CBSE EXAMINATION PAPER-2025

CHEMISTRY

(Solved)

Time allowed : 3 hours | Maximum Marks : 81

General Instructions :

Read the following instructions carefully and follow them :

i. This question paper contains **40 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 20** are multiple choice questions

v. **Section C** – questions number **21 to 26** are very short answer

vi. **Section D** – questions number **27 to 34** are short answer

vii. **Section E** – questions number **35 to 40** are long answer

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

ix. Use of calculator is NOT allowed.

Section A

Question 1. The spontaneous flow of the solvent through a semipermeable membrane from a pure solvent to a solution or from a dilute solution to a concentrated solution is called osmosis. The phenomenon of osmosis can be demonstrated by taking two eggs of the same size. In an egg, the membrane below the shell and around the egg material is semipermeable. The outer hard shell can be removed by putting the egg in dilute hydrochloric acid. After removing the hard shell, one egg is placed in distilled water and the other in a saturated salt solution. After some time, the egg placed in distilled water swells-up while the egg placed in salt solution shrinks. The external pressure applied to

stop the osmosis is termed as osmotic pressure (a colligative property). Reverse osmosis takes place when the applied external pressure becomes larger than the osmotic pressure.

Question 2.

Amines have a lone pair of electrons on nitrogen atom due to which they behave as Lewis base. Greater the value of Kb or smaller the value of pKb, stronger is the base. Amines are more basic than alcohols, ethers, esters, etc. The basic character of aliphatic amines should increase with the increase of alkyl substitution. But it does not occur in a regular manner as a secondary aliphatic amine is unexpectedly more basic than a tertiary amine in aqueous solutions. Aromatic amines are weaker bases than ammonia and aliphatic amines. Electron releasing groups such as —CH3' —OCH3, —NH2, etc., increase the basicity while electron-withdrawing substituents such as —N02, —CN, halogens etc., decrease the basicity of amines. The effect of these substitute is more at p- than at m position.

(1)

Why pKb of aniline is more than that of methylamine ?

[1 Marks]

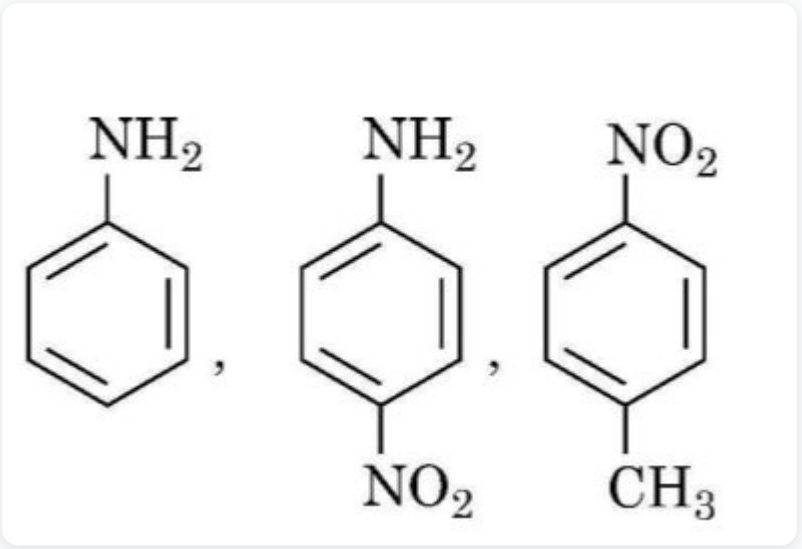
Answer: Answer: The pKb of aniline is more than that of methylamine because in aniline, the lone pair of electrons on nitrogen delocalizes into the benzene ring reducing its availability to accept a proton, thus decreasing its basicity. In contrast, methylamine has an alkyl group which releases electrons (+I effect) increasing electron density on nitrogen, making it more basic and lowering its pKb value, as explained in the case passage.

Key Points: Aniline lone pair delocalisation reduces basicity - Methylamine has +I effect increasing basicity - Higher pKb means weaker base

(2)

Arrange the following in the increasing order of their basic character.

Give reason :



[2 Marks]

Answer: The increasing order of basicity is aniline < ammonia < ethylamine < diethylamine. This is because aniline is aromatic and its lone pair is delocalized in the benzene ring, making it less available for bonding, so it is the weakest base. Ammonia is next as it has no alkyl groups to donate electrons. Ethylamine and diethylamine are aliphatic amines with electron-releasing alkyl groups that increase electron density on nitrogen, making them more basic. Diethylamine has more alkyl groups than ethylamine, so it is the strongest base among them, as explained in the case passage.

Key Points: Aniline has delocalized lone pair making it least basic - Alkyl groups increase basicity through +I effect - Diethylamine is more basic due to more alkyl groups

(3)

Why ammonolysis of alkyl halides is not a good method toprepare pure amines ?

[1 Marks]

Answer: Ammonolysis of alkyl halides is not a good method to prepare pure amines because it produces a mixture of primary, secondary, tertiary amines and quaternary ammonium salts due to multiple substitutions. As explained in the case paragraph, the reaction of ammonia with alkyl halides leads to all these products making separation difficult and reducing purity of amines.

Key Points: Ammonolysis produces mixture of amines-substitution occurs multiple times-difficult to obtain pure amine

(4)

Arrange the following in the increasing order of their basic character in an aqueous solution .

$(CH_3)_3N$, $(CH_3)_2NH$, NH_3, CH_3NH_2

[1 Marks]

Answer: The increasing order of basicity in aqueous solution is $(CH_3)_3N < NH_3 < CH_3NH_2 < (CH_3)_2NH$. According to the case passage, secondary amines are more basic than tertiary amines in aqueous solutions due to solvation effects. Alkyl groups increase basicity, but tertiary amine's steric hindrance reduces it. Ammonia is less basic than alkyl amines as it has no alkyl groups. Thus, $(CH_3)_2NH$ is the strongest base among these.

Key Points: Amines are Lewis bases due to lone pair on nitrogen - Basicity increases with alkyl substitution but tertiary amines are less basic than secondary in water - Increasing order is $(CH_3)_3N < NH_3 < CH_3NH_2 < (CH_3)_2NH$

Question 3.

