CHAPTER # 11

ORGANIC CHEMISTRY

Q1. Define Organic chemistry?

Ans: Organic chemistry:

The Study of Carbon containing compounds and their properties is called organic chemistry.

However, few compounds of carbon such as carbon dioxide, carbon monoxide, carbonates and carbides are considered to be inorganic substance. This is because they have totally different properties thana organic compounds.

Q2. Define Organic compounds?

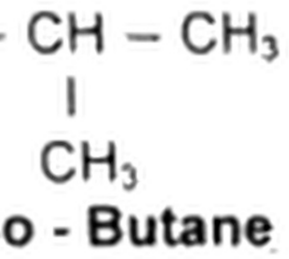
Ans: Organic compounds:

Organic compounds are defined as the hydrocarbons and their derivatives.

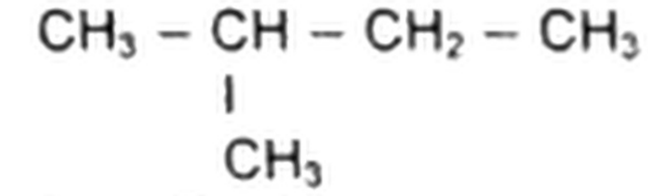
Q3. What is the molecular formula of the following compounds?

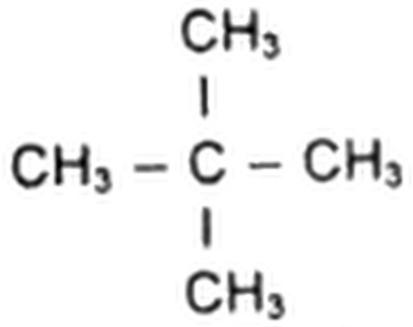
Ans: For example, two compounds have molecular formula C_4H_{10}.

(i) $CH_3 - CH_2 - CH_2 - CH_3$
n - Butane

(ii)

iso - Butane

(iii) $CH_3 - CH_2 - CH_2 - CH_2 - CH_3$
n - Pentane

(iv)

iso - Pentane

(v)

neo - Pentane

Solution:

i. Molecular formula C_4H_{10}

ii. Molecular formula C_4H_{10}

iii. Molecular formula C_5H_{12}

iv. Molecular formula C_5H_{12}

v. Molecular formula C_5H_{12}

Q4. What is the number of isomers in pentane?

Ans. Pentane has three isomers.

Q5. What is the number of isomers in hexane?

Ans. Hexane has five isomers.

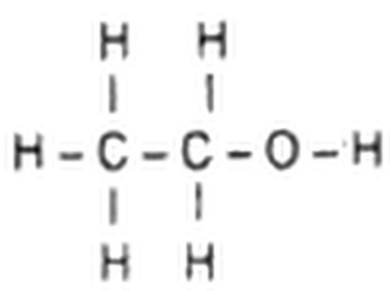
Q6. What do you mean by the term structural formula?

Ans. Structural formula:

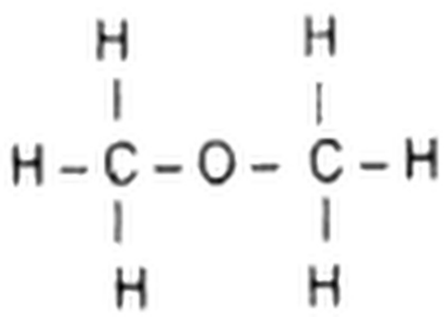
A formula that describes the arrangement of atoms in molecule is called as structural formula.

Examples:

For example, two organic compounds have the molecular formula C_2H_6O. they have different arrangement of atoms.



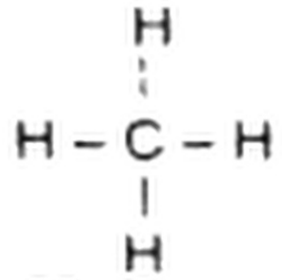
Ethanol



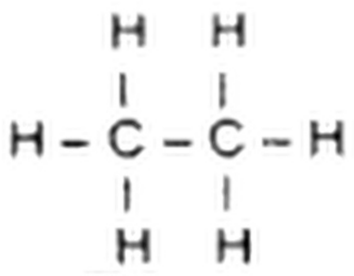
Dimethy ether

Q7. Write structural formulas, the condensed structural formulas and molecular formulas of first three members of alkanes?

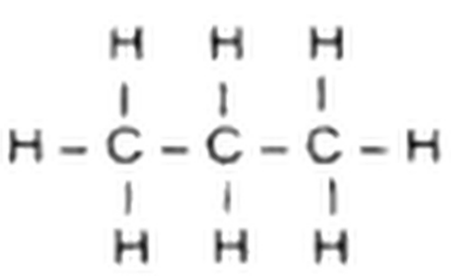
Ans: The simple alkanes are straight-chain hydrocarbons. First three members of alkanes have following **structural formulas.**



Methane



Ethane



Propane

Condensed structural formulas:

The condensed structural formulas of first three alkanes are

CH_4 CH_3CH_3 $CH_3CH_2CH_3$

Molecular formulas:

The corresponding molecular formulas are CH_4, C_2H_6, C_3H_8.

Q8. Briefly explain the term condensed formula?

Ans: Condensed formula:

A condensed formula is a structural formula that uses established abbreviation for various group of chain. In condensed structural formula, we list the main chain carbon atoms and the hydrogen atoms attached to them in the sequence in which they appear in the naming system.

For instance:

