



Alkenes

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Introduction & electronic structures of alkenes

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- Aliphatic unsaturated hydrocarbons containing $\begin{array}{c} | & | \\ \text{C} = & \text{C} \\ | & | \end{array}$ are called *alkenes*.



- They are also known as *olefins*.
- General molecular formula is C_nH_{2n} .

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- Hydrocarbons Containing **two** carbon-carbon double bonds are called **Alkadienes**.



- Hydro carbons containing **three** – $\begin{array}{c} | \\ \text{C} \\ | \end{array} = \begin{array}{c} | \\ \text{C} \\ | \end{array}$ – double bonds are called **Alkatrienes**.



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Electronic structure of Ethene (C_2H_4) : -

➤ Lewis dot structure

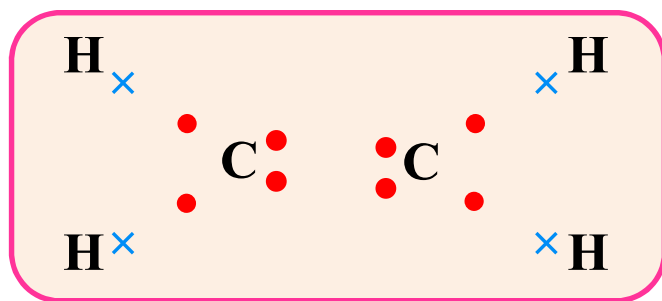
➤ Dash structure

➤ Ball and stick model

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Electronic structure of Ethene (C_2H_4) : -

1) Lewis dot structure

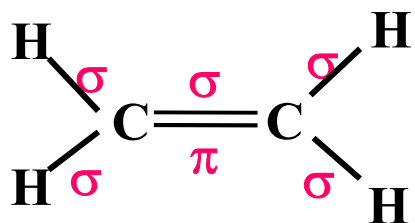


- → Electron of **Carbon**
- × → Electron of **Hydrogen**

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Electronic structure of Ethene (C_2H_4) : -

2) Dash structure



Bond length - $\text{C} = \text{C}$ - is 1.34 \AA

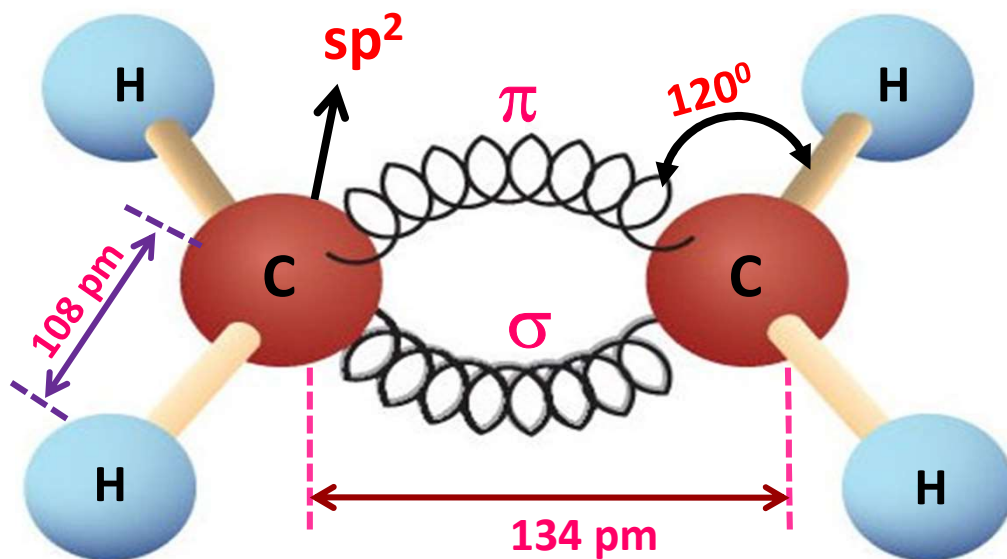
Bond length = $\text{C} - \text{H}$ - is 1.08 \AA

Hybridization at each carbon is sp^2 , and bond angle is 120°

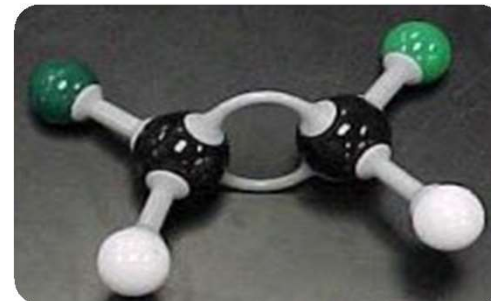
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Electronic structure of Ethene (C_2H_4) : -

3) Ball & stick model :-



$\text{C} = \text{C}$ consists of one σ - bond & one π - bond



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1. No. of σ and π bonds in ethylene molecule...

MCQs

 a) 5, 1

b) 1, 5

c) 1, 1

d) 5, 5

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2. General formula of olefins is...



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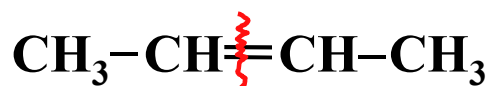
Classification of alkenes & Isomerism

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Classification of alkenes:

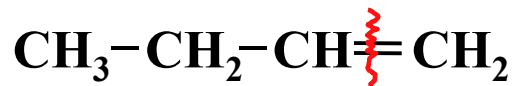
Alkene

Symmetrical



The alkenes in which similar groups are attached to the double bonded carbon atoms.

Unsymmetrical



alkene in which different groups are attached to the double bonded carbon atoms.

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Isomerism

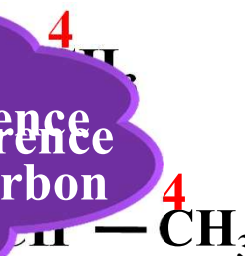
Isomerism

The presence of two or more compounds with the same molecular formula but different structural formula is

Chain isomerism

Position isomerism

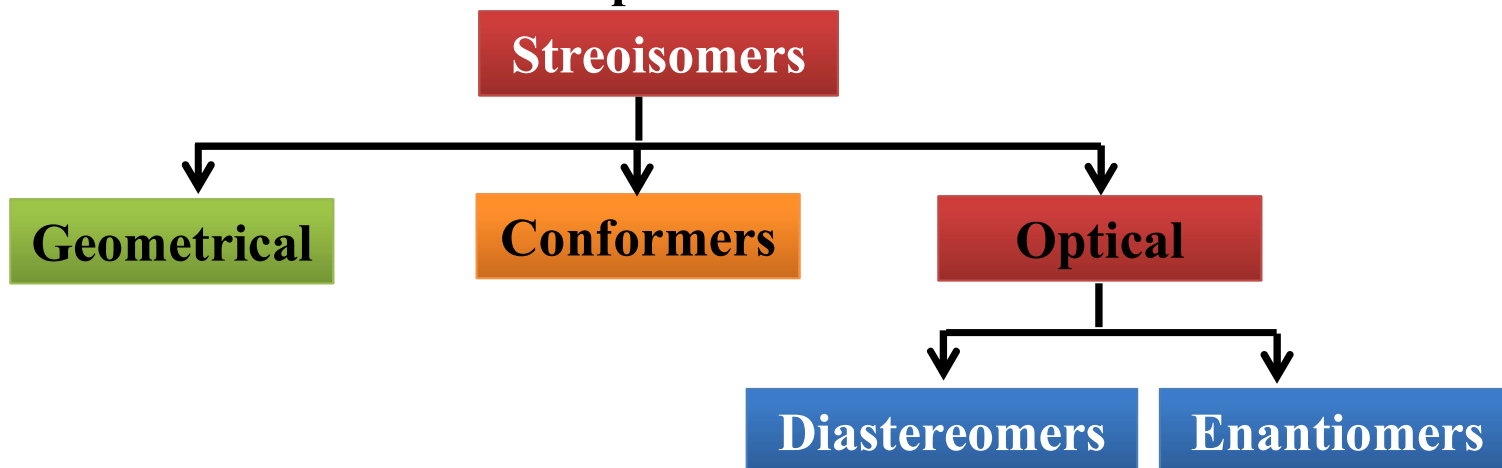
Isomerism arising due to the difference in position of double bond in the carbon chain.



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STREOISOMERS

- Isomers having same molecular formula but differing in 3 dimensional orientation of their atoms in a space are called stereoisomers and the phenomenon is known as stereoisomerism.

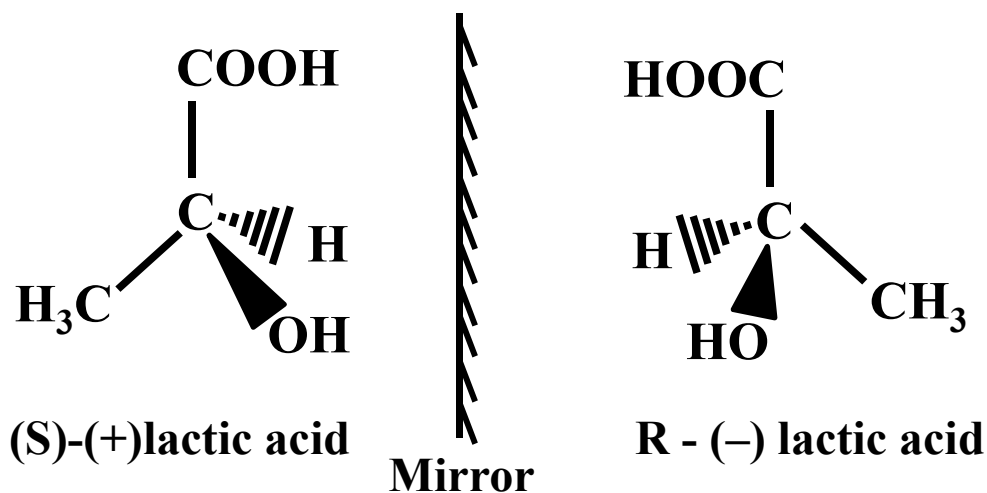


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Enantiomers

- The isomers which are non - super imposable mirror images are called **enantiomers**.

e.g:

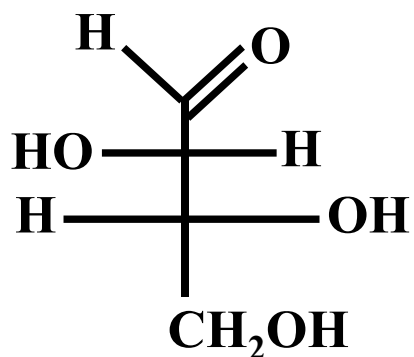


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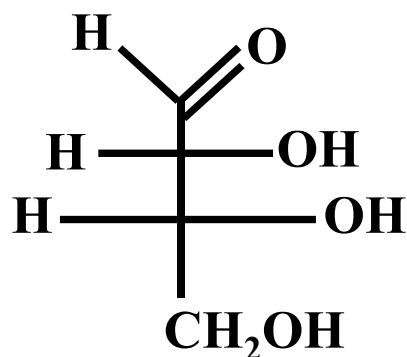
Diastereomers

- Stereoisomers that are non-mirror images and non-superimposable are called **Diastereoisomers**.

e.g:



D- Threose



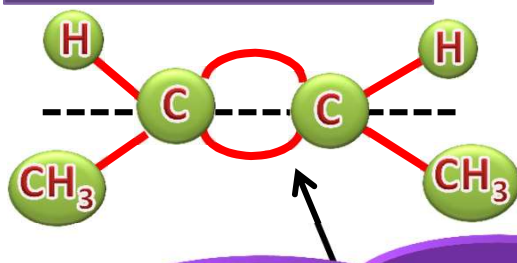
D- Erythrose

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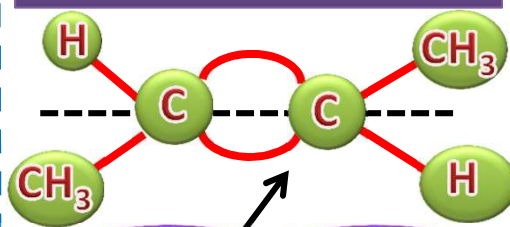
Geometrical isomerism

- It describes the relative orientation of atom (or) group of atoms on the double bonded carbon atoms.

1) Cis – isomer :-



2) Trans – isomer :-

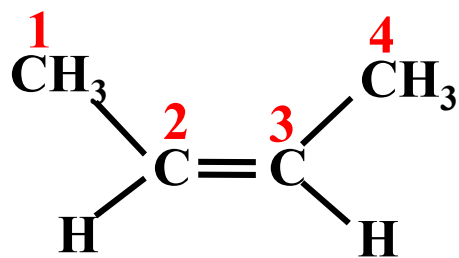


The isomer in which two identical atoms or groups lie on the same side of the double bonded carbon is called **Cis** isomer.

