CBSE EXAMINATION PAPER-2025

CHEMISTRY

(Solved)

Time allowed : 3 hours | Maximum Marks : 82

General Instructions :

Read the following instructions carefully and follow them :

i. This question paper contains **39 questions.** All questions are **compulsory.**

ii. This question paper is divided into **5 sections.**

iii. **Section A** – questions number **1 to 3** are case based questions

iv. **Section B** – questions number **4 to 19** are multiple choice questions

v. **Section C** – questions number **20 to 25** are very short answer

vi. **Section D** – questions number **26 to 33** are short answer

vii. **Section E** – questions number **34 to 39** are long answer

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

ix. Use of calculator is NOT allowed.

Section A

Question 1. Carbohydrates are polyhydroxy aldehydes or ketones that represent enormous structural diversity in terms of the arrangement of atoms in space, resulting in hundreds of stereoisomers. Although the chemical properties of most stereoisomers may not be very different, their metabolic rate and utilization in biological systems is significantly different and known to influence the overall carbohydrate metabolism. Structural variants, which arise due to a different arrangement of atoms in three-dimensional space are known as stereoisomers. The number of stereoisomers can be theoretically estimated by using the formula 2n, where ‘n’ is the number of stereocenters or

asymmetric (chiral) carbon atoms in a molecule. Out of these stereoisomers, there are some structures, which are mirror images of each other, and they are referred to as enantiomers.

Question 2.

Carbohydrates are polyhydroxy aldehydes or ketones that represent enormous structural diversity in terms of the arrangement of atoms in space, resulting in hundreds of stereoisomers. Although the chemical properties of most stereoisomers may not be very different, their metabolic rate and utilization in biological systems is significantly different and known to influence the overall carbohydrate metabolism. Structural variants, which arise due to a different arrangement of atoms in three-dimensional space are known as stereoisomers. The number of stereoisomers can be theoretically estimated by using the formula 2n, where 'n' is the number of stereocenters or asymmetric (chiral) carbon atoms in a molecule. Out of these stereoisomers, there are some structures, which are mirror images of each other, and they are referred to as enantiomers.

Answer the following questions :

(1)

Give chemical reactions to show the presence of an aldehydic groupand straight chain in glucose.

[2 Marks]

Answer: Glucose contains an aldehydic group, which can be demonstrated by its reaction with Tollens' reagent ($AgNO_3 + NH_3$) resulting in the formation of a silver mirror. The straight-chain form of glucose can be represented by its structural formula: $C_6H_{12}O_6$, where the -CHO group indicates the aldehyde functional group. The presence of the straight chain is confirmed in its open chain form, which has the structure $HOCH_2-(CHOH)_4-CHO$.

Key Points: Presence of aldehyde group shown by reaction with Tollens' reagent - Structural formula of glucose confirms straight chain - Reaction indicating glucose's aldehydic nature

(2)

Draw the structure of β-D-Glucopyranose.

[1 Marks]

Answer: The structure of β-D-Glucopyranose is represented as a six-membered ring where the oxygen atom is part of the ring. The carbon atoms are numbered from 1 to 6, with the hydroxyl (OH) group attached to the first carbon (C1) in equatorial position, indicating the beta form. The structure can be depicted in a Haworth projection, as shown below:\n\n O\n / \\\n HO C1\n | |\nC2 - C3 -C4\n | |\n C5 --- C6 \n | |\n CH2OH\n\nThis structure illustrates the glucopyranose form of glucose.

Key Points: Cyclic structure; six-membered ring; beta anomer; Haworth representation; hydroxyl group position

(3)

Define anomers.

[1 Marks]

Answer: Anomers are a specific type of stereoisomer found in carbohydrates that differ in configuration around the anomeric carbon atom, which is the carbon atom that is derived from the carbonyl carbon during the formation of a cyclic structure. They can exist as alpha (α) or beta (β) forms, depending on the orientation of the hydroxyl group attached to the anomeric carbon.

Key Points: Type of stereoisomerism- differ around anomeric carbon- exist as alpha or beta forms

(4)

Sucrose is known as invert sugar. Explain.

[1 Marks]

Answer: Sucrose is known as invert sugar because it can be hydrolyzed into its constituent monosaccharides, glucose and fructose, which optically rotate light in opposite directions. This inversion of optical activity occurs due to the formation of these two different enantiomers from the non-reducing sugar sucrose during hydrolysis.

Key Points: Sucrose as invert sugar-hydrolyzed into glucose and fructose-opposite optical rotation

Question 3.

Werner's coordination theory in 1893 was the first attempt to explain the bonding in coordination complexes. It must be remembered that this theory was put forward before the electron had been discovered by J.J. Thomson in 1897, and before the electronic theory of valency. Werner did not have any of the modern instrumental techniques and all his studies were made using simple experimental techniques. Werner was able to explain the nature of bonding in complexes and he concluded that in complexes, the metal shows two different sorts of valency : primary and secondary. Primary valences are normally ionisable whereas secondary valences are non ionisable.

Answer the following questions :

(1)

One mole of $CrCl_3 \cdot 4H_2O$ precipitates one mole of AgCl whentreated with excess of $AgNO_3$ solution. Write (i) the structuralformula of the complex, and (ii) the secondary valency of Cr.

[2 Marks]

Answer: (i) The structural formula of the complex is $[Cr(H_2O)_4Cl_2]Cl$. (ii) The secondary valency of Cr in this complex is 6, as it is satisfied by four water molecules and two chloride ions.

Key Points: The structural formula is $[Cr(H_2O)_4Cl_2]Cl$-primary valence is 3-non ionisable secondary valence is 6

(2)

What is the difference between a complex and a double salt ?

[1 Marks]

Answer: A complex consists of a central metal atom bonded to surrounding ligands, which can be ions or molecules, forming coordination compounds. In contrast, a double salt is a compound formed by the combination of two different salts that crystallize together, but do not have a coordination complex structure.

Key Points: Complex involves a central metal atom and ligands-Double salt is formed by two salts crystallizing together-Complexes have coordination bonds while double salts do not

(3)

Arrange the following complexes in the increasing order of conductivity of their solution :

$[Cr(NH_3)_3Cl_3]$, $[Cr(NH_3)_6]Cl_3$, $[Cr(NH_3)_5Cl]Cl_2$

[1 Marks]

Answer: $[Cr(NH_3)_6]Cl_3 < [Cr(NH_3)_5Cl]Cl_2 < [Cr(NH_3)_3Cl_3]$. This order is based on the ionization of the complexes in solution, where $[Cr(NH_3)_6]Cl_3$ has the least number of ions since it only dissociates into Cr(III) and 3 Cl^-, making it the weakest conductor. $[Cr(NH_3)_5Cl]Cl_2$ dissociates into Cr(III), 2 Cl^- ions, and an additional Cl^- in solution, which increases its conductivity. Finally, $[Cr(NH_3)_3Cl_3$ dissociates into Cr(III) and 3 Cl^- ions, providing the highest conductivity among them.