The spontaneous flow of the solvent through a semipermeable membrane from a pure solvent to a solution or from a dilute solution to a concentrated solution is called osmosis. The phenomenon of osmosis can be demonstrated by taking two eggs of the same size. In an egg, the membrane below the shell and around the egg material is semipermeable. The outer hard shell can be removed by putting the egg in dilute hydrochloric acid. After removing the hard shell, one egg is placed in distilled water and the other in a saturated salt solution. After some time, the egg placed in distilled water

swells-up while the egg placed in salt solution shrinks. The external pressure applied to stop the osmosis is termed as osmotic pressure (a colligative property). Reverse osmosis takes place when the applied external pressure becomes larger than the osmotic pressure.

(1)

Define reverse osmosis. Name one SPM which can be used in the process of reverse osmosis .

[2 Marks]

Answer: Reverse osmosis is the process in which external pressure greater than osmotic pressure is applied to a solution, causing the solvent to flow from the concentrated solution to the pure solvent side through a semipermeable membrane. This is opposite to natural osmosis where solvent flows from dilute to concentrated solution. A common semipermeable membrane (SPM) used in this process is a **thin film composite membrane**. Reverse osmosis is used in water purification and desalination, as explained in the case passage.

Key Points: Reverse osmosis is solvent flow from concentrated to pure solvent on applying pressure higher than osmotic pressure - It is opposite to natural osmosis - Thin film composite membrane is used as SPM in reverse osmosis

(2)

Which one of the following will have higher osmotic pressure in1 M KCl or 1 M urea solution. Justify your answer.

[1 Marks]

Answer: 1 M KCl solution will have higher osmotic pressure than 1 M urea solution because KCl is an electrolyte and dissociates into two ions K^+ and Cl^- increasing the number of solute particles. Urea does not dissociate and has fewer particles. As osmotic pressure depends on the number of solute particles (colligative property), KCl solution has higher osmotic pressure.

Key Points: Osmotic pressure depends on number of solute particles - KCl dissociates into ions increasing particle number - Urea does not dissociate so fewer particles - Higher particle concentration means higher osmotic pressure

(3)

What do you expect to happen when red blood corpuscles (RBC's) are placed in 0.5% NaCl solution ?

[1 Marks]

Answer: Answer: When RBCs are placed in 0.5% NaCl solution, which is less than the normal 0.9% salt concentration of blood, water moves into the cells by osmosis causing them to swell. This happens because the solution is hypotonic compared to the inside of RBCs, as explained in the case where solvent flows from dilute to concentrated solutions through a semipermeable membrane.

Key Points: RBCs in 0.5% NaCl - solution is hypotonic - water enters RBCs by osmosis - RBCs swell

(4)

Why osmotic pressure is a colligative property ?

[1 Marks]

Answer: Osmotic pressure is a colligative property because it depends on the number of solute particles in the solution and not on their identity.
This means osmotic pressure increases with solute concentration, as explained in the case of eggs swelling or shrinking due to osmosis.
It is one of the properties like lowering of vapour pressure, elevation of boiling point, and depression of freezing point that depend only on solute quantity, not type.

Key Points: Depends on number of solute particles - Independent of solute identity - Related to concentration of solution

Section B

Question 4.

The charge required for the reduction of 1 mol of $Mn0^{-}_{4}$ to $Mn0_{2}$ is

[1 Marks]

(A) 5F

(B) 3F

(C) 1F

(D) 6F

Explanation:

The correct answer is 3F. The reduction of MnO_4^- to MnO_2 involves a change in the oxidation state of manganese from +7 in MnO_4^- to +4 in MnO_2, requiring the transfer of 3 electrons per Mn atom. This means that for one mole of MnO_4^-, 3 moles of electrons are needed. Since 1 mole of electrons corresponds to one Faraday (F), the total charge required for the reduction of 1 mole of MnO_4^- to MnO_2 is **3F**.

Question 5.

Which among the following is false statement?

[1 Marks]

(A) Half-life of a zero order reaction is inversely proportional to the rate constant.

(B) Molecularity of a reaction may be zero.

(C) Rate of zero order reaction is independent of initial concentration of reactant.

(D) For a first order reaction, $t_1/_2 = 0.693/k$

Explanation:

The false statement is 'Molecularity of a reaction may be zero.' This is incorrect because **molecularity refers to the number of reactant molecules involved in an elementary reaction**, and it is always a **positive integer** (1 for unimolecular, 2 for bimolecular, etc.). **It can never be zero**, as that would imply that the reaction occurs without any reactant molecules, which is not possible in chemical reactions.

Question 6.

The number of molecules that react with each other in an elementary reaction is a measure of the:

[1 Marks]

(A) stoichiometry of the reaction

(B) order of the reaction

(C) activation energy of the reaction

(D) molecularity of the reaction

Explanation:

The correct answer is 'molecularity of the reaction' because molecularity refers to the number of reacting species (atoms, ions, or molecules) that must collide simultaneously to initiate a chemical reaction, which is specifically defined for elementary reactions.

Question 7.

The element having $[Ar]3d^{10}4s^{1}$ electronic configuration is:

[1 Marks]

(A) Zn

(B) Cr

(C) Cu

(D) Mn

Explanation: The correct option is Cu (Copper). The electronic configuration of Copper is $[Ar]\ 3d^{10}\ 4s^{1}$, which matches the given configuration. This is because Copper has one electron in the 4s orbital and a completely filled 3d orbital, making it unique among the transition metals listed.

Question 8.

The complex ions $[Co(NH_3)_5(NO_2)]^{2+}$ and $[Co(NH_3)_5(ONO)]^{2+}$ are called:

[1 Marks]

(A) Geometrical isomers

(B) Linkage isomers

(C) Co-ordination isomers

(D) Ionization isomers

Explanation:

The correct option is 'Linkage isomers' because the two complex ions differ in how the nitrite ligand (NO_2) coordinates to the cobalt ion; it can bind either through the nitrogen atom or the oxygen atom, resulting in different linkage in the coordination complex.

Question 9.

