CBSE EXAMINATION PAPER-2026

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. Alcohols and Phenols are acidic in nature. Electron withdrawing groups in phenol increase its acidic strength and electron releasing groups decrease it. Alcohols undergo nucleophilic substitution with hydrogen halides to yield alkyl halides. Dehydration of alcohols gives alkenes. On oxidation, primary alcohols yield aldehydes with mild oxidising agents and carboxylic acids with strong oxidising agents, while secondary alcohols yield ketones. Tertiary alcohols are resistant to oxidation. The presence of – OH group in phenols activates the aromatic ring towards electrophilic substitution and directs the incoming group to ortho and para positions due to resonance effect.

Question 2. Alcohols and Phenols are acidic in nature. Electron withdrawing groups in phenol increase its acidic strength and electron releasing groups decrease it. Alcohols undergo nucleophilic substitution with hydrogen halides to yield alkyl halides. Dehydration of alcohols gives alkenes. On oxidation, primary alcohols yield aldehydes with mild oxidising agents and carboxylic acids with strong oxidising agents, while secondary alcohols yield ketones. Tertiary alcohols are resistant to oxidation. The presence of – OH group in phenols activates the aromatic ring towards electrophilic substitution and directs the incoming group to ortho and para positions due to resonance effect.

(1) Write the mechanism of acid dehydration of ethanol to yield ethene.

[1 Marks]

Answer: The acid dehydration of ethanol to ethene involves three steps:
1. Protonation of the hydroxyl group of ethanol by acid forms an oxonium ion.
2. Loss of water molecule forms a carbocation intermediate.
3. A proton is removed from the carbocation by a base to form ethene.
This reaction shows how alcohols give alkenes on dehydration as mentioned in the case passage.

Key Points: Protonation of –OH group-loss of water-carbocation formation-deprotonation-formation of ethene

(2) Why are tertiary alcohols resistant to oxidation ?

[1 Marks]

Answer: Tertiary alcohols are resistant to oxidation because they do not have a hydrogen atom attached to the carbon bearing the – OH group, which is necessary for oxidation to occur. Hence, as per the case passage, unlike primary and secondary alcohols, tertiary alcohols cannot form aldehydes, ketones or acids on oxidation and thus remain unreactive to oxidation.

Key Points: Tertiary alcohols lack hydrogen on carbon with – OH group - Oxidation requires hydrogen on – OH bearing carbon - Tertiary alcohols do not form oxidised products like aldehydes or ketones

(3) Why is ortho-nitrophenol more acidic than ortho-methoxyphenol ?

[1 Marks]

Answer: Ortho-nitrophenol is more acidic than ortho-methoxyphenol because nitro group is an electron withdrawing group which increases acidity by stabilizing the phenoxide ion, whereas methoxy group is an electron releasing group which decreases acidity by destabilizing the phenoxide ion. This is explained in the case where electron withdrawing groups increase acidic strength in phenol while electron releasing groups decrease it.

Key Points: Nitro group is electron withdrawing - Methoxy group is electron releasing - Electron withdrawing groups increase acidity - Electron releasing groups decrease acidity

(4) Write the structure of the major product expected from the dinitration of 3-methylphenol.

[1 Marks]

Answer: Dinitration of 3-methylphenol mainly gives 2,4-dinitro-3-methylphenol as major product. This is because the –OH group activates the aromatic ring and directs the incoming nitro groups to the ortho and para positions relative to itself.
Since the methyl group is at position 3, nitration occurs at positions 2 and 4.
Hence, the major product is 2,4-dinitro-3-methylphenol.

Key Points: –OH group activates aromatic ring - Electrophilic substitution occurs at ortho and para positions - Major product is 2,4-dinitro-3-methylphenol

Question 3. Carbohydrates are optically active polyhydroxy aldehydes or ketones or the compounds which produce such units on hydrolysis. They have been broadly classified into three groups — monosaccharides, oligosaccharides and polysaccharides. The carbohydrates may also be classified as either reducing or non-reducing sugars. An important monosaccharide glucose is an aldohexose and is correctly named as D(+)–glucose. It was assigned the open structure on the basis of its reactions with HI, NH_2OH, Br_2 water, $(CH_3CO)_2O$ and nitric acid. Despite having the – CHO group, glucose does not give Schiff's test and hydrogen sulphite addition product with $NaHSO_3$. It was found that glucose forms a six-membered ring in which one of the – OH groups add to the – CHO group and form a cyclic hemiacetal structure.

(1) How do you explain the following ? (i) Presence of a carbonyl group in glucose (ii) Presence of five – OH groups in glucose which are attached to different carbon atoms.

[1 Marks]

Answer: (i) Glucose has a carbonyl group (–CHO) in its open chain form which reacts with various reagents, confirming its presence as stated in the case passage.
(ii) Glucose contains five –OH groups attached to different carbon atoms; the –OH at C-5 reacts with the –CHO group to form a six-membered cyclic hemiacetal, explaining the presence of the different hydroxyl groups and ring formation.

Key Points: Glucose contains –CHO group in open form - Five –OH groups attached to different carbons - –OH at C-5 forms cyclic hemiacetal with –CHO group

(2) What type of carbohydrates are called reducing sugars ?

[1 Marks]

Answer: Reducing sugars are carbohydrates that have free aldehyde or ketone groups which can reduce Fehling's solution or Tollens' reagent. All monosaccharides like glucose and ketose sugars are reducing sugars because their aldehydic or ketonic groups are free as mentioned in the case. Sugars like maltose and lactose are also reducing sugars. Sugars with bonded aldehydic or ketonic groups like sucrose are non-reducing.

Key Points: Reducing sugars have free aldehyde or ketone groups - They reduce Fehling's solution and Tollens' reagent - All monosaccharides are reducing sugars

(3) Draw the six-membered ring structure of α–D(+)–glucose.

[1 Marks]

Answer: The six-membered ring structure of α-D(+)-glucose is formed when the –OH group at carbon 5 reacts with the –CHO group at carbon 1 forming a cyclic hemiacetal. This creates a six-membered ring called the pyranose form. In the α form, the –OH at carbon 1 is positioned below the plane of the ring, as explained in the case passage that ring formation explains the absence of the open chain –CHO group.

Key Points: Glucose forms a six-membered cyclic hemiacetal ring - –OH at carbon 5 attacks –CHO at carbon 1 - α form has –OH below the plane at carbon 1 - ring structure explains absence of free –CHO group - cyclic form coexists with open chain form in equilibrium

(4) In D(+)–glucose, what do the letter 'D' and sign '(+)' represent ?

[1 Marks]

Answer: In D(+)–glucose, letter 'D' represents the configuration of the molecule which is related to the position of —OH group on the lowest asymmetric carbon being on the right side similar to D-glyceraldehyde. The sign '(+)' indicates that glucose is dextrorotatory and rotates plane-polarized light to the right as mentioned in the case paragraph.