Key Points: Conductivity depends on the number of ions produced in solution-Primary valence associated with Cl^- ions-Degree of ionization of complexes

(4)

Write two differences between primary and secondary valences in coordination compounds.

[1 Marks]

Answer: Primary valences in coordination compounds are ionisable and are satisfied by negative ions, while secondary valences are non-ionisable and are typically satisfied by neutral molecules or negative ions.

Key Points: Primary valences are ionisable; Primary valences are satisfied by negative ions; Secondary valences are non-ionisable; Secondary valences are satisfied by neutral molecules or negative ions

Section B

Question 4.

The role of a catalyst is to change:

[1 Marks]

(A) Gibbs energy of reaction

(B) enthalpy of reaction

(C) activation energy of reaction

(D) equilibrium constant

Explanation: The correct option is 'activation energy of reaction'. A catalyst lowers the activation energy required for a reaction to occur, allowing the reaction to proceed faster without altering the Gibbs energy or the equilibrium constant. It provides a new reaction pathway with lower energy, enhancing the rate of reaction.

Question 5.

Which of the following molecules is chiral in nature?

[1 Marks]

(A) 1-chlorobutane

(B) 2-chlorobutane

(C) 1-chloropropane

(D) 2-chloropropane

Explanation: The correct answer is 2-chlorobutane. Chiral molecules have non-superimposable mirror images, and this occurs when a carbon atom is bonded to four different groups. In 2-chlorobutane, the second carbon is bonded to a chlorine atom, a methyl group, an ethyl group, and a hydrogen atom, thus making it chiral. The other options do not meet this criterion.

Question 6.

CH_3CH_2OH can be converted to CH_3CHO by:

[1 Marks]

(A) treatment with PCC

(B) treatment with $KMnO_4$

(C) treatment with $LiAlH_4$

(D) catalytic hydrogenation

Explanation: The correct option is 'treatment with PCC.' CH_3CH_2OH (ethanol) is a primary alcohol that can be oxidized to an aldehyde (CH_3CHO, acetaldehyde) using PCC (Pyridinium Chlorochromate), a mild oxidizing agent. Other options like $LiAlH_4$ and catalytic hydrogenation do not lead to this transformation, and $KMnO_4$ typically leads to further oxidation.

Question 7.

The IUPAC name for CH_3-CH_2-N(CH_3)-CH_2-CH_2-CH_3 is:

[1 Marks]

(A) N,N-dimethylpropan-1-amine

(B) N-ethyl-N-methylpropan-1-amine

(C) N,N-diethylpropan-1-amine

(D) N-methylpentan-2-amine

Explanation:

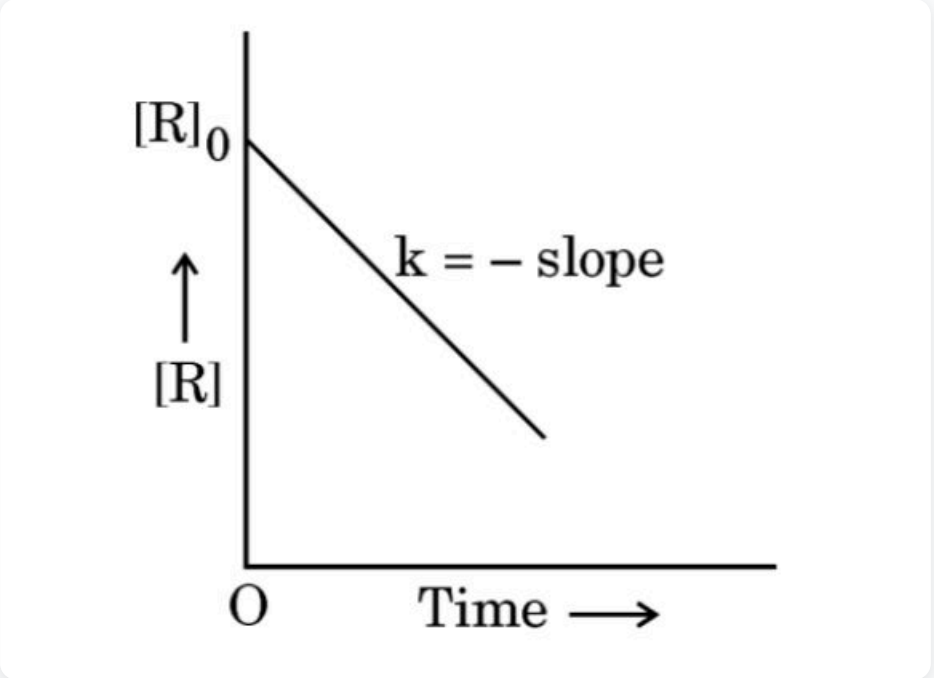
The correct answer is N-ethyl-N-methylpropan-1-amine. The structure consists of a propanamine base (3 carbon atoms) with an ethyl group (C2H5) and a methyl group (CH3) attached to the nitrogen

atom (N). This naming follows the IUPAC conventions where substituents and the longest carbon chain are identified, hence leading to the correct name.

Question 8.

A plot between concentration of reactant [R] and time 't' is shown below. Which of the given order of reaction is indicated by the graph?

[1 Marks]



(A) Zero order

(B) Third order

(C) First order

(D) Second order

Explanation:

The graph for a zero order reaction shows a linear relationship between the concentration of the reactant [R] and time. This is because, in a zero order reaction, the rate of reaction is constant and does not depend on the concentration of the reactants. Therefore, the concentration decreases linearly with time.

Question 9.

The treatment of ethyl bromide with alcoholic silver nitrite gives:

[1 Marks]

(A) ethyl nitrite

(B) nitromethane

(C) ethene

(D) nitroethane

Explanation:

On heating with an ethanolic solution of silver nitrate, alkyl halides yield nitroalkanes. Some of the alkyl nitrites are also formed because nitrite is an ambidentate ligand. It has a lone pair of electrons on nitrogen as well as oxygen. Thus it can be bonded to an alkyl halide through oxygen to from alkyl nitrite and via Nitrogen to form nitroalkane. Hence, the treatment of ethyl bromide with alcoholic silver nitrite gives Nitroethane.

