CBSE EXAMINATION PAPER-2022

CHEMISTRY

(Solved)

Time allowed : 3 hours | Maximum Marks : 43

General Instructions :

Read the following instructions carefully and follow them :

i. This question paper contains **17 questions.** All questions are **compulsory.**

ii. This question paper is divided into **3 sections.**

iii. **Section A** – questions number **1 to 2** are case based questions

iv. **Section B** – questions number **3 to 4** are short answer

v. **Section C** – questions number **5 to 17** are long answer

vi. There is no overall choice given in the question paper. However, an internal choice has been provided in few questions.

vii. Use of calculator is NOT allowed.

Section A

Question 1. Aldehydes, ketones and carboxylic acids are some of the important classes of organic compounds containing the carbonyl group. These are highly polar molecules due to the higher electronegativity of oxygen relative to carbon in the carbonyl group. Aldehydes are prepared by dehydrogenation or controlled oxidation of primary alcohols and controlled reduction of acyl halides. Ketones are prepared by oxidation of secondary alcohols and hydration of alkynes. Aldehydes and ketones undergo nucleophilic addition reactions onto the carbonyl group but carboxylic acids do not undergo nucleophilic addition reaction. The alpha (α) - hydrogens of aldehydes and ketones are acidic. Therefore, aldehydes and ketones having at least one α-hydrogen undergo Aldol condensation.

Question 2.

Read the passage given below and answer the questions that follow:

Aldehydes, ketones and carboxylic acids are some of the important classes of organic compounds containing carbonyl group. These are highly polar molecules due to higher electro-negativity of oxygen relative to carbon in the carbonyl group. Aldehydes are prepared by dehydrogenation or controlled oxidation of primary alcohols and controlled reduction of acyl halides. Ketones are prepared by oxidation of secondary alcohols and hydration of alkynes.

Aldehydes and ketones undergo nucleophilic addition reactions onto the carbonyl group but carboxylic acid does not undergo nucleophilic addition reaction. The alpha (a) hydrogens of aldehydes and ketones are acidic. Therefore aldehydes and ketones having at least one a-hydrogen undergo Aldol condensation.

Aldehydes are easily oxidised by mild oxidising agents such as Tollens' reagent and Fehling's reagent. Carboxylic acids are prepared by the oxidation of primary alcohols, aldehydes and by hydrolysis of nitriles. Aromatic carboxylic acids are prepared by side-chain oxidation of alkyl benzenes. Carboxylic acids are considerably more acidic than alcohols and most of simple phenols.

(1)

Arrange the following in the increasing order of their reactivity towards nucleophilic addition reaction.:

CH_3COCH_3, CH_3, CHO, HCHO, $C_6H_5COCH_3$,

[1 Marks]

Answer: The increasing order of reactivity towards nucleophilic addition reaction is C6H5COCH3 < CH3COCH3 < CH3CHO < HCHO. This is because reactivity increases with the strength of the electron-withdrawing group and the availability of the carbonyl carbon for attack by nucleophiles.

Key Points: C6H5COCH3 is less reactive due to the stabilizing effect of the benzene ring; CH3COCH3 is less reactive than aldehydes; CH3CHO is more reactive than ketones; HCHO is the most reactive due to the absence of steric hindrance.

(2)

Give a simple chemical test to distinguish betweco Ethanal and Propanone.

[1 Marks]

Answer: To distinguish between Ethanal (an aldehyde) and Propanone (a ketone), you can use Tollens' reagent. Ethanal will react with Tollens' reagent and form a silver mirror, indicating it is an aldehyde, while Propanone will not react and no silver mirror will form.

Key Points: Use Tollens' reagent - Ethanal forms silver mirror - Propanone does not react

(3)

Why carboxylic acid does not give nucleophilic addition reactions like aldehydes and ketones?

[1 Marks]

Answer: Carboxylic acids do not undergo nucleophilic addition reactions like aldehydes and ketones because they contain a hydroxyl (-OH) group that can participate in hydrogen bonding and stabilize the negative charge formed during the reaction. This leads to the formation of stable carboxylate ions, making the carbonyl carbon less electrophilic and less reactive towards nucleophiles.

