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Lecture 5 Alkene

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Alkenes



ALKENES

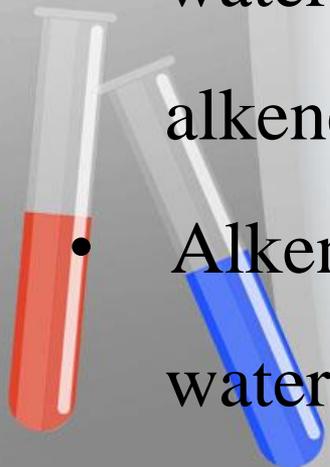
□ Introduction

- Alkenes are hydrocarbons whose molecules contain the C–C double bond.
- Also called olefins
- Contain at least one carbon-carbon double bond (C=C)
- General formula, C_nH_{2n} ($n=2,3,\dots$)
- Classified as unsaturated hydrocarbons (compound with double or triple carbon-carbon bonds that enable them to add hydrogen atoms).
- **sp²** -hybridized
- For example:
 C_2H_4 – Ethene (ethylene) $CH_2=CH_2$



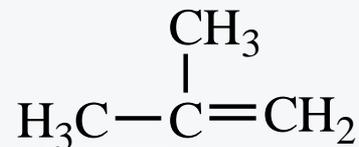
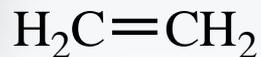
PHYSICAL PROPERTIES OF ALKENES

- Alkenes and alkynes have physical properties similar to those of corresponding alkanes.
 - 1) Alkenes and alkynes up to four carbons (except 2-butyne) are gases at room temperature.
 - 2) Alkenes and alkynes dissolve in nonpolar solvents or in solvents of low polarity.
- Alkenes and alkynes are only *very slightly soluble* in water (with alkynes being slightly **more** soluble than alkenes).
- Alkenes and alkynes have densities **lower** than that of water.



Nomenclature of Alkenes and cycloalkenes

1) Alkene common names:



IUPAC: Ethene

IUPAC: Propene

IUPAC: 2-Methylpropene

Common: Ethylene

Common: Propylene

Common: Isobutylene

2) IUPAC rules

1. Determine the **parent name** by selecting **the longest chain** that **contains the double bond** and change the ending of the name of the alkane of identical length from **-ane to -ene**.

2. **Number the chain** so as to **include both carbon atoms** of the double bond, and begin numbering at **the end of the chain nearer the double bond**. Designate the **location of the double bond** by using **the number of the first atom** of the double bond as a prefix:

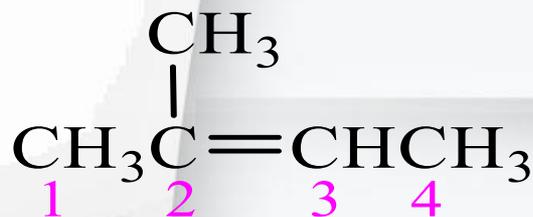


1-Butene (*not* 3-Butene)



2-Hexene (*not* 4-hexene)

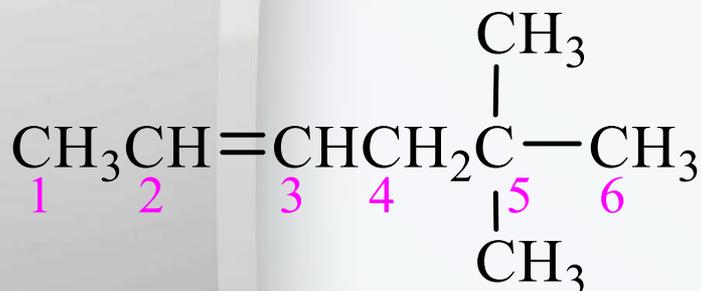
3. Indicate the **locations** of the **substituent groups** by the numbers of the carbon atoms to which they attached.



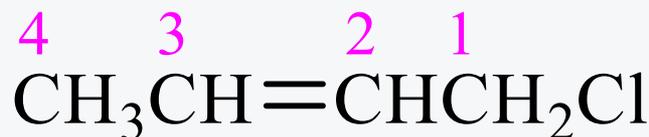
2-Methyl-2-butene
(not 3-methyl-2-butene)



2,5-Dimethyl-2-hexene
(not 2,5-dimethyl-4-hexene)

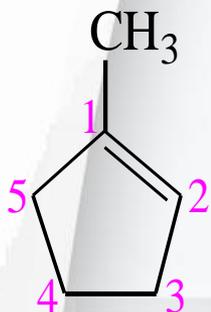


5,5-Dimethyl-2-hexene

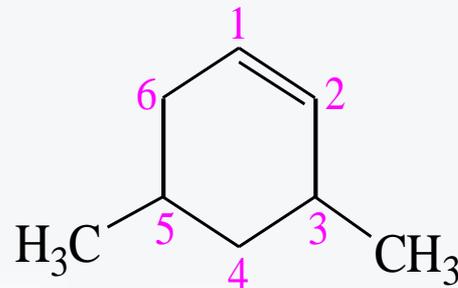


1-Chloro-2-butene

4. Number substituted cycloalkenes in the way that **gives the carbon atoms of the double bond the 1 and 2 positions** and that also **gives the substituent groups the lower numbers at the first point of difference**.

