Class : Chemistry
Class : XI

Kannada

HYDROCARBONS

Classification

- Types of carbon-carbon bonds present, they can be classified into three main categories - (i) saturated (ii) unsaturated and (iii) aromatic

Alkanes

- Alkanes are inert under normal conditions as they do not react with acids. bases and other reagents.
- The general formula for the alkane homologous series is C_nC_{2n+2}.
- Saturated open chain hydrocarbons containing carbon - carbon single bonds.
- Methane has a tetrahedral structure in which all $H-C-H$ bond angles are of $109.5°$

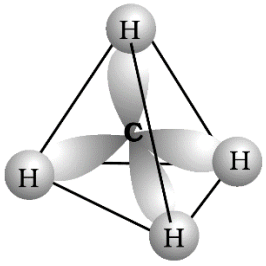
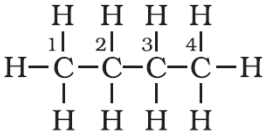


Fig.:-Structure of Methane

Nomenclature and Isomerism:

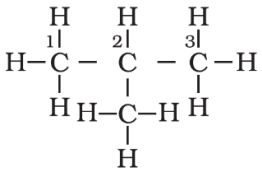
For C_4H_{10}

I



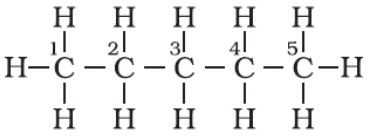
Butane (*n*- butane), (b.p. 273 K)

II



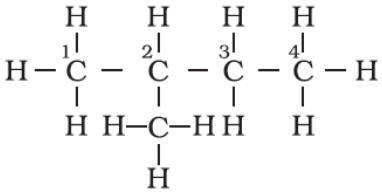
2-Methylpropane (isobutane)
(b.p.261 K)

III



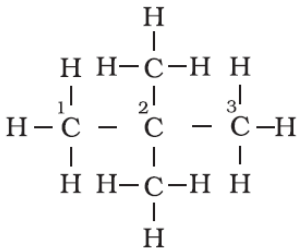
Pentane (*n*-pentane)
(b.p. 309 K)

IV



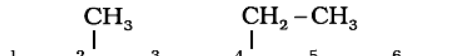
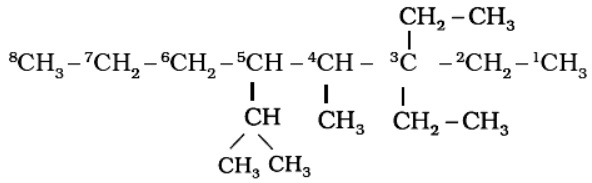
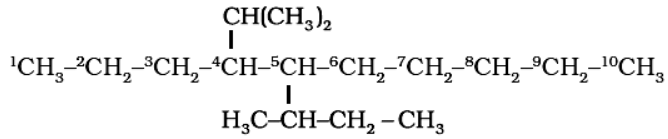
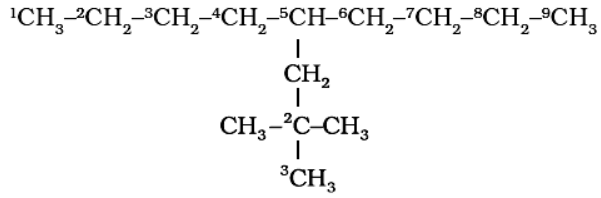
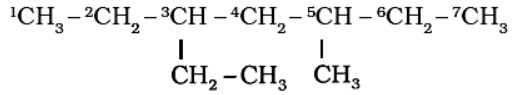
2-Methylbutane (isopentane)
(b.p. 301 K)

V



2,2-Dimethylpropane (neopentane)
(b.p. 282.5 K)

Table: Nomenclature of a Few Organic compounds

Structure and IUPAC Name	Remarks
(a)  (4 – Ethyl – 2 – methylhexane)	Lowest sum and alphabetical arrangement
(b)  (3,3-Diethyl-5-isopropyl-4-methyloctane)	Lowest sum and alphabetical arrangement
(c)  5-*sec*– Butyl-4-isopropyldecane	*sec* is not considered while arranging alphabetically; isopropyl is taken as one word
(d)  5-(2,2– Dimethylpropyl)nonane	Further numbering to the substituents of the side chain
(e)  3–Ethyl–5–methylheptane	Alphabetical priority order

Preparation :

From unsaturated hydrocarbons

Hydrogenation :

- $CH_2 = CH_2 + H_2 \xrightarrow{Pt/Pd/Ni} CH_3 - CH_3$

  Ethene Ethane
- $CH_3 - CH = CH_2 + H_2 \xrightarrow{Pt/Pd/Ni} CH_3 - CH_2 - CH_3$
- Propene Propane
- $CH_3 - C = C - H + 2H_2 \xrightarrow{Pt/Pd/Ni} CH_3 - CH_2 - CH_3$
- Propyne Propane

From alkyl halides :

- Reduction with zinc and dilute hydrochloric
- $CH_3 - Cl + H_2 \xrightarrow{Zn.H^+} CH_4 + HCl$

  Chloromethane Methane
- $CH_3CH_2CH_2Cl + H_2 \xrightarrow{Zn.H^+} CH_3CH_2CH_3 + HCl$

  1-Chloropropane Propane

Wurtz reaction :

- $\underset{\text{Bromomethane}}{CH_3Br} + 2Na + BrCH_3 \rightarrow CH_3 - \underset{\text{Ethane}}{CH_3} + 2NaBr$

From carboxylic acids:

- $CH_3COO^-Na^+ + NaOH \xrightarrow[\Delta]{CaO} CH_4 + Na_2CO_3$

  Sodium ethanoate

  Kolbe's electrolytic method

  $2CH_3COO^-Na^+ + 2H_2O \xrightarrow{\text{Electrolysis}} CH_3 - CH_3 + H_2 + 2NaOH$

  Sodium acetate

Physical properties :

- Alkanes are almost non-polar molecules because of the covalent nature of $C-C$ and $C-H$ bonds and due to very little difference of electronegativity between carbon and hydrogen atoms.
- Due to weak vander waals forces $C_1 - C_4$ are gases, $C_5 - C_{17}$ are liquids and those containing 18 C atoms or more solids at 298 K.
- Alkanes are colourless and odourless.
- Petrol and lower fractions of petroleum are also used for dry cleaning of clothes to remove grease stains.
- With increase in molecular mass. Boiling point increases.
- With the increase in number of branched chains in the structure boiling point decreases due to smaller area of contact and weak intermolecular forces.