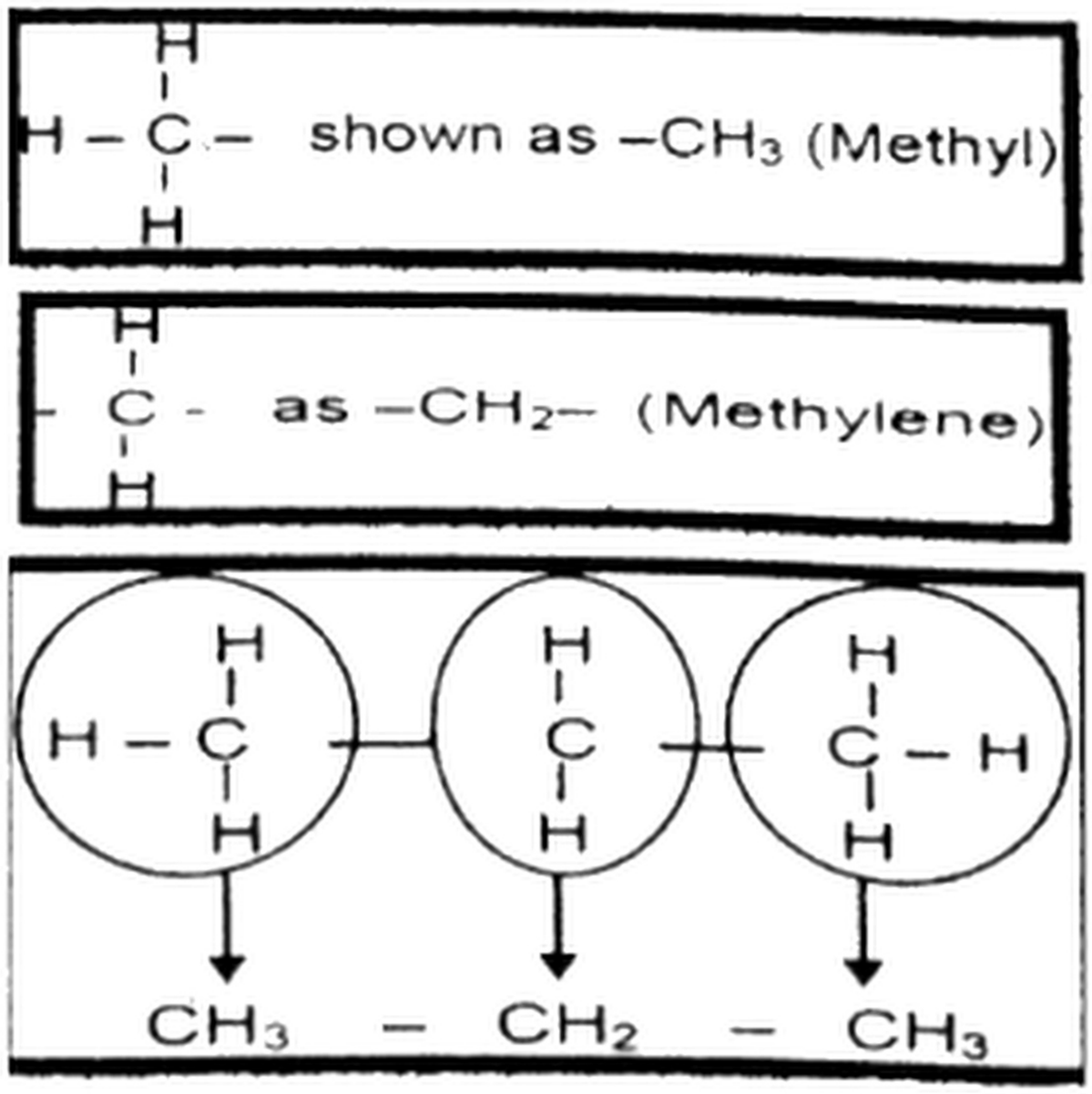


Table shows the condensed formulas of some alkanes.

Condensed structural formula of some alkanes:

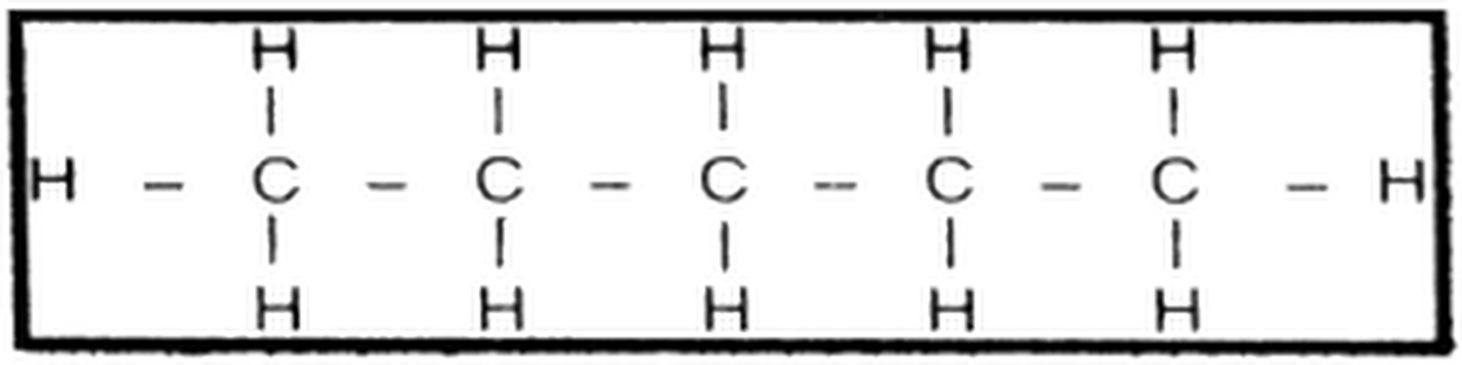
Name	Molecular formula	Condensed formula
Butane	C_4H_{10}	$CH_3—CH_2—CH_2—CH_3$
Pentane	C_5H_{12}	$CH_3CH_2CH_2CH_2CH_3$
Hexane	C_6H_{12}	$CH_3CH_2CH_2CH_2CH_2CH_3$

Heptane	C_7H_{14}	$CH_3CH_2CH_2CH_2CH_2CH_2CH_3$
Octane	C_8H_{16}	$CH_3CH_2CH_2CH_2CH_2CH_2CH_2CH_3$
Nonane	C_9H_{18}	$CH_3CH_2CH_2CH_2CH_2CH_2\ CH_2\ CH_2CH_3$
Decane	$C_{10}H_{20}$	$CH_3CH_2CH_2CH_2\ CH_2CH_2CH_2CH_2\ CH_2CH_3$

Q9. Example 11.1: Give the molecular formula, the structural formula and the condensed the structural formula for pentane?

Solution: C—C—C—C—C

Structural formula:



Condensed structural formula: $CH_3—CH_2—CH_2—CH_2—CH_3$

Molecular formula: $C_5H_{2\cdot5+2} = C_5H_{12}$

Self-Assessment Exercise 11.1

Give the molecular, structural and condensed structural formulas for

(a) Butane (b) Hexane (c) Octane

Solution:

(a) Butane

Molecular formula: C_4H_{10}

Structural formula: $CH_3—CH_2—CH_2—CH_3$

n- butane

Condensed structural formula: $CH_3CH_2CH_2CH_3$

(b) Hexane

Molecular formula: C_6H_{12}

Structural formula: $CH_3—CH_2—CH_2—CH_2—CH_2—CH_3$

n-hexane

Condensed structural formula: $CH_3CH_2CH_2CH_2CH_2CH_3$

(c)Octane

Molecular formula: C_8H_{18}

Structural formula: $CH_3—CH_2—CH_2—CH_2—CH_2—CH_2—CH_2—CH_3$

n-octane

Condensed structural formula: $CH_3CH_2CH_2CH_2CH_2CH_2CH_2CH_3$

Q10. Distinguish between saturated and unsaturated hydrocarbons.

OR

What are unsaturated and saturated hydrocarbons? Write down the structural formulas and names of two saturated and the two unsaturated hydrocarbons?

Ans: Hydrocarbons:

Hydrocarbons are compounds containing carbon and hydrogen only.

Saturated hydrocarbons:

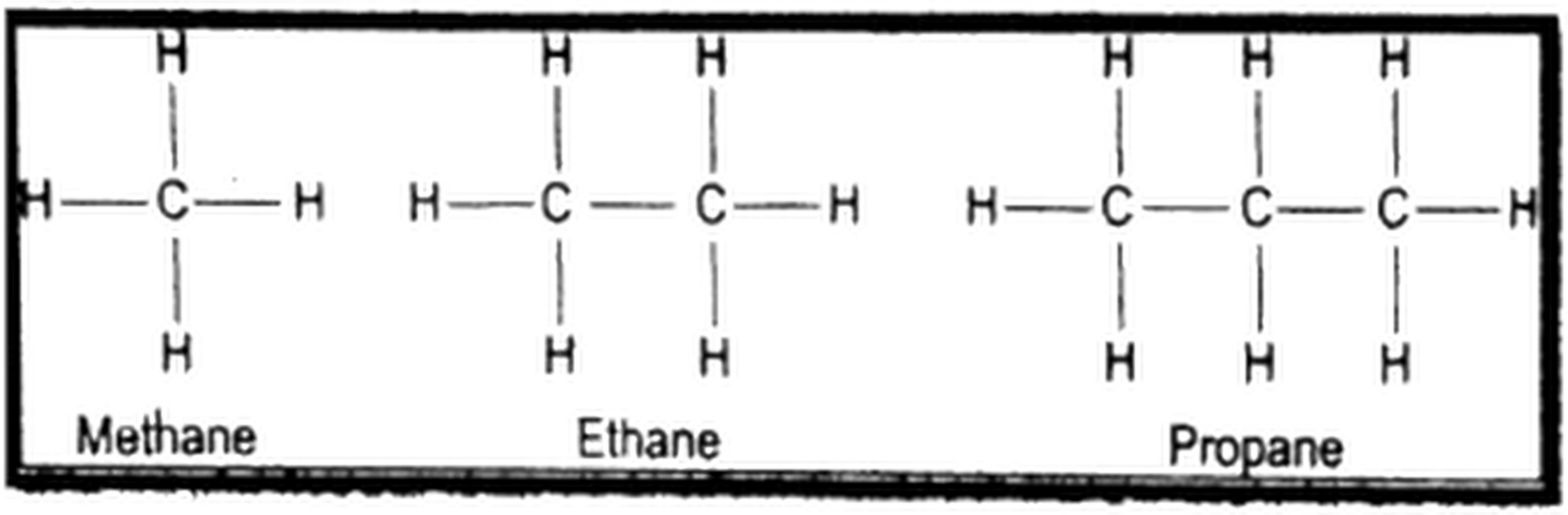
Hydrocarbons whose carbon – carbon bonds are all single bonds are called saturated. Saturated hydrocarbons are also called alkanes.