Question 10.

Which of the following aqueous solutions will have the highest freezing point?

[1 Marks]

(A) 1·0 M Na_2SO_4

(B) 1·0 M KCl

(C) 1·0 M Glucose

(D) 1·0 M $AlCl_3$

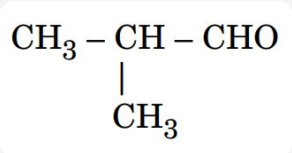
Explanation: 1.0 M Glucose will have the highest freezing point among the options because it is a non-electrolyte and does not dissociate into ions in solution, resulting in a van 't Hoff factor (i) of 1. In contrast, $AlCl_3$, Na_2SO_4, and KCl are strong electrolytes that dissociate into multiple ions, increasing the number of particles in solution and thus causing greater freezing point depression. Therefore, since glucose has the least effect on lowering the freezing point, it has the highest freezing point.

Question 11.

Which of the following aldehydes will undergo Cannizzaro reaction?

[1 Marks]

(A)



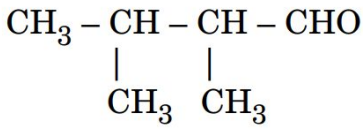
(B)

$(CH_3)_3C\ CHO$

(C)

$CH_3 - CH_2 - CHO$

(D)



Explanation:

$(CH_3)_3C–CHO$
→ This is **pivaldehyde (trimethylacetaldehyde)**.
→ The carbon adjacent to –CHO is a **tertiary carbon** with **no α-hydrogens**.
✅ **Will undergo Cannizzaro reaction.**

Question 12.

In which of the following groups are both ions coloured in aqueous solution?

I. Cu^+ II. Ti^{4+} III. Co^{2+} IV. Fe^{2+}

[Atomic number : Cu = 29, Ti = 22, Co = 27, Fe = 26]

[1 Marks]

(A) I and IV

(B) II and III

(C) I and II

(D) III and IV

Explanation:

The correct option is 'III and IV' because Co^{2+} (Cobalt ion) and Fe^{2+} (Iron ion) are known to be coloured in aqueous solution. Co^{2+} typically appears blue while Fe^{2+} can appear green or yellow depending on its concentration. Cu^+ is generally colourless and Ti^{4+} is often colourless as well, which eliminates I and II as options.

Question 13.

CH_3CH_2CHO and CH_3CH_2COOH can be distinguished by:

[1 Marks]

(A) Iodoform test

(B) Sodium bicarbonate test

(C) Hinsberg test

(D) Lucas test

Explanation:

- **Sodium bicarbonate test:** Carboxylic acids (like CH3CH2COOH) react with sodium bicarbonate (NaHCO3) to produce carbon dioxide gas, which causes effervescence. Aldehydes (like CH3CH2CHO) do not react with sodium bicarbonate.

Question 14.

Match the type of cell given in Column I with their use given in Column II.

[1 Marks]

	Column I		*Column II*
i.	Lead storage cell	a.	Wall clock
ii.	Mercury cell	b.	Apollo Space Programme
iii.	Dry cell	c.	Wrist watch
iv.	Fuel cell	d.	Inverter

(A) i-a, ii-b, iii-c, iv-d

(B) i-d, ii-c, iii-a, iv-b

(C) i-b, ii-a, iii-d, iv-c

(D) i-c, ii-d, iii-b, iv-a

Explanation:

The correct option is i-d, ii-c, iii-a, iv-b. Each type of cell is used based on its characteristics and application needs. Lead storage cells are rechargeable and provide high current, so they are used in inverters. Mercury cells provide a stable voltage for long durations, making them ideal for wrist watches. Dry cells are portable and commonly used in household items like wall clocks. Lastly, fuel

cells generate electricity efficiently using hydrogen and oxygen, which made them suitable for advanced missions like the Apollo Space Programme.

Question 15.

While doing qualitative analysis in chemistry lab, Abhishek added yellow coloured potassium chromate solution into a test tube. He was surprised to see the colour of the solution changing immediately to orange. He realised that the test tube was not clean and contained a few drops of some liquid. Which of the following substances will be the most likely liquid to be present in the test tube before adding potassium chromate solution?

[1 Marks]

(A) Sodium hydroxide solution

(B) Methyl orange solution

(C) HCl solution

(D) Sodium hydrogen carbonate solution

Explanation:

The correct answer is HCl solution. The color change from yellow to orange occurs due to the conversion of chromate ions (CrO4^2-) to dichromate ions (Cr2O7^2-) in acidic conditions. Since hydrochloric acid (HCl) is an acid, its presence in the test tube would facilitate this transformation when potassium chromate is added.

Question 16.

Assertion (A) : For measuring resistance of an ionic solution an AC source is used.

Reason (R) : Concentration of ionic solution will change if DC source is used.

[1 Marks]

(A) Assertion (A) is true, but Reason (R) is false.

(B) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of the Assertion (A).

(C) Both Assertion (A) and Reason (R) are true, but Reason (R) is not the correct explanation of the Assertion (A).

(D) Assertion (A) is false, but Reason (R) is true

Explanation:

Both Assertion (A) and Reason (R) are true, but Reason (R) is not the correct explanation of the Assertion (A). Assertion (A) is correct because an AC source is used to prevent changes in the ionic solution, while Reason (R) is a separate fact that explains a consequence of using DC but does not directly clarify why AC is preferred.

Question 17.

Assertion (A) : Henry's law constant (KH) decreases with increase in temperature.

Reason (R) : As the temperature increases, solubility of gases in liquids decreases.

[1 Marks]

(A) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of the Assertion (A).

(B) Assertion (A) is true, but Reason (R) is false.

(C) Both Assertion (A) and Reason (R) are true, but Reason (R) is not the correct explanation of the Assertion (A).

(D) Assertion (A) is false, but Reason (R) is true

Explanation:

Both Assertion (A) and Reason (R) are true, but Reason (R) is not the correct explanation of Assertion (A). The context reveals that higher KH indicates lower solubility, which means that as temperature increases, KH actually increases, leading to lower solubility of gases. Therefore, even though both statements are true, the reasoning does not correctly explain the assertion.

Question 18.

Assertion (A) : The solubility of aldehydes and ketones in water decreases with increase in size of the alkyl group.

Reason (R) : Aldehydes and ketones have dipole-dipole interaction.

