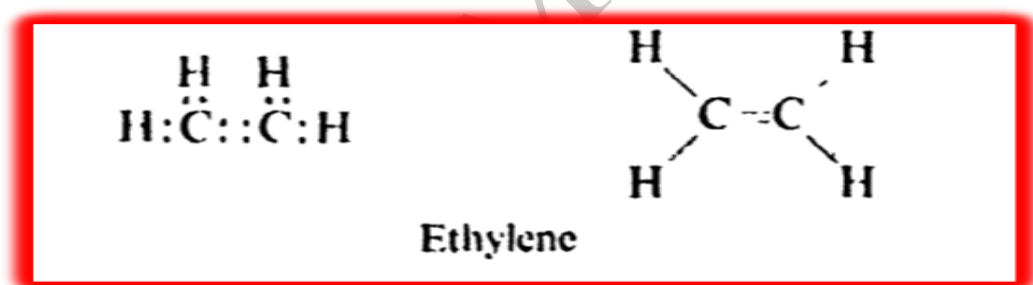


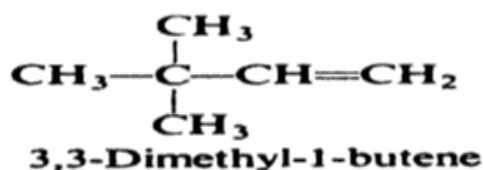
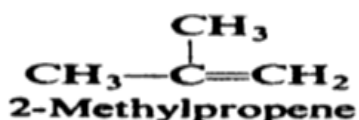
Alkenes

Other hydrocarbons are referred to as **unsaturated hydrocarbons**. may contain **double bonds**; alkenes contain at least **one carbon–carbon double bond, and this is indicated in the family name and in names for specific compounds by an -ene ending**. The simplest member of the alkene family is ethylene, C_2H_4 . have the general molecular formula C_nH_{2n} . In view of the ready conversion of ethylene into ethane, we can reasonably expect certain structural similarities between the two compounds. To start, we connect the carbon atoms with a covalent bond and attach two hydrogen atoms to each carbon atom. At this stage, we find that each carbon atom has only six electrons in its valence shell, rather than the required eight, and the entire molecule needs an additional pair of electrons to be neutral. We can solve both these problems by assuming that the carbon atoms can share two pairs of electrons. To describe this sharing of two pairs of electrons, we say that the carbon atoms are joined by a double bond. The carbon-carbon double bond is the distinguishing feature of the alkene structure.



The IUPAC rules of the system are:

1) Select as the parent structure the longest continuous chain that contains the carbon-carbon double bond; then consider the compound to have been derived from this structure by replacement of hydrogen by various alkyl groups. **The parent structure is known as ethene, propene, butene, pentene, and so on**, depending upon the number of carbon atoms; each name is derived by changing **the ending -ane** of the corresponding alkane name to **-ene**:



2) Indicate by a number the position of the double bond in the parent chain. Although the double bond involves two carbon atoms, designate its position by the number of the first doubly-bonded carbon encountered when numbering from the end of the chain nearest the double bond; thus, **1-butene** and **2-butene**

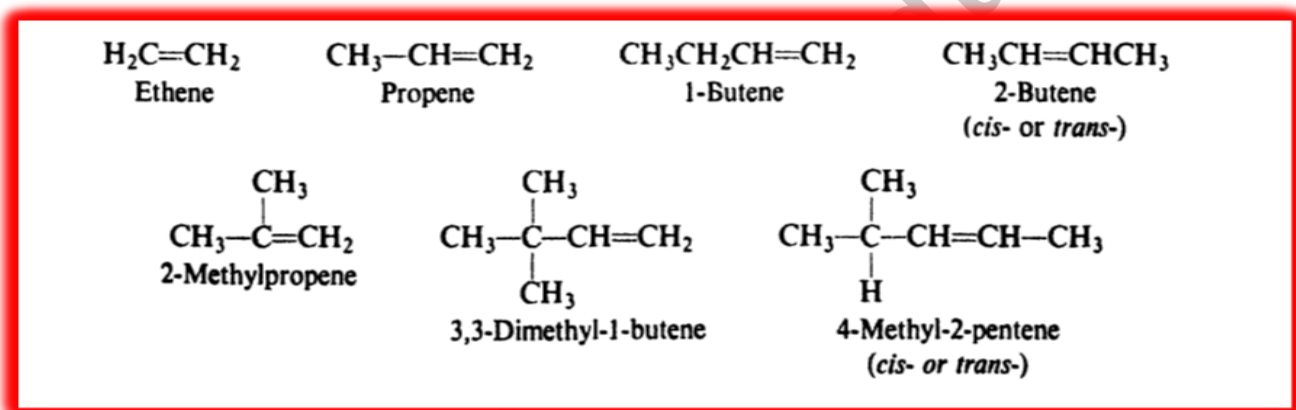
3) Indicate by numbers the positions of the alkyl groups attached to the parent chain.

ALKENES

Name	Formula
Ethylene	$\text{CH}_2=\text{CH}_2$
Propylene	$\text{CH}_2=\text{CHCH}_3$
1-Butene	$\text{CH}_2=\text{CHCH}_2\text{CH}_3$
1-Pentene	$\text{CH}_2=\text{CH}(\text{CH}_2)_2\text{CH}_3$
1-Hexene	$\text{CH}_2=\text{CH}(\text{CH}_2)_3\text{CH}_3$
1-Heptene	$\text{CH}_2=\text{CH}(\text{CH}_2)_4\text{CH}_3$
1-Octene	$\text{CH}_2=\text{CH}(\text{CH}_2)_5\text{CH}_3$
1-Nonene	$\text{CH}_2=\text{CH}(\text{CH}_2)_6\text{CH}_3$
1-Decene	$\text{CH}_2=\text{CH}(\text{CH}_2)_7\text{CH}_3$
<i>cis</i>-2-Butene	$\text{cis-CH}_3\text{CH}=\text{CHCH}_3$
<i>trans</i>-2-Butene	$\text{trans-CH}_3\text{CH}=\text{CHCH}_3$
Isobutylene	$\text{CH}_2=\text{C}(\text{CH}_3)_2$
<i>cis</i>-2-Pentene	$\text{cis-CH}_3\text{CH}=\text{CHCH}_2\text{CH}_3$
<i>trans</i>-2-Pentene	$\text{trans-CH}_3\text{CH}=\text{CHCH}_2\text{CH}_3$
3-Methyl-1-butene	$\text{CH}_2=\text{CHCH}(\text{CH}_3)_2$
2-Methyl-2-butene	$\text{CH}_3\text{CH}=\text{C}(\text{CH}_3)_2$
2,3-Dimethyl-2-butene	$(\text{CH}_3)_2\text{C}=\text{C}(\text{CH}_3)_2$

Common Names;

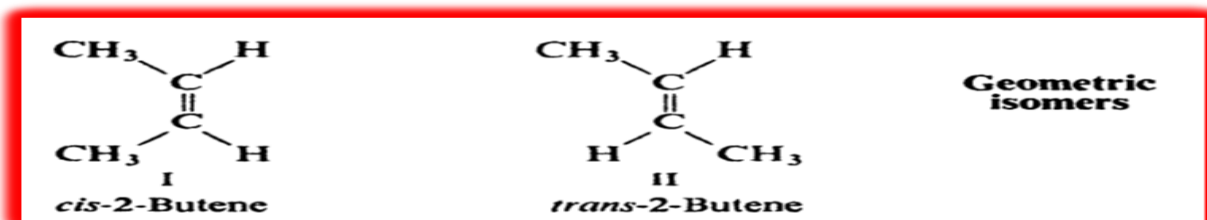
Used except for three simple alkenes: **ethylene, propylene, and isobutylene**. The various alkenes of a given carbon number are, however, sometimes referred to collectively as the **pentylenes (amylenes), hexylenes, heptylenes, and so on**. (One sometimes encounters the naming of alkenes as derivatives of ethylene: as, for example, tetramethyl ethylene for $(\text{CH}_3)_2\text{C}=\text{C}(\text{CH}_3)_2$).



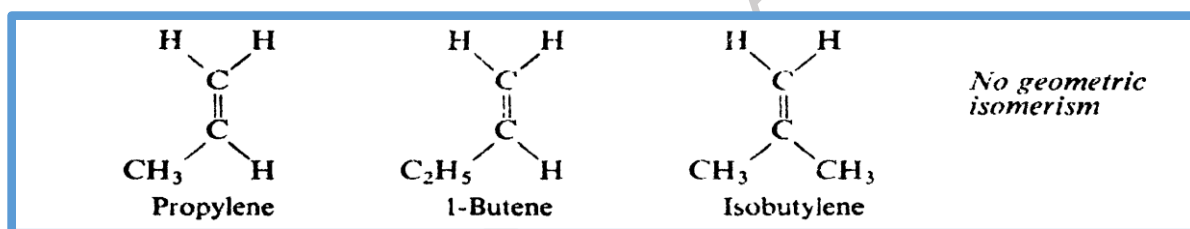
The Cis - Trans System (Geometric isomerism) (Stereochemistry)

The isomeric **2-butenes** **differ** from one another only in the way the atoms are oriented in space (but are like one another with respect to which atoms are attached to which other atoms); they belong to the general class we have called **stereoisomers**. They are not **mirror images** of each other, and hence are not enantiomers. As we have already said, stereoisomers that are not mirror images of each other are called **diastereomers**. The particular kind of diastereomers that owe their existence to hindered rotation about double bonds are called geometric isomers. **The isomeric 2-butenes**, then, are diastereomers, and more specifically, geometric isomers. We recall that the arrangement of atoms that characterizes a particular stereoisomer is called its **configuration**. The configurations of the **isomeric 2-butenes** are the structures **I and II**. These configurations are differentiated in their names by the prefixes **cis-** (**Latin: on this side**) and **trans-** (**Latin: across**), which

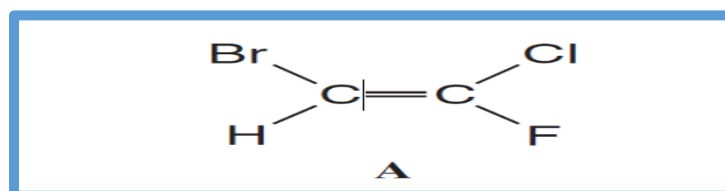
indicate that the methyl groups are on the same side or on opposite sides of the molecule.



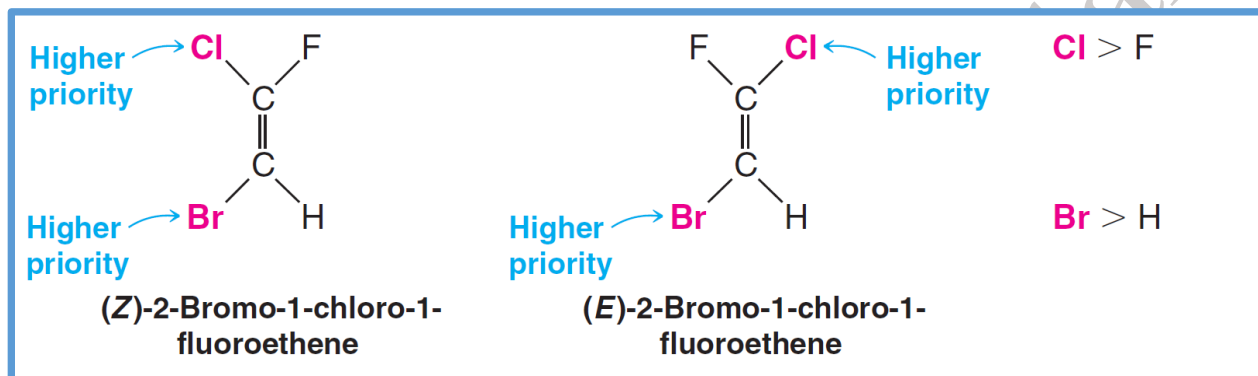
There is hindered rotation about any carbon-carbon double bond, but it gives rise to geometric isomerism only if there is a certain relationship among the groups attached to the doubly-bonded carbons. We can look for this isomerism by drawing the possible structures



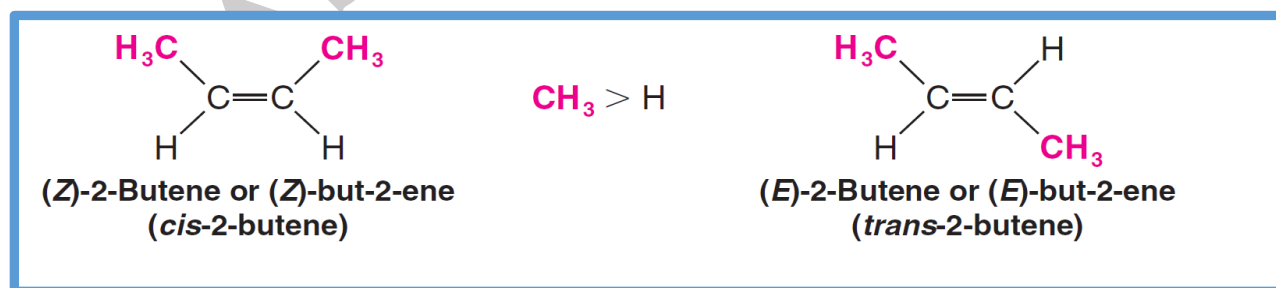
In the **Cis** example, carbon atoms of the main chain (**carbons 1 and 4**) are on the same side of the double bond. In the **trans** example, the same carbon atoms of the main chain are on opposite sides of the double bond. Rotation around the double bond is restricted because the bond would have to be broken to allow rotation. Thus, the double bond is rigid, and geometric isomers are formed. We learned to use the terms **cis** and **trans** to designate the stereochemistry of alkene diastereomers. These terms are unambiguous, however, **only when applied to disubstituted alkenes**. If the alkene is **trisubstituted or tetrasubstituted**, the terms **cis** and **trans** are either ambiguous or do not apply at all. Consider the following alkene as an example



It is impossible to decide whether **A** is **Cis** or **Trans** since **no two** groups are the same. This system, called the (E)–(Z) system, applies to alkene diastereomers of all types. In the (E)–(Z) system, we examine the two groups attached to one carbon atom of the double bond and decide which has higher priority. Then we repeat that operation at the other carbon atom.

