CBSE EXAMINATION PAPER-2023

CHEMISTRY

(Solved)

Time allowed : 3 hours | Maximum Marks : 77

General Instructions :

Read the following instructions carefully and follow them :

i. This question paper contains **41 questions.** All questions are **compulsory.**

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

iii. **Section A** – questions number **1 to 4** are case based questions

iv. **Section B** – questions number **5 to 22** are multiple choice questions

v. **Section C** – questions number **23 to 30** are very short answer

vi. **Section D** – questions number **31 to 36** are short answer

vii. **Section E** – questions number **37 to 41** 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 rate of reaction is concerned with decrease in concentration of reactants or increase in the concentration of products per unit time. It can be expressed as instantaneous rate at a particular instant of time and average rate over a large interval of time. Mathematical representation of rate of reaction is given by rate law. Rate constant and order of a reaction can be determined from rate law or its integrated rate equation.

Question 2.

The rate of reaction is concerned with decrease in concentration of reactants or increase in the concentration of products per unit time. It can be expressed as instantaneous rate at a particular instant of time and average rate over a large interval of time. Mathematical representation of rate of reaction is given by rate law. Rate constant and order of a reaction can be determined from rate law or its integrated rate equation.

Question 3.

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

The rate of reaction is concerned with decrease in concentration of reactants or increase in the concentration of products per unit time. It can be expressed as instantaneous rate at a particular instant of time and average rate over a large interval of time. Mathematical representation of rate of reaction is given by rate law. Rate constant and order of a reaction can be determined from rate law or its integrated rate equation.

(1)

What is average rate of reaction ?

[1 Marks]

Answer: Average rate of reaction is the change in concentration of a reactant or product divided by the time interval over which the change occurs.
It is calculated by dividing the difference in concentration by the difference in time, showing how fast the reactant is used or product is formed on average during that time.
This is explained in the case paragraph as the rate concerned with the decrease in reactant concentration or increase in product concentration per unit time over a period.

Key Points: Average rate is change in concentration over time - It is an average value over a time interval - Expresses how fast reactants decrease or products increase

(2)

Write two factors that affect the rate of reaction.

[1 Marks]

Answer: Two factors that affect the rate of reaction are: concentration of reactants and temperature.
According to the case, these factors change how fast the concentration of reactants or products change over time, thus affecting the rate.

Key Points: concentration of reactants - temperature - factors affecting rate of reaction

(3)

(1) What happens to rate of reaction for zero order reaction ?

(2) What is the unit of k for zero order reaction ?

[2 Marks]

Answer: For zero order reaction, the rate of reaction remains constant and does not depend on the concentration of the reactant. This means the rate is independent of reactant concentration as given in the passage which says rate depends on concentration to the power of order.
The unit of rate constant k for zero order reaction is mole per liter per second (mol L^{-1} s^{-1}).
This is because rate = k and rate has the unit concentration/time as explained in the case.
Thus, the zero order reaction has constant rate and k unit as mol L^{-1} s^{-1}.

Key Points: Rate of zero order reaction is constant - Rate does not depend on reactant concentration - Unit of rate constant k is mol L^{-1} s^{-1}

(4)

(1) For a reaction P + 2Q → Products Rate = k[P]$^{1/2}$ [Q]^{1}. What is the order of the reaction ?

(2) Define pseudo first order reaction with an example.

[2 Marks]

Answer: (1) The order of a reaction is the sum of the powers of concentration terms in the rate law. Here, rate = k[P]$^{1/2}$ [Q]^{1}. So, order = 1/2 + 1 = 3/2 or 1.5.
(2) A pseudo first order reaction is a reaction which actually has order more than one but behaves like a first order reaction because the concentration of one reactant is in large excess and remains nearly constant. For example, in the hydrolysis of an ester in excess water, the reaction is second order but appears as first order with respect to the ester as water concentration is constant. This is useful as mentioned in the case where rate constants are determined from rate laws.

Key Points: Order of reaction is sum of exponents in rate law - Pseudo first order reactions have one reactant in large excess - Example: hydrolysis of ester in excess water behaves as first order reaction

Question 4.

In coordination compounds, metals show two types of linkages, primary and secondary. Primary valencies are ionisable and are satisfied by negatively charged ions. Secondary valencies are non-ionisable and are satisfied by neutral or negative ions having lone pair of electrons. Primary valencies are non-directional while secondary valencies decide the shape of the complexes.

(1)

If $PtCl_2 . 2NH_3$ does not react with $AgNO_3$, what will be its formula ?

[1 Marks]

Answer: If $PtCl_2 . 2NH_3$ does not react with $AgNO_3$, it means there are no free chloride ions. According to the case, primary valencies are ionisable and react with $AgNO_3$. Here, both Cl^- are coordinated, so the correct formula is $[PtCl_2(NH_3)_2]$.

Key Points: Primary valencies are ionisable and satisfied by negative ions - Secondary valencies are non-ionisable and satisfied by neutral or negative ions with lone pairs - No reaction with $AgNO_3$ means no free Cl^- ions outside coordination sphere

(2)

What is the secondary valency of $[Co(en)_3]^{3+}$?

[1 Marks]

Answer: The secondary valency is the coordination number of the metal ion, which equals the number of ligand atoms directly attached to the metal. In $[Co(en)_3]^{3+}$, there are three ethylenediamine (en) ligands, each coordinated through two donor atoms, so the secondary valency is 6 as explained in the given passage.

Key Points: Secondary valency is non-ionisable valency - Secondary valency equals coordination number - In $[Co(en)_3]^{3+}$, coordination number is 6

(3)

(1) Write the formula of Iron(III)hexacyanidoferrate(II).

(2) Write the IUPAC name of $[Co(NH_3)_5Cl]\ Cl_2$.

[1 Marks]

Answer: (1) The formula of Iron(III)hexacyanidoferrate(II) is $Fe_4[Fe(CN)_6]_3$ because Fe^{3+} is the cation and $[Fe(CN)_6]^{4-}$ is the complex anion.

