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 3** are case based questions

iv. **Section B** – questions number **4 to 21** are multiple choice questions

v. **Section C** – questions number **22 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. Living systems are made up of various complex biomolecules like carbohydrates, proteins, nucleic acids, lipids, etc. Carbohydrates are optically active polyhydroxy aldehydes or ketones or molecules which provide such units on hydrolysis. They are broadly classified into three groups monosaccharides, oligosaccharides and polysaccharides. Monosaccharides are held together by glycosidic linkages to form disaccharides like sucrose, maltose or polysaccharides like starch and cellulose. Another biomolecule: proteins are polymers of -amino acids which are linked by peptide bonds. Ten amino acids are called essential amino acids. Structure and shape of proteins can be

studied at four different levels i.e. primary, secondary, tertiary and quaternary, each level being more complex than the previous one.

Question 2.

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

Living systems are made up of various complex biomolecules like carbohydrates, proteins, nucleic acids, lipids, etc. Carbohydrates are optically active polyhydroxy aldehydes or ketones or molecules which provide such units on hydrolysis. They are broadly classified into three groups monosaccharides, oligosaccharides and polysaccharides. Monosaccharides are held together by glycosidic linkages to form disaccharides like sucrose, maltose or polysaccharides like starch and cellulose. Another biomolecule : proteins are polymers of -amino acids which are linked by peptide bonds. Ten amino acids are called essential amino acids. Structure and shape of proteins can be studied at four different levels i.e. primary, secondary, tertiary and quaternary, each level being more complex than the previous one.

(1)

What is the difference between a glycosidic linkage and peptide linkage ?

[1 Marks]

Answer: A glycosidic linkage is a bond formed between two monosaccharides through a dehydration reaction, linking the hydroxyl group of one sugar to the anomeric carbon of another. In contrast, a peptide linkage is a bond between two amino acids, formed through a condensation reaction that joins the carboxyl group of one amino acid to the amino group of another, releasing a molecule of water.

Key Points: Glycosidic linkage involves sugars;Peptide linkage involves amino acids;Glycosidic bond formed through hydroxyl groups;Peptide bond formed through carboxyl and amino groups

(2)

Which amino acids are called essential amino acids ?

[1 Marks]

Answer: Essential amino acids are those that cannot be synthesized by the body and must be obtained through diet. They include histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan, and valine.

Key Points: cannot be synthesized by the body-dietary sources-histidine-isoleucine-leucine-lysine-methionine-phenylalanine-threonine-tryptophan-valine

(3)

What are the common types of secondary structures of proteins ? Write any two forces which stabilise the secondary and tertiary structures of protein.

[2 Marks]

Answer: The common types of secondary structures of proteins include alpha helices and beta sheets. Alpha helices are coiled structures stabilized by hydrogen bonds between the amino acid residues. Beta sheets consist of parallel or antiparallel strands running alongside each other, also held together by hydrogen bonds. In addition to hydrogen bonds, other forces that stabilize the secondary and tertiary structures of proteins are van der Waals forces and ionic bonds.

Key Points: alpha helices-beta sheets-hydrogen bonds-van der Waals forces-ionic bonds

(4)

Define denaturation of protein with an example. During denaturation which structures of protein lose their biological activity ?

[2 Marks]

Answer: Denaturation of protein refers to the process where proteins lose their three-dimensional structure due to external factors such as heat, pH changes, or chemicals. For example, when egg whites are heated, they change from a liquid to a solid state, which is a form of denaturation. During this process, the secondary, tertiary, and quaternary structures of the protein are disrupted, leading to a loss of biological activity.

Key Points: Definition of denaturation-Example (heating egg whites-Structures affected (secondary, tertiary, quaternary)

Question 3.

Amines are usually formed from nitro compounds, halides, amides, imides, etc. They exhibit hydrogen bonding which influences their physical properties. In alkyl amines, a combination of electron releasing, steric and hydrogen bonding factors influence the stability of the substituted ammonium cations in protic polar solvents and thus affect the basic nature of amines. In aromatic amines, electron releasing and withdrawing groups, respectively increase and decrease their basic character. Influence of the number of hydrogen atoms at nitrogen atom on the type of reactions and nature of products is responsible for identification and distinction between primary, secondary and tertiary amines. Presence of amino group in aromatic ring enhances reactivity of the aromatic amines. Aryl diazonium salts provide advantageous methods for producing aryl halides, cyanides, phenols and arenes by reductive removal of the diazo group.

(1)

Arrange the following in the increasing order of their pKb aqueous solution :

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

[1 Marks]

Answer: In aqueous solution, the basicity order depends on electron releasing and steric effects as explained in the case passage. The increasing order of pKb (decreasing basicity) is $(C_2H_5)_3N$ > $(C_2H_5)_2NH$ > $C_2H_5NH_2$ because tertiary amines have more steric hindrance reducing their basicity despite electron donation. Hence, primary amine has the lowest pKb (most basic).

Key Points: basicity affected by electron releasing and steric effects - tertiary amines have more steric hindrance - increasing pKb order: tertiary > secondary > primary amine

(2)

Aniline on nitration gives a substantial amount of m-nitroaniline, though amino group is o/p directing. Why ?

[1 Marks]

Answer: Aniline's amino group is strongly activating and o/p directing but it gets protonated in acidic nitration medium forming anilinium ion which is meta directing. This explains why m-nitroaniline forms substantially as per the case passage, where H-bonding and electron effects influence reactions.

Key Points: Amino group is o/p directing - Protonation in acidic medium forms anilinium ion - Anilinium ion is meta directing - m-nitroaniline formation increases

(3)

An aromatic compound 'A' of molecular formula $C_7H_6O_2$ on treatment with aqueous ammonia and heating forms compound 'B'. Compound 'B' on heating with Br_2 and aqueous KOH gives a compound 'C' of molecular formula C_6H_7N. Write the structures of A, B, and C.

