CBSE EXAMINATION PAPER-2024

CHEMISTRY

(Solved)

Time allowed : 3 hours | Maximum Marks : 74

General Instructions :

Read the following instructions carefully and follow them :

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

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

iii. **Section A** – questions number **1 to 5** are case based questions

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

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

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

vii. **Section E** – questions number **35 to 39** are long answer

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

ix. Use of calculator is NOT allowed.

Section A

Question 1. Carbohydrates are essential for life in both plants and animals. Carbohydrates are used as storage molecules as starch in plants and glycogen in animals. Chemically they are polyhydroxy aldehydes or ketones. On the basis of their behaviour on hydrolysis, carbohydrates are classified as monosaccharides, oligosaccharides and polysaccharides. All monosaccharide like glucose is aldohexose and its molecular formula was found to be C6H12O6. After reacting with different reagents like HI, H2N OH, Bromine water, (CH3CO)2O, etc. its structure was found to contain one aldehyde group, one primary alcoholic group, (CH2OH) and four secondary alcoholic groups (CHOH). Despite having the aldehyde group, glucose does not give some of the reactions of aldehyde group like Schiff

addition. This explains the existence of glucose in two cyclic hemiacetal forms which differ only in the configuration of the hydroxyl group at C 1.

Question 2.

Carbohydrates are essential for life in both plants and animals. Carbohydrates are used as storage molecules as starch in plants and glycogen in animals. Chemically they are polyhydroxy aldehydes or ketones. On the basis of their behaviour on hydrolysis, carbohydrates are classified as monosaccharides, oligosaccharides and polysaccharides. All

Question 3.

Carbohydrates are essential for life in both plants and animals. Carbohydrates are used as storage molecules as starch in plants and glycogen in animals. Chemically they are polyhydroxy aldehydes or ketones. On the basis of their behaviour on hydrolysis, carbohydrates are classified as monosaccharides, oligosaccharides and polysaccharides. All monosaccharides are reducing sugars, meaning they can be oxidized by Tollens' reagent and Fehling's solution. monosaccharides are reducing sugars, meaning they can be oxidized by Tollens' reagent and Fehling's solution. A monosaccharide like glucose is aldohexose and its molecular formula was found to be C6H12O6. After reacting with different reagents like HI, H2N OH, Bromine water, (CH3CO)2O, etc. its structure was found to contain one aldehyde group, one primary alcoholic group, (CH2OH) and four secondary alcoholic groups (CHOH). Despite having the aldehyde group, glucose does not give some of the reactions of aldehyde group like Schiff's test ,NaHSO3 addition. This explains the existence of glucose in two cyclic hemiacetal forms which differ only in the configuration of the hydroxyl group at C 1.

Question 4. The following questions are case-based questions. Read the case carefully and answer the questions that follow Carbohydrates are essential for life in both plants and animals. Carbohydrates are used as storage molecules as starch in plants and glycogen in animals. Chemically they are polyhydroxy aldehydes or ketones. On the basis of their behaviour on hydrolysis, carbohydrates are classified as monosaccharides, oligosaccharides and polysaccharides. All monosaccharides are reducing sugars, meaning they can be oxidized by Tollens' reagent and Fehling's solution. monosaccharides are reducing sugars, meaning they can be oxidized by Tollens' reagent and Fehling's solution. A monosaccharide like glucose is aldohexose and its molecular formula was found to be $C_6H_{12}O_6$. After reacting with different reagents like HI, H_2N -OH, Bromine water, $(CH_3CO)_2O$, etc. its structure was found to contain one aldehyde group, one primary alcoholic group, (- CH_2OH) and four secondary alcoholic groups (CHOH). Despite having the aldehyde group, glucose does not give some of the reactions of aldehyde group like Schiff's test, $NaHSO_3$ addition. This explains the existence of glucose in two cyclic hemiacetal forms which differ only in the configuration of the hydroxyl group at C -1. Answer the following questions:

(1) What are reducing sugars ?

[1 Marks]

Answer: Reducing sugars are carbohydrates which have a free aldehyde or ketone group that can reduce Tollens' reagent and Fehling's solution.
All monosaccharides are reducing sugars as they have free aldehyde or ketone groups. For example, glucose is a reducing sugar because it contains a free aldehyde group in its open chain form as explained in the case passage.

Key Points: Reducing sugars reduce Tollens' reagent and Fehling's solution - Monosaccharides are reducing sugars - Presence of free aldehyde or ketone group makes a sugar reducing

(2) Name the polysaccharide which is known as 'animal starch'. Why is it called 'animal starch'?

[2 Marks]

Answer: The polysaccharide known as 'animal starch' is glycogen. It is called animal starch because it is the storage form of carbohydrate in animals, similar to starch in plants. Glycogen has a structure similar to amylopectin but is more highly branched, allowing animals to store glucose efficiently in the liver, muscles, and brain, as mentioned in the case passage.

Key Points: Polysaccharide known as animal starch is glycogen - Glycogen is similar to amylopectin but more branched - It is the carbohydrate storage form in animals stored in liver and muscles

(3)

(i) Name the isomers of glucose which in the cyclic form differ only in the configuration of the OH group at C-1.

(ii) Presence of which functional group was detected when glucose reacted with Br_2 water?

[2 Marks]

Answer: (i) The isomers of glucose which differ only in the configuration of the OH group at carbon-1 in the cyclic form are called "anomers". They are named as alpha (\u03b1) and beta (\u03b2) forms of glucose.
(ii) When glucose reacts with bromine water it indicates the presence of an aldehyde group (–CHO). The aldehyde group is oxidized to a carboxylic acid group confirming glucose is an aldose sugar. This reaction supports the open chain form of glucose in equilibrium with the cyclic forms.

Key Points: Anomers are isomers differing in OH configuration at C-1 - Alpha and beta forms of glucose are anomers - Aldehyde group detected by reaction with bromine water

(4) Classify the following into monosaccharide and disaccharide : Fructose, Sucrose, Lactose, Galactose

[1 Marks]

Answer: Fructose and Galactose are monosaccharides as they are simple sugars that cannot be hydrolysed further. Sucrose and Lactose are disaccharides as they consist of two monosaccharide units linked together. This classification is based on the definition in the passage that monosaccharides cannot be hydrolysed further.