Key Points: D represents the configuration - (+) indicates dextrorotatory nature - Based on lowest asymmetric carbon and optical rotation

Section B

Question 4.

Oxidation of chloroform by air in the presence of sunlight produces a poisonous gas known as :

[1 Marks]

(A) Tear gas

(B) Mustard gas

(C) Phosgene gas

(D) Chlorine gas

Explanation: Chloroform is slowly oxidised by air in the presence of light (sunlight) to produce carbonyl chloride, which is also known as phosgene gas. Phosgene is an extremely poisonous gas, and this reaction explains why chloroform is stored in closed dark coloured bottles to prevent its formation.

Question 5.

Lucas reagent produces cloudiness immediately with :

[1 Marks]

(A) 2-methyl-1-propanol

(B) Butan-2-ol

(C) Butan-1-ol

(D) 2-methyl-2-propanol

Explanation: Lucas reagent contains concentrated HCl and $ZnCl_2$, which reacts with alcohols to produce alkyl halides that are immiscible and cause turbidity (cloudiness). Tertiary alcohols, like 2-methyl-2-propanol, react immediately with Lucas reagent to form the halide and produce cloudiness because they form carbocations easily. Primary and secondary alcohols react slower, so they do not produce immediate cloudiness.

Question 6.

Which of the following d-orbitals experience more repulsion in the crystal field splitting of octahedral complex ?

[1 Marks]

(A) d_xy , d_yz , d_xz

(B) $d_{x^2 - y^2}$, d_{z^2}

(C) d_xy , $d_{x^2 - y^2}$

(D) d_xz , d_{z^2}

Explanation: In an octahedral crystal field, the ligands are positioned along the x, y, and z axes, so the d orbitals pointing directly at the ligands experience more repulsion. These orbitals are $d_{x^2 - y^2}$ and d_{z^2}, which form the eg set and have higher energy due to increased repulsion. The other three orbitals d_xy, d_xz, and d_yz point between the ligands and hence experience less repulsion and lower energy.

Question 7.

The chelating ligand used for the treatment of lead poisoning is :

[1 Marks]

(A) EDTA

(B) Oxalate ion

(C) Dimethylglyoxime

(D) Ethane-1,2-diamine

Explanation: EDTA (Ethylenediaminetetraacetate ion) is an important hexadentate ligand that can form strong coordination compounds with metal ions. It is specifically used in the treatment of lead poisoning because it binds to lead ions and facilitates their removal from the body. Other options like Ethane-1,2-diamine, Dimethylglyoxime, and Oxalate ion are not commonly used for this purpose in treatment.

Question 8. Manganate ion is paramagnetic due to the presence of :

[1 Marks]

(A) two unpaired electrons

(B) three unpaired electrons

(C) one unpaired electron

(D) fully paired electrons

Explanation: The manganate ion is paramagnetic because it has one unpaired electron. Paramagnetism arises due to the presence of unpaired electrons, which create a magnetic moment. According to the given context, the green manganate ion is paramagnetic specifically due to the presence of one unpaired electron, whereas the permanganate ion is diamagnetic because it has no unpaired electrons.

Question 9.

The correct order of decreasing basicities of $C_2H_5NH_2$, $(C_2H_5)_2NH$ and $(C_2H_5)_3N$ in aqueous solution is :

[1 Marks]

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

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

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

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

Explanation: The correct order of basic strength is $(C_2H_5)_2NH > C_2H_5NH_2 > (C_2H_5)_3N$. This is because the secondary amine (diethylamine) is more basic than the primary amine (ethylamine) due to greater electron donating effect of the alkyl groups, which increases the availability of the lone pair on nitrogen for protonation. However, in the case of the tertiary amine ($(C_2H_5)_3N$), although there are more alkyl groups, steric hindrance and the solvation effect in aqueous solution decrease its basicity compared to the secondary amine.

Question 10.

The boiling point of one molal NaCl solution, assuming NaCl to be completely dissociated in water is : (K_b for water = 0·52 K kg mol^{-1})

[1 Marks]

(A) 100·04ºC

(B) 100·52ºC

(C) 101·52ºC

(D) 101·04ºC

Explanation: The boiling point elevation (ΔT_b) is calculated using the formula ΔT_b = i × K_b × m, where i is the van 't Hoff factor, K_b is the ebullioscopic constant, and m is the molality. NaCl dissociates completely into Na^+ and Cl^- ions, so i = 2. Given K_b = 0.52 K kg mol^{-1} and m = 1 molal, the boiling point elevation is ΔT_b = 2 × 0.52 × 1 = 1.04°C. Therefore, the new boiling point is 100 + 1.04 = 101.04°C. Hence, the correct answer is 101·04ºC.

Question 11.

When a liquid and its vapour are at equilibrium and the pressure is suddenly decreased :

[1 Marks]

(A) equilibrium remains unaffected

(B) cooling occurs

(C) heating occurs

(D) vapour pressure of the solution increases

Explanation: When liquid and its vapour are at equilibrium, the system maintains a balance where the number of molecules evaporating equals the number condensing. If the pressure is suddenly decreased, the vapour molecules expand, which causes a drop in temperature (cooling) due to the absorption of energy for evaporation. Hence, cooling occurs to restore equilibrium at the new pressure.

Question 12. Consider the following cell at 298 K : Mg (s) | Mg^{2+} (1·0 M) || Cu^{2+} (1·0 M) | Cu (s) How can we increase the emf of the cell using the same substances ?

[1 Marks]

(A) By decreasing only the [Mg^{2+}] to 0·1 M

(B) By increasing both [Mg^{2+}] and [Cu^{2+}] to 2·0 M

(C) By increasing only the [Mg^{2+}] to 2·0 M

(D) By decreasing only the [Cu^{2+}] to 0·1 M

Explanation: The emf of the cell depends on the ion concentration as given by the Nernst equation. For the cell Mg(s) | Mg^{2+} || Cu^{2+} | Cu(s), the cell reaction is $Mg \rightarrow Mg^{2+} + 2e^-$ (oxidation) and $Cu^{2+} + 2e^- \rightarrow Cu$ (reduction). Increasing the concentration of Mg^{2+} will shift the equilibrium and change the reaction quotient, thereby increasing the emf. Decreasing or changing the concentration of Cu^{2+} or Mg^{2+} in other ways will not increase the emf as effectively as increasing [Mg^{2+}]. Therefore, increasing only the [Mg^{2+}] to 2·0 M increases the emf of the cell.

Question 13.

Nucleic acids are polymers of :

[1 Marks]

(A) amino acids

(B) nucleotides

(C) pentose sugar

(D) nucleosides

Explanation: Nucleic acids such as DNA and RNA are long chain polymers made up of nucleotides. Each nucleotide consists of a nitrogenous base, a pentose sugar, and a phosphate group. These nucleotides are linked together by phosphodiester bonds to form the structure of nucleic acids.