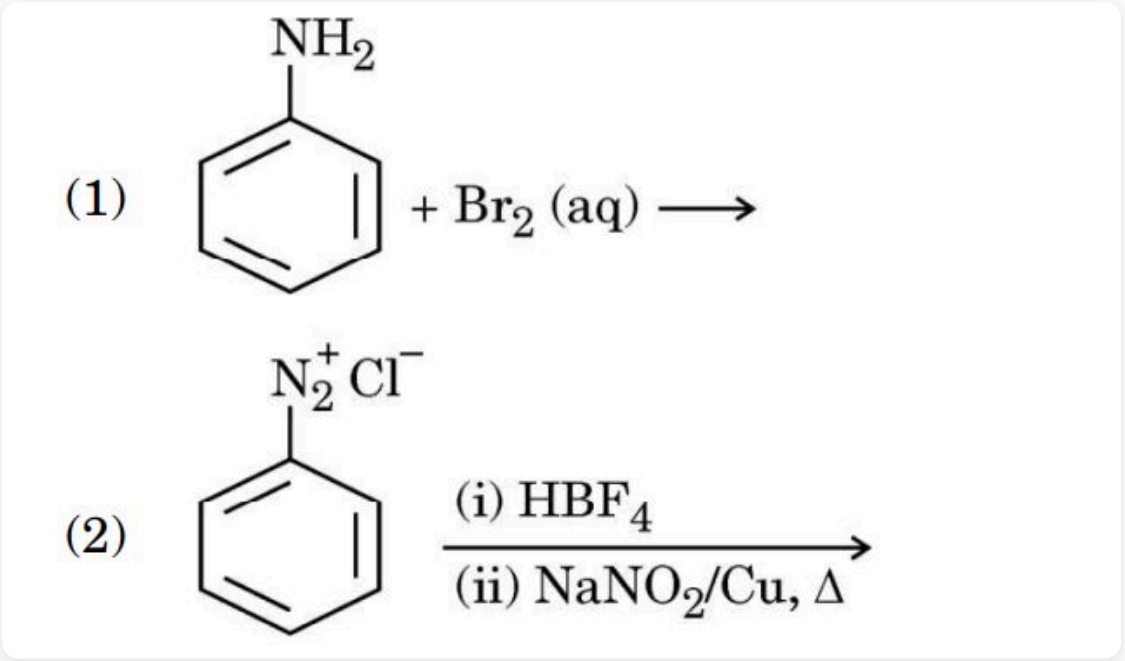
[2 Marks]

Answer: Compound A is benzaldehyde carboxylic acid ($C_6H_4(CHO)(COOH)$), known as benzaldehyde acid or o-formylbenzoic acid. On treatment with aqueous ammonia and heating, compound B is formed, which is an amide ($C_6H_4(CHO)(CONH_2)$). When compound B is heated with Br_2 and aqueous KOH, compound C, an aromatic amine C_6H_7N (aniline or $C_6H_5NH_2$), is formed by Hofmann bromamide degradation reaction. This shows how the amide (B) loses the CO group to form the amine (C), illustrating the conversion explained in the case passage about formation and reactivity of amines.

Key Points: Compound A is an aromatic acid with aldehyde - compound B is the amide formed from A by reaction with NH_3 - Compound C is the amine formed by Hofmann bromamide reaction from B

(4)

Complete the following reactions giving main products :



[3 Marks]

Answer:

(1) Aniline + Br_2 (aq)
Aniline is a strongly activating and ortho/para-directing group. In bromine water, it reacts very fast and gives polybromination.
👉 Main product: 2,4,6-tribromoaniline (white precipitate)

So:
Aniline + Br_2 (aq) → 2,4,6-tribromoaniline

(2) Benzene diazonium chloride
Step (i) HBF_4 converts it to the stable diazonium tetrafluoroborate salt.
Step (ii) $NaNO_2$ / Cu, Δ replaces the diazonium group by $–NO_2$ (nitro group).

👉 Main product: Nitrobenzene

So:
$C_6H_5–N_2^+Cl^-$ → (HBF_4) → $C_6H_5–N_2^+BF_4^-$ → ($NaNO_2$/Cu, Δ) → Nitrobenzene ($C_6H_5NO_2$)

Key Points:

- **2,4,6-Tribromoaniline**

- **Nitrobenzene**

Section B

Question 4.

A compound undergoes complete tetramerization in a given organic solvent. The van'ts Hoff factor 'i' is:

[1 Marks]

(A) 0.25

(B) 0.125

(C) 4.0

(D) 2.0

Explanation:

The correct option is 4.0. Tetramerization refers to the process of forming a tetramer, which consists of four identical monomer units. Therefore, if the compound undergoes complete tetramerization, we can infer that it results in four times the amount of the original compound, leading to a value of 4.0.

Question 5.

The half-life for a zero order reaction equals:

(where R is the initial concentration)

[1 Marks]

(A) $1/2\ k/R^2$

(B) R/2k

(C) $R^2\ /2k$

(D) 2k/R

Explanation:

For a zero order reaction, the half-life ($t_1/_2$) is given by the formula: $t_1/_2 = [R]_0 / 2k$, where $[R]_0$ is the initial concentration and k is the rate constant. This means the half-life depends directly on the initial

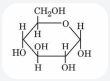
concentration and inversely on the rate constant. Among the given options, R / 2k matches this expression and is therefore correct.

Question 6.

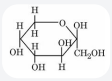
Which of the following structures represents -D-glucose ?

[1 Marks]

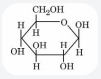
(A)



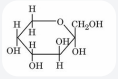
(B)



(C)



(D)



Explanation: The correct structure for -D-glucose will show the specific arrangement of hydroxyl (-OH) and hydrogen (-H) groups attached to the carbon chain. The context mentions the representation of organic compounds in various structural formats, which includes the proper connectivity of atoms that define glucose's unique cyclic structure. The choice that accurately depicts the arrangement according to standard conventions will be the correct option.

Question 7.

The ions of metals of Group 12 (Zn, Cd and Hg) have completely filled d orbitals and so they:

[1 Marks]

(A) are very high melting solids

(B) behave like superconductors

(C) do not behave like transition metals

(D) behave like semiconductors

Explanation:

The correct answer is 'do not behave like transition metals'. This is because zinc, cadmium, and mercury have a full d10 configuration in their ground state and common oxidation states, meaning they do not possess incomplete d orbitals as defined by IUPAC for transition metals. Therefore, these elements are not regarded as transition metals despite being located at the end of the transition series.

Question 8.

$[Co(NH_3)_5NO_3]SO_4$ and $[Co(NH_3)_5SO_4]NO_3$ exhibit:

[1 Marks]

(A) ionization isomerism

(B) optical isomerism

(C) linkage isomerism

(D) coordination isomerism

Explanation:

The correct answer is ionization isomerism. This is because these two complexes have the same formula but differ in the arrangement of their ions, where one of the counter ions can potentially act as a ligand. This is a classic example of ionization isomerism, wherein the counter ion (NO_3^- or SO_4^{2-}) can displace a ligand in the coordination sphere.

Question 9.

