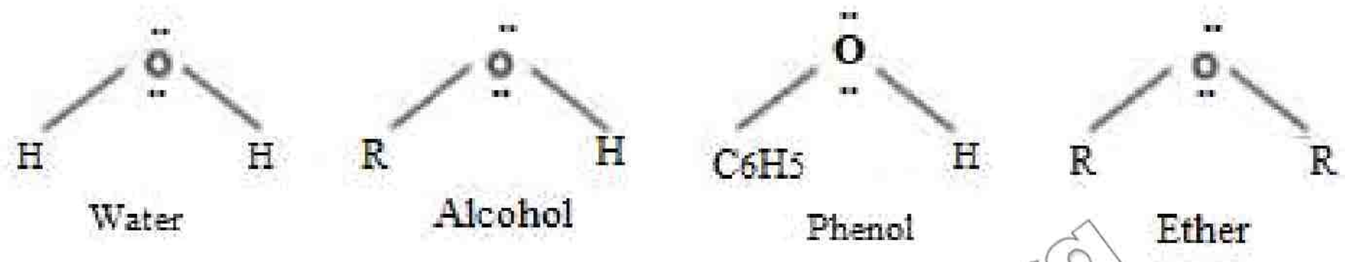
Chapter#11

Alcohols, Phenols and Ethers

1. Why are alcohol, phenol and ether considered as derivatives of water?

Ans: Alcohols, phenols and ethers are classes of organic compounds which are much closer to water in structure and hence considered as derivatives of water.



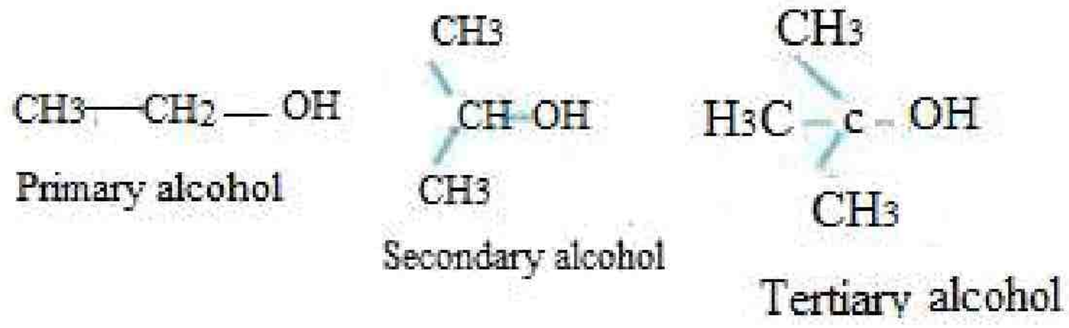
Alcohols and phenols are much more close to one another in structure and properties. Both contain hydroxyl (-OH) group so they may also be termed as hydroxy derivatives of alkanes and benzene respectively. In ether both hydrogens of water are replaced by alkyl or phenyl groups.

2. How are alcohols classified?

Ans: Alcohols are classified into monohydric and polyhydric alcohols. Monohydric alcohols contain one -OH group while polyhydric alcohols may contain two, three or more OH groups and named as dihydric or trihydric alcohols, etc.

3. What are primary, secondary and tertiary alcohols?

Ans: In primary alcohols, -OH functional group is attached with primary carbon atom, in secondary alcohols with secondary carbon atom and in tertiary alcohols it is attached with a tertiary carbon atom.



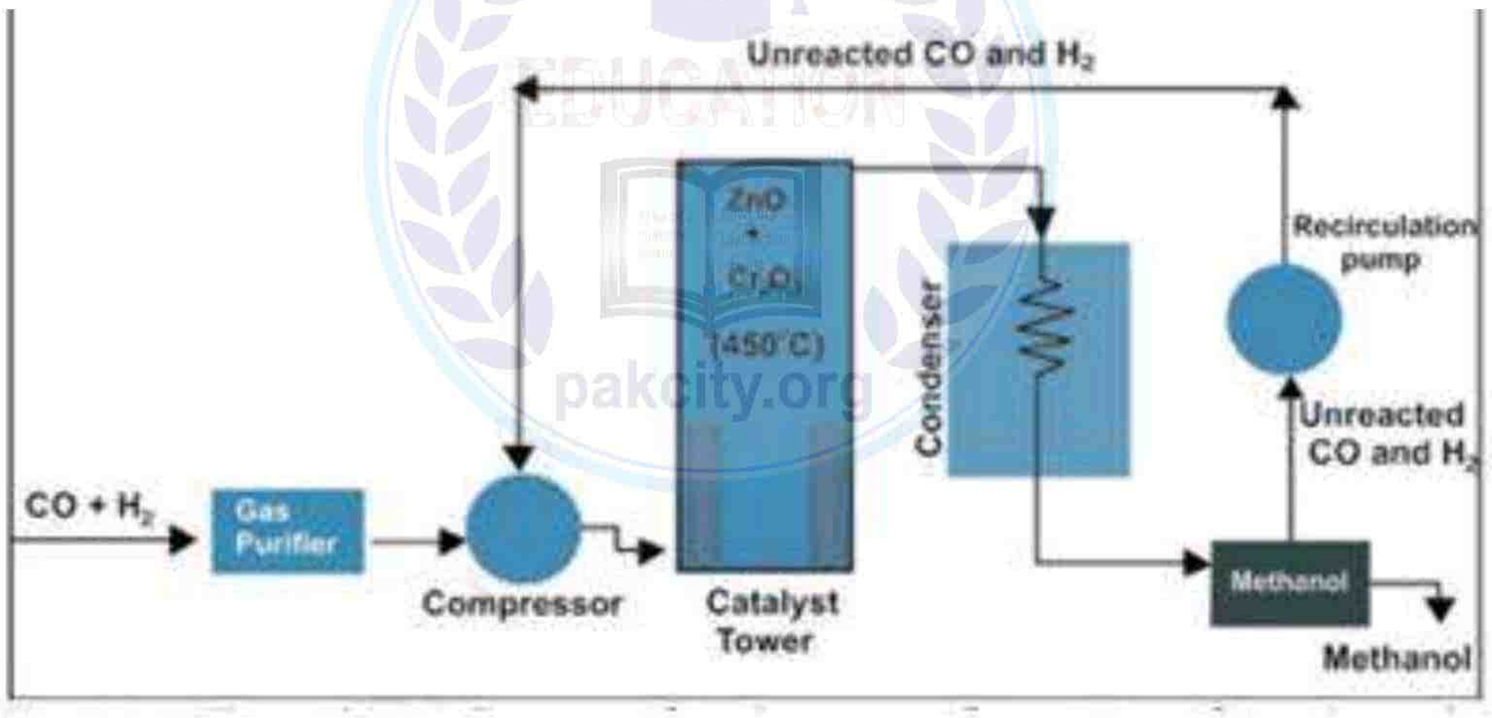
4. What are monohydric alcohols?