Chemical properties :

Substitution reactions :

- **Halogenation :**
- $CH_4 + Cl_2 \xrightarrow{h\nu} CH_3Cl + HCl$

  Chloromethane
- $CH_3Cl + Cl_2 \xrightarrow{h\nu} CH_2Cl_2 + HCl$

  Dichloromethane
- $CH_2Cl_2 + Cl_2 \xrightarrow{h\nu} CHCl_3 + HCl$

  trichloromethane
- $CHCl_3 + Cl_2 \xrightarrow{h\nu} CCl_4 + HCl$

  tetrachloromethane

Rute of replacement of hydrogens of alkanes is : $3^\circ > 2^\circ > 1^\circ$.

Rute of reaction of alkanes with halogens is $F_2 > Cl_2 > Br_2 > I_2$.

Iodination can be carried out in the presence of oxidizing agent, like HIO_3 or HNO_3.

$CH_4 + I_2 = CH_3I + HI$

$HIO_3 + 5HI \longrightarrow 3I_2 + 3H_2O$

Mechanism :

Initiation : $Cl - Cl \underset{\text{hydrolysis}}{\overset{h\nu}{\rightarrow}} \underset{\text{Chlorine free radicals}}{\dot{C}l + \dot{C}l}$

Propagation :

(a) $CH_4 + \dot{C}l \rightarrow \dot{C}H_3 + H - Cl$

(b) $\dot{C}H_3 + Cl - Cl \xrightarrow{hv} CH_3 - Cl + \dot{C}l$

Chlorine free radical

Termination:

(a) $\dot{C} + \dot{C} \rightarrow Cl - Cl$

(b) $H_3\dot{C} + \dot{C}H_3 \rightarrow H_3C - CH_3$

(c) $H_3\dot{C} + \dot{C}l \rightarrow H_3C - Cl$

Combustion:

$$C_4H_{10}(g) + 13/2O_2(g) \longrightarrow 4CO_2(g) + 5H_2O(l)$$

$$C_nH_{2n+2} + \left(\frac{3n+1}{2}\right)O_2 \longrightarrow nCO_2 + (n+1)H_2O$$

Controlled oxidation:

- $2CH_4 + O_2 \xrightarrow{Cu/523/100atm} \underset{\text{Methanol}}{2CH_2OH}$
- $CH_4 + O_2 \xrightarrow[\Delta]{Mo_2O_2} \underset{\text{Methanal}}{HCHO} + H_2O$
- $2CH_3CH_3 + 3O_2 \xrightarrow[\Delta]{(CH_3COO)_2Mn} \underset{\text{Ethanoic acid}}{2CH_3COOH} + 2H_2O$
- Alkanes having tertiary H atom can be oxidized by potassium permanganate

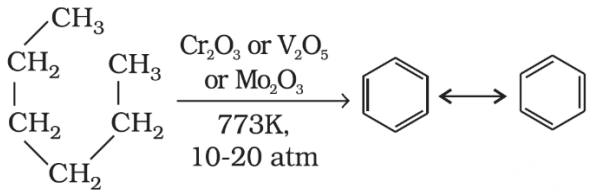
$\underset{\text{2-Metlylpropane}}{(CH_3)_3CH} \xrightarrow[\text{Oxidation}]{KMnO_4} \underset{\text{2-Methylpropan-2-ol}}{(CH_3)_3COH}$

Isomerisation :

$$\underset{\text{n-Hexane}}{CH_3(CH_2)_4CH_3} \xrightarrow{\text{Anhy.}AlCl_3/HCl} CH_3\underset{\displaystyle CH_3}{\underset{|}{CH}}\text{-}(CH_2)_2\text{-}CH_3 + CH_3\text{-}CH_2\text{-}\underset{\displaystyle CH_3}{\underset{|}{CH}}\text{-}CH_2\text{-}CH_3$$

3-Methylpentane

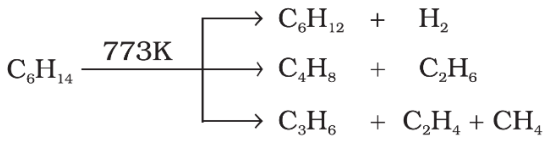
Aromatization



Reaction with steam:

$\underset{\text{n-Hexane}}{CH_4H_2O} \xrightarrow[\Delta]{Ni} CO + 3H_2$

Pyrolysis: Higher alkanes on heating to higher temperature decompose into lower alkanes, alkenes etc.



Conformations:

- Spatial arrangements of atoms which can be converted into one another by rotation around a $C-C$ single bond are called conformations or enfformers or rotamers.

Conformations of ethane :

- The rotation around $C-C$ bond results into infinite number of spatial arrangements of H atoms attached to one C atom with respect to the hydrogen atoms attached to other C atom. These are called conformation isomers.
- **Eclipsed conformation :** In which hydrogen atoms attached to two carbon atoms are as closed as possible.
- **Staggered conformation:** In which hydrogen atoms are as for apart as possible.

Skew conformation: intermediate conformation between eclipse and 5 staggered conformation.
Eclipsed and staggered conformation can be represented by Sawhorse and Newman projections.
Sawhorse projections :

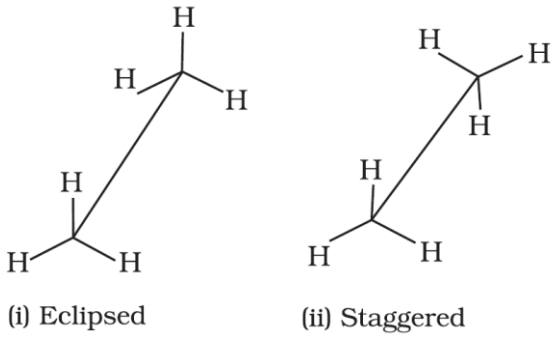
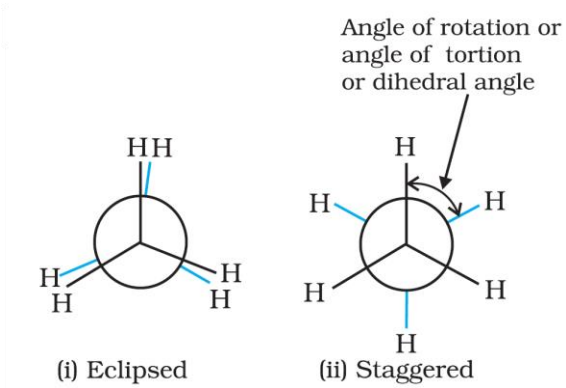


Fig.: Sawhorse projections of ethane

Newman projections :



- Fig.: Newman's projections of ethane

- Staggered > Eclipsed
(least torsional strain) (move torsional strain)

Alkenes

- General formula for alkenes is C_nH_{2n}.
- Alkenes are also known as olefins (oil forming)
- Structure of Double Bond: The presence of the pi (π) bond make behave as sources of loosely held mobile electrons. Therefore, alkene easily attacked by electrophilic reagents.