(2) The IUPAC name of $[Co(NH_3)_5Cl]Cl_2$ is pentaamminechloridocobalt(III) chloride. The central metal is cobalt with oxidation state +3, five ammine and one chloride as ligands, and two chloride ions as counter ions.

Key Points: Primary valencies are ionisable and satisfied by negative ions - Secondary valencies are non-ionisable and satisfied by neutral or negative ions with lone pairs - Iron(III)hexacyanidoferrate(II) formula is Fe4[Fe(CN)6]3 - IUPAC name includes ligands in alphabetical order and oxidation state of metal

(4)

Write the hybridization and magnetic behaviour of $[Ni(CN)_4]^{2-}$.[Atomic number : Ni = 28]

[2 Marks]

Answer: In $[Ni(CN)_4]^{2-}$, Ni has an oxidation state of +2 and electronic configuration of $3d^8 4s^0$. CN^- is a strong field ligand causing pairing of electrons. Therefore, hybridization is dsp^2 leading to a square planar shape as explained through secondary valencies in the case. It is diamagnetic due to all electrons being paired.

Key Points: Ni in +2 state has 3d8 configuration - CN- is a strong field ligand causing electron pairing - hybridization is dsp2 with square planar geometry - complex is diamagnetic due to paired electrons

Section B

Question 5.

The colligative property used for the determination of molar mass of polymers and proteins is :

[1 Marks]

(A) Elevation is boiling point

(B) Depression in freezing point

(C) Relative lowering in vapour pressure

(D) Osmotic pressure

Explanation:

Osmotic pressure is the correct answer because it is a colligative property that depends on the number of solute particles in a solution. This property is especially useful for determining the molar mass of large molecules like polymers and proteins, as it allows for the calculation based on the effect of solute concentration on the osmotic pressure.

Question 6.

Low concentration of oxygen in the blood and tissues of people living at high altitude is due to :

[1 Marks]

(A) low atmospheric pressure

(B) both low temperature and high atmospheric pressure

(C) low temperature

(D) high atmospheric pressure

Explanation:

The correct answer is 'low atmospheric pressure.' At high altitudes, the atmospheric pressure is significantly lower than at sea level, which means that the amount of oxygen available in the air is also reduced. This leads to lower concentrations of oxygen in the blood and tissues.

Question 7.

The correct cell to represent the following reaction is : $Zn + 2Ag^{+} \rightarrow Zn^{2+} + 2Ag$

[1 Marks]

(A) $Ag^{+} \mid Ag \parallel Zn^{2+} \mid Zn$

(B) $Ag \mid Ag^{+} \parallel Zn \mid Zn^{2+}$

(C) $2Ag \mid Ag^{+} \parallel Zn \mid Zn^{2+}$

(D) $Zn \mid Zn^{2+} \parallel Ag^{+} \mid Ag$

Explanation:

The correct option is '$Zn \mid Zn^{2+} \parallel Ag^{+} \mid Ag$'. This representation correctly shows zinc on the left side as the anode (oxidizing agent) where it loses electrons to form Zn^{2+}, while silver ions (Ag^{+}) on the right side gain electrons to form solid silver (Ag) at the cathode. The notation follows the standard format of an electrochemical cell where the oxidation half-reaction is listed first.

Question 8.

ΔG and $E°_{cell}$ for a spontaneous reaction will be :

[1 Marks]

(A) positive, positive

(B) negative, positive

(C) negative, negative

(D) positive, negative

Explanation:

For a spontaneous reaction, ΔG must be negative. This aligns with the thermodynamic criteria where $\Delta G < 0$ indicates that the process is spontaneous. Since $E°_{cell}$ is related to the change in Gibbs free energy ($\Delta G = -nFE°_{cell}$), a negative ΔG translates to a positive $E°_{cell}$. Therefore, the correct option is 'negative, positive'.

Question 9.

Which of the following is affected by catalyst?

[1 Marks]

(A) ΔG

(B) ΔH

(C) ΔS

(D) E_a

Explanation: A catalyst affects the activation energy (E_a) of a reaction by lowering it, thereby providing an alternative reaction pathway that requires less energy. It does not change the Gibbs free energy (ΔG), enthalpy (ΔH), or entropy (ΔS) of the reaction.

Question 10.

The order of the reaction $H_2(g) + Cl_2(g) \xrightarrow{(hv)} 2HCl(g)$ is :

[1 Marks]

(A) 0

(B) 3

(C) 1

(D) 2

Explanation:

The reaction between hydrogen and chlorine to form hydrochloric acid is a first-order reaction with respect to both H_2 and Cl_2, making the overall order of the reaction 2. Thus, the correct answer is 2.

Question 11.

The most common and stable oxidation state of a Lanthanoid is :

[1 Marks]

(A) + 4

(B) + 6

(C) + 3

(D) + 2

Explanation: The most common and stable oxidation state of Lanthanoids is +3. This is due to the fact that they typically lose three electrons, corresponding to the removal of the outermost 6s and 4f electrons, which is a characteristic behavior of these elements.

Question 12.

The compounds $[Co(SO_4)(NH_3)_5]Br$ and $[Co(Br)(NH_3)_5]SO_4$ represent :

[1 Marks]

(A) ionisation isomerism

(B) linkage isomerism

(C) coordination isomerism

(D) optical isomerism

Explanation:

The correct answer is ionisation isomerism. This is because ionisation isomers differ in the arrangement of counter ions and can exchange ligands with counter ions, as shown in the provided example of isomers [Co(NH3)5(SO4)]Br and [Co(NH3)5Br]SO4, where the sulfate and bromide ions are interchangeably present.

Question 13.

The synthesis of alkyl fluoride is best obtained from :

[1 Marks]

(A) Sandmeyer reaction

(B) Finkelstein reaction

(C) Free radicals

(D) Swartz reaction

Explanation:

The correct answer is 'Swartz reaction'. This reaction is specifically used to convert alkyl halides (like chlorides or bromides) into alkyl fluorides by using a fluoride ion source, making it the most suitable method for synthesizing alkyl fluorides among the options provided.

