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Where Minds Pollinate

Class 11
Chemistry

Chapter 16
Hydrocarbons
Handwritten Notes

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Chapter # 16

HYDROCARBONS

Question:-

What are hydrocarbon and
How are they classified?

Answer:-

Hydrocarbon
Organic Compound containing
Carbon and hydrogen only
are called hydrocarbon.

Classification of Hydrocarbon

Open Chain hydrocarbon :

OR
Acyclic hydrocarbon

Hydrocarbon in which carbon
atom are attached with
each other in open chain
are called open chain hydro-
carbons.

They are further classified into
two types.

Saturated Hydrocarbon:-

- Hydrocarbon in which there is

single bond between carbons atoms.

- They under-go free radical substitution reaction
- All carbons atoms are sp^3 hybridized
- They may be straight chain or branch chain.

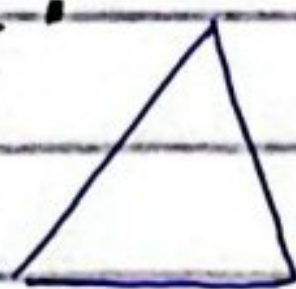
Un-saturated Hydrocarbon :

- Hydrocarbon in which there is double or triple bond between carbon atoms.
- They under-go electrophilic addition reaction.
- All carbon atoms are sp or sp^2 hybridized.
- They may be straight or branch chain.

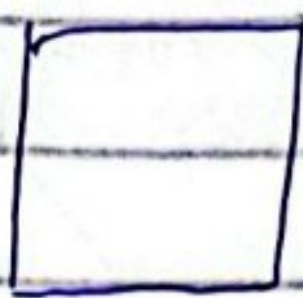
Close Chain Hydrocarbon

Hydrocarbon in which carbon atoms are attached with each other form ring are called close chain hydrocarbon.

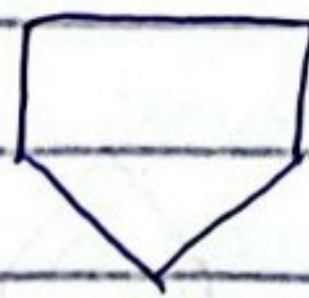
e.g.:-



cyclopropane



Cyclobutane



Cyclopentane.

They are further divided into two types.

Alicyclic Hydrocarbon:

OR

Non-Aromatic Hydrocarbon:

- Close chain hydrocarbon without benzene ring are called Alicyclic hydro-carbon.
- They do not obey Huckel Rule.
- They are non-benzonoid.

e.g.:-



Cyclopropane



Cyclobutane

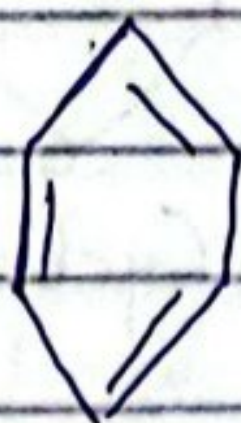


Cyclopentane.

Aromatic Hydrocarbon:

- Close Chain hydrocarbon containing at-least one benzene ring
- They are obey Huckel Rule.
- They are benzonoid

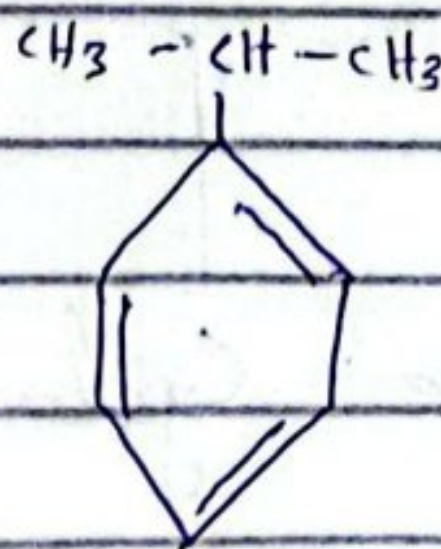
e.g.:



Benzene



ethylbenzene



1-methylethylbenzene

Reactivity of Alkane

- Alkane are also called paraffins.
- The word paraffins is combination of two latin words.
- "Parum" means little and "affinis" means reactivity.
- Alkane are non-polar hydrocarbon.
- Alkane are less reactive.

The low reactivity of alkanes is attributed to two factors.

1. Non-polar Bonds:

- The electronegativity values of carbon and hydrogen atoms are 2.5 and 2.1 respectively.
- The difference in their electronegativity is negligible.
- The bonding electrons are symmetrically distributed among them.
- The carbon-hydrogen bonds in alkanes are non-polar.

- Since alkanes are non-polar, so acids, bases, oxidizing agents and reducing agents will not react with alkanes.

Strength of Sigma Bond:

- Alkanes have only sigma (σ) bond.
- Alkanes do not have pi (π) bond.
- Alkanes do not react with other reagents under normal condition.
- Alkanes react with some substances at high temperature.
- Sigma bond are strong bond because electrons lies very close to each other.

Important reactions of alkanes:-

Free Radical Substitution Reaction:

Free Radical substitution reaction require ultraviolet light for free radical formation.

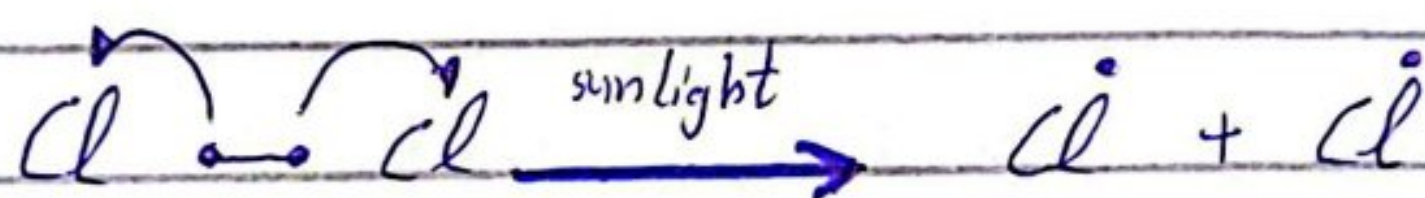
Cracking:

Cracking requires heating to break large molecule and convert them to smaller more useful molecule.

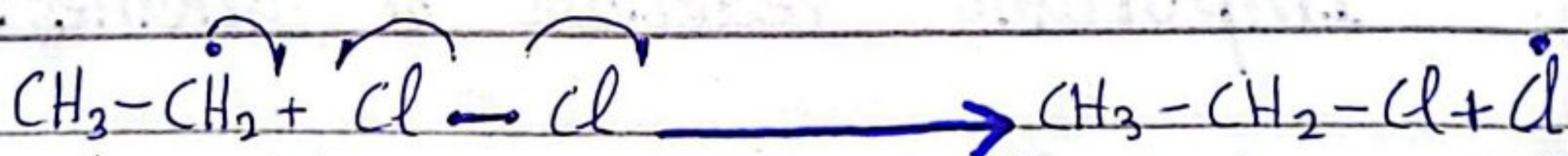
Free Radical Substitution of Ethane:

Substitution reaction of ethane involve halogen free radicals which are very reactive species and attack on ethane molecule. There are three steps in this reaction.

1. Initiation:-

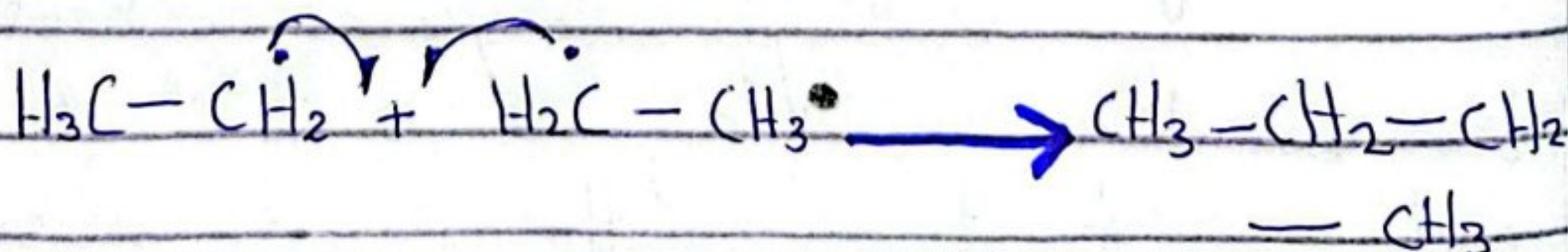
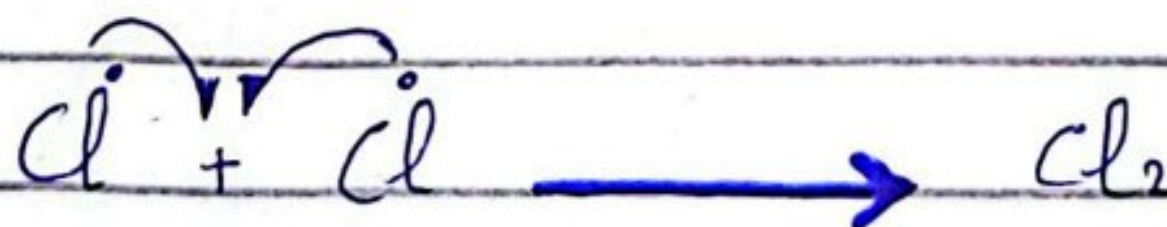


2. Propagation:-



This step take place until all hydrogen of ethane is replaced by chlorine.

3. Termination:-

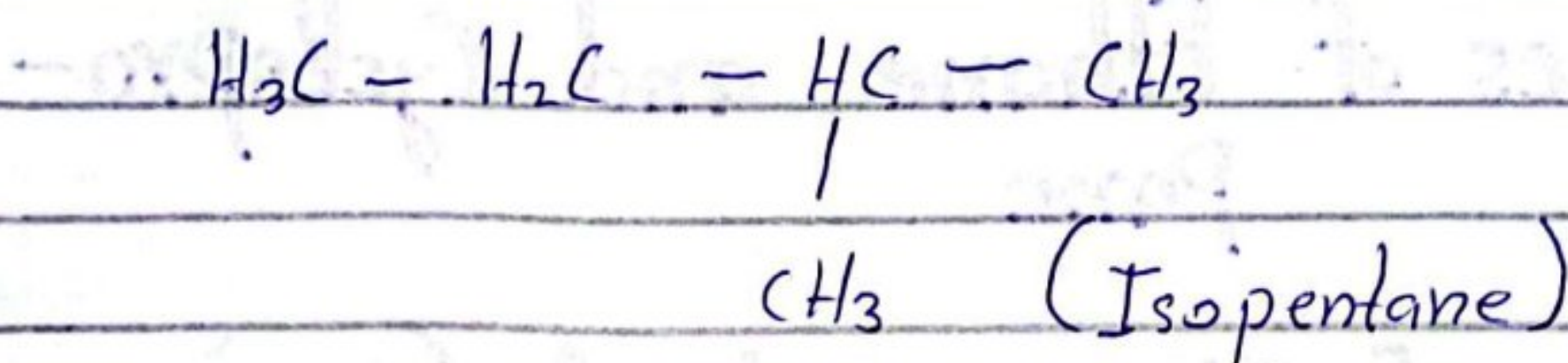
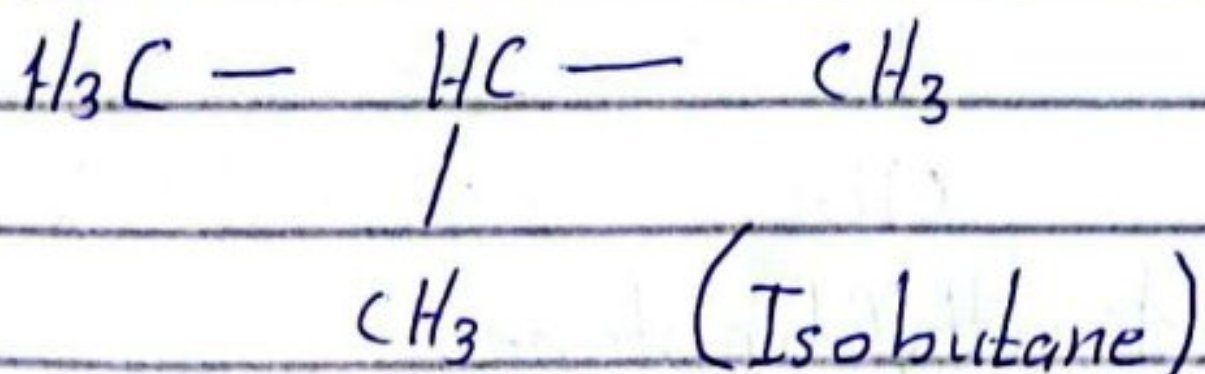


Nomenclature of Alkane

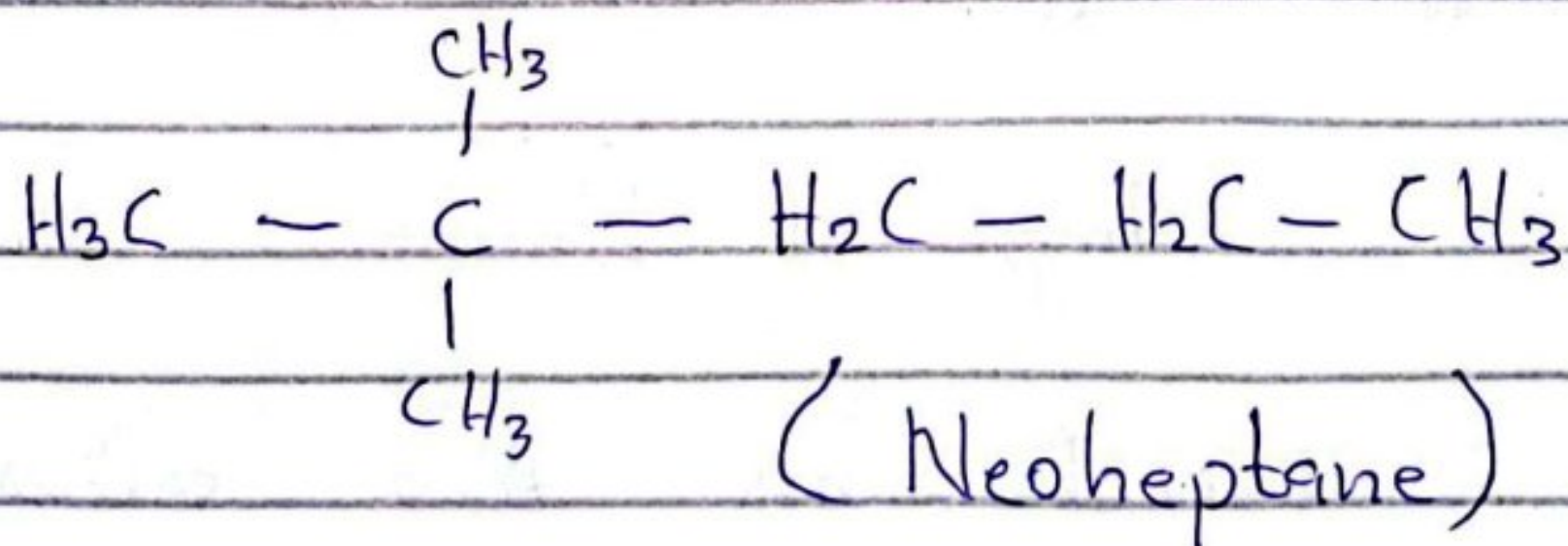
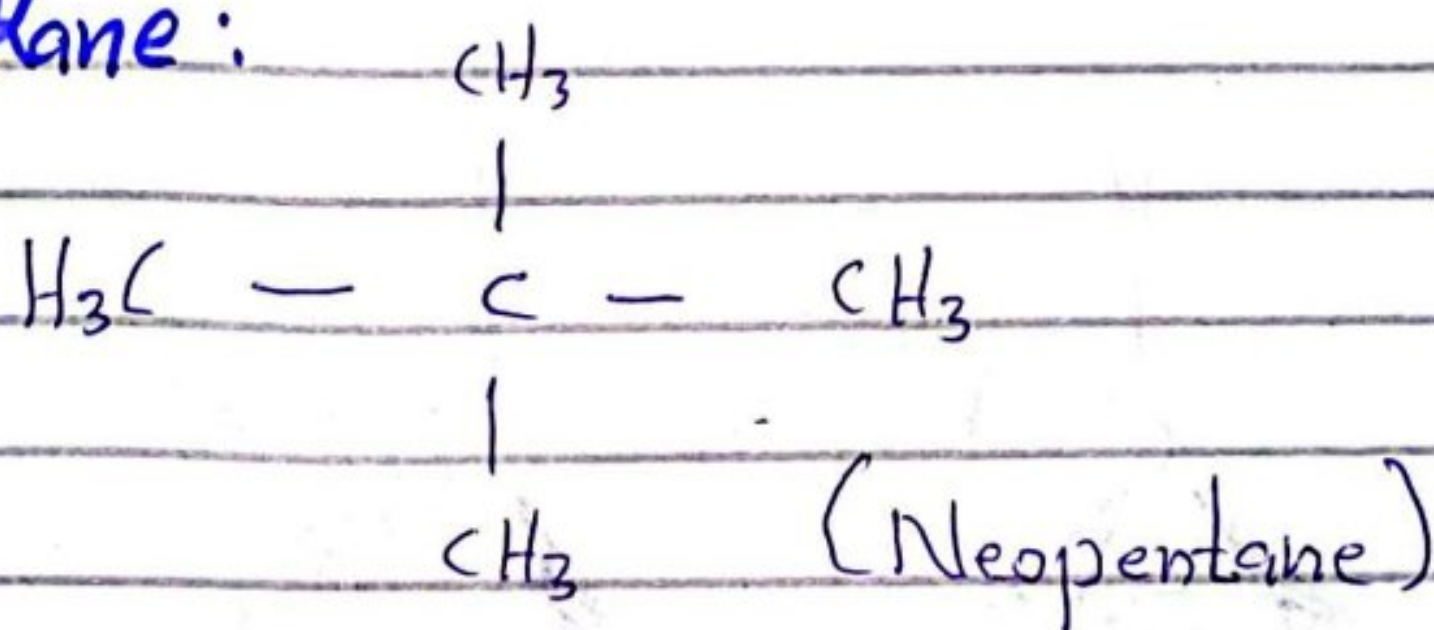
Common Name : (Trivial name)

CH_4 = Marsh gas.

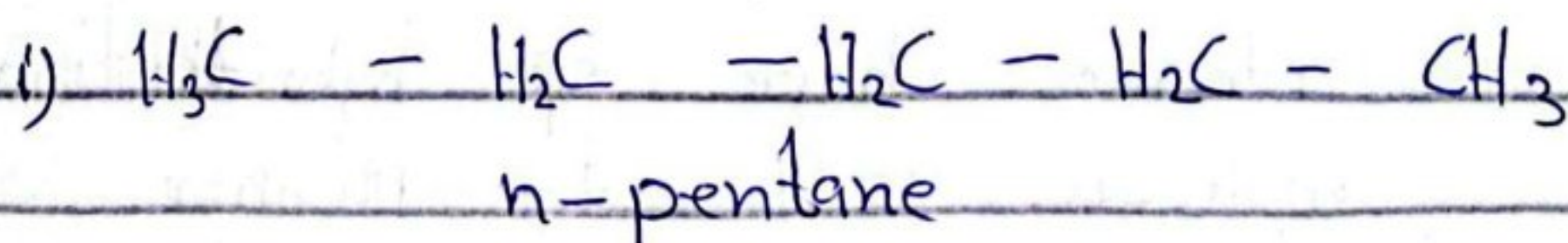
Isoalkane:

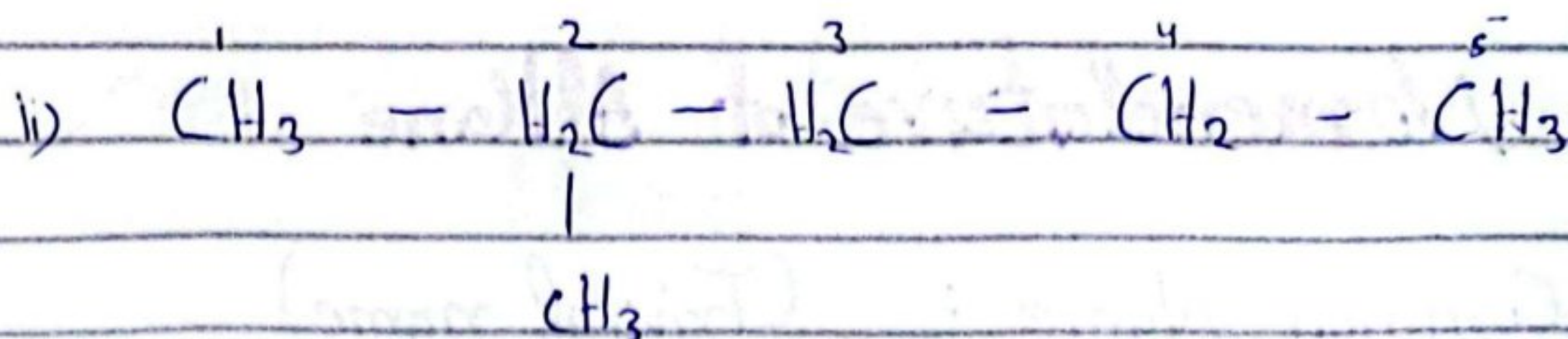


Neoalkane:

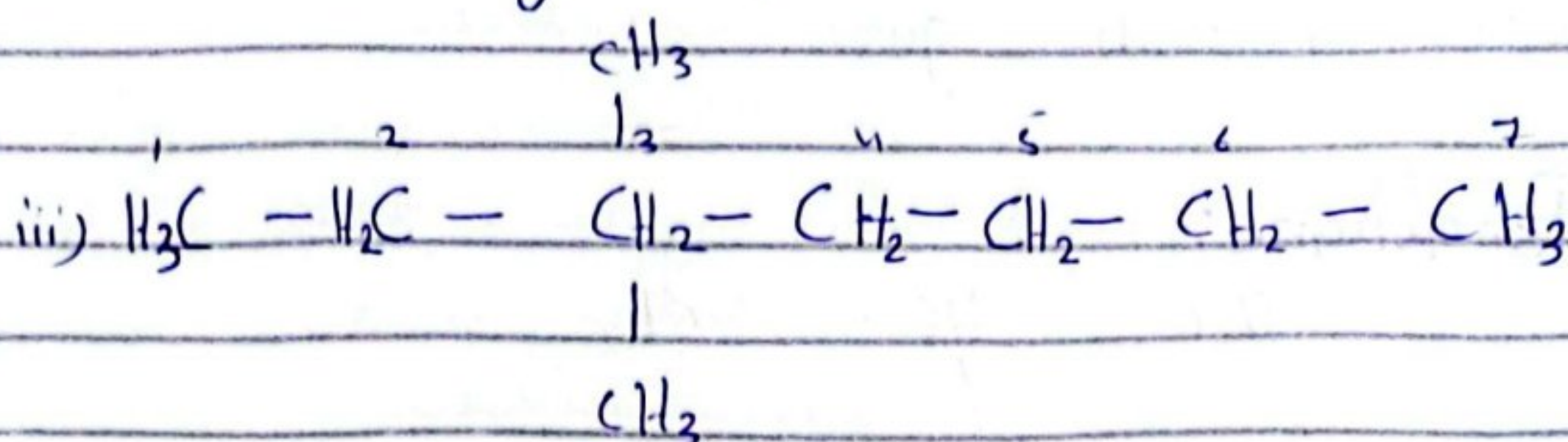


IUPAC Name :-





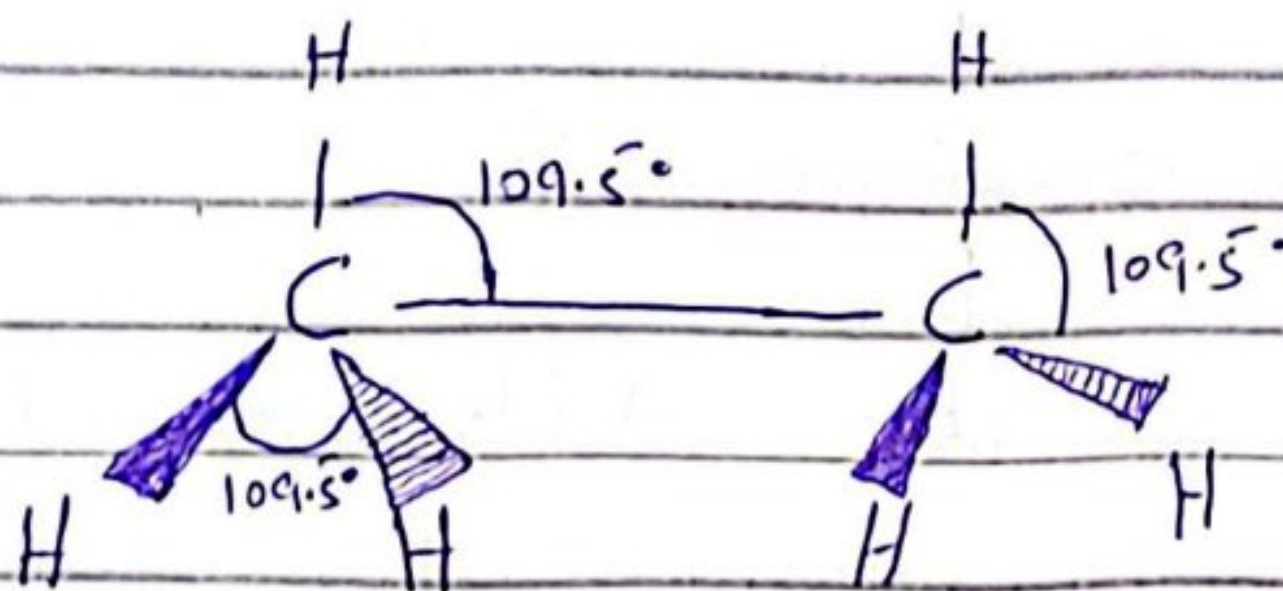
2-Methyl pentane.