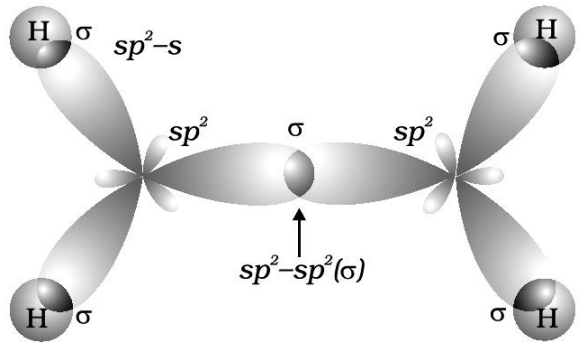


Fig.: Orbital picture of ethene depicting σ bonds only

Nomenclature : The longest chain of carbon atoms containing the double bond is selected.

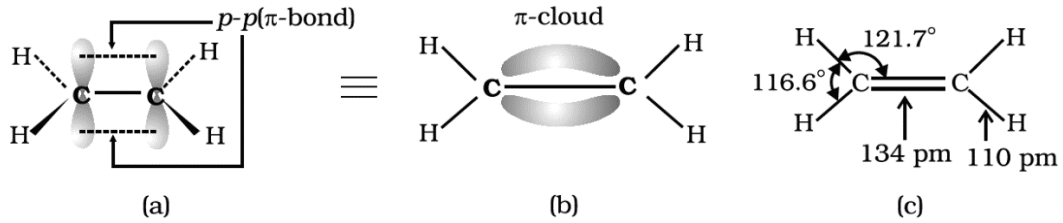


Fig.: Orbital picture of ethene showing formation of (a) π-bond,
(b) π-cloud and (c) bond angles and bond lengths

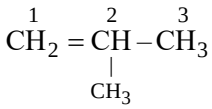
The suffix 'ene' replaces 'ane' of alkanes.

Structure	**IUPAC name**
$CH_3 - CH = CH_2$	Propene
$CH_3 - CH_2 - CH = CH_2$	But - 1 - ene
$CH_3 - CH^2 = CH - CH_3$	But-2-ene
$CH_2 = CH - CH = CH_2$	Buta - 1,3 - diene
$CH_2 = \underset{\displaystyle CH_3}{\overset{\displaystyle \vert}{C}} - CH_3$	2-Methylprop-1-ene
$CH_2 = CH - \underset{\displaystyle CH_3}{\overset{\displaystyle \vert}{CH}} - CH_3$	3-Methylbut-1-ene

Isomerism:

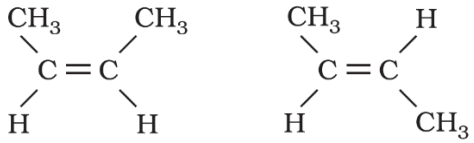
Structural isomerism : Alkenes possessing C_4H_8 as molecular formula can be written in the following three ways:

- $\overset{1}{CH_2} = \overset{2}{CH} - \overset{3}{CH_2} - \overset{4}{CH_3}$
  But-1-ene
  (C_4H_8)
- $\overset{1}{CH_2} - \overset{2}{CH} = \overset{3}{CH} - \overset{4}{CH_3}$

- But-2-ene
  (C_4H_8)
- 
- 2-Methylprop-1-ene
  (C_4H_8)

Geometrical Isomerism:

- Restricted rotation of atoms or groups around the doubly bonded carbon atoms gives rise to different geometries stereoisomers of this type are called geometrical isomers:



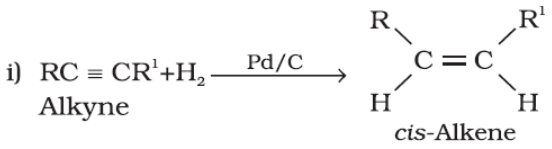
cis-But-2-ene *trans*-But-2-ene

trans-But-2-ene identical atoms lie identical groups lie

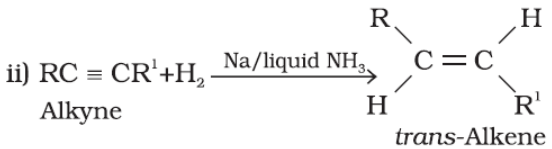
- Due to different arrangement of atoms in space, these isomers differ in their properties.

	Property	**cis isomer**	**Trans isomer**
1	Polarity	More polar	Less polar
2	Dipole moment	Dipole moment ($\mu = 0.33\Delta$)	Dipole moment = 0 (μ)
3	Melting point/ Boiling point	b.p. 277K	b.p. 274 K

- **Preparation:**
- **From alkynes:**

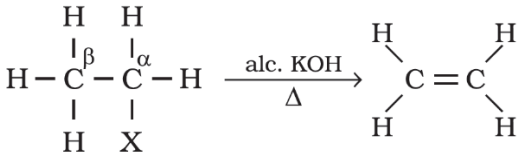


cis-Alkene



- *trans*-Alkene

- **From Alkyl halides:**



(X = Cl, Br, I)

(Dehydrohalogenation ß-elimination reaction)

- For halogens, the rate is: iodine > bromine > chlorine, while for alkyl groups it is : tert > secondary > primary.

