CBSE EXAMINATION PAPER-2024

CHEMISTRY

(Solved)

Time allowed : 3 hours | Maximum Marks : 72

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 5** are case based questions

iv. **Section B** – questions number **6 to 21** are multiple choice questions

v. **Section C** – questions number **22 to 27** are very short answer

vi. **Section D** – questions number **28 to 34** are short answer

vii. **Section E** – questions number **35 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. The nature of bonding, structure of the coordination compound can be explained to some extent by valence bond theory. The central metal atom/ion makes available a number of vacant orbitals equal to its coordination number. The appropriate atomic orbitals (s, p and d) of the metal hybridise to give a set of equivalent orbitals of definite geometry such as square planar, tetrahedral, octahedral and so on. A strong covalent bond is formed only when the orbitals overlap to the maximum extent. The d-orbitals involved in the hybridisation may be either inner d-orbitals i.e. (n-1)d or outer d-orbitals i.e. nd. The complexes formed are called inner orbital complex (low spin complex) and outer orbital complex (high spin complex) respectively. Further, the complexes can be

paramagnetic or diamagnetic in nature. The drawbacks of this theory are that this involves number of assumptions and also does not explain the colour of the complex.

Question 2.

Question 3.

20. The nature of bonding, structure of the coordination compound can be explained to some extent by valence bond theory. The central metal atom/ion makes available a number of vacant orbitals equal to its coordination number. The appropriate atomic orbitals (s, p and d) of the metal hybridise to give a set of equivalent orbitals of definite geometry such as square planar, tetrahedral, octahedral and so on. A strong covalent bond is formed only when the orbitals overlap to the maximum extent. The d-orbitals involved in the hybridisation may be either inner d-orbitals i.e. (n—l) d or outer d-orbitals i.e. nd. The complexes formed are called inner orbital complex (low spin complex) and outer orbital complex (high spin complex) respectively. Further, the complexes can be paramagnetic or diamagnetic in nature. The drawbacks of this theory are that this involves number of assumptions and also does not explain the colour of the complex.

Answer the following questions :

Question 4.

The following questions are case-based questions. Read the case carefully a answer the questions that follow.

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Answer the following questions:

(1)

Predict whether $(CoF_6)^{3-}$ is diamagnetic or paramagnetic and why?

[Atomic number: Co=27]

[1 Marks]

Answer: Answer: Co in $(CoF_6)^{3-}$ has oxidation state +3 with electronic configuration $3d^6$. F is a weak field ligand causing no pairing of electrons, so the complex is high spin and paramagnetic due to unpaired electrons. This aligns with valence bond theory where outer d orbitals are used for hybridisation forming a high spin complex.

Key Points: Co oxidation state +3 - F ligand is weak field causing high spin - Complex is paramagnetic due to unpaired electrons

(2)

What is the coordination number of Co in $[Co(en)_2, Cl_2]^+$?

[1 Marks]

Answer: Answer: In the complex $[Co(en)_2Cl_2]^+$, the ligand 'en' (ethylenediamine) is bidentate, so each 'en' ligand donates 2 coordination sites. There are 2 'en' ligands, giving 4 coordination sites, and 2 chloride ions, each donating 1 site. Hence, the total coordination number of Co is 4 + 2 = 6 according to the valence bond theory described in the case passage.
Explanation: Coordination number equals total number of donor atoms bonded to the central metal. Here it is 6.

Key Points: Coordination number equals number of donor atoms - ‘en’ is bidentate ligand donating 2 sites each - Total coordination sites = 4 (from 2 en) + 2 (from 2 Cl) = 6

(3)

(i) Write the IUPAC name of the given complex

$[Pt(NH_3)_2 Cl_2]^{2+}$

(ii) Explain $[Co(NH_3)_6]^{3+}$ is an inner orbital or outer orbital complex.

[2 Marks]

Answer: (i) The IUPAC name of the complex $[Pt(NH_3)_2Cl_2]^{2+}$ is diamminedichloroplatinum(IV).

(ii) $[Co(NH_3)_6]^{3+}$ is an inner orbital complex because cobalt uses its (n-1)d orbitals for hybridisation forming low spin complexes as explained by valence bond theory in the case passage.

Key Points: IUPAC name of complex- Use of (n-1)d orbitals in inner orbital complex- low spin complexes explained by valence bond theory

(4)

Using valence bond theory, deduce the shape and hybridisation of $[Ni(NH_3)_6]^{2+}$ Atomic nomber of Ni =28]

[2 Marks]

Answer: Using valence bond theory for $[Ni(NH_3)_6]^{2+}$ with atomic number 28, Ni has the electronic configuration $3d^8\ 4s^2$. In the complex, Ni^{2+} loses two 4s electrons resulting in $3d^8$. The 3d orbitals pair up electrons to form inner d^2sp^3 hybridisation using two 3d, one 4s and three 4p orbitals. This leads to an octahedral geometry. The strong field NH_3 ligand causes low spin complex formation as explained in the case passage.

Key Points: Ni electronic configuration is 3d8 4s2 - Ni2+ ion has 3d8 configuration - Inner d2sp3 hybridisation forms octahedral shape - NH3 ligand causes pairing resulting in low spin complex

Question 5.

In a galvanic cell, chemical energy of a redox reaction is converted into electrical energy, whereas in an electrolytic cell the redox reaction occurs on passing electricity. The simplest galvanic cell is in which Zn rod is placed in a solution of $ZnSO_4$, and Cu rod is placed in a solution of $CuSO_4$. The two

rods are connected by a metallic wire through a voltmeter. The two solutions are joined by a salt bridge. The difference between the two electrode potentials of the two electrodes is known as electromotive force. In the process of electrolysis, the decomposition of a substance takes place by passing an electric current. One mole of electric charge when passed through a cell will discharge half a mole of a divalent metal ion such as Cu^{2+} This was first formulated by Faraday in the form of laws of electrolysis.

(1)

What is the function of a salt bridge in a galvanic cell?