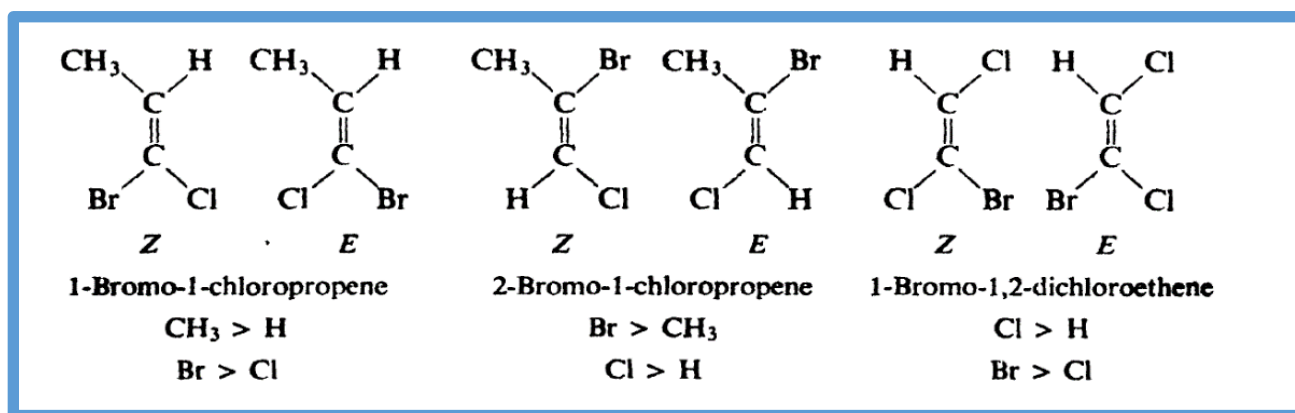


We take the group of higher priority on one carbon atom and compare it with the group of higher priority on the other carbon atom. If the two groups of higher priority **are on the same side of the double bond**, the alkene is designated **(Z)** (from the German word **zusammen**, meaning **together**). If the two groups of higher priority are **on opposite sides of the double bond**, the alkene is designated **(E)** (from the German word **entgegen**, meaning **opposite**). The following example illustrates this



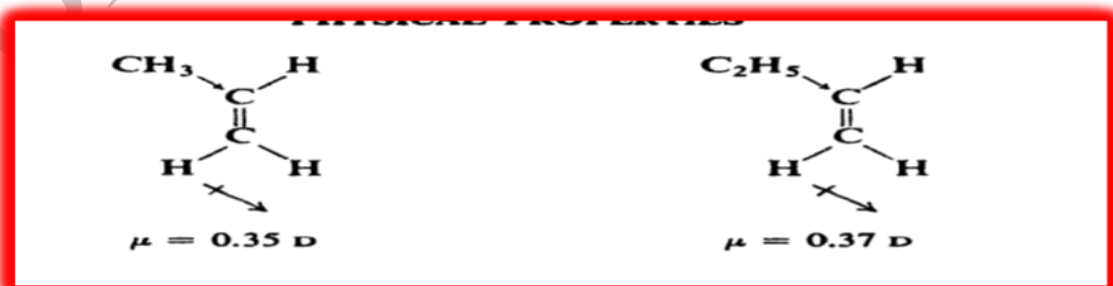
We then take the group of higher priority on one carbon and the group of higher priority on the other carbon, and tell whether they are on the same side of the molecule or on opposite sides. So that it will be clear that we are using this method

of specification, we use the letter **Z** to mean on the same side cis, and the letter **E** to mean on opposite sides. **trans** (From the German: zusammen, together, and opposite.)



Physical properties

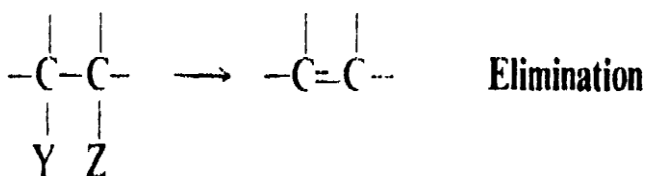
As a class, the alkenes possess physical properties that are essentially the same as those of the alkanes. 1-They are insoluble in water, but quite soluble in nonpolar solvents like **benzene, ether, chloroform, or ligroin**. 2-They are less dense than water. Like alkanes, 3-alkenes are at most only weakly polar. Since the loosely held electrons of the double bond are easily pulled or pushed, **dipole moments are larger than for alkanes**. They are still small, however: compare the dipole moments shown for propylene and 1-butene, for example, with the moment of 1.83 D for methyl chloride. The bond joining the alkyl group to the doubly-bonded carbon has a small polarity, which is believed to be in the direction shown, that is, with the alkyl group releasing electrons to the doubly-bonded carbon. Since this polarity is not cancelled by a corresponding polarity in the opposite direction, it gives a net dipole moment to the molecule.



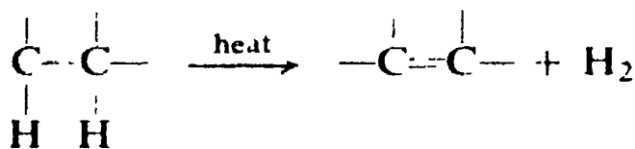
Industrial source

Alkenes are obtained in industrial quantities chiefly by **the cracking of petroleum**. The smaller alkenes can be obtained in pure form by **fractional distillation** and are thus available for conversion into a large number of important aliphatic compounds. **Higher alkenes**, which cannot be separated from the complicated cracking mixture, remain as valuable components of **gasoline**.

Alkenes containing up to **five carbon atoms** can be obtained in pure form from the **petroleum industry**. Pure samples of more complicated alkenes must be prepared by methods like those. The introduction of a carbon-carbon double bond into a molecule containing only single bonds must necessarily involve the elimination of atoms or groups from two adjacent carbons:



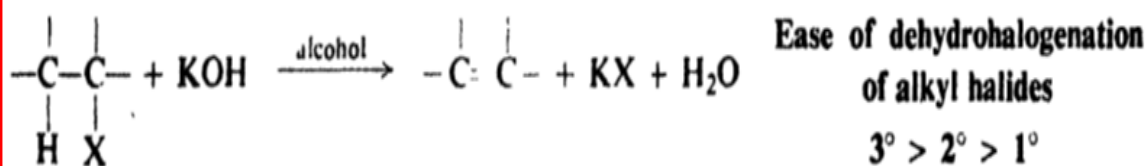
for example,



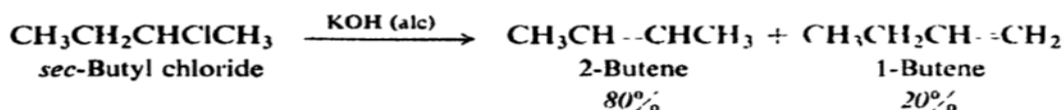
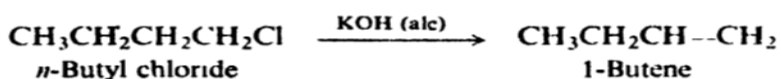
Prparation of Alkenes

1. Dehydrohalogenation of alkyl halides.

Alkyl halides are converted into alkenes by dehydrohalogenation: **elimination of the elements of hydrogen halide**. Dehydrohalogenation involves the removal of the halogen atom together with a hydrogen atom from a carbon adjacent to it.

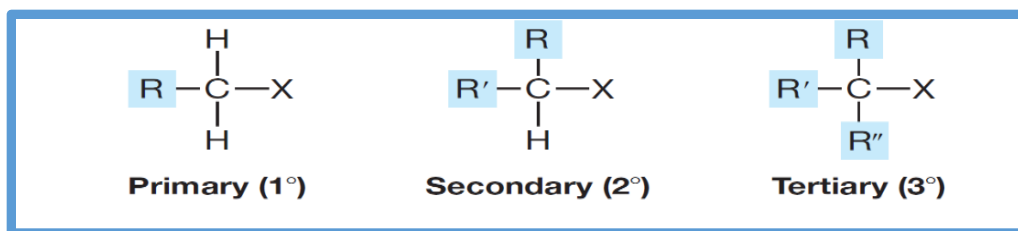


Examples:



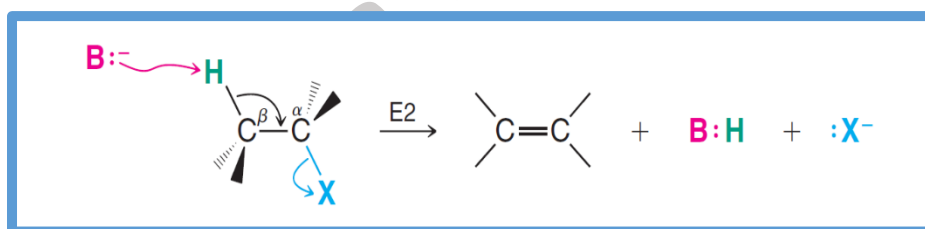
Alkyl Halides

- An alkyl halide has a **halogen atom bonded to an sp^3 -hybridised (tetrahedral) carbon atom**.
- **The carbon-halogen bond** in an alkyl halide is polarized because the halogen is more electronegative than carbon. Therefore, the carbon atom has a partial positive charge. Alkyl halides are classified as **primary (1°), secondary (2°), or tertiary (3°)** according to the number of carbon groups (R) directly bonded to the carbon bearing the halogen atom.



Mechanism of dehydrohalogenation

Elimination reactions are the most important means for **synthesizing alkenes**. The best reaction conditions to use when synthesizing an alkene by **dehydrohalogenation** are those that **promote an E2 mechanism**. In an E2 mechanism, a base **removes a beta hydrogen from the beta carbon, as the double bond forms and a leaving group departs from the alpha carbon**. The carbocation intermediate that accompanies an E1 reaction can **undergo rearrangement of the carbon skeleton**,



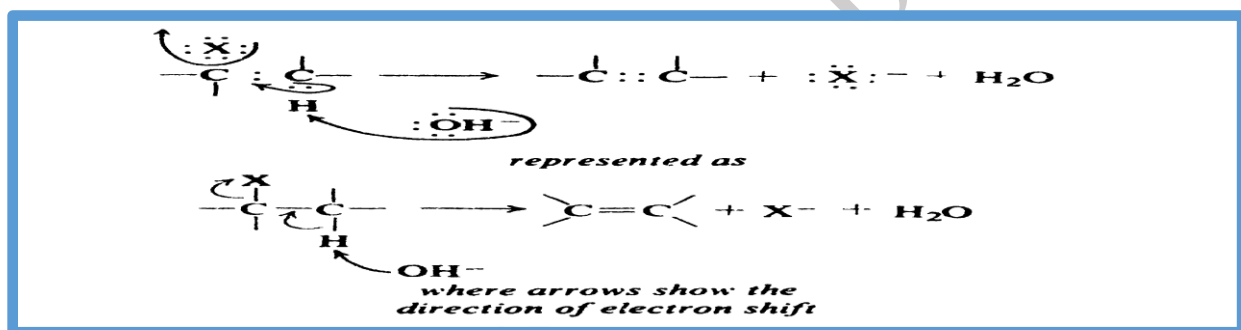
How to Favour an E2 Mechanism

1. Use a secondary or tertiary alkyl halide
2. Use a bulky base.
3. Use a high concentration of a strong base such as an alkoxide
4. Sodium ethoxide in ethanol (**EtONa/EtOH**) and potassium tert-butoxide in tert-butylalcohol (**t-BuOK/t-BuOH**) are bases typically used to promote **E2 reactions**.
5. Use elevated temperature because heat generally favours elimination over substitution.