- **From vicinal dihalides:**

  by dehalogenation :

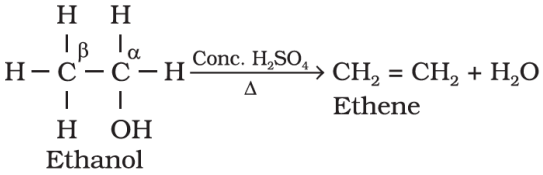
- $CH_2Br - CH_2Br + Zn \longrightarrow CH_2 = CH_2 + ZnBr_2$

  Ethene

  $CH_3CHBr - CH_2Br + Zn \longrightarrow CH_3CH = CH_2 + ZnBr_2$

  propene

- **From alcohols by acidic dehydration:**



(ß-elimination reaction)

Physical properties :

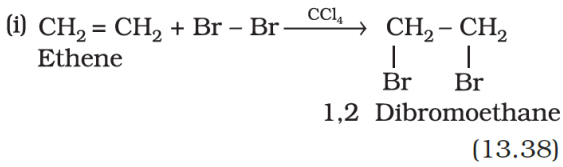
- The first three members are gases, the next fourteen are liquids and the higher ones are solids.
- Insoluble in water but fairly soluble in nonpolar solvents like benzene, petroleum ether.
- Straight chain alkene have higher boiling point than isomeric branched chain compounds.

Chemical properties:

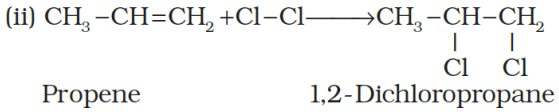
- **Addition of dihydrogen :**

- $CH_2 = CH_2 + H_2 \xrightarrow{Pt/Pd/Ni} CH_3 - CH_3$

- **Addition of halogens :**



(13.38)



1,2-Dichloropropane

(brown colour disappear)

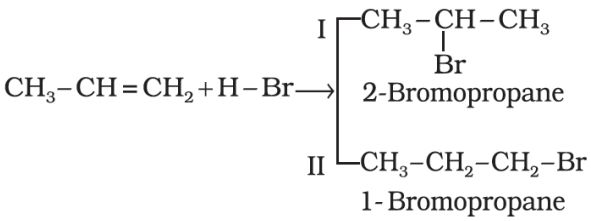
Addition of hydrogen halides:

- The order of reactivity of the hydrogen halides is HI > HBr > HCl.
- Addition reactions of HBr to symmetrical alkenes (similar groups attached to double bond) take place by electrophilic addition mechanism.

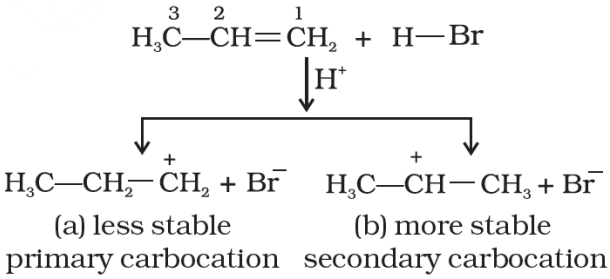
- $CH_2 = CH_2 + H - Br \longrightarrow CH_3 - CH_2 - Br$

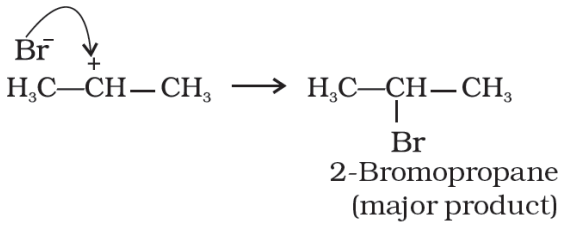
  $CH_3 - CH = CH - CH_3 + HBr \rightarrow CH_3 - CH_2 - CHBrCH_3$

- Addition reaction of HBr to unsymmetrical alkenes (Markovnikov rule)
- Markovnikov rule states that negative part of the addendum (adding molecule) gets attached to that carbon atom which possesses lesser number of hydrogen atoms.

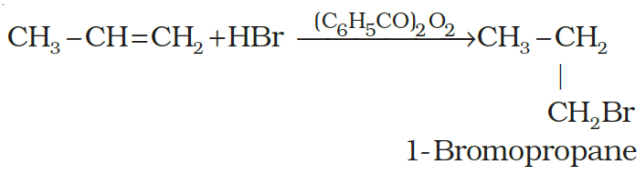


- **Mechanism :** Hydrogen bromide provides an electrophile, H^+, which attacks the double bond to form carbocation as shown below :





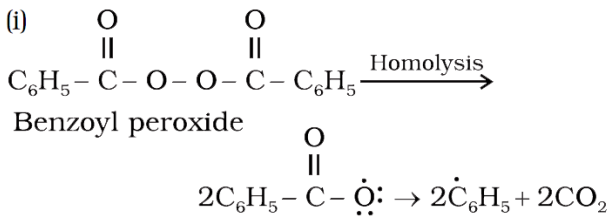
Anti Markovnikov addition or peroxide effect or Kharash effect:

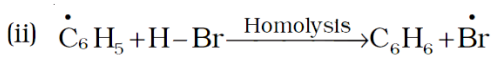


- This reaction is known as peroxide or Kharash effect or addition reaction anti to Markovnikov rule.

Mechanism :

- Benzoyl peroxide





(iii) $CH_3—CH=CH_2 + \dot{B}r$

Homolysis

$CH_3—\dot{C}H—CH_2Br$ (a) (less stable primary free radical)

$CH_3—CH—\dot{C}H_2—Br$ (b) (more stable secondary free radical)

(iv) $CH_3-\dot{C}H-CH_2Br + H-Br \xrightarrow{\text{Homolysis}} CH_3-CH_2-CH_2Br + \dot{B}r$ (major product)

(v) $CH_3-\underset{Br}{CH}-\dot{C}H_2 + H-Br \xrightarrow{\text{Homolysis}} CH_3-\underset{Br}{CH}-CH_3 + \dot{B}r$ (minor product)

- The peroxide effect is not observed in addition of HCl and HI. This may be due to the fact that the $H-Cl$ bond being stronger ($430.5\ kJ\ mol^{-1}$) than $H-Br$ bond ($363.7\ kJ\ mol^{-1}$), is not cleaved by the free radical. Whereas the $H-1$ bond is weaker ($296.8\ kJ\ mol^{-1}$) and iodine free radicals combine to form iodine molecules instead of adding to the double bond.

Addition of Sulphuric acid:

$CH_3-CH=CH_2 + HOSO_2OH \rightarrow CH_3-\underset{OSO_2OH}{CH}-CH_3$

Propyl hydrogen sulphate

- propyl hydrogen sulphate
(According to Markovnikov rule)

Addition of water:

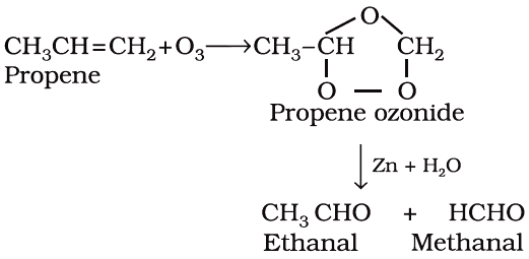
$CH_3-\underset{CH_3}{C}=CH_2 + H_2O \xrightarrow{H^+}$ $CH_3-\underset{CH_3}{\overset{CH_3}{C}}-CH_3$ (OH)

2-Methylpropene — 2-Methylpropan-2-ol

Oxidation: Alkenes on reaction with cold, dilute, aqueous solution of potassium permanganate (Baeyer's reagent) produce vicinal glycols.

- $CH_3-CH=CH_2 + H_2O + O \xrightarrow[273\ K]{\text{dil. } KMnO_4} \underset{\text{Propane-1, 2-diol}}{CH_3CH(OH)CH_2OH}$
- Decolorisation of $KMnO_4$ solution is used as a test for unsaturation.

Ozonolysis :



Polymerisation:

- $n(CH_3 - CH = CH_2) \xrightarrow[\text{Catalyst}]{\text{High temp./Pressure}} (CH_3 - CH_2)_n$ Polypropene

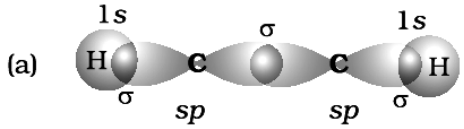
Alkynes

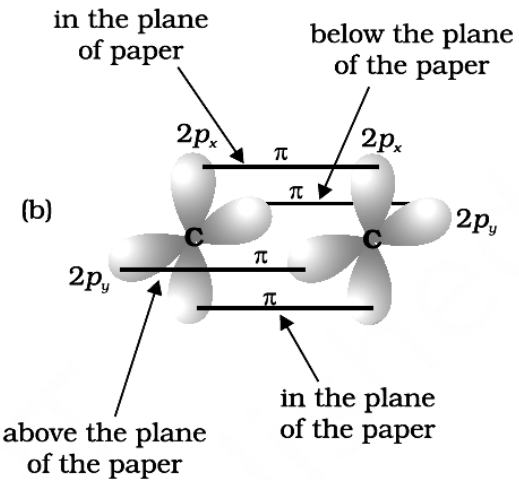
- Their general formula is C_nH_{2n-2}.
- Nomenclature and Isomerism: Alkynes are named as derivatives of the corresponding alkanes replacing 'ane' by the suffix 'yne'.

  Table: Common and IUPAC Names of Alkynes (C_nH_{2n-2})

Formula	Structure	Common name	IUPAC name
C_2H_2	$H - C \equiv CH$	Acetylene	Ethyne
C_3H_4	$CH_3 - C \equiv CH$	Methylacetylene	Propyne
C_4H_6	$CH_3CH_2 - C \equiv CH$	Ethylacetylene	But-1-yne
C_4H_6	$CH_3 - C \equiv C - CH_3$	Dimethylacetylene	But-2-yne

Structure of Triple Bond:





Orbital picture of ethyne showing (a) sigma overlaps (b) pi overlaps

Preparation

From Calcium Carbide:

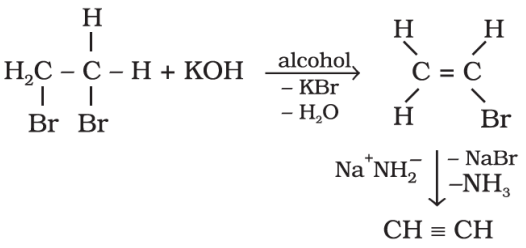
$CaCO_3 \xrightarrow{\Delta} CaO + CO_2$

$CaCO_3 + 3C \longrightarrow CaC_2 + CO$

Calcium carbide

$CaC_2 + 2H_2O \longrightarrow Ca(OH)_2 + C_2H_2$

From Vicinal dihalides:



Physical properties :

- First three members are gases, the next eight are liquids and the higher ones are solids.
- All alkynes are colourless.
- Ethyene has characteristic odour. Other members are odourless.
- Alkynes are weakly polar in nature.
- They are lighter than water and immiscible with water but soluble in organic solvents like ethers, carbon tetrachloride and benzene.
- Their melting point, boiling point and density increase with increase in molar mass.

Chemical properties :

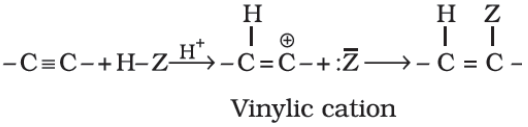
- **Acidic character of alkyne:** Sodium metal and sodamide ($NaNH_2$) are strong bases. They react with ethyne to form sodium acetylide with the liberation of dihydrogen gas.
- $HC \equiv CH + Na \rightarrow \underset{\text{Monosodium ethynide}}{HC \equiv C^-Na^+} + 1/2H_2$

  $HC \equiv C^-Na^+ + Na \rightarrow \underset{\text{Disodium ethynide}}{Na^+C^- \equiv C^-Na^+} + 1/2H_2$
- $CH_3 - C \equiv C - H + Na^+NH_2^- \rightarrow \underset{\text{Sodium propynide}}{CH_3 - C \equiv C^-Na^+} + NH_3$
- Alkanes, alkenes and alkynes follow the following trend in 1 acidic behaviour :

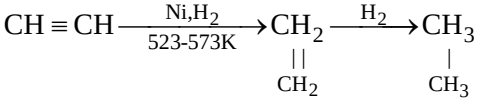
  (i) $HC \equiv CH > H_2C = CH_2 > CH_3 - CH_3$

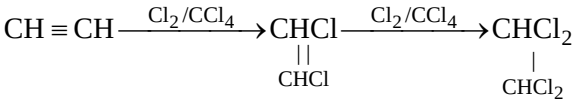
  (ii) $HC \equiv CH > CH - C \equiv CH \gg CH_3 - C \equiv C - CH_3$

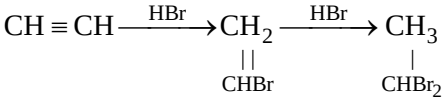
Addition reactions:

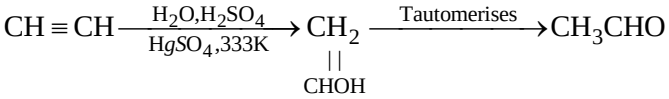


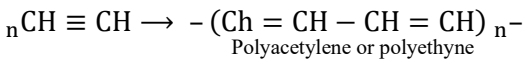
A few addition reactions are given below:

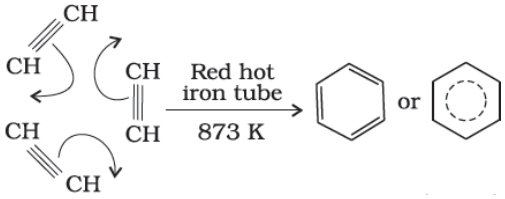






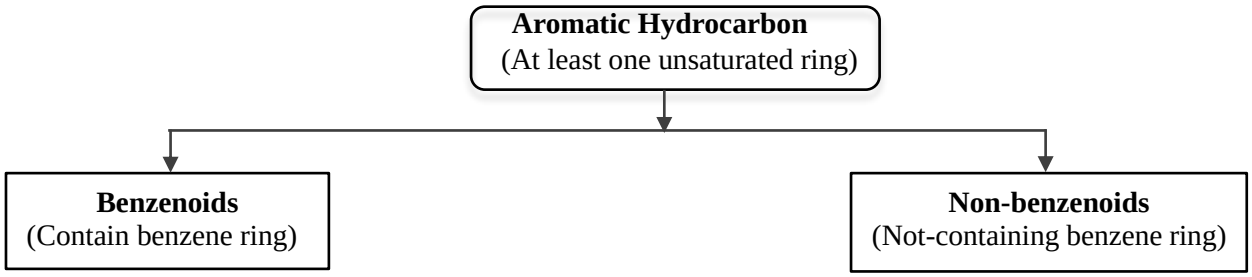


- **Linear polymerisation:**
- 
- **Cyclic polymerisation:**



- **Aromatic Hydrocarbon**

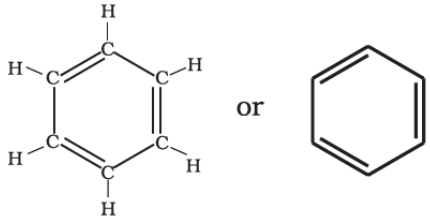
These hydrocarbons are also known as 'arenes".



- **Nomenclature and Isomerism :** When two hydrogen atoms in benzene are replaced by two similar or different monovalent atoms or groups, three different position isomers are possible.
- 1, 2 or 1, 6 : ortho isomer
- 1, 3 or 1, 3: meta isomer
- 1, 4 : para isomer

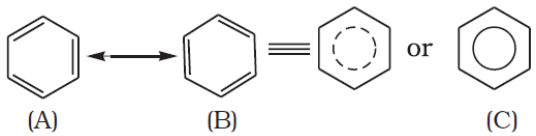
Structure of benzene:

Kekule proposed the structure of benzene having cyclic arrangement of six carbon atoms with alternate single and double bonds and one hydrogen atom attached to each carbon atom.



Resonance and stability of benzene:

Benzene is a hybrid of various resonating structures.



X-ray data indicates that all the six C-C bond lengths are of the same order (139 pm)which is intermediate between C-C single bond (154 pm) and C-C double bond (133 pm).

Aromaticity:

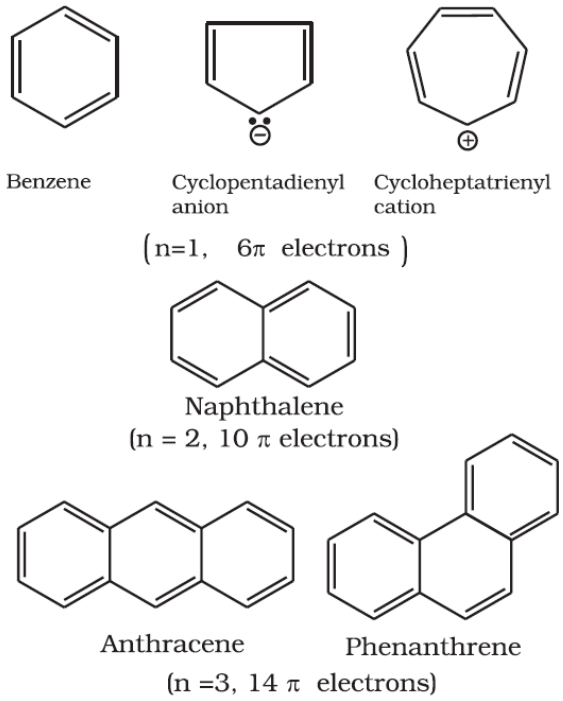
An aromatic compound should have following characteristic:

(i) Planarity

(ii) Complete delocalisation of the π electrons in the ring.

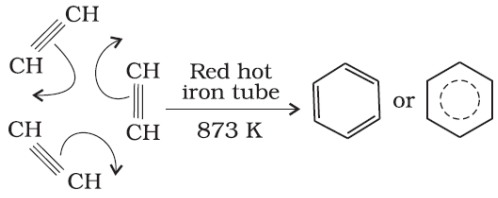
(iii) Presence of (4n+2) π electrons in the ring where n is an integer (n = 0,1,2….)

This is often referred to as Huckel Rule.

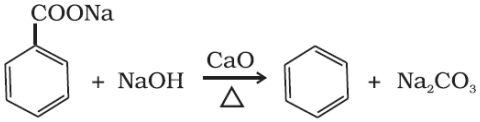


Preparation of Benzene:

Cyclic polymerisation of ethyne:



Decarboxylation of aromatic acids:



Reduction of Phenol:



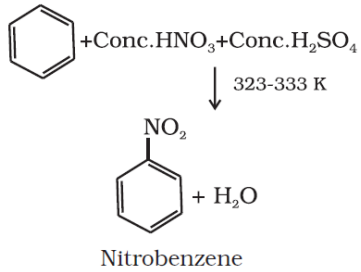
Physical properties:

- Non-polar, colourless with a characteristic aroma.
- Immiscible with water but are readily miscible with organic solvents.
- They burn with sooty flame.

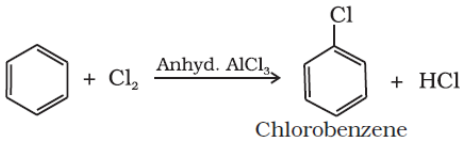
Chemical Properties:

Electrophilic substitution reactions:

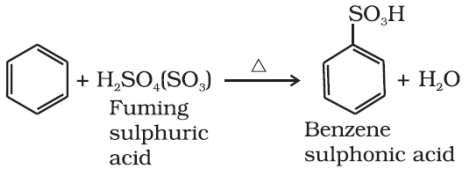
Nitration:



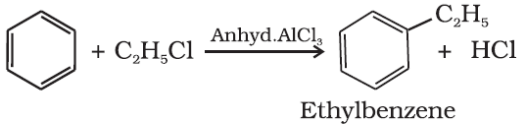
Halogenation:



Sulphonation:

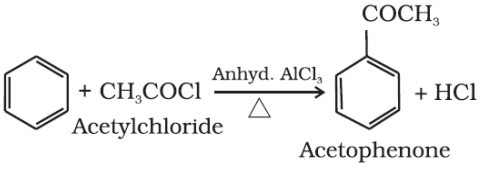


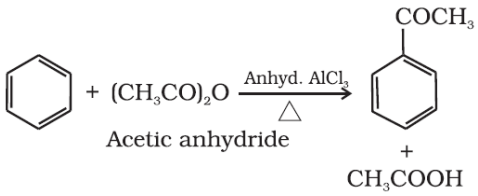
Friedel - Crafts alkylation reaction:



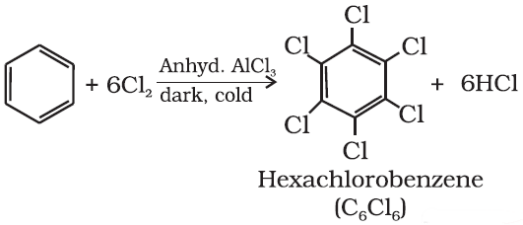
We get isopropyl benzene on treating benzene with I-Chloropropane instead of n-propyl benzene because 2° carbocation is more stable.

Friedel - Crafts acylation reaction:



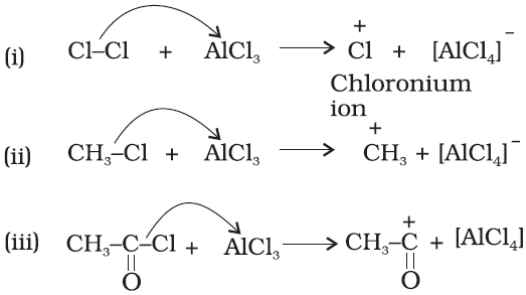


In excess of electrophilic reagent is used, further substitution reaction may take place.



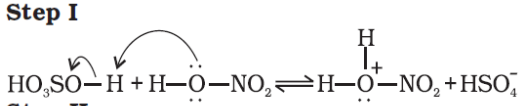
Mechanism of electrophilic substitution reactions:

(i) Generation of electrophilic $E^{\oplus}$:

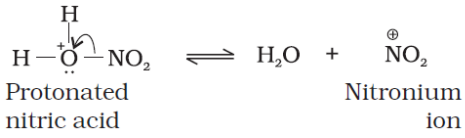


In the case of nitration, ethe electrophilic, nitronium ion, $\overset{+}{N}O_2$ is produced by transfer of a proton (from sulphuric acid) to nitric acid in the following manner:

Step I

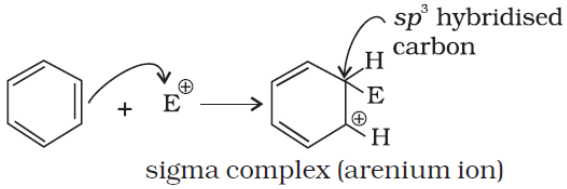


Step II

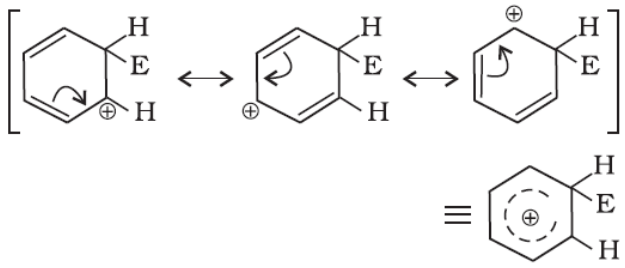


In the process of generation of nitronium ion, sulphuric acid serves as an acid and nitric acid as a base. Thus, it is a simple acid – base equilibrium.

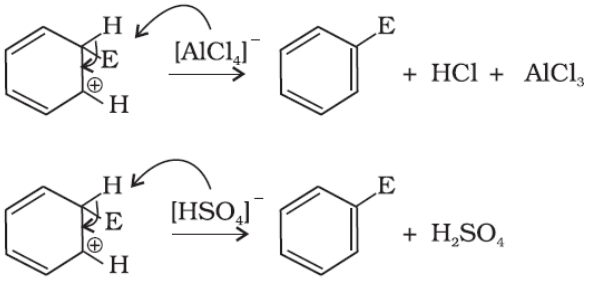
(ii) Formation of Carbocation (Arenium ion):



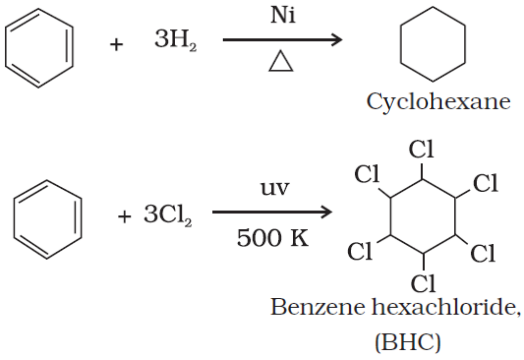
The arenium ion gets stabilised by resonance:



(iii) Removal of Proton:



Addition reactions:



Combustion:

$$C_6H_6 + \frac{15}{2}O_2 \longrightarrow 6CO_2 + 3H_2O$$

General combustion reaction for any hydrocarbon.

$$C_xH_y + \left(x + \frac{y}{4}\right)O_2 \longrightarrow xCO_2 + \frac{y}{2}H_2O$$

Ortho and para directing groups:

$-NH_2, -NHR, -NHCOCH_3, -OCH_3, -CH_3, -C_2H_5$, etc.

Meta directing group:

$-NO_2, -CN, -CHO, -COR, -COOH, -COOR, -SO_3H$, etc.