3-3 dimethyl heptane.

Shapes of Ethane and Cyclopropane

1 Shape of Ethane Molecule (C_2H_6)



Shape of Ethane.

Ethane molecule has two carbon atoms.

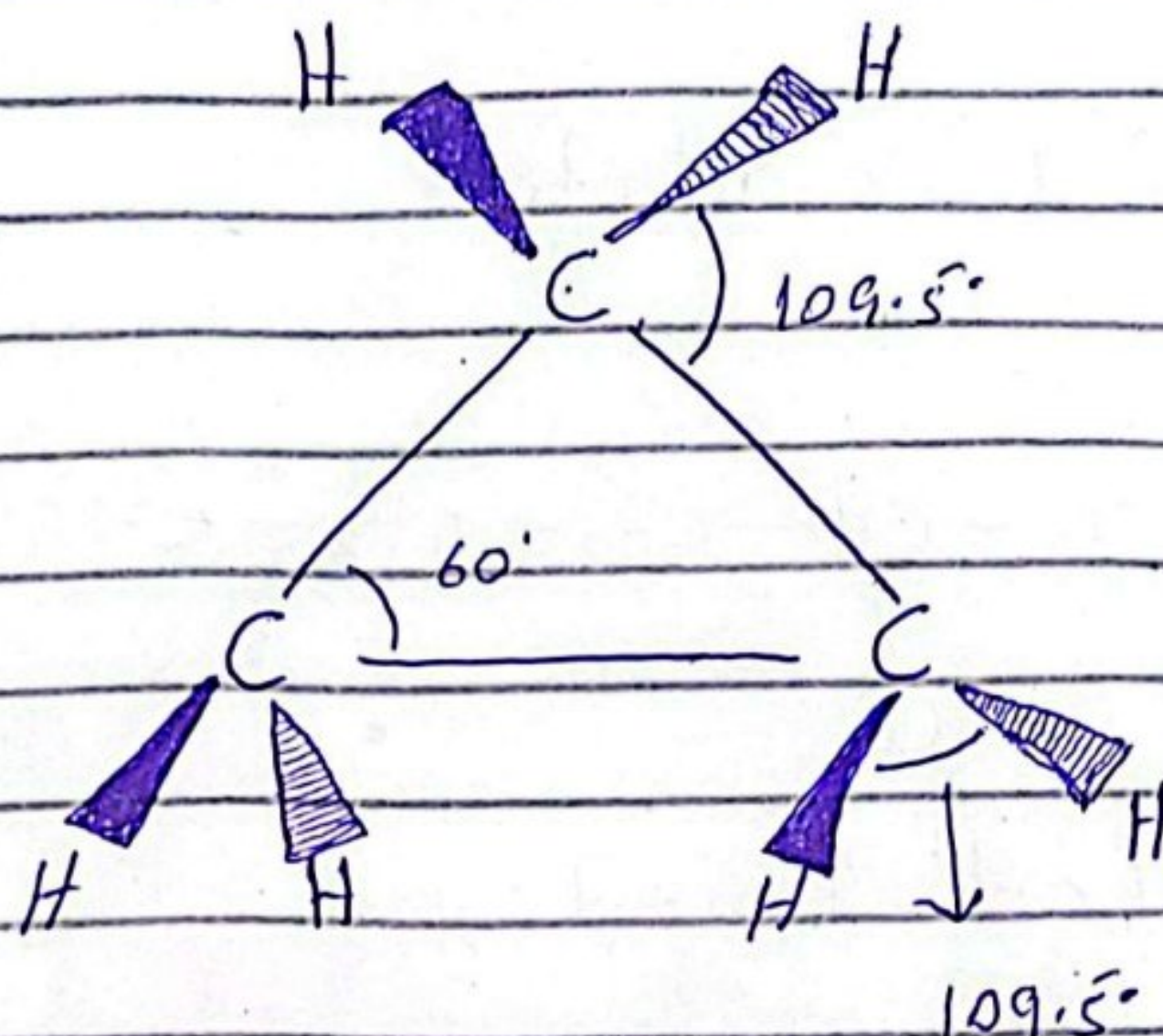
Ethane molecule has six hydrogen atoms.

Ethane molecule have sp^3 hybridization

Ethane molecule is not planar.

Carbon atoms makes an angle of 109.5° .

Shape of Cyclopropane Molecule (C_3H_4)



Shape of cyclopropane.

Cyclopropane molecule has three carbon atoms.

Cyclopropane molecule has 4 (four) hydrogen atoms.

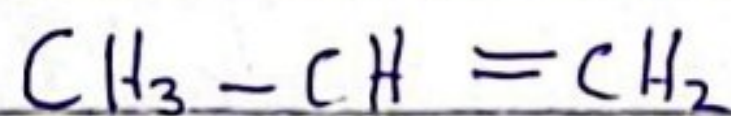
Cyclopropane molecule shows sp^3 hybridization.

These are in three dimension. So it is not planar.

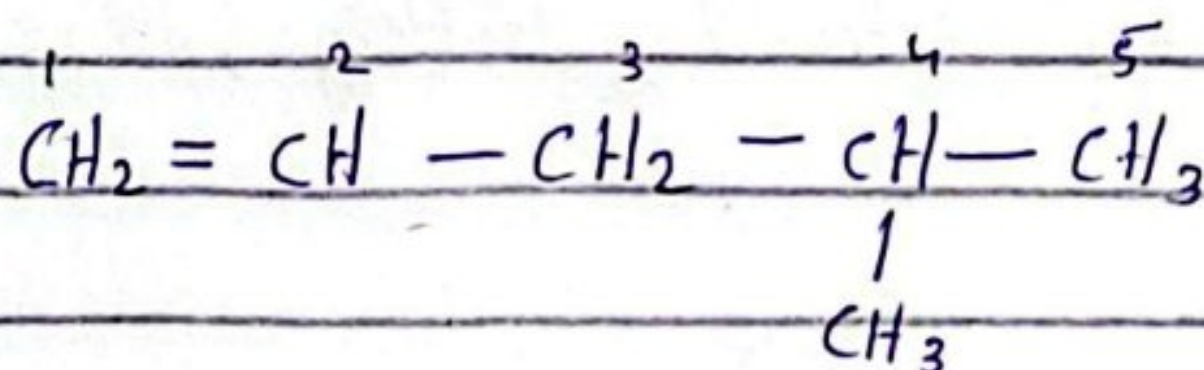
The C-C-C angle is 60° .

The H-C-H angles are 109.5° .

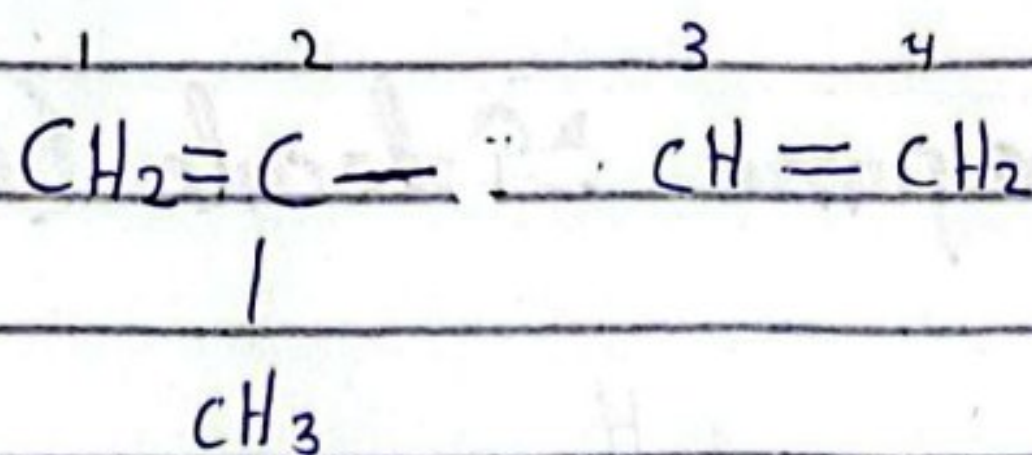
Nomenclature of Alkene :-



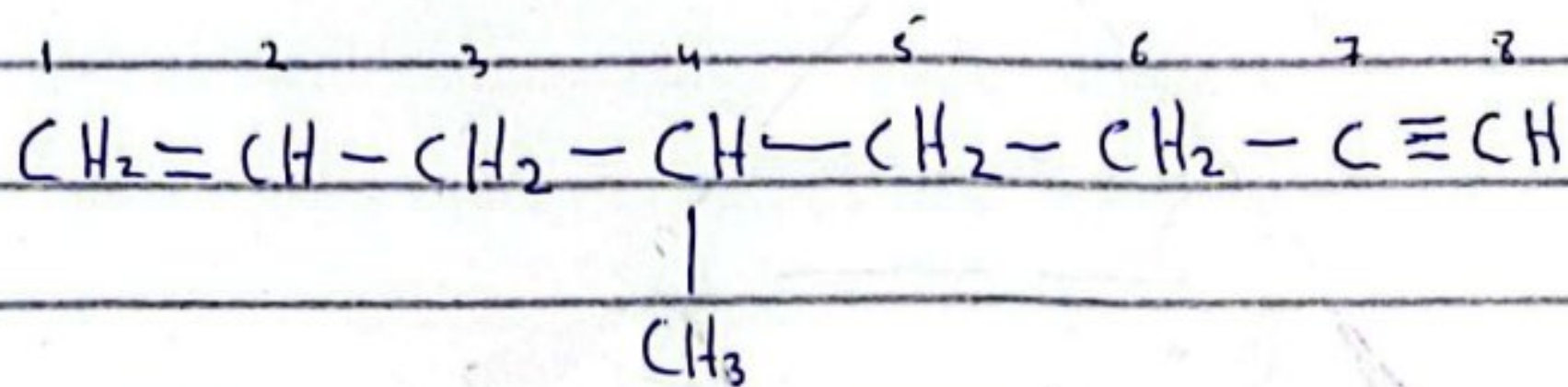
Propene



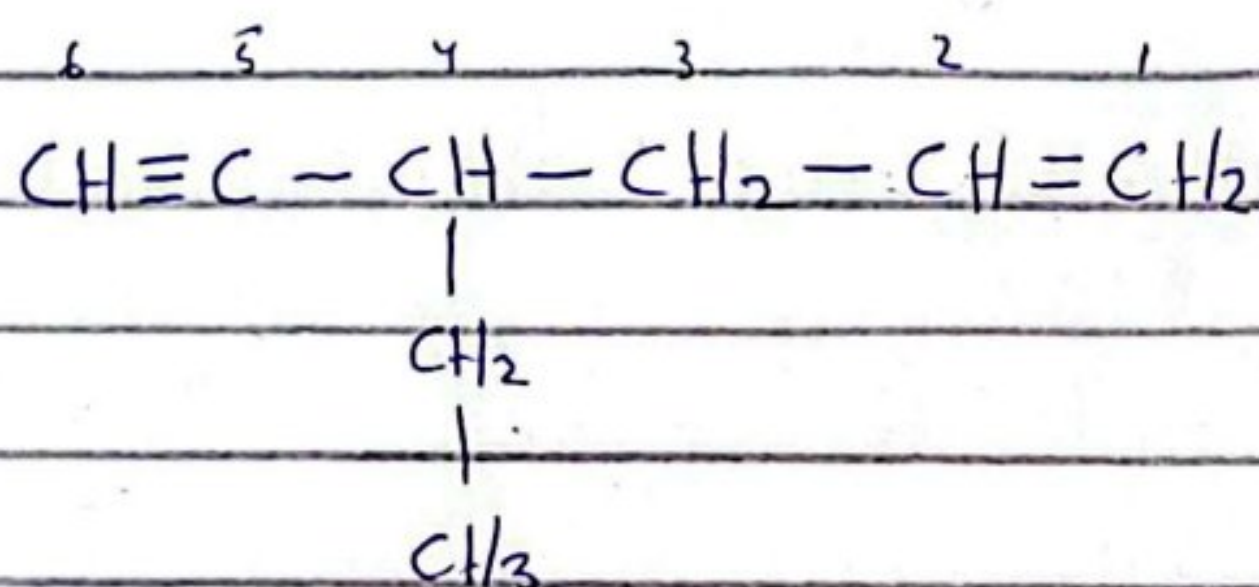
(4 methylpentene)



2-methyl-1,3-dibutene



4-methyloct-1-en-7-yne



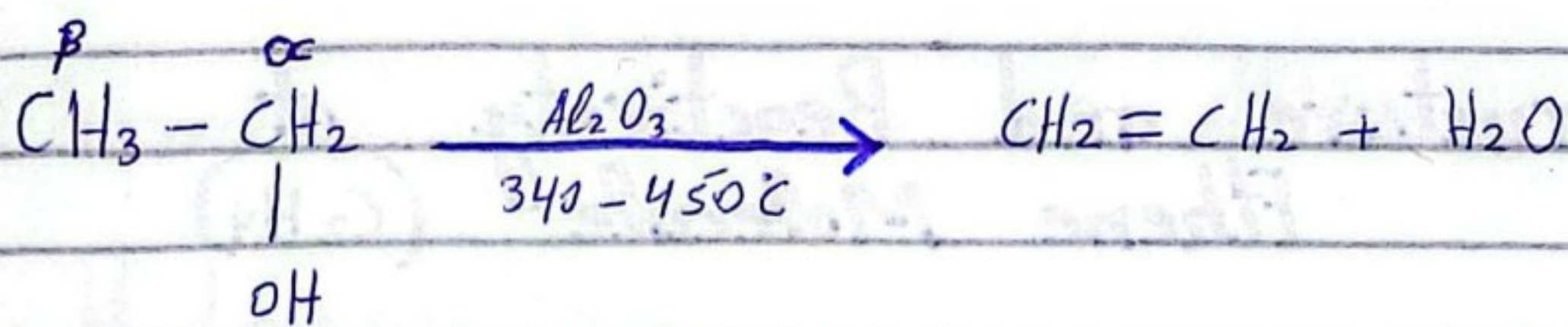
4-ethylhex-1-en-5-yne

Preparation of Alkenes:

1. Dehydration of Alcohols:

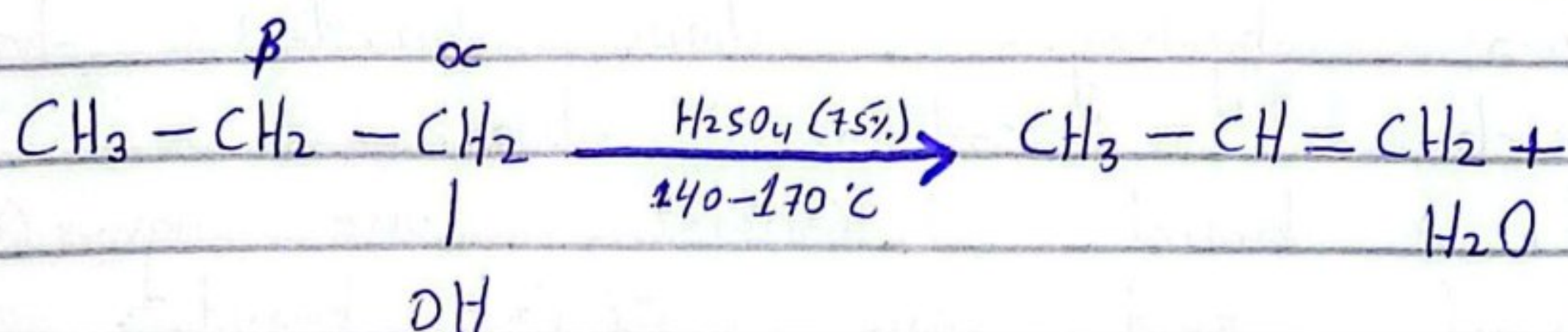
Removal of water from alcohols is called dehydration

Dehydrating agents = H_2SO_4 , H_3PO_4 , Al_2O_3 , P_4O_{10} .



ethanol

ethene.



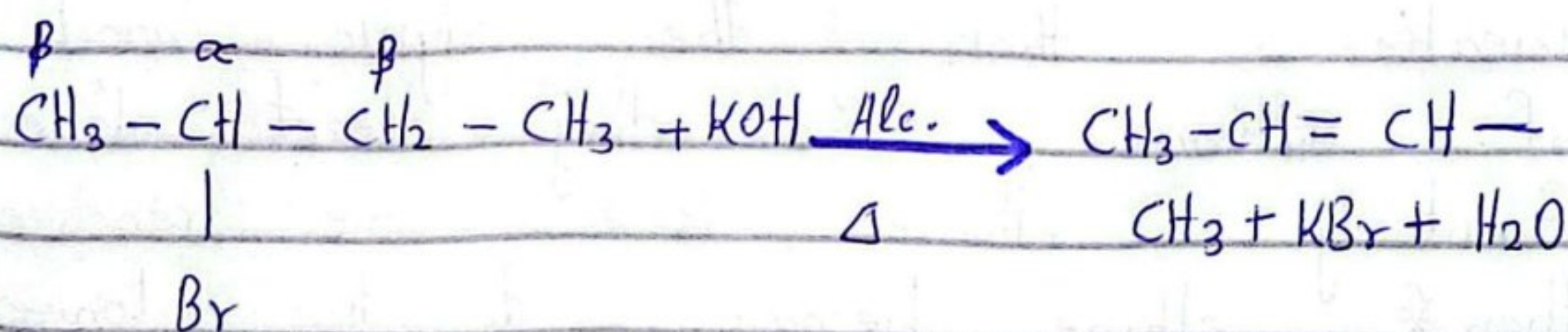
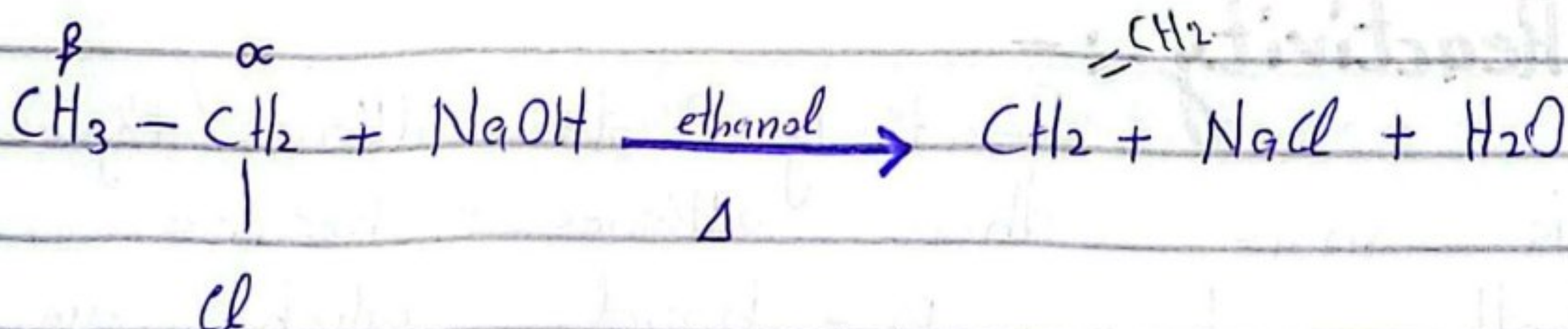
2. Dehydrohalogenation of Halogeno-alkane :

OR

Alkyl Halids

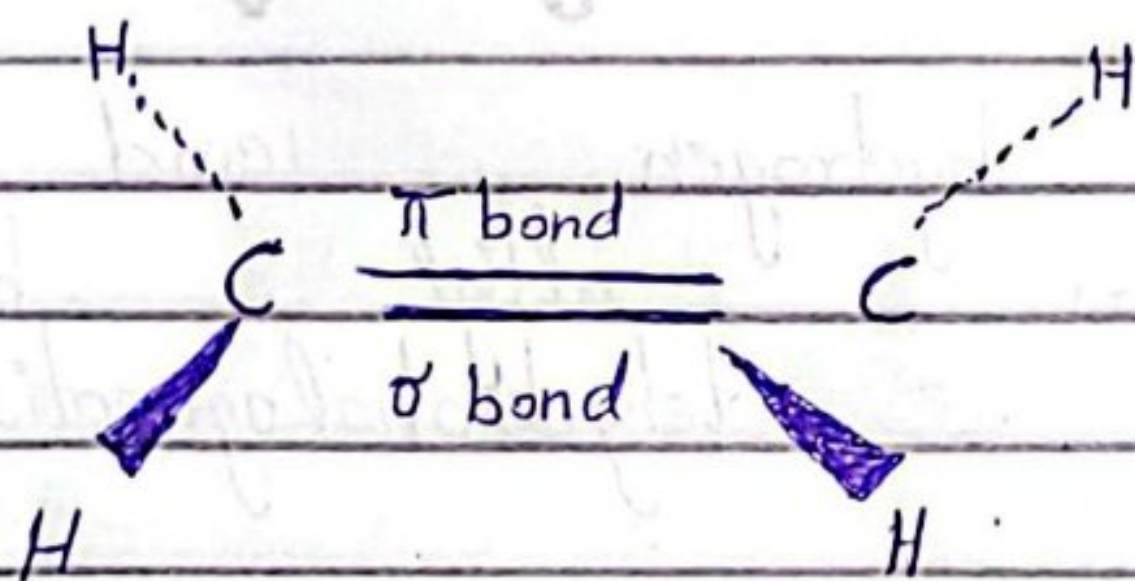
Removal of hydrogen and halogen from alkyl halide is called dehydrohalogenation.

Reagents i) Ethanols NaOH
ii) Alcoholic KOH .



Structure and Reactivity of Ethene Molecule (C_2H_4)

- Ethene Molecule has two carbon atoms bonded.
- Two hydrogen atoms bonded to each carbon atom.
- The bond consists one sigma (σ) bond and one pi (π) bond.
- Carbon atoms show sp^2 hybridization with trigonal planar.
- Sigma (σ) bond is a strong bond.
- Pi (π) bond is a weak bond.



Shape of Ethene Molecule.

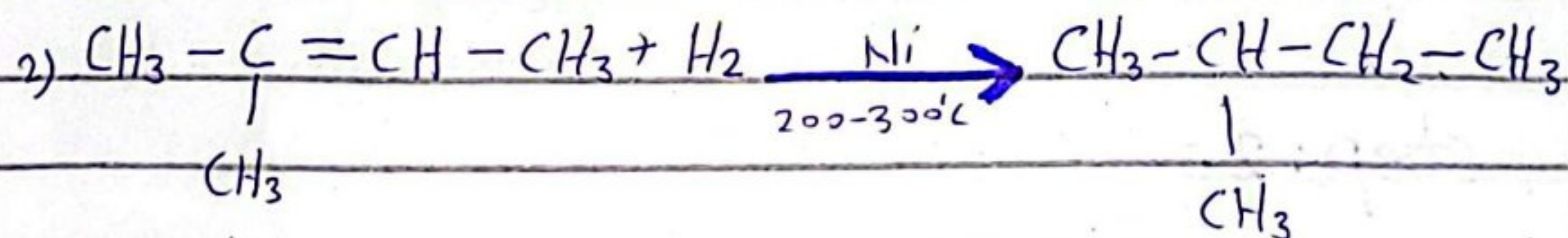
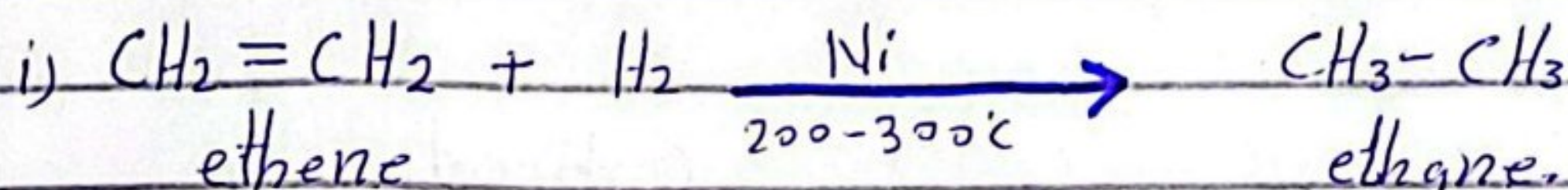
Reactivity :-

Reactivity of alkenes/alkynes is more than alkanes because both have pi-bond which are weaker than the sigma-bonds of alkanes. So they react faster. Similarly, ethene is more reactive than ethyne because it has longer distance between carbon atoms than ethyne.

