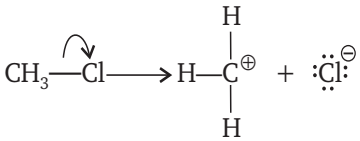
11 Alcohols, Phenols and Ethers

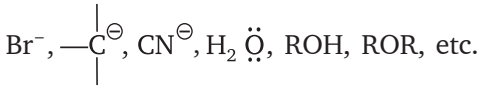
Facts that Matter

- **Alcohols:** Organic compounds that contain the –OH group. The common name of an alcohol is derived from the common name of the alkyl group and adding the word alcohol to it. In systematic chemical nomenclature alcohol names end in the sufix –ol. Examples are methanol, CH_3OH and ethanol, C_2H_5OH. These are classified as mono-, di- and trihydric alcohols or phenols according to the number of –OH groups contained in their molecules.
- **Dihydric alcohols:** Two —OH groups must be attached to different carbon atoms.
- **Trihydric alcohols:** Alcohols which contain three hydroxyl groups (–OH) are called trihydric alcohols.
- **Carbonium ion (Carbocation):** An atom or a group of atoms in which carbon atom has positive charge due to incomplete octet is called carbonium ion. e.g.,



Carbonium ion

- **Carbanion:** An atom or group of atoms in which carbon atom carries a negative charge due to its complete octet is called carbanion.
- **Electrophile:** It is a positively charged or neutral species which is electron deficient *e.g.*, H^+, H_3O^+, $Cl^{\oplus}$, $\overset{\oplus}{N}O_2$ NH_4^+, BF_3, $AlCl_3$.
- **Nucleophile:** It is negatively charged or neutral species with lone pair of electrons.

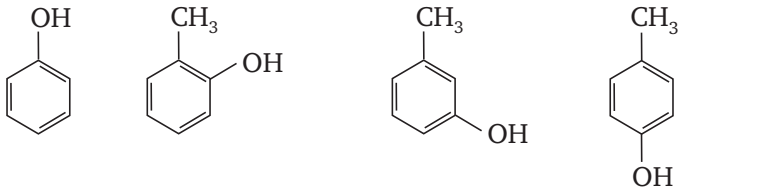


- **Nomenclature of Some Alcohols**

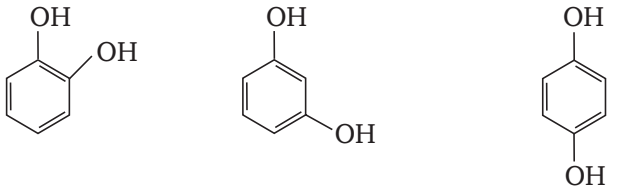
Compound	Common name	IUPAC name
$CH_3 - OH$	Methyl alcohol	Methanol
$CH_3 - CH_2 - CH_2 - OH$	*n*-Propyl alcohol	Propan–1–ol
$CH_3 - \underset{\displaystyle OH}{\underset{\vert}{CH}} - CH_3$	Isopropyl alcohol	Propan–2–ol
$CH_3 - CH_2 - CH_2 - CH_2 - OH$	*n*-Butyl alcohol	Butan–1–ol
$CH_3 - \underset{\displaystyle OH}{\underset{\vert}{CH}} - CH_2 - CH_3$	*sec*-Butyl alcohol	Butan–2–ol
$CH_3 - \underset{\displaystyle CH_3}{\underset{\vert}{CH}} - CH_2 - OH$	Isobutyl alcohol	2–Methylpropan–1–ol

$CH_3-\underset{\displaystyle CH_3}{\overset{\displaystyle CH_3}{\overset{|}{\underset{|}{C}}}}-OH$	*tert*–Butyl alcohol	2–Methylpropan–2–ol
$CH_2(OH)-CH(OH)-CH_2(OH)$	Glycerol	Propane–1, 2, 3–triol

- **Nomenclature of some Phenols**



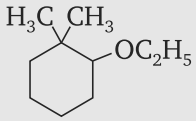
Common name:	Phenol	*o*–Cresol	*m*–Cresol	*p*–Cresol
IUPAC name:	Phenol	2–Methylphenol	3–Methylphenol	4–Methylphenol



Common name:	Catechol	Resorcinol	Hydroquinone or Quinol
IUPAC name:	Benzene–1, 2–diol	Benzene-1, 3–diol	Benzene–1, 4–diol

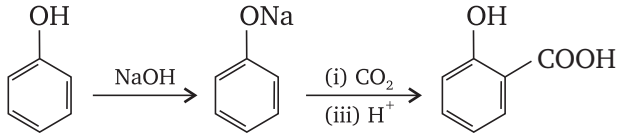
- **Nomenclature of some Ethers**

Compound	Common name	IUPAC name
CH_3OCH_3	Dimethyl ether	Methoxymethane
$C_2H_5OC_2H_5$	Diethyl ether	Ethoxyethane
$CH_3OCH_2CH_2CH_3$	Methyl *n*-propyl ether	1–Methoxypropane
$C_6H_5OCH_3$	Methylphenyl ether	1–Methoxybenzene (Anisole)
$C_6H_5OCH_2CH_3$	Ethylphenyl ether (Phenetole)	1–Ethoxybenzene
$C_6H_5O(CH_2)_6-CH_3$	Heptylphenyl ether	1–Phenoxyheptane
$CH_3O-\underset{\displaystyle CH_3}{\overset{|}{CH}}-CH_3$	Methyl isopropyl ether	2–Methoxypropane
$C_6H_5-O-CH_2-CH_2-\underset{\displaystyle CH_3}{\overset{|}{CH}}-CH_3$	Phenyl isopentyl ether	3–Methylbutoxy benzene

$CH_3 - O - CH_2 - CH_2 - OCH_3$	–	1, 2–Dimethoxyethane
	–	2-Ethoxy–1,1–dimethyl cyclohexane

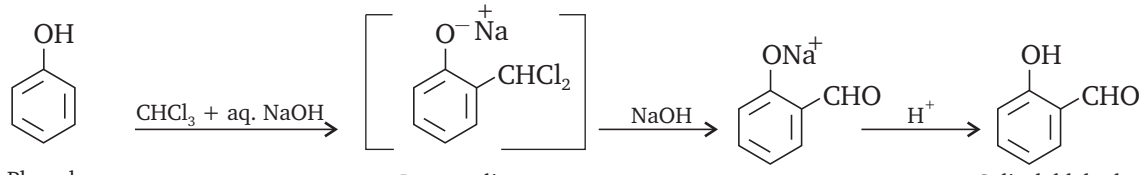
- **Name Reactions**

1. Kolbe's Reaction–(Phenol to Salicylic Acid)



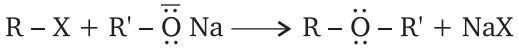
Phenol — 2-Hydroxybenzoic acid (Salicylic acid)

2. Reimer-Tiemann Reaction–(Phenol to Salicylaldehyde)



Phenol — Intermediate — Salicylaldehyde

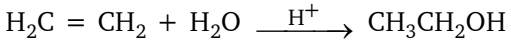
3. Williamson Synthesis–(Alkyl Halide to Ether)



Alkyl Halide — Sodium Alkoxide — Ether

Some Important Mechanisms:

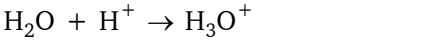
(*i*) Hydration of Ethene

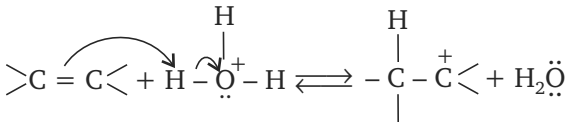


Mechanism

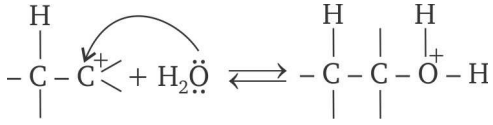
The mechanism of the reaction involves the following three steps:

Step 1: Protonation of alkene to form carbocation by electrophilic attack of H_3O^+:

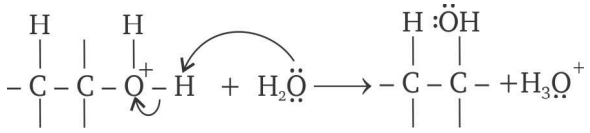




Step 2: Nucleophilic attack of water on the carbocation:



Step 3: Deprotonation to form an alcohol:

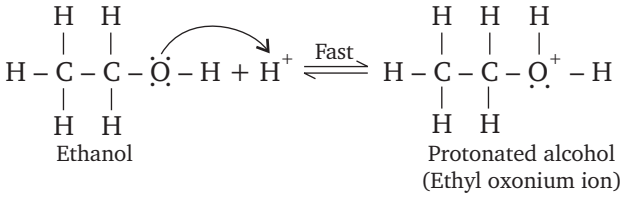


(*ii*) Dehydration of Ethanol

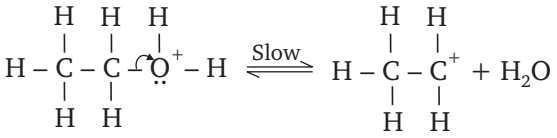
$$CH_3CH_2OH \xrightarrow{H^+} CH_2 = CH_2$$

Mechanism

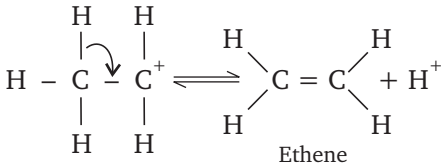
Step 1: Formation of protonated alcohol:



Step 2: Formation of carbocation: It is the slowest step and hence, the rate determining step of the reaction.

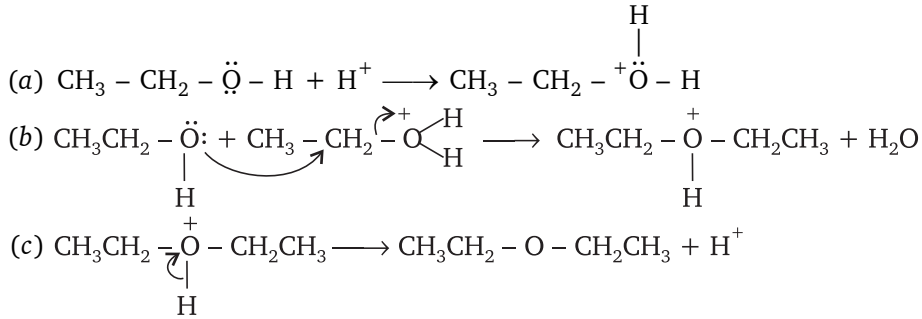


Step 3: Formation of ethene by elimination of a proton:



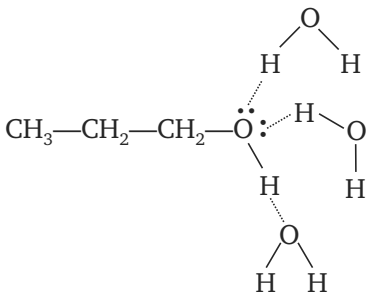
(*iii*) Dehydration of Ethanol (in Excess of alcohol)

$$2CH_3CH_2OH \xrightarrow[-H_2O]{H^+} CH_3CH_2 - O - CH_2CH_3$$

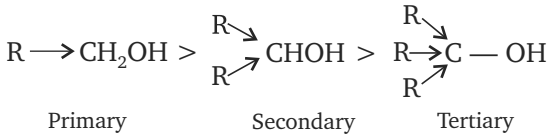


Physical Properties of Alcohols:

- **Solubility:** Solubility of alcohols and phenols in water is due to their ability to form hydrogen bond with water molecules as shown. The solubility of alcohols decreases with increase in the size of alkyl/aryl (hydrophobic) group. Several of the lower molecular mass alcohols are miscible with water in all proportions.

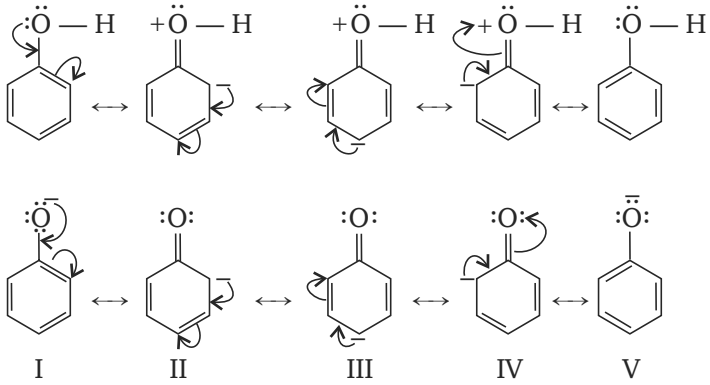


- **Boiling Points:** The boiling point of alcohols and phenols increases with increase in the number of carbon atoms (increase in van der Waals forces). In alcohols, the boiling point decreases with increase of branching in carbon chain (because of decrease in van der Waals forces with decrease in surface area).
- **Acidity of Alcohols:** The acidic character of alcohols is due to the polar nature of O–H bond. An electron-releasing group (—CH_3, —C_2H_5) increases the electron density on the oxygen atom which tends to decrease the polarity of O—H bond. This effect decreases the acid strength. For this reason, the acid strength of alcohols decreases in the following order:



Phenol is more acidic than aliphatic alcohol: The reaction of phenol with aqueous sodium hydroxide indicates that phenols are stronger acids than alcohols and water.

Due to resonance peroxide ion is more stable than phenol.



Due to the higher electronegativity of sp^2 hybridised carbon of phenol to which –OH is attached, electron density decreases on oxygen and increases the polarity of O–H bond.

- **Effect on acidic character of phenol due to presence of EWG and ERG group:** In substituted phenols, the presence of electron withdrawing groups such as nitro group, enhances the acidic strength of phenol. This effect is more pronounced when such a group is present at *ortho* and *para* positions. It is due to the effective delocalisation of negative charge in phenoxide ion. On the other hand electron releasing groups such as alkyl groups in general do not favour the formation of phenoxide ion resulting in decrease in acid strength. Cresols, for example are less acidic than phenol.

The acidic strength of alcohol depends on pK_a value, the higher the value of pK_a lower is acidic strength. The pK_a is inversely proportional to K_a.

pK_a values of some Alcohols

Compound	Formula	pK_a
o–Nitrophenol	*o*–O_2N–C_6H_4–OH	7.2
m–Nitrophenol	*m*–O_2N–C_6H_4–OH	8.3

p–Nitrophenol	p–O_2N–C_6H_4–OH	7.1
Phenol	C_6H_5–OH	10.0
o–Cresol	o–CH_3–C_6H_4–OH	10.2
m–Cresol	m–CH_3–C_6H_4–OH	10.1
p–Cresol	p–CH_3–C_6H_4–OH	10.2
Ethanol	C_2H_5OH	15.9

From the above data you will note that phenol is million times more acidic than ethanol.

Chemical Test for Distinguishing between the pair of Compounds

(*i*) Lucas Reagent Test: The primary, secondary and tertiary alcohols can be distinguished by the Lucas reagent test ($ZnCl_2$ + conc. HCl).

Organic compound + Lucas reagent ⟶

(*a*) If turbidity appears immediately then the given organic compound is a tertiary alcohol (or 3° alcohol).

(*b*) If turbidity appears after 5 minutes, then the given organic compound is a secondary alcohol (or 2° alcohol).

(*c*) If turbidity does not appear at room temperature then the given organic compound is a primary alcohol.

(*ii*) Ferric Chloride Test (Only for Phenol):

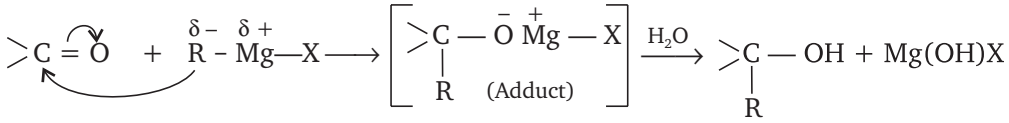
Phenol + neutral Ferric chloride ⟶ Violet colour.

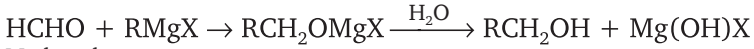
Appearance of violet colour indicates the presence of phenol.