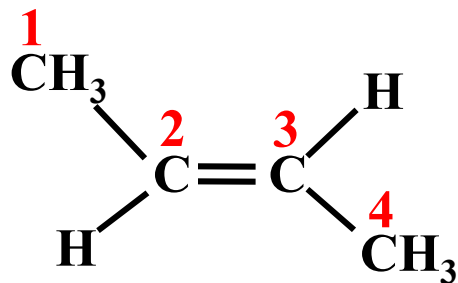
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Geometrical isomerism

E.g



cis -But-2-ene

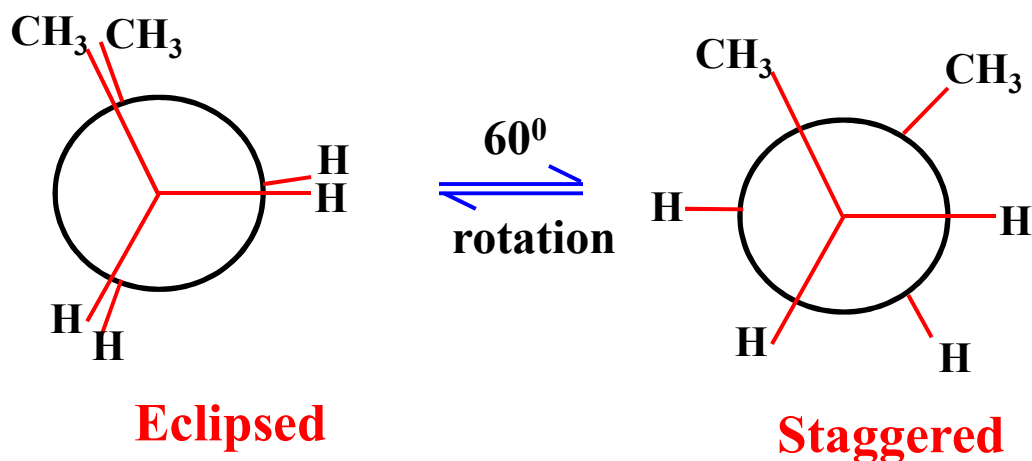


trans -But-2-ene

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Conformers

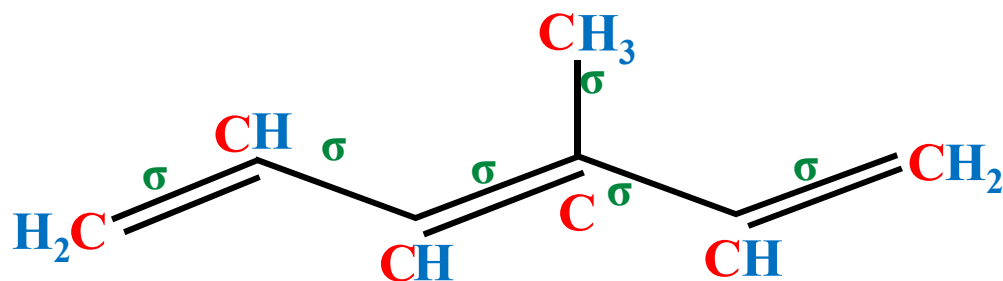
- A form of stereoisomerism in which the isomers can be **interconverted** exclusively by **rotation** about C–C single bonds. These are also called **rotamers**.



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➤ How many σ & π bond are there in following alkene?

Ans:



1) No. of C – C = 6 σ

2) No. of C – H = 10 σ

Total = 16 σ & 3 π bonds

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MCQs

1. Which of the following alkene can exhibit geometrical isomerism?



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2. Geometrical isomerism is basically due to

 a) **Restricted rotation about C=C**

b) **Free rotation about C-C**

c) **Free rotation about C=C**

d) **None of these**

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NOMENCLATURE OF ALKENES

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NOMENCLATURE:

a) Common name :

- Common name of alkene is obtained by replacing the suffix 'ane' of the parent alkane by 'ylene'.
- Position of double bond is indicated by Greek letters $\alpha, \beta, \gamma, \dots$ etc.

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NOMENCLATURE:

a) Common name :

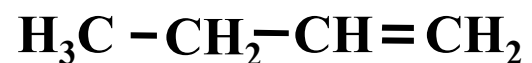
Example:



Ethylene



Propylene



α -Butylene



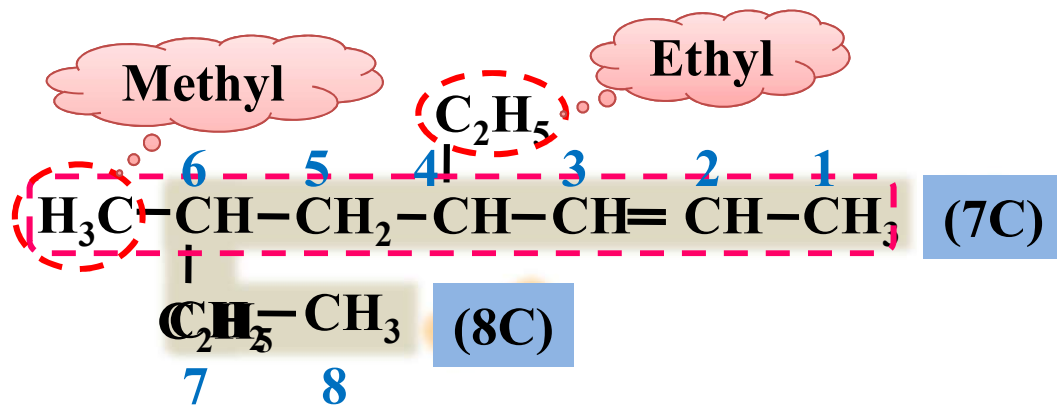
β -Butylene

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NOMENCLATURE:

b) IUPAC name:

- 1) Longest carbon chain.
- 2) The suffix of alkene is 'ene'.
- 3) Lowest locant rule.
- 4) Alphabetical order to be followed for substituents.

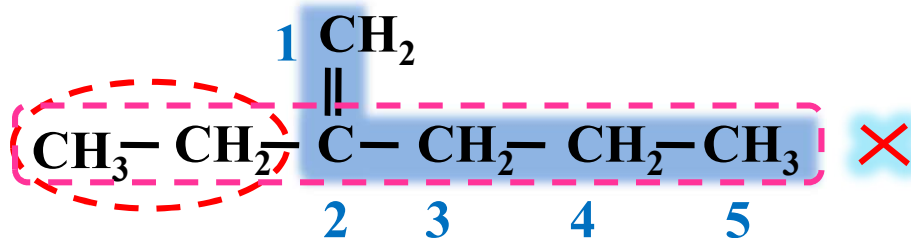


4-Ethyl-6-methyloct-2-ene

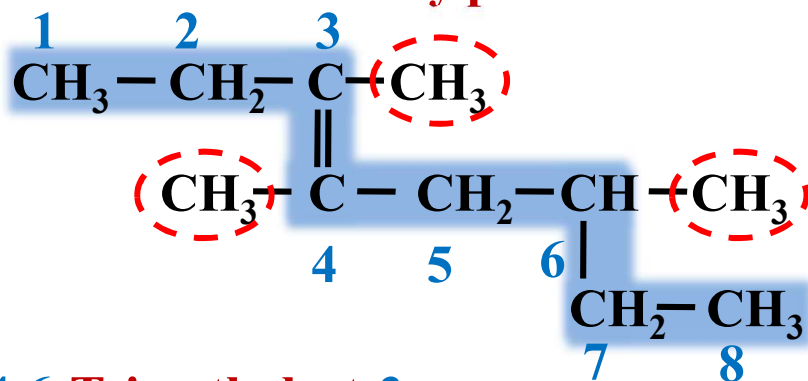
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NOMENCLATURE:

b) IUPAC name:



2-Ethylpent-1-ene

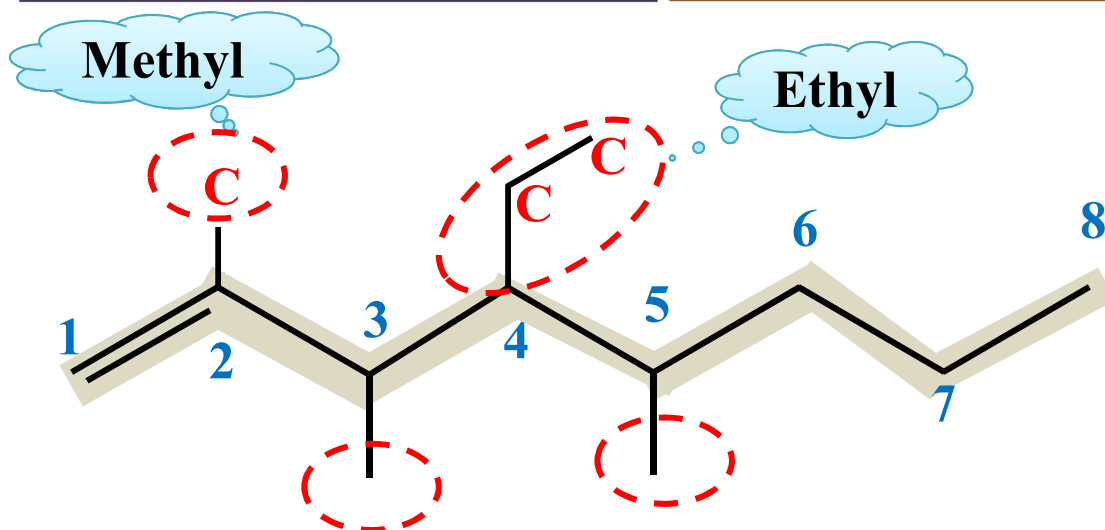


3,4,6-Trimethyloct-3-ene

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NOMENCLATURE:

b) IUPAC name:



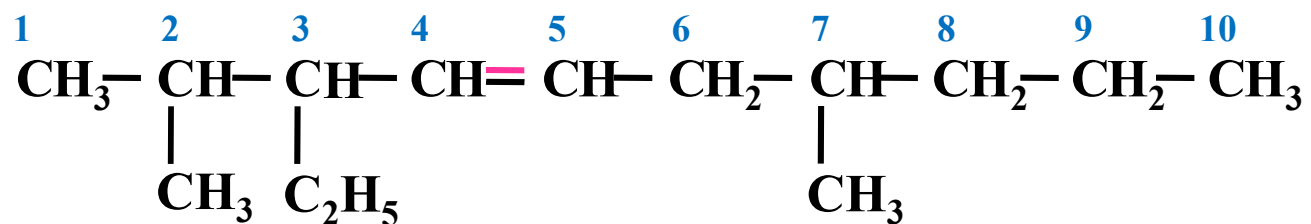
4-Ethyl-2,3,5-trimethyloct-1-ene

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NOMENCLATURE:

b) IUPAC name:


3-Ethyl -2,7-dimethyl dec -4- ene



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Structure	Common Name	I.U.P.A.C.
$\text{H}_3\text{C}-\text{CH}_2-\text{CH}=\text{CH}_2$	α - butylene	But-1-ene
$\text{H}_3\text{C}-\text{HC}=\text{CH}-\text{CH}_3$	β - butylene	But-2-ene
$\text{H}_3\text{C}-\text{CH}_2-\text{CH}=\text{CH}-\text{CH}_3$	β - pentylene	Pent-2-ene

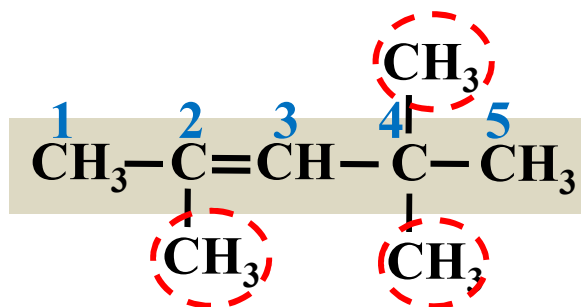
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$ \begin{array}{c} \text{H}_3\text{C}-\text{C}=\text{CH}_2 \\ \\ \text{H}_3\text{C} \end{array} $ 	isobutylene	2 -Methylpropene
$ \begin{array}{c} \text{CH}_3-\text{CH}-\text{CH}=\text{CH}_2 \\ \\ \text{CH}_3 \end{array} $	isopentylene	3-Methylbut-1-ene
$\text{H}_2\text{C}=\text{CH}-\text{CH}=\text{CH}-\text{CH}_3$	————	Penta-1,3-diene

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1. Give IUPAC name of the $(\text{CH}_3)_2\text{C} = \text{CH}-\text{C}(\text{CH}_3)_3$

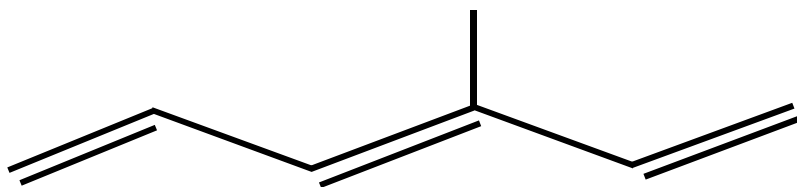
Ans:



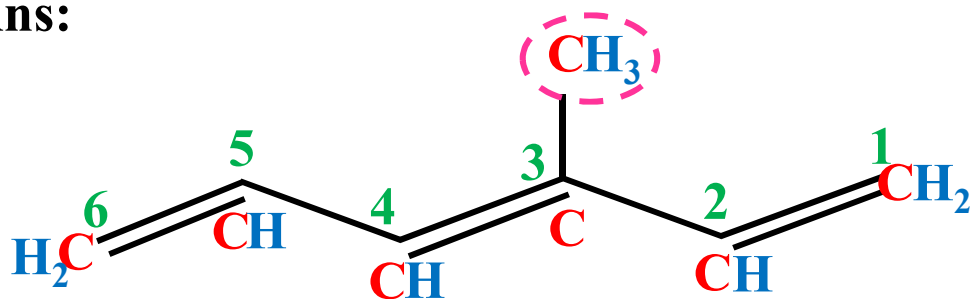
2,4,4-Trimethylpent-2-ene

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2. Write its complete structural formula and give IUPAC name.



Ans:



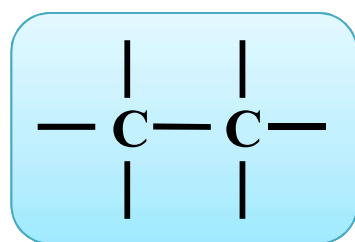
3-Methylhexa -1,3,5-triene

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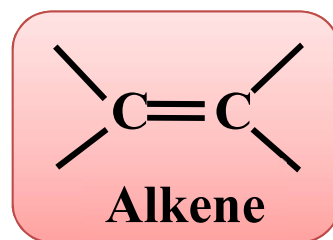
PREPARATION OF ALKENE (PART 1)

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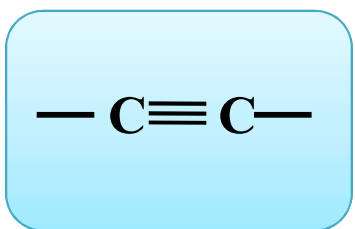
PREPARATION OF ALKENE :



**Elimination
Reaction**



**Addition
Reaction**



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PREPARATION OF ALKENE :

1) From catalytic hydrogenation of alk

Lindlar's catalyst:

It is a heterogeneous catalyst that consists of palladium deposited on calcium carbonate or barium sulphate which is then poisoned with quinoline or various forms of lead or sulphur .

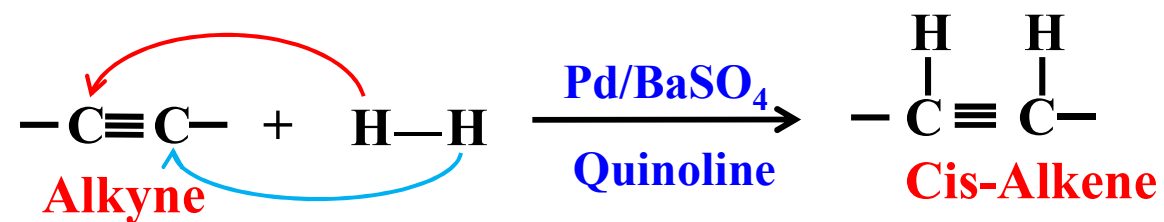
Alkynes on partial reduction with hydrogen in presence of **Lindlar's catalyst** form **cis-alkene**.



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PREPARATION OF ALKENE :

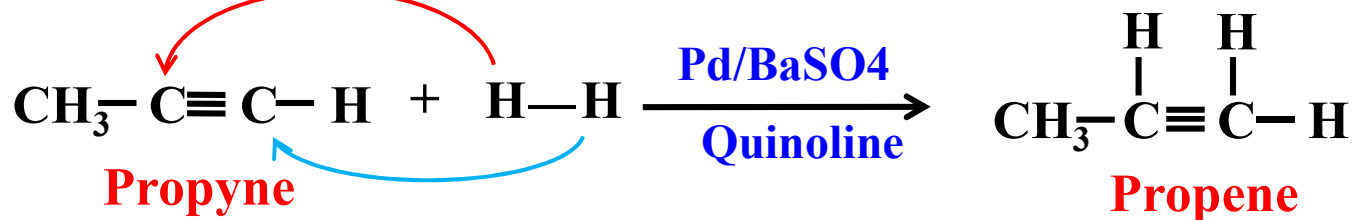
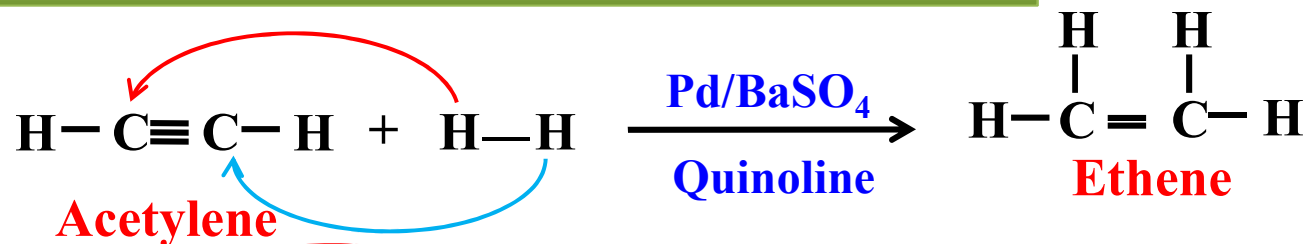
1) From catalytic hydrogenation of alkynes:



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PREPARATION OF ALKENE :

1) From catalytic hydrogenation of alkynes:

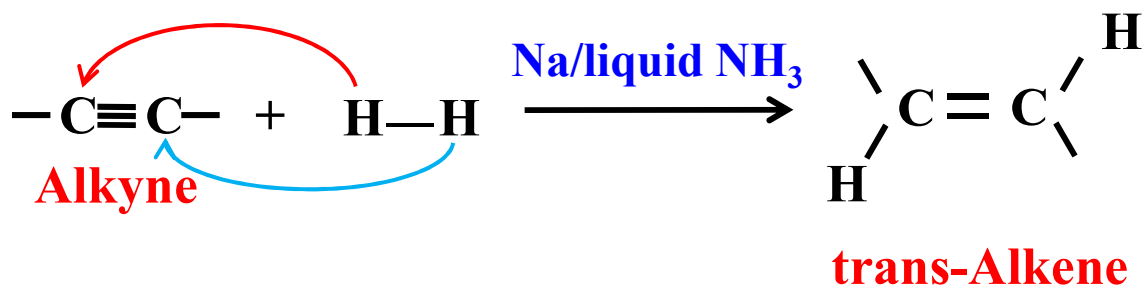


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PREPARATION OF ALKENE :

1) From catalytic hydrogenation of alkyne

Alkynes on reduction with sodium in liquid ammonia form **trans alkenes**.



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MCQs

1. Lindlar's reagent is ...

a) Ni/H_2

 b) $\frac{\text{Pd}-\text{BaSO}_4}{\text{Quinoline}}$

c) alc. KOH

d) Aq.KOH

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2. Reagent used in Dehydrohalogenation of alkyl halides..

 a) alc.KOH

b) $\text{Hg}^{2+}/\text{H}_2\text{SO}_4$

c) aq. KOH

d) $\text{O}_3/\text{Zn} + \text{H}_2\text{O}$

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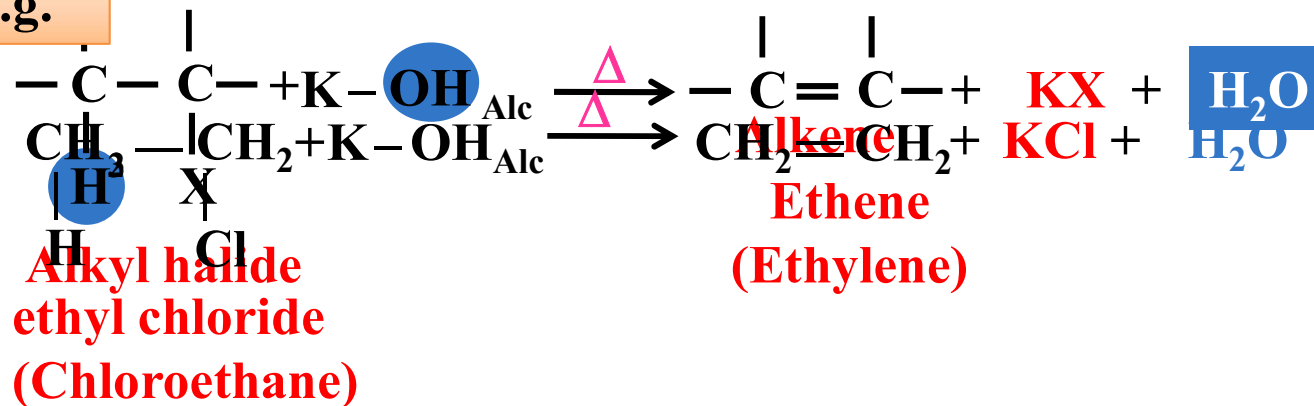
PREPARATION OF ALKENE (PART -2)

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PREPARATION OF ALKENE :

2) From dehydrohalogenation of alkyl halide:

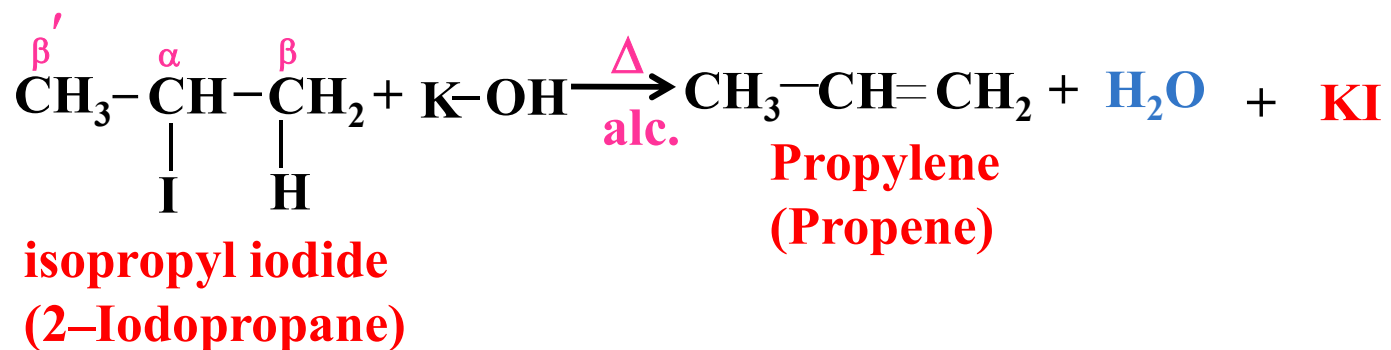
e.g.



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PREPARATION OF ALKENE :

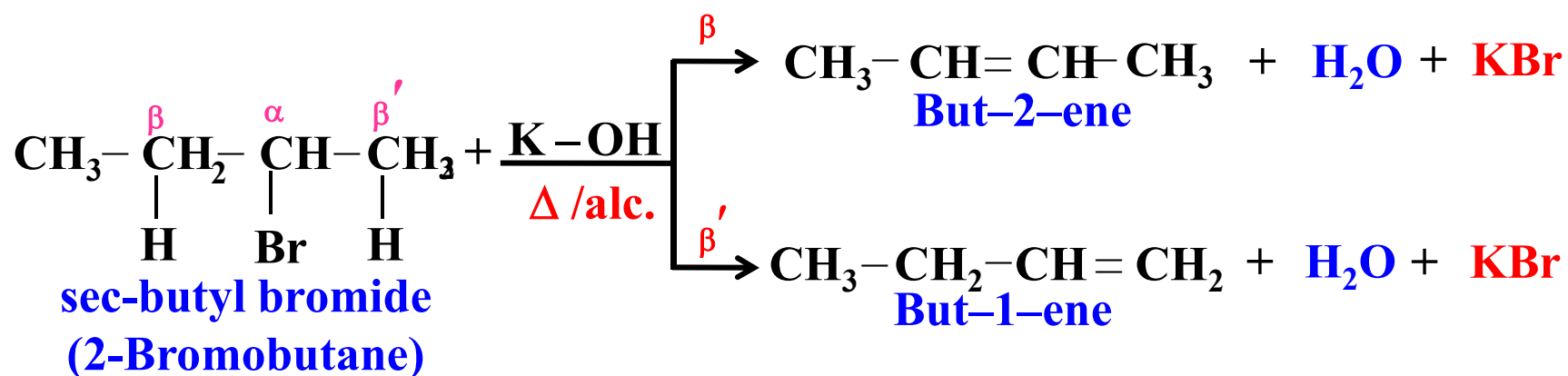
2) From dehydrohalogenation of alkyl halide:



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PREPARATION OF ALKENE :

2) From dehydrohalogenation of alkyl halide:



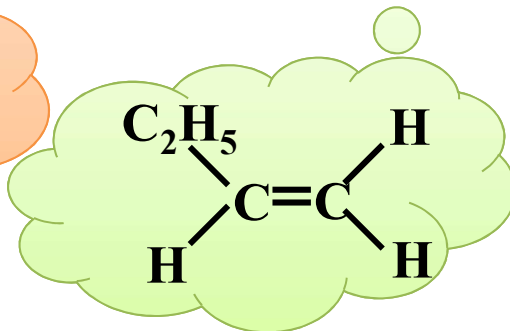
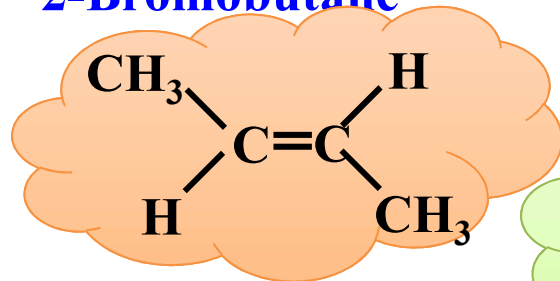
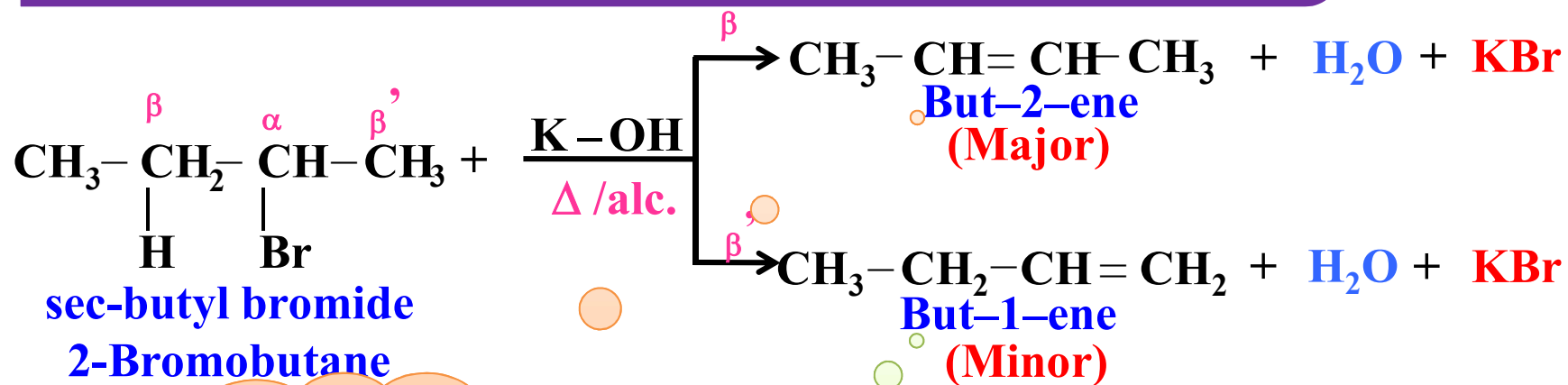
Which elimination reaction
will be stable ?

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Saytzeff's rule

In elimination reaction, the **preferred alkene** is that which has the **greater number of alkyl groups attached to the doubly bonded carbon atoms.** (*more substituted alkene*)

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1. Ethyl chloride on dehydrohalogenation gives...

MCQs

a) Ethane


b)  Ethene

c) Ethyne

d) None of these

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2. Reagent used in dehydrohalogenation is...

- a) Zn/HCl
-  b) Alc KOH
- c) Aq KOH
- d) Zn

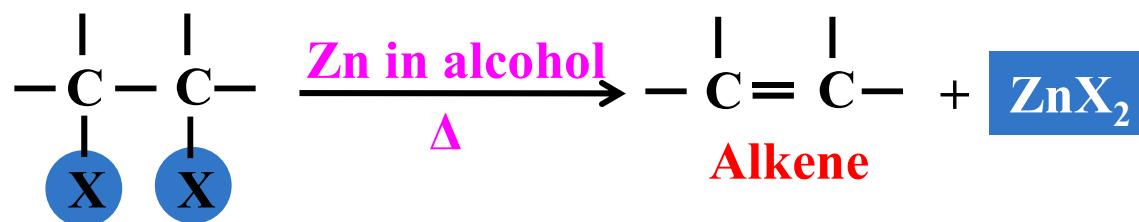
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PREPARATION OF ALKENE (PART 3)

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PREPARATION OF ALKENE :

3) Dehalogenation of vicinal dihalide:



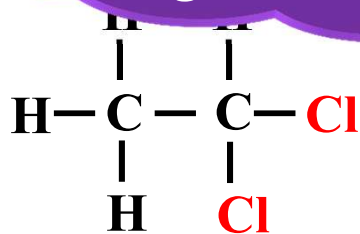
Vicinal Dihalide

What is vicinal dihalide?

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Geminal dihalide

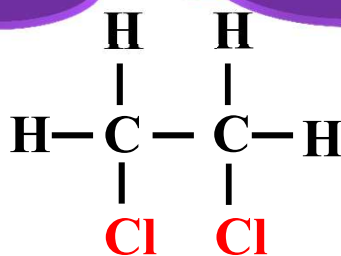
Halogens on the same carbon means geminal (Gem)



Ethylidene **dichloride**
1,1-Dichloroethane

Vicinal dihalide

Halogens on adjacent carbons means Vicinal(Vic)



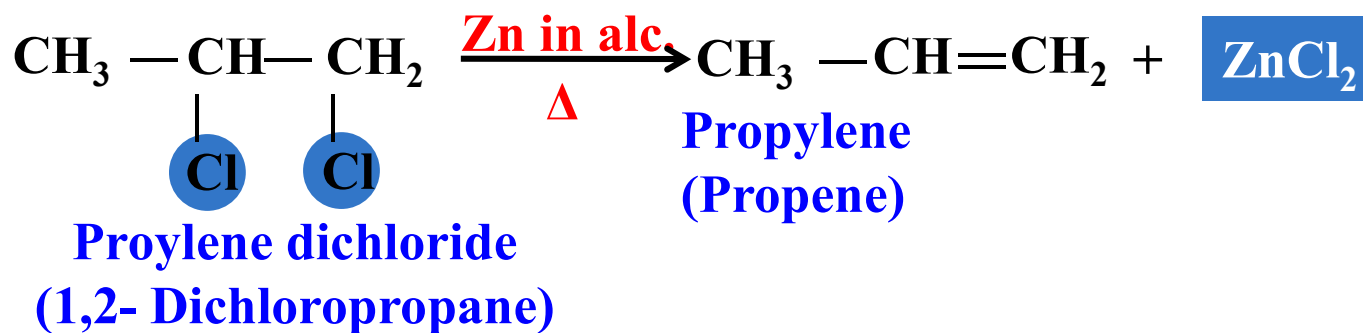
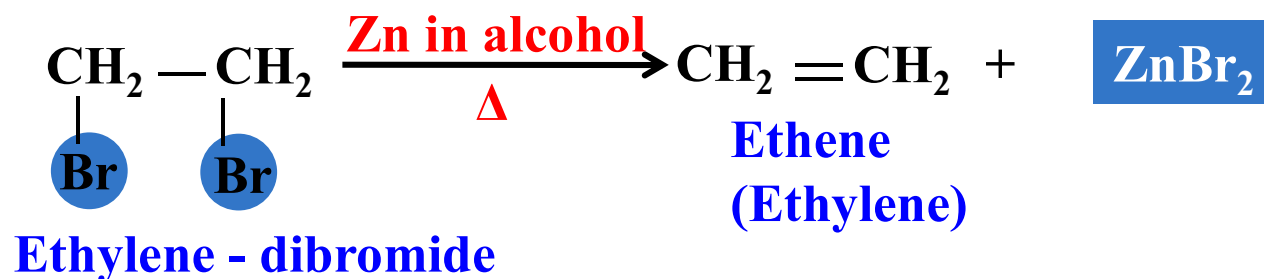
Ethylene **dichloride**
1,2-Dichloroethane

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PREPARATION OF ALKENE :

3) Dehalogenation of vicinal dihalide:

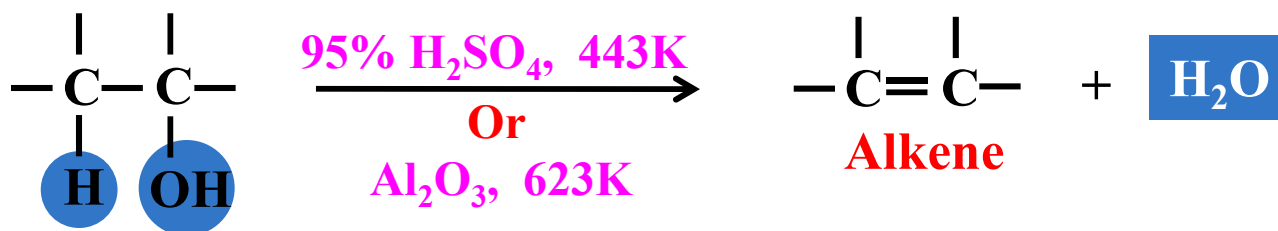
e.g. :



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PREPARATION OF ALKENE :

4) Dehydration of alcohol:

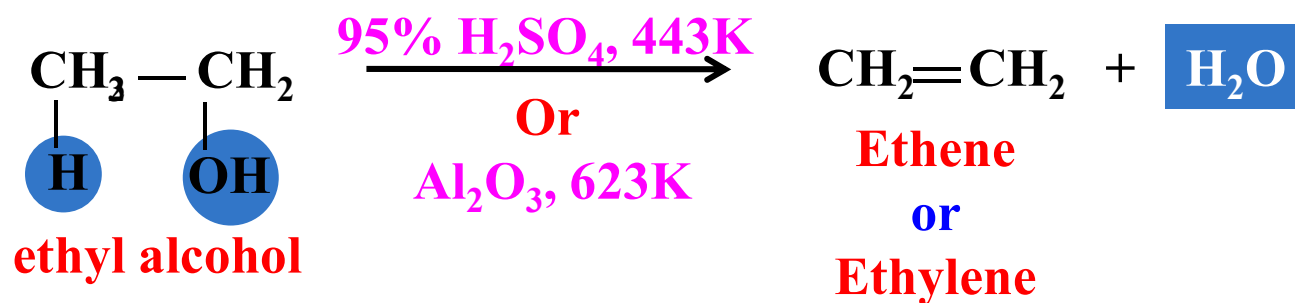


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PREPARATION OF ALKENE :

4) Dehydration of alcohol:

E.g.

