14 ALKENES

14.1 Introduction :

Q.1.What are alkenes ?

Ans : *Alkenes are aliphatic unsaturated hydrocarbons containing a carbon-carbon double bond* (C=C) *in their molecules.*

e.g. $CH_2 = CH_2$ Ethylene

$CH_3 - CH = CH_2$ Propylene

i) General formula of alkenes is C_nH_{2n}.

ii) They contain two hydrogen atoms less than corrosponding alkanes.

iii) Alkenes are also called olefins i.e. oil forming because ethylene, the first member, forms an oily product with chlorine.

iv) The C = C is called ethylenic bond or olefinic linkage.

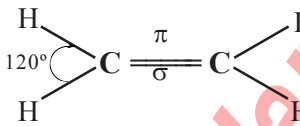
14.2 Electronic structure of ethene

Q.2.Give the electronic structure of ethene

Ans :

i) The molecular formula of ethene is C_2H_4.

ii) The structural and electronic formulae of ethylene are :



Structural formula

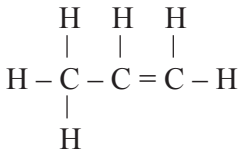
Electronic formula

(Lewis electron-dot formula)

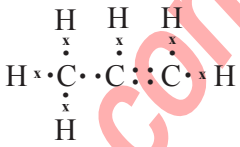
Q.3.Give the structural and electronic structures of propene .

Ans : i) Propene : Molecular formula : C_3H_6

$CH_3 - CH = CH_2$



Structural formula



Electronic formula

(Lewis electron-dot formula)

14.3 Nomenclature of alkenes

a) Common names (Trivial names) :

i) Common names of alkenes are obtained from the parent alkane by changing the suffix **-ane** to **-ylene** .

e.g. ethane → ethylene ; propane → propylene.

ii) The position of double bond is indicated by the greek letters α , β, γ etc to show that double bond originates at first, second or third carbon respectively.

b) IUPAC names :

i) Select the longest continuous carbon chain containing the double bond as parent alkane.

ii) From name of parent alkane the suffix **-ane** is replaced by **-ene**.

iii) Number the carbon atoms in basic chain from the end nearer to the double bond.

iv) The position of double bond is indicated by the number of carbon atom at which the double bond is originated.

v) The position of side chain, if present, is indicated by proper number.

Compound	Common name	IUPAC name
$CH_2=CH_2$	Ethylene	Ethene
$CH_3-CH=CH_2$	Propylene	Propene
$CH_3-CH_2-CH=CH_2$	α-Butylene	But-1-ene
$CH_3-CH=CH-CH_3$	β-Butylene	But-2-ene
$CH_3-\underset{\displaystyle CH_3}{\overset{\displaystyle \vert}{C}}=CH_2$	Isobutylene	2-methylpropen

Q.4. Give the IUPAC names to :

i) $CH_3 - \underset{\underset{CH_3}{|}}{CH} - CH = CH_2$

ii) $CH_2 = \underset{\underset{CH_3}{|}}{C} - \underset{\underset{CH_3}{|}}{CH} - CH_3$

iii) $CH_3 - \underset{\underset{CH_3}{|}}{C} = \underset{\underset{Br}{|}}{CH} - CH_2 - CH_3$

iv) $(C_2H_5)_2C = CH_2$

v) $(CH_3)_2CH - \underset{\underset{CH_2}{||}}{C} - C_2H_5$

Ans : i) 3-methylbut-1-ene.
ii) 2,3- dimethylbut-1-ene.
iii) 3-bromo-2-methylpent-2-ene.
iv) 2-ethylbut-1-ene
v) 2 - ethyl-3-methylbut-1-ene

Q.5. Give the structures of following alkenes.

i) 2,3-Dimethy1hex-3-ene

Ans:

ii) 2-Bromo-4-ethyl-2-methylhex-3-ene.