Question 14.

The rate of a first order reaction is $5{\cdot}6 \times 10^{-4}$ mol L^{-1} s^{-1}, when the concentration of reactant is 0·2 mol L^{-1} The rate constant 'k' is :

[1 Marks]

(A) $5{\cdot}6 \times 10^{-3}$ s^{-1},

(B) $2{\cdot}8 \times 10^{-4}$ s^{-1},

(C) $2{\cdot}8 \times 10^{-3}$ s^{-1}

(D) $2{\cdot}8 \times 10^{-5}$ s^{-1},

Explanation: For a first order reaction, the rate equation is Rate = k [Reactant]. Given the rate is 5.6×10^{-4} mol L^{-1} s^{-1} and the concentration is 0.2 mol L^{-1}, the rate constant k can be calculated as k = Rate / [Reactant] = $(5.6 \times 10^{-4}) / 0.2 = 2.8 \times 10^{-5}$ s^{-1}. This matches the option 2.8×10^{-5} s^{-1}, which is correct. The units of k for a first order reaction are s^{-1} as explained in the context.

Question 15.

In the reaction of NaOBr with amide, the carbonyl carbon is lost as :

[1 Marks]

(A) HCO_3^-

(B) CO^{2-}_3

(C) CO_2

(D) CO

Explanation: In the given reaction, the amide (R-C(O)-NH2) reacts with sodium hypobromite (NaOBr) and sodium hydroxide (NaOH). This reaction results in the removal of the carbonyl carbon from the amide as carbonate ion (CO3 2-). The balanced reaction shows the formation of Na2CO3 (sodium carbonate) as a by-product, indicating that the carbonyl carbon is lost in the form of CO3 2- ions.

Question 16. Assertion (A) : Alcohols act as Bronsted bases as well as Bronsted acids. Reason (R) : It is due to the presence of unshared electron pairs on oxygen atom and presence of polar O – H bond.

[1 Marks]

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

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

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

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

Explanation: Alcohols can act both as Bronsted acids and Bronsted bases. They act as Bronsted acids because they can donate a proton (H+) due to the polar nature of the O–H bond. They also act as Bronsted bases because the oxygen atom has unshared electron pairs that can accept a proton. Therefore, the presence of unshared electron pairs on oxygen and the polar O–H bond explains why alcohols exhibit both acidic and basic properties.

Question 17.

Assertion (A) : Diazonium salts of aromatic amines are more stable than those of aliphatic amines. Reason (R) : Diazonium salts of aliphatic amines undergo resonance.

[1 Marks]

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

(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 true, but Reason (R) is false.

Explanation: Diazonium salts of aromatic amines (arenediazonium salts) are more stable than those of aliphatic amines because the arenediazonium ion is stabilized by resonance involving the aromatic ring. In contrast, diazonium salts of aliphatic amines are highly unstable and do not have resonance stabilization. Therefore, the assertion is true, but the reason given is incorrect as it states that aliphatic diazonium salts undergo resonance, which they do not.

Question 18.

Assertion (A) : For complex reaction, order of reaction is given by the slowest step. Reason (R) : Order of a reaction is an experimental quantity.

[1 Marks]

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

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

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

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

Explanation: The assertion is true because in a complex reaction the slowest step (rate-determining step) controls the overall reaction rate and thus determines the order of the reaction. The reason is also true because the order of a reaction is determined experimentally and cannot be inferred from the balanced chemical equation alone. However, the reason does not explain the assertion since the connection between the slowest step and the reaction order is based on the kinetics of the stepwise mechanism, not simply because the order is experimentally determined.

Question 19.

Assertion (A) : E ° _Sc^{3+} / Sc^{2+} E has low value. Reason (R) : Because of the stability of Sc^{3+} ion which has a noble gas configuration.

[1 Marks]

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

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

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

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

Explanation:

The standard electrode potential E° for the Sc^{3+}/Sc^{2+} couple has a low value because the Sc^{3+} ion is particularly stable due to its noble gas configuration (like argon). This stability makes removing an electron to form Sc^{3+} more favorable and hence the potential is low. Therefore, both the assertion and the reason are true, and the reason correctly explains the assertion.

Section C

Question 20.

(a) Reactions of which order will show the rate to be independent of the concentration of the reactant ? Give one example of this order.

(b) State the condition under which a bimolecular reaction may be kinetically a first order reaction.

[2 Marks]

Answer: (a) Zero order reactions show the rate independent of the concentration of the reactant. The rate law is Rate = k, where k is the rate constant and does not depend on concentration.
Example: Decomposition of ammonia on a platinum surface, $2NH_3(g) \rightarrow N_2(g) + 3H_2(g)$.

(b) A bimolecular reaction may behave like a first order reaction if one reactant is in large excess, so its concentration remains practically constant during the reaction. Hence, the rate depends effectively on the concentration of the other reactant only, giving an apparent first order kinetics.

> **Key Points: Zero order reaction-rate independent of concentration - Example ammonia decomposition - Bimolecular reaction with one reactant in excess behaves like first order**

Question 21.

(a) Explain the following with the help of Henry's law :

(i) Bends

(ii) Anoxia

[2 Marks]

Answer: (i) Bends: According to Henry's law, the amount of dissolved gas in a liquid is proportional to the pressure of the gas above it. When a diver ascends too quickly, the pressure decreases rapidly, causing dissolved nitrogen in the blood to form bubbles. These bubbles cause pain and damage, known as bends.
(ii) Anoxia: Anoxia is the deficiency of oxygen in body tissues. Under Henry's law, if the partial pressure of oxygen decreases, less oxygen dissolves in blood, leading to insufficient oxygen supply and causing anoxia.

> **Key Points: Henry's law - gas solubility proportional to pressure - bends caused by nitrogen bubbles due to rapid pressure change - anoxia caused by low oxygen pressure leading to less oxygen dissolved**

Question 22.

How does sprinkling of salt help in clearing the snow covered roads in hilly areas ? Write the name of the colligative property involved in this process.

[2 Marks]

Answer: Answer: Sprinkling salt on snow-covered roads lowers the freezing point of ice. Salt dissolves in the thin layer of water on the surface of ice, forming a salt solution which freezes at a

temperature lower than 0 degC. This causes the ice to melt even when the temperature is below freezing point. This process makes the roads safer by removing the slippery ice. The colligative property involved in this process is **freezing point depression**.

> **Key Points: Salt lowers freezing point - Ice melts below 0 degC due to salt - Colligative property: Freezing point depression**

Question 23.

