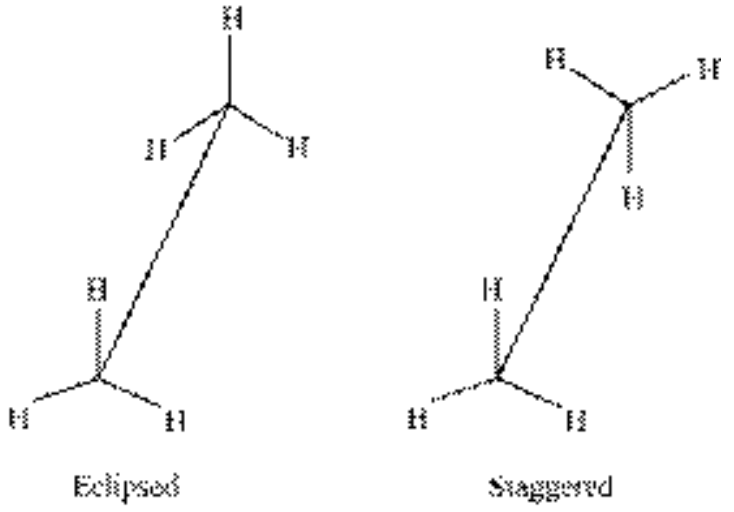
Hydrocarbons

Alkanes:

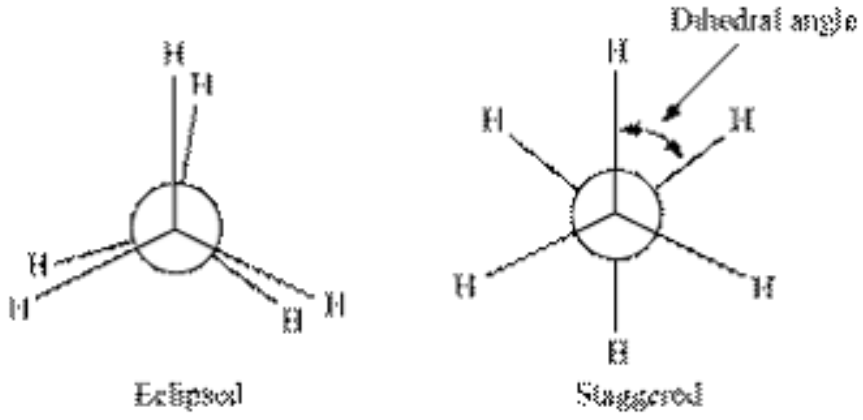
- General formula is C_nH_{2n+2}.
- Isomerism: Structural isomer → Difference in structure
  Chain isomer → Difference in chain

- Conformations: The spatial arrangements of atoms which can be converted into one another by rotation around a C–C single bond

  1. Sawhorse projections



  2. Newman projections



Alkanes:

- General formula is C_nH_{2n+2}.
- Occurence:
  - Methane is the main constituent of marsh gas.
  - Methane is exhaled by animals that feed on food containing cellulose.
  - Methane is found in the intestinal gas of humans and animals.
  - Methane is found in cavities in coal.
- Prepared by:
  - Reduction of unsaturated hydrocarbons
  - Reduction of alkyl halides
  - Wurtz reaction
  - Decarboxylation reaction
  - Kolbe's electrolysis
- Properties
  - Non-polar, colourless and odourless
  - Hydrophobic
  - Combustion reaction produces carbon dioxide
  - Controlled oxidation converts them to alcohols, aldehydes or carboxylic acids
  - Undergo isomerisation in the presence of $AlCl_3$ and HCl
  - Aromatization reaction takes place at 773 K at 10−20 atmospheric pressure in the presence of the oxides of V, Mo, or Cr supported over alumina
  - On heating to a higher temperature, higher alkanes decompose into lower alkanes or alkenes (**Pyrolysis and cracking**)
  - Alkyl halides can be prepared by substitution reaction of alkanes
- Uses:
  - Preparation of acetylene, formaldehyde, methanol, chloromethane and tetrachloro methane
  - Domestic fuel
  - Preparation of a useful solvent in dry cleaning

Alkenes:

- General formula is C_nH_{2n}.
- Isomerism

1.Position isomer

$$\overset{1}{CH_2}=\overset{2}{CH}-\overset{3}{CH_2}-\overset{4}{CH_2}-\overset{5}{CH_3}$$

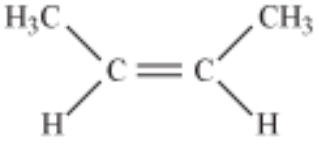
$$\text{Pent}-1-\text{ene}$$

$$\overset{1}{CH_3}-\overset{2}{CH}=\overset{3}{CH}-\overset{4}{CH_2}-\overset{5}{CH_3}$$

$$\text{Pent}-2-\text{ene}$$

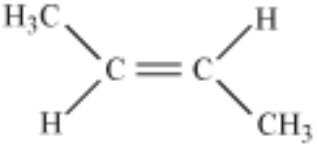
2. Geometrical isomerism

- *Cis*-isomer: Two identical atoms or groups are on the same side of the double bond



cis-But-2-ene

- *Trans*-isomer: Two identical atoms or groups lie on the opposite side of the double bond



trans-But-2-ene

Alkenes:

- General formula is C_nH_{2n}.
- Alkenes are unsaturated hydrocarbons containing at least one double bond.
- Carbon-carbon double bond in alkenes consist of one sigma bond and one pi bond.
- **Prepared by:**
  - Partial reduction of alkynes
  - Dehydrohalogenation by heating alkyl halides with acloholic KOH
  - Dehalogenation by reacting vicinal dihalides with Zn metal
  - Dehydration of alcohols using
    - Concentrated H_2SO_4
    - Heated Al_2O_3

- **Properties**:
  - Colourless, odourless, insoluble in water and fairly soluble in non-polar solvents
  - Undergo addition reactions:
    - Addition of hydrogen to form alkanes
    - Addition of halogen to form dihalides
    - Addition of hydrogen halide to form alkyl halides
    - Addition of H_2SO_4
    - Addition of water
  - Oxidation of alkenes with
    - Baeyer's reagent converts them to vicinal glycols
    - Acidic $KMnO_4$ or acidic $K_2Cr_2O_7$ oxidises them to give ketones or acids (depending upon the nature of alkenes)
  - Undergoes ozonolysis to form aldehydes
  - Polymerises at high temperature in presence of suitable catalyst
  - Undergoes combustion to form a large amount of heat
- **Uses**:
  - Manufacture of synthetic chemicals, polythene, raw materials for detergents
  - For ripeninng of fruits
  - producing oxy-ethylene

Alkynes

- General formula is CnH_{2n-2}
- They are named as the corresponding alkanes replacing ‘ane’ by the suffix ‘yne’.
- Each carbon atom of ethyne has two *sp* hybridised orbitals.
- **Preparation of Ethynes**
  - From calcium carbide (CaC_2)
  - From vicinal dihalides
- **Properties**
  - Colourless, odourless, weakly polar
  - Immisicible in water
  - Hydrogen attached to triply bonded carbon atom is acidic
  - Undergoes addition reactions
    - Addition of dihydrogen
    - Addition of halogens
    - Addition of hydrogen halides (HX; X = Cl, Br, I)
    - Addition of water
  - Undergoes linear and cyclic polymerisation

- Shows oxidation reaction
- Undergoes ozonolysis to produce ozonides

- **Uses**:
  - Oxy-acetylene welding at very high temperatures
  - Illuminant in oxy-acetylene lamp
  - Ripening and preservation of fruits
  - Manufacture of several products like polymers. artificial rubber, oxalic acid, acetaldehyde, acetic acid, etc.

Aromatic hydrocarbon:

Aromaticity

1. Planarity

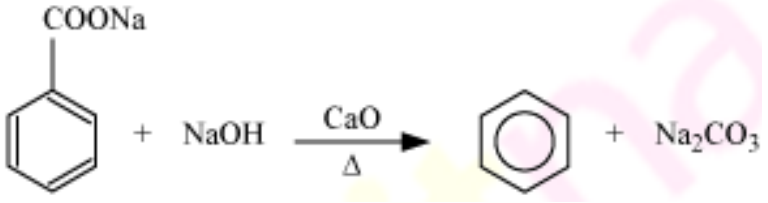
2. Complete delocalization of the electrons in the ring

3. Huckel rule → Presence of $(4n + 2)\pi$ electrons in the ring (n = 0, 1, 2…)

- **Preparation of benzene**

1. Cyclic polymerization of ethyne

2. Decarboxylation of aromatic acids



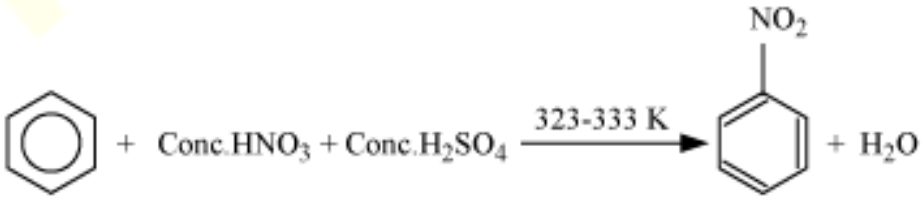
- **Physical properties**

  Immiscible with water but readily miscible with organic solvents

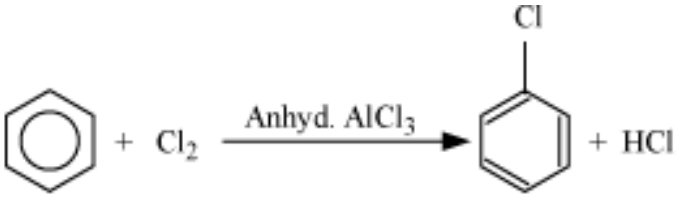
- **Chemical properties**

1. Electrophilic substitution

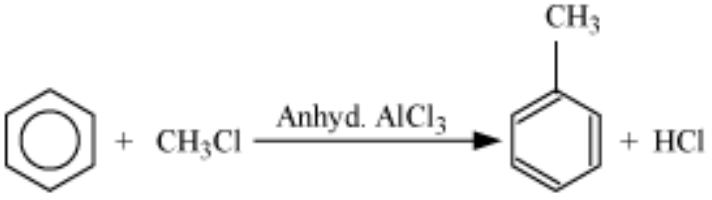
2. Nitration



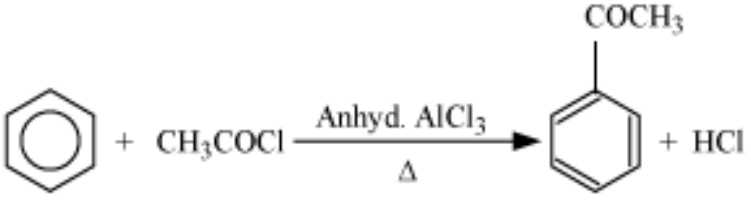
3. Halogenation



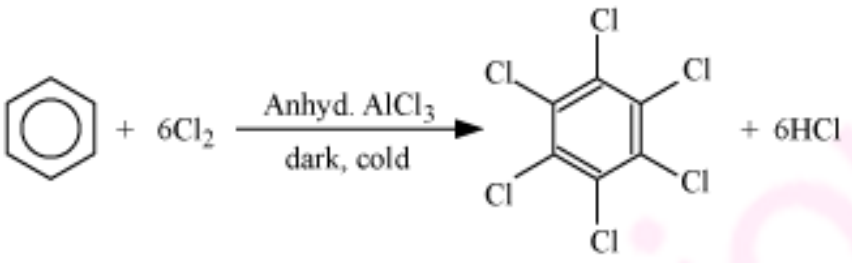
4. Friedel-Crafts alkylation



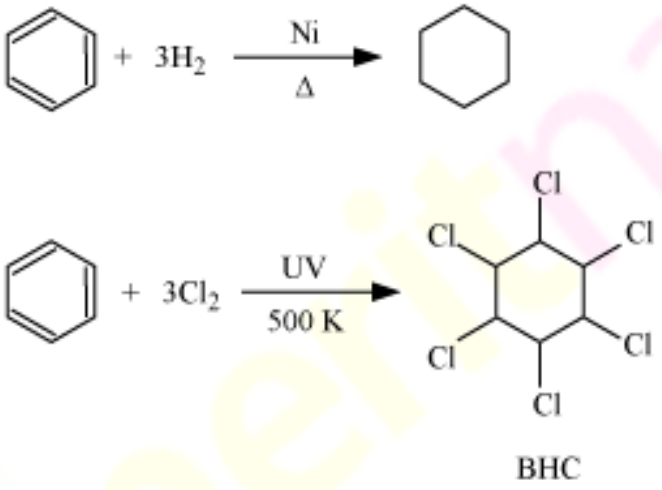
5. Friedel-Crafts acylation



6. On treatment with excess of chlorine



7. Addition reaction



- **Directive influence of functional group in benzene ring**

1. Ortho and para directing groups:

$$-OH, -NH_2, -NHR, -NHCOCH_3, -OCH_3, -CH_3, -C_2H_5$$

2. Meta directing groups:

$$-NO_2, -CN, -CHO, -COR, -COOH, -COOR, -SO_3H$$

- **Carcinogenicity and toxicity**

Benzene and polynuclear hydrocarbons containing more than two benzene rings are toxic and can cause cancer