In alkanes each carbon atom is bonded to other four carbon atoms. Methane is the simplest alkane.

General formula of alkane:

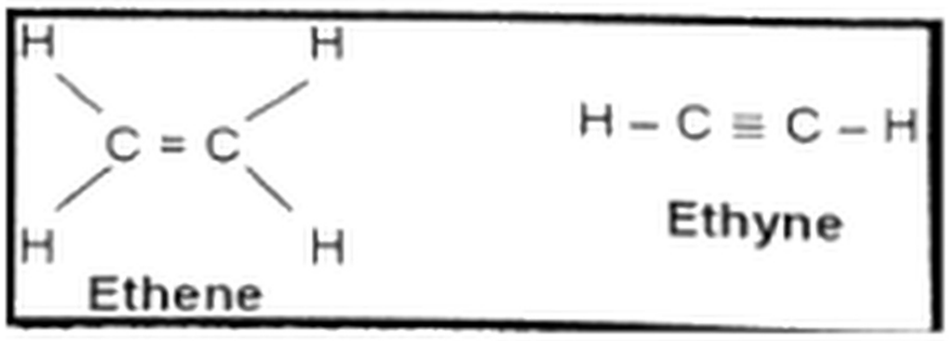
The general formula of alkanes in C_nH_{2n+2}, where **n** is the number of carbon atoms.

Three saturated hydrocarbons:



Unsaturated hydrocarbons:

Hydrocarbons containing carbon-carbon multiple bonds are called unsaturated.



Classification of unsaturated hydrocarbons:

Unsaturated hydrocarbons are further divided into:

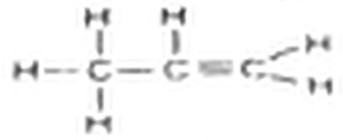
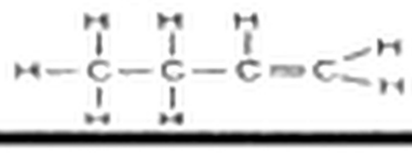
(i) Alkenes:

Unsaturated hydrocarbons containing at least one carbon-carbon double bond are called alkenes. They have general formula C_nH_{2n}, for example ethene.

(ii) Alkynes:

Unsaturated hydrocarbons containing at least one carbon-carbon triple bond are called alkynes. They have general formula C_nH_{2n-2}, for example ethyne.

Three unsaturated hydrocarbons:

Number of Carbon atoms	Name	Molecular Formula	Structural Formula
2	Ethene	C_2H_4	
3	Propene	C_3H_6	
4	Butene	C_4H_8	

Self-Assessment Exercise 11.2

Identify saturated and unsaturated compounds from the following:

(i) $CH_3—CH_2—CH_3$ **(ii)** $CH_3\text{-}CH{\equiv}CH$

(iii) $CH_3—CH{=}CH_2$ **(iv)** $CH_2{=}CH\text{-}CH{=}CH_2$

Solution:

(i) $CH_3—CH_2—CH_3$

Saturated hydrocarbon (single covalent bond)

(ii) $CH_3\text{-}CH{\equiv}CH$

Unsaturated hydrocarbon (triple covalent bond)

(iii) $CH_3—CH{=}CH_2$

Unsaturated Hydrocarbon (double covalent bond)

(iv) $CH_2=CH-CH=CH_2$

Unsaturated Hydrocarbon (double covalent bond)

Q11. Briefly explain rules for naming alkanes according to IUPAC name?

Ans: Naming alkanes:

The key point in naming a straight chain alkane is that the name is based on the number of carbon atoms in the chain. The IUPAC (international union of pure and applied chemistry) names has three parts.

(i) Stem:

The stem tells the number of carbon atoms in the chain.

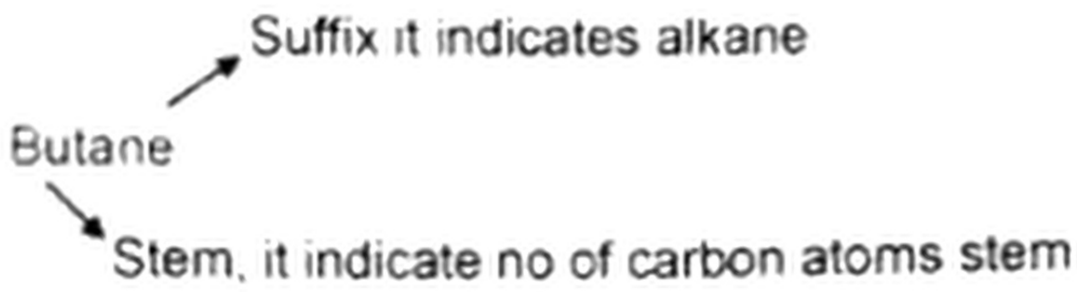
Numerical stems for carbon chains:

Stem	Number of carbon atoms
Meth-	1
Eth-	2
Prop-	3
But-	4
Pent-	5
Hex-	6
Hept-	7
Oct-	8

Non-	9
Dec-	10

(ii) Suffix:

Suffix is placed after the stem; it tells the class od compound. For alkane, the suffix **"ane"** is used.



Q12. Example 11.2: Write IUPAC names of the following compounds.

(i) $CH_3—CH_2—CH_2—CH_3$ (ii) $CH_3—CH_2—CH_2—CH_2—CH_3$

Problem solving strategy:

(i) Count number of carbon atoms in the chain and select stem for it.

(ii) Add suffix – ane to the stem

Solution:

(i) No. of carbon atoms 4

Stem → But

Name: Butane

(ii) No. of carbon atoms 5

Stem → Pent

Name: Pentane

Self-Assessment Exercise 11.3

Write IUPAC names of the following of the following alkanes.

(i) $CH_3—CH_2—CH_2—CH_2—CH_2—CH_3$

(ii) $CH_3—CH_2—CH_2—CH_2—CH_2—CH_2—CH_2—CH_3$

(iii) $CH_3—CH_2—CH_2—CH_2—CH_2—CH_2—CH_3$

(iv) $CH_3—CH_2—CH_2—CH_2—CH_2—CH_2—CH_2—CH_2—CH_2—CH_3$

(v) $CH_3—CH_2—CH_2—CH_2—CH_2—CH_2—CH_2—CH_2—CH_3$

Solution:

(i) $CH_3—CH_2—CH_2—CH_2—CH_2—CH_3$

Number of carbon atoms = 6, name= hexane

(ii) $CH_3—CH_2—CH_2—CH_2—CH_2—CH_2—CH_2—CH_3$

Number of carbon atoms = 8, name= octane

(iii) $CH_3—CH_2—CH_2—CH_2—CH_2—CH_2—CH_3$

Number of carbon atoms = 7, name= heptane

(iv) $CH_3—CH_2—CH_2—CH_2—CH_2—CH_2—CH_2—CH_2—CH_2—CH_3$

Number of carbon atoms = 10, name= decane

(v) $CH_3—CH_2—CH_2—CH_2—CH_2—CH_2—CH_2—CH_2—CH_3$

Number of carbon atoms = 9, name= nonane

Q13. Recognize and identify the uses of organic compounds?