Key Points: Fructose and Galactose are monosaccharides - Sucrose and Lactose are disaccharides - Monosaccharides cannot be hydrolysed further

Question 5. Transition metals have incomplete d-subshell either in neutral atom or in their ions. The presence of partly filled d-orbitals in their atoms makes transition elements different from that of the non-transition elements. With partly filled d-orbitals, these elements exhibit certain characteristic properties such as display of a variety of oxidation states, formation of coloured ions and entering into complex formation with a variety of ligands. The transition metals and their compounds also exhibit catalytic properties and paramagnetic behaviour. The transition metals are very hard and have low volatility. An examination of the $E°M^{2+}/M$ shows the varying trends : Answer the following questions:

$E^{o}_{M^{2+}/M}$	
V	– 1·18
Cr	– 0·91
Mn	– 1·18
Fe	– 0·44
Co	– 0·28
Ni	– 0·25
Cu	+ 0·34
Zn	– 0·76

(1) On what basis can we say that Cu is a transition element but Zn is not ? (Atomic number : Cu = 29, Zn = 30)

[1 Marks]

Answer: According to the case, Cu is a transition element because it has partly filled d-orbitals either in the atom or in its ions, which allows it to show variable oxidation states and form coloured ions. Zn is not a transition element because it has a completely filled d10 configuration even in its common oxidation state and does not exhibit these properties.

Key Points: Cu has partly filled d-orbitals - Zn has completely filled d10 configuration - Transition elements show variable oxidation states and coloured ions

(2) On what basis can we say that Cu is a transition element but Zn is not ? (Atomic number : Cu = 29, Zn = 30)

[1 Marks]

Answer: Cu is a transition element because it has an incomplete d-subshell in its atoms or ions, showing partly filled d-orbitals that lead to variable oxidation states and coloured ions.

Zn is not a transition metal as it has a full d^{10} configuration in both its atom and common ions, so it lacks these properties, as mentioned in the passage.

> **Key Points: Cu has partly filled d-orbitals - Zn has full d^{10} configuration - Transition elements have variable oxidation states and coloured ions**

(3)

(i) Why do $E°M^{2+}/M$ values show irregular trend from Vanadium to Zinc ?

(ii) How is the variability in oxidation states of transition metals different from that of the non-transition elements ?

[2 Marks]

Answer: (i) The $E°M^{2+}/M$ values show irregular trend from Vanadium to Zinc because the stability of the M^{2+} ions depends on the electronic configuration of the d-orbitals, which varies irregularly across the series due to electron-electron interactions and varying nuclear charge.

(ii) Transition metals exhibit variable oxidation states due to the involvement of both (n-1)d and ns electrons in bonding, unlike non-transition elements which usually show fixed oxidation states as they involve only valence s or p electrons. This is explained in the case where partly filled d-orbitals allow multiple oxidation states.

> **Key Points: Irregular $E°M^{2+}/M$ trend due to d-electron configuration variability - Transition metals have multiple oxidation states due to participation of d and s electrons - Non-transition metals generally have fixed oxidation states involving only s and p electrons**

(4)

(i) Of the d^4 species, Cr^{2+} is strongly reducing while Mn^{3+} is strongly oxidizing. Why ? (Atomic number : Cr = 24, Mn = 25)

(ii) Complete the following ionic equation :

$2Mno_4^- + H_2O + I^- \rightarrow$

[2 Marks]

Answer: (i) Cr2+ has d4 configuration which is less stable and tends to lose electrons to become Cr3+ with a half-filled d3 configuration, making it a strong reducing agent.
Mn3+ is strongly oxidizing because it can gain electrons to form Mn2+ with d5 half-filled stable configuration. Stability of half-filled or fully filled d-orbitals influences their redox behaviour, as explained in the case passage.
(ii) The balanced ionic equation is : 2MnO4- + H2O + 3I- → 2MnO2 + 2OH- + 3I-

Key Points: Cr2+ is reducing due to instability of d4 - Mn3+ is oxidizing due to gain of electron to form stable d5 - Half-filled d-orbital stability influences redox behavior

Section B

Question 6.

When MnO_2 is fused with KOH in air, it gives :

[1 Marks]

(A) K_2MnO_4

(B) Mn_2O_7

(C) Mn_2O_3

(D) $KMnO_4$

Explanation: When manganese dioxide (MnO_2) is fused with potassium hydroxide (KOH) in the presence of air (oxygen), it reacts to form potassium manganate (K_2MnO_4). The reaction is $2\ MnO_2 + 4\ KOH + O_2 \rightarrow 2\ K_2MnO_4 + 2\ H_2O$. This shows that the product is K_2MnO_4, not $KMnO_4$ or the other options.

Question 7.

Ligand $EDTA^{4-}$ is an example of a :

[1 Marks]

(A) Monodentate ligand

(B) Didentate ligand

(C) Tridentate ligand

(D) Polydentate ligand

Explanation:

EDTA4- is a polydentate ligand because it has multiple binding sites (six in total) that can coordinate to a metal ion, allowing it to form stable complexes.

Question 8.

Which of the following ligand forms chelate complex ?

[1 Marks]

(A) $C_2O_4^{2-}$

(B) Cl^-

(C) NH_3

(D) NO_2-

Explanation: The correct answer is C2O4²-. This ligand is a bidentate ligand, meaning it can bind to a metal ion through two donor atoms simultaneously, thus forming a chelate complex. In contrast, the other options such as NO2-, NH3, and Cl- are either unidentate or do not have the capability to form stable chelate structures.

Question 9.

Which of the following contains sp^2 hybridised carbon bonded to X ?

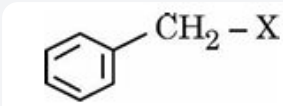
[1 Marks]

(A) CH_3 -CH_2 -X

(B) CH_2=CH-X

(C) CH_2=CH-CH_2 -X

(D)



Explanation:

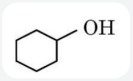
The correct option is CH2=CH-X because it contains a double bond between the two carbon atoms, which indicates that one of the carbon atoms is sp2 hybridized. The presence of the halogen X directly connected to one of these sp2 hybridized carbon atoms confirms that this compound has the required bonding structure.