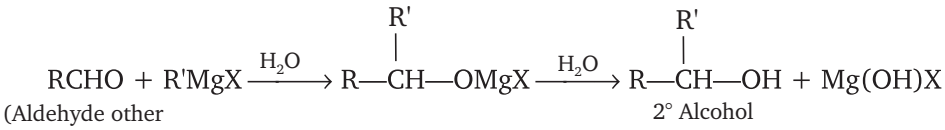
Important Reaction with the Reagents (Based on Preparation and Properties):

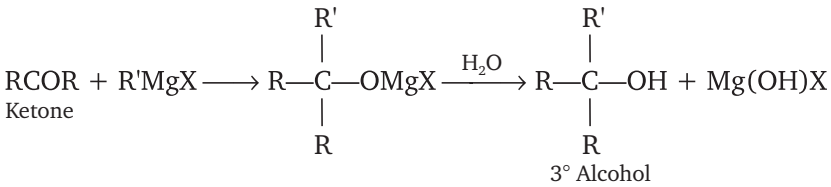
- **Preparation of alcohols:**

1. ***From Grignard Reagent–***









2. ***From Carbonyl Compounds***

(*a*) *By reduction of aldehyde and ketones*

$$\underset{\text{Aldehyde}}{RCHO} + H_2 \xrightarrow{Pd} RCH_2OH$$

$$\underset{\text{Ketone}}{RCOR'} \xrightarrow{NaBH_4} R{-}\underset{\displaystyle OH}{\underset{|}{CH}}{-}R'$$

2° alcohol

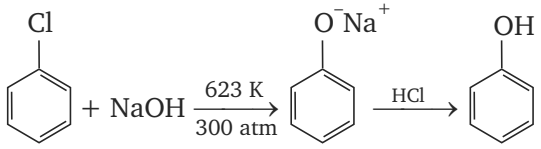
(*b*) *By reduction of carboxylic acids and esters*

$$\underset{\text{Carboxylic acid}}{RCOOH} \xrightarrow[(ii)\ H_2O]{(i)\ LiAlH_4} \underset{\text{Pri. alcohol}}{RCH_2OH}$$

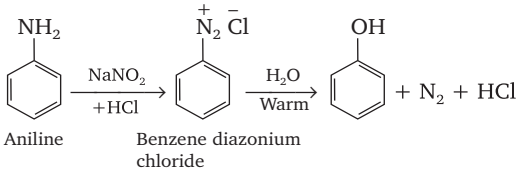
$$RCOOH \xrightarrow[H^+]{R'OH} \underset{\text{Ester}}{RCOOR'} \xrightarrow[\text{Catalyst}]{H_2} RCH_2OH + R'OH$$

- **Preparation of phenol—**

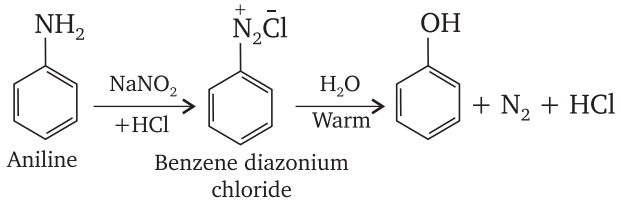
1. ***From chlorobenzene***



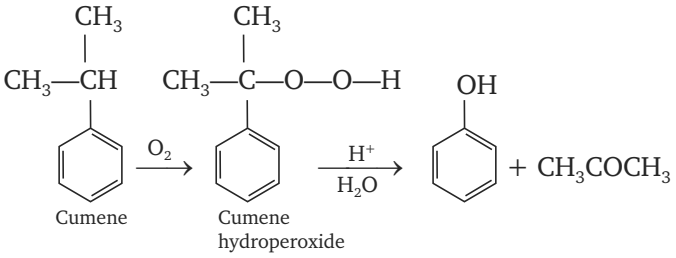
2. ***From benzene sulphonic acid***



3. ***From benzene diazonium chloride***



4. ***From cumene***



Properties of Alcohol

- **Esterification:** Alcohols and phenols react with carboxylic acid, acid chloride and acid anhydride to form esters.

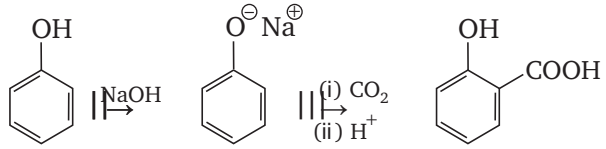
$$\underset{\text{Phenol/Alcohol}}{\text{Ar/R–OH}} + \underset{\text{Carboxylic acid}}{\text{R'COOH}} \overset{H^+}{\rightleftharpoons} \underset{\text{Ester}}{\text{Ar/ROCOR}} + H_2O$$

$$\text{Ar/R– OH} + \underset{\text{Acid anhydride}}{(\text{R'CO})_2\text{O}} \overset{H^+}{\rightleftharpoons} \text{Ar/ROCOR'} + \text{R'COOH}$$

$$\text{R/ArOH} + \underset{\text{Acid chloride}}{\text{R'COCl}} \xrightarrow{\text{Pyridine}} \text{R/ArOCOR'} + \text{HCl}$$

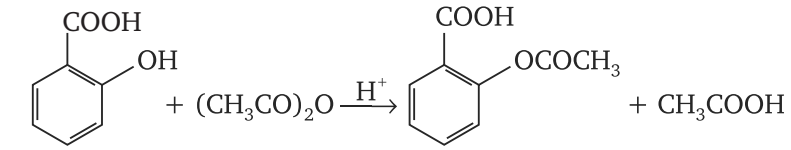
- **Esterification Method Used for the Conversion of Phenol to Aspirin**

1. Phenol is converted to salicylic acid by Kolbe's reaction.



Phenol Salicylic acid

2. Salicylic acid is then converted to aspirin by esterification.



Salicylic acid Acetylsalicylic acid (Aspirin)

- **Oxidation:** Oxidation of alcohols involve formation of carbon oxygen double bond (carbonyl group). The number of carbon atoms in the alcohol, aldehyde and carboxylic acid are same.

$$\underset{\text{Pri. Alcohol}}{RCH_2OH} \xrightarrow{\text{Oxidation}} \underset{\text{Aldehyde}}{R-\overset{H}{\overset{|}{C}}=O} \longrightarrow \underset{\text{Carboxylic acid}}{R-\overset{OH}{\overset{|}{C}}=O}$$

A better reagent for the oxidation of primary alcohols into aldehydes in good yield is pyridinium chlorochromate (PCC), a complex of chromium trioxide with pyridine and HCl.

$$\underset{1^\circ \text{ alcohol}}{CH_3-CH=CH-CH_2OH} \xrightarrow{PCC} CH_3-CH=CH-CHO$$

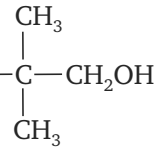
Secondary alcohols are oxidised to form ketones by chromic anhyride (CrO_3):

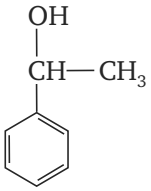
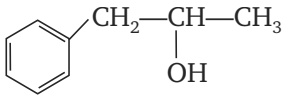
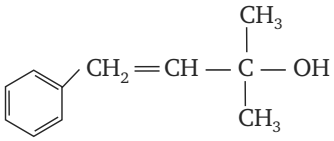
$$\underset{\underset{2^\circ \text{ alcohol}}{OH}}{R-\overset{|}{CH}-R'} \xrightarrow{CrO_3} \underset{\underset{\text{Ketone}}{O}}{R-\overset{\|}{C}-R'}$$

Tertiary alcohols do not undergo oxidation reaction. Under strong reaction conditions such as strong oxidising agents ($KMnO_4$) and elevated temperatures, cleavage of various C–C bond takes place and a mixture of carboxylic acids containing lesser number of carbon atoms is formed.

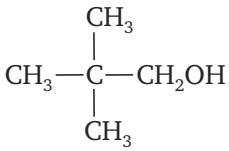
NCERT IN-TEXT QUESTIONS SOLVED

11.1. Classify the following as primary, secondary and tertiary alcohols.

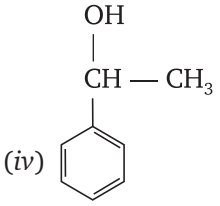
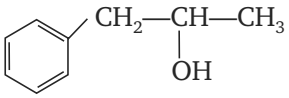
(*i*)  (*ii*) $H_2C{=}CH{-}CH_2OH$ (*iii*) $CH_3{-}CH_2{-}CH_2{-}OH$

(*iv*)  (*v*)  (*vi*) 

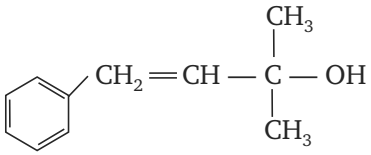
Ans. Primary alcohols:

(*i*)  (*ii*) $H_2C{=}CH{-}CH_2OH$ (*iii*) $CH_3{-}CH_2{-}CH_2{-}OH$

Secondary alcohols:

(*iv*)  (*v*) 

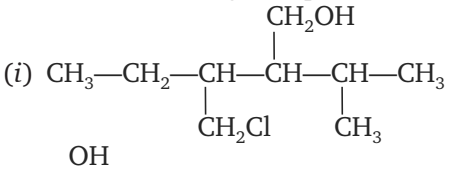
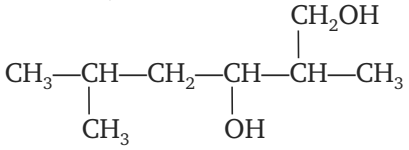
Tertiary alcohols:

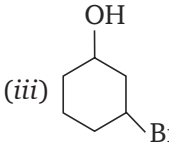
(*vi*) 

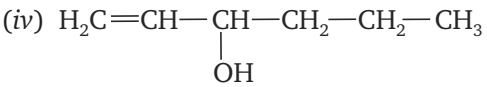
11.2. Identify allylic alcohols in the above examples.

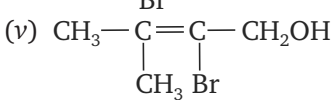
Ans. Allylic alcohols are (*ii*) and (*vi*)

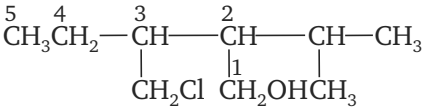
11.3. Name the following compounds according to IUPAC system.

(*i*)  (*ii*) 

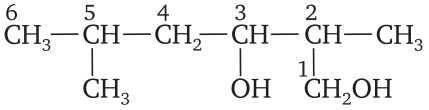
(*iii*) 

(*iv*) 

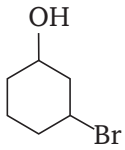
(*v*) 

Ans. (*i*) 

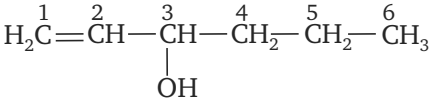
3-chloromethyl-2-isopropylpentan-1-ol

(*ii*) 

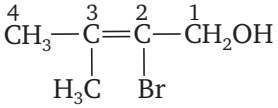
2, 5-Dimethylhexane-1, 3-diol

(*iii*) 

3-Bromocyclohexan-1-ol

(*iv*) 

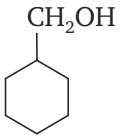
Hex-1-en-3-ol

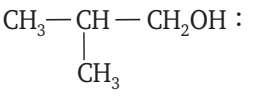
(*v*) 

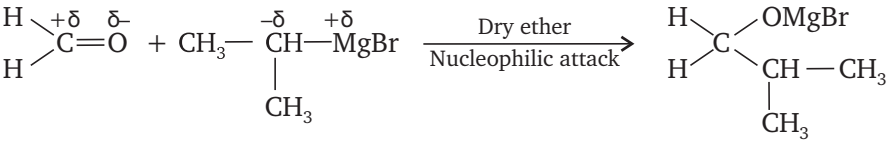
2-Bromo-3-methylbut-2-en-1-ol

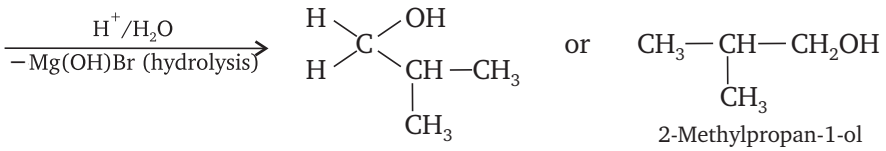
11.4. Show how are the following alcohols prepared by the reaction of a suitable Grignard reagent on methanal?

(*i*)

(*ii*) 

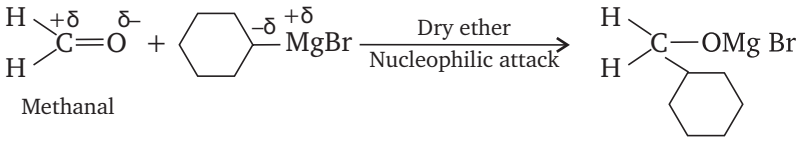
Ans. (*i*)  :



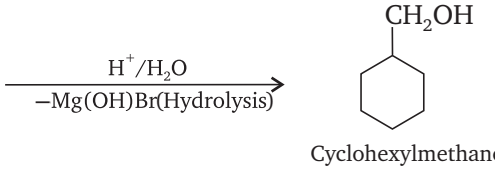


or

2-Methylpropan-1-ol
(Isobutyl alcohol)

(*ii*) 

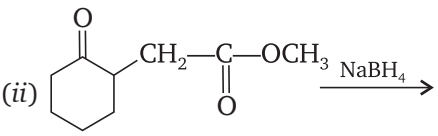
Methanal



Cyclohexylmethanol

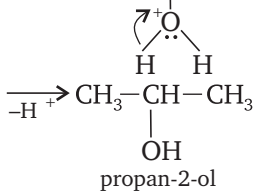
11.5. Write structures of the products of the following reactions:

(*i*) $CH_3—CH=CH_2 \xrightarrow{H_2O/H^+}$

(*ii*) 

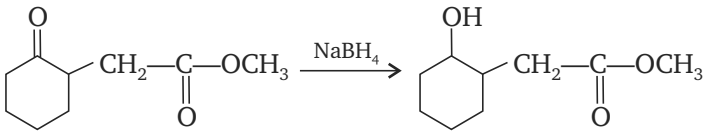
(*iii*) $CH_3—CH_2—\underset{\displaystyle CH_3}{\underset{|}{CH}}—CHO \xrightarrow{NaBH_4}$

Ans. (*i*) $CH_3-CH=CH_2 \xrightarrow[\text{electrophilic attack by } H^+]{H^+/H_2O} CH_3-\overset{+}{C}H-CH_3 \xrightarrow{H_2\ddot{O}:} CH_3—CH—CH_3$



propan-2-ol

(*ii*) $NaBH_4$ is a weak reducing agent, it reduces the aldehydes and ketones but not the esters. Thus,



Methyl (2-hydroxycyclohexyl ethanoate)

(*iii*) The –CHO group is reduced to CH_2OH. Thus,

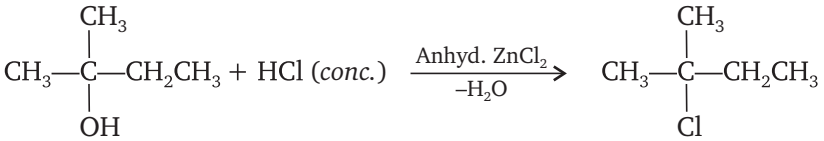
$$CH_3—CH_2—\underset{\displaystyle CH_3}{\underset{|}{CH}}—CHO \xrightarrow{NaBH_4} CH_3—CH_2—\underset{\displaystyle CH_3}{\underset{|}{CH}}—CH_2OH$$

2-Methylbutanal — 2-Methylbutan-1-ol

11.6. Give structures of the products you would expect when each of the following alcohols react with (*a*) HCl –$ZnCl_2$ (*b*) HBr and (*c*) $SOCl_2$

(*i*) Butan-1-ol (*ii*) 2-Methylbutan-2-ol

Ans. (*i*) (*a*) With HCl –$ZnCl_2$ (Lucas reagent): 2–Methylbutan-2-ol (*ii*) Being a 3° alcohol, reacts with Lucas reagent to produce turbidity immediately due to the formation of an insoluble *tert*. alkyl chloride. While butan-1-ol (*i*) being a 1° alcohol does not react with Lucas reagent at room temperature.