Chemical Reactions of Alkenes

i) Hydrogenation (Sabatier Sender's reaction)

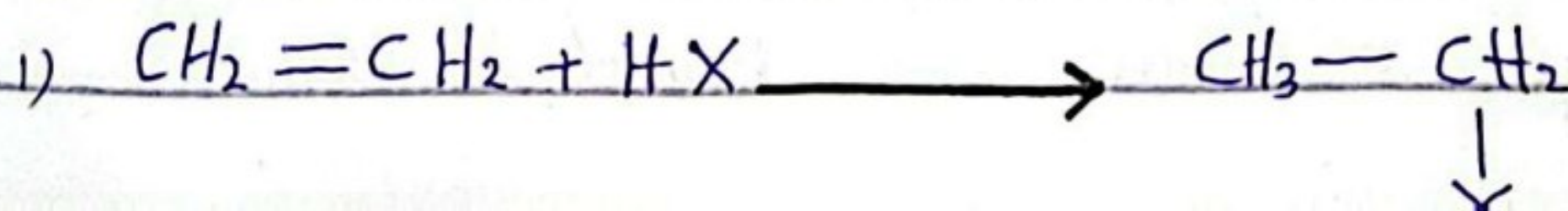
Addition of hydrogen in the molecule is called hydrogenation. It takes place in the presence of Metallic catalyst, Ni, Pt, Pd, it is important in industry because vegetable ghee is prepared from vegetable oil.

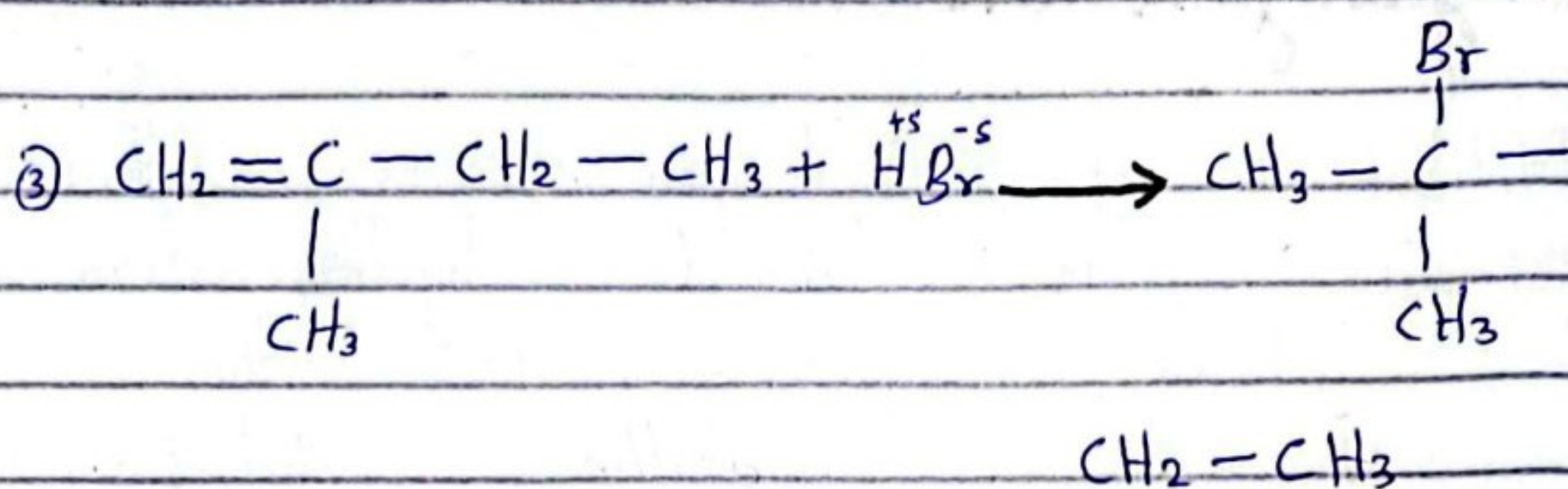
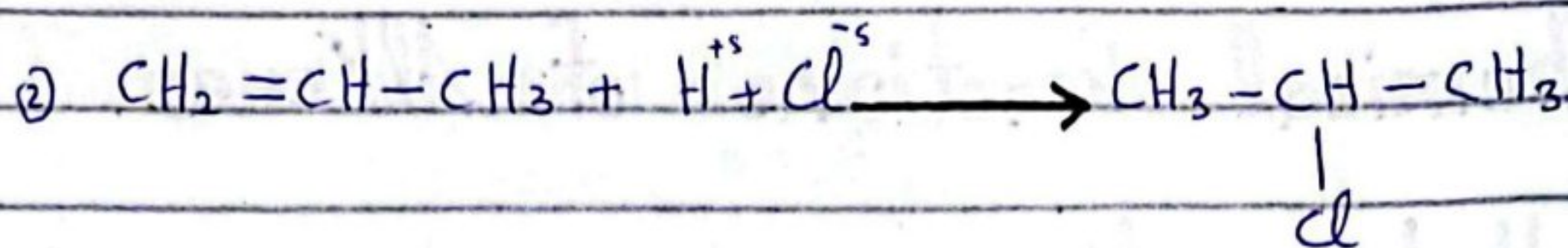


2-methyl-2-butene.

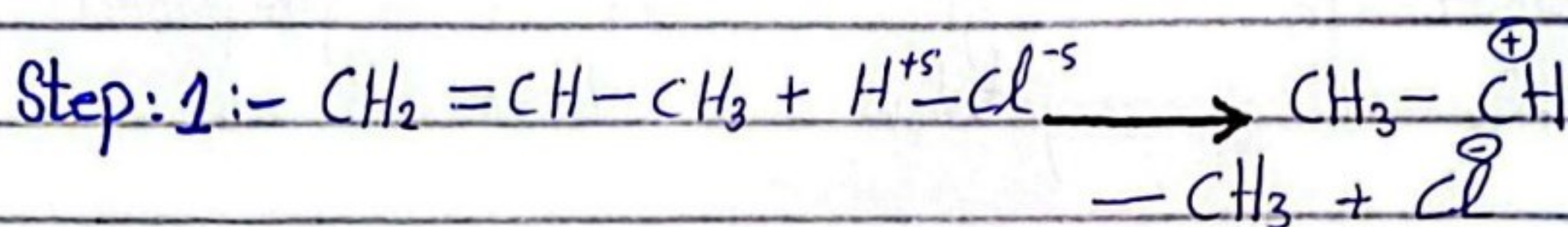
ii) Hydrohalogenation of Alkenes:

Addition of hydrogen and halogen in the molecule is called hydrohalogenation.





Mechanism :-

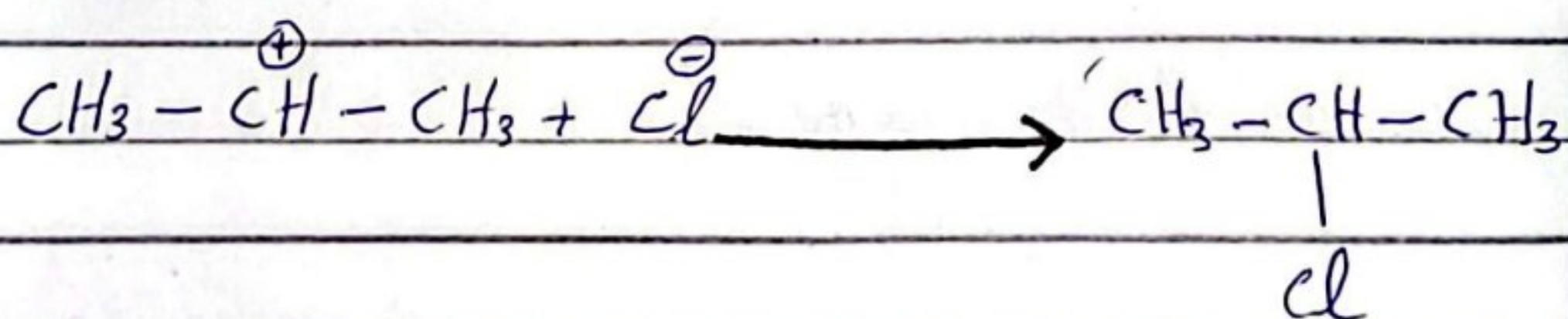


Carbocation

or

Carbonium ion

step: 2.



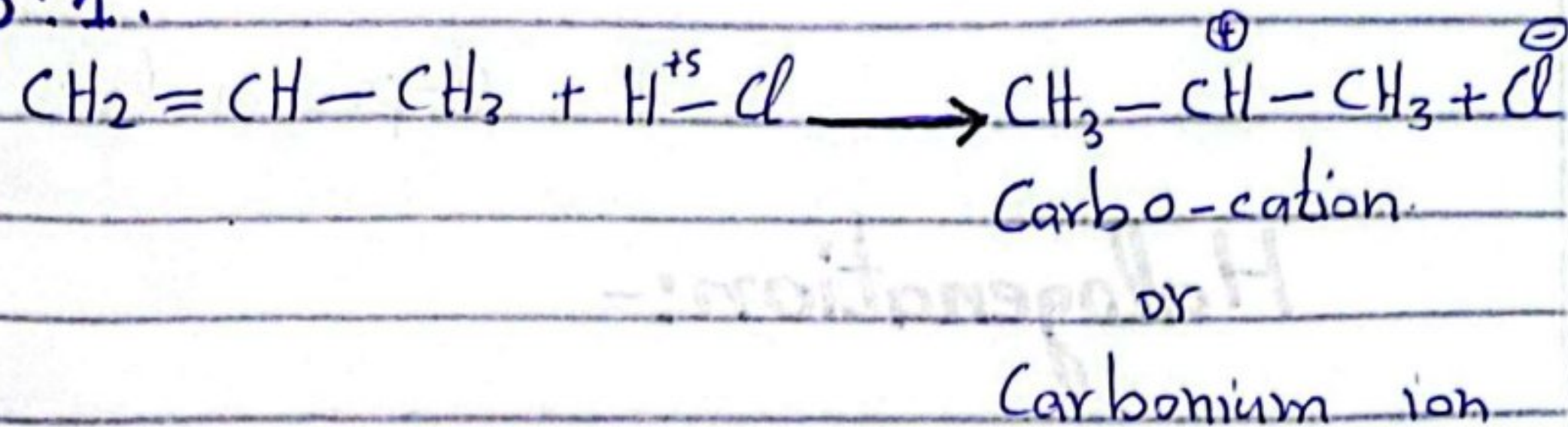
Markownikov's Rule :

According to this rule when an unsymmetrical reagent is added to an unsymmetrical alkene the negative part of the reagent goes to that carbon of alkene consisting double bond which

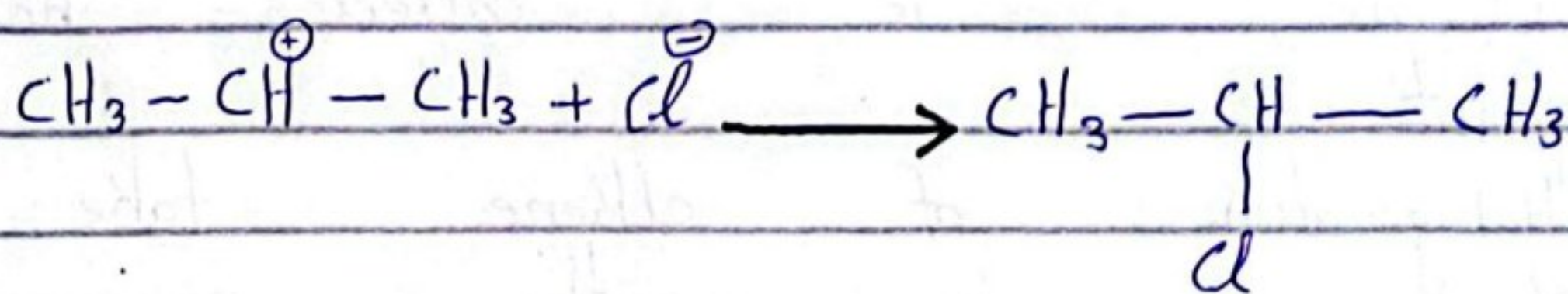
Less no. of hydrogen atoms.

For example:

Step: 1.

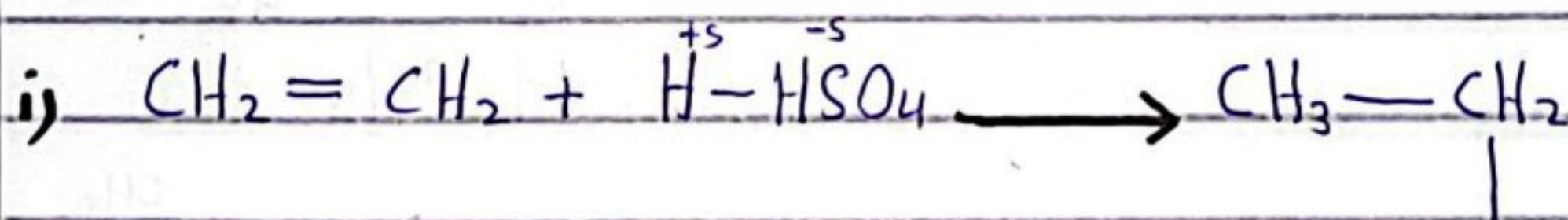


Step: 2

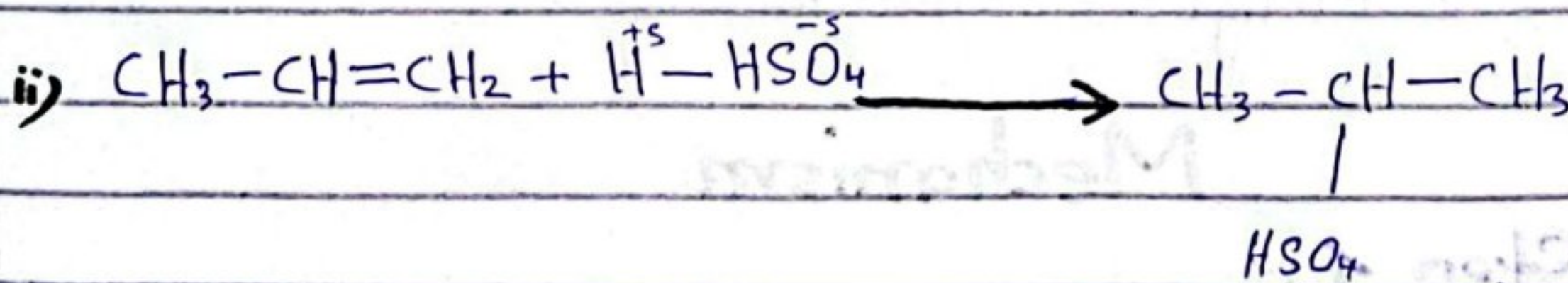
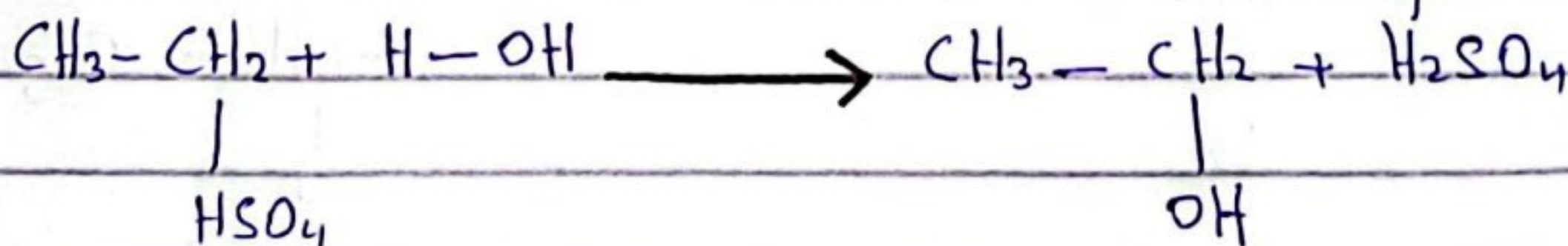


Hydration:

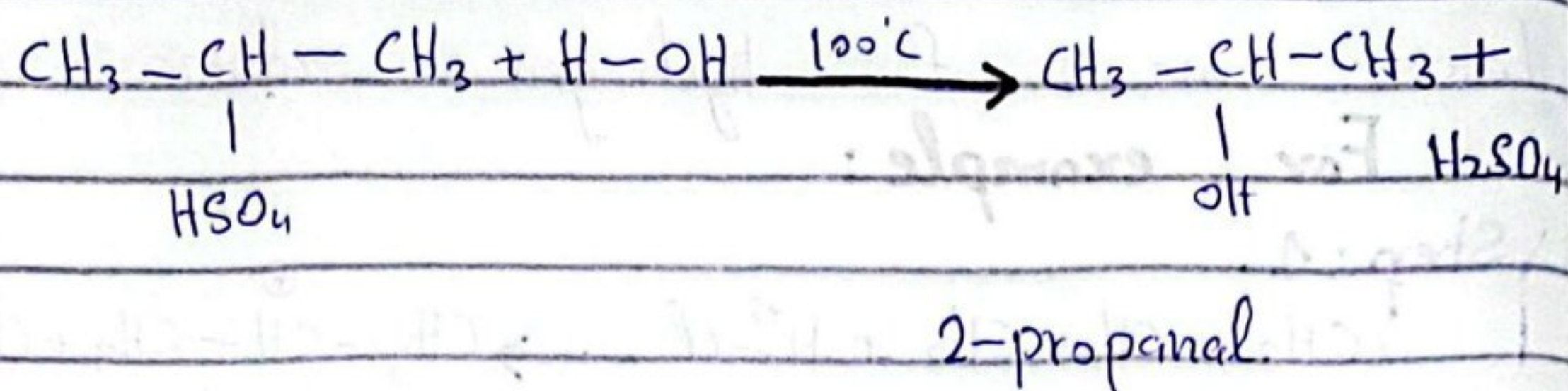
Addition of water in the molecule is called hydration.



ethyl hydrogen sulphate.

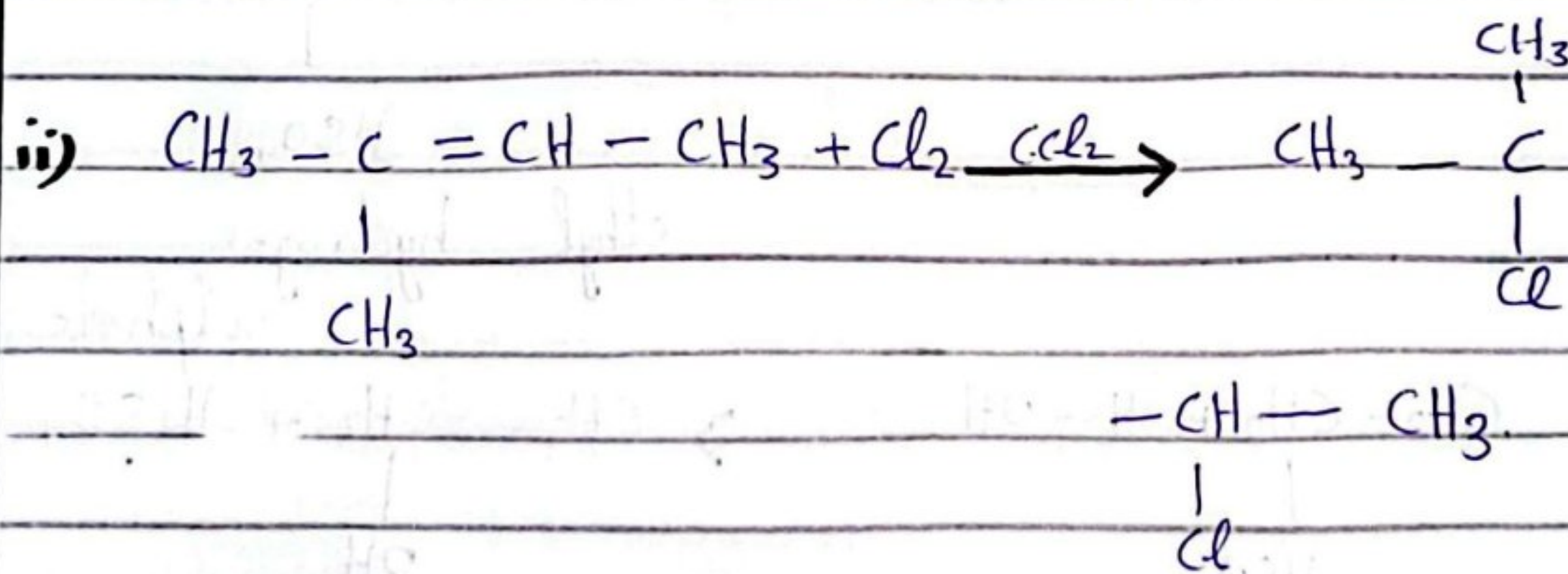
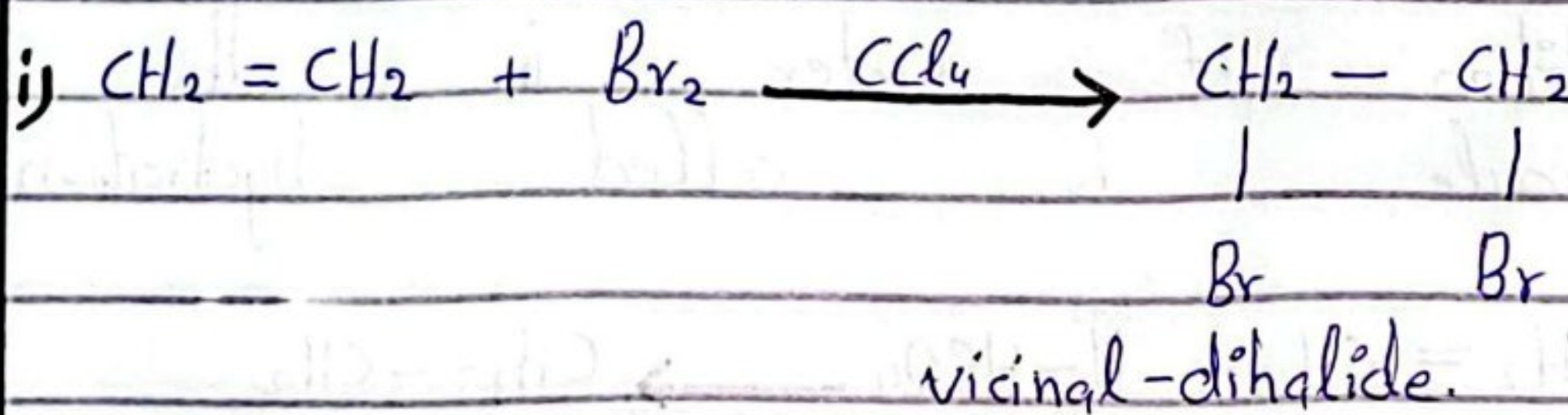


Sec-Propyl hydrogen sulphate.



Halogenation:-

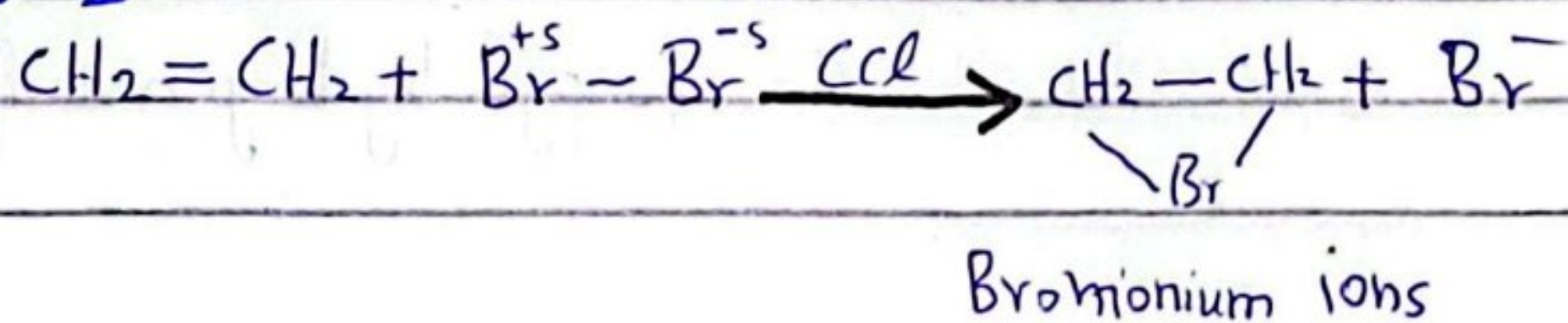
- Addition of halogen in the molecule is called halogenation.
- Halogenation of alkene takes place in the presence of inert solvent CCl_4 .