Question 10.

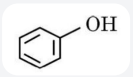
Which of the following is most acidic ?

[1 Marks]

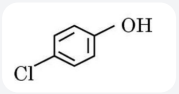
(A)



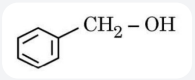
(B)



(C)



(D)



Explanation:

- Ordinary alcohols like **benzyl alcohol** and **cyclohexanol** are much weaker acids (pKa ~16–18).
- **Phenol** is more acidic (pKa ~10) because the phenoxide ion is resonance-stabilized.
- In **p-chlorophenol** , the **Cl** substituent withdraws electron density (–I effect), **stabilizing the phenoxide ion even more**, so it's **more acidic than phenol**.

Question 11.

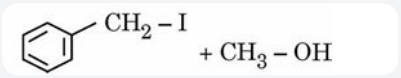
Anisole reacts with HI to give :

[1 Marks]

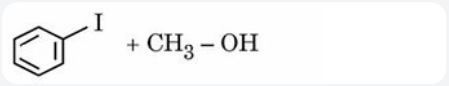
(A)



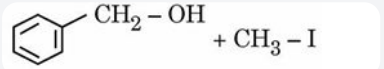
(B)



(C)



(D)



Explanation:

Anisole, which is an ether (methoxybenzene), reacts with hydroiodic acid (HI) to give iodoalkane (iodobenzene) and methanol. The reaction involves the cleavage of the C-O bond in the ether, leading to the formation of the alkyl iodide and alcohol.

Question 12.

Ethanol on heating with conc. H_2SO_4 at 413 K gives :

[1 Marks]

(A) C_2H5 -O -CH_3

(B) $CH_2=CH_2$

(C) C_2H_5- O- C_2H_5

(D) $C_2H_5OSO_3H$

Explanation:

The correct answer is CH2=CH2 (ethene). When ethanol is heated with concentrated sulfuric acid, it undergoes dehydration to form ethene and water. This process involves the elimination of a water molecule from ethanol, resulting in the formation of an alkene (ethene).

Question 13.

An azeotropic solution of two liquids has boiling point lower than either of them when it :

[1 Marks]

(A) shows positive deviation from Raoult's law

(B) is saturated

(C) shows negative deviation from Raoult's law

(D) show no deviation from Raoult's law

Explanation:

The correct answer is 'shows negative deviation from Raoult's law'. This is because an azeotropic mixture exhibits a lower boiling point than the boiling points of the individual components due to the strong intermolecular attractions between the different species, leading to a negative deviation from Raoult's law.

Question 14.

The relative lowering of vapour pressure of an aqueous solution containing non-volatile solute is 0·0225. The mole fraction of the non-volatile solute is :

[1 Marks]

(A) 0·725

(B) 0·0225

(C) 0·15

(D) 0·80

Explanation:

The correct option is 0·0225, because the relative lowering of vapor pressure is equal to the mole fraction of the solute in dilute solutions, according to Raoult's law. Thus, if the relative lowering of vapor pressure is 0.0225, the mole fraction of the solute would also be 0.0225.

Question 15.

During electrolysis of aqueous solution of NaCl :

[1 Marks]

(A) $O_2(g)$ is liberated at anode

(B) Na is formed at cathode

(C) $Cl_2(g)$ is liberated at cathode

(D) $H_2(g)$ is liberated at cathode

Explanation:

H2(g) is liberated at the cathode during the electrolysis of an aqueous solution of NaCl because the cathode is the negative electrode where reduction occurs. In this case, water is reduced to hydrogen gas and hydroxide ions, leading to the liberation of H2(g).

Question 16.

The addition of catalyst during a chemical reaction alters which of the following quantities of the reaction ?

[1 Marks]

(A) Activation energy

(B) Entropy

(C) Enthalpy

(D) Internal energy

Explanation:

The correct answer is Activation energy. A catalyst lowers the activation energy of a reaction, thus speeding up the reaction without altering the overall enthalpy, internal energy, or entropy of the reaction.

Question 17.

For the elementary reaction P → Q, if the rate of disappearance of P increases by a factor of 8 upon doubling the concentration of P, the order of the reaction with respect to P is

[1 Marks]

(A) 4

(B) 1

(C) 3

(D) 2

Explanation: The rate of disappearance of P increases by a factor of 8 when the concentration of P is doubled. This indicates that the rate is proportional to the concentration of P raised to the power of 3, since 2^3 = 8. Therefore, the order of the reaction with respect to P is 3.

Question 18.

Assertion (A) : Aliphatic primary amines can be prepared by Gabriel phthalimide synthesis.

Reason (R) : Alkyl halides undergo nucleophilic substitution with anion formed by phthalimide.

[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). Gabriel phthalimide synthesis involves the nucleophilic substitution of alkyl halides with the anion of phthalimide to form primary amines, making both statements accurate and logically connected.

Question 19.

Assertion (A) : Uracil base is present in DNA.

Reason (R) : DNA undergoes self-replication.

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

(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 false, but Reason (R) is true. Uracil is not found in DNA; it is present in RNA. On the other hand, it is correct that DNA undergoes self-replication. Therefore, the two statements are not related, making the assertion incorrect while the reason is valid.

Question 20.

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

Reason (R) : Diazonium salts of aliphatic amines show resonance.

[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:

Assertion (A) is true, but Reason (R) is false. Diazonium salts of aromatic amines are indeed more stable due to the stability provided by resonance in the aromatic system, while diazonium salts of aliphatic amines are less stable and do not benefit from the same level of resonance stabilization. Therefore, the reason provided does not correctly explain the assertion.

Question 21.

Assertion (A) : p-nitroaniline is a weaker base than p-toluidine.

Reason (R) : The electron withdrawing effect of NO_2 group in p-nitroaniline makes it a weaker base.

[1 Marks]

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

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

(C) Assertion (A) is 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 and Reason (R) is the correct explanation of the Assertion (A) because the electron-withdrawing -NO2 group decreases the electron density available on the nitrogen atom in p-nitroaniline, making it less capable of accepting protons compared to p-toluidine, which has a -CH3 group that is an electron-donating substituent.