The diamagnetic species is:

[At. No. Co = 27,Fe = 26, Ni = 28]

[1 Marks]

(A) $[Ni(CN)_4]^{2-}$

(B) $[NiCl_4]^{2-}$

(C) $[CoF_6]^{3-}$

(D) $[Fe(CN)_6]^{3-}$

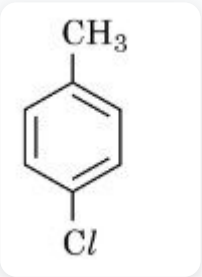
Explanation:

$[Ni(CN)_4]^{2-}$ is the correct answer as it is diamagnetic. In this complex, nickel is in the +2 oxidation state with an electronic configuration of $3d^8$. The configuration allows for paired electrons in the d-orbitals, resulting in no unpaired electrons. This is supported by the context which states that this species is tetrahedral and diamagnetic, contrasting with other options that are all paramagnetic due to having unpaired electrons.

Question 10.

Which is the correct IUPAC name for

[1 Marks]



(A) 1-Chloro-4-Methylbenzene

(B) 1-Methyl-4-Chlorobenzene

(C) Methylchlorobenzene

(D) Toluene

Explanation:

The correct IUPAC name is 1-Chloro-4-Methylbenzene. This name indicates that there is a chlorine atom (−Cl) attached to the benzene ring at position 1 and a methyl group ($-CH_3$) attached at position

4. This naming aligns with IUPAC rules, where substituents are numbered to give the lowest locants, and alphabetical order is used to determine the priority when both substituents are at equal positions. Hence, "chloro" comes before "methyl" in the name.

Question 11.

What will be formed after oxidation reaction of secondary alcohol with chromic anhydride (CrO_3)?

[1 Marks]

(A) Aldehyde

(B) Ketone

(C) Carboxylic acid

(D) Ester

Explanation:

The correct answer is 'Ketone' because secondary alcohols are oxidized to ketones when treated with chromic anhydride (CrO_3), as indicated in the provided context.

Question 12.

The conversion of phenol to salicylic acid can be accomplished by:

[1 Marks]

(A) Kolbe reaction

(B) Friedel-Crafts reaction

(C) Coupling reaction

(D) Reimer-Tiemann reaction

Explanation:

The correct answer is Kolbe's reaction. In this reaction, **phenol** is first treated with **sodium hydroxide (NaOH)** to form **sodium phenoxide**, which is then heated with **carbon dioxide (CO_2)** under pressure (around **125°C and 6–7 atm**). This introduces a **–COOH group** at the **ortho position** of the aromatic ring, forming **sodium salicylate**, which upon acidification gives **salicylic acid**.

Question 13.

Which of the following is/are examples of denaturation of protein?

[1 Marks]

(A) Clotting of blood

(B) Coagulation of egg white

(C) Both Curdling of milk and Coagulation of egg white

(D) Curdling of milk

Explanation:

The correct options are Curdling of milk and Coagulation of egg white, which are examples of denaturation of proteins as explained in the context. Denaturation occurs when proteins lose their secondary and tertiary structures due to changes in temperature or pH, while the primary structure remains intact. The context specifically mentions curdling of milk due to lactic acid from bacteria and coagulation of egg white upon boiling as common examples.

Question 14.

Nucleotides are joined together by:

[1 Marks]

(A) Peptide linkage

(B) Hydrogen bonding

(C) Glycosidic linkage

(D) Phosphodiester linkage

Explanation:

The correct answer is 'Phosphodiester linkage' because nucleotides are linked together via phosphodiester bonds that form between the 5' and 3' carbon atoms of the pentose sugar in the nucleotide structure. This linkage is essential in forming the backbone of nucleic acids such as DNA and RNA.

Question 15.

Scurvy is caused due to deficiency of:

[1 Marks]

(A) Vitamin B_1

(B) Vitamin B_2

(C) Glutamic acid

(D) Ascorbic acid

Explanation:

Scurvy is caused by a deficiency of Vitamin C, also known as Ascorbic acid, which is highlighted in the context as leading to bleeding gums. The other options listed do not cause Scurvy.

Question 16.

Assertion (A) : In a first order reaction, if the concentration of the reactant is doubled, its half-life is also doubled.

Reason (R) : The half-life of a reaction does not depend upon the initial concentration of the reactant in a first order reaction.

[1 Marks]

(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:

Assertion (A) is false, but Reason (R) is true. The half-life of a first order reaction is independent of the initial concentration of the reactant, meaning that doubling the concentration does not affect the half-life.

Question 17.

Assertion (A) : In a first order reaction, if the concentration of the reactant is doubled, its half-life is also doubled

Reason (R) : The half-life of a reaction does not depend upon the initial concentration of the reactant in a first order reaction.

[1 Marks]

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

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

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

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

Explanation:

Assertion (A) is false, because in a first order reaction, the half-life is constant and does not change with the concentration of the reactant; it is independent of initial concentration. Reason (R) is true, as it accurately describes that the half-life for first order reactions remains the same regardless of changes in reactant concentration.

Question 18.

Assertion (A) : Cu cannot liberate H_2 on reaction with dilute mineral acids.

Reason (R) : Cu has positive electrode potential .

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

Explanation:

Both Assertion (A) and Reason (R) are true and reason is the correct explanation of assertion. CU lies below hydrogen in electrochemical series and has positive electrode potential. Hence cannot liberate hydrogen from acids.

Question 19.

Assertion (A) : Aromatic primary amines cannot be prepared by Gabriel Phthalimide synthesis.

Reason (R) : Aryl halides do not undergo nucleophilic substitution reaction with the anion formed by phthalimide.

[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 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) 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 Assertion (A). Aromatic primary amines cannot be synthesized through the Gabriel Phthalimide method because aryl halides do not react with the nucleophilic anion derived from phthalimide, thereby confirming Assertion (A) with Reason (R).

Question 20.

Assertion (A) : Vitamin D cannot be stored in our body.

Reason (R) : Vitamin D is fat soluble vitamin and is not excreted from the body in urine.

[1 Marks]

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

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

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

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

Explanation:

Assertion (A) is false, but Reason (R) is true. Vitamin D is a fat-soluble vitamin, meaning it can actually be stored in the body, primarily in the liver and adipose tissues, which contradicts Assertion (A). Reason (R) is true as fat-soluble vitamins are not readily excreted in urine, but it does not support the incorrect assertion.

Section C

Question 21.

The rate constant for a zero order reaction A → P is 0.0030 mol $L^{-1}s^{-1}$. How long will it take for the initial concentration of A to fall from 0.10 M to 0.075 M ?