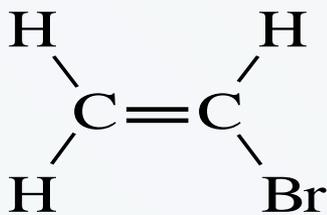
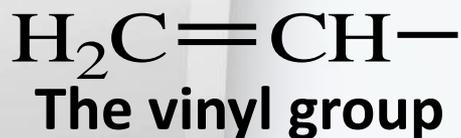


1-Methylcyclopentene
(not 2-methylcyclopentene)



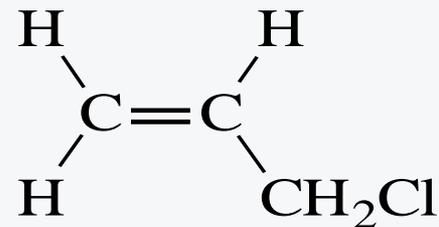
3,5-Dimethylcyclohexene
(not 4,6-dimethylcyclohexene)

5. The **vinyl group** and the **allyl group**.

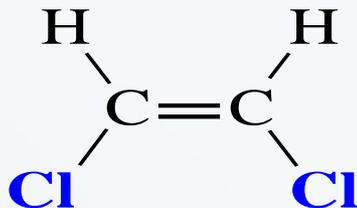


Bromoethene or
vinyl bromide (common)

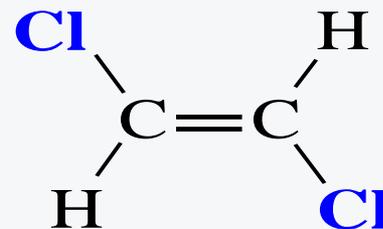
3-Chloropropene or
allyl chloride (common)



6. **Cis-** and **trans-**alkenes:.