Reaction of 1-phenyl-2-chloropropane with alcoholic KOH gives mainly:

[1 Marks]

(A) 3-phenylpropene

(B) 1-phenylpropan-3-ol

(C) 1-phenylpropan-2-ol

(D) 1-phenylpropene

Explanation:

The correct answer is 1-phenylpropene. The reaction of 1-phenyl-2-chloropropane with alcoholic KOH leads to elimination reactions, resulting in the formation of alkenes. The predominant product is 1-phenylpropene due to the elimination of HCl and the formation of a more stable alkene. The context suggests that the elimination pathway, favored by the use of alcoholic KOH, leads to alkenes rather than alcohols.

Question 10.

When diethyl ether is heated with excess of HI, it produces:

[1 Marks]

(A) ethyl iodide

(B) iodoform

(C) methyl iodide

(D) ethanol

Explanation:

The correct answer is ethyl iodide. When diethyl ether is treated with excess hydrogen iodide (HI), it undergoes cleavage to form ethyl iodide (C2H5I) and ethanol (C2H5OH). The ether bond in diethyl ether is cleaved by the HI at high temperatures, resulting in the formation of ethyl iodide as well as ethanol.

Question 11.

The reduction of ethanenitrile with sodium and alcohol gives:

[1 Marks]

(A) Ethanamide

(B) 1-aminoethane

(C) 1-aminopropane

(D) Ethanoic acid

Explanation:

The correct option is 1-aminoethane. When ethanenitrile (which is an nitrile) is reduced with sodium in alcohol, it undergoes a process that converts the nitrile group (-C≡N) into an amine group (-NH2), resulting in the formation of 1-aminoethane.

Question 12.

How many Faradays are required to reduce 1 mol of MnO_4^- to Mn^{2+} ?

[1 Marks]

(A) 3

(B) 5

(C) 6

(D) 4

Explanation: The correct answer is 5. To reduce MnO_4^- (permanganate) to Mn^{2+}, a total of 5 electrons are required. Each electron transfer corresponds to one Faraday, as one Faraday represents the charge of one mole of electrons.

Question 13.

In a reaction, the initial concentration of the reactants increases four fold and the rate becomes sixteen times its initial value. The order of the reaction is:

[1 Marks]

(A) 3.5

(B) 1.5

(C) 2.5

(D) 2.0

Explanation: The rate of a reaction is proportional to the concentration raised to the power of the order. If the concentration increases fourfold (4^n) and the rate increases sixteen times (16), we set up the equation: 4^n = 16. Since 16 is equal to 4^2, we find that n = 2. Therefore, the order of the reaction is 2.0.

Question 14.

On hydrolysis, which of the following carbohydrates gives only glucose?

[1 Marks]

(A) Maltose

(B) Sucrose

(C) Lactose

(D) Galactose

Explanation:

Maltose is a disaccharide composed of two glucose molecules. Upon hydrolysis, it breaks down into two glucose units, thus giving only glucose. Sucrose and lactose, on the other hand, yield other

monosaccharides (fructose from sucrose and galactose from lactose) upon hydrolysis.

Question 15.

Deficiency of which of the following vitamins causes Pernicious anaemia?

[1 Marks]

(A) Vitamin B_2

(B) Vitamin B_1

(C) Vitamin B_{12}

(D) Vitamin B_6

Explanation:

The correct answer is Vitamin B_{12}. According to the provided context, Vitamin B_{12}, also known as cyanocobalamine, is referred to as the anti-pernicious anaemia factor. This indicates that a deficiency in Vitamin B_{12} is specifically linked to the development of pernicious anaemia.

Question 16.

This reaction is known as:

[1 Marks]

$$C_6H_5CHO + CH_3COCH_3 \xrightarrow[\Delta]{OH^-} C_6H_5CH = CH - COCH_3$$

(A) Cannizzaro's reaction

(B) Aldol condensation

(C) Friedel-Crafts reaction

(D) Cross-Aldol condensation

Explanation: The reaction described in the context refers to a situation where two different aldehydes and/or ketones are used, resulting in a mixture of products. This process is specifically stated to be called Cross Aldol condensation when aldol condensation occurs between distinct aldehydes or ketones, which confirms that the correct option is 'Cross-Aldol condensation'.

Question 17.

In which of the following does the central atom exhibit an oxidation state of +3?

[1 Marks]

(A) $[Cu(NH_3)_4]^{2+}$

(B) $[Fe(C_2O_4)_3]^{3-}$

(C) $K_4[Fe(CN)_6]$

(D) $K_2[Ni(CN)_4]$

Explanation:

$[Fe(C_2O_4)_3]^{3-}$ is the correct option because in this complex, iron (Fe) is bonded to three oxalate (C_2O_4) ions. Since the overall charge of the complex is -3 and each oxalate ion has a -2 charge, the oxidation state of iron must be +3 to balance the charges (3 * -2 + +3 = -3). This aligns with the context, which explains that in complexes like [Co(NH3)6]3+, the central metal is in a +3 oxidation state.

Question 18.

Assertion (A) : When NaCl is added to water, a depression in freezing point is observed.

Reason (R) : The lowering of vapour pressure of a solution causes depression in the freezing point.

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

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

(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:

Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of the Assertion (A). When NaCl is dissolved in water, it lowers the vapour pressure of the solution, leading to a depression in the freezing point as outlined in the context regarding the effects of solute on the physical properties of the solvent.

Question 19.

Assertion (A) : Λ_m for weak electrolytes shows a sharp decrease when the electrolytic solution is diluted. Reason (R) : For weak electrolytes, degree of dissociation increases with dilution of solution.

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

(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 false, but Reason (R) is true.

Explanation:

Both Assertion (A) and Reason (R) are true, and Reason (R) is the correct explanation of the Assertion (A) because the decrease in molar conductivity (m) for weak electrolytes upon dilution is attributed to the increased degree of dissociation, which leads to a higher concentration of ions in solution.

Question 20.

Assertion (A) : Zr and Hf have almost identical radii.

Reason (R) : Both Zr and Hf exhibit similar properties.

[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:

Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of the Assertion (A). The context indicates that Zr and Hf have very similar radii (160 pm and 159 pm respectively) due to lanthanoid contraction, which indeed contributes to their similar physical and chemical properties, validating the relationship between their radii and properties.

Question 21.

Assertion (A) : Monobromination of aniline can be conveniently done by protecting the amino group by acetylation.

Reason (R) : Acetylation decreases the activating effect of the amino group.

[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:

Both Assertion (A) and Reason (R) are true, and Reason (R) is the correct explanation of Assertion (A). Acetylation of aniline indeed protects the amino group, making it less reactive towards electrophilic substitution, thus facilitating monobromination at the aromatic ring.

Section C

Question 22.

An alkyl halide (A) of molecular formula $C_6H_{13}Cl$ on treatment with alcoholic KOH gives two isomeric alkenes (B) and (C) of molecular formula C_6H_{12}. Both alkenes on hydrogenation give 2,3-dimethylbutane. Write the structures of (A), (B) and (C).