Write IUPAC names of the following compounds :

(a) $[Cr(NH_3)_4\ (ONO)Cl]\ NO_3$

(b) $Na[Ag(CN)_2]$

[2 Marks]

Answer: (a) The complex $[Cr(NH_3)_4\ (ONO)Cl]\ NO_3$ consists of a cationic coordination complex and a nitrate ion as the counter ion. In naming, first name the ligands in alphabetical order ignoring any numerical prefixes, then the metal with its oxidation state in Roman numerals in parentheses.
Ligands are ammine (NH_3), chloro (Cl), and nitrito-O (ONO) because the NO group is bonded through oxygen. Alphabetically: ammine, chloro, nitrito-O.
The metal is chromium. The overall charge on the complex ion is +1 to balance the nitrate ion NO_3^-.
Oxidation state of Cr is +3.
So, the name is: **tetraamminechloronitrito-Ochromium(III) nitrate**.

(b) The complex $Na[Ag(CN)_2]$ has a sodium ion and a complex ion $[Ag(CN)_2]^-$.
The ligands are cyanide (CN), and as there are two cyanides, we use the prefix dicyano.
The metal is silver with oxidation state +1.
Since the complex ion is an anion, the metal name ends with 'ate' and uses its Latin name 'argentum' becoming 'argentate'.
The complex is named as **sodium dicyanoargentate(I)**.

> **Key Points: Identify ligands and their naming - Determine oxidation state of central metal - Follow IUPAC rules for naming coordination complexes including ligand prefixes and metal oxidation state**

Question 24.

What are the hydrolysis products of the following ?

(a) Lactose

(b) DNA containing Thymine

[2 Marks]

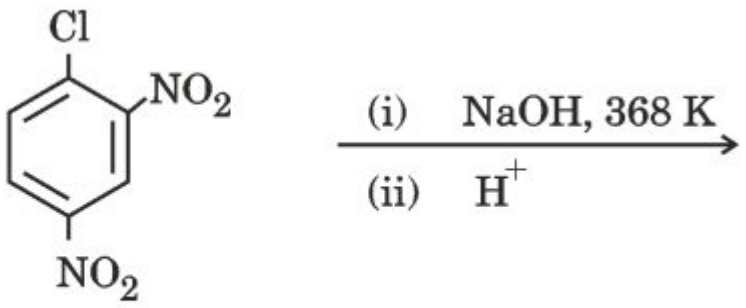
Answer: (a) Lactose on hydrolysis breaks down into two monosaccharides: glucose and galactose. Lactose is a disaccharide made of one glucose unit and one galactose unit linked together. When water is added in the presence of an enzyme like lactase, the bond breaks and produces glucose and galactose.
(b) A nucleotide from DNA containing thymine on hydrolysis breaks into three parts: thymine (the nitrogenous base specific to DNA), deoxyribose sugar (a five-carbon sugar), and phosphate group(s). Hydrolysis splits the nucleotide into thymine, deoxyribose, and phosphate ions by breaking the bonds between them.

Key Points: Lactose hydrolyzes into glucose and galactose - DNA nucleotide hydrolyzes into thymine, deoxyribose sugar, and phosphate group - Hydrolysis breaks chemical bonds using water

Question 25.

Draw the structures of major product(s) in each of the following reactions :

[2 Marks]

(a) 

(b) $CH_3CH = C(CH_3)_2 + HBr \longrightarrow$

Answer: (a) In the mononitration of 3-methylphenol, the major product is 2-nitro-3-methylphenol. Here, the -OH group is an activating ortho/para directing group, so nitration occurs mainly at the ortho position relative to -OH and para to the methyl group. (b) Dinitration leads to 2,4-dinitro-3-methylphenol as the major product, where two nitro groups attach at ortho and para positions to the -OH group while methyl remains at position 3. The reaction is electrophilic aromatic substitution

favoring positions activated by -OH and methyl groups. Major products are mainly monosubstituted or disubstituted derivatives depending on reaction conditions. Minor isomers may form but are negligible.

Key Points: Mononitration forms mainly 2-nitro-3-methylphenol - Hydroxyl group activates ortho/para positions - Dinitration gives 2,4-dinitro-3-methylphenol as major product

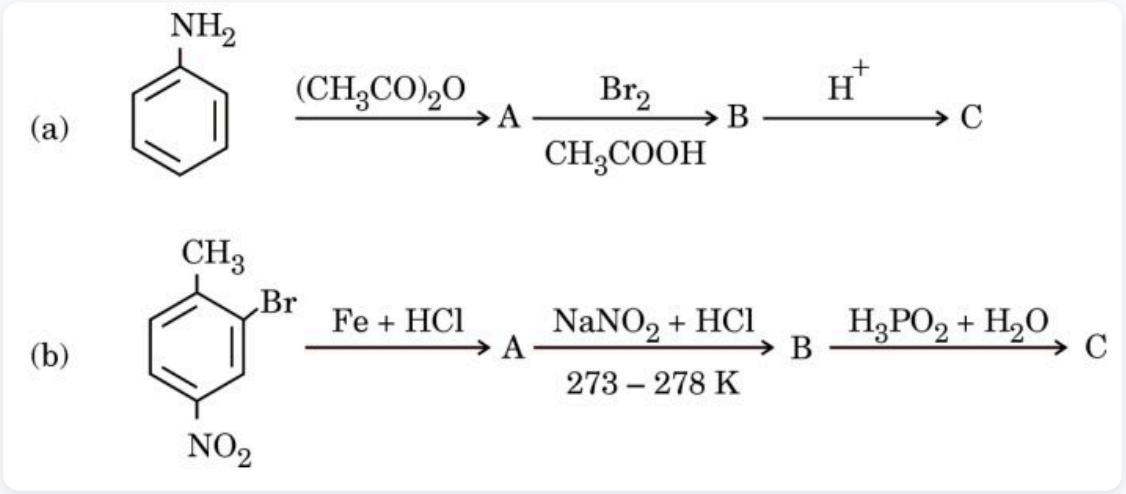
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Section D

Question 26.

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

[3 Marks]



Answer: (a) Structure of A: It is the Grignard reagent, usually represented as R-MgBr, where R is an alkyl or aryl group attached to magnesium bromide.
(b) Structure of B: It is the alkyl halide, represented as R'-X, where R' is an alkyl or aryl group and X is a halogen (Cl, Br, or I).
(c) Structure of C: It is the product formed after the reaction of A and B in dry ether, typically yielding an organomagnesium compound intermediate which upon hydrolysis with H_2O or D_2O gives the corresponding alkane R-R' or isotopically labeled product.
Explanation: In the reaction between Grignard reagent (A) and alkyl halide (B), the nucleophilic carbon in A attacks the alkyl halide B leading to formation of a new carbon-carbon bond in product C. The product after hydrolysis is an alkane with the combined alkyl groups. This mechanism involves nucleophilic attack, formation of organomagnesium intermediate, and its subsequent hydrolysis to yield the final alkane product. The reaction requires dry ether as solvent to stabilize the Grignard reagent.

Key Points: Identify Grignard reagent structure - Identify alkyl halide structure - Explain formation of product via nucleophilic attack and hydrolysis

Question 27.