cis-1,2-Dichloroethene

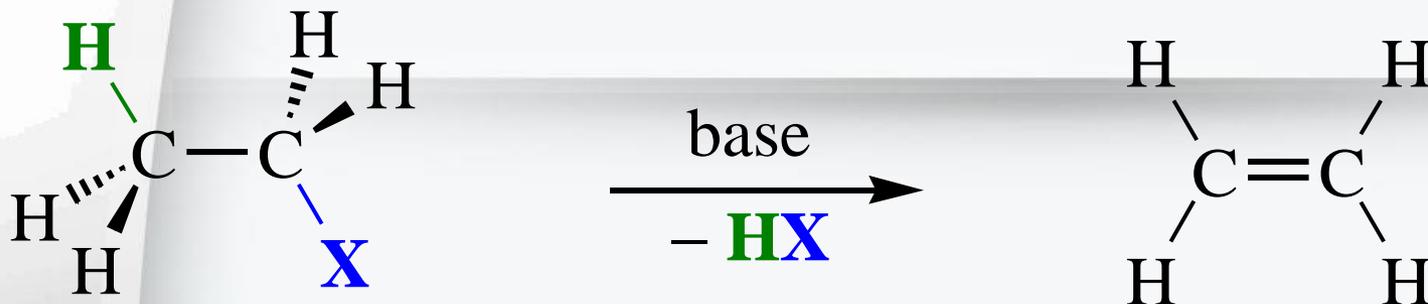


trans-1,2-Dichloroethene

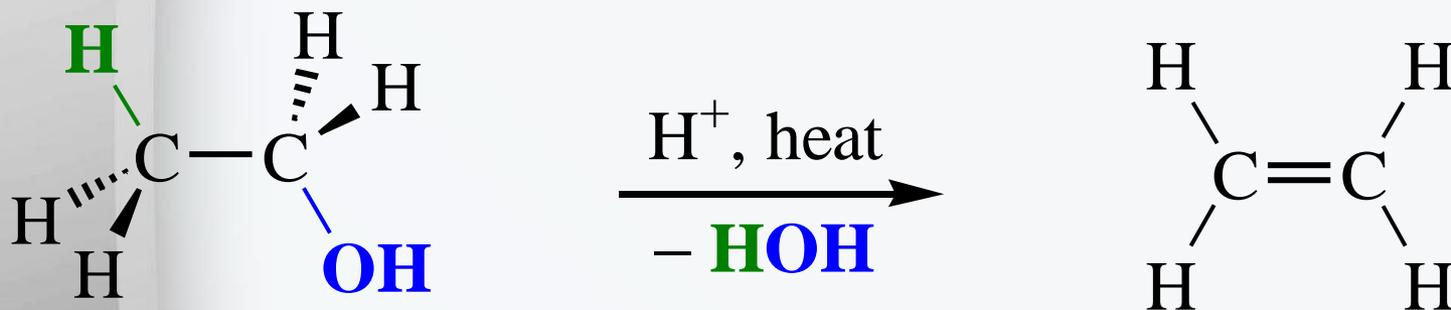


Synthesis of Alkenes via Elimination Reactions

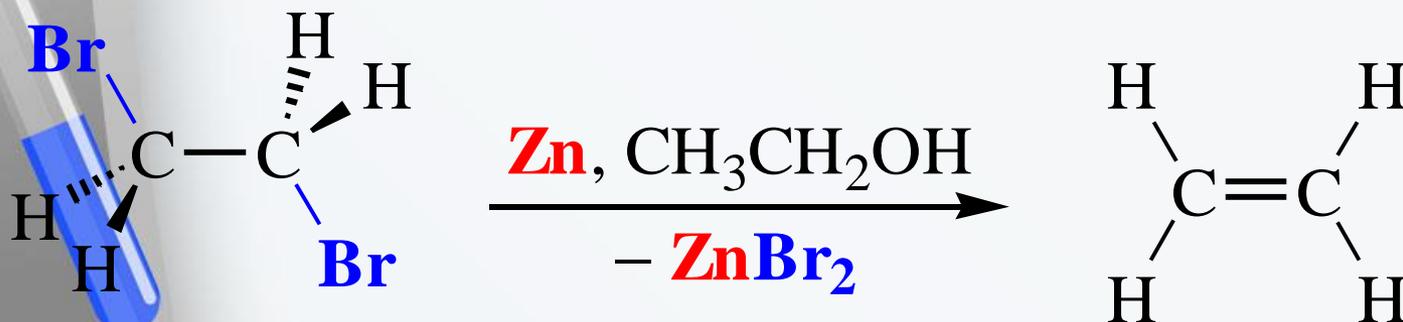
1. Dehydrohalogenation of Alkyl Halides



2. Dehydration of Alcohols

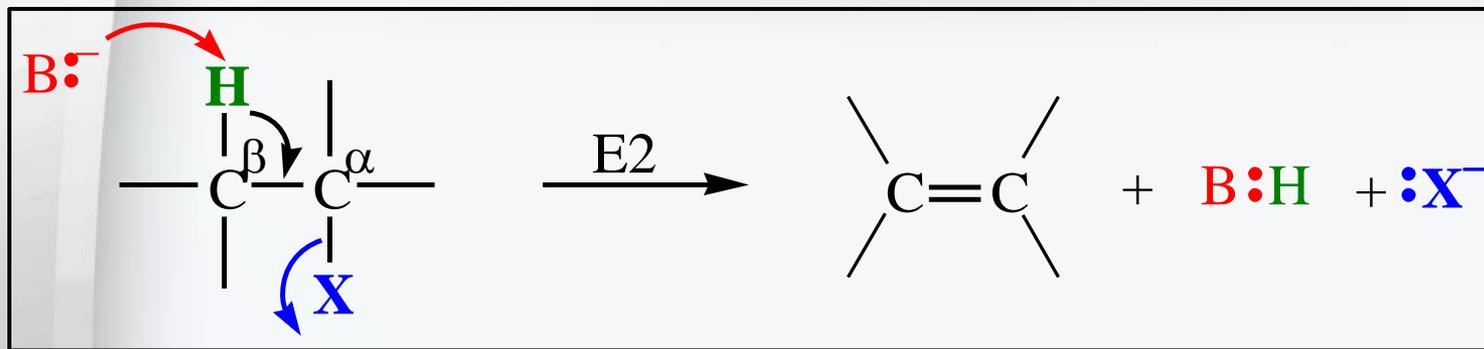


3. Dehalogenation of *Vic*-Dihalides

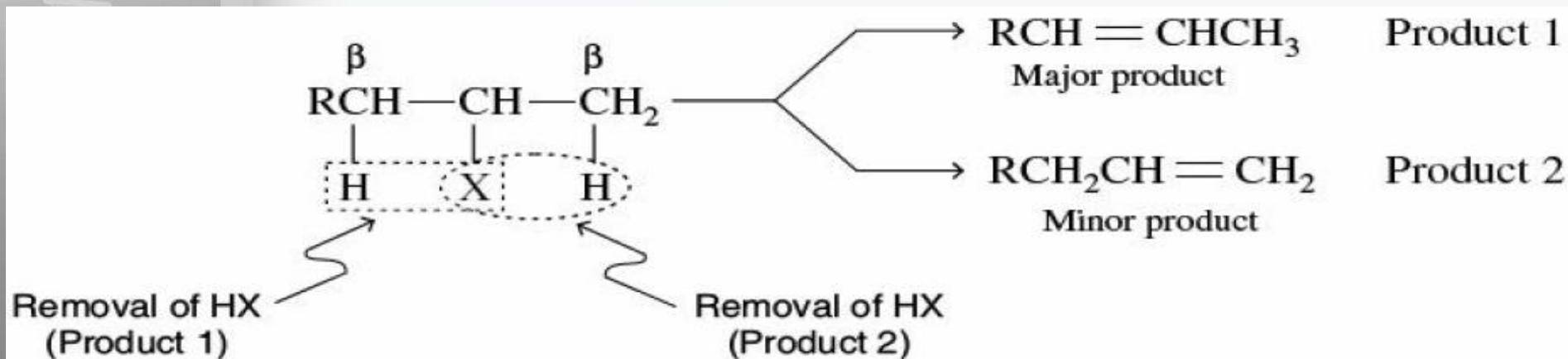


Dehydrohalogenation of haloalkanes [Saytzeff elimination]

Haloalkanes undergo **elimination reaction** (dehydrohalogenation) on heating with **potassium hydroxide** in presence of **ethanol** (alcoholic KOH) to form alkenes.

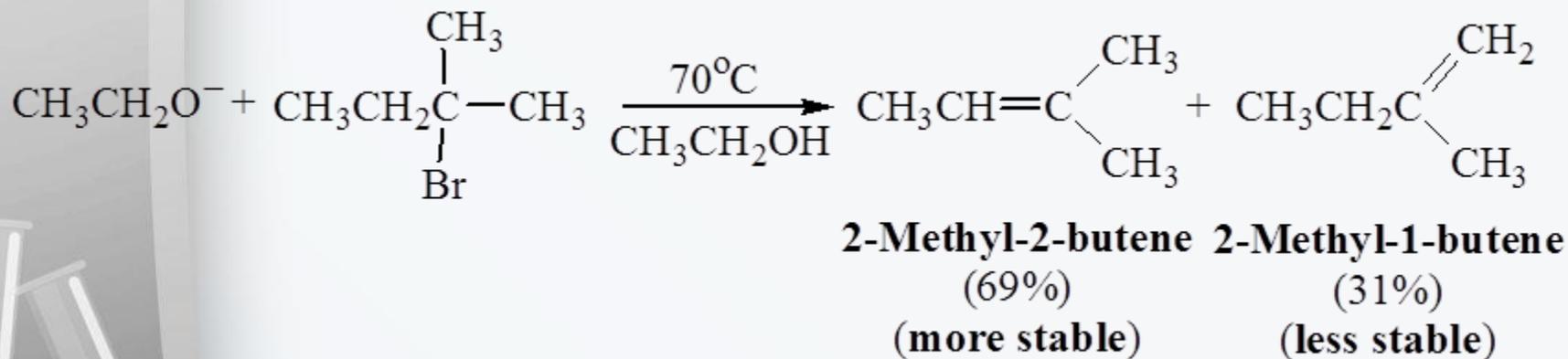


In haloalkanes, β -elimination occurs, that is, hydrogen is removed from **β -carbon** (the carbon adjacent to halogen bearing carbon) during dehydrohalogenation.