[2 Marks]

Answer: For a zero order reaction, the rate law is given by: Rate = k = - d[A]/dt.

The integrated rate law for zero order reaction is: $[A] = [A]_0 - kt$.

Given:

Initial concentration, $[A]_0 = 0.10$ M

Final concentration, [A] = 0.075 M

Rate constant, k = 0.0030 mol L^{-1} s^{-1}

Substitute values in the equation: 0.075 = 0.10 - 0.0030 * t

0.10 - 0.075 = 0.0030 * t

0.025 = 0.0030 * t

t = 0.025 / 0.0030 = 8.33 seconds.

Therefore, it will take 8.33 seconds for the concentration of A to fall from 0.10 M to 0.075 M.

Key Points: Zero order integrated rate law - Substitution of concentration and rate constant values - Calculation of time taken for concentration change

Question 22.

The decomposition of NH_3 on platinum surface is zero order reaction. what are the rates of production of N_2 and H_2 if k = 2.5 x 10^{-4} mol L^{-1} s^{-1} ?

[2 Marks]

Answer: Given: The decomposition of NH_3 is a zero order reaction with rate constant k = 2.5 x 10^{-4} mol L^{-1} s^{-1}.

Step 1: Write the balanced reaction: 2 NH_3 → N_2 + 3 H_2.

Step 2: Rate of reaction (r) = k since it is zero order.

Step 3: The rate of disappearance of NH_3 = k = 2.5 x 10^{-4} mol L^{-1} s^{-1}.

Step 4: Using stoichiometry, rate of production of N_2 = (1/2) * rate of NH_3 = (1/2)* 2.5 x 10^{-4} = 1.25 x 10^{-4} mol L^{-1} s^{-1}.

Step 5: Rate of production of H_2 = (3/2) * rate of NH_3 = (3/2)* 2.5 x 10^{-4} = 3.75 x 10^{-4} mol L^{-1} s^{-1}.

Answer: Rate of formation of N_2 is 1.25 x 10^{-4} mol L^{-1} s^{-1} and rate of formation of H_2 is 3.75 x 10^{-4} mol L^{-1} s^{-1}.

Key Points: NH3 decomposition is zero order - Rate = k = 2.5 x 10^-4 mol L^-1 s^-1 - Rates of N2 and H2 calculated using stoichiometric ratios

Question 23.

Define the following terms :

(a) Pseudo first order reaction

(b) Half-life period of reaction($t_{½}$)

[2 Marks]

Answer: (a) Pseudo first order reaction: It is a reaction that is actually of higher order but appears to be first order because the concentration of one or more reactants is kept constant and in large excess.
(b) Half-life period of reaction ($t_{½}$): It is the time required for the concentration of a reactant to decrease to half of its initial value during the reaction.

> **Key Points: Definition of pseudo first order reaction - Definition of half-life period - Explanation of concentration change in half-life**

Question 24.

Examine the following observations :

(a) Transition elements generally form coloured compounds.

(b) Zinc is not regarded as a transition element.

[2 Marks]

Answer: (a) Transition elements form coloured compounds because they have incompletely filled d orbitals, which allow d-d electronic transitions that absorb visible light and produce colours.
(b) Zinc is not a transition element because its 3d orbitals are fully filled (3d10) in both ground and common oxidation states. Since it does not have partially filled d orbitals, it does not exhibit typical properties of transition elements such as variable oxidation states and coloured compounds.

> **Key Points: Transition elements have partially filled d orbitals - Colour arises due to d-d electronic transitions - Zinc has fully filled 3d orbitals therefore is not a transition element**

Question 25.

Name the following coordination compounds according to IUPAC norms :

(a) $[Co(NH_3)_4(H_2O)Cl]Cl_2$

(b) $[CrC1_2(en)_2]Cl$

[2 Marks]

Answer: (a) The complex ion is $[Co(NH_3)_4(H_2O)Cl]^{2+}$ with two chloride ions as counter ions. The ligands are named in alphabetical order: ammine, aqua, chloro. The metal is cobalt with oxidation state +3. Hence, the name is **tetraammineaquachloridocobalt(III) chloride**.

(b) The complex ion is $[CrCl_2(en)_2]^+$ with one chloride ion as counter ion. The ligands are ethane-1,2-diamine abbreviated as en and chloro. Alphabetically, chloro comes before ethane-1,2-diamine. The oxidation state of chromium is +3. So, the name is **dichloridobis(ethane-1,2-diamine)chromium(III) chloride**.

Key Points: Identify ligands and their count - Arrange ligands alphabetically in the name - Determine metal oxidation state - Name complex with ligands first then metal with oxidation state - Name counter ions last

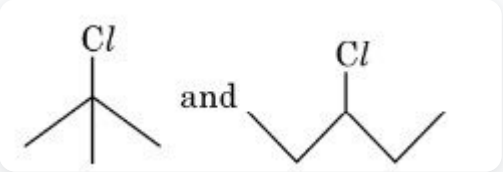
Question 26.

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

(b) Arrange the following compounds in increasing order of their reactivity towards S_n2 displacement :

2—Bromo—2—methylbutane, I—Bromopentane, 2—Bromopentane.

[2 Marks]



Answer: (a) The compound that undergoes the S_N1 reaction faster is the one that can form a more stable carbocation intermediate. Typically, tertiary alkyl halides react faster than secondary, which react faster than primary due to carbocation stability. Hence, the tertiary halogen compound undergoes S_N1 reaction faster because it forms a more stable tertiary carbocation.

(b) For S_N2 reactions, steric hindrance plays a major role. Primary alkyl halides react faster than secondary, which react faster than tertiary. Among the compounds given, 2-Bromo-2-methylbutane is tertiary and most hindered, 2-Bromopentane is secondary, and 1-Bromopentane (I-Bromopentane) is primary. So, the increasing order of reactivity is: 2-Bromo-2-methylbutane < 2-Bromopentane < I-Bromopentane.

Key Points: S_N1 reaction depends on carbocation stability - tertiary halides react faster in S_N1 - S_N2 reaction is influenced by steric hindrance - primary halides react faster in S_N2 - 2-Bromo-2-methylbutane is tertiary and least reactive in S_N2

Section D

Question 27.

