CLASSIFICATION OF REACTIONS

The organic reactions can be classified into the following types:

(1) Addition reaction
(2) Substitution reaction
(3) Elimination reaction

Addition reaction

The reaction in which a small molecule combines with an unsaturated molecule.

Example

$$C_2H_4 + Br_2 \longrightarrow C_2H_4Br_2$$

Mechanism

Types of Addition Reaction

(1) Nucleophilic addition reactions

These reactions are brought about by nucleophile These are typical reactions of aldehydes and ketones.

Example

Addition of base-catelysed HCN to an aldehyde or ketone

$$\underset{\text{Base}}{^-OH} + HCN \longrightarrow H_2O + \underset{\text{Nucleophile}}{CN^-}$$

$$>C{=}O + CN^- \longrightarrow >C(CN)-O^- \xrightarrow{H^+ \text{ of HCN}} >C(CN)-OH$$

Cynohydrin (Addition product)

Electrophilic addition reaction

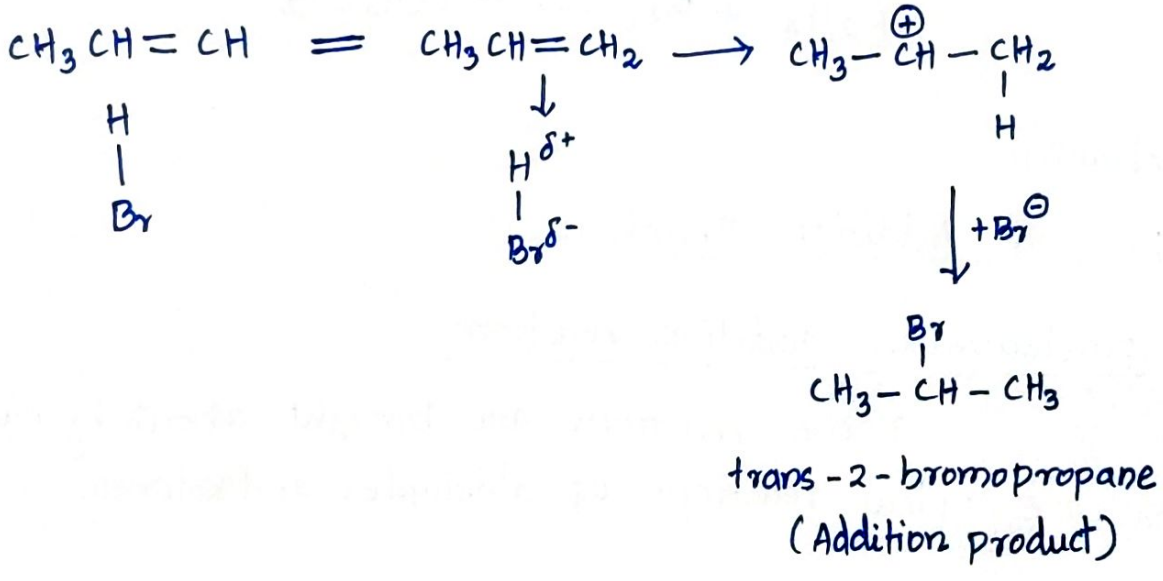
These reactions are brought about by electrophiles. These are typical reactions of alkenes and Alkynes.

Example

Addition of HBr to propene

(i) In the first step (rate-determining step), H^+ (From HBr) is added to propene to form a π-complex, which then forms isopropyl carbocation (2° carbocation, which is stable than Primary carbocation.

(ii) The second step is the attack of the nucleophile, Br^- to yield trans addition product.



trans-2-bromopropane
(Addition product)

Free radical addition reactions

These reactions are brought about by free radicals.

Example.