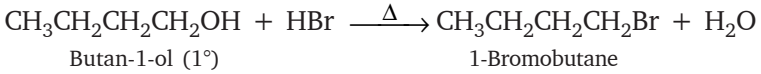


2-Chloro-2-methylbutane
(white turbidity)

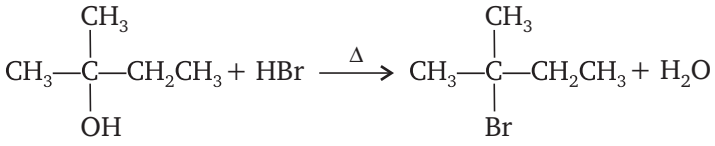
$CH_3CH_2CH_2CH_2—OH + HCl\ (conc.) \xrightarrow{Anhyd.\ ZnCl_2}$ No reaction at room temperature

Butan-1-ol (1°)

(*b*) Both the alcohols will react to produce the corresponding alkyl bromides:

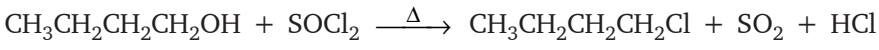


Butan-1-ol (1°) 1-Bromobutane

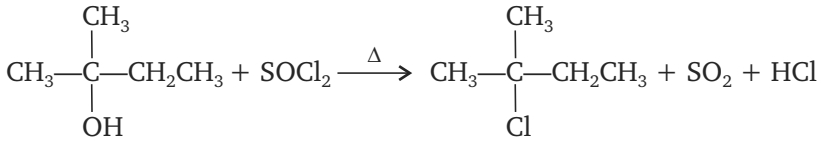


2-Methylbutan-2-ol (3°) 2-Bromo-2-methylbutane

(*c*) Both the alcohols will react to form the corresponding alkyl chlorides:



1-Chlorobutane

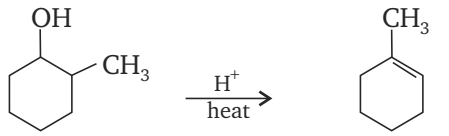


2-Methylbutan-2-ol 2-Chloro-2-methylbutane

11.7. Predict the major product of acid catalysed dehydration of

(*i*) 1-Methylcyclohexanol and (*ii*) Butan-1-ol

Ans. (*i*)



1-Methylcyclohexanol 1-Methylcyclohexene

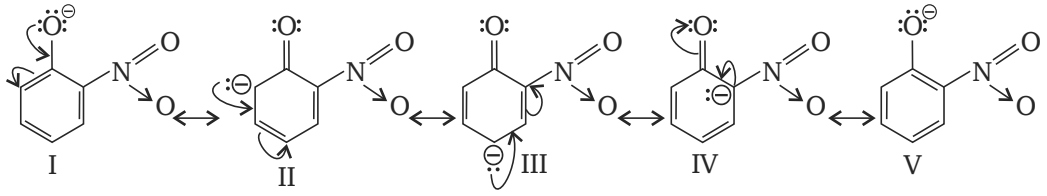
(*ii*) $CH_3CH_2CH_2CH_2OH \xrightarrow{H^+} CH_3CH_2CH_2\overset{\oplus}{C}H_2 \longleftrightarrow CH_3CH_2\overset{\oplus}{C}HCH_3 \xrightarrow{HSO_4^-}$

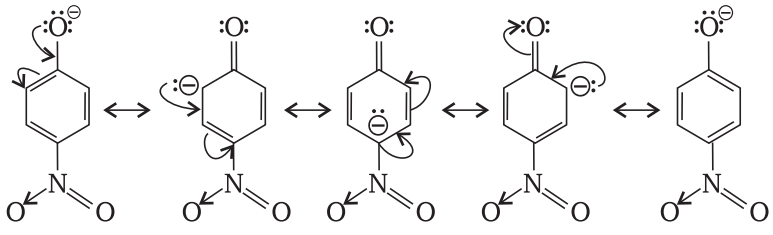
$CH_3—CH_2—CH=CH_2 + CH_3—CH=CH—CH_3$

But-1-ene (Major product) But-2-ene (Minor product)

11.8. *Ortho* and *para* nitrophenols are more acidic than phenol. Draw the resonance structures of the corresponding phenoxide ions.

Ans.



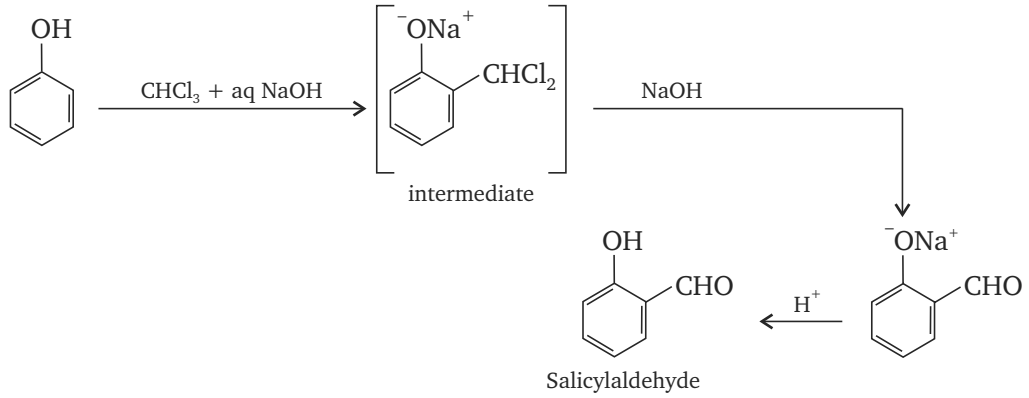


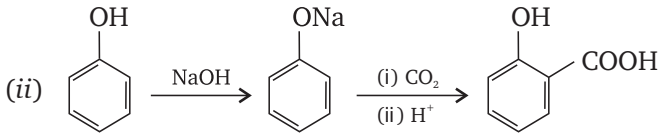
11.9. Write the equations involved in the following reactions:

(*i*) Reimer-Tiemann reaction

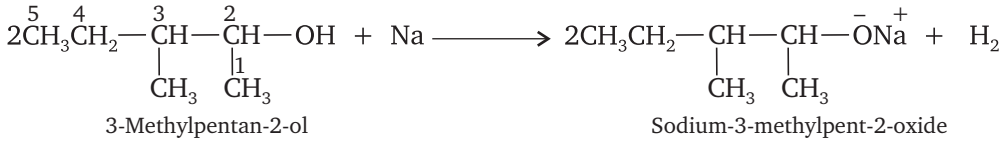
(*ii*) Kolbe's reaction

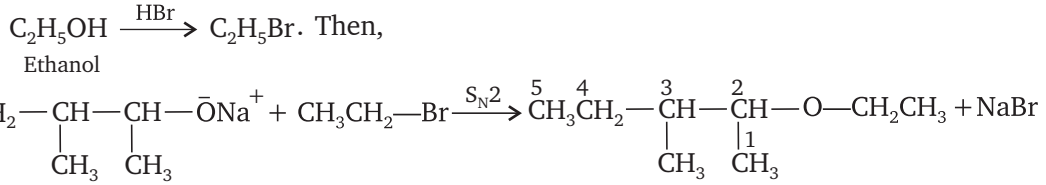
Ans. (*i*) Reimer-Tiemann reaction



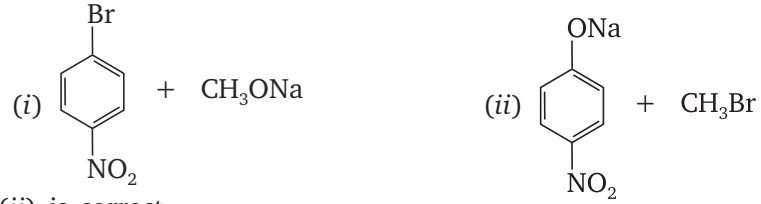


11.10. Write the reactions of Williamson synthesis of 2-ethoxy-3-methylpentane starting from ethanol and 3-methylpentan-2-ol.

Ans. 



11.11. Which of the following is an appropriate set of reactants for the preparation of 1-methoxy-4-nitrobenzene and why?

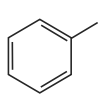


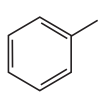
Ans. (*ii*) is correct.

In (*i*) there is a double bond character between C—Br bond, which is difficult to break.

11.12. Predict the products of the following reactions:

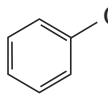
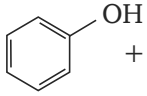
(*i*) $CH_3—CH_2—CH_2—O—CH_3 + HBr \longrightarrow$

(*ii*)  $+ HBr \longrightarrow$

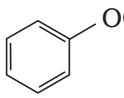
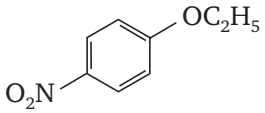
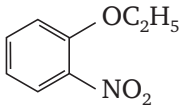
(*iii*)  $\xrightarrow[conc.\ HNO_3]{conc.\ H_2SO_4}$

(*iv*) $(CH_3)_3C—OC_2H_5 \xrightarrow{HI}$

Ans. (*i*) $CH_3CH_2CH_2OCH_3 + HBr \longrightarrow CH_3CH_2CH_2OH + CH_3Br$

(*ii*)  $+ HBr \xrightarrow{373\ K}$  $+ CH_3CH_2Br$

Ethoxybenzene — Phenol — Bromoethane

(*iii*)  $\xrightarrow[conc.HNO_3]{conc.H_2SO_4}$  $+$ 

Ethoxybenzene — 4-Ethoxynitrobenzene — 2-Ethoxynitrobenzene

(*iv*) $(CH_3)_3C—OC_2H_5 \xrightarrow{HI} CH_3—\underset{\displaystyle I}{\overset{\displaystyle CH_3}{\underset{|}{\overset{|}{C}}}}—CH_3 + C_2H_5OH$

NCERT TEXTBOOK QUESTIONS SOLVED

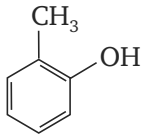
11.1. Write IUPAC names of the compounds:

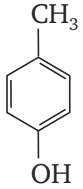
(*i*) $CH_3—\underset{\displaystyle CH_3}{\underset{|}{CH}}—\underset{\displaystyle OH}{\underset{|}{CH}}—\underset{\displaystyle CH_3}{\overset{\displaystyle CH_3}{\overset{|}{\underset{|}{C}}}}—CH_3$

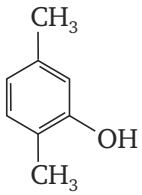
(*ii*) $H_3C—\underset{\displaystyle OH}{\underset{|}{CH}}—CH_2—\underset{\displaystyle OH}{\underset{|}{CH}}—\underset{\displaystyle C_2H_5}{\underset{|}{CH}}—CH_2—CH_3$

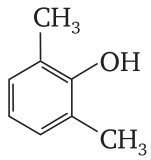
(*iii*) $CH_3—\underset{\displaystyle OH}{\underset{|}{CH}}—\underset{\displaystyle OH}{\underset{|}{CH}}—CH_3$

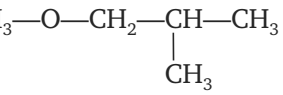
(*iv*) $HO—CH_2—\underset{\displaystyle OH}{\underset{|}{CH}}—CH_2—OH$

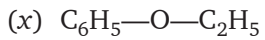
(*v*) 

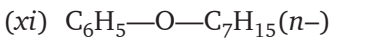
(*vi*) 

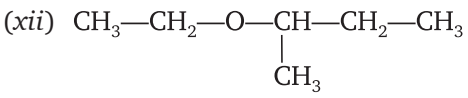
(*vii*) 

(*viii*) 

(*ix*) 

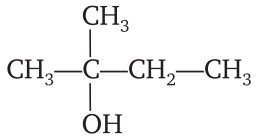
(*x*) 

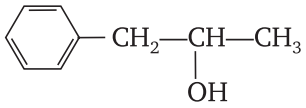
(*xi*) 

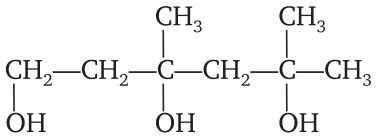
(*xii*) 

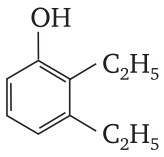
Ans. (*i*) 2, 2, 4-Trimethylpentan-3-ol
(*ii*) 5 – Ethylheptane –2, 4–diol
(*iii*) Butane-2, 3-diol
(*iv*) Propane–1, 2, 3–triol
(*v*) 2-Methylphenol
(*vi*) 4–Methylphenol
(*vii*) 2, 5-Dimethylphenol
(*viii*) 2, 6–Dimethylphenol
(*ix*) 1–Methoxy-2–methylpropane
(*x*) 1–Ethoxybenzene
(*xi*) 1–Phenoxyheptane
(*xii*) 2–Ethoxybutane

11.2. 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

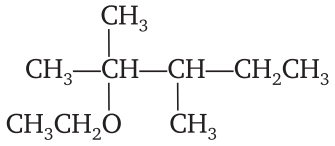
Ans. (*i*) 

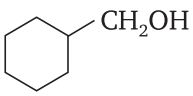
(*ii*) 

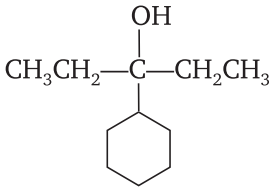
(*iii*) 

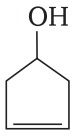
(*iv*) 

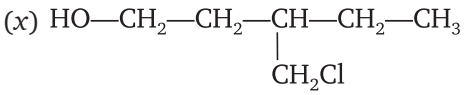
(*v*)

(*vi*) 

(*vii*) 

(*viii*) 

(*ix*) 

(*x*) 

11.3. (*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.

Ans. Eight isomers are possible. These are:

(*a*) $CH_3CH_2CH_2CH_2CH_2OH$
Pentan-1-ol(1°)

(*b*) $CH_3CH_2CH_2—\underset{\displaystyle OH}{\underset{|}{CH}}—CH_3$
Pentan-2-ol(2°)

(*c*) $CH_3CH_2—\underset{\displaystyle OH}{\underset{|}{CH}}—CH_2CH_3$
Pentan-3-ol(2°)

(*d*) $CH_3CH_2—\underset{\displaystyle CH_3}{\underset{|}{CH}}—CH_2OH$
2-Methylbutan-1-ol(1°)

(*e*) $CH_3—\underset{\displaystyle CH_3}{\underset{|}{CH}}—CH_2CH_2—OH$
3-Methylbutan-1-ol(1°)

(*f*) $CH_3—\underset{\displaystyle OH}{\underset{|}{\overset{\displaystyle CH_3}{\overset{|}{C}}}}—CH_2CH_3$
2-Methylbutan-2-ol(3°)

(*g*) $CH_3—\underset{\displaystyle CH_3}{\overset{\displaystyle CH_3}{\overset{|}{\underset{|}{CH}}}}—CH_2OH$
2, 2-Dimethylpropan-1-ol(1°)

(*h*) $CH_3—\overset{\displaystyle CH_3}{\overset{|}{CH}}—\overset{\displaystyle OH}{\overset{|}{CH}}—CH_3$
3-Methylbutan-2-ol(2°)

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

Ans. The molecules of butane are held together by weak van der Waals' forces of attraction while those of propanol are held together by stronger intermolecular forces of hydrogen bonding.

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

Ans. Alcohols can form H–bond with water molecules and break the H-bonds already existing between the water molecules. Therefore, they are soluble in water.

$$R—\overset{\delta-}{O}\cdots\cdots\overset{\delta+}{H}—\overset{\delta-}{O}\cdots\cdots\overset{\delta+}{H}—\overset{\delta-}{O}\cdots\cdots$$
$$\qquad\qquad\quad H\qquad\qquad\quad H\qquad\qquad\quad R$$

On the other hand hydrocarbons do not have the ability to form H–bond with water molecules. Hence they are insoluble in water.

11.6. What is meant by hydroboration–oxidation reaction? Illustrate it with an example

Ans. The addition of diborane to alkenes to form trialkylboranes followed by their oxidation with alkaline hydrogen peroxide solution to form alcohols is called hydroboration-oxidation reaction. For example,

$$\underset{\text{Propene}}{CH_3CH=CH_2} + \underset{\text{Diborane}}{(BH_3)_2} \xrightarrow[\text{ether}]{\text{Dry}} CH_3—\underset{\displaystyle H}{\underset{|}{CH}}—\underset{\displaystyle BH_2}{\underset{|}{CH_2}} \xrightarrow{CH_3CH=CH_2} (CH_3CH_2CH_2)_2B—H$$

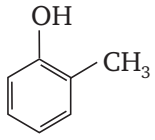
$$\xrightarrow{CH_3CH=CH_2} \underset{\text{Tri-n-propylborane}}{(CH_3CH_2CH_2)_3B}$$

$$\underset{\text{Tri-}n\text{-propylborane}}{(CH_3CH_2CH_2)_3B} + 3H_2O_2 \xrightarrow{OH^-,H_2O} \underset{\text{Propan-1-ol}}{3CH_3CH_2CH_2OH} + \underset{\text{Boric acid}}{B(OH)_3}$$

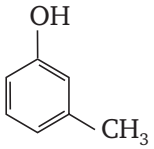
The alcohols obtained by this process seems to have been formed by the direct addition of water to the alkene, contrary to Markovnikov's rule.

11.7. Give the structures and IUPAC names of monohydric phenols of molecular formula C_7H_8O.

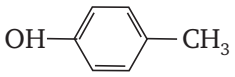
Ans. The three isomers are:



2-Methylphenol
or *o*-Cresol



3-Methylphenol
or *m*-Cresol



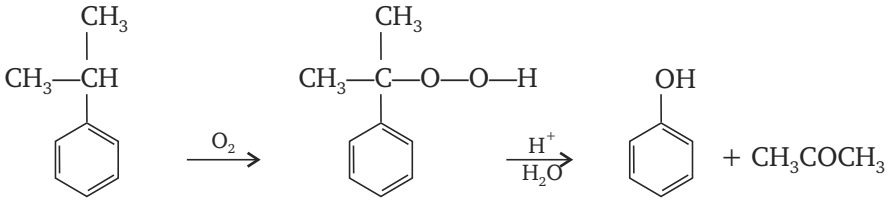
4-Methylphenol
or *p*-Cresol

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

Ans. The *ortho* and *para* isomers can be separated by steam distillation. *o*–Nitrophenol is steam volatile due to intramolecular hydrogen bonding while *p*–nitrophenol is less volatile due to intermolecular hydrogen bonding, which causes the association of molecules.

