# HYDROCARBON: SATURATED AND UNSATURATED

***Hydrocarbons***

*[compounds containing carbon and hydrogen only]*

*Saturated*

*[contains only C-C single bonds]*

*Examples are*

*Methane [$CH_4$],Ethane [$C_2H_6$]*

*They are also called Alkanes.*

*Unsaturated*

*[contains at least one double or triple bond between two C atoms]*

*Alkenes (contain double (=) bond)*

*Example Ethene [$C_2H_4$] ,Propene $C_3H_6$]*

*Alkynes ( contain triple (≡) bond )*

*[Examples Ethyne [$C_2H_2$], Propyne [$C_3H_4$]*

**SPHS CHEM DEPT**

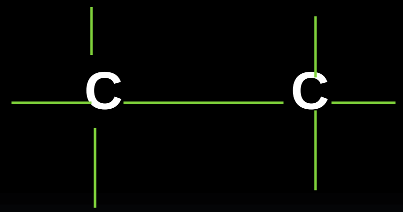
# Structures of saturated Hydrocarbons

In order to arrive at the structure of simple hydrocarbons, we need to follow two steps.

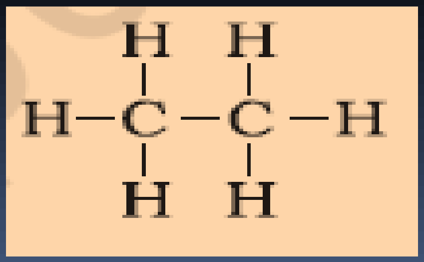
- Step 1: to link the carbon atoms together with single bond, which is called 'Carbon Skeleton'. [C-C]
- Step 2: use the hydrogen atoms to satisfy the remaining valencies of carbon.

Example, structure of a compound ethane with formula C2$H_6$ can be derived as

**Step 1**




**Step 2**

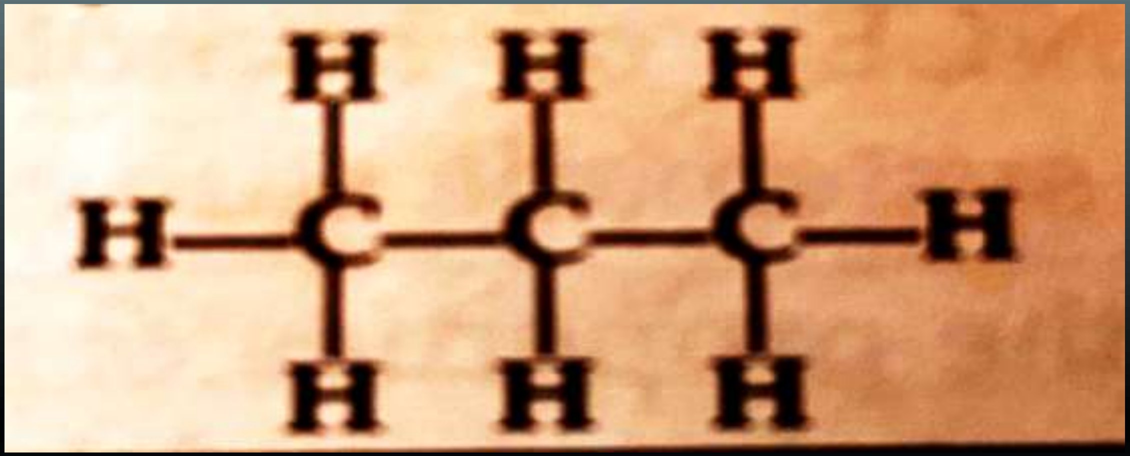



SPHS CHEM DEPT

Similar way the structure of the compound with formula $C_3H_8$ (propane) can be drawn.