Ans: Uses of organic compound:

(i) Natural gas and petroleum are used primarily as fuel. These are also used as starting materials for the productions of variety of organic compounds.

(ii) Propane and butane which are gases obtained from natural gas are widely available as liquid in fuel cylinders. (LPG)

(iii) Ethylene is the major starting material for the manufacture of organic chemicals and products such as polythene (plastics), ethyl alcohol, acetic acid and ethylene glycol called anti-freeze.

(iv) Acetylene is widely used in the oxy-acetylene welding and cutting metals. Acetylene is also used in the preparation of polymers like PVC (polyvinyl chloride), polyvinyl acetate, synthetic rubber, nylon etc.

(v) Acetylene is used for artificial ripening of fruits.

(vi) Compounds of phenol help to ensure antiseptic conditions in hospital operating rooms.

(vii) Methanol is used as a solvent for fats, oils, paints and varnishes.

(viii) Many organic compounds are used in the manufacture of drugs, dyes, cosmetics, detergent and soaps, nylon, emulsions, paints etc.

Self-Assessment Exercise 11.4

1. **List the names of major sources of alkanes**
2. **What is natural gas?**
3. **Write some uses of acetylene.**

Solution:

Major sources of alkanes:

The major commercial sources of alkanes are coal, natural gas, petroleum, and living organisms.

Natural gas:

Natural gas is a mixture of low boiling hydrocarbons. Natural gas is mostly methane. It also contains smaller amounts of ethane, propane and butane.

Uses of acetylene:

Acetylene is widely used in the oxy-acetylene welding and cutting metals. Acetylene is also used in the preparation of polymers like PVC (polyvinyl chloride), polyvinyl acetate, synthetic rubber, nylon etc.

Acetylene is used for artificial ripening of fruits.

Q14. Differentiate between alkane and alkyl radicals?

Ans: Alkane and Alkyl Radicals:

Recall that an alkane is a hydrocarbon containing only single bonds and have general formula C_nH_{2n+2}.

An alkyl radical is a group of atoms obtained by removing one hydrogen atoms for alkane. Alkyl radical are represented by the symbol R.

Alkyl radicals have general formula C_nH_{2n+1}.

Q15. Example 11.3 Converting alkanes into alkyl radicals

Convert following alkanes into alkyl radical.

(i) Methane (ii) Ethane

Solution: (i) CH_4 $CH_3—$

Methane Methyl

(ii) CH_3CH_3 $CH_3CH_2—$

Ethane **Ethyl**

Q16. What is the difference between methane and methyl radical?

Which one contains a free valency?

Ans: Methyl radical is obtained by removing one hydrogen atom from methane.

CH4 $CH_3—$

Methane **Methyl**

Methyl radical contain free valency.

Self-Assessment Exercise 11.5

Derive alkyl radicals from the following alkanes.

a. **Ethane** **b. Butane** **c. Propane**

Solution:

a. CH_3CH_3 $CH_3CH_2—$

Ethane Ethyl

b. $CH_3CH_2CH_2CH_3$ $CH_3CH_2CH_2—$

Butane Butyl

c. $CH_3CH_2CH_3$ $CH_3CH_2CH_2—$

Propane Propyl

DO YOU KNOW

Alkyl radical contains one less hydrogen than its parent alkane.

Q17. Classify organic compounds into straight chain, branched chain and cyclic compounds.

Ans: Classification of organic Compounds:

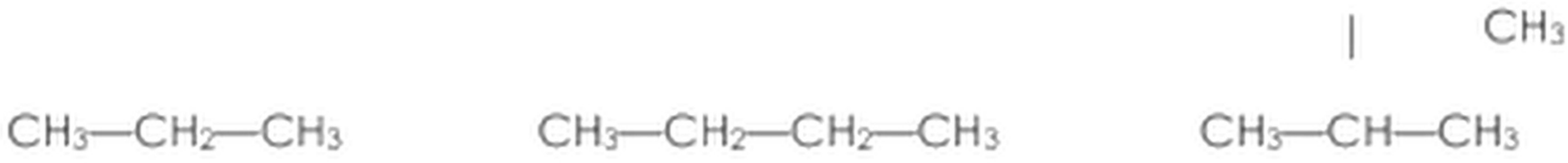
Organic compounds are broadly classified into two main groups.

(i) Open chain compounds or alicyclic compounds.

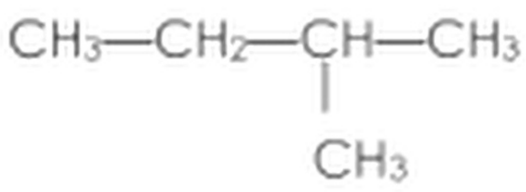
(ii) Closed chain or cyclic compounds

(i) Open chain compounds or alicyclic compounds:

Open chain compound contains an open chain of carbon atoms. For instance,



Propane **Butane** **Iso-butane**

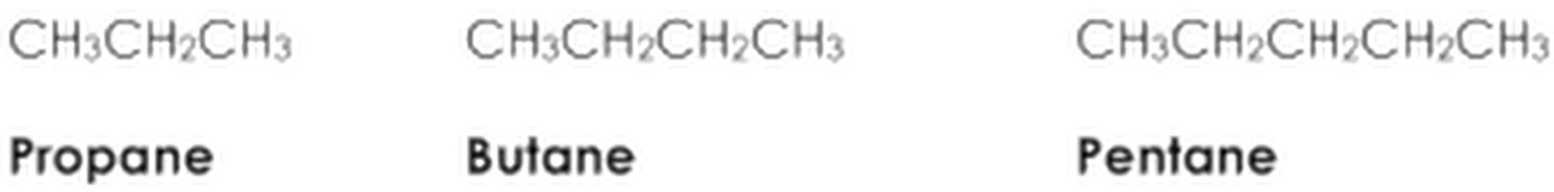


Iso-pentane

Types of open chain compounds:

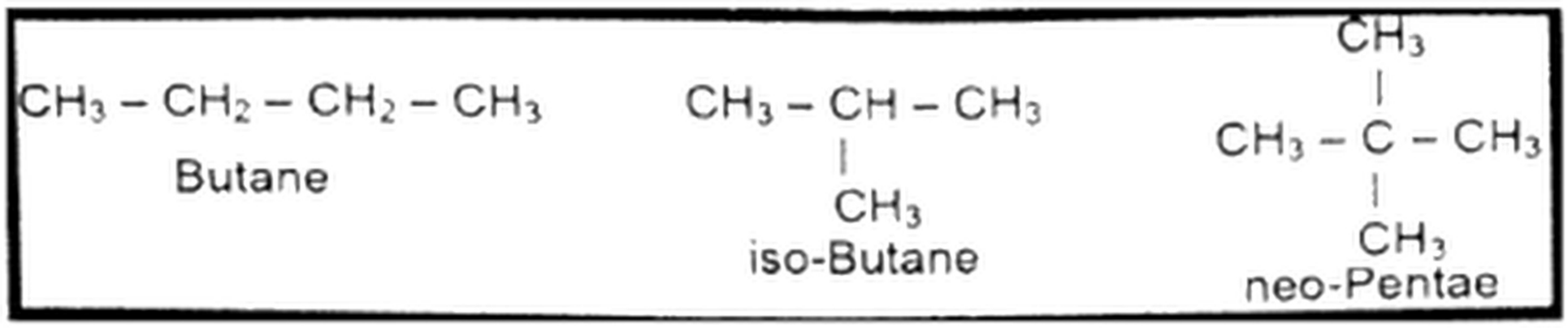
Open chain compounds may be either straight-chain or branched-chain. Those compounds which contain any number of carbon atom joined one after the other in a chain or row are called **straight-chain compounds.**