Addition of HBr to Propene in Presence of peroxide

$$RO:OR \longrightarrow 2RO^{\circ}$$

$$2RO + HBr \longrightarrow ROH + Br^{\circ} \quad \text{(Initiation)}$$

Bromine free radical

$$CH_3-CH=CH_2 + \dot{B}r \xrightarrow{\text{Slow}} CH_3-\dot{C}H-CH_2Br$$

$$CH_3-\dot{C}H-CH_2Br + HBr \xrightarrow{\text{Fast}} CH_3-CH_2-CH_2Br + \dot{B}r$$

1-bromopropane (Propagation)

$$\dot{B}r + \dot{B}r \longrightarrow Br_2$$

(Termination)

SUBSTITUTION REACTION

Substitution reactions involve the replacement of one atom (or) group by another

$$RX + y \longrightarrow Ry + X$$

NUCLEOPHILIC SUBSTITUTION

- ✓ It is a fundamental class of reactions in which an electron rich nucleophile selectively bonds with the positive charge of an atom or a group of atoms to replace the leaving group.
- ✓ The positive atom is referred to as an electrophile

$$Nuc: \; R - LG \longrightarrow R - Nuc + LG:$$

Nac - Nucleophile
LG - Leaving group

Example: Hydrolysis of an alkyl bromide

$$R - \boxed{Br} + \boxed{OH^-} \longrightarrow R - OH + Br^-$$

Leaving group — Nucleophile

(i) R-Br under basic conditions

(ii) Attacking Nucleophile is OH^-

(iii) Leaving group is Br^-

Mechanism of Nucleophilic Substitution Reaction.

A nucleophilic substitution reaction may proceed through either of two mechanisms:

I

Two step substitution mechanism (SN1):

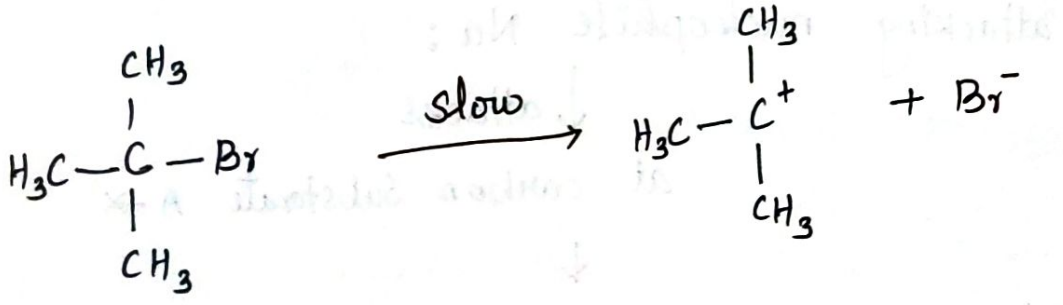
* Step 1 : Slow step - old bonds break
* Step 2 : Fast step - New Bonds Formation

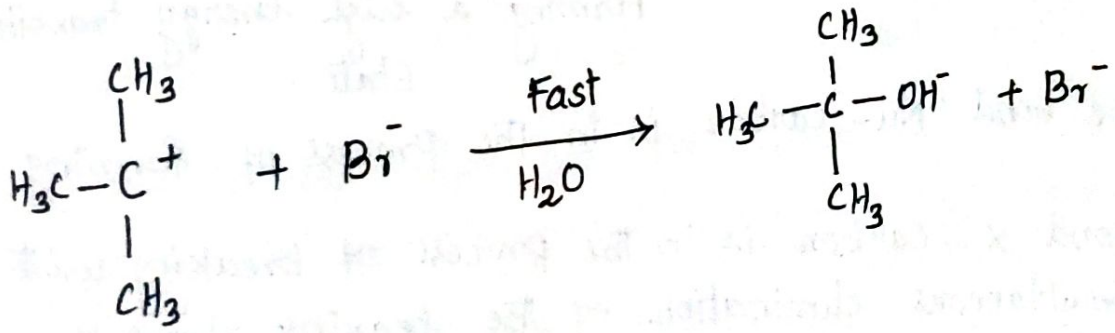
$$A - X \xrightarrow{\text{slow}} A^+ + X^-$$

$$\bar{N}u + A^+ \xrightarrow{\text{Fast}} Nu - A$$

Example

The nucleophile substitution of tert-butyl bromide





* First step is the rate determining step
* First step doesnot involve attacking nucleophile
* The rate of the reaction depends only on the molar concentration of one reactant.
* The overall reaction follows first order kinetics