Step 1: C-C-C (carbon skeleton)

Step 2:




***These are examples of saturated hydrocarbons and normally they are not very reactive.***

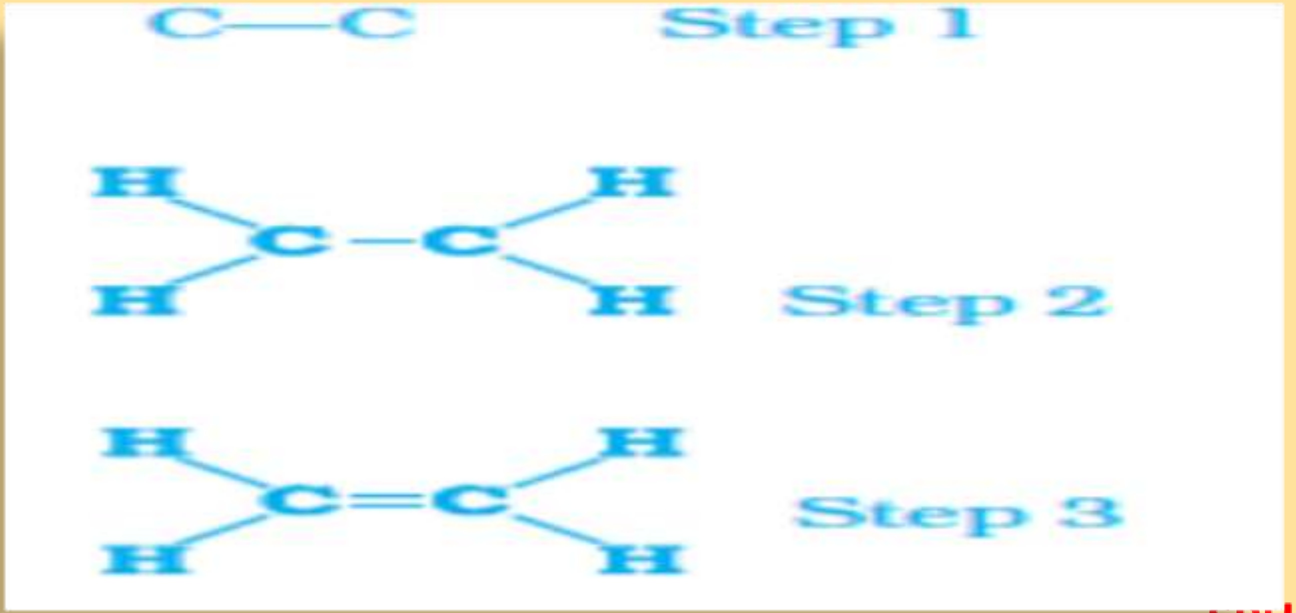
# Structures of unsaturated hydrocarbons

**Structure of $C_2H_4$**

Step 1: C-C (carbon skeleton)

Step 2: each carbon atom gets two hydrogen atoms

Step 3: still one valency per carbon atom remains unsatisfied. This can be *satisfied only if there is a double bond* between two carbon atoms. So we get



# Structure of ethyne ($C_2H_2$)

Step 1: C-C (as usual)

Step 2: H-C-C-H

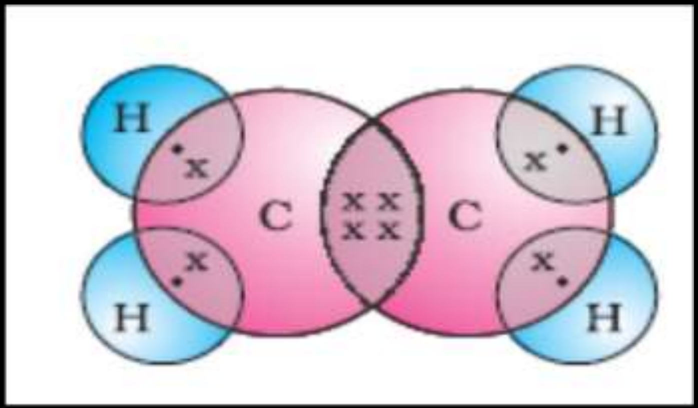
still two valencies of each carbon atom remain unsatisfied.

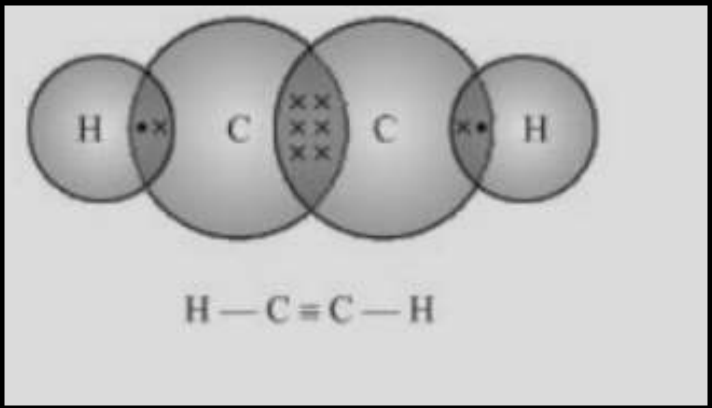
Step 3: those can be satisfied ***only by making a triple bond*** between the two carbon atoms.