For example



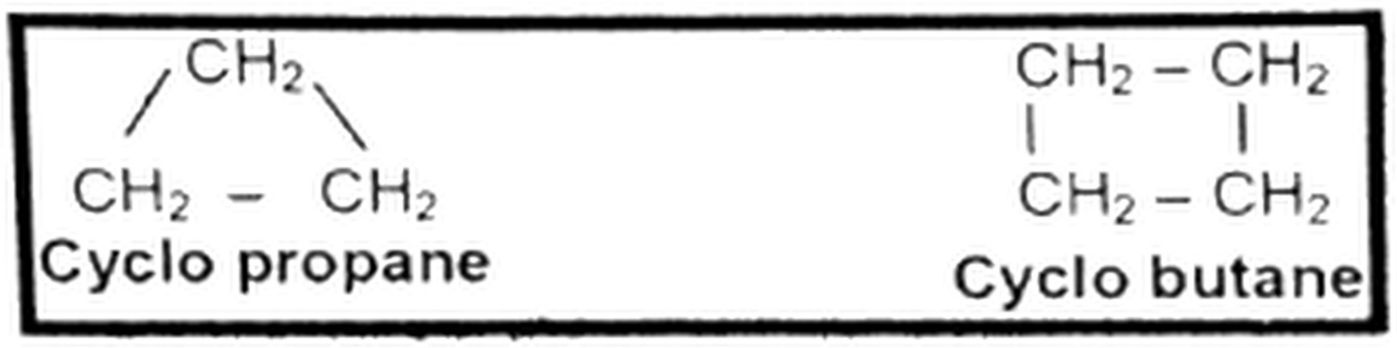
Propane **Butane** **Pentane**

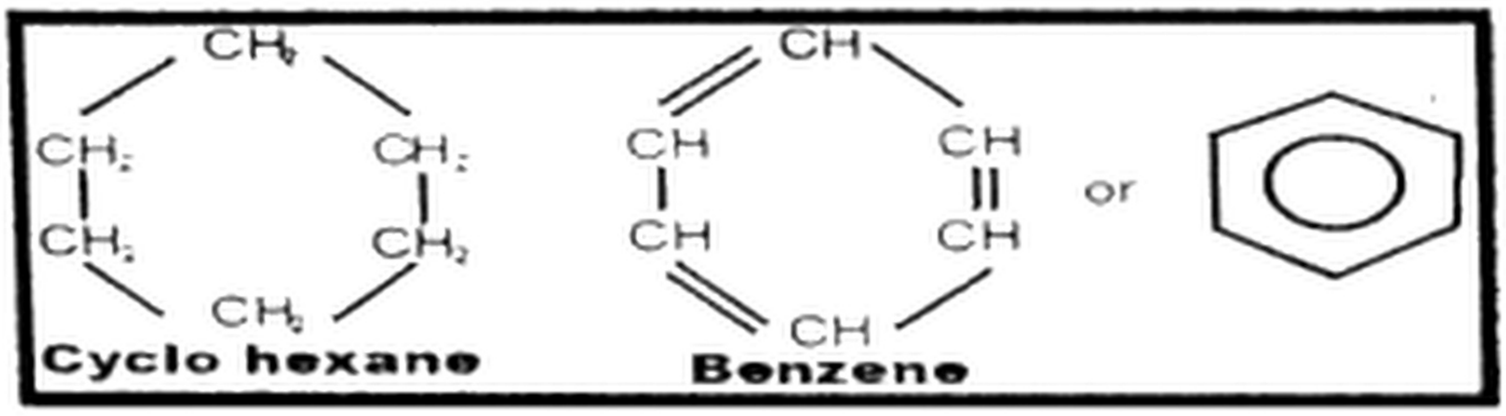
Those compounds which contain carbon atoms on the sides of chain are called branched chain compounds. Which of the following is a branched chain compound?



(ii) Closed chain or Cyclic Compound:

Organic compounds which contain rings of atoms are called closed chain or cyclic compounds.





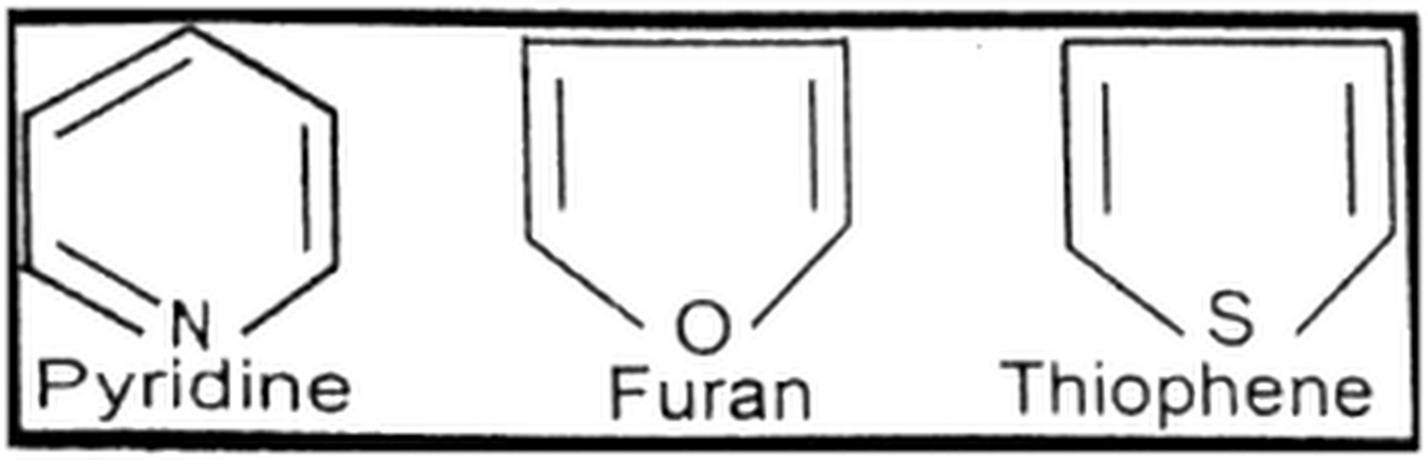
Types of cyclic compounds:

Homocyclic or carbocyclic compounds:

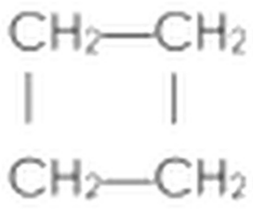
Cyclic compounds which contain rings of carbon atoms are called homocyclic or carbocyclic compounds.

Heterocyclic compounds:

Cyclic compounds that contain one or more atoms other than carbon atoms in the ring are called heterocyclic compounds.



