CHAPTER

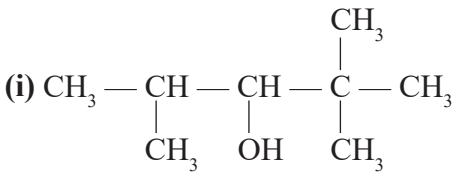
7

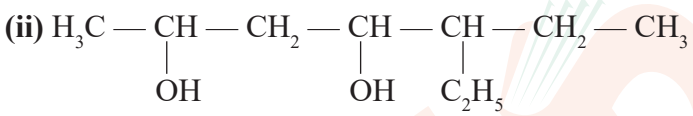
Alcohols, Phenols & Ethers

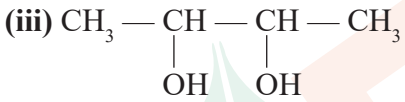
CLASS 12TH

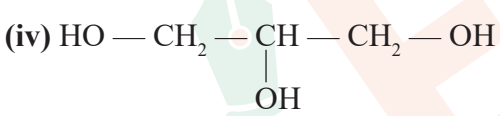
NCERT EXERCISE AND SOLUTIONS - CHEMISTRY

Q. 1. **Write IUPAC names of the following compounds:**

(i) 

(ii) 

(iii) 

(iv) 

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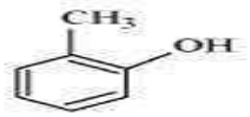

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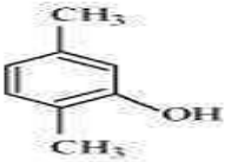

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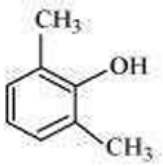

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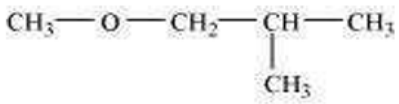
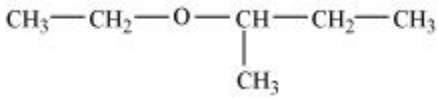


(x) $C_6H_5-O-C_2H_5$

(xi) $C_6H_5-O-C_7H_{15}(n-)$

(xii)



ANSWER:-

(i) 2, 2, 4-Trimethylpentan-3-ol

(ii) 5-Ethylheptane-2, 4-diol

(iii) Butane-2, 3-diol

(iv) Propane-1, 2, 3-triol

(v) 2-Methylphenol

(vi) 4-Methylphenol

(vii) 2,5-Dimethylphenol

(viii) 2, 6-Dimethylphenol

(ix) 1-Methoxy-2-methylpropane

(x) Ethoxybenzene

(xi) 1-Phenoxyheptane

(xii) 2-Ethoxybutane

Q. 2. Write structures of the compounds whose IUPAC names are as follows:

(i) 2-Methylbutan-2-ol

(ii) 1-Phenylpropan-2-ol

(iii) 3,5-Dimethylhexane −1, 3, 5-triol

(iv) 2,3 – Diethylphenol

(v) 1 – Ethoxypropane

(vi) 2-Ethoxy-3-methylpentane

(vii) Cyclohexylmethanol

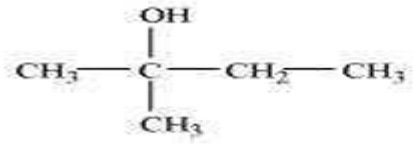
(viii) 3-Cyclohexylpentan-3-ol

(ix) Cyclopent-3-en-1-ol

(x) 3-Chloromethylpentan-1-ol.

ANSWER:-

(i)



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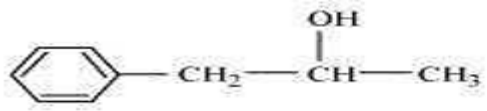

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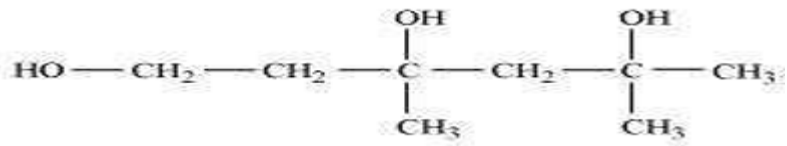

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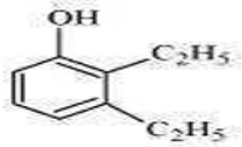
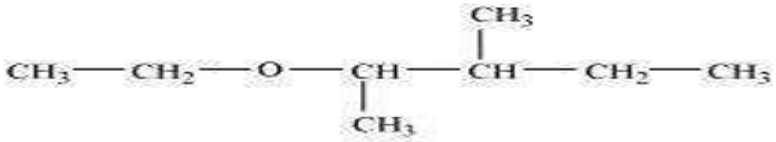


(v)

$CH_3-CH_2-O-CH_2-CH_2-CH_3$

(vi)



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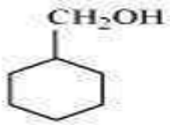

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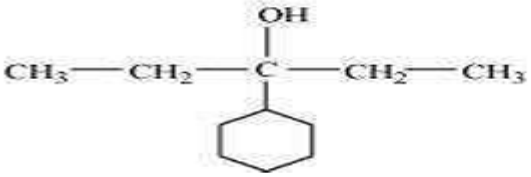

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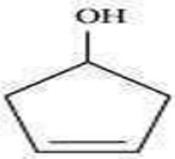

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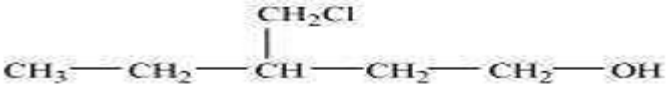


Q. 3. **(i) Draw the structures of all isomeric alcohols of molecular formula $C_5H_{12}O$ and give their IUPAC names.**

(ii) Classify the isomers of alcohols in question 11.3 (i) as primary, secondary and tertiary alcohols.

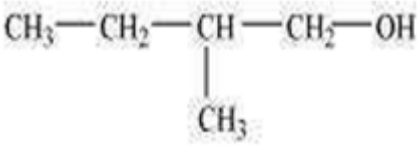
ANSWER:-

(i) These are the possible isomers of alcohols with the molecular formula $C_5H_{12}O$.