What happens when :

(a) Propanenitrile is treated with phenyl magnesium bromide followed by hydrolysis ?

(b) p-fluorotoluene is treated with CrO_3 in the presence of acetic anhydride followed by hydrolysis with aqueous acid.

(c) Phthalic acid is treated with NH_3 followed by heating ?

Write chemical reactions in support of your answer.

[3 Marks]

Answer: (a) When propanenitrile (CH_3CH_2-C≡N) is treated with phenyl magnesium bromide (C_6H_5MgBr), the nucleophilic phenyl group attacks the electrophilic carbon of the nitrile group, forming an intermediate imine magnesium bromide complex. Upon hydrolysis with aqueous acid, this intermediate converts to an aryl ketone, specifically phenyl propyl ketone (C_6H_5-CO-CH_2CH_3).

C_2H_5-C≡N + C_6H_5MgBr → C_6H_5-C=NMgBr-CH_2CH_3 → (hydrolysis) → C_6H_5-CO-CH_2CH_3

(b) When p-fluorotoluene is treated with CrO_3 in the presence of acetic anhydride followed by hydrolysis with aqueous acid, the methyl (-CH_3) group is oxidised to a carboxylic acid group (-COOH), transforming p-fluorotoluene into p-fluorobenzoic acid.

C_6H_4F-CH_3 + CrO_3/Ac_2O → (oxidation) → C_6H_4F-COOH + other products

(c) When phthalic acid (benzene-1,2-dicarboxylic acid) is treated with ammonia (NH_3) followed by heating, it forms phthalamide. The reaction involves the conversion of one carboxylic acid group into an amide group (-$CONH_2$) through ammonolysis.

$C_6H_4(COOH)_2$ + NH_3 → $C_6H_4(COOH)(CONH_2)$ + H_2O (upon heating)

Summary: (a) Formation of aryl ketone from nitrile and Grignard reagent.

(b) Oxidation of methyl group to carboxylic acid using CrO_3 in Ac_2O.

(c) Conversion of carboxylic acid to amide by ammonolysis of phthalic acid.

Key Points: Propanenitrile reacts with phenyl magnesium bromide to give aryl ketone after hydrolysis - p-fluorotoluene is oxidised to p-fluorobenzoic acid using CrO3 in acetic anhydride then hydrolysis - Phthalic acid reacts with NH3 to form phthalamide on heating

Question 28.

Answer the following questions :

(a) Why is direct current (DC) not used to measure the resistance of an ionic solution ?

(b) Why are the products of electrolysis different for the electrolysis of aqueous solution of $AgNO_3$ with silver electrodes and electrolysis of aqueous solution of $AgNO_3$ with platinum electrodes ?

(c) Why are magnesium blocks fixed to the iron pipelines carrying water ?

[3 Marks]

Answer: (a) Direct current (DC) is not used to measure the resistance of an ionic solution because passing DC causes electrochemical reactions at the electrodes, which changes the composition of the solution over time. This affects the accuracy of the resistance measurement. Instead, alternating current (AC) is used as it prevents such changes.
(b) The products of electrolysis differ because with silver electrodes, silver ions from the solution are deposited on the silver electrodes, maintaining the electrode material and ion concentration. With platinum electrodes, which are inert, silver deposits only on the cathode and oxygen or other products form at the anode. Thus, electrode material affects the products formed.
(c) Magnesium blocks are fixed to iron pipelines carrying water to act as sacrificial anodes. Magnesium is more reactive than iron, so it corrodes (oxidizes) first, protecting the iron pipelines from rusting and corrosion. This method is called cathodic protection.

Key Points: DC causes changes in ionic solution composition due to electrochemical reactions - Silver electrodes participate in electrolysis maintaining silver ion concentration - Platinum electrodes are inert producing different products - Magnesium acts as sacrificial anode to protect iron pipelines - Cathodic protection prevents rusting of iron

Question 29.

When a coordination compound $CoCl_3 . 6NH_3$ is mixed with excess of $AgNO_3$ solution, 3 moles of AgCl are precipitated per mole of the compound. Write the structural formula of the complex, IUPAC name, its hybridisation and magnetic behaviour on the basis of valence bond theory.

[3 Marks]

Answer: (a) Structural formula: Since 3 moles of AgCl are precipitated, 3 chloride ions are outside the coordination sphere and 3 NH_3 molecules and no chloride ion are coordinated to cobalt. Thus, the coordination complex is $[Co(NH_3)_6]^{3+}$ with 3 Cl^- ions outside. So the formula is $[Co(NH_3)_6]Cl_3$.
(b) IUPAC name: Hexaamminecobalt(III) chloride.
(c) Hybridisation: Cobalt is in +3 oxidation state. Electron configuration of Co^{3+} is $3d^6$. In the presence of strong field ligand NH_3, pairing of electrons occurs forming d^2sp^3 hybridisation.

(d) Magnetic behaviour: As all six electrons are paired in d^2sp^3 hybridisation, the complex is diamagnetic (no unpaired electrons).

Therefore, the coordination compound is $[Co(NH_3)_6]Cl_3$, named Hexaamminecobalt(III) chloride, with d^2sp^3 hybridisation and diamagnetic behaviour according to valence bond theory.

Key Points: 3 moles AgCl precipitated means 3 Cl- ions are outside coordination sphere - Structural formula is [Co(NH3)6]Cl3 - IUPAC name is Hexaamminecobalt(III) chloride - Hybridisation is d2sp3 due to Co(III) and NH3 ligands - Magnetic behaviour is diamagnetic due to all paired electrons

Question 30.

(i) How many geometrical isomers are possible in each of the following complexes ?

(I) $[Cr(C_2O)_3]^{3-}$

(II) $[Co(NH_3)_3Cl_3]$

(ii) $[Co(NH_3)_6]^{3+}$ is an inner orbital complex whereas $[Ni(NH_3)_6]^{2+}$ is an outer orbital complex. Why ?

[Atomic number : Co = 27, Ni = 28]

(iii) Write the formula of Wilkinson catalyst and its use.

[3 Marks]

Answer: (i) (I) [Cr(C2O4)3]3-: This complex has three bidentate oxalate ligands arranged octahedrally. It can have **2 geometrical isomers**, which are **facial (fac)** and **meridional (mer)** forms.
(II) [Co(NH3)3Cl3]: This octahedral complex with three NH3 and three Cl ligands can show **2 geometrical isomers**: **facial (fac)** where three similar ligands are on one face and **meridional (mer)** where they are in one plane.
(ii) [Co(NH3)6]3+ is an **inner orbital complex** because Co3+ is a d6 ion and undergoes d2sp3 hybridisation involving 3d orbitals, making it **low spin** and diamagnetic.
[Ni(NH3)6]2+ is an **outer orbital complex** because Ni2+ is d8 and forms sp3d2 hybridisation involving 4s and 4p orbitals (outer orbitals), so it is **high spin** and paramagnetic.
(iii) The formula of Wilkinson catalyst is **RhCl(PPh3)3**. It is used as a catalyst in **homogeneous hydrogenation of alkenes to alkanes** under mild conditions.