Key Points: Carboxylic acids have a hydroxyl group-They stabilize carboxylate ions-They are less electrophilic than aldehydes and ketones

(4)

Write the products in the following

[1 Marks]

Answer: Aldehydes can be oxidized to carboxylic acids, while ketones do not readily undergo oxidation to yield products like aldehydes or acids. The primary products are aldehydes and carboxylic acids resulting from the oxidation of alcohols.

Key Points: Aldehydes from primary alcohols; Ketones from secondary alcohols; Aldehydes can be oxidized to carboxylic acids

(5)

Why a-hydrogen of aldehydes and ketones are acidic in nature?

[1 Marks]

Answer: The a-hydrogens in aldehydes and ketones are acidic due to the presence of the carbonyl group (C=O). This high electronegativity of oxygen creates polarization, allowing the hydrogen atom to be easily released as a proton (H+). Thus, aldehydes and ketones can undergo reactions such as Aldol condensation, making the a-hydrogens significant in organic reactions.

Key Points: Presence of carbonyl group; high electronegativity of oxygen; ability to release proton (H+); participation in Aldol condensation

(6)

Write the major products of the following reactions:

[2 Marks]

Answer: The major products of the following reactions are as follows: 1. Oxidation of primary alcohols yields aldehydes. For example, oxidation of ethanol gives ethanal (acetaldehyde). 2. Oxidation of aldehydes results in carboxylic acids. For example, oxidation of ethanal gives acetic acid. 3. Oxidation of secondary alcohols yields ketones. For example, oxidation of isopropanol gives acetone.

Key Points: Oxidation of primary alcohols gives aldehydes-Oxidation of aldehydes gives carboxylic acids-Oxidation of secondary alcohols gives ketones

Section B

Question 3.

Define rate of reaction. Write two factors that affect the rate of reaction.

[2 Marks]

Answer: The rate of reaction is defined as the change in concentration of a reactant or product per unit time. It measures how quickly reactants are converted into products. Factors that influence the rate include the concentration of reactants and temperature. An increase in the concentration of reactants generally speeds up the reaction, as there are more particles available for collisions. Similarly, raising the temperature increases the energy and movement of particles, resulting in more frequent and effective collisions, thus enhancing the reaction rate.

Key Points: Definition of rate of reaction; Change in concentration per unit time; Factors: concentration of reactants, temperature

Question 4.

write the Nernst equation for the following cell reaction :

$Zn(s) + Cu^{2}$ 9aq) $\rightarrow Zn^{2+}(aq) + Cu(s)$ (1)

How will the E^{c}_{ell} be affected when concentration of

(i) Cu^{2} + ions is increased and

(ii) Zn^2 + ions is increased ? (1)

[2 Marks]

Answer: (a) The Nernst equation for the cell reaction $Zn(s) + Cu^{2+}(aq) \rightarrow Zn^{2+}(aq) + Cu(s)$ is given by:

$E_{cell} = E°_{cell} - (RT / 2F) * \ln([Zn^{2+}] / [Cu^{2+}])$

where $E°_{cell}$ is the standard cell potential, R is the gas constant, T is the temperature in Kelvin, F is the Faraday constant, $[Zn^{2+}]$ and $[Cu^{2+}]$ are the concentrations of zinc and copper ions respectively.

(b) Effect on E_{cell} when concentrations change:

(i) If the concentration of Cu^{2+} ions is increased, the ratio $[Zn^{2+}]/[Cu^{2+}]$ decreases and $\ln([Zn^{2+}]/[Cu^{2+}])$ becomes more negative, thus E_{cell} increases.

(ii) If the concentration of Zn^{2+} ions is increased, the ratio $[Zn^{2+}]/[Cu^{2+}]$ increases and $\ln([Zn^{2+}]/[Cu^{2+}])$ becomes more positive, thus E_{cell} decreases.