Question 14.

In a reaction what is the correct order of reactivity of alcohal ?

[1 Marks]

$$R - OH + HCl \xrightarrow{ZnCl_2} RCl + H_2O,$$

(A) 3° > 2° > `1°

(B) 1° < 2° < 3°

(C) 1° > 3° > 2°

(D) 1° > 2° > 3°

Explanation:

The correct order of reactivity of alcohols with HCl is 3° > 2° > 1°. This is because tertiary alcohols are the most reactive due to the stability of the carbocation formed during the reaction, followed by secondary alcohols and then primary alcohols, which are the least reactive.

Question 15.

CH_3CONH_2 on reaction with NaOH and Br_2 in alcoholic medium gives :

[1 Marks]

(A) CH_3COONa

(B) CH_3NH_2

(C) CH_3CH_2Br

(D) $CH_3CH_2NH_2$

Explanation: When acetamide (CH_3CONH_2) reacts with sodium hydroxide (NaOH) and bromine (Br_2) in an alcoholic medium, it undergoes the Hoffmann bromamide degradation reaction. In this reaction, the amide is converted to a primary amine with one less carbon atom. Therefore, acetamide (CH_3CONH_2) forms methylamine (CH_3NH_2) as the product.

Question 16.

Which of the following is least basic?

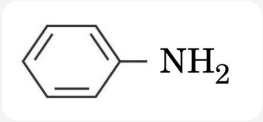
[1 Marks]

(A) NH_3

(B) $(CH_3)_3N$

(C) $(CH_3)_2NH$

(D) NH2



Explanation:

(CH3)2NH is the least basic among the options provided because it has a lower availability of a lone pair of electrons for donation compared to (CH3)3N and NH3. The steric hindrance in (CH3)2NH

lessens its basicity, while NH3 is more basic due to having a lone pair readily available for bonding.

Question 17.

The glycosidic linkage involved in linking the glucose units in amylase part of starch is :

[1 Marks]

(A) C_1- C_4 β linkage

(B) C_1 -C_6 α linkage

(C) C_1- C_6 βlinkage

(D) C_1 -C_4 α linkage

Explanation: The glycosidic linkage in the amylase part of starch is an α-1,4 glycosidic bond. This bond connects carbon 1 (C1) of one glucose molecule to carbon 4 (C4) of the next glucose molecule, forming the main chain in starch. The α linkage means the bond is formed by the alpha form of glucose.

Question 18.

An α- helix is a structural feature of :

[1 Marks]

(A) Starch

(B) Sucrose

(C) Polypeptides

(D) Nucleotides

Explanation: The correct answer is Polypeptides. An α-helix is a common secondary structure found in polypeptides (proteins), formed by hydrogen bonding between the amino acid residues in the polypeptide chain, as described in the provided context.

Question 19.

Assertion (A) -NH_2 group is o- and p-directing in electrophilic substitution reactions.

Reason (R) : Aniline cannot undergo Friedel-Crafts reaction.

[1 Marks]

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

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

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

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

Explanation:

Both Assertion (A) and Reason (R) are true, but Reason (R) is not the correct explanation of the Assertion (A). The -NH2 group is indeed o- and p-directing due to its strong electron-donating resonance effect, making it activate the aromatic ring for electrophilic substitutions. However, while it is true that aniline cannot undergo Friedel-Crafts reactions due to salt formation with aluminium chloride, this does not explain why the -NH2 group is directing; the directing effect is due to resonance, not the inability to undergo Friedel-Crafts reactions.

Question 20.

Assertion (A) : Acetylation of aniline gives a monosubstituted product.

Reason (R) : Activating effect of -$NHCOCH_3$ group is more than that of amino 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) Assertion (A) is false, but Reason (R) is true.

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

Explanation:

Assertion (A) is true as acetylation of aniline indeed results in the formation of a monosubstituted product. However, Reason (R) is false because the activating effect of the -NHCOCH3 group is actually less than that of the amino (-NH2) group, as stated in the context. Therefore, the correct answer is that Assertion (A) is true, but Reason (R) is false.

Question 21.

Assertion (A) : The molecularity of the reaction $H_2 + Br_2 \rightarrow 2HBr$ appears to be 2.

Reason (R) : Two molecules of the reactants are involved in the given elementary reaction.

[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:

Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of the Assertion (A). The molecularity of a reaction refers to the number of reactant molecules involved in an elementary reaction, and since there are two molecules (H2 and Br2) reacting to form 2HBr, Assertion (A) is correct and is accurately explained by Reason (R).

Question 22.

Assertion (A) : Low spin tetrahedral complexes are rarely observed.

Reason (R) : Crystal field splitting energy is less than pairing energy for tetrahedral complexes.

[1 Marks]

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

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

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

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

Explanation:

Both Assertion (A) and Reason (R) are true, but Reason (R) is not the correct explanation of the Assertion (A). Low spin tetrahedral complexes are indeed rare because the crystal field splitting energy in tetrahedral complexes is smaller than that in octahedral complexes, leading to weak field ligands causing less pairing compared to octahedral arrangements. However, the rarity of low spin tetrahedral complexes is not directly explained by the relationship between crystal field splitting and pairing energy.

Section C

Question 23.

(a) On diluting two electrolytes 'A' and 'B', the λ_m of 'A' increases 25 times while that of 'B' increases by 1.5 times. Which of the two electrolytes is strong? Justify your answer graphically.

(b) The electrical resistance of a column of 0.05 mol L^{-1} NaOH solution of diameter 1 cm and length 50 cm is 5.55×10^3 ohm. Calculate the conductivity.