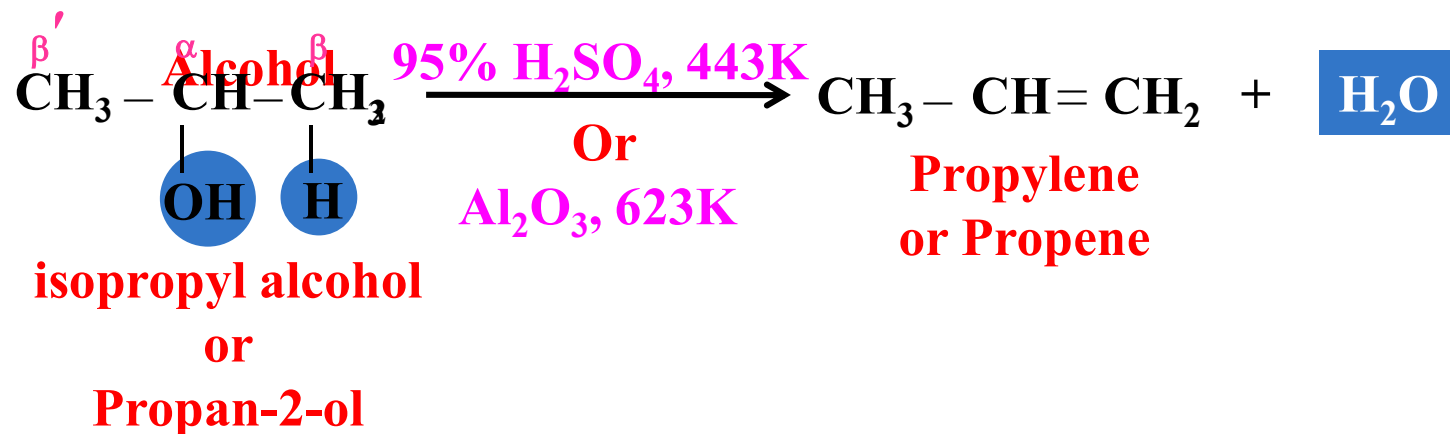


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PREPARATION OF ALKENE :

4) Dehydration of alcohol:

E.g.



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Q) Match the entries of list-1 with appropriate entries of list-2.

List - 1	List - 2
1) Dehydration	a) H_2 /Pd-BaSO ₄
2) Dehydrohalogenation	b) Conc. H_2SO_4
3) Hydrogenation	c) Zn in alcohol
4) Dehalogenation	d) Alc. KOH

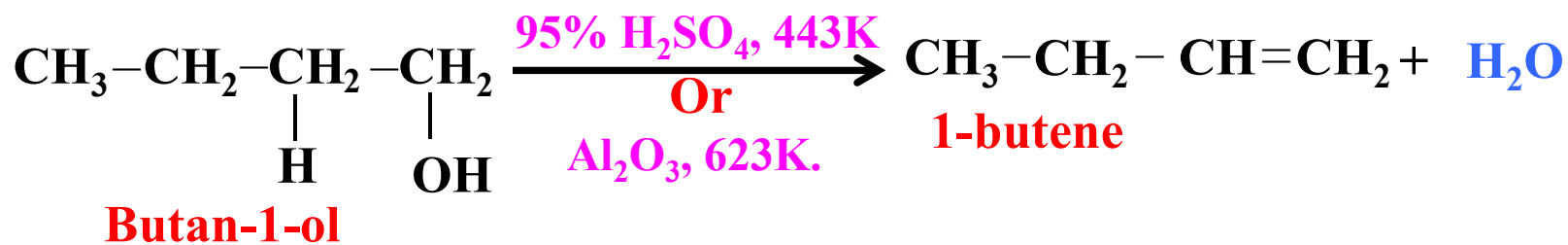
Ans: 1) – (b), 2) – (d), 3) – (a), 4) – (c)

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Q) Write the chemical equations for preparation of But-1-ene

a) From alcohol:

Ans:

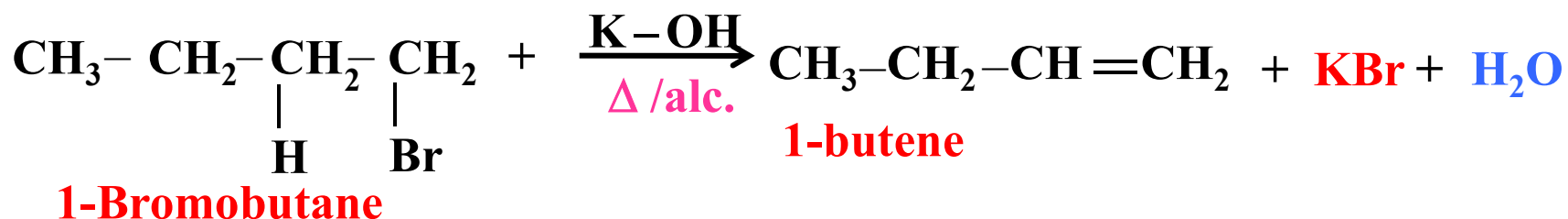


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Q) Write the chemical equations for preparation of But-1-ene

b) From alkyl halide :

Ans:

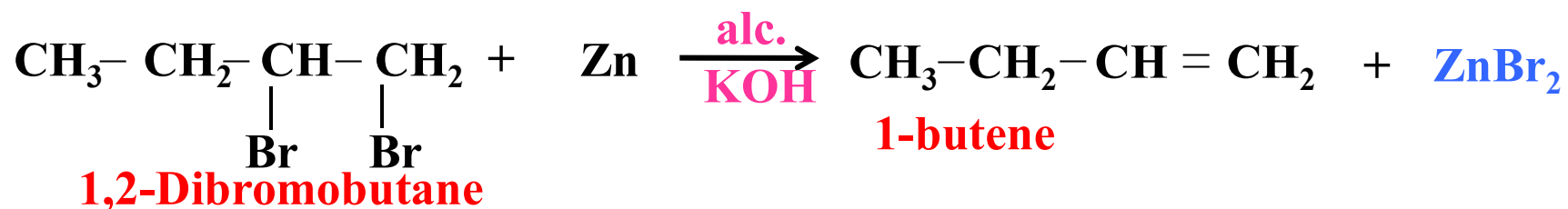


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Q) Write the chemical equations for preparation of But-1-ene

c) From vicinal dihalide:

Ans:



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MCQs

1. Reagent used in dehydration of aliphatic alcohols is...

a) $\text{Con.H}_2\text{SO}_4$ at 170°C .

b) $\text{Al}_2\text{O}_3/623\text{K}$

 c) a, b

d) aq. KOH

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2. Reagent used in dehalogenation of di, (or) tetra halogen derivatives of alkanes is ...

a) Alc. KOH

b) Ni/H₂O

c) KMnO₄/HO⁻

 d) Zn/alcohol

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Physical & chemical properties of alkenes

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Physical Properties of alkene:

- The first **three members** are **gases**, the **next fourteen members** are **liquids** and the higher ones are solids.
- Ethene is a **colourless gas** with faint sweet smell.
All other alkenes are colourless and odourless.
- Insoluble in water but fairly soluble in non-polar solvents like benzene, ether.

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Physical Properties of alkene:

- With increase of size of alkyl group boiling point increases.
- Branched chain compounds have lower boiling point than straight chain alkenes.

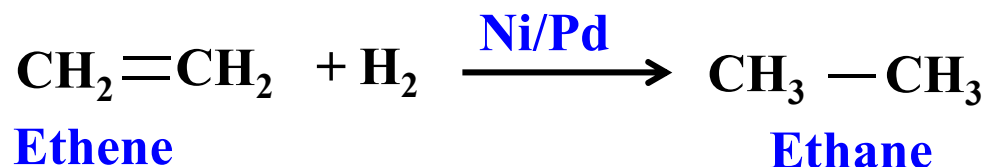
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Chemical Properties of alkene:

Addition of dihydrogen :-

- Addition of dihydrogen gas with alkenes in the presence of **finely divided nickel**, palladium or platinum to form **alkanes**.

e.g. :



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Chemical Properties of alkene:

Addition of halogens :-

- Halogens like bromine or chlorine add to alkene to form **vicinal dihalides**.
- The reddish orange colour of bromine solution in **carbon tetrachloride** is discharged, when bromine adds to an unsaturation site.

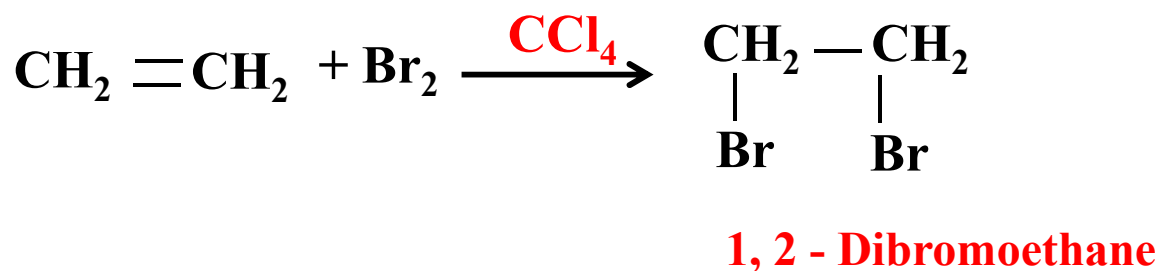
This reaction is **used as a test for unsaturation**.

This is electrophilic addition reaction.

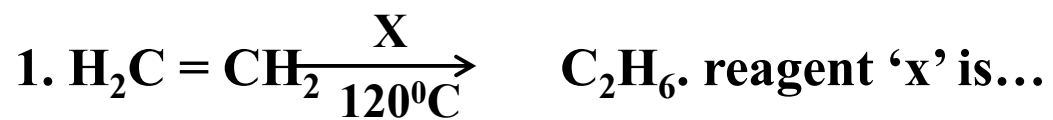
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Chemical Properties of alkene:

Addition of halogens :-



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MCQs

a) Ni/H₂


b) Pd/H₂

c) Pt/H₂

 d) All the above

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2. Alkene + (H) $\xrightarrow[120^{\circ}\text{C}]{\text{Ni/H}_2}$ Alkane. regarding this correct statement is...

- a)  Hybridization of Alkene changes from Sp^2 to Sp^3
- b) Bond length of $\text{C}=\text{C}$ bond increases
- c) Bond length at each carbon increases from 120° to 109°
- d) All the above

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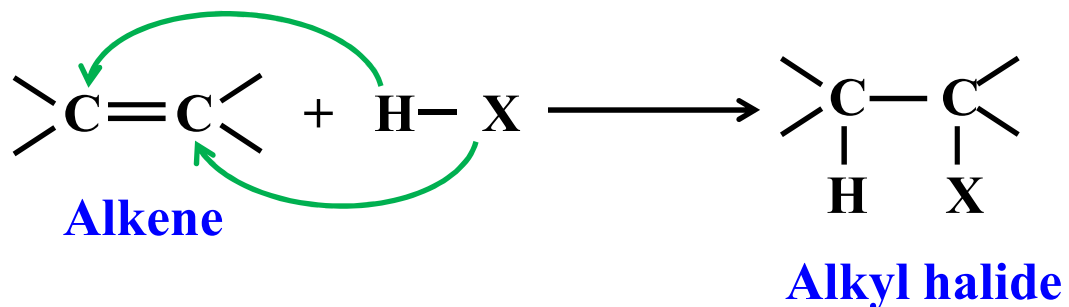
Chemical properties of alkenes (part 2)

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Chemical Properties of alkene:

Addition of hydrogen halides:- (Formation of alkyl halide)

The addition of hydrogen halide (HX) across the double bond of alkene is known as **hydrohalogenation**.