Section C

Question 22.

A 6% solution of glucose (molar mass = 180 g mol^{-1}) is isotonic with 25% solution of an unknown organic substance. Calculate the molecular weight of the unknown organic substance.

[2 Marks]

Answer: Given that the 6% glucose solution is isotonic with 25% solution of the unknown substance, their molar concentrations are the same.
Step 1: Calculate moles of glucose in 100 g solution = 6 g / 180 g/mol = 0.0333 mol.
Step 2: Mass of solvent (water) in glucose solution = 100 g - 6 g = 94 g = 0.094 kg.
Step 3: Molality of glucose solution = 0.0333 mol / 0.094 kg = 0.354 mol/kg.
Step 4: For unknown solution, mass of solute = 25 g, solvent = 75 g = 0.075 kg.
Step 5: Let molecular weight of unknown = M.
Step 6: Molality of unknown = (25 / M) mol / 0.075 kg = 333.33 / M mol/kg.
Step 7: Since solutions are isotonic, molality of glucose = molality of unknown.
So, 0.354 = 333.33 / M
Therefore, M = 333.33 / 0.354 = 942.5 g/mol.
Answer: Molecular weight of the unknown substance is approximately 943 g/mol.

Key Points: Isotonic solutions have equal molar concentrations - Calculate moles and molality of glucose solution - Use equality of molality to find molecular weight of unknown

Question 23.

A first order reaction has a rate constant 1.25 x 10^{-3} s^{-1}. How long will 5 g of this reactant take to reduce to 2.5 g ?

| log2=0.301, log 3-0.4771, log 4 = 0.6021]

[2 Marks]

Answer: Given: k = 1.25 x 10^{-3} s^{-1}, initial mass = 5 g, final mass = 2.5 g.
For a first order reaction: The relation is $\ln([A]_t/[A]_0) = -kt$.
Here $[A]_0$ = 5 g and $[A]_t$ = 2.5 g.
So, ln(2.5/5) = ln(0.5) = -kt.
Using log base 10: ln(0.5) = 2.303 * log10(0.5) = 2.303 * (-0.301) = -0.693.
Therefore, -0.693 = -kt => t = 0.693 / k = 0.693 / (1.25 x 10^{-3}) = 554.4 seconds.
Hence, it will take approximately 554 seconds for the reactant to reduce from 5 g to 2.5 g in this first order reaction.

Key Points: First order reaction equation - Use of ln and log conversion - Calculation of time using t = 0.693/k

Question 24.

What is lanthanoid contraction ? Actinoid contraction is greater from element to element than lanthanoid contraction. Why ?

[2 Marks]

Answer:

(a) **Lanthanoid contraction** is the gradual decrease in the atomic or ionic radii of the lanthanoid elements (atomic numbers 57 to 71) as we move from one element to the next in the periodic table. **Actinoid contraction** is similar but occurs in the actinoid series (atomic numbers 89 to 103). The contraction is greater in actinoids than in lanthanoids because the 5f electrons in actinoids provide poor shielding effect, leading to a stronger attraction of the nucleus on the electrons and thus greater decrease in size from element to element.

> **Key Points: Lanthanoid contraction is the decrease in size of lanthanoids - Actinoid contraction occurs in actinoids and is greater than lanthanoid contraction - Poor shielding by 5f electrons causes greater contraction in actinoids**

Question 25.

Why do transition metals have high enthalpy of atomization ? Which element of 3d-series has lowest enthalpy of atomization ?

[2 Marks]

Answer: (a) Transition metals have high enthalpy of atomization because they have many unpaired d-electrons that create strong metallic bonds due to overlapping orbitals. This strong bonding requires more energy to break the atoms apart into gaseous atoms.
(b) Zinc, among the 3d-series elements, has the lowest enthalpy of atomization because it has a completely filled d^{10} electronic configuration with no unpaired electrons, resulting in weaker metallic bonds and lower energy required to separate its atoms.

> **Key Points: Transition metals have many unpaired d-electrons - Strong metallic bonds cause high enthalpy of atomization - Zinc has lowest enthalpy due to filled d^{10} configuration and no unpaired electrons**

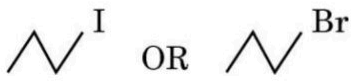
Question 26.

(a) In the following pair of compounds, which compound undergoes SN_2 reaction faster and why ?

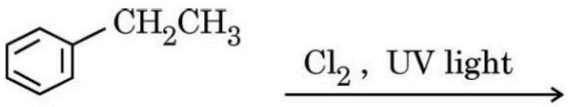
(b) Write the major product in the following:

[2 Marks]

(a) In the following pair of compounds, which compound undergoes S_N2 reaction faster and why ?



(b) Write the major product in the following :



Answer:

(a) Between the two given compounds (1-iodopropane and 1-bromopropane), **1-iodopropane undergoes the S_N2 reaction faster**. The carbon skeleton is the same in both, so steric factors are identical. The difference is the leaving group: **I^- is a better leaving group than Br^-** because the C–I bond is weaker and iodide is larger and more stable after leaving. A better leaving group lowers the activation energy, so substitution by S_N2 is faster with the iodide.

(b) Ethylbenzene reacts with **Cl_2 in UV light** by a free-radical substitution at the **benzylic position**, because the benzylic radical formed is resonance-stabilized and hence most favorable. Therefore, chlorine replaces one hydrogen on the benzylic carbon to give **1-chloroethylbenzene (C_6H_5–CHCl–CH_3)** as the major product.

Key Points: steric hindrance-primary vs tertiary-alhyl halide-SN2 mechanism

Question 27.

Define the following terms :

(a) Denaturation of protein

(b) Invert sugar

[2 Marks]

Answer: (a) **Denaturation of protein** is the process in which a protein in its native form loses its natural three-dimensional structure due to physical factors like change in temperature or chemical factors like change in pH. This causes the hydrogen bonds to break, unfolding the protein globules and uncoiling the helix, resulting in loss of biological activity. The primary structure remains intact while secondary and tertiary structures get destroyed. Example: Coagulation of egg white on boiling.
(b) **Invert sugar** is a mixture of glucose and fructose formed when sucrose (cane sugar) is hydrolysed by acids or enzymes. The reaction splits sucrose into glucose and fructose, both of which are sweeter and easier to digest. It is called invert sugar because the optical rotation of the solution changes from positive to negative during the process.

