Unsaturated hydrocarbons

Chapter 3

Alkenes

1432-2011

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By the end of this chapter you should be familiar with:

- ☐ definition for Alkenes.
- ☐ The hybridization of Alkenes.
- ☐ IUPAC naming of Alkenes.
- ☐ Geometric isomerism among the Alkenes.
- ☐ Physical properties of Alkenes.
- ☐ General Methods of Preparation of Alkenes.
- ☐ Reactions of Alkenes.

Alkenes:

The second class of simple hydrocarbons the **alkenes**, consists of molecules that contain at least **one double-bonded** carbon pair.

The chemical formula for the simple **alkenes** follows the expression:

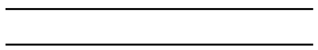
$$C_nH_{2n}$$

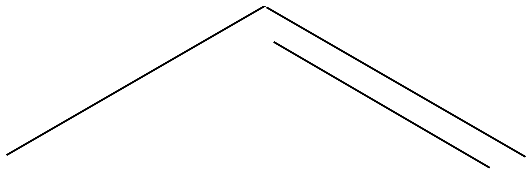
⚠ Alkenes are also called **OLEFINS** because they form oily liquids on reaction with chlorine gas

Nomenclature

The simplest members of the alkenes series (**C_2** and **C_3**) are usually called by their common Names, which are derived from the corresponding alkanes by replacing the (***-ane***) ending by **(*-ylene*).**

$CH_2{=}CH_2$ $CH_3{-}CH{=}CH_2$





Common Name:	Ethylene	Propylene
IUPAC Name:	Ethene	Propene

The IUPAC rules for naming **alkenes** are similar to those used for naming alkanes.

The rules are:

1. The longest continuous carbon chain ***containing the double bond*** is selected as the parent chain.
2. The name of the parent carbon chain is obtained by replacing the ***-ane*** ending of the corresponding alkane by ***-ene***.
3. The parent carbon chain is numbered in a manner than will give the doubly bonded carbon atoms the ***lowest*** numbers even if it resuls in the substituents getting higher numbers.
4. The postion of the double bond is indicated by the number of the ***lower*** numbered doubly bond.
5. In **cycloalkenes**, the double bond is always found between carbon 1 and carbon 2. It is therefore not necessary to specify the position of the double bond with a number. If the substituent are present , the ring must be numbered, starting from the double bond, in the direction that gives the substituents the ***lowest*** number(s).

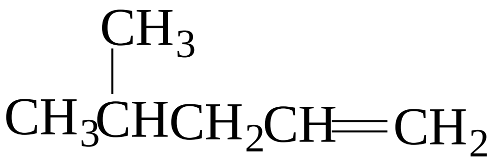
Examples

$CH_3CH_2CH{=}CH_2$

1-Butene
(***not*** 3-Butene)

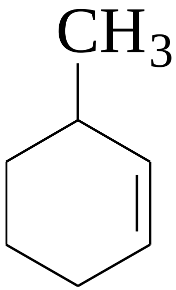
$CH_3CH{=}CHCH_3$

2- Butene

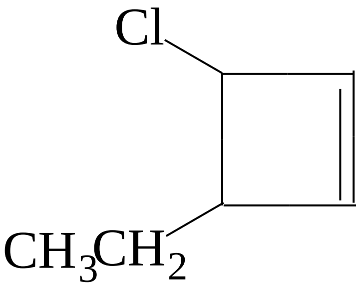


$$CH_3\overset{\overset{\displaystyle CH_3}{|}}{C}HCH_2CH{=}CH_2$$

4-Methyl-1-pentene
(***not*** 2-Methyl-4-pentene)



3-Methylcyclohexene
(***not*** 1-Methyl-2-cyclohexene)



3-Chloro-4-ethylcychlobutene
(***not*** 1-Chloro-2-ethylcyclobutene)

Important derivatives from Alkenes:

1- Vinyl group

$$CH_2{=}CH_2 \Longrightarrow CH_2{=}CH{-}R$$ (derived from ethylene)

2- Allyl group

$$CH_2{=}CHCH_3 \Longrightarrow CH_2{=}CHCH_2{-}R$$ (derived from propylene)

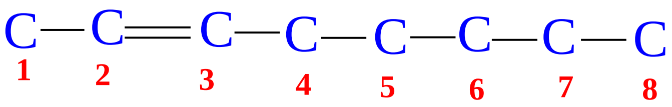
Examples

	$CH_2{=}CH{-}Br$	$CH_2{=}CHCH_2{-}Cl$
Common Name:	**Vinyl bromide**	**Allyl chloride**
IUPAC Name:	**Bromoethene**	**3-Chloro-1-Propene**

Excercise:

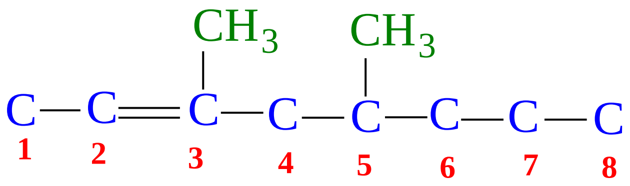
Write the structural formula of 3,5-dimethyl-4-isoprpyl-2-octene.

(1)



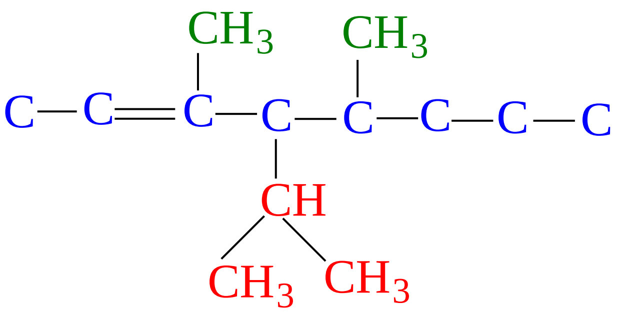
$$\underset{1}{C}-\underset{2}{C}=\underset{3}{C}-\underset{4}{C}-\underset{5}{C}-\underset{6}{C}-\underset{7}{C}-\underset{8}{C}$$

(2)



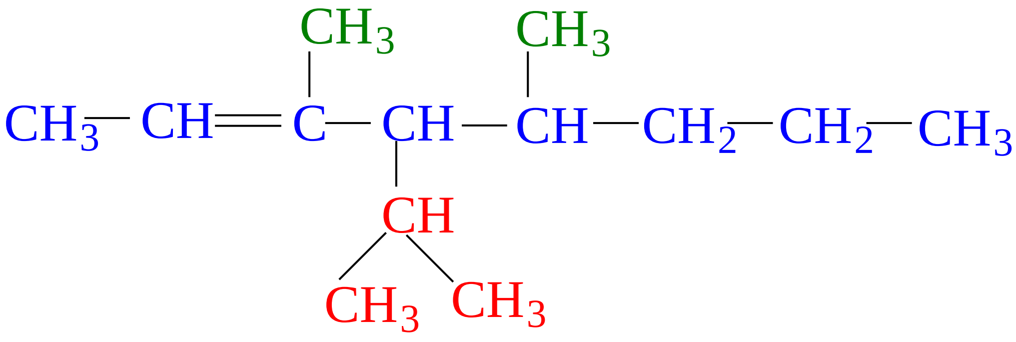
$$\underset{1}{C}-\underset{2}{C}=\underset{3}{\overset{\overset{CH_3}{|}}{C}}-\underset{4}{C}-\underset{5}{\overset{\overset{CH_3}{|}}{C}}-\underset{6}{C}-\underset{7}{C}-\underset{8}{C}$$

(3)



$$C-C=\overset{\overset{CH_3}{|}}{C}-\underset{\underset{\underset{CH_3\quad CH_3}{\diagup\quad\diagdown}}{CH}}{\underset{|}{C}}-\overset{\overset{CH_3}{|}}{C}-C-C-C$$

(4)

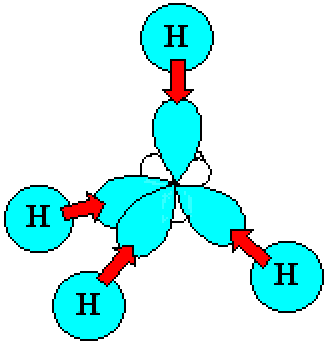


$$CH_3-CH=\overset{\overset{CH_3}{|}}{C}-\underset{\underset{\underset{CH_3\quad CH_3}{\diagup\quad\diagdown}}{CH}}{\underset{|}{CH}}-\overset{\overset{CH_3}{|}}{CH}-CH_2-CH_2-CH_3$$

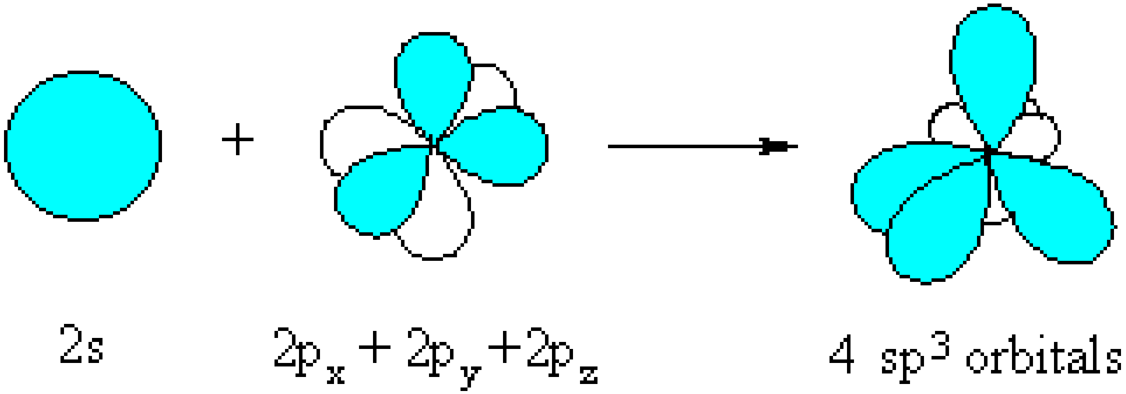
Rapid Revision

In Alkanes:

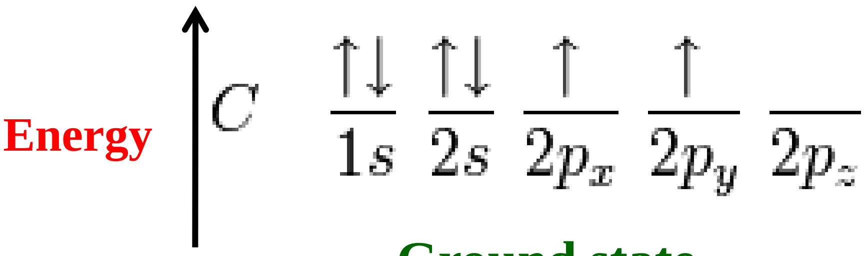
When **C** is bound to four groups, as we saw with ***methane***, it is sp3-hybridized, 4 equivalent **C-H** s bonds (σ bond) can be made by the interactions of Csp^3 with a H1s



In order to minimize the forces of electrostatic repulsion, ***the electron pairs will arrange themselves in the configuration which allows them to be as far away from each other as possible***. They are directed to the corners of a regular **tetrahedron**.

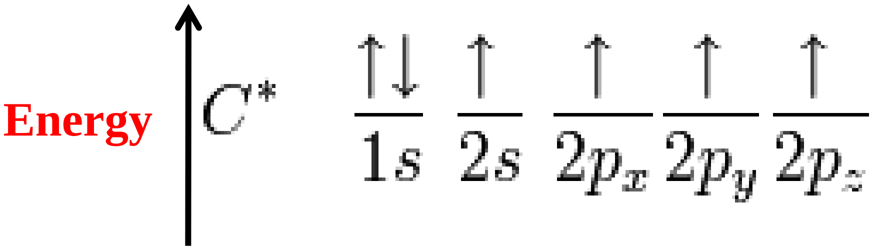


Hybridization & Structure



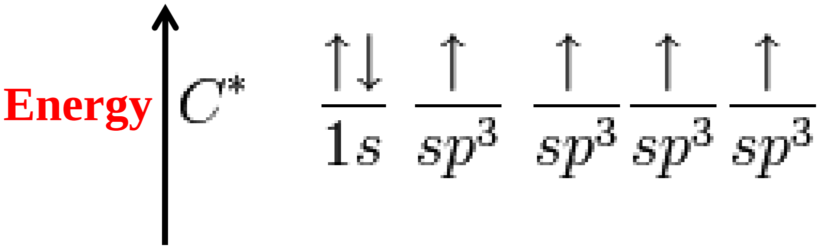
Ground state

Promotion $\longrightarrow$

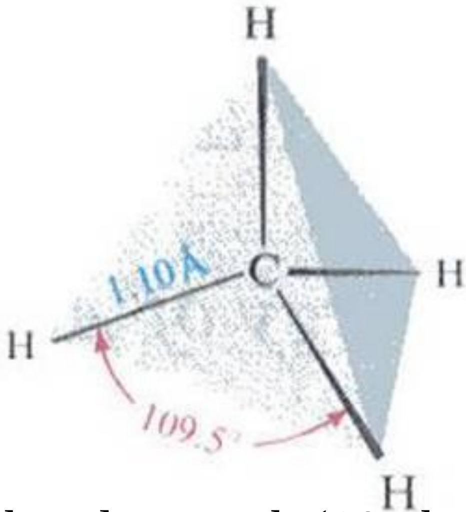


The excitation of one of the *2s* electrons, resulting in the presence of **four unpaired electrons**.

hybridization $\longrightarrow$



The 2s orbital mixes with the three 2p orbitals to form **four *sp*^{3}** hybrids.