Note: $\text{EtONa} \backslash \text{EtOH} = \text{C}_2\text{H}_5\text{ONa} \backslash \text{C}_2\text{H}_5\text{OH}$

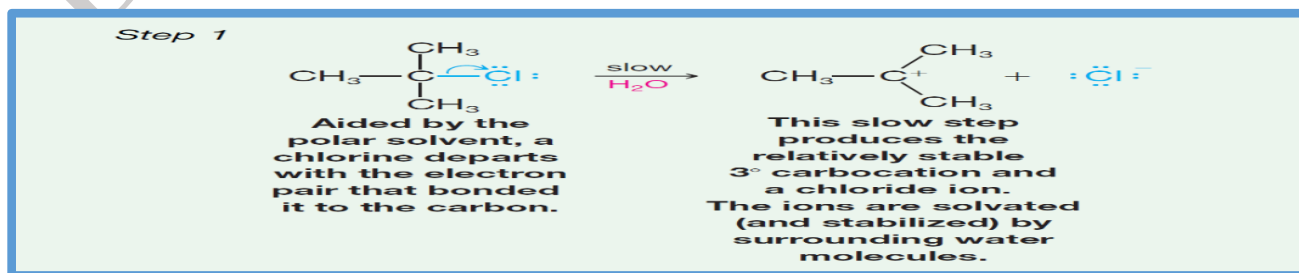
$\text{t-BuOK} \backslash \text{t-BuOH} = (\text{CH}_3)_3\text{COK} \backslash (\text{CH}_3)_3\text{COH}$

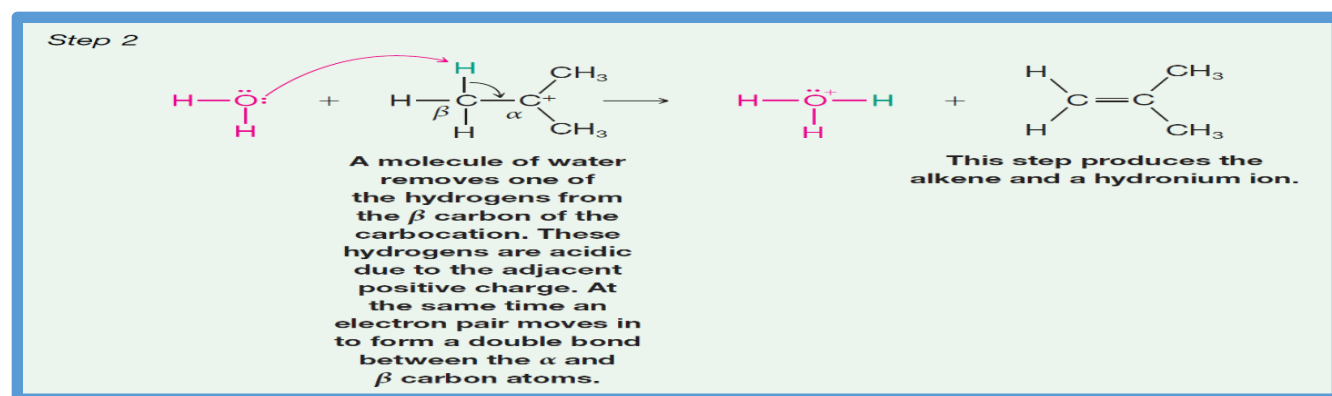
The function of the hydroxide ion is **to pull a hydrogen ion away from carbon**; simultaneously, **a halide ion separates**, and **the double bond forms**. In contrast to free radical reactions, the breaking of the C-H and C-X bonds occurs in an unsymmetrical fashion: hydrogen relinquishes both electrons to carbon, and the halogen retains both electrons. The electrons left behind by hydrogen are now available for the formation of the second bond (**the = bond**) between the carbon atoms. **We call this type of elimination an E2 reaction.**



Some elimination reactions follow a pathway that exhibits first-order kinetics. We call these types of eliminations **E1** reactions. Treating tert-butyl **chloride** with 80% aqueous ethanol at 25 °C, for example, gives substitution products in 83% yield by elimination product.

For example:





As one proceeds along a series of alkyl halides from **1** to **2** to **3**, the structure becomes more branched at the carbon carrying the halogen. This increased branching has two results: **it provides a greater number of hydrogens for attack by a base**, and hence **a more favourable probability factor toward elimination**; and it leads to a more highly branched, more stable alkene, and hence a more stable transition state and lower activation energy. As a result of this combination of factors, in dehydrohalogenation, the order of reactivity of **RX** is **3 > 2 > 1**.

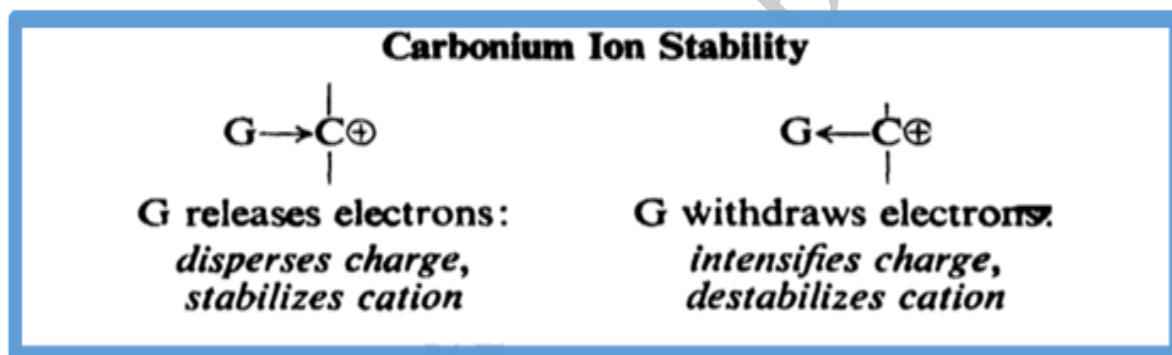
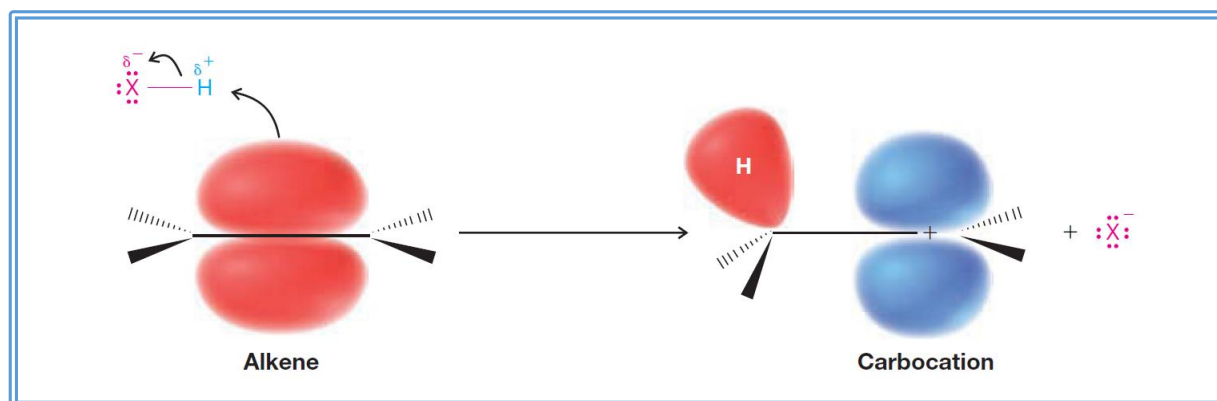
Tertiary Halides: **E1** reactions proceed through the formation of a common intermediate; the two types respond in similar ways to factors affecting reactivity. **E1** reactions are favoured with substrates that can form stable carbocations (i.e., tertiary halides); they are also favoured by the use of poor nucleophiles (weak bases), and they are generally favoured by the use of polar solvents.

. In general, however, substitution reactions of tertiary halides do not find wide use as synthetic methods. Such halides undergo eliminations much too easily.

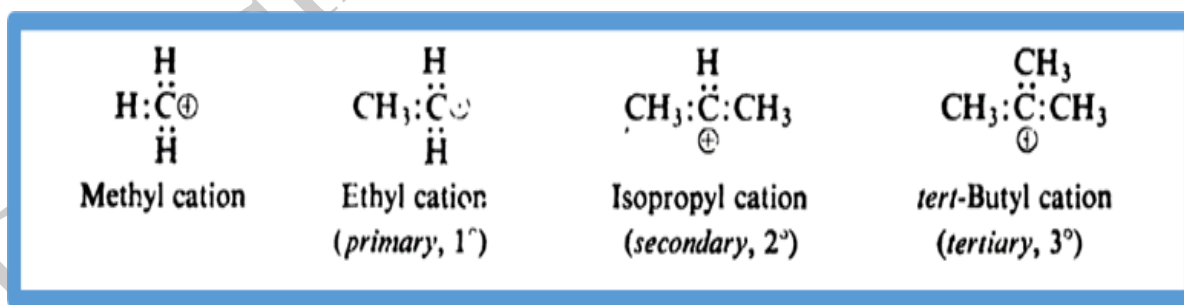
Increasing the temperature of the reaction favours the reaction by the E1 mechanism.

Carbonium ions

The carbonium ion is a group of atoms that contains **a carbon atom bearing only six electrons**. Carbonium ions are classified as **primary, secondary, or tertiary** after the carbon **bearing the positive charge**. They are named by the use of the word **cation**. For example:

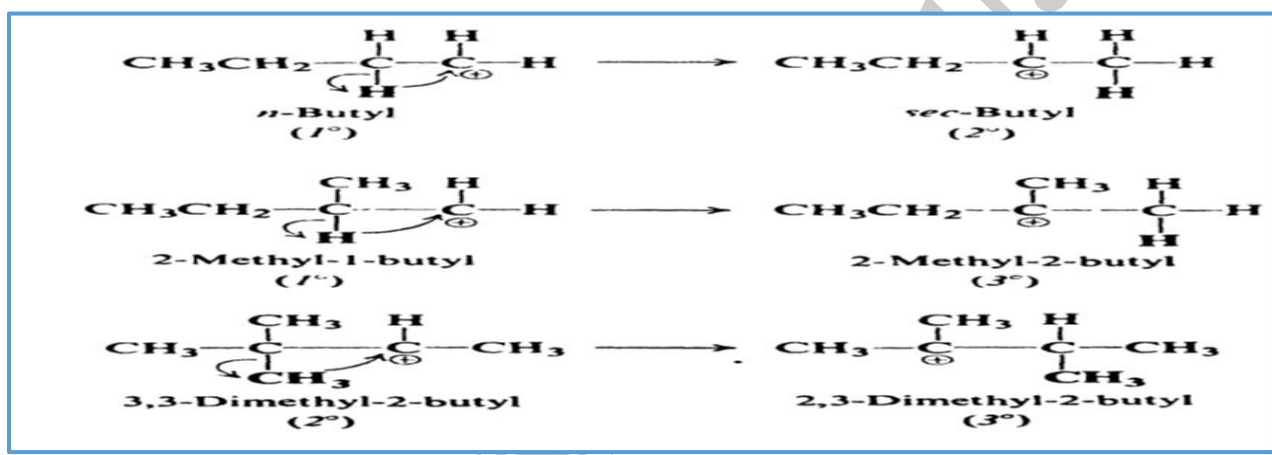


The facts are. Then, the greater the number of alkyl groups. **The more stable the carbonium ion**



Stability of carbonium ions $3^{\circ} > 2^{\circ} > 1^{\circ} > \text{CH}_3^{+}$

In the case of the **t-butyl cation**, a shift of hydrogen yields the more stable **t'-butyl cation**; migration of an ethyl group would simply form a different w-butyl cation. In the case of the 2-methyl-1-butyl cation, a hydride shift yields a tertiary cation, and hence is preferred over a methyl shift, which would only yield a secondary cation. In the case of **the 3,3-dimethyl-2-butyl cation**, on the other hand, a methyl shift can yield a tertiary cation and **is the rearrangement that takes place**.