At 25 ^{0}C the saturated vapour pressure of water is 24 mm Hg. Find the saturated vapour pressure of a 5% aqueous solution of urea at the same temperature. (Molar mass of urea = 60 g mol^{-1})

[3 Marks]

Answer: Given: Mass of urea = 5 g in 100 g solution (5% solution), mass of water = 95 g, molar mass of urea = 60 g/mol, vapour pressure of pure water at 25 deg C = 24 mm Hg.
Step 1: Calculate moles of urea = 5 / 60 = 0.0833 mol
Step 2: Calculate moles of water = 95 / 18 = 5.28 mol
Step 3: Calculate mole fraction of water, X_{water} = moles of water / (moles of water + moles of urea) = 5.28 / (5.28 + 0.0833) = 0.9845
Step 4: Use Raoult's law: vapour pressure of solution = X_{water} * vapour pressure of pure water = 0.9845 * 24 = 23.63 mm Hg
Answer: The saturated vapour pressure of 5% aqueous urea solution at 25 deg C is approximately 23.63 mm Hg.

Key Points: Calculate moles of solute and solvent - Determine mole fraction of solvent - Apply Raoult's law to find vapour pressure of solution

Question 28.

The electrical resistance of a column of 0.05 M NaOH solution of area 0.8 cm^{2} and length 40 cm is 5 x 10^{3} ohm. Calculate its resistivity, conductivity and molar conductivity.

[3 Marks]

Answer: Given data: Concentration, c = 0.05 mol L^{-1}, Area, A = 0.8 cm^{2} = 0.8 * 10^{-4} m^{2}, Length, l = 40 cm = 0.4 m, Resistance, R = 5 x 10^{3} ohm.

(a) Resistivity (\rho):
Resistivity \rho = R * A / l = (5 x 10^{3}) * (0.8 * 10^{-4}) / 0.4 = 1 ohm m.

(b) Conductivity (\kappa):
Conductivity \kappa = 1 / \rho = 1 / 1 = 1 S m^{-1}.

(c) Molar conductivity (\Lambda$_{m}$):
First, convert concentration to mol/m^{3}: c = 0.05 mol L^{-1} = 0.05 * 1000 = 50 mol m^{-3}.
Molar conductivity \Lambda$_{m}$ = \kappa / c = 1 / 50 = 0.02 S m^{2} mol^{-1} = 20 S cm^{2} mol^{-1} (since 1 m^{2} = 10^{4} cm^{2}).

Summary:

Resistivity = 1 ohm m, Conductivity = 1 S m^{-1}, Molar conductivity = 20 S cm^2 mol^{-1}.

Key Points: Calculate resistivity using R, A and l - Conductivity is inverse of resistivity - Convert concentration to mol/m^3 for molar conductivity calculation

Question 29.

Complete and balance the following chemical equations:

[3 Marks]

(a) $MnO_4^- + C_2O_4^{2-} + H^+ \longrightarrow$

(b) $KMnO_4 \xrightarrow[513\ K]{Heat}$

(c) $Cr_2O_7^{2-} + H_2S + H^+ \longrightarrow$

Answer: Steps to balance the chemical equations:

1. Write the unbalanced equation.
2. Separate the reaction into oxidation and reduction half-reactions.
3. Balance all atoms except hydrogen and oxygen.
4. Balance oxygen atoms by adding H_2O molecules.
5. Balance hydrogen atoms by adding OH^- ions (since the medium is basic).
6. Balance the charge by adding electrons (e^-) to the appropriate side.
7. Equalize the number of electrons in both half-reactions by multiplying as needed.
8. Add the two half-reactions together and cancel common species including electrons.
9. Verify that atoms and charges are balanced on both sides.

Following these steps ensures the final equation obeys the law of conservation of mass and charge, with only coefficients changed and subscripts intact.

Key Points: Write unbalanced equation - Separate oxidation and reduction half reactions - Balance atoms except H and O - Balance oxygen with H2O - Balance hydrogen with OH-

- Balance charges with electrons - Equalize electron transfer - Add and cancel to finalize balance

Question 30.

Using valence bond theory, explain the hybridization and magnetic character of the following :

(a) $[Co(NH_3)_6]^{3+}$

(b) $[Ni(CO)_4]$

[At. no. : Co = 27, Ni = 28]

[3 Marks]

Answer: (a) In $[Co(NH_3)_6]^{+}$, Co is in +3 oxidation state with $3d^6$ configuration. NH_3 is a strong field ligand causing pairing of electrons. The electronic configuration becomes $(t_2g)^6(eg)^0$. Hybridization involves two 3d, one 4s and three 4p orbitals forming d_0sp^3 hybrid orbitals resulting in an octahedral shape. It is diamagnetic due to all electrons paired.
(b) In $[Ni(CO)_4]$, Ni is in 0 oxidation state with $3d_8\ 4s_2$ electronic configuration. CO is a strong field ligand leading to pairing of electrons. Hybridization occurs involving one 3d, one 4s and two 4p orbitals resulting in dsp^2 hybridization giving a square planar geometry. It is diamagnetic because all electrons are paired.

Key Points: Co in +3 state with 3d6 configuration - NH3 strong field ligand causes electron pairing - d2sp3 hybridization and octahedral geometry - diamagnetic; Ni in 0 state with 3d8 4s2 configuration - CO strong field ligand causes pairing - dsp2 hybridization and square planar geometry - diamagnetic

Question 31.

(a) Define the following :

(i) Enantiomers

(ii) Racemic mixture

(b) Why is chlorobenzene resistant to nucleophilic substitution reaction ?

[3 Marks]

Answer: (a)(i) **Enantiomers** are a pair of molecules that are non-superimposable mirror images of each other, having chiral centres and identical physical properties except for the direction in which they rotate plane-polarised light.
(a)(ii) A **racemic mixture** is an equimolar mixture of two enantiomers of a chiral compound which shows no optical activity because the rotations caused by each enantiomer cancel each other.
(b) Chlorobenzene is resistant to nucleophilic substitution because the lone pair of electrons on

chlorine delocalises into the benzene ring through resonance, making the C-Cl bond stronger and less reactive. Also, the aromatic ring is electron-rich, repelling nucleophiles and stabilising the molecule, thus hindering the attack of nucleophiles and making nucleophilic substitution difficult.