Key Points: Number of geometrical isomers in [Cr(C2O4)3]3- is 2 fac and mer - Number of geometrical isomers in [Co(NH3)3Cl3] is 2 fac and mer - Reason for inner and outer orbital complex based on d electron configuration and hybridisation - Formula of Wilkinson catalyst RhCl(PPh3)3 - Use in homogeneous hydrogenation

Question 31.

Calculate the vapour pressure of a solution containing 61 g of benzoic acid (molar mass = 122 g mol^{-1}) dissolved in 500 g of benzene when the vapour pressure of pure benzene at this temperature of experiment is 66 torr. Assume complete dimerization of benzoic acid in benzene.

[3 Marks]

Answer: Step 1: Calculate the moles of benzoic acid monomer = 61 g / 122 g mol-1 = 0.5 mol.
Step 2: Since benzoic acid dimerizes completely, moles of dimer = 0.5 mol / 2 = 0.25 mol.
Step 3: Calculate moles of benzene = 500 g / 78 g mol-1 = 6.41 mol.
Step 4: Use mole fraction formula of benzene: x_benzene = moles benzene / (moles benzene + moles dimer) = 6.41 / (6.41 + 0.25) = 6.41 / 6.66 = 0.9625.
Step 5: Calculate vapour pressure of solution using Raoult's law: P_solution = x_benzene * P_pure benzene = 0.9625 * 66 torr = 63.53 torr.
Answer: The vapour pressure of the solution is approximately 63.5 torr.

Key Points: Calculate moles of benzoic acid - Consider dimerization to find moles of dimer - Calculate mole fraction of benzene - Apply Raoult's law to find vapour pressure of solution

Question 32.

Consider the decomposition of hydrogen peroxide (H_2O_2) as per the equation given below :

$2H_2O_2 \xrightarrow{I^-/\text{Alkaline Medium}} 2H_2O + O_2$

The mechanism for this reaction was found to be :

Step I : $H_2O_2 + I^- \rightarrow H_2O + IO^-$ (slow)

Step II : $H_2O_2 + IO^- \rightarrow H_2O + I^- + O2$ (fast)

(a) Write the rate law expression.

(b) Determine the order of reaction with respect to H_2O_2, I^- and overall order of reaction.

(c) What is the molecularity of the reaction in Step II ?

[3 Marks]

Answer: (a) The rate law expression is based on the slow step which is the rate determining step.
Step I: $H_2O_2 + I^- \rightarrow H_2O + IO^-$ (slow)
Rate = $k[H_2O_2][I^-]$

(b) Order with respect to H_2O_2 is 1 because the rate depends on $[H_2O_2]$ to the power 1.
Order with respect to I^- is 1 because the rate depends on $[I^-]$ to the power 1.

Overall order of the reaction = 1 + 1 = 2 (second order reaction).

(c) The molecularity of the reaction in Step II is 2 because two reactant species (H_2O_2 and IO^-) are involved in the elementary step.

Thus, the reaction is first order with respect to both H_2O_2 and I^- and second order overall, and Step II is bimolecular in nature.

Key Points: Rate law depends on slow step - Order with respect to H_2O_2 is 1 - Order with respect to I^- is 1 - Overall order is 2 - Molecularity of Step II is 2 (bimolecular)

Question 33.

Answer the following :

(a) Which isomer of C_4H_9Br is most reactive towards S_N1 reaction ?

(b) Predict the alkene that would be formed by dehydrohalogenation of 1-Bromo-1-methylcyclohexane.

(c) Although chlorine shows strong – I effect, yet it is ortho- and para-directing in electrophilic aromatic substitution reactions. Why

[3 Marks]

Answer: (a) The most reactive isomer of C_4H_9Br towards S_N1 reaction is the tertiary bromide because the carbocation formed after the loss of Br^- is most stable due to alkyl group electron donation and hyperconjugation.
(b) Dehydrohalogenation of 1-Bromo-1-methylcyclohexane produces 1-methylcyclohexene as the major alkene. This occurs by elimination of HBr from the carbon adjacent to the carbon bonded to the Br, forming a double bond in the cyclohexane ring with the methyl substituent at position 1.
(c) Although chlorine shows a strong – I (inductive electron withdrawing) effect, it has a +R (resonance electron donating) effect due to its lone pairs which can delocalize electron density into the benzene ring. This resonance effect dominates in electrophilic aromatic substitution, making chlorine ortho- and para-directing despite its – I effect.

Key Points: Tertiary isomer most reactive for S_N1 - Dehydrohalogenation forms 1-methylcyclohexene - Chlorine's resonance effect causes ortho/para directing despite – I effect

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Section E

Question 34.

(i) Account for the following :

(I) MnO is basic while Mn_2O_7 is acidic.

(II) Iron has higher enthalpy of atomization than that of copper.

(III) Mn^{3+} is a stronger oxidising agent than Cr^{3+}.

(ii) How do you prepare potassium dichromate from sodium chromate ? Write balanced chemical equation for each step.

[5 Marks]

Answer: (i) Account for the following :

(I) MnO is basic because it contains manganese in +2 oxidation state which forms a metal oxide behaving as a base and reacts with acids to form salts. Mn_2O_7 is acidic as manganese is in +7 oxidation state, it is a highly oxidised oxide and reacts with water to form permanganic acid ($HMnO_4$), showing acidic character.

(II) Iron has higher enthalpy of atomization than copper because iron atoms are held together by stronger metallic bonds due to more unpaired electrons available for bonding compared to copper, which has a filled d-subshell and weaker metallic bonds. Thus, more energy is required to atomize iron.

(III) Mn^{3+} is a stronger oxidising agent than Cr^{3+} because Mn^{3+} tends to gain electrons to reach the more stable Mn^{2+} state, whereas Cr^{3+} is more stable and less likely to gain electrons. Thus, Mn^{3+} more readily accepts electrons, making it a stronger oxidising agent.

(ii) Preparation of potassium dichromate from sodium chromate :

Step 1: Acidification of sodium chromate solution with sulfuric acid converts chromate ion (CrO_4^{2-}) into dichromate ion ($Cr_2O_7^{2-}$)

$Na_2CrO_4 + H_2SO_4 \rightarrow Na_2SO_4 + K_2Cr_2O_7$ (balanced as below)

$2\ Na_2CrO_4 + H_2SO_4 \rightarrow Na_2SO_4 + Na_2Cr_2O_7 + H_2O$

Step 2: Potassium dichromate is obtained by double displacement reaction with potassium chloride

$Na_2Cr_2O_7 + 2\ KCl \rightarrow K_2Cr_2O_7 + 2\ NaCl$

Thus, potassium dichromate is prepared from sodium chromate by acidification followed by salt metathesis.

