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Alkenes

These are hydrocarbons that caontain aa double bond →

General formula ia C_nH_{2n} $n \geq 2$

Examples are

Ethene $CH_2=CH_2$

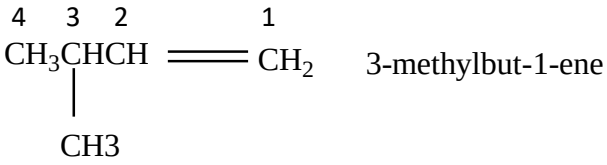
Propene $CH_3CH=CH_2$

But-1-ene $CH_3CH_2CH=CH_2$

But-2-ene $CH_3CH=CHCH_2$

For branched alkene we number the carbon atoms from the side nearest the double bond

For example



3-methylbut-1-ene

Physical properties

They like those of alkane

- they are insoluble in water
- they are soluble in organic solvents
- they are solvents
- they range from gases to liquids to waxy solides

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Chemical properties

1. **Combustion**
   They burn in air to produce carbon dixide, water and heat.

   $C_2H_4\ (g) + 3O_2\ (g) \longrightarrow 2CO_2(g) + 2H_2O$ + heat

   Because they produce heat they are used as fuel.

2. **Reduction**
   They are reduced by hydrogen in presence of catalysts; nickel or platnum to alkenes
   Example
   $CH_2{=}CH_2 \xrightarrow{H_2/Ni} CH_3CH_3$

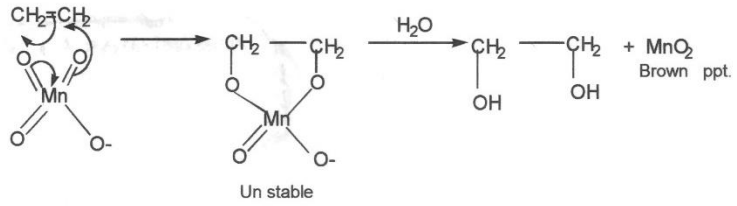
3. **Hydraton reaction**
   (i) Reaction of alkenes with $KMnO_4$ solution
   Dilute alkaline KMnO4 solution convert alkenes into compound called GLYCOLS (dihydroxyl alcohols)

Examples

(a) $CH_2{=}CH_2 \xrightarrow{KMnO_4,\ OH^-}$ $CH_2(OH)-CH_2(OH)$

Cis-Ethane-1,2-diol

MECHANISM



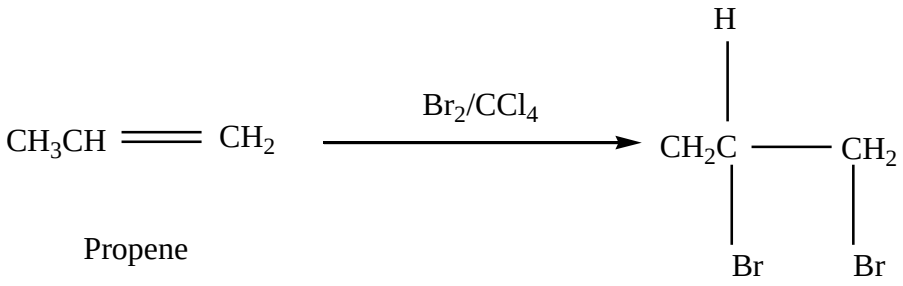
NB. (a) Since oxidation of alkenes with $KMnO_4$ proceeds with decolorisation of solution, this can be used as a test for unsaturation.

(i) Addition of halogens
Halogens add across a double bond to form dihalogeno compounds.The reaction is carried out in an innert solvent (like tet

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Example 1

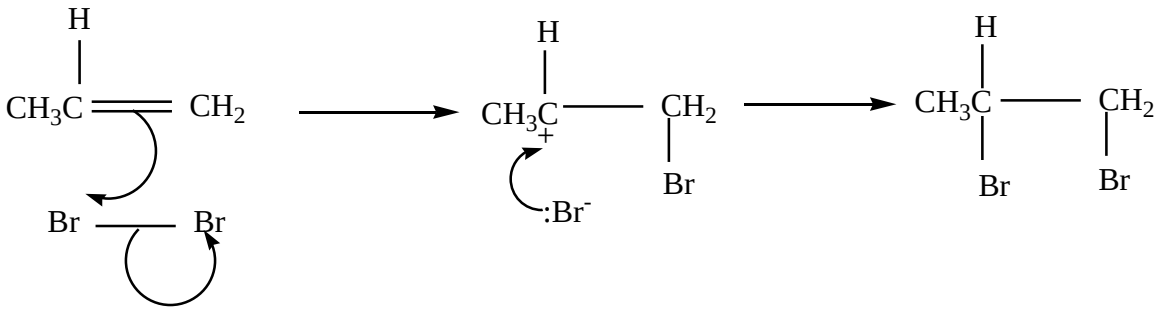
Propene racts with bromine in presence of innert solvents (trachloromethane) to form 1,2-dibromopropane



Propene

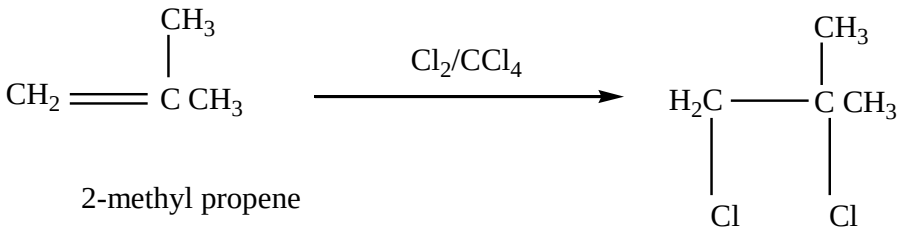
1,2-dibromopropane

Mechanism



Example 2

2-methylpropene plus chlorine in presence of tetrachloromethane give 1,2-dibromo-2-methylpropane

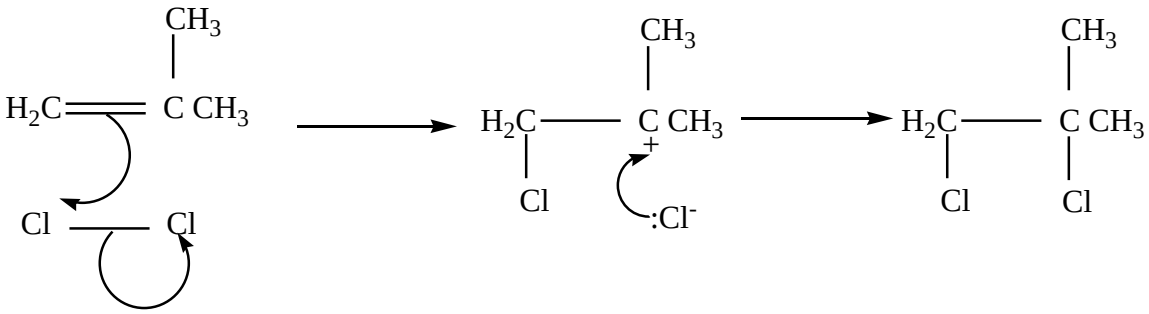


2-methyl propene

1,2-dichloro-2-mthylpropane

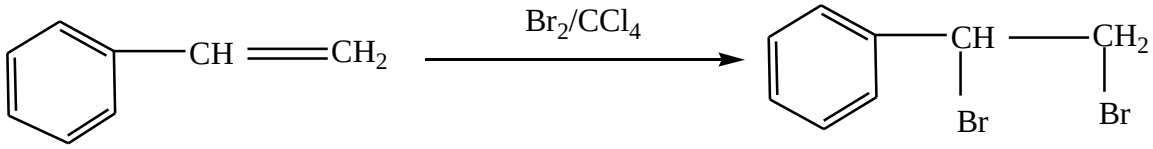
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Mechanism



Example 3

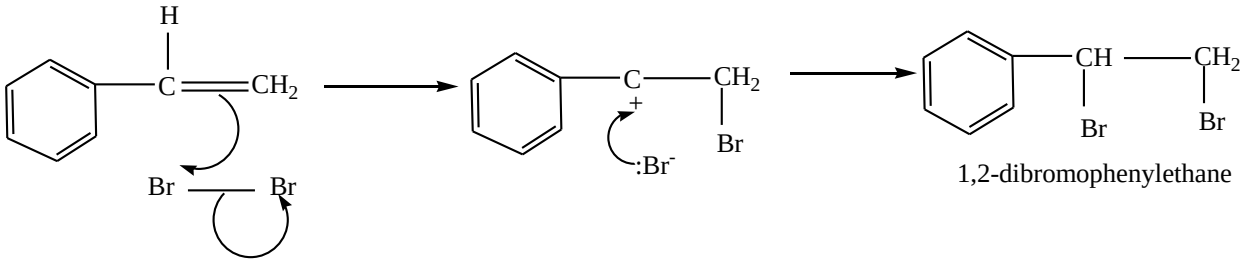
Phenylethene plus bromine in presence of tetrachloromethane give 1,2-dibromophenylethane