[1 Marks]

Answer: The salt bridge in a galvanic cell maintains the flow of ions and preserves electrical neutrality by allowing ions to move between the two solutions, preventing charge buildup. This keeps the redox reaction continuous and allows the cell to produce electricity, as explained in the passage.

Key Points: maintains electrical neutrality - allows ion flow between solutions - prevents charge buildup stopping the reaction

(2)

When does galvanic cell behave like an electrolytic cell?

[1 Marks]

Answer: Answer: A galvanic cell behaves like an electrolytic cell when an external voltage greater than its emf is applied in the opposite direction. This reverses the cell reaction, making the spontaneous reaction nonspontaneous, so electrical energy drives the reaction as in electrolysis. Hence, the cell acts as an electrolytic cell under these conditions.

Key Points: Galvanic cell converts chemical energy to electrical energy - Applying external voltage greater than emf reverses reaction - Cell behaves like electrolytic cell when reaction becomes nonspontaneous

(3)

How much charge in terms of Faraday is required for the following:

(1) 1 mal of MnO^{-}_{4} to M n^{2+}

(ii) 1 mol of H_2O to O_2

[2 Marks]

Answer: According to Faraday's laws of electrolysis mentioned in the case, 1 mole of electric charge (1 Faraday) discharges 0.5 mole of divalent ions. (i) For MnO_4^- to Mn^{2+}, the change involves 5 electrons, so 1 mole needs 5 Faradays of charge. (ii) For H_2O to O_2, 4 electrons are involved, so 1 mole requires 4 Faradays. Thus, the charge in terms of Faraday is 5 for MnO_4^- to Mn^{2+} and 4 for H_2O to O_2.

Key Points: Faraday's laws of electrolysis - Electron transfer for MnO_4^- to Mn^{2+} is 5 - Electron transfer for H_2O to O_2 is 4

(4)

Can copper sulphate solution be stored in a pot made of zinc ?

Explain with the help of the value of E° cell.

(E° Cu^{2+} / Cu = 0.34V)

(E° Zn^{2+} / Zn = - 0.76V)

[2 Marks]

Answer: Copper sulphate solution contains Cu□⁺ ions and a zinc pot is made of Zn metal. The electrode potential of Cu□⁺ / Cu is +0.34 V and that of Zn□⁺ / Zn is -0.76 V. The cell voltage E^+ cell = E° Cu□⁺ / Cu - E° Zn□⁺ / Zn = 0.34 - (-0.76) = 1.10 V, which is positive. This means Zn will oxidize and Cu□⁺ will reduce causing zinc pot to corrode and copper to deposit. Hence, storing copper sulphate solution in a zinc pot is not safe as the pot will get damaged (corroded).

Key Points: Copper sulphate contains Cu□⁺ ions - Zinc has lower electrode potential than copper - Positive cell voltage causes zinc to oxidize, copper ion to reduce - Zinc pot corrodes and copper deposits - Therefore, copper sulphate cannot be stored in zinc pot

Section B

Question 6.

The molar ionic conductivities of Ca^{2+} and Cl– are 119.0 and 76.3 S cm^2 mol^{-1} respectively. The value of limiting molar conductivity of $CaCl_2$ will be

[1 Marks]

(A) 195.3 S cm^2 mol^{-1}

(B) 271.6 S cm^2 mol^{-1}

(C) 314.3 S cm^2 mol^{-1}

(D) 433.8 S cm^2 mol^{-1}

Explanation: The limiting molar conductivity of $CaCl_2$ can be calculated using Kohlrausch's law: $\Lambda_0 m = \lambda_0(Ca^{2+}) + 2 \times \lambda_0(Cl^-) = 119.0 + 2 \times 76.3 = 271.6$ S cm^2 mol^{-1}. Hence, the correct answer is 271.6 S cm^2 mol^{-1}.

Question 7.

Which of the following acids represents Vitamin C?

[1 Marks]

(A) Benzoic acid

(B) Saccharic acid

(C) Gluconic acid

(D) Ascorbic acid

Explanation:

The correct answer is Ascorbic acid, as it is the chemical name for Vitamin C, which is vital for various bodily functions, including the maintenance of healthy skin, blood vessels, bones, and cartilage.

Question 8.

Rosenmund reduction is used for the preparation of Aldehydes. The catalyst used in this reaction is.

[1 Marks]

(A) Iron (II) oxide

(B) Pd-$BaSO_4$

(C) $HgSO_4$

(D) Anhydrous $AlCl_3$

Explanation:

The correct answer is Pd-$BaSO_4$. In the Rosenmund reduction, palladium on barium sulfate (Pd-$BaSO_4$) is used as a catalyst to selectively reduce acyl chlorides to aldehydes in the presence of hydrogen.

Question 9.

Which alkyl halide from the given options will undergo SN1 reaction faster?

[1 Marks]

(A) $(CH_3)_3C$-Br

(B) CH_3-CH_2-Br

(C) $(CH_3)_2CH$-Br

(D) $(CH_3)_3C$-CH_2-Br

Explanation:

The correct option is $(CH_3)_3C$-Br, which is a tertiary alkyl halide. SN1 reactions generally proceed more quickly with tertiary substrates due to the stability of the carbocation formed during the reaction. In contrast, primary and secondary alkyl halides do not stabilize the carbocation as effectively, making $(CH_3)_3C$-Br the fastest to undergo an SN1 reaction.

Question 10.

From the elements of 3d series given below, which element shows the maximum number of oxidation states?

[1 Marks]

(A) Manganese

(B) Titanium

(C) Scandium

(D) Chromium

Explanation:

Manganese shows the maximum number of oxidation states in the 3d series, with a total of seven oxidation states ranging from -3 to +7, due to its electronic configuration and the ability to lose or share its 3d and 4s electrons.

Question 11.