Reactions of involved rearrangements that followed; of the carbonium ion. **The occurrence (or non-occurrence)** of rearrangements of the kind we have seen here is the best and sometimes the only evidence for (or against) the intermediate formation of carbonium ions. In our short acquaintance with the carbonium ion, we have encountered two

of its reactions. A carbonium ion may:

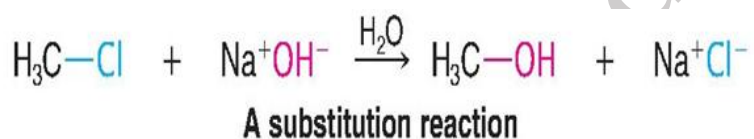
- eliminate a hydrogen ion to form an alkene;**
- Rearrange to a more stable carbonium ion.**

In rearrangement, as in every other reaction of a carbonium ion, the electron-deficient carbon atom gains a pair of electrons, this time at the expense of a neighbouring carbon atom, one that can better accommodate **the positive charge**.

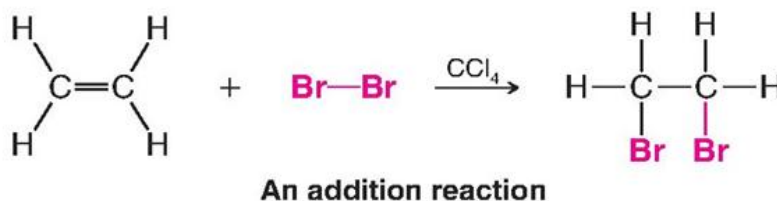
Organic Reactions

Virtually all organic reactions fall into one of four categories: **substitutions, additions, eliminations, or rearrangements.**

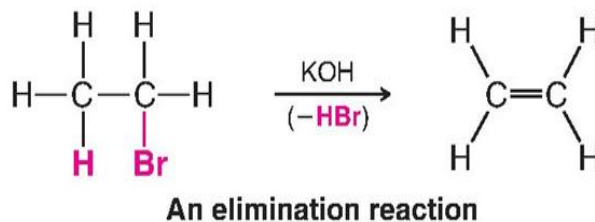
1-Substitution reaction



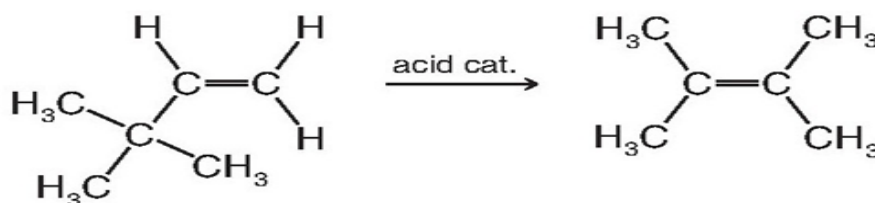
2-Additions reaction ;



3-Eliminations reaction



4- Rearrangement reaction

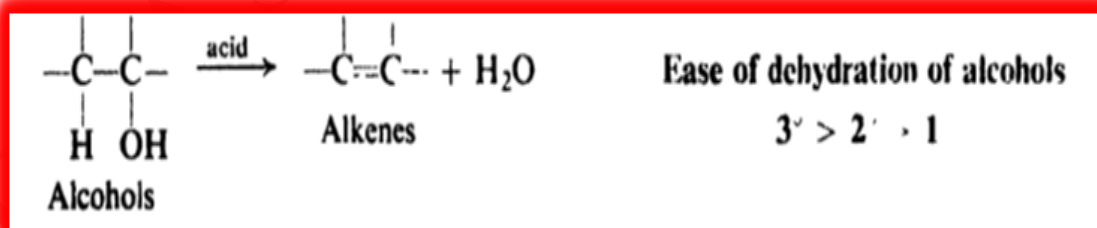


A rearrangement

2-Dehydration of alcohols;

An alcohol is converted into an alkene by dehydration: **elimination of a molecule of water**. Dehydration requires the presence of an acid and the application of heat. It is generally carried out in either of two ways:

- (a) heating the alcohol with sulfuric or phosphoric acid to temperatures as high as 200, or
- (b) passing the alcohol vapour over alumina, Al_2O_3 , at 350-400, alumina here serving as a Lewis acid.

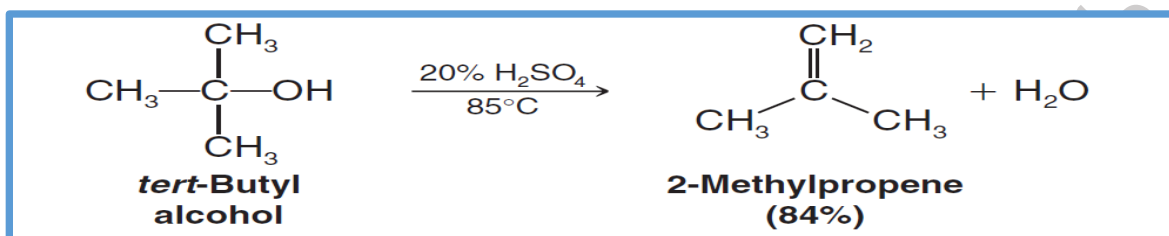


1. The temperature and concentration of acid required to dehydrate an alcohol depend on **the structure of the alcohol substrate**.

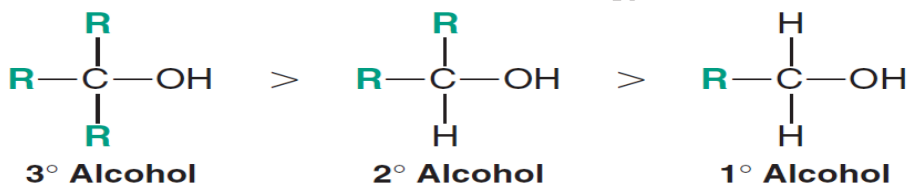
(a) Primary alcohols are the most difficult to dehydrate. Dehydration of ethanol, for example, **requires concentrated sulfuric acid and a temperature of 180°C**:

(b) Secondary alcohols usually dehydrate under **milder conditions**

(c) Tertiary alcohols are usually **so easily dehydrated that extremely mild conditions can** be used. Tert-butyl alcohol, for example, dehydrates in 20% aqueous sulfuric acid at a temperature of 85°C:

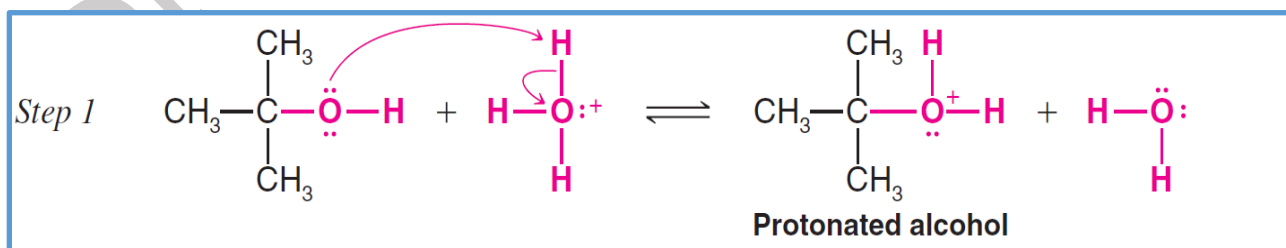


Thus, overall, the relative ease with which **alcohols undergo dehydration** is in the following order:



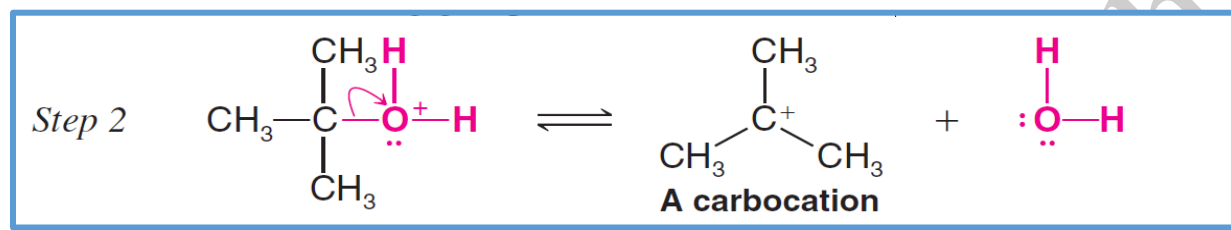
Mechanism for Dehydration of Secondary and Tertiary Alcohols: An E1 Reaction

The mechanism is an E1 reaction in which the substrate is a protonated alcohol. Consider the dehydration of tert-butyl alcohol as an example:

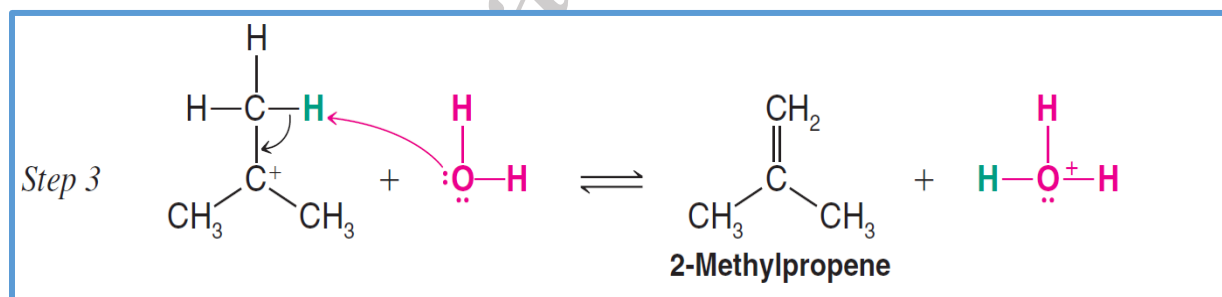


In this step, in an acid–base reaction, a proton is rapidly transferred from the acid to one of the unshared electron pairs of the alcohol. In dilute sulfuric acid,

the acid is a hydronium ion; in concentrated sulfuric acid, the initial proton donor is sulfuric acid itself. **This step is characteristic of all reactions of an alcohol with a strong acid.** The presence of the positive charge on the oxygen of the protonated alcohol weakens all bonds to oxygen, including the carbon–oxygen bond, and in step 2 the carbon–oxygen bond breaks. **The leaving group is a molecule of water:**



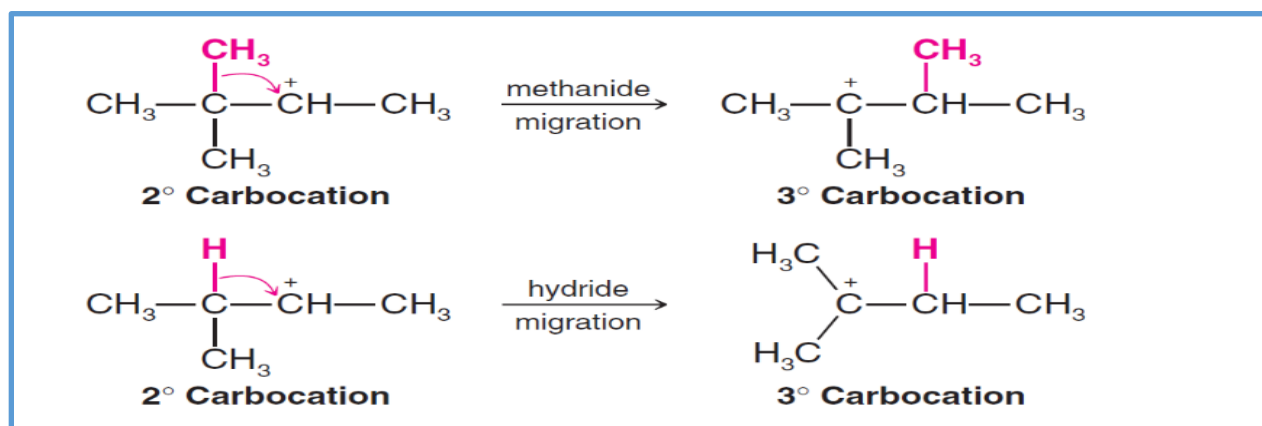
The carbon–oxygen bond breaks heterolytically. The bonding electrons depart with the water molecule and leave behind a carbocation. **The carbocation** is, of course, highly reactive **because the central carbon atom has only six electrons in its valence level, not eight.** Finally, in step 3, a water molecule removes a proton from the **β** carbon of the carbocation. The result is the formation of a hydronium ion and an alkene:



In step 3, also an acid–base reaction, any one of the nine protons available at the three methyl groups can be transferred to a molecule of water. The electron pair left behind when a proton is removed becomes the second bond of the double bond of the alkene. Notice that this step restores an octet of electrons to the central carbon atom. An orbital representation of this process, with the transition state, is as follows.

Formation of the more stable alkene is the general rule in acid-catalysed dehydration of alcohols (**Zaitsev's rule**).