[1 Marks]

(A) Assertion (A) is false, but Reason (R) is true

(B) Assertion (A) is true, but Reason (R) is false.

(C) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of the Assertion (A).

(D) Both Assertion (A) and Reason (R) are true, but Reason (R) is not the correct explanation of the Assertion (A).

Explanation:

Both Assertion (A) and Reason (R) are true, but Reason (R) is not the correct explanation of the Assertion (A). The assertion is true as the solubility of aldehydes and ketones decreases with increasing size of the alkyl group due to their hydrophobic nature. However, the reason provided does not directly explain this as it refers to dipole-dipole interactions, which do not account for the significant effect of the hydrophobic alkyl chains on solubility.

Question 19.

Assertion (A) : The boiling points of alkyl halides decrease in the order RI > RBr > RCl > RF.

Reason (R) : The van der Waals forces of attraction decrease in the order RI > RBr > RCl > RF

[1 Marks]

(A) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of the Assertion (A).

(B) Assertion (A) is true, but Reason (R) is false.

(C) Both Assertion (A) and Reason (R) are true, but Reason (R) is not the correct explanation of the Assertion (A).

(D) Assertion (A) is false, but Reason (R) is true

Explanation:

Both Assertion (A) and Reason (R) are true, and Reason (R) is the correct explanation of the Assertion (A).
The assertion is true as the boiling points of alkyl halides decrease in the order RI > RBr > RCl > RF due to the increasing strength of van der Waals forces with increasing atomic size and mass of the halogen atom. The reason is also true because van der Waals forces are stronger in heavier halogens (like iodine) due to greater polarizability. Since stronger intermolecular forces require more energy to overcome, the boiling point increases. Therefore, the reason correctly explains the assertion.

Section C

Question 20.

Calculate the elevation of boiling point of a solution when 3 g of $CaCl_2$ (Molar mass = 111 g mol^{-1}) was dissolved in 260 g of water, assuming that $CaCl_2$ undergoes complete dissociation. (Kb for water = 0·52 K kg mol^{-1})

[2 Marks]

Answer: To find the elevation of the boiling point, we first determine the number of moles of $CaCl_2$: moles = mass / molar mass = 3 g / 111 g/mol = 0.027 moles. Since $CaCl_2$ dissociates into 3 ions (1 Ca^{2+} and 2 Cl^-), the effective particle concentration (i) is 3. The molality (m) = moles of solute / kg of solvent = 0.027 moles / 0.260 kg = 0.1046 mol/kg. Therefore, the boiling point elevation (ΔTb) = Kb × m × i = 0.52 K kg/mol × 0.1046 mol/kg × 3 = 0.163 K.

Key Points: Calculate moles of $CaCl_2$ from mass; use i = 3 for dissociation; determine molality with solvent mass; apply ΔTb = Kb × m × i.

Question 21.

Liquids 'X' and 'Y' form an ideal solution. The vapour pressure of pure 'X' and pure 'Y' are 120 mm Hg and 160 mm Hg respectively. Calculate the vapour pressure of the solution containing equal moles of 'X' and 'Y'.

[2 Marks]

Answer: Since liquids X and Y form an ideal solution, we use Raoult's law.
Given:
Vapour pressure of pure X, P_X = 120 mm Hg
Vapour pressure of pure Y, P_Y = 160 mm Hg
Number of moles are equal, so mole fraction of X, x_X = 0.5 and mole fraction of Y, x_Y = 0.5
According to Raoult's law, vapor pressure of solution, P = x_X * P_X + x_Y * P_Y = 0.5 * 120 + 0.5 * 160 = 60 + 80 = 140 mm Hg.
Therefore, vapour pressure of the solution is 140 mm Hg.

Key Points: Raoult's law applied - Equal mole fractions means x_X and x_Y = 0.5 - Total vapour pressure is sum of partial pressures

Question 22.

Based on the data given above, give plausible reason for the variation of conductivity and molar conductivity with concentration.

[2 Marks]

Concentration of KCl solution in mol / L	*Conductivity at 298·15 K in S cm^{-1}*	*Molar Conductivity at 298·15 K in S cm^2 mol^{-1}*
1·000	0·1113	111·3
0·100	0·0129	129·0
0·010	0·00141	141·0

Answer: Conductivity and molar conductivity vary with electrolyte concentration due to changes in ion movement and dissociation. As concentration decreases, the number of ions decreases, leading to lower conductivity. For strong electrolytes, molar conductivity increases slowly, while it rises steeply for weak electrolytes at very low concentrations. This is because weak electrolytes dissociate more effectively in dilute solutions, resulting in higher molar conductivity. The limiting molar conductivity is achieved when concentration approaches zero.

Key Points: Conductivity decreases with decreasing concentration; differences in strong and weak electrolytes; limiting molar conductivity at zero concentration; ion movement affects conductivity; higher dissociation in weaker electrolytes results in increased molar conductivity at low concentrations.

Question 23.

(a) Write the rate law expression for the reaction $2HI \rightarrow H_2 + I_2$, if the order of the reaction is zero.

(b) What is the effect of temperature on the rate of reaction ? Write a mathematical expression for the same.

[2 Marks]

Answer: (a) For the reaction $2HI \rightarrow H_2 + I_2$ with zero order, the rate law is given by rate = k, where k is the rate constant and the rate is independent of the concentration of HI.
(b) The increase in temperature increases the rate of reaction because particles gain more kinetic energy and collide more frequently with greater energy. The temperature dependence of the rate constant k is given by the Arrhenius equation: k = A * e^(-E_a/(RT)), where A is the frequency factor, E_a is the activation energy, R is the gas constant, and T is the absolute temperature in kelvin.

Key Points: Zero order rate law: rate = k - Rate independent of concentration - Effect of temperature increases rate - Arrhenius equation: k = A * e^(-E_a / RT)

Question 24.

Explain the mechanism of acid catalysed hydration of ethene.

[2 Marks]

Answer: The mechanism involves three steps. First, ethene is protonated by an acid, forming a carbocation. This step is slow and forms a positively charged intermediate. Next, water acts as a nucleophile, attacking the carbocation to form an alcohol. Finally, a proton is eliminated, regenerating the acid catalyst and producing ethanol. To favor product formation, ethene is continuously removed from the reaction. This process follows Markovnikov's rule when unsymmetrical alkenes are involved.

Key Points: Protonation of ethene; Formation of carbocation; Nucleophilic attack by water; Elimination of proton; Regeneration of acid; Continuous removal of ethene

Question 25.