Therefore, increasing Cu^{2+} concentration increases E_{cell}, and increasing Zn^{2+} concentration decreases E_{cell}.

> **Key Points: Nernst equation formula - Effect of Cu^{2+} concentration on E_{cell} - Effect of Zn^{2+} concentration on E_{cell}**

Section C

Question 5.

Following ions of 3d-transition series are given:Ti4+, Vat3+, Cr 3+, Mn^{3+}

(Atomic number: Ti = 22 V = 23 Cr = 24 Mn = 25)

Identify the ion which is :

(i) colourless in aqueous solution. (1)

(ii) a strong oxidising agent. (1)

(iii)colourless in aqueous solution. (1)

Give Suitable reason in each .

[3 Marks]

Answer: (a) The ion which is colourless in aqueous solution is Ti^{4+}. This is because Ti^{4+} has electronic configuration $[Ar]3d^0$. It has no electrons in the 3d orbitals to absorb visible light, so it appears colourless.

(b) The ion which is a strong oxidising agent is Mn^{3+}. Manganese in +3 oxidation state has a strong

tendency to gain electrons and get reduced to a more stable state such as Mn^{2+}. Therefore, Mn^{3+} ion acts as a strong oxidising agent.

(c) The ion which is colourless in aqueous solution is also Ti^{4+}. Similar to (a), Ti^{4+} has no d electrons and cannot absorb visible light, hence it remains colourless.

Summary:

1. Ti^{4+} is colourless due to $3d^0$ electronic configuration.
2. Mn^{3+} is a strong oxidising agent due to its high tendency to be reduced.
3. Ti^{4+} is colourless again as explained in (a).

Key Points: Ti4+ is colourless due to 3d0 configuration - Mn3+ is a strong oxidising agent due to its ability to gain electrons - Ti4+ is colourless because it has no d electrons to absorb visible light

Question 6.

(i)On the basis of crystal field theory, write the electronic configuration for d4 ion if Δ0<P.(1)

(ii) Using valence bond theory, predict the hybridization and magnetic character of $[Ni(CN),_4]^{2-}$ (Atomic number of Ni = 28). (1)

(iii)Write the formula of the following complex using IUPAC norma Dichloridobis (ethane-1,2- diamine) cobalt (III). (1)

[3 Marks]

Answer: (a) For d^4 ion when \u03940 < P, the complex is high spin and electrons do not pair up in lower energy orbitals. Hence, electronic configuration is $t_{2g}^3\ e_g^1$.

(b) In $[Ni(CN)_4]^{2-}$, Ni is in +2 oxidation state with electronic configuration $3d^8$. CN^- is a strong field ligand causing pairing of electrons and resulting in dsp^2 hybridization. This leads to square planar geometry. Due to pairing of electrons, the complex is diamagnetic.

(c) The formula for Dichloridobis (ethane-1,2-diamine) cobalt (III) according to IUPAC is $[CoCl_2(en)_2]^{3+}$.

Key Points: High spin configuration for d4 is t2g3 eg1 - [Ni(CN)4]2- has dsp2 hybridization and is diamagnetic - IUPAC formula is [CoCl2(en)2]3+

Question 7.

When a co-ordination compound $NiCl_2$, $6H_2O$ mixed with $AgNO_3$, 2 moles of AgCl are precipitated per mole of the compound.

(i) Write Structural formula of the complex.(1)

(ii) Write Secondary valency of Ni' in the complex(1)

(iii) Write IUPAC name of the complex.

[3 Marks]

Answer: (a) Structural formula of the complex is $[Ni(H_2O)_6]Cl_2$ because Ni is the central metal ion surrounded by 6 water molecules as ligands and 2 chloride ions outside the coordination sphere.
(b) Secondary valency (coordination number) of Ni in the complex is 6 as it is bonded to six water molecules.
(c) IUPAC name of the complex is Hexaaquanickel(II) chloride because there are six aqua ligands and nickel has oxidation state +2, with two chloride ions as counter ions outside the complex.