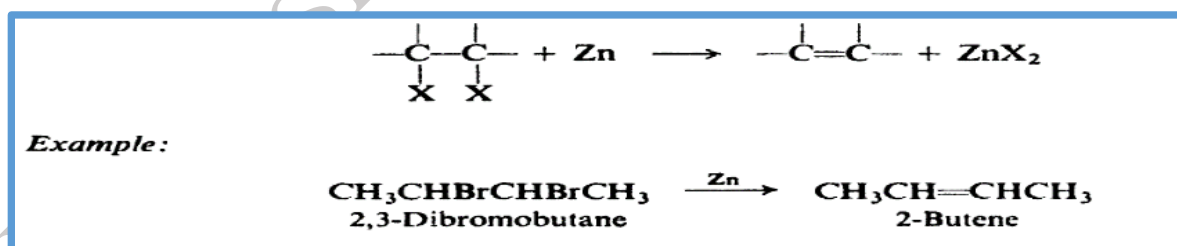
Studies of many reactions involving carbocations show that rearrangements occur. They occur almost invariably when **the migration of a methyl cation or hydride ion** can lead to a **more stable carbocation**. The following are examples.



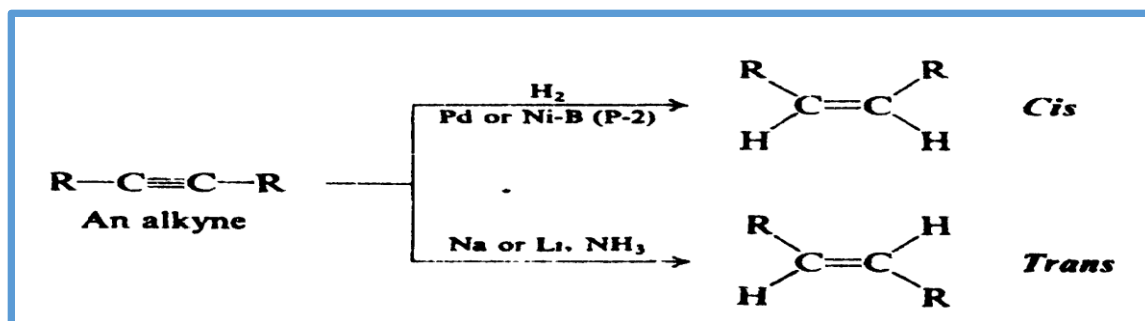
. Whenever an **elimination occurs to give the more stable**, more highly substituted alkene. The reason for this behaviour is related to the double-bond character that develops in the transition state

3-Dehydration of a vicinal dihalide

Neighbouring dihalide treatment with zinc to form a double bond



4. Reduction of alkynes.



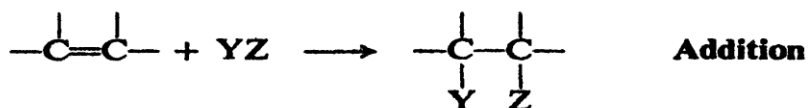
Reaction of Alkenes: Electrophilic and Free-Radical Addition

A reaction in which two molecules combine to yield a single molecule of product is called an **addition reaction**. The reagent is simply added to the organic molecule, **in contrast to a substitution reaction where part of the reagent is substituted for a portion of the organic molecule**. Addition reactions are **necessarily limited to compounds that contain atoms sharing more than one pair of electrons**, that is, electrons holding together the carbon nuclei. As a result, they are themselves held less tightly. These acidic reagents that are seeking a pair of electrons are called **electrophilic reagents (Greek: electron-loving)**. Reagents of another kind, **free radicals**, seek electrons or, rather, seek an electron. And so we find that alkenes also undergo **free-radical addition**.

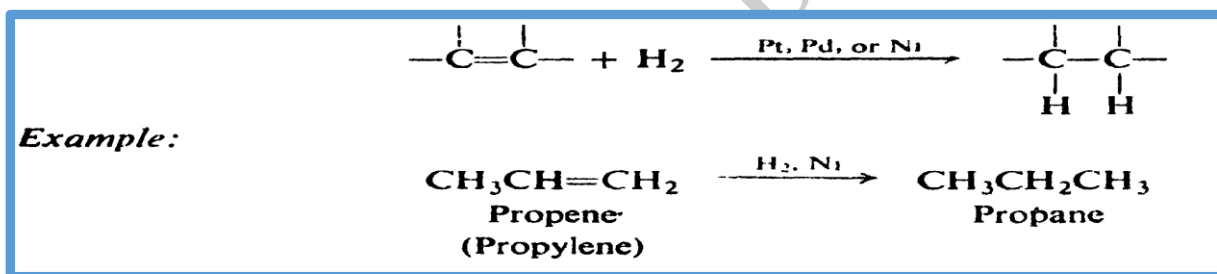
Electrophilic Addition: Electrons in the **π bond** of alkenes react with electrophiles. Electrophiles are electron-seeking reagents. They have the property of being electrophilic.

Reaction of Alkenes

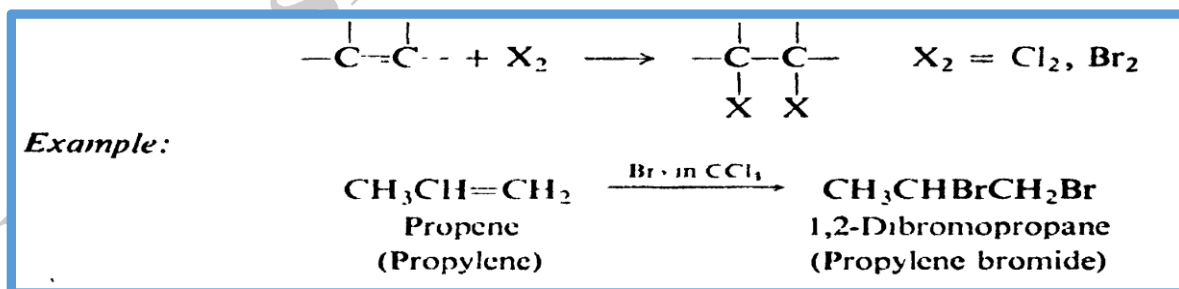
Addition Reactions: involve the breaking of this weaker bond. The typical reactions of the double bond are of the sort where **the π bond is broken**, and **two strong σ bonds are formed in its place**. A reaction in which two molecules combine to yield a single molecule of product is called an **addition reaction**. The reagent is simply added to the organic molecule, in contrast to a substitution reaction where part of the reagent is substituted for a portion of the organic molecule. Addition reactions are necessarily limited to compounds that contain atoms sharing more than one pair of electrons, that is, to compounds that contain multiply-bonded atoms.

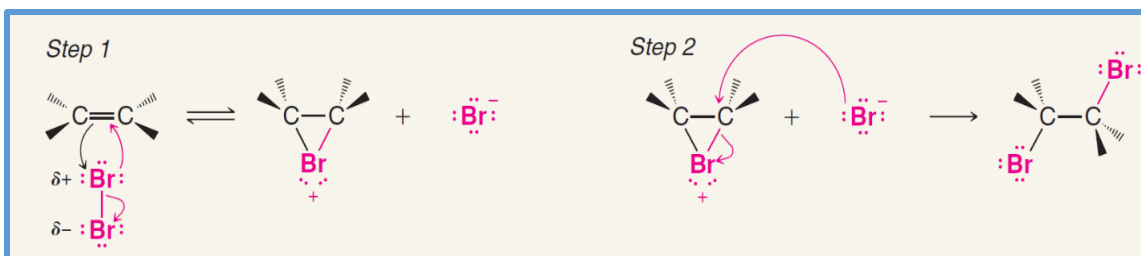


1. Addition of hydrogen.



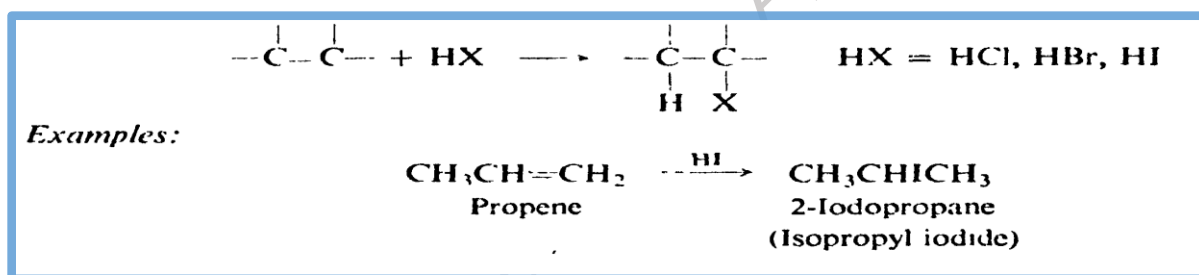
2. Addition of halogens





3-Addition of hydrogen halides.

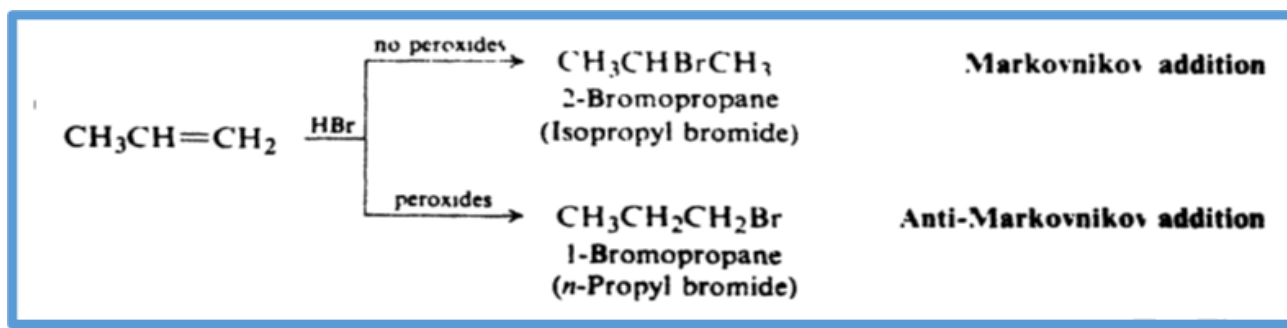
An alkene is converted by hydrogen chloride, hydrogen bromide, or hydrogen iodide into the corresponding alkyl halide., Ethylene is converted into an ethyl halide, the hydrogen becoming attached to **one doubly-bonded carbon and the halogen to the other**.



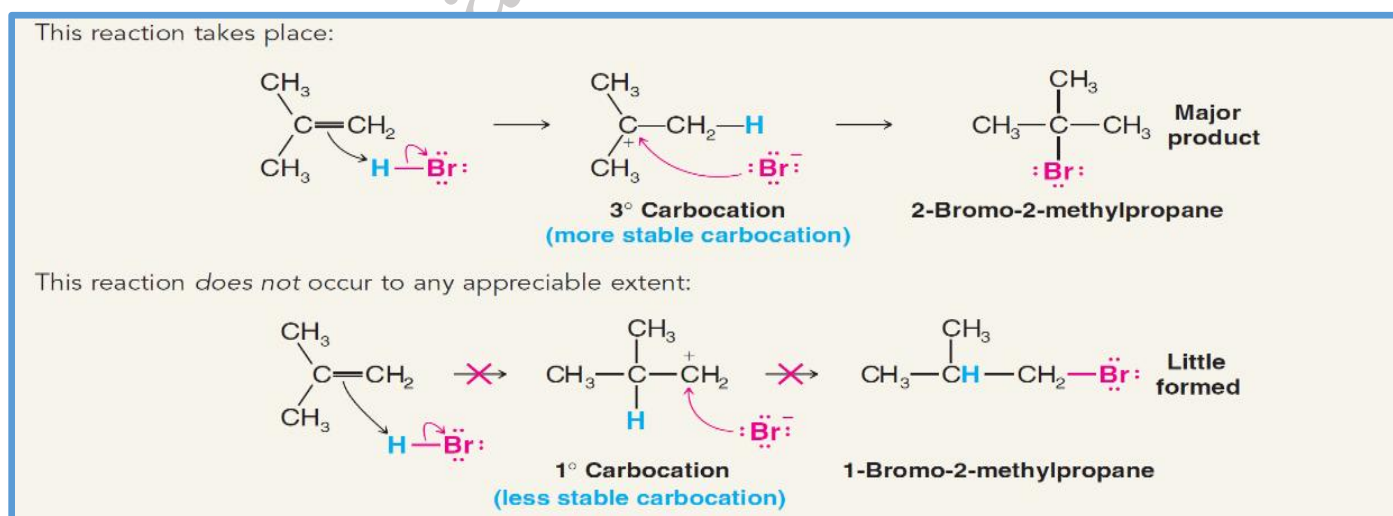
In the ionic addition of an acid to the carbon-carbon double bond of an alkene, the hydrogen of the acid attaches itself to the carbon atom that already holds the greater number of hydrogens. This statement is generally **known as Markovnikov's rule**.

