

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.
 • $\text{HCl} \rightarrow \text{H}^+ + \text{Cl}^-$ (acid) • $\text{NaOH} \rightarrow \text{Na}^+ + \text{OH}^-$ (base)
- 02 BRONSTED - LOWRY CONCEPT Acids are protons (H^+) donors and bases are proton acceptors.
 Eg : $\text{CH}_3\text{COOH} + \text{H}_2\text{O} \rightleftharpoons \text{CH}_3\text{COO}^- + \text{H}_3\text{O}^+$
 acid base Base acid
 base + $\text{H}^+ \rightarrow$ Conjugate acid acid - $\text{H}^+ \rightarrow$ Conjugate base
 • Conjugate acid of $\text{H}_2\text{O} \rightarrow \text{H}_3\text{O}^+$ • Conjugate base of $\text{H}_2\text{O} \rightarrow \text{OH}^-$
- 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 accommodate 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 $[\text{H}_2\text{O}]$ is taken as constant

- 01 IONISATION OF WATER
 $\text{H}_2\text{O} + \text{H}_2\text{O} \rightleftharpoons \text{H}_3\text{O}^+ + \text{OH}^-$
 Ionisation constant of water, $K_w = [\text{H}_3\text{O}^+][\text{OH}^-]$ or $K_w = [\text{H}^+][\text{OH}^-]$
- 02 IONISATION OF ACID
 $\text{CH}_3\text{COOH} + \text{H}_2\text{O} \rightleftharpoons \text{CH}_3\text{COO}^- + \text{H}_3\text{O}^+$
 Ionisation constant, $K_a = \frac{[\text{CH}_3\text{COO}^-][\text{H}_3\text{O}^+]}{[\text{CH}_3\text{COOH}]}$ or $K_a = \frac{[\text{CH}_3\text{COO}^-][\text{H}^+]}{[\text{CH}_3\text{COOH}]}$
- 03 IONISATION OF BASE
 Eg : NH_4OH
 Ionisation constant of base $K_b = \frac{[\text{NH}_4^+][\text{OH}^-]}{[\text{NH}_4\text{OH}]}$

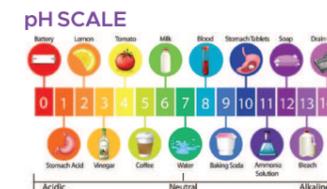
04

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

VALUE OF IONIC PRODUCT

At 25°C , $K_w = [\text{H}_3\text{O}^+][\text{OH}^-] = 1 \times 10^{-14}$
 01 If $[\text{H}^+] = [\text{OH}^-] = 1 \times 10^{-7} \text{ mol/L}$: solution will be neutral
 02 If $[\text{H}^+] > [\text{OH}^-]$ i.e $[\text{H}^+] > 1 \times 10^{-7} \text{ mol/L}$ solution will be acidic
 03 If $[\text{H}^+] < [\text{OH}^-]$ i.e $[\text{H}^+] < 1 \times 10^{-7} \text{ mol/L}$ solution will be basic

pH pH of a neutral solution is 7
 pH of an acidic solution is < 7
 pH of a basic solution is > 7
pH = - log [H⁺]



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

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

DEGREE OF DISSOCIATION (α)

$$\alpha = \frac{\text{Number of moles ionised}}{\text{Total no. of moles}}$$
 Eg : 30% ionisation means $\alpha = \frac{30}{100} = 0.3$

Weak acid $K_a = C\alpha^2$
 $\alpha = \sqrt{K_a/c}$
 $[\text{H}_3\text{O}^+] = C\alpha$
 $[\text{H}^+] = \sqrt{K_a \cdot c}$

Weak base $K_b = C\alpha^2$
 $\alpha = \sqrt{K_b/c}$
 $[\text{OH}^-] = C\alpha$
 $[\text{OH}^-] = \sqrt{K_b \cdot c}$

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) $\text{HF} > \text{HCN} > \text{HCOOH}$
 (b) $\text{HF} > \text{HCOOH} > \text{HCN}$
 (c) $\text{HCN} > \text{HF} > \text{HCOOH}$
 (d) $\text{HCOOH} > \text{HCN} > \text{HF}$