The correct Mathematical expression of Arrhenius equation is

[1 Marks]

(A) $k = A\, e^{Ea/RT}$

(B) $k = Ae^{-Ea/RT}$

(C) $k = e^{Ea/RT}$

(D) $k = -A\, e^{Ea/RT}$

Explanation: The Arrhenius equation expresses the rate constant k as k = A exp(-E_a/RT), where A is the frequency factor, E_a is the activation energy, R is the gas constant, and T is the temperature. This shows that the rate constant depends exponentially on the negative ratio of activation energy to thermal energy. Therefore, the correct expression is k = Ae^{-E_a/RT}.

Question 12.

Identify the tertiary amine from the following:

[1 Marks]

(A) $CH_3–NH–CH_2–CH_3$

(B) $CH_3–CH(NH_2)–CH_3$

(C) $(C_2H_5)_2CHNH_2$

(D) $CH_3–N(CH_3)–CH_3$

Explanation:

The correct answer is $CH_3–N(CH_3)–CH_3$, which is a tertiary amine. Tertiary amines have the structure R_3N, where R represents alkyl groups. In this case, the nitrogen atom is bonded to three methyl groups (CH_3), which classifies it as tertiary. The other options represent primary or secondary amines based on their structures.

Question 13.

Nucleophilic addition of Grignard reagent to ketones followed by hydrolysis with dilute acids forms

[1 Marks]

(A) Tertiary alcohol

(B) Alkene

(C) Primary alcohol

(D) Secondary alcohol

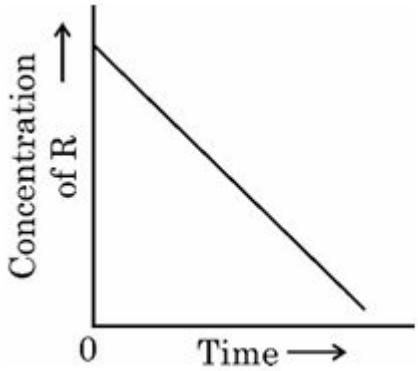
Explanation:

The correct answer is 'Tertiary alcohol' because when a Grignard reagent adds to a ketone, it forms a tertiary alcohol after hydrolysis. According to the context provided, nucleophilic addition to ketones yields a tertiary alcohol, while primary alcohols are produced from aldehydes.

Question 14.

In a given graph of zero order reaction, the slope and intercept are:

[1 Marks]



(A) Slope = k, Intercept = $[R]_0$

(B) Slope = k/2.303, Intercept = $\ln[R]_0$

(C) Slope = -k/2.303, Intercept = n

(D) Slope = -k, Intercept = $[R]_0$

Explanation:

The correct option is 'Slope = -k, Intercept = $[R]_0$'. In a zero-order reaction, the concentration of the reactant [R] decreases linearly over time, so the graph of [R] vs. time has a slope equal to -k (where k is the rate constant) and the y-intercept is the initial concentration $[R]_0$.

Question 15.

Match the reagents required for the given reactions

[1 Marks]

Match the reagents required for the given reactions :

I.	Oxidation of primary alcohols to aldehydes	(p)	$NaBH_4$
II.	Butan-2-one to Butan-2-*ol*	(q)	85% phosphoric acid at 440 K
III.	Bromination of Phenol to 2, 4, 6-Tribromophenol	(r)	PCC
IV.	Dehydration of propan-2-ol to propene	(s)	Bromine water

(A) I - (s) II - (q) III (p), IV - (r)

(B) I - (q)II - (r) III (p), IV - (s)

(C) I - (r) II - (p) III -(s), IV - (q)

(D) I - (p) II - (s) III (r), TV - (q)

Explanation:

The correct option is I - (p), II - (s), III - (r), IV - (q). This matches the reagents to the specified reactions describing how different chemical species interact, such as Cu(II) oxidizing I-ions and the comparative behavior of bromine with iodide ions. The context indicates that certain reagents are required for specific interactions and these match correctly in the provided option.

Question 16.

Assertion (A): p-nitrophenol is less acidic than phenol. Reason

(R): Nitro group is electron withdrawing and helps in the stabilization of p-nitrophenoxide ion.

[1 Marks]

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

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

Explanation:

Assertion (A) is false, but Reason (R) is true. p-Nitrophenol is actually more acidic than phenol due to the strong electron-withdrawing effect of the nitro group, which stabilizes the p-nitrophenoxide ion.

This contradicts the assertion.

Question 17.

Assertion (A): Benzoic acid does not undergo Friedel–Crafts reaction. Reason

(R): Carboxyl group is deactivating and the catalyst aluminium chloride gets bonded to the carboxyl group.

[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). While it's true that the carboxyl group is a deactivating group that prevents Friedel-Crafts reactions, the explanation that aluminium chloride bonds to the carboxyl group is inaccurate. The main reason for the lack of reaction is the electron-withdrawing nature of the carboxyl group, which decreases the electrophilicity of the aromatic ring.

Question 18.

Assertion (A): Fructose is a reducing sugar.

Reason (R): Fructose does not reduce Fehling solution and Tollen's reagent.

[1 Marks]

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

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

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

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

Explanation:

Assertion (A) is true, but Reason (R) is false. Fructose is indeed a reducing sugar as it can reduce Fehling's solution and Tollen's reagent under certain conditions, despite it being a ketose, which may not react as easily as aldoses.

Question 19.

Assertion (A): For a Daniell cell, Zn/Zn^{2+} (1 M)| | Cu^{2+} (1 M)/Cu with E° cell = 1.1 V, if the external opposing potential is more than 1.1 V, the electrons flow from Cu to Zn. Reason

(R): Cell acts like a galvanic cell.

[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, 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 assertion is correct because when the external opposing voltage exceeds the cell's standard emf (1.1 V), the cell undergoes a reverse reaction and electrons flow from the copper electrode to the zinc electrode, opposite to the normal (spontaneous) direction. The reason states that the cell acts like a galvanic cell, which is true under normal operation (when external voltage is less than 1.1 V). However, when the external voltage is greater than 1.1 V, the cell acts like an electrolytic cell, not a galvanic cell. Therefore, although both the assertion and reason are true statements, the reason is not the correct explanation for the assertion.