[2 Marks]

Answer: (a) Electrolyte 'A' is strong because on dilution its molar conductivity (λ_m) increases significantly (25 times), indicating almost complete dissociation even at higher concentrations. Electrolyte 'B' is weak as its λ_m increase is small (1.5 times), showing incomplete dissociation. Graphically, λ_m vs sqrt(concentration) plot for strong electrolyte shows sharp increase and tends to a constant (λ_m^0), while weak electrolyte shows gradual increase.
(b) Given: Concentration c = 0.05 mol L^{-1}, Diameter d = 1 cm, Length l = 50 cm, Resistance R = 5.55 * 10^3 ohm.
Cross-sectional area A = π * $(d/2)^2$ = 3.1416 * $(0.01/2)^2$ = 7.85 * 10^{-5} m^2.
Conductivity κ = l / (R * A) = 0.50 m / (5550 ohm * 7.85 * 10^{-5} m^2) = 1.15 * 10^{-3} S/m.
Therefore, conductivity of the NaOH solution is 1.15 * 10^{-3} S/m.

> **Key Points: Strong electrolyte shows large increase in molar conductivity on dilution - Weak electrolyte shows small increase in molar conductivity on dilution - Conductivity calculation uses κ = l / (R * A)**

Question 24.

Complete the following equation:

(a) $2MnO_4^- + 5NO_2^- + 6H^+ \rightarrow$

(b) $Cr_2O_7^{2-} + 14H^+ + 6e^- \rightarrow$?

[2 Marks]

Answer: (a) $2MnO_4^- + 5NO_2^- + 6H^+ \rightarrow 2Mn^{2+} + 5NO_3^- + 3H_2O$
(b) $Cr_2O_7^{2-} + 14H^+ + 6e^- \rightarrow 2Cr^{3+} + 7H_2O$

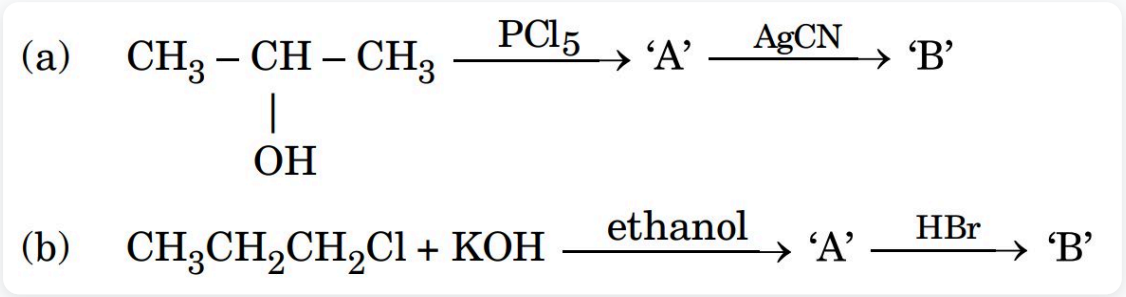
Explanation:
In (a), permanganate ion (MnO_4^-) acts as an oxidizing agent and is reduced to Mn^{2+}, while nitrite ion (NO_2^-) is oxidized to nitrate ion (NO_3^-). The hydrogen ions balance the charge and participate in water formation.
In (b), dichromate ion ($Cr_2O_7^{2-}$) gains 6 electrons (is reduced) in an acidic medium to form chromium ion (Cr^{3+}) and water. This is a standard reduction half-equation.

Key Points: MnO_4^- is reduced to Mn^{2+} - NO_2^- is oxidised to NO_3^- - $Cr_2O_7^{2-}$ is reduced to Cr^{3+} in acid medium

Question 25.

Identify 'A' , and 'B' in the above reactions.

[2 Marks]



Answer:

(a)

Starting compound: **CH_3–CH(OH)–CH_3** (2-propanol)

1. **PCl_5** converts alcohol → alkyl chloride
   So **A = CH_3–CH(Cl)–CH_3** (2-chloropropane)

2. **AgCN** gives **isocyanide** (R–NC, not R–CN)
   So from 2-chloropropane:

B = $(CH_3)_2$CH–NC (isopropyl isocyanide)

(b)

Starting compound: **$CH_3CH_2CH_2Cl$** (1-chloropropane)

1. **Alcoholic KOH** → elimination (E2) → alkene
   So **A = CH_3–CH=CH_2** (propene)

2. **HBr** adds to propene (Markovnikov addition, no peroxide mentioned)
   So Br goes to middle carbon:

B = CH_3–CH(Br)–CH_3 (2-bromopropane)

Key Points:

Brutally honest exam tip: remember AgCN gives isocyanide (R–NC), KCN gives nitrile (R–CN) — this is a very common trap.

Question 26.

Account for the following:

(i) Phenol is a stronger acid than an alcohol.

(ii) The boiling point of alcohols decreases with increase in branching of alkyl chain.

[2 Marks]

Answer: (i) Phenol is a stronger acid than alcohol because the –OH group in phenol is attached to an sp2 hybridised carbon of the aromatic ring, which is more electronegative than the sp3 carbon of alcohols. This causes the electron density on oxygen to decrease, increasing the polarity of the O–H bond and making phenol ionise more easily to give phenoxide ion. Also, the phenoxide ion is resonance stabilised, which stabilises the conjugate base and increases acidity.
(ii) The boiling point of alcohols decreases with increase in branching of the alkyl chain because branching reduces the surface area of the molecule. This leads to weaker van der Waals forces between molecules. As a result, less energy is required to break these forces and boil the substance, causing a lower boiling point.

Key Points: Phenol acidity due to sp2 carbon and resonance - Phenol ionises more easily - Branching reduces surface area and van der Waals forces - Lower boiling point with more branching

Question 27.

(i) Write the mechanism of the following reaction :

(ii) Write the equation involved in Reimer-Tiemann reaction.

[2 Marks]

$$CH_3CH_2OH \xrightarrow[443\ K]{H^+} CH_2 = CH_2 + H_2O$$

Answer:

(i) Mechanism: Dehydration of Ethanol to Ethene (Acid-catalyzed, 443 K)

Overall reaction:
$CH_3CH_2OH \xrightarrow{H^+,\ 443\ K} CH_2=CH_2 + H_2O$

This is an acid-catalyzed elimination (for 1° alcohol mainly E2-like, but written stepwise).

