ST. LAWRENCE HIGH SCHOOL

A JESUIT CHRISTIAN MINORITY INSTITUTION

STUDY MATERIAL FOR CHEMISTRY (CLASS-11)

TOPIC- HYDROCARBON

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SET NUMBER-09

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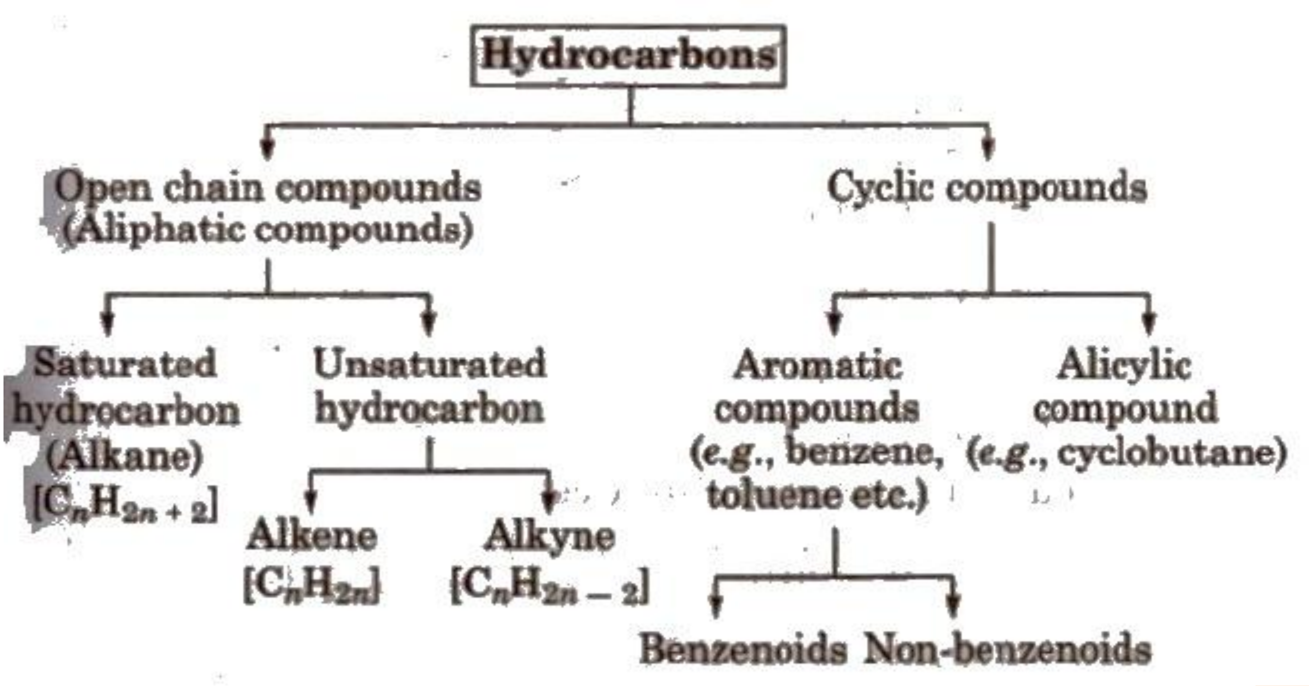
Hydrocarbons are the organic compounds containing carbon and hydrogen only, e.g., alkane, alkene and alkynes.

Classification of Hydrocarbons



Alkanes

Alkanes are saturated, open chain hydrocarbons containing carbon-carbon single bonds. e.g., methane (CH_4), ethane (C_4H_6) propane (C_3H_8), etc.
These hydrocarbons are inert under normal conditions [i.e.,do not react with acids. bases and other reagents). Hence, they were earlier known 88 paraffins (Latin :parum-little; affins-affinity)

Alkanes exhibit chain isomensm, position isomerism and conformational isomerism.

Methods of Preparation of Alkanes

i) **From hydrogenation of alkenes and alkynes**

$$\underset{\text{ethene}}{CH_2{=}CH_2} + H_2 \xrightarrow{Pt/Pd/Ni} \underset{\text{ethane}}{CH_3{-}CH_3}$$

$$CH_3{-}C{\equiv}C{-}H + 2H \xrightarrow{Pt/Pd/Ni} \underset{\text{propane}}{CH_3{-}CH_2{-}CH_3}$$

Ease of hydrogenation depends on the steric crowding across the multiple bond. More is the steric crowding, the less is the reactivity towards hydrogenation.

(ii) By sodalime Decarboxylation of sodium or potassium salts of fatty acids [decarboxylation reaction]

$$RCOONa + NaOH \xrightarrow[\Delta]{CaO} R{-}H + Na_2CO_3$$

This reaction is used for descending of series as the alkane obtained has one carbon less than the parent compound. CaO is more hygroscopic than NaOH and it keeps NaOH in dry state.

(iii) By Wurtz reaction

$$R{-}\underset{\text{alkyl halide}}{\boxed{X + 2\,Na + X}}{-}R \xrightarrow{\text{Dry ether}} R{-}R + NaX$$

This reaction is used to increase the length of the carbon chain.

(iv) By reduction of alkyl halides

$$R{-}X + 2[H] \xrightarrow{Zn{-}Cu/Alcohol} R{-}H + HX$$

Reducing agents like Zn/HCl, HI/Red P, H_2/Pd can also be used.

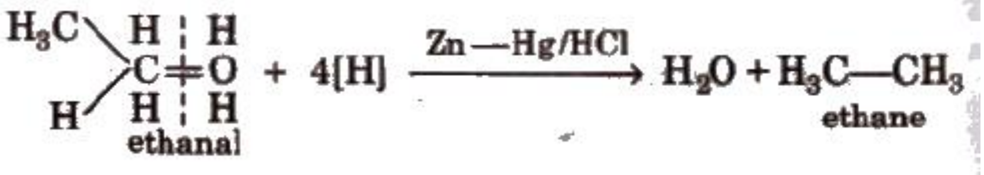
(v) By Kolbe's electrolysis

$$2CH_3COONa + 2H_2O \xrightarrow{\text{Electrolysis}} CH_3{-}CH_3 + 2NaOH + 2CO_2 + H_2$$

Only alkanes with even number of carbon atoms can be formed.

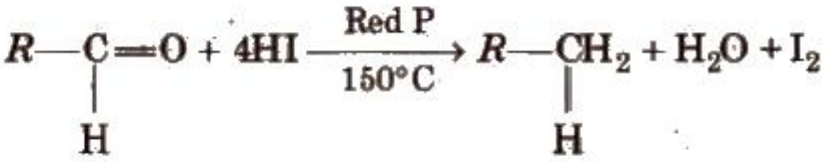
Alkane and CO_2 are liberated at anode while H_2 is liberated at cathode.

(vi) Clemmensen's reduction



(vii) **<u>From compounds containing oxygen</u>** Alcohols, aldehydes ketones, carboxylic acids and their derivatives give alkane when treated with hot conc HI and red P in a sealed tube.

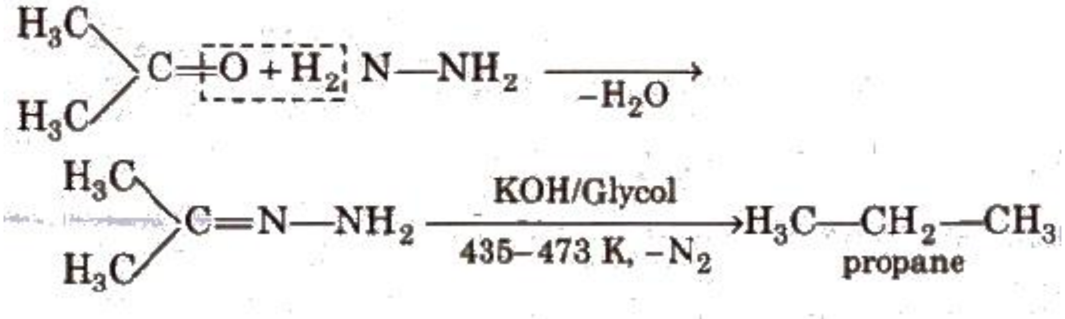
$$ROH + 2HI \xrightarrow[150°C]{\text{Red P}} R—H + H_2O + I_2$$



$$R—\underset{\substack{|\\H}}{C}=O + 4HI \xrightarrow[150°C]{\text{Red P}} R—\underset{\substack{|\\H}}{CH_2} + H_2O + I_2$$

$$RCOOH + 6HI \xrightarrow[150°C]{\text{Red P}} R—CH_3 + 2H_2O + 3I_2$$

(viii) **<u>Wolff-Kishnerts reduction</u>**



(ix) **<u>From carbides</u>**

$$\underset{\substack{\text{aluminium}\\\text{carbide}}}{Al_4C_3} + \underset{\text{steam}}{12H_2O} \longrightarrow 4Al(OH)_3 + \underset{\text{methane}}{3CH_4}$$

and $$\underset{\text{beryllium carbide}}{Be_2C} + 4H_2O \longrightarrow 2Be(OH)_2 + \underset{\text{methane}}{CH_4}$$