Phenylethene

1,2-dibromophenylethane

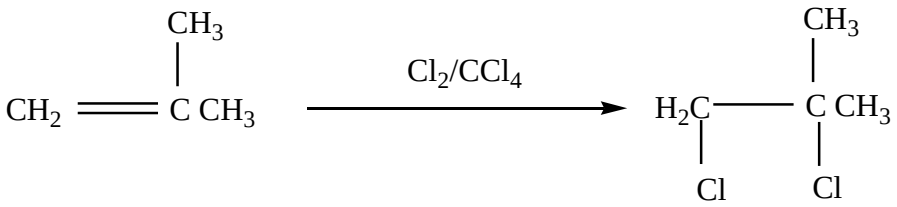
Mechanism



1,2-dibromophenylethane

Example 4

2-methylpropene plus chlorine in presence of tetrachloromethane gives 1, 2-dichloro-2-methylpropane

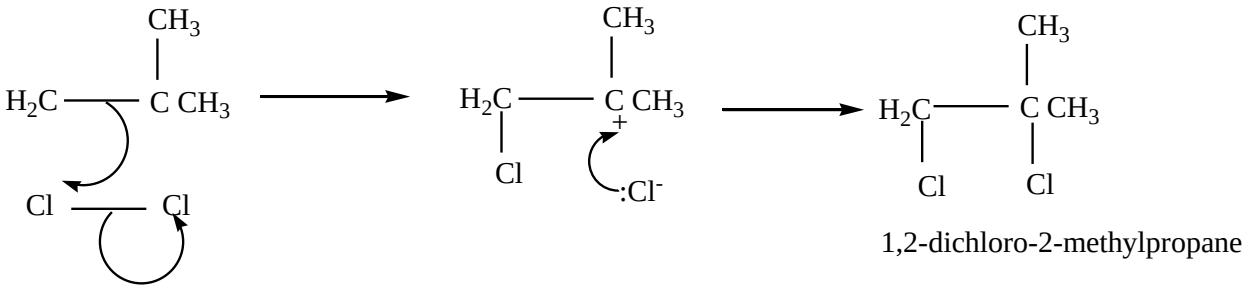


2-methylpropene

1,2-dichloro-2-methylpropane

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Mechanism



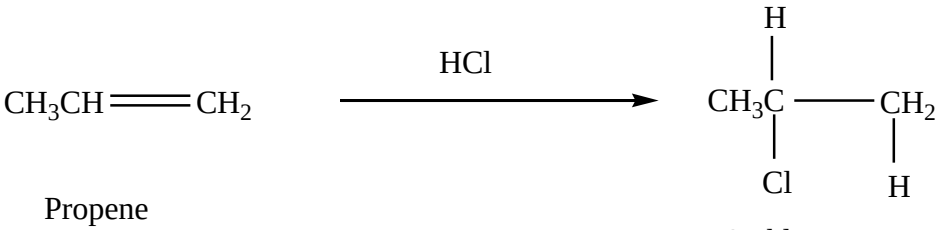
1,2-dichloro-2-methylpropane

(ii) Reaction of alkenes with HX (X = Cl, Br, I)

The reaction is carried out by bubbling HX through alkenes.

Example 5

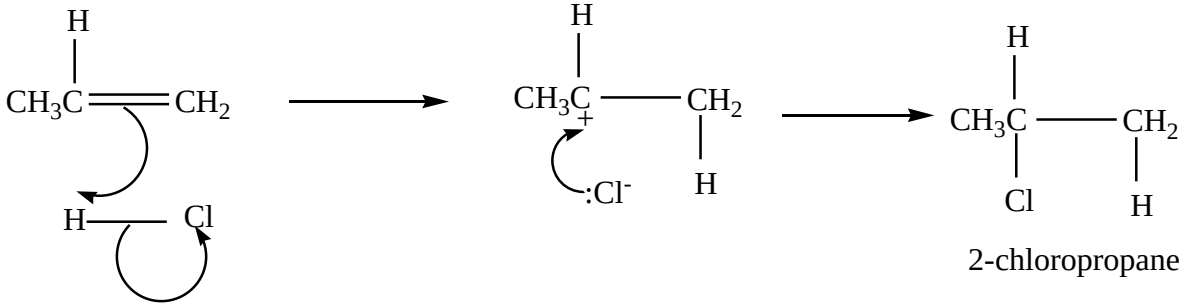
Propene plus hydrochloric acid gives 2-chloropropane



Propene

2-chloropropane

Mechanism

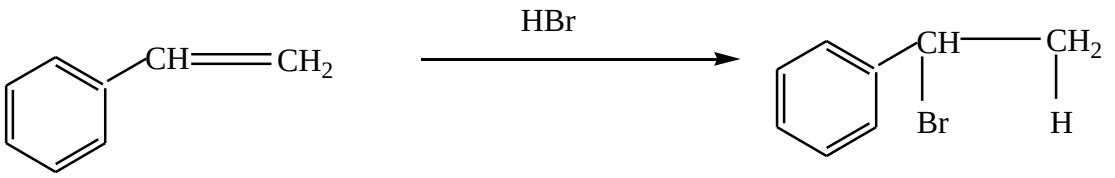


2-chloropropane

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Example 6

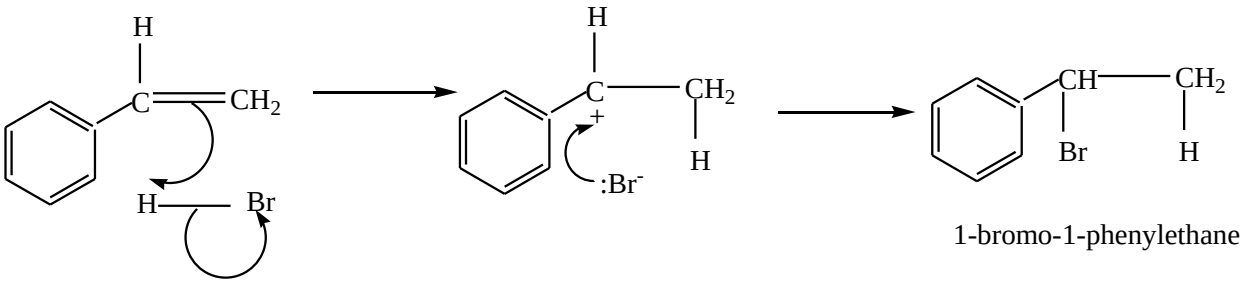
Phenylethene plus hydrogen bromide give 1-bromo-1-phenylethane



Phenylethene

1-bromo-1-phenylethane

Mechanism

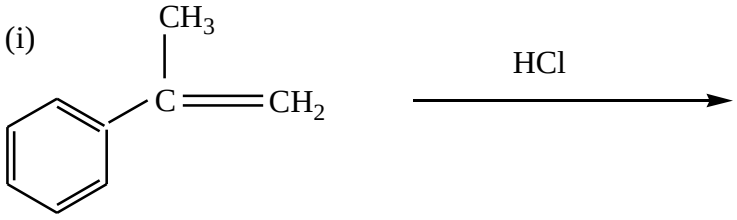


1-bromo-1-phenylethane

Trial 1

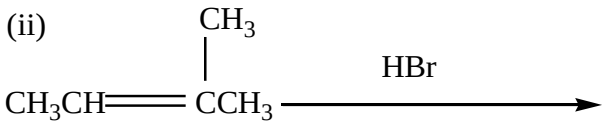
Complete and write a mechanism

(i)