11.9. Give the equations of reactions for the preparation of phenol from cumene.

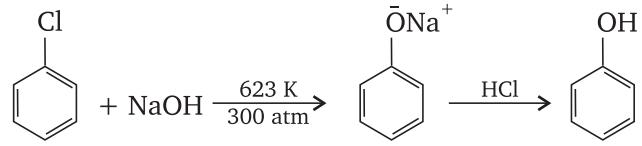
Ans.



Cumene — Cumene hydroperoxide

11.10. Write chemical reaction for the preparation of phenol from chlorobenzene

Ans.



Cumene

11.11. Write the mechanism of hydration of ethene to yield ethanol.

Ans.

$$\underset{\text{Ethene}}{CH_2{=}CH_2} \xrightarrow{H^+} CH_3{-}\overset{\oplus}{C}H_2$$

$$CH_3{-}\overset{\oplus}{C}H_2 + H_2O \longrightarrow CH_3{-}CH_2{-}\overset{\oplus}{O}(H){-}H \xrightarrow{H^+} \underset{\text{Ethanol}}{CH_3{-}CH_2{-}OH}$$

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

Ans.

$$\underset{\text{Benzene}}{C_6H_6} \xrightarrow[\text{(Sulphonation)}]{\text{Conc. } H_2SO_4,\Delta} \underset{\text{Benzene sulphonic acid}}{C_6H_5SO_3H} \xrightarrow[-\,Na_2SO_3]{\text{NaOH, fuse, 573 K}} \underset{\text{Sod. phenoxide}}{C_6H_5ONa} \xrightarrow[-\,NaCl]{\text{Dil. HCl}} \underset{\text{Phenol}}{C_6H_5OH}$$

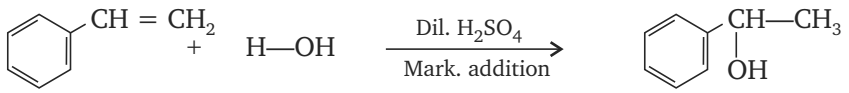
11.13. Show how will you synthesise:

(*i*) 1–Phenylethanol from a suitable alkene.

(*ii*) cyclohexylmethanol using an alkyl halide by an S_N2 reaction.

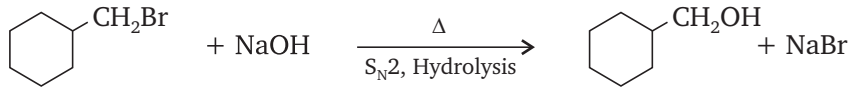
(*iii*) Pentan-1-ol using a suitable alkyl halide?

Ans. (*i*) Addition of H_2O to ethylbenzene in the presence of dil. H_2SO_4 gives 1-phenylethanol.



Etheylbenzene 1-Phenylethanol

(*ii*) Hydrolysis of cyclohexylmethyl bromide by aqueous NaOH gives cyclohexyl-methanol.



Cyclohexylmethyl bromide Cyclohexylmethanol

(*iii*) Hydrolysis of 1–bromopentane by aqueous NaOH gives pentan –1–ol.

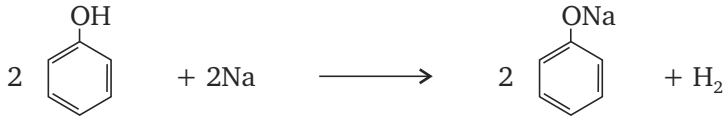
$$\underset{\text{1-Bromopentane}}{CH_3 — CH_2 — CH_2 — CH_2 — CH_2 — Br} + NaOH(aq) \xrightarrow[S_N2,\ \text{Hydrolysis}]{\Delta} CH_3CH_2 — CH_2 — CH_2 — CH_2 — OH + NaBr$$

Propan-1-ol

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

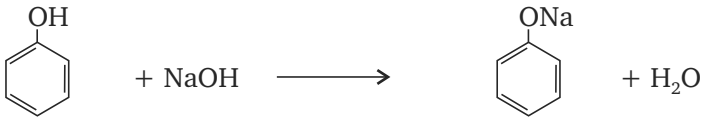
Ans. The reactions showing acidic nature of phenol are:

(*i*) **Reaction with sodium:** Phenol reacts with active metals like sodium to liberate H_2 gas.



Phenol Sod. phenoxide

(*ii*) **Reaction with NaOH:** Phenol dissolves in NaOH to form sodium phenoxide and water.



Sodium Sod. phenoxide

11.15. Explain why is *ortho* nitrophenol more acidic than *ortho* methoxyphenol?

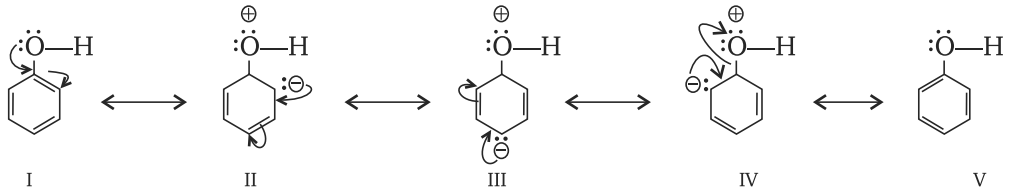
[*CBSE* 2015]

Ans. *Ortho* nitrophenol is more acidic than *ortho* methoxyphenol because nitro group is an electron withdrawing and it will increase +ve charge on the oxygen atom to

make it more acidic whereas $-OCH_3$ group is an electron releasing group and it will decrease +ve charge on the oxygen atom, thus making it less acidic and hence the O–H bond will not break easily.

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

Ans.



I II III IV V

Since there is –ve charge at *o* and *p*-positions, therefore, –OH group activates the benzene ring towards electrophilic substitution reactions.

11.17. Give equations of the following reactions:

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

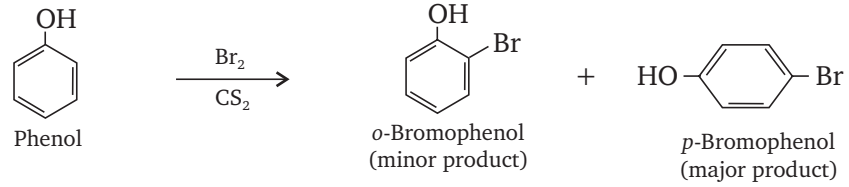
(*ii*) Bromine in CS_2 with phenol.

(*iii*) Dilute HNO_3 with phenol.

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

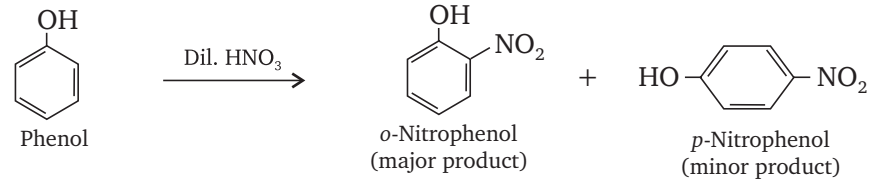
Ans. (*i*) $\underset{\text{Propan-1-ol}}{CH_3CH_2CH_2OH} + 2(O) \xrightarrow[\text{Oxidation}]{\text{Alk. } KMnO_4} \underset{\text{Propanoic acid}}{CH_3CH_2COOH} + H_2O$

(*ii*)



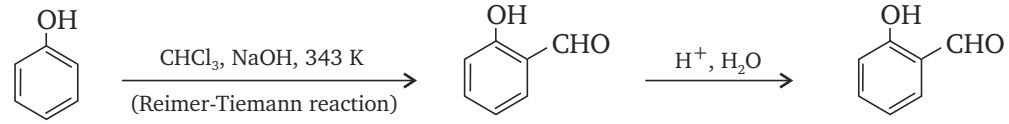
Phenol — *o*-Bromophenol (minor product) — *p*-Bromophenol (major product)

(*iii*)



Phenol — *o*-Nitrophenol (major product) — *p*-Nitrophenol (minor product)

(*iv*)



Phenol — Salicylaldehyde (major product)

11.18. Explain the following with an example

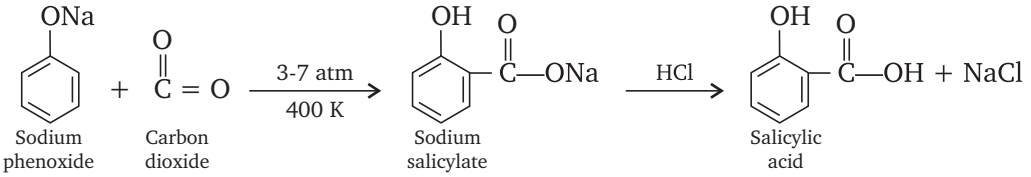
(*i*) Kolbe's reaction

(*ii*) Reimer-Tiemann reaction

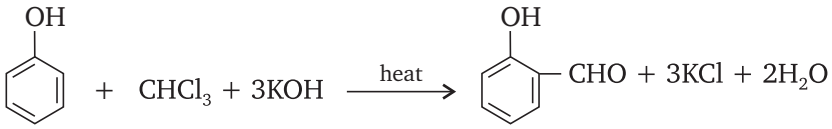
(*iii*) Williamson ether synthesis

(*iv*) Unsymmetrical ether

Ans. (*i*) **Kolbe's reaction:** When sodium phenoxide is treated with CO_2 at 400 K under 3–7 atm pressure, sodium salicylate is formed which on hydrolysis gives salicylic acid.



(*ii*) **Reimer-Tiemann reaction:** When phenol is heated with $CHCl_3$ and KOH, salicyladehyde is formed.



(*iii*) **Williamson ether synthesis:** $C_2H_5ONa + CH_3I \longrightarrow C_2H_5OCH_3 + NaI$

(*iv*) The ether which has two different alkyl groups are called unsymmetrical ether, *e.g.* $CH_3CH_2CH_2OCH_3$

11.19. Write the mechanism of acid dehydration of ethanol to yield ethene.

Ans. (*i*) $CH_3CH_2OH \xrightarrow{H^+} CH_3CH_2\overset{\oplus}{O}H_2$

Ethanol

(*ii*) $CH_3—CH_2—\overset{\oplus}{O}H_2 \xrightarrow{-H_2O} CH_3—\overset{\oplus}{C}H_2$

(*iii*) $H—\underset{H}{\overset{H}{C}}—\overset{H}{\underset{\oplus}{C}}—H + HSO_4^{\ominus} \longrightarrow H—\underset{}{\overset{H}{C}}=\overset{H}{C}—H + H_2SO_4$

Ethene

11.20. How are the following conversions carried out?

(*i*) Propene $\longrightarrow$ Propan–2–ol

(*ii*) Benzyl chloride $\longrightarrow$ Benzyl alcohol

(*iii*) Ethyl magnesium chloride $\longrightarrow$ Propan–1–ol

(*iv*) Methyl magnesium bromide $\longrightarrow$ 2–Methylpropan–2–ol

Ans. (*i*) $CH_3—CH = CH_2 + \textit{conc.}\ H_2SO_4 \longrightarrow CH_3—\underset{OSO_3H}{CH}—CH_3$

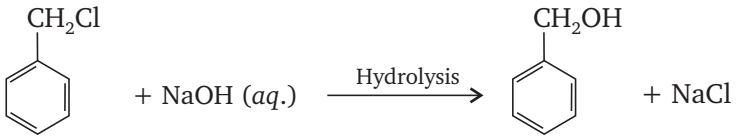
Propene

Isopropyl hydrogen sulphate

$CH_3—\underset{OSO_3H}{CH}—CH_3 + H_2O \xrightarrow[\text{(Boiling)}]{} CH_3—\underset{OH}{CH}—CH_3 + H_2SO_4$

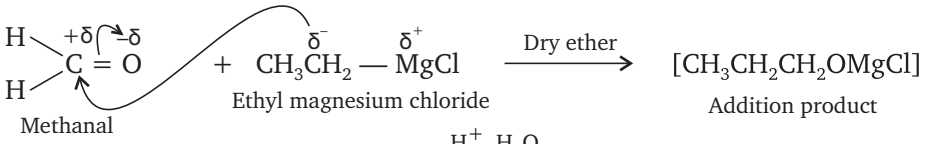
Propan-2-ol

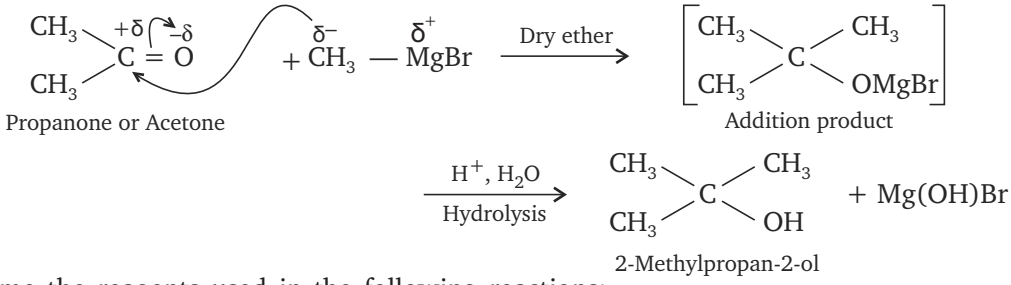
(*ii*)



Benzyl chloride

Benzyl alcohol

(*iii*) 

(*iv*) 

11.21. Name the reagents used in the following reactions:

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

Ans. (*i*) Acidified potassium dichromate or neutral acidic or alkaline potassium permanganate (followed by hydrolysis with dil. HCl).

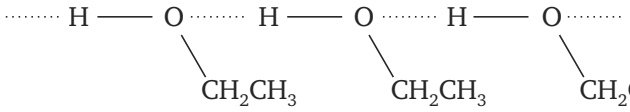
(*ii*) Pyridinium chlorochromate (PCC), $C_2H_5\overset{+}{N}HClCrO_3^-$ in CH_2Cl_2 or

Pyridinium dichromate (PDC), $(C_5H_5\overset{+}{N}H)_2Cr_2O_3^{2-}$ in CH_2Cl_2

(*iii*) Aqueous bromine, *i.e.* Br_2/H_2O
(*iv*) Acidified or alkaline potassium permangante (followed by hydrolysis with dil. HCl).
(*v*) Conc. H_2SO_4 at 433–443 K or 85% phosphoric acid at 443 K.
(*vi*) Ni/H_2 or $NaBH_4$ or $LiAlH_4$

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

Ans. Ethanol undergoes intermolecular H-bonding due to the presence of a hydrogen atom attached to the electronegative oxygen atom. As a result, ethanol exists as associated molecules.

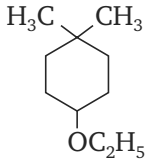


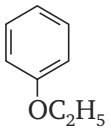
Consequently, a large amount of energy is required to break these hydrogen bonds. Therefore, the boiling point of ethanol is higher than that of methoxymethane which does not form H–bonds.

11.23. Give the IUPAC names of the following ethers.

(*i*) $C_2H_5OCH_2—\underset{\displaystyle CH_3}{\underset{|}{CH}}—CH_3$ (*ii*) $CH_3—O—CH_2CH_2Cl$

(*iii*) $O_2N—C_6H_4—OCH_3$ (*p*) (*iv*) $CH_3CH_2CH_2OCH_3$

(*v*) 

(*vi*) 

Ans. (*i*) 1–Ethoxy–2–methylpropane (*ii*) 2–Chloro–1–methoxyethane

(*iii*) 4–Nitroanisole (*iv*) 1–Methoxypropane

(*v*) 1–Ethoxy–4, 4–dimethylcyclohexane

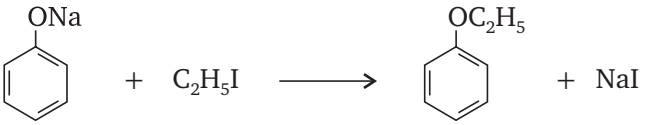
(*vi*) Ethoxybenzene

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

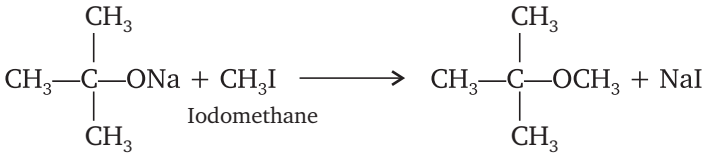
(*i*) 1–Propoxypropane (*ii*) Ethoxybenzene

(*iii*) 2–Methoxy–2–methylpropane (*iv*) 1–Methoxyethane

Ans. (*i*) $CH_3—CH_2—CH_2—ONa + \underset{\text{Iodopropane}}{CH_3CH_2CH_2I} \longrightarrow \underset{\text{1–Propoxypropane}}{CH_3CH_2CH_2OCH_2CH_2CH_3} + NaI$

(*ii*) 

Sodium phenoxide Iodoethane Ethoxybenzene

(*iii*) 

Sodium 2-Methyl-propan-2-oate

(*iv*) $\underset{\text{Sodium ethoxide}}{CH_3CH_2ONa} + \underset{\text{Iodomethane}}{CH_3I} \longrightarrow CH_3CH_2OCH_3 + NaI$

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

Ans. Ethers containing secondary and tertiary alkyl groups cannot be prepared in good yield by Williamson's synthesis. For example, di–isopropyl ether and di–*tert*–butyl ether cannot be prepared by Williamson's synthesis.