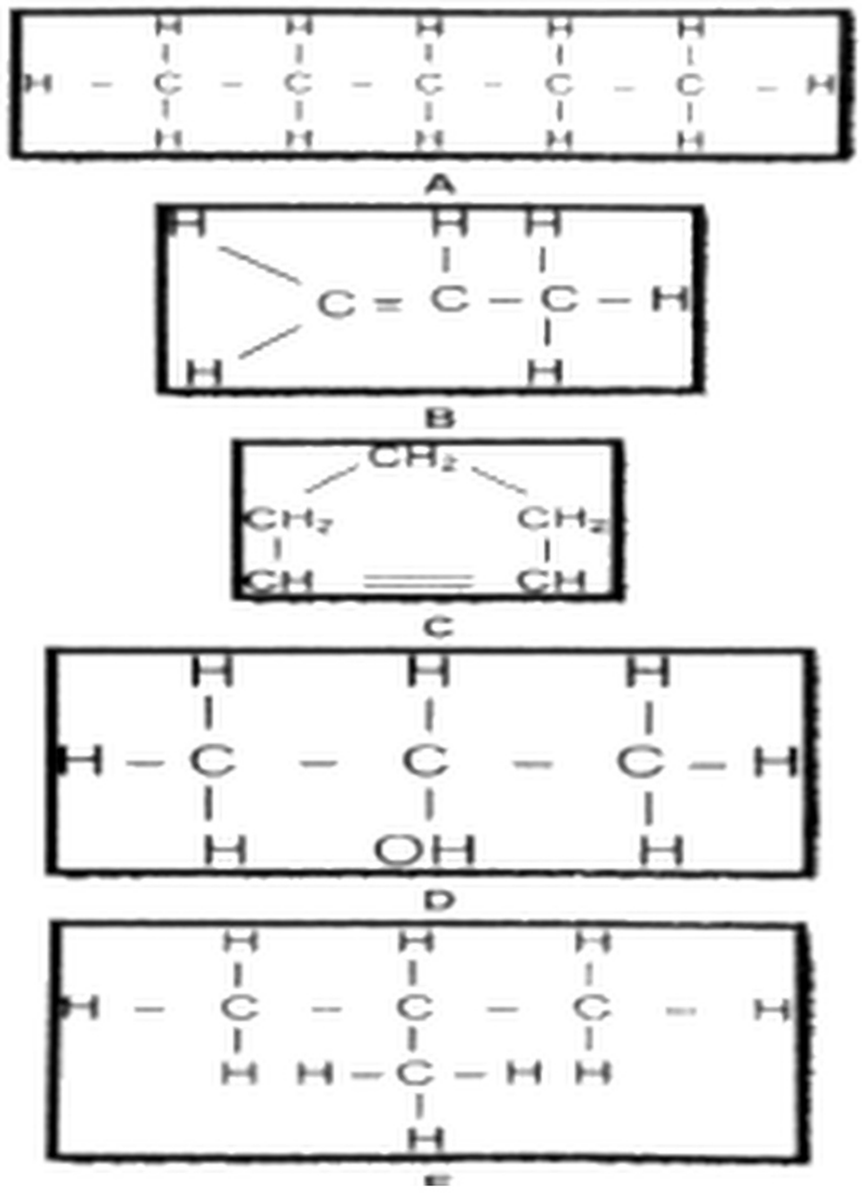
Q18. Is the compound having following structure an open chain compound?



Ans: compound is closed chain or cyclic compound. The name of compound is cyclo butane.

Self-Assessment Exercise 11.6

A to E are the structural formulas of some organic compounds.



Give the letters which each represents.

(i) A branched chain compounds.

(ii) A cyclic compound.

(iii)Two straight chain compounds.

Solution:

(i) A branched chain compounds.

D, E

(ii) A cyclic compound.

C

(iii)Two straight chain compounds.

A, B

Q19. List the functional groups containing carbon, hydrogen and halogens?

OR

What do you understand by haloalkanes?

Ans: Functional groups containing carbon, hydrogen and halogens:

(Haloalkanes)

Haloalkanes are characterized by the presence of the halogen atom. The haloalkanes is compound in which one hydrogen atom of an alkane is substituted by one halogen atom.

Example of haloalkanes:

$CH_3—Cl$ $CH_3—Br$

Chloromethane **Bromomethane**

Q20. Which of the following molecules are haloalkanes?

CH_4 $CH_3—Cl$ $CH_3—Br$

Methane **Chloromethane** **Bromoethane**

CH_3CH_3 CH_3CH_2Cl

Ethane **Chloroethane**

Ans: Chloromethane, Bromoethane and Chloroethane are haloalkanes.

Q21. List the functional groups containing carbon, hydrogen and oxygen?

Ans: i. Alcohols **ii.** Phenols

iii. Ethers **iv.** Aldehydes

v. Ketones **vi.** Carboxylic Acid

vii. Esters

Q22. What do you understand by the functional group of alcohols?

Ans: Alcohols:

Alcohols are characterized by the presence of the hydroxyl group. (--OH) attached to a hydrocarbon chain.

$CH_3—OH$ $CH_3—CH_2—OH$

Methanol **Ethanol**

(Methyl Alcohol) **(Ethyl Alcohol)**

General formula for alcohols:

R—OH is the general formula for alcohols. Which of the following compounds is alcohol?

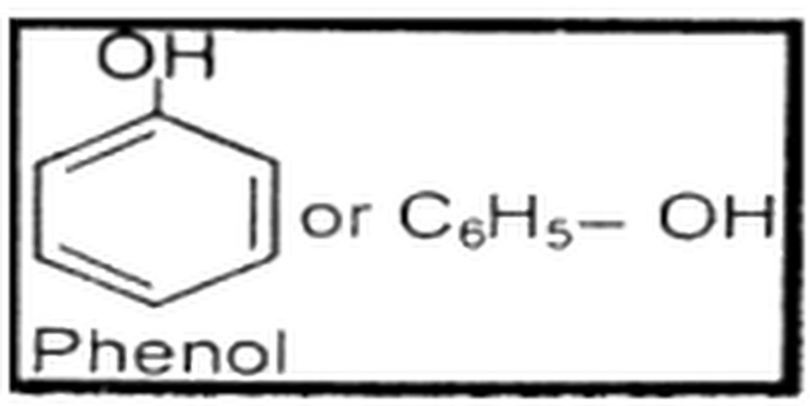
$CH_3CH_2CH_2OH$ $CH_3CH_2CH_2CH_2OH$

1-Propanonol **1- Butanol**

Q23. What do you understand by the functional group of phenols?

Ans: Phenols:

When an –OH group is attached to a benzene ring, the compound is called a phenol.



Phenol was the first antiseptic used in operation theatre.

Q24. What do you mean understand by the functional group of ethers?

Ans: Ethers:

Organic compounds that have two alkyl groups attached to the same oxygen atom are called ethers. These compounds have C—O—C linkage in their molecules.

$CH_3—O—CH_3$ $CH_3—O—CH_2—CH_3$ $CH_3—CH_2—O—CH_2—CH_3$

Dimethyl ether **Ethyl Methyl Ether** **Diethyl ether**

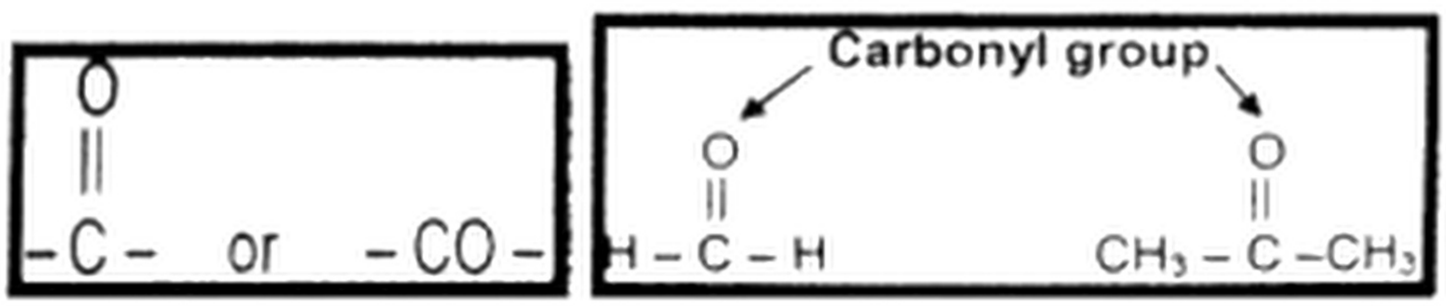
General formula for ethers:

The general formula for ethers is R—O--R'. Where R and R' are alkyl groups which may be same or different.