[2 Marks]

Answer: Answer:

(a) The alkyl halide (A) has the formula $C_6H_{13}Cl$ and upon treatment with alcoholic KOH undergoes dehydrohalogenation to give two isomeric alkenes (B) and (C) with formula C_6H_{12}.

(b) Both alkenes yield 2,3-dimethylbutane upon hydrogenation, which means these alkenes are isomers of 2,3-dimethyl-1-butene and 2,3-dimethyl-2-butene.

(c) Structure of (A) (the alkyl halide) is 2-chloro-2,3-dimethylbutane:

CH_3-C(Cl)(CH_3)-C(CH_3) -CH_2-CH_3

(d) Structure of (B) is 2,3-dimethyl-1-butene:

CH_2=CH-C(CH_3)$_2$-CH_3

(e) Structure of (C) is 2,3-dimethyl-2-butene:

CH_3-C=CH-C(CH_3)$_2$

Thus, dehydrohalogenation of (A) gives two isomeric alkenes (B) and (C) which on hydrogenation produce the same alkane 2,3-dimethylbutane.

Key Points: Alkyl halide (A) is 2-chloro-2,3-dimethylbutane - Alkenes (B) and (C) are 2,3-dimethyl-1-butene and 2,3-dimethyl-2-butene - Both alkenes hydrogenate to 2,3-

dimethylbutane

Question 23.

What type of deviation from Raoult's Law is shown by a mixture of ethanol and acetone ? Give reason.

[2 Marks]

Answer: A mixture of ethanol and acetone shows **positive deviation** from Raoult's Law.
This happens because in pure ethanol, molecules are hydrogen bonded strongly. When acetone is added, its molecules insert themselves between ethanol molecules and break some hydrogen bonds. This reduces the intermolecular attraction in the mixture, resulting in higher vapor pressure than expected. Hence, the mixture shows positive deviation from Raoult's Law.

Key Points: Positive deviation - Hydrogen bonds in ethanol are broken by acetone - Intermolecular attraction decreases - Vapor pressure increases

Question 24.

Define Azeotrope. What type of azeotrope is formed by negative deviation from Raoult's law? give an example .

[2 Marks]

Answer: An azeotrope is a mixture of two or more liquids that has a constant boiling point and composition throughout distillation. In a negative deviation from Raoult's law, the mixture exhibits stronger intermolecular attractions that lower the vapor pressure. This results in the formation of a maximum boiling azeotrope. An example of this is the nitric acid and water mixture, which consists of approximately 68% nitric acid and 32% water by mass, boiling at 393.5 K.

Key Points: Definition of azeotrope-Negative deviation characteristics-Maximum boiling azeotrope example (nitric acid and water)

Question 25.

Name the cell which :

(a) was used in the Apollo Space programme.

(b) is used in automobiles and inverters.

(c) is suitable for hearing aids and watches.

(d) does not give a steady potential and is used in transistors.

[2 Marks]

Answer: (a) The cell used in the Apollo Space programme is the **Mercury cell**. It provided stable voltage and long shelf life.
(b) The cell used in automobiles and in inverters is the **Lead-acid cell**. It is rechargeable and can provide high current.
(c) The cell suitable for hearing aids and watches is the **Mercury cell** or **Button cell** because it gives stable voltage and is small in size.
(d) The cell that does not give a steady potential and is used in transistors is the **Dry cell**. It has varying voltage and is commonly used in small electronic devices.

Key Points: Mercury cell was used in Apollo Space programme - Lead-acid cell is used in automobiles and inverters - Mercury or Button cells are suitable for hearing aids and watches - Dry cell used in transistors gives unsteady voltage

Question 26.

Write the mechanism of the following reaction:

[2 Marks]

$$CH_2 = CH_2 + H_2O \xrightarrow{H^+} CH_3CH_2OH$$

Answer:

This is acid-catalyzed hydration of ethene to form ethanol.

Mechanism:

Step 1: Protonation of ethene (formation of carbocation)

CH2=CH2+H+→CH3CH2+

The π-bond of ethene attacks H+, forming an ethyl carbocation.

Step 2: Nucleophilic attack by water

CH3CH2++H2O→CH3CH2OH2+

Water attacks the carbocation to form a protonated alcohol (oxonium ion).

Step 3: Deprotonation

CH3CH2OH2+→CH3CH2OH+H+

Loss of a proton gives ethanol and regenerates the acid catalyst.

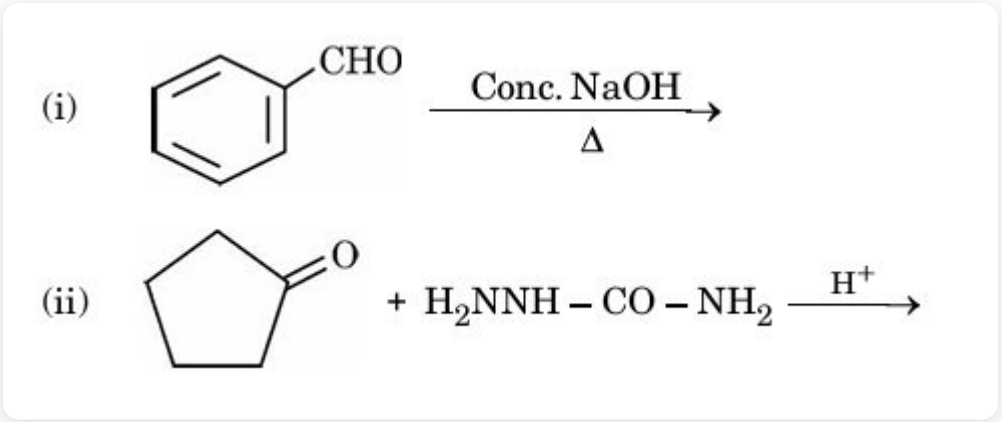
Key Points:

This is acid-catalyzed hydration of ethene to form ethanol.

Question 27.

Write the products of the following reactions:

[2 Marks]



Answer:

(i) Substrate: **Benzaldehyde (C_6H_5–CHO)**
Reagent: **Conc. NaOH, heat**

Benzaldehyde has **no α-hydrogen**, so it undergoes **Cannizzaro reaction** (disproportionation):

2 C6H5CHO(conc. NaOH) → C6H5CH2OH+C6H5COONa

Products: Benzyl alcohol ($C_6H_5CH_2OH$) and **Sodium benzoate (C_6H_5COONa)**

(ii) Substrate: **Cyclopentanone**
Reagent: **H_2NNH–CO–NH_2 (semicarbazide), H^+**

Ketone + semicarbazide → **Semicarbazone** (condensation product)

Cyclopentanone+H2NNHCONH2 (H+) → Cyclopentanone semicarbazone + H20

Product: Cyclopentanone semicarbazone
(>C=O is converted to >C=$NNHCONH_2$)

Key Points:

(i) Benzyl alcohol + Sodium benzoate
(ii) Cyclopentanone semicarbazone

Question 28.