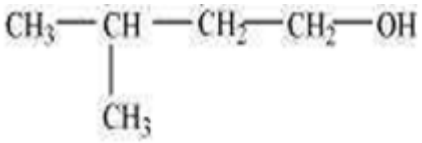
(a) $CH_3-CH_2-CH_2-CH_2-CH_2-OH$

Pentan-1-ol (1°)

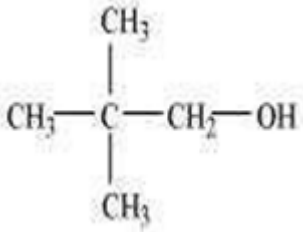
(b)



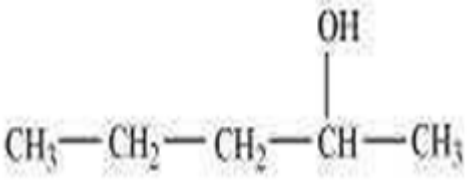
2-Methylbutan-1-ol (1°)

(c) 

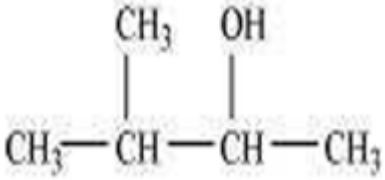
3-Methylbutan-1-ol (1°)

(d) 

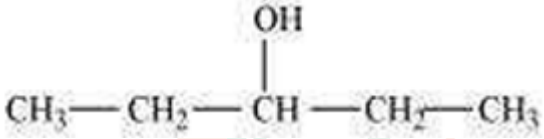
2, 2-Dimethylpropan-1-ol (1°)

(e) 

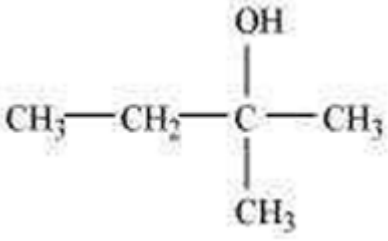
Pentan-2-ol (2°)

(f) 

3-Methylbutan-2-ol (2°)

(g) 

Pentan-3-ol (2°)

(h) 

2- Methylbutan-2-ol (3°)

(ii) **Primary alcohol:** Pentan-1-ol; 2-Methylbutan-1-ol; 3-Methylbutan-1-ol; 2, 2-Dimethylpropan-1-ol

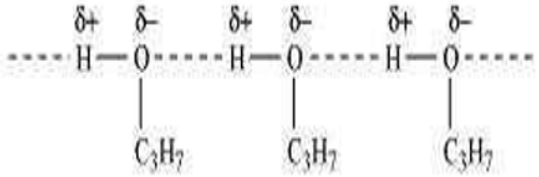
Secondary alcohol: Pentan-2-ol; 3-Methylbutan-2-ol; Pentan-3-ol

Tertiary alcohol: 2-methylbutan-2-ol

Q. 4. Explain why propanol has higher boiling point than that of the hydrocarbon, butane?

ANSWER:-

Propanol forms hydrogen bonds due to its -OH group, while butane, lacking such a group, only experiences weaker Van der Waals forces.

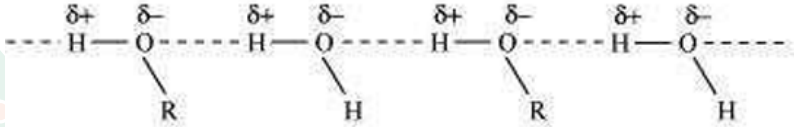


As a result, additional energy is needed to break hydrogen bonds, which is why propanol has a higher boiling point than the hydrocarbon butane.

Q. 5. Alcohols are comparatively more soluble in water than hydrocarbons of comparable molecular masses. Explain this fact.

ANSWER:-

Alcohols can form hydrogen bonds with water because of their −OH group, whereas hydrocarbons cannot form hydrogen bonds with water.

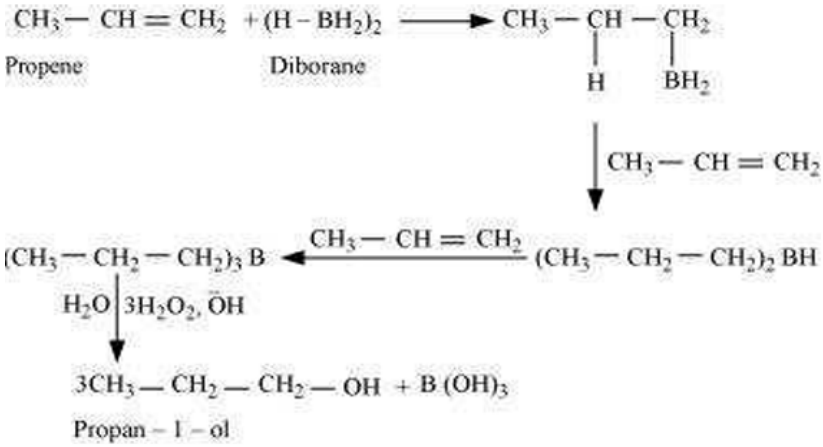


Consequently, alcohols are generally more soluble in water than hydrocarbons with similar molecular masses.

Q. 6. What is meant by hydroboration-oxidation reaction? Illustrate it with an example.

ANSWER:-

The hydroboration-oxidation reaction involves the addition of borane followed by oxidation. For instance, propan-1-ol is synthesized through the hydroboration-oxidation of propene. In this process, propene reacts with diborane $(BH_3)_2$ to form trialkyl borane as an addition product, which is then oxidized to an alcohol using hydrogen peroxide in the presence of aqueous sodium hydroxide.



Q. 7 **Give the structures and IUPAC names of monohydric phenols of molecular formula, C_7H_8O.**

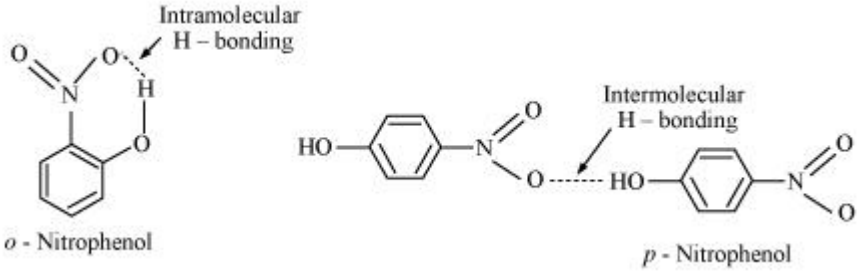
ANSWER:-

The structures and IUPAC names of monohydric phenols of molecular formula, **C_7H_8O.**

Q. 8. **While separating a mixture of ortho and para nitrophenols by steam distillation, name the isomer which will be steam volatile. Give reason.**

ANSWER:-

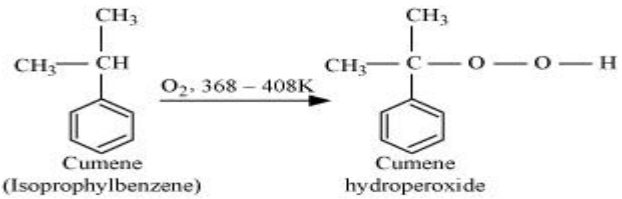
In o-nitrophenol, intramolecular hydrogen bonding occurs between the hydroxyl group and the nitro group, which reduces the intermolecular interactions and lowers the boiling point, making it steam volatile. In contrast, p-nitrophenol exhibits strong intermolecular hydrogen bonding between its molecules, which leads to a higher boiling point and lower volatility during steam distillation. Hence, o-nitrophenol is steam volatile, whereas p-nitrophenol is not.