Key Points: MnO basic due to +2 oxidation state and metal oxide nature - Mn2O7 acidic due to +7 oxidation state and formation of permanganic acid - Iron has higher enthalpy of atomization because of stronger metallic bonds from unpaired electrons - Mn3+ is stronger oxidising agent as it reduces to stable Mn2+ - Potassium dichromate prepared by acidifying sodium chromate and then exchanging sodium ions with potassium ions

Question 35.

Answer the following questions :

(i) Why is chemistry of actinoids more complicated as compared to lanthanoids ?

(ii) $E°_M^{2+}/M$ values are not regular for first row transition elements (3d series). Why ?

(iii) Identify the following :

(I) Oxoanion of chromium which is stable in acidic medium.

(II) The lanthanoid element that exhibits +4 oxidation state.

(iv) Write the products obtained on heating $KMnO_4$.

(v) Predict which of the following ions will be coloured in aqueous solution :

Cu^+, Sc^{3+}, Fe^{2+}, Ti^{3+}, Zn^{2+}

[5 Marks]

Answer: (i) The chemistry of actinoids is more complicated than that of lanthanoids because actinoids have 5f, 6d and 7s electrons participating in chemical bonding. Also, the actinoids exhibit a wider range of oxidation states compared to lanthanoids, whose chemistry is largely dominated by +3 state due to 4f electron localization. Moreover, actinoids show more variable ionic sizes and greater radioactive instability.

(ii) The $E°_M^{2+}/M$ values are not regular in first row transition elements because of the irregular variation in stability of half-filled and fully filled d sublevels, changes in atomic size, and differing nuclear charge which affect ionization energies and electron configurations, causing variations in their reduction potentials.

(iii) (I) The oxoanion of chromium stable in acidic medium is the dichromate ion, $Cr_2O_7^{2-}$.

(II) Cerium (Ce) is the lanthanoid element that exhibits +4 oxidation state.

(iv) On heating $KMnO_4$, the products obtained are K_2MnO_4 (potassium manganate), MnO_2 (manganese dioxide), and O_2 (oxygen gas).

(v) Ions coloured in aqueous solution are Cu^+ (has d^{10} but colour arises due to d-d transitions or charge transfer), Fe^{2+} (d^6 configuration), Ti^{3+} (d^1). Sc^{3+} (d^0) and Zn^{2+} (d^{10}) are colourless because they have no d-d transitions possible.

Key Points: Actinoids have 5f and 6d electrons - Actinoids exhibit multiple oxidation states - Lanthanoids mainly show +3 oxidation state - Irregularities in E° values due to electronic configurations - $Cr_2O_7^{2-}$ stable in acidic medium - Cerium exhibits +4 oxidation state - Heating $KMnO_4$ gives K_2MnO_4, MnO_2, O_2 - Cu^+, Fe^{2+}, Ti^{3+} coloured ions - Sc^{3+}, Zn^{2+} colourless ions

Question 36.

(i) How will you bring about the following conversions :

(I) Bromobenzene to 1-phenylethanol

(II) Benzene to m-nitroacetophenone

(ii) An organic compound with the molecular formula C_8H_8O forms 2,4-DNP derivative, reduces Tollens' reagent and undergoes Cannizzaro reaction. On vigorous oxidation with acidic or alkaline $KMnO_4$ it gives Benzene-1,2-dicarboxylic acid. Identify the compound and write the products when it undergoes Cannizzaro reaction.

(iii) Arrange the following compounds in increasing order of their acid strength :

C_6H_5COOH, $O_2N - CH_2 - COOH$, $CF_3 - COOH$, HCOOH

[5 Marks]

Answer: (i) (I) **Conversion of Bromobenzene to 1-phenylethanol:** Step 1: Bromobenzene is treated with magnesium in dry ether to form phenylmagnesium bromide (Grignard reagent). Step 2: Phenylmagnesium bromide is then reacted with acetaldehyde. Step 3: Acidic hydrolysis of the addition product gives 1-phenylethanol.
(II) **Conversion of Benzene to m-nitroacetophenone:** Step 1: Acetophenone is prepared from benzene by Friedel-Crafts acylation using acetyl chloride (CH3COCl) and AlCl3. Step 2: Acetophenone undergoes nitration with a mixture of concentrated HNO3 and H2SO4 to give m-nitroacetophenone because the acetyl group is meta-directing.
(ii) **Identification of the compound:** The compound C8H8O forms 2,4-DNP derivative (indicating a carbonyl group), reduces Tollens reagent (indicating it is an aldehyde), and undergoes Cannizzaro reaction (aldehydes without alpha hydrogens). Its oxidation with KMnO4 yields Benzene-1,2-dicarboxylic acid. Therefore, the compound is o-hydroxybenzaldehyde (salicylaldehyde).
Cannizzaro reaction: Salicylaldehyde undergoes Cannizzaro reaction producing benzyl alcohol and o-hydroxybenzoic acid (salicylic acid) as products.
(iii) **Increasing order of acid strength:** C6H5COOH < O2N-CH2-COOH < HCOOH < CF3-COOH
Explanation: Electron withdrawing groups increase acid strength. CF3 is strongly electron withdrawing, making CF3COOH the strongest acid. Nitro group also increases acidity but less than CF3 group. Formic acid (HCOOH) is stronger than benzoic acid (C6H5COOH) due to resonance stabilization and lack of phenyl group electron donation.

Key Points: Bromobenzene to 1-phenylethanol via Grignard reagent with acetaldehyde - Benzene to m-nitroacetophenone by Friedel-Crafts acylation and nitration - Compound C8H8O is salicylaldehyde based on reactions and oxidation product - Cannizzaro reaction products are benzyl alcohol and salicylic acid - Acid strength order influenced by electron withdrawing groups CF3 > NO2 > H > C6H5

Question 37.

(i) Write the products formed when benzaldehyde reacts with the following reagents :

(I) 2,4-Dinitrophenylhydrazine

(II) Acetophenone in the presence of dilute NaOH followed by heating

(ii) Give reasons for the following :

(I) Benzoic acid does not undergo Friedel-Crafts reaction.

(II) Carboxylic acids have higher boiling point than alcohols of comparable molecular mass.

(iii) Write simple chemical test to distinguish between propanal and propanone.

[5 Marks]

Answer: (i) **Reactions of benzaldehyde:**

(I) With 2,4-Dinitrophenylhydrazine, benzaldehyde forms a yellow or orange precipitate called 2,4-dinitrophenylhydrazone derivative of benzaldehyde. This is a characteristic test for aldehydes and ketones.