**H-C≡C-H**

Ethene, ethyne are examples of unsaturated hydrocarbons and they are generally more reactive than saturated carbon compounds

Here are the electron dot structures of ethane and ethene.




***[Can you draw the electron dot structure of ethyne?]***

# ISOMERISM

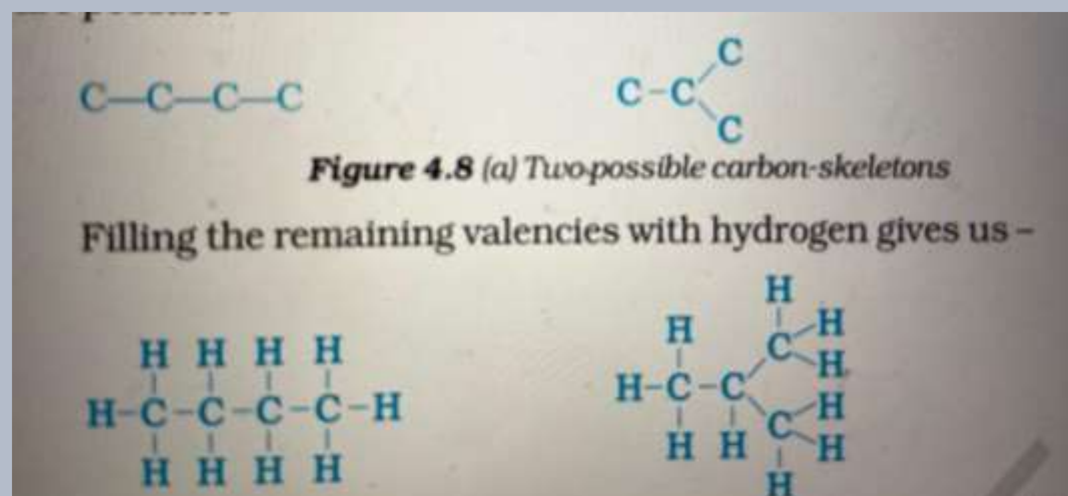
# ***Important definition:*** *Carbon compounds having same molecular formula but different structural formula are called* ***Structural*** **Isomers** *and the phenomenon is known as* **Isomerism.**

**Examples:** **The carbon skeleton of the compound $C_4H_{10}$ (butane) can be represented in the following two ways:**

**C-C-C-C** **and** **C-C-C** (with a **C** branching from the middle carbon)

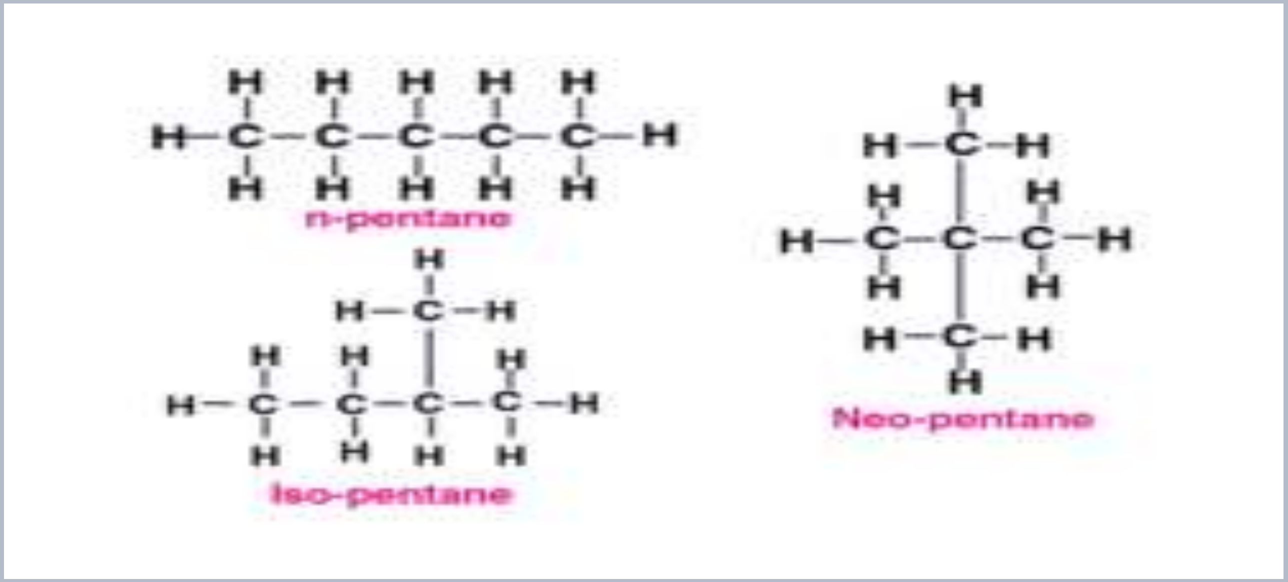
**Hence, filling the remaining valencies with hydrogen we finally get two different structures.**