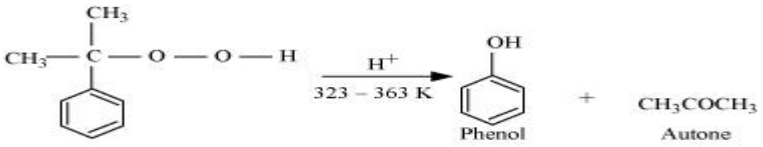
Q. 9. **Give the equations of reactions for the preparation of phenol from cumene.**

ANSWER:-

To prepare phenol, Cumene is oxidized with air to form cumene hydro-peroxide.



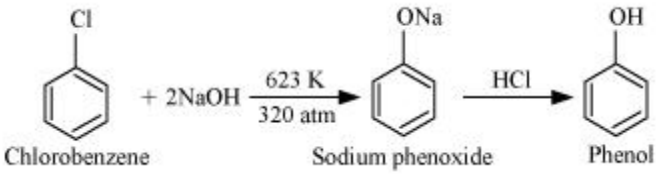
Cumene hydroperoxide is then treated with dilute acid to yield phenol, with acetone as a by-product.



Q. 10. Write chemical reaction for the preparation of phenol from chlorobenzene.

ANSWER:-

Chlorobenzene is fused with NaOH at 623 K and 320 atm pressure to yield sodium phenoxide, which, when acidified, forms phenol.

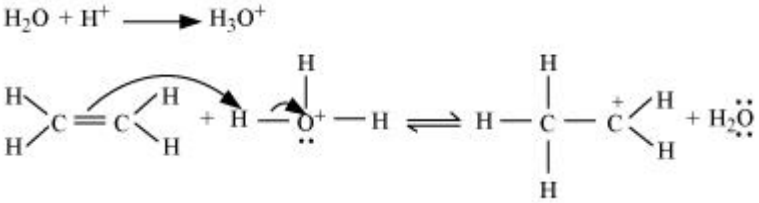


Q. 11. Write the mechanism of hydration of ethene to yield ethanol.

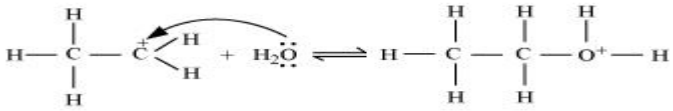
ANSWER:-

The mechanism of ethene hydration to form ethanol involves three steps.

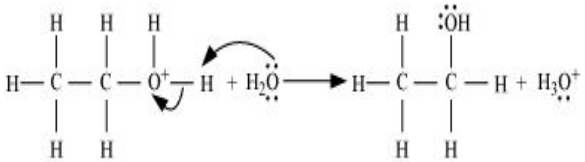
Step 1: Ethene undergoes protonation to form a carbocation through the electrophilic attack of H_3O^+.



Step 2: The carbocation undergoes a nucleophilic attack by water.



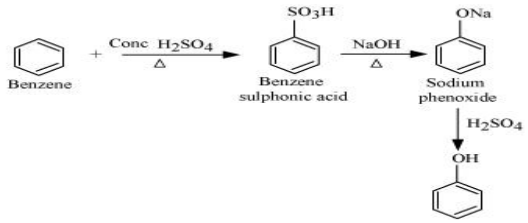
Step 3: The final step involves deprotonation, resulting in the formation of ethanol.



Q. 12. You are given benzene, conc. H_2SO_4 and NaOH. Write the equations for the preparation of phenol using these reagents.

ANSWER:-

Preparation of phenol using benzene, conc. H_2SO_4 and NaOH



Q. 13. Show how will you synthesize:

(i) 1-phenylethanol from a suitable alkene.

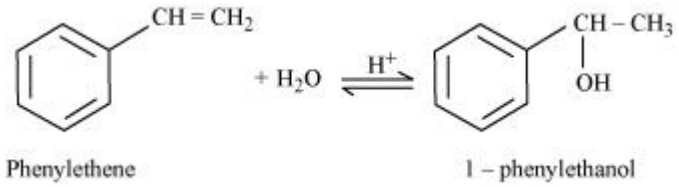
(ii) cyclohexylmethanol using an alkyl halide by an SN^2 reaction.

(iii) pentan-1-ol using a suitable alkyl halide?

ANSWER:-

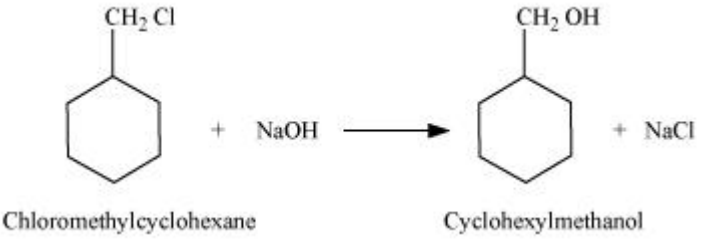
(i) 1-phenylethanol from a suitable alkene

1-Phenylethanol can be synthesized by the acid-catalyzed hydration of styrene (ethylbenzene).



(ii) cyclohexylmethanol using an alkyl halide by an SN^2 reaction.

When chloromethylcyclohexane is treated with sodium hydroxide, cyclohexylmethanol is obtained.



(iii) pentan-1-ol using a suitable alkyl halide

$$\underset{\text{1-Chloropentane}}{CH_3CH_2CH_2CH_2CH_2Cl} + NaOH \longrightarrow \underset{\text{Pentan-1-ol}}{CH_3CH_2CH_2CH_2CH_2OH} + NaCl$$

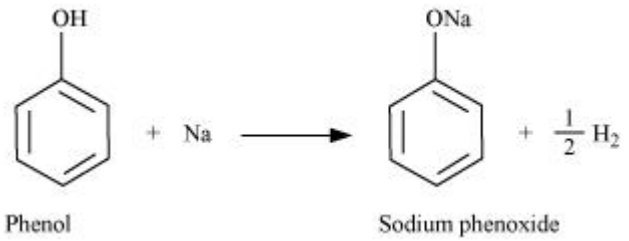
Pentan-1-ol is formed when 1-chloropentane is treated with NaOH.

Q. 14. Give two reactions that show the acidic nature of phenol. Compare acidity of phenol with that of ethanol.

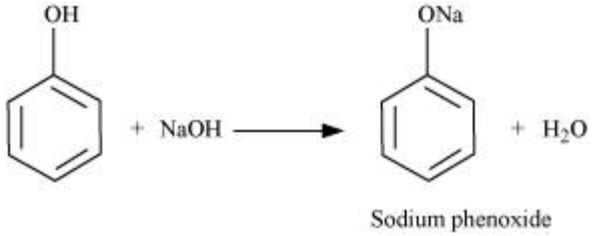
ANSWER:-

The acidic nature of phenol is demonstrated by the following reactions:

(i) Phenol reacts with sodium to form sodium phenoxide, releasing H_2.