Addition of hydrogen chloride and hydrogen iodide to alkenes follows Markovnikov's rule. That addition of hydrogen bromide to a particular alkene yields a product in agreement with Markovnikov's rule; he brought order to this chemical chaos by discovering that the orientation of addition of hydrogen bromide to the carbon-carbon double bond is determined solely by the presence or **absence of peroxides**.

Addition of hydrogen bromide.

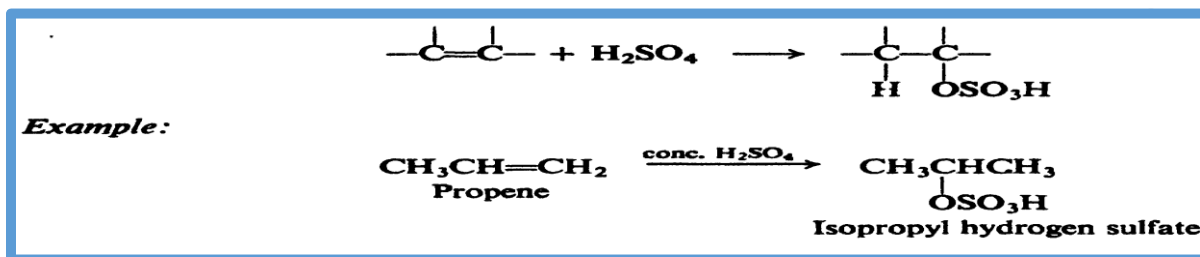


Mechanism of Addition of HBr in the presence of H_2O_2 and in the absence of H_2O_2

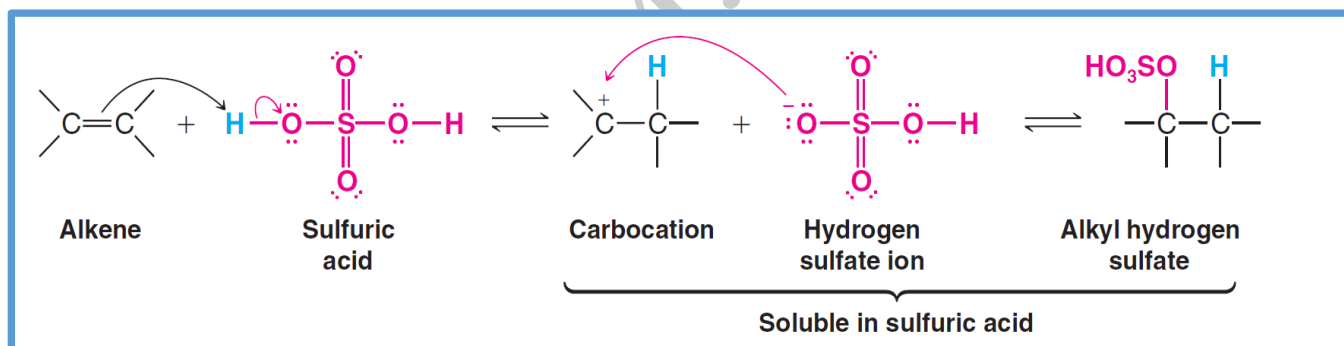


4. Addition of sulfuric acid.

The addition of **sulfuric acid** is also regioselective, and it **follows Markovnikov's rule**. Alkenes react with cold, concentrated sulfuric acid to form compounds of the **general formula ROSO_3H** , known as alkyl hydrogen sulfates. These products are formed by addition of a hydrogen ion to one side of the double bond and bisulfate

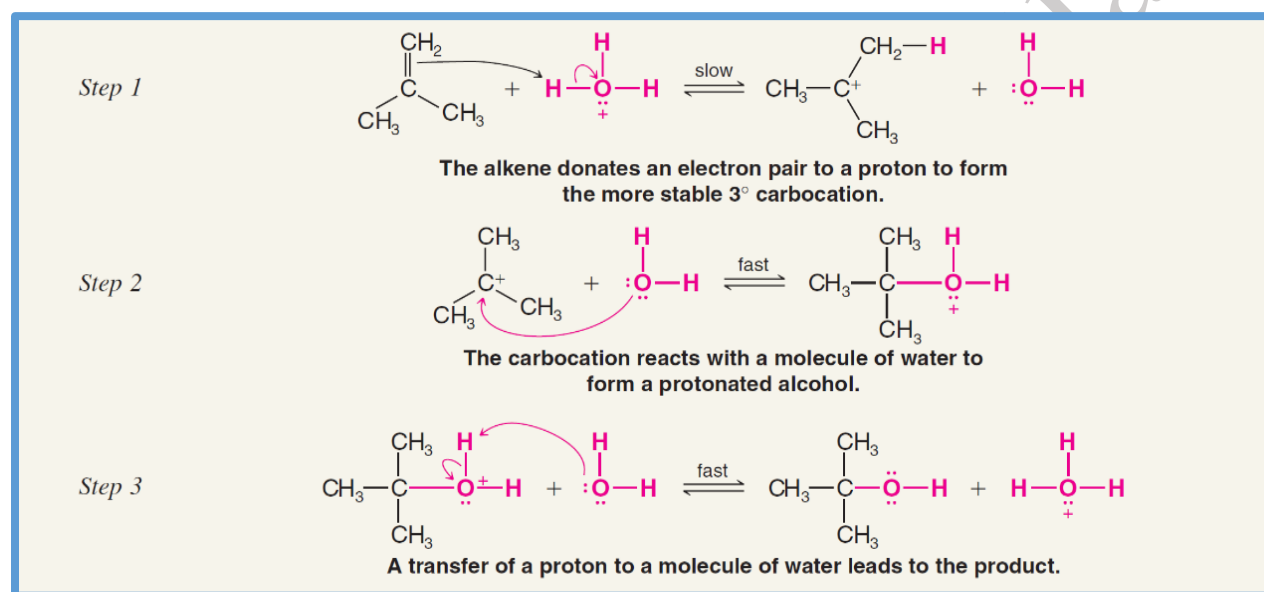
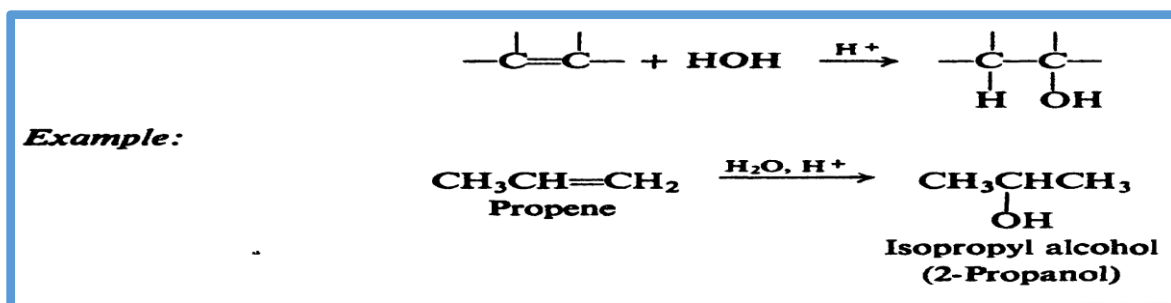


The mechanism is similar to that for the addition of HX. In the first step of this reaction, the alkene donates a pair of electrons to a proton from sulfuric acid to form a carbocation; in the second step, the carbocation reacts with a hydrogen sulfate ion to form an alkyl hydrogensulfate:



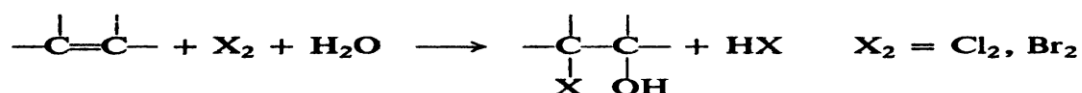
5-Addition of water. Hydration

Water adds to the more reactive alkenes in **the presence of acids** to yield **alcohols**. This addition, too, **follows Markovnikov's rule**.

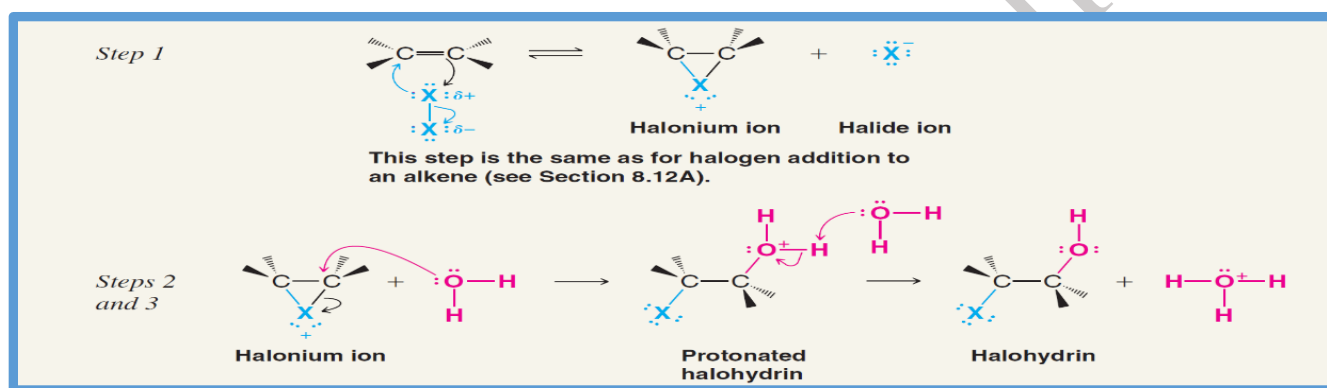
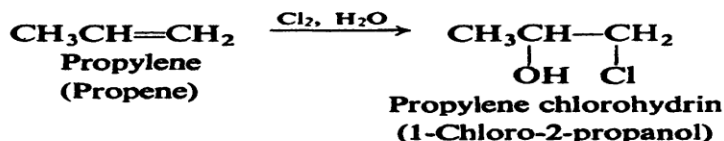


6 -Halohydrin formation.

Addition of chlorine or bromine in the presence of water can yield compounds containing **halogen and hydroxyl groups** on adjacent carbon atoms. These compounds are commonly referred to as **halohydrins**



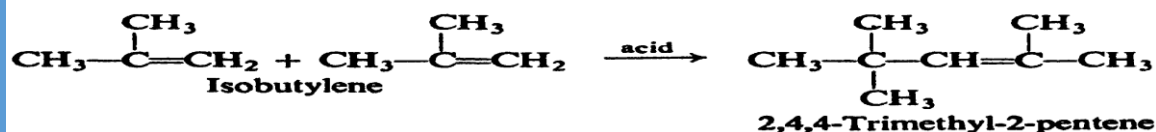
Example:



7-Addition of alkenes (Dimerisation)

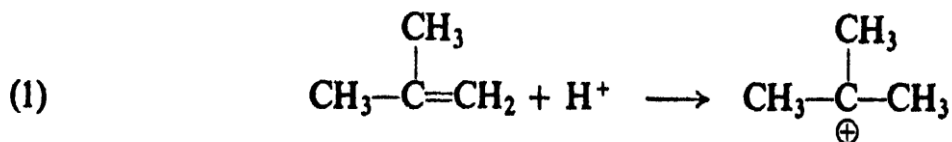
Alkenes produced contain exactly twice the number of carbon and hydrogen atoms; they are known as dimers (di = two, mer = part). The reaction is called dimerization. Other alkenes undergo analogous dimerizations..for example, **isobutylene**

Example:

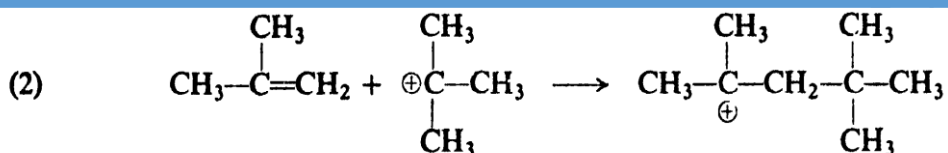


Mecanism

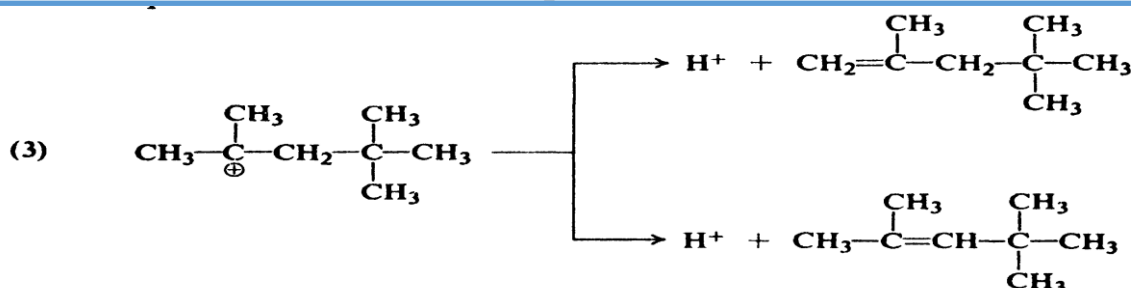
Step (1) addition of a hydrogen ion to isobutylene to form the carbonium ion; the tertiary cation is the preferred ion.