***As they have same molecular formula but different structures, so these two are Isomers.***




**SPHS CHEM DEPT**

The compound pentane ($C_5H_{12}$) has three isomers.

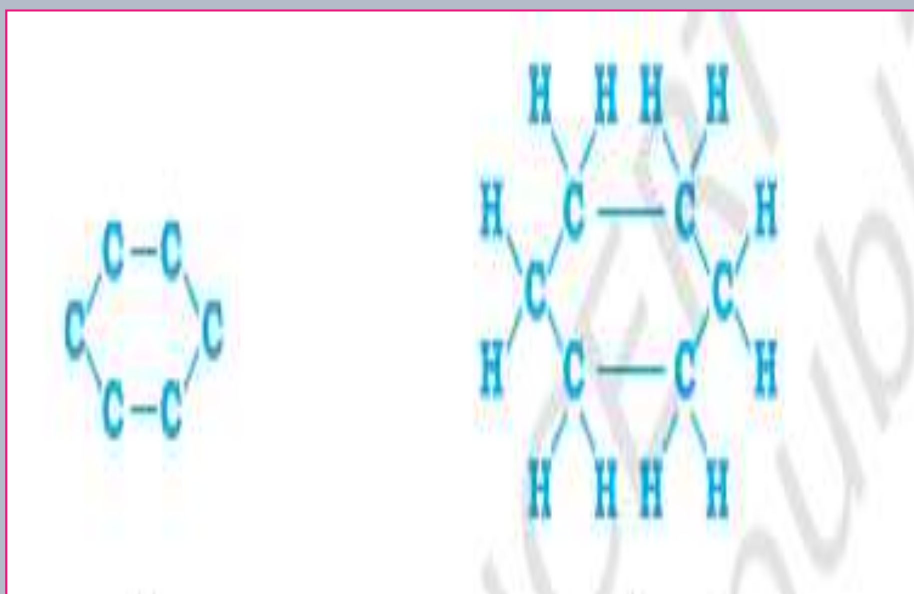


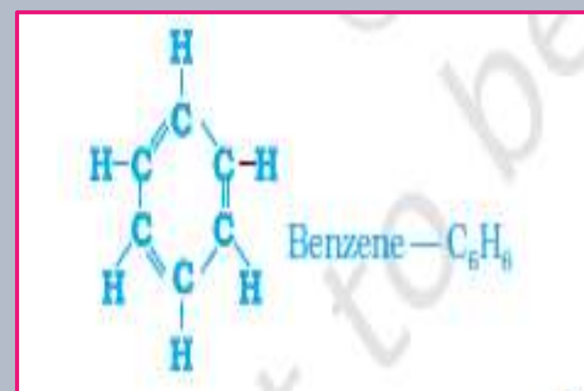

*This type of isomerism is called* ***'Chain*** *isomerism'*.

# Structures of Cyclic hydrocarbons

- In addition to straight and branched carbon chains, some compounds have carbon atoms arranged in the form of a ring.
- Examples are : i) Cyclohexane ($C_6H_{12}$) [saturated cyclic hydrocarbon]

  ii) Benzene ($C_6H_6$) [unsaturated cyclic hydrocarbon]





# Functional Group

rbon seems to be very friendly element, other than hydrogen, carbon also forms bonds with other elements such as **halogens, oxygen, nitrogen and sulphur**.

a hydrocarbon chain, one or two hydrogen can be replaced by these elements, so that the valency of carbon remains satisfied.