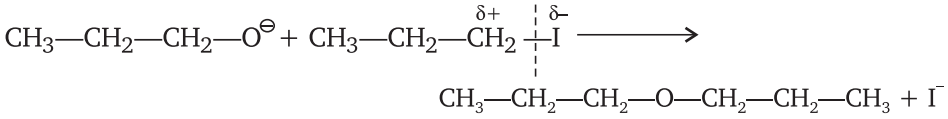
11.26. How is 1–propoxypropane synthesised from propan–1–ol? Write the mechanism of this reaction?

Ans. $CH_3—CH_2—CH_2OH + Na \longrightarrow CH_3CH_2CH_2ONa + CH_3CH_2CH_2I \longrightarrow CH_3CH_2CH_2OCH_2CH_2CH_3 + NaI$

Mechanism:

$$CH_3CH_2CH_2OH + Na \longrightarrow CH_3CH_2CH_2ONa + \frac{1}{2}H_2(g)$$

$$CH_3CH_2CH_2ONa \longrightarrow CH_3CH_2CH_2O^{\ominus} + Na^{+}$$



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

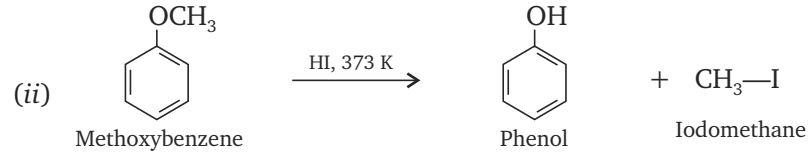
Ans. Dehydration of secondary and tertiary alcohols to give corresponding ethers is not suitable as elimination competes over substitution reaction and as a consequence alkenes are easily formed.

11.28. Write the equation of the reaction of hydrogen iodide with

(*i*) 1–propoxypropane (*ii*) methoxybenzene (*iii*) benzyl ethyl ether

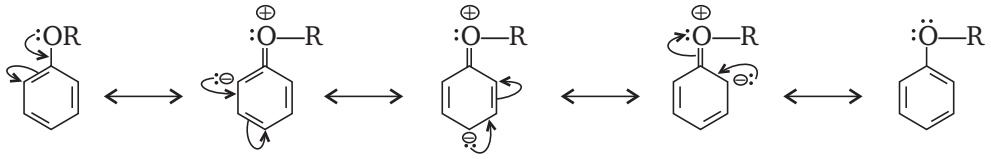
Ans. (*i*) $CH_3CH_2CH_2—O—CH_2CH_2CH_3 \xrightarrow[373K]{HI} CH_3CH_2CH_2—OH + CH_3CH_2CH_2—I$

1–Propoxypropane; Propan–1–ol; 1–Iodopropane



11.29. 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.

Ans.



Since there is –ve charge at *ortho* and *para*–positions, therefore –OR group is activating towards electrophilic substitution reaction and electrophilic will attack at *o* – and *p* –positions.

11.30. Write the mechanism of the reaction of HI with methoxymethane.

Ans. With equimolar amounts of HI and methoxymethane, a mixture of methyl alcohol and methyl iodide is formed by the following mechanism:

Setp 1. $CH_3—\ddot{O}—CH_3 + H—I \underset{+ I^-}{\overset{- I^-}{\rightleftharpoons}} CH_3—\overset{H}{\overset{|}{\overset{+}{O}}}—CH_3 + I^-$

Methoxymethane; Dimethyl oxonium ion

Setp 2. $I^- + CH_3—\overset{H}{\overset{|}{\overset{+}{O}}}—CH_3 \xrightarrow[Slow]{S_N2} CH_3—I + CH_3—OH$

Methyl iodide; Methyl alcohol

11.31. Write equations of the following reactions:

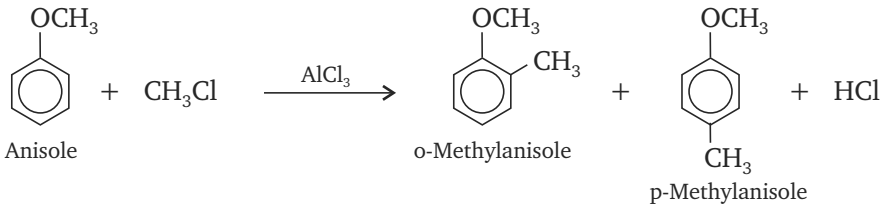
(*i*) Friedel-Craft's reaction – alkylation of anisole.

(*ii*) Nitration of anisole

(*iii*) Bromination of anisole in ethanoic acid medium

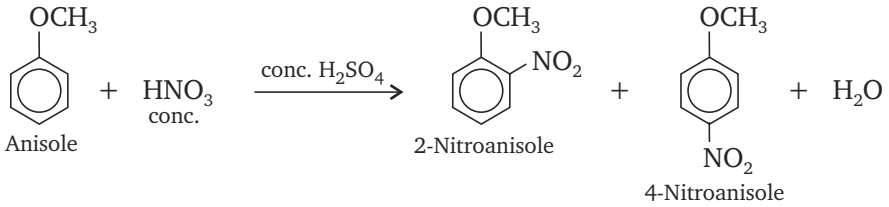
(*iv*) Friedel-Crafts acetylation of anisole

Ans. (*i*)



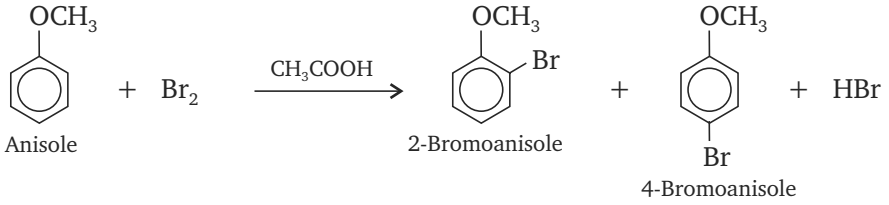
Anisole o-Methylanisole p-Methylanisole

(*ii*)



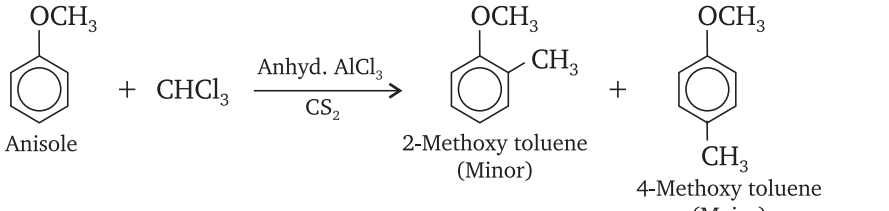
Anisole 2-Nitroanisole 4-Nitroanisole

(*iii*)



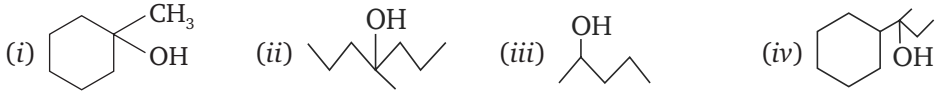
Anisole 2-Bromoanisole 4-Bromoanisole

(*iv*)



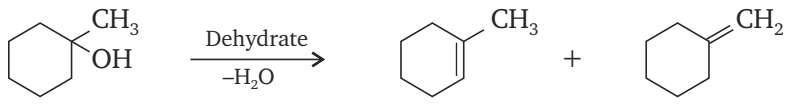
Anisole 2-Methoxy toluene (Minor) 4-Methoxy toluene (Major)

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



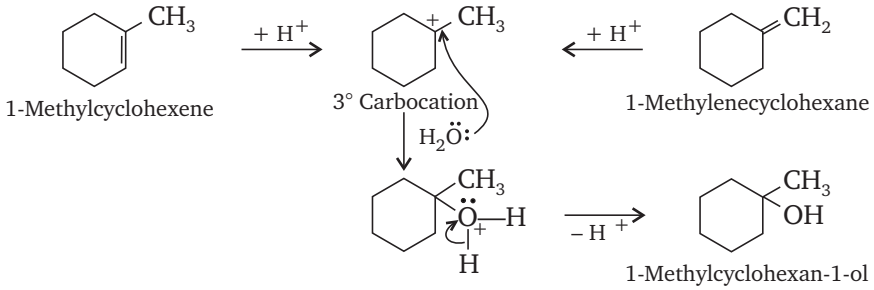
Ans. Since addition and elimination are reverse of each other, therefore, the general strategy is to first dehydrate a suitable alcohol to give either a single alkene or a mixture of alkenes. If a mixture of alkenes is possible, then find out which of the alkenes will give the desired alcohol. Please note that acid-catalysed addition of H_2O to alkenes occurs in accordance with **Markovnikov's rule**.

(*i*)



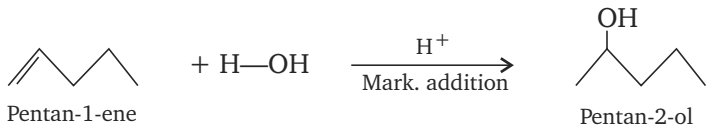
1-Methylcyclohexan-1-ol 1-Methylcyclohexene Methylenecyclohexane

Addition of H_2O to the alkenes as shown give the desired alcohol:

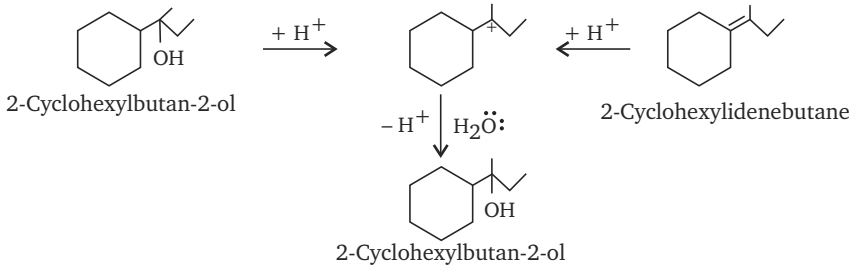


(*ii*) Addition of H_2O to 4–methylhept–3–ene in the presence of an acid gives the desired alcohol.

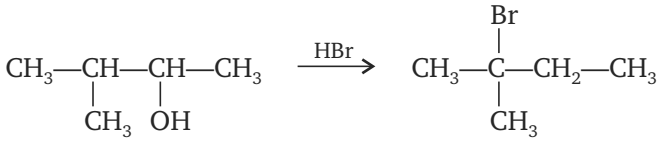
(*iii*) Addition of H_2O to pent-1–ene gives the desired alcohol.



(*iv*) Addition of H_2O to both 2–cyclohexylbut–2–ene and 2–cyclohexylidenebutane in presence of an acid gives the desired alcohol:

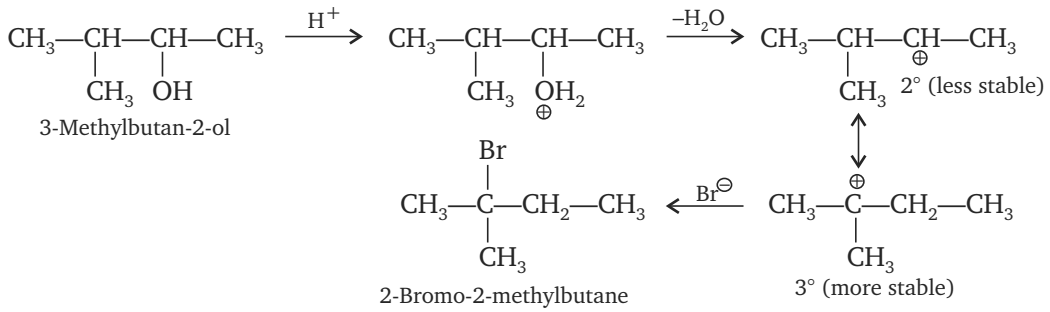


11.33. When 3–methylbutan–2–ol is treated with HBr, the following reaction takes place:



Give a mechanism for this reaction

Ans.



11.34. Give reasons for the following: (*CBSE* 2015)

(*i*) *o*-nitrophenol is more acidic than *o*-methoxyphenol.

(*ii*) Butan-l-ol has a higher boiling point than diethyl either.

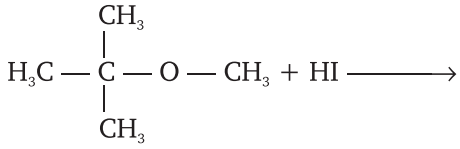
(*iii*) $(CH_3)_3C - O - CH_3$ on reaction with HI gives $(CH_3)_3C–I$ and $CH_3–OH$ as the main products and not $(CH_3)_3C–OH$ and $CH_3–I$.

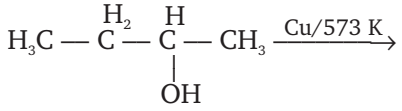
Ans. (*i*) The nitro group ($–NO_2$)is an electron-withdrawing group. It decreases the electron density on the O – H bond. Thus, the proton can be easily lost. In the presence of an electron-withdrawing group, the phenoxide ion gets more stabilised. Due to the high stability of phenoxide ion, the acidic nature increases. On the other hand, the methoxy group is an electron-releasing group. It increases the density in the O – H bond. Thus, the proton cannot be given out easily. Thus, the phenoxide ion is less stabilised. Due to this reason, *o*-nitrophenol is more acidic than *o*-methoxyphenol.

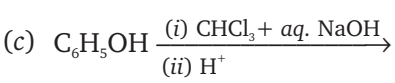
(*ii*) Butan-l-ol has a higher boiling point because it contains a hydroxyl group which is capable of forming intermolecular hydrogen bonding. Molecules of diethyl ether on the other hand are incapable of forming hydrogen bonds with each other.

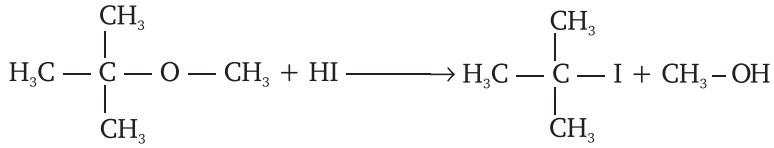
(*iii*) $(CH_3)_3C–O–CH_3$ is an ether with two different alkyl groups, of which $(CH_3)_3C–$, a tertiary alkyl group on reaction with hydrogen halide (HI) forms a tertiary halide. This occurs as the reaction follows S_N1 mechanism. The reaction involves the formation of a stable carbocation. If the ether has a primary alkyl group, then the reaction follows the S_N2 mechanism.

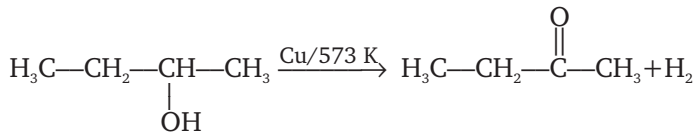
11.35. Write the final product(s) in each of the following reactions: (*CBSE* 2016)

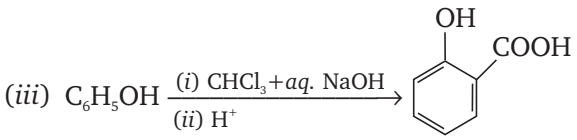
(*a*) 

(*b*) 

(*c*) 

Ans. (*a*) 

(*b*) 

(*iii*) 

2-Hydroxybenzoic acid

ADDITIONAL QUESTIONS SOLVED

I. Very Short Answer Type Questions

Q1. How do you account for the miscibility of ethoxyethane with water? [*CBSE* 2009]

Ans. Because of intermolecular hydrogen bonding between ether and water molecules, ethoxyethane are soluble in water.

Q2. Give reason for the following ortho–nitrophenol is more acidic than ortho–methoxyphenol. [AI CBSE 2006]

Ans. It is because nitro group is electron withdrawing which increases the acidic character due to stabilisation of *o*-nitrophenoxide ion whereas–OCH_3 group is electron releasing which decreases acidic character due to destabilisation of *o*–methoxyphenoxide ion. *(1 mark)*

Q3. How will you synthesise salicyclic acid from phenol?

Ans. By treating phenol with carbon tetrachloride and aqueous NaOH at 340 K followed by hydrolysis with dil. HCl.

(Riemer-Tiemann reaction)

Q4. How will you know whether a given OH group is alcoholic or phenolic in nature?

Ans. Phenolic OH group gives blue or violet colouration with natural $FeCl_3$ solution whereas alcoholic OH group does not.

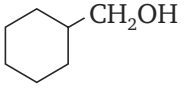
Q5. Name one reagent which is used to distinguish between primary, secondary and tertiary alcohols.