II

ONE STEP SUBSTITUTION MECHANISM (SN2)

This type of Reaction } Involves → Simultaneous Breaking + Bond making

$$\bar{N}u: + A-X \longrightarrow \left[Nu^{\delta+} \cdots A \cdots X^{\delta-} \right] \longrightarrow Nu-A + \bar{X}:$$

Transition state

In this attacking nucleophile Nu:

↓ attacks

at carbon substrate A–X

↓

Forming a high energy transition state

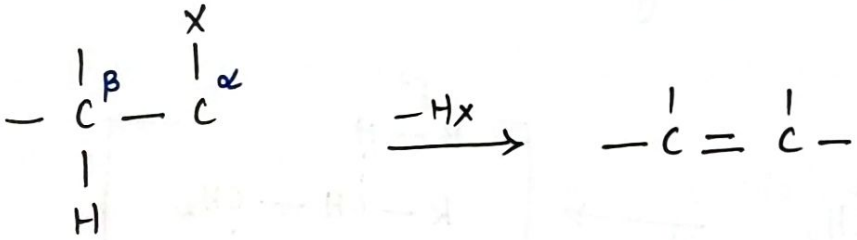
(a) The bond Nu–carbon is in the process of forming

(b) Bond X–carbon is in the process of breaking with simultaneous elimination of the leaving group X

* The molar concentrations of two reactants are changed
* The reaction follows 2nd order kinetics
* Hence it is called SN2 reaction.

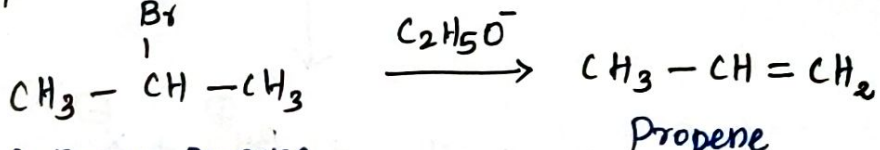
ELIMINATION REACTIONS

- Elimination reactions are reverse of addition reactions
- In these reactions two atoms or group attached to adjacent carbon atoms of the substrate is eliminated to form a multible bonds.