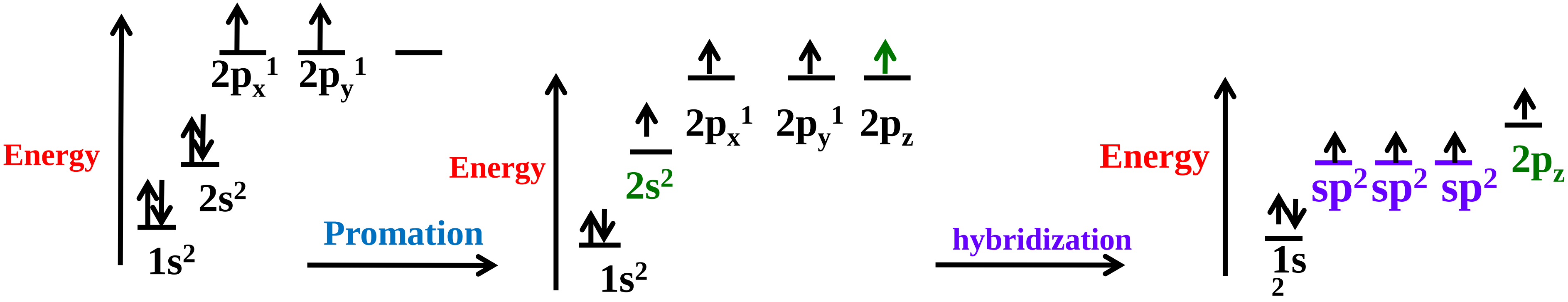


The four bonds are of the same length (1.10 Angstroms) and bond strength (104 kcal / mol). The angle between any two of the orbitals is the tetrahedral angle 109.5 degrees.

Hybridization in Alkenes:

Example:

For the simplest alkene, **Ethylene,**



Energy

$2p_x^1$ $2p_y^1$

$2s^2$

$1s^2$

Promation

Energy

$2p_x^1$ $2p_y^1$ $2p_z$

$2s^2$

$1s^2$

hybridization

Energy

sp^2 sp^2 sp^2

$2p_z$

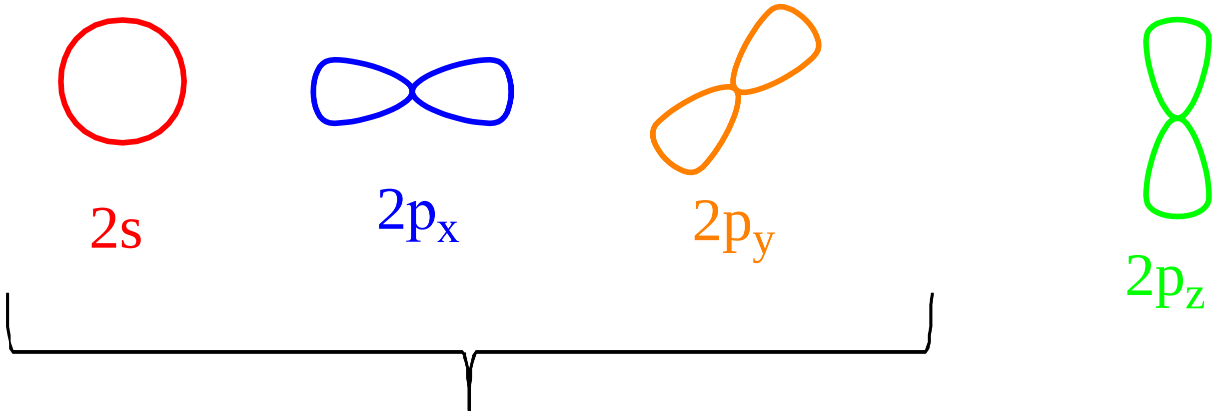
1s
2

These orbitals are formed in the following manner:

- 2s ***orbital*** and ***only two*** of the three 2p orbitals hybridize, the result is 3 equivalent ***sp^2 hybrid orbitals*** and one unhybridized orbital ***$2p_z$*** orbital.

The double bond is always attached to only three other atoms. As a consequence, the doubly bound carbon ***must*** use a different kind of hybridization & ***must*** assume a different shape.

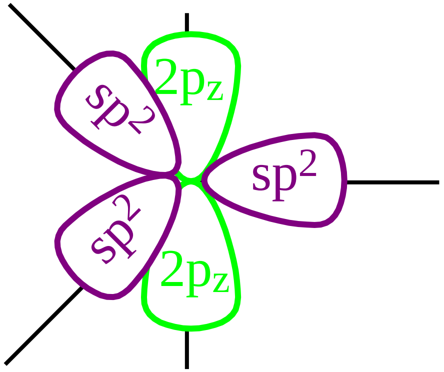
(a)



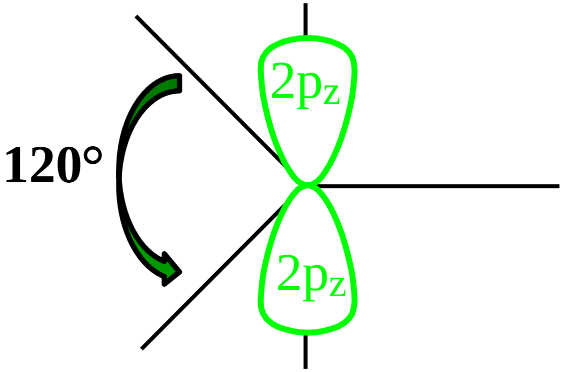
Hybridization

The hybridization of
$2s$, $2p_x$ and $2p_y$ to form….

(b)



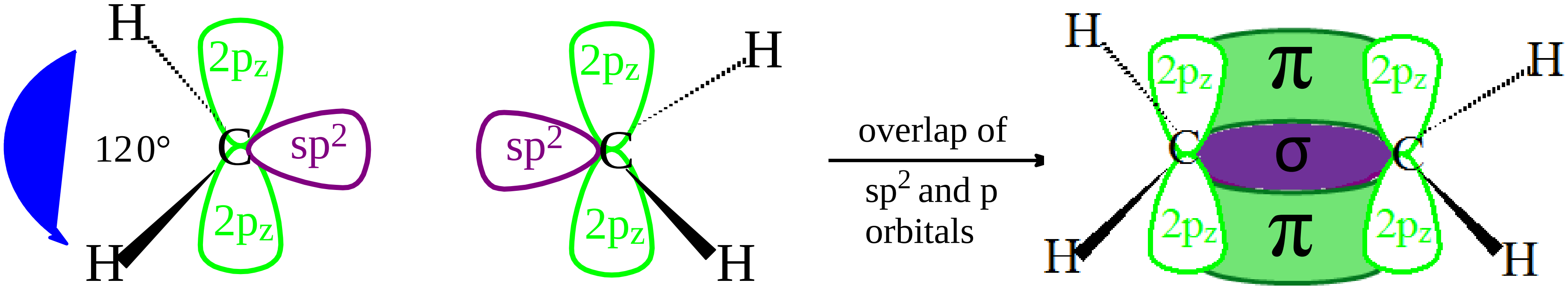
(or)



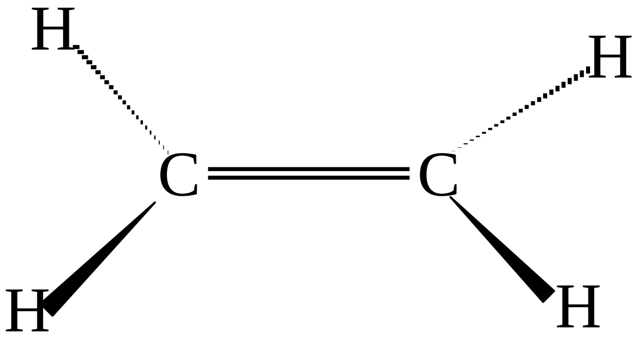
Three planar ***sp^2-hybridized orbitals*** with bond angles of **120°** and a **$2p_z$ orbital Perpendicular to the plane.**

The three sp^2 orbitals get as far away from each other as possible assuming a planer arrangement with an angle of 120° between hybrid orbitals, (trigonal planer).

The remaining **unhybridized 2p$_z$** orbital is perpendicular to the plane of the sp^2 orbitals.



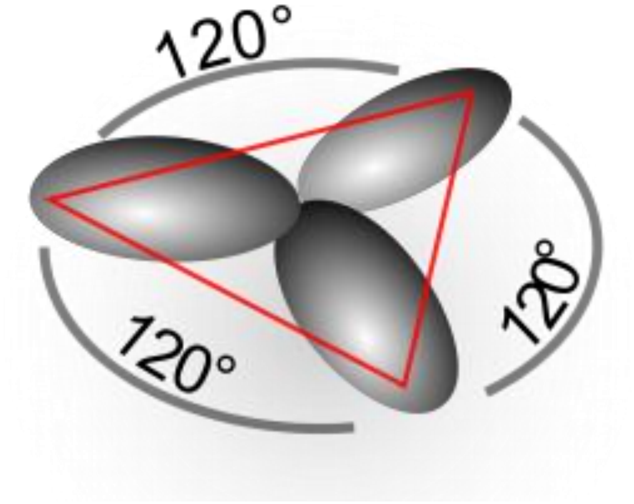
Equivalent to



The two carbons of Ethylene are attached to gather by an Sp^2-----Sp^2= σ bond.

The *2p$_z$ – 2p$_z$ overlap resulting the carbon---carbon double bond= π bond*

The Ethylene molecule has trigonal planer geometrical shape, with a bond angle equal to 120°, and bond length 1.34 A°



Note that; the restricted rotation about the carbon – carbon double bond and the planar geometry give type of geometric isomersim called

The E/Z notation

The pi-bond in an alkene does not permit rotation, thus all of the atoms attached directly to the alkene lie in a plane. The restricted rotation about C=C and the planer geometry give rise to a type of isomerism.

Called… ***Geometric Isomerism***

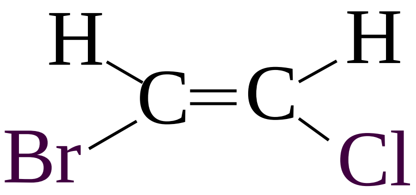
Case 1:

Two different substituents

Groups attached to the alkene could be positioned…

on the same side of the alkene,

on opposite sides of the alkene.



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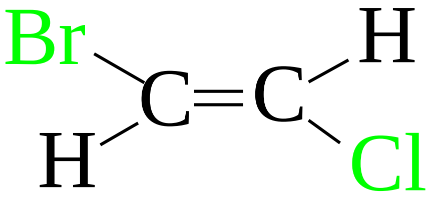
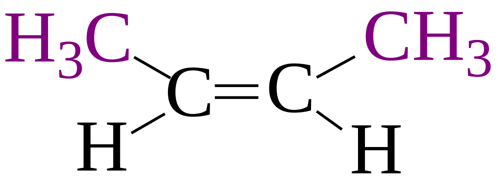


Cis-1- Bromo-2-chloroethene

Trans-1-Bromo-2-chloroethene

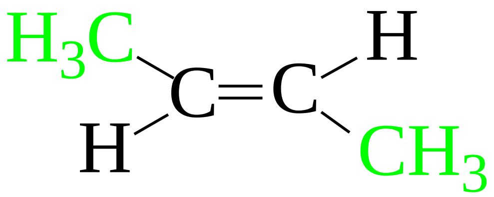
Geometric isomers differ from one another only in the way in which the substituents are arranged in space related to the plane of the C=C bond.

Example: the isomers of 2-Butene



Cis-2-Butene

(mp= -139°C; bp= 3.7°C)



Trans-2-Butene

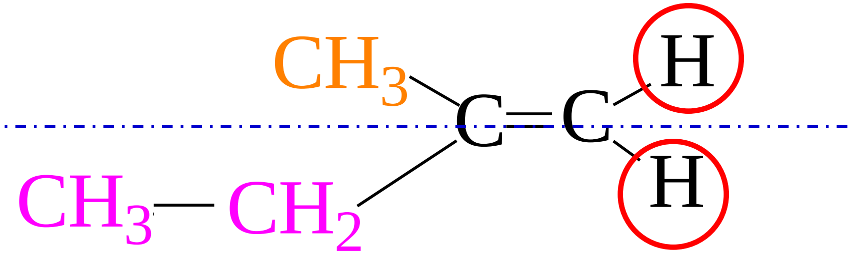
(mp= -106°C; bp= 0.9°C)

Cis and ***Trans*** are stable molecules have different ***physical properties*** and same ***chemical properties***.

Does this molecule have geometric isomers?