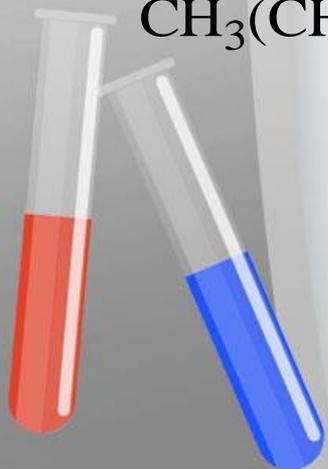
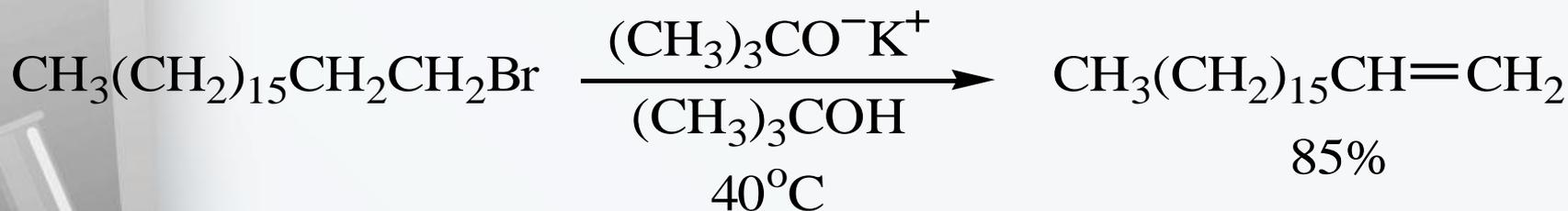
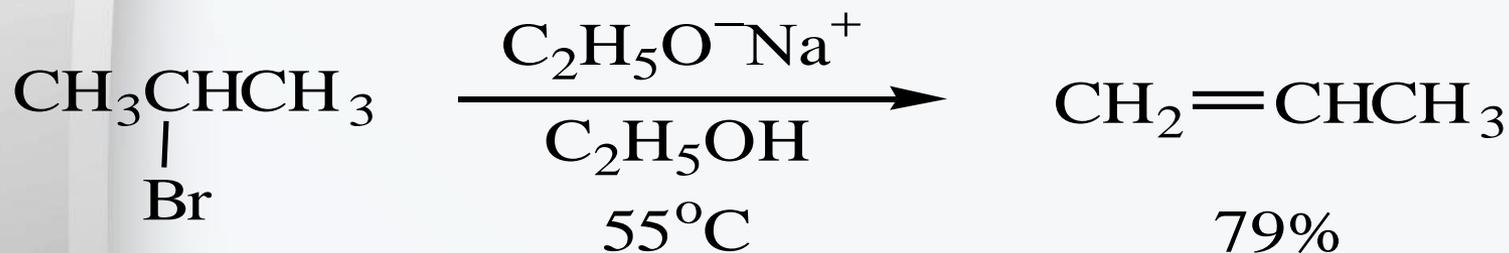


Saytzeff's rule: This rule states that whenever there is a possibility of formation of two alkenes by elimination, the formation of *more substituted alkene* is favoured. *In other words*, the hydrogen is removed from β -carbon having *lesser* number of hydrogen(s).

- So ease dehydrogenation $3^\circ > 2^\circ > 1^\circ$
- When a small base such as **ethoxide ion** or **hydroxide ion** is used, the major product of the reaction will be **the more stable alkene**.

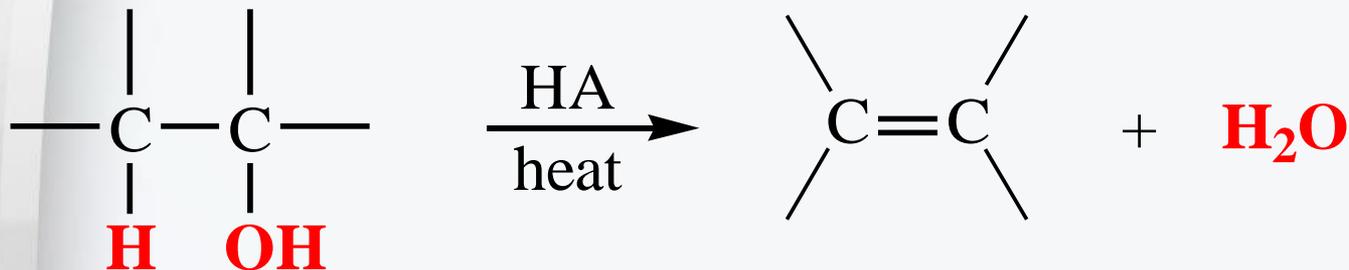


- The more stable alkene has the more highly substituted double bond.
- For some dehydrohalogenation reactions, a single elimination product is possible:.