(a) How can acetaldehyde be prepared from acetyl chloride ?

(b) Propanal is more reactive than propanone towards nucleophilic addition reaction. Give reason.

[2 Marks]

Answer: (a) Acetaldehyde can be prepared from acetyl chloride by reacting acetyl chloride with cold dilute zinc amalgam or by reducing acetyl chloride using hydrogen in the presence of palladium catalyst. The reaction is: $CH_3COCl + 2[H] \rightarrow CH_3CHO + HCl$.
(b) Propanal is more reactive than propanone because aldehydes have less steric hindrance and their carbonyl carbon is more electrophilic than ketones. In propanone, two alkyl groups attached to the carbonyl carbon donate electrons by their +I effect, reducing its electrophilicity, whereas in propanal only one alkyl group is attached, making it more susceptible to nucleophilic attack.

Key Points: Acetaldehyde prepared by reduction of acetyl chloride - Aldehydes have less steric hindrance than ketones - Carbonyl carbon in aldehydes is more electrophilic than in ketones

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Section D

Question 26.

Shweta mixed two liquids A and B of 10 mL each. After mixing, the volume of the solution was found to be 20·2 mL.

(i) Why was there a volume change after mixing the liquids ?

(ii) Will there be an increase or decrease of temperature after mixing ?

(iii) Give one example for this type of solution.

[3 Marks]

Answer: The volume change when mixing liquids A and B occurs due to molecular interactions between the liquid components. When these two liquids combine, some molecules occupy the volume between others, leading to a total volume lower than the expected combined volume of 20 mL. Typically, the temperature will decrease upon mixing due to endothermic interactions where energy is absorbed during the mixing process. An example of such a solution is the mixing of ethanol and water, where significant volume contraction is observed.

Key Points: Molecular interactions cause volume change; temperature decreases due to endothermic mixing; example is ethanol and water mixture.

Question 27.

(i) How does sprinkling of salt help in clearing the snow covered roads in hilly areas ?

(ii) What happens when red blood cells are kept in 0·5% (mass/vol) NaCl solution ? Justify your answer.

(iii) Write an application of reverse osmosis.

[3 Marks]

Answer: Sprinkling salt on snow-covered roads helps melt the snow because salt lowers the freezing point of water, a process known as freezing point depression. When salt is added to the snow, it dissolves and creates a brine solution that remains liquid at lower temperatures, thus effectively melting the ice and preventing further accumulation. This is crucial in hilly areas where snow can cause dangerous driving conditions. Moreover, red blood cells in a 0.5% NaCl solution will swell and may burst due to the hypotonic nature of the solution, prompting water to enter the cells. An application of reverse osmosis is in water purification, where it removes impurities from water by applying pressure to overcome osmotic pressure, allowing clean water to be obtained.

Key Points: Salt lowers freezing point of water, preventing snow accumulation; Red blood cells swell in hypotonic solution, causing osmosis; Reverse osmosis purifies water effectively.

Question 28.

For the reaction A + B → Products, the following initial rates were obtained at various initial concentrations of reactants: Determine the order of the reaction with respect to A and B and overall order of the reaction.

[3 Marks]

Sl. No.	$[A]/mol\ L^{-1}$	$[B]/mol\ L^{-1}$	$Initial\ rate/mol\ L^{-1}\ s^{-1}$
1	0·1	0·1	0·05
2	0·2	0·1	0·10
3	0·1	0·2	0·05

Answer: To determine the order of the reaction with respect to A and B, we can analyze the initial rate data provided. The rate equation is given by Rate = k[A]^x[B]^y, where x denotes the order with respect to A and y with respect to B. By varying the concentrations of A and B and observing changes

in the rate, we can deduce the value of x and y. For instance, if doubling [A] while keeping [B] constant doubles the rate, then x = 1. Similarly, if doubling [B] while keeping [A] constant quadruples the rate, then y = 2. Thus, the overall order of the reaction is x + y. If x is 1 and y is 2, the overall order is 3.

Key Points: Initial rate data analysis - Rate equation: Rate = k[A]^x[B]^y - Determine x and y from concentration changes - Overall order = x + y

Question 29.

(a) What is meant by crystal field splitting energy ? For a d^4 ion, write the configuration if

(i) $\Delta o < P$,and (ii) $\Delta o > P$.

(b) Explain why in tetrahedral coordination entities, low spin configurations are rarely observed.

[3 Marks]

Answer: (a) Crystal field splitting energy, denoted by Δo, is the energy difference between the higher energy eg and lower energy t2g d orbitals when a transition metal ion is placed in an octahedral crystal field created by surrounding ligands.

For a d^4 ion:

(i) When $\Delta o < P$ (weak field ligands), the electron pairing energy is higher, so electrons occupy higher energy orbitals to remain unpaired resulting in a high spin configuration: $t2g^3\ eg^1$.

(ii) When $\Delta o > P$ (strong field ligands), crystal field splitting is large and electrons pair up in lower energy orbitals giving a low spin configuration: $t2g^4\ eg^0$.

(b) In tetrahedral coordination, the crystal field splitting energy (Δt) is smaller than that in octahedral field and the d orbitals split differently. Since Δt is usually less than the pairing energy, electrons prefer to remain unpaired leading to high spin configurations. Thus, low spin states are rarely observed in tetrahedral complexes because the energy gained by pairing does not compensate for the smaller splitting energy.

Key Points: Definition of crystal field splitting energy - Configurations of d4 ion for weak and strong fields - Low spin configurations rare in tetrahedral due to small splitting energy

Question 30.

Account the following:

(a) The C – Cl bond length in chlorobenzene is shorter than that in methyl chloride.

(b) Grignard reagents should be prepared under anhydrous conditions

(c) In case of optically active alkyl halides, SN_1 reactions are accompanied by racemisation.

[3 Marks]

Answer: (a) In chlorobenzene, the C – Cl bond length is shorter than in methyl chloride because the lone pair of electrons on chlorine overlaps with the delocalized pi-electrons of the benzene ring. This partial double bond character shortens the C – Cl bond. In methyl chloride, such resonance does not occur, so the bond is longer.
(b) Grignard reagents are highly reactive and react readily with water to form hydrocarbons and destroy the reagent. Therefore, they must be prepared under anhydrous (water-free) conditions to prevent their decomposition and to ensure successful reaction.
(c) SN_1 reactions involve the formation of a planar carbocation intermediate which is achiral. When an optically active alkyl halide undergoes SN_1 reaction, the nucleophile can attack from either side of the planar carbocation, resulting in a mixture of enantiomers. This leads to racemisation, i.e., loss of optical activity.