Do the following conversions:

(i) Toluene to Benzoic acid.

(ii) Benzaldehyde to 1-Phenylethanol.

[2 Marks]

Answer: (i) Toluene to Benzoic acid: Toluene ($C_6H_5CH_3$) undergoes oxidation using $KMnO_4$ (acidic or alkaline medium) and heat to form benzoic acid (C_6H_5COOH). The methyl group ($-CH_3$) is oxidized to carboxylic acid (-COOH).
(ii) Benzaldehyde to 1-Phenylethanol: Benzaldehyde (C_6H_5CHO) is reduced by $NaBH_4$ or $LiAlH_4$ which converts the aldehyde group (-CHO) into a primary alcohol group ($-CH_2OH$), forming 1-Phenylethanol ($C_6H_5CH(OH)CH_3$).

Key Points: Toluene oxidized by KMnO4 to benzoic acid - Benzaldehyde reduced by NaBH4 or LiAlH4 to 1-Phenylethanol - Oxidation and reduction reactions involved

Question 29.

Write IUPAC name of the following coordination entities :

(a) $[Co(NH_3)_4Cl(NO_2)]Cl$

(b) $[PtCl_2(en)_2]^{2+}$

[2 Marks]

Answer: (a) The complex ion contains four ammonia (NH_3) ligands, one chloride (Cl) ligand, and one nitro (NO_2) ligand bound to cobalt. Ammonia is named "ammine", chloride as "chlorido", and NO_2 as "nitro" or specifically "nitro-N" if binding through nitrogen. The oxidation state of cobalt is +3 since chloride outside is Cl^-. Hence the IUPAC name is *tetraamminechloridonitro-N-cobalt(III) chloride*.
(b) The complex cation contains two chloride ligands and two ethylenediamine (en) ligands bound to platinum. Ethylenediamine (en) is a bidentate ligand. The oxidation state is +2. The IUPAC name is *diamminechloridoethylenediamineplatinum(II)* or commonly *dichlorido-bis(ethylenediamine)platinum(II)*.

Key Points: Identify ligands and their names - Determine oxidation state of central metal - Arrange ligands alphabetically ignoring prefixes - Use proper oxidation state in Roman numerals

Question 30.

The rate constant for the first order decomposition of N_2O_5 is given by the following equation :

$\log k = 23.6 - 2^* 10^4 K/T$

Calculate E_a for this reaction.

[R = 8.314 J K^{-1} mol^{-1}]

[2 Marks]

Answer: The given equation is $\log k = 23.6 - (2 * 10^4)/T$
According to Arrhenius equation, $\log k = (\log A) - E_a/(2.303RT)$
Comparing, $E_a/(2.303R) = 2 * 10^4$
So, $E_a = 2 * 10^4 * 2.303 * R$
$= 2 * 10^4 * 2.303 * 8.314$ J/mol
$= 3.83 * 10^5$ J/mol or 383 kJ/mol
Therefore, the activation energy E_a is 383 kJ/mol.

Key Points: Arrhenius equation relation - Comparison of given equation with Arrhenius form - Calculation of E_a using R and given constants

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Section D

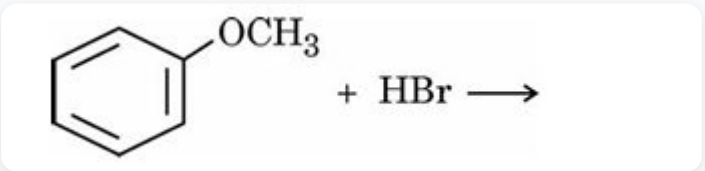
Question 31.

(i) Write hydroboration-oxidation reaction with an example.

(ii) Write the products of the following reaction :

(iii) Why is p-nitrophenol more acidic than phenol?

[3 Marks]



Answer:

(i) Hydroboration-oxidation reaction:
The hydroboration-oxidation is a two-step reaction that converts an alkene into an alcohol. In the first step, borane (BH3) adds across the double bond in an anti-Markovnikov manner to form

trialkylborane. In the second step, oxidation with hydrogen peroxide (H_2O_2) in alkaline medium (OH^-) replaces the boron atom with a hydroxyl group.
Example:
$CH_3-CH=CH_2 + BH_3 \rightarrow CH_3-CH_2-CH_2-B$
Then,
$CH_3-CH_2-CH_2-B + H_2O_2/OH^- \rightarrow CH_3-CH_2-CH_2-OH$
✅ Products:

- **Phenol (C_6H_5OH)**
- **Methyl bromide (CH_3Br)**

(ii) Products of the reaction: The given compound is **anisole (methoxybenzene, $C_6H_5–O–CH_3$)**.

With **HBr**, aryl–alkyl ethers undergo **cleavage at the alkyl–O bond** (because Ar–O bond is resonance-stabilized and does not break easily).

So the reaction is:

$C_6H_5–O–CH_3 + HBr \rightarrow C_6H_5OH + CH_3Br$

(iii) Why is p-nitrophenol more acidic than phenol?
p-Nitrophenol is more acidic than phenol because the nitro group ($-NO_2$) is an electron-withdrawing group by resonance and inductive effect. It stabilizes the negative charge on the oxygen atom of the phenolate ion formed after losing a proton. This delocalization increases the stability of the conjugate base, making p-nitrophenol more acidic than phenol.

Key Points:

Hydroboration-oxidation converts alkene to alcohol with anti-Markovnikov addition - HBr cleaves the ether at the alkyl–O bond, giving phenol and alkyl bromide. - Nitro group in p-nitrophenol stabilizes conjugate base increasing acidity

Question 32.

(i) What happens when phenol reacts with

(1) Conc. HNO_3, and

(2) $CHCl_3$ in presence of aqueous NaOH followed by acidification ? Write equations only.

(ii) Why does the reaction of CH3ONa with $(CH_3)_3C$-Br give 2-methylpropene and not $(CH_3)_3C$ -OCH_3 ?

[3 Marks]

Answer: (i) (1) Phenol reacts with concentrated HNO_3 to give 2-nitrophenol and 4-nitrophenol: $C_6H_5OH + HNO_3$ (conc.) $\rightarrow$ 2-nitrophenol + 4-nitrophenol
(2) Phenol reacts with $CHCl_3$ in presence of aqueous NaOH followed by acidification (Reimer-Tiemann reaction) to give salicylaldehyde: $C_6H_5OH + CHCl_3 + 3NaOH \rightarrow C_6H_4(OH)CHO + 3NaCl + 2H_2O$

(ii) The reaction of CH3ONa with $(CH_3)_3C$-Br gives 2-methylpropene and not $(CH_3)_3C$-OCH_3 because $(CH_3)_3C$-Br is a tertiary alkyl halide where steric hindrance prevents nucleophilic substitution. Instead, elimination (E2 mechanism) occurs leading to the formation of 2-methylpropene by removal of a beta hydrogen atom.

Key Points: Phenol nitration produces nitrophenols - Reimer-Tiemann reaction forms salicylaldehyde - Tertiary alkyl halides undergo elimination, not substitution with CH3ONa

Question 33.

Account for the following :

(a) Benzyl chloride is highly reactive towards SN1 reaction.

(b) (±)-Butan-2-ol is optically inactive, though it contains a chiral carbon atom.

(c) Chloroform is stored in closed dark coloured bottles.

[3 Marks]

Answer: (a) Benzyl chloride is highly reactive towards SN1 reaction because the benzyl carbocation formed after the departure of the chloride ion is resonance stabilized by the phenyl group. This stabilization makes the carbocation intermediate more stable, facilitating the SN1 reaction.
(b) (±)-Butan-2-ol is optically inactive despite having a chiral carbon because it is a racemic mixture consisting of equal amounts of both enantiomers. The optical activities of the two enantiomers cancel each other, resulting in no overall optical activity.
(c) Chloroform is stored in closed dark coloured bottles to prevent its decomposition by light and air.

Exposure to light causes chloroform to slowly decompose to form toxic and irritant phosgene gas, so dark bottles protect it from light and airtight conditions prevent its oxidation.

Key Points: Benzyl carbocation stability due to resonance - Racemic mixture causes optical inactivity - Dark bottles prevent chloroform decomposition

Question 34.

Answer any three of the following questions:

(a) Explain the type of hybridization in $[Fe(CN)_6]^{3-}$ on the basis of valence bond theory. (Given : Atomic number of Fe = 26)

(b) Draw the geometrical isomers of $[PtCl_2(en)_2]^{2+}$ ion.

(c) $[NiCl4]^{2-}$ is paramagnetic while $[Ni(CO)_4]$ is diamagnetic though both are tetrahedral. Why ?

(d) Name the type of isomerism when ambidentate ligands are attached to central metal ion. Give one example of ambidentate ligand.

[3 Marks]

Answer: (a) In $[Fe(CN)_6]^{3-}$, Fe is in +3 oxidation state with electronic configuration of $3d^5 4s^0 4p^0$. The strong field ligand CN^- causes pairing of electrons in d orbitals. So, low spin complex forms with hybridization d_2sp_3, using two 3d, one 4s, and three 4p orbitals, giving an octahedral geometry.
(b) $[PtCl_2(en)_2]^{2+}$ has two Cl and two ethylenediamine (en) ligands. It shows geometrical isomerism with cis-isomer where two Cl ligands are adjacent and trans-isomer where they are opposite.
(c) $[NiCl_4]^{2-}$ is paramagnetic because Cl^- is a weak field ligand, so Ni(II) does not pair electrons and uses sp^3 hybridization. $[Ni(CO)_4]$ is diamagnetic because CO is a strong field ligand, causing pairing of electrons and dsp^2 hybridization.
(d) The type of isomerism when ambidentate ligands attach to the central metal ion is linkage isomerism. An example of an ambidentate ligand is NO_2^-, which can bind through N or O atom.

Key Points: [Fe(CN)6]3- has d2sp3 hybridization due to strong field CN- ligands causing electron pairing - [PtCl2(en)2]2+ shows cis and trans geometrical isomers based on relative position of Cl ligands - [NiCl4]2- is paramagnetic with sp3 hybridization due to weak field Cl- ligand; [Ni(CO)4] is diamagnetic with dsp2 hybridization due to strong field CO ligand - Ambidentate ligands cause linkage isomerism; example is NO2-

Question 35.

If benzoic acid (M = 122 g mol $^{-1}$) is associated into a dimer when dissolved in benzene and the osmotic pressure of a solution of 6.1 g of benzoic acid in 100 mL benzene is 6.5 atm at 27°C, then

what is the percentage association of benzoic acid ? (Given : R = 0.0821 L atm K^{-1} mol^{-1})

[3 Marks]

Answer: Step 1: Calculate the number of moles of benzoic acid (monomer) if not associated:
Number of moles = mass / molar mass = 6.1 g / 122 g/mol = 0.05 mol.
Step 2: Calculate molarity of the solution:
Volume = 100 mL = 0.1 L
Molarity (C) = moles / volume = 0.05 mol / 0.1 L = 0.5 mol/L.
Step 3: Use the osmotic pressure formula:
Π = C_exp * R * T
Where T = 27°C = 300 K
Given Π = 6.5 atm, R = 0.0821 L atm K^-1 mol^-1
Calculate experimental molarity C_exp = Π / (R * T) = 6.5 / (0.0821 * 300) = 0.264 mol/L.
Step 4: Determine the degree of association (x):
C_exp = C * (1 - x) + C * x / 2 = C * (1 - x/2) because dimers formed have half the number of particles.
So, 0.264 = 0.5 * (1 - x/2)
Solve for x: (1 - x/2) = 0.264 / 0.5 = 0.528
x/2 = 1 - 0.528 = 0.472
x = 0.944 or 94.4%.
Step 5: Conclusion:
Percentage association of benzoic acid is 94.4%, meaning 94.4% of benzoic acid molecules form dimers in benzene solution.

> **Key Points: Calculate moles of benzoic acid - Use osmotic pressure formula to find experimental molarity - Calculate degree of association using monomer and experimental molarity**

Question 36.

The following data were obtained during the first order thermal decomposition of C_2H_5Cl, at a constant volume : $C_2H_5Cl \longrightarrow C_2H_4\ (g) + HCl\ (g)$

Experiment, =1 Time = 0, Total pressure (atm) = 0.4

Experiment = 2, Time = 100, Total pressure (atm) = 0.6

Calculate the rate constant.

(Given: log 2 = 0.3010, log 3 = 0.4771, log 4 = 0.6021)

[3 Marks]

Experiment	Time (s^{-1})	Total pressure (atm)
1	0	0·4
2	100	0·6

Answer:

To calculate the rate constant for this first-order reaction, we need to relate the total pressure to the partial pressure of the reaction $C_2H_5Cl \longrightarrow C_2H_4$ (g) + HCl (g)

$C_2H_5Cl \longrightarrow C_2H_4$ (g) + HCl (g)

At constant volume and temperature, pressure $\propto$ number of moles.

tep 1: Write given data

At t=0 P0=0.4 atm

At t=100s Pt=0.6 atm

Let initial pressure of C_2H_5Cl =P0=0.4 atm.