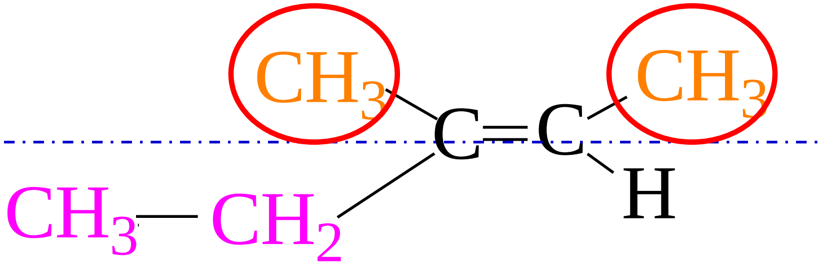
1. ***Must contain a C=C (or another double bond).***

2. On ***each C of the C=C, there must be 2 different groups.***

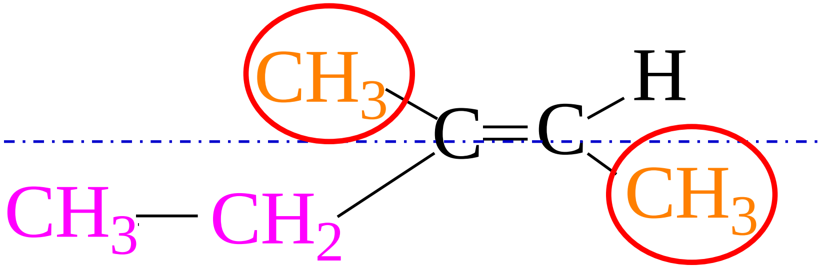


The molecule above ***does not have cis or trans isomers. On the right C of the C=C, there are 2 H atoms (must*** have different groups on ***each C of the C=C.)***

Find the 2 groups ***that are the same on the 2 C of the C=C and circle them; if they're on the same side of the line: cis; different sides: trans.***



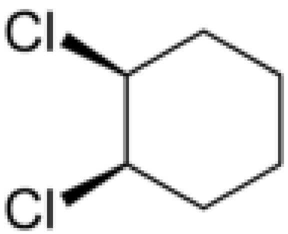
Cis



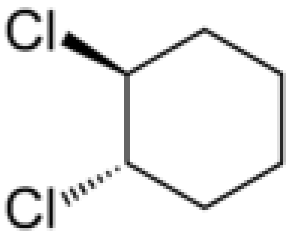
trans

Examples on *Cis&Trans* isomers

1-

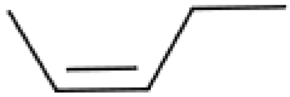


cis-1,2-dichlorocyclohexane



trans-1,2-dichlorocyclohexane

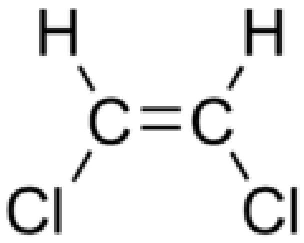
2-



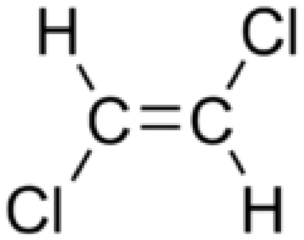
cis-2-pentene

trans-2-pentene

3-



cis-1,2-dichloroethene

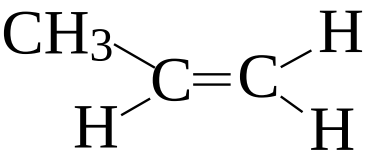


trans-1,2-dichloroethene

Exercise:

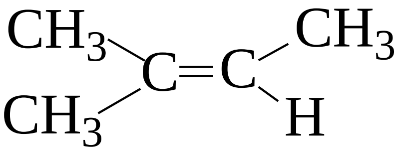
which of the following compound has geometric isomerism? Why?

(a) Propene



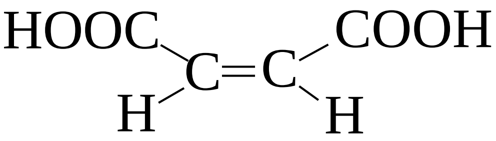
Geometric isomerisim is not possible

(b) 2-Methyl-2-butene

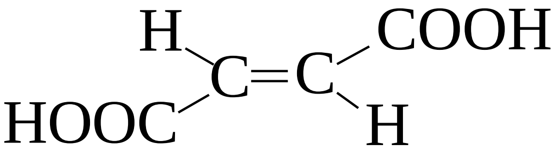


Geometric isomerisim is not possible

(c) 2-butenedioic acid

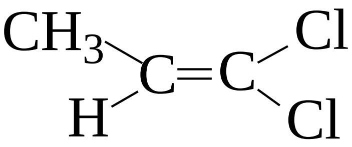


Cis-form (Maleic acid)



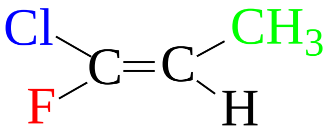
Trans-form (Fumaric acid)

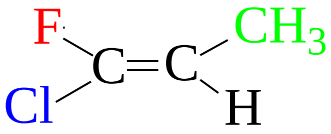
(d) 1,1-Dichloropropene



Geometric isomerisim is not possible

(e) 1-chloro-1-floropropene





New type of Isomerism

Z- 1-chloro-1-floropropene

E- 1-chloro-1-floropropene

Case 2:

For alkenes with *3 to 4 different substituents* such as:

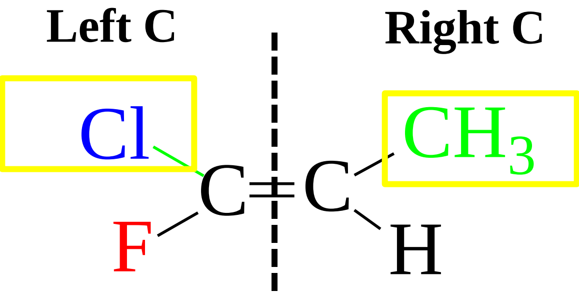
The ***cis/trans* system** for naming isomers is not effective when there are more than two different substituents on a double bond.

Another system such as;The ***E/Z system*** should then be used for distinguishing **the two geometric isomers**.

How can I apply the E-Z system to substituted alkenes?

- ✓ In the **E-Z** system the geometry is specified by **the relative positions** of **the two highest priority substituents on the two carbons of the double bond.**
  - ✓**The priorities** of **the substituents** are determined by **the atomic number** with atoms of higher atomic number having higher priority.

Example

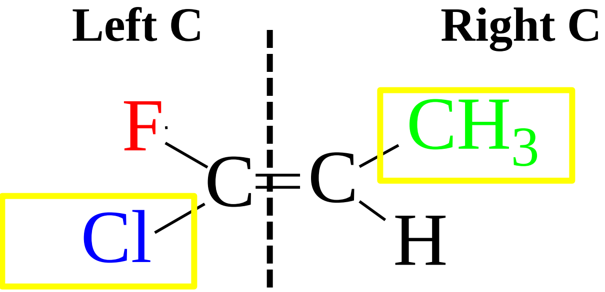


Cl , F
Cl > F

CH_3 , H
CH_3 > H

If the two groups of higher priority are on the same side of the C=C plane,
the isomer is labeled **Z**
(from Germen *zusammen*, **together**)

Z- 1-Chloro-1-fluoropropene



Cl , F
Cl > F

CH_3 , H
CH_3 > H

If the two groups of higher priority are in opposite sides of the C=C plane,
the isomer is labeled **E**
(from the Germen *entgegen*; **opposite**)

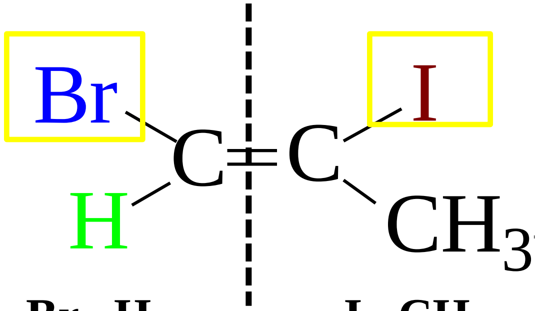
E-1-Chloro-1-fluoropropene

Exercise

Name the following compounds using the E, Z nomenclature.

Left C **Right C**

1-



Br , H
Br > H

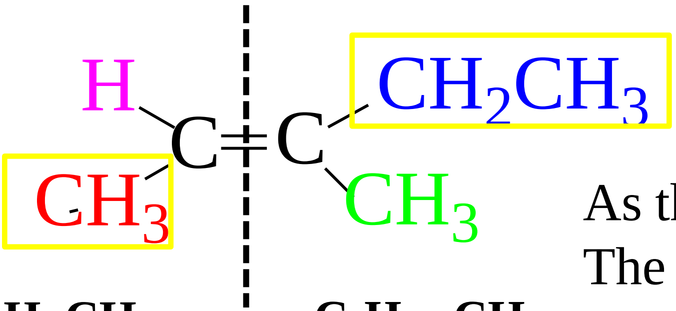
I , CH_3
I > CH_3

As the two atoms of high priority **in the same side**
The compound is **Z**

Z-1-Bromo-2-Iodopropene

Left C **Right C**

2-



H, CH_3
CH_3 > H

C_2H_5 , CH_3
C_2H_5 > CH_3

As the two atoms of high priority **in the opposite side**
The compound is **E**

E- 3-methyl-2-pentene

H.W

Page: 66, problems 3.4, 3.5

Page: 67, problem 3.6

❑The Physical Properties of Alkenes

- ***Physical State:***

The first lower member like ethene, propene and butene are colorless gases.
Alkenes with five to seventeen carbon atoms are liquids.
and higher ones are solids at ordinary temperatures.

- ***Solubility***

Alkenes are ***insoluble*** in ***water*** and ***soluble*** in ***nonpolar organic solvents*** such as benzene C_6H_6 or carbontetrachloride CCl_4.

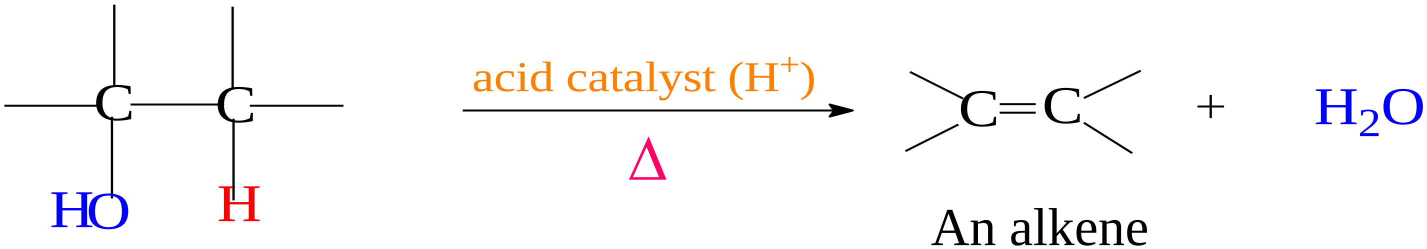
- ***Boiling point***

1.The boiling points of alkenes ***gradually increase*** with an **increase in the molecular mass** (or chain length).
2. Branched chain alkenes have lower boiling points than the corresponding straight chain isomers.

❑General Methods of Preparing Alkenes

Alkenes are prepared in the laboratory by one of two general methods. They can be prepared from ***alcohols*** or ***alkyl halides*** by ***Elimination reactions***.

1. Dehydration of Alcohols



An alcohol

An alkene

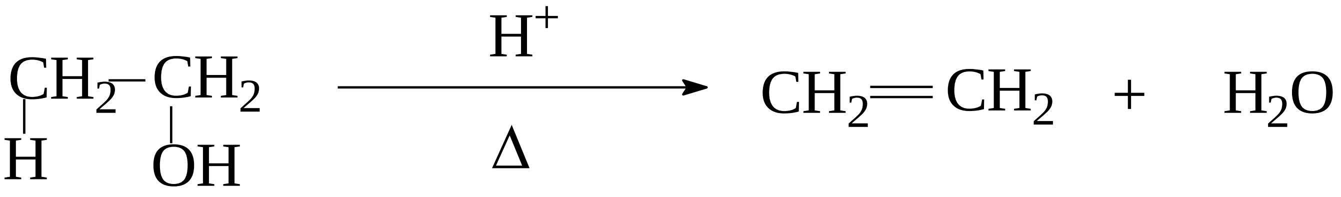
When an alcohol is heated in the presence of a mineral acid catalyst, it loses a molecule of water to give an alkene.

The acid catalyst **H**$^+$ ex; H_2SO_4 or H_3PO_4 & Δ is ***Heat*** .