Step (2) addition of the tert-butyl cation to isobutylene; again, the orientation of addition is such as to yield the more stable tertiary cation.

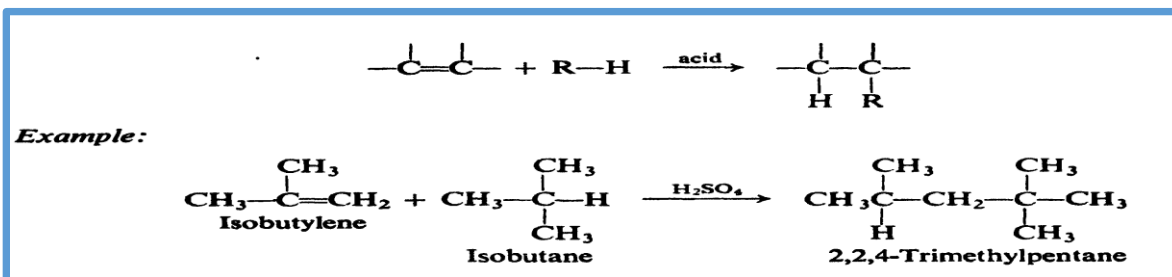


Step (3). The hydrogen ion can be lost from a carbon on either side of the positively charged carbon; two products should be possible.



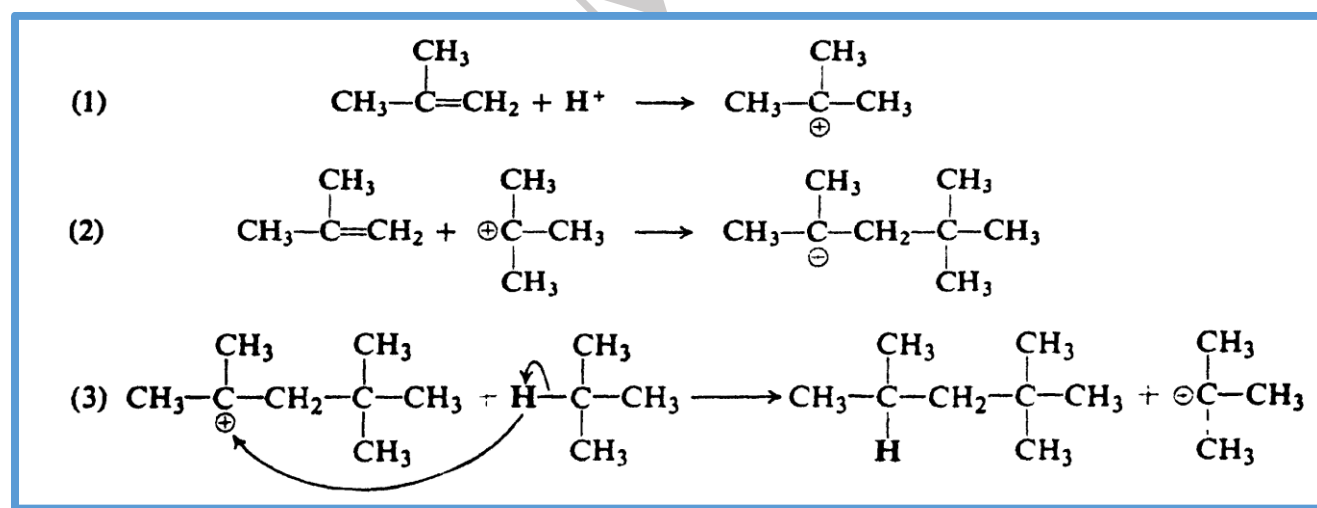
8-Addition of alkenes (Alkylation.)

This reaction is, in effect, addition of an alkane to an alkene, in the presence of an acidic catalyst, to form directly 2,2,4-trimethylpentane, or "iso-octane"



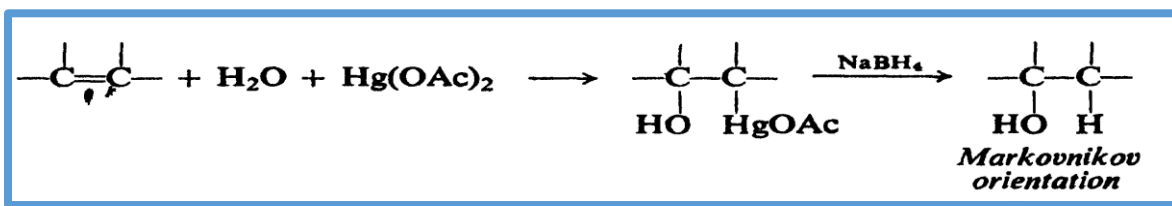
Mecanisum

The first two steps are identical with those of the dimerization reaction. In step (3), a carbonium ion abstracts a hydrogen atom with its pair of electrons from a molecule of alkane. This abstraction of a hydride ion yields an alkane of eight carbons, and a new carbonium ion to continue the chain. As we might expect, abstraction occurs in the way that yields the tert-butyl cation rather than the less stable (1°) isobutyl cation

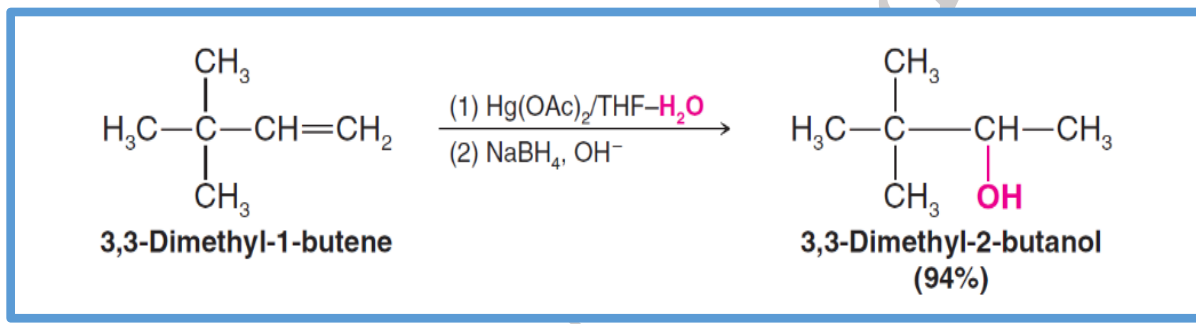


9- Oxymercuration-demercuration

In oxymercuration–demercuration, the net orientation of the addition of the elements of water, **H** and **OH**, is in accordance **with Markovnikov's rule (Markovnikov's orientation)**. The H becomes attached to the carbon atom **of the double bond** with the greater number of hydrogen atoms.

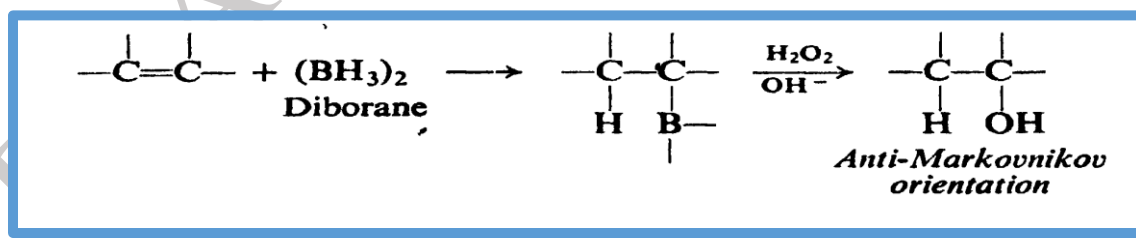


For example:

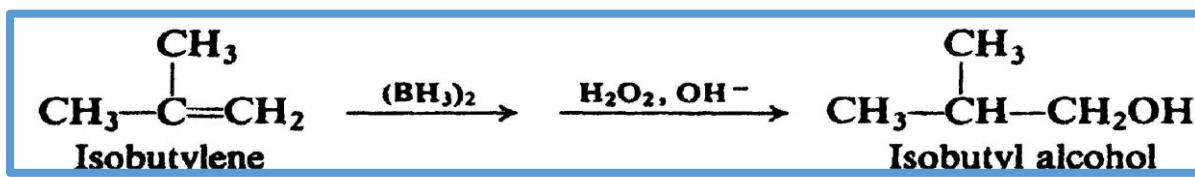


10- Hydroboration-oxidation.

Anti-Markovnikov orientation of a double bond can be achieved through the use of **diborane (B₂H₆)** or a solution of **borane** in tetrahydrofuran (BH₃:THF).

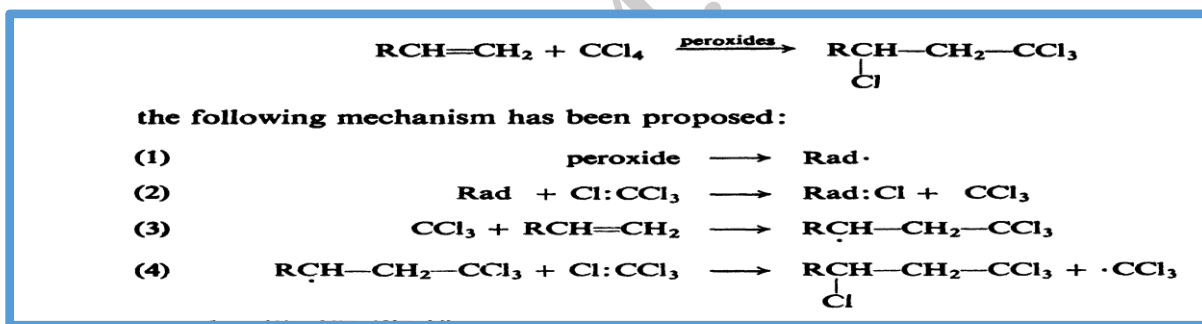
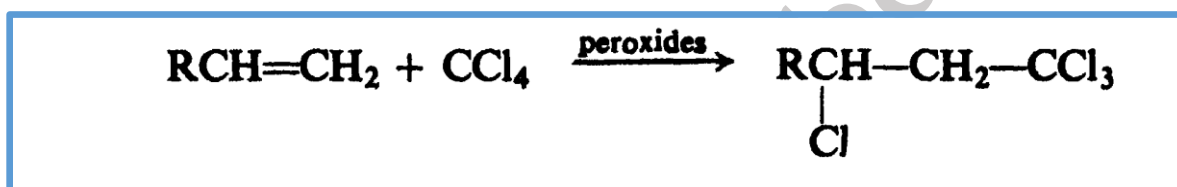


For example:



11. Addition of free radicals

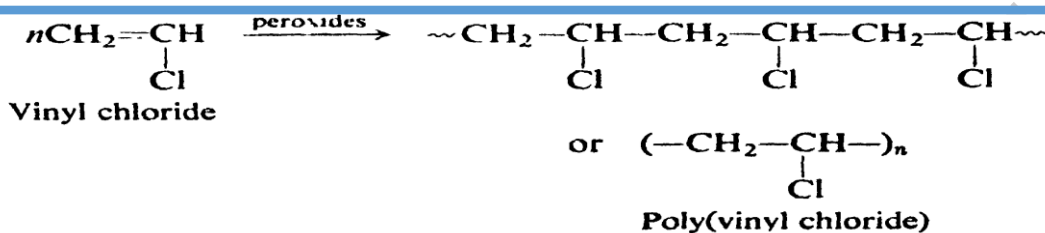
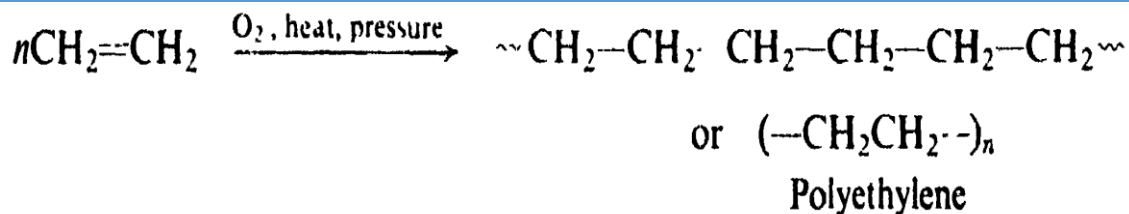
The addition of **carbon tetrachloride** to an alkene by a free-radical addition polymerization



then (3), (4), (3), (4), etc.