Ans: Monohydric alcohols contain one -OH group while polyhydric alcohol as may contain two, three or more OH groups and named as dihydric or trihydric alcohol, etc. Monohydric alcohols are further classified into primary secondary and tertiary alcohols.

5. Write about industrial preparation of methanol OR Give preparation of methanol by reaction between CO and H_2.

Ans: Formerly methanol was prepared by distillation of wood. That is why, it is also called as wood spirit. Now-a-days methanol is prepared from carbon monoxide and hydrogen or water gas as follows:

$$CO + 2H_2 \xrightarrow[450\ ^oC,\ 200\ atm]{(ZnO+Cr_2O_3)} CH_3OH$$



First of all a mixture of carbon monoxide and hydrogen is purified. It is compressed under a pressure of 200 atmospheres and taken into a reaction chamber by means of coiled pipes.

Here the catalyst is heated up to 450-500 °C. Gases react to form methanol vapours. These vapours are passed through a condenser to get methanol. Unreacted gases are recycled through compressor to reaction chamber.

6. Define fermentation. What are the conditions of fermentation? OR Which compound may be obtained by fermentation on industrial scale?

Ans: Ethanol is prepared on industrial scale world over, by the process of fermentation. Fermentation is a biochemical process which occurs in the presence of certain enzymes secreted by microorganisms such as yeast. Optimum temperature for this process of fermentation is 25-35°C. Moreover, proper aeration, dilution of solution and the absence of any preservative are essential conditions for fermentation.

7. Explain industrial preparation of ethanol from molasses.

Ans: **From Molasses**

The residue obtained after the crystallization of sugar from concentrated sugar cane juice is called molasses. It undergoes fermentation in the presence of enzymes present in yeast to give ethanol.

$$\underset{\text{Molasses}}{C_{12}H_{22}O_{11} + H_2O} \xrightarrow[\text{Yeast}]{\text{Invertase}} C_6H_{12}O_6 + C_6H_{12}O_6$$

$$\underset{\text{Glucose}}{C_6H_{12}O_6} \xrightarrow[\text{Yeast}]{\text{Zymase}} 2C_2H_5OH + 2CO_2$$

8. Explain industrial preparation of ethanol from starch.

Ans:

From Starch

From Starch

$$2(C_6H_{10}O_5) + nH_2O \xrightarrow[\text{Yeast}]{\text{Diastase}} nC_{12}H_{22}O_{11}$$

Starch → Maltose

$$C_{12}H_{22}O_{11} + H_2O \xrightarrow[\text{Yeast}]{\text{Maltase}} 2C_6H_{12}O_6$$

Glucose

$$C_6H_{12}O_6 \xrightarrow[\text{Yeast}]{\text{Zymase}} 2C_2H_5OH + 2CO_2$$

9. Why we cannot get ethanol beyond 12 or 14% through fermentation?

Ans: Alcohol obtained by fermentation is only up to 12% and never exceeds 14% because beyond this limit enzymes become inactive.

10. What is rectified spirit or absolute alcohol?

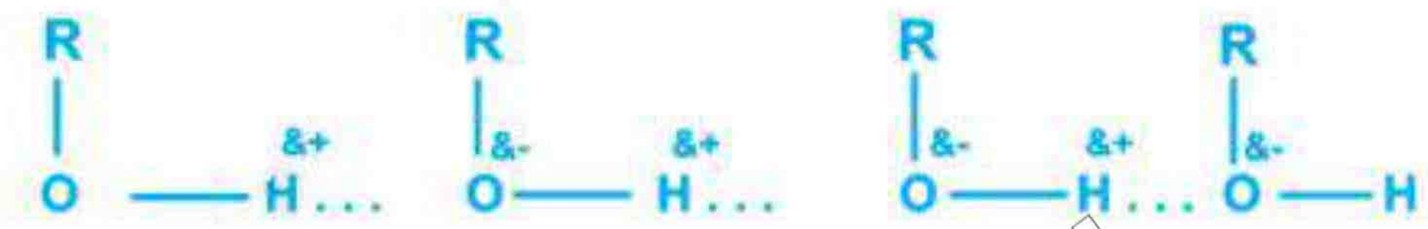
Ans: Alcohol is distilled again and again to obtain 95% alcohol which is called rectified spirit. Absolute alcohol can be obtained by re-distillation of rectified spirit in the presence of CaO which absorbs its moisture.

11. Define denaturing of alcohol OR How methylated spirit is prepared?

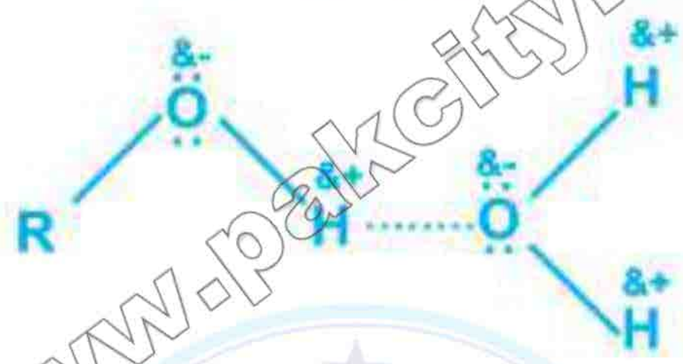
Ans: Sometimes ethanol is denatured by addition of 10% methanol to avoid its use for drinking purposes. Such alcohol is called methylated spirit. A small quantity of pyridine or acetone may also be added for this purpose.

12. Why lower alcohols are soluble in water but higher alcohols insoluble?

Ans: Lower alcohols are soluble in water due to hydrogen bonding but as the chain length increases the solubility decreases as the alkyl chain is non-polar.



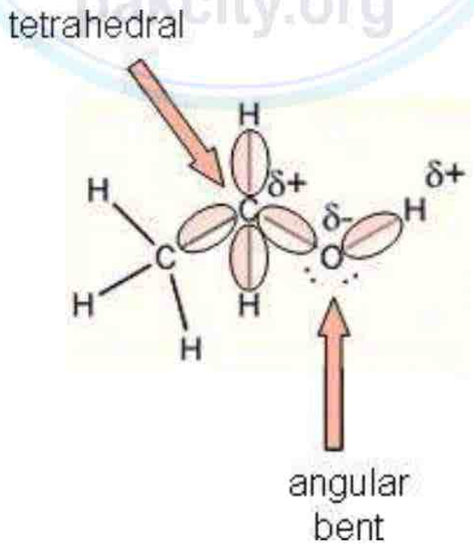
Hydrogen bonding in alcohol



Hydrogen bonding between water and alcohol

13. Why ethanol is more soluble in water than methanol?

Ans: Ethanol is more soluble in water than methanol due to greater charge separation in ethanol. This can be understood well through structure:



partial charge notation

This clears that because of more charges on ethanol it is more soluble in water making stronger hydrogen bonding.

14. How can we distinguish between primary, secondary and tertiary alcohol? OR what is Lucas test?

Ans: Primary, secondary and tertiary alcohols are identified and distinguished by reacting them with conc. HCI in anhydrous $ZnCl_2$.

An oily layer of alkyl halides separates out in these reactions.

1. Tertiary alcohols form an oily layer immediately
2. Secondary alcohols form an oily layer in five to ten minutes.
3. Primary alcohols form an oily layer only on heating

(i) Tertiary alcohols form an oily layer immediately.

$$R_3C\text{-}OH + HCl \xrightarrow[\text{immediately}]{ZnCl_2} R_3C\text{-}Cl + H_2O$$

(ii) Secondary alcohols form an oily layer in 5 to10minutes.

$$R_2CHOH + HCl \xrightarrow[5\text{to}10\text{minutes}]{ZnCl_2} R_2CH\text{-}Cl + H_2O$$

(iii) Primary alcohols form an oily layer only on heating.

$$R\text{-}CH_2OH + HCl \xrightarrow[\Delta]{ZnCl_2} R\text{-}CH_2\text{-}Cl + H_2O$$

15. Distinguish ethanol and tertiary butyl alcohol by Lucas Test.

Ans: Ethanol and tertiary butyl alcohol are distinguished by reacting them with concentrated HCl in anhydrous $ZnCl_2$. An oily layer of alkyl halides separates out in these reactions

1Ethyl alcohol forms an oily layer immediately

$$CH_3\text{-}CH_2OH + HCl \xrightarrow[\Delta]{ZnCl_2} CH_3\text{-}CH_2\text{-}Cl + H_2O$$

2. Tertiary Butyl alcohol forms an oily layer only on heating

$$(CH_3)_3C\text{-}OH + HCl \xrightarrow[\text{immediately}]{ZnCl_2} (CH_3)_3C\text{-}Cl + H_2O$$

16. Which type of reactions is given by alcohols?

Ans: Alcohols react with other reagents in two ways

(i) Reactions in which C — O bond breaks

(ii) Reactions in which O — H bond breaks

17. Give any four uses of Methyl alcohol OR Give uses of methyl alcohol.

Ans: Following are the uses of methyl alcohol:

1. Methanol is widely used in the production of acetic acid and formaldehyde
2. In order to stop use of ethanol for drinking purposes, methanol is often added to it as a denaturant
3. This compound is also used as an antifreeze (an additive that is used to lower the freezing point of a liquid)in many pipelines
4. It is also used as solvent for fats, oils and paints.

18. Write two uses each of methanol and ethanol.

Ans: Uses of methanol

i. Methanol is used as an antifreeze

ii. It is also used as solvent for

fats, oils and paints

Uses of ethanol

i. It is used as a fuel in some countries

ii. It is used as preservative for biological specimens

19. Write any four uses of ethyl alcohol.

Ans: Uses of ethanol are as follows:

(i) It is used as solvent

(ii) It is used as a drink

(iii) It is used as a fuel

(iv) It is used as a preservative for biological specimen.

20. When the C-O bond breaks?

Ans: If a nucleophile attacks, it is the C — O bond which breaks.

$$CH_3—CH_2^{\delta+}OH^{\delta-} \xrightarrow{\text{Nucleophile}} CH_3—CH_2^{+} + OH^{-}$$

21. When the O-H bond breaks?

Ans: If an electrophile attacks on alcohol, it is the O — H bond which breaks.

$$CH_3—CH_2—O^{\delta-}—H^{\delta+} \xrightarrow{\text{Electrophile}} CH_3—CH_2—O^{-} + H^{+}$$

22. How can you distinguish between methanol and ethanol?

Ans: Ethanol gives iodoform with iodine in the presence of NaOH. Formation of yellow crystals indicates that the alcohol is ethanol. Methanol does not give iodoform test.

$$C_2H_5OH + 4I_2 + 6NaOH \rightarrow \underset{\text{Iodoform}}{CHI_3} + HCOONa + 5NaI + 5H_2O$$

$$CH_3OH + I_2 + NaOH \rightarrow \text{No yellow ppt}$$

23. Ethanol gives different products with conc.H_2SO_4 under different conditions.

Justify?

Ans: Ethyl Alcohol gives different products with conc. H_2SO_4 on different temperatures;

At 180 °C with conc. H_2SO_4.