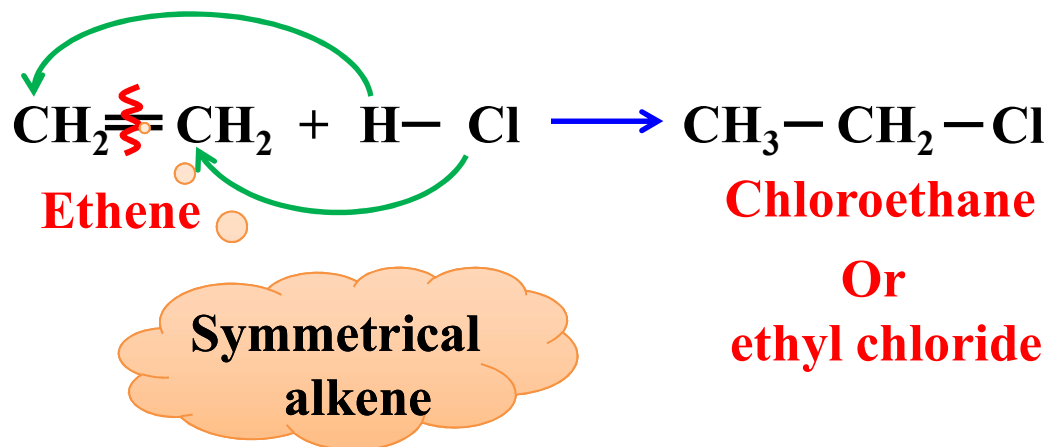
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Chemical Properties of alkene:

Addition of hydrogen halides:-

A)

Symmetrical alkene :



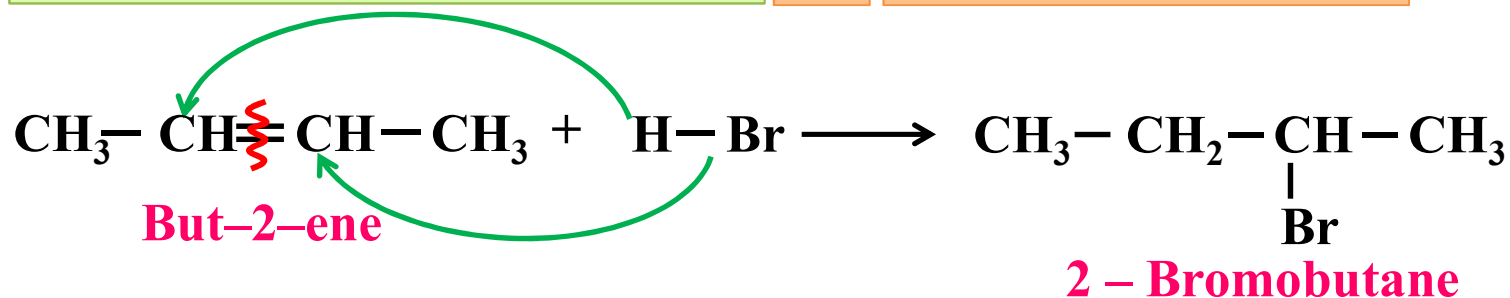
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Chemical Properties of alkene:

Addition of hydrogen halides:-

A)

Symmetrical alkene :



Order of reactivity of HX - **HI > HBr > HCl**

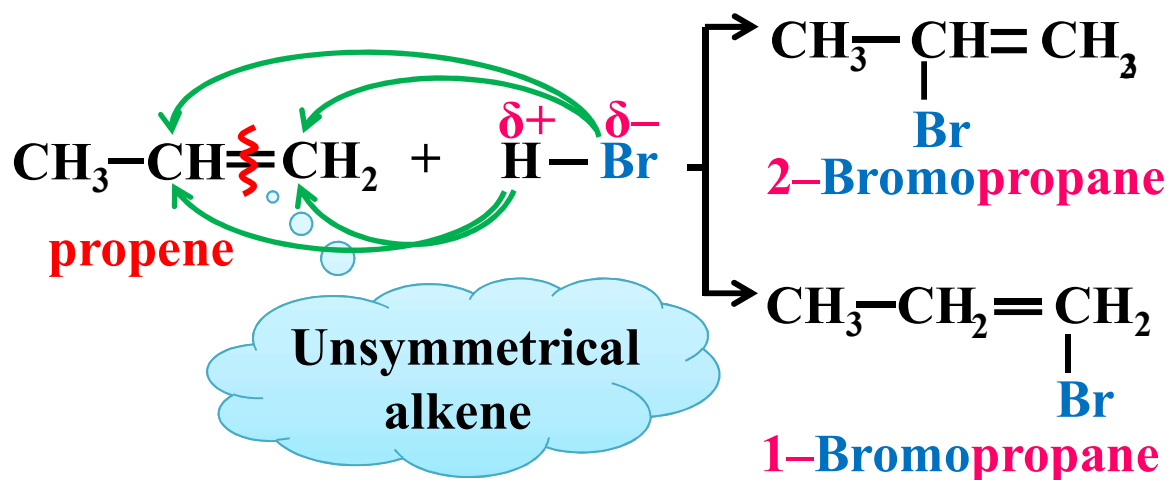
ALKENES

Chemical Properties of alkene:

Addition of hydrogen halides:-

B)

Unsymmetrical alkene :



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Chemical Properties of alkene:

Addition of hydrogen halides:-

B)

Unsymmetrical alkene :

But according to Markownikoff's rule:

- When unsymmetrical alkene reacts with unsymmetrical reagent, then **negative part** of the reagent gets added to the carbon atom containing the **less number of H - atoms** across the carbon – carbon double bond.

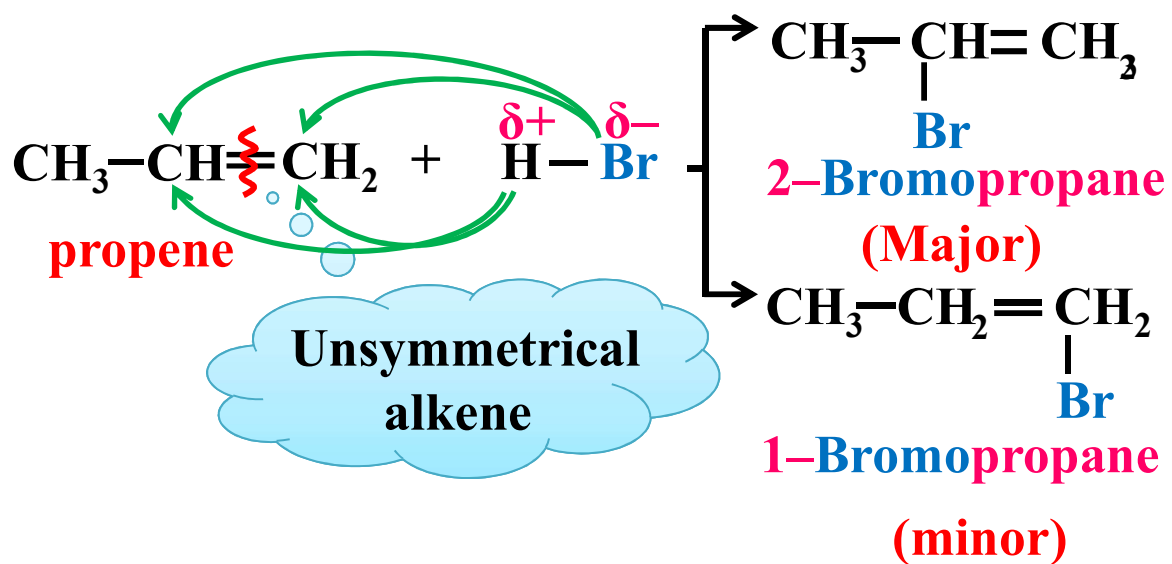
ALKENES

Chemical Properties of alkene:

Addition of hydrogen halides:-

B)

Unsymmetrical alkene :



ALKENES

Chemical Properties of alkene:

Addition of hydrogen halides:-

B)

Unsymmetrical alkene :

Mechanism: It is an electrophilic addition reaction

Step 1 :- Generation of electrophile -



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Chemical Properties of alkene:

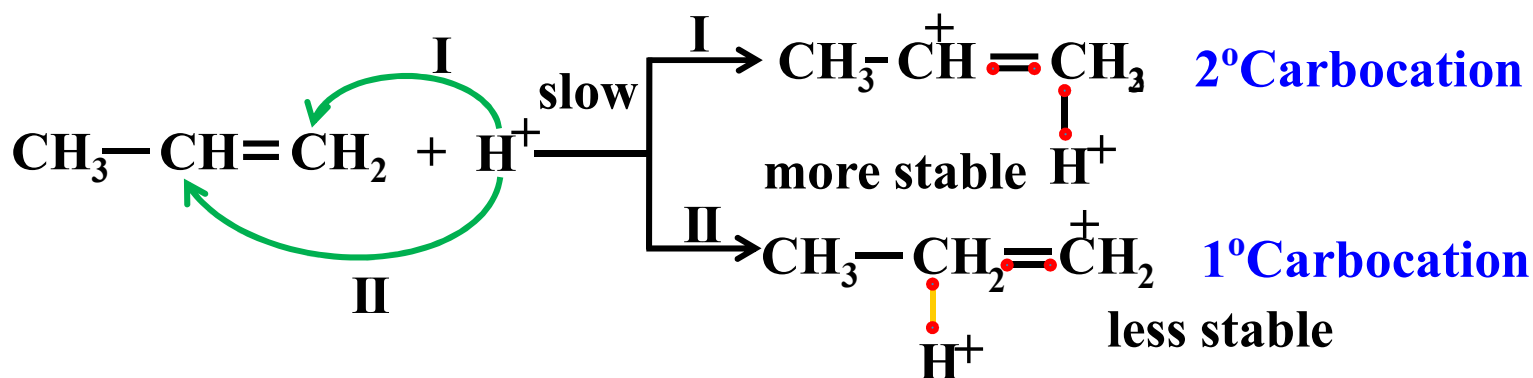
Addition of hydrogen halides:-

B)

Unsymmetrical alkene :

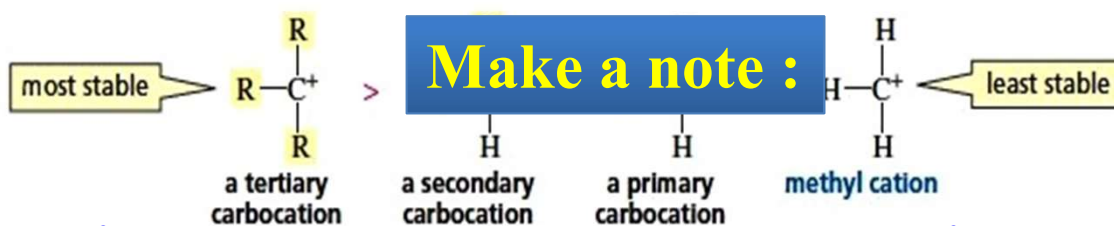
Mechanism:

Step 2 :- Attack of electrophile on alkene -



ALKENES

relative stabilities of carbocations



➤ 2° carbocation is more stable than 1° carbocation & formed at faster rate.

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Chemical Properties of alkene:

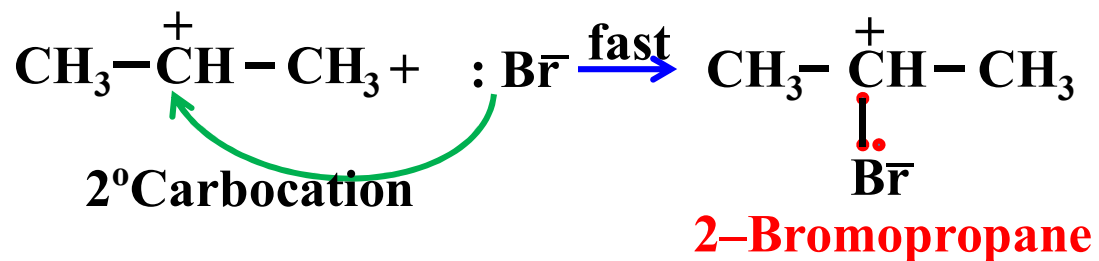
Addition of hydrogen halides:-

B)

Unsymmetrical alkene :

Mechanism:

Step 3 :- Formation of product -



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Q) Hex-1-ene reacts with HBr to give

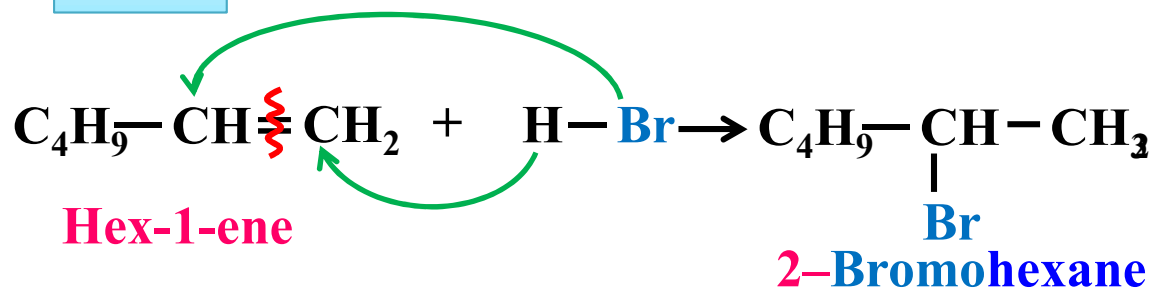
a) 1-Bromohexane

b)  2-Bromohexane

c) 1,2-Dibromohexane

d) 2,3-Dibromohexane


Soln:



ALKENES

MCQs

1. During the hydrobromination of unsymmetrical alkene by means of peroxides in presence of sunlight. The reaction proceeds through

- a) Elimination reaction
-  b) Addition reaction
- c) Substitution reaction
- d) Molecular rearrangement