Question 20.

The general electronic configuration of d-block elements is :

[1 Marks]

(A) $(n-1)d^{1-10}\ ns^{1-2}$

(B) $(n-1)d^{10}\ ns^{2\ -3}$

(C) $(n-1)\ d^{0}\ ns^{1-2}$

(D) $(n-1)d^{10}\ ns^{1-2}$

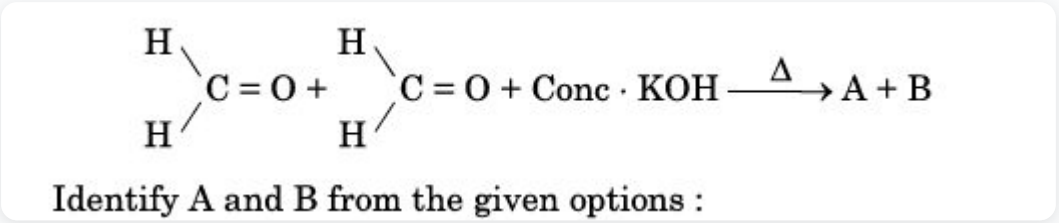
Explanation:

The correct option is (n-1)d^{10} ns^{1-2} because d-block elements, which include transition metals, typically have their outermost electrons filling the d subshell. The general configuration indicates that the d-subshell can hold a maximum of 10 electrons while the s-subshell can hold 2, leading to the configuration of (n-1)d^{10} ns^{1-2}.

Question 21.

Consider the following reaction :

[-1 Marks]



Identify A and B from the given options :

(A) A- Methanol, B -Potassium formate

(B) A- Ethanol, B -Potassium formate

(C) A- Methanol, B -Potassium acetate

(D) A- Methanol, B -Potassium Ethanol

Explanation: The reaction produces methanol (CH3OH), which contains the alcohol -OH group, and potassium formate (HCOOK) as the products. Therefore, the correct option is A- Methanol, B - Potassium formate.

Section C

Question 22.

Define the following terms:

(a) Order of a reaction

(b) Activation energy

[2 Marks]

Answer: (a) **Order of a reaction** is the sum of the powers of the concentration terms in the rate law of the reaction. It indicates how the rate depends on the concentration of reactants.
(b) **Activation energy** is the minimum amount of energy that reacting molecules must have to start a chemical reaction. It is the energy barrier that must be overcome for reactants to transform into products.

Key Points: Order is determined from the rate law - Order shows dependency of rate on concentration - Activation energy is the minimum energy needed for reaction to occur

Question 23. 18 g of a non-volatile solute is dissolved in 200 g of H_2O that freezes at 272.07 K. Calculate the molecular mass of the solute (Kf for water = 1.86 K kg mol^{-1}).

[2 Marks]

Answer: Given: Mass of solute (w_2) = 18 g, Mass of solvent (w_1) = 200 g, Freezing point of solution = 272.07 K, Normal freezing point of water = 273.15 K, K_f = 1.86 K kg mol^{-1}

Step 1: Calculate freezing point depression, ΔT_f = 273.15 K - 272.07 K = 1.08 K

Step 2: Use formula for molecular mass M = (K_f * w_2 * 1000) / (ΔT_f * w_1)

Step 3: Substitute values: M = (1.86 * 18 * 1000) / (1.08 * 200) = (33480) / (216) = 155 g/mol

Answer: Molecular mass of the solute is 155 g/mol.

Key Points: Calculate freezing point depression - Use formula M = (Kf * mass solute * 1000) / (ΔTf * mass solvent) - Substitute given values correctly to find molecular mass

Question 24.

(a) Which compound in the given pair would undergo substitution reaction at a faster rate and why?
(a) CH_3 — CH_2 — I and CH_3 — CH_2 — Br.

(b) Arrange the following compounds in the increasing order of their boiling points:

Butane, 1-Bromobutane, 1-Iodobutane, 1-Chlorobutane.

[2 Marks]

Answer: (a) CH3 — CH2 — I undergoes substitution reaction faster than CH3 — CH2 — Br because the carbon-iodine bond is weaker and longer, making it easier to break. Iodide ion is a better leaving group than bromide ion, so the substitution reaction proceeds faster.
(b) Increasing order of boiling points is: Butane < 1-Chlorobutane < 1-Bromobutane < 1-Iodobutane. This is because boiling point increases with increasing molecular weight and polarizability of the halogen atom in the compound.

Key Points: Iodide ion is better leaving group than bromide - C-I bond weaker than C-Br bond - Boiling points increase with molecular weight and polarizability - Order: Butane < 1-Chlorobutane < 1-Bromobutane < 1-Iodobutane

Question 25.

Write the stepwise mechanism of nucleophilic addition reactions in the carbonyl compounds

[2 Marks]

Answer: Stepwise mechanism of nucleophilic addition in carbonyl compounds:

1. The carbonyl compound has a polar C=O bond where carbon is electrophilic due to oxygen's higher electronegativity.
2. A nucleophile, which is an electron-rich species, attacks the electrophilic carbon atom in the carbonyl group from a direction perpendicular to its plane.
3. The attack changes carbon's hybridisation from sp^2 to sp^3, breaking the double bond and forming a tetrahedral alkoxide intermediate.
4. In the intermediate, the oxygen bears a negative charge, which can be stabilized by protonation.
5. Finally, protonation of the alkoxide oxygen results in the formation of an alcohol.

This mechanism explains why nucleophilic addition is common in aldehydes and ketones.

Key Points: Nucleophile attacks electrophilic carbon in carbonyl group - Carbon hybridisation changes from sp2 to sp3 forming tetrahedral intermediate - Alkoxide intermediate gets protonated to form alcohol

Question 26.

How will you convert with following :

(i) Toluene to benzoic acid

(ii) Ethanol to 3- Hydroxybutanal

[2 Marks]

Answer: (i) Conversion of Toluene to Benzoic Acid: Toluene is oxidized by heating it with alkaline potassium permanganate ($KMnO_4$) solution. The methyl side chain is oxidized to a carboxylic acid group, giving benzoic acid (C_6H_5COOH).