Q25. Briefly explain the functional group of aldehydes and ketones?

Ans: Aldehydes and ketones:

Aldehyde and ketones contain the carboxyl group.



An aldehyde has at least one hydrogen atom or two hydrogen atoms attached to the carbonyl carbon atom.

A ketone has two hydrocarbon groups (alkyl) bonded to the carbonyl carbon atom.

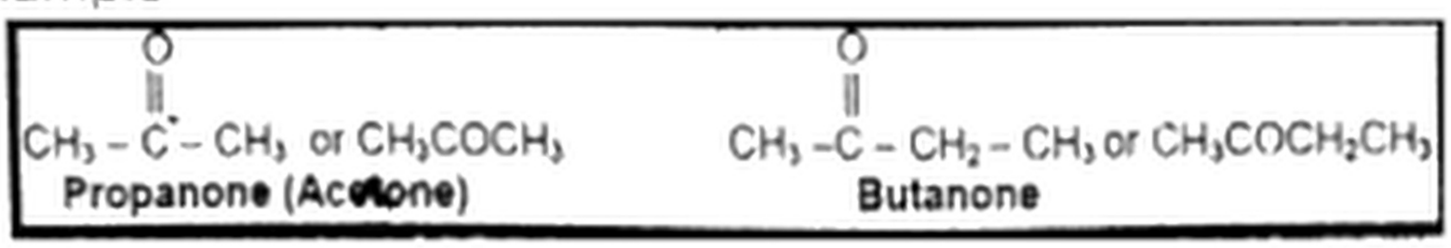
O
||
--C—H group in condensed form is written as **–CHO**. It is characteristic group of aldehydes.

O || HCHO or H – C – H **Methanal** **(Formaldehyde)**	O || CH_3CHO or CH_3 – C – H **Ethanal** **(Acetaldehyde)**

General formula for ketone:

The general formula for ketone is R—C—R' and in condensed form it is written as RCOR'. Where R and R' are alkyl groups which may be same or different.

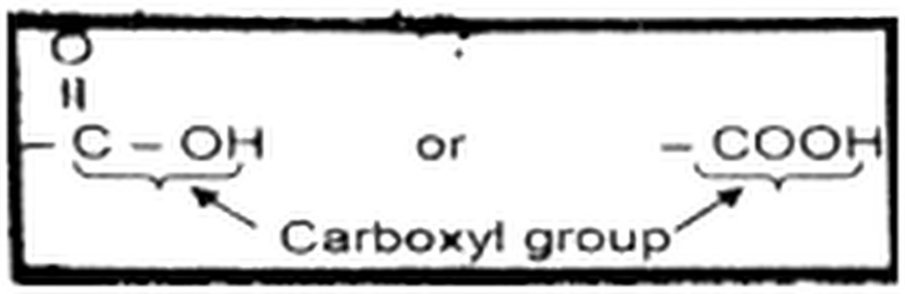
For example



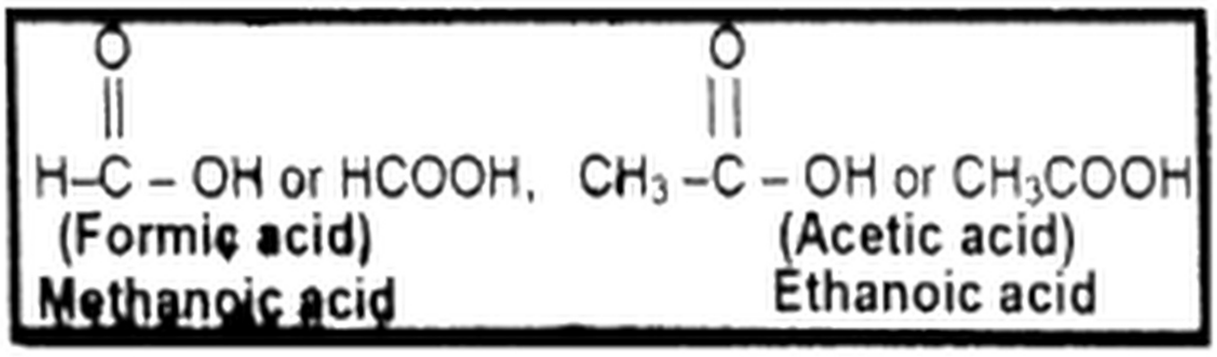
Q26. What do you understand by the functional group of carboxylic acid?

Ans: Carboxylic acid:

The functional group of organic acid is called the carboxyl group.



Examples:

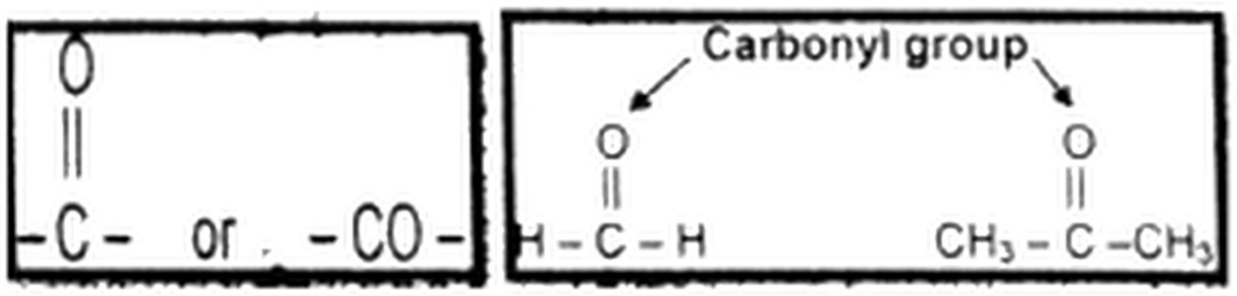


The general formula for carboxylic acids is R—COOH or R—C—OH.

Q27. What is the difference between a carbonyl and carboxyl groups?

Ans: Carbonyl group:

Carbonyl group is a functional group with double bonded oxygen to a carbon. Aldehydes and ketones are known as organic molecules with a

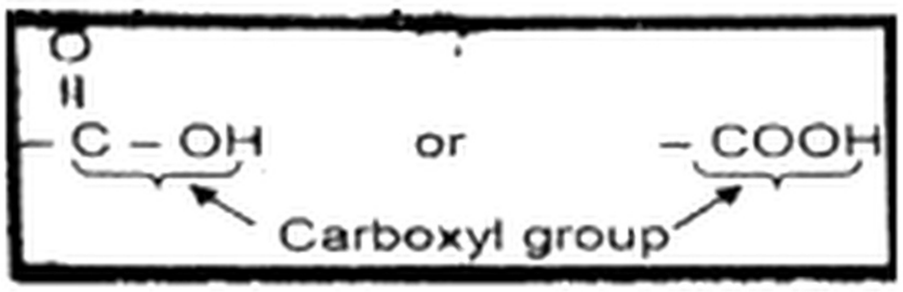


carbonyl group.

Aldehyde and ketones contain the carbonyl group.