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Anti-Markownikoff's rule

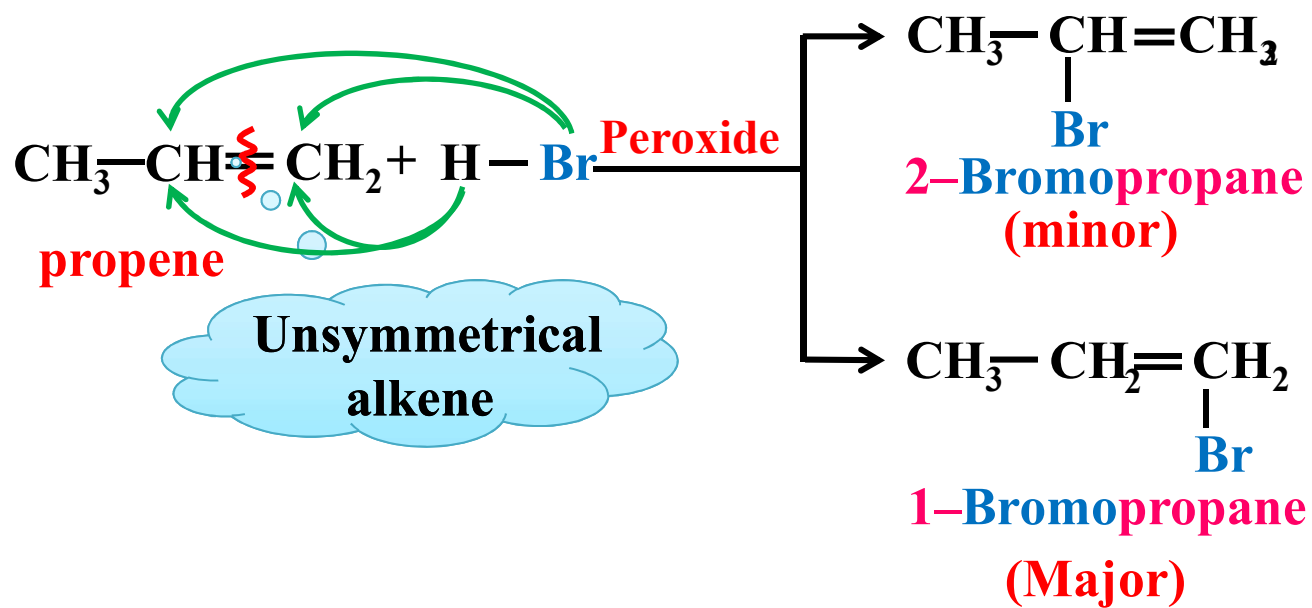
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Anti-Markownikoff's rule

- If addition of HBr is carried out in the presence of sun light and peroxide such as Na_2O_2 or benzoyl peroxide, the addition can proceed opposite to the Markownikoff's rule. This is known as Peroxide effect or Kharasch effect or Anti-Markownikoff's rule.

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Anti-Markownikoff's rule

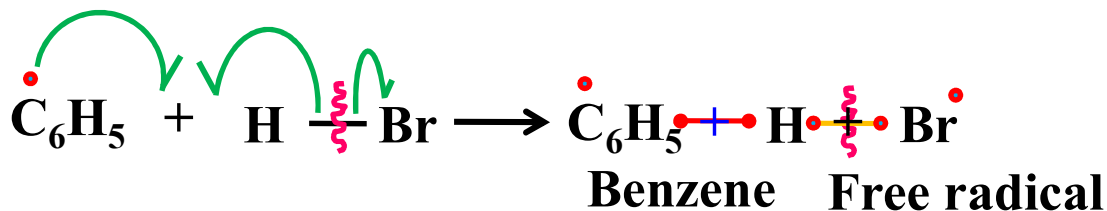
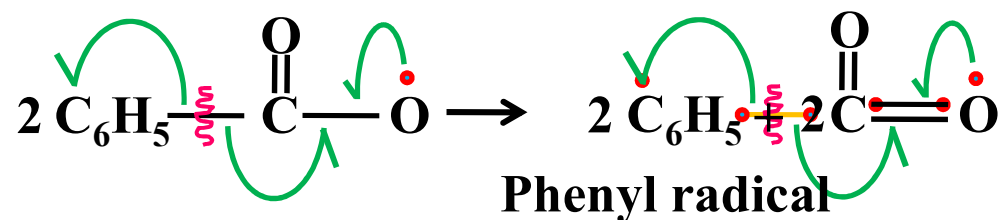
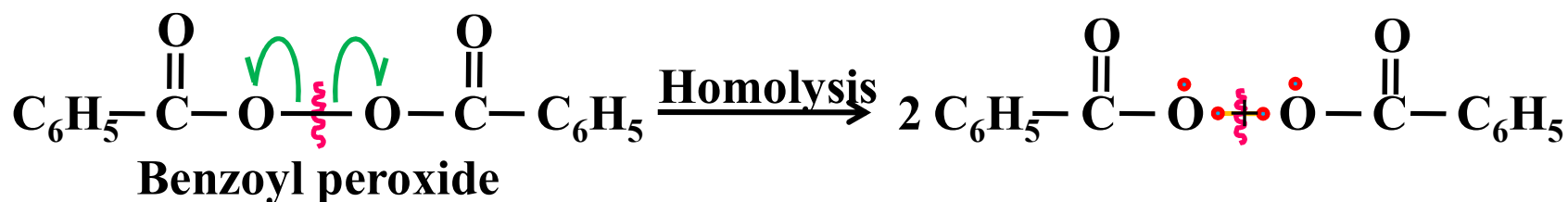


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Mechanism:

Step 1 :-

Generation of Free radical (Chain initiating step)

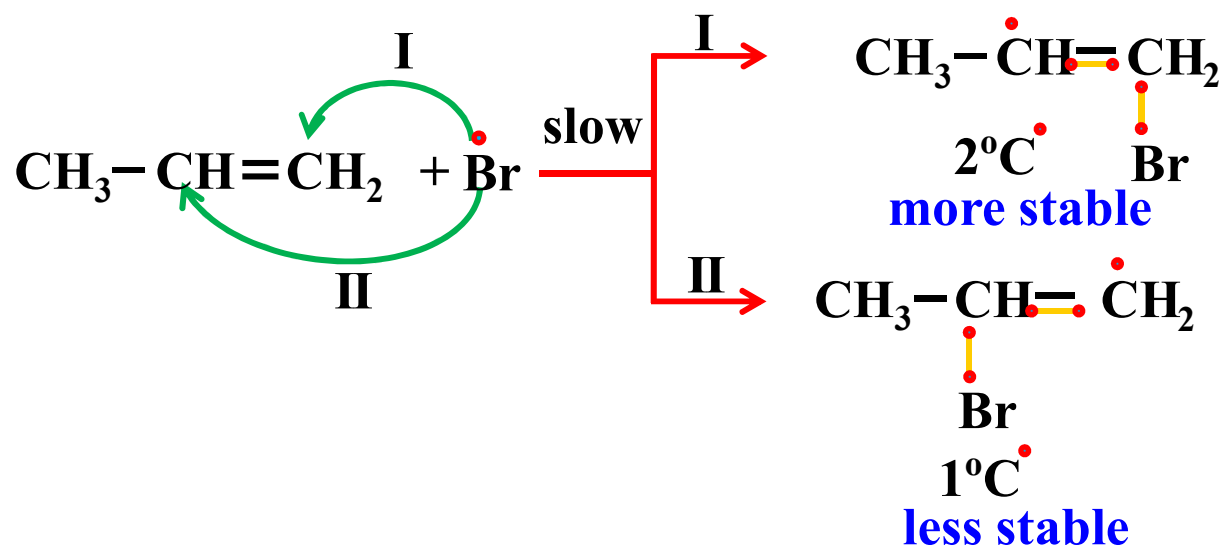


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Mechanism:

Step 2 :-

Attack of free radical $\dot{\text{Br}}$:



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Make a note :

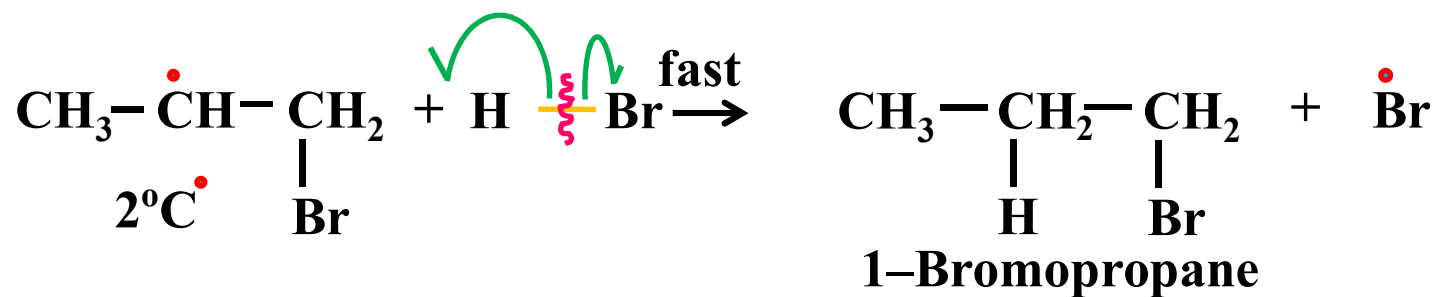
2^o free radical is **more stable** than **1^o** free radical & formed at faster rate.

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Mechanism:

Step 3 :-

Formation of product -



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Make a note :

- **Anti-Markownikoff's rules are only applicable for HBr, peroxide & sun light only.**
- **Markownikoff's and Anti-Markownikoff's rules are only applicable for unsymmetrical alkene.**

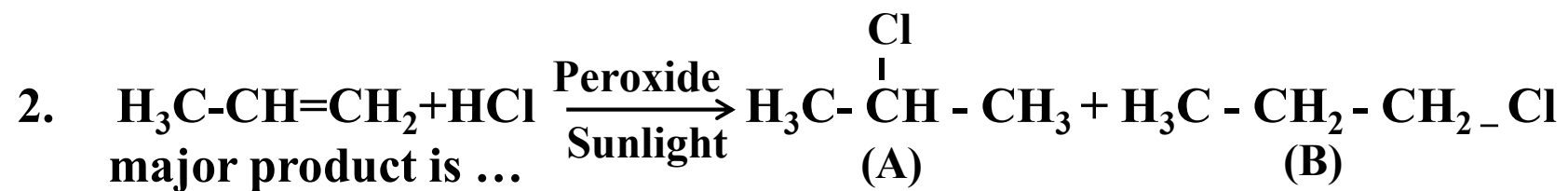
ALKENES

MCQs

1. Kharash effect can be studied in case of...

- a) Oct-4-ene
- b) Hex-3-ene
- c)  Pent-2-ene
- d) But-2-ene

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 A

b) B

c) Both 'A' and 'B' are equally formed

d) None of the above

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Chemical Properties of alkenes (part 3)

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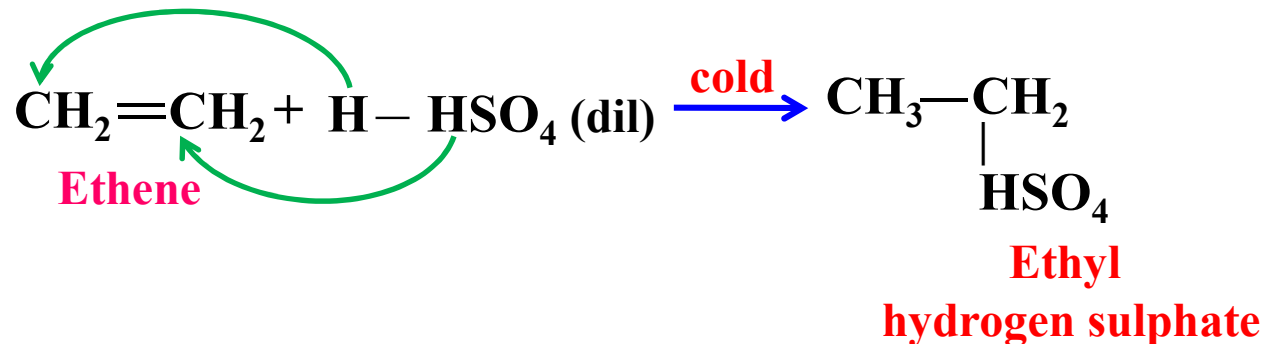
Chemical Properties of alkene:

Addition of Sulphuric Acid :-

a)

Step 1:

- Cold concentrated sulphuric acid adds to alkenes in accordance with Markovnikov's rule to form alkyl hydrogen sulphate by electrophilic addition reaction.