Step 1: Protonation of alcohol (makes good leaving group)

$CH_3CH_2OH + H^+ \rightarrow CH_3CH_2OH_2^+$

(Oxygen gets protonated → forms oxonium ion)

Step 2: Loss of water

$CH_3CH_2OH_2^+ \rightarrow CH_3CH_2^+ + H_2O$

(Water leaves, forming ethyl carbocation – very unstable, so next step is fast)

Step 3: Elimination of proton to form alkene

$CH_3CH_2^+ \rightarrow CH_2=CH_2 + H^+$

(A base like H_2O removes a proton, double bond forms, H^+ is regenerated)

So product: Ethene + Water

(ii) Reimer–Tiemann Reaction (Equation)

Reimer–Tiemann reaction introduces –CHO group into phenol (at ortho position mainly) using $CHCl_3$ + NaOH.

General equation:

Phenol + $CHCl_3$ + 3 NaOH → o-hydroxybenzaldehyde (salicylaldehyde) + 3 NaCl + 2 H_2O

In formula form:

$C_6H_5OH + CHCl_3 + 3\ NaOH \rightarrow o\text{-}HOC_6H_4–CHO + 3\ NaCl + 2\ H_2O$

(Para isomer also forms in small amount)

Key Points:

(i) Acid-catalyzed dehydration of ethanol proceeds via protonation of –OH, loss of water, and elimination of H^+ to give ethene.
(ii) Reimer–Tiemann reaction:
$C_6H_5OH + CHCl_3 + 3\ NaOH \rightarrow o\text{-}HOC_6H_4–CHO + 3\ NaCl + 2\ H_2O$

Question 28.

Explain briefly :

(a) Carbylamine reaction

(b) Gabriel phthalimide synthesis

[2 Marks]

Answer: (a) **Carbylamine reaction:** When primary aliphatic or aromatic amines are heated with chloroform ($CHCl_3$) and ethanolic potassium hydroxide (KOH), they form isocyanides or carbylamines which have a foul smell. Secondary and tertiary amines do not show this reaction.
(b) **Gabriel phthalimide synthesis:** This is a method to prepare primary amines. Phthalimide reacts with potassium hydroxide to form potassium salt, which then reacts with an alkyl halide to give N-alkyl phthalimide. Hydrolysis of N-alkyl phthalimide gives the primary amine. This method avoids contamination by secondary and tertiary amines.

Key Points: Carbylamine reaction forms isocyanides with foul smell - Only primary amines react in Carbylamine reaction - Gabriel synthesis prepares primary amines using phthalimide

Question 29.

(a) Write chemical reaction to show that open structure of D-glucose contains the straight chain.

(b) What type of linkage is responsible for the formation of protein ?

[2 Marks]

Answer:

(a) The open chain structure of D-glucose can be represented by its linear form: C6H12O6 in which the aldehyde group is at one end. The mutarotation process shows interconversion between cyclic and open chain forms in solution, proving the open chain structure exists.

(b) The linkage responsible for protein formation is the **peptide linkage**. It is formed by a condensation reaction between the carboxyl group of one amino acid and the amino group of another, creating a bond -CONH- between amino acid units.

Key Points: Open chain form of D-glucose exists - Mutarotation shows cyclic and open forms - Peptide linkage forms proteins

Question 30.

What is Henry's law? Give one application of it.

[2 Marks]

Answer: Henry's Law states that the amount of gas dissolved in a liquid is directly proportional to the pressure of the gas above the liquid at a constant temperature. Mathematically, C = k_H * P, where C is the concentration of the gas dissolved, k_H is Henry's law constant, and P is the gas pressure. **Application:** It is used in carbonated beverages where CO2 is dissolved in the drink under high pressure. When the bottle is opened, pressure decreases and CO2 comes out causing fizz.

Key Points: Henry's law definition - Gas solubility proportional to pressure - Application in carbonated drinks

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Section D

Question 31.

(a) Differentiate between Ideal solution and Non-ideal solution.

(b) 30 g of urea is dissolved in 846 g of water. Calculate the vapour pressure of water for this solution if vapour pressure of pure water at 298 K is 23.8 mm Hg.

[3 Marks]

Answer: (a) **Ideal solution:** It obeys Raoult's law at all concentrations; forces between all molecules are similar; no heat is evolved or absorbed; volume is additive. **Non-ideal solution:** It does not obey Raoult's law; forces between different molecules differ; heat is absorbed or evolved during mixing; volume change occurs on mixing.
(b) Given: Mass of urea = 30 g, mass of water = 846 g, vapour pressure of pure water P_0 = 23.8 mm Hg. Molar mass of urea (NH_2CONH_2) = 60 g/mol, molar mass of water = 18 g/mol. Moles of urea = 30 / 60 = 0.5 mol, moles of water = 846 / 18 = 47 mol. Mole fraction of water X_{water} = 47 / (47 + 0.5) = 0.9895. According to Raoult's law, vapour pressure P = X_{water} * P_0 = 0.9895 * 23.8 = 23.53 mm Hg. Therefore, vapour pressure of water in the solution is 23.53 mm Hg.

Key Points: Ideal solution obeys Raoult's law-No heat change or volume change-Non-ideal solution does not obey Raoult's law-Calculate moles of solute and solvent-Use mole fraction and Raoult's law to find vapour pressure

Question 32.

Write main product formed when :

(a) Methyl chloride is treated with NaI/Acetone.

(b) 2,4,6-trinitrochlorobenzene is subjected to hydrolysis.

(c) 2,4,6-trinitrochlorobenzene is subjected to hydrolysis.

[3 Marks]

Answer: (a) When methyl chloride (CH_3Cl) is treated with NaI in acetone, an SN2 reaction occurs where iodide ion replaces the chlorine atom. The main product formed is methyl iodide (CH_3I).
(b) When 2,4,6-trinitrochlorobenzene undergoes hydrolysis, the chlorine atom is substituted by a hydroxyl group because the nitro groups strongly activate the ring towards nucleophilic substitution. The main product is 2,4,6-trinitrophenol.
(c) This is the same as (b), so again the main product formed is 2,4,6-trinitrophenol due to nucleophilic substitution of chlorine by hydroxyl group during hydrolysis.