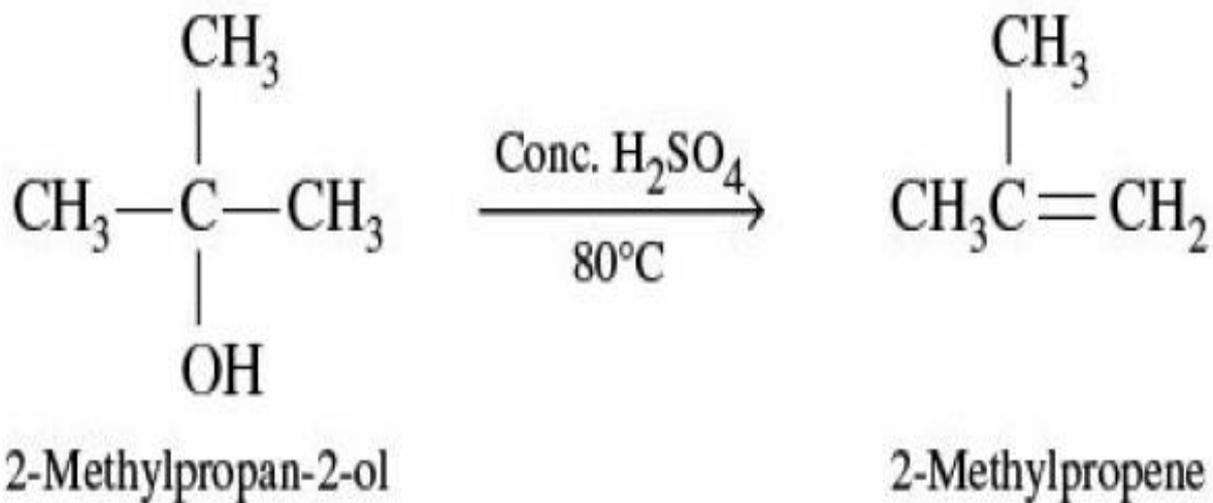
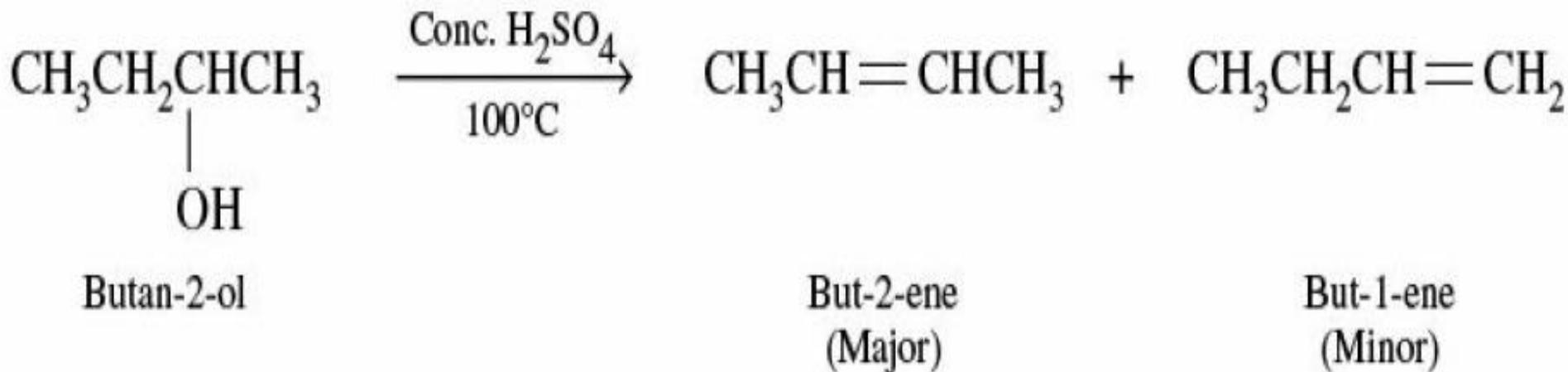
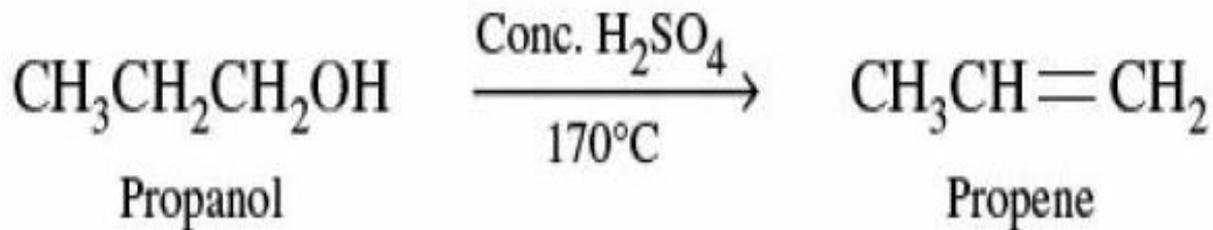


2-Dehydration of Alcohols

- ❖ Heating most **alcohols** with a **strong acid** causes them to lose a molecule of water and form an alkene:

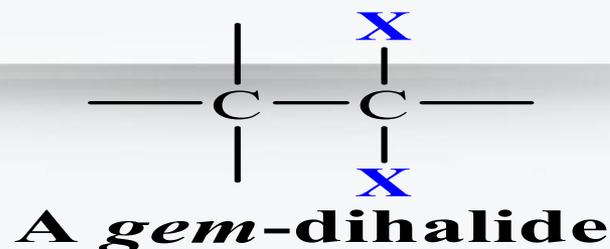
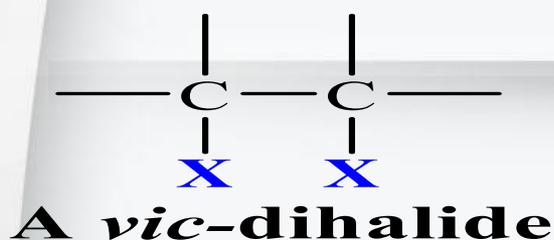


- ❖ The elimination of water from alcohols involves the removal of hydrogen from β -carbon in accordance with Saytzeff's rule.
- ❖ The reaction is an **elimination** and is favored at higher temperatures.
- ❖ The most commonly used acids in the laboratory are Brønsted acids — proton donors such as **sulfuric acid and phosphoric acid**.