Key Points: Structural formula is [Ni(H2O)6]Cl2 - Secondary valency of Ni is 6 - IUPAC name is Hexaaquanickel(II) chloride

Question 8.

A first order reaction is 50% complete in 40 minutes. Calculate the time required for the completion of 90% of reaction.

[Given: log 20.3010, log 10=1]

[3 Marks]

Answer: To calculate the time required for the completion of 90% of a first-order reaction, we'll start with the known half-life and the relationship between the rate constant (k) and half-life (t1/2). For first-order reactions, t1/2 = 0.693/k. Given that 50% of the reaction is complete in 40 minutes, we find k using k = 0.693 / 40 min = 0.017325 min^{-1}. Now, for 90% completion, we use the first-order kinetics formula: t = (2.303 / k) * log($[A]_0$ / [A]). Here, $[A]_0$ is the initial concentration and [A] for 90% completion is 10% of the original amount. Thus, we calculate t = (2.303 / 0.017325) * log(10) = (2.303 / 0.017325) * 1 = 132.74 minutes.

Key Points: First-order reaction; Half-life calculation; Rate constant (k); 90% completion time calculation; Usage of logarithmic identities

Question 9.

Illustrate the following reactions giving suitable example in each case:

(i) Gabriel phthalimide synthesis.(1)

(ii) Carbylamine reaction.(1)

(iii) Hoffmann bromamide degradation reaction.(1)

[3 Marks]

Answer: (i) **Gabriel phthalimide synthesis:** This reaction is used to prepare primary amines. Phthalimide reacts with potassium hydroxide to give potassium salt, which then reacts with an alkyl halide (R-X) to give N-alkyl phthalimide. Hydrolysis gives primary amine R-NH_2.

$C_6H_4(CO)_2NH + KOH \rightarrow C_6H_4(CO)_2NK + H_2O$

$C_6H_4(CO)_2NK + R\text{-}X \rightarrow C_6H_4(CO)_2NR + KX$

$C_6H_4(CO)_2NR + 2H_2O + HCl \rightarrow R\text{-}NH_2 + C_6H_4(COOH)_2 + KCl$

(ii) **Carbylamine reaction:** This reaction detects primary amines. When a primary amine reacts with chloroform and ethanolic KOH, an isocyanide (carbylamine) with a foul smell is formed.

$R\text{-}NH_2 + CHCl_3 + 3KOH \rightarrow R\text{-}NC + 3KCl + 3H_2O$

Example: $CH_3NH_2 + CHCl_3 + 3KOH \rightarrow CH_3NC + 3KCl + 3H_2O$

(iii) **Hoffmann bromamide degradation reaction:** This reaction is used to prepare primary amines from amides. An amide reacts with bromine and alkali to form a primary amine with one carbon less than the original amide.

$R\text{-}CONH_2 + Br_2 + 4KOH \rightarrow R\text{-}NH_2 + K_2CO_3 + 2KBr + 2H_2O$

Example: $C_6H_5CONH_2 + Br_2 + 4KOH \rightarrow C_6H_5NH_2 + K_2CO_3 + 2KBr + 2H_2O$

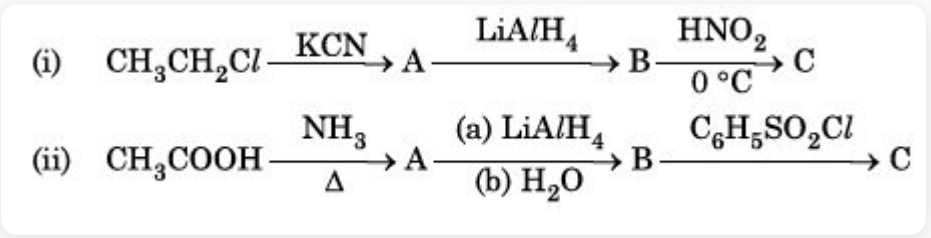
In all reactions, the primary amine is obtained by specific mechanisms and conditions.