Ans. Lucas reagent (anhyd. $ZnCl_2$ + Conc. HCl)

Q6. How is ethanol obtained from 2–butene? [*AI* 2006 C, 2005 C]

Ans. $CH_3—CH = CH—CH_3 \xrightarrow[(ii)\ Zn/H_2O]{(i)\ O_3} 2CH_3—\overset{\overset{O}{\|}}{C}—H \xrightarrow{LiAlH_4} 2CH_3CH_2OH$

But-2-ene — Ethanol

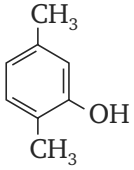
Q7. Write the IUPAC name of  [*Delhi* 2005 C]

Ans. Cyclohexylmethanol

Q8. How is *tert*-butyl alcohol obtained from acetone? [*AI* 2005 C]

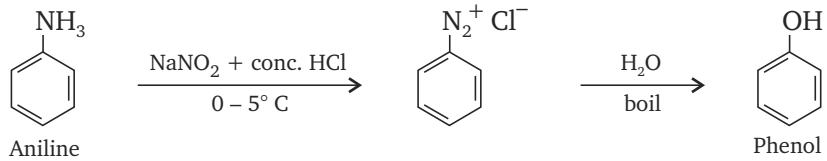
Ans. $CH_3—\overset{\overset{O}{\|}}{C}—CH_3 + CH_3MgBr \longrightarrow CH_3—\overset{\overset{OMgBr}{|}}{\underset{\underset{CH_3}{|}}{C}}—CH_3 \xrightarrow{H_2O/H^+} CH_3—\overset{\overset{OH}{|}}{\underset{\underset{CH_3}{|}}{C}}—CH_3$

Acetone — Methylmagnesium bromide — *tert.* butyl alcohol

Q9. Write the IUPAC name of  [*CBSE* 2004 C]

Ans. 2, 5 –Dimethylphenol

Q10. How is phenol obtained from aniline? [*AI* 2004 C]

Ans. 

Aniline — Phenol

Q11. Give one chemical test to distinguish between the following pair of compounds phenol and Benzoic acid.
[*AI* 2003 C]

Ans. On adding neutral $FeCl_3$ solution phenol will give violet colour whereas benzoic acid does not react.

Q12. Name the products obtained when anisole is treated with HI.

Ans. Phenol and methyl iodide.

Q13. Why are higher ethers insoluble in water?

Ans. Higher ethers are insoluble in water because due to bigger size of the alkyl group, the oxygen atom in ethers fails to form the intermolecular hydrogen bond with water.

Q14. Mention two important uses of methanol.

Ans. (*i*) In the manufacture of formaldehyde which is widely used in the manufacture of formaldehyde resins such as bakelite, melamine, formaldehyde, etc.

(*ii*) In the denaturation of ethyl alcohol.

Q15. How will you convert ethanol to ethylene?

Ans. By heating ethanol with concentrated H_2SO_4 at 433 – 443 K.

Q16. What is the order of acidic character of an alcohol, an organic acid and a phenol?

Ans. Organic acid > phenol > alcohol

Q17. Name any two reagents used for bringing about the oxidation of alcohols to carboxylic acids.

Ans. Acidic or alkaline $KMnO_4$, acidic $K_2Cr_2O_7$

Q18. What is the order of acidic character of primary, secondary and tertiary alcohols?

Ans. Primary > Secondary > Tertiary.

Q19. How will you know whether a given OH group is alcoholic or phenolic in nature?

Ans. Phenolic OH group gives blue or violet colouration with neutral FCl_3 while alcoholic OH group does not.

Q20. What is rectified spirit?

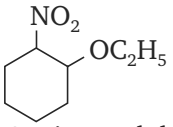
Ans. 95% ethyl alcohol is called rectified spirit.

Q21. Arrange the following compounds in increasing order of their acid strength.

Propan–1–ol; 2, 4, 6–trinitrophenol; 3–nitrophenol; 3, 5–dinitrophenol; 4–methyl- phenol

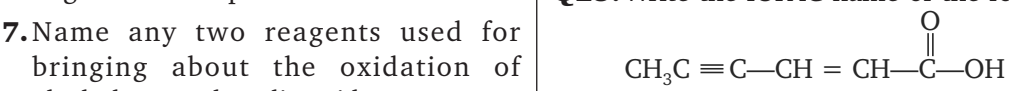
Ans. Propan–1–ol < 4–methylphenol< 3–nitrophenol < 3, 5–dinitrophenol< 2, 4, 6–trinitrophenol

Q22. Give the IUPAC name of the compound



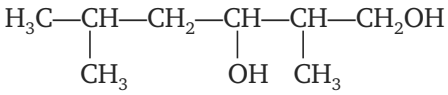
Ans. 1–Ethoxy–2–nitrocyclohexane

Q23. Write the IUPAC name of the following:

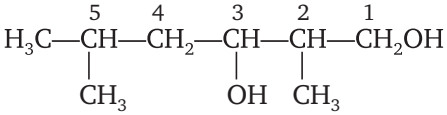


Ans. Hex-4-en-2-ynoic acid

Q24. Write the IUPAC name of the following compound:



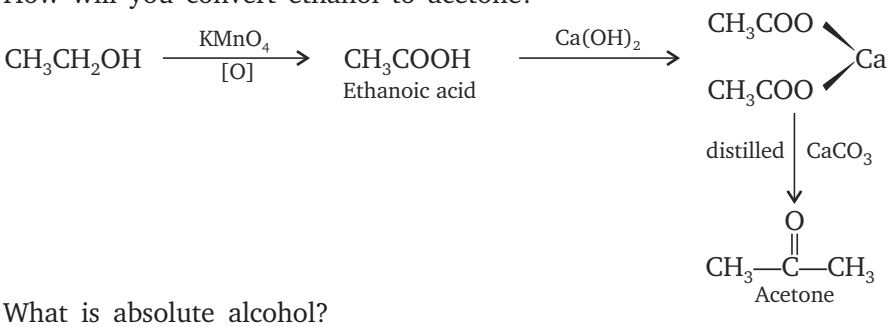
Ans.



2, 5 dimethylhexane-1, 3-diol

Q25. How will you convert ethanol to acetone?

Ans.



Q26. What is absolute alcohol? [*CBSE* 2005]

Ans. 100% ethanol is known as absolute alcohol. To prepare absolute alcohol, rectified spirit (95% alcohol) and benzene mixture is fractionally distilled.

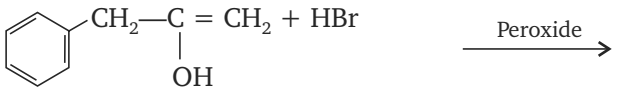
Q27. Write the IUPAC name of the following:

Ans. 4–methoxybenzenamine

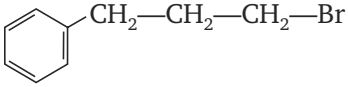
Q28. Draw the structures of 4–methyl pent–3–en–2–one [*CBSE* 2004]

Ans. $CH_3—\overset{\overset{O}{\|}}{C}—CH = \overset{\overset{CH_3}{|}}{C}—CH_3$

Q29. Write the product of the following reaction:



Ans.



Q30. Define fermentation.

Ans. The process of breaking down large molecules into smaller ones in the presence of biological catalysts is called fermentation. We can prepare ethyl alcohol from mollasses or starch by fermentation process.

Q31. What happens when ethanol is treated with phosphorus tribromide?

Ans. $3CH_3CH_2OH + PBr_3 \longrightarrow 3CH_3CH_2Br + H_3PO_3$

Q32. Write the IUPAC name of

$CH_3—\overset{\overset{OH}{|}}{CH}—CH_2Cl$

Ans. 1–chloropropan–2–ol

Q33. Write the IUPAC name of

$CH_3—\overset{\overset{CH_3}{|}}{\underset{\underset{C_2H_5}{|}}{C}}—CH_2OH$

Ans. 2, 2, Dimethylbutan–1–ol

Q34. Name a compound which is used as an antiseptic as well as disinfectant.

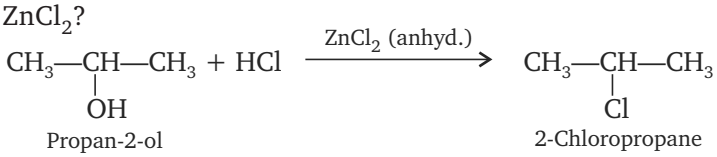
Ans. 0.2% solution of phenol is used as an antiseptic and 2% solution of phenol is used as a disinfectant.

Q35. How is 1–bromopropane obtained from 1 –propanol?

Ans. $CH_3CH_2CH_2OH + HBr \xrightarrow{\text{reflux}} CH_3CH_2CH_2Br + H_2O$

Q36. What happens when 2–propanol is treated with HCl in the presence of anhydrous $ZnCl_2$?

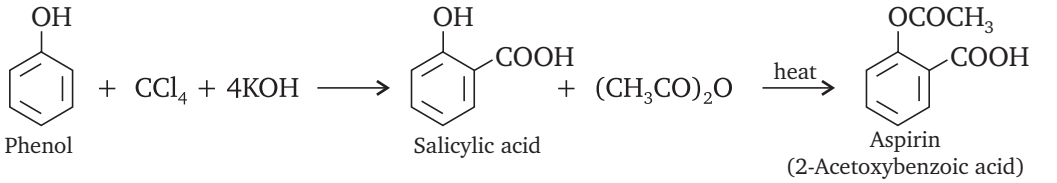
Ans.



Propan-2-ol 2-Chloropropane

Q37. How will you convert phenol to aspirin? Give chemical equation.

Ans.



Phenol Salicylic acid Aspirin (2-Acetoxybenzoic acid)

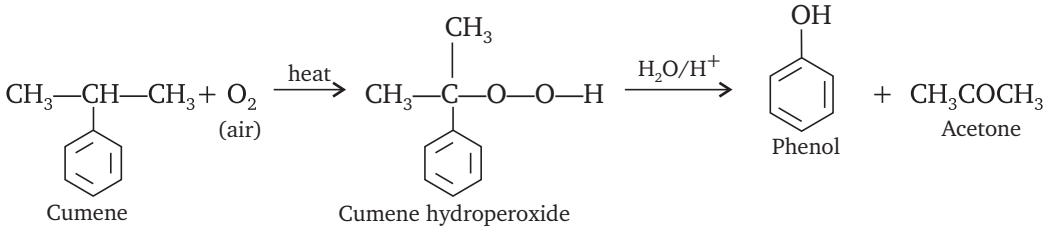
$+ CH_3COOH$

Q38. What happens when ethyl alcohol is heated with red phosphorus and HI?

Ans. $C_2H_5OH + 2HI \xrightarrow{\text{red P}} C_2H_6 + I_2 + H_2O$

Q39. What happens when cumene is treated with oxygen and the product is hydrolysed with dilute acid?

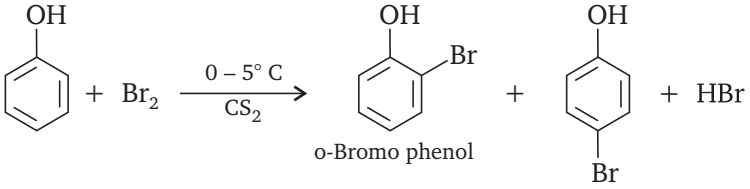
Ans.



Cumene Cumene hydroperoxide Phenol Acetone

Q40. What happens when phenol is treated with ice cold bromine dissolved in CS_2?

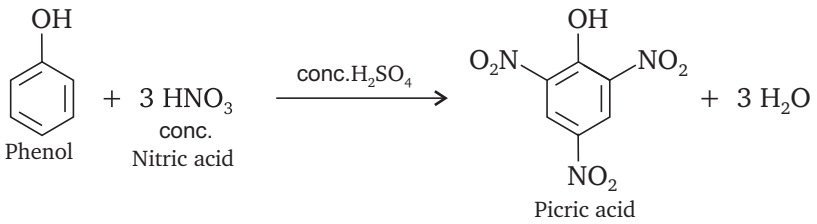
Ans.



o-Bromo phenol

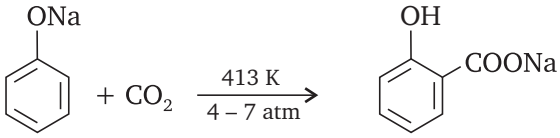
Q41. What happens when (give equation only) phenol is treated with excess of nitrating mixture?

Ans.



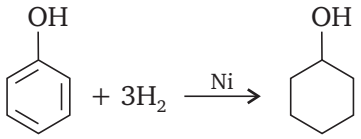
Phenol Picric acid

Q42. What happens when (give equation only) sodium phenoxide is treated with CO_2 at 413 K and 4 to 7 atmosphere pressure?

Ans. 

Sodium salicylate

Q43. What happens when (give equation only) phenol is treated with H_2 in presence if nickel?

Ans. 

Cyclohexanol

Q44. What happens when ethylene is treated with hypochlorous acid?

Ans. $CH_2{=}CH_2 + HOCl \longrightarrow CH_2OH{-}CH_2Cl$

Q45. What is Lucas reagent? For what purpose is it used?

Ans. Conc. HCl + anhydrous $ZnCl_2$. It is used to distinguish between 1°, 2°, and 3° alcohols.

Q46. How is alcohol made unfit for drinking purposes?

Ans. By adding methanol/acetone or pyridine.

Q47. What is a nitrating mixture?

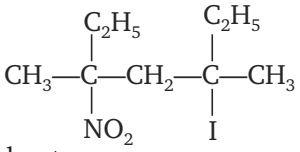
Ans. Mixture of HNO_3 (*conc.*) and (*conc.*) H_2SO_4 is called nitrating mixture.

Q48. What happens when (give equation only) propene is treated with chlorine at 773 K?

Ans. $CH_3{-}CH{=}CH_2 + Cl_2 \xrightarrow{773K} ClCH_2{-}CH{=}CH_2 + HCl$

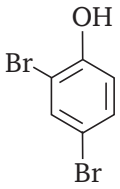
Propene — Allyl chloride

Q49. Give the IUPAC name of:



Ans. 5 Iodo–3, 5–dimethyl–3–nitroheptane

Q50. Write the IUPAC name of



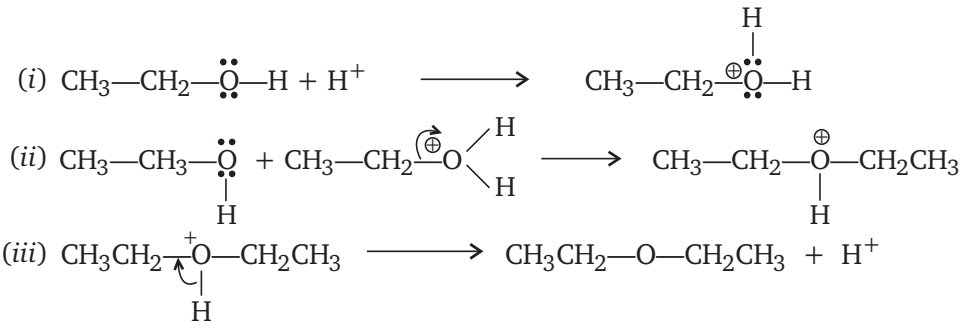
Ans. 2, 4-Dibromophenol

II. Short Answer Type Questions *(2 or 3 Marks)*

Q1. Describe the mechanism of the formation of diethyl ether from ethanol in the presence of concentrated sulphuric acid. [*CBSE* 2009]

Ans. $2CH_3CH_2OH \xrightarrow[413\ K]{conc.\ H_2SO_4} C_2H_5OC_2H_5 + H_2O$

Mechanism:



Q2. Give chemical test to distinguish between compounds in each of the following pairs:

(*i*) Phenol and Benzyl alcohol

(*ii*) Butan–2 –ol and 2–Methylpropan –2 –ol [*CBSE* 2009]

Ans. (*a*) Addition of neutral ferric chloride solution to phenol will give a violet colouration, while no such colouration will be observed in case of benzyl alcohol.

(*b*) On addition of Lucas reagent (a mixture of concentrated hydrochloric acid and anhydrous zinc chloride) to 2–methyl–2–propanol will give a white turbidity immediately while 2 –Butanol will give turbidity after five minutes.

Q3. Which is a stronger acid-phenol or cresol? Explain

Ans. Phenol is a stronger acid. In cresol methyl group due to +I effect concentrates the negative charge on the oxygen, thus destabilizing the intermediate phenoxide ion in cresol.

Q4. How would you account for the following:

(*i*) Phenols are much more acidic than alcohols.

(*ii*) The boiling point of ethers are much lower than those of the alcohols of comparable molar masses. [*CBSE* 2007]

Ans. (*i*) Since the phenoxide ion left after the removal of a proton is stabilized by resonance whereas alkoxide ion left after the removal of a proton from alcohol is not.

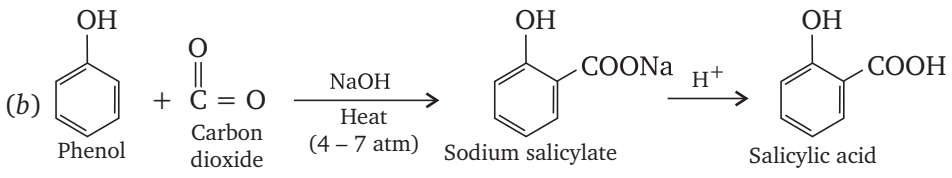
(*ii*) The large difference in boiling points of alcohols and ethers is due to the presence of hydrogen bonding in alcohols.