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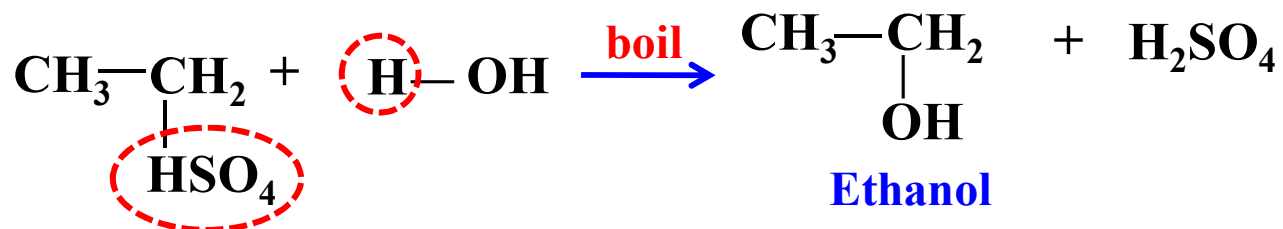
Chemical Properties of alkene:

Addition of water :-

b)

Step 2:

- In the presence of a few drops of concentrated sulphuric acid, alkenes react with water to form alcohols, in accordance with Markownikoff's rule.

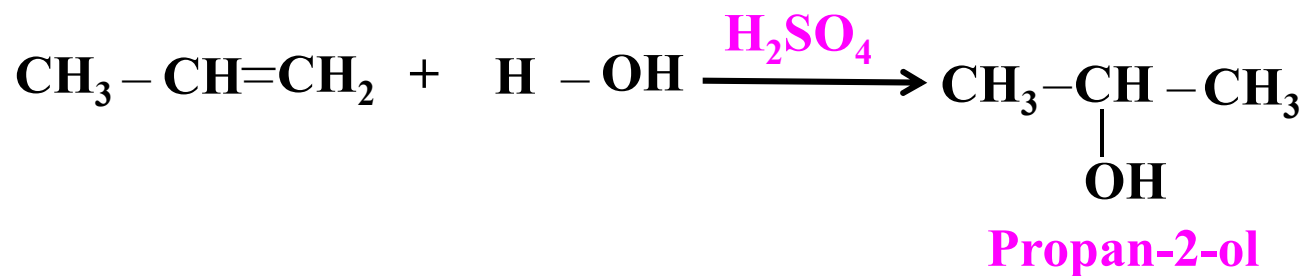


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Chemical Properties of alkene:

Addition of water :-


b)



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MCQs

1. Reagent used in hydration of alkenes is...

-  a) aq. H_2SO_4
- b) $\text{Hg}^{2+}/\text{H}_2\text{SO}_4$
- c) aq. KOH
- d) None of these

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Chemical Properties of alkenes (part 4)

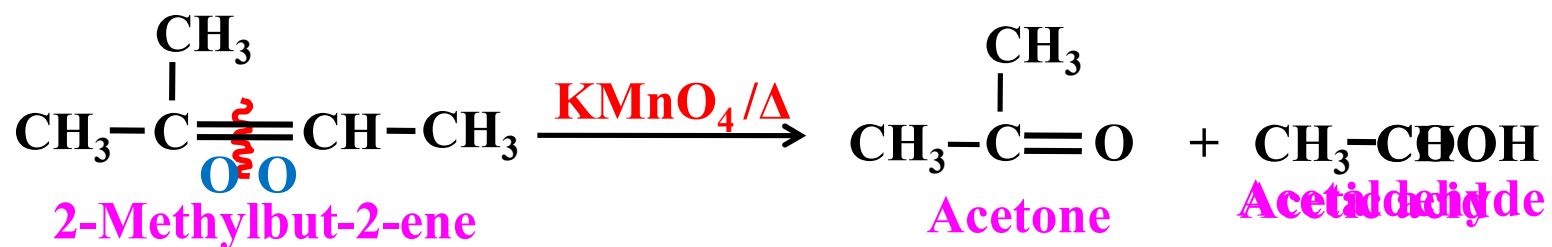
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Chemical Properties of alkene:

Oxidation:

- When alkenes react with hot, acidified KMnO_4 gives carboxylic acid

e.g. 1



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Chemical Properties of alkene:

Oxidation:

- When alkenes react with cold, dilute & alkali KMnO_4 (Baeyer's reagent) gives diols.

e.g. 2



Baeyer's reagent



Butane-2,3-diol

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Chemical Properties of alkene:

Ozonolysis:

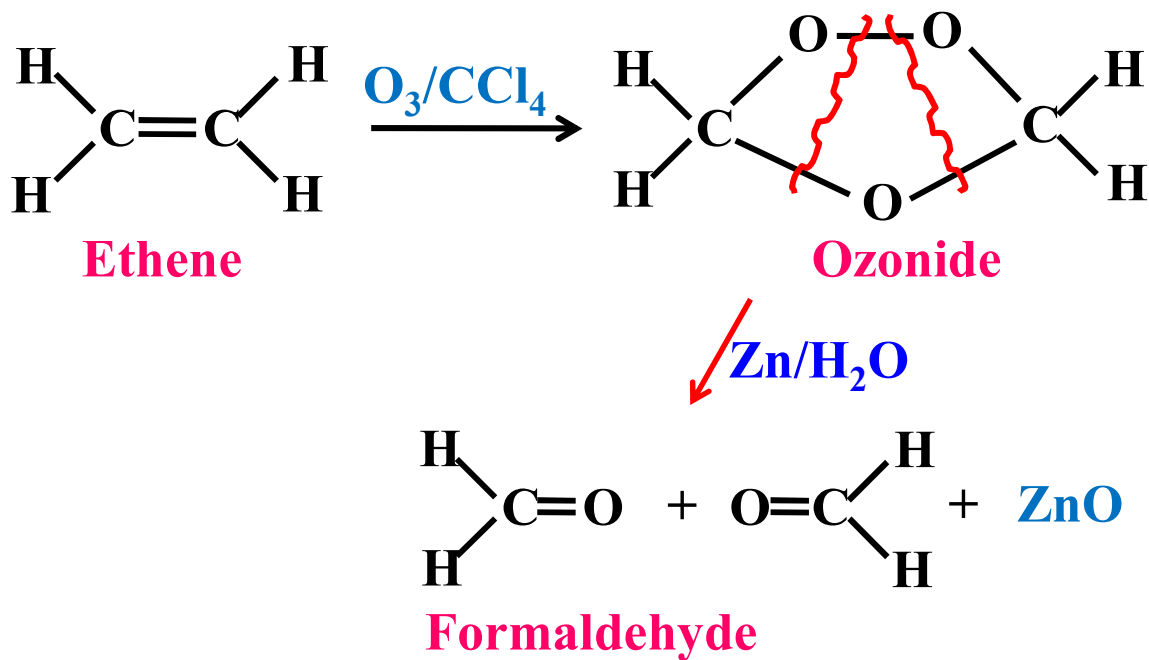
- Addition of ozone molecules to alkenes form **ozonide**, and then **cleavage** of the ozonide by $\text{Zn-H}_2\text{O}$ to **smaller molecules**.
- This reaction is used to **locate the position** and **find** the number of double bonds present in alkenes.

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Chemical Properties of alkene:

Ozonolysis:

Eg: 1

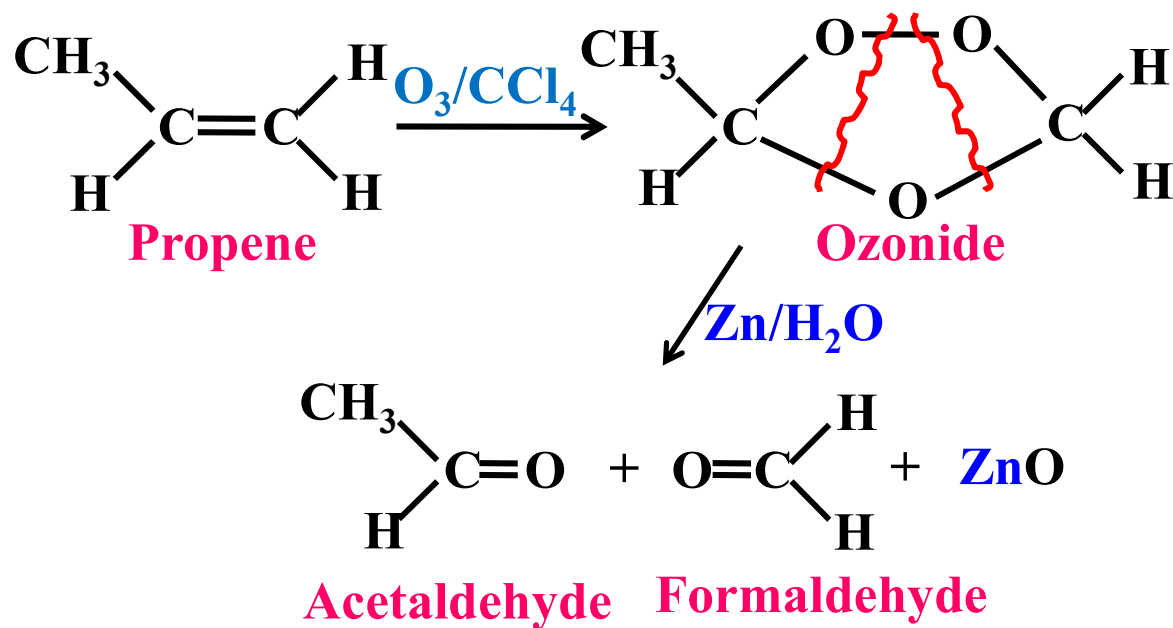


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Chemical Properties of alkene:

Ozonolysis:

Eg: 2



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Q) An alkene on ozonolysis produces a mixture of acetaldehyde and acetone. Identify the alkene.

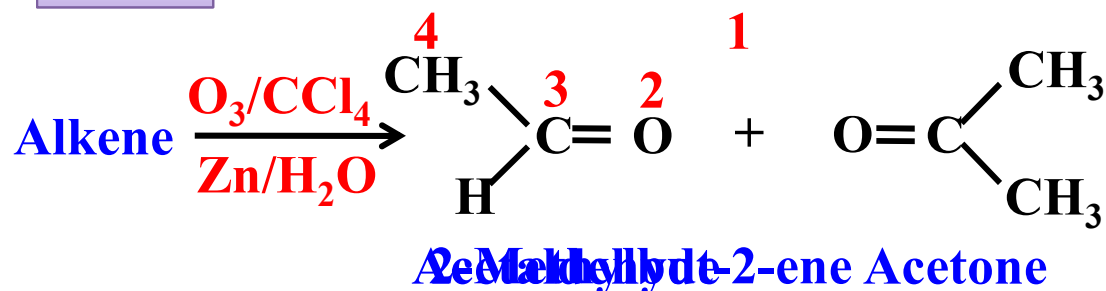
a) But-1-ene

b) But-2-ene

c) 2-Methylbut-1-ene

d) ✓ 2-Methylbut-2-ene


Soln:



ALKENES

1. Baeyer's reagent is..

MCQs

- a) $\text{KMnO}_4/\text{H}^+/\Delta$
- b) $\text{K}_2\text{Cr}_2\text{O}_7/\text{H}^+$
- c)  Cold, alkaline KMnO_4
- d) $\text{FeSO}_4/\text{H}_2\text{O}_2$

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Chemical Properties of alkenes (part 5) & uses of alkenes

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Chemical Properties of alkene:

Polymerisation of ethene:

- A process in which a large number of small molecules combine together to form a long chain molecule (polymer) **is called polymerisation.**
- A polymer is a macromolecule consisting of a large number of repeating units known as **monomers.**

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Chemical Properties of alkene:

Polymerisation of ethene:

- Polymers have very **high molecular weight**.



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Uses of alkenes:

- Ethene is used in **oxy-ethylene** flame which is used for **cutting and welding** metal.
- Ethene is used in **preparation** of **ethylene glycol**, which is used as an **antifreeze agent** in automobiles and coolant.
- Ethene is used in **preparation** of **organic compounds** like **ethyl alcohol, acetaldehyde, acetic acid** etc.



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Uses of alkenes:


- Ethene is also used to **manufacture polythene** which is used to prepare **pipes, bottles, bags** etc.
- Ethene is used for **artificial ripening of fruits**.



ALKENES

MCQs

1. Phenomenon of adding of simple molecules like monomers, to form big or giant organic molecule is...

- a) Ozonolysis
- b) Hydrogenation
-  c) Polymerisation
- d) Oxidation