(x) Corey-Bouse synthesis This method can be used to prepare alkanes having odd number of carbon atoms.

$$RX + 2Li \xrightarrow{\text{Ether}} R\text{—}Li + LiX$$

$$2R\text{—}Li + CuI \longrightarrow LiR_2Cu$$

$$LiR_2Cu + R'X \longrightarrow \underset{\text{alkane}}{R\text{—}R'} + R\text{—}Cu + LiX$$

Physical Properties of Alkanes:

(i) The first four members are colourless gas, next thirteen members are colourless liquids and next higher members are
colourless solids.

(It can be explained on the basis of magnitude of attraction forees.)

(ii). Boiling point of alkanes decreases on branching.

BP $\propto$ VWF (van der Waals' forces)

VWF $\propto$ molecular mass or VAF $\propto$ SA (surface area)

So boiling point order can be given as

n-octane>iso-octane> 2, 2, 3, 3-tetramethyl butane

(iii). Alkanes with even number of carbon atoms have higher melting points as compared to next higher or lower alkanes with odd number of carbon atoms.

(iv). Alkanes being non-polar in nature, soluble in non-polar solvents but insoluble in polar solvent such as water.

Chemical Properties of Alkanes

(i) Halogenation of alkanes

(a) Chlorination

$$CH_4 + Cl_2 \xrightarrow[-HCl]{h\nu} CH_3Cl \xrightarrow[\substack{Cl_2 \\ -HCl}]{h\nu} CH_2Cl_2 \xrightarrow[-HCl]{Cl_2/h\nu} CHCl_3 \xrightarrow[-HCl]{Cl_2/h\nu} CCl_4$$

(b) Bromination of alkanes proceeds in the same way but not so easily.

(c) Iodination

$$CH_4 + I_2 \rightleftharpoons CH_3I + HI$$

Order of reactivity of halogens is

$$F_2 > Cl_2 > Br_2 > I$$

Order of reactivity of hydrogen of alkane is

$$3° > 2° > 1°$$

Mechanism of halogenation of alkanes is free radical in nature, i.e., the attacking reagent is a halogen free radical (X.). It is a chain reaction.

(ii) Combustion

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

Due to the evolution of a large amount of heat during combustion, alkanes are used as fuels.

(iii) Controlled oxidation

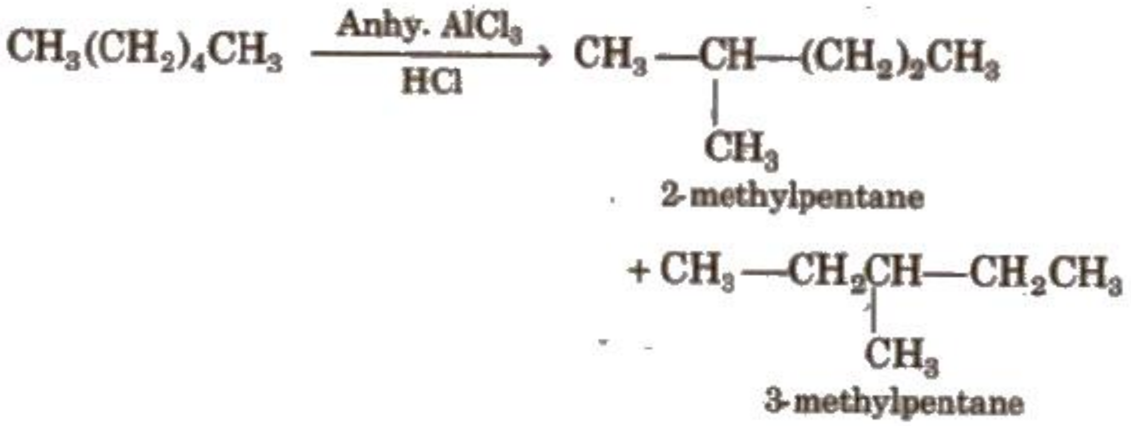
$$\text{(i)}\ \underset{9:1}{2CH_4 + O_2} \xrightarrow{Cu\ /\ 523\ K\ /\ 100\ atm} \underset{\text{methanol}}{2\ CH_3OH}$$

$$\text{(ii)}\ CH_4 + O_2 \xrightarrow[\Delta]{Mo_2O_3} HCHO + H_2O$$

$$\text{(iii)}\ 2CH_3—CH_3 + 3O_2 \xrightarrow[\Delta]{(CH_3COO)_2Mn} 2CH_3COOH + 2H_2O$$

$$\text{(iv)}\ CH_4 + \underset{\text{limited}}{O_2} \xrightarrow{\text{Burn}} \underset{\text{carbon black}}{C} + 2H_2O$$

(iv) Isomerisation



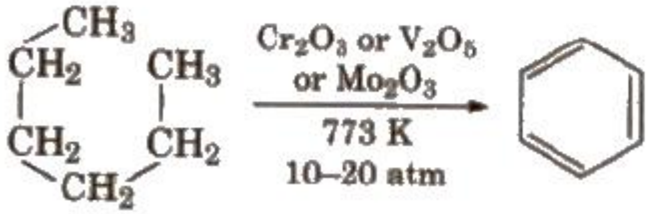
$$CH_3(CH_2)_4CH_3 \xrightarrow[HCl]{Anhy.\ AlCl_3} CH_3-\underset{\underset{CH_3}{|}}{CH}-(CH_2)_2CH_3$$

2-methylpentane

$$+\ CH_3-CH_2\underset{\underset{CH_3}{|}}{CH}-CH_2CH_3$$

3-methylpentane

(v) Aromatisation



(vi) Reaction with steam

$$CH_4 + H_2O \xrightarrow[\Delta]{Ni} CO + 3H_2$$

(vii) Pyrolysis

$$C_{12}H_{26} \xrightarrow{Pt\ or\ Pd\ or\ Ni} C_7H_{16} + C_5H_{10} + \text{Other products}$$