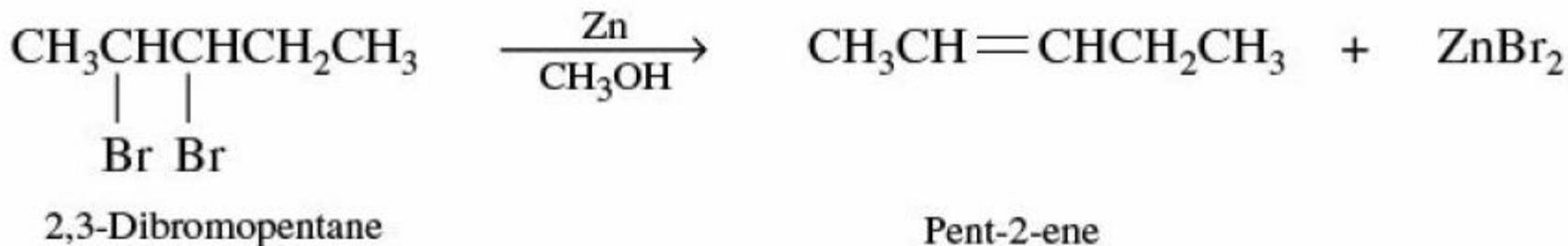
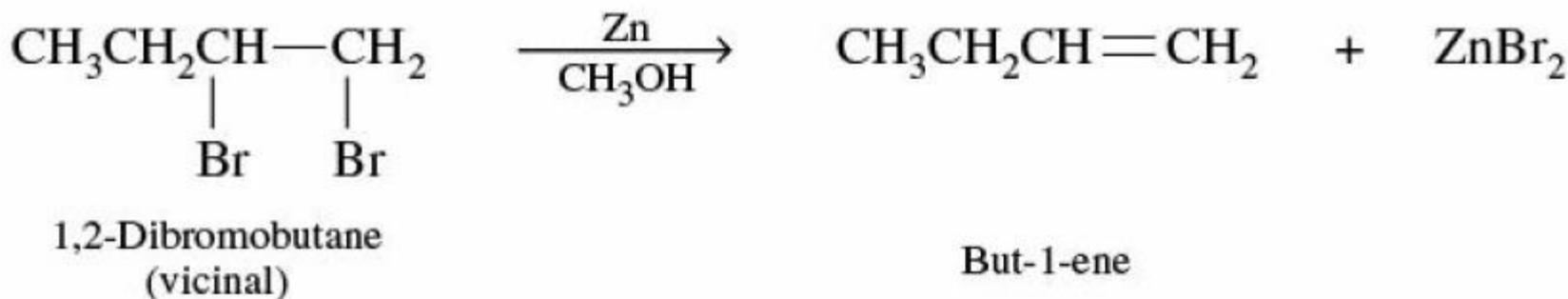


3-Dehalogenation of Vicinal Dihalides

□ Vicinal (or *vic*) and geminal (or *gem*) dihalides:

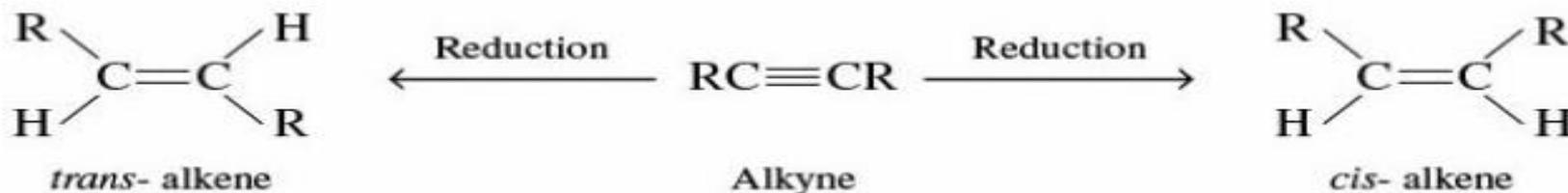


The vicinal dihaloalkanes undergo dehalogenation in presence of **zinc** and **methanol** to produce alkenes. The other dehalogenating agents used for this purpose are Zn–Cu couple, magnesium etc.



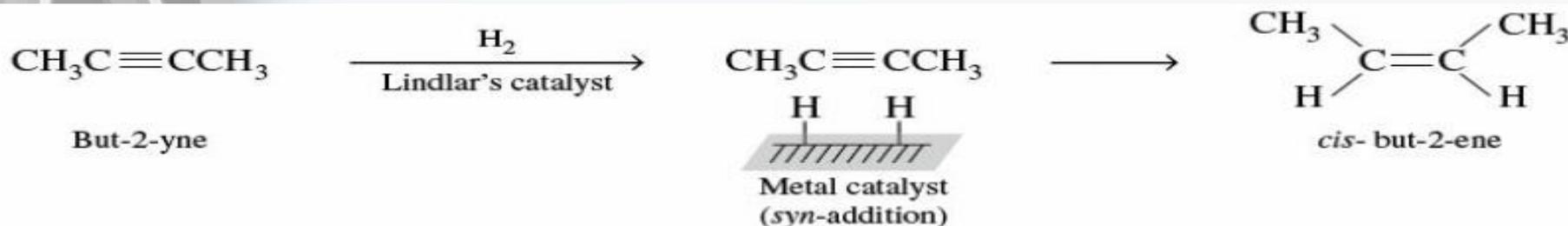
Synthesis of Alkenes via Reduction of Alkyne

partial hydrogenation of alkynes may be carried out using specific catalysts/reagents, which results in the formation of alkenes with specific stereochemistry, that is, formation of *cis*- or *trans*- alkenes.



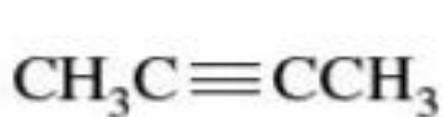
1. Preparation of *cis*- alkenes: catalytic hydrogenation

The hydrogenation of alkynes can be easily carried out using *deactivated catalysts* such as 'Lindlar's catalyst' (Pd/CaCO₃ in lead acetate poisoned with a small amount of quinoline) or 'nickel boride' (known as P-2 catalyst) to produce *cis*-alkenes. For example

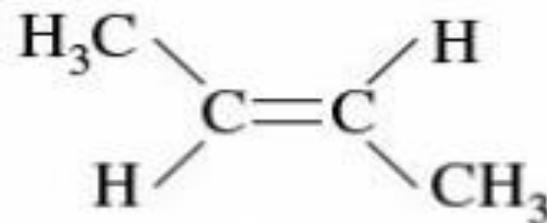
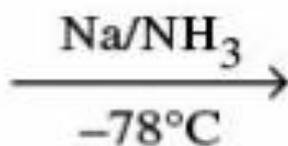


2. Preparation of *trans*- alkenes: dissolving metal reduction (Birch reduction)

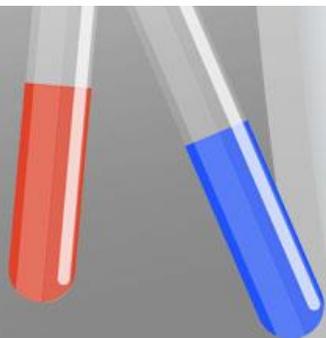
The reduction of alkynes with **lithium** or **sodium metal** in presence of **liquid ammonia** (or ethyl amine) at **low temperature**, results in the formation of *trans*-alkenes.