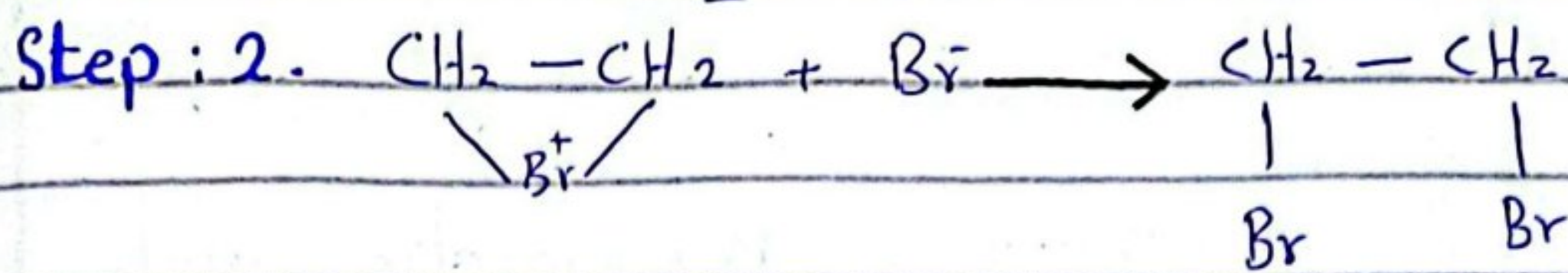


2-Methyl-2-Butene.

Mechanism

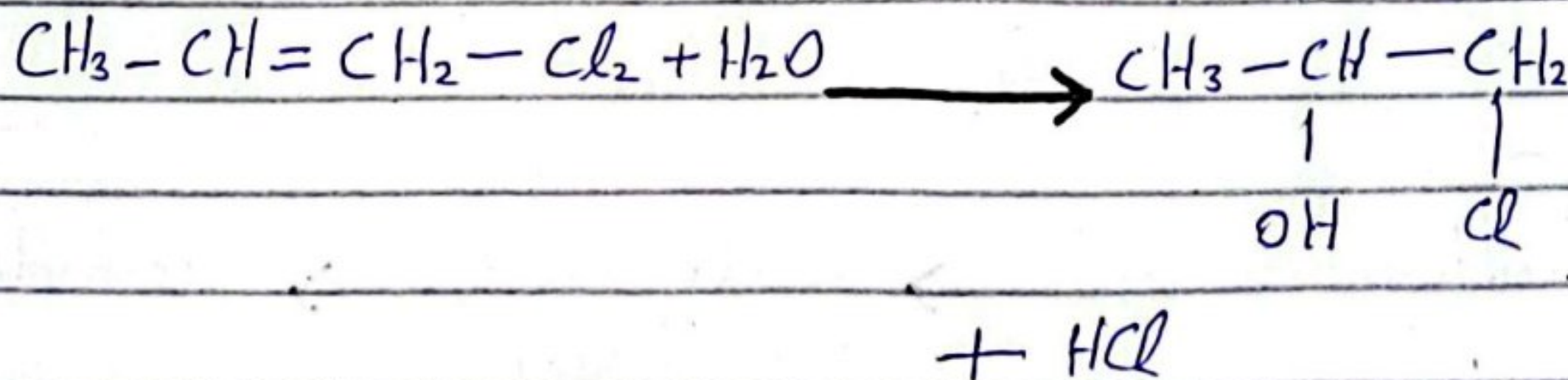
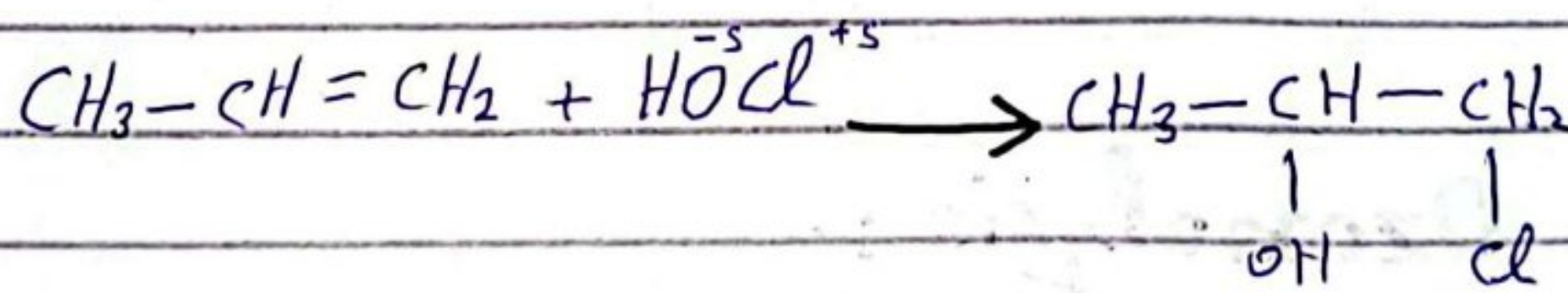
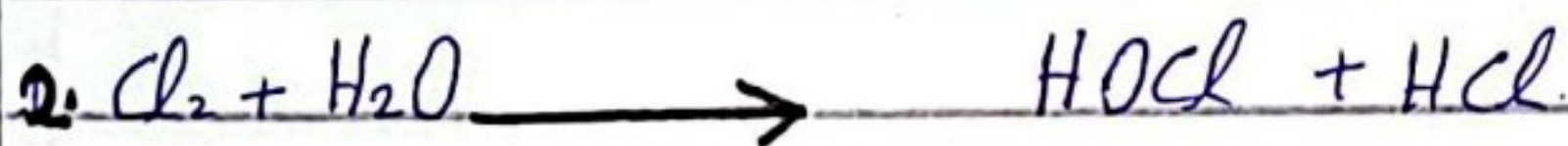
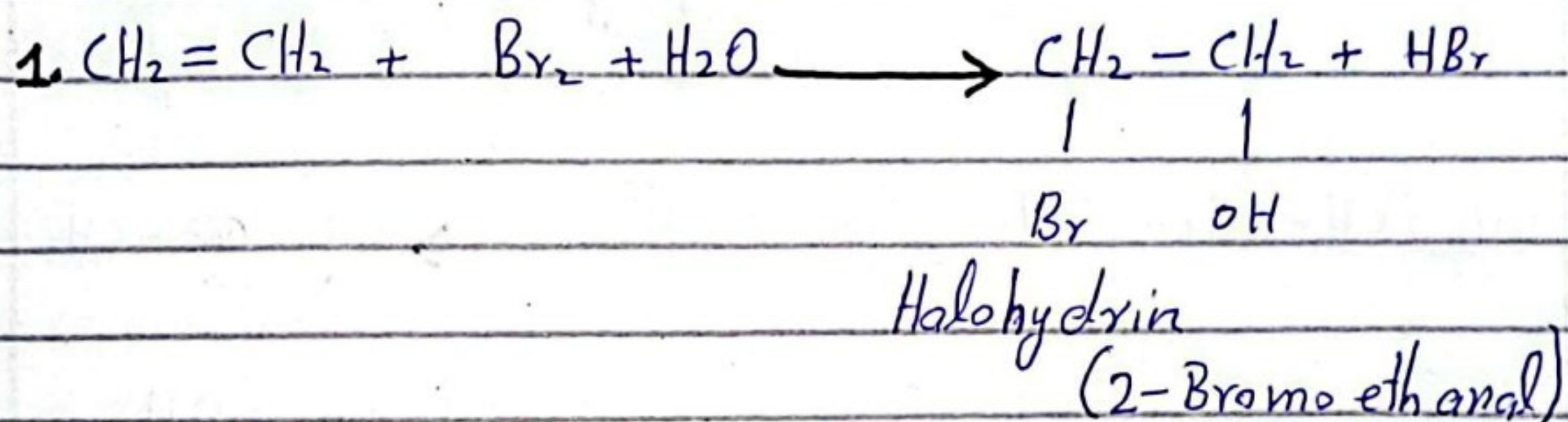
Step 1:-





Halohydration:-

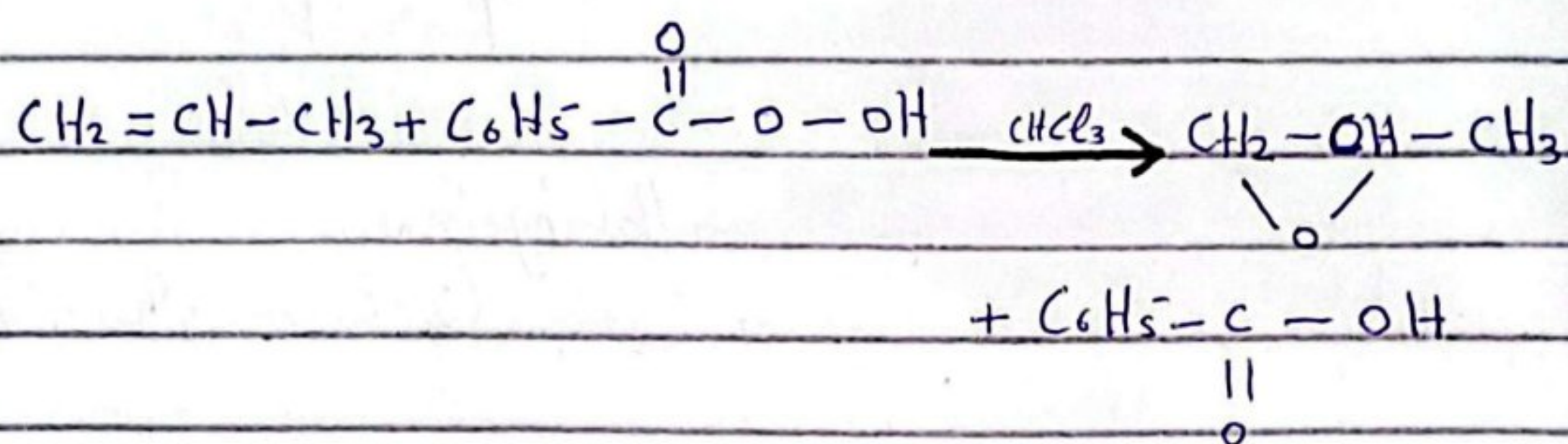
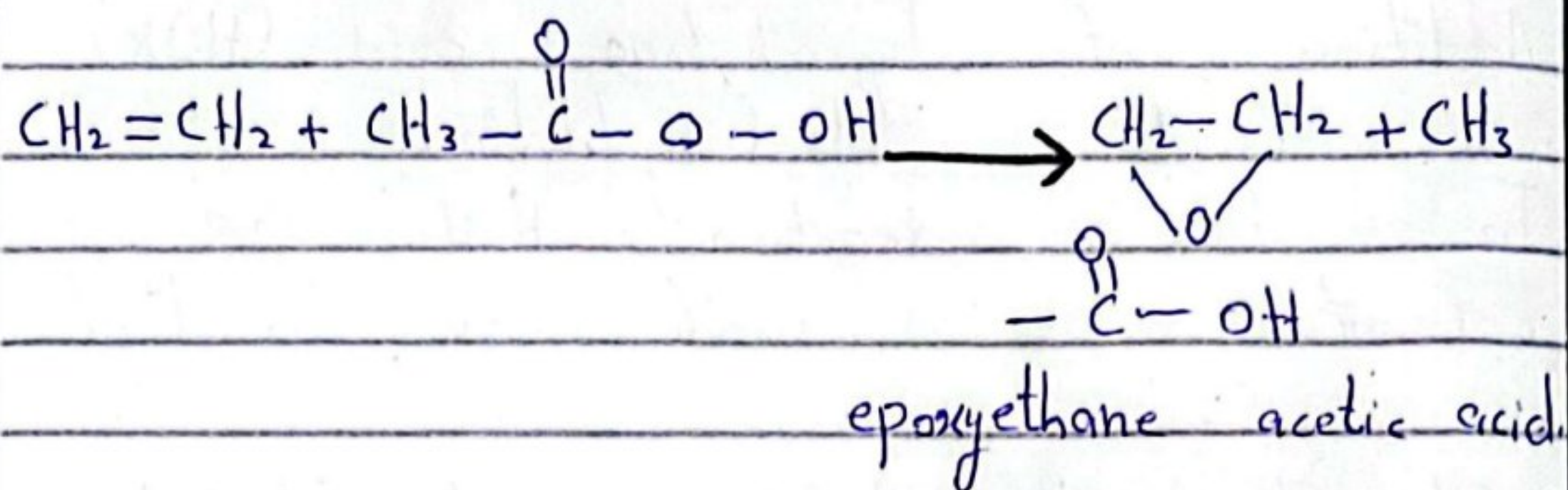
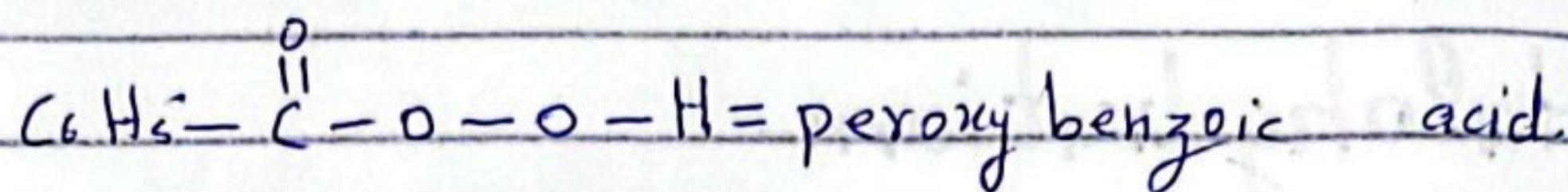
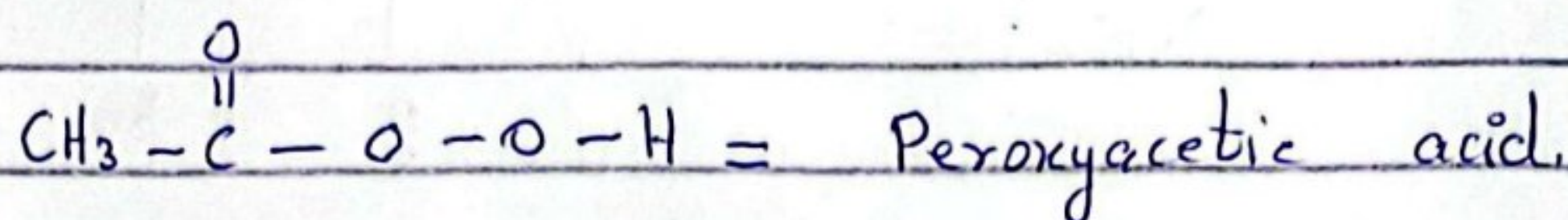
- Addition of hypohalous acid (HOX) is called halohydration.
- In this reaction H_2O act as solvent as well as reactant



Epoxidation:-

When alkene is reacted with peroxyacids in the presence of CHCl_3 epoxy alkane are.

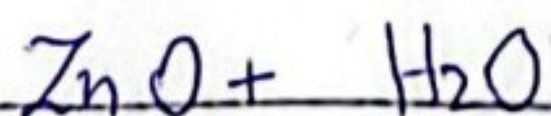
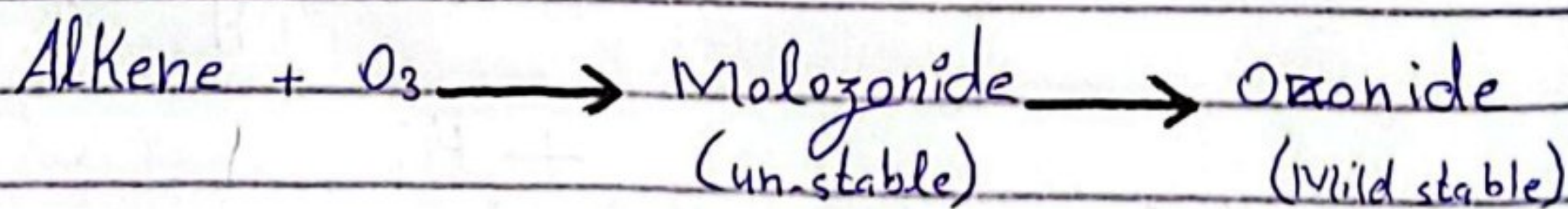
obtained ,

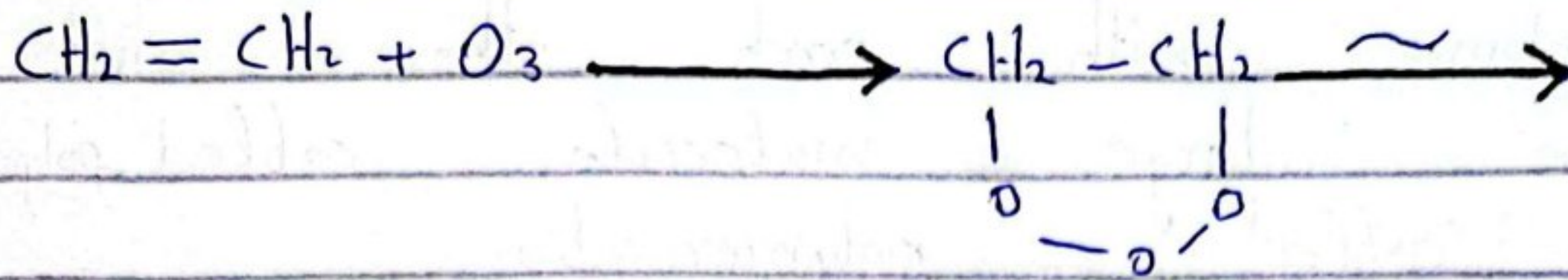
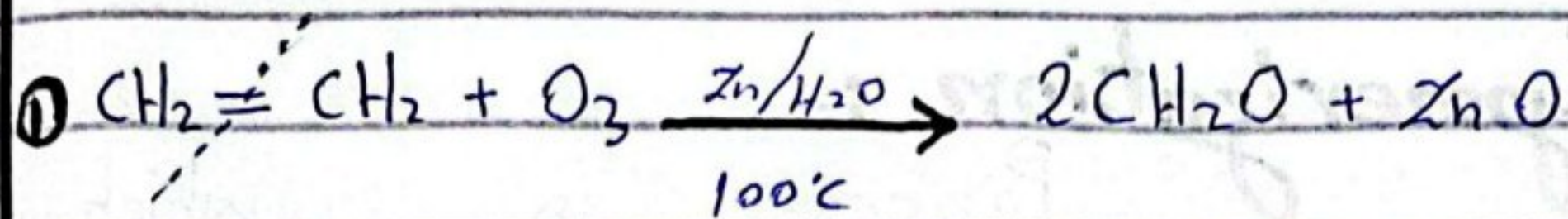


epoxy propene Benzoic acid.

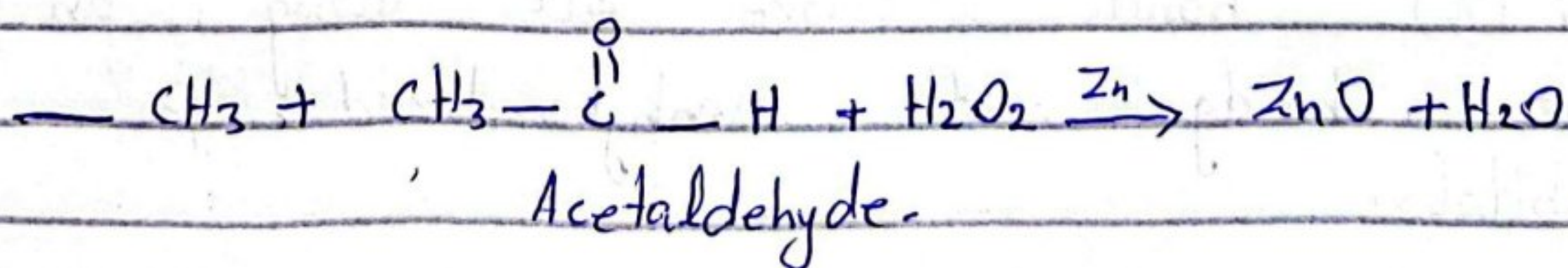
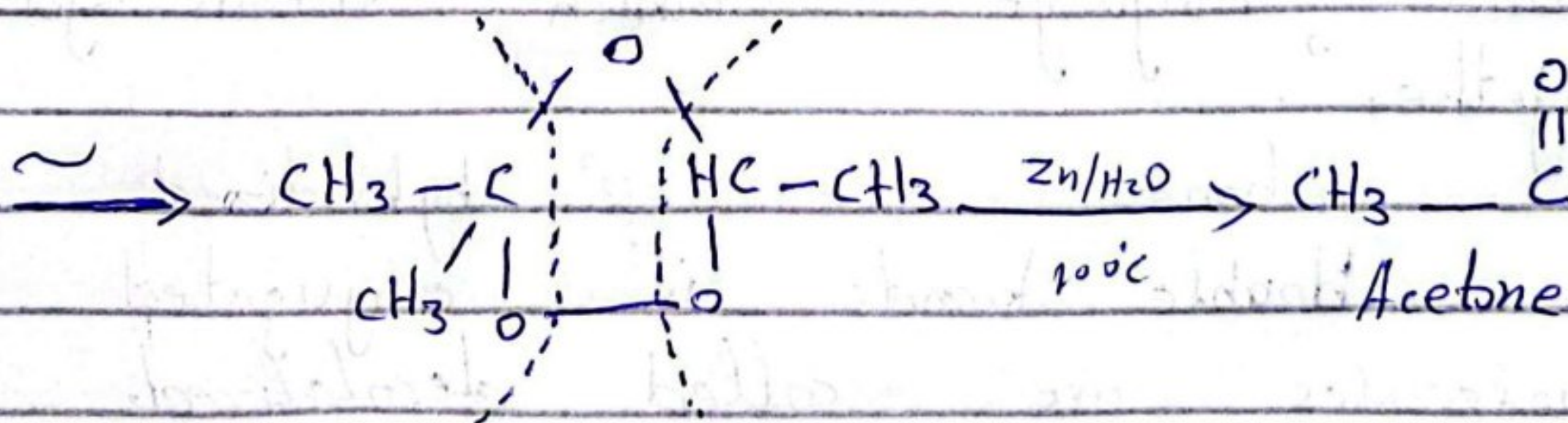
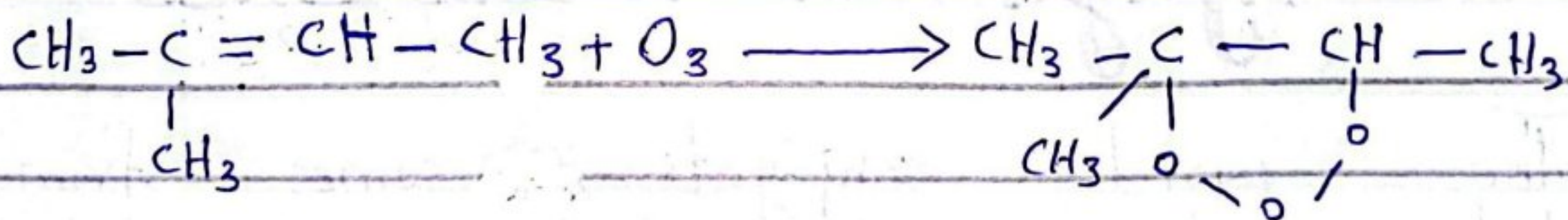
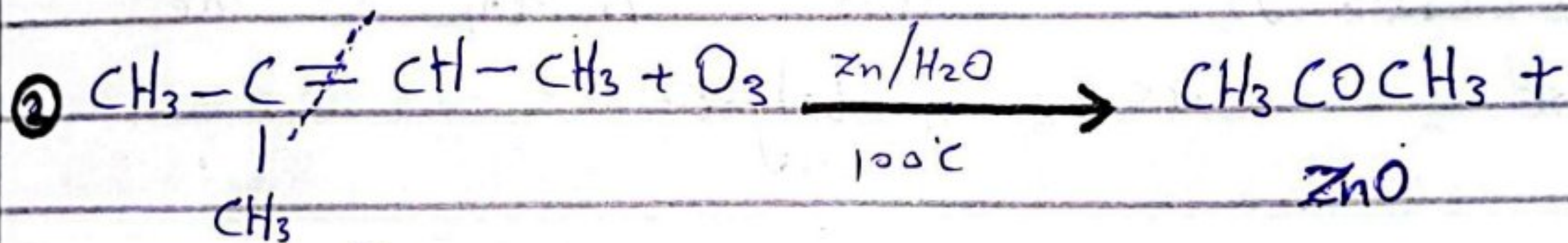
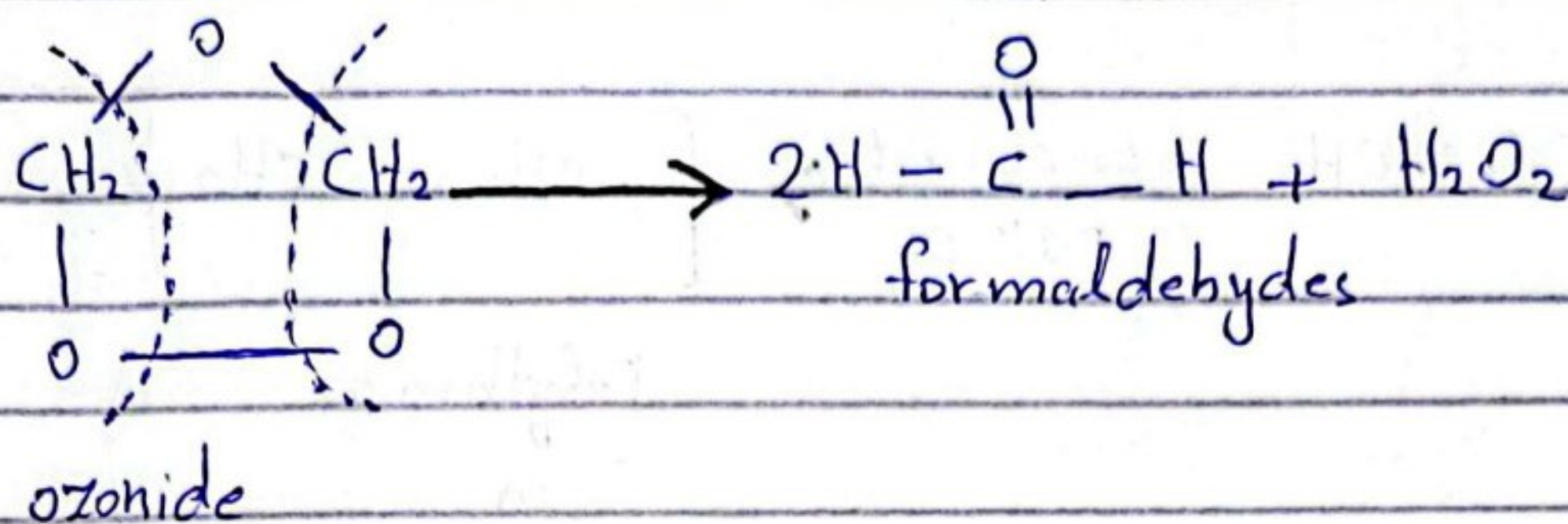
Ozonolysis :-

This least is used to locate position of double in alkene.