Carboxylic acids:

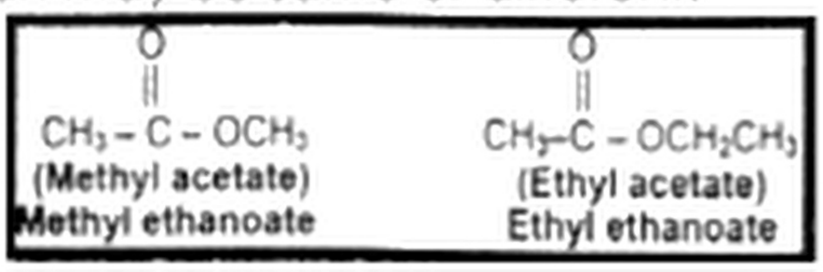
The functional group of organic acid is called the carboxyl group.



Q28. What do you understand by the functional group of esters?

Ans: Esters:

Compounds having general formula R—C—R' are called esters. R and R' are alkyl groups which may be same or different.



—C—OR' is the functional group of esters.

Q29. List functional groups contain carbon, hydrogen and nitrogen?

Ans: Functional groups contain carbon, hydrogen and nitrogen:

Amines:

The functional group of amines is —NH_2.

CH_3—NH_2	$CH_3CH_2NH_2$
Methyl amine	Ethyl amine

General formula for amines:

The general formula for amines is R—NH_2.

Q30. List functional group contain double and triple bond?

Ans: Functional group contain double and triple bond:

Alkene:

An alkene is a hydrocarbon that contains one or more carbon-carbon double bond

Bond: C=C is the functional group for alkenes.

CH_2=CH_2

Alkyne:

An alkyne is a hydrocarbon that contains one or more carbon-carbon triple bond. C≡C is the functional group for alkynes. Which of the following compound is alkene which is alkyne?

HC≡CH	**CH_3—C≡CH_2**

Q31. Which of the following compound is alkene, which is alkyne?

$CH_2=CH_2$ $HC\equiv CH$ $CH_3—C\equiv CH_2$

(i) **(ii)** **(iii)**

Ans: **(i)** is alkene where as **(ii)** and **(iii)** are alkynes.

Q32. Example 11.4: Differentiate different organic compounds on the basis for the functional groups.

Classify the following compounds as an alcohol, ether or phenol.

(a) $CH_2CH_2OCH_2CH_3$, is an aesthetic, but it uses an aesthetic is now limited. This is because it is inflammable and causes nausea.

(b) C_6H_5OH is a strong germicide. It is commonly used as disinfectant for floors, furniture and washrooms.

(c) CH_3OH is poisonous and can cause blindness or death if taken internally.

Problem solving strategy:

(i) Identify alkyl group in the molecule and functional group.

(ii) When —OH group is attached to an alkyl group, the compound is an alcohol, but when —OH is attached to benzene ring, the compound is phenol.

(iii) When O— atom is attached to two alkyl groups, the compound is an ether.

Solution: **(a)** Ether **(b)** Phenol **(c)** Alcohol

Self-Assessment Exercise 11.7

Classify the following as alcohol, ether or phenol

(a)$CH_2CH_2OCH_2CH_3$

(b)$CH_2CH_2CH_2OH$

(c)C_6H_5OH

(d)C_2H_5OH

Solution:

(a)$CH_2CH_2OCH_2CH_3$

Ether because O— atom is attached to two alkyl group.

(b)$CH_2CH_2CH_2OH$

Alcohol because OH group is attached to an alkyl group.

(c)C_6H_5OH

Phenol because —OH is attached to benzene ring.

(d)C_2H_5OH

Alcohol because OH group is attached to an alkyl group.

Q33. Example 11.5: Differentiate different organic compounds on the basis for the functional groups.

Classify the following compounds as an aldehyde, ketone and carboxylic acid.

(a) CH_3COCH_3, is a common solvent for organic materials such as fats, rubbers, plastics and varnishes.

(b) CH_3CH_2CHO has a foul irritating odor.

(c) CH_3COOH is present in vinegar and used to flavor food and making a polymer called polyvinyl acetate.

Problem solving strategy:

(i) In the aldehyde a hydrogen atom is attached to the carbonyl carbon atom.

(ii) In carboxylic acid —OH group is attached to the carbonyl carbon atom.

(iii) In ketone, the carbonyl carbon is between two other carbon atoms.

Solution: **(a)** A ketone **(b)** An aldehyde **(c)** An organic acid

Self-Assessment Exercise 11.8

Identify the following compounds as an aldehyde, or a ketone or carboxylic acid.

(a) $CH_3COCH_2CH_3$ **(b)** $CH_3CH_2CH_2\overset{\overset{O}{\|}}{C}H$ **(c)** $CH_3CH_2\overset{\overset{O}{\|}}{C}OH$

Solution:

(a) ketone because the carbonyl carbon is between two other carbon atoms.

(b) Aldehyde because a hydrogen atom is attached to the carbonyl carbon atom.

(c) Carboxylic acid because —OH group is attached to the carbonyl carbon atom.

Society, Technology and Science

Synthesis scheme:

To develop a synthesis scheme for a particular substance produced by the plants and animals or new effective drug, pharmaceuticals chemists first analyze the target molecule. They look for suitable starting material.

The synthesis involves two steps:

(i) Changes in the carbon skeleton

(ii) Inter conversion of functional group

So, pharmaceutical chemists determine whether the reaction changes the carbon skeleton or inter convert the functional groups. If both the molecules have same carbon atoms, then they can accomplish the synthesis by one or more functional group inter-conversion. If they are of different sizes, then they modify the carbon skeleton. For this they look for a molecule that allows them to make a possible carbon containing skeleton to obtain the product. Then they look for ways to obtain the functional groups of the target molecule.

Skills

Q34. Activity 11.1: differentiate between saturated and unsaturated compounds using iodine, bromine and potassium promgenante.

Carry out the following:

- Dissolve 2-3cm^3 of mustard oil in 5cm^3 of carbon tetrachloride. Divide this solution into three parts.
- To one part add few drops of iodine solution and shake. What happens?

- To the third part a add few drops of alkaline $KMnO_4$ solution and shake. (Bayer's test). What happens?
- Repeat these steps with kerosene oil. What happens?

Un-saturated compound discharge:

(i) Reddish brown color of bromine water

(ii) Purple color of iodine solution

(iii) Purple color of alkaline $KMnO_4$.

Q35. Activity 11.2: Identifying carboxylic acids, phenols, amines, aldehyde and ketones in terms of functional groups.

Perform this activity in chemistry laboratory

Carry out the following

i) Test for carboxylic acids:

- Take $5cm^3$ of vinegar in a test tube and a pinch of $NaHCO^3$, test the gas evolved with lime water. What happens?
- Dip blue litmus paper in vinegar. What happens? These two tests indicate the presence of carboxylic group in vinegar.

ii) Test for phenol:

- Dissolve a pinch of carbolic acid (phenol) in $5cm^3$ of water in a test tube.
- Add bromine water in the above solution.
- What happens? Phenol gives white ppt with bromine water.

iii) Test for amine:

- Heat a pinch of an amine in $2cm^3$ of alcoholic solution of KOH and $0.5cm^3$ of chloroform.
- Note the odor of fumes given out.

An amine gives extremely unpleasant or foul odor.

iv) Test for aldehyde:

- Mix equal volumes of Fehling's solution A and B in a test tube.
- Add a pinch of glucose in it and boil for some time.
- What happens?

Aldehyde give red precipitate with Fehling's solution.

v) Test for ketone:

- Take 2-3 cm^3 of sodium nitro-prusside solution in attest tube and few drops of NaOH solution.
- Add one cm^3 of acetone in the above test tube.
- What happens?

Ketones give red color with alkaline sodium nitro-prusside.