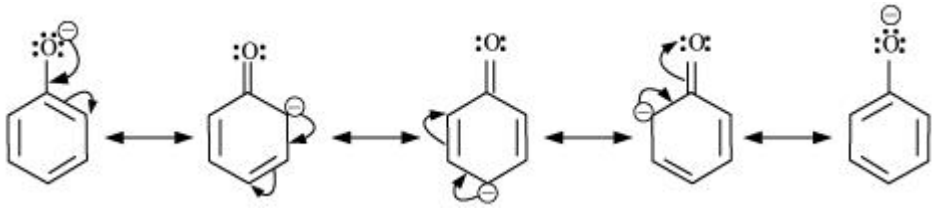


(ii) Phenol reacts with sodium hydroxide to produce sodium phenoxide and water.



Sodium phenoxide

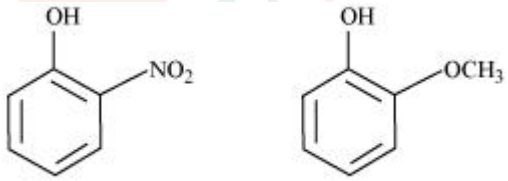
Phenol is more acidic than ethanol because, upon losing a proton, the phenoxide ion is stabilized through resonance, whereas the ethoxide ion does not undergo such stabilization.



Q. 15. Explain why is ortho nitrophenol more acidic than ortho methoxyphenol?

ANSWER:-

The nitro group is an electron-withdrawing group. When it is present in the ortho position, it reduces the electron density in the O−H bond, making it easier to lose a proton. Additionally, the o-nitrophenoxide ion formed after proton loss is stabilized by resonance. Therefore, ortho-nitrophenol is a stronger acid. In contrast, the methoxy group is an electron-donating group, which increases the electron density in the O−H bond, making it harder for the proton to dissociate. As a result, ortho-nitrophenol is more acidic than ortho-methoxyphenol.

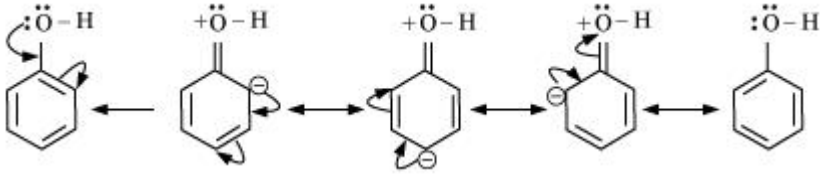


o – Nitrophenol o – Methoxyphenol

Q. 16. Explain how does the −OH group attached to a carbon of benzene ring activate it towards electrophilic substitution?

ANSWER:-

The −OH group is an electron-donating group, which enhances the electron density in the benzene ring, as depicted in the resonance structure of phenol. As a result, the benzene ring becomes activated, making it more reactive towards electrophilic substitution.



Q. 17. **Give equations of the following reactions:**

(i) **Oxidation of propan-1-ol with alkaline $KMnO_4$ solution.**

(ii) **Bromine in CS_2 with phenol.**

(iii) **Dilute HNO_3 with phenol.**

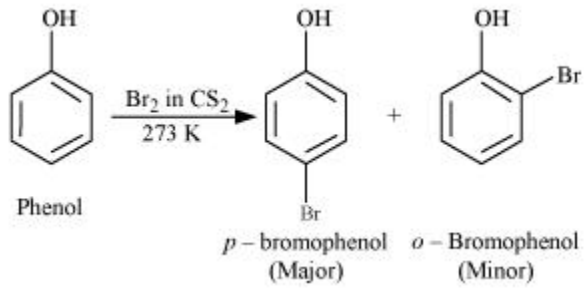
(iv) **Treating phenol with chloroform in presence of aqueous NaOH.**

ANSWER:-

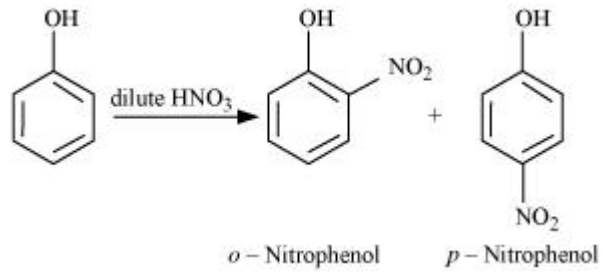
(i) $CH_3CH_2CH_2OH \xrightarrow{\text{alk } KMnO_4} CH_3CH_2COOH$

Propan-1ol → Propanoic acid

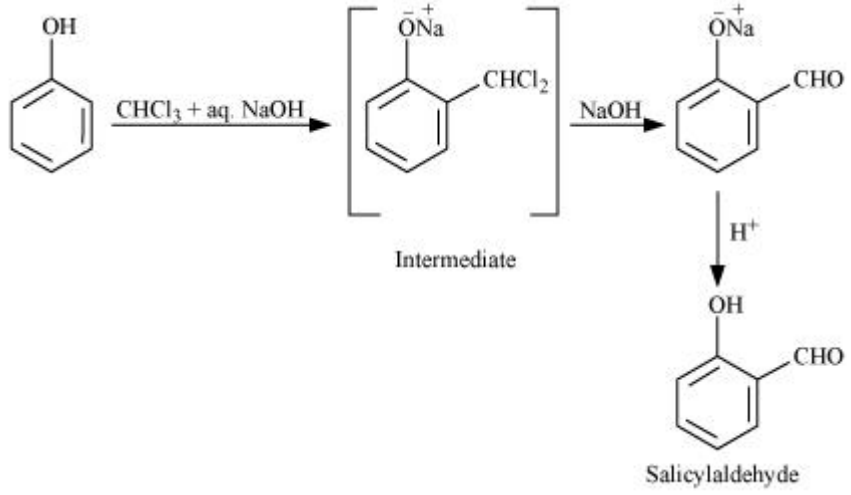
(ii)



(iii)



(iv)



