H^+] = [OH^-] = 1 \times 10^{-7}$ mol/L : solution will be neutral

02 If $[H^+] > [OH^-]$ i.e $[H^+] > 1 \times 10^{-7}$mol/L solution will be acidic

03 If $[H^+] < [OH^-]$ i.e $[H^+] < 1 \times 10^{-7}$mol/L solution will be basic

pH

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

- pH of a neutral solution is 7
- pH of an acidic solution is < 7
- pH of a basic solution is > 7

pH SCALE

05 What will be the ionisation constant of formic acid if its 0.01 M solution is 14.5% ionised?
(a) 2.1×10^{-4} (b) 14.5
(c) 0.145 (d) 1.45×10^{-4}

IMPORTANT EQUATIONS

- $pH = -\log [H^+]$
- $pKa = -\log [K_a]$
- $pOH = -\log [OH^-]$
- $pKb = -\log [K_b]$
- $pKw = pH + pOH = 14$
- $K_a x K_b = K_w = 1 \times 10^{-14}$ at 25°C
- $pKa + pKb = 14$ at 25°C

DEGREE OF DISSOCIATION (α)

$\alpha = \dfrac{\text{Number of moles ionised}}{\text{Total no. of moles}}$

Eg : 30% ionisation means $\alpha = \dfrac{30}{100} = 0.3$

Weak acid	Weak base
$K_a = C\alpha^2$	$K_b = C\alpha^2$
$\alpha = \sqrt{K_a / c}$	$\alpha = \sqrt{K_b / c}$
$[H_3O^+] = C\alpha$	$[OH^-] = C\alpha$
$[H^+] = \sqrt{K_a . c}$	$[OH^-] = \sqrt{K_b . c}$

06 Equimolar solutions of HF, HCOOH and HCN at 298 K have the values of K_a as 6.8×10^{-4}, 1.8×10^{-4} and 4.8×10^{-9} respectively. What will be the order of their acidic strength?
(a) HF > HCN > HCOOH
(b) HF > HCOOH > HCN
(c) HCN > HF > HCOOH
(d) HCOOH > HCN > HF

ACID STRENGTH

- acid strength α K_a
- acid strength $\alpha \dfrac{1}{pKa}$

For an acid HA

- As HA bond strength decreases, acid strength increases
- As we move from top to bottom, size of anion increases
  ∴ HA bond strength decreases & acid strength increases.
  eg :- Acid strength of HI > HBr > HCl > HF
- As we move from left to right, electronegativity increases
  ∴ HA bond becomes more polar & acid strength increases.
  eg :- Acid strength of HF > H_2O > NH_3 > CH_4

07 For a polybasic acid, the dissociation constants have a different values for each step, *e.g.*,
$H_3A \rightleftharpoons H^+ + H_2A^-$; $K = K_{a_1}$
$H_2A^- \rightleftharpoons H^+ + HA^{2-}$; $K = K_{a_2}$
$HA^{2-} \rightleftharpoons H^+ + A^{3-}$; $K = K_{a_3}$
What is the observed trend of dissociation constants in successive stages?
(a) $K_{a_1} > K_{a_2} > K_{a_3}$ (b) $K_{a_1} = K_{a_2} = K_{a_3}$
(c) $K_{a_1} < K_{a_2} < K_{a_3}$ (d) $K_{a_1} = K_{a_2} + K_{a_3}$

POLYPROTIC ACIDS & POLYHYDROXY BASES

- Acids having ionisable hydrogen are known as protic acids or basic acids. eg :- HCl, H_2SO_4, $H_2C_2O_4$, H_3PO_4, CH_3COOH etc
- Here H_2SO_4, $H_2C_2O_4$ & H_3PO_4 are having more than one ionisable hydrogen, they are known as polyprotic acids
- Polyprotic acids ionises in stepwise.
- Here the removal of H^+ ion from neutral molecule is easy, but it is difficult to remove further H^+ ions from their corresponding anions
  ∴$Ka_1 > Ka_2 > Ka_3$
- In case of polyhydroxy bases or polyacidic bases like $Fe(OH)_3$, $Ba(OH)_2$ etc $Kb_1 > Kb_2 > Kb_3$