In Latin” *De-”* means= removal of

Examples

(a)

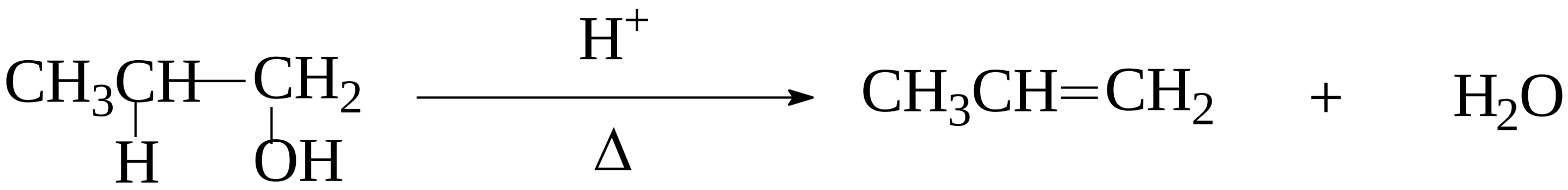


$$\underset{\displaystyle H}{CH_2}-\underset{\displaystyle OH}{CH_2} \xrightarrow[\Delta]{H^+} CH_2{=}CH_2 + H_2O$$

IUPAC Name: Ethanol Ethene

Common Name: Ethyl alcohol Ethylene

(b)

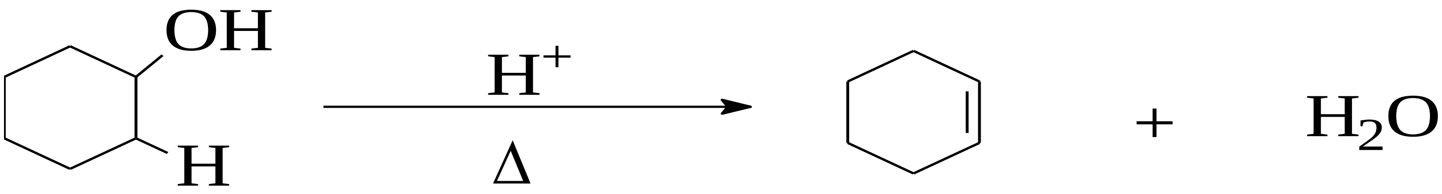


$$CH_3\underset{\displaystyle H}{CH}-\underset{\displaystyle OH}{CH_2} \xrightarrow[\Delta]{H^+} CH_3CH{=}CH_2 + H_2O$$

IUPAC Name: 1-Propanol Propene

Common Name: *n*-propyl alcohol Propylene

(c)

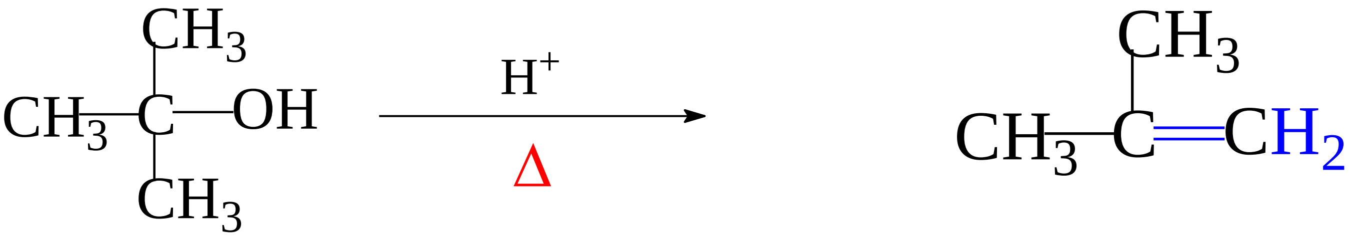


IUPAC Name: Cyclohexanol Cyclohexene

Common Name: Cyclohexyl alcohol

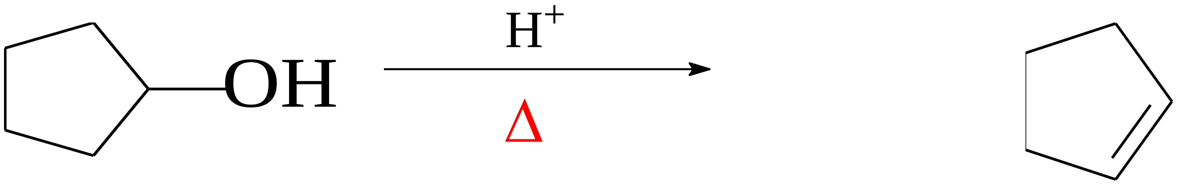
Problem 3.7 Write the structure of the product of the dehydration of each of the following alcohols.

(a)



$$CH_3-\overset{\overset{CH_3}{|}}{\underset{\underset{CH_3}{|}}{C}}-OH \xrightarrow[\Delta]{H^+} CH_3-\overset{\overset{CH_3}{|}}{C}=CH_2$$

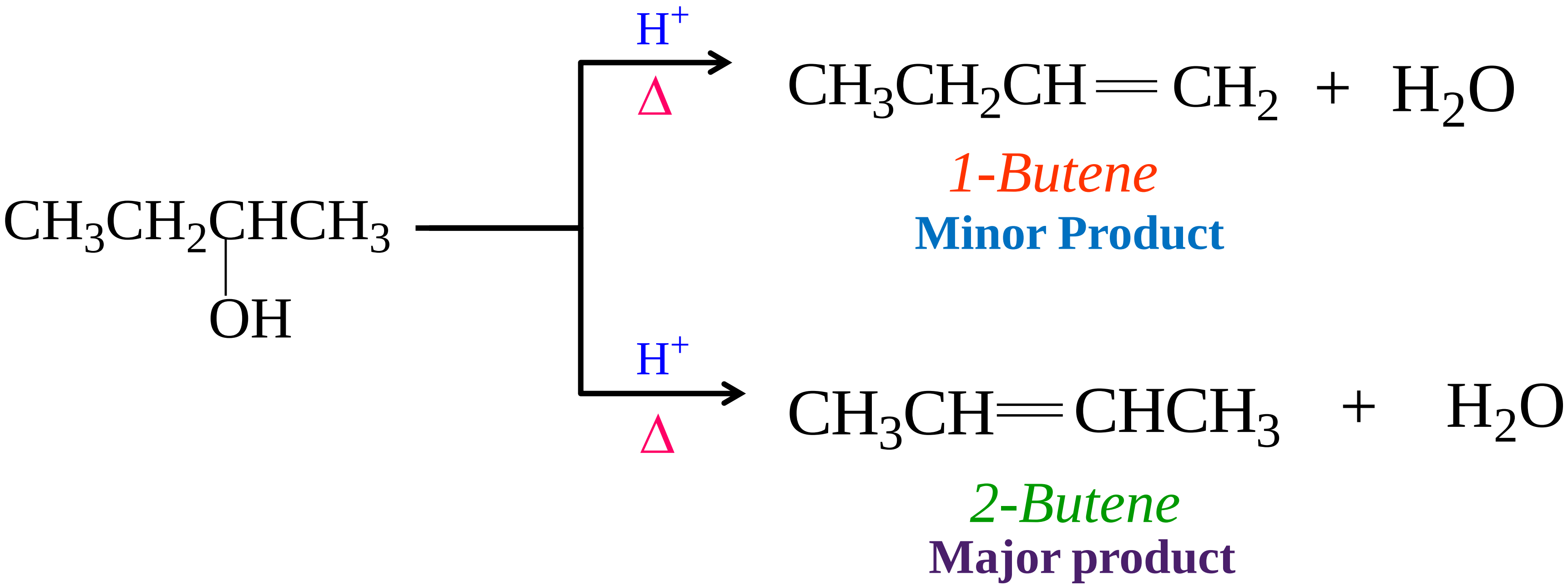
(b)



The previous examples of dehydration of alcohols produced a single alkenes as a possible product.

Suppose, that the loss of water from adjacent carbon atoms can give rise to more than ***one alkene*** as in:

The dehydration of ***2-Butanol***



$$CH_3CH_2\underset{OH}{\underset{|}{C}}HCH_3 \xrightarrow[\Delta]{H^+} CH_3CH_2CH{=}CH_2 + H_2O$$

1-Butene

Minor Product

$$CH_3CH_2\underset{OH}{\underset{|}{C}}HCH_3 \xrightarrow[\Delta]{H^+} CH_3CH{=}CHCH_3 + H_2O$$

2-Butene

Major product

Which *alkene* predominates,

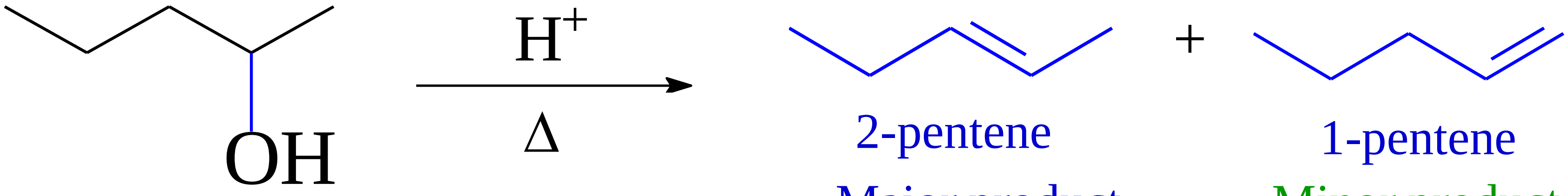
1-Butene or ***2-Butene***

Saytzeff's Rule

The *major product* is always the alkene with *the most substituents* attached on the double-bonded carbons.

Problem 3.8 Give the major and the minor product of the dehydration of

(a)

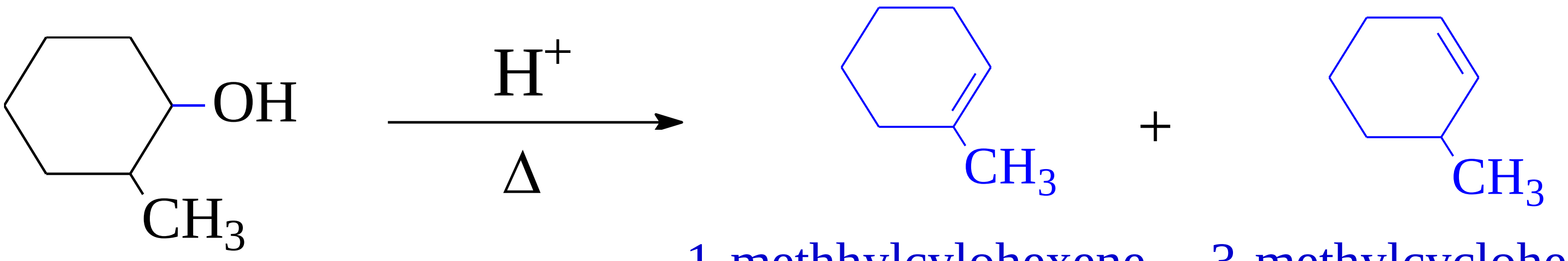


2-pentanol

2-pentene
Major product

1-pentene
Minor product

(b)



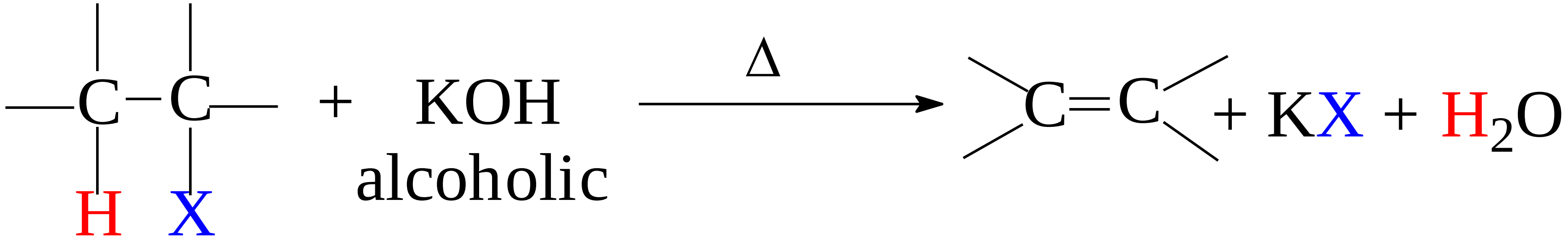
2-methylcyclohexanol

1-methhylcylohexene
Major product

3-methylcyclohexene
Minor product

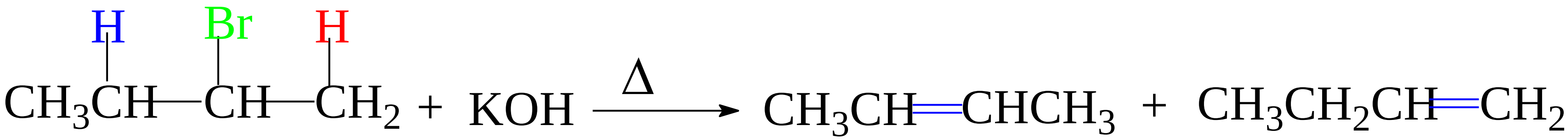
2. Dehydrohaloganation of Alkyl halids

The second method for preparing an alkene by using **dehydrohlogenation** reaction, The reaction involves the **elimination** of **H** and of **X** from adjacent carbon.



Heating an alkyl halide with a solution of KOH, in alcohol, yields an alkenes.