Key Points: SN2 reaction with NaI and acetone replaces Cl with I in methyl chloride - Hydrolysis of 2,4,6-trinitrochlorobenzene replaces Cl with OH forming 2,4,6-trinitrophenol - Nitro groups activate ring for nucleophilic substitution

Question 33.

How do you convert the following : (Any three)

(a) Phenol to picric acid

(b) Propanone to 2-Methylpropan-2-ol

(c) Phenol to anisole

(d) Phenol to anisole

[3 Marks]

Answer: (a) **Phenol to picric acid:** Treat phenol with concentrated nitric acid at low temperature. This results in nitration at 2,4,6-positions giving 2,4,6-trinitrophenol, known as picric acid.
(b) **Propanone to 2-Methylpropan-2-ol:** React propanone with methyl magnesium iodide (a Grignard reagent) followed by acidic hydrolysis. The methyl group adds to the carbonyl carbon forming 2-methylpropan-2-ol.
(c) **Phenol to anisole:** React phenol with methyl iodide in presence of a base like K_2CO_3. This alkylation forms anisole (methoxybenzene) by replacing the hydrogen of the hydroxyl group with a methyl group.

Key Points: Phenol nitration with concentrated HNO3 forms picric acid - Grignard reagent adds methyl to propanone forming tertiary alcohol - Alkylation of phenol with methyl iodide forms anisole

Question 34.

Explain why:

(i) Carboxyl group in benzoic acid is meta directing.

(ii) Sodium bisulphite is used for the purification of aldehydes and ketones.

(iii) Carboxylic acids do not give characteristic reactions of carbonyl group.

[3 Marks]

Answer: (i) The carboxyl group (-COOH) in benzoic acid is meta directing because it is an electron withdrawing group by both induction and resonance. This decreases electron density on the ortho and para positions of the benzene ring, making the meta position more reactive to electrophilic substitution.
(ii) Sodium bisulphite forms addition compounds with aldehydes and ketones by adding to the carbonyl group. These addition compounds are solid and can be separated easily, thus sodium bisulphite is used to purify aldehydes and ketones.
(iii) Carboxylic acids do not give characteristic reactions of the carbonyl group because the carbonyl carbon is strongly bonded to the -OH group, which forms hydrogen bonds. This reduces the reactivity of the carbonyl group and prevents addition reactions typical of aldehydes and ketones.

Key Points: Carboxyl group is electron withdrawing and meta directing - Sodium bisulphite forms addition compounds for purification - Carboxylic acids have less reactive carbonyl due to hydrogen bonding

Question 35.

An organic compound 'A', having the molecular formula C_3H_8O on treatment with Cu at 573 K, gives 'B'. 'B' does not reduce Fehling's solution but gives a yellow precipitate of the compound 'C' with I_1/NaOH. Deduce the structures of A, B and C.

[3 Marks]

Answer: The organic compound 'A' with the formula C3H8O is likely isopropyl alcohol (propan-2-ol). When treated with copper at 573 K, 'A' undergoes dehydrogenation to form compound 'B', which is propene (C3H6). Propene does not reduce Fehling's solution, indicating it is a hydrocarbon. On treating 'B' with NaOH, it undergoes a reaction forming a yellow precipitate of compound 'C', which is likely 2,4-dinitrophenylhydrazone (DNP) derivative of a carbonyl compound formed from an intermediate. Thus, 'A' is propan-2-ol, 'B' is propene, and 'C' is 2,4-DNP derivative.

Key Points: 1. 'A' is propan-2-ol (C3H8O) 2. 'B' is propene (C3H6), formed via dehydrogenation. 3. 'B' does not react with Fehling's solution; indicates it is a

hydrocarbon. 4. 'C' is likely a 2,4-dinitrophenylhydrazone derivative from the carbonyl compound formed.

Question 36.

(a) What are the hydrolysis products of (i) Lactose, (ii) Maltose ?

(b) Give the basic structural difference between starch and cellulose.

[3 Marks]

Answer: (a) (i) Lactose on hydrolysis gives two monosaccharides: β-D-Galactose and β-D-Glucose. Lactose is made of these two sugars linked by a β(1→4) glycosidic bond. (ii) Maltose on hydrolysis gives two glucose units. Maltose consists of two α-D-Glucose molecules linked by an α(1→4) glycosidic bond.
(b) The basic structural difference between starch and cellulose is the type of glycosidic linkage and the arrangement of glucose units. Starch contains α-D-glucose units linked mainly by α(1→4) bonds and has a helical structure making it digestible by humans. Cellulose contains β-D-glucose units linked by β(1→4) bonds, resulting in a straight chain that forms strong fibers and is not digestible by humans. This difference in linkage affects their properties and biological functions.

Key Points: Hydrolysis of lactose gives β-D-Galactose and β-D-Glucose - Hydrolysis of maltose gives two α-D-Glucose units - Starch has α(1→4) glycosidic bonds while cellulose has β(1→4) glycosidic bonds

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Section E

Question 37.

(i) State Kohlrausch's law of independent migration of ions. Write an expression for the limiting molar conductivity of acetic acid according to Kohlrausch's law.

(ii) Calculate the maximum work and log Kc for the given reaction at 298 K:

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

Given: $E°Ni^{2+}/Ni = -0.25\ V$, $E°Ag^{+}/Ag = +0.80\ V$,

$1\ F = 96500\ C\ mol^{-1}$.

[5 Marks]

Answer: (i) Kohlrausch's Law of Independent Migration of Ions: It states that at infinite dilution, the molar conductivity of an electrolyte can be represented as the sum of the individual contributions of its constituent ions, independent of the nature of the other ion present in the electrolyte.