2-phenylpropene

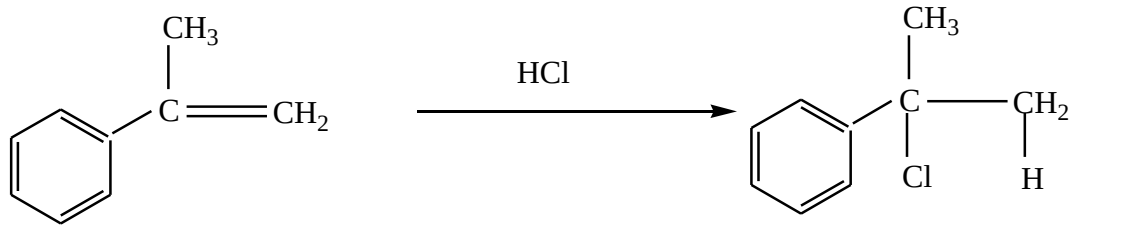
(ii)



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Solution to the exercise

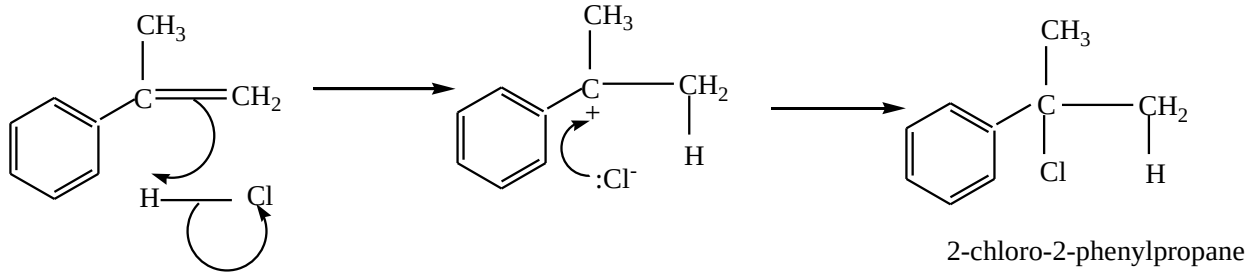
(i) 2-phenylpropene plus HCl gives 2-chloro-2-phenylpropane



2-phenylpropene

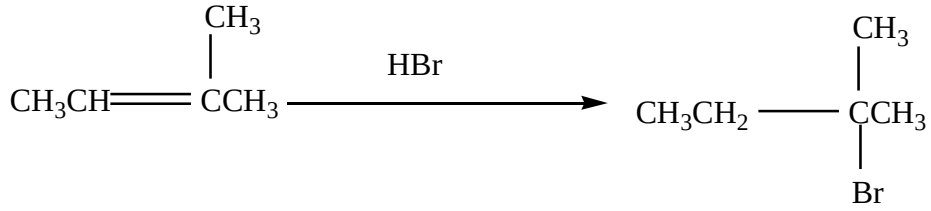
2-chloro-2-phenylpropane

Mechanism



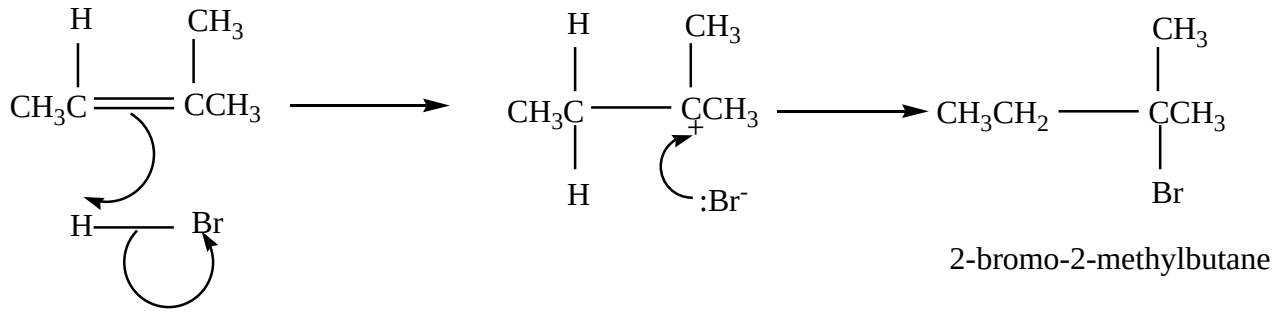
2-chloro-2-phenylpropane

(ii) 2-methylbut-2-ene plus HBr gives 2-bromo-2-methylbutane



2-bromo-2-methylbutane

Mechanism



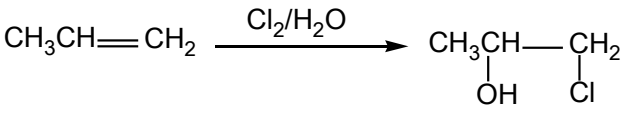
2-bromo-2-methylbutane

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(ii) Reaction of alkenes with halogens in presence of water.

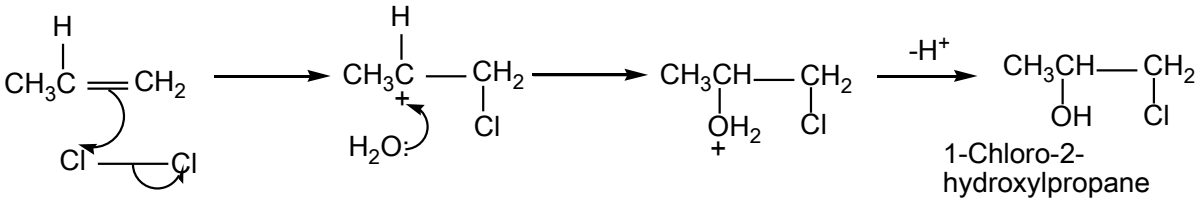
The reaction is carried out by bubbling alkenes through aqueous halogens.

Example 7



1-Chloro-2-hydroxylpropane

MECHANISM

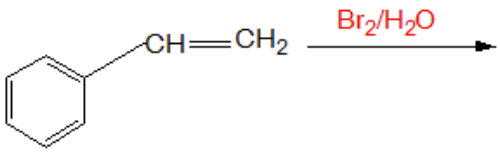


1-Chloro-2-hydroxylpropane

Trial 2

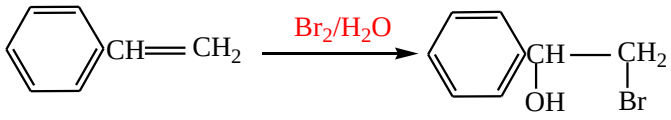
Complete the following and write meachnaism (do not look at the answer before)

(i)



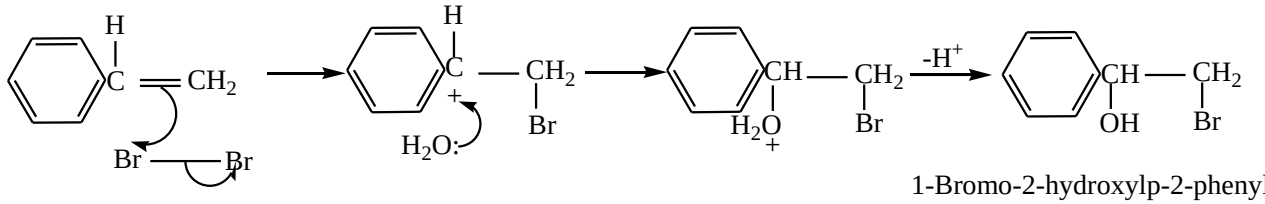
Phenylethene

Solution



1-Bromo-2-hydroxylp-2-phenylethane

MECHANISM

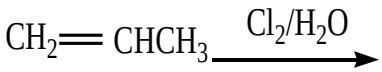


1-Bromo-2-hydroxylp-2-phenylethane

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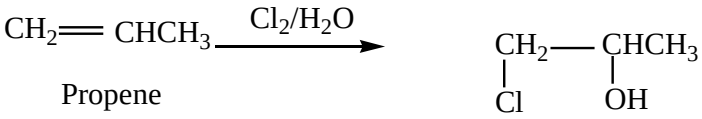
Trial 3

Complete and write a mechanism



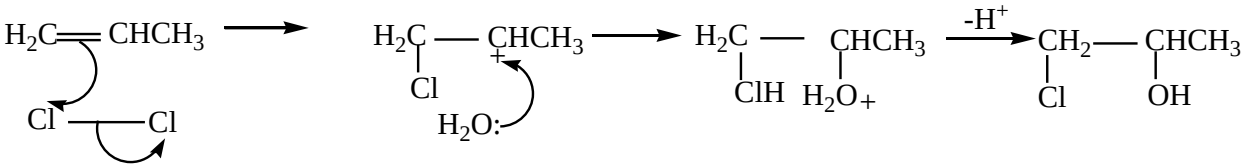
Propene

Solution



Propene

MECHANISM

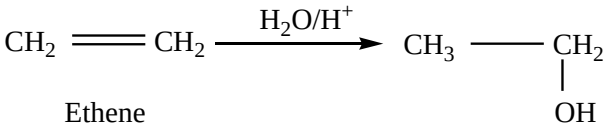


(d) Reeaction of alkene with water.