(ii) Conversion of Ethanol to 3-Hydroxybutanal: First, ethanol undergoes aldol condensation. Two molecules of ethanal (formed by oxidation of ethanol) undergo base-catalyzed aldol condensation to form 3-hydroxybutanal.

Key Points: Toluene oxidized by KMnO4 to benzoic acid - Ethanol oxidized to ethanal - Aldol condensation forms 3-hydroxybutanal

Question 27.

(a) What happens when glucose reacts with bromine water? write chemical equation.

(b) Two bases are mentioned below, identify which is present in DNA and which one is present in RNA:

(i) Thymine (ii) Uracil

[2 Marks]

Answer: (a) When glucose reacts with bromine water, bromine water gets decolorised and glucose is oxidised to gluconic acid. The chemical equation is:

$C_6H_{12}O_6 + Br_2 + H_2O \rightarrow C_6H_{12}O_7 + 2HBr$.

(b) (i) Thymine is a nitrogenous base present in DNA.

(ii) Uracil is a nitrogenous base present in RNA.

> **Key Points: Glucose oxidises bromine water to gluconic acid - Thymine is present in DNA - Uracil is present in RNA**

Section D

Question 28.

(a) Draw the geometrical isomers of the given complex :

$[Pt(en)_2Cl_2]^{2+}$

(b) Write the electronic configuration for d4 ion if $\Delta_o < P$ on the basis of crystal field theory.

(c) What is meant by a unidentate ligand ? Give an example.

[3 Marks]

Answer: (a) The complex [Pt(en)\u2082Cl\u2082]$^{2+}$ shows geometrical isomerism due to the positions of two Cl ligands. The two geometrical isomers are:

1. Cis-isomer: Both Cl ligands are adjacent to each other.

2. Trans-isomer: Cl ligands are opposite to each other.

Because en is a bidentate ligand, it occupies two coordination positions, so the arrangement of Cl ligands defines the isomerism.

(b) For a d^4 ion with crystal field splitting energy \u0394\u208a less than pairing energy P (\u0394\u208a < P), the complex is high spin. The electronic configuration is:

$t_{2g}^3\ e_g^1$ (i.e., three electrons occupy lower energy t_{2g} orbitals singly, and one electron occupies higher

energy e_g orbital unpaired).

(c) A unidentate ligand is a ligand that can coordinate to the central metal atom through only one donor atom (one coordination site).

Example: Cl^- (chloride ion) is a unidentate ligand as it binds through one atom only.

Key Points: Geometrical isomers are cis and trans forms - d4 high spin electronic configuration is t2g3 eg1 for Delta o less than P - Unidentate ligand binds through one donor atom e.g. Cl-

Question 29.

Calculate emf of the following cell at 25∘C :

$Sn/Sn^{2+}(0.001M)\ ||\ H^+(0.01M)|H_2(g)(1\ bar)\ |\ Pt_{(s)}$

Given : $E^\circ(Sn^{2+}/Sn)=-0.14\ V, E^\circ H+/H_2=0.00\ V (log10=1)$

[3 Marks]

Answer: Given cell is: Sn | Sn^{2+} (0.001 M) || H^+ (0.01 M) | H_2 (1 bar) | Pt The half reactions and their standard electrode potentials are:

$Sn^{2+} + 2e^- \rightarrow Sn$; E° = -0.14 V (reduction)

$2H^+ + 2e^- \rightarrow H_2$; E° = 0.00 V (reduction)

In the cell notation, Sn electrode is on left and hydrogen electrode on right. Sn is being oxidized and H^+ reduced.

Oxidation half-reaction: $Sn \rightarrow Sn^{2+} + 2e^-$; E°_ox = +0.14 V

Reduction half-reaction: $2H^+ + 2e^- \rightarrow H_2$; E°_red = 0.00 V

Cell reaction: $Sn + 2H^+ \rightarrow Sn^{2+} + H_2$

Now use Nernst equation for the cell at 25 degC:

E = E°_cell - (0.0592/2) * log Q

Where, E°_cell = E°_red - E°_ox = 0.00 - (-0.14) = +0.14 V

Reaction quotient Q = $[Sn^{2+}] / [H^+]^2$ = 0.001 / (0.01)^2 = 0.001 / 0.0001 = 10

So, log Q = log 10 = 1

Therefore, E = 0.14 - (0.0592 / 2) * 1 = 0.14 - 0.0296 = 0.1104 V

Answer: The emf of the cell at 25 degC is approximately 0.11 V.

Key Points: Identify electrode potentials - Determine cell reaction and standard emf - Use Nernst equation with given concentrations - Calculate reaction quotient Q - Compute emf at given conditions

Question 30.

Write chemical equations for the following reactions : (Do any three)

(a) Hydroboration — oxidation reaction

(b) Williamson Synthesis

(c) Friedel-Crafts Alkylation of Anisole

(d) Reimer-Tiemann Reaction

[3 Marks]

Answer: (a) **Hydroboration - Oxidation reaction:** This reaction converts an alkene into an alcohol.
Equation: CH_3-CH=CH_2 + BH_3 → CH_3-CH_2-CH_2BH_2 (hydroboration)
Then, CH_3-CH_2-CH_2BH_2 + H_2O_2 / OH^- → CH_3-CH_2-CH_2OH + $B(OH)_3$ (oxidation)
This forms 1-propanol by adding -OH group to the less substituted carbon.

(b) **Williamson Synthesis:** This reaction synthesizes ethers from an alkoxide ion and an alkyl halide.
Equation: C_2H_5ONa + CH_3I → C_2H_5-O-CH_3 + NaI
Here, ethoxide ion reacts with methyl iodide to form ethyl methyl ether.