Q5. Write the reactions and conditions involved in the conversion of:

(*a*) Propene to Propan-1-ol (*b*) Phenol to Salicylic acid. [*Delhi* 2006]

Ans. (*a*) $CH_3CH = CH_2 \xrightarrow[(ii)\ H_2O_2/OH^-]{(i)\ B_2H_6} \underset{\text{1-Propanol}}{CH_3CH_2CH_2OH}$

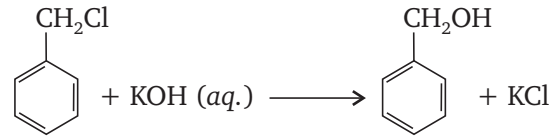
(*b*)

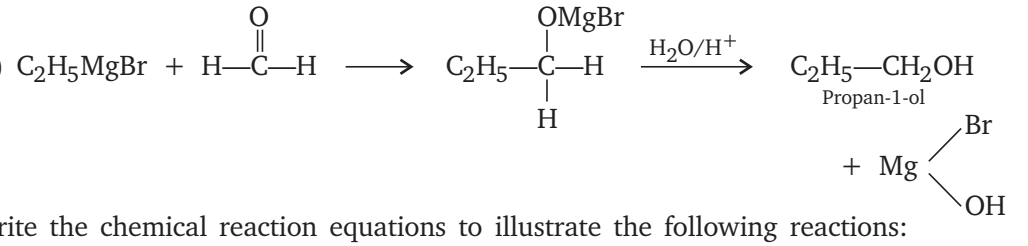


Q6. How are following conversions carried out?

(*a*) Benzyl chloride to benzyl alcohol

(*b*) Ethyl magnesium bromide to propan–1–ol [*CBSE* 2006 C]

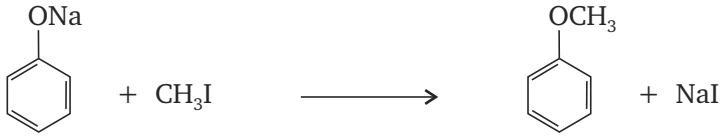
Ans. (*a*) 

(*b*) 

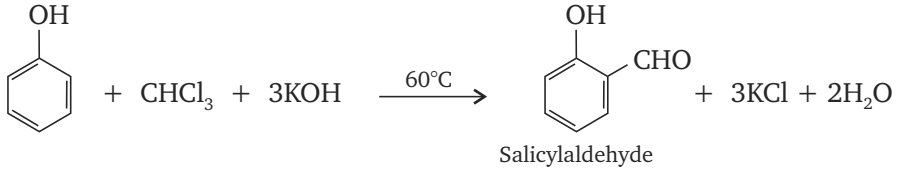
Q7. Write the chemical reaction equations to illustrate the following reactions:

(*i*) Williamsons synthesis of ethers (*ii*) Reimer-Tiemann reaction [*Foreign* 2007]

Ans. (*i*) Williamson Synthesis



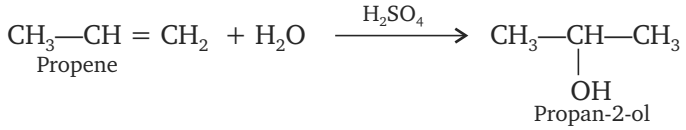
(*ii*) Riemer-Tiemann Reaction

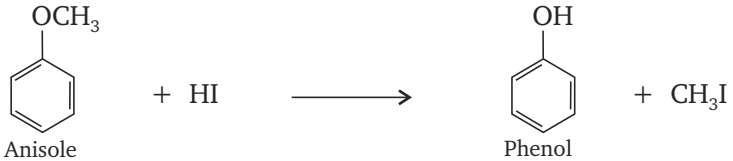


Q8. How may the following conversion be carried out

(*i*) Propene to propan–2–ol (*ii*) Anisole to phenol?

(Write reactions only) [*AI* 2007]

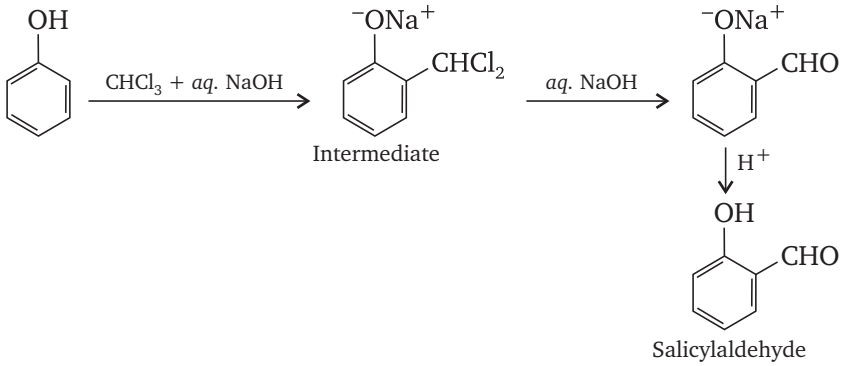
Ans. (*i*) 

(*ii*) 

Q9. Give an illustration of Riemer-Tiemann reaction. [*CBSE* 2005]

Ans. On treating phenol with chloroform in the presence of sodium hydroxide a —CHO group is introduced at the *ortho* position of benzene ring. This reaction is known as Riemer-Tiemann reaction.

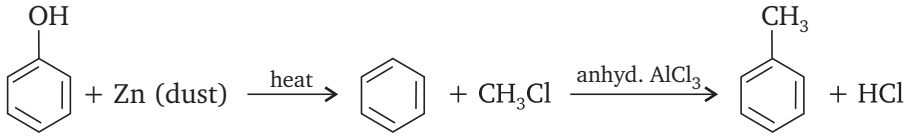
The intermediate substituted benzal chloride is hydrolysed in the presence of alkali to produce salicylaldehyde.



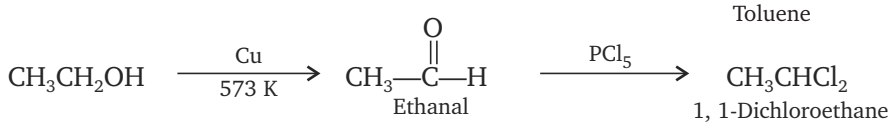
Q10. How are the following conversions carried out?

(*i*) Phenol to Toluene (*ii*) Ethanol to 1, 1–dichloroethane. [*CBSE* 2005 C]

Ans. (*i*)

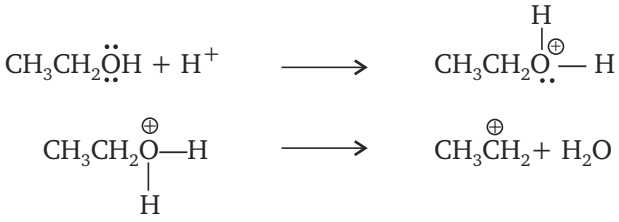


(*ii*)

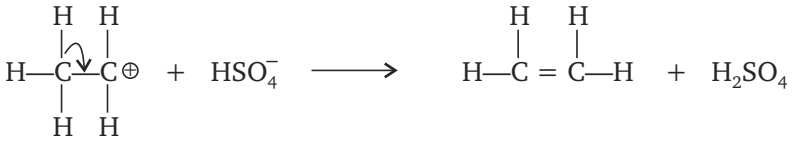


Q11. What happens when ethanol is heated with concentrated sulphuric acid at 453 K? Explain the mechanism of this reaction. [*AI* 2004]

Ans. When ethanol is heated with concentrated sulphuric acid at 453 K, ethene is formed.



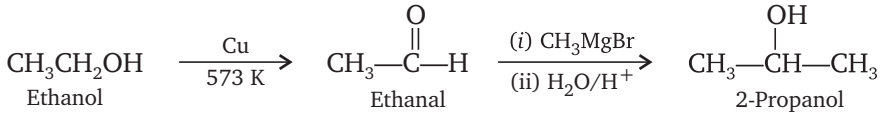
Mechanism:



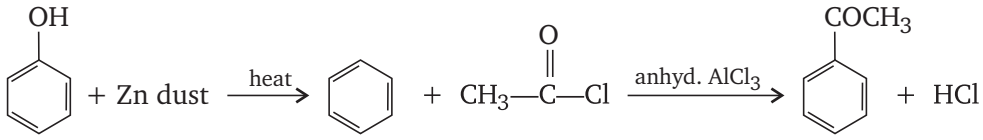
Q12. How are the following conversions carried out? (Write the reactions and conditions in each case):

(*i*) Ethanol to 2–propanol (*ii*) Phenol to Acetophenone [*Delhi* 2005 C]

Ans. (*i*)



(*ii*) **Phenol to Acetophenone**



Q13. Describe the mechanism by which the hydroxyl group attached to an aromatic ring is more acidic than the hydroxyl group attached to an alkyl group. How does the presence of nitro group in phenol affects its acidic character? [*Foreign* 2004]

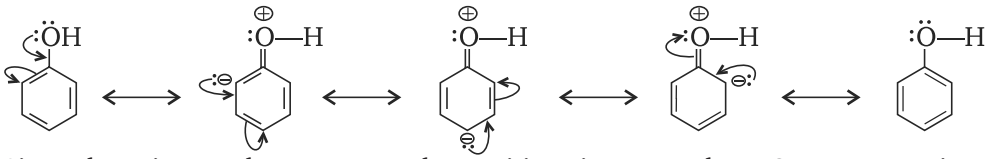
Ans. The reaction of phenol with aqueous sodium hydroxide solution indicates that phenol is a stronger acid than alcohols in water.

Because phenoxide ion formed is stabilised by resonance whereas alkoxide ion formed is destabilised by positive inductive effect of alkyl group.

Presence of electron withdrawing group such as nitro group enhances the acidic strength of phenol. It is due to the effective delocalisation of the negative charge in phenoxide ion.

Q14. Explain how an OH group attached to a carbon atom in the benzene ring activates benzene towards electrophilic substitution. [*AI* 2005]

Ans.



Since there is –ve charge at *o* and *p*-position, it means that –OH group activates the benzene ring towards electrophilic substitution reaction.

Q15. How are the following conversions carried out (write reactions with conditions)

(*a*) 1–Propanol to 1–Chloro–2–Propanol

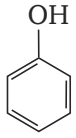
(*b*) Phenol to Salicylic acid [*CBSE* 2004]

Ans. (*a*) $\underset{\text{1-Propanol}}{CH_3—CH_2—CH_2OH} \xrightarrow[443\ K]{conc.\ H_2SO_4} \underset{\text{Propene}}{CH_3—CH=CH_2} + HOCl \longrightarrow$

$$CH_3—\underset{\displaystyle OH}{\underset{|}{CH}}—CH_2Cl$$

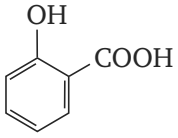
1-Chloropropan-2-ol

(*b*)



Phenol

$+ CCl_4 + 4\,KOH \xrightarrow{heat}$



Salicylic acid

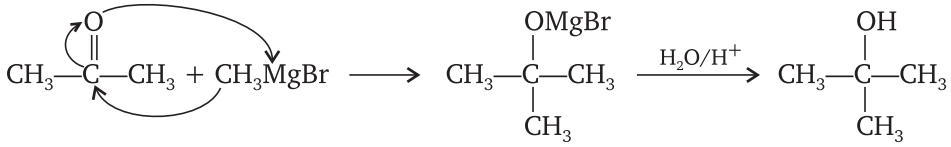
$+ 4KCl + 2H_2O$

Q16. Write the reactions and conditions for the following conversions:

(*i*) 2–Propanone into 2–methyl–2–Propanol

(*ii*) n–Propyl alcohol into hexane [*CBSE* 2003]

Ans. (*i*)

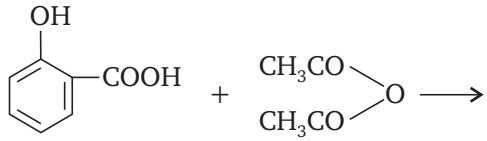


(*ii*) $\underset{\text{n–propyl alcohol}}{CH_3CH_2CH_2OH} + PCl_5 \longrightarrow CH_3CH_2CH_2Cl + POCl_3 + HCl$

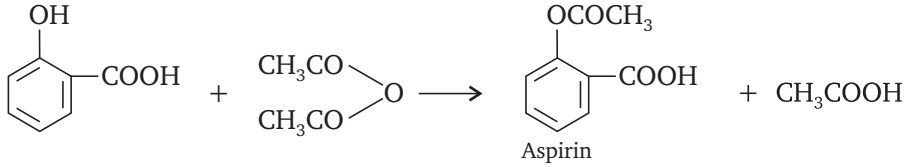
$$\underset{\text{1–Chloropropane}}{2CH_3CH_2CH_2Cl} + 2Na \xrightarrow[ether]{Dry} \underset{\text{n-Hexane}}{CH_3CH_2CH_2CH_2CH_2CH_3} + 2NaCl$$

Q17. Complete the following reactions:

(*i*) $(CH_3)_2CO \xrightarrow{LiAlH_4}$

(*ii*) 

Ans. (*i*) $CH_3-\overset{\overset{O}{\|}}{C}-CH_3 \xrightarrow{LiAlH_4} CH_3-\overset{\overset{OH}{|}}{CH}-CH_3$

(*ii*) 

Aspirin

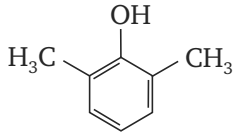
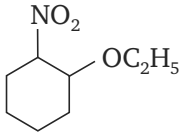
Q18. Write IUPAC names of the following compounds:

(*i*) $C_6H_5OC_2H_5$ (*ii*) $C_6H_5OC_7H_{15}$ (*iii*) $CH_3CH_2-O-\underset{\underset{CH_3}{|}}{CH}CH_2CH_3$

Ans. (*i*) Ethoxybenzene (*ii*) 1–Phenoxyheptane (*iii*) 2–Ethoxybutane

Q19. Give IUPAC names of the following compounds:

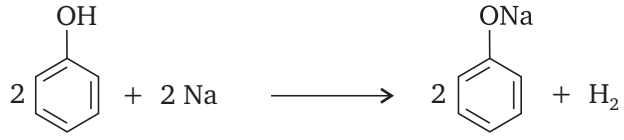
(*i*) $CH_3-\underset{\underset{Cl}{|}}{CH}-\underset{\underset{CH_3}{|}}{CH}-\underset{\underset{CH_3}{|}}{CH}-CH_2OH$ (*ii*) $CH_3-\underset{\underset{CH_3}{|}}{CH}-O-CH_2CH_3$

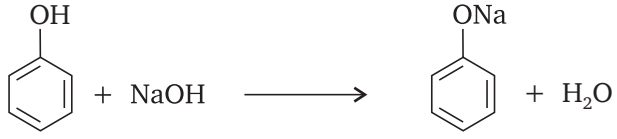
(*iii*)  (*iv*) 

Ans. (*i*) 4–Chloro–2, 3–dimethylpentan –1 –ol (*ii*) 2–Ethoxypropane

(*iii*) 2, 6–Dimethylphenol (*iv*) 1–Ethoxy–2–nitrocyclohexane

Q20. Give two reactions that show the acidic nature of phenol. Compare the acidity of phenol with that of ethanol.

Ans. (*i*) 

(*ii*) 

Phenol is more acidic than ethanol because phenoxide ion is more stable than ethoxide ion due to resonance effect.