*ese elements are referred as 'heteroatoms', as they replace hydrogen.*

***ese heteroatoms and the group containing these, confer specific properties to the compound, irrespective of the length and nature of the carbon chain and hence they are called functional groups.'***

# Examples of some important functional groups:

Free valency or valencies of the group are shown by single line. The functional group is attached to the carbon chain through this valency by replacing one H atom or atoms.

| Hetero atom | Class of compounds | Formula of functional group |
|---|---|---|
| Cl/Br | Halo- (Chloro/bromo) alkane | —Cl, —Br (substitutes for hydrogen atom) |
| Oxygen | 1. Alcohol | —OH |
| | 2. Aldehyde | $-C(H)=O$ |
| | 3. Ketone | $-C(=O)-$ |
| | 4. Carboxylic acid | $-C(=O)-OH$ |

# HOMOLOGOUS SERIES

***Homologous series is a group of carbon compounds having similar structures, similar chemical properties and whose successive members differ by a –$CH_2$ group.***

Examples are: Alkanes, Alkenes, Alkynes, Alcohols etc.

Members of a homologous series have/show

- *same elements and functional groups*
- *same general molecular formula*
- *Similar chemical properties (same functional group)*
- *Increase in molecular weight – down a series (mol wt of two adjacent members differs by 14, $CH_2 = 12+2 = 14$)*
- *Gradual gradation seen in physical properties with increase in molecular weight , e.g., boiling point, solubility etc.*

# Examples of homologous series:

| Name | General formula | First four members | Difference between two successive members |
|---|---|---|---|
| ALKANE | $C_nH_{2n+2}$ | $CH_4$ (n=1)<br>$C_2H_6$ (n=2)<br>$C_3H_8$ (n=3)<br>$C_4H_{10}$ (n=4) | $-CH_2$ |
| Alkenes | $C_nH_{2n}$ | $C_2H_4$ (n =2)<br>$C_3H_6$ (n=3)<br>$C_4H_8$ (n= 4)<br>$C_5H_{10}$ (n=5) | $-CH_2$ |
| Alkynes | $C_nH_{2n-2}$ | $C_2H_2$ (n=2)<br>$C_3H_4$ (n=3)<br>$C_4H_6$ (n=4)<br>$C_5H_8$(n= 5) | $-CH_2$ |
| Alcohols | $C_nH_{2n+1}OH$ | $CH_3OH$ (n=1)<br>$C_2H_5OH$ (n=2)<br>$C_3H_7OH$ (n=3)<br>$C_4H_9OH$ (n=4) | $-CH_2$ |

SPHS CHEM DEPT

# Significance of homologous series:

- Helps in systematic study of organic compounds
- Predicts the properties and nature of other members of the series, if the same is known for the first few members.

Now let us try to solve some questions on homologous series:

**Activity 4.2**
Calculate the difference in the formulae and molecular masses for (a) $CH_3OH$ and $C_2H_5OH$ (b) $C_2H_5OH$ and $C_3H_7OH$, and (c) $C_3H_7OH$ and $C_4H_9OH$.
Q. Is there any similarity in these three?
Q. Arrange these alcohols in the order of increasing carbon atoms to get a family. Can we call this family a homologous series?
Q. Generate the homologous series for compounds containing up to four carbons for the other functional groups given in Table 4.3. (NCERT)

# Answers

A1.

| Mol. formula | Difference | Mol. mass | difference |
|---|---|---|---|
| $CH_3OH$ and $C_2H_5OH$ | $CH_2$ | 32u and 46u | 14u |
| $C_2H_5OH$ and $C_3H_7OH$ | $CH_2$ | 46u and 60u | 14u |
| $C_3H_7OH$ and $C_4H_9OH$ | $CH_2$ | 60u and 74u | 14u |

A2. Yes. They have same functional group (-OH).

A3. $CH_3OH$, $C_2H_5OH$, $C_3H_7OH$, $C_4H_9OH$

yes, it is a homologous series of alcohols as they have same functional group and successive members of this series differ by $-CH_2$ unit.

A4. Try yourself