In similar way to that in the dehydration of an alcohol, **Saytzeff's rule** again applies; that is, ***" the alkene with the most alkyl substituents on the double-bonded carbons Predominates".*** For example,

(a) 

$$CH_3\overset{H}{\overset{|}{C}}H-\overset{Br}{\overset{|}{C}}H-\overset{H}{\overset{|}{C}}H_2 + KOH \xrightarrow{\Delta} CH_3CH=CHCH_3 + CH_3CH_2CH=CH_2$$

2-Bromobutane

Alcoholic

2-Butene

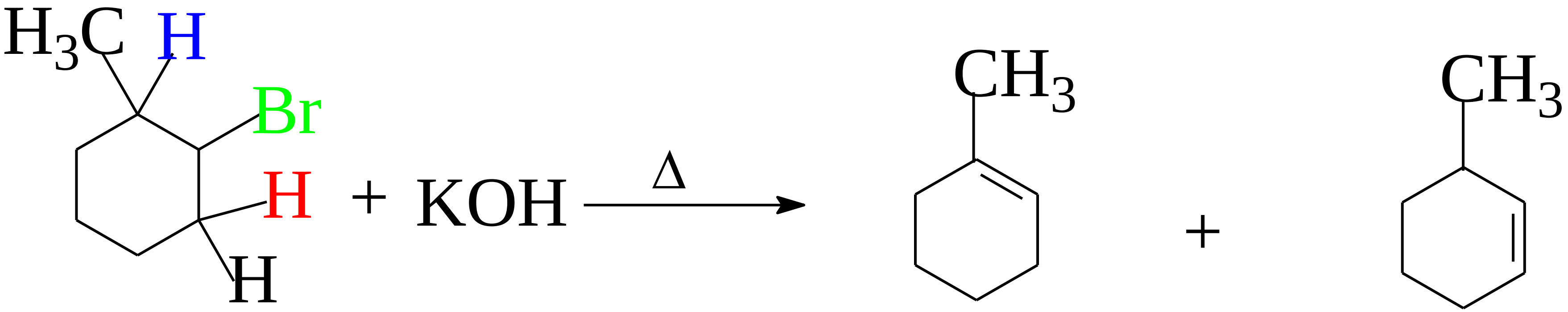
Major product

(81%)

1-Butene

Minor product

(19%)

(b) 

1-Bromo-2-methylcyclohexane

1-Methylcyclohexene

Major product

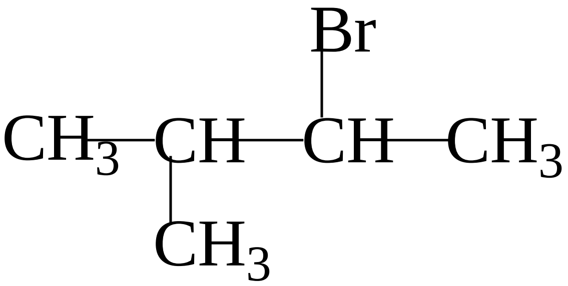
3-Methylcyclohexene

Minor product

Problem 3.12

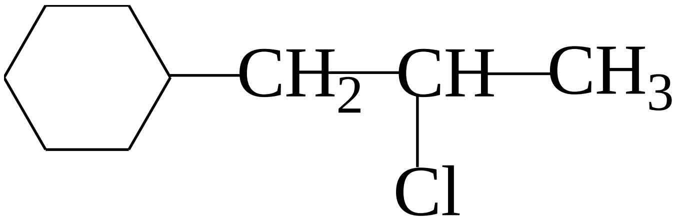
Give the structure of the major and minor products of dehydrohalogenation of:

(a)



$CH_3-CH(CH_3)-CH(Br)-CH_3$

(b)



❑ Reactions of Alkenes

All alkenes contain (C=C + a saturated alkyl chain) as part of molecule – except ethylene – .

$$\xcancel{\mathrm{CH_2{=}CH_2}}$$

Ethylene

$$\mathrm{CH_2{=}CH}\overbrace{\mathrm{CH_2CH_2CH_3}}$$

Any alkene ex: 1-pentene

As the ethylene has no saturated alkyl chain

I.E. The chemistry of alkenes can therefore be divided into :

Reactions of Alkenes

Two types of reactions

Addition reactions

On (C=C)

1. Addition of H_2
2. Addtion of X_2
3. Addition of HX.
4. Addition of $H\text{-}OSO_3H$
5. Addition of H_2O
6. Addition of halohydrin XOH
7. Oxidation(visual test for unsaturation)
8. Ozonolysis
9. Polymerization

Substitution reactions

on the saturated alkyl chain

1. Halogenation at High temperature

1st Type of Reactions

Substitution reactions

on the saturated alkyl chain

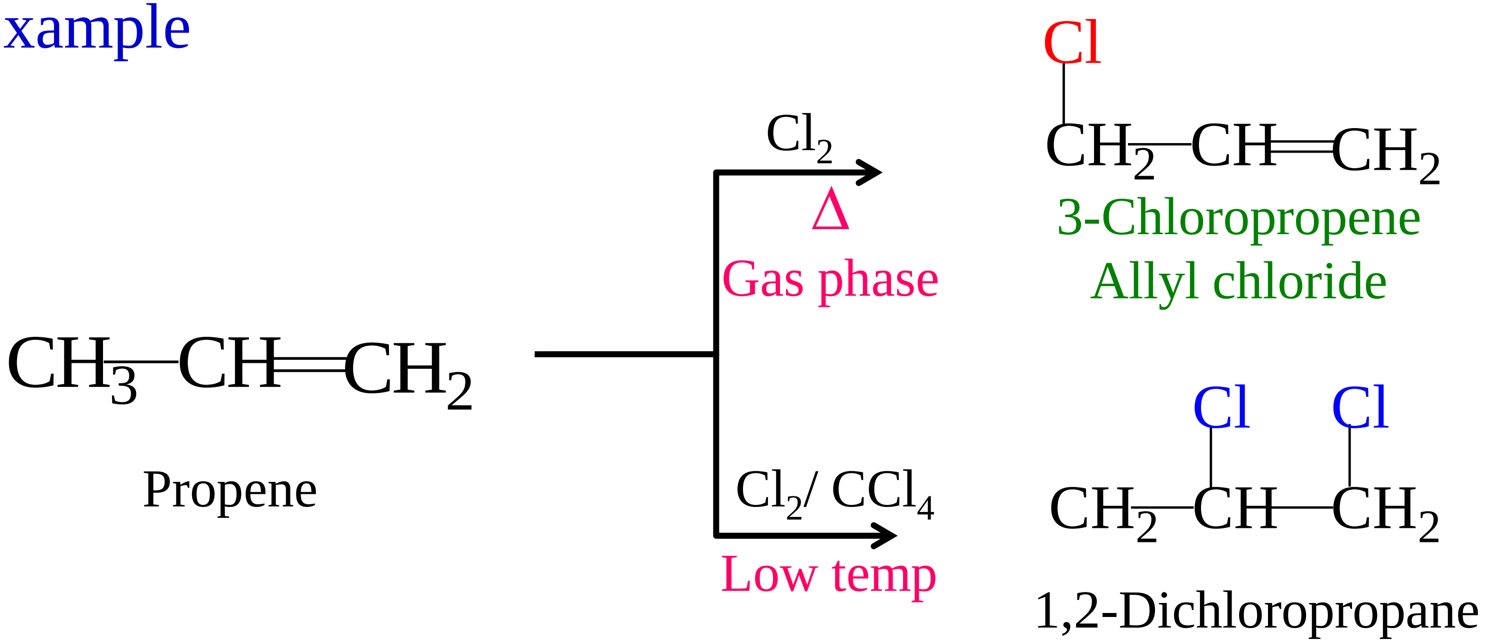
1. Halogenation at High temperature

Alkenes are **more reactive** than *alkanes*.

Their reactions therefore take place under milder experimental conditions.

Alkenes undergo *addition of halogen* at low temperature, even in dark, and generally in liquid phase. On the other hand, alkanes undergo *substitution by halogen* only at elevated temperatures or under the influence of UV light, and generally in the gas phase.

Example



$CH_3-CH=CH_2$

Propene

$\xrightarrow[\Delta]{Cl_2}$ Gas phase

$ClCH_2-CH=CH_2$

3-Chloropropene

Allyl chloride

$\xrightarrow{Cl_2/\ CCl_4}$ Low temp

$CH_2Cl-CHCl-CH_3$

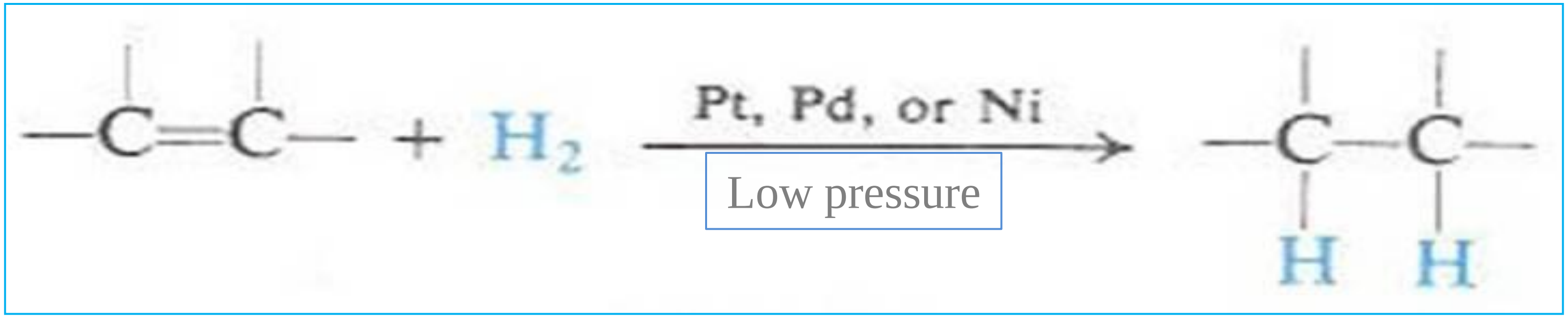
1,2-Dichloropropane

Addition Reactions on the C=C

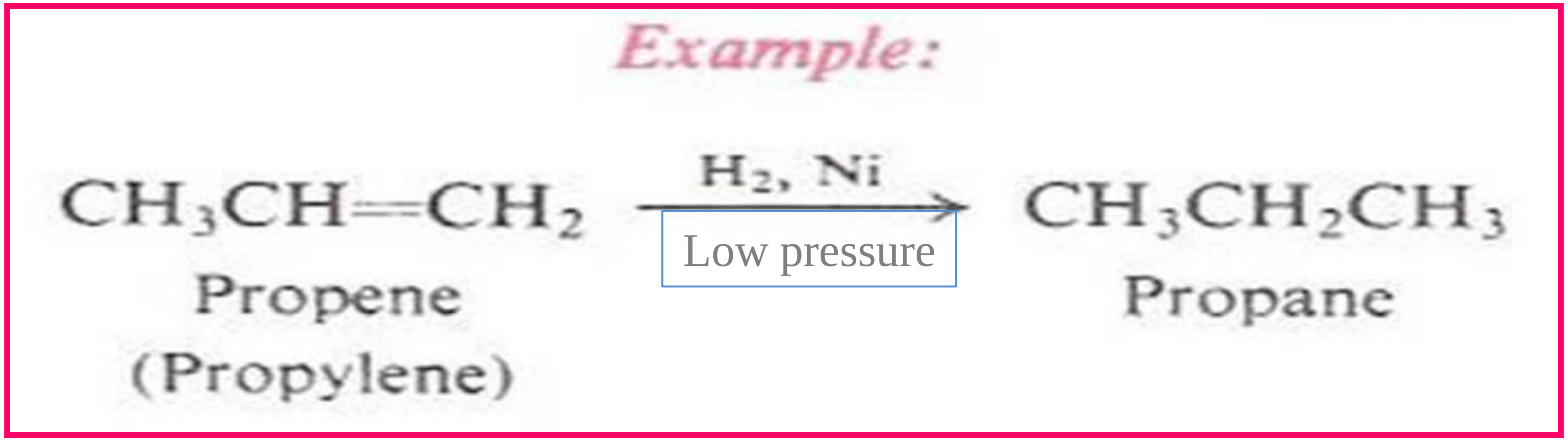
1. Addition of Hydrogen: Catalytic Hydrogenation

The C=C of alkene can add a mole of Hydrogen in the presence of suitable catalyste such as (Pt, Ni or Pd) at low pressure to give an alkane. This method is called ***Catalytic Hydrogenation***.

The General equation



$$-\overset{|}{C}=\overset{|}{C}- + H_2 \xrightarrow[\text{Low pressure}]{\text{Pt, Pd, or Ni}} -\underset{H}{\overset{|}{\underset{|}{C}}}-\underset{H}{\overset{|}{\underset{|}{C}}}-$$



Example:

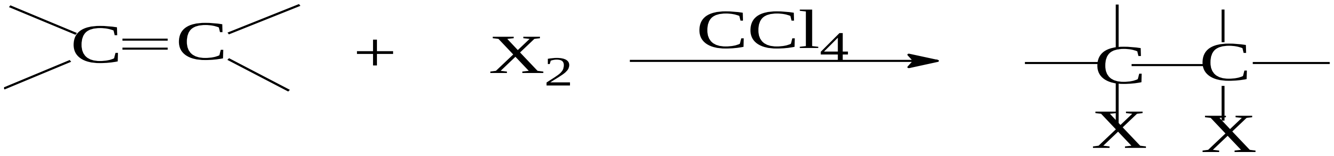
$$CH_3CH{=}CH_2 \xrightarrow[\text{Low pressure}]{H_2,\ Ni} CH_3CH_2CH_3$$

Propene (Propylene) → Propane

2. Addition of Halogens: Halogenation

When an alkene is treated at room temperature with a solution of bromine Br_2 or chlorine Cl_2 in carbon tetrachloride , the halogen adds rapidly to the double bond of the alkene to give the correspounding ***vicinal dihalide.***

The General equation



(X= Cl or Br)

Examples

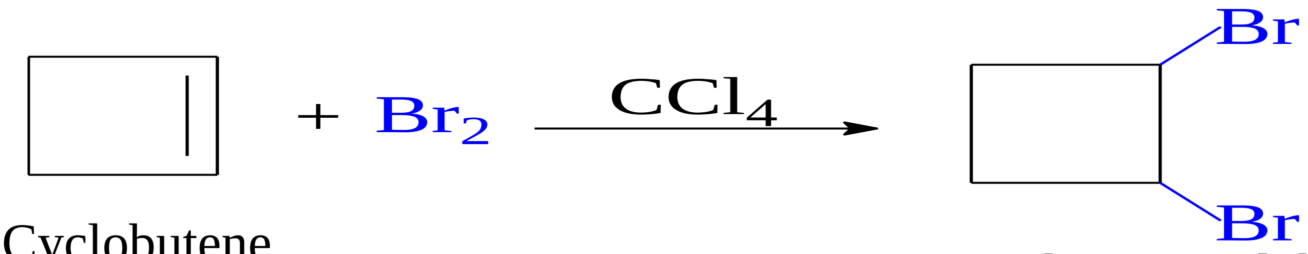
(a)

$$CH_3CH{=}CH_2 + Cl_2 \xrightarrow{CCl_4} CH_3\overset{Cl}{C}H{-}\overset{Cl}{C}H_2$$

Propene

1,2-Dichloropropane

(b)



Cyclobutene

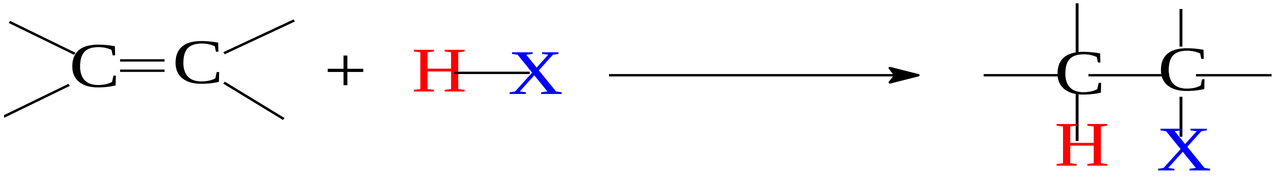
1,2-Dibromocyclobutane

Note that, I “Iodine” is too unreactive and will not add to the C=C of an alkene, F ”Fluorine” is too reactive and reacts explosively making the alkene unstable.

3. Addition of Hydrogen Halides: Hydrohlogenation

Alkenes react with hydrogen chloride, HCl, hydrogen bromide, HBr, and hydrogene Iodide, HI, to form alkylhalides, RX. This reaction is known as ***hydrohalogenation*** As H and X is added to the double-bonded carbons.

The General equation

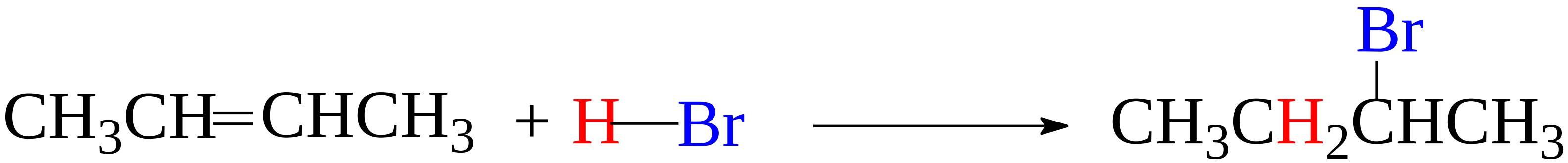


X= (Cl, Br, or I)

Examples

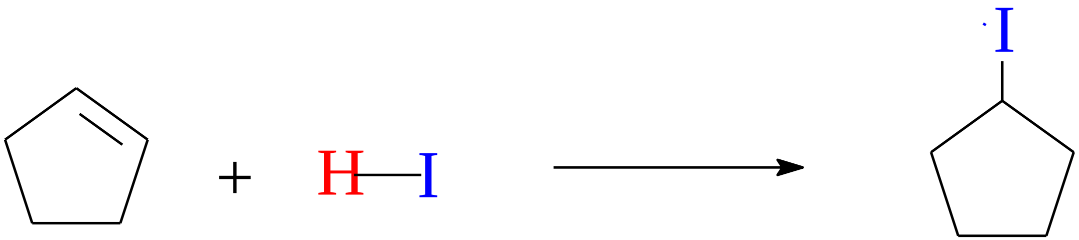
(a) $CH_2{=}CH_2 + H{-}Cl \longrightarrow CH_3CH_2Cl$

(b)

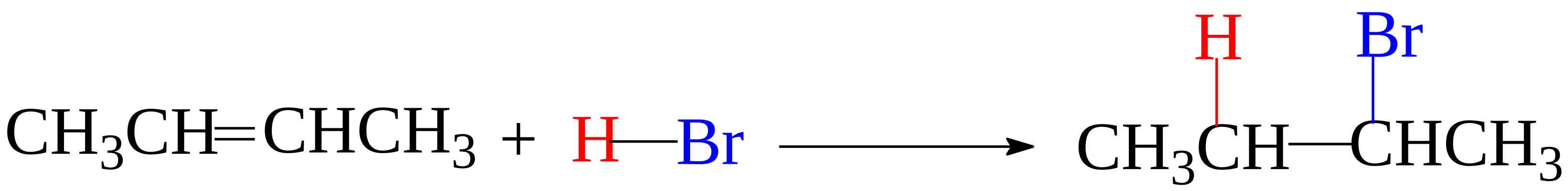


$$CH_3CH{=}CHCH_3 + H{-}Br \longrightarrow CH_3CH_2\overset{Br}{\overset{|}{C}}HCH_3$$

(c)



When hydrogen halide is added to a ***symmetric alkene*** such as; 2-Butene [RCH=CHR], there is ***only one possible product*** because the two double-double bonded carbons are equivalent.

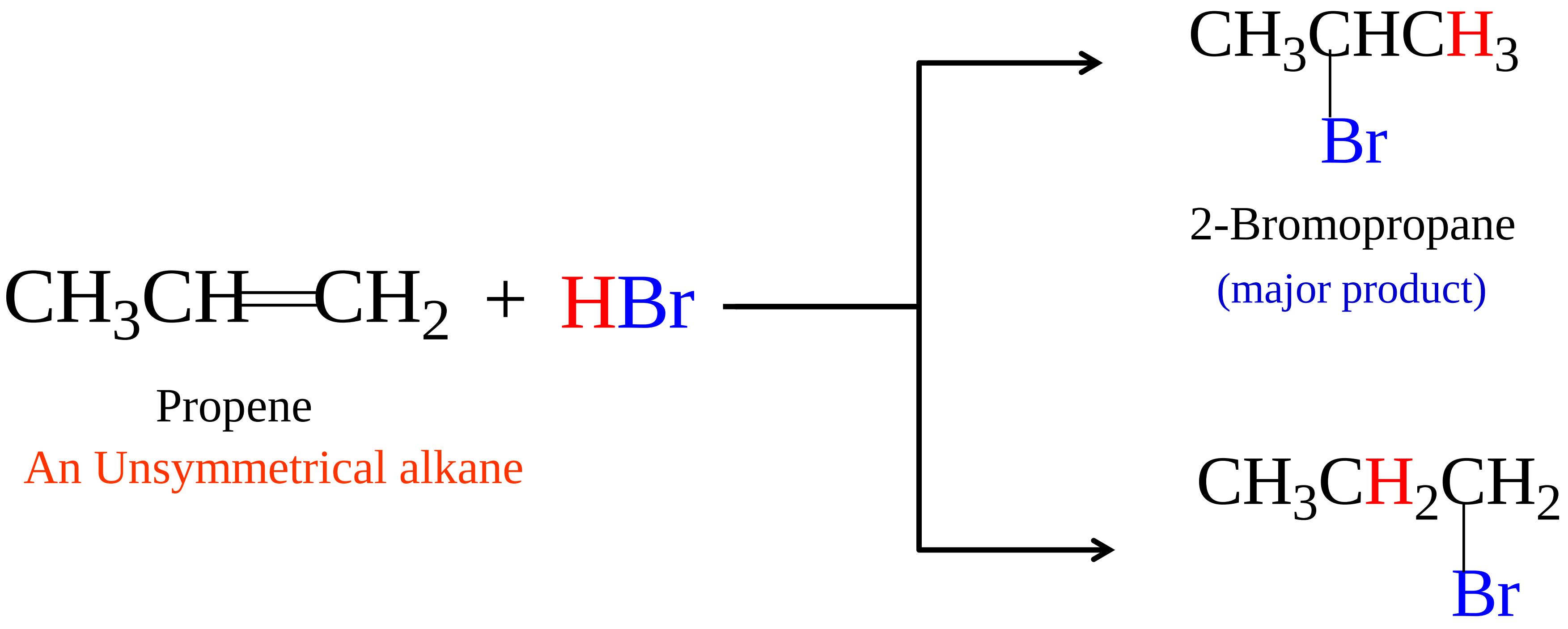


$$CH_3CH{=}CHCH_3 + H{-}Br \longrightarrow CH_3\overset{H}{\overset{|}{C}}H{-}\overset{Br}{\overset{|}{C}}HCH_3$$

2-Butene
A symmetrical alkene

2-Bromobutane
Only one product possible

With unsymmetrical alkenes; such as Propene [RCH=CHR’] as (R ≠ R’), the possibility exists for the HX to add in two ways



$CH_3CH{=}CH_2 + HBr$

Propene

An Unsymmetrical alkane

$CH_3CH(Br)CH_3$

2-Bromopropane

(major product)

$CH_3CH_2CH_2Br$

1-Bromopropane

(minor product)

Markovnikov’s rule

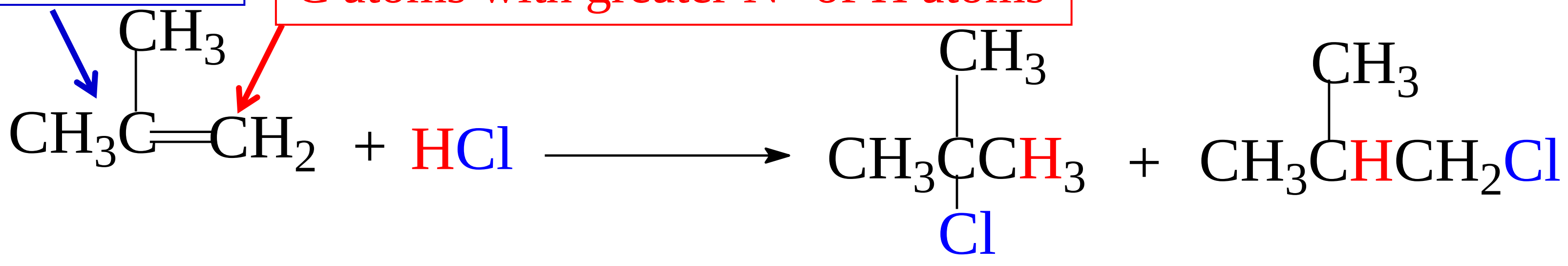
In this type of addition of H---X to unsymmetrical alkenes

The **H^+** of the hydrogen halid adds to the double-bonded carbon that bears the greater number of hydrogen atoms and the X^- ion adds to the other double-bonded carbon.

Examples

The X^- part bonds up to the other C, or to the C rich in substituents

C atoms with greater N° of H atoms



$$CH_3\overset{CH_3}{C}{=}CH_2 + HCl \longrightarrow CH_3\overset{CH_3}{\underset{Cl}{C}}CH_3 + CH_3\overset{CH_3}{C}HCH_2Cl$$

2-methyl propene

2-Chloro-2-methylpropane

Major product

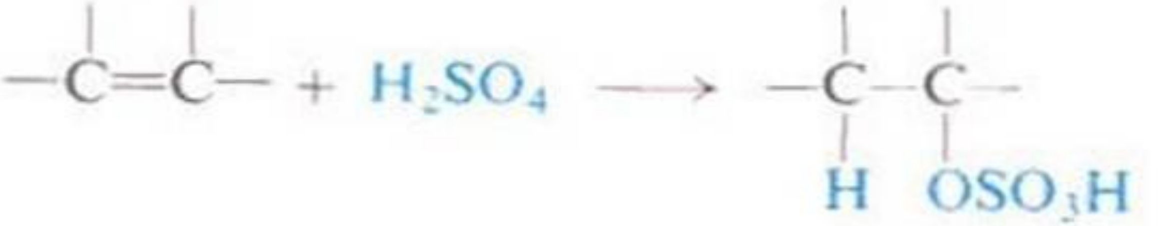
1-Chloro-2-methylpropane

Minor product

4. Addition of Sulfuric Acid

Cold sulfuric acid adds across the double bond of alkene to give alkyl hydrogen sulfate.