Key Points: Definition of enantiomers - Definition of racemic mixture - Resonance effect in chlorobenzene makes nucleophilic substitution difficult

Question 32.

Explain the following reactions and write chemical equation involved:

(a) Wolf-Kishhner reducation

(b) Etard reaction

(c) Cannizzaro reaction

[3 Marks]

Answer: (a) Wolff-Kishner Reduction: This reaction reduces aldehydes and ketones to alkanes by removing the oxygen atom. The carbonyl compound first reacts with hydrazine (NH_2NH_2) to form hydrazone. On heating with a strong base like KOH and high temperature, nitrogen gas is released and the carbonyl group is reduced to a CH_2 group.

$COR + NH_2NH_2 \rightarrow RCH{=}NNH_2$ (Hydrazone)

$RCH{=}NNH_2 + KOH/heat \rightarrow RH + N_2 + H_2O$

(b) Etard Reaction: This reaction is used to oxidize methyl groups attached to aromatic rings into aldehydes. Chromyl chloride (CrO_2Cl_2) reacts with toluene to form an intermediate complex which on hydrolysis gives benzaldehyde.

$C_6H_5CH_3 + CrO_2Cl_2 \rightarrow complex \rightarrow C_6H_5CHO$ + other products

(c) Cannizzaro Reaction: This reaction involves aldehydes with no alpha hydrogen. When treated with concentrated alkali, one molecule of aldehyde is reduced to alcohol and another is oxidized to carboxylic acid salt.

$2\ RCHO + OH^- \rightarrow RCH_2OH + RCOO^-$

Example: $2\ C_6H_5CHO + OH^- \rightarrow C_6H_5CH_2OH + C_6H_5COO^-$

These reactions demonstrate redox processes involving aldehydes under different conditions.

Key Points: Wolff-Kishner reduces carbonyl group to alkane - Etard selectively oxidizes methyl group to aldehyde - Cannizzaro is a disproportionation of aldehydes without alpha hydrogen

Question 33.

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

[3 Marks]

(a) $CH_3COOH \xrightarrow{SOCl_2} A \xrightarrow{H_2,\ Pd\text{-}BaSO_4} B \xrightarrow{H_2N\text{–}NH_2} C$

(b) $CH_3CN \xrightarrow[2.\ H_2O]{1.(DIBAL\text{–}H)} A \xrightarrow{Dil.\ NaOH} B \xrightarrow{\Delta} C$

Answer: Answer:

(a) Structure of A: A is the initial organic compound, which in this reaction sequence is typically an alkyl halide such as bromobenzene (C_6H_5Br). So, structure A is bromobenzene where a bromine atom is attached to the benzene ring.

(b) Structure of B: B is the Grignard reagent formed by reacting A with magnesium in dry ether. For bromobenzene, this forms phenylmagnesium bromide (C_6H_5MgBr). Its structure contains the phenyl group bonded to magnesium which is also bonded to bromine.

(c) Structure of C: C is the product formed when the Grignard reagent B reacts with a compound such as an aldehyde or ketone followed by hydrolysis with water or acid. For example, if B reacts with formaldehyde (HCHO), after hydrolysis, C would be benzyl alcohol ($C_6H_5CH_2OH$). The structure of C shows a benzene ring attached to a $-CH_2OH$ group.

Hence, the sequence: A (bromobenzene) —Mg/ether→ B (phenylmagnesium bromide) —reacts with aldehyde + hydrolysis→ C (benzyl alcohol).

Key Points: A is the alkyl halide (e.g., bromobenzene) - B is the Grignard reagent (e.g., phenylmagnesium bromide) - C is the final product after reaction with aldehyde and hydrolysis (e.g., benzyl alcohol)

Question 34.

Define the following terms :

(a) Glycosidic linkage

(b) Invert sugar

(c) Oligosaccharides

[3 Marks]

Answer: (a) **Glycosidic linkage** is a type of covalent bond that connects two monosaccharide units in a carbohydrate molecule. It forms when the hydroxyl group (-OH) of one sugar reacts with the anomeric carbon of another sugar, resulting in the loss of a water molecule (condensation reaction). This bond is important in forming disaccharides and polysaccharides.

(b) **Invert sugar** is a mixture of glucose and fructose obtained by the hydrolysis of sucrose. When sucrose is treated with acid or enzyme invertase, it breaks down into equal parts of glucose and

fructose. This sugar mixture is called invert sugar because it inverts the direction of rotation of plane-polarized light from dextrorotatory (sucrose) to levorotatory (invert sugar).
(c) **Oligosaccharides** are carbohydrates composed of 2 to 10 monosaccharide units linked together by glycosidic linkages. They are intermediate in size between monosaccharides and polysaccharides and are commonly found on the surface of cells, playing important roles in cell recognition and signaling.

Key Points: Glycosidic linkage connects monosaccharides by oxygen bond - Invert sugar is hydrolyzed sucrose containing glucose and fructose - Oligosaccharides contain 2 to 10 monosaccharide units

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Section E

Question 35.

(a) Give the IUPAC name of CH_3−CH=CH−CHO.

(b) Give a simple chemical test to distinguish between propanal and propanone.

(c) How will you convert the following :

(i) Toluene to benzoic acid

(ii) Ethanol to propan—2—ol

(iii) Propanal to 2—hydroxy propanoic acid

[5 Marks]