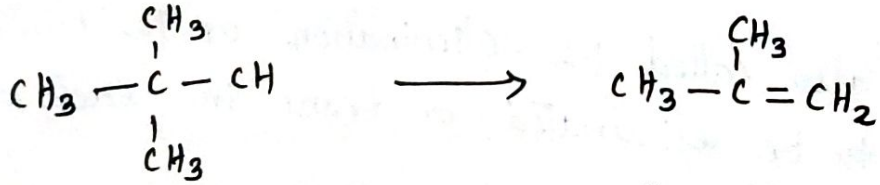


This method is used to prepare alkenes and alkynes

Example



2-Bromo propane — Propene

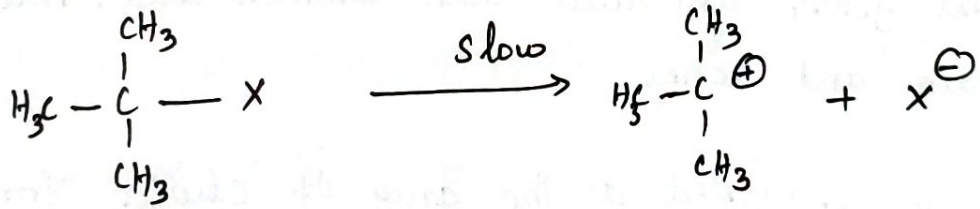


t-Butyl alcohol — 2-methyl propene

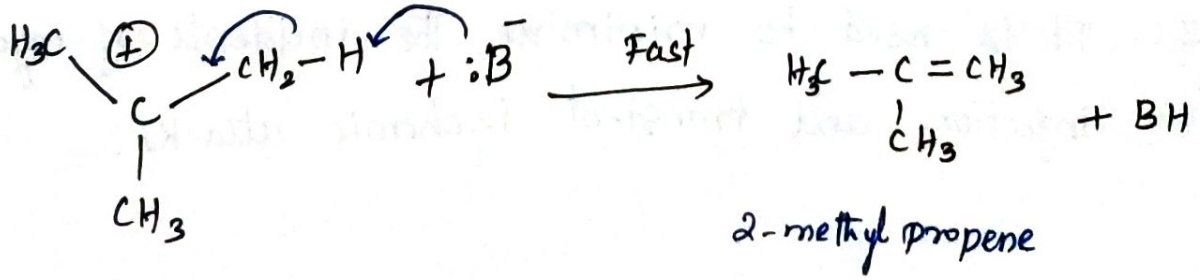
Unimolecular Elimination Reaction (E1)

* In this reaction, Rate of elimination depends only the concentration of the substrate.
* The reaction is of the first order Reaction.
* Like SN1 reaction, the E1 reaction is also a two step process.
* The first step is the slow ionization of alkyl halide to give the carbocation.
* The second step involves the abstraction of a proton from the adjacent β-carbon atom giving rise to the formation of an alkene.

First step



Second step



2-methyl propene

Bimolecular – Elimination Reactions (E_2)

(i) The rate of elimination depends on the substrate and nucleophile.

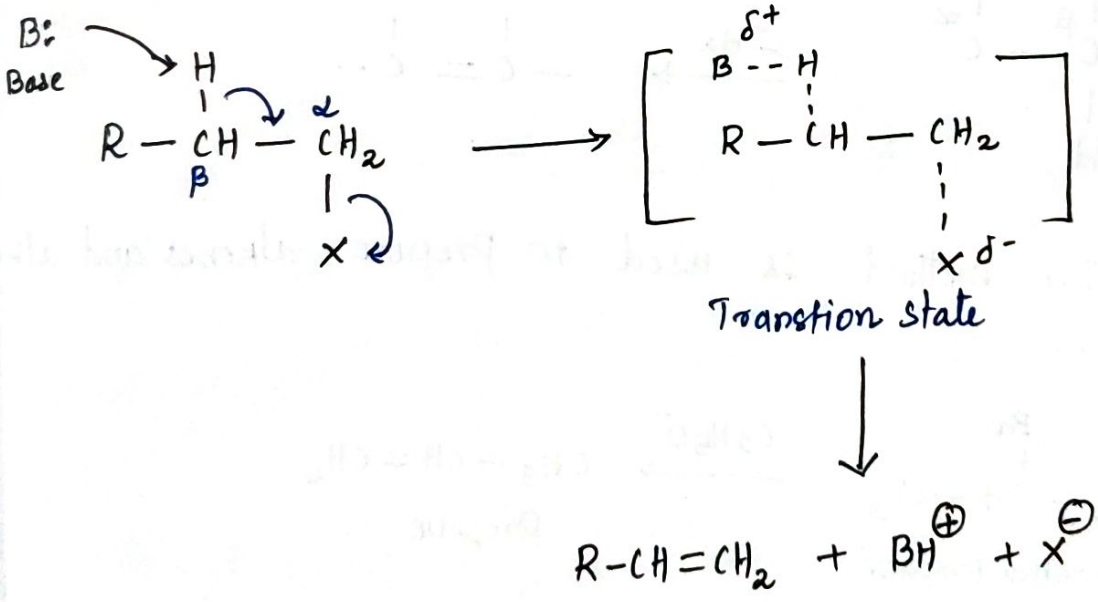
(ii) The rate of the reaction is second order

(iii) It is represented as E_2

(iv) Like SN2, the E_2 reaction is also one step process.