$C_6H_5CHO + H_2NNH\text{-}2,4\text{-}(NO_2)_2C_6H_3 \text{ ---> } C_6H_5CH{=}NNH\text{-}2,4\text{-}(NO_2)_2C_6H_3 + H_2O$

(II) Benzaldehyde reacts with acetophenone in the presence of dilute NaOH followed by heating to give an aldol condensation product called cinnamaldehyde (an α,β-unsaturated aldehyde). This reaction involves the formation of β-hydroxy ketone intermediate which on heating undergoes dehydration.

$C_6H_5CHO + C_6H_5COCH_3 \text{ (NaOH) ---> } C_6H_5CH{=}CHC_6H_4CHO + H_2O$

(ii) **Reasons:**

(I) Benzoic acid does not undergo Friedel-Crafts reaction because the -COOH group is strongly deactivating and meta directing due to its electron withdrawing effect and also it reacts with $AlCl_3$ catalyst forming a complex, thus poisoning the catalyst and preventing the reaction.

(II) Carboxylic acids have higher boiling points than alcohols of comparable molecular mass because carboxylic acids form dimers through strong hydrogen bonding involving two hydrogen bonds per dimer, whereas alcohols form hydrogen bonds individually. This increases the intermolecular forces and thus boiling points.

(iii) **Chemical test to distinguish propanal and propanone:**

Use Tollen's reagent (ammoniacal silver nitrate). Propanal (an aldehyde) gives a silver mirror with Tollen's reagent, whereas propanone (a ketone) does not give this reaction. Thus, silver mirror test distinguishes them.

Key Points: Benzaldehyde forms 2,4-DNP derivative with 2,4-DNP - Benzaldehyde and acetophenone undergo aldol condensation in dilute NaOH - Benzoic acid does not

undergo Friedel-Crafts due to catalyst poisoning - Carboxylic acids have higher boiling point due to dimer formation - Tollen's test distinguishes aldehydes and ketones

Question 38.

(i) Calculate E°_cell for the following reaction which is at equilibrium :

$Cu\ (s) + 2Ag^{+}\ (aq) \rightleftharpoons Cu^{2+}\ (aq) + 2Ag\ (s)$

Equilibrium constant (K_c) for the cell is 10^{15}.

[Given : log 10 = 1]

(ii) Write anode, cathode and overall reaction of lead storage battery when it is in use.

(iii) How much electricity is required in coulombs for the oxidation of 1 mol of FeO to Fe_2O_3?

[5 Marks]

Answer: (i) This reaction is at equilibrium so E_cell = 0 V.
We use the relation E°_cell = (0.059 / n) * log K_c, where n = number of electrons transferred.
Here, Cu → Cu²+ + 2e⁻, and $2Ag^{+} + 2e^{2} \rightarrow 2Ag$, so n = 2.
Given K_c = 10^{i5} and log 10 = 1.
So, E°_cell = (0.059 / 2) * 15 = 0.059 * 7.5 = 0.4425 V.

(ii) **Lead storage battery reactions when in use:**
Anode (oxidation): $Pb\ (s) + SO_4^{2-}\ (aq) \rightarrow PbSO_4\ (s) + 2e^{-}$
Cathode (reduction): $PbO_2\ (s) + SO_4^{2-}\ (aq) + 4H^{+}\ (aq) + 2e^{-} \rightarrow PbSO_4\ (s) + 2H_2O\ (l)$
Overall reaction: $Pb\ (s) + PbO_2\ (s) + 2H_2SO_4(aq) \rightarrow 2PbSO_4\ (s) + 2H_2O\ (l)$

(iii) To oxidize 1 mole of FeO to Fe_2O_3, first write the oxidation reaction:
$4FeO + O_2 \rightarrow 2Fe_2O_3$
Fe changes oxidation state from +2 (FeO) to +3 (Fe_2O_3), so 1 mole Fe loses 1 electron.
For 4 moles Fe, 4 moles electrons are lost.
So, 1 mole FeO loses 1 mole electrons.

Charge required = n * F = 1 mole electrons * 96500 C/mole = 96500 C.

Thus, 96500 coulombs of electricity are required for the oxidation of 1 mole of FeO to Fe_2O_3.

Key Points: E_cell = (0.059 / n) * log K_c - Lead storage battery reactions: anode, cathode and overall reaction - Charge calculation using moles of electrons and Faraday's constant

Question 39.

(i) Conductivity of 0·0024 M acetic acid is $7{\cdot}2 \times 10^{-5}$ S cm^{-1}. If Λ°_m for acetic acid is 390·5 S cm^2 mol^{-1}, then calculate the degree of dissociation (α) of acetic acid.

(ii) Calculate the cell potential for the following half cell reaction at 25ºC :

$Ag^+(aq) + 1\ e^- \rightarrow Ag\ (s)$

Given that : $[Ag^+] = 0{\cdot}01$ M and

$E^\circ_{Ag^+/Ag} = +\ 0{\cdot}80$ V

[log 10 = 1]

(iii) Write the name of the electrolyte used in :

(I) Dry cell

(II) Fuel cell ($H_2 – O_2$)

[5 Marks]

Answer: (i) Given:
Concentration, c = 0.0024 M
Conductivity, κ = 7.2 × 10⁻5 S cm⁻1
Molar conductivity at infinite dilution, Λ°_m = 390.5 S cm^2 mol^{-1}

Step 1: Calculate molar conductivity, $\Lambda_m = \kappa / c = (7.2 \times 10^{-5}) / 0.0024 = 0.03$ S cm^2 mol^{-1}

Step 2: Calculate degree of dissociation, $\alpha = \Lambda_m / \Lambda^\circ_m = 0.03 / 390.5 = 7.68 \times 10^{-5}$

Thus, the degree of dissociation α of acetic acid is 7.68×10^{-5}.

(ii) Given:
$E^\circ = +0.80$ V
$[Ag^+] = 0.01$ M
T = 25 ºC
Number of electrons, n = 1
R = 8.314 J mol^{-1} K^{-1}, F = 96500 C mol^{-1}, T in K = 298 K

Using Nernst equation:
$E = E^\circ - (RT / nF) * \ln(1 / [Ag^+])$
Since log 10 = 1 and ln = 2.303 * log,
$E = 0.80 - (0.0591 / 1) * \log(1 / 0.01)$
$E = 0.80 - 0.0591 * 2 = 0.80 - 0.1182 = 0.6818$ V

Therefore, the cell potential is 0.6818 V.

(iii)

(I) Electrolyte used in dry cell: Zinc chloride ($ZnCl_2$) or ammonium chloride (NH_4Cl)

(II) Electrolyte used in fuel cell ($H_2 – O_2$): Concentrated phosphoric acid (H_3PO_4)

This completes the solution for all parts.

Key Points: Calculate molar conductivity from conductivity and concentration - Use $\alpha = \Lambda_m / \Lambda^\circ_m$ for degree of dissociation - Apply Nernst equation properly for cell potential - Know electrolytes in dry cell and fuel cell