The reaction is catalysed by an acid sulphuric acid or phosphoric acid. Alcohols are produced

Example

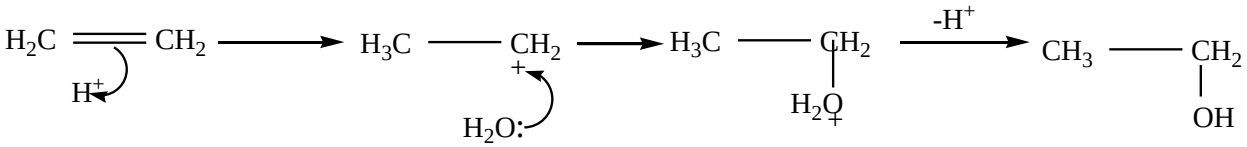
Ethene reacts with acidified water to produce ethanol.



Ethene

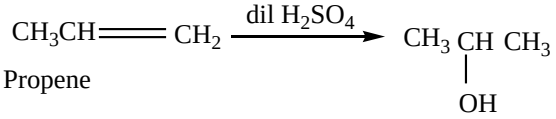
Ethanol

MECHANISM



Example 8

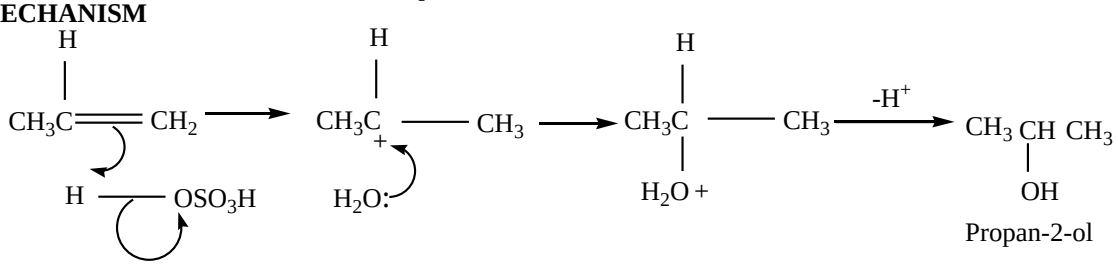
Propene reacts with dilute sulphuric acid to form propan-2-ol



Propene

Propan-2-ol

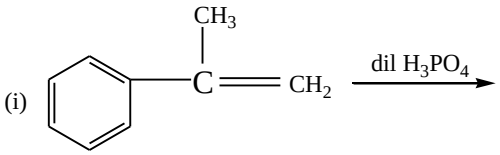
MECHANISM

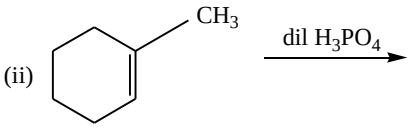


Propan-2-ol

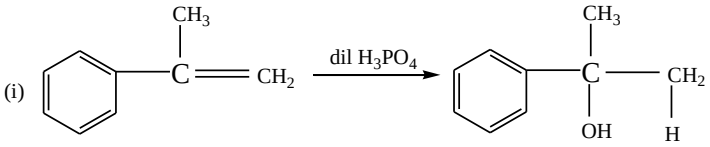
Trial 4

Complete the following equations and suggest mechanisms





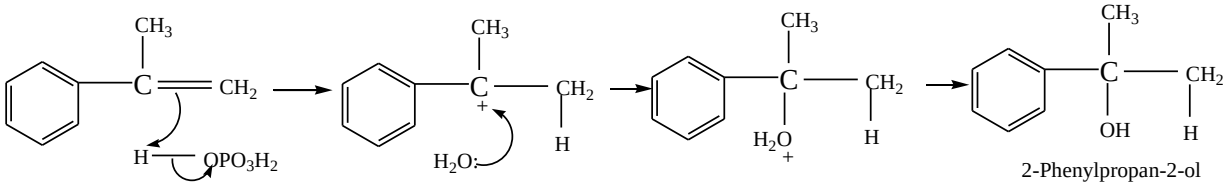
Solution



2-Phenylpropene

2-Phenylpropan-2-ol

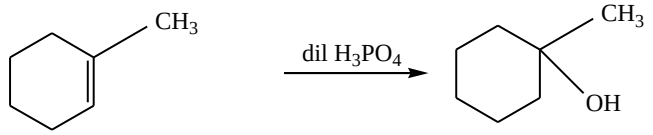
Mechanism



2-Phenylpropan-2-ol

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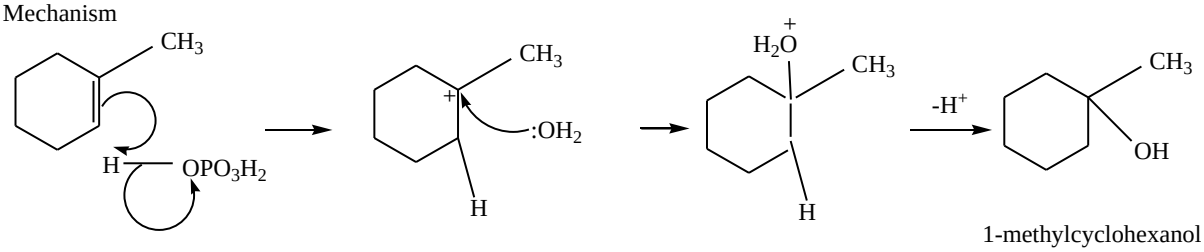
(ii)



1- Methylcyclohexene

1-methylcyclohexanol

Mechanism



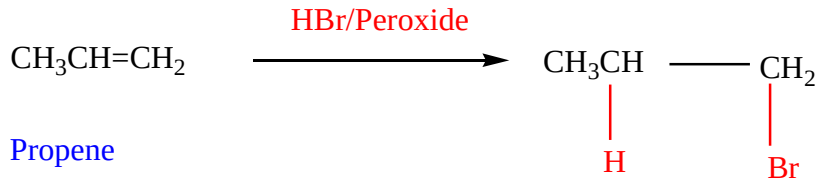
1-methylcyclohexanol

NB. The charges must be accounted for at every stage

(e) Addition of hydrogen bromide in presence of a peroxide

In presence of a peroxide, alkenes react with HBr by free radial mechanisms; but in this case hydrogen atom goes a carbon atom that carry the leat number of a hydrogen atoms of those that form a double bond otherwise the bromine atom goes to a carbon with the highest number of hydrogen atoms.

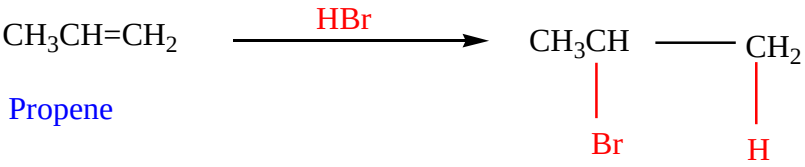
Examples 9



Propene

1-bromopropane

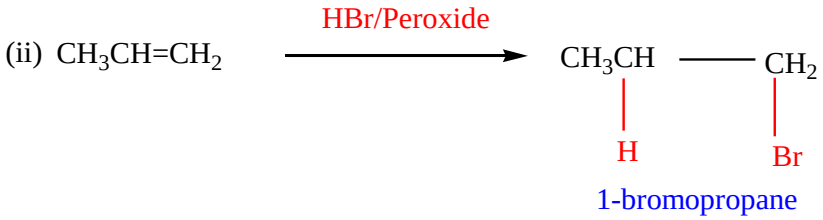
Instead of

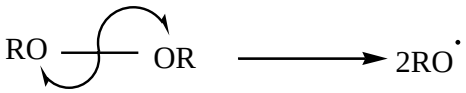


Propene

2-bromopropane

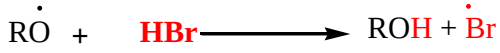
Mechanism



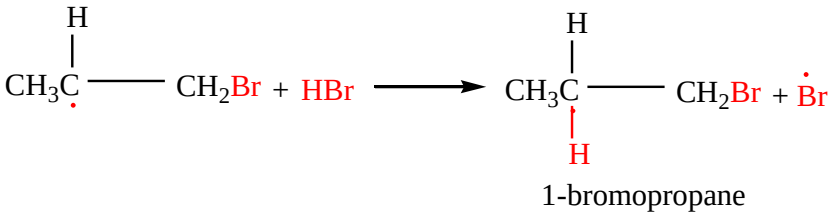


the dot on the oxygen atom indicates that the oxygen atom has one unpaired electron