Mathematically, the limiting molar conductivity of acetic acid (CH_3COOH), which dissociates into H^+ and CH_3COO^-, is written as:

$\Lambda_m^0(CH_3COOH) = \Lambda_m^0(H^+) + \Lambda_m^0(CH_3COO^-)$

(ii) Calculation of maximum work and log K_c for the reaction:

Given redox reaction: $Ni\ (s) + 2Ag^+\ (aq) \rightleftharpoons Ni^{2+}\ (aq) + 2Ag\ (s)$

Standard electrode potentials: $E°(Ni^{2+}/Ni) = -0.25$ V, $E°(Ag^+/Ag) = +0.80$ V

The cell reaction involves oxidation of Ni to Ni^{2+} and reduction of Ag^+ to Ag.

Calculate standard cell potential $E°_{cell}$:

$E°_{cell} = E°_{cathode} - E°_{anode} = 0.80\ V - (-0.25\ V) = 1.05\ V$

Maximum work done (W_{max}) = -n F $E°_{cell}$, where n is number of electrons transferred per reaction (n=2), F = 96500 C mol^{-1}

$W_{max} = -2 * 96500 * 1.05 = -202650$ J/mol (negative sign indicates work done by the system)

Using the relation between Gibbs free energy and equilibrium constant:

$\Delta G° = -RT \ln K_c$, and $\Delta G° = W_{max}$

Therefore,

$\ln K_c = n F E°_{cell} / RT$

At T = 298 K, R = 8.314 J mol^{-1} K^{-1}

$\ln K_c = (2 * 96500 * 1.05) / (8.314 * 298) = 81.76$

Then,

$\log K_c = \ln K_c / 2.303 = 81.76 / 2.303 = 35.5$

Final answers:

Maximum work, $W_{max} = -202650$ J/mol

Equilibrium constant, $\log K_c = 35.5$

> **Key Points: Kohlrausch's law states molar conductivity at infinite dilution is sum of ionic contributions - Expression Λm0(CH3COOH) = Λm0(H+) + Λm0(CH3COO-) - Calculate E°cell as difference of cathode and anode potentials - Use Wmax = -nFE°cell to find maximum work - Calculate equilibrium constant from ΔG° = -RT ln Kc and ΔG° = Wmax**

Question 38.

(i) State Faraday's first law of electrolysis. How much charge, in terms of Faraday, is required for the reduction of 1 mol Cu^{2+} to Cu?

(ii) Calculate emf of the following cell at 298 K for

Mg (s) | Mg^{2+} (0.01 M) || Cu^{2+} (0 .01 M) | Cu (s)

[$E°_{cell}$ = + 2.71 V, 1 F = 96500 C mol^{-1}, log 10 = 1]

[5 Marks]

Answer: (i) Faraday's First Law of Electrolysis: It states that the mass of a substance deposited or liberated at an electrode during electrolysis is directly proportional to the quantity of electricity passed through the electrolyte.

For the reduction of 1 mole of Cu^{2+} to Cu, 2 moles of electrons are required because the copper ion has a charge of +2. The total charge required = n * F, where n = 2 and F = 1 Faraday (96500 C). Therefore, charge required = 2 Faradays.

(ii) Calculation of emf of the cell at 298 K:

Given cell: Mg (s) | Mg^{2+} (0.01 M) || Cu^{2+} (0.01 M) | Cu (s)
Standard emf, $E°_{cell}$ = +2.71 V
Using Nernst equation:
$E_{cell} = E°_{cell} - (RT/nF) * \ln(Q)$
At 298 K, RT/F = 0.0257 V, and n = 2 (number of electrons transferred)
$Q = [Mg^{2+}]/[Cu^{2+}] = 0.01 / 0.01 = 1$
ln(1) = 0, so $E_{cell} = E°_{cell}$ = +2.71 V.

Hence, emf of the cell at given concentrations is 2.71 V.

> **Key Points: Faraday's first law states mass deposited is proportional to charge passed - Reduction of 1 mol Cu2+ requires 2 Faradays of charge - Use of Nernst equation to calculate emf at non-standard concentration**

Question 39.

Assign reason for each of the following :

(i) Manganese exhibits the highest oxidation state of +7 among the 3d series of transition elements.

(ii) Transition metals and their compounds are generally found to be good catalysts in chemical reactions.

(iii) Cr^{2+} is reducing in nature while with the same d-orbital configuration (d^4) Mn^{3+} is an oxidising agent.

(iv) Zn has lowest enthalpy of atomization.

(v) Cu^+ is unstable in an aqueous solution.

[5 Marks]

Answer: (i) **Manganese exhibits the highest oxidation state of +7:** Manganese has electronic configuration [Ar] 3d5 4s2, allowing it to lose all seven valence electrons (5 from 3d and 2 from 4s) to achieve +7 oxidation state which is the highest in 3d series.

(ii) **Transition metals and their compounds are good catalysts:** They have variable oxidation states and incompletely filled d orbitals, which facilitate the formation of intermediate complexes and accelerate reaction rates.

(iii) **Cr^{2+} is reducing while Mn^{3+} is oxidising even with d4 configuration:** Cr^{2+} (d4) tends to lose an electron to form Cr^{3+}, so it acts as a reducing agent. Mn^{3+} (also d4) gains an electron to form Mn^{2+}, acting as an oxidising agent. The difference in stability of oxidation states governs their behavior.

(iv) **Zn has lowest enthalpy of atomization:** Zinc has completely filled 3d10 and 4s2 orbitals, leading to weak metallic bonding and hence low energy required to convert solid Zn into atoms.

(v) **Cu^+ is unstable in aqueous solution:** Cu^+ tends to disproportionate into Cu^{2+} and metallic Cu due to its intermediate stability and tendency to attain a more stable oxidation state, so it is unstable in aqueous medium.