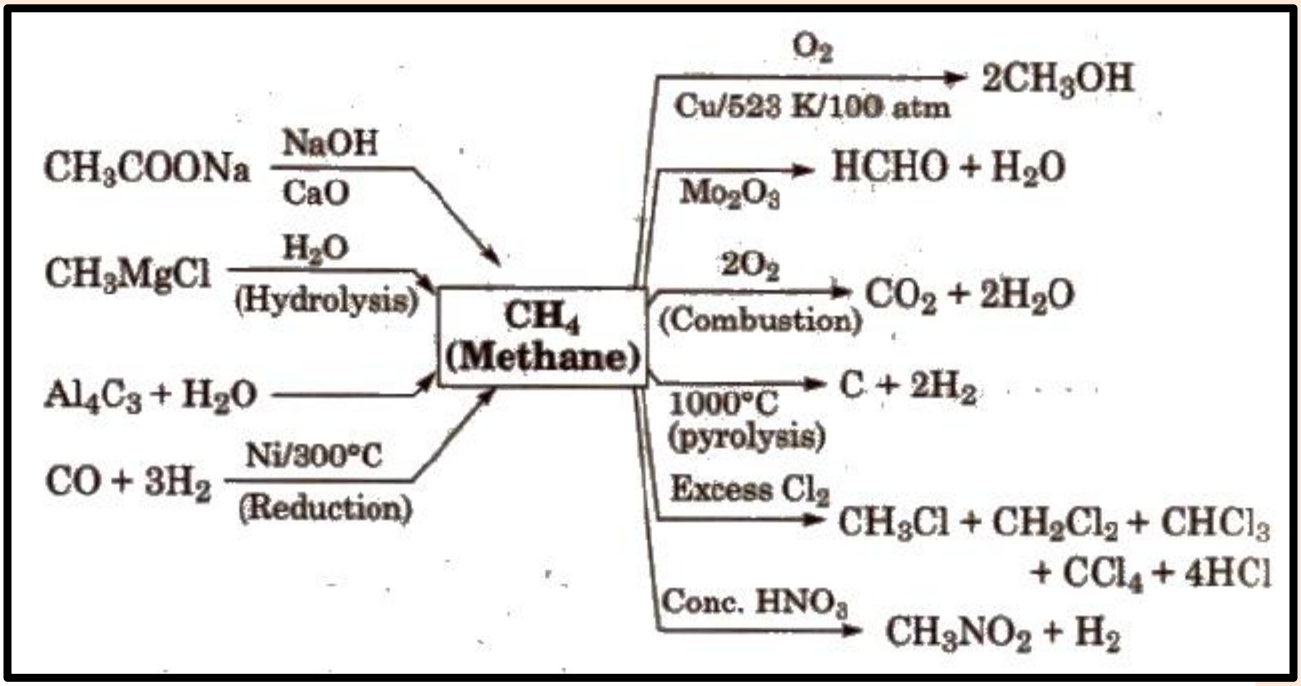
(viii) Nitration

$$C_6H_{13}-H + HO-NO_2 \xrightarrow{\Delta} \underset{\text{nitrohexane}}{C_6H_{13}NO_2} + H_2O$$

(ix) Sulphonation

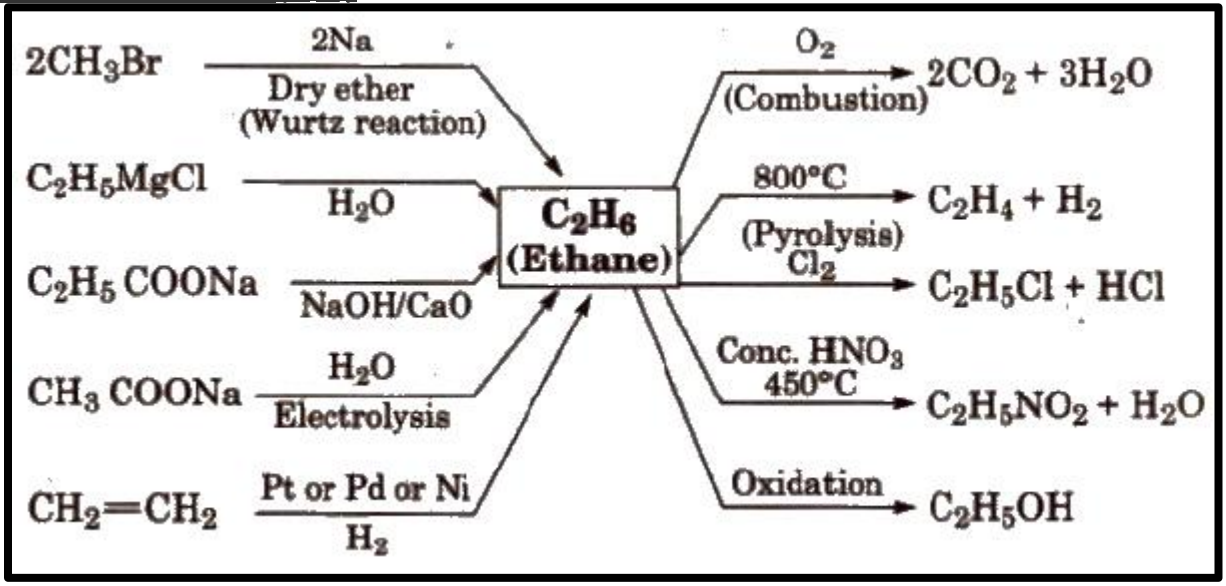
$$C_6H_{13}-H + HOSO_3H\ \text{(conc.)} \xrightarrow{400^\circ C} \underset{\text{hexane sulphonic acid}}{C_6H_{13}-SO_3H} + H_2O$$

Reactions for Methane (CH_4)



(Methane cannot be prepared by Wurtz reaction, Kolbe's electrolytic process and by reduction of alkenes or alkynes).

Reactions for Ethane(C_2H_6)

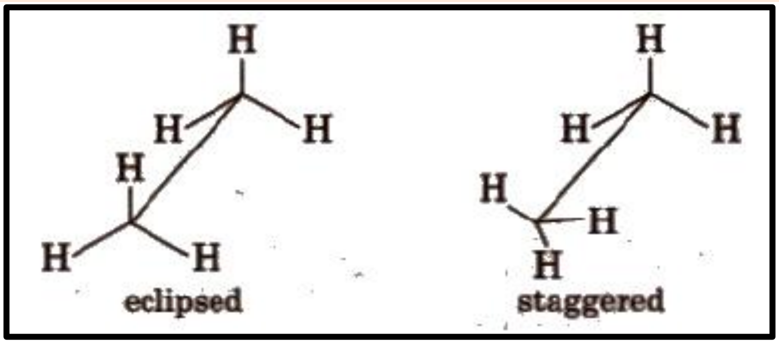


Conformations of Alkanes-

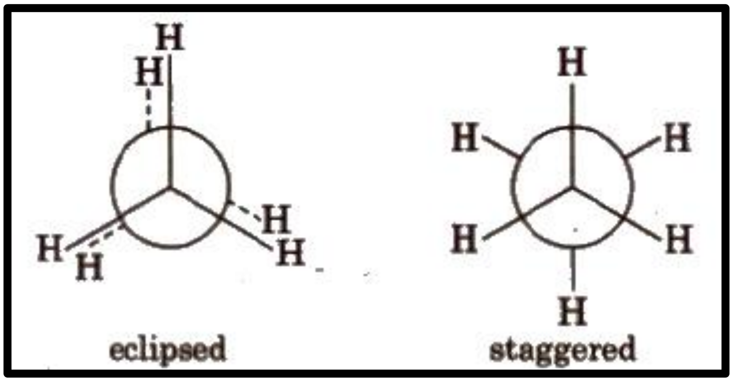
Alkanes have C-C sigma (σ) bonds and rotation about C-C single bond is allowed. This rotation results in different spatial arrangements of atoms in space which can change into one another, such spatial arrangements are called conformations or conformers or rotamers.

Conformations of ethane-

(i) Sawhorse projections



(ii) Newman projections



Intermediate conformation between eclipsed and staggered are known as skew (gauche) conformations.

Eclipsed form is least stable but staggered form is most stable due to greater distance between the bond pairs or lesser torsional strain.

The energy difference between the two extreme forms is of the order of 12.5 kJ mol^{-1}.

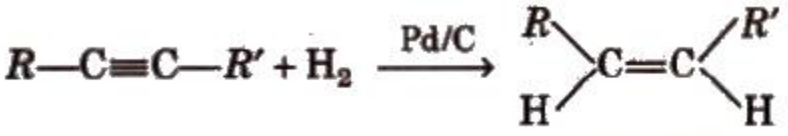
Alkenes

These are unsaturated non-cyclic hydrocarbons which have.sp^{2} -hybridisation with 120° bond angle.
Alkenes are also called olefins [oil.forming] which indicates their high reactive nature.

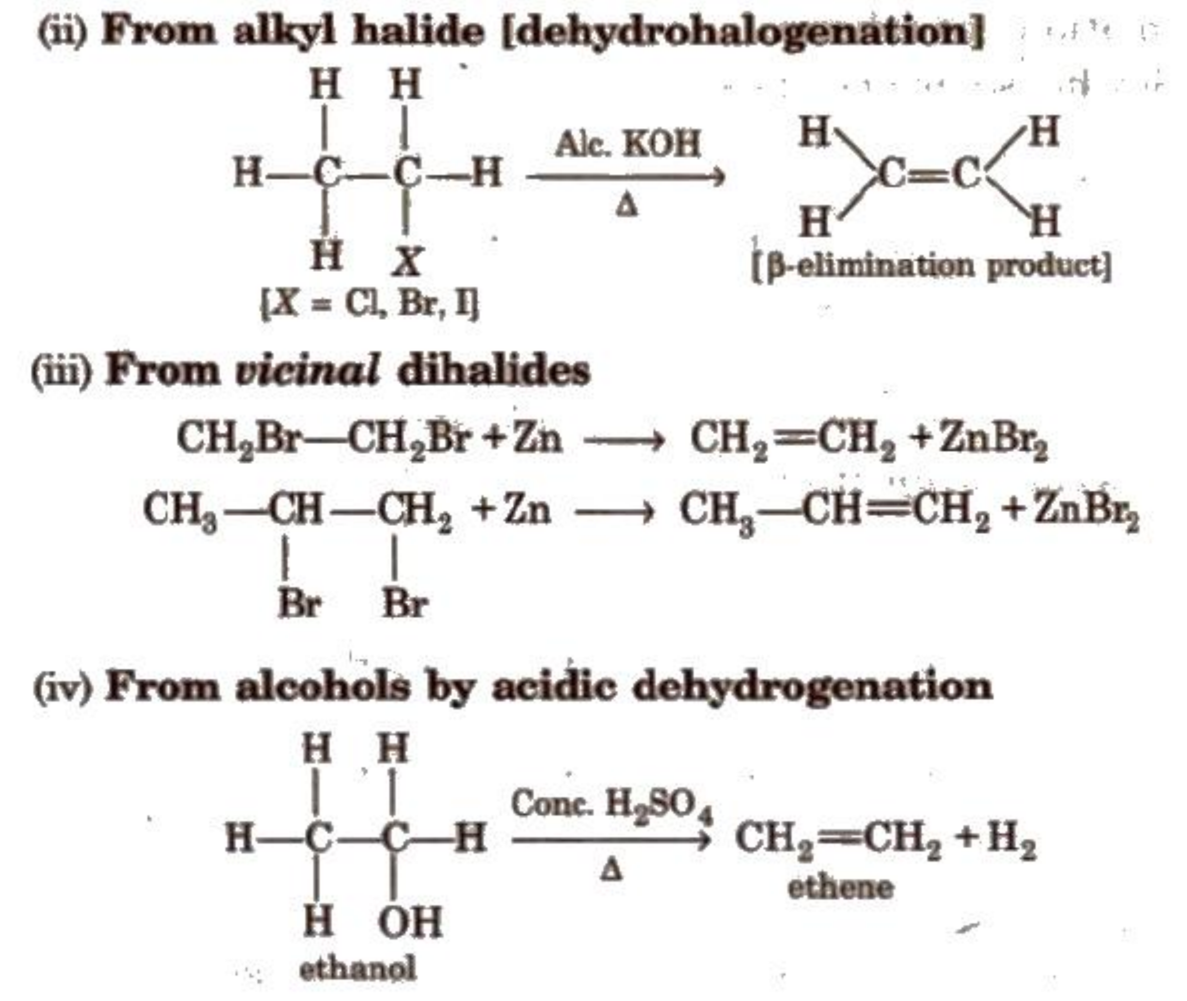
Alkenes have general formula $C_n H_{2n}$, where n = 2,3,4 …
C_2H_4 (ethene), C_3H_6 (propene), etc.

Methods of Preparation of Alkenes

(i) From alkynes



cis-alkene



(ii) From alkyl halide [dehydrohalogenation]

$$\mathrm{H{-}\overset{\displaystyle H}{\underset{\displaystyle H}{C}}{-}\overset{\displaystyle H}{\underset{\displaystyle X}{C}}{-}H \xrightarrow[\Delta]{\text{Alc. KOH}} \begin{matrix}H\\H\end{matrix}\!>\!C{=}C\!<\!\begin{matrix}H\\H\end{matrix}}$$

[X = Cl, Br, I]

[β-elimination product]

(iii) From *vicinal* dihalides

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

$$CH_3{-}\underset{\displaystyle Br}{CH}{-}\underset{\displaystyle Br}{CH_2} + Zn \longrightarrow CH_3{-}CH{=}CH_2 + ZnBr_2$$

(iv) From alcohols by acidic dehydrogenation

$$\mathrm{H{-}\overset{\displaystyle H}{\underset{\displaystyle H}{C}}{-}\overset{\displaystyle H}{\underset{\displaystyle OH}{C}}{-}H \xrightarrow[\Delta]{\text{Conc. } H_2SO_4} CH_2{=}CH_2 + H_2}$$

ethanol

ethene

Physical Properties of Alkenes

Alkene as a class resemble alkanes in physical properties, except in types of isomerism and difference in polar nature.

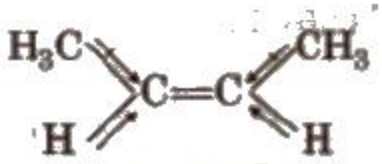
C_1 to C_3 are gases, the next fourteen are liquids and the higher members are solids. Alkenes show a regular increase in boiling point with increase in size.

Isomerism in Alkenes

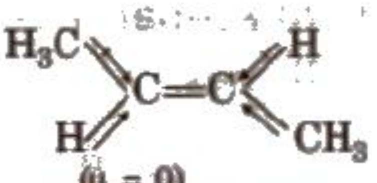
Alkene show both structural isomerism and geometrical isomerism.

Structural isomerism exhibited by alkenes are chain isomerism and position isomerism.

Alkenes also exhibit stereoisomerism as geometrical (cis-trans) isomerism.



(μ = 0.33D)
[*cis*-but-2-ene]

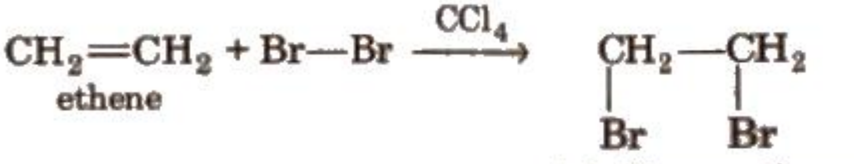


(μ = 0)
[*trans*-but-2-ene]

Isomerism in Alkenes

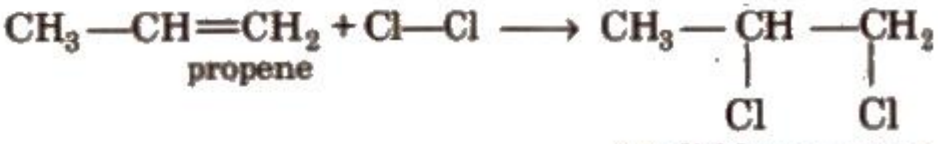
Chemical Properties of Alkenes

(i) Addition of halogens



$CH_2{=}CH_2 + Br{-}Br \xrightarrow{CCl_4} \underset{Br}{\underset{|}{CH_2}}{-}\underset{Br}{\underset{|}{CH_2}}$

1,2-dibromoethane



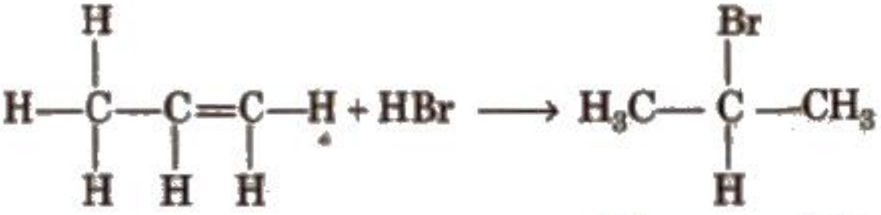
$CH_3{-}CH{=}CH_2 + Cl{-}Cl \longrightarrow CH_3{-}\underset{Cl}{\underset{|}{CH}}{-}\underset{Cl}{\underset{|}{CH_2}}$

1,2-dichloropropane

(ii) Addition of hydrogen halides HCl, HBr, HI add up to alkenes to form alkyl halides as per their reactivity order

HI >HBr> HCl

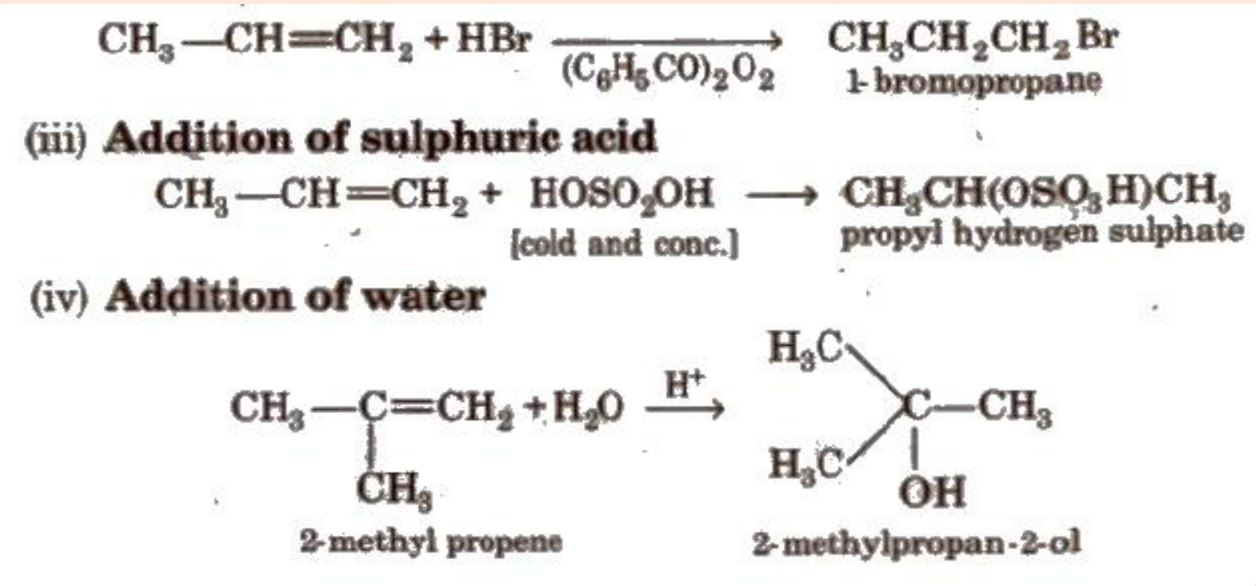
Addition reaction of HBr to unsymmetrical alkenes (Markownikoff’s rule) According to Markownikofrs rule, the negative part of the addendum (adding molecule) gets attached to that carbon atom which possesses lesser number of hydrogen atom.



$H{-}\underset{H}{\underset{|}{\overset{H}{\overset{|}{C}}}}{-}\underset{H}{\underset{|}{C}}{=}\underset{H}{\underset{|}{C}}{-}H + HBr \longrightarrow H_3C{-}\underset{H}{\underset{|}{\overset{Br}{\overset{|}{C}}}}{-}CH_3$

2-bromopropane

Anti-Markownikoff addition or peroxide effect or kharash effect In the presence of organic peroxide, addition of only HBr molecule on unsymmetrical alkene takes place contrary to the Markownikoffs rule.



$$CH_3-CH=CH_2 + HBr \xrightarrow[(C_6H_5CO)_2O_2]{} \underset{\text{1-bromopropane}}{CH_3CH_2CH_2Br}$$

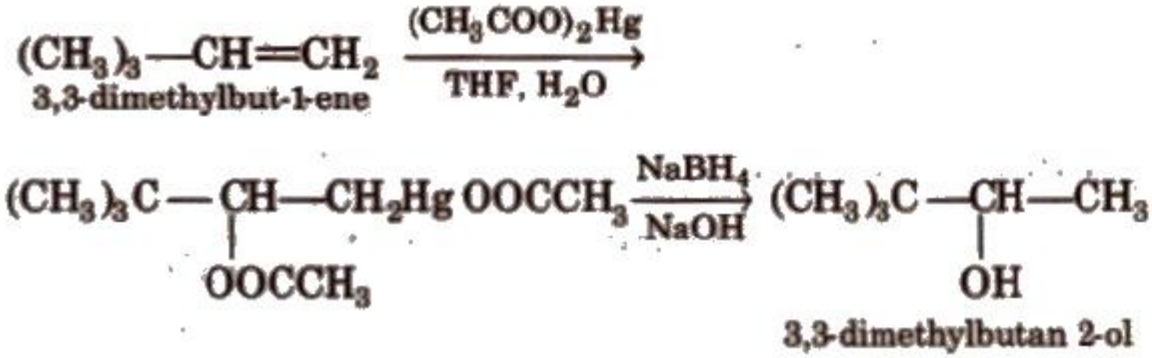
(iii) Addition of sulphuric acid

$$CH_3-CH=CH_2 + \underset{\text{[cold and conc.]}}{HOSO_2OH} \longrightarrow \underset{\text{propyl hydrogen sulphate}}{CH_3CH(OSO_3H)CH_3}$$

(iv) Addition of water

$$\underset{\text{2-methyl propene}}{CH_3-\underset{\underset{CH_3}{|}}{C}=CH_2} + H_2O \xrightarrow{H^+} \underset{\text{2-methylpropan-2-ol}}{(H_3C)_2\underset{\underset{OH}{|}}{C}-CH_3}$$

(v) Oxymercuration-demercurationThis reaction is an example of hydration of alkene according to Markownikoffs rule.



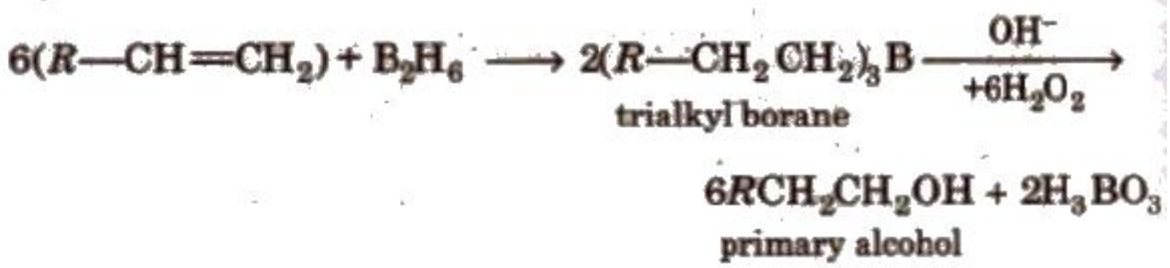
$$\underset{\text{3,3-dimethylbut-1-ene}}{(CH_3)_3-CH=CH_2} \xrightarrow[\text{THF, }H_2O]{(CH_3COO)_2Hg}$$

$$(CH_3)_3C-\underset{\underset{OOCCH_3}{|}}{CH}-CH_2Hg\,OOCCH_3 \xrightarrow[NaOH]{NaBH_4} \underset{\text{3,3-dimethylbutan 2-ol}}{(CH_3)_3C-\underset{\underset{OH}{|}}{CH}-CH_3}$$

It is an anti-addition reaction.

It is better than catalytic hydration by dil. H_2SO_4, as it avoids rearrangement.

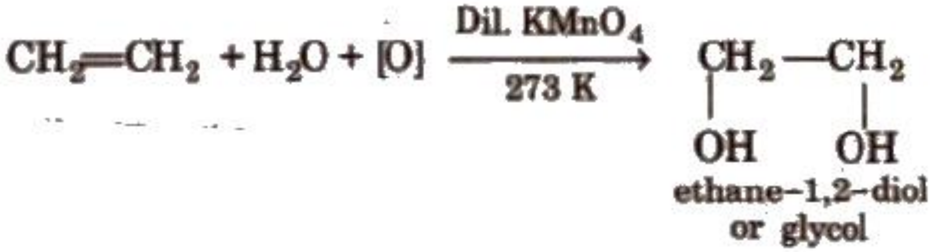
(vi) Bydroboration oxidation



$$6(R-CH=CH_2) + B_2H_6 \longrightarrow \underset{\text{trialkyl borane}}{2(R-CH_2CH_2)_3B} \xrightarrow[+6H_2O_2]{OH^-} \underset{\text{primary alcohol}}{6RCH_2CH_2OH} + 2H_3BO_3$$

This reaction involved syn-addition of reagent.

(vii) Oxidation Alkenes decolourise cold dilute aqueous solution of potassium permanganate (Baeyer’s reagent). It is used as a test for unsaturation.



$$CH_2{=}CH_2 + H_2O + [O] \xrightarrow[273\ K]{Dil.\ KMnO_4} \underset{OH}{CH_2}{-}\underset{OH}{CH_2}$$

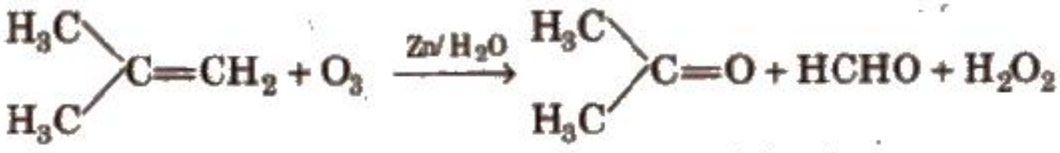
ethane-1,2-diol
or glycol

Acidic $KMnO_4$ or acidic $K_2Cr_2O_7$ oxidise alkenes to ketones and/or acids depending upon the nature of alkene and the experimental conditions.

$$\underset{\text{2-methyl propene}}{(CH_3)_2C{=}CH_2} \xrightarrow{KMnO_4/H^+} \underset{\text{propane-2-one}}{(CH_3)_2CO} + CO_2 + H_2O$$

$$\underset{\text{but-2-ene}}{CH_3{-}CH{=}CH{-}CH_3} \xrightarrow{KMnO_4/H^+} \underset{\text{ethanoic acid}}{2CH_3COOH}$$

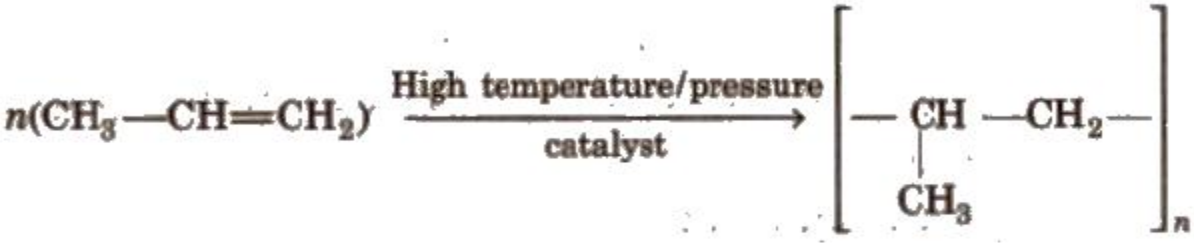
(viii) **Ozonolysis**



$$Zn + H_2O_2 \longrightarrow ZnO + H_2O$$

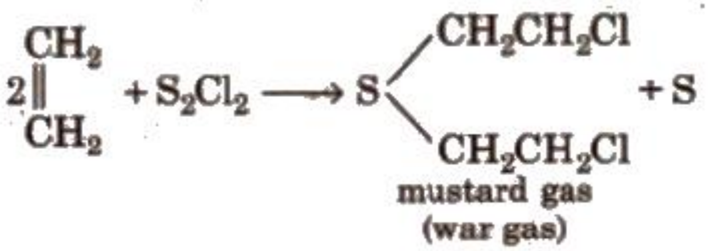
(ix) **Polymerisation**

$$n(CH_2{=}CH_2) \xrightarrow[\text{catalyst}]{\text{High temperature/pressure}} \underset{\text{polythene}}{{-}[CH_2{-}CH_2{-}]_n}$$



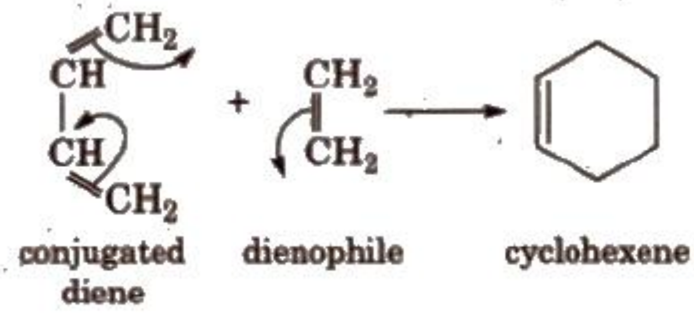
$$n(CH_3{-}CH{=}CH_2) \xrightarrow[\text{catalyst}]{\text{High temperature/pressure}} \left[{-}\underset{CH_3}{CH}{-}CH_2{-}\right]_n$$

(x) **Reaction with sulphurmonochloride**

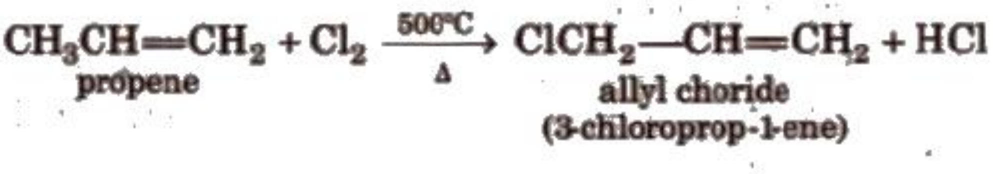


mustard gas
(war gas)

(xii) **Diels-Alder reaction**

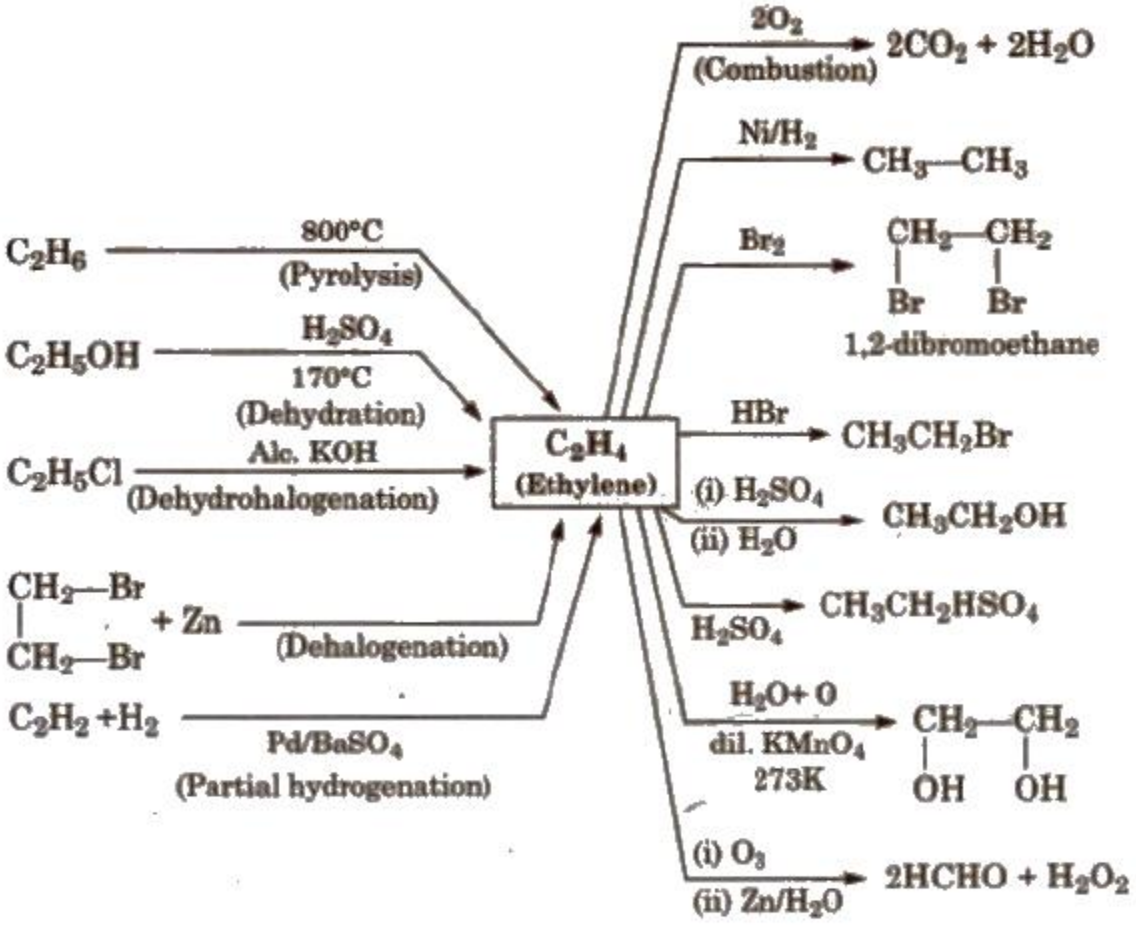


(xiii) **Substitution reactions** These occur at very high temperature at allylic position



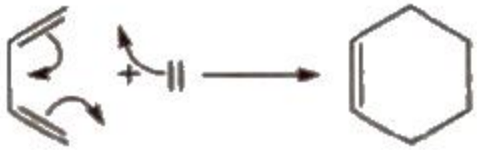
$$\underset{\text{propene}}{CH_3CH{=}CH_2} + Cl_2 \xrightarrow[\Delta]{500°C} \underset{\substack{\text{allyl choride}\\ \text{(3-chloroprop-1-ene)}}}{ClCH_2{-}CH{=}CH_2} + HCl$$

Reactions for Ethene [Ethylene] (C_2 H_4)



Conjugated dienes

Dienes having alternate single (-) and double bonds (=) are called conjugated alkenes. These give Diels, Alder reaction.



Alkynes

These are unsaturated hydrocarbons with general formula C_nH_{2n-2} e.g., C_2H_2 (ethyne), C_3H_4 (propyne)

Alkynes also exhibit electrophilic addition reaction but less reactive than alkenes because the dissociation of x-electron cloud requires more energy.

In alkynes, position of triple bond is determined by ozone (O_3).

H – C = C – H contains 3σ and 2π – bonds and bond length is 120 pm. In acetylene. H – C – C bond angle is 180°.

Methods of Preparation of Alkynes

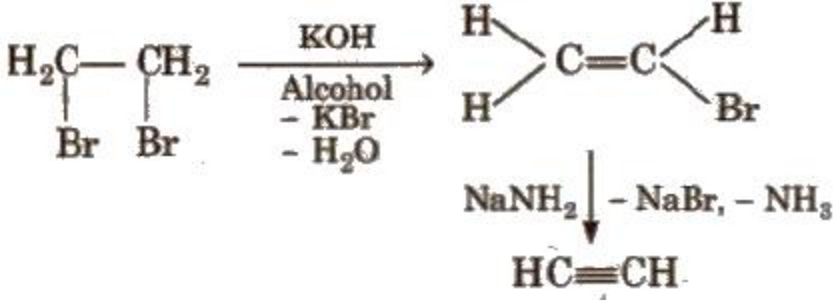
(i) **From calcium carbide**

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

$$CaO + C \longrightarrow CaC_2 + CO$$

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

(ii) **From vicinal dihalides**



$$H_2\underset{Br}{\underset{|}{C}}-\underset{Br}{\underset{|}{C}}H_2 \xrightarrow[\substack{\text{Alcohol} \\ -KBr \\ -H_2O}]{KOH} \begin{matrix} H \\ H \end{matrix}\!\!>C=C\!\!<\!\!\begin{matrix} H \\ Br \end{matrix} \xrightarrow[-NaBr,\ -NH_3]{NaNH_2} HC\equiv CH$$

(iii) **From tetrahalides**

$$Br_2CH—CHBr_2 + 2Zn \xrightarrow[\Delta]{CH_3OH} H—C\equiv C—H + 2ZnBr_2$$

Physical Properties of Alkynes

1. The rust two members are gases next eight members (C_5 – C_{12}) are liquids and higher members are solids.
2. They are all colourless and odourless with the exception of acetylene which has slightly garlic odour due to the presence of PH_3 and H_2S as impurities.

3. Alkynes are insoluble in water but soluble in organic solvents like ethers, carbon tetrachloride and benzene.

4. Melting point, boiling point and density increase with increase in molar mass.

Chemical Properties of Alkynes

Alkynes show electrophilic as well as nucleophilic addition reactions.

(i) **Acidic character of alkyne**

$$HC\equiv CH + Na \longrightarrow \underset{\text{monosodium acetylides}}{HC\equiv C^{-}Na^{+}} + \frac{1}{2}H_2$$

$$H-C\equiv \bar{C}Na^{+} + Na \longrightarrow \underset{\text{disodium acetylides}}{Na^{+}-C\equiv \bar{C}Na^{+}} + \frac{1}{2}H_2$$

$$CH_3-C\equiv C-H + NaNH_2 \longrightarrow \underset{\text{sodium propynide}}{CH_3-C\equiv \bar{C}Na^{+}} + NH_3$$

These reactions are not shown by alkenes, alkanes and non-terminal alkynes, hence used for distinction between alkane, alkene and alkyne.

Acetylenic hydrogens are acidic in nature due to 50% a-character in sp-hybridised orbitals.

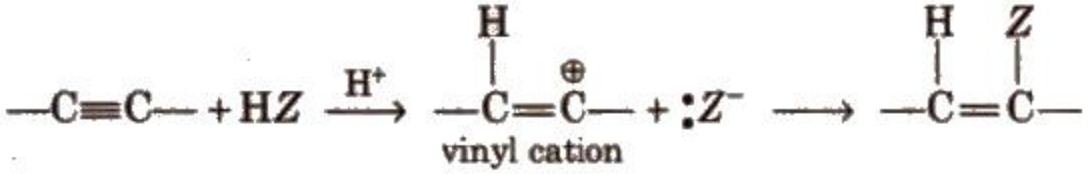
Acidity of alkynes is lesser than water.

Acidic behaviour order

$$\text{(i) } \underset{sp}{HC}\equiv CH > CH_{\underset{sp^2}{2}}=CH_2 > CH_{\underset{sp^3}{3}}-CH_3$$

$$\text{(ii) } HC\equiv CH > CH_3-C\equiv CH >> CH_3-C\equiv C-CH_3$$

(ii) **Electrophilic addition reactions**



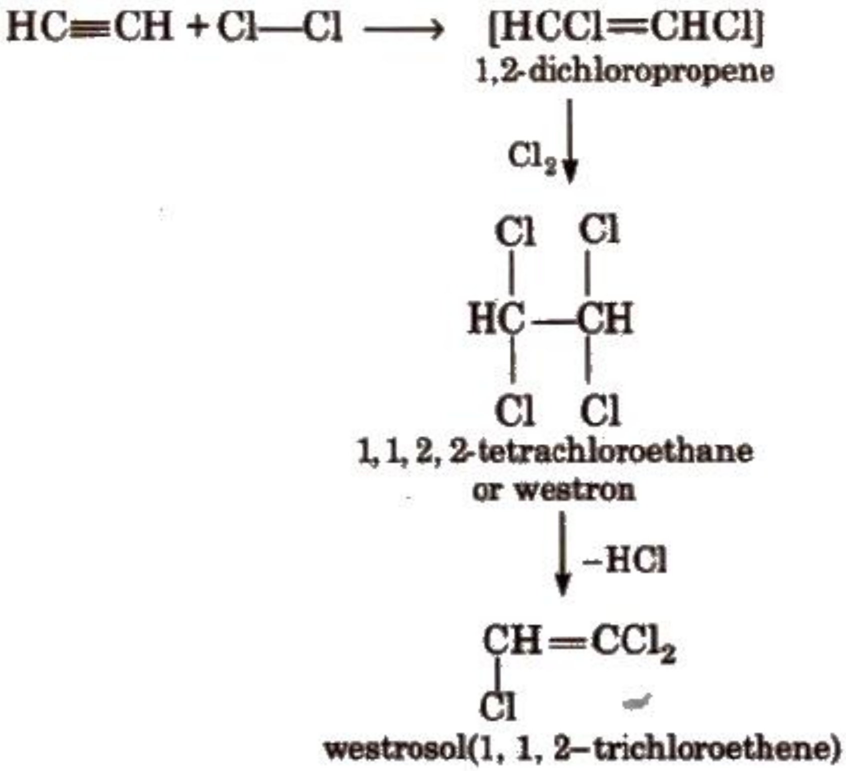
$$-C\equiv C- + HZ \xrightarrow{H^+} \underset{\text{vinyl cation}}{-\overset{\overset{H}{|}}{C}=\overset{\oplus}{C}-} + :Z^- \longrightarrow -\overset{\overset{H}{|}}{C}=\overset{\overset{Z}{|}}{C}-$$

The addition product formed depends upon the stability of vinylic cation. Addition on unsymmetrical alkynes takes place according to Markovnikov’s rule.