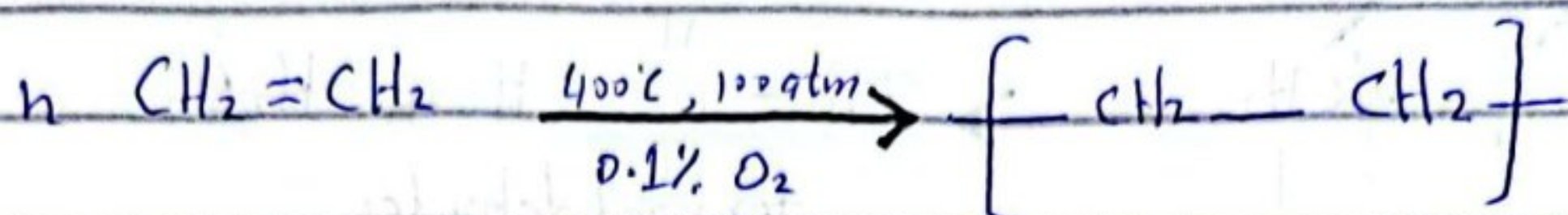


Molozonide



(8) Polymerization :-

Process in which small molecule called monomer combine with each other and form large molecule called polymer is called polymerization.



Polythene.

or

polyethylene.

For good quality polythene $\text{Al}(\text{C}_2\text{H}_5)_3$ and TiCl_4 are used as catalyst.

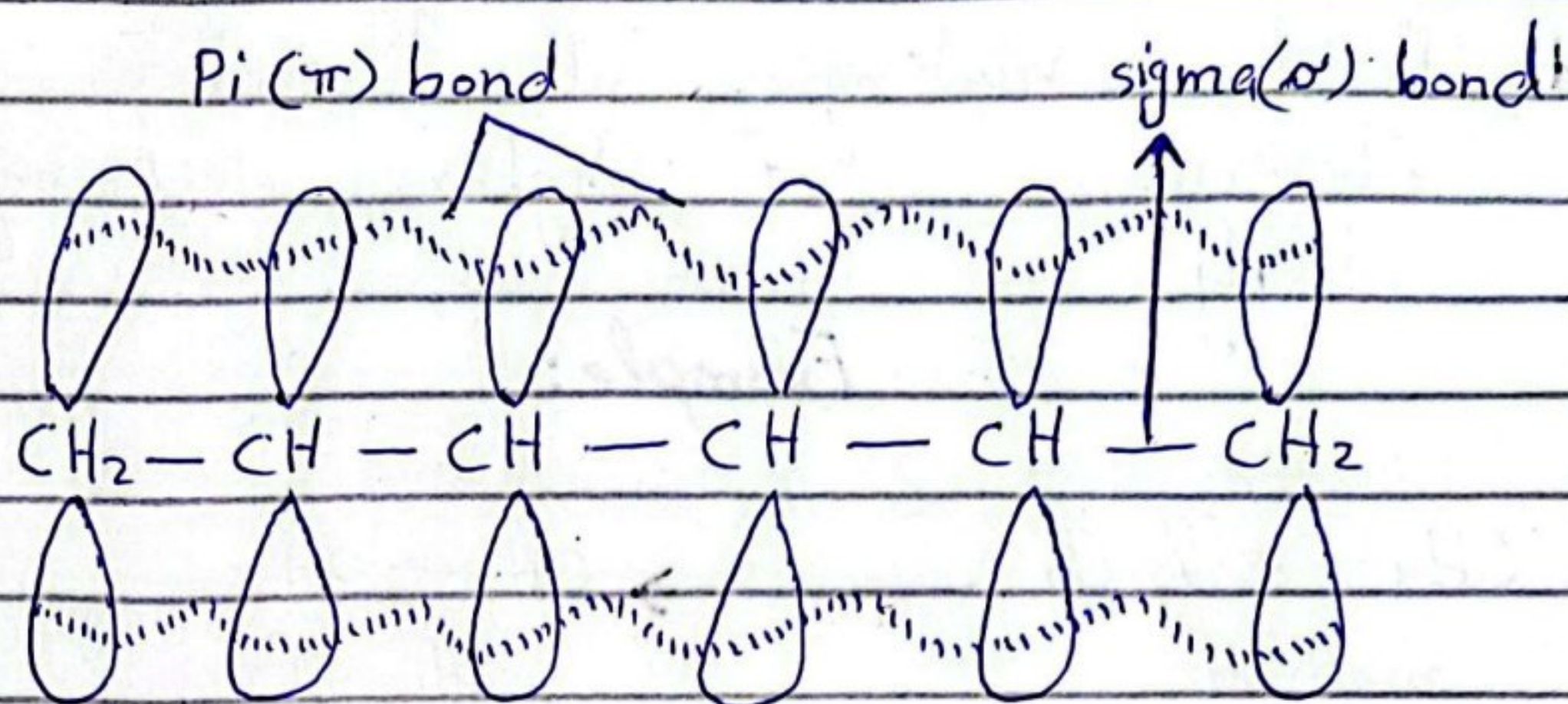
Conjugation in Alkenes

- The word conjugation comes from Latin language which means "join together".
- The carbons are sp^2 hybridized.
- The double bonds in conjugated molecules are called delocalized.
- π (π) bonds move all along on the bridge of unhybridized "p" orbitals.

example:-



hexa-1,3,5-triene.



Pi (π) electrons moving on unhybridized "p" orbitals bridge.

Redox Reactions of Organic Compounds :-

- The word "Redox" refers to reduction and oxidation reaction.
- In organic chemistry, we come across redox reactions very frequently.
- Since oxidation and reduction reaction take place simultaneously.

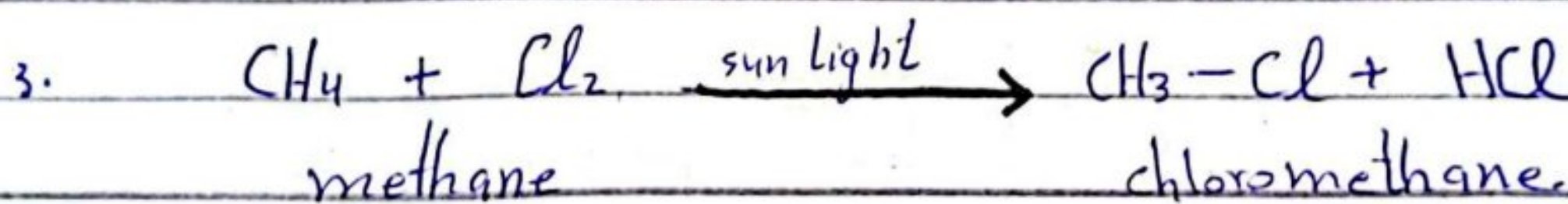
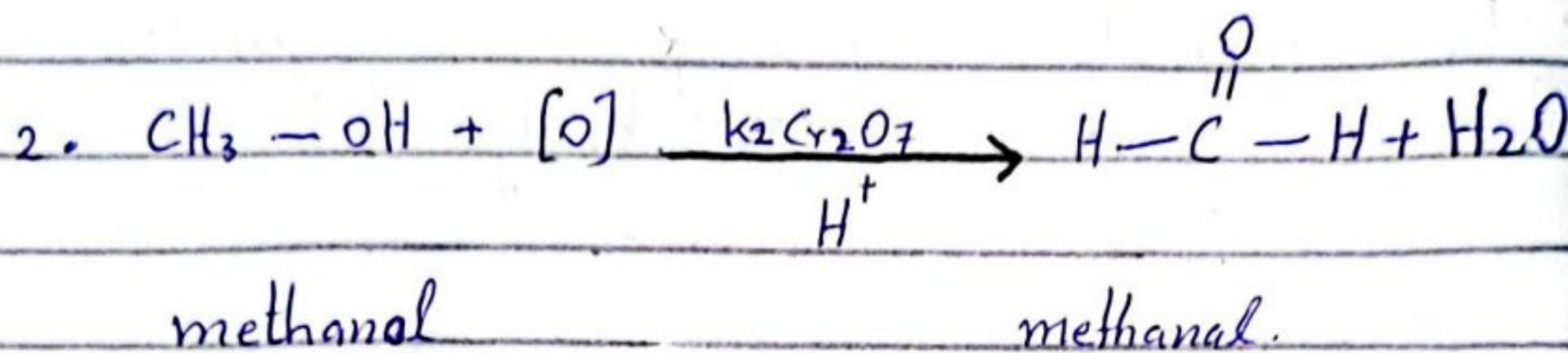
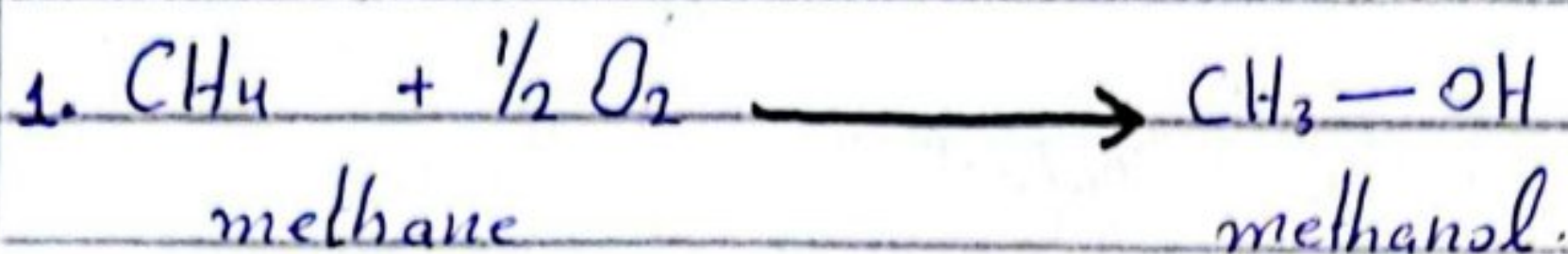
1. Oxidation Reaction:

Oxidation reaction is defined in

four ways.

- addition of oxygen.
- loss of hydrogen.
- Increase in number of bonds of carbon with oxygen.
- Bond making of carbon with element of higher electronegativity.

Example:



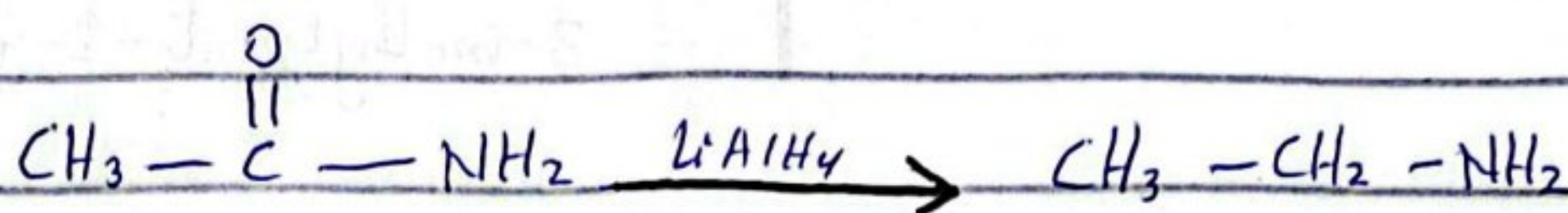
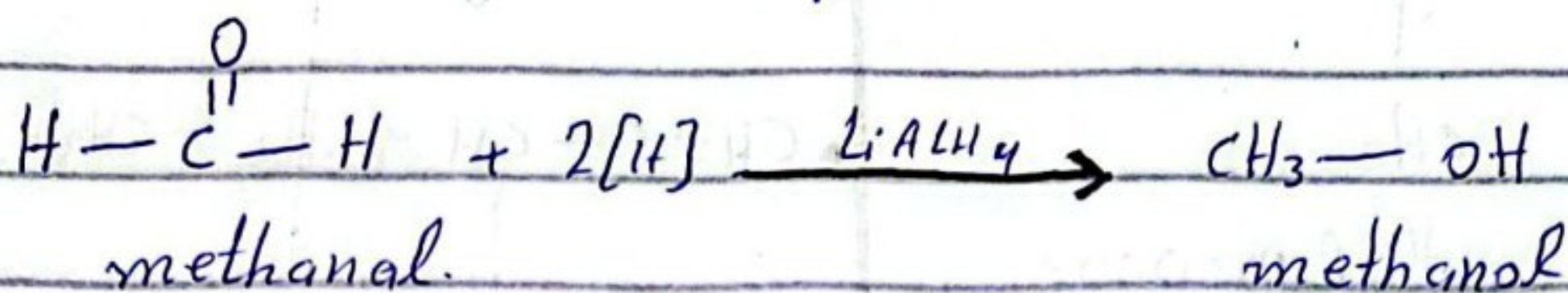
Reduction Reaction:-

Reduction Reaction is defined in four ways.

- Addition of Hydrogen
- loss of oxygen
- decrease in number of carbon bonds with oxygen.

d. Bond making of carbon with element of lower electronegativity value.

Example:



Concept Assessment

Exercise 16.1

(i) Differentiate between saturated and Un-saturated Compounds.
Gives example.

Saturated

- There is single bond b/w Carbon atom
- They under-go free radical substitution reaction
- All carbons atom are sp^3 hybridized.

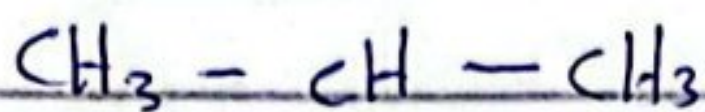
Un-saturated

- There is double or triple bond b/w carbon atoms
- They under-go electrophilic addition reaction.
- All carbon atoms are sp or sp^2 hybridized.

example:



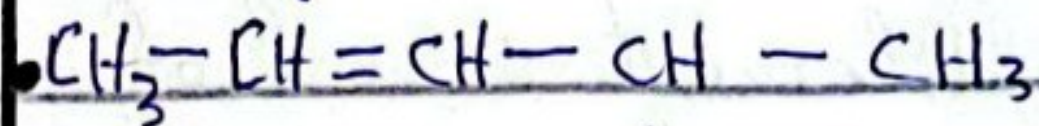
butane



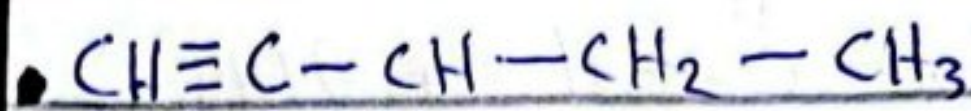
CH₃

2-methyl propane

example:



4-methyl pent-2-ene



CH₃

3-methyl pent-1-yne

(ii) Define aliphatic and aromatic compounds. Give two examples of each.

Answer:-

Aliphatic Compound:

- Close chain hydrocarbon without benzene ring are called Alicyclic hydrocarbon.
- They do not obey Huckel rule. They are non-benzonoid.

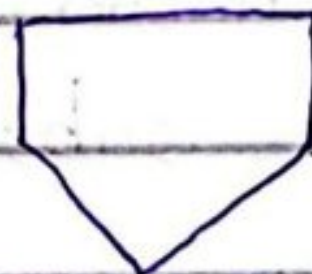
example:



Cyclopropane



Cyclobutane

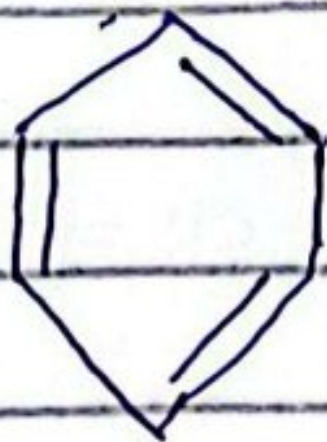


Cyclopentene

Aromatic Compound:

- Close Chain hydrocarbon containing at least one benzene ring.
- They are obey Huckel rule.
- They are benzoniod.

example:

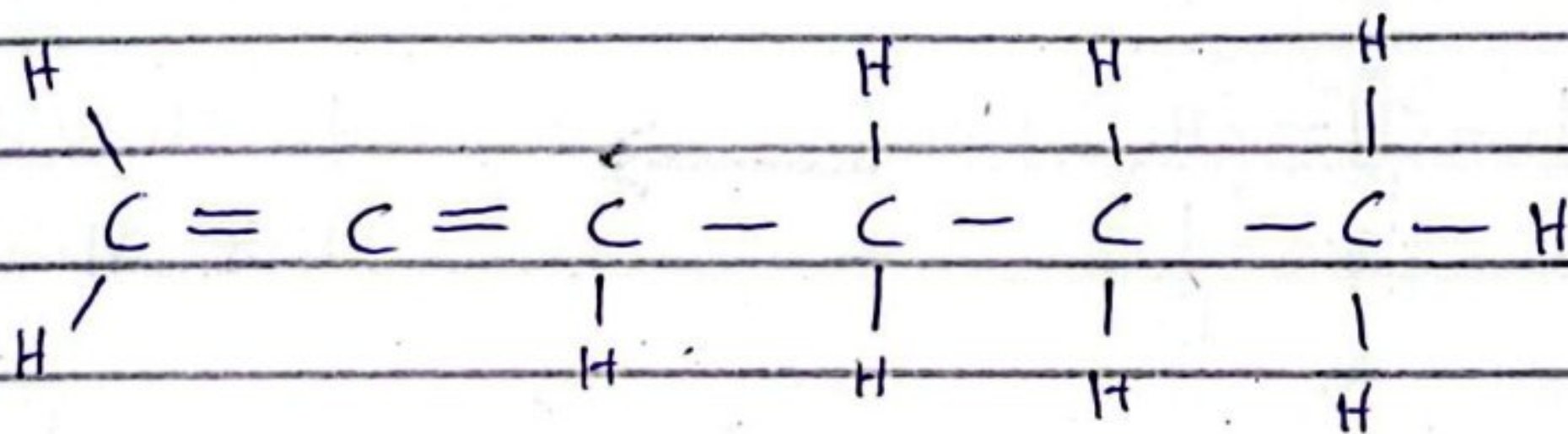


Benzene



ethyl benzene.

(iii) What type of hybridization is shown by each carbon of hexa-1,2-diene.



$$C_1 = 3 + 0 = 3 (sp^2)$$

$$C_2 = 2 + 0 = 2 (sp)$$

$$C_3 = 3 + 0 = 3 (sp^2)$$

$$C_4 = 4 + 0 = 4 (sp^3)$$

$$C_5 = 4 + 0 = 4 (sp^3)$$

$$C_6 = 4 + 0 = 4 (sp^3)$$

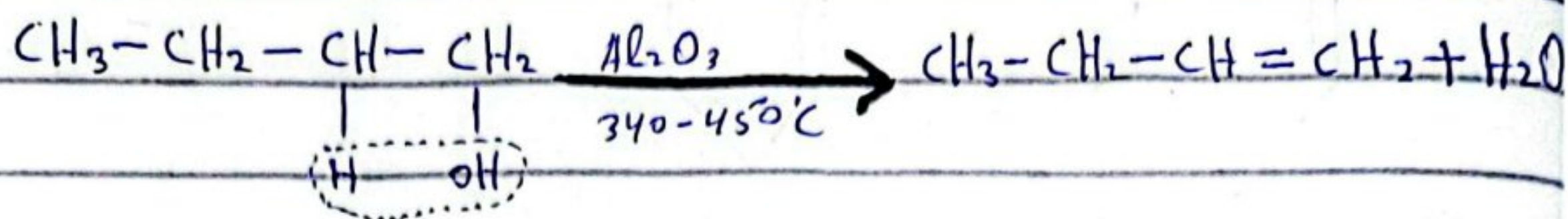
$\therefore$ No. of sigma b. + lone pair =

$\therefore$ No. of sigma bond + lone pair = Ans.

Exercise 16.2

Prepare but-1-ene by the following preparatory methods.