Q21. Name the reagents used in the following reactions:

(*i*) Oxidation of a primary alcohol to carboxylic acid

(*ii*) Oxidation of a primary alcohol to an aldehyde

(*iii*) Bromination of phenol to 2, 4, 6-tribromophenol

Ans. (*i*) $KMnO_4/KOH$ (alkaline $KMnO_4$)

(*ii*) Cu/573 K (Hot reduced copper)

(*iii*) $Br_2(aq)$ (Bromine water)

Q22. Name the reagents used in the following reactions:

(*i*) Benzyl alcohol to Benzoic acid

(*ii*) Dehydration of propan-2-ol to propene

(*iii*) Butan-2-one to butan-2-ol

Ans. (*i*) $KMnO_4$/dil. H_2SO_4 (acidified $KMnO_4$)

(*ii*) Conc. H_2SO_4 at 443 K

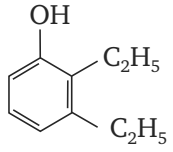
(*iii*) $LiAlH_4$

Q23. Write structures of the compounds whose IUPAC names are as follows:

(*i*) 2, 3 –Diethylphenol (*ii*) 1–Ethoxypropane

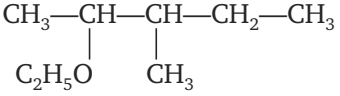
(*iii*) 2–Ethoxy–3–methylpentane

Ans. (*i*)



(*ii*) $C_2H_5O—CH_2—CH_2—CH_3$

(*iii*)



Q24. Write the equation of the reaction of hydrogen iodide with

(*i*) 1-Propoxypropane (*ii*) methoxybenzene

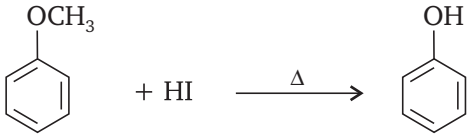
(*iii*) benzylethyl ether

Ans. (*i*) $CH_3CH_2CH_2OCH_2CH_2CH_3 + HI \xrightarrow{373K} CH_3CH_2CH_2OH + CH_3CH_2CH_2I$

1-Propoxypropane — 1-Propanol — 1-Idopropane

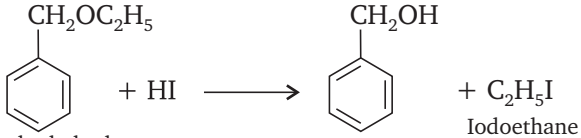
$$CH_3CH_2CH_2OCH_2CH_2CH_3 + \underset{\text{excess}}{2HI} \xrightarrow{373K} 2CH_3CH_2CH_2I + H_2O$$

(*ii*)



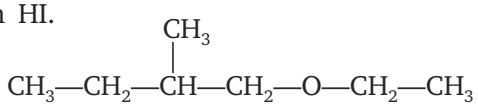
Methoxybenzene — Phenol — Iodomethane

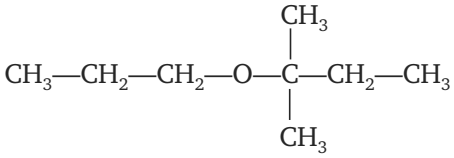
(*iii*)

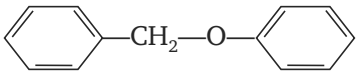


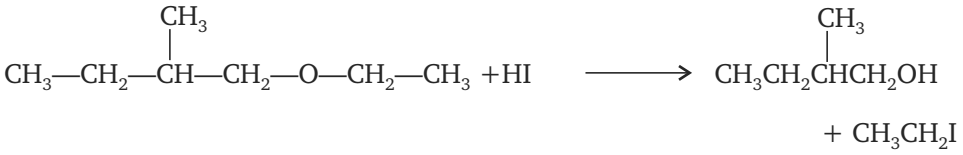
Benzyl ethyl ether — Benzylalcohol — Iodoethane

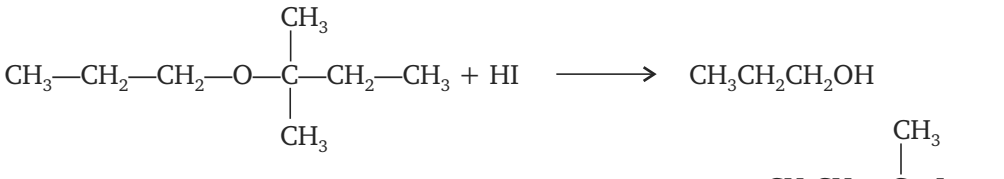
Q25. Give the major products that are formed by heating each of the following ethers with HI.

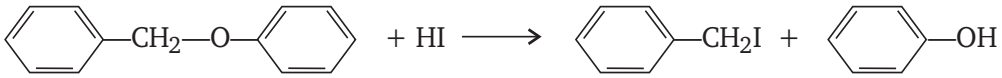
(*i*) 

(*ii*) 

(*iii*) 

Ans. (*i*) 

(*ii*) 

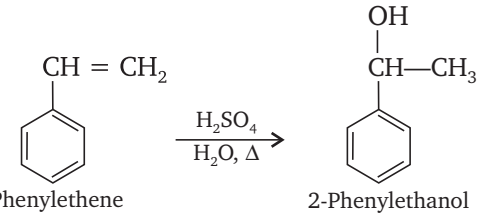
(*iii*) 

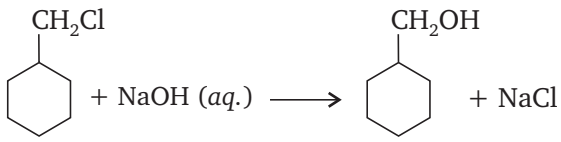
Q26. Show how will you synthesise

(*i*) 1 –Phenylethanol from a suitable alkene

(*ii*) Cyclohexylmethanol using an alkyl halide by an S_N2 reaction

(*iii*) Pentane–1–ol using a suitable alkyl halide

Ans. (*i*) 

(*ii*) 

(*iii*) $\underset{\text{1-Chloropentane}}{CH_3CH_2CH_2CH_2CH_2Cl} + NaOH\ (aq) \longrightarrow \underset{\text{Pentan-1-ol}}{CH_3CH_2CH_2CH_2CH_2OH} + NaCl$

Q27. Write Kolbe's reaction with an example. [*AI* 2011 C]

Ans. Refer to 'NCERT TEXTBOOK QUESTIONS SOLVED' Ans. 11.18 (*i*).

Q28. Explain the mechanism of acid catalysed hydration of alkenes to form the corresponding alcohol. [*AI* 2012]

Ans. Refer to 'some important mechanisms–point.

Q29. Write the mechanism of hydration of ethene to ethanol. [*Foreign*, 2009 C, 2010, 11]

Ans. Refer to 'some important mechanisms–point.

Q30. Explain the following behaviour:

(*a*) Alcohols are more soluble in water than hydrocarbons of comparable molecular mass?

(*b*) *Ortho* nitrophenol is more acidic than *ortho* methoxyphenol? [*AI* 2012, 2015]

Ans. (*a*) Due to hydrogen bonding in alcohol molecules.

(*b*) Higher the stability of phenoxide ion more will be the acidic character. NO_2 group (EWG) increases the stability of phenoxide ion whereas methoxy group (ERG) destabilises the phenoxide ion. That is why *o*-nitrophenol is more acidic than *o*-methoxyphenol.

Q31. Give reason for the following:

(*a*) The boiling point of ethanol is higher than that of methanol?

(*b*) Phenol is a stronger acid than alcohols. [CBSE 2009, 2011 C]

Ans. (*a*) The boiling points of alcohols increases with the increase in the number of carbon atoms due to increase in van der Waals forces. Hence boiling point of ethanol is higher than that of methanol.

(*b*) Due the higher electronegativity of sp^2 hybridised carbon atom of phenol to which—OH group is attached, electron density decreases on the oxygen atom. This increases the polarity of O—H bond and results in an increase in ionisation of phenols as compared to that of alcohols. Therefore phenol is a stronger acid than alcohols.

III. Long Answer Type Questions *(5 Marks)*

Q1. What is fermentation? How is ethanol obtained by fermentation of molasses? Give chemical equations.

Ans. The process of fermentation involves breaking down of large molecules into simpler ones in the presence of enzymes.

In India, ethanol is mainly prepared by fermentation of molasses–a dark brown coloured product left after crystallisation of sugar.

$$\underset{\text{Maltose}}{C_{12}H_{22}O_{11}} + H_2O \xrightarrow[\text{(from yeast)}]{\text{Maltase}} \underset{\text{Glucose}}{2C_6H_{12}O_6}$$

$$\underset{\text{Glucose}}{C_6H_{12}O_6} \xrightarrow{\text{Zymase}} \underset{\text{Ethyl alcohol}}{2C_2H_5OH} + 2CO_2$$

Q2. How can diethyl ether be prepared from (*i*) ethyl iodide (*ii*) ethyl alcohol? Why is the boiling point of an ether lower than that of the isomeric alcohols.

Ans. (*i*) $\underset{\text{Ethanol (excess)}}{2CH_3CH_2OH} \xrightarrow[413\ K]{conc.\ H_2SO_4} \underset{\text{Ethoxyethane}}{CH_3CH_2 - O - CH_2CH_3} + H_2O$

(*ii*) $\underset{\text{Alcohol}}{2R' - OH} + 2Na \longrightarrow 2R'-O-Na + H_2$

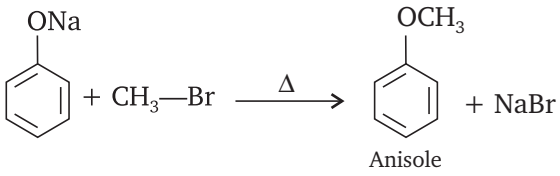
(*iii*) $R'-O^-Na^+ + R-X \xrightarrow{S_N2} \underset{\text{Ether}}{R'-O-R} + Na^+X^-$

Boiling points: Ethers are isomeric with monohydric alcohols but their boiling points are much lower than those of the isomeric alcohols. This is due to the reason that unlike alcohols, ethers do not form hydrogen bonds. As a result ethers do not show molecular association and hence have lower boiling point than corresponding alcohols.

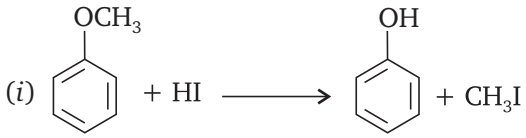
Q3. How is anisole prepared? What happens when it is treated with

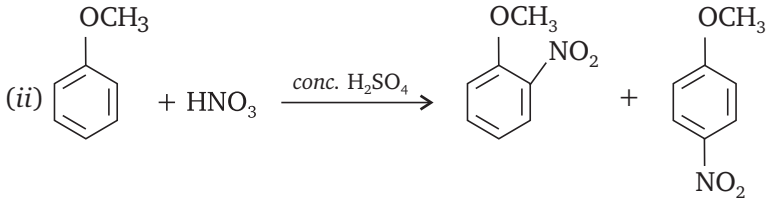
(*i*) HI (*ii*) nitrating mixture (*iii*) Br_2 dissolved in CS_2?

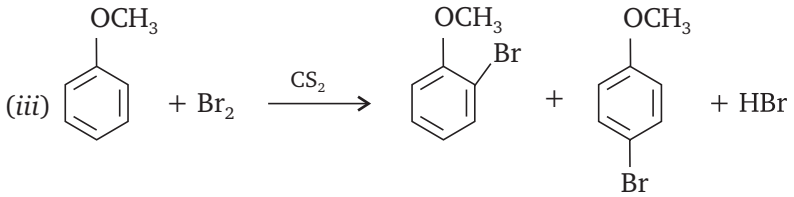
Ans. Anisole is prepared by the reaction of sodium phenoxide with methylbromide as follows:



Anisole







IV. Value-Based Questions

Q1. Laboratory alcohol should not be used for sterilisation of wounds.

(*a*) Why?

(*b*) What values do you derive from this?

Ans. (*a*) Laboratory alcohol is denatured with methanol. Methanol is extremely poisonous. Hence it should not be used for sterilisation.

(*b*) Laboratory reagents/equipments should not be used for any purpose other than for laboratory works.

Q2. Ramu had drunk from a local wine shop. He complained of blurred vision, started losing his eyesight slowly and died in a couple of days.

(*a*) What could be the reason for his death?

(*b*) Give IUPAC name of the main component of wine.

(*c*) What values can be derived from the sad incident?

Ans. (*a*) The reason of his death was denatured alcohol. In local wine shops manufacturer used to make wine from cheap commercial alcohols which generally contains methyl alcohol, pyridine, acetone, copper sulphate, etc. and in general it is called methylated spirit, which is poisonous.

(*b*) Ethanol

(*c*) Self awareness

Q3. Recently Delhi Police launched a special drive to curb the crime and accidents related to "Drunken–Driving". An instrument known as "Alcometer" is used to test whether a driver has consumed alcohol or not.

(*i*) Write the name and chemical formula of the compound used in alcometer.

(*ii*) By preventing alcohol drinking during driving, name the value, which Delhi Police tries to inculcate in drivers and general public.

(*iii*) Write the chemistry involved in the above test.

Ans. (*i*) Potassium permanganate.

(*ii*) Social responsibility and self awareness.

(*iii*) Potassium permanganate get oxidised by alcohol and pink colour of potassium permanganate is lost.

Q4. An owner of a paint company who was using ethanol as a solvent noted that his stock of ethanol was misused by his employee.

To prevent this misuse, he decided to add small amount of a blue colour compound (A) and another nitrogen containing heterocyclic base (B) which gives a foul smell to alcohol.

(*a*) Do you think that he took the right decision?

(*b*) Write the names of compound A and B? Name the process of adding compound A and B to ethanol?

(*c*) Mention the values associated with the above decision.

Ans. (*a*) It was a right decision.

(*b*) Compound (A) is copper sulphate and compound (B) is pyridine. To make the alcohol unfit for drinking purposes, these substances are added. It is called denatured alcohol.

(*c*) Critical thinking and decision making.

Q5. A driver is drunken and he is denying. How can you help the police to check whether the driver is drunken or not?

Ans. Acidified solution of potassium dichromate provides a test to find out whether a driver is drunken or not. The orange coloured solution is taken in a beaker or tube and the driver is asked to breathe into the solution. If colour of the solution changes to green, this means that the dirver is in drunken state. If the colour remains unchanged, this means that the driver has not consumed any alcohol.

Q6. In view of the limited petroleum reserves alternative sources of energy is needed. How can alcohol be used as a source of energy?

Ans. It has been found that absolute alcohol mixed with gasoline and benzene can be used as a motor fuel. That is known as power alcohol and petrol roughly in the ratio–20:80.

Q7. We know that alcohol is used in large quantities in the manufacture of alcohol or pyridine and some colouring matter. alcoholic liquor or beverages throughout the world. If aclohol is used in small quantities, it stimulates the human system without any apparent injurious effects. However, its continuous use can damage the kidneys. What measures could be taken to refrain people from drinking alcohol?

Ans. To refrain people from drinking alcohol, it can be denatured by addition of posionous substances like methyl

V. HOTS Questions

Q1. Give names of the reagents which are used to bring about the following transformations:

(*i*) Ethanoic acid to ethanol (*ii*) Propane–1–ol to propanal

(*iii*) Pent–3–en–2–ol to pent–3–en–2–one (*iv*) Sodium benzoate to benzene

Ans. (*i*) $LiAlH_4/H_3O^+$ (*ii*) PCC

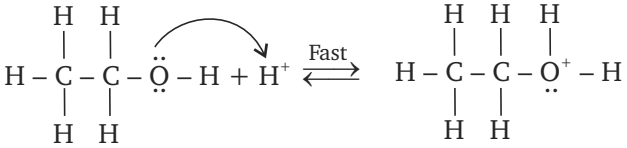
(*iii*) PCC (*iv*) Sodalime

Q2. Write the mechanism of dehydration of ethanol.

Ans. $CH_3CH_2OH \xrightarrow{conc.\ H_2SO_4} CH_2 = CH_2 + H_2O$

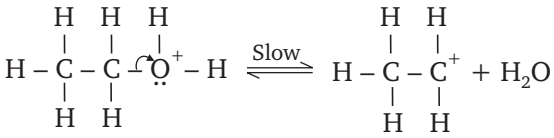
Mechanism

Step 1: Formation of protonated alcohol:

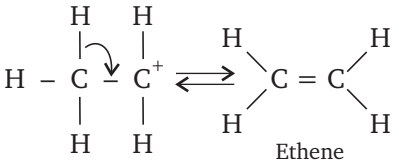


Ethanol — Protonated alcohol (Ethyl oxonium ion)

Step 2: Formation of carbocation: It is the slowest step and hence the rate determining step of the reaction:



Step 3: Formation of ethene by elimination of a proton.



Ethene

Q3. A compound 'A' with molecular formula $C_4H_{10}O$ is unreactive towards sodium metal. It does not add Bromine water and does not react with $NaHSO_3$ solution. On refluxing 'A' with excess of HI, it gives 'B' which reacts with aqueous NaOH to form 'C'. 'C' can be converted into 'B' by reacting with red P and I_2. 'C' on treating with conc. H_2SO_4 forms 'D'. 'D' decolourises bromine water. Identify A to D and write the reactions involved.

Ans. 'A' is not an alcohol therefore it does not react with sodium metal. 'A' is also not an aldehyde or a ketone as it does not react with $NaHSO_3$. 'A' is not an unsaturated hydrocarbon as it does not add Br_2 (*aq*). So, it is likely to be a ether.

$\therefore$

$$\underset{\substack{\text{'A'}\\(C_4H_{10}O)}}{CH_3CH_2OC_2H_5} + \underset{\text{(excess)}}{2HI} \longrightarrow \underset{\text{'B'}}{2C_2H_5I} + H_2O$$

$$\underset{\text{'B'}}{2C_2H_5I} + \underset{\text{(excess)}}{NaOH\ (aq.)} \longrightarrow \underset{\text{'C'}}{C_2H_5OH} + NaI$$

$$\underset{\text{'C'}}{C_2H_5OH} \xrightarrow{P/I_2} \underset{\text{'B'}}{C_2H_5I}$$

$$\underset{\text{'C'}}{C_2H_5OH} \xrightarrow{\textbf{conc.}\ H_2SO_4} \underset{\text{'D'}}{CH_2=CH_2}$$

❑❑