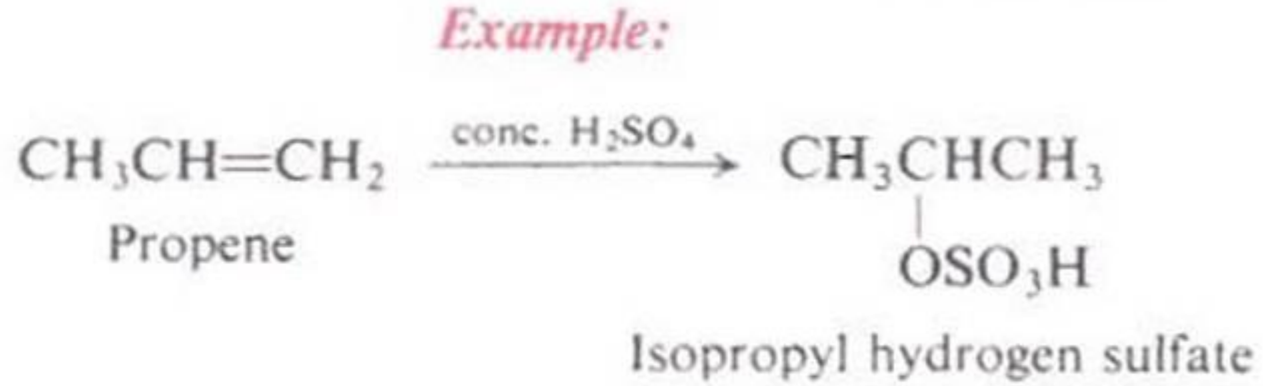
The General equation



$$-\overset{|}{C}=\overset{|}{C}- + H_2SO_4 \longrightarrow -\underset{H}{\overset{|}{\underset{|}{C}}}-\underset{OSO_3H}{\overset{|}{\underset{|}{C}}}-$$

An alkyl hydrogen sulfate

Addition of sulfuric acid to alkenes also follows Markovnikov's rule, as the example



Example:

$$CH_3CH{=}CH_2 \xrightarrow{\text{conc. } H_2SO_4} CH_3\underset{OSO_3H}{\underset{|}{C}H}CH_3$$

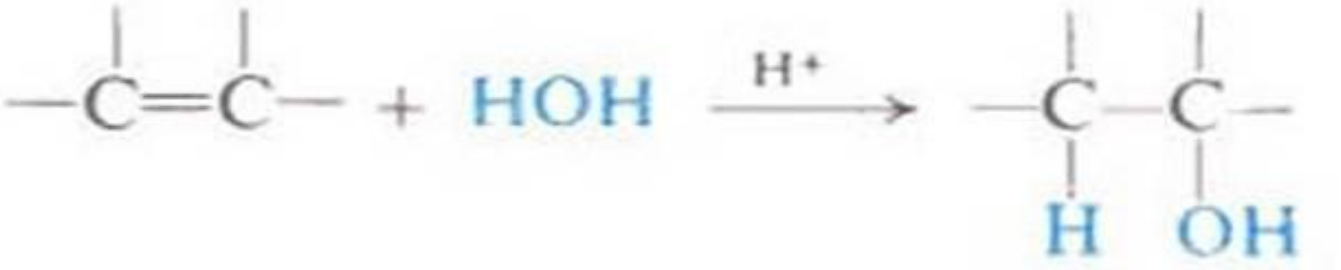
Propene

Isopropyl hydrogen sulfate

5. Addition of Water: Hydration

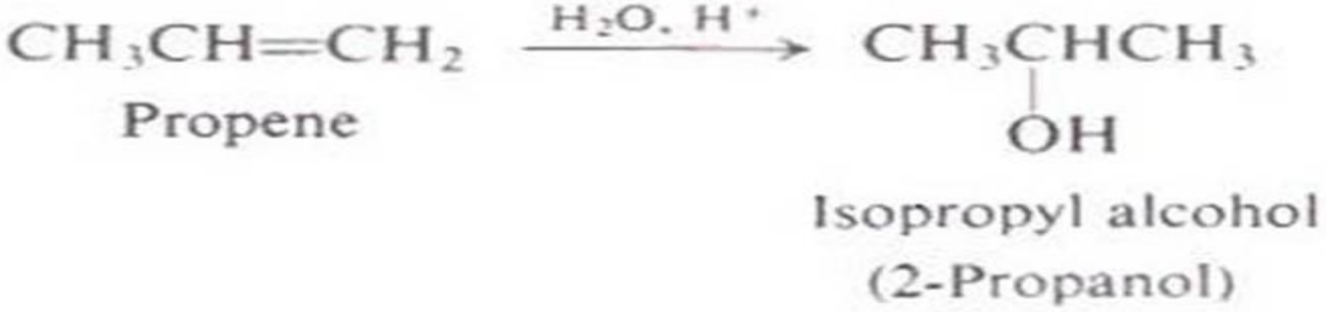
When heated with water in the presence of an acid catalyst (usually sulfuric acid), alkenes yield alcohols (ROH). The process is called ***hydration*** of alkenes because it involves the addition of water across the double bond (C=C).

The General equation



$$-\overset{|}{C}=\overset{|}{C}- + HOH \xrightarrow{H^+} -\underset{H}{\overset{|}{\underset{|}{C}}}-\underset{OH}{\overset{|}{\underset{|}{C}}}-$$

Example:



$$CH_3CH{=}CH_2 \xrightarrow{H_2O,\ H^+} CH_3\underset{OH}{\underset{|}{C}H}CH_3$$

Propene

Isopropyl alcohol
(2-Propanol)

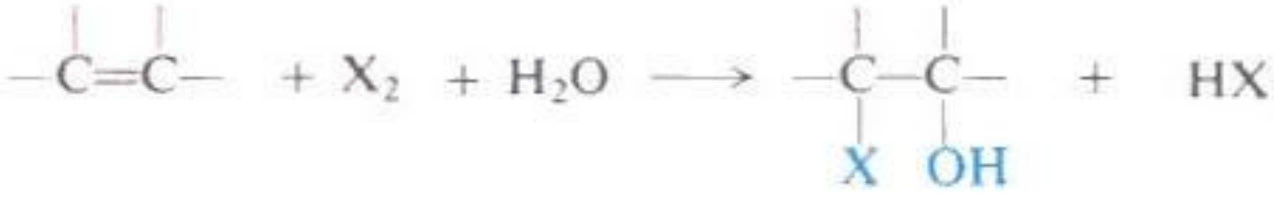
Note that,

The addition of HOH across the double bond is **in accordance** with ***Markovnikov's rule***.

6. Addition of HOX: Halohydrin formation

When an alkene is treated with aqueous chlorine or aqueous bromine, the addition product is a **halohydrin**. (when Cl_2 is used, the product is chlorohydrin; When Br_2 is used the product is a bromohydrin)

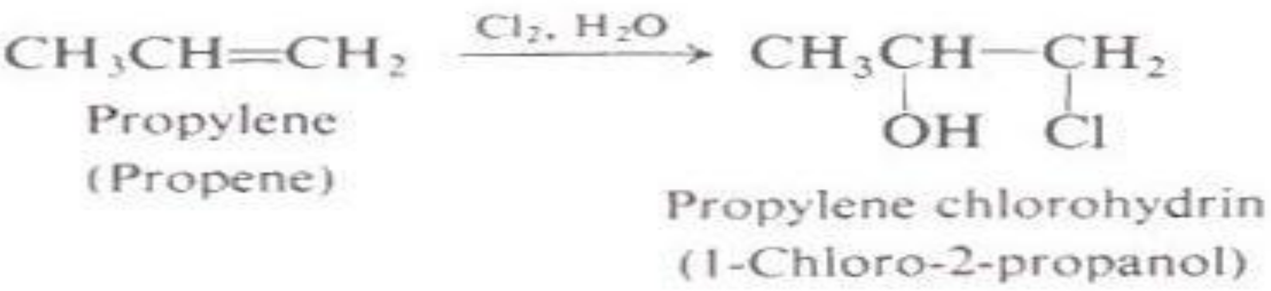
The General equation



$$-\overset{|}{C}=\overset{|}{C}- + X_2 + H_2O \longrightarrow -\underset{X}{\overset{|}{\underset{|}{C}}}-\underset{OH}{\overset{|}{\underset{|}{C}}}- + HX$$

The addition of the chloronium ion, Cl^+ or bromonium ion, Br^+ and the hydroxid ion, ^-OH, follows the Markovnikov's rule as illustrated in the following example.

Example:



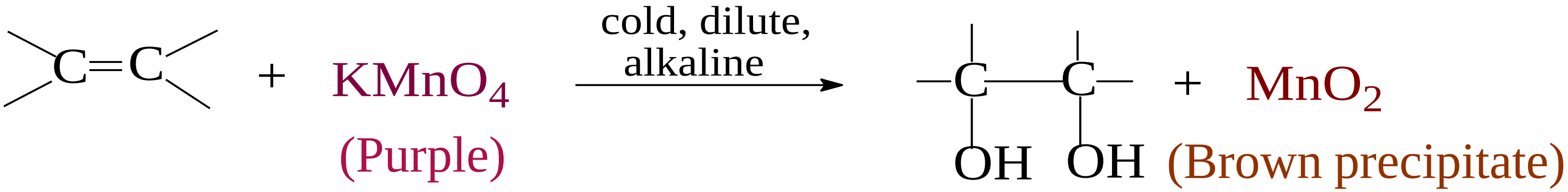
$$\underset{\substack{\text{Propylene}\\\text{(Propene)}}}{CH_3CH{=}CH_2} \xrightarrow{Cl_2,\ H_2O} \underset{\substack{\text{Propylene chlorohydrin}\\\text{(1-Chloro-2-propanol)}}}{CH_3\underset{OH}{\underset{|}{C}H}-\underset{Cl}{\underset{|}{C}H_2}}$$

7. Oxidation of Alkenes(visual test for unsaturation)

A simple visual test can be used to detect unsaturation:

Alkenes can easily be oxidized by potassium permanganate ($KMnO_4$) and other oxidizing agents. When alkenes are added to the purple alkaline potassium manganate, there is a color change to brown manganese dioxide (MnO_2) as the alkenes are being oxidized. This reaction is called ***Baeyer test*** for the unsaturation.

The General equation



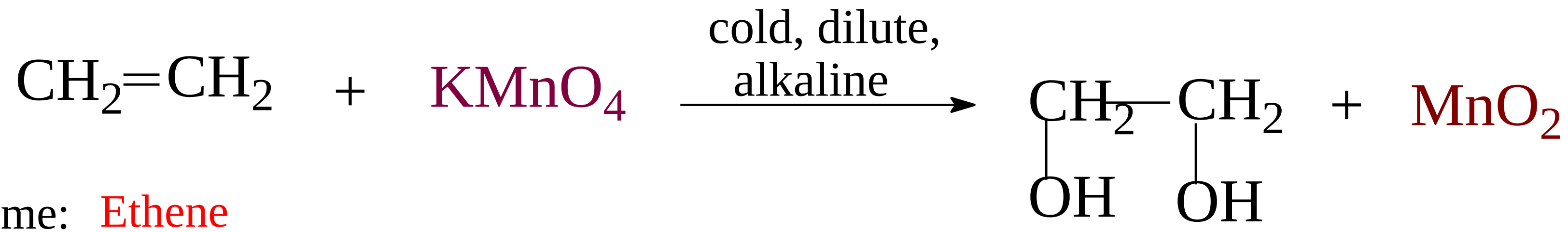
A glycol

The reaction conditions can be summarized as follows

At cold temperatures with low concentrations of oxidizing reagents, alkenes tend to form glycols (diol.)

Examples

(a)



$$CH_2{=}CH_2 + KMnO_4 \xrightarrow{\text{cold, dilute, alkaline}} \underset{OH}{\underset{|}{CH_2}}-\underset{OH}{\underset{|}{CH_2}} + MnO_2$$

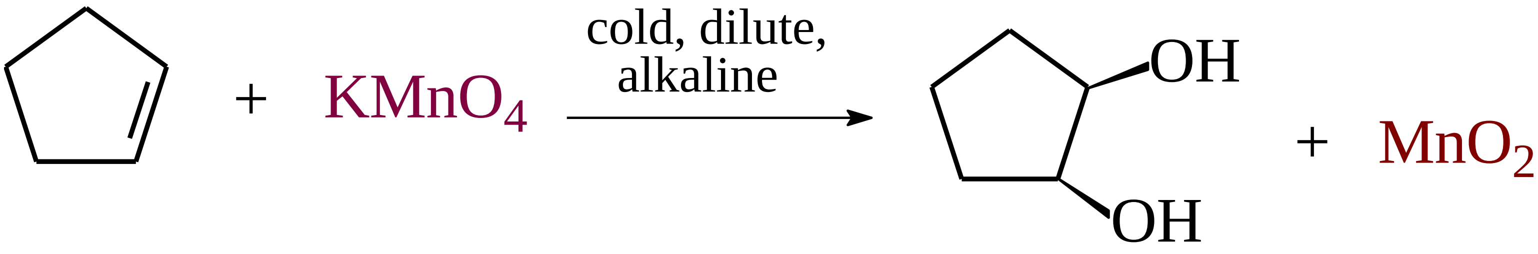
IUPAC Name: Ethene

Common Name: Ethylene

1,2-ethanediol

Ethylene glycol

(b)