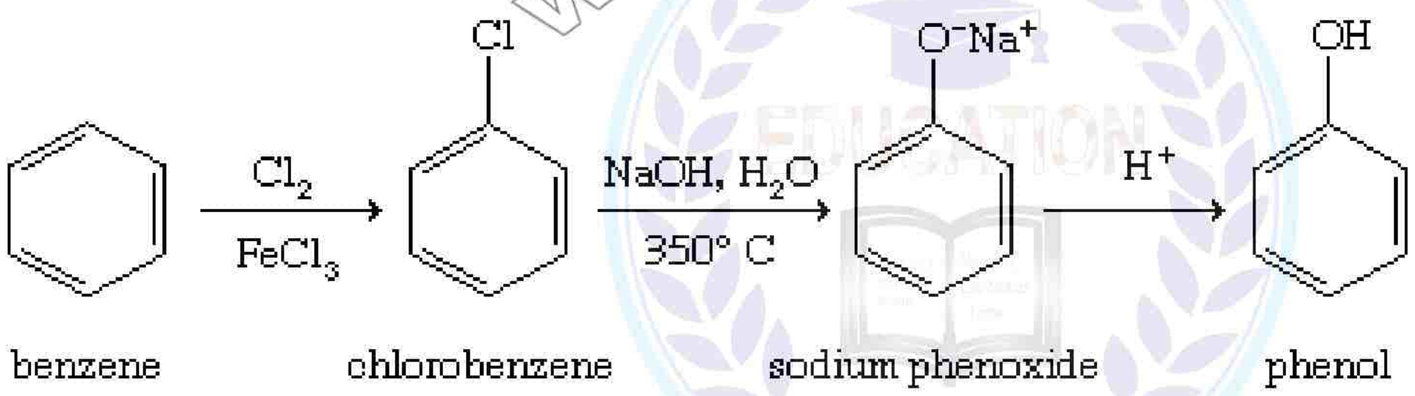
$$C_2H_5\text{-}OH \longrightarrow CH_2= CH_2+ H_20$$

At 140 °C with conc.H_2SO_4.

$$2C_2H_5\text{-}OH \longrightarrow C_2H_5\text{-}O\text{-}C_2H_5+H_20$$

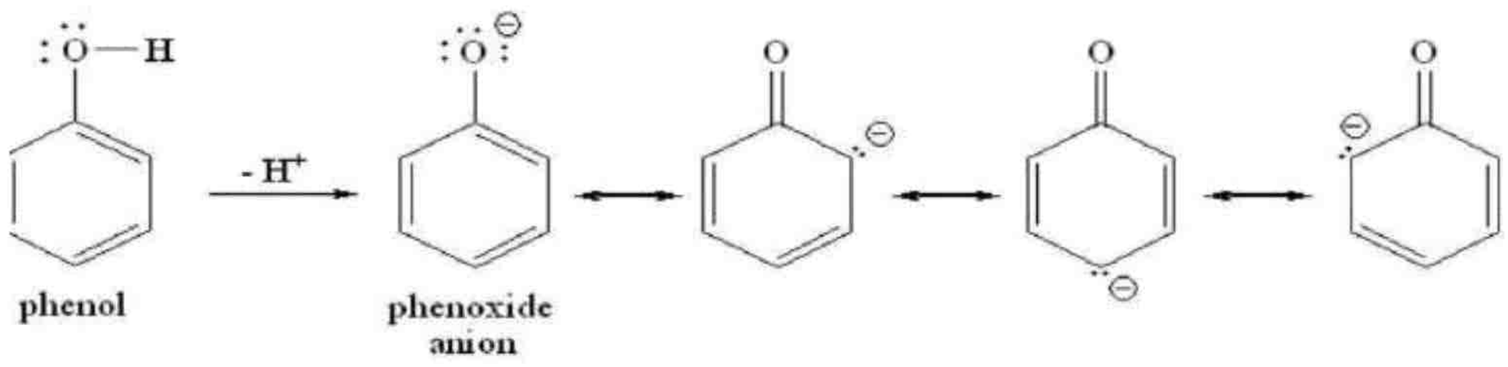
24. Prepare Phenol from Chlorobenzene by Dow's method.

Ans: In this method chlorobenzene is treated with 10%NaOH at 360°C and 150 atmospheres pressure sodium phenoxide is produced which on treating with HCl gives phenol.



25. Explain acidic behaviour of phenol.

Ans: Phenol is much more acidic than alcohols but less acidic than carboxylic acids. It dissolves readily in alkalies but it is too weak to affect the litmus paper or to evolve CO_2 from carbonates. Its dissociation constant (K_a) is $1.3x10^{-10}$.



Phenol is partially soluble in water and its solution has a pH of around 5 or 6. This makes phenol different from aliphatic alcohols. The reason why phenol is acidic lies in the nature of the phenoxide ion. The negative charge on oxygen atom can become involved with the p-electron cloud on the benzene ring. The negative charge is thus delocalized in the ring and the phenoxide ion becomes relatively stable. This type of delocalization is not possible with alcohols.

26. Compare acidic strength of alcohol, phenol, water and carboxylic acid.

carboxylic acid > phenol > water > alcohol

Ans: Relative acidic strength of alcohol, phenol, water, and carboxylic acid is as follows:

Hence, carboxylic acids are more acidic than phenol and alcohol because of greater resonance stabilization of their conjugate base.

27. Compare the reaction of conc.H_2SO_4 with

Ans:

(i) Ethyl alcohol

Ethyl Alcohol gives different products with concH_2SO_4 on different temperatures;

At 180 ^{0}C with conc. H_2SO_4.