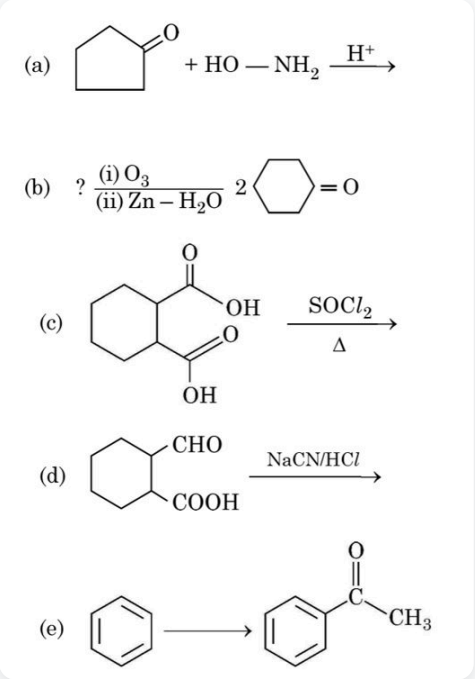
Answer: (a) The given compound is CH_3-CH=CH-CHO. The longest chain containing the aldehyde group (–CHO) has three carbon atoms. The double bond is between carbon 2 and carbon 3. Therefore, the IUPAC name is **prop-2-enal** or **acrolein**.
(b) To distinguish between propanal and propanone, perform the **Tollen's test**. Aldehydes like propanal react with Tollen's reagent to give a silver mirror on the inner surface of the test tube, while ketones like propanone do not give this test.
(c) (i) Toluene to benzoic acid: Oxidize toluene using $KMnO_4$ in alkaline medium with heat. The methyl group is oxidized to the carboxylic acid group, forming benzoic acid.
(ii) Ethanol to propan-2-ol: First convert ethanol to bromoethane using PBr_3, then carry out a Grignard reaction with formaldehyde followed by acidic hydrolysis to get propan-2-ol.
(iii) Propanal to 2-hydroxy propanoic acid: React propanal with HCN to form cyanohydrin, then hydrolyze the nitrile group (-CN) using dilute acid to get 2-hydroxy propanoic acid (lactic acid).

Key Points: IUPAC name of CH3-CH=CH-CHO is prop-2-enal - Tollen's test distinguishes aldehyde from ketone - Oxidation of toluene to benzoic acid using KMnO4 - Ethanol to propan-2-ol via bromination and Grignard reaction - Propanal to 2-hydroxy propanoic acid via cyanohydrin formation and hydrolysis

Question 36.

Complete each synthesis by giving missing starting material, reagent or products:

[5 Marks]



Answer: 1. Hexan-1-ol to hexanal: Hexan-1-ol is a primary alcohol which can be oxidized to an aldehyde. The reagent used is PCC (Pyridinium chlorochromate). The product formed is hexanal.
2. Cyclohexanol to cyclohexanone: Cyclohexanol is a secondary alcohol that can be oxidized to a ketone using reagents like chromic acid (H_2CrO_4) or PCC. The product is cyclohexanone.
3. p-Fluorotoluene to p-fluorobenzaldehyde: p-Fluorotoluene is an aromatic compound and can be converted to p-fluorobenzaldehyde by side chain oxidation using reagents such as $KMnO_4$ or chromyl chloride (Etard reaction). The methyl group oxidizes to the aldehyde group.
4. Ethanitrile to ethanal: Ethanitrile (CH_3CN) can be partially hydrolyzed or reduced to ethanal using reagents like diisobutylaluminium hydride (DIBAL-H) at low temperature. This reduces the nitrile group to an aldehyde.

In summary, these syntheses involve careful selection of reagents to convert functional groups stepwise. The reaction conditions and reagents determine whether oxidation or reduction occurs. Understanding the role of each reagent helps in predicting the products and completing the synthesis steps.

Key Points: Identify starting materials - Select appropriate reagents for oxidation or reduction - Understand functional group transformations

Question 37.

(a) Calculate the standard Gibbs energy (Δ_rG^0) of the following reaction at 25 ^{0}C: Au(S) + ca^{2+}(1M)→ Au^{3+} (1M) +Ca(s)

E^0Au^{3+}/Au= + 1.5 V,E^0Ca^{2+}/Ca=- 2.87 v

Predict whether the reaction will be spontaneous or not at 25 ^{0}C. [1 F = 96500 C mol^{-1}]

(b) Tarnished silver contains Ag2S. Can this tarnish be removed by placing tarnished silverware in an aluminium pan containing an inert electrolytic solution such as NaCl ? The standard electrode potential for half reaction :

$Ag_2S(s) + 2e^- \rightarrow 2Ag(s) + S^{2-}$ is -0.71V

and for $Al^{3+} + 3e^- \rightarrow 2Al(s)$ is -1.66 V

[5 Marks]

Answer: (a) The given reaction is: $Au(s) + Ca^{2+}(1M) \rightarrow Au^{3+}(1M) + Ca(s)$

Given standard electrode potentials:

$E^0_{Au^{3+}/Au} = +1.5$ V and $E^0_{Ca^{2+}/Ca} = -2.87$ V

The overall cell reaction can be seen as Au oxidizing to Au^{3+} (oxidation) and Ca^{2+} reducing to Ca(s) (reduction)

Calculate $E^0cell = E^0cathode - E^0anode = E^0_{reduction} - E^0_{oxidation}$

Since Au is oxidized, its oxidation potential = -1.5 V and Ca^{2+} is reduced, its reduction potential = -2.87 V

$E^0cell = (-2.87) - (-1.5) = -1.37$ V

Using $\Delta G^0 = -nFE^0cell$, where n is the number of electrons transferred,

In Au oxidation, Au changes from 0 to +3 oxidation state, so n=3

F = 96500 C mol^{-1}

$\Delta G^0 = -3 * 96500 * (-1.37) = +397,965$ J = +398 kJ

A positive ΔG^0 indicates the reaction is non-spontaneous at 25 degC.

(b) Tarnished silver contains Ag_2S which can be removed by placing the silverware in an aluminium pan with inert electrolyte like NaCl.

Half reactions given:

$Ag_2S(s) + 2e^- \rightarrow 2Ag(s) + S^{2-}$; $E^0 = -0.71$ V

$Al^{3+} + 3e^- \rightarrow Al(s)$; $E^0 = -1.66$ V

The more negative E^0 for Al means aluminium is more easily oxidized than silver sulfide reduction.
Al will lose electrons, reducing Ag_2S to Ag and removing the tarnish.
Thus, tarnish can be removed by this method due to the difference in electrode potentials favoring the reaction.

Key Points: Calculation of E0cell by subtracting electrode potentials - Use of ΔG0 = -nFE0 to find Gibbs free energy - Positive ΔG0 means non-spontaneous reaction - Comparing electrode potentials to predict oxidation and reduction in silver tarnish removal - Aluminium's higher reactivity helps in removing Ag2S tarnish

Question 38.