Key Points: C–Cl bond in chlorobenzene is shorter due to resonance partial double bond character - Grignard reagents react with water; thus must be prepared in anhydrous conditions - SN1 reaction involves planar carbocation intermediate leading to racemisation in optically active alkyl halides

Question 31.

(a) Arrange the following compounds in the increasing order of their acidic strength :

3,5-dinitrophenol, 4-methylphenol, phenol, 2,4,6-trinitrophenol

(b) What happens when : (write equations)

(i) Phenol is distilled with Zn dust ?

(ii) Anisole is treated with HBr ?

[3 Marks]

Answer: (a) The increasing order of acidic strength of the given compounds is: 4-methylphenol < phenol < 3,5-dinitrophenol < 2,4,6-trinitrophenol. This is because electron withdrawing nitro groups increase acidity by stabilizing the phenoxide ion through resonance, while the electron donating methyl group decreases acidity.

(b) (i) When phenol is distilled with Zn dust, it gets reduced to benzene and zinc oxide is formed. The reaction is:
$C_6H_5OH + Zn \rightarrow C_6H_6 + ZnO$

(ii) When anisole (methoxybenzene) is treated with HBr, it undergoes cleavage to give bromobenzene and methanol:
$C_6H_5OCH_3 + HBr \rightarrow C_6H_5Br + CH_3OH$

Key Points: Acidic strength increases with electron withdrawing groups - Electron donating groups decrease acidity - Phenol reduces to benzene with Zn dust - Anisole reacts with HBr to form bromobenzene and methanol

Question 32.

An organic compound 'A' (molecular formula C_8H_8O) gives 2,4-DNP test. It does not give Tollen's test, but gives a yellow precipitate 'B' with NaOH and I_2. On drastic oxidation, it gives a carboxylic acid 'C' with formula $C_7H_6O_2$. Identify 'A', 'B', 'C' and write the reactions involved.

[3 Marks]

Answer: The organic compound 'A' is likely to be phenylacetone (C_8H_8O). It gives a positive 2,4-DNP test indicating the presence of a carbonyl group, and it does not give a Tollen's test, suggesting it is a ketone. The yellow precipitate 'B' formed with NaOH and I_2 is iodoform, confirming the presence of a methyl ketone. Upon oxidation, it forms 'C', which is benzoic acid ($C_7H_6O_2$). The reactions are as follows: \n1. For 2,4-DNP test:\n A + 2,4-DNP → A-2,4-DNP (yellow precipitate)\n2. For iodoform reaction:\n A + I_2 + NaOH → B (yellow precipitate)\n3. For oxidation:\n A + [O] → C (benzoic acid)

Key Points: A is phenylacetone-2,4-DNP test positive-ketone does not give Tollen's test-iodoform reaction with NaOH and I_2-yellow precipitate-B is iodoform-drasitc oxidation gives benzoic acid-C is $C_7H_6O_2$

Question 33.

(a) Name the type of linkage responsible for the formation of proteins from a-amino acids.

(b) Write any two differences between DNA and RNA.

[3 Marks]

Answer: (a) The type of linkage responsible for the formation of proteins from a-amino acids is called the peptide bond. This bond is formed between the amino group of one amino acid and the carboxyl group of another amino acid through a condensation reaction.
(b) Differences between DNA and RNA:

1. Sugar component: DNA contains 2-deoxyribose sugar, whereas RNA contains ribose sugar.
2. Bases: DNA has thymine as one of the bases, but in RNA thymine is replaced by uracil.
3. Structure: DNA is double-stranded forming a double helix, while RNA is single-stranded.
4. Function: DNA stores genetic information, RNA is involved in protein synthesis.

Key Points: Peptide bond links amino acids to form proteins - DNA contains 2-deoxyribose and RNA contains ribose - DNA has thymine, RNA has uracil - DNA is double stranded, RNA is single stranded

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Section E

Question 34.

(i) For a galvanic cell, the following half reactions are given. Decide, which will remain as reduction reaction and which will be reversed to become an oxidation reaction. Give reason for your answer.

(I) $Cr^{3+} + 3e^- \rightarrow Cr(s)$; $E° = –0.74$ V

(II) $Fe^{2+} + 2e^- \rightarrow Fe(s)$; $E° = –0.44$ V

(ii) Represent the cell in which the following reaction takes place:

$Mg(s) + 2Ag^+ (0.001\ M) \rightarrow Mg^{2+} (0.100\ M) + 2Ag(s)$.

Calculate E_{cell} if $E°_{cell} = 3.17$ V. (log 10 = 1)

[5 Marks]

Answer: (i) To determine which half reaction will be reduction and which will be oxidation, we compare their standard electrode potentials (E°). The half reaction with higher (less negative) E° value will occur as reduction, and the other will be oxidation.
Given:
$Cr^{3+} + 3e^- \rightarrow Cr(s)$; $E° = -0.74$ V
$Fe^{2+} + 2e^- \rightarrow Fe(s)$; $E° = -0.44$ V
Since -0.44 V > -0.74 V, Fe^{2+}/Fe has a higher reduction potential, so $Fe^{2+} + 2e^- \rightarrow Fe(s)$ is the reduction half reaction.
Therefore, $Cr(s) \rightarrow Cr^{3+} + 3e^-$ will be reversed and act as the oxidation half reaction.

(ii) The given reaction is:
$Mg(s) + 2Ag^+ (0.001\ M) \rightarrow Mg^{2+} (0.100\ M) + 2Ag(s)$
This is a redox reaction where Mg is oxidized and Ag^+ is reduced.
Cell representation:
$Mg(s) \mid Mg^{2+} (0.100\ M) \parallel Ag^+ (0.001\ M) \mid Ag(s)$

Given: E°_cell = 3.17 V, Temperature = 298 K (assumed), log 10 = 1
Using Nernst equation:
E_cell = E°_cell - (0.0592 / n) * log Q
Here, n = 2 (number of electrons transferred)
Reaction quotient Q = $[Mg^{2+}] / [Ag^{+}]^2 = 0.100 / (0.001)^2 = 0.100 / 0.000001 = 100000$
Log Q = log 100000 = 5
Therefore,
E_cell = 3.17 - (0.0592 / 2) * 5 = 3.17 - 0.0296 * 5 = 3.17 - 0.148 = 3.022 V

Hence, the emf of the cell under given conditions is 3.022 V.