(c) **Friedel-Crafts Alkylation of Anisole:** Anisole reacts with an alkyl halide in the presence of $AlCl_3$ to give alkylated anisole.
Equation: $C_6H_5OCH_3$ + CH_3Cl + $AlCl_3$ → CH_3-C_6H_4-OCH_3 + HCl
Alkyl group substitutes at the ortho and para positions of anisole.

(d) **Reimer-Tiemann Reaction:** Phenol reacts with chloroform and sodium hydroxide to form salicylaldehyde.
Equation: C_6H_5OH + $CHCl_3$ + 3NaOH → $C_6H_4(OH)CHO$ + 3NaCl + $2H_2O$
A formyl group is introduced at the ortho position of phenol to give salicylaldehyde.

> **Key Points: Hydroboration-oxidation converts alkenes to alcohols via anti-Markovnikov addition-Williamson synthesis produces ethers via alkoxide and alkyl halide reaction-Friedel-Crafts alkylation adds alkyl groups to anisole using AlCl3-Reimer-Tiemann reaction formylates phenol using chloroform and NaOH**

Question 31.

(a) Give chemical tests to distinguish between the following pairs of compounds :

(i) Phenol and Benzoic acid

(ii) Propanal and Propanone

(b) Which one of the given compounds is a stronger acid and why ?

$CH_2FCH_2CH_2COOH$ or CH_3CHFCH_2COOH

[3 Marks]

Answer: (a)(i) To distinguish between Phenol and Benzoic acid:
- Take dilute iron(III) chloride solution and add it to each compound. Phenol gives a violet or purple color with $FeCl_3$ due to the formation of a phenol-Fe complex, whereas benzoic acid does not give any color.
- Add sodium bicarbonate ($NaHCO_3$) solution to each. Benzoic acid reacts with $NaHCO_3$ releasing carbon dioxide gas (effervescence), but phenol does not react.
(ii) To distinguish between Propanal and Propanone:
- Use Brady's reagent (2,4-dinitrophenylhydrazine). Both aldehyde and ketone give a yellow/orange precipitate.
- Use Tollens' test (ammoniacal silver nitrate solution). Propanal (aldehyde) gives silver mirror or black precipitate whereas propanone (ketone) gives no reaction.
(b) $CH_2FCH_2CH_2COOH$ is a stronger acid than CH_3CHFCH_2COOH because the fluorine atom in $CH_2FCH_2CH_2COOH$ is closer to the carboxyl group and exerts stronger electron-withdrawing inductive effect (-I effect). This stabilizes the conjugate base more effectively, increasing acidity. In the second compound, the fluorine is further away or less effectively positioned, so the acid strength is lower.

Key Points: Chemical test FeCl3 for phenol - NaHCO3 test for benzoic acid - Tollens test distinguishes aldehyde from ketone - Inductive effect influences acid strength

Question 32.

Explain the following terms :

(a) Essential amino acids

(b) Peptide bond

(c) Denaturation

[3 Marks]

Answer: (a) **Essential amino acids** are amino acids that cannot be made by the human body and must be obtained from food. They are necessary for protein synthesis and normal body functions.
(b) **Peptide bond** is a chemical bond formed between the carboxyl group (-COOH) of one amino acid and the amino group (-NH2) of another amino acid through a dehydration reaction. This bond links amino acids into polypeptides, forming proteins.
(c) **Denaturation** is the process in which the three-dimensional structure of a protein is altered by external factors like heat, pH changes, or chemicals, causing the protein to lose its natural shape and function. Denaturation is usually irreversible.

Key Points: Essential amino acids must be obtained from diet - Peptide bond links amino acids by dehydration reaction - Denaturation alters protein structure causing loss of function

Question 33.

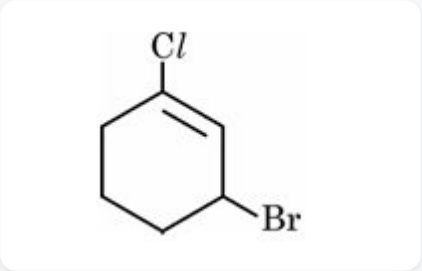
(a) Write the IUPAC name of the given compound :

(b) The presence of —$N0_2$ group at ortho or para position increases the reactivity of haloarenes towards nucleophilic substitution reactions.

Give reason to explain the above statement.

(c) What happens when ethyl chloride is treated with alcoholic potassium hydroxide ?

[3 Marks]



Answer:

(a) The IUPAC name of the given compound is not specified in the question, so if the compound was given, the name would be based on the longest carbon chain and the positions of substituents according to IUPAC rules it is 3-Bromo-1-chlorocyclohex-1-ene.

(b) The presence of the electron withdrawing —NO2 group at ortho or para positions increases the reactivity of haloarenes towards nucleophilic substitution because —NO2 is a strong electron withdrawing group. It stabilizes the intermediate formed during nucleophilic aromatic substitution by delocalizing the negative charge through resonance. This makes it easier for the nucleophile to attack and replace the halogen atom, thus increasing the reactivity.

(c) When ethyl chloride is treated with alcoholic potassium hydroxide, an elimination reaction occurs resulting in the formation of ethene (an alkene). The OH- ion acts as a base, removing a beta hydrogen from ethyl chloride, and thereby eliminating HCl. The reaction can be written as C2H5Cl + KOH (alc) → C2H4 + KCl + H2O.

Key Points: IUPAC name based on structure - —NO_2 group is electron withdrawing increasing reactivity - Nucleophilic substitution facilitated by resonance stabilization - Ethyl chloride reacts with alcoholic KOH giving ethene by elimination

Question 34.

Show that the time required for 99.9% completion in a first order reaction is 10 times of half-life ($t_{1/2}$) of the reaction [log 2 = 0.3010, log 10 = 1].