But-2-yne

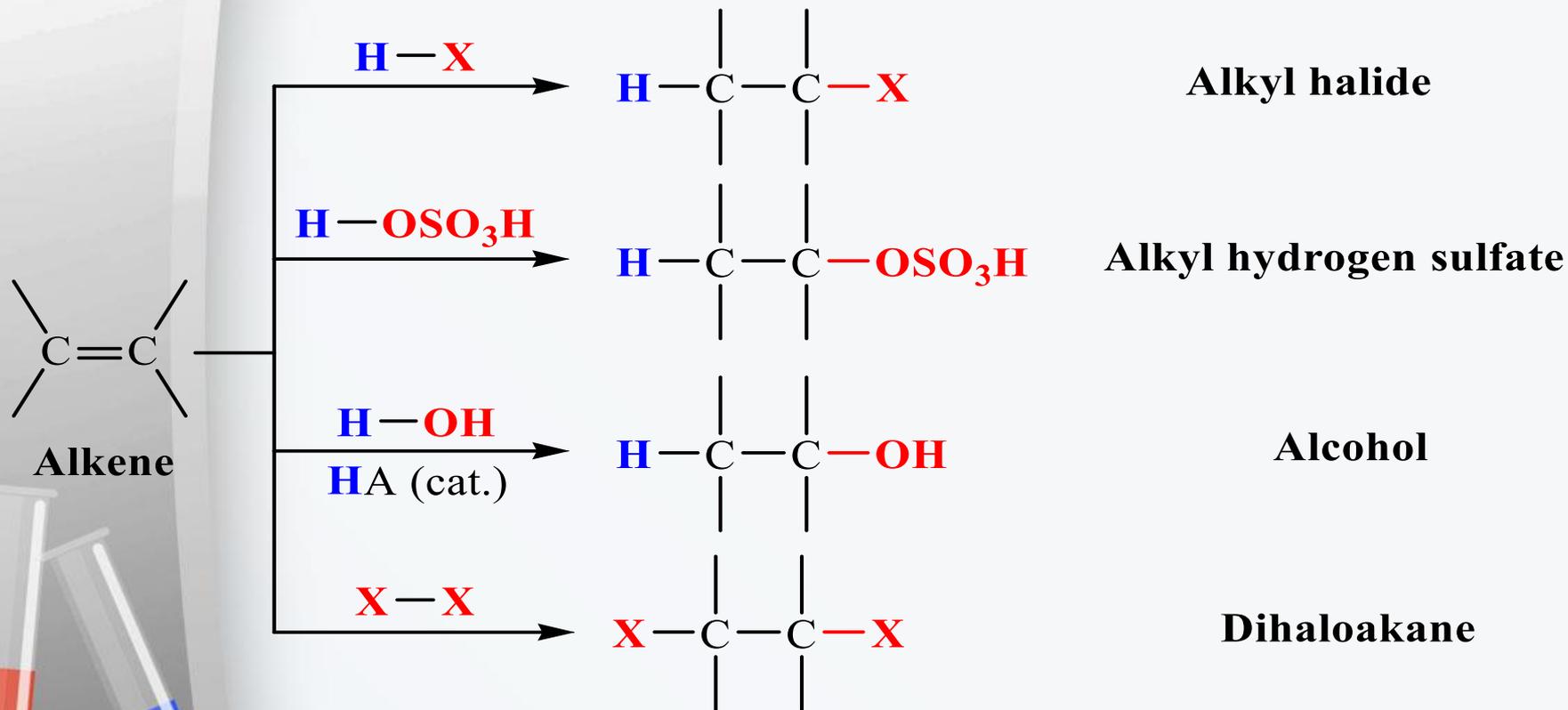


trans-but-2-ene



Reactions of Alkenes

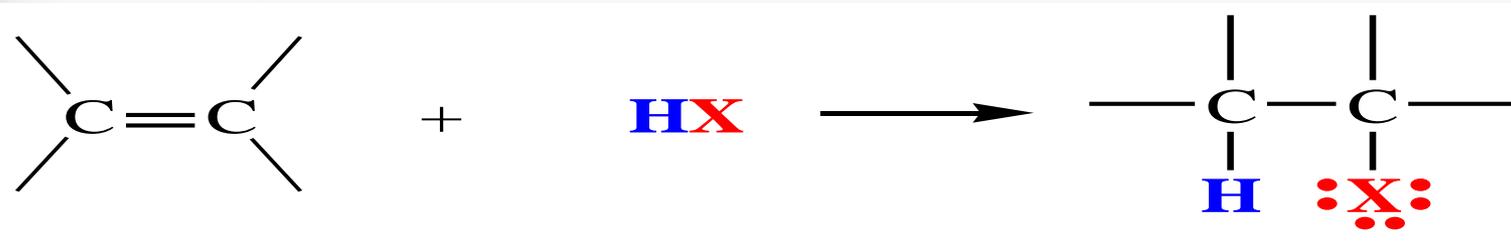
ALKENES ADDITION REACTIONS : Additions to Alkenes



Addition reaction of alkenes

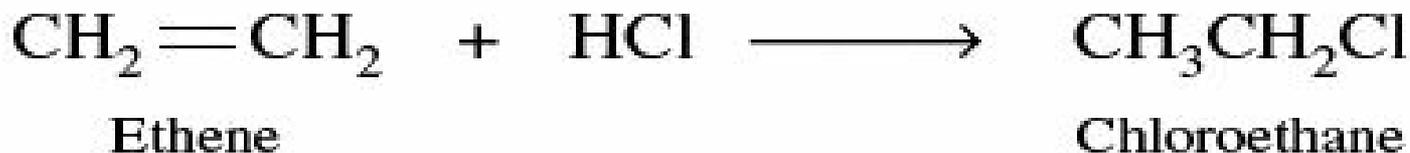
1-Addition of Hydrogen Halides to Alkene: [Regioselectivity and Markovnikov's Rule]

- ❖ The reaction of alkenes with hydrogen halides (HX, where X = F, Cl, Br, I) results in the formation of corresponding haloalkanes. The reaction is carried out in a solvent such as acetic acid or by passing dry gaseous HX directly over an alkene.