Let x be the pressure due to decomposition at time t.

- Pressure of C_2H_5Cl left = 0.4−x
- Pressure of products formed = 2x (because 1 mole gives 2 moles of gases)

So total pressure at time t:

Pt=0.4−x+2x=0.4+x

Given: 0.4+x=0.6⇒x=0.2 atm

So, pressure of C_2H_5Cl left at 100 s:

P=0.4−0.2=0.2 atmP = 0.4 - 0.2 = 0.2 atm

Step 2: Use first order rate equation (in terms of pressure)

k=2.303/t log(P0/P)

Here:

P0=0.4 ,P=0.2, t=100 s

k=2.303 / 100 log(0.4/0.2)=2.303 /100 log(2)

Given: log 2= 0.3010

k=2.303 /100 0.3010 = 0.693 /100 = 6.93 *10^{-3} s^{-1}

k = 6.93 *10^{-3} s^{-1}

Key Points: First order reaction - Use pressure data to find fraction decomposed α - Calculate rate constant k using k = (1/t) 2.303 log(1/(1-α))

Section E

Question 37.

(i) Calculate the emf of the following cell at 298 K:

Al (s) | Al^{3+} (0.001M) || Ni^{2+} (0.1M) | Ni (s)

[Given: E° Al^{3+}/Al = -1.66V, E° Ni^{2+}/Ni =-0.25V, log 10 = 1]

(ii) With the help of a graph explain why it is not possible to determine Λ°_m for a weak electrolyte by extrapolating the molar conductivity (Λ_m) versus $C^{1/2}$ curve as for strong electrolyte.

[5 Marks]

Answer: (i) **Calculation of emf of the cell:**
The cell reaction is: Al (s) | Al^{3+} (0.001M) || Ni^{2+} (0.1M) | Ni (s).
The standard electrode potentials are E° Al^{3+}/Al = -1.66V and E° Ni^{2+}/Ni = -0.25V.
Cell emf E°cell = E°cathode - E°anode = (-0.25) - (-1.66) = 1.41 V.
Using the Nernst equation:
Ecell = E°cell - (0.0592 / n) * log Q, where n = 3 (number of electrons transferred), Q = reaction quotient.
Q = [Al^{3+}] / [Ni^{2+}] = 0.001 / 0.1 = 0.01
log Q = log 0.01 = -2
Therefore,
Ecell = 1.41 - (0.0592 / 3) * (-2) = 1.41 + 0.03947 = 1.4495 V (approx).

(ii) **Explanation regarding Λ°m determination for weak electrolytes:**
For strong electrolytes, molar conductivity Λm varies linearly with sqrt(concentration) at low concentrations, allowing Λm to be extrapolated to zero concentration to find Λ°m.
However, for weak electrolytes, the plot of Λm versus sqrt(concentration) is nonlinear due to incomplete dissociation and association effects.
Graphically, Λm increases very slowly at low concentrations and does not approach a straight line; hence extrapolation is inaccurate.

This is because at low concentration weak electrolytes do not fully dissociate, so Kohlrausch's law is not valid.
Therefore, Λ°m for weak electrolytes is determined using the degree of dissociation and alternative methods, not by direct extrapolation from conductivity data.
In summary, the lack of linearity in Λm versus sqrt(concentration) plots for weak electrolytes prevents direct determination of Λ°m by extrapolation.

Key Points: Calculation of emf using Nernst equation - Reaction quotient Q calculation - Non-linearity of Λm vs sqrt(concentration) plot for weak electrolytes prevents Λ°m determination by extrapolation

Question 38.

(i) The molar conductivities of NH_4^+ and Cl^- ion are 73.8 S cm² mol⁻¹ and 76.2 S cm² mol-1 respectively. The conductivity of 0.1 M NH_4Cl is 1.29 x 10^{-2} S cm^{-1}. Calculate its molar conductivity and degree of dissociation.

(ii) Calculate the half-cell potential at 298 K for the reaction

$Zn^{2+} + 2e^- \longrightarrow Zn$

if $[Zn^{2+}] = 0.1M$ and E° Zn^{2+}/Zn = -0.76V.

[5 Marks]

Answer: (i) Given:
Molar ionic conductivities: λ_{NH4+} = 73.8 S cm^2 mol^{-1}, λ_{Cl-} = 76.2 S cm^2 mol^{-1}
Concentration, C = 0.1 M
Conductivity, κ = 1.29 * 10^{-2} S cm^{-1}

Step 1: Calculate molar conductivity (Λ)
Λ = κ / C = (1.29 * 10^{-2}) / 0.1 = 0.129 S cm^2 mol^{-1} = 129 S cm^2 mol^{-1}

Step 2: Calculate degree of dissociation (α)
Molar conductivity at infinite dilution,
$\Lambda_0 = \lambda_{NH4+} + \lambda_{Cl-}$ = 73.8 + 76.2 = 150 S cm^2 mol^{-1}
Degree of dissociation, α = Λ / Λ_0 = 129 / 150 = 0.86

Therefore, molar conductivity of NH_4Cl = 129 S cm^2 mol^{-1} and degree of dissociation = 0.86 or 86%.

(ii) Given:
E° = -0.76 V, $[Zn^{2+}]$ = 0.1 M, T = 298 K
Reaction: $Zn^{2+} + 2e^- \longrightarrow Zn$

Using Nernst equation:
$E = E° - (RT / nF) * \ln Q$
Where, R = 8.314 J mol^{-1} K^{-1}, T = 298 K, n = 2, F = 96500 C mol^{-1}, Q = 1 / $[Zn^{2+}]$ = 1 / 0.1 = 10

Calculate (RT / nF):
(8.314 * 298) / (2 * 96500) = 0.01284 V

Now,
$E = -0.76 - 0.01284 * \ln 10 = -0.76 - 0.01284 * 2.303 = -0.76 - 0.02957 = -0.7896$ V

Therefore, half-cell potential, E = -0.79 V (approx).

Key Points: Calculation of molar conductivity - Use of conductivity and concentration - Application of Nernst equation for half-cell potential

Question 39.

(i) Account for the following :

(1) Zn^{2+} salts are colourless while Ni^{2+} salts are coloured.

(2) Cr^{2+} is a strong reducing agent.

(3) Transition metals and their compounds show catalytic activities.