Key Points: Gabriel synthesis produces primary amines using phthalimide-potassium salt and alkyl halide-Gabriel synthesis involves N-alkylation and hydrolysis-Carbylamine reaction detects primary amines by forming isocyanides-Hoffmann bromamide degradation converts amides to primary amines with one carbon less

Question 10.

Write the structures of A, B and C in the following reactions:

[3 Marks]



Answer: In the context of the general reaction A + B ⇌ C + D, let's consider A as a reactant that can represent hydrogen (H_2), B as oxygen (O_2), and product C as water (H_2O). The balanced chemical equation for the reaction is: $2H_2 + O_2 \rightleftharpoons 2H_2O$. In this reaction, A ($H_2$) and B ($O_2$) combine to form C ($H_2O$) in a redox process where the oxidation states change. Structure A (H_2) consists of two hydrogen atoms bonded together, while structure B (O_2) comprises two oxygen atoms. The product C

(H_2O) is composed of two hydrogen atoms covalently bonded to one oxygen atom, representing the water molecule formed in this combination reaction. Understanding these structures is crucial in analyzing the reactions and their equilibrium concentrations.

Key Points: A is hydrogen (H_2); B is oxygen (O_2); C is water (H_2O); Reaction is $2H_2 + O_2 \rightleftharpoons 2H_2O$; A and B react to form C; Identifying structures important for equilibrium.

Question 11.

Account for the following :

(i) Transition elements have higher enthalpies of atomisation.(1)

(ii) Separation of a mixture of Lanthanoid elements is difficult.(1)

(iii) Account for the following: The $E°_{m^{2+}m}$ value for copper is positive.(1)

[3 Marks]

Answer: (i) Transition elements have higher enthalpies of atomisation because they possess unpaired d electrons which participate in strong metallic bonding by overlapping orbitals, making the bonds between atoms stronger and thus requiring more energy to break.
(ii) Separation of a mixture of Lanthanoid elements is difficult because they have very similar chemical properties and ionic radii due to the lanthanoid contraction, which makes their behavior almost indistinguishable in chemical processes.
(iii) The $E^{+}{}_{o}+$ value for copper is positive because Cu^{+} ion is less stable than Cu^{2+} ion, so copper tends to lose two electrons to form Cu^{2+} rather than just one. This makes the reduction potential higher and positive.

Key Points: Transition elements have strong metallic bonds due to unpaired d electrons - Lanthanoids have similar chemical properties and ionic radii causing separation difficulty - Positive $E^{+}{}_{o}+$ for copper due to relative stability of Cu□+ over Cu^{+}+

Question 12.

Define transition elements. Which of the d-block elements may not be regarded as the transition elements ? Why transition metals generally form coloured compounds?

[3 Marks]

Answer: Transition elements, primarily those found in the d-block of the periodic table, are defined as elements that have partially filled d orbitals in their elemental or common oxidation states. They exhibit characteristic properties that differentiate them from other elements, including variable oxidation states, paramagnetic behavior due to unpaired electrons, and significant catalytic activity. However, elements such as scandium (Sc) and zinc (Zn) are typically not regarded as transition elements.

Scandium has an empty d orbital in its stable ion, while zinc possesses a completely filled d orbital, leading to a lack of variable oxidation states typical of transition metals. The distinct colors associated with many transition metal compounds arise from the presence of partially filled d orbitals. When light hits these compounds, d-d transitions occur, where electrons jump between different energy levels within the d orbitals. This absorption of light corresponds to specific wavelengths, with the complementary colors being observed. Additionally, the formation of complexes with different ligands can also alter the energies of these d orbitals, further contributing to the variety of colors seen in transition metal compounds.

Key Points: Definition of transition elements; characteristics like variable oxidation states and paramagnetic behavior; distinction of Sc and Zn as non-transition elements; explanation of color formation due to d-d transitions and complex formation.

Question 13.