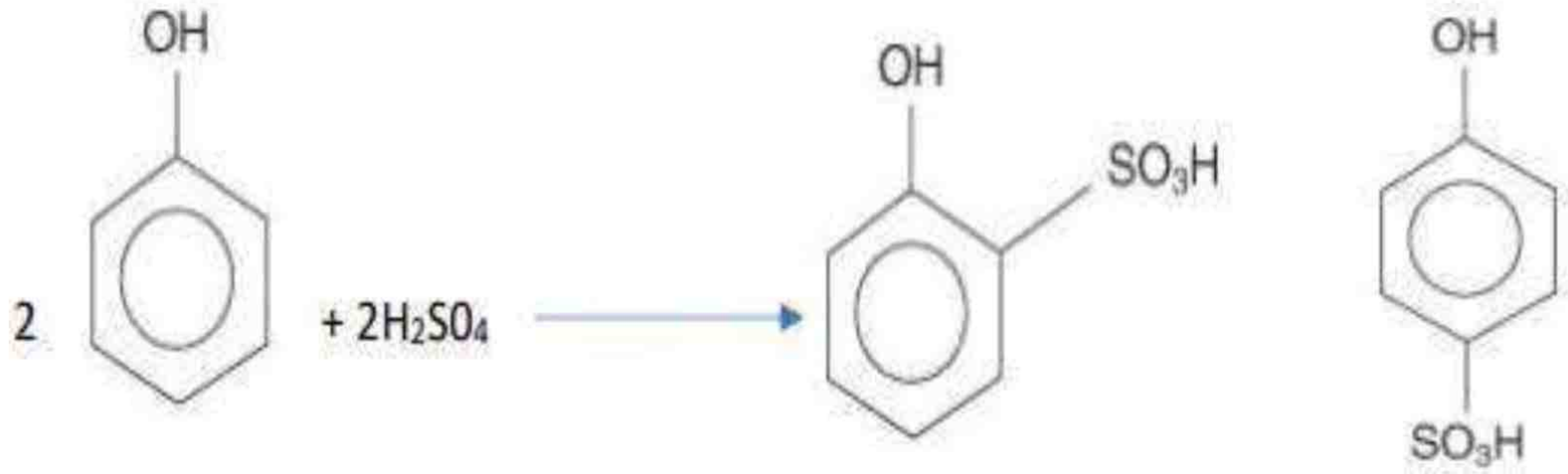
$$C_2H_5\text{-}OH \xrightarrow{} CH_2= CH_2+ H_2O$$

At140 ^{0}C with conc. H_2SO_4.

$$2C_2H_5\text{-}OH \xrightarrow{} C_2H_5\text{-}O\text{-}C_2H_5+H_2O$$

(ii) Phenol.

Phenol reacts with conc. sulphuric acid at room temp.as follows;



o-hydroxybenzene sulphonic acid

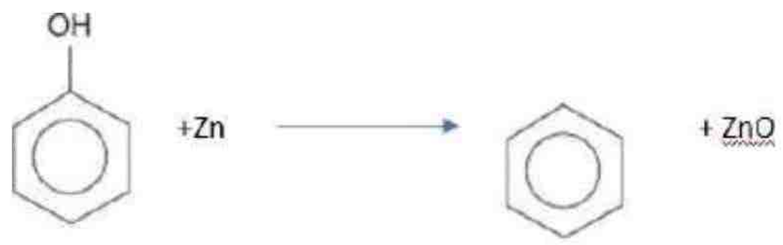
p-hydroxybenzene sulphonic acid

28. Picric acid is a phenol which behaves like an acid. Justify.

Ans: Picric acid 2,4,6-Trinitrophenol has 3 nitro groups present which have electron withdrawing nature. Nitro groups can engage the negative charge on benzene ring in delocalization, setting the proton free for longer time. So picric acid acts as an acid.

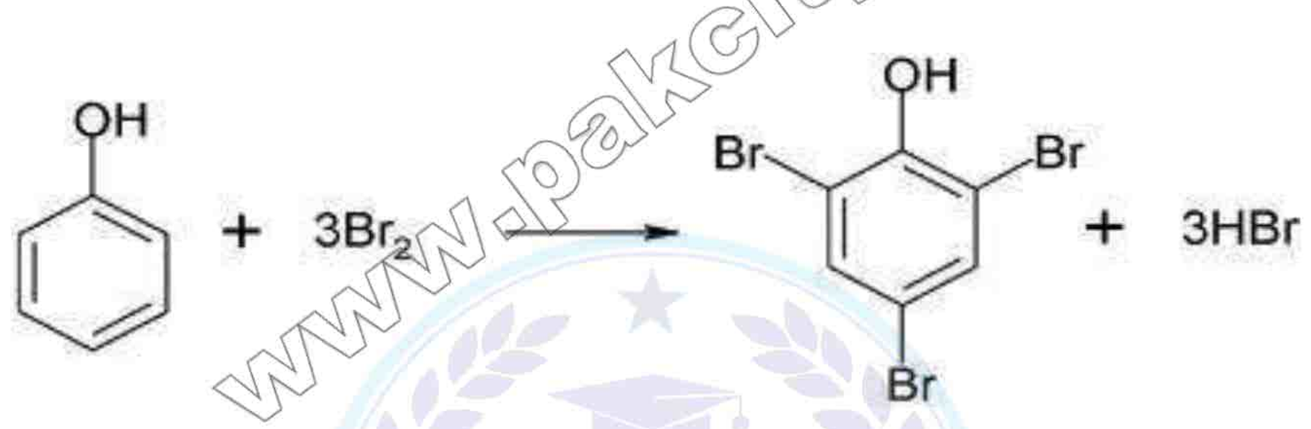
29. How phenol can be converted to benzene?

Ans: Phenol can be converted into Benzene by the reduction with Zinc.



30. How does phenol react with bromine water?

Ans: An aqueous solution of phenol reacts with bromine water to give white ppts of 2,4, 6-Tribromophenol.



31. How does phenol react with alkali?

Ans: Phenol reacts with sodium hydroxide solution to give a colourless solution containing sodium phenoxide.

32. How are ethers classified?

Ans: Ethers are classified into two categories

1. Simple or symmetrical ethers, which contain two same alkyl groups e.g. dimethyl ether CH_3OCH_3 and diethyl ether $CH_3— CH_2— O — CH_2 — CH_3$.