Key Points: Denaturation involves loss of protein structure and activity - Primary structure remains intact - Invert sugar is a mixture of glucose and fructose formed by hydrolysis of sucrose

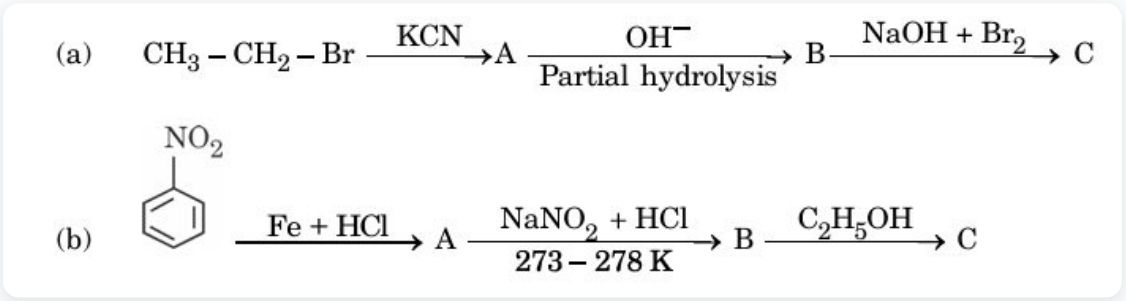
---

Section D

Question 28.

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

[3 Marks]



Answer: Answer:

(a) **Structure of A:** A is the reactant organomagnesium compound, known as the Grignard reagent. Its general formula is R-MgX, where R is an alkyl or aryl group and X is a halogen.

Example: Phenylmagnesium bromide, C_6H_5-MgBr.

(b) **Structure of B:** B is the halide or electrophile reacting with the Grignard reagent. It is generally an alkyl halide such as RX.

Example: Bromobenzene, C_6H_5-Br.

(c) **Structure of C:** C is the product formed after the reaction of A and B followed by hydrolysis with water or deuterium oxide (D_2O). This product is an alkane or corresponding hydrocarbon with the R groups joined.

Example: Biphenyl, C_6H_5-C_6H_5.

This reaction proceeds by nucleophilic attack of the Grignard reagent (A) on the alkyl halide (B) to form C after protonation.

Summary: A is the Grignard reagent (R-MgX), B is the alkyl or aryl halide (R-X), and C is the coupled hydrocarbon formed after addition and hydrolysis (R-R).

Key Points: Structure of A is Grignard reagent R-MgX - Structure of B is alkyl or aryl halide RX - Structure of C is the coupled hydrocarbon product formed after hydrolysis

Question 29.

Write the reaction involved in the following :

(a) Wolff-Kishner reduction

(b) Decarboxylation reaction

(c) Cannizzaro reaction

[3 Marks]

Answer: (a) **Wolff-Kishner reduction:** In this reaction, a carbonyl compound like an aldehyde or ketone reacts with hydrazine (NH_2NH_2) to form a hydrazone, which on heating with a strong base like KOH converts into an alkane.
Example: R-CO-R + NH_2NH_2 → R-CH=NNH_2 → (heat with KOH) R-CH_2-R

(b) **Decarboxylation reaction:** This reaction removes a carboxyl group (COOH) from a carboxylic acid as CO_2, producing an alkane.
Example: R-CH_2-COOH + NaOH + heat → R-CH_3 + Na_2CO_3

(c) **Cannizzaro reaction:** This is a redox reaction where aldehydes without an alpha-hydrogen undergo simultaneous oxidation and reduction in presence of concentrated alkali to form a primary alcohol and a carboxylate salt.
Example: 2 R-CHO + NaOH → R-CH_2OH + R-COONa

Key Points: Wolff-Kishner reduces carbonyl to alkane using hydrazine and base - Decarboxylation removes CO_2 from carboxylic acids to give alkanes - Cannizzaro reaction is a disproportionation of aldehydes without alpha hydrogen in alkali

Question 30.

The vapour pressure of a solvent at 283 K is 100 mm Hg. Calculate the vapour pressure of a dilute solution containing 1 mole of a strong electrolyte AB in 50 moles of the solvent at 283 K (assuming complete dissociation of solute AB).

[3 Marks]

Answer: Given:
Vapour pressure of pure solvent, P0 = 100 mm Hg
Moles of solute AB = 1 mole
Moles of solvent = 50 moles
AB is a strong electrolyte and dissociates completely into A^+ and B^- ions, so van't Hoff factor i = 2

Step 1: Calculate total moles of particles in solution = moles of solvent + i * moles of solute = 50 + 2 *

1 = 52

Step 2: Calculate mole fraction of solvent, X_solvent = moles of solvent / total moles = 50 / 52 = 0.9615

Step 3: Apply Raoult's law for vapour pressure of solution:

P_solution = X_solvent * P0 = 0.9615 * 100 = 96.15 mm Hg

Therefore, the vapour pressure of the solution at 283 K is approximately 96.15 mm Hg.

Key Points: Strong electrolyte dissociates completely - van't Hoff factor i = 2 - use mole fraction of solvent in Raoult's law to find vapour pressure

Question 31.

The rate of a gaseous reaction triples when temperature is increased from 17ºC to 27ºC. Calculate the energy of activation for this reaction.

[Given : 2.303 R = 19.15 JK^{-1} mol^{-1}, log 3 = 0.48]

[3 Marks]

Answer: Given: Rate triples when temperature increases from 17 deg C to 27 deg C.