Then

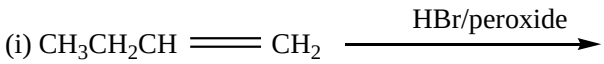


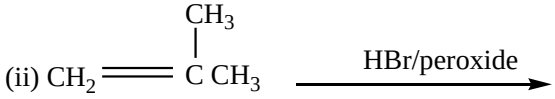




Trial 4

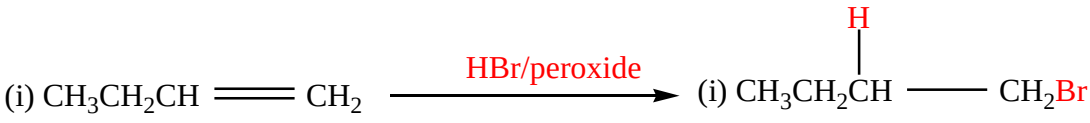
Complete and write a mechanism (it advisable you attempt these questions and mark yourself)

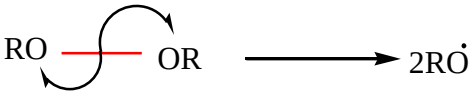




Solutions to the exercise

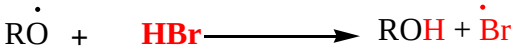
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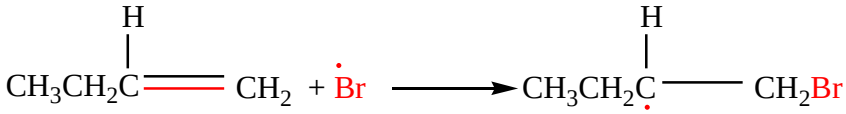


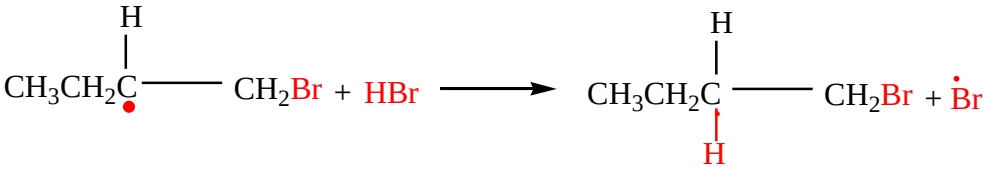


the dot on the oxygen atom indicates that the oxygen atom has one unpaired electron

Then







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(ii) $CH_2=C(CH_3)CH_3$ —HBr/peroxide→ $CH_2(Br)-C(H)(CH_3)CH_3$

$RO-OR \longrightarrow 2RO^{\bullet}$ the dot on the oxygen atom indicates that the oxygen atom has one unpaired electron

Then

$RO^{\bullet} + HBr \longrightarrow ROH + Br^{\bullet}$

$CH_2=C(CH_3)CH_3 + Br^{\bullet} \longrightarrow CH_2(Br)-C^{\bullet}(CH_3)CH_3$

$CH_2(Br)-C(CH_3)CH_3 + HBr \longrightarrow CH_2(Br)-C(H)(CH_3)CH_3 + Br^{\bullet}$

(f) Ozonolysis (reaction of ozone with alkenes)

Ozone reacts with alkene to form unstable ozonide that is reduced by zinc in presence of hydrochloric acid to form carbonyl compounds.

Example

$CH_3CH=CH_2$ —1. O_3, -78^{0}C; 2. Zn/HCl→ $CH_3C(=O)H$ + $O=CH_2$

From the products of ozonolysis, it is possible to tell the position of the double bond in the compound that was ozonolyzed because ozonolysis breaks a compound at the double bond.

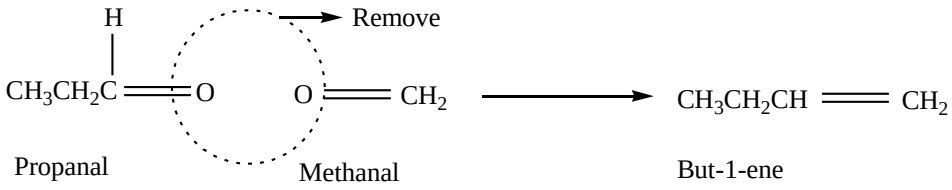
Example 10

Write the structure of an alkene which on ozonolysis gave

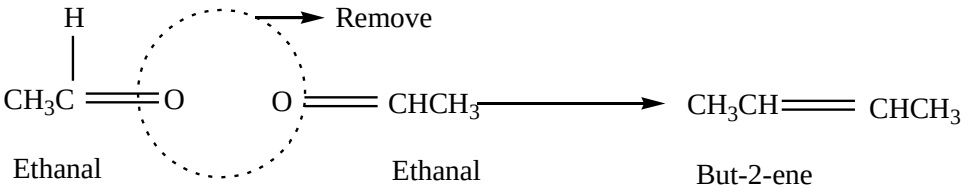
(i) Propanal (CH_3CH_2CHO) and methanol ($HCHO$)

By removing the oxygen atoms from each compound create a double bond and hence the compound.

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(ii) One product ethanal



Trial 5

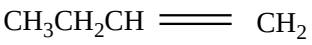
An alkene X has molecular formula C_4H_8

(a) Write an name all structural formula of compound X.

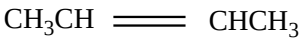
(b) On ozonolysis X gave propanone (CH_3COCH_3) and methanal (HCHO). Identify X.

Solution

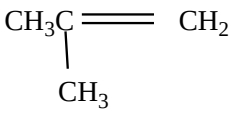
(a)



But-1-ene

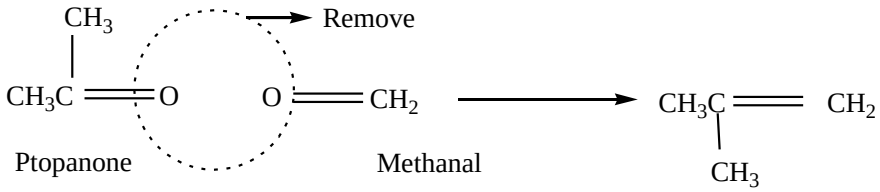


But-2-ene



2-Methylpropene

(b) By removing oxygen atoms from the products of ozonolysis, the position of a double bond is created.



Therefore X is 2-methylpropene.

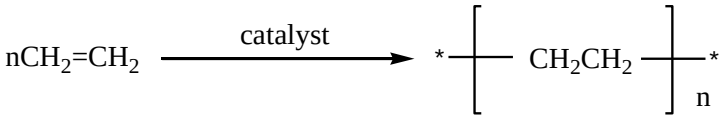
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Polymerization

This is the is the joining of very many small molecules called monomers to form big molecules called polymers

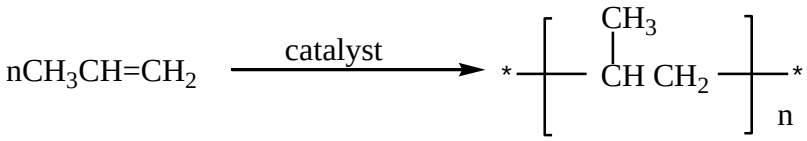
In presence of a catalyst, (acid) alkenes polymerize to form polyalkenes.

For example ethane plus a catalyst you get polyethene



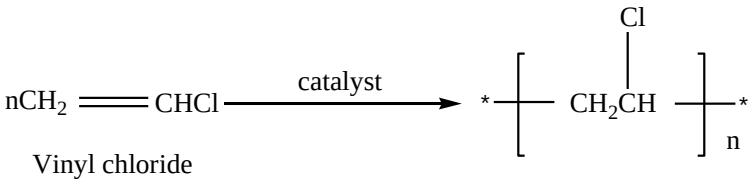
Ethene Polyethene

(ii) Propene polymerize to form polypropene



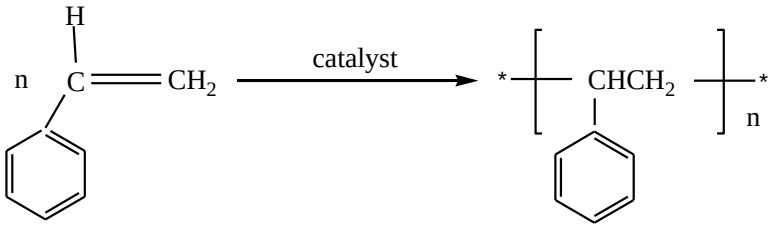
Propene Polypropene

(iii) Vinyl chloride polymerize to form polyvinylchloride (PVC)



Vinyl chloride Polyvinyl chloride

(iv) Styrene polymerize to form polystyrene.