Carcinogenicity and Toxicity

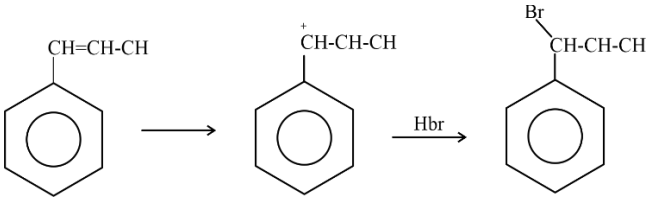
- Benzene and polynuclear hydrocarbons containing more than two benzene rings fused together are toxic and said to possess cancer producing (carcinogenic) property. Such polynuclear hydrocarbons are formed on incomplete combustion of organic materials like tobacco, coal and petroleum.

NEET/JEE Main//Board

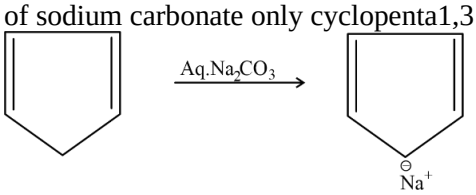
- Aromatic compounds (Huckel's Rule) $= (4n + 2)\pi$ electrons
  Anti-aromatic compounds $= (4n)\pi$ electrons
  Non-aromatic compounds = Neither $(4n)$ nor $(4n + 2)\pi$ electrons
- Eclipsed conformer is least stable while staggered conformer is most stable. The dihedral angle of eclipsed conformer is $0°$.
- DIBAL-H is a reducing agent used to reduce esters to aldehyde. B_2H_6 (diborane) is used to reduce carboxylic acid to the corresponding alcohols, red phosphorus also acts as reducing agent. CaO is used with $NaOH$ in decarboxylation reaction to prepare alkanes.
- Ozonolysis is a method of oxidatively cleaving alkenes or alkynes using ozone
- Chlorination of neopentane with Cl_2 in the UV light gives monochloro substiwited product because all the hydrogen atoms are similar.
- Alky bromide in the presence of sodium and ether gives alkanes.
- Ozonolysis is a method of oxidatively cleaving alkenes or alkynes using ozone and products obtained are carbonyl compounds.
- Chlorination of neopentane with Cl_2 in the UV light gives monochloro substifited product because all the hydrogen atoms are similar.
- Alkyl bromide in the presence of sodium and ether gives alkanes. The correct order of acidic strength

  $H^- - C \equiv C - H \quad > \quad H_3C - C = C - H \quad > \quad H_2C = CH_2 \quad > \quad CH_3 - CH_3$

  (Two acidic hydrogen) (one acidic hydrogen) (sp^2 Carbon) (less difference is electronegativity less acidic)
- In staggered conformation any two H-atom on adjacent carbon atoms are as far apart as possible and there is minimal repulsion between the electron clouds of σ bond of two non-bonded H-atoms.
- When hexene is treated with acidic $KMnO_4$, then on heating it gives dicarboxylic acid while in the presence of aqueous $KMnO_4$ and heating at 273 K it gives a diol. In $Cl - CH = CH - NO_2$ double bond character in carbon chlorine bond is maximum due to resonance and so the bond length is shortest.
- Alkyne on reaction with Ag_2O gives precipitate confirms the presence of triple bond. If alkyne is propyne then, in the presence of $HgSO_4$ and H_2SO_4 it gives enol which on tautomerisation gives a ketone. Further when it is reduced with $NaBH_4$ gives a 2° alcohol. The presence of 2° alcohol can be confirmed by treating it with lucas reagent $(ZnCl_2 + HCl)$ which gives turbidity within 5 minutes. When 1 -phenyl propyne reacts with HBr.



- Among cyclopropene, cyclobutene, cyclopenta-1,3-diene and cyclohexa-1,3diene on reaction with aqueous solution of sodium carbonate only cyclopenta1,3 diene gives aromatic ring with $6\pi e^-$hence it is stable.



- N-bromosuccinimide results into bromination at allylic and benzylic positions.

Tips/Tricks/Techniques ONE-LINERS(Exam Special)

- The lower the ΔH_h (heat of hydrogenation), the more stable the alkene is.
- Alkynes add water molecule in presence of mercuric sulphate and dil. H_2SO_4 and form carbonyl compounds.
- Terminal alkynes have acidic H-atoms, so they form metal alkynides with Na. ammonical cuprous chloride solution and ammonical silver nitrate All m-directing groups are ring deactivating groups.

  They are : $-CHO$, $COOH$, $-NO_2$, $-CN$, $-\overset{+}{N}R_3$, etc.

- **Conformations of *n*-Butane C_4H_{10} :**
  Order of stability:
  Anti > Gauche > Skew > Eclipsed > Fully Eclipsed
  Hydroboration: Diborane readily reacts with alkenes giving trialkyl boranes.
  Terminal alkenes give primary alkylborane, which can be oxidised by alkaline hydrogen peroxide to primary alcohol.

$$3R\text{-}CH{=}CH_2{=}BH_3(B_2H_6) \rightarrow (R\text{-}CH_2\text{-}CH_2)_3B \xrightarrow{H_3O^+} 3RCH_2CH_3 \text{ (Alkane)}$$

$$3R\text{-}CH{=}CH_2{=}BH_3(B_2H_6) \rightarrow (R\text{-}CH_2\text{-}CH_2)_3B \xrightarrow{H_3OH^-} 3RCH_2CH_2OH \text{ (1° Alcohol)}$$

$$3R\text{-}CH{=}CH_2{=}BH_3(B_2H_6) \rightarrow (R\text{-}CH_2\text{-}CH_2)_3B \xrightarrow{ClNH_2} 3RCH_2CH_2NH_2 \text{ (1-Alkane amine)}$$

Hydroxylation:

With 1% alkaline $KMnO_4$ (Baeyer reagent):

$$CH_3\text{-}CH{=}CH\text{-}CH_3 + H_2O + (O) \xrightarrow{1\%KMnO_4} CH_3\text{-}\underset{OH}{CH}\text{-}\underset{OH}{CH}\text{-}CH_3$$

With per acid (RCOOOH):

$$R\text{-}CH{=}CH_2 + H\text{-}\overset{O}{\overset{\|}{C}}\text{-}O\text{-}OH \xrightarrow{\text{-HCOOH}} R\text{-}\underset{/\ \backslash}{\overset{O}{CH}}\text{-}CH_2 \xrightarrow{H_2O} R\text{-}\underset{OH}{\overset{OH}{CH}}\text{-}\underset{OH}{CH_2}$$

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PW Web/App - https://smart.link/7wwosivoicgd4

Library- https://smart.link/sdfez8ejd80if