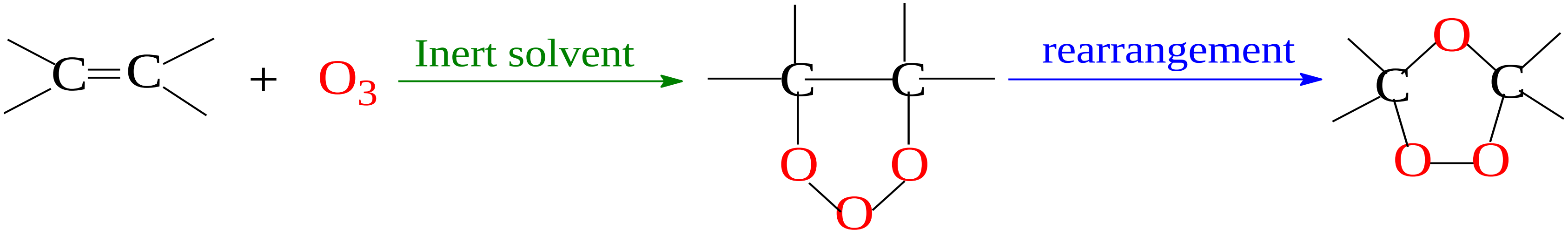
IUPAC Name: cyclopentene

Cis-1,2-cyclopentadiol

8. Ozonolysis

Oxidation of alkenes by ozone "O_3" leads to destruction of both the **σ** and **π** bonds of the double-bond system. This cleavage of an alkene double bond, generally accomplished in good yield, is called ***ozonolysis*.**

The General equation



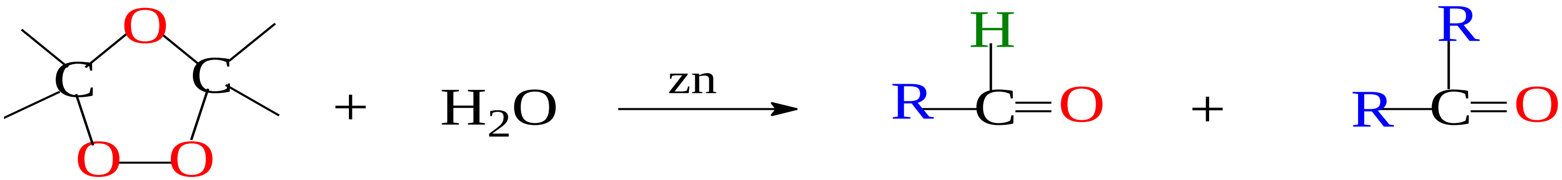
Ozone

Molozonide
Unstable intermediate

An ozonide
(not isolated)

Further addition of water in the presence of zinc catalyst results in the formation of two carbonyl groups compounds,(at the position of the C=C double bond was.

These products of ozonolysis may be aldehydes and ketones.



An ozonide

aldehyde

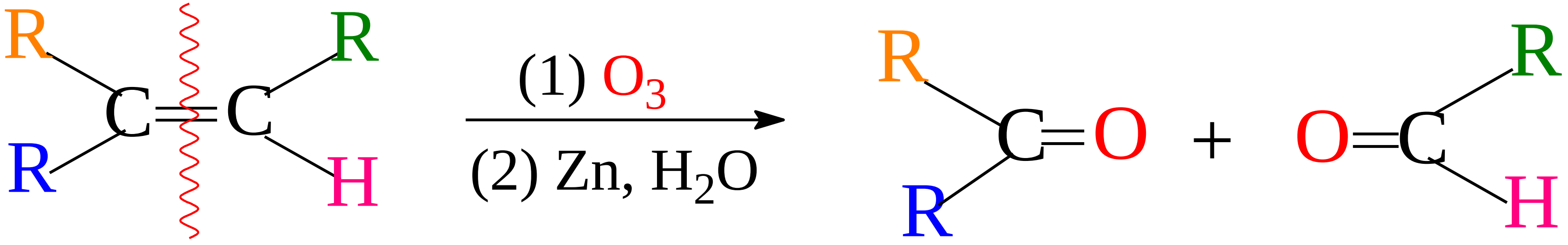
ketone

Examples

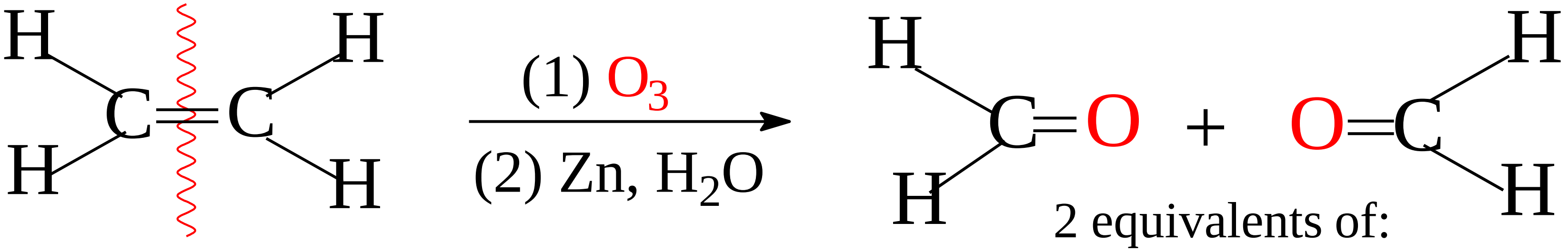
What would be the product of the reaction of each of the following with O_3 followed by Zn/H_2O?

(a) Ethene (b) 1-Butene (c) 2-Butene (d) Isopropylidenecyclohexane

The ozonolysis reaction can be **summarized** by the following equation:



(a) Ethene

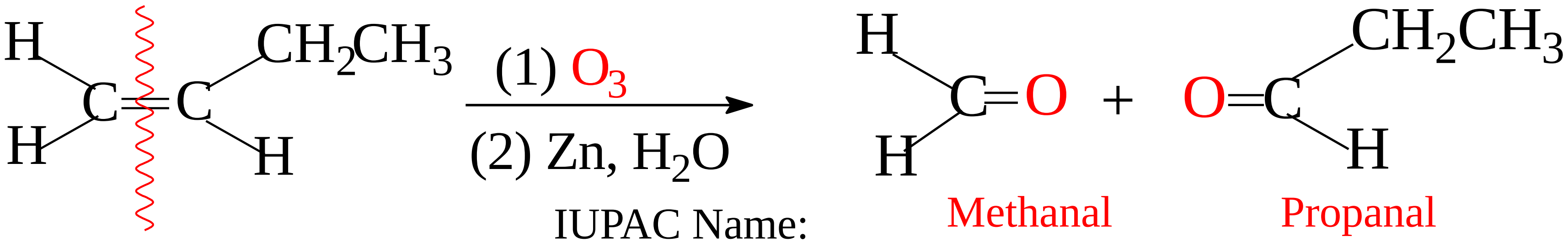


2 equivalents of:

IUPAC Name: Methanal

Common Name: Formaldehyde

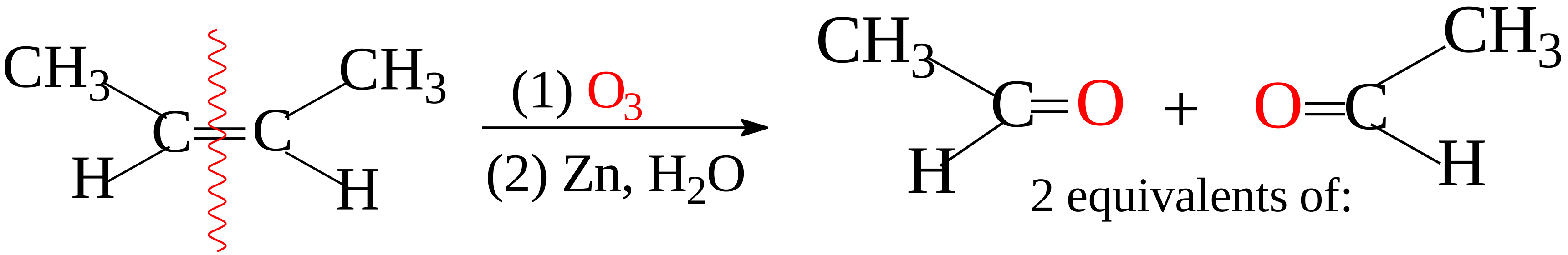
(b) 1-Butene



IUPAC Name: Methanal Propanal

Common Name: Formaldehyde Propaldehyde

(c) 2-Butene

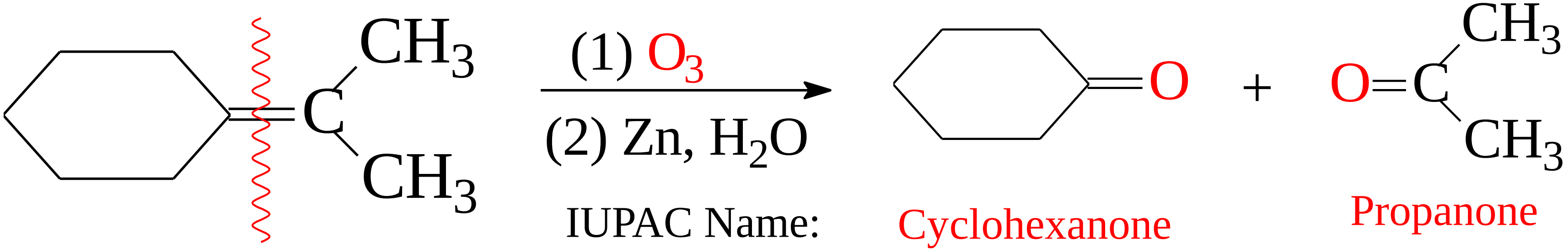


2 equivalents of:

IUPAC Name: Ethanal

Common Name: Acetaldehyde

(d) Isopropylidenecyclohexane



IUPAC Name: Cyclohexanone Propanone

Common Name: Acetone

8. Polymerzation

can be defined as; the joining together of many small molecules to form very large molecules with repeating identical structural units or "mers“. For alkenes; The ***polymerization process*** can be classified as an addition reaction , in which the alkene units ***monomer*** are join together with themselves to give a single giant molecules called ***polymers***.

The basic alkene unit is called ***monomer***
The Huge molecule formed is called ***Polymer***
(from the Greek; *poly* = many & *meros* = units)

Example

When ethylene is heated in the presence of suitable catalyst, thousands of *ethene* molecules join together to make poly(ethene) - commonly called *polyethylene*.

$$\sim\sim CH_2-CH_2-CH_2-CH_2-CH_2-CH_2\sim\sim$$

$$n\ CH_2=CH_2 \xrightarrow[\text{catalyst}]{\text{heat}} -\left[CH_2-CH_2 \right]_n-$$

$$\boxed{n = (600\text{-}1{,}000)}$$

Monomers

Polyethylene polymer

The substitution of one of the H’s of the ethylene by some other group produces a vinyl compound

$CH_2{=}CH-$

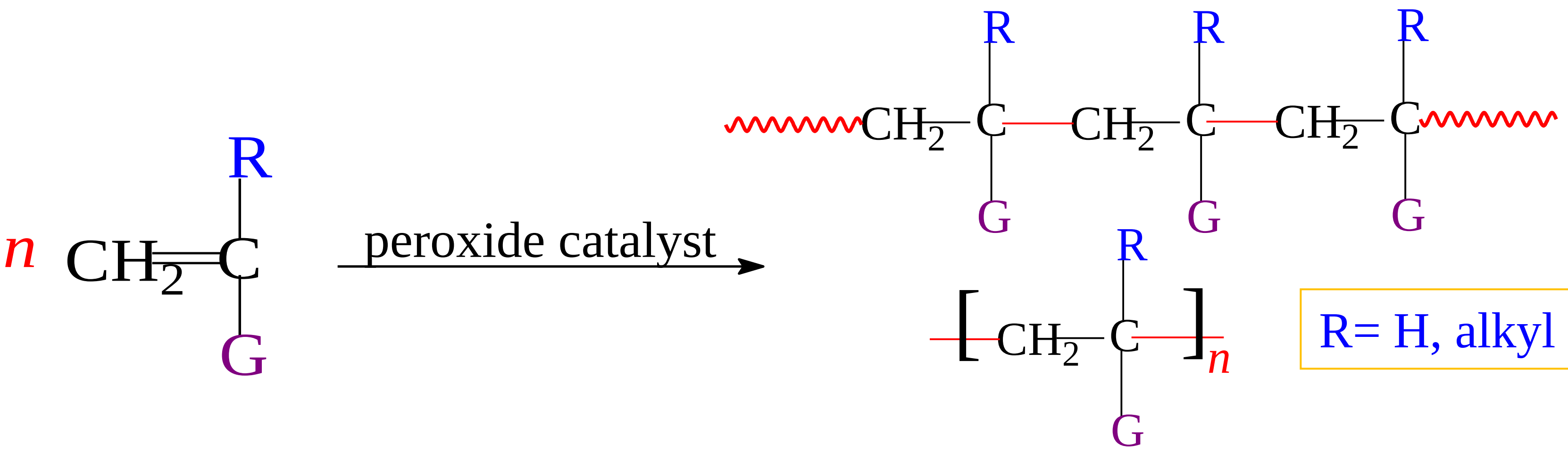
Vinyl group

$CH_2{=}CH-G$

Vinyl compound

Similarly, as vinyl compound is used as the ***monomer***, therefore; the ***vinyl polymerization*** can be represented by the following equation

The general equation



$$n\;CH_2{=}\overset{R}{\underset{G}{C}}\xrightarrow{\text{peroxide catalyst}}\sim\!\sim CH_2-\overset{R}{\underset{G}{C}}-CH_2-\overset{R}{\underset{G}{C}}-CH_2-\overset{R}{\underset{G}{C}}\sim\!\sim\qquad\left[CH_2-\overset{R}{\underset{G}{C}}\right]_n$$

A vinyl compound

A vinyl polymer

R= H, alkyl or Cl

H.W

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Good Luck