Key Points: Compare standard electrode potentials to determine oxidation and reduction half reactions - Higher E° half reaction undergoes reduction - Write cell representation with anode and cathode - Use Nernst equation to calculate E_cell - Calculate reaction quotient Q from concentrations - Substitute values to find the emf under non-standard conditions

Question 35.

(i) State Kohlrausch's law. Give any two applications of it.

(ii) $\wedge_m°NH_4Cl$, $\wedge°_mNaOH$ and $\wedge°_m$ NaCl are 129.8, 217.4, and 108.9 S cm^2 mol^{-1} respectively. Molar conductivity of 1 × 10^{-2} M solution of NH_4OH is 9.33 S cm^2 mol^{-1}. Calculate the degree of dissociation (α) of NH_4OH solution at this concentration.

[5 Marks]

Answer: (i) **Kohlrausch's Law** states that the molar conductivity at infinite dilution of an electrolyte can be represented as the sum of the individual contributions of its ions. Mathematically,
Λ^0_m(electrolyte) = $\sum \lambda^0$(cations) + $\sum \lambda^0$(anions).
Applications of Kohlrausch's law:
1. It helps in calculating the molar conductivity of weak electrolytes from the molar conductivities of strong electrolytes.
2. It is used to determine the degree of dissociation (α) of weak electrolytes.

(ii) Given data:
Λ^0_m NH_4Cl = 129.8 S cm^2 mol^{-1}
Λ^0_m NaOH = 217.4 S cm^2 mol^{-1}
Λ^0_m NaCl = 108.9 S cm^2 mol^{-1}
Molar conductivity of 1 × 10^{-2} M NH_4OH = 9.33 S cm^2 mol^{-1}

Step 1: Calculate Λ^0_m of NH_4OH using Kohlrausch's law:

$\Lambda^0_m\ NH_4OH = \Lambda^0_m\ NH_4Cl - \Lambda^0_m\ NaCl + \Lambda^0_m\ NaOH$

$= 129.8 - 108.9 + 217.4 = 238.3\ S\ cm^2\ mol^{-1}$

Step 2: Use formula for degree of dissociation $\alpha = (\Lambda_m / \Lambda^0_m)$ where Λ_m is molar conductivity at given concentration.

$\alpha = 9.33 / 238.3 = 0.0391 \approx 0.039$ or 3.91%

Therefore, the degree of dissociation of 0.01 M NH_4OH is approximately 3.9%.

> **Key Points: Kohlrausch's law defines molar conductivity at infinite dilution as sum of ionic contributions - Applications include calculating molar conductivity of weak electrolytes and degree of dissociation - Degree of dissociation calculated using ratio of molar conductivity at concentration to that at infinite dilution**

Question 36.

(i) In a chemistry practical class, the teacher gave his students an amine 'X' having molecular formula C_2H_7N, and asked the students to identify the type of amine. One of the students, Neeta, observed that it reacts with $C_6H_5SO_2Cl$, to give a compound which dissolves in NaOH solution. Can you help Neeta to identify the compound 'X'?

(ii) Arrange the following in the increasing order of their pK_b value in aqueous phase:

$C_6H_5NH_2$, $(CH_3)_2NH$, NH_3, CH_3NH_2, $(CH_3)_3N$.

(iii) Aniline on nitration gives considerable amount of meta product along with ortho and para products. Why?

(iv) Convert aniline to:

(I) p-bromoaniline

(II) phenol

[5 Marks]

Answer: (i) The molecular formula C_2H_7N corresponds to ethylamine ($CH_3CH_2NH_2$), which is a primary amine. Primary amines react with $C_6H_5SO_2Cl$ (benzenesulphonyl chloride) to form sulphonamides, which are soluble in NaOH because the sulphonamide group is acidic.

(ii) The basic strength is inversely related to pK_b value. The increasing order of pK_b (least basic to most basic) is: $(CH_3)_3N < C_6H_5NH_2 < NH_3 < CH_3NH_2 < (CH_3)_2NH$.

(iii) In aniline, the -NH_2 group donates electrons and activates the ring for electrophilic substitution at ortho and para positions. However, under nitrating conditions, -NH_2 gets protonated to form -NH_3^+, which is a deactivating meta-directing group. This leads to formation of a considerable amount of meta-nitroaniline along with ortho and para products.

(iv) Conversion of aniline:
(I) To p-bromoaniline: React aniline with Br_2 water at room temperature; substitution occurs at para position to give p-bromoaniline.
(II) To phenol: First diazotise aniline by reacting with $NaNO_2$ and HCl below 5 deg C to form diazonium salt; then warm with water to replace diazonium group with OH, forming phenol.

Key Points: Ethylamine is a primary amine reacting with benzenesulphonyl chloride to form soluble sulphonamide - pK_b values inversely related to basic strength - Protonation of -NH_2 group in aniline causes meta substitution during nitration - p-Bromoaniline formed by bromination of aniline - Phenol formed by diazotisation and subsequent replacement of diazonium group with OH

Question 37.

(i) When pyrolusite ore is fused with KOH, in presence of air, a dark green coloured product 'A' is obtained which changes to purple coloured compound 'B' in acidic medium.

(I) Write the formulae of 'A' and 'B'.

(II) Write the ionic equation for the reaction when compound 'B' reacts with Fe^{2+} in acidic medium.

(ii) Give reasons:

(I) Ce^{4+} in aqueous solution is a good oxidising agent.

(II) The actinoid contraction is greater from element to element than lanthanoid contraction.

(III) $E°Zn^{2+}/Zn$ value is more negative than expected, whereas $E°Cu^{2+}/Cu$ is positive.

[5 Marks]

Answer: (i) (I) When pyrolusite ore (MnO_2) is fused with KOH in presence of air, the dark green coloured compound 'A' formed is potassium manganate, K_2MnO_4. On acidifying 'A', it changes to the purple coloured compound 'B' which is potassium permanganate, $KMnO_4$.
Formula of A: K_2MnO_4
Formula of B: $KMnO_4$

(II) Ionic equation when compound B reacts with Fe^{2+} in acidic medium is:
$MnO_4^- + 8\ H^+ + 5\ Fe^{2+} \rightarrow Mn^{2+} + 4\ H_2O + 5\ Fe^{3+}$

(ii) Reasons:

(I) Ce^{4+} in aqueous solution is a good oxidising agent because it has a high positive standard electrode potential and readily gains electrons to get reduced to Ce^{3+}, thereby oxidising other species.