An organic compound 'X' with the molecular formula C_5H_{10} O forms 2,4-DNP derivative, does not reduce Tollens' reagent but gives positive iodoform test on heating with I2, in the presence of NaOH. Compound 'X' gives ethanoic acid and propanoic acid on vigorous oxidation. Write the:

(i) Structure of the compound X.(1)

(ii) Structure of the product obtained when compound 'X' reacts with 2,4-DNP reagent.(1)

(iii) Structures of the products obtained when compound X is heated with I_2, in the presence of NaOH. (1)

[3 Marks]

Answer: (a) The compound X with molecular formula $C_5H_{10}O$ forms a 2,4-DNP derivative indicating it is a ketone or aldehyde. It does not reduce Tollens' reagent, so it is not an aldehyde. It gives a positive iodoform test, which confirms the presence of a methyl ketone group. On vigorous oxidation, it gives ethanoic acid and propanoic acid. The structure of compound X is CH_3-CO-CH_2-CH_2-CH_3 (pentan-2-one).
(b) When compound X reacts with 2,4-DNP reagent, it forms a 2,4-Dinitrophenylhydrazone derivative. The structure includes the carbonyl group of X replaced by the hydrazone group (-NH-N=), bonded to the 2,4-DNP molecule. This confirms the presence of the carbonyl group in X.
(c) On heating compound X with I_2 and NaOH, the methyl ketone group undergoes iodoform reaction producing iodoform (CHI_3), a yellow precipitate, and the corresponding carboxylate ion. In this case, the products are iodoform and sodium propanoate (from the CH_3CO- part) and sodium acetate (from further oxidation of side chain). Thus, the important products are iodoform (CHI_3) and carboxylate salts like sodium acetate and sodium propanoate.

Key Points: Compound X is pentan-2-one - 2,4-DNP reaction forms hydrazone derivative - Iodoform test produces CHI_3 and carboxylate salts on heating with $I_2/NaOH$

Question 14.

Write any three differences between physisorption and chemisorption..

[3 Marks]

Answer: Physisorption and chemisorption are two distinct processes of adsorption with notable differences. Firstly, physisorption involves weak van der Waals forces, resulting in a low binding energy (typically less than 40 kJ/mol), whereas chemisorption involves strong chemical bonds, leading to higher binding energy (often exceeding 80 kJ/mol). Secondly, physisorption is generally a reversible process, meaning adsorbates can be easily desorbed, while chemisorption tends to be irreversible due to the formation of stable chemical bonds. Lastly, physisorption occurs rapidly and often at lower temperatures, while chemisorption usually requires higher temperatures to overcome activation energy, thus being a slower process. Understanding these differences is crucial in fields like chromatography and catalyst design where adsorption plays a significant role.

Key Points: 1. Binding energy: Physisorption has weak van der Waals forces (<40 kJ/mol) while chemisorption has strong chemical bonds (>80 kJ/mol). 2. Reversibility: Physisorption is reversible; chemisorption is often irreversible. 3. Rate and temperature: Physisorption occurs rapidly at low temperatures; chemisorption is slower and generally requires higher temperatures.

Question 15.

Define the following terms with a suitable example in each:

(i) Lyophilic sol. (1)

(ii) Macromolecular colloid. (1)

(iii) Coagulation. (1)

[3 Marks]

Answer: (a) **Lyophilic sol** is a type of colloidal solution in which the dispersed phase has an affinity for the dispersion medium, leading to a stable and easily reversible solution. For example, starch in water forms a lyophilic sol.
(b) **Macromolecular colloid** consists of large molecules (macromolecules) dispersed in a medium, which do not dissociate into smaller particles. An example is a solution of proteins like gelatin in water.
(c) **Coagulation** is the process of removing the stability of a colloidal solution causing the dispersed particles to aggregate and settle down. It can be caused by adding an electrolyte or by changing temperature or pH. For example, adding NaCl to an alum sol causes coagulation.

Key Points: Lyophilic sol is stable with affinity between dispersed phase and medium - Macromolecular colloids contain large molecules like proteins - Coagulation causes aggregation and settling of colloidal particles

Question 16.