ACID STRENGTH

- acid strength $\propto K_a$
- acid strength $\propto \frac{1}{\text{pKa}}$
- For an acid HA**
- As HA bond strength decreases, acid strength increases
- As we move from top to bottom, size of anion increases \therefore HA bond strength decreases & acid strength increases.
 eg :- Acid strength of $\text{HI} > \text{HBr} > \text{HCl} > \text{HF}$
- As we move from left to right, electronegativity increases \therefore HA bond becomes more polar & acid strength increases.
 eg :- Acid strength of $\text{HF} > \text{H}_2\text{O} > \text{NH}_3 > \text{CH}_4$

07

For a polybasic acid, the dissociation constants have a different values for each step, e.g.,
 $\text{H}_2\text{A} \rightleftharpoons \text{H}^+ + \text{HA}^-$; $K = K_{a1}$
 $\text{HA}^- \rightleftharpoons \text{H}^+ + \text{A}^{2-}$; $K = K_{a2}$
 $\text{HA}^{2-} \rightleftharpoons \text{H}^+ + \text{A}^{3-}$; $K = K_{a3}$
 What is the observed trend of dissociation constants in successive stages?
 (a) $K_{a1} > K_{a2} > K_{a3}$ (b) $K_{a1} = K_{a2} = K_{a3}$
 (c) $K_{a1} < K_{a2} < K_{a3}$ (d) $K_{a1} = K_{a2} + K_{a3}$

POLYPROTIC ACIDS & POLYHYDROXY BASES

- Acids having ionisable hydrogen are known as protic acids or basic acids. eg :- HCl, H_2SO_4 , $\text{H}_2\text{C}_2\text{O}_4$, H_3PO_4 , CH_3COOH etc
- Here H_2SO_4 , $\text{H}_2\text{C}_2\text{O}_4$ & 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 $\therefore K_{a1} > K_{a2} > K_{a3}$
- In case of polyhydroxy bases or polyacidic bases like $\text{Fe}(\text{OH})_3$, $\text{Ba}(\text{OH})_2$ etc $K_{b1} > K_{b2} > K_{b3}$

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

- $\text{Salt} + \text{H}_2\text{O} \xrightarrow{\text{hydrolysis}} \text{acid} + \text{base}$
- SALT OF STRONG ACID & STRONG BASE
 Strong acid (SA) & strong base (SB) \rightarrow Neutral, It's pH = 7
 eg :- NaCl $\text{NaOH} + \text{HCl} \rightarrow$ Neutral Na_2SO_4 $\text{NaOH} + \text{H}_2\text{SO}_4 \rightarrow$ Neutral
 SB SA 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 $\text{NH}_4\text{OH} + \text{HCl} \rightarrow$ acidic (cationic hydrolyses)
 WB SA
 - SALT OF WEAK ACID & STRONG BASE (WA + SB \rightarrow Basic), It's pH > 7
 eg :- CH_3COONa $\text{CH}_3\text{COOH} + \text{NaOH} \rightarrow$ Basic (anionic hydrolysis)
 - SALT OF WEAK ACID & WEAK BASE
 WA + WB \rightarrow slightly acidic/basic
 $\text{pH} = 7 + \frac{1}{2} [\text{pKa} - \text{pKb}]$
 eg : $(\text{NH}_4)_2\text{CO}_3$

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. $\text{CH}_3\text{COOH} / \text{CH}_3\text{COONa}$.

$$\text{pH} = \text{pKa} + \log \frac{[\text{salt}]}{[\text{acid}]}$$
 Henderson - Hasselbalch equation
2. Basic buffer : Mixture of equimolar concentrations of a weak base and it's salt with a strong acid. $\text{NH}_4\text{OH} / \text{NH}_4\text{Cl}$.

$$\text{pOH} = \text{pKb} + \log \frac{[\text{salt}]}{[\text{base}]}$$

10

The solubility of $\text{AgCl}_{(s)}$ with solubility product 1.6×10^{-10} in 0.1 M NaCl solution would be
 (a) $1.26 \times 10^{-5} \text{ M}$ (b) $1.6 \times 10^{-9} \text{ M}$
 (c) $1.6 \times 10^{-11} \text{ M}$ (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

$$\text{AgCl} \rightleftharpoons \underset{S}{\text{Ag}^+} + \underset{S}{\text{Cl}^-}$$

$$K_{sp} = [\text{Ag}^+][\text{Cl}^-] = S \times S = S^2$$
- 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

IONIC EQUILIBRIUM