Q. 18. **Explain the following with an example.**

(i) **Kolbe's reaction**

(ii) **Reimer-Tiemann reaction**

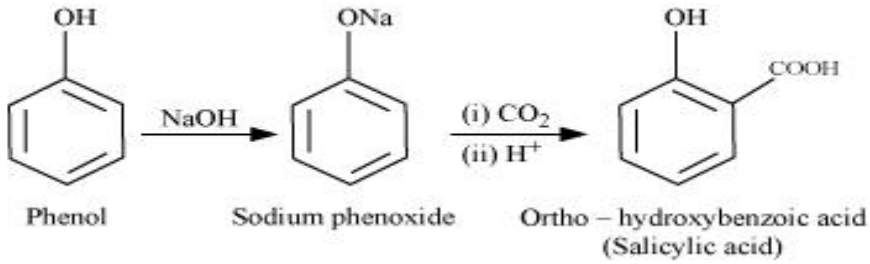
(iii) **Williamson ether synthesis**

(iv) **Unsymmetrical ether**

ANSWER:-

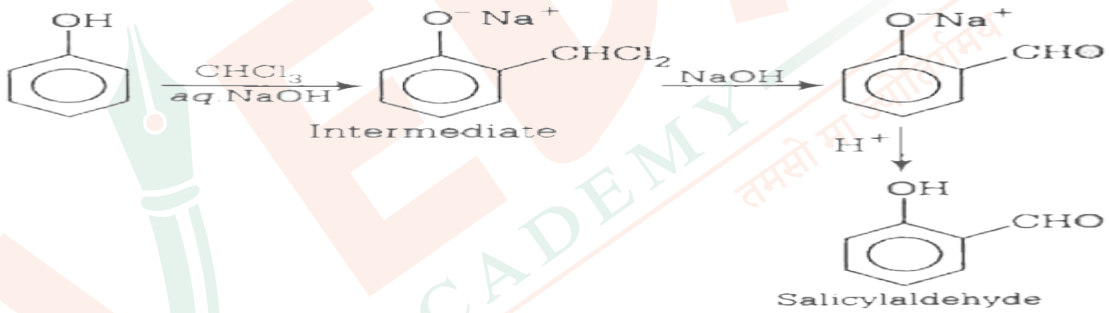
(i) Kolbe's reaction:

When phenol is treated with sodium hydroxide, sodium phenoxide is formed. This sodium phenoxide, upon reaction with carbon dioxide followed by acidification, undergoes electrophilic substitution to yield ortho-hydroxybenzoic acid as the primary product. This reaction is referred to as Kolbe's reaction**.**



(ii) Reimer-Tiemann reaction

When phenol is treated with chloroform ($CHCl_3$) in the presence of sodium hydroxide, a −CHO group is introduced at the ortho position of the benzene ring. This reaction is called the Reimer-Tiemann reaction. The intermediate product is then hydrolyzed with alkali to form salicyclaldehyde.



(iii) Williamson ether synthesis

The Williamson ether synthesis is an organic reaction, forming an ether from an organohalide and a deprotonated alcohol (alkoxide). It involves the reaction of an alkoxide ion with a primary alkyl halide via an S_N2 reaction.

If the alkyl halide is secondary or tertiary, then elimination competes over substitution.

(iv) Unsymmetrical ether

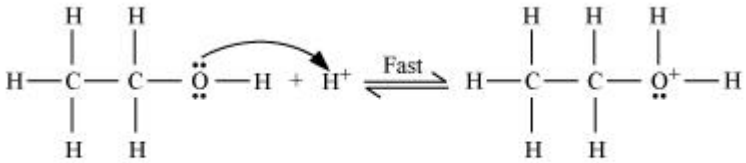
An unsymmetrical ether is an ether in which the two groups attached to the oxygen atom are different, meaning they have an unequal number of carbon atoms. For example, ethyl methyl ether (CH_3–O–CH_2CH_3).

Q. 19. Write the mechanism of acid-catalysed dehydration of ethanol to yield ethene.

ANSWER:-

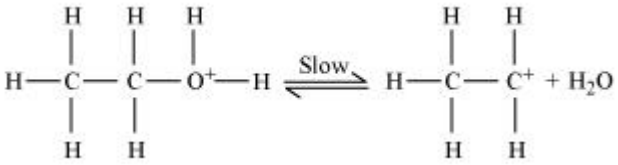
The mechanism of acid-catalyzed dehydration of ethanol to form ethene involves three steps.

Step 1: Ethanol is protonated to form an ethyl oxonium ion.

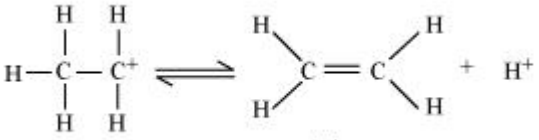


Ethanol — Protonated ethanol (Ethyl oxonium ion)

Step2: The formation of the carbocation (rate-determining step).



Step3: Elimination of a proton to form ethene:



Ethene

Q. 20. How are the following conversions carried out?

(i) Propene → Propan-2-ol

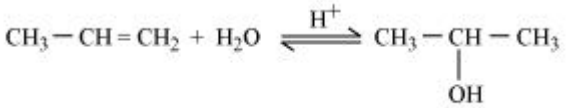
(ii) Benzyl chloride → Benzyl alcohol

(iii) Ethyl magnesium chloride → Propan-1-ol.

(iv) Methyl magnesium bromide → 2-Methylpropan-2-ol

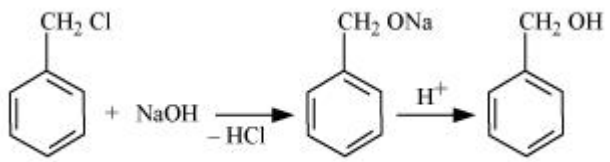
ANSWER:-

(i) Propene → Propan-2-ol



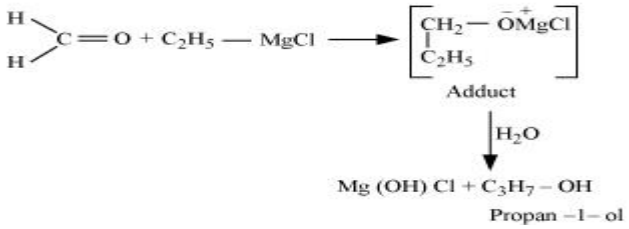
Propene — Propan – 2 – ol

(ii) Benzyl chloride → Benzyl alcohol

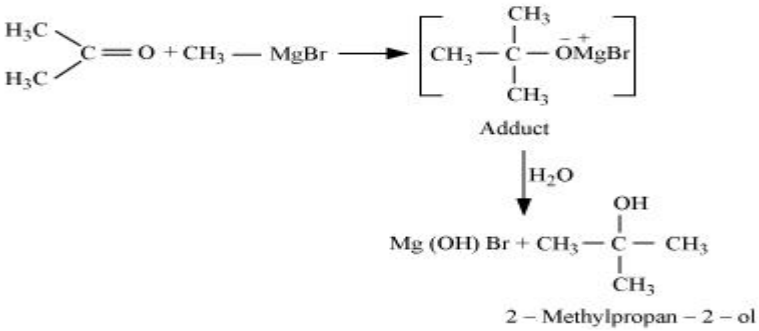


Benzyl chloride — Benzyl alcohol

(iii) Ethyl magnesium chloride → Propan-1-ol



(iv) Methyl magnesium bromide → 2-Methylpropan-2-ol



Q. 21. Name the reagents used in the following reactions:

(i) Oxidation of primary alcohol to carboxylic reaction.
(ii) Oxidation of primary alcohol to aldehyde.
(iii) Bromination of phenol of 2,4,6-tribromophenol.
(iv) Benzyl alcohol to benzoic acid
(v) Dehydration of propan-2-ol to propene.
(vi) Butane-2-one to Butan-2-ol

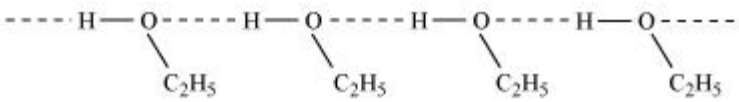
ANSWER:-

(i) Acidified potassium permanganate
(ii) Pyridinium chlorochromate (PCC)
(iii) Bromine water
(iv) Acidified potassium permanganate
(v) 85% phosphoric acid
(vi) $NaBH_4$ or $LiAlH_4$

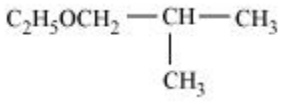
Q. 22. Give reason for the higher boiling point of ethanol in comparison to methoxymethane.