Step 1: Convert temperatures to Kelvin:

$T_1 = 17 + 273 = 290$ K

$T_2 = 27 + 273 = 300$ K

Step 2: Use Arrhenius equation in logarithmic form:

$\log(k_2/k_1) = (E_a/2.303R) * (1/T_1 - 1/T_2)$

Given $k_2/k_1 = 3$, log 3 = 0.48, and 2.303R = 19.15 J K^{-1} mol^{-1}

Step 3: Substitute values:

$0.48 = (E_a/19.15) * (1/290 - 1/300)$

(1/290 - 1/300) = (300 - 290) / (290*300) = 10 / 87000 = 0.00011494

Step 4: Calculate E_a:

$0.48 = (E_a/19.15) * 0.00011494 \Rightarrow E_a = 0.48 * 19.15 / 0.00011494$

$E_a = 79971$ J mol^{-1} or 79.97 kJ mol^{-1}

Answer: The activation energy of the reaction is approximately 80 kJ mol^{-1}.

Key Points: Convert temperatures to Kelvin - Use logarithmic form of Arrhenius equation - Calculate activation energy E_a using given data

Question 32.

Give the equations of reactions for the preparation of :

(a) Phenol from chlorobenzene

(b) Salicylaldehyde from phenol

(c) 2-Methoxyacetophenone from anisole

(d) Picric acid from phenol

[3 Marks]

Answer: (a) Preparation of Phenol from Chlorobenzene:
$C_6H_5Cl + NaOH$ (at 300 deg C and high pressure) $\rightarrow C_6H_5OH + NaCl$

(b) Preparation of Salicylaldehyde from Phenol (Reimer-Tiemann Reaction):
$C_6H_5OH + CHCl_3 + NaOH \rightarrow$ o-Hydroxybenzaldehyde (Salicylaldehyde) + other products

(c) Preparation of 2-Methoxyacetophenone from Anisole:
$C_6H_5OCH_3 + CH_3COCl$ (Friedel-Crafts Acylation in presence of $AlCl_3$) $\rightarrow$ 2-Methoxyacetophenone + HCl

(d) Preparation of Picric acid from Phenol:
$C_6H_5OH + 3\ HNO_3$ (dilute) $\rightarrow$ 2,4,6-Trinitrophenol (Picric acid) + $3\ H_2O$

Explanation:
(a) Chlorobenzene reacts with NaOH at high temperature and pressure to give phenol.
(b) In Reimer-Tiemann reaction, phenol reacts with chloroform and NaOH to form salicylaldehyde at the ortho position.
(c) Anisole undergoes Friedel-Crafts acylation with acetyl chloride (CH_3COCl) in presence of $AlCl_3$ catalyst to give 2-methoxyacetophenone.
(d) Phenol nitrates on treatment with dilute nitric acid to give picric acid which is 2,4,6-trinitrophenol.

Key Points: Phenol from chlorobenzene by nucleophilic substitution - Salicylaldehyde from phenol by Reimer-Tiemann reaction - 2-Methoxyacetophenone from anisole by Friedel-Crafts acylation - Picric acid from phenol by nitration with dilute HNO_3

Question 33.

Give reasons for the following :

(a) Chlorine is ortho/para directing in electrophilic aromatic substitution reactions, though chlorine is an electron withdrawing group.

(b) Racemic mixture is optically inactive.

(c) Allyl chloride is hydrolysed more readily than n-propyl chloride.

[3 Marks]

Answer: (a) Chlorine is ortho/para directing because, despite being an electron withdrawing group by induction, it donates electrons through resonance to the aromatic ring. This resonance effect stabilizes the carbocation intermediate formed during electrophilic substitution at the ortho and para positions, making these positions more reactive.

(b) A racemic mixture contains equal amounts of two enantiomers which rotate plane-polarized light in opposite directions. Their effects cancel out, making the mixture optically inactive.

(c) Allyl chloride is hydrolysed more readily because the allylic carbocation formed during hydrolysis is resonance stabilized, making it more stable and easier to form than the primary carbocation formed from n-propyl chloride. Thus, the reaction rate is faster for allyl chloride.

Key Points: Chlorine shows resonance electron donation - Resonance stabilizes intermediate at ortho/para positions - Racemic mixture has equal opposite enantiomers - Optical rotations cancel - Allylic carbocation is resonance stabilized - Hydrolysis of allyl chloride is faster

Question 34.

Calculate emf of the following cell :

Zn (s) | Zn^{2+} (0 1 M) || Sn^{2+} (0·001 M) Sn (s)

Given: E°zn^{2+}/zn = -0.76V, E°sn^{2+}/sn = - 0.14 V

[log 10 = 1]

[3 Marks]

Answer: Step 1: Identify the half cells and their standard electrode potentials.

Zn/Zn^{2+} E° = -0.76 V (oxidation)

Sn/Sn^{2+} E° = -0.14 V (reduction)

Step 2: Calculate the standard emf of the cell:

E°cell = E°cathode - E°anode = (-0.14) - (-0.76) = 0.62 V

Step 3: Use Nernst equation to find emf under given concentrations:

Ecell = E°cell - (0.059 / 2) * log ($[Zn^{2+}]$ / $[Sn^{2+}]$)

Given $[Zn^{2+}]$ = 0.1 M, $[Sn^{2+}]$ = 0.001 M and log 10 = 1

Therefore, Ecell = 0.62 - (0.059 / 2) * log (0.1 / 0.001) = 0.62 - 0.0295 * log 100 = 0.62 - 0.0295 * 2 = 0.62 - 0.059 = 0.561 V

Answer: emf of the cell = 0.561 V

Key Points: Identify half cells and their potentials - Calculate standard emf - Apply Nernst equation for emf under non-standard conditions

---

Section E

Question 35.

Answer any five of the following:

(a) How is the crystal field splitting energy for octahedral complex (Δo) related to that of tetrahedral complex (Δ_t) ?

(b) Write the IUPAC name of the following complex : $[PtCl_2(en)_2]\ (NO_3)_2$

(c) Write the geometry and magnetic behaviour of the complex [Ni(CO)4] on the basis of Valency Bond Theory (VBT).

(d) What type of isomerism is shown by the complex $[Co(NH_3)_6]\ [Cr(CN)_6]$?

(e) For the coordination compound on the basis of crystal field theory, write the electronic configuration for d^4 ion if Δo < P. Is the coordination compound a high spin or low spin complex ?