[3 Marks]

Answer: Given: log 2 = 0.3010, log 10 = 1

Step 1: Write the integrated rate equation for first order reaction:

$\log([R]_0/[R]) = kt / 2.303$

Step 2: Calculate half-life ($t_{1/2}$):

At half-life, $[R] = [R]_0/2$,

So, $\log([R]_0/([R]_0/2)) = kt_{1/2} / 2.303$

$\log 2 = kt_{1/2} / 2.303$

$t_{1/2} = (2.303 / k) * \log 2 = (2.303 / k) * 0.3010$

Step 3: Calculate time for 99.9% completion (t):

At 99.9% completion, $[R] = 0.1\%$ of $[R]_0 = [R]_0 * 0.001$

$\log([R]_0/([R]_0 * 0.001)) = kt / 2.303$

$\log(1/0.001) = kt / 2.303$

$\log 1000 = kt / 2.303$

Since log 10 = 1, log 1000 = 3

So, $3 = kt / 2.303$

$t = (2.303 / k) * 3$

Step 4: Find the ratio $t / t_{1/2}$:

$t / t_{1/2} = [(2.303 / k) * 3] / [(2.303 / k) * 0.3010] = 3 / 0.3010 \approx 10$

Conclusion:

The time required for 99.9% completion of a first order reaction is 10 times its half-life, as shown.

Key Points: Integrated rate equation for first order reaction - Calculation of half-life using log 2 - Using log 10 to find time for 99.9% completion - Time for 99.9% completion is 10 times half-life

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Section E

Question 35.

Attempt any five of the following:

(a) Why is Zinc not regarded as a transition element?

(b) What is Lanthanoid contraction?

(c) Why is first ionization enthalpy of chromium lower than that of Zn ?

(d) Explain how transition elements behave as catalysts.

(e) Compounds of transition metals are generally coloured. Give reason.

(f) Out of KMn04 and K2Mn04, which one is paramagnetic and why ?

(g) Complete the following ionic equation: $Cr_2O_7^{2-} + 14H^+ + 6e^- \rightarrow$

[5 Marks]

Answer: (a) Zinc is not regarded as a transition element because it has completely filled 3d orbitals ($3d^{10}$) in all its oxidation states, so it does not have partially filled d orbitals, which is a requirement for transition elements.

(b) Lanthanoid contraction is the gradual decrease in the size of lanthanoid elements from La to Lu, despite increasing atomic number, due to poor shielding effect of 4f electrons.

(c) The first ionization enthalpy of chromium is lower than that of zinc because chromium has a $4s^1$ $3d^5$ configuration that is less stable and the electron is removed easily, whereas zinc has a stable fully filled $3d^{10}$ $4s^2$ configuration.

(d) Transition elements behave as catalysts because they can change their oxidation states easily, providing alternative reaction paths with lower activation energy, and their ability to adsorb reactant molecules on their surfaces.

(e) Compounds of transition metals are generally coloured due to d-d electronic transitions between different energy levels of d orbitals split by the ligand field.

(f) $KMnO_4$ is paramagnetic because Mn is in +7 oxidation state with unpaired electrons, whereas K_2MnO_4 has Mn in +6 oxidation state which is diamagnetic due to no unpaired electrons.

(g) The completed ionic equation is: $Cr_2O_7^{2-} + 14H^+ + 6e^- \rightarrow 2Cr^{3+} + 7H_2O$.

Key Points: Zinc has fully filled d orbitals so not a transition element - Lanthanoid contraction causes decrease in atomic size due to poor f electron shielding - Chromium has lower ionization enthalpy due to less stable electron configuration - Transition elements act as catalysts by variable oxidation states and surface adsorption - Colour arises due to d-d electronic transitions in transition metal compounds - KMnO4 is paramagnetic due to unpaired electrons in Mn +7 - Ionic equation completion with Cr2O7, H+, e- leads to Cr3+ and water

Question 36.

(i) Define reverse osmosis.

(ii) Why are aquatic species more comfortable in cold water in comparison to warm water ?

(iii) A solution containing 2 g of glucose (M = 180 g mol $^{-1}$) in 100 g of water is prepared at 303 K. If the vapour pressure of pure water at 303 K is 32.8 mm Hg, what would be the vapour pressure of the solution ?

[5 Marks]

Answer: (a) **Reverse osmosis** is a process in which external pressure greater than the osmotic pressure is applied to a solution, causing the solvent to move from the solution to the pure solvent side through a semipermeable membrane, thus reversing the natural osmosis process.

(b) Aquatic species are more comfortable in cold water because cold water holds more dissolved oxygen than warm water. Oxygen is essential for their respiration. Also, cold water reduces their metabolic rate, requiring less oxygen, leading to better survival and comfort.

(c) Given: Mass of glucose = 2 g, Molar mass (M) = 180 g mol^{-1}, Mass of water = 100 g, Temperature (T) = 303 K, Vapour pressure of pure water (P_0) = 32.8 mm Hg.
Number of moles of glucose = 2 / 180 = 0.0111 mol.
Number of moles of water = 100 / 18 = 5.56 mol.
Mole fraction of glucose ($X_{glucose}$) = 0.0111 / (0.0111 + 5.56) = 0.00199.
Mole fraction of water (X_{water}) = 1 - 0.00199 = 0.998.
Vapour pressure of solution, P = X_{water} * P_0 = 0.998 * 32.8 = 32.73 mm Hg.
So, vapour pressure of the solution is approximately 32.73 mm Hg.

Key Points: Definition of reverse osmosis - Reason aquatic species prefer cold water due to higher oxygen solubility - Calculation of vapour pressure lowering using mole fraction of solute

Question 37.

(i) Predict whether Van't Hoff factor will be less or greater than one, when Ethanoic acid is dissolved in benzene.

(ii) Define ideal solution.

(iii) Calculate the mass of $CaCl_2$ (molar mass 111 g mol^{-1}) to be dissolved in 500 g of water to lower its freezing point by 2K, assuming that $CaCl_2$ undergoes complete dissociation. (Kf for water = 1.86 K kg mol^{-1})

[5 Marks]

Answer: (i) When ethanoic acid is dissolved in benzene, it does not dissociate because benzene is a non-polar solvent and ethanoic acid molecules remain intact. Therefore, the Van't Hoff factor (i) will be approximately 1, as the number of particles in solution does not increase.