2. Mixed or unsymmetrical ethers, which contain different alkyl or phenyl groups, e.g., ethyl methyl ether $CH_3— O — CH_2 — CH_3$

33. What is Williamson's synthesis?

Ans: Alcohols are reacted with metallic sodium to form alkoxides. This alkoxide ion is a strong nucleophile and readily reacts with alkyl halide to produce ether. This method is called Williamson's synthesis.

$$2C_2H_5OH+2Na \longrightarrow 2C_2H5O^-Na^+ + H_2$$

$$C_2H_5O^-Na^+ + C_2H_5Br \longrightarrow C_2H_5OC_2H_5 + NaBr$$

34. How will you convert:

Ans:

iii. Methanol into Ethanol

$$CH_3OH \xrightarrow{HI} CH_3I$$

$$CH_3I + Mg \xrightarrow{Ether} CH_3MgI$$

$$CH_3MgI + HCHO \xrightarrow{H3O^+} CH_3CH_2OH$$

iv. Ethanol into Methanol

$$CH_3CH_2OH + H_2SO_{4\,(conc.)} \xrightarrow{170-180C} CH_2=CH_2$$

$$CH_2=CH_2 + Zn/H_2O \xrightarrow{Ozonolysis} 2HCHO$$

$$HCHO \xrightarrow{LiAlH} CH_3OH$$

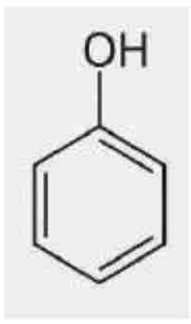
Ans:

v.		Methoxyethane	CH_3-O-CH_3
vi.		Ethoxybenzene	C_6H_5-O-C_2H_5

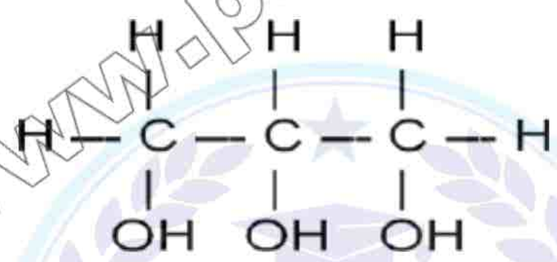
36. Write structural formulas of:

Ans:

i. Carbolic acid



ii. Glycerol

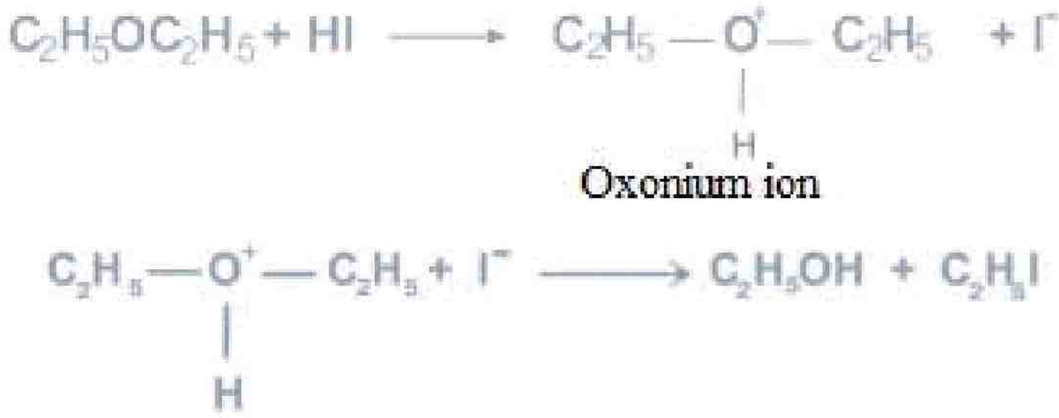


37. Why ethers are referred to as inert compounds?

Ans: Ethers are comparatively inert substances. The reagents like ammonia, alkalies, dilute acids and metallic sodium, have no reaction on ethers in cold state. Moreover, they are not oxidized or reduced easily. That's why ethers are considered as inert.

38. Explain chemical reactivity of ethers.

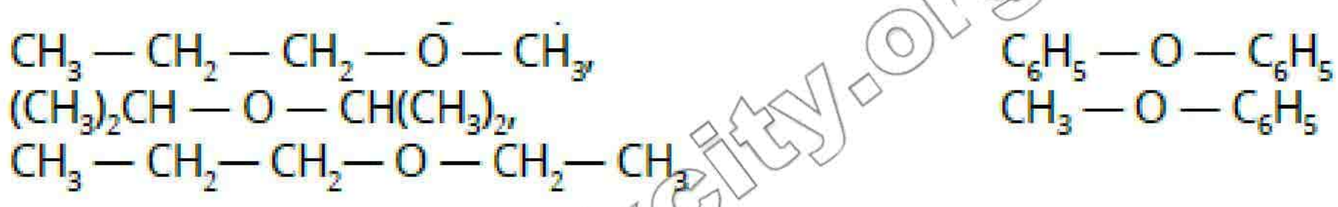
Ans: Ethers are comparatively inert substances. The reagents like ammonia, alkalies, dilute acids and metallic sodium, have no action on ethers in cold state. Moreover, they are not oxidized or reduced easily. However ethers show some reactions, e.g.