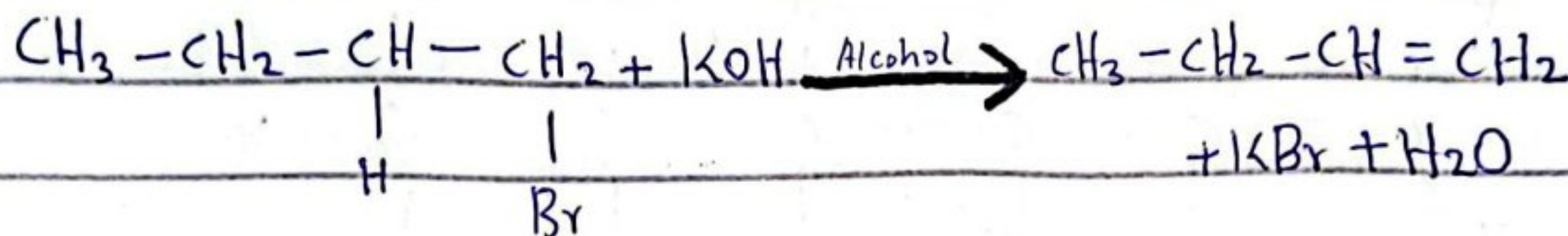
i) Dehydration of alcohols:-



(1-Butanol)

(But-1-ene)

(ii) Dehydrohalogenation of halogenoalkanes:-



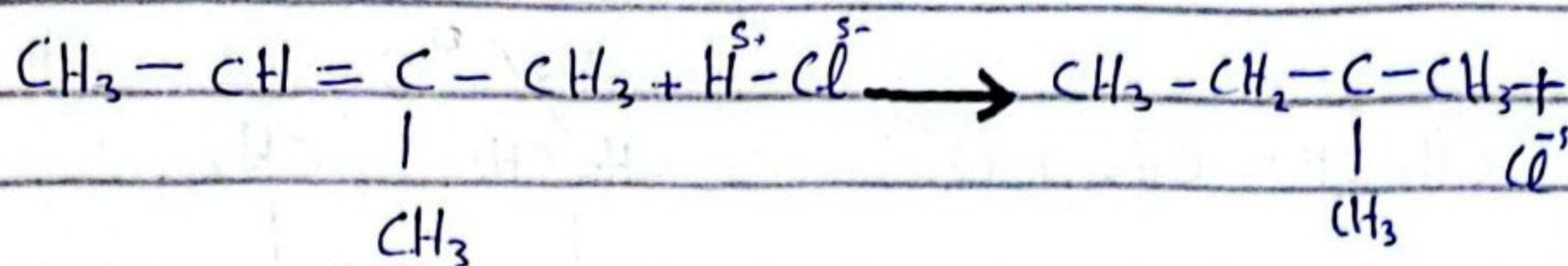
(n-Butyl Bromide)

(But-1-ene)

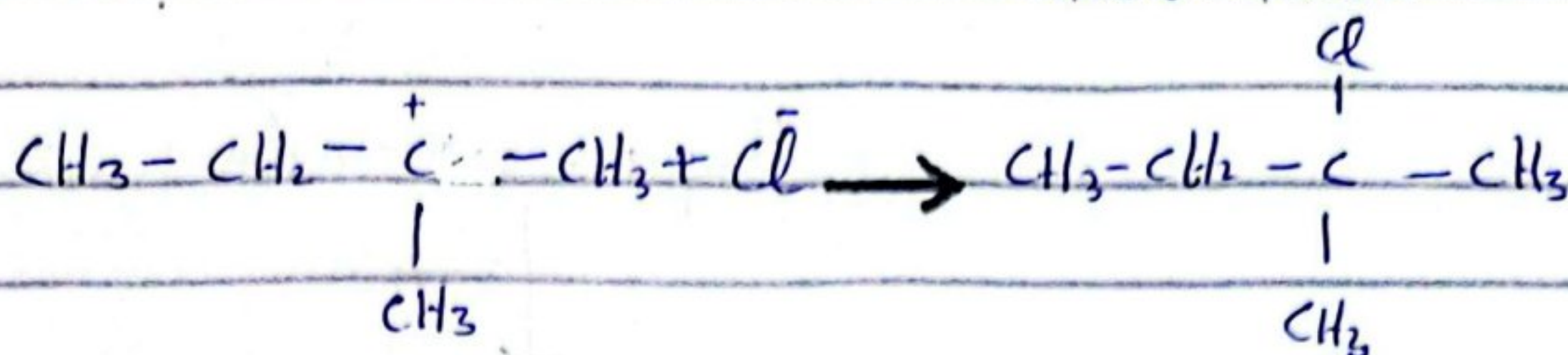
Exercise 16.3

What are the products of hydrochlorination of:

(i) 2-methylbut-2-ene

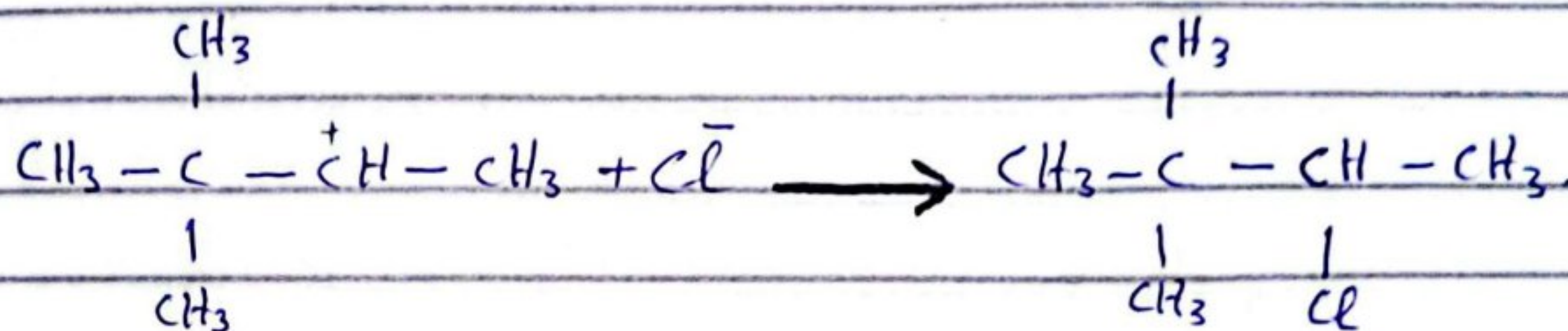
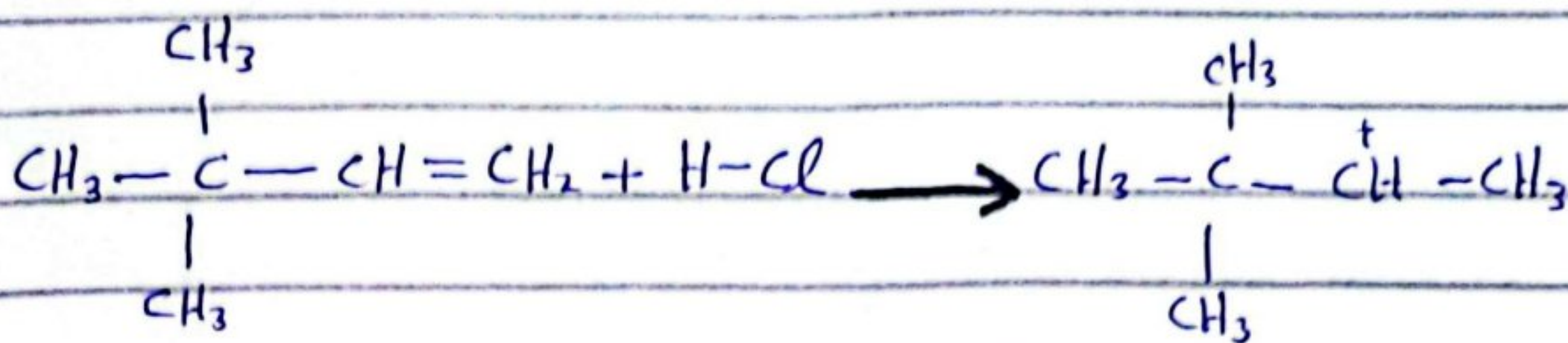


Carbocation.



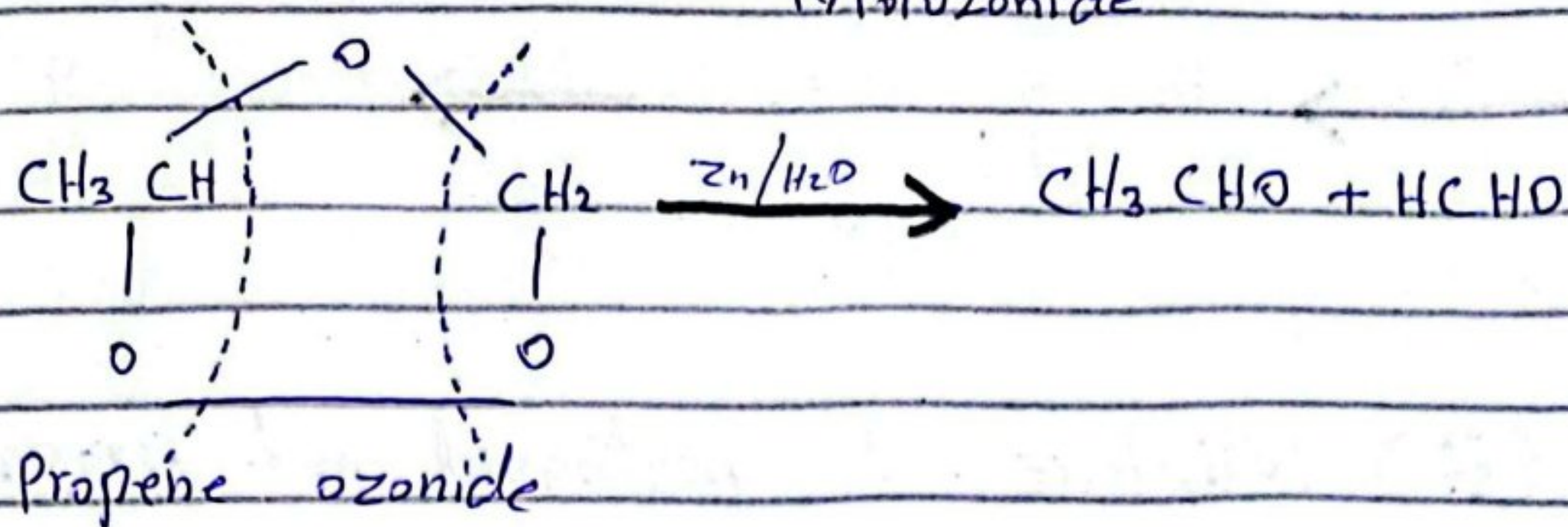
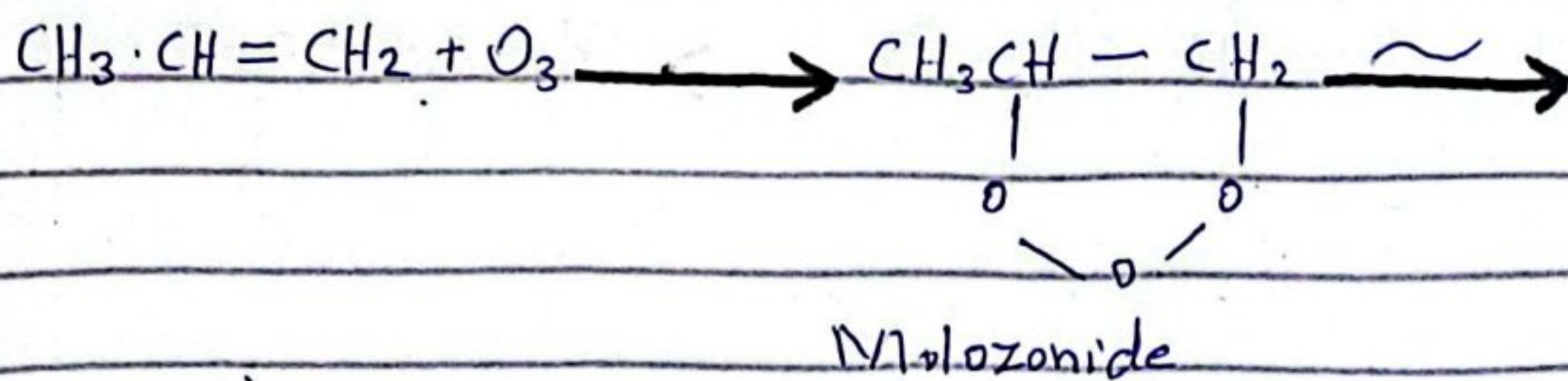
2-Chloro-2-methylbutane.

(ii) 3,3-dimethylbut-1-ene:

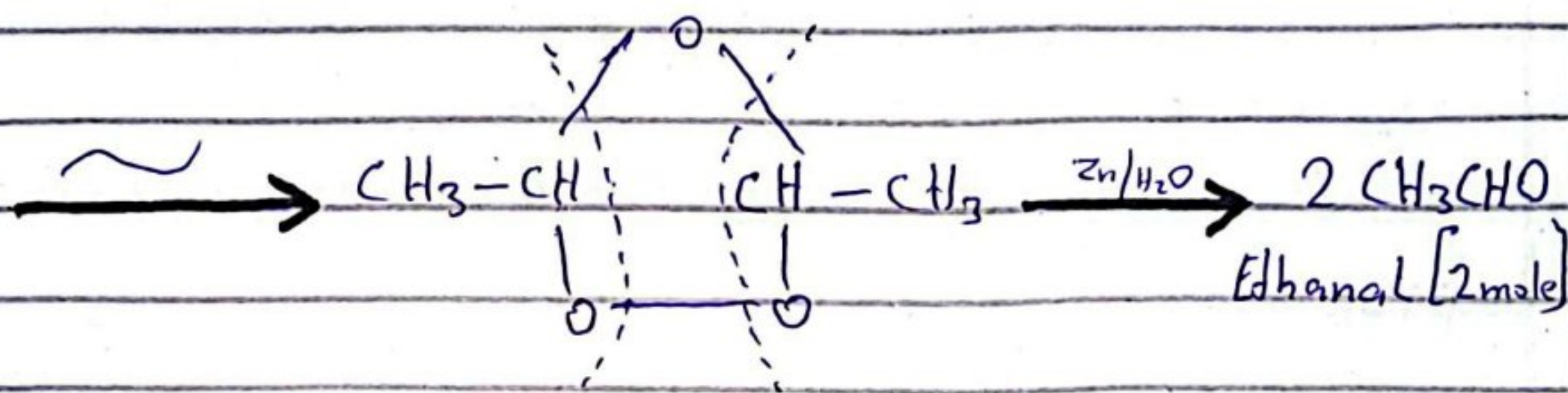
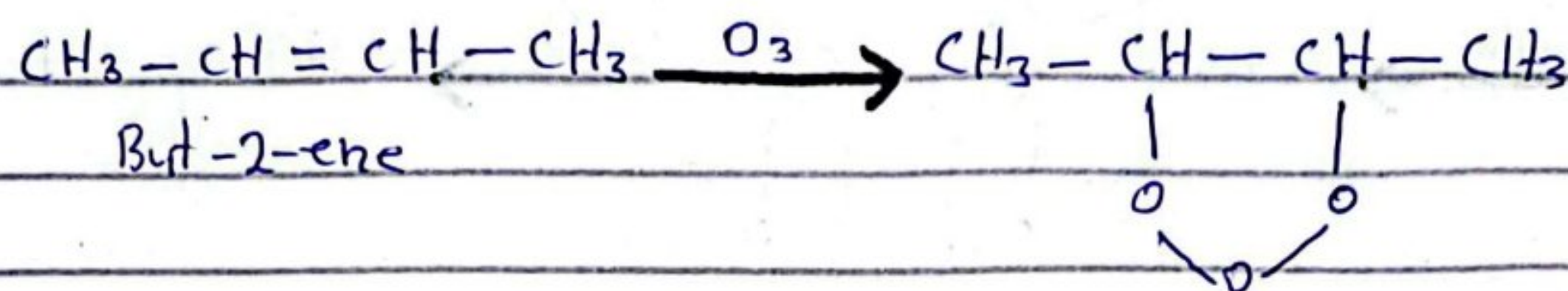
Exercise 16.4

• What are the products of ozonolysis of :

1. Propene.



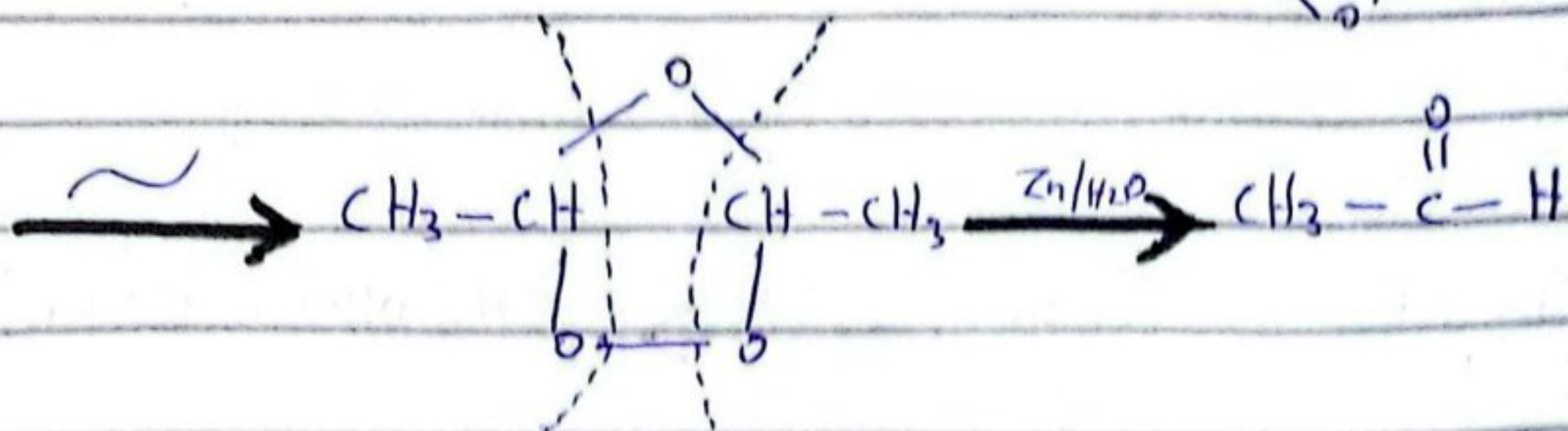
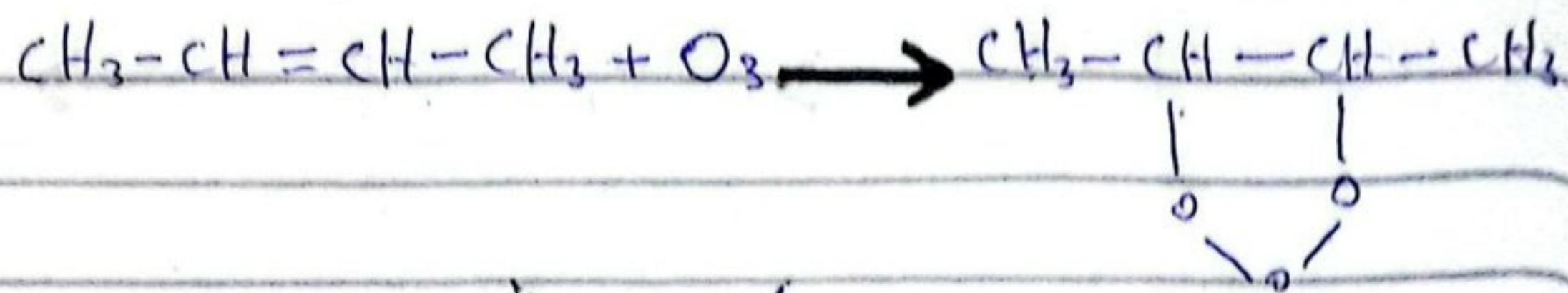
(::) but-2-ene.



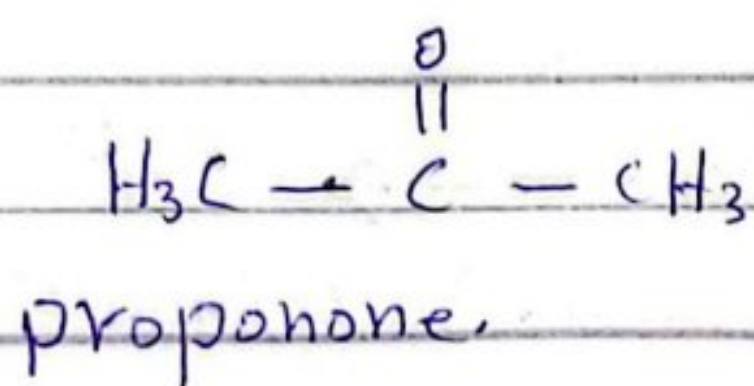
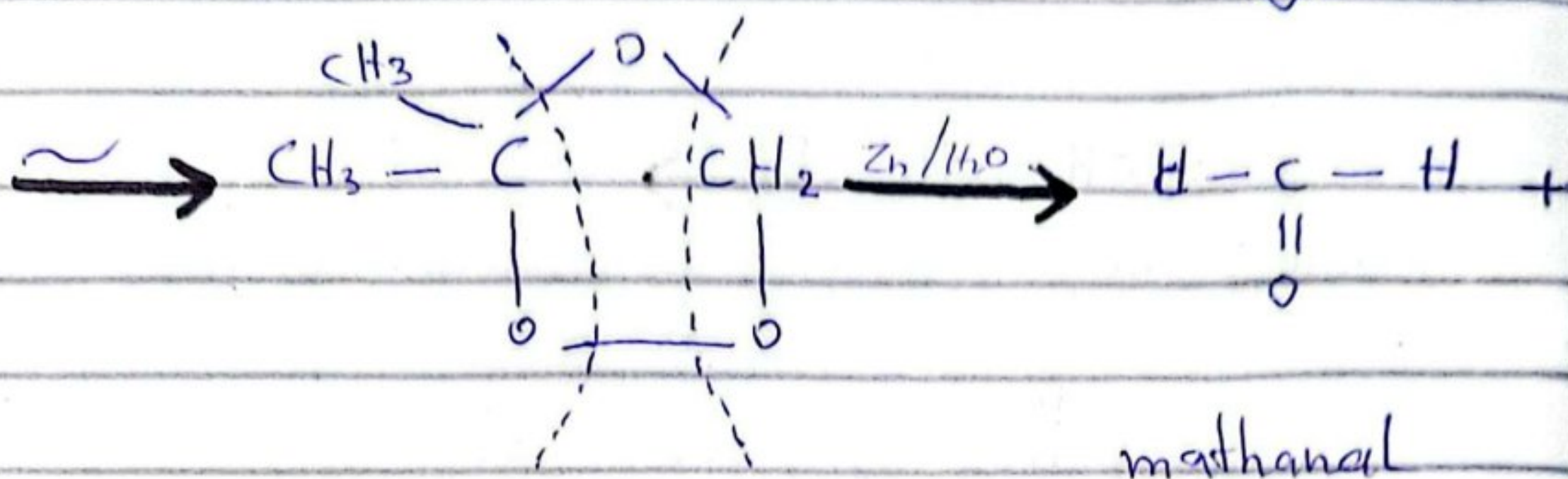
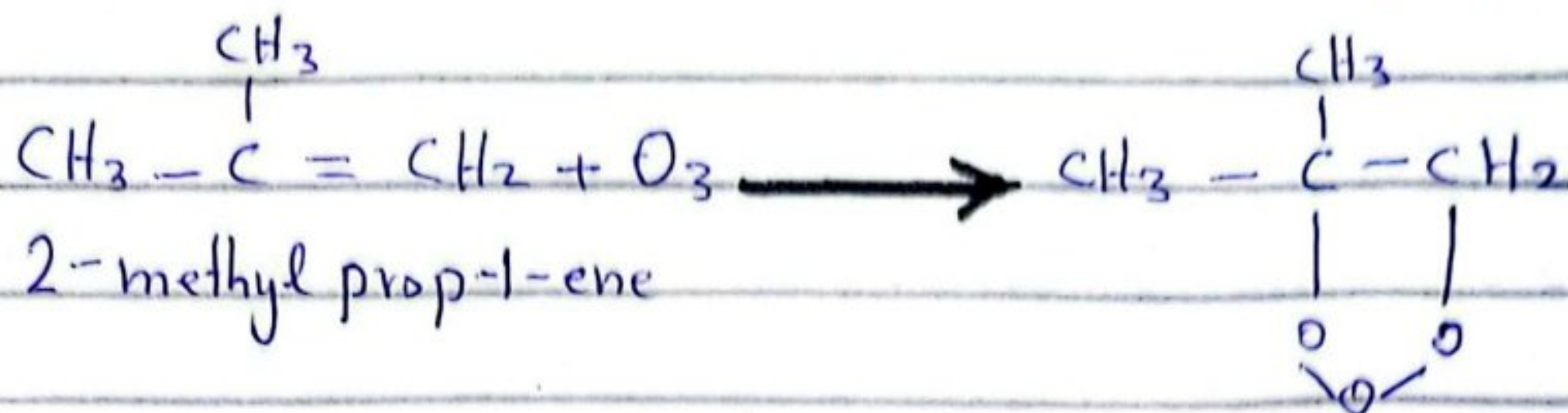
• Name the alkene which give the following compounds on their Ozono-lysis:-

(i) only ethanal:-

But-2-ene reacts with ozonolysis to form the product ethanal.



(ii) Mixture of methanal and propanone



Exercise 16.5

Explain which one of the following compounds shows conjugation:-

1. ethene = $\text{H}_2\text{C}=\text{CH}_2$

It is non-conjugated (isolated)

ii) but-1-ene = $\text{CH}_3 - \text{CH}_2 - \text{CH} = \text{CH}_2$

It is non-conjugated (isolated)

iii) penta, 1,2-diene = $\overset{5}{\text{CH}_3} - \overset{4}{\text{CH}_2} - \overset{3}{\text{CH}} = \overset{2}{\text{C}} = \overset{1}{\text{CH}_2}$

It is cumulative double bond alkene.

iv) buta-1,2-diene: $\overset{4}{\text{CH}_3} - \overset{3}{\text{CH}} = \overset{2}{\text{C}} = \overset{1}{\text{CH}_2}$

It is cumulative double bond alkene.

v) Penta-1,3-diene: $\overset{5}{\text{CH}_3} - \overset{4}{\text{CH}} = \overset{3}{\text{CH}} - \overset{2}{\text{CH}} = \overset{1}{\text{CH}_2}$

It is alternate double and single bond, so it is conjugated alkene.

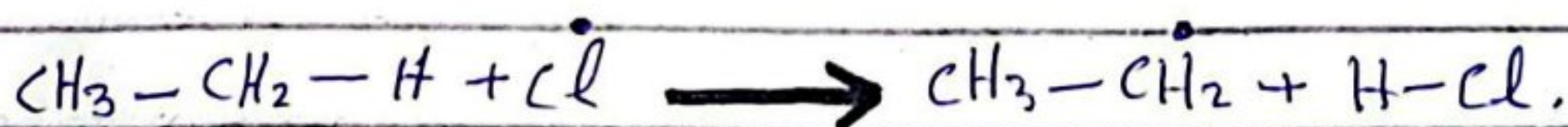
Exercise

2. Give short-answers

i:- Justify why the second step in halogenation of alkane is named propagation?

Answer

The second step in free radical mechanism is named propagation because it occurs like a chain reaction.



This step take place until all hydrogen of ethane is replaced by chlorine.