Key Points: Manganese has electronic configuration allowing +7 oxidation state - Transition metals have variable oxidation states and incomplete d orbitals aiding catalysis - Cr2+ loses electron acting as reducing agent while Mn3+ gains electron acting as oxidising agent - Zinc has full d and s orbitals resulting in weak metallic bonds and low enthalpy of atomization - Cu+ is unstable in aqueous solution due to disproportionation tendency

Question 40.

(i) Carry out the following conversions :

(1) Ethanal to But-2-en-1-al

(2) Propanoic acid to 2-chloropropanoic acid

(ii) An alkene with molecular formula C_5H_{10} on ozonolysis gives a mixture of two compounds 'B' and 'C'. Compound 'B' gives positive Fehling test and also reacts with iodine and NaOH solution. Compound 'C' does not give Fehling solution test but forms iodoform. Identify the compounds 'A', 'B' and 'C'.

[5 Marks]

Answer: (i) (1) **Conversion of Ethanal to But-2-en-1-al:**

Ethanal (CH_3CHO) undergoes aldol condensation under alkaline conditions to give But-2-en-1-al.

Reagents: Dilute NaOH (aq), heat

Explanation: Two molecules of ethanal condense, one acts as nucleophile and other as electrophile, forming beta-hydroxy aldehyde which on dehydration forms But-2-en-1-al ($CH_3CH=CHCHO$).

(2) **Conversion of Propanoic acid to 2-chloropropanoic acid:**
This is achieved by Hell-Volhard-Zelinsky (HVZ) reaction.
Reagents: PCl_3 and Cl_2
Explanation: Propanoic acid reacts with PCl_3 and Cl_2 to form 2-chloropropanoyl chloride which hydrolyses to give 2-chloropropanoic acid.

(ii) **Identification of compounds A, B, C from the alkene C_5H_{10}:**
Let the alkene be 'A'. Ozonolysis of 'A' gives two compounds 'B' and 'C'.
Given that 'B' gives positivo Fehling test and reacts with iodine and NaOH (iodoform test positive).
This indicates 'B' is an aldehyde with a methyl group next to carbonyl; the compound is Propanal.
'C' does not give Fehling test but forms iodoform, which means 'C' is a methyl ketone. The likely compound is Acetone (Propanone).
Hence,
'A' is 2-methylbut-2-ene (or suitable alkene that on ozonolysis gives Propanal and Acetone).
'B' is Propanal (CH_3CH_2CHO)
'C' is Acetone (CH_3COCH_3)
This fits the molecular formula and test results.
Therefore, alkene 'A' undergoes ozonolysis to produce aldehyde 'B' (propanal) and methyl ketone 'C' (acetone).

Key Points: Aldol condensation converts ethanal to but-2-en-1-al - HVZ reaction converts propanoic acid to 2-chloropropanoic acid - Ozonolysis of alkene C5H10 gives propanal (B) and acetone (C); identification based on Fehling and iodoform tests

Question 41.

(i) Distinguish with a suitable chemical test:

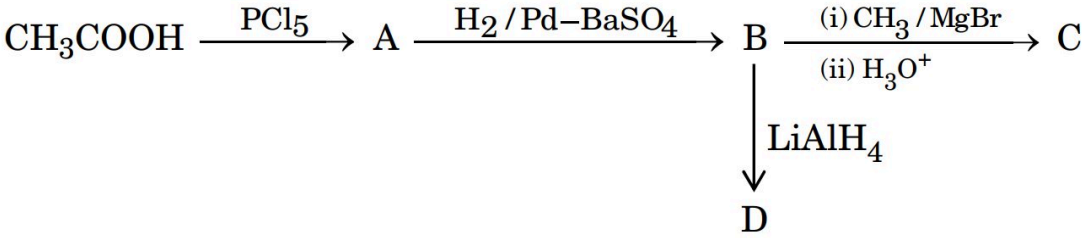
(1) $CH_3COCH_2CH_3$ and $CH_3CH_2CH_2CHO$

(2) Ethanal and Ethanoic acid

(ii) Write the structure of oxime of acetone.

(iii) Identify A to D.

[5 Marks]



Answer:

(i)(1) $CH_3COCH_2CH_3$ (butanone) and $CH_3CH_2CH_2CHO$ (butanal) can be distinguished by the Tollen's test.
Butanal (an aldehyde) gives a silver mirror with Tollen's reagent, but butanone (a ketone) does not react.
(i)(2) Ethanal and ethanoic acid can be distinguished by sodium bicarbonate test.
Ethanoic acid reacts with sodium bicarbonate to release carbon dioxide gas (effervescence), whereas ethanal does not react.
(ii) Structure of oxime of acetone:
Acetone structure is CH_3-CO-CH_3.
The oxime of acetone is formed by the reaction of acetone with hydroxylamine (NH_2OH).
Its structure is CH_3-C=NOH-CH_3 where the =O group of acetone is replaced by =N-OH.
(iii) Identification of compounds A to D:
Step 1: With PCl_5

Carboxylic acid → acid chloride

So,
A = CH_3COCl (Acetyl chloride)

Step 2: A —H_2 / Pd–$BaSO_4$→ B

Pd–$BaSO_4$ is Rosenmund reduction → acid chloride → aldehyde

So,
B = CH_3CHO (Acetaldehyde)

From B, two reactions:

Step 3(a): B —(i) CH_3MgBr (ii) H_3O^+→ C

Grignard reagent adds CH_3 to aldehyde → gives secondary alcohol

CH_3CHO + CH_3MgBr → after hydrolysis →
C = CH_3–CH(OH)–CH_3 (2-propanol / isopropyl alcohol)

Step 3(b): B —$LiAlH_4$→ D

$LiAlH_4$ reduces aldehyde → primary alcohol

$CH_3CHO \rightarrow CH_3CH_2OH$

So,

D = CH_3CH_2OH (Ethanol)

These identifications are based on their functional groups and molecular formulas.

Key Points: Tollen's test distinguishes aldehyde from ketone - Sodium bicarbonate test distinguishes acid from aldehyde - Oxime of acetone has C=NOH group replacing C=O - A to D are Benzene, Anisole, Aniline, and Acetophenone respectively