(f) Out of $[Co(NH_3)_6]_3^+$ and $[Co(NH_3)_4Cl_2]^+$, which complex is heteroleptic and why ?

(g) Draw the structures of optical isomers of $[PtCl_2(en)_2]^{2+}$.

[5 Marks]

Answer: (a) The crystal field splitting energy for a tetrahedral complex (Δ_t) is smaller than that of an octahedral complex (Δo). It is related as $\Delta_t = 4/9 * \Delta o$. This means that Δ_t is about 44% of Δo because in tetrahedral complexes ligands approach between axes causing less repulsion.

(b) The IUPAC name of the complex $[PtCl_2(en)_2](NO_3)_2$ is Dichlorobis(ethane-1,2-diamine)platinum(IV) nitrate.

(c) According to Valence Bond Theory, [Ni(CO)4] has dsp^2 hybridisation resulting in a tetrahedral geometry. It is diamagnetic because CO is a strong field ligand causing pairing of all Ni electrons.

(d) The complex $[Co(NH_3)_6]\ [Cr(CN)_6]$ shows **ionisation isomerism** because two different ions exchange ligands but have the same composition.

(e) For a d^4 ion, if Δo < P, it means pairing energy is more than the crystal field splitting energy. The electronic configuration is $t_{2g}^3\ e_g^1$ resulting in four unpaired electrons. Therefore, the complex is a **high spin complex**.

(f) $[Co(NH_3)_6]^{3+}$ is a homoleptic complex because it contains only one type of ligand (NH_3). $[Co(NH_3)_4Cl_2]^+$ is a **heteroleptic complex** because it contains more than one type of ligand, NH_3 and Cl^-.

(g) The complex $[PtCl_2(en)_2]^{2+}$ shows optical isomerism. The two optical isomers are non-superimposable mirror images (enantiomers). They can be drawn as two different spatial arrangements of ethane-1,2-diamine and chloride ligands around Pt in an octahedral geometry.

Key Points: Δ_t is approximately 4/9 of Δo - IUPAC name is Dichlorobis(ethane-1,2-diamine)platinum(IV) nitrate - [Ni(CO)4] is tetrahedral and diamagnetic with dsp2 hybridisation based on VBT - Ionisation isomerism is shown by $[Co(NH_3)_6][Cr(CN)_6]$ - d4 ion with $\Delta o < P$ is high spin with configuration t2g3 eg1 - $[Co(NH_3)_4Cl_2]+$ is heteroleptic, $[Co(NH_3)_6]3+$ is homoleptic - $[PtCl_2(en)_2]2+$ has optical isomers (enantiomers) due to chiral arrangement

Question 36.

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

(ii) Arrange the following in increasing order of their reactivity towards HCN : CH3COCH3 , $(CH_3)_3C$-$COCH_3$, CH_3CHO

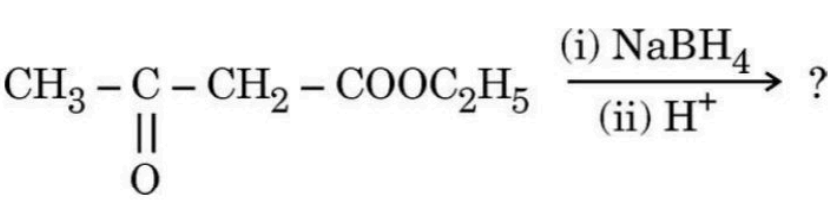
(iii) How can you convert phenyl magnesium bromide to benzoic acid ?

(iv) Give a simple chemical test to distinguish between ethanoic acid and ethanal.

(v) Write the main product in the following reaction:

[5 Marks]

(v) Write the main product in the following reaction :



Answer:

(i) The 2,4-dinitrophenylhydrazone of benzaldehyde is formed by the reaction of benzaldehyde 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 at the 2 and 4 positions of the phenyl ring.
(ii) The increasing order of reactivity towards HCN is: (CH3)3C-COCH3 < CH3COCH3 < CH3CHO. This is because steric hindrance decreases reactivity and aldehydes are more reactive than ketones.
(iii) Phenyl magnesium bromide reacts with carbon dioxide (dry ice) followed by acid hydrolysis to produce benzoic acid. The reaction is: C6H5MgBr + CO2 → C6H5COOMgBr → (acid work-up) → C6H5COOH.
(iv) Ethanoic acid gives effervescence with sodium bicarbonate due to formation of CO2 gas, whereas

ethanal does not. This is the simple test to distinguish between them.

(v) The given compound is **$CH_3–CO–CH_2–COOC_2H_5$** (ethyl acetoacetate type: it has a **ketone** and an **ester** group).

$NaBH_4$ is a **selective reducing agent**: it **reduces ketones and aldehydes**, but **does not reduce esters** under these conditions. So only the **ketone (>C=O)** group is reduced to a **secondary alcohol**, while the **ester ($–COOC_2H_5$)** remains unchanged.

Therefore, the main product after (i) $NaBH_4$ and (ii) H^+ is:

$CH_3–CH(OH)–CH_2–COOC_2H_5$

i.e., **ethyl 3-hydroxybutanoate** (a β-hydroxy ester).

Key Points: Structure of 2,4-dinitrophenylhydrazone - Reactivity order: (CH3)3C-COCH3 < CH3COCH3 < CH3CHO - Preparation of benzoic acid from phenyl magnesium bromide and CO2

Question 37.

(i) Account for the following:

(1) Oxidation of aldehydes is easier as compared to ketones.

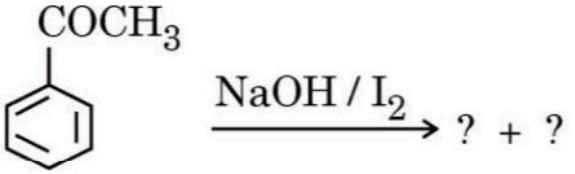
(2) The alpha (α) hydrogen atoms of aldehydes are acidic in nature.