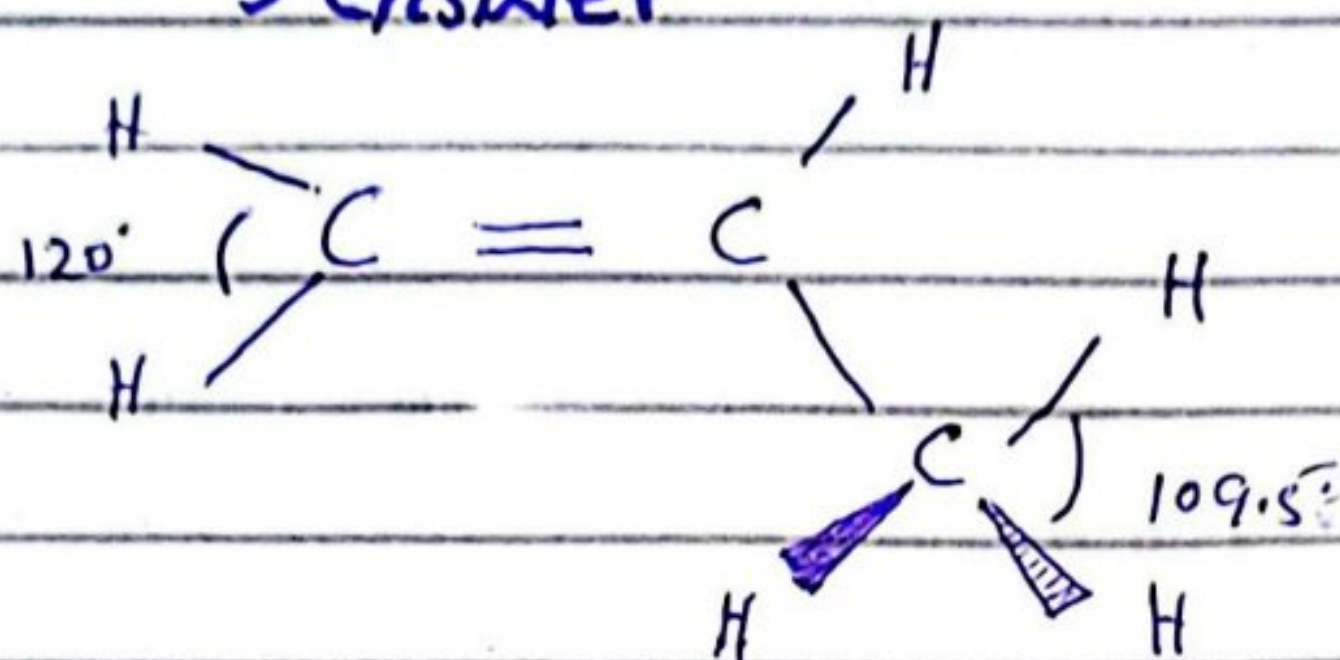
ii. Draw the structure of ethane molecule.

Answer

Page 08

iii. Draw stereochemical formula of propene:

Answer

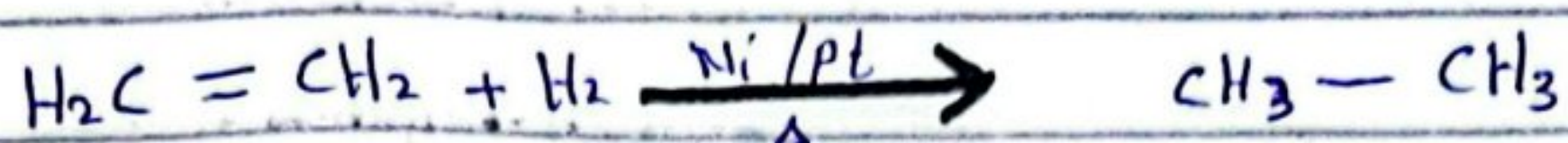


The carbon atoms of double bond are sp^2 hybridized and so they are planar with bond angle of 120° . The third carbon atom is sp^3 hybridized so it is tetrahedral with bond angle of 109.5° .

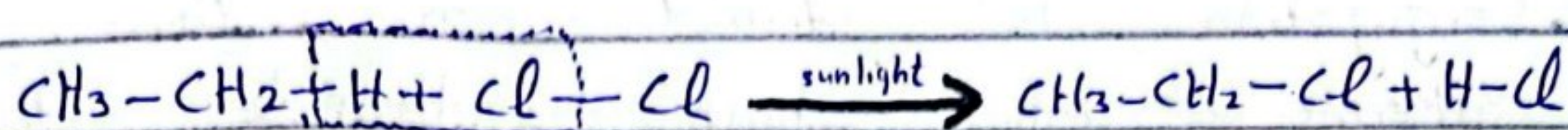
iv. Alkenes show addition reaction while alkanes cannot. why?

Answer

Alkenes shows addition reactions in which a molecule is added to alkenes across double bond.



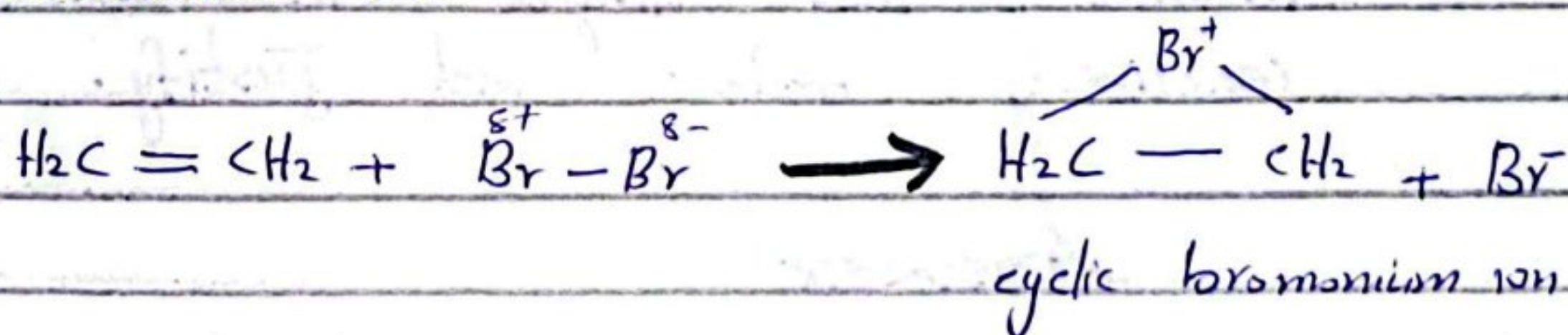
Alkane do not have double bond. So that they cannot give addition reaction.



v. Halogen is a non-polar molecule. How can it act as electrophile in halogenation of alkenes?

Answer

When a non polar bromine comes close to ethene molecule then due to repulsion between electron cloud of bromine and ethene molecule, the halogen molecule get polarized. The positive part of the bromine molecule acts as electrophile and attract the pi-electron cloud producing cyclic bromonium ion.



vi:- How can we prepare poly (ethene) by polymerization reaction?

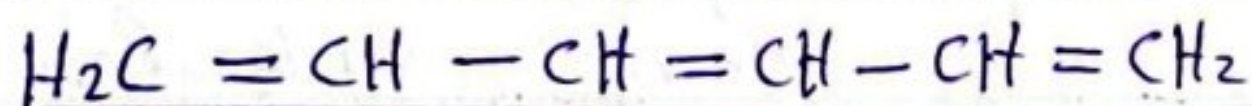
Answer

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vii. Explain how can conjugation bring stability to alkenes?

Answer

- Conjugation is found in those alkenes which have alternates double and single bond.
- The unhybridized "p" orbitals bridge extends till the last double bond carbons in the molecules.
- The double bond in conjugation molecule are called delocalized.
- The delocalization of electrons increases the stability of alkenes.



Hexa-1,3,5-triene.

Q.No.3: Generally, hydrocarbons are less reactive. Arrange, alkanes, alkenes, and alkynes in their reactivity order and Justify.

Answer

- In alkanes only sigma bond is

present, which is difficult to break. These are also non-polar. Hence alkanes are less reactive.

• In alkenes a double bond consisting of one sigma and one pi bond is present. Electron of pi bond are exposed to attack by electrophiles. Hence alkenes are quite reactive.

• In alkynes a triple bond consisting of one sigma bond and two pi bonds is present. Due to high electron density between carbon atoms, these come close to each other and bond length becomes shorter. Those pi-electrons of a triple bond are less exposed and less reactive than alkenes.

Alkenes > Alkynes > Alkanes.

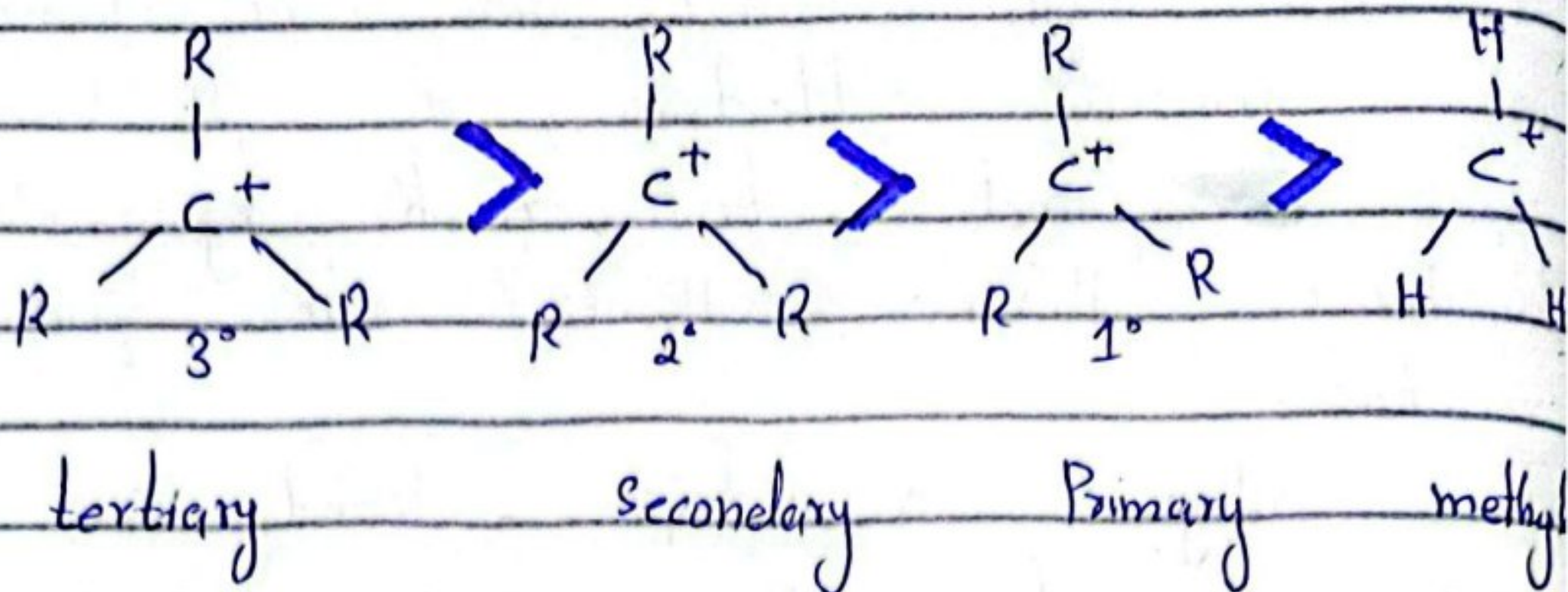
4. Define Primary, secondary and tertiary carbocations. Justify their order of reactivity in relation with hydrochlorination of pent-1-ene.

Answer

• The stability of carbocation depends on the extent of positive inductive effect of alkyl group.

There are three types of carbocation i.e. Primary, secondary and tertiary carbocations.

Follow are the stability order:



The alkyl group will donate electrons to the positively charged carbon to stabilize the carbocation. This donation of electrons via sigma bonds is known as the inductive effect. As a result, the positive charge density of the carbocation decreases, making the carbocation more stable.

5. Define Markovnikov's rule.

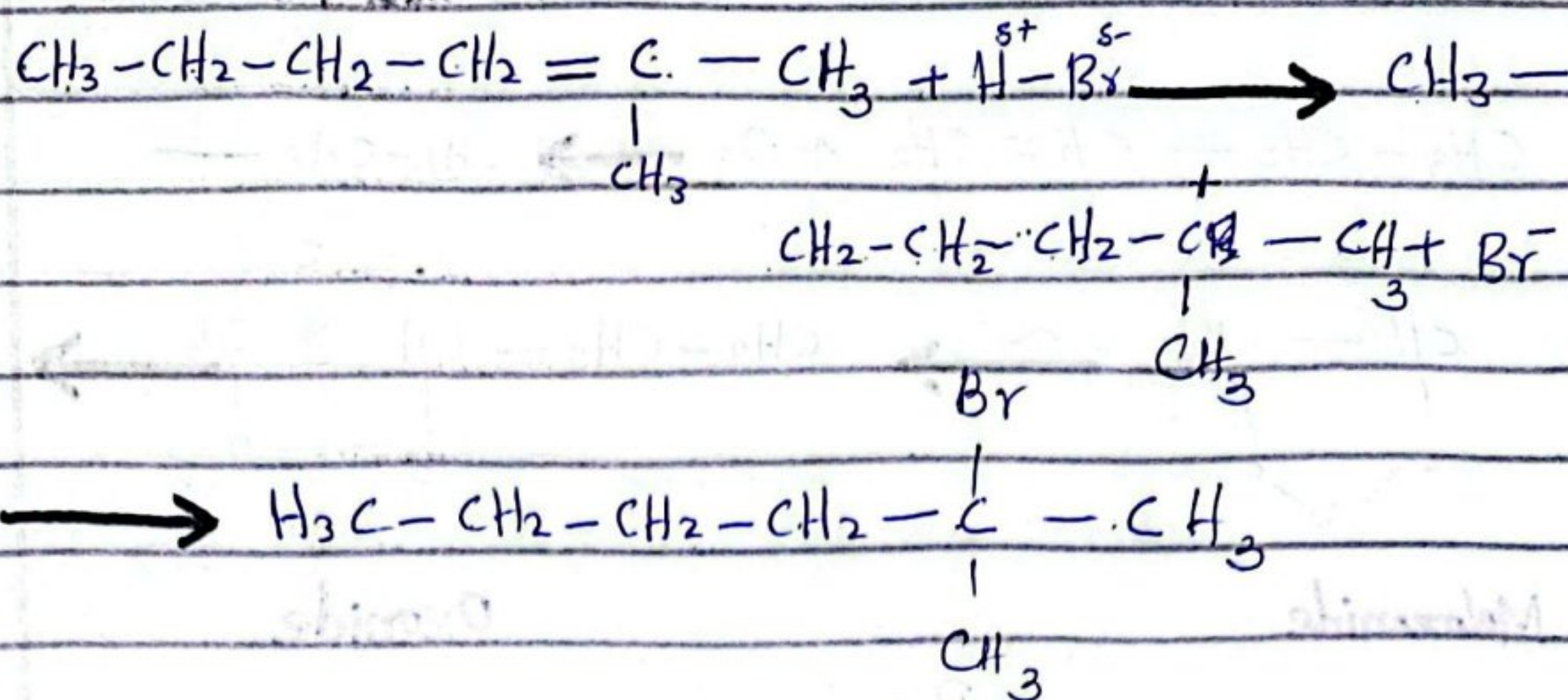
Give Mechanism of hydrobromination of 2-methylhex-2-ene.

Answer

It states:

When an unsymmetrical reagent (H-Br) attacks an unsymmetrical alkene (propene), the hydrogen atom adds to that carbon which has the most hydrogen atoms.

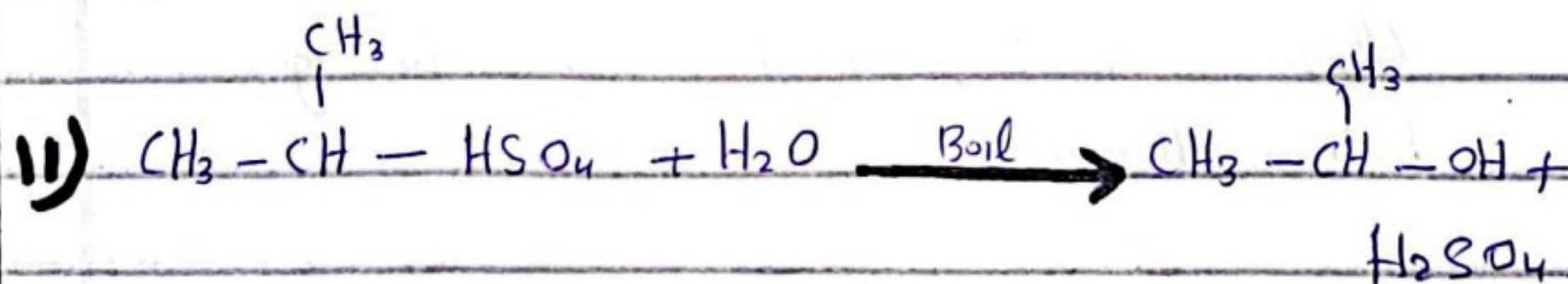
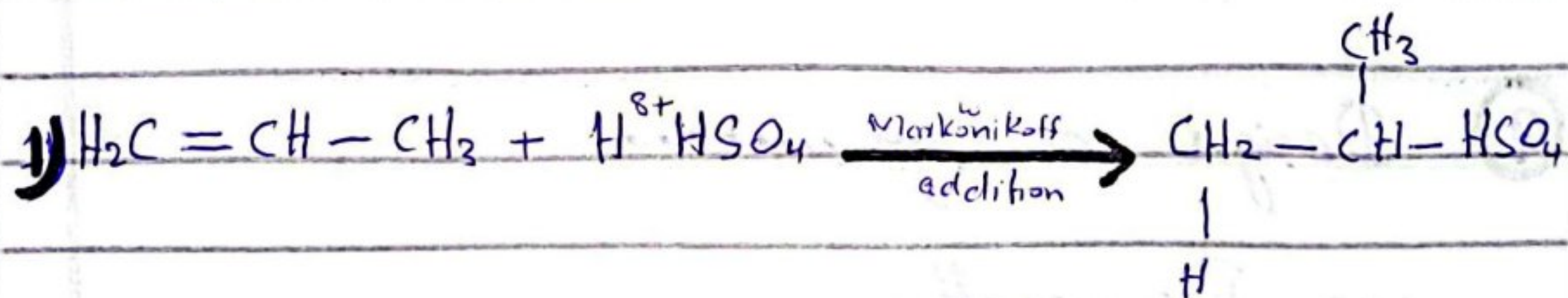
double bond carbon which has more hydrogen atoms.



6. Hydration of alkenes is acid-catalyzed reaction - Justify and exemplify this statement by propene.

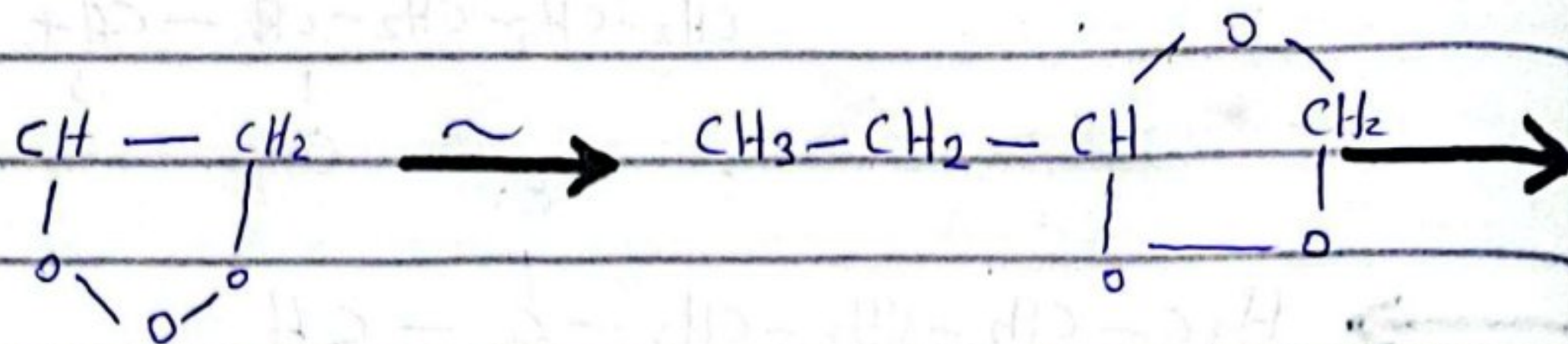
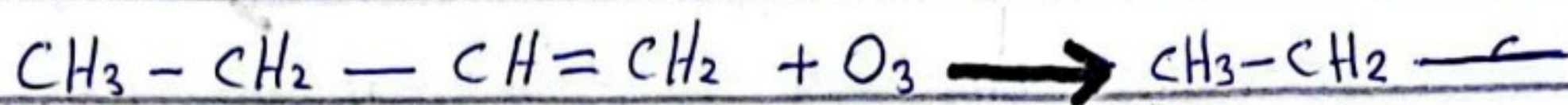
Answer

Hydration of alkenes is an addition reaction which occurs in the presence of a mineral acid e.g. H_2SO_4 .



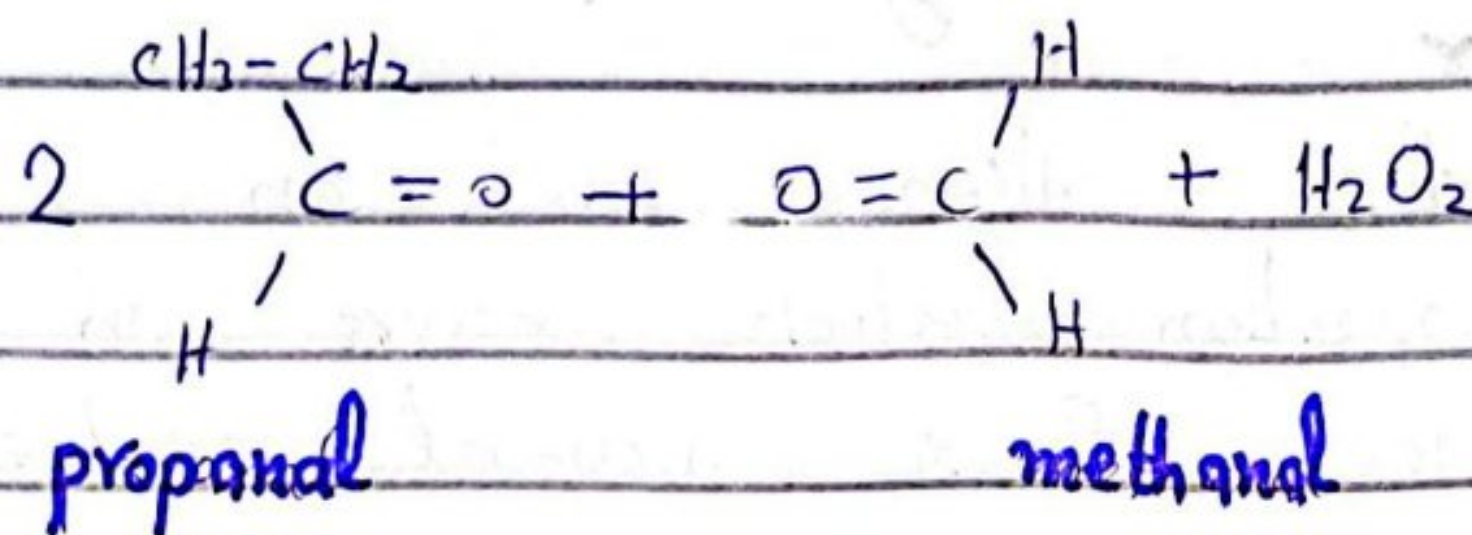
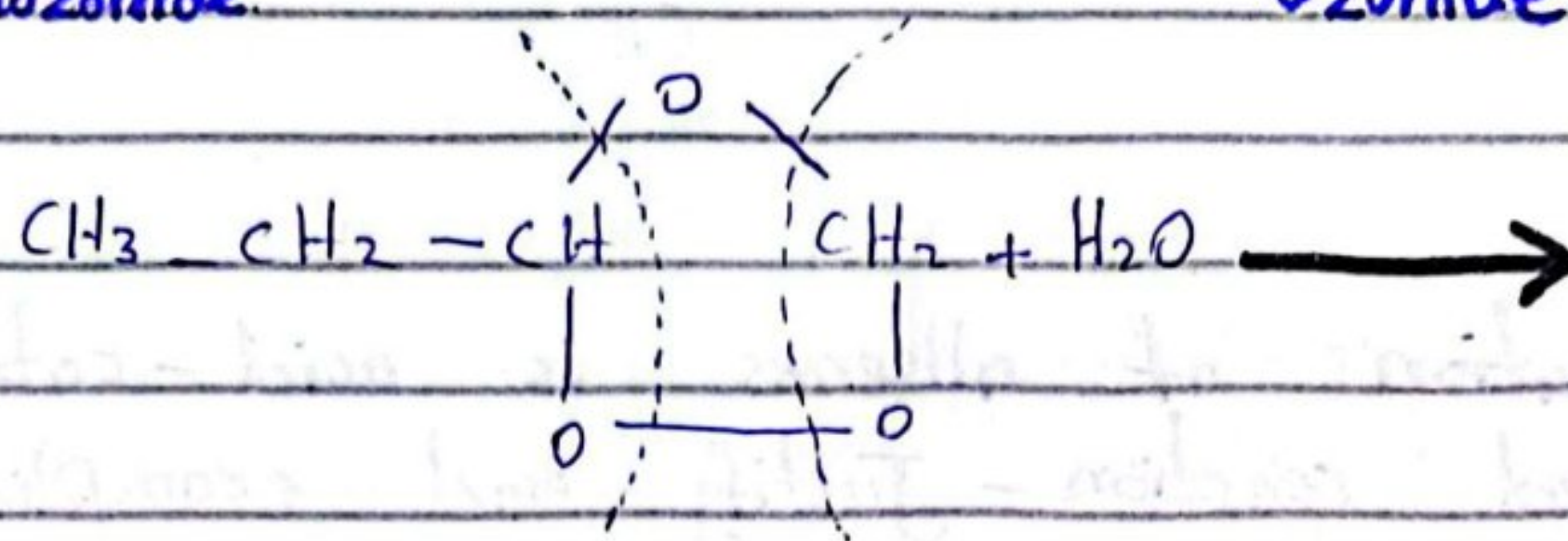
Sulphuric acid is used in the first step and regenerated in the second step. So it is acid catalyst for this reaction.