Styrene Polystyrene

All polyalkenes can be used as insulators, packing materials and pipes.

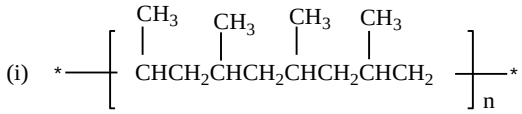
Alkenes undergo a type of polymerization called addition polymerization in that when the monomers of alkenes add to form a polymer, there is no loss of any atom, or particle from them.

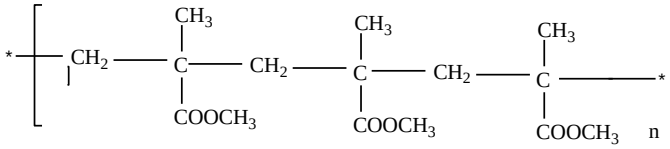
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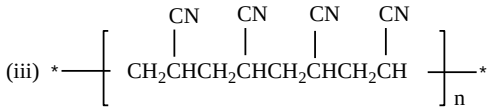
Note that when given a polymer without a double bond the monomer is a substituted two carbon compound with a single double bond.

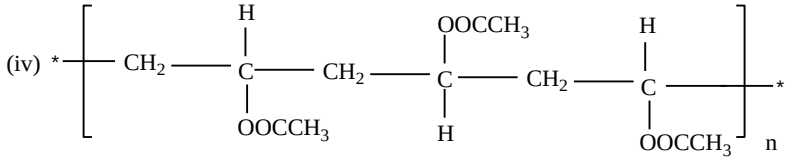
Exercise 11

Write the structure and the names of monomer for the following polymers

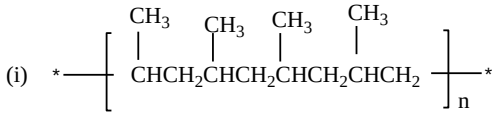
(i) 

(ii) 

(iii) 

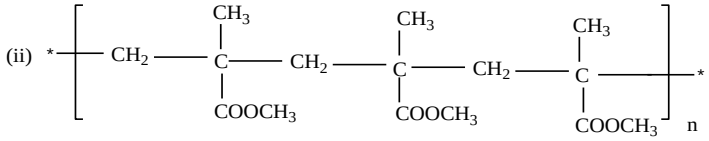
(iv) 

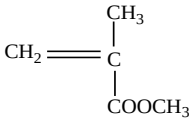
Solutions

(i) 

Polypropene

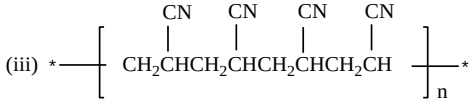
$CH_3CH=CH_2$
Propene

(ii) 



methylmethacrylate

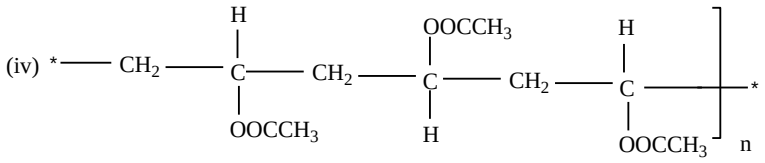
polymethylmethacrylate

(iii) 

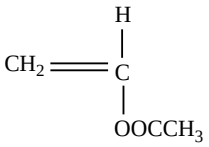
Polyacrylonitride

$CH_2=CHCN$
Acrylonitride

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(iv) 

Polyvinylacetate



vinylacetate

Uses of polyalkenes

- packing materials
- water pipes
- insulators

Alkene undergo a type of polymerization called addition polymerization because monomers add to form a polymer without loss of any atom.

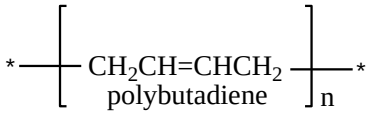
Polyalkenes are also called thermoplastics because they soften on heating and can be remolded.

Polymerization of dienes

Alkenes with conjugated double bond undergo polymerization to form polyalkenes with double bonds

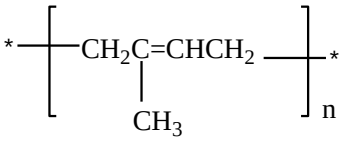
Example

(i) $nCH_2=CHCH=CH_3$
But-1,3-diene



polybutadiene

(ii) $nCH_2=C(CH_3)CH=CH_2$
methylbut-1.3-diene



Reaction with carbon monoxide

$$RCH=CH_2 + CO + H_2 \xrightarrow[\text{Heat/high pressure}]{Co_2(CO)_8} R\,CH_2CH_2CHO$$

Example

(a) $CH_2 = CH_2$ $\xrightarrow[\text{Heat/high pressure}]{CO,\ H_2\ /Co_2(CO)_8}$ CH_3CH_2CHO Propanal

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Preparation of alkenes

1. From alcohols

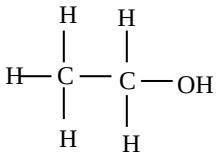
Alkenes are produced by dehydration of alcohols by hot sulphuric or phosphoric acid. Alcohols are organic compounds that contain hydroxyl group (-OH). The mechanism depends on the class of alcohol.

Classification of alcohols,

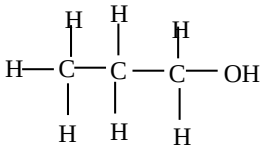
They are **three** classes of alcohols according to the number of alkyl groups attached to a carbon atom that carry -OH group.

(a) Primary alcohols have one alkyl group on the carbon atom that carry OH group

Examples 11



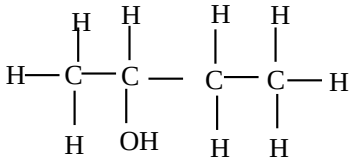
Ethanol



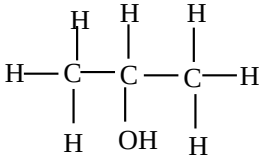
Propan-1-ol

(b) Secondary alcohols have two alkyl groups attached to a carbon atom that carry OH group

Examples12



Butan-2-ol

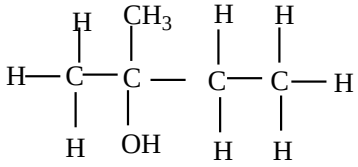


Propan-2-ol

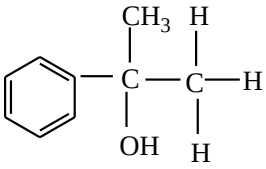
(c) Tertiary alcohols

Tertiary alcohols have three alkylgroups attached to the carbon atoms that carry OH group

Examples



2-methylbutan-2-ol



2-phenylpropan-2-ol

Mechanism

Depends on the class of alcohol.

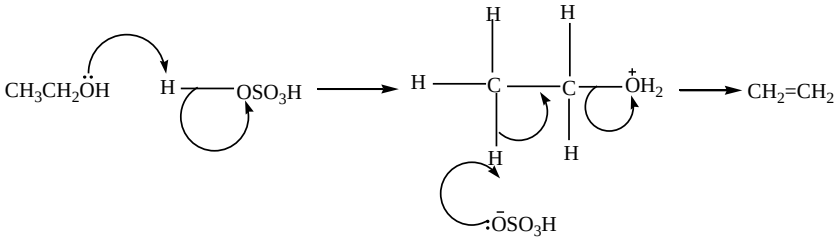
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(a) Primary alcohol: undergo a mechanism called elimination bimolecular(E2). It is an elimination reaction because water molecule is removed from the alcohol. It bimolecular because the slow step involves two species.