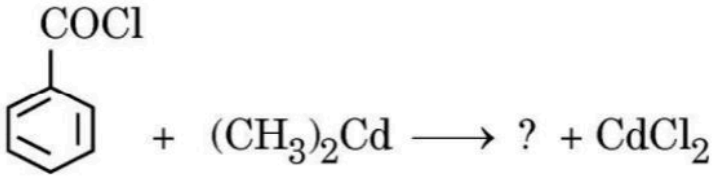
(ii) Write the main product in the following reaction :

(iii) Give a simple chemical test to distinguish between benzaldehyde and ethanal.

[5 Marks]

(ii) Write the products in the following reactions :

(1) 

(2) 

Answer:

(i)(1) Oxidation of aldehydes is easier than ketones because aldehydes have a hydrogen atom attached to the carbonyl carbon which can be easily removed during oxidation, whereas ketones have two alkyl groups attached to the carbonyl carbon which makes them more resistant to oxidation.
(2) The alpha (α) hydrogen atoms of aldehydes are acidic because the hydrogen atoms on the carbon adjacent to the carbonyl group are polarized and can be easily removed due to resonance stabilization of the resulting enolate ion, making them more acidic.
(ii) **1)** The first compound is **acetophenone ($C_6H_5–CO–CH_3$)**. With **NaOH / I_2**, this is the **iodoform (haloform) reaction** because it contains the **$–CO–CH_3$ (methyl ketone)** group. In this reaction, the methyl group is converted into **CHI_3 (iodoform)** and the rest becomes a **carboxylate salt**.
So the products are:
$C_6H_5–COONa$ (sodium benzoate) + **CHI_3 (iodoform, yellow precipitate)**.

(2) The second compound is **benzoyl chloride ($C_6H_5–COCl$)**. With **$(CH_3)_2Cd$ (dimethyl cadmium)**, acid chlorides are converted into **ketones** by replacing Cl with one alkyl group. Here, one **CH_3** group is introduced, giving:
$C_6H_5–CO–CH_3$ (acetophenone) + **$CdCl_2$**.
(iii) To distinguish between benzaldehyde and ethanal, Tollens' test can be used. Benzaldehyde gives a positive Tollens' test producing a silver mirror, while most ketones do not. Alternatively, Fehling's test can be used where ethanal gives a red precipitate but benzaldehyde does not react significantly.

> **Key Points: Aldehydes oxidize more easily due to presence of hydrogen on carbonyl carbon - Alpha hydrogen in aldehydes acidic due to resonance stabilization of enolate ion - Tollens test distinguishes aldehydes from ketones (benzaldehyde positive, ethanal positive)**

Question 38.

(i) The resistance of 0.05 M CH_3COOH solution is found to be 100 ohm. If the cell constant is 0.0354 cm^{-1}, calculate the molar conductivity of the acetic acid solution.

(ii) State faraday's first law of electrolysis. how much charge is Faraday is required for the reduction of 1 mol of MnO^-_4 to Mn^{2+} ?

[5 Marks]

Answer: (i) Given: Resistance R = 100 ohm, Cell constant = 0.0354 cm^{-1}, Concentration c = 0.05 mol L^{-1}.
First, calculate the conductivity (k) using the formula: k = Cell constant / Resistance = 0.0354 / 100 = 0.000354 S cm^{-1}.
Then, calculate molar conductivity (Λ_m) using: Λ_m = k / c = 0.000354 / 0.05 = 0.00708 S cm^2 mol^{-1}.
Therefore, molar conductivity of acetic acid solution is 7.08 S cm^2 mol^{-1}.
(ii) Faraday's first law of electrolysis states: 'The amount of substance liberated or deposited at an electrode during electrolysis is directly proportional to the quantity of electricity passed through the

electrolyte.'

Reduction reaction: MnO_4^- → Mn^{2+}.

Number of electrons involved (n) = 5.

Charge required for 1 mole of electrons (Faraday constant, F) = 96500 C.

Therefore, total charge Q = n * F = 5 * 96500 = 482500 Coulombs.

Thus, 482500 C of charge is required for reduction of 1 mol of MnO_4^- to Mn^{2+}.

Key Points: Calculation of conductivity using resistance and cell constant - Molar conductivity formula and calculation - Faraday's first law of electrolysis - Electron requirement for MnO4- reduction - Charge calculation using Faraday constant and number of electrons

Question 39.

(i) The conductivity of 0.0025 mol L^{-1} acetic acid is 5.25 *10 $^{-5}$ S cm^{-1}. Calculate its degree of dissociation if λ°_m for acetic acid is 390 S cm^2 mol^{-1}.

(ii) Write anode, cathode and overall reaction of lead storage battery.

[5 Marks]

Answer: (i) Calculation of degree of dissociation (\u03B1) of acetic acid:

Given:

Concentration (c) = 0.0025 mol L^{-1}

Conductivity (\u03BA) = 5.25 * 10^{-5} S cm^{-1}

Molar conductivity at infinite dilution ($\u03BB^0_m$) = 390 S cm^2 mol^{-1}

Step 1: Calculate molar conductivity ($\u03BB_m$) at given concentration:

$\u03BB_m$ = \u03BA / c = (5.25 * 10^{-5}) / 0.0025 = 0.021 S cm^2 mol^{-1}

Step 2: Calculate degree of dissociation \u03B1:

\u03B1 = $\u03BB_m$ / $\u03BB^0_m$ = 0.021 / 390 = 5.38 * 10^{-5}

Therefore, the degree of dissociation of acetic acid = 5.38 * 10^{-5} which is very small as expected for a weak acid.

(ii) Lead storage battery reactions:

Anode (oxidation): Pb (s) + HSO_4^- (aq) → $PbSO_4$ (s) + H^+ (aq) + $2e^-$

Cathode (reduction): PbO_2 (s) + HSO_4^- (aq) + $3H^+$ (aq) + $2e^-$ → $PbSO_4$ (s) + $2H_2O$ (l)

Overall reaction:

Pb (s) + PbO_2 (s) + $2H_2SO_4$ (aq) → $2PbSO_4$ (s) + $2H_2O$ (l)

This is a reversible reaction which makes the lead storage battery rechargeable.

Key Points: Calculate molar conductivity using conductivity and concentration - Degree of dissociation is molar conductivity over molar conductivity at infinite dilution - Write oxidation and reduction half reactions and then overall cell reaction of lead storage battery