7. Give Complete mechanism of Ozonolysis of but-1-ene.



Molozonide

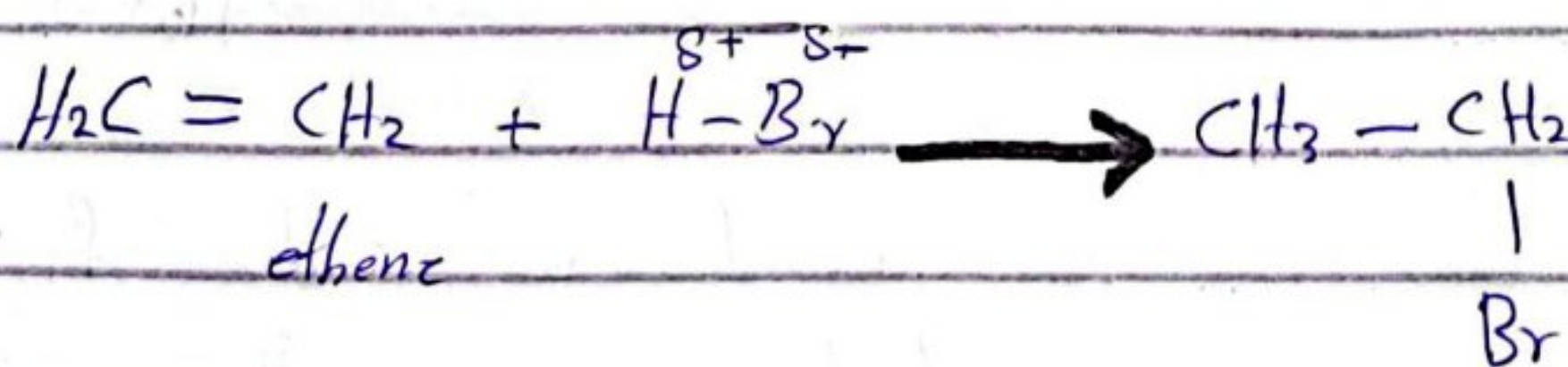
Ozonide



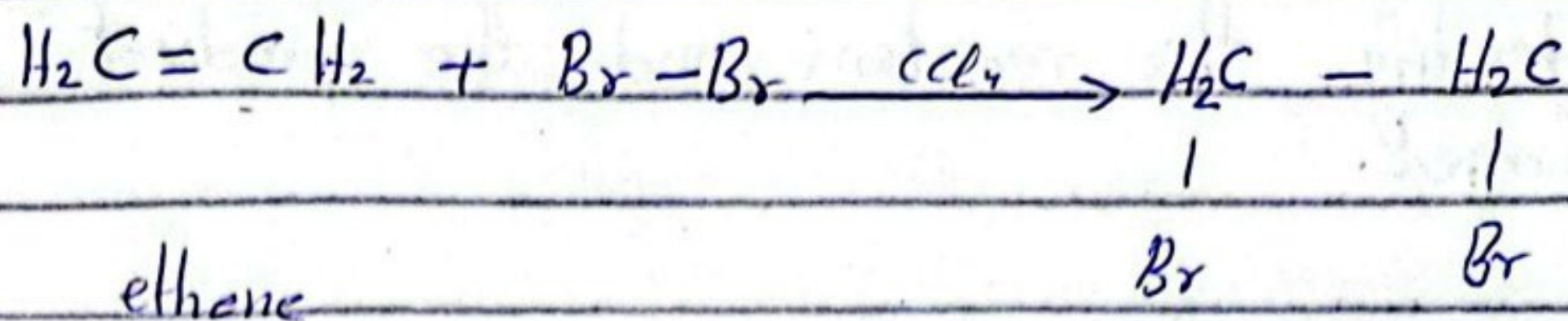
9. Design a syn

(a) Bromoethane

Ethene reacts with HBr to give bromoethane



(b) 1,2-dibromoethane

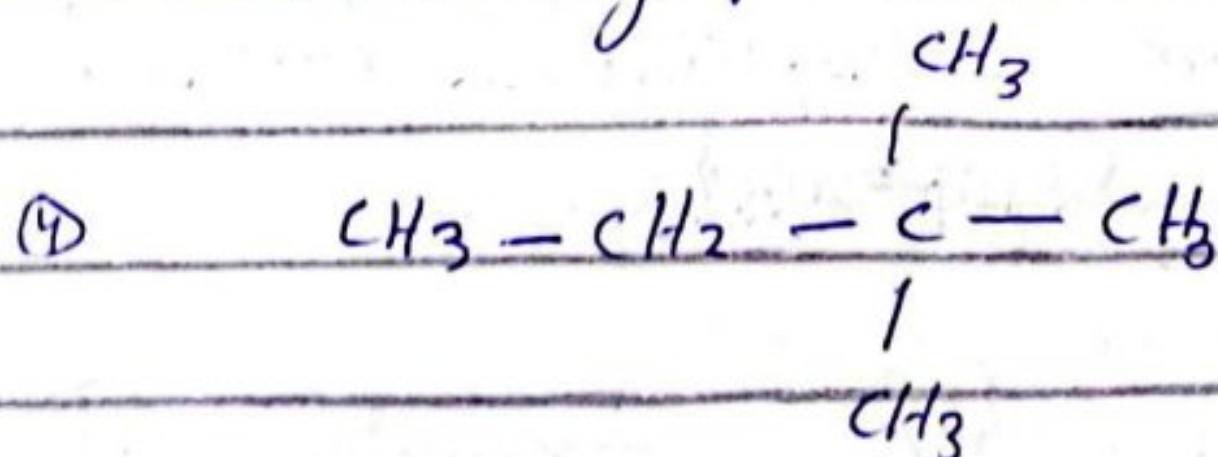
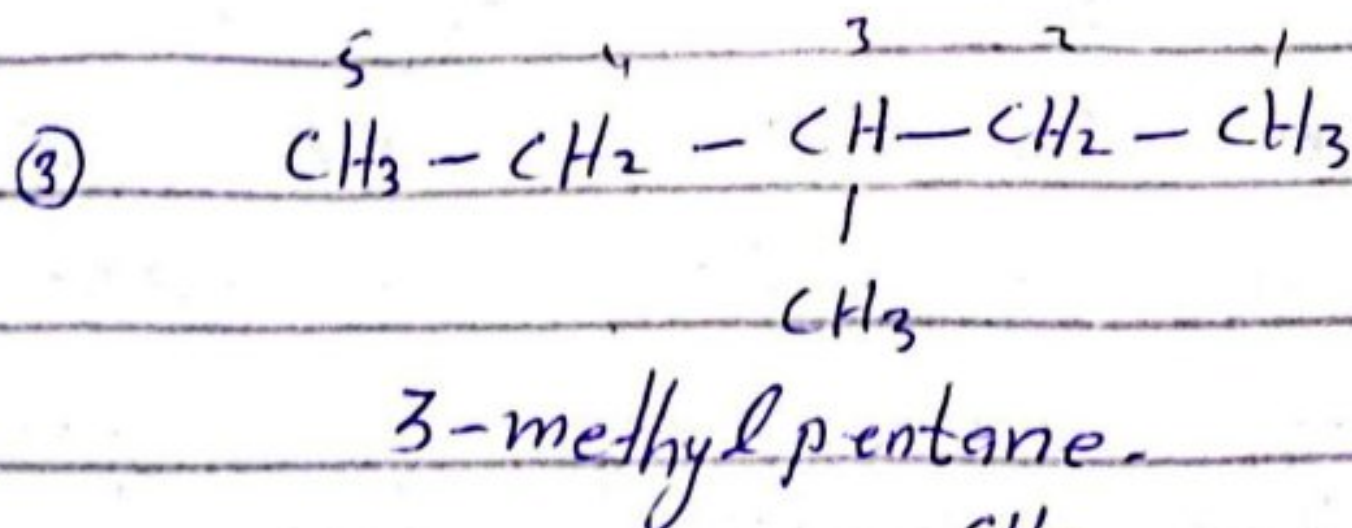
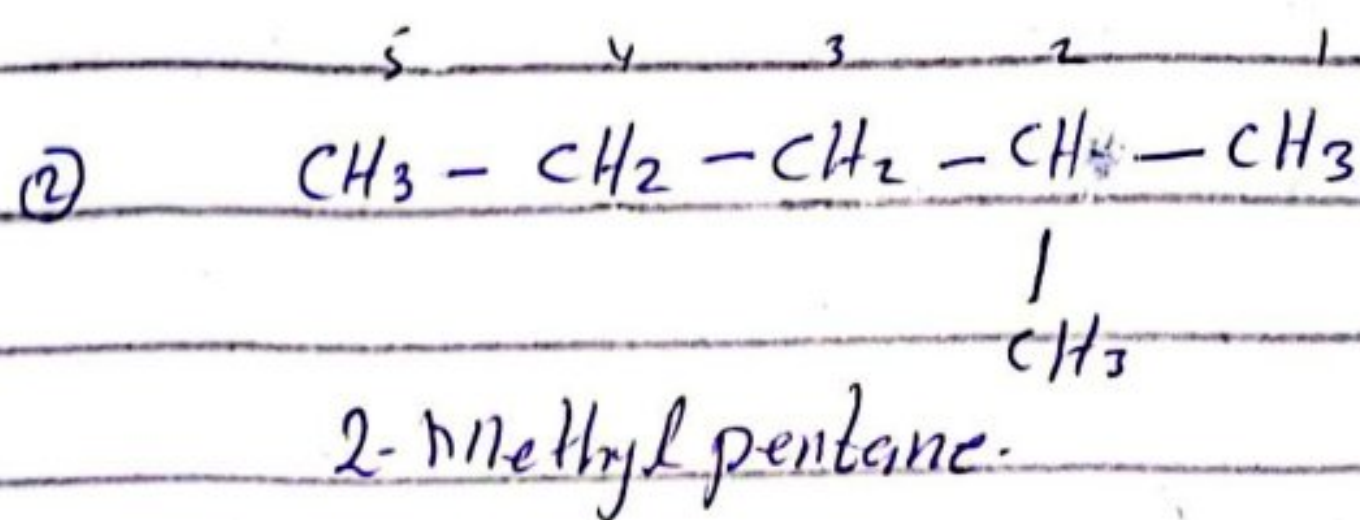
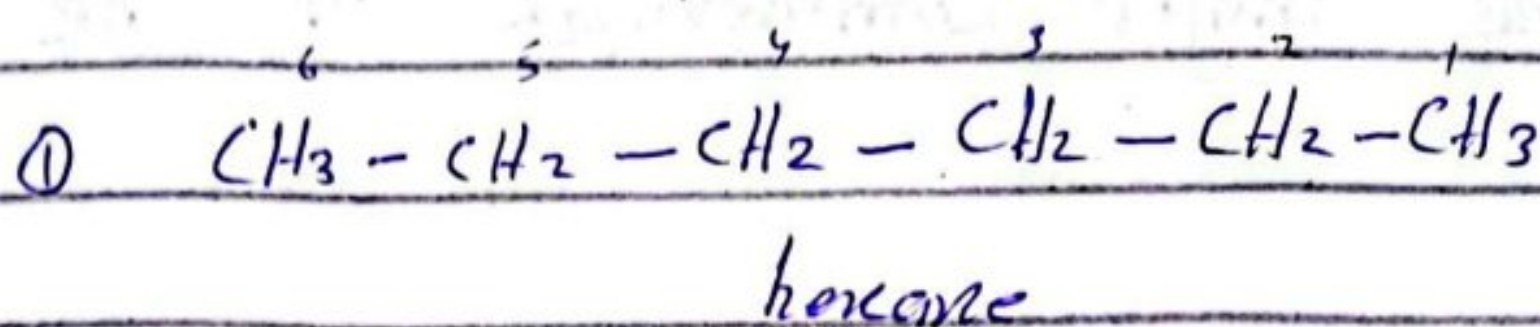


1,2-dibromoethane

10 (a) i list three characteristics of homologous series.

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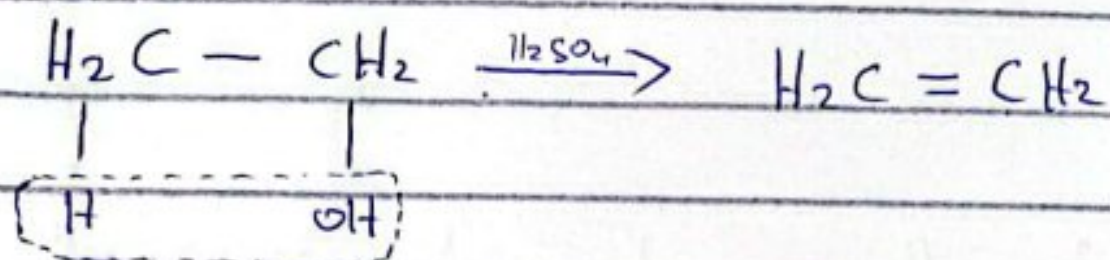
(ii) Draw the possible structure isomers of C_6H_{14} .



2,2-dimethylbutane

(b) Ethanol undergoes dehydration in the presence of sulphuric acid.

i- Identify this reaction and the product formed.



ii- Evaluate the role of sulphuric acid.

Sulphuric acid acts as a dehydrating agent.

iii- Write one major commercial use of the product.

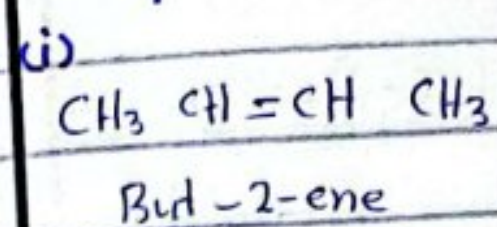
Ethene is used to make polyethene which is an important industrial polymer.

11. The Condensed formulae of six Compounds, A-F are given. Each carbon has atoms in its molecule.

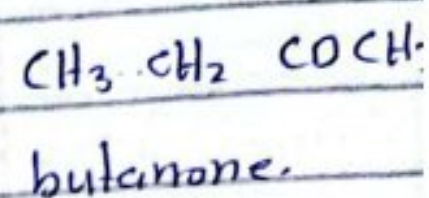
(i) a. What is the empirical formula of all these Compounds?

(ii) Draw the skeletal formulae of all these Compounds.

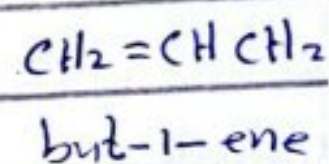
Compound



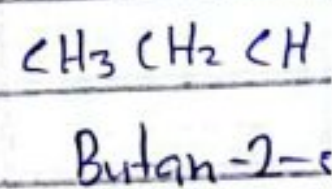
(ii) Compound



(iii) Compound



(iv) Compound



Compound	Molecular formula	Empirical formula
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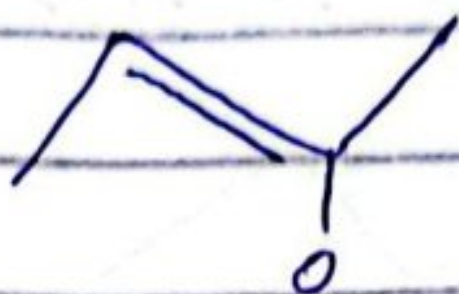
i) $\text{CH}_3\text{CH}=\text{CHCH}_3$ But-2-ene	(C_4H_8)	(CH_2)
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Skeletal formula.



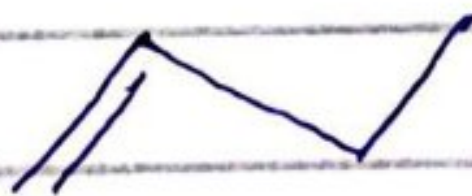
(ii) Compound	Molecular formula	Empirical F.
$\text{CH}_3\text{CH}_2\text{COCH}_3$ butanone.	$(\text{C}_4\text{H}_8\text{O})$	$(\text{C}_4\text{H}_8\text{O})$

Skeletal formula.



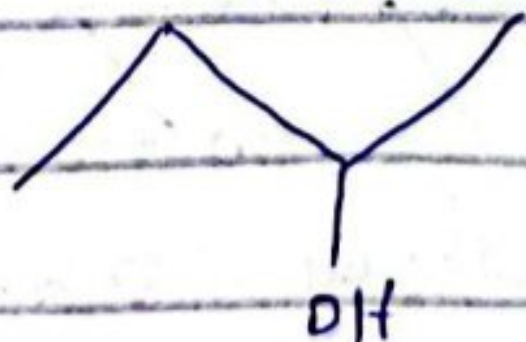
(iii) Compound	Molecular formula	Empirical F.
$\text{CH}_2=\text{CHCH}_2\text{CH}_3$ but-1-ene	(C_4H_8)	(CH_2)

Skeletal formula.



iv) Compound	Molecular formula	Empirical F.
$\text{CH}_3\text{CH}_2\text{CH}(\text{OH})\text{CH}_3$ Butan-2-ol.	$\text{C}_4\text{H}_{10}\text{O}$	$\text{C}_4\text{H}_{10}\text{O}$

Skeletal formula:

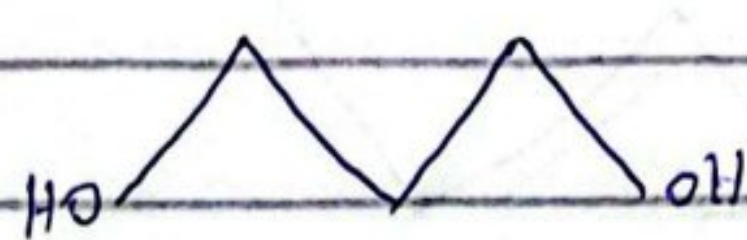


Compound	Molecular F.	Empirical F.
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$\text{HOCH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{OH}$	$(\text{C}_4\text{H}_{10}\text{O}_2)$	$(\text{C}_2\text{H}_5\text{O})$
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Butane 1,4-diol

Skeletal formula.

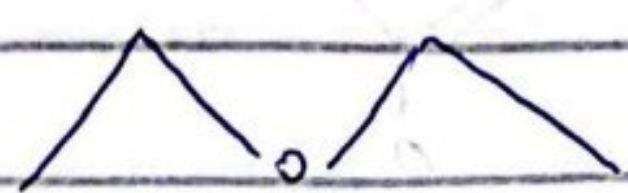


Compound	Molecular F.	Empirical F.
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$\text{CH}_3\text{CH}_2\text{OCH}_2\text{CH}_3$	$(\text{C}_4\text{H}_{10}\text{O})$	$(\text{C}_4\text{H}_{10}\text{O})$
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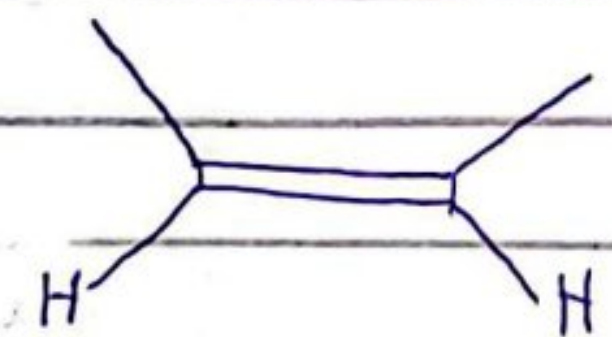
ethoxyethane.

Skeletal formula

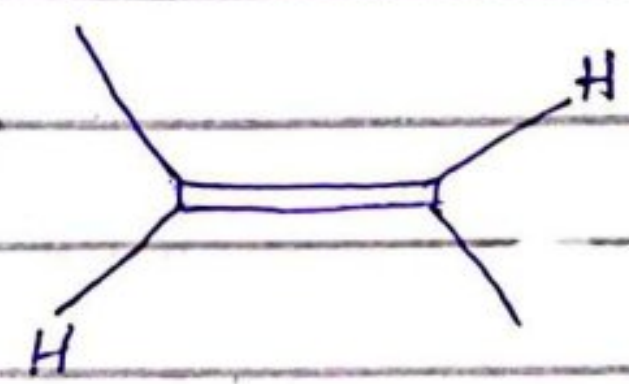


(iii) Which two compound show different types of isomerism?

(a) But-2-ene show geometrical isomerism

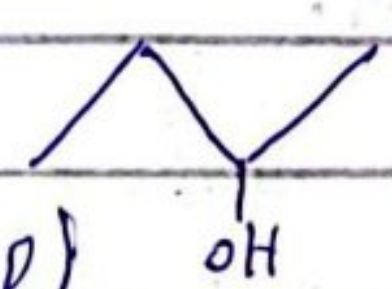


cis but-2-ene.

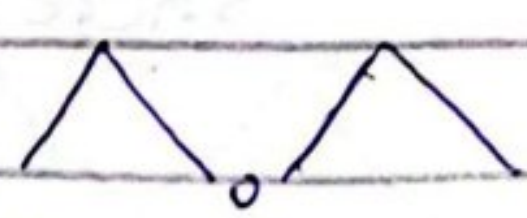


trans-but-2-ene

(b) Butan-2-ol and ethoxyethane are functional group isomers.



(Butan-2-ol)



ethoxyethane.

(iv) What type of isomerism - can each Six Compound show?

(i) Geometrical : cis - and trans -
Position : but-1-ene , but-2-ene.

(ii) Functional group :
butanone and butanal.

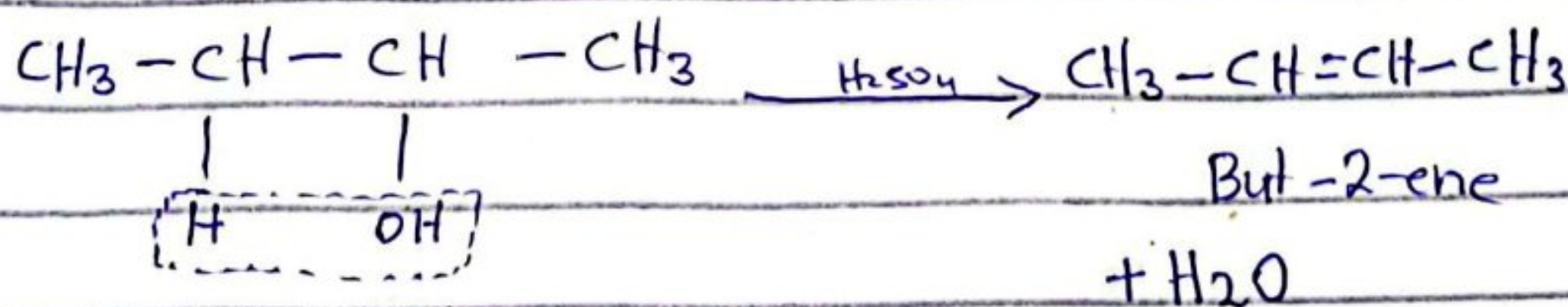
(iii) Positional
but-1-ene , but-2-en.

(iv) Functional group.
Butan-2-al , ethoxyethane.
Position : Butan-1-ol , Butane-2-ol.

(v) Position : OH group can be at different.
carbon atoms.

(vi) Butan-2-ol , ethoxyethane.
Metamerism : ethoxyethane , methoxy-
propane.

(b). Compound D can be converted into C.



buten-2-ol.

WHAT type of reaction is this?

It is dehydration reaction.

What re-agent is used in this reaction.

Sulphuric acid is used as dehydrating agent.

What is formed when compound E undergoes the same reaction in excess of the same reagent?

Butan-1,4-diol dehydrates in the presence of acid catalyst to give tetrahydrofuran (THF). The THF is a very important organic solvent.