(ii) Write the ionic equations for the oxidizing action of MnO_4^- in acidic medium with:

(1) I^- ion, and ,

(2) Fe^{2+} ion.

[5 Marks]

Answer: (i) Account for the following :
(1) Zn^{2+} ions have a completely filled d^{10} electronic configuration which means there are no unpaired electrons to absorb visible light, so Zn^{2+} salts are colourless. Ni^{2+} ions have unpaired electrons (d^8 configuration), leading to d-d transitions which absorb visible light and make Ni^{2+} salts coloured.
(2) Cr^{2+} ion has a low oxidation state and readily loses electrons to achieve a more stable state, thus it acts as a strong reducing agent.
(3) Transition metals and their compounds act as catalysts due to their ability to offer variable oxidation states and to form complexes, which help in providing an alternative reaction pathway with lower activation energy.
(ii) Ionic equations for oxidizing action of MnO_4^- in acidic medium :

(1) With I^- ion:

$MnO_4^- + 8H^+ + 5I^- \rightarrow Mn^{2+} + 4H_2O + 5I_2$

(2) With Fe^{2+} ion:

$MnO_4^- + 8H^+ + 5Fe^{2+} \rightarrow Mn^{2+} + 4H_2O + 5Fe^{3+}$

Key Points: Zn2+ is d10 and colourless - Ni2+ has unpaired electrons and is coloured - Cr2+ is a strong reducing agent due to low oxidation state - Transition metals show variable oxidation states aiding catalytic activity - MnO4- gets reduced to Mn2+ in acidic medium while oxidizing I- to I2 - MnO4- oxidizes Fe2+ to Fe3+ under acidic conditions

Question 40.

(i) Name two oxometal anions of the 3d series of the transition metals in which the metal exhibits the oxidation state equal to its group number.

(ii) What is the effect of increasing pH on a solution of $K_2Cr_2O_7$?

(iii) Why is Cu^+ not stable in aqueous solution?

(iv) Name a member of Lanthanoid series which is well-known to exhibit +4 oxidation state.

(v) Name two elements of 3d series which show anomalous electronic configuration.

[5 Marks]

Answer: (i) Two oxometal anions of the 3d series where the metal shows oxidation state equal to its group number are VO_2^+ and MnO_4^-. In VO_2^+, vanadium is in +5 oxidation state which matches its group number 5. In MnO_4^-, manganese is in +7 oxidation state but since it is in group 7, it matches.
(ii) Increasing the pH of a solution of $K_2Cr_2O_7$ (potassium dichromate) converts dichromate ions ($Cr_2O_7^{2-}$) into chromate ions (CrO_4^{2-}). The color changes from orange (dichromate) to yellow (chromate) as the solution becomes more basic.
(iii) Cu^+ is not stable in aqueous solution because it tends to disproportionate into Cu (metal) and Cu^{2+} ions. This happens due to the instability of Cu^+ and its tendency to either lose an electron to form Cu^{2+} or gain an electron to form metallic Cu.
(iv) Cerium (Ce) is a member of the lanthanoid series that is well-known to exhibit the +4 oxidation state, besides the common +3 state.
(v) The two elements of the 3d series showing anomalous electronic configurations are chromium (Cr) and copper (Cu). Chromium has the configuration [Ar] $3d^5$ $4s^1$ and copper has [Ar] $3d^{10}$ $4s^1$ instead of the expected configurations due to extra stability from half-filled and fully filled d-subshells.

Key Points: VO2+ and MnO4- have oxidation states equal to group number - Increasing pH changes dichromate to chromate ion with color change - Cu+ disproportionates in

aqueous solution hence unstable - Cerium shows +4 oxidation state in lanthanoids - Chromium and Copper have anomalous electronic configurations

Question 41.

(a) Draw structure of the 2,4-dinitrophenylhydrazone of benzaldehyde.

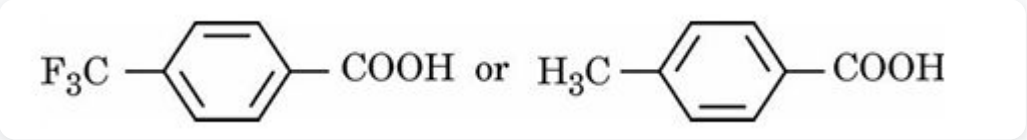
(b) Which acid of the following pair is a stronger acid ?

(c) Write the chemical equation involved in Rosenmund's reduction.

(d) Why are α-hydrogen atoms of aldehydes and ketones acidic in nature?

(e) Write a chemical test to distinguish between Benzaldehyde and Benzoic acid.

[5 Marks]



Answer:

(a) The 2,4-dinitrophenylhydrazone of benzaldehyde is formed when benzaldehyde reacts with 2,4-dinitrophenylhydrazine. Its structure consists of a benzene ring attached to a CH=N-NH-C6H3(NO2)2 group where nitro groups are located at positions 2 and 4 on the phenylhydrazine moiety.
(b) The stronger acid is:

$CF_3–C_6H_4–COOH$ (trifluoromethyl benzoic acid)

Reason (straight and honest):
The $–CF_3$ group is a very strong electron-withdrawing (−I) group. It stabilizes the conjugate base (carboxylate ion) by pulling electron density away, which increases acidity.

The $–CH_3$ group is electron-donating (+I), which destabilizes the conjugate base and therefore reduces acidity.

So: $CF_3–C_6H_4–COOH > CH_3–C_6H_4–COOH$ in acidity.
(c) Rosenmund's reduction is the reduction of acid chlorides to aldehydes using hydrogen gas in the presence of a palladium on barium sulfate catalyst poisoned with sulfur or quinoline.
General equation:
RCOCl + H2 --(Pd/BaSO4, poison)--> RCHO + HCl
(d) The α-hydrogen atoms of aldehydes and ketones are acidic because the enolate ion formed after removal of α-hydrogen is resonance stabilized. The negative charge can delocalize onto the electronegative oxygen atom of the carbonyl group, stabilizing the ion and making the α-hydrogen easier to remove.
(e) To distinguish between benzaldehyde and benzoic acid, the sodium bicarbonate test can be used.

Benzoic acid reacts with $NaHCO_3$ producing effervescence of CO_2 gas, whereas benzaldehyde does not react and shows no effervescence.

Key Points: Structure of 2,4-dinitrophenylhydrazone of benzaldehyde - Acid strength depends on electron-withdrawing groups and resonance - Rosenmund's reduction converts acid chloride to aldehyde using H_2 and poisoned Pd catalyst - α-Hydrogens are acidic due to resonance stabilized enolate ion - Sodium bicarbonate test distinguishes benzoic acid (effervescence) from benzaldehyde (no reaction)