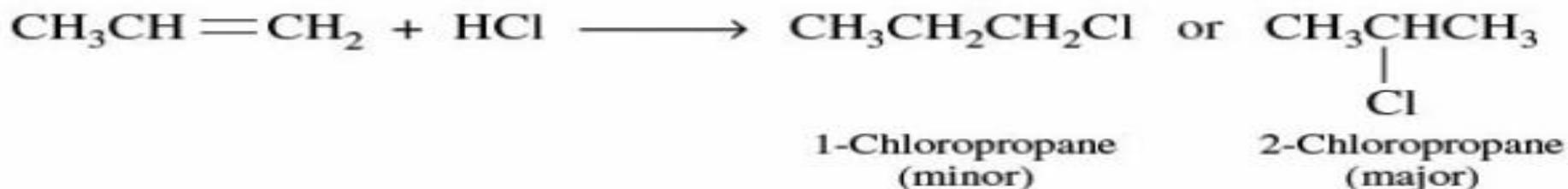
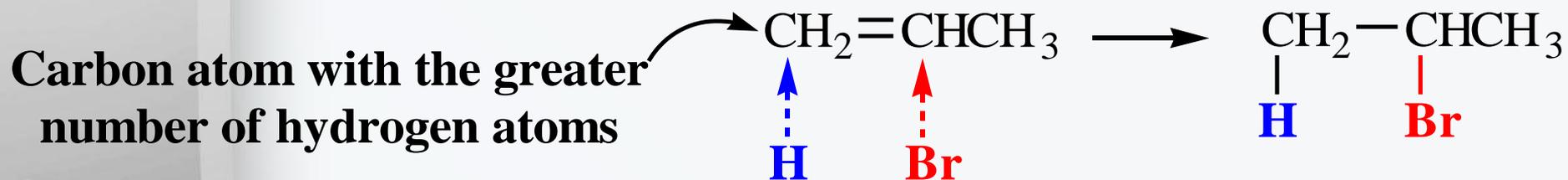
- ❖ The order of reactivity of the HX is $\text{HI} > \text{HBr} > \text{HCl} > \text{HF}$:

Example:



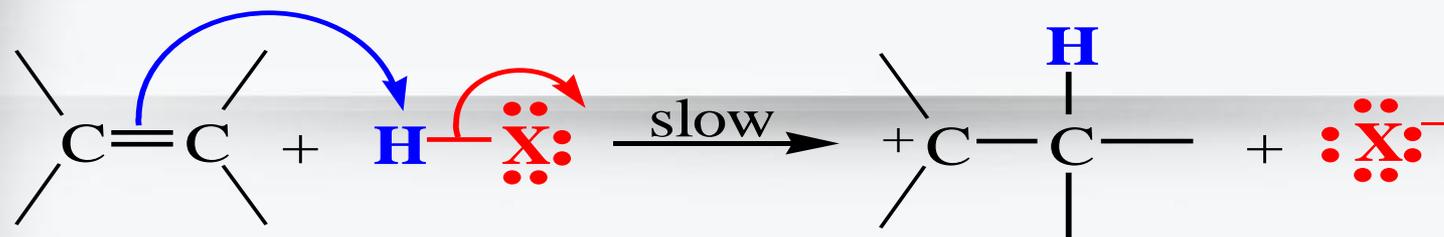
In case of an unsymmetrical alkene like propene, reaction with HCl may result in the formation of two products, namely 1-chloropropane or 2-chloropropane. However, it is 2-chloropropane which is produced selectively.

Markovnikov's rule: The addition of polar reagents like HX to unsymmetrical alkenes follows Markovnikov's rule, which states that *the negative part of the addendum (polar reagent) adds to that carbon of double bond which has minimum number of hydrogen(s).*



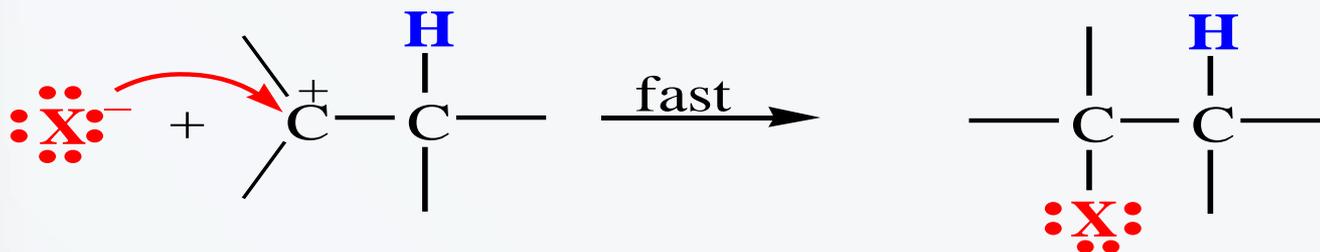
A Mechanism for the Reaction

Step 1



The π electron of the alkene form a bond with a proton from HX to form a carboncation and a halide ion.

Step 2



The halide ion reacts with the carboncation by donating an electron pair; the result is an alkyl halide.

*Thank
You!*