Example 12

$$\underset{\text{Ethanol}}{CH_3CH_2OH} \xrightarrow[\text{heat } (180^0C)]{\text{Conc.}H_2SO_4} \underset{\text{Ethene}}{CH_2{=}CH_2}$$

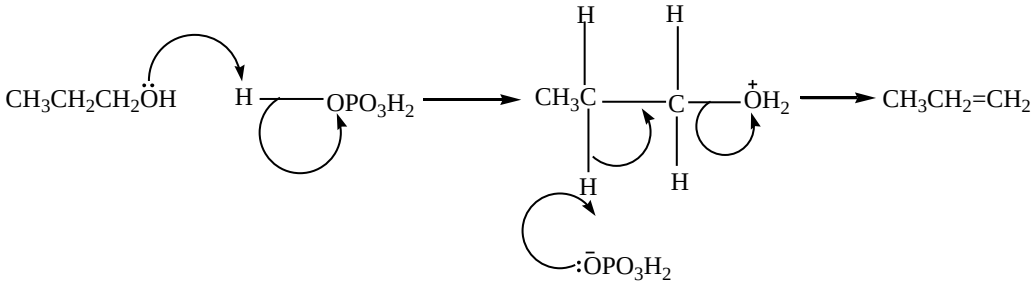
Mechanism



Example 13

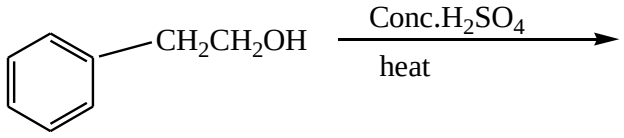
$$\underset{\text{Propan-1-ol}}{CH_3CH_2CH_2OH} \xrightarrow[\text{heat}]{\text{Conc.}H_3PO_4} \underset{\text{Propene}}{CH_3CH{=}CH_2}$$

Mechanism

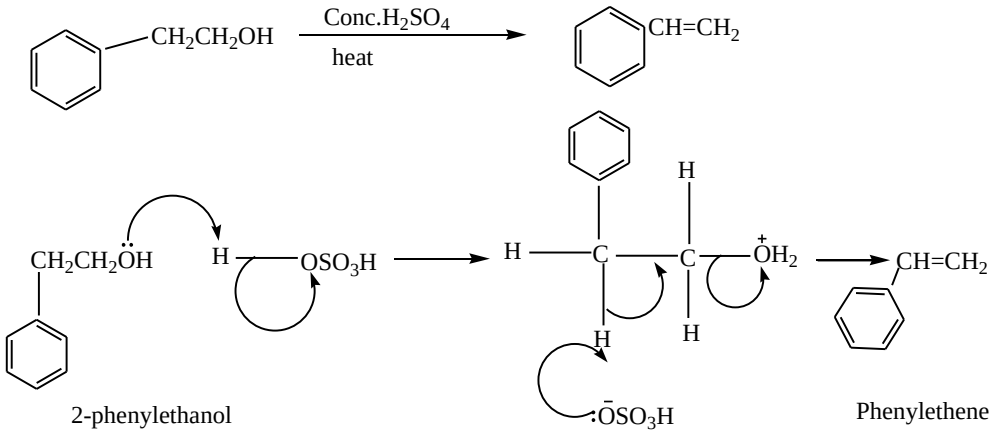


Trial 6

Complete and write a mechanism

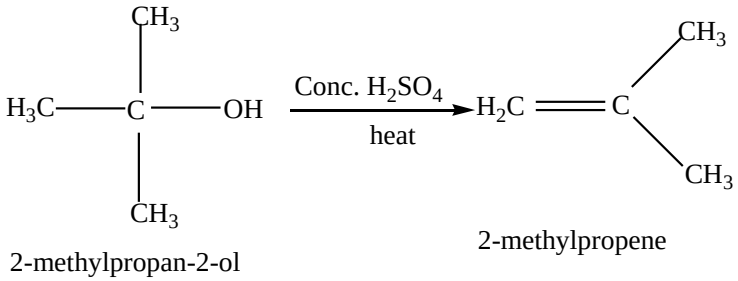


Solution



2. Secondary alcohols undergo the same mechanism as primary alcohol or that of tertiary alcohol
3. Tertiary alcohol undergo a mechanism called E1 or elimination unimolecular because a water molecule is eliminated and the slowest step involve one molecule only.

Example 16

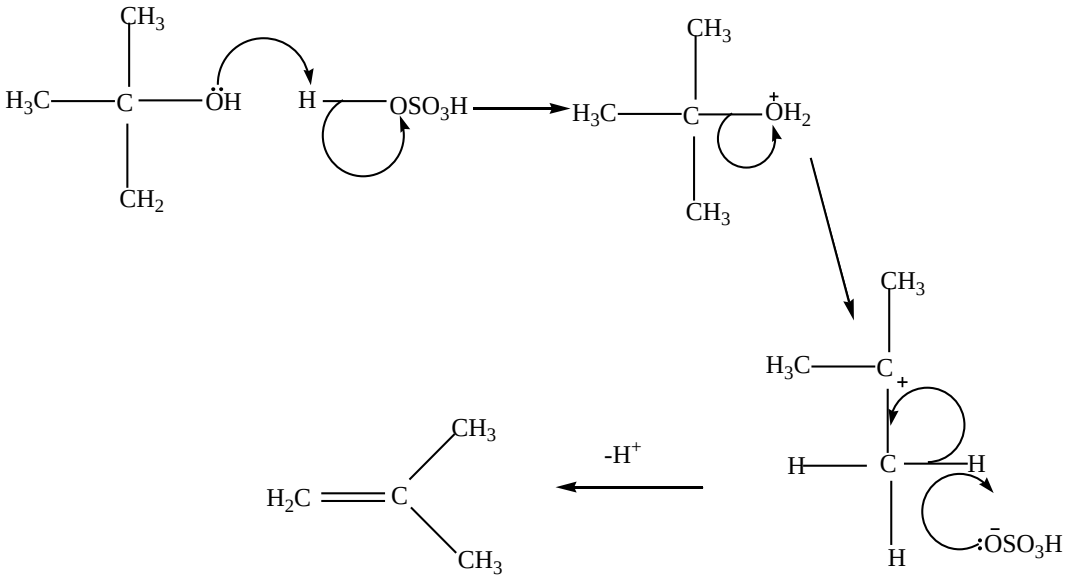


2-methylpropan-2-ol

2-methylpropene

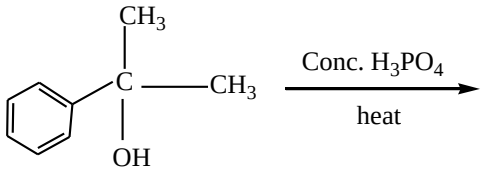
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Mechanism

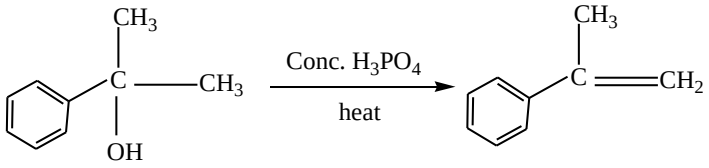


Trial 17

Complete and write a mechanism

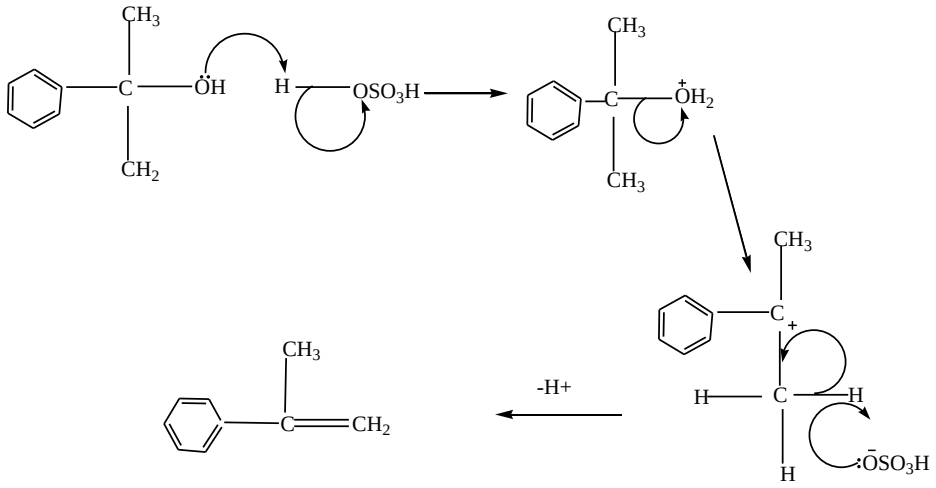


Solution



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Mechanism

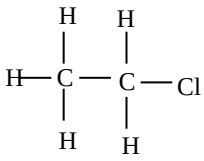


Preparation of alkenes from alkylhalide (R-X where R is alkyl group and X is Cl, Br or I)
The mechanism depends on the class of alkylhalide