ANSWER:-

Ethanol forms intermolecular hydrogen bonds due to the presence of the −OH group, leading to the association of molecules. As a result, extra energy is needed to break these hydrogen bonds. In contrast, methoxymethane does not form hydrogen bonds. Therefore, ethanol has a higher boiling point than methoxymethane.



Q. 23. **Give IUPAC names of the following ethers:**

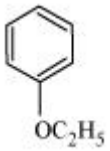
(i) 

(ii) $CH_3OCH_2CH_2Cl$

(iii) $O_2N-C_6H_4-OCH_3(p)$

(iv) $CH_3CH_2CH_2OCH_3$

(v) 

(vi) 

ANSWER:-

(i) 1-Ethoxy-2-methylpropane

(ii) 2-Chloro-1-methoxyethane

(iii) 4-Nitroanisole

(iv) 1-Methoxypropane

(v) 1-Ethoxy-4, 4-dimethylcyclohexane

(vi) Ethoxybenzene

Q. 24. **Write the names of reagents and equations for the preparation of the following ethers by Williamson's synthesis:**

(i) **1-Propoxypropane**

(ii) **Ethoxybenzene**

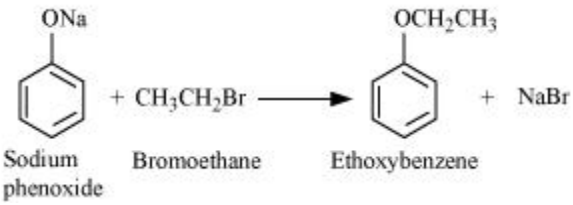
(iii) **2-Methoxy-2-methylpropane**

(iv) **1-Methoxyethane**

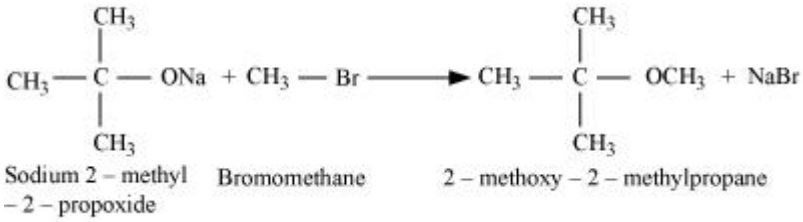
ANSWER:-

(i) $\underset{\text{Sodium propoxide}}{CH_3CH_2\,CHONa} + \underset{\text{1-Bromopropane}}{CH_3CH_2CH_2Br} \longrightarrow \underset{\text{1- Propoxypropane}}{C_2H_5CH_2-O-CH_2C_2H_5} + NaBr$

(ii)



(iii)



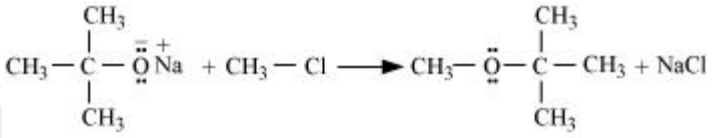
(iv) $CH_3CH_2 - ONa + CH_3 - Br \longrightarrow CH_3CH_2 - O - CH_3 + NaBr$

Sodium ethoxide Bromomethane 1-Methoxyethane

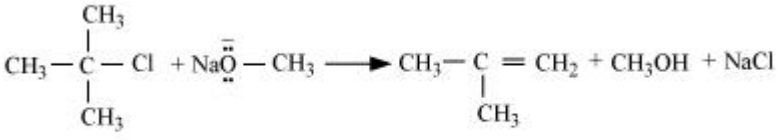
Q. 25. Illustrate with examples the limitations of Williamson synthesis for the preparation of certain types of ethers.

ANSWER:-

The Williamson synthesis reaction involves an SN^2 attack, where an alkoxide ion reacts with a primary alkyl halide.



However, if secondary or tertiary alkyl halides are used instead of primary alkyl halides, elimination may compete with substitution. This leads to the formation of alkenes because alkoxides are both nucleophiles and strong bases. As a result, they can also react with alkyl halides in an elimination reaction.



Q. 26. How is 1-propoxypropane synthesised from propan-1-ol? Write mechanism of this reaction.

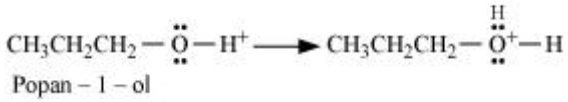
ANSWER:-

1-Propoxypropane can be synthesized from propan-1-ol by dehydration. When propan-1-ol is treated with protic acids (such as H_2SO_4 or H_3PO_4), it undergoes dehydration to form 1-propoxypropane.

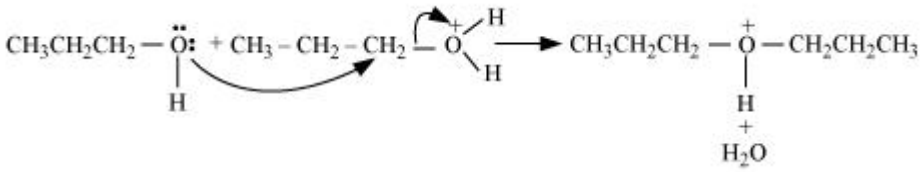
$$\underset{\text{Propane-1-ol}}{2CH_3CH_2CH_2 - OH} \xrightarrow{H^+} \underset{\text{1-Propoxypropane}}{CH_3CH_2CH_2 - O - CH_2CH_2CH_3}$$

Mechanism of the reaction involves three steps

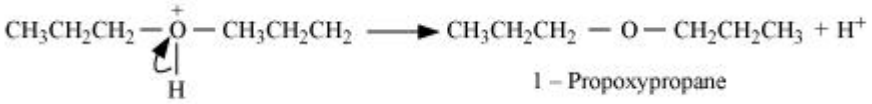
Step 1: Protonation



Step 2: Nucleophilic attack



Step 3: Deprotonation



Q. 27. **Preparation of ethers by acid dehydration of secondary or tertiary alcohols is not a suitable method. Give reason.**

ANSWER:-

The formation of ethers by alcohol dehydration is a bimolecular (SN^2) reaction, where an alcohol molecule attacks a protonated alcohol molecule. For this method to be effective, the alkyl group should be unhindered. In the case of secondary or tertiary alcohols, the alkyl group is hindered, leading to elimination predominating over substitution. As a result, alkenes are formed instead of ethers.