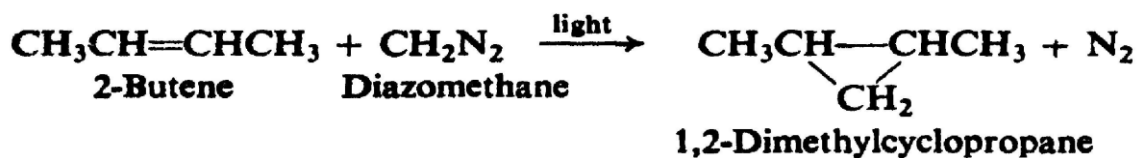
12. Polymerization

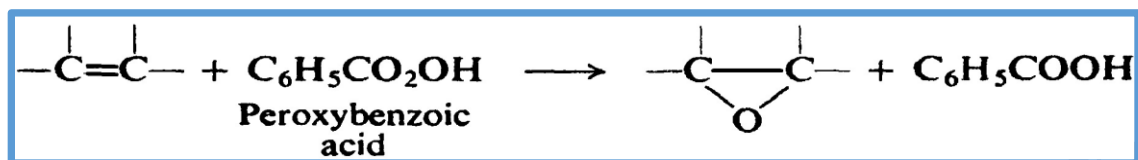
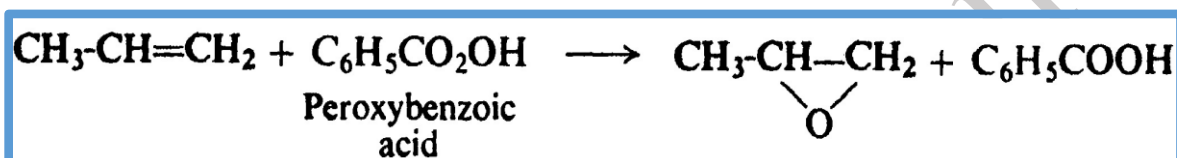
polymerization: the joining together of many small molecules to make very large molecules. The compound composed of these very large molecules is called a polymer.



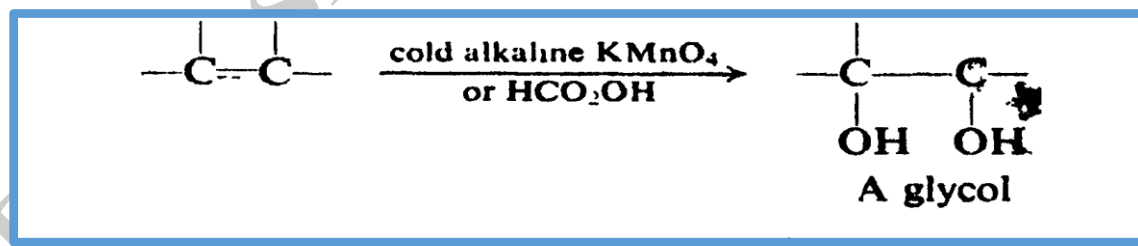
13. Addition of carbenes

The simplest carbene is the compound called methylene ($:\text{CH}_2$). Methylene can be prepared by the decomposition of diazomethane (CH_2N_2), a very poisonous yellow gas,

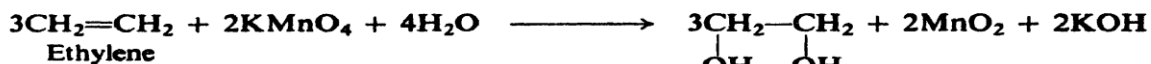


14-Epoxidation:**Example:****15-Hydroxylation. Glycol formation**

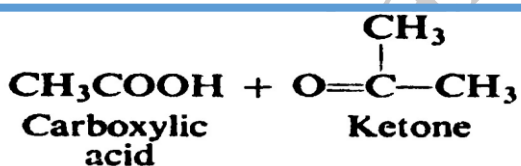
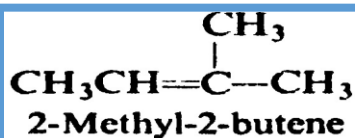
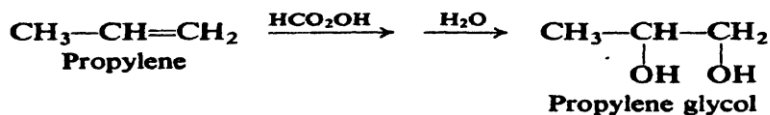
Alkenes undergo a number of reactions in which **the carbon-carbon double bond** is oxidized. **1,2-Dihydroxylation** is an important oxidative addition reaction of alkenes. Osmium tetroxide is widely used to synthesize **1,2-diols** (the products of 1,2-dihydroxylation, sometimes also called **glycols**). **Potassium permanganate can also be used**, although because it is a stronger oxidizing agent, it is prone to cleave the diol through further oxidation. Certain oxidising agents convert alkenes into compounds known as glycols. **Glycols are simply dihydroxy alcohols**



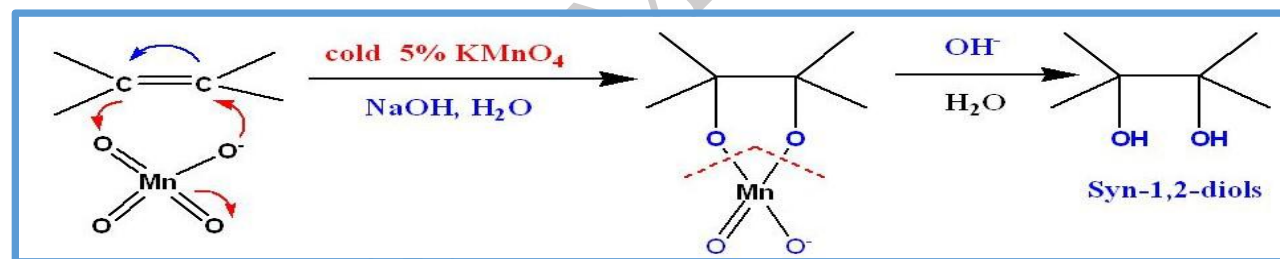
Of the numerous oxidizing agents that cause hydroxylation, two of the most commonly used are (a) **cold alkaline KMnO₄**, and (b) **peroxyformic acid, HCO₂OH**.



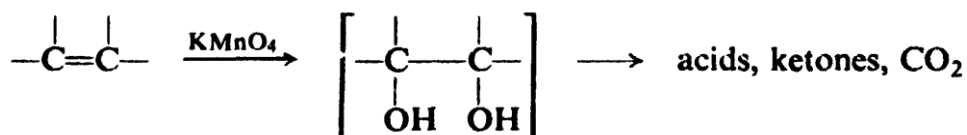
Ethylene glycol



Mechanism:

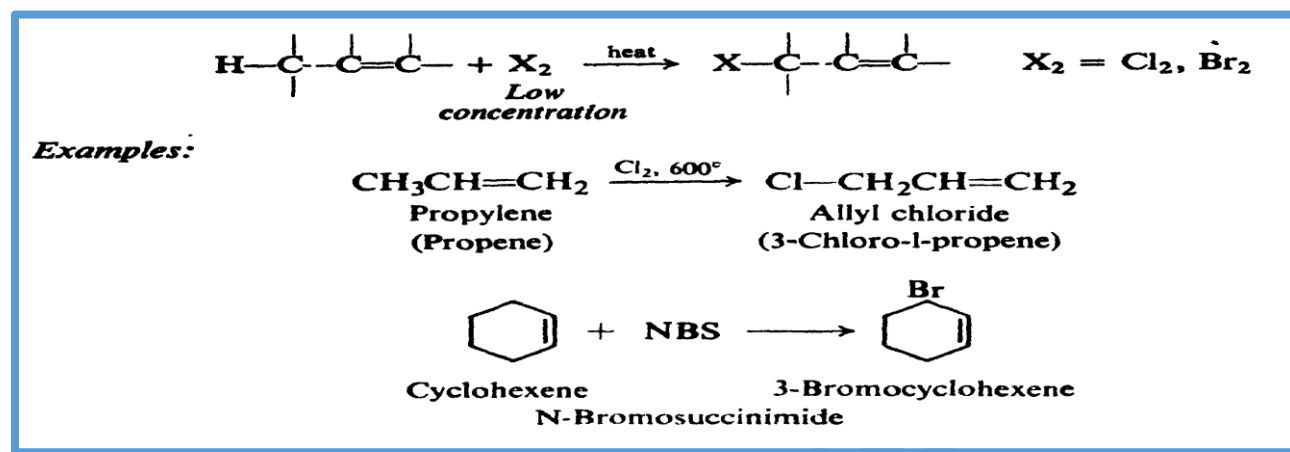


Reaction with KMnO_4 (Cold)



Substitution Reactions

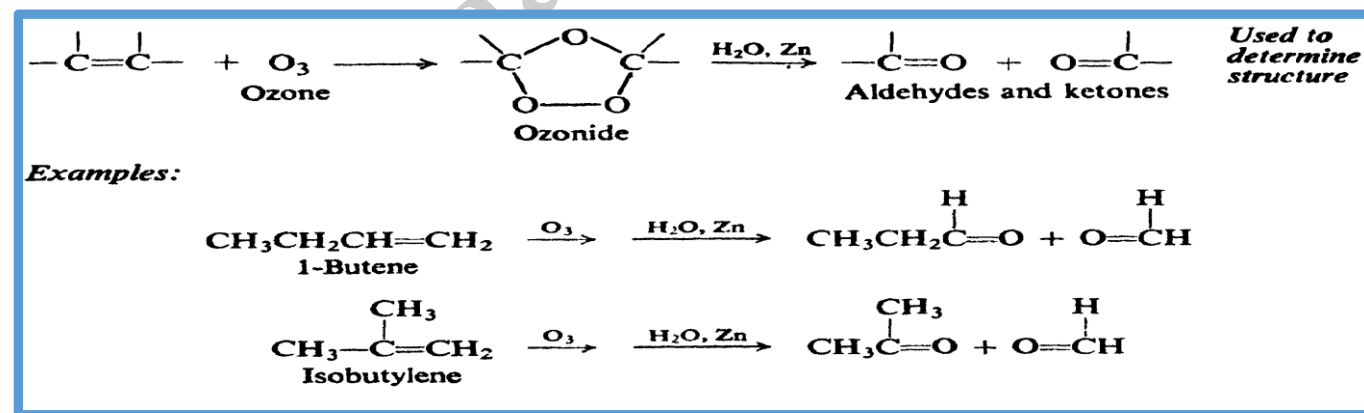
16- Halogenation. Allylic substitution



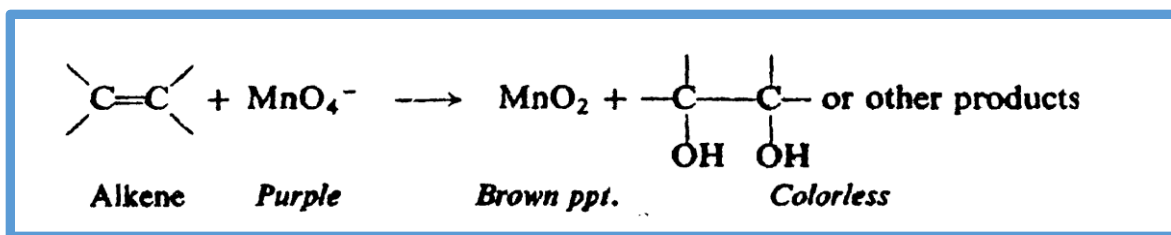
Cleavage Reactions

17- Ozonolysis.

The most useful method for cleaving alkenes is to use ozone (O₃). Ozonolysis consists of bubbling ozone into a very cold (-78°C) solution of the alkene. The overall result is as follows:



The mechanism of ozone addition to alkenes begins with the formation of unstable compounds called **initial ozonides** (sometimes called **molozonides**). The process occurs vigorously and leads to spontaneous (and sometimes noisy) rearrangement of compounds known as **ozonides**. The rearrangement is believed to occur with dissociation of the initial ozonide into **reactive fragments that recombine to yield**



3- Alkenes dissolve in cold concentrated sulfuric acid, H_2SO_4 : Alcohols and ethers dissolve in H_2SO_4 , but alkanes and haloalkanes do not react with it.

4- Instrumental method: Infrared spectroscopy IR can be used as an analytical instrument to detect alkenes.