(II) The actinoid contraction is greater than lanthanoid contraction because the 5f electrons in actinoids are less effectively shielded compared to 4f electrons in lanthanoids, resulting in a greater decrease in atomic and ionic radii across the series.

(III) The standard electrode potential E^0 for Zn^{2+}/Zn is more negative than expected because Zn loses electrons easily and forms a stable dication, whereas Cu^{2+}/Cu has a positive E^0 value because Cu is less reactive and more reluctant to lose electrons, so it acts as a good oxidising agent.

Key Points: Pyrolusite fused with KOH forms K2MnO4 (A) - Acidification converts K2MnO4 to KMnO4 (B) - Ionic equation for MnO4- and Fe2+ in acid medium - Ce4+ has high oxidising power due to high electrode potential - Actinoid contraction > lanthanoid due to poor shielding by 5f electrons - Zn has more negative E0 due to high reactivity; Cu has positive E0 due to lower reactivity

Question 38.

(i) While studying the periodic properties, Arti came across an abnormal behaviour in the atomic size of Hf. She found that, even though Hf is placed below Zr in the same group, both have almost similar atomic sizes.

(I) Which phenomenon is responsible for the above behaviour ? Define it.

(II) Mention any other consequence of the above phenomenon.

(ii) Give reasons for the following :

(I) Transition metals exhibit catalytic properties.

(II) Transition metals have high enthalpy of atomisation.

(III) Sc is a transition element, while Zn is not.

[5 Marks]

Answer: (i)(I) The phenomenon responsible for the similar atomic sizes of Hafnium (Hf) and Zirconium (Zr) is called the **lanthanide contraction**. It is defined as the steady decrease in the atomic and ionic radii of the lanthanide elements from La (Lanthanum) to Lu (Lutetium) due to poor shielding effect of the 4f electrons. This results in smaller atomic size for elements following the lanthanide series than expected.

(ii)(II) Another consequence of lanthanide contraction is that elements after the lanthanides in the periodic table have higher density, melting and boiling points and exhibit similar chemical properties,

making their separation difficult.
(ii)(I) Transition metals exhibit catalytic properties because they can exhibit variable oxidation states and can form intermediate compounds by adsorption of reactants on their surface. This makes them efficient catalysts in speeding up chemical reactions.
(ii)(II) Transition metals have high enthalpy of atomisation due to strong metallic bonding arising from the presence of unpaired d electrons. These unpaired electrons can overlap and form strong metallic bonds requiring more energy to break.
(ii)(III) Scandium (Sc) is a transition element because it has an incomplete d sub-shell in its ground state or in its common oxidation states, i.e., it has electronic configuration [Ar] 3d1 4s2. Zinc (Zn), however, has a completely filled d sub-shell (3d10 4s2) and does not exhibit variable oxidation states, so it is not considered a transition element.

Key Points: Lanthanide contraction - Similar atomic size of Hf and Zr - Transition metals catalytic properties due to variable oxidation states - High enthalpy of atomisation due to unpaired d electrons - Sc has incomplete d subshell - Zn has complete d subshell

Question 39.

(i) Arun heated a mixture of ethylamine and $CHCl_3$ with ethanolic KOH, which forms a foul smelling gas. Write the chemical equation involved.

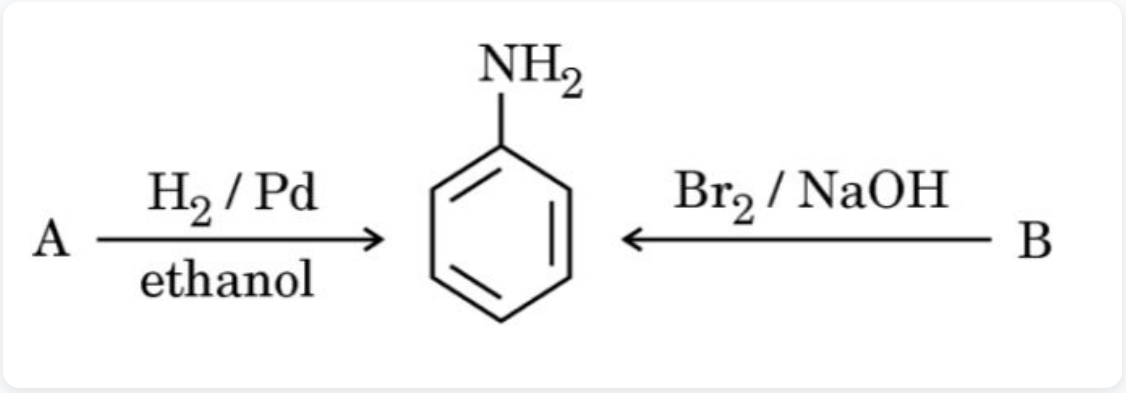
(ii) Identify A and B in the following reactions:

(iii) Convert aniline to :

(I) benzene

(II) sulphanilic acid

[5 Marks]



Answer: (i) The reaction of ethylamine with chloroform (CHCl3) in presence of ethanolic KOH produces ethyl isocyanide (a foul smelling gas) and potassium chloride.
$C_2H_5NH_2 + CHCl_3 + 3KOH$ (ethanolic) $\rightarrow C_2H_5NC + 3KCl + 3H_2O$

(ii) Identification of A and B depends on the reaction scheme which is not provided here. Please

provide the reaction to identify A and B.

(iii) Conversion of aniline:

(I) Aniline to benzene:

Step 1: Diazotisation of aniline using $NaNO_2$ and HCl at 0-5 degC to form benzene diazonium chloride:

$C_6H_5NH_2 + NaNO_2 + 2HCl \rightarrow C_6H_5N_2^+Cl^- + NaCl + 2H_2O$

Step 2: Reduction of diazonium salt with hypophosphorous acid (H_3PO_2) or alcohol to give benzene:

$C_6H_5N_2^+Cl^- + H_3PO_2 \rightarrow C_6H_6 + N_2 + HCl$

(II) Aniline to sulphanilic acid:

Sulphonation of aniline with concentrated sulfuric acid at 10 degC:

$C_6H_5NH_2 + H_2SO_4$ (conc.) $\rightarrow$ p-HO_3S-C_6H_4-NH_2 (sulphanilic acid)

Hence, these are the required chemical equations and conversions.

Key Points: Carbylamine reaction forms foul smelling isocyanide gas - Diazotisation of aniline to benzene diazonium salt then reduction to benzene - Sulphonation of aniline produces sulphanilic acid