(v) The abstraction of Proton from the β- carbon atom and the explosion of an atom or group from the α- carbon atom occur simultaneously.

The mechanism is given as follows.

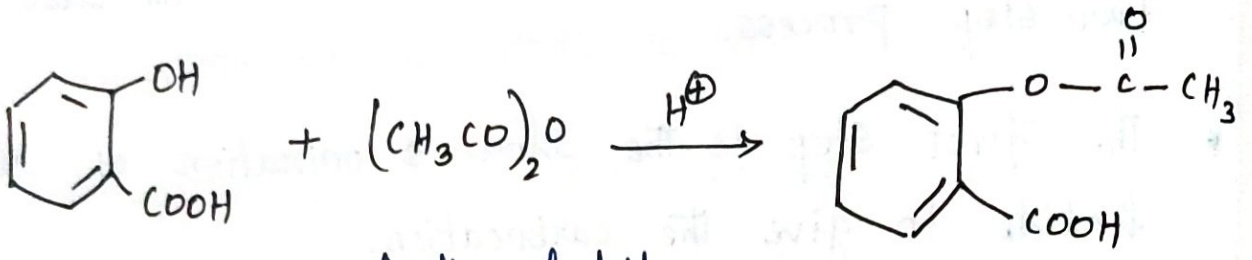


$$R\text{-}CH{=}CH_2 + BH^{\oplus} + X^{\ominus}$$

This is also called 1,2 -elimination or β- elimination Two groups to be eliminated or trans in each other Hence It is called Trans elimination.

Synthesis of Aspirin and its uses.

The reaction of salicylic acid with acetic anhydride yields Aspirin. The crude product thus obtained may be recrystallized from benzene. Mixture of acetic acid and water (1:1) and various other non aqueous Solvents.



Salicylic acid. Acetic anhydride Acetyl salicylic acid

Uses:

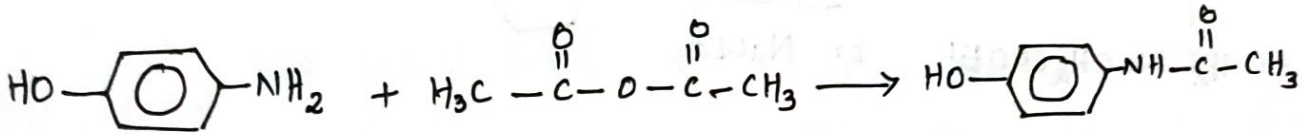
1. It is used as an antipyretic, anti-inflammatory and analgesic drug for treating headache, discomfort and fever associated with common cold, muscular pain and aches.

2. It is regarded as the drug of choice for reducing fever because of its high degree of effectiveness and safety.

3. It is used to minimize the incidents of myocardial infection and transient ischemic attacks.

Synthesis of Paracetamol

Paracetamol is made by reacting 4-aminophenol with ethanoic anhydride (more commonly called acetic anhydride). This reaction forms an amide bond and ethanoic acid as a by product. When the reaction is complete the paracetamol is then isolated. The crude product can be purified by recrystallization from water / Ethanol mixture (1:1) or from other appropriate solvents.

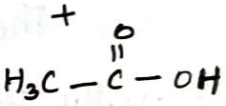


4-aminophenol

acetic anhydride

Paracetamol

+



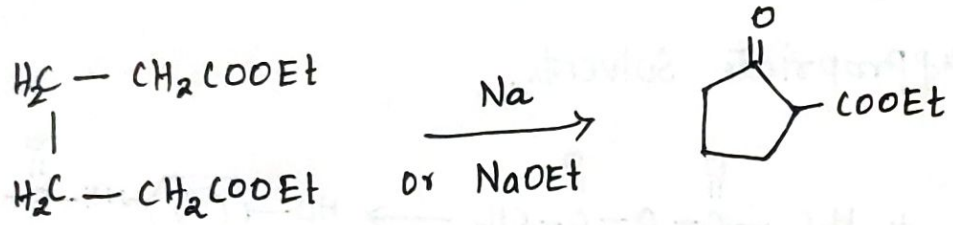
acetic acid

Uses:

1. It is used as a antipyretic and analgesic drug.
2. It can be effectively used for arthritic and rheumatic conditions linked with musculoskeletal pain, headache neuralgias, myalgias and dysmenorrhea.
3. It is particularly useful in aspirin sensitive patients.