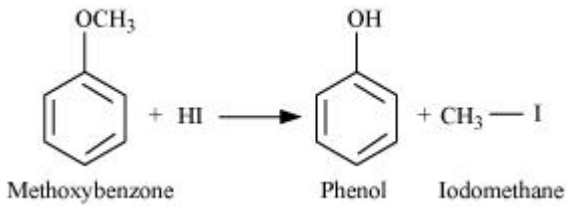
Q. 28. **Write the equation of the reaction of hydrogen iodide with:**

(i) **1-propoxypropane** **(ii)** **Methoxybenzene** **(iii)** **Benzyl ethyl ether**

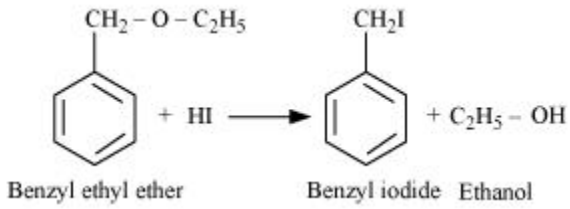
ANSWER:-

(i) $\underset{\text{1-Propoxypropane}}{C_2H_5CH_2-O-CH_2C_2H_5} + HI \xrightarrow{373K} \underset{\text{Propan-1-ol}}{CH_3CH_2CH_2-OH} + \underset{\text{1-Iodopropane}}{CH_3CH_2CH_2-I}$

(ii)



(iii)



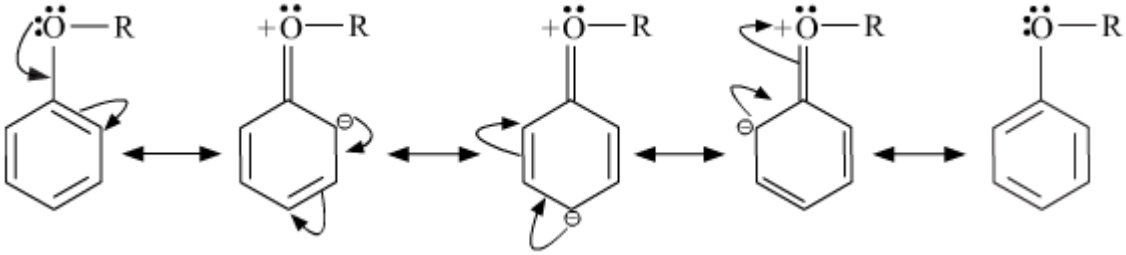
Q. 29. **Explain the fact that in aryl alkyl ethers**

(i) The alkoxy group activates the benzene ring towards electrophilic substitution and

(ii) It directs the incoming substituents to ortho and para positions in benzene ring.

ANSWER:-

(i) In aryl alkyl ethers, the +R effect of the alkoxy group increases the electron density in the benzene ring, as depicted in the resonance structure below. Therefore, the alkoxy group activates the benzene ring towards electrophilic substitution.



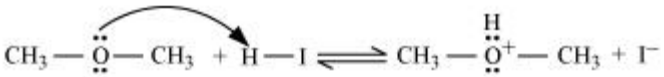
(ii) The resonance structures also show that the electron density is higher at the ortho and para positions than at the meta position. Consequently, incoming substituents are directed towards the ortho and para positions on the benzene ring.

Q. 30. **Write the mechanism of the reaction of HI with methoxymethane.**

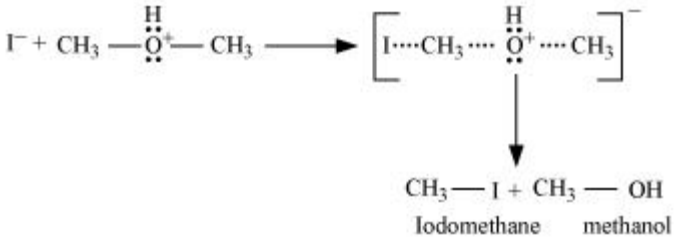
ANSWER:-

The mechanism of the reaction between HI and methoxymethane involves the following steps:

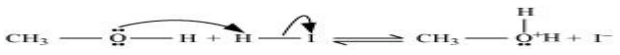
Step 1: Protonation of methoxymethane.



Step 2: Nucleophilic attack of I^-:



Step 3: When excess HI is used and the reaction is carried out at a high temperature, the methanol produced in the second step reacts with another molecule of HI, forming methyl iodide.



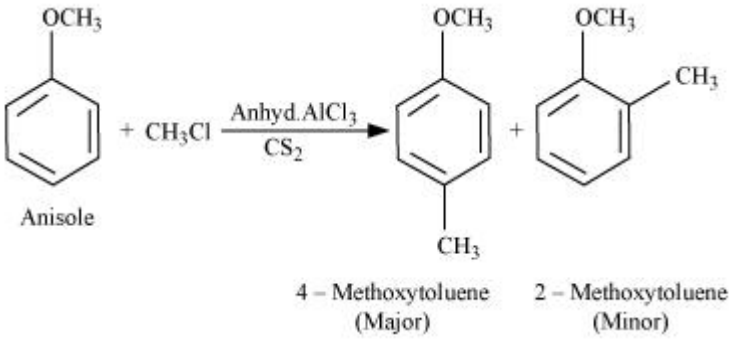
$$I^- + CH_3 - OH_2 \longrightarrow CH_3 - I + H_2O$$

Q. 31. Write equations of the following reactions:

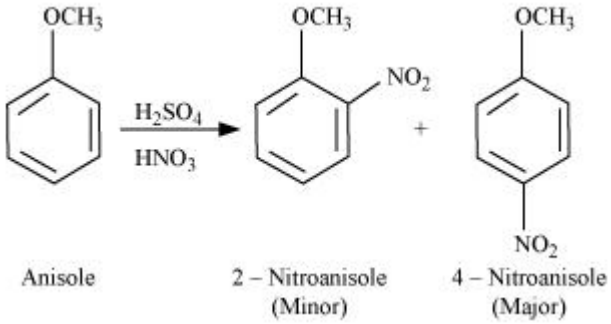
(i) Friedel-Crafts reaction–alkylation of anisole.
(ii) Nitration of anisole.
(iii) Bromination of anisole in ethanoic acid medium.
(iv) Friedel-Craft's acetylation of anisole.