(a)The standard Gibbs energy (△ArG°) for the following cell reaction is -300 kJ mol $^{-1}$:

Zn(s) + 2Ag +(aq) → Zn2+ (aq) + 2Ag(s)

Calculate E° for the reaction. (Given: 1F 96500 mol^{-1}) (2)

(b) Calculate $\lambda_m^o$for MgCl2 if λ^o values for Mg2+ ion and Cl $^-$ion are 106 S cm^{2}mol^{-1} and 76.3 S cm^{2}mol^{-1} respectively.(1)

[3 Marks]

Answer: (a)Given, \u2206ArG\u00b0 = -300 kJ mol\u207b\u2071 = -300000 J mol\u207b\u2071, F = 96500 C mol\u207b\u2071, n = 2 (since 2 electrons are transferred in the reaction). We know the relation between Gibbs energy and EMF of the cell is:
\u2206ArG\u00b0 = - n F E\u00b0
Rearranging for E\u00b0:
E\u00b0 = - \u2206ArG\u00b0 / (n F) = - (-300000) / (2 * 96500) = 300000 / 193000 = 1.55 V

(b) Given, \u03bb\u2090\u00b0 (Mg2+) = 106 S cm\u00b2mol\u207b\u2071, \u03bb\u2090\u00b0 (Cl\u207b) = 76.3 S cm\u00b2mol\u207b\u2071
For $MgCl_2$,
\u03bb\u2090\u00b0 = \u03bb\u2090\u00b0 (Mg2+) + 2 * \u03bb\u2090\u00b0 (Cl\u207b)
= 106 + 2 * 76.3 = 106 + 152.6 = 258.6 S cm\u00b2mol\u207b\u2071

Key Points: Use relation \u2206ArG\u00b0 = - n F E\u00b0 - Calculate E\u00b0 by rearranging the equation - Calculate molar conductivity by summing ionic conductivities of ions

Question 17.

Arrange the following compounds as directed :

(i) In decreasing order of basic strength in aqueous solution :

$C_2H_5NH_2$, $(C_2H_5)_2$ NH, $(C_2H_5)_3N$ (1)

(ii) In increasing order of solubility in water :

$(C_2H_5)NH$, C_2H_5 NH_2 , C_2H_6 NH_2 (1)

(iii) In decreasing order of Their pKb values:

$C_6H_5NH_2$, $C_2H_5NH_2$,NH_3 (1)

[3 Marks]

Answer: (i) Decreasing order of basic strength in aqueous solution is:

$(C_2H_5)_2NH > (C_2H_5)_3N > C_2H_5NH_2$

Explanation: Diethylamine ($(C_2H_5)_2NH$) has more electron-donating ethyl groups than triethylamine ($(C_2H_5)_3N$), but in triethylamine steric hindrance reduces availability of lone pair on nitrogen for protonation. Ethylamine ($C_2H_5NH_2$) has less alkyl substitution, so it is less basic than the other two.

(ii) Increasing order of solubility in water:

$C_2H_6NH_2 < (C_2H_5)NH < C_2H_5NH_2$

Explanation: The more alkyl groups in amines, the less soluble they are in water due to nonpolar hydrocarbon chains. Hence, primary amine $C_2H_5NH_2$ is more soluble than secondary $(C_2H_5)NH$. The notation $C_2H_6NH_2$ appears unusual but is interpreted as ethylamine ($C_2H_5NH_2$), so based on common understanding, primary amines have higher solubility.

(iii) Decreasing order of their pKb values:

$C_6H_5NH_2 > NH_3 > C_2H_5NH_2$

Explanation: pKb is inversely related to basic strength. Aniline ($C_6H_5NH_2$) has the highest pKb because the lone pair on nitrogen is delocalized into the benzene ring, reducing basicity. Ammonia (NH_3) is next, and ethylamine ($C_2H_5NH_2$) has the lowest pKb (highest basicity) due to the electron-releasing alkyl group increasing electron density on nitrogen.

Key Points: Basic strength order depends on alkyl substitution and steric hindrance - Solubility decreases with increasing alkyl groups due to hydrophobic character - pKb values inversely relate to basic strength and are affected by resonance and alkyl groups