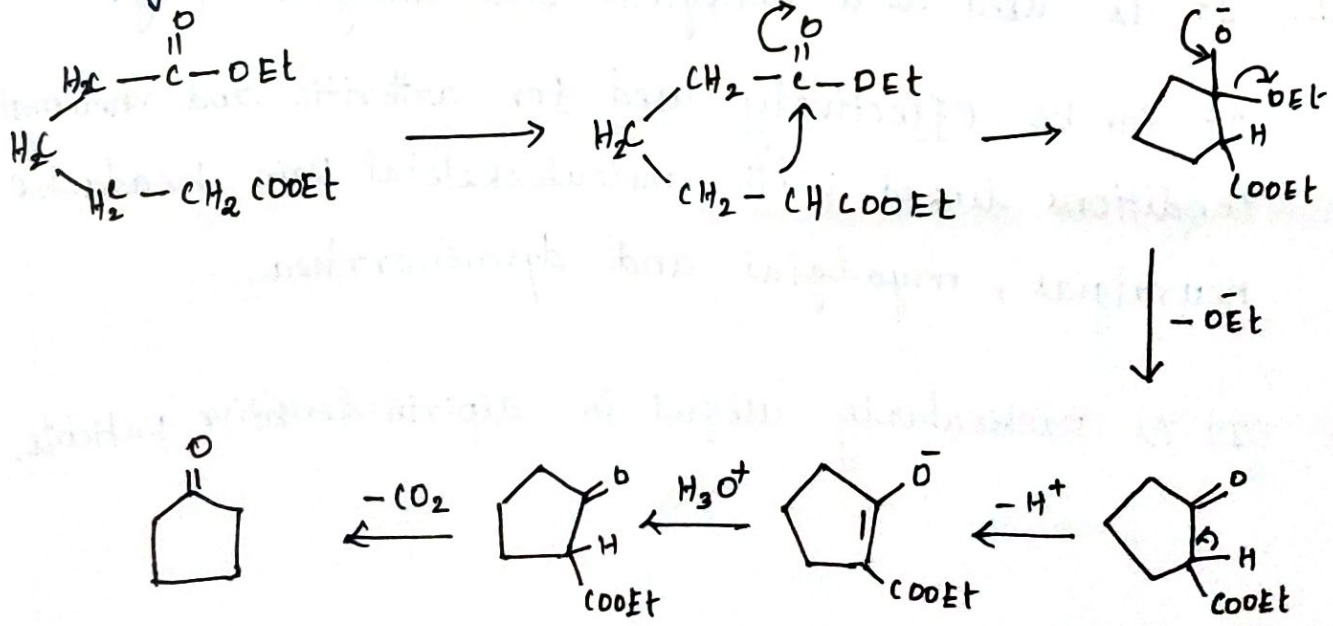
DIECKMANN CONDENSATION

It is an intramolecular claisen condensation and is useful for the preparation of cyclic ketones. Diesters of C_6 and C_7 dibasic acids give good yields of cyclic-β-keto-esters. Thus ethyl esters of adipic acid give 2-carboxycyclopentanone.



Mechanism.

The mechanism involves the intermolecular attack of initially formed enolate anion to the carbonyl group of other ester group. The expulsion of ethoxide anion (EtO^-) leads to the formation of β-ketoester which on hydrolysis, followed by decarboxylation is converted into cyclic ketone.



RING OPENING REACTIONS

Addition of reagents such as Cl_2, Br_2, HI, H_2SO_4, H_2O to cyclopropane leads to ring opening and the corrosponding reactions are given below: