UNIT – 13
HYDROCARBONS

HYDROCARBONS :- The simplest Organic compound containing carbon and hydrogen only are c/d hydrocarbons. These are widely distributed in nature in the form of petroleum, natural gas and coal. Thus hydrocarbons are considered to be the parent organic compounds while all other compounds are though to be have been derived from them by replacement of one or more of their hydrogen atom by functional groups.

Classification of hydrocarbons :- On the basis of st., hydrocarbons can be broadly divided into the following 2 types :-

I **Acyclic or open chain hydrocarbons** :- These compounds contain open chains of carbon atoms in their molecules. They are also c/d aliphatic hydrocarbons. These are of following types –

1. Alkanes
2. Alkenes
3. Alkynes

An alkane has only carbon – carbon single bond.

e.g $CH_3 - CH_3$, $CH_3 - CH_2 - CH_3$
Ethane Propane

An alkene has one carbon – carbon double bond.

e.g $CH_2 = CH_2$, $CH_3 - CH = CH_2$
Ethene Propene.

An alkyne has one carbon – carbon triple bond.

e.g $CH \equiv CH$, $CH_3 - C \equiv CH$

Ethyne Propyne

II Cyclic or closed chain hydrocarbons :- These compounds contain closed chains of carbon atoms in their molecules. These are of 2 types –

1. Alicyclic hydrocarbons :- Hydrocarbons which contains a ring of 3 or more carbon atoms and have properties similar to those of aliphatic hydrocarbons are called alicyclic hydrocarbons. These are further divided into 3 categories.

a. Cycloalkanes
b. Cycloalkenes
c. Cycloalkynes

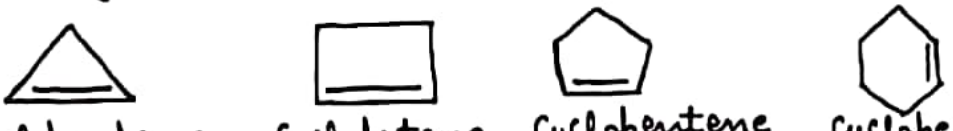
a. Cycloalkanes :- Saturated acyclic hydrocarbons in which all the c – atoms are joined by single covalent bond are called cycloalkanes.

e.g

Cyclopropane Cyclobutane Cyclopentane Cyclohexane

b. Cycloalkenes :- Unsaturated acyclic hydrocarbons which contain one carbon – carbon double bond are called cycloalkenes.

e.g



Cyclopropene Cyclobutene Cyclopentene Cyclohexene

c. Cycloalkynes :- Unsaturated acyclic hydrocarbons which contains one c – c triple bond are c/d cycloalkynes.

An alkyne has one carbon – carbon triple bond.

e.g $CH \equiv CH$, $CH_3 - C \equiv CH$

Ethyne Propyne

II Cyclic or closed chain hydrocarbons :- These compounds contain closed chains of carbon atoms in their molecules. These are of 2 types –

1. Alicyclic hydrocarbons :- Hydrocarbons which contains a ring of 3 or more carbon atoms and have properties similar to those of aliphatic hydrocarbons are called alicyclic hydrocarbons. These are further divided into 3 categories.

a. Cycloalkanes
b. Cycloalkenes
c. Cycloalkynes

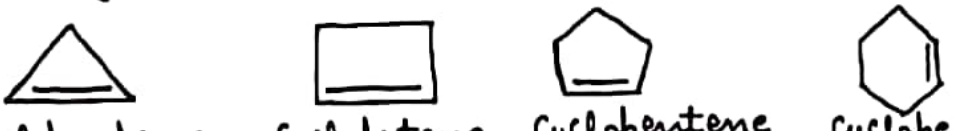
a. Cycloalkanes :- Saturated acyclic hydrocarbons in which all the c – atoms are joined by single covalent bond are called cycloalkanes.

e.g

Cyclopropane Cyclobutane Cyclopentane Cyclohexane

b. Cycloalkenes :- Unsaturated acyclic hydrocarbons which contain one carbon – carbon double bond are called cycloalkenes.

e.g



Cyclopropene Cyclobutene Cyclopentene Cyclohexene

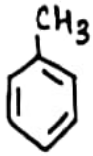
c. Cycloalkynes :- Unsaturated acyclic hydrocarbons which contains one c – c triple bond are c/d cycloalkynes.

b. Aromatic hydrocarbons :- These are of 2 types -

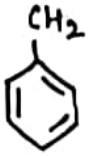
(i) Benzenoid aromatic compounds :- Hydrocarbons and their alkyl, alkenyl and alkynyl derivatives which contain one or more benzene rings either fused or isolated in their molecules are c/d benzenoid aro-matic hydrocarbons. They are also c/d arenes.

e.g

Benzene

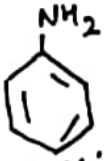


Toluene



Ethylbenzene

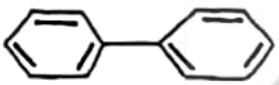
Nitro benzene



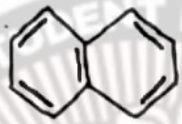
Aniline or Aminobenzene

Arenes may also contain 2 or more isolated or fused benzene rings.

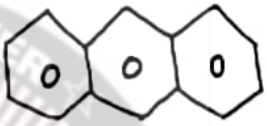
e.g



Diphenyl



Naphthalene



Anthracene

(ii) Non-benzenoid aromatic compounds :-

Aromatic hydrocarbons which donot contain a benzene ring but instead contain other highly unsatu-rated rings are c/d non-benzenoid aromatic hydro-carbons

e.g Tropone, tropolene, Azulene etc.

Tropone

ALKANES :- These are the saturated hydrocarbons c... - taining carbon-carbon single bond.

e.g $CH_3 - CH_2 - CH_3$, $CH_3 - CH_2 - CH_2 - CH_3$

Propane Butane

Their general formula is C_nH_{2n+2}

Where $n = 1, 2, 3 \ldots\ldots$

Nomenclature of Alkanes :-

formula	IUPAC name
CH_4	Methane
C_2H_6	Ethane
C_3H_8	Propane
C_4H_{10}	Butane
C_5H_{12}	Pentane
C_6H_{14}	Hexane

Isomerism of Alkanes :-

Methane, ethane and propane have only one structure since there is only one way in which 1, 2 and 3 C-atoms can be connected.

e.g Butane, two isomers are possible since 4 C-atoms can be joined in 2 different ways —

$CH_3 - CH_2 - CH_2 - CH_3$

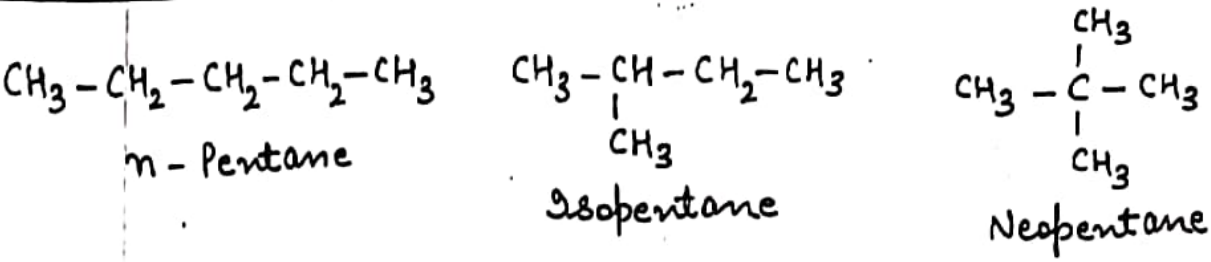
Butane

(n-Butane)

$CH_3 - \underset{\displaystyle CH_3}{\underset{|}{CH}} - CH_3$

2-Methylpropane (isobutane)

5 C-atoms can be joined in 3 different ways and hence pentane has 3 isomers.



Similarly we can show hexane has 5, heptane has 9, Octane has 18, nonane has 35 & decane has 75 isomers. Such structural isomers which differ in arrangement of carbon chain are called chain / nuclear isomers.

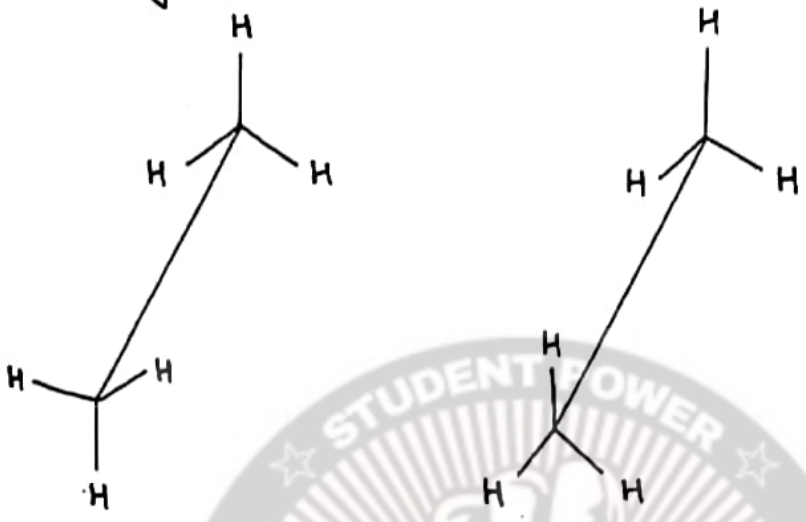
CONFORMATIONS :- The infinite number of momentary arrangements of the atoms in space which results through rotation about a single bond are c/d Conformations / rotational isomers / simply rotamers.

Conformations of ethane :- In ethane molecule ($CH_3 - CH_3$), the two carbon atoms are connected by single covalent bond (i.e σ bond) while the remaining three valencies are satisfied by hydrogen atoms. If one of the methyl gps. in ethane molecule is kept fixed and the other is rotated about the C-C bond, a large no. momentary arrangements of the hydrogen atom on one C-atom with respect to the hydrogen atoms on the other C-atom in space are obtained.

The conformations of ethane are usually represented by following 2 methods —

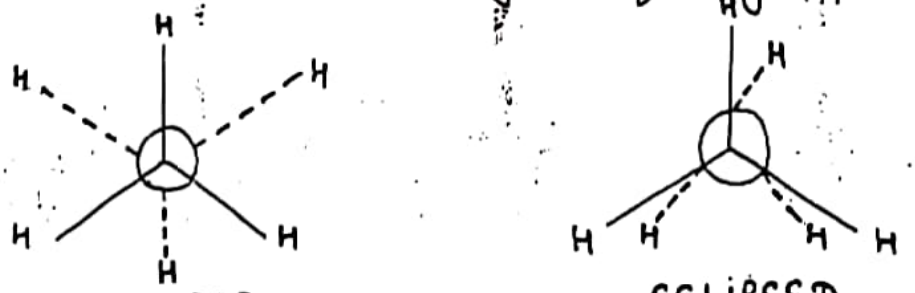
1. Sawhorse formula :- This is a simple method of representing 3-D formula on paper. The molecule is viewed slightly from above and from the right & projected on the paper. The bond b/w the 2 C-atoms

is drawn diagonally and is slightly elongated for the clarity. The lower left hand carbon is considered to be towards the front and the upper right hand carbon towards the back. The sawhorse representation of the staggered and eclipsed conformations of ethane are shown in figure.



STAGGERED ECLIPSED

2. Newman Projection formulae :- Newman devised a simple and highly useful method of represen-ting 3-D formulae on paper. After his name, these are c/d Newman projections. In this formula, the C-atom near the eye is represented by a point and 3 atoms are attached to it by 3 equally spaced radii. The C-atom farther from the eye is designated by a circle and 3 atoms are attached to it by 3 equally spaced radii.



STAGGERED ECLIPSED

Physical properties of Alkanes :-

1. Boiling point :- The boiling points of straight chain alkanes increases regularly with increase in their molecular masses.

Reason :- Due to increase in carbon content, there is increase in molecular size and hence the surface area of the molecules. As a result, the vanderwalls forces of attraction goes up and hence the boiling point inc. accordingly.

Amongst the isomeric alkanes, the branched chain alkane isomer has lower b.pt. than corresponding n-alkanes.

Reason :- With branching, the surface area of the molecule decreases, as a result, the vanderwalls forces of attraction become weaker and hence lesser amount of energy is required to overcome them. As a result the b.pt. decreases.

2. Melting point :- It has been found that alkanes with even no. of C-atoms have higher m.pt. than those containing an odd no. of C-atoms. This property is K/as alternation effect.

Reason :- The m.pt. of a substance depends not only upon the size and shape of the molecules but also upon how closely the molecules are packed in crystal lattice. Due to sp^3 hybridisation in alkanes, any 2 bonds of C-atom make an angle of 109°.28' with one another. As a result in alkanes, the C-atoms are arranged in a Zig-Zag chain.

Therefore, in n-alkanes, containing an even no. of C-atoms, the 2 terminal methyl gps. lie