Ans:

14.4 Isomerism in alkenes :

Q.6. Explain isomerism in alkenes.

Alkenes containing four or greater number of carbon atoms show following types of isomerism

a) Chain isomerism : *It is due to difference in the constitution of carbon chain (i.e. straigh or branched).*

e.g.i) α-Butylene & isobutylene are chain isomers.

α – Butylene : $CH_3 - CH_2 - CH = CH_2$
(Straight chain)

Isobutylene : $CH_3 - \underset{\underset{CH_3}{|}}{C} = CH_2$
(Branched chain)

ii) α – pentylene and iso – pentylene are chain isomers

α – pentylene : $CH_3 - CH_2 - CH_2 - CH = CH_2$
(Straight chain)

Isopentylene : $CH_3 - \underset{\underset{CH_3}{|}}{CH} - CH = CH_2$
(Branched chain)

b) Position isomersim : *It is due to difference in the position of double bond in the same type of carbon chain.*

e.g. i) but-1-ene & but-2-ene are position isomers.

but-1-ene : $CH_3 - CH_2 - CH = CH_2$

but-2-ene : $CH_3 - CH = CH - CH_3$

ii) pent-1-ene and pent-2-ene are chain isomers

pent-1-ene : $CH_3 - CH_2 - CH_2 - CH = CH_2$

pent-2-ene : $CH_3 - CH_2 - CH = CH - CH_3$

c) Geometrical isomerism or Cis-trans isomerism

Alkenes show geometrical isomerism due to restriction or hinderance of rotation about the carbon carbon double bond. The rotation about C = C is not allowed as it would break π -bond which required higher energy (about 251 kJ / mol)

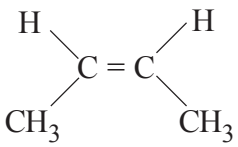
The compounds having same molecular and structural formula but different spatial arrangement of atoms or groups about the carbon carbon double bond are called geometrical isomers and this phenomenon is called geometrical isomerism.

Geometrical isomers are of two types

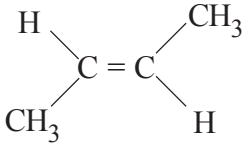
i) Cis- isomer : *The isomer in which identical atoms / groups are present on the same side of the double bond, is called cis-isomer.*

ii) Trans– isomer: *The isomer in which identical atoms / groups are present on the opposite sides of the double bond is called trans - isomer.*

e.g. geometrical isomers of but-2-ene i.e. cis & tras isomers



cis- but-2-ene



trans - but-2-ene

14.5.General Methods of Preparation of Alkenes

i) By dehydration of alcohols.

ii) By dehydrohalogenation of alky1 halides.

iii) By dehalogenation of vicinal dihalides.

i) By Dehydration of Alcohols

Q.7. Explain preparation of alkenes by dehydration of alcohols.

Ans : When alcohols are heated with dehydrating agents like conc. sulphuric acid.

or alumina (Al_2O_3), alkenes are obtained.

In this reaction -OH & -H are eliminated from the adjacent carbon atoms of alcohol as water molecule therefore the name is dehydration.

e.g. i) ethyl alcohol upon dehydration gives ethylene.

$$\underset{\text{Ethyl alcohol}}{CH_3\text{-}CH_2OH} \xrightarrow[Al_2O_3/\ 623\ K]{95\%\ H_2SO_4\ /\ 443\ K} \underset{\text{Ethylene}}{CH_2{=}CH_2} + H_2O$$

ii) n-propyl alcohol gives propylene on dehydration.

$$\underset{\text{n-Propyl alcohol}}{CH_3\text{-}CH_2\text{-}CH_2OH} \xrightarrow[Al_2O_3/\ 623\ K]{95\%\ H_2SO_4\ /\ 443\ K} \underset{\text{Propylene}}{CH_3\text{-}CH{=}CH_2} + H_2O$$

ii) By Dehydrohalogenation of Alkyl halides

Q.8.How will you prepare alkene by dehydrohalogenation of alky1 halide ? 2

Ans : When alkyl halide is boiled with alcoholic caustic potash (KOH) alkene is obtained.

In this reaction hydrogen & halogen atoms are eliminated as HX molecule from adjacent carbon atoms of alkyl halide, hence the name is dehydrohalogenation.

e.g. Ethyl chloride when heated with alcoholic KOH gives ethene.

$$\underset{\text{Cl}}{CH_3\text{–}\overset{|}{C}H\text{–}CH_3} + \underset{\text{(alc.)}}{KOH} \xrightarrow{\Delta} \underset{\text{Ethene}}{CH_2{=}CH_2} + KCl + H_2O$$

Note the following :

i) The ease of dehydrohalogenation of alkyl halide is $3^0 > 2^0 > 1^0$.

ii) Ease of elimination of halogens is I > Br > Cl.

Q.9. What is the action of alcoholic caustic potash on

a] Ethyl bromide b] n-propyl iodide

c] Isopropyl iodide?

Ans: These alkyl halides on heating with alcoholic caustic potash (KOH) give corrosponding alkenes.

a) $\underset{\text{Ethyl bromide}}{CH_3\text{-}CH_2\text{-}Br} + \underset{\text{(alc.)}}{KOH} \xrightarrow{\Delta} \underset{\text{Ethylene}}{CH_2{=}CH_2} + KBr + H_2O$

b) $\underset{\text{n-propyl iodide}}{CH_3CH_2CH_2I} + \underset{\text{(alc.)}}{KOH} \xrightarrow{\Delta} \underset{\text{Propylene}}{CH_3CH{=}CH_2} + KI + H_2O$

c) $\underset{\text{Iso propyl iodide}}{CH_3\text{–}\overset{|}{\underset{I}{C}}H\text{–}CH_3} + \underset{\text{(alc.)}}{KOH} \xrightarrow{\Delta} \underset{\text{Propene}}{CH_2{=}CH\text{–}CH_3} + KI + HI$

Q.10. How will you prepare propylene from

a) n-Propyl bromide b) Isopropyl bromide

Q.11.What is the action of ethanolic KOH on

a) n-Butyl chloride b) sec-Butyl chloride

c) t- Butyl chloride d) Iso-butyl chloride 4

Ans a) n-Butyl chloride upon dehydrohalogenation gives 1-Butene

$$\underset{\text{n-Butyl chloride}}{CH_3CH_2CH_2CH_2Cl} + \underset{\text{(alc.)}}{KOH} \xrightarrow{\Delta} \underset{\text{But-1-ene}}{CH_3CH_2CH{=}CH_2} + KCl + H_2O$$

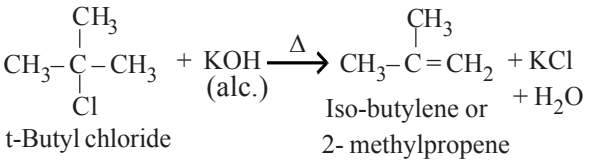
b) sec-Butyl chloride upon dehydrohalogenation gives 2-Butene as the major product (according to Saytzeff's rule).

$$\underset{\text{(sec-Butyl chloride)}}{CH_3CH_2\text{–}\overset{|}{\underset{Cl}{C}}H\text{–}CH_3} + \underset{\text{(alc.)}}{KOH} \xrightarrow{\Delta} \underset{\text{But-2-ene (Major)}}{CH_3\text{–}CH{=}CH\text{–}CH_3} + \underset{\text{But-1-ene (Minor)}}{CH_3\text{-}CH_2\text{-}CH{=}CH_2} + KCl + H_2O$$

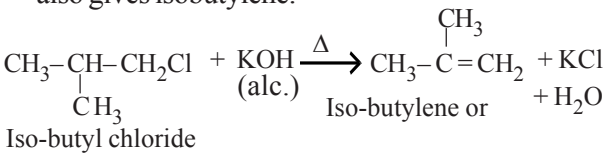
Note the following :

Saytzeff's rule for Elimination : In dehydrohalogenation the-H is preferentailly eliminated from the adjacent carbon atom which contains smaller number of H-atoms

c) t-Butyl chloride upon dehydrohalogenation gives isobutylene or 2- Methylpropene



d) Iso-butyl chloride upon dehydrohalogenation also gives isobutylene.



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iii) By dehalogenation of vicinal dihalides.

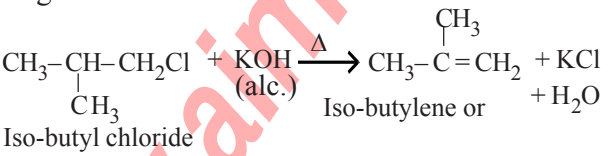
Note the following :

i) The dihalogen compounds in which the halogen atoms are attached to the adjacent carbon atoms are called vicinal dihalides.
ii) Common name of vicinal dihalide is alkylene dihalide .

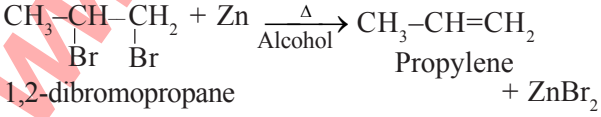
Q.12. How alkenes are prepared by dehalogenation of vicinal dihalides ?

When vicinal dihalides are heated with zinc dust in alcohol alkenes are obtained. In this reaction there is elimination of halogen atoms from the adjacent carbon atoms of the dihalide hence the name is dehalogenation.

e.g. i) When ethylene dibromide is heated with Zn dust in alcohol it undergoes dehalogenation to give ethene.



i) Propylene dibromide on dehalogenation gives propylene.



14.6. Chemical properties

a) Alkenes are more reactive than alkanes due to presence of a double bond. The C=C bond contains a strong σ bond & a weak π bond. During reaction the π bond breaks easily and two new strong σ bonds are formed in its place.

b) The characteristic reactions of alkenes are addition reactions.

Note the following :

Addition reactions: The reaction in which two molecules of reactants combine together to form a single molecule of product is called as addition reaction.
In this reaction there is no elimination of molecules.

Reactions of alkenes :

i) Hydrogenation **ii) Halogenation**
iii) Hydrohalogenation **iv) Addition of H_2SO_4**
v) Ozonolysis **vi) Action of $KMnO_4$**
vii) Polymerisation

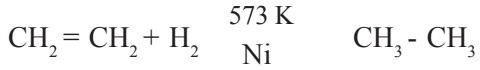
i) Hydrogenation :

Q. 13. Explain the addition of hydrogen on alkene.

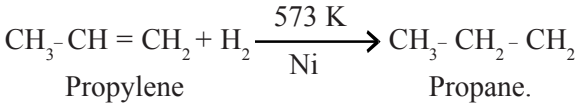
Ans : When vapours of alkene and H_2 gas is passed over heated catalyst (finely divided Ni,Pt or Pd) at 573 K , alkanes are obtained.

Thus alkenes upon catalytic hydrogenation (H_2 / Ni) at 573 K give alkanes.

e.g.i) Ethylene gives ethane upon catalytic hydrogenation.



ii) propylene gives propane upon catalytic hydrogenation.



Q.14.How will you convert

i) Ethene into ethane

ii) Propene into propane.

ii) Halogenation

Q.15.Explain the addition of halogen on alkene.

Ans : Alkenes reacts with halogens in presence of CCl_4 to give vicinal dihalides.

The order of reactivity of halogens : $Cl_2 > Br_2 > I_2$

i) When ethene reacts with chlorine in the presence of carbon tetrachloride to form ethylene dichloride

$$\underset{\text{Ethene}}{CH_2=CH_2} + Cl_2 \xrightarrow{CCl_4} \underset{\text{Ethylene dichloride (1, 2- Dichloroethane)}}{CH_2(Cl)-CH_2(Cl)}$$

ii) When propene reacts with bromide in the presence of carbon tetrachloride to form propylene dibromide

$$\underset{\text{Propene}}{CH_2=CH-CH_3} + Br_2 \xrightarrow{CCl_4} \underset{\text{Propylene dibromide (1, 2- Dibromopropane)}}{CH_2(Br)-CH(Br)-CH_3}$$

iii) Hydrohalogenation :

Q. 16. Explain the Addition of hydrogen halides .

Alkenes upon addition of halogen acids give alkyl halides. The reactivity of halogen acids is HI > HBr > HCl.

a) **Symmetrical alkenes** react with HX to give only one product (i.e. alkyl halides).

e.g. i) $CH_2=CH_2 + HCl \rightarrow CH_3CH_2Cl$ (Ethylene → Ethyl chloride)

ii) $CH_2=CH_2 + HBr \rightarrow CH_3CH_2Br$ (Ethylene → Ethyl bromide)

iii) $CH_2=CH_2 + HI \rightarrow CH_3\text{-}CH_2I$ (Ethylene → Ethyl iodide)

b) **Unsymmetrical alkenes** react with HX to give theoretically two products. The main product is formed according to Markownikoff's rule.

Markownikoff's rule : *When an unsymmetrical reagent is added to an unsymmetrical alkene, the negative part of the reagent goes to the carbon having smaller number of H-atoms.*

e.g.i) propylene reacts with HCl to give isopropyl chloride as the major product.

$$\underset{\text{Propene}}{CH_3-CH=CH_2} + HCl \xrightarrow{\text{Markownikoff's add}^n} \underset{\text{2- chloropropane (Major) 80 \%}}{CH_3-\underset{\underset{Cl}{|}}{CH}-CH_3} + CH_3\text{-}CH_2\text{-}CH_2\text{-}Cl$$

ii) propylene reacts with HBr to give isopropyl bromide as the major product.

$$\underset{\text{Propene}}{CH_3-CH=CH_2} + HBr \xrightarrow{\text{Markownikoff's add}^n} \underset{\text{2- bromopropane (Major) 80 \%}}{CH_3-\underset{\underset{Br}{|}}{CH}-CH_3} + CH_3\text{-}CH_2\text{-}CH_2\text{-}Br$$

iii) propylene reacts with HI to give isopropyl iodide as the major product.

$$\underset{\text{Propene}}{CH_3-CH=CH_2} + HI \xrightarrow{\text{Markownikoff's add}^n} \underset{\text{2- iodopropane (Major) 80 \%}}{CH_3-\underset{\underset{I}{|}}{CH}-CH_3} + CH_3\text{-}CH_2\text{-}CH_2\text{-}I$$

Peroxide Effect or Kharasch effect :

When an unsymmetrical reagent is added to an unsymmetrical alkene, in the presence of peroxide the negative part of the reagent goes to the carbon having more number of H-atoms.

This anti - Markownikoff's addition is called peroxide effect or Kharasch effect.

Peroxide effect is shown by only HBr and not by HCl or HI.

e.g. When propylene reacts with HBr in the presence of peroxide normal propyl bromide is obtained as major product.

$$\underset{\text{propene}}{CH_3-CH=CH_2} + HBr \xrightarrow{\text{Peroxide}} \underset{\text{1- bromopropane (Major)}}{CH_3-CH_2-CH_2Br}$$

Q.17. How will you prepare from propene :

a) Isopropyl chloride b) 1–Chloropropane

c) 1-Bromopropane d) 2-Bromopropane.

a) Isopropyl chloride :

$$\underset{\text{Propene}}{CH_3-CH=CH_2} + HCl \rightarrow \underset{\text{Isopropyl chloride (Major)}}{CH_3-\underset{\underset{Cl}{|}}{CH}-CH_3}$$

b) 1-Chloropropane : Since peroxide effect is not observed in addition of HCl, 1-chloropropane can't be prepared in good yields from propene by this method.

c) 1- Bromopropane :

$$CH_3–CH=CH_2 + HBr \xrightarrow{R–O–O–R} CH_3–CH_2–CH_2Br$$

propene — 1- Bromopropane (Major)

d) 2- Bromopropane :

$$CH_3–CH=CH_2 + HBr$$

Propene — $CH_3–\underset{\underset{Br}{|}}{CH}–CH_3$ Isopropyl bromide (Major)

Q.18.Define Markownikoff's rule. Explain it with suitable example.

Q.19. Explain Kharash effect 2

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iv) Addition of H_2SO_4 :

Q.20. Explain the addition of concentrated H_2SO_4 on ethene.

Ans : Ethene reacts with cold and concentrated sulphuric acid to form ethyl hydrogen sulphate.

$$CH_2=CH_2 + HOSO_3H \xrightarrow[\text{Conc.}]{\text{Cold}} CH_3 - CH_2O\ SO_3H$$

Ethene — Ethylhydrogen sulphate

Q.21. How will you convert ethene into ethyl hydrogen sulphate.

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v) Ozonolysis :

Q.22.Explain ozonolysis of ethene OR what is the action of ozone on ethene.

Ans : When ethene reacts with ozone in ether to form ethylene ozonide which on hydrolysis in the presence of zinc dust to form formaldehyde.

a) $CH_2=CH_2 + O_3 \xrightarrow[\text{Addition}]{\text{Ether}} \underset{\underset{O———O}{|\quad\quad|}}{CH_2\text{-}O\text{-}CH_2}$

Ethylene — Ethylene ozonide

b) $\underset{\underset{O———O}{|\quad\quad|}}{CH_2\text{-}O\text{-}CH_2} + H_2O \xrightarrow{Zn} 2\ HCHO + H_2O_2$

Formaldehyde

Zinc is used to decompose hydrogen peroxide (H_2O_2) which otherwise would oxidise the aldehyde into acid.

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

vi) Action of alkaline $KMnO_4$ (oxidation) :

Q.23.What is action of alkaline $KMnO_4$ on ethene.

OR

How will you convert ethene into ethylene glycol. OR

Give the Baeyer's test for ethene.

Ans : When ethene reacts with alkaline solution of $KMnO_4$ in cold to form ethylene glycol.

In this reaction pink colour of $KMnO_4$ is disappear so this reaction is used for test of unsaturation.

(ethene)

$$(2\ KMnO_4 + H_2O \rightarrow 2\ MnO_2 + 2\ KOH + 3\ [O]\ )$$

$$CH_2=CH_2 + H_2O + [O] \xrightarrow[273\ K]{alk.KMnO_4}$$

Ethylene — $\underset{\underset{OH}{|}}{CH_2} – \underset{\underset{OH}{|}}{CH_2}$ Ethylene glycol (Ethandiol)

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vii) Polymerisation of ethylene :

Q.24.Explain polymerisation of ethylene.

Ans : When ethene is heated at 473 - 673 K under high pressure, in presence of traces of oxygen polyethene is obtained.

$$n\ CH_2=CH_2 \xrightarrow[\text{High pressure}]{473 - 673\ K} (–CH_2–CH_2–)_n$$

Ethylene — Polyethene

(Where n = 600 - 1000)

Uses of Alkenes :-

Q.25. Give uses of alkenes. 2

i) Ethylene is used for artificial ripening of fruits. e.g. apples, oranges, bananas.

ii) Ethylene is used in oxyethylene flame for cutting and welding of metals.

iii) Ethylene is used as general anaesthetic.

iv) Ethylene is used in preparation of important compounds like acetaldehyde, acetic acid, ethylene glycol etc.

v) Ethylene is used in preparation of plastics like polythene.

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