1. With hydrogen iodide ethers give alcohols which can react further to give alkyl iodides.

2. Ethers also react with hot phosphorus pentachloride to give alkyl chloride.

39. Name the following compounds



Ans:

$CH_3-CH_2-CH_2-O-CH_3$	Methoxy propane
$C_6H_5-O-C_6H_5$	Phenoxy benzene
$(CH_3)_2CH-O-CH(CH_3)_2$	Isopropoxy iso-propane
$CH_3-O-C_6H_5$	Methoxy benzene
$CH_3-CH_2-CH_2-O-CH_2-CH_3$	Ethoxy propane

40. Write the structural formulas of the following compounds

Ans:

(i) Methoxy ethane $CH_3-O-C_2H_5$

(ii) Ethoxy benzene $C_2H_5\text{-}O\text{-}C_6H_5$

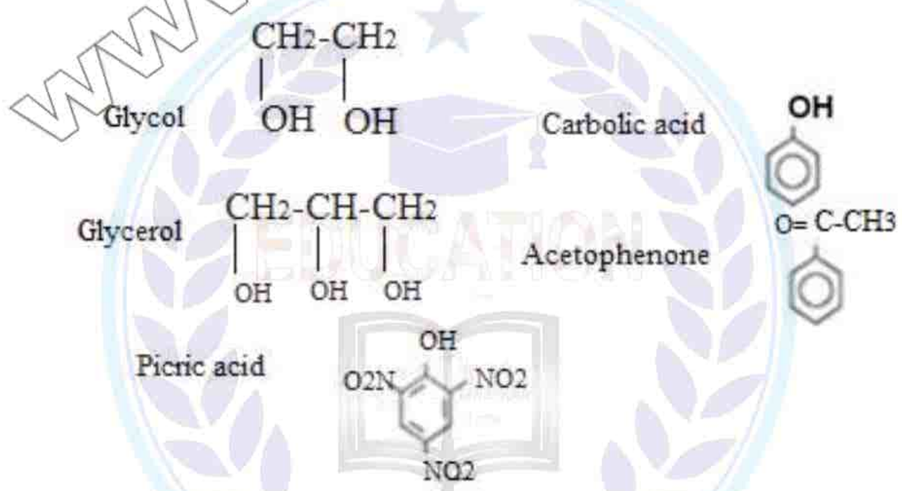
(iii) Sodium ethoxide $CH_3CH_2\overset{-}{O}\overset{+}{Na}$

(iv) Sodium phenoxide 

(v) Propoxy propane $CH_3\text{-}CH_2\text{-}CH_2\text{-}O\text{-}CH_2\text{-}CH_2\text{-}CH_3$

41. Write structural formulas of the following compounds

Ans:



42. Write IUPAC names of the following compounds

Ans:

(i)	$(CH_3)_2CH\text{–}OH$	2-propanol
(ii)	$(CH_3)_2CHCH_2OH$	2-methyl-1-propanol
(iii)	$(CH_3)_3COH$	2-methyl-2-propanol
(iv)	$C_2H_5\text{–}\underset{\displaystyle CH_3}{\underset{\vert}{CH}}\text{–}OH$	2-butanol

43. Explain the following terms using ethyl alcohol as an example

i) Oxidation ii) Dehydration iii) Esterification
iv) Ether formation

Ans:

Oxidation

Ethyl alcohol on oxidation changes to acetaldehyde and finally acetic acid.

Mixture of $K_2Cr_2O_7$ and conc. H_2SO_4 is a good oxidizing agent.

$$CH_3\text{-}CH_2\text{-}OH + [O] \xrightarrow[H_2SO_4]{K_2Cr_2O_7} CH_3CHO + H_2O$$

$$CH_3CHO + [O] \longrightarrow CH_3COOH$$

Dehydration

Ethyl alcohol when reacted with conc. H_2SO_4 at 180 ºC releases water. This phenomenon is called dehydration.

$$CH_3 - CH_2 - OH \xrightarrow[180°C]{\text{Conc. } H_2SO_4} CH_2 = CH_2 + H_2O$$

Esterification

When excess amount of ethyl alcohol reacts with less amount of conc. H_2SO_4 at 140 ºC ether is formed.

$$C_2H_5OH + CH_3COOH \xrightarrow{H_2SO_4} CH_3COOC_2H_5 + H_2O$$

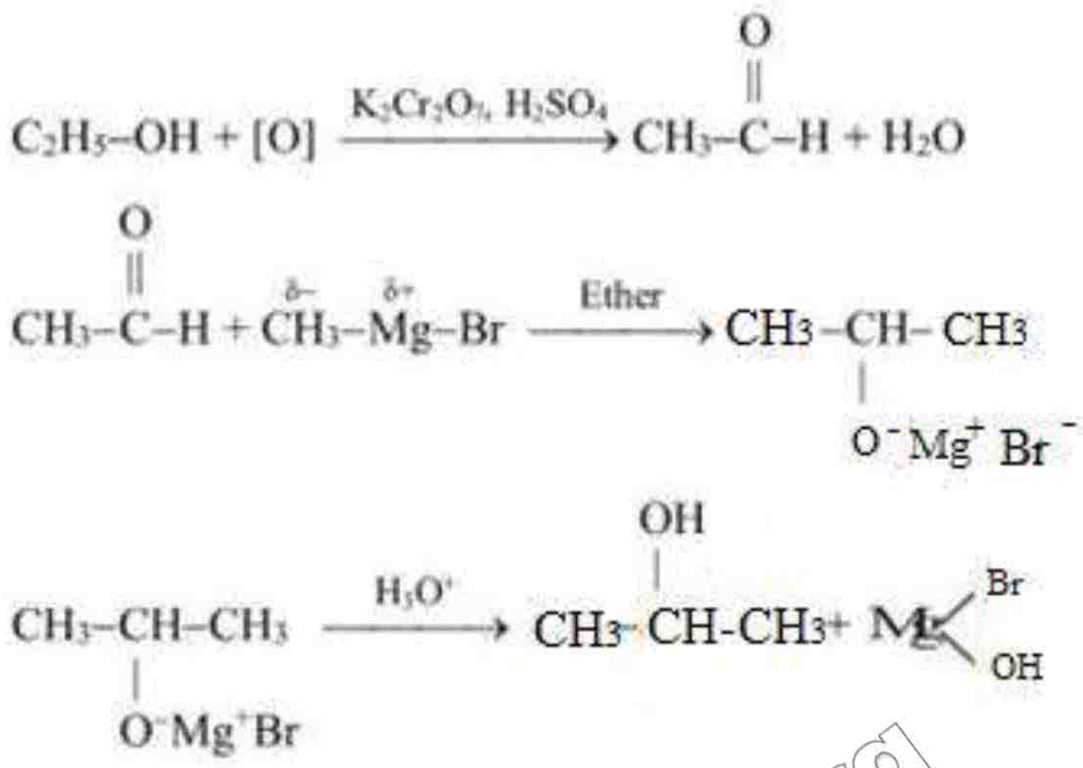
Ether Formation

When excess amount of ethyl alcohol reacts with less amount of conc. H_2SO_4 at 140 ºC then ether is formed as a product.