(ii) An *ideal solution* is one in which the intermolecular forces between the different components are equal to the forces between the molecules of each pure component. As a result, the solution obeys Raoult's law at all concentrations, exhibiting no volume change or heat change upon mixing.

(iii) Given:
Freezing point depression, $\Delta Tf = 2$ K
Mass of water, m solvent = 500 g = 0.5 kg
Kf for water = 1.86 K kg mol^{-1}
Molar mass of $CaCl_2$ = 111 g mol^{-1}
Van't Hoff factor, i = 3 ($CaCl_2$ dissociates into Ca^{2+} and $2Cl^-$)

Formula for freezing point depression:
$\Delta Tf = i * Kf *$ molality (m)
=> molality, $m = \Delta Tf / (i * Kf) = 2 / (3 * 1.86) = 0.358$ mol kg^{-1}

Molality = moles of solute / kg of solvent
Moles of $CaCl_2$ = molality * kg solvent = 0.358 * 0.5 = 0.179 mol

Mass of $CaCl_2$ = moles * molar mass = 0.179 * 111 = 19.87 g

Therefore, 19.87 g of $CaCl_2$ must be dissolved in 500 g of water to lower its freezing point by 2 K assuming complete dissociation.

> **Key Points: Van't Hoff factor approximately 1 for ethanoic acid in benzene - Definition of ideal solution - Calculation of mass of CaCl2 using freezing point depression formula**

Question 38.

An amide 'A' with molecular formula C_7H_70N undergoes Hoffmann Bromamide degradation reaction to give amine 'B'. B' on treatment with nitrous acid at 273-278 K form 'C' and on treatment with chloroform and ethanolic potassium hydroxide forms 'D'. 'C' on treatment, with ethanol gives 'E'. Identify 'A', 'B', 'C' 'D' and 'E.' and write the sequence of chemical equations

[5 Marks]

Answer: Answer:
(a) Identification of compounds:
A is Benzamide ($C_6H_5CONH_2$) - molecular formula C_7H_7ON

B is Aniline ($C_6H_5NH_2$) - amine obtained after Hoffmann bromamide degradation

C is Benzene diazonium chloride ($C_6H_5N_2^+Cl^-$) - formed on treatment of aniline with nitrous acid at 273-278 K

D is Phenyl isocyanide (C_6H_5NC) - formed by reaction of aniline with chloroform and ethanolic KOH (Carbylamine test)

E is Ethyl benzoate ($C_6H_5COOC_2H_5$) - formed when benzene diazonium salt reacts with ethanol

(b) Sequence of reactions:

1. Hoffmann Bromamide degradation:

$C_6H_5CONH_2 + Br_2 + 4NaOH \rightarrow C_6H_5NH_2 + Na_2CO_3 + 2NaBr + 2H_2O$

2. Formation of diazonium salt:

$C_6H_5NH_2 + HNO_2 + HCl\ (273\text{-}278\ K) \rightarrow C_6H_5N_2^+Cl^- + 2H_2O$

3. Carbylamine test (formation of isocyanide):

$C_6H_5NH_2 + CHCl_3 + 3KOH \rightarrow C_6H_5NC + 3KCl + 3H_2O$

4. Reaction of diazonium salt with ethanol:

$C_6H_5N_2^+Cl^- + C_2H_5OH \rightarrow C_6H_5OC_2H_5 + N_2 + HCl$

Summary:

A: Benzamide

B: Aniline

C: Benzene diazonium chloride

D: Phenyl isocyanide

E: Ethyl benzoate

The above sequence explains the identity of compounds and their respective reactions in the given process.

> **Key Points: Amide A is benzamide - Hoffmann bromamide degradation converts amide to primary amine B (aniline) - B with nitrous acid forms diazonium salt C - B with chloroform and KOH forms isocyanide D - C reacts with ethanol to form ester E**

Question 39.

(i) (1)What is Hinsberg's reagent ?

(2) Arrange the following compounds in the increasing order of their basic strength in gaseous phase : $C_2H_5NH_2$, $(C_2H_5)_3N$,$(C_2H_5)_2NH$

(ii) Give reasons for the following :

(1) Methyl amine is more basic than aniline.

(2) Aniline readily reacts with bromine water to give 2, 4, 6tribromoaniline.

(3) Primary amines have higher boiling points than tertiary amines.

[5 Marks]

Answer: (i) (1) Hinsberg's reagent is benzenesulfonyl chloride ($C_6H_5SO_2Cl$). It is used to differentiate primary, secondary, and tertiary amines based on their reaction with this reagent.
(2) Increasing order of basic strength in gaseous phase is: $(C_2H_5)_3N < C_2H_5NH_2 < (C_2H_5)_2NH$. This is because in gaseous phase, steric hindrance affects the availability of the lone pair on nitrogen atom and tertiary amines are less basic than the secondary and primary amines.
(ii) (1) Methyl amine is more basic than aniline because methyl group is an electron releasing group which increases electron density on nitrogen and thus its ability to accept a proton. In aniline, the lone pair on nitrogen is delocalized into the benzene ring through resonance, decreasing its availability to accept a proton.
(2) Aniline reacts readily with bromine water to give 2,4,6-tribromoaniline because the amino group ($-NH_2$) activates the benzene ring toward electrophilic substitution by donating electron density, especially at ortho and para positions, leading to rapid bromination.
(3) Primary amines have higher boiling points than tertiary amines because primary amines can form more hydrogen bonds due to the presence of two N-H bonds, whereas tertiary amines cannot form hydrogen bonds as there is no N-H bond. This increases intermolecular forces and thus raises the boiling point of primary amines.

Key Points: Hinsberg's reagent is benzenesulfonyl chloride - Increasing basic strength order in gaseous phase: tertiary < primary < secondary amine - Methyl amine is more basic due to electron releasing effect and aniline's resonance decreases basicity - Amino group activates aniline for bromination at ortho and para positions - Primary amines have higher boiling points due to hydrogen bonding