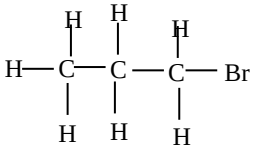
Classification of alkyl halide

They are **three** classes of alkylhalide according to the number of alkyl groups attached to a carbon atom that carry a halide

(a) Primary alkylhalide have one alkyl group on the carbon atom that carries a halide.
Examples



Chloroethane

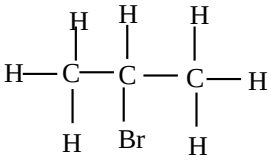


1-Bromopropane

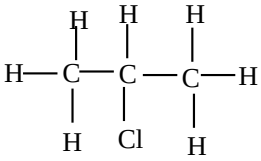
(b) Secondary alkylhalide have two alkyl groups attached to a carbon atom that carry halogen atom

Examples

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2-Bromopropane

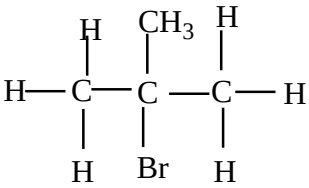


2-chlorobutane

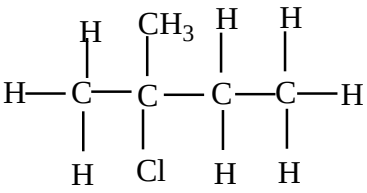
(c) Tertiary alkylhalide

Tertiary alkylhalide have three alkylgroups attached to the carbon atoms that carry OH group

Examples



2-bromo-2-methylpropane



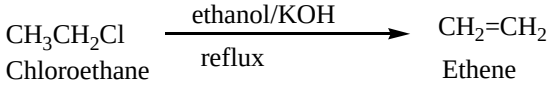
2-chloro-2-methylbutane

Mechanism

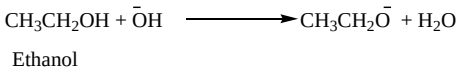
Depend on the class of alcohol.

(a) Primary alkyl halide: undergo a mechanism called elimination bimolecular(E2). It is an elimination reaction because HX is removed from the alkylhalide. It bimolecular because the slow step involves two species.

Example 17

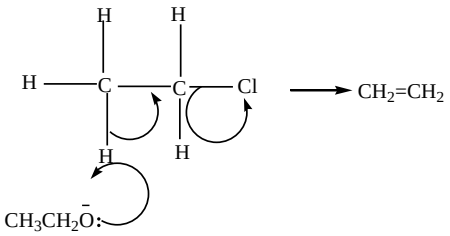


Mechanism



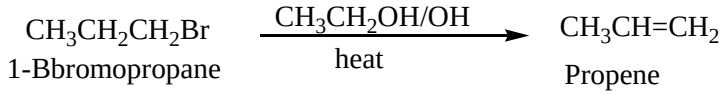
Ethanol

Then

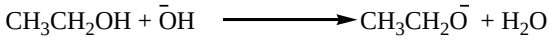


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Example 18

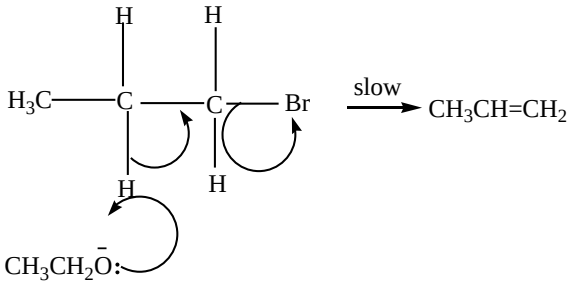


Mechanism



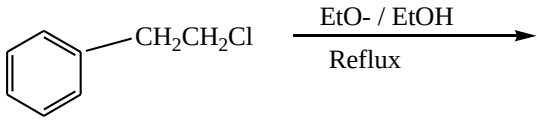
Ethanol

Then

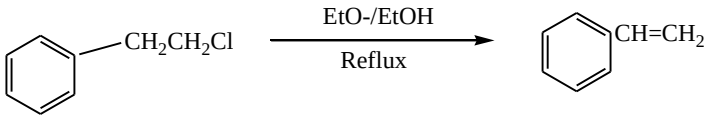


Trial 7

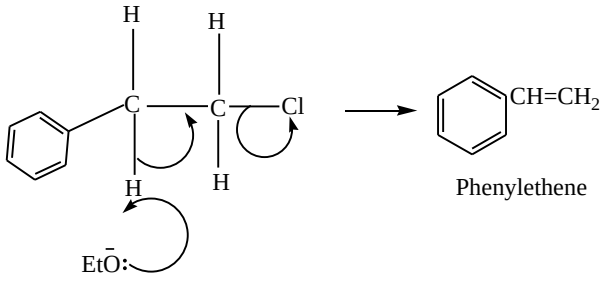
Complete and write a mechanism



Solution



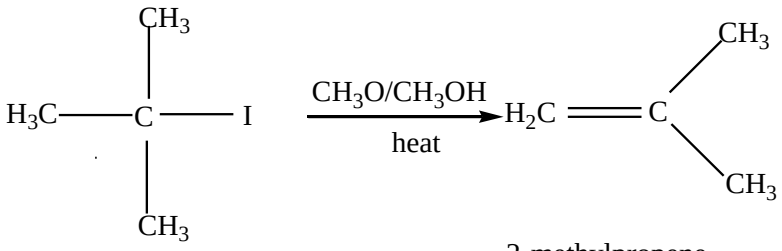
Mechanism



Phenylethene

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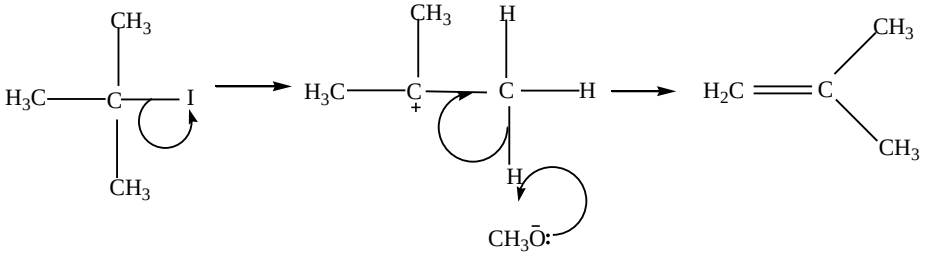
4. Secondary alkylhalides undergo the same mechanism as primary alcohol or that of tertiary alcohol
5. Tertiary alkylhalides undergo a mechanism called E1 or elimination uni-molecular because a water molecule is eliminated and the slowest step involve one molecule only.
   Example



2-Iodo-2-methylpropane

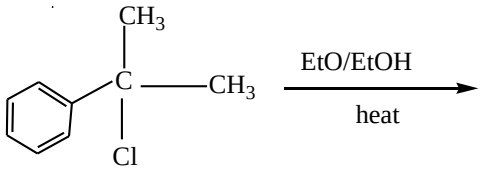
2-methylpropene

Mechanism

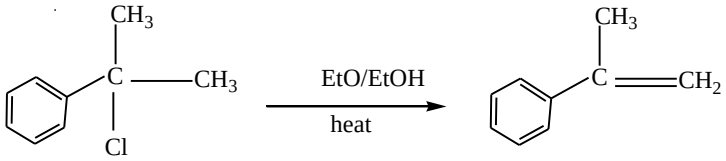


Trial 8

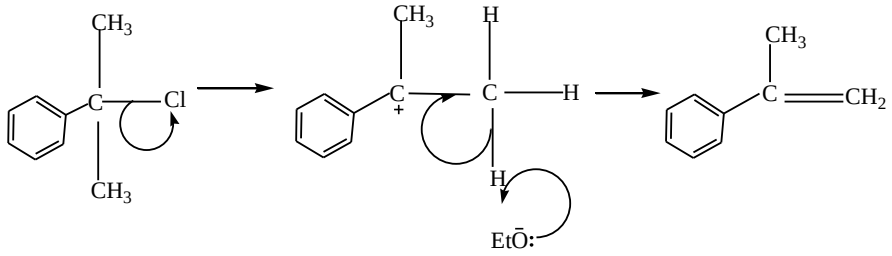
Complete and write a mechanism



Solution



Mechanism



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