$$CH_3CH_2OH + CH_3CH_2O \xrightarrow{H_2SO_4/140\ ^oC} CH_3CH_2OCH_2CH_3$$

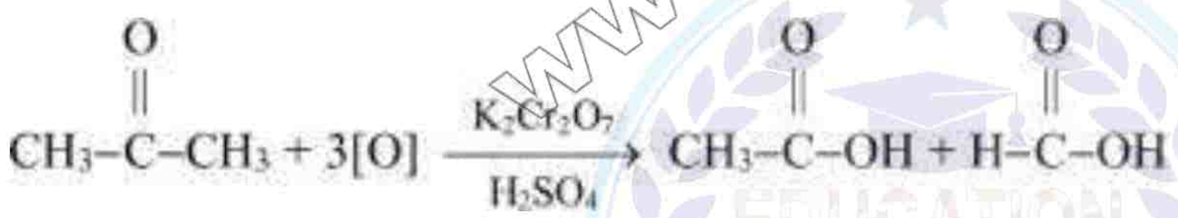
44. How will you convert ethanol into isopropyl alcohol?

Ans:



45. How will you convert acetone into ethyl alcohol?

Ans:



46. How will you convert formaldehyde into ethyl alcohol?

Ans:

47. Ethyl alcohol is a liquid while methyl chloride is a gas. Why?

Ans: Ethyl alcohol has strong hydrogen bonding between its molecules whereas methyl chloride does not have rather its molecules experience weaker dipole-dipole forces.

Therefore, ethyl alcohol is a liquid while methyl chloride is a gas.

48. Ethanol has higher boiling point than diethyl ether. Why?

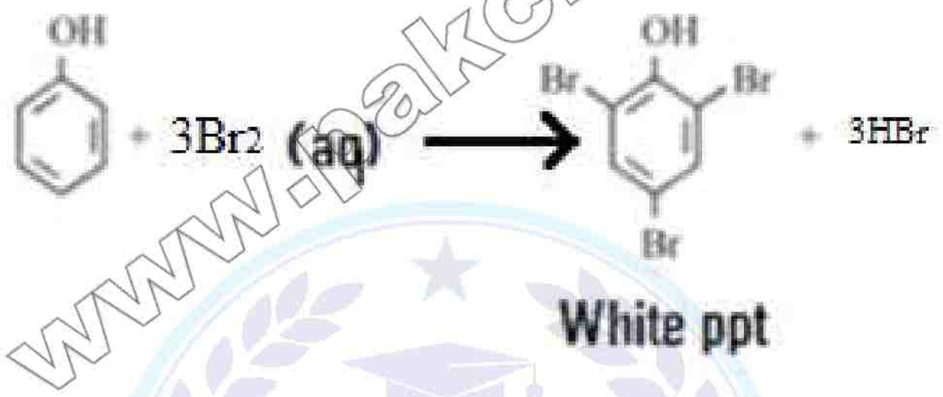
Ans: Due to strong hydrogen bonding in ethanol it has higher boiling point than diethyl ether.

49. Why water has higher boiling point than ethanol?

Ans: In water there is strong three-dimensional hydrogen bonding due to only one hydrogen bond per molecule. Hence, boiling point of water is higher than ethanol.

50. How will you distinguish between an alcohol and a phenol?

Ans: Phenol gives white ppt. with bromine water while alcohols do not react with bromine water.



51. How will you distinguish between an alcohol and an ether?

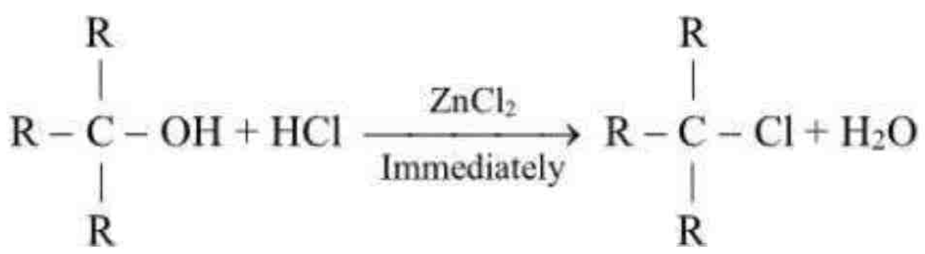
Ans: Alcohols give an oily layer of alkyl halides while reacting with conc. HCl in anhydrous $ZnCl_2$

$$R\text{-}CH_2\text{-}OH + HCl \xrightarrow{ZnCl_2/Heat} R\text{-}CH_2\text{-}Cl + H_2O$$

Ethers do not give this reaction

52. How will you distinguish between a tertiary alcohol and a primary alcohol?

Ans: Tertiary alcohols form an oily layer immediately when reacted with conc. HCl in anhydrous $ZnCl_2$



While primary alcohols form an oily layer on heating

$$R\text{–}CH_2\text{–}OH + HCl \xrightarrow[\text{Heat}]{ZnCl_2} R\text{–}CH_2\text{–}Cl + H_2O$$

53. How will you distinguish between 1-propanol and 2-propanol?

Ans: We can distinguish between 1-propanol and 2-propanol by Lucas test

$$CH_3\text{–}CH_2\text{–}CH_2\text{–}OH + HCl \xrightarrow[\text{Heat}]{ZnCl_2} CH_3\text{–}CH_2\text{–}CH_2\text{–}Cl + H_2O$$

$$CH_3\text{–}\underset{\displaystyle OH}{\underset{|}{CH}}\text{–}CH_3 + HCl \xrightarrow[\text{5-10 min}]{ZnCl_2} H\text{–}\underset{\displaystyle CH_3}{\underset{|}{C}}\text{–}Cl + H_2O$$

2-propanol