(a) Define the following :

(i) Cell potential

(ii) Fuel cell

(b) Calculate emf of the following cell at 25^0C :

$Zn(s)\ I\ Zn^{2+}_{(0.1m)}IICd^{2+}_{(0.01m)}I\ Cd(s)$

Given : $E^0cd^{2+}/cd = -0.40V$

$E^0Zn^{2+}/Zn = -0.76V$

[log 10=1]

[5 Marks]

Answer: (a) (i) **Cell potential** is the voltage or electromotive force (emf) of an electrochemical cell that drives electrons from the anode to the cathode through an external circuit. It is the difference in electrode potentials of the two half cells.
(ii) **Fuel cell** is a device that converts chemical energy of a fuel, usually hydrogen or hydrocarbons, directly into electrical energy through electrochemical reactions without combustion.
(b) To calculate emf of the cell Zn(s) | Zn^{2+}(0.1M) || Cd^{2+}(0.01M) | Cd(s) at 25 deg C:
Given: $E^0_{Cd^{2+}/Cd} = -0.40$ V and $E^0_{Zn^{2+}/Zn} = -0.76$ V
Standard cell potential, $E^0_{cell} = E^0_{cathode} - E^0_{anode} = (-0.40) - (-0.76) = 0.36$ V
The overall cell reaction involves 2 electrons, so n = 2.
Using Nernst equation:
$E_{cell} = E^0_{cell} - (0.059/2) * \log([Zn^{2+}]/[Cd^{2+}])$
Substituting values:
$E_{cell} = 0.36 - (0.059/2) * \log(0.1/0.01) = 0.36 - 0.0295 * \log(10) = 0.36 - 0.0295 * 1 = 0.3305$ V
Therefore, emf of the cell under given conditions is approximately 0.33 V.

Key Points: Definition of cell potential - Definition of fuel cell - Calculation of emf using Nernst equation with ion concentrations and standard electrode potentials

Question 39.

An organic compound 'A', molecular formula C_2H_60 oxidises with $Cr0_3$ to form a compound 'B'. Compound 'B' on warming with iodine and aqueous solution of NaOH gives a yellow precipitate of compound 'C'. When compound 'A' is heated with conc. H_2S0_4 at 413 K gives a compound 'D', which on reaction with excess HI gives compound 'E'. Identify compounds 'A', 'B', 'C', 'D' and 'E' and write chemical equations involved.

[5 Marks]

Answer: Answer:

(a) Compound A with molecular formula C_2H_6O is ethanol (CH_3CH_2OH).

(b) On oxidation with CrO_3, ethanol (A) forms compound B which is ethanal (acetaldehyde, CH_3CHO).

Equation: $CH_3CH_2OH + [O] \xrightarrow{CrO_3} CH_3CHO + H_2O$

(c) Compound B (ethanal) on warming with iodine and NaOH gives a yellow precipitate (compound C) of iodoform (CHI_3) indicating a methyl ketone or aldehyde with methyl group.

Equation: $CH_3CHO + 3I_2 + 4NaOH \rightarrow CHI_3$ (yellow ppt) $+ HCOONa + 3NaI + 3H_2O$

(d) When compound A (ethanol) is heated with concentrated H_2SO_4 at 413 K, dehydration occurs producing compound D which is ethene ($CH_2=CH_2$).

Equation: $CH_3CH_2OH \xrightarrow{\text{conc } H_2SO_4,\ 413\ K} CH_2=CH_2 + H_2O$

(e) Compound D (ethene) on reaction with excess HI gives compound E which is ethyl iodide (C_2H_5I).

Equation: $CH_2=CH_2 + HI \rightarrow CH_3CH_2I$

Summary:

A - Ethanol (CH_3CH_2OH)

B - Ethanal (CH_3CHO)

C - Iodoform (CHI_3)

D - Ethene ($CH_2=CH_2$)

E - Ethyl iodide (CH_3CH_2I)

These reactions show typical oxidation, haloform test, dehydration and addition reaction of ethanol and its derivatives.

Key Points: Compound A is ethanol - Oxidation of ethanol forms ethanal - Iodoform test gives yellow precipitate of iodoform - Dehydration of ethanol forms ethene - Ethene reacts with HI to form ethyl iodide

Question 40.

(a) Write chemical equations of the following reactions :

(i) Phenol is treated with conc. HNO3

(ii) Propene is treated with B H followed by oxidation by H202/OH-.

(iii) Sodium t-butoxide is treated with CH3 Cl.

(b) Give a simple chemical test to distinguish between butan—1—ol and butan—2—ol.

(c) Arrange the following in increasing order of acid strength : phenol, ethanol, water.

[5 Marks]

Answer: (a)

(i) When phenol is treated with concentrated nitric acid, nitration occurs mainly at the ortho and para positions forming a mixture of 2-nitrophenol and 4-nitrophenol. The reaction can be written as:

C6H5OH + HNO3 (conc.) -> o-nitrophenol + p-nitrophenol + H2O

(ii) Propene reacts with borane (B H3) to give an organoborane intermediate which on oxidation with hydrogen peroxide (H2O2) in alkaline medium (OH-) gives propanol. The hydroboration-oxidation reaction gives anti-Markovnikov addition of water.

CH3-CH=CH2 + B H3 -> organoborane intermediate

Organoborane + H2O2/OH- -> CH3-CH2-CH2OH

(iii) Sodium t-butoxide reacts with methyl chloride (CH3 Cl) via nucleophilic substitution to give t-butyl methyl ether.

((CH3)3CO-)Na+ + CH3Cl -> (CH3)3COCH3 + NaCl

(b)

To distinguish between butan-1-ol and butan-2-ol, use Lucas test. When treated with Lucas reagent (ZnCl2 in concentrated HCl), butan-2-ol reacts faster forming turbidity due to formation of alkyl chloride, while butan-1-ol reacts slowly. Thus, appearance of turbidity immediately indicates butan-2-ol, while delayed turbidity or no turbidity indicates butan-1-ol.

(c)

The increasing order of acid strength among phenol, ethanol and water is:

ethanol < water < phenol

This is because phenol has resonance stabilization of its phenoxide ion, making it more acidic than water and ethanol. Water is more acidic than ethanol due to better stabilization of its conjugate base.

Key Points: Chemical equations for nitration of phenol - Hydroboration-oxidation of propene - Williamson synthesis of ether - Lucas test to distinguish alcohols - Acid strength order based on resonance and stability of conjugate base