08 Which of the following salts does not show its correct nature mentioned against it?
(a) NaCl solution - Neutral
(b) NaCN solution - Acidic
(c) NH_4NO_3 solution - Acidic
(d) KF solution - Basic

HYDROLYSIS OF SALTS

Salt + $H_2O \xrightarrow{\text{hydrolysis}}$ acid + base

- SALT OF STRONG ACID & STRONG BASE
  Strong acid (SA) & strong base (SB) $\rightarrow$ Neutral, It's pH = 7
  eg :- NaCl
  $NaOH + HCl \rightarrow$ Neutral
  SB SA
  Na_2SO_4
  $NaOH + H_2SO_4 \rightarrow$ Neutral
  SB SA
  Note : Neutral salts do not undergo hydrolysis
- SALT OF STRONG ACID & WEAK BASE. (SA + WB $\rightarrow$ acidic), It's pH < 7
  eg :- NH_4Cl $NH_4OH + HCl \rightarrow$ acidic (cationic hydrolyses)
  WB SA
- SALT OF WEAK ACID & STRONG BASE (WA + SB $\rightarrow$ Basic), It's pH > 7
  eg :- CH_3COONa $CH_3COOH + NaOH \rightarrow$ Basic (anionic hydrolysis)
- SALT OF WEAK ACID & WEAK BASE
  WA + WB $\rightarrow$ slightly acidic/basic
  $pH = 7 + \frac{1}{2}[pKa - pKb]$
  eg : $(NH_4)_2CO_3$

09 Which one of the following pairs of solution is not an acidic buffer?
(a) CH_3COOH and CH_3COONa
(b) H_2CO_3 and Na_2CO_3
(c) H_3PO_4 and Na_3PO_4
(d) $HClO_4$ and $NaClO_4$

COMMON ION EFFECT

Ionisation of a weak electrolyte can be suppressed by the addition of salt which contain common ion.

- Ionisation of a weak acid, CH_3COOH can be suppressed by the addition of a salt like CH_3COONa. Common ion : CH_3COO^-
- Ionisation of a weak base, NH_4OH can be suppressed by the addition of a salt like NH_4Cl. Common ion : NH_4^+

BUFFER SOLUTIONS

Solution which can resist the change in pH on addition of small drops of acids or base.

1. Acidic buffer : Mixture of equimolar concentrations of a weak acid and it's salt with a strong base. CH_3COOH / CH_3COONa.
   $pH = pKa + \log \dfrac{[salt]}{[acid]}$ Henderson - Hasselbalch equation
2. Basic buffer : Mixture of equimolar concentrations of a weak base and it's salt with a strong acid. NH_4OH / NH_4Cl.
   $pOH = pKb + \log \dfrac{[salt]}{[base]}$

10 The solubility of $AgCl_{(s)}$ with solubility product 1.6×10^{-10} in 0.1 M NaCl solution would be
(a) 1.26×10^{-5} M (b) 1.6×10^{-9} M
(c) 1.6×10^{-11} M (d) zero.

SOLUBILITY PRODUCT

- Solubility is the concentration of an ion in a saturated solution(S)
- Solubility product is the equilibrium constant for solubility equilibrium
- Sparingly soluble salt $\rightarrow$ salts which can dissolve only slightly into ions
  eg: AgCl, $BaSO_4$, $PbCl_2$, etc.
- K_{sp} can be calculated easily by using a sparingly soluble salt.
  Consider the ionisation of a sparingly soluble salt AgCl
  $AgCl \rightleftharpoons Ag^+ + Cl^-$
  S S
  $K_{sp} = [Ag^+]\,[Cl^-] = S \times S = S^2$
- If the value of ionic product = K_{sp}, solution is saturated.
- If the value of ionic product < K_{sp}, solution is unsaturated.
- If the value of ionic product > K_{sp}, solution is super saturated, here precipitation takes place