ANSWER:-

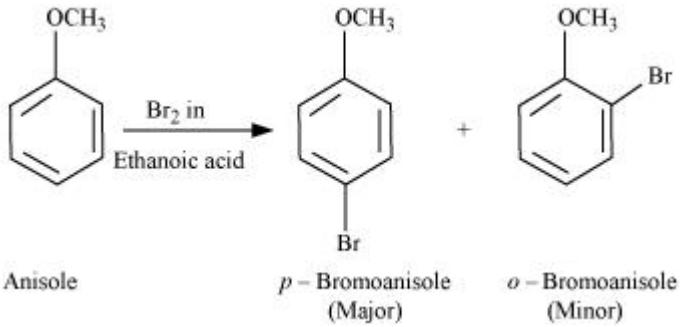
(i) Friedel-Crafts reaction–alkylation of anisole



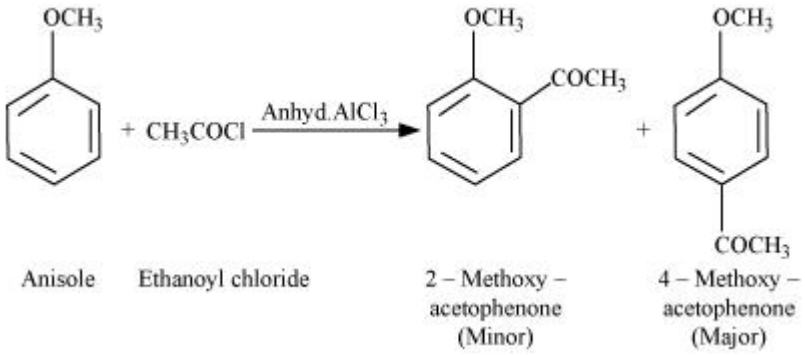
(ii) Nitration of anisole



(iii) Bromination of anisole in ethanoic acid medium.

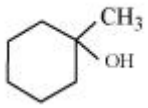


Friedel-Craft's acetylation of anisole.

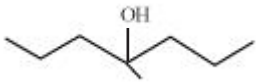


Q. 32. Show how would you synthesise the following alcohols from appropriate alkenes?

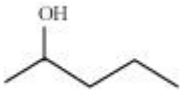
(i)



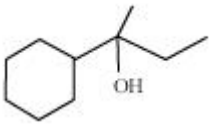
(ii)



(iii)



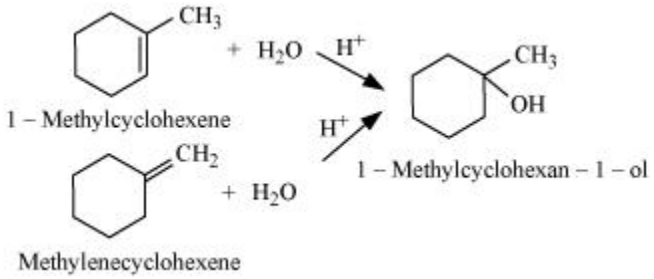
(iv)



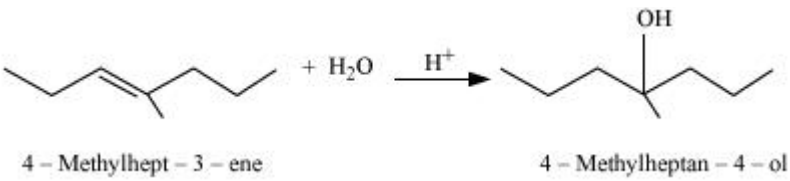
ANSWER:-

The desired alcohols can be synthesized by following Markovnikov's rule in the acid-catalyzed hydration of the suitable alkenes.

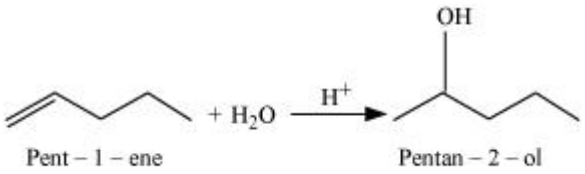
(i)



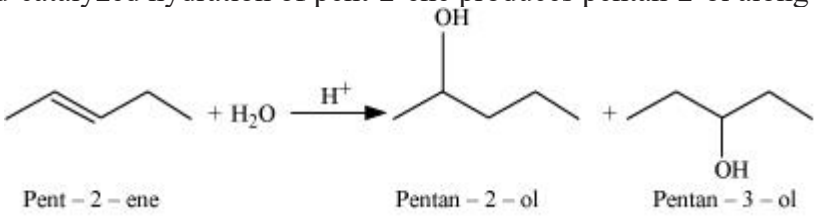
(ii)



(iii) (a) Pent-1-ene react with H_2O to form pentan-2-ol

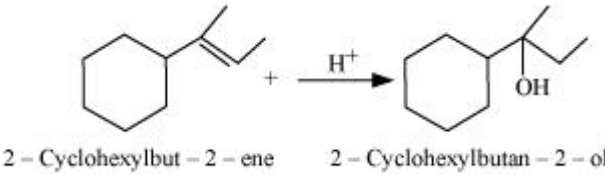


(b) The acid-catalyzed hydration of pent-2-ene produces pentan-2-ol along with pentan-3-ol.

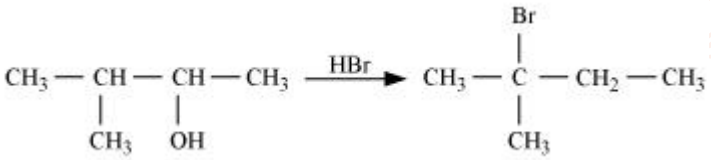


Therefore, (a) is preferred over the (b) to get pentan-2-ol.

(iv)



Q. 33. When 3-methylbutan-2-ol is treated with HBr, the following reaction takes place:

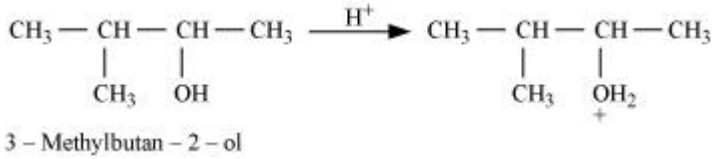


Give a mechanism for this reaction. (Hint : The secondary carbocation formed in step II rearranges to a more stable tertiary carbocation by a hydride ion shift from 3rd carbon atom.

ANSWER:-

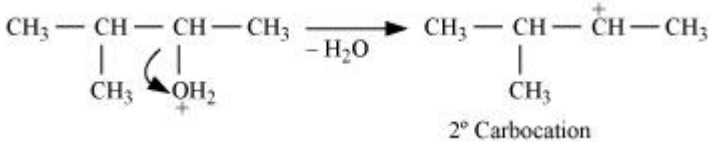
The mechanism of the given reaction proceeds through the following steps:

Step 1: Protonation.



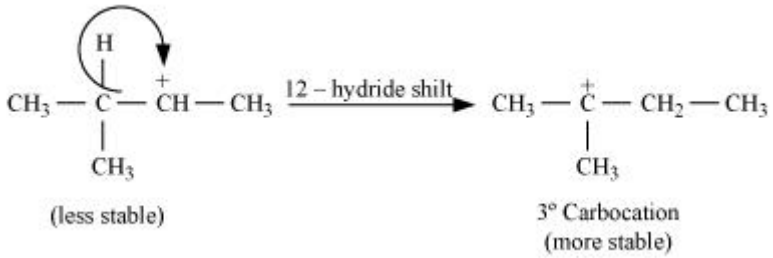
3 – Methylbutan – 2 – ol

Step 2: The formation of a secondary carbocation through the elimination of a water molecule.



2° Carbocation

Step 3: Re-arrangement by the hydride-ion shift



Step 4: Nucleophilic attack