(a) Addition of dihydrogen

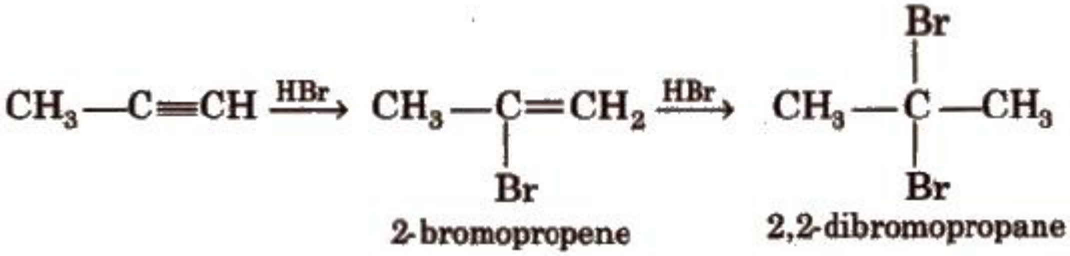
$$H_3CC\equiv C-H + H_2 \xrightarrow{Pt/Pd/Ni} \underset{\text{propene}}{[CH_3-CH=CH_2]} \xrightarrow{H_2} \underset{\text{propane}}{CH_3CH_2CH_3}$$

(b) Addition of halogens



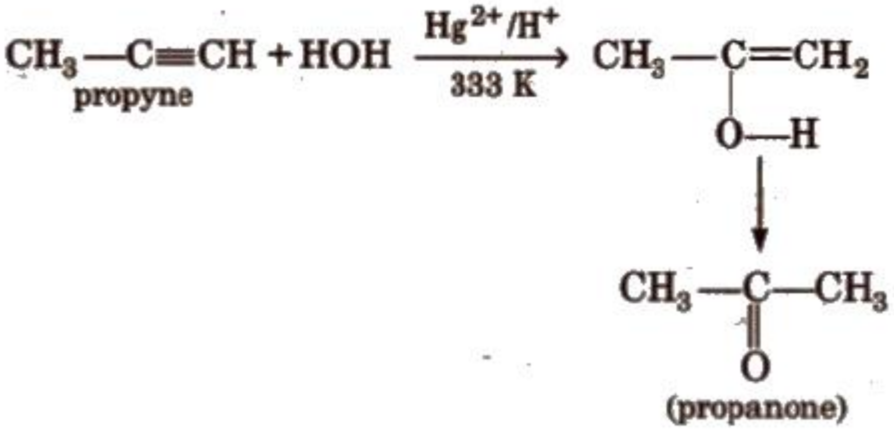
$$HC\equiv CH + Cl-Cl \longrightarrow \underset{\text{1,2-dichloropropene}}{[HCCl=CHCl]} \xrightarrow{Cl_2} \underset{\text{1,1, 2, 2-tetrachloroethane or westron}}{Cl_2HC-CHCl_2} \xrightarrow{-HCl} \underset{\text{westrosol(1, 1, 2–trichloroethene)}}{CHCl=CCl_2}$$

(c) **Addition of hydrogen halides**



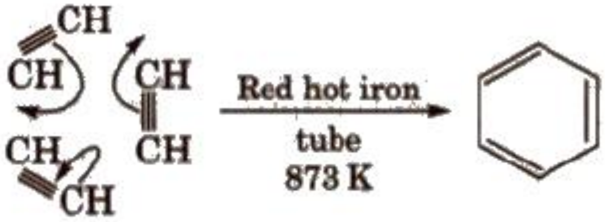
$$CH_3-C\equiv CH \xrightarrow{HBr} \underset{\text{2-bromopropene}}{CH_3-\underset{Br}{C}=CH_2} \xrightarrow{HBr} \underset{\text{2,2-dibromopropane}}{CH_3-\overset{Br}{\underset{Br}{C}}-CH_3}$$

(d) **Addition of water**

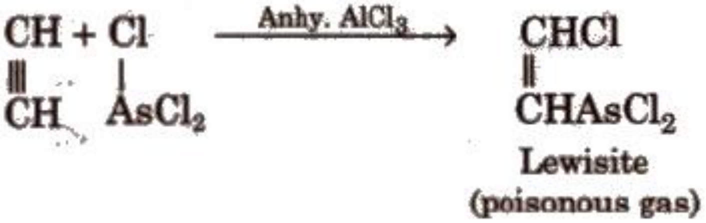


$$\underset{\text{propyne}}{CH_3-C\equiv CH} + HOH \xrightarrow[333\ K]{Hg^{2+}/H^+} CH_3-\underset{\underset{O-H}{|}}{C}=CH_2 \longrightarrow \underset{\text{(propanone)}}{CH_3-\underset{\underset{O}{\|}}{C}-CH_3}$$

(iii) **Cyclic polymerisation**

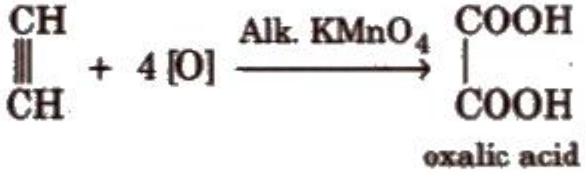


(iv) **Reaction with $AsCl_3$ (arsenic trichloride)**

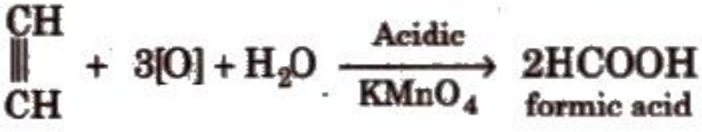


$$\begin{matrix}CH\\ |||\\ CH\end{matrix} + \begin{matrix}Cl\\ |\\ AsCl_2\end{matrix} \xrightarrow{\text{Anhy. } AlCl_3} \underset{\substack{\text{Lewisite}\\ \text{(poisonous gas)}}}{\begin{matrix}CHCl\\ \|\\ CHAsCl_2\end{matrix}}$$

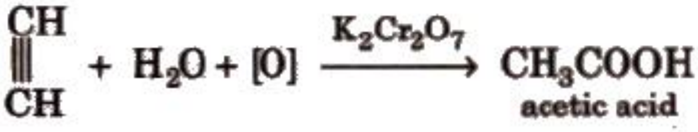
(v) **Oxidation**



$$\begin{matrix}CH\\ |||\\ CH\end{matrix} + 4[O] \xrightarrow{\text{Alk. } KMnO_4} \underset{\text{oxalic acid}}{\begin{matrix}COOH\\ |\\ COOH\end{matrix}}$$

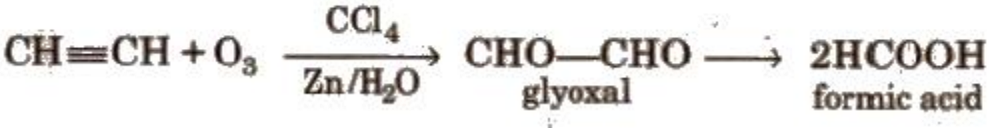


$$\begin{matrix}CH\\ |||\\ CH\end{matrix} + 3[O] + H_2O \xrightarrow[KMnO_4]{\text{Acidic}} \underset{\text{formic acid}}{2HCOOH}$$



$$\begin{matrix}CH\\ |||\\ CH\end{matrix} + H_2O + [O] \xrightarrow{K_2Cr_2O_7} \underset{\text{acetic acid}}{CH_3COOH}$$

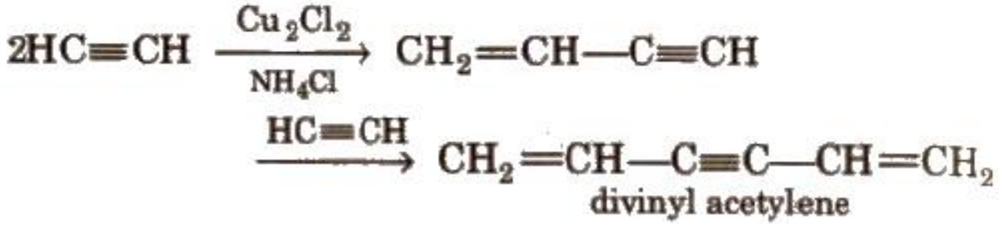
Ozonolysis



$$CH{\equiv}CH + O_3 \xrightarrow[Zn/H_2O]{CCl_4} \underset{\text{glyoxal}}{CHO{-}CHO} \longrightarrow \underset{\text{formic acid}}{2HCOOH}$$

Higher alkynes give diketones which are further oxidised to carboxylic acid.

(vi) **Linear polymerization**



$$2HC{\equiv}CH \xrightarrow[NH_4Cl]{Cu_2Cl_2} CH_2{=}CH{-}C{\equiv}CH \xrightarrow{HC{\equiv}CH} \underset{\text{divinyl acetylene}}{CH_2{=}CH{-}C{\equiv}C{-}CH{=}CH_2}$$

Reactions for Acetylene (C_2H_2)