Chapter 11

ORGANIC CHEMISTRY

Conceptual Linkage

Before reading this chapter, the student must know the:

- Concept of valency
- Difference between ion, atom and radical
- Lewis structural formulae

Time Allocation

Teaching periods	= 10
Assessment periods	= 03
Weightage	= 05%

LEARNING OUTCOMES

Students will be able to:

- Recognize structural, condensed and molecular formulas of the straight chain hydrocarbons up to ten carbon atoms. (Understanding)
- Identify some general characteristics of organic compounds. (Remembering)
- Explain the diversity and magnitude of organic compounds. (Understanding)
- List some sources of organic compound. (Applying)
- List the uses of organic compounds. (Remembering)
- Recognize and identify a molecule's functional groups. (Understanding)
- Distinguish between saturated and unsaturated hydrocarbons. (Understanding)
- Name the alkanes up to decane. (Remembering)
- Convert alkanes into alkyl radicals. (Applying)
- Differentiate between alkanes and alkyl radicals. (Analyzing)
- Define functional group. (Remembering)
- Differentiate between different organic compounds on the basis of their functional groups. (Analyzing)
- Classify organic compounds into straight chain, branched chain and cyclic compounds. (Understanding)

Introduction

The chemistry which is the science of matter deals with two basic types of materials, one type that has its origin from the non-livings like rocks and other earth material, and the other type of material that comes directly

from the living organisms, like carbohydrates from the plants, this type of matter that originated from the living organisms has been classified as the organic matter and the study of such matter has named organic chemistry, while rest of the material has been classified as the inorganic matter and the study of this matter was carried out in the branch of chemistry named as inorganic chemistry.

Although organic chemistry deals with the study of the chemical compounds, which are of the origin of living organisms and for the production of such compounds a vital force had been considered as necessary. With the evolution of modern era of science and technology many of such organic compounds were prepared in artificially in laboratories. In this context Fredrick Wohler, a German scientist in 1828 prepared urea, a well known organic compound by heating an inorganic chemical compound ammonium cyanate, thus urea is regarded as the first synthetic organic compound.

$$NH_4CNO \xrightarrow[\Delta]{\sim} CO(NH_2)_2$$

(Where (~) is sign used to show intramolecular rearrangement)

After the synthesis of urea scientists prepared many of the organic compounds, and now a days millions of organic compounds have been prepared and more new being added in this list each year.

It has been observed that these organic compounds have their origin from the basic hydrocarbon series, the hydrocarbons are the compounds that contains only two elements the carbon and hydrogen.

In view of this the organic chemistry is now a days defined as the chemistry of the hydrocarbons and their derivatives.

This is to be remembered that some abundant and important chemical compounds which contain carbon and hydrogen too are not included in the list of organic compounds. e.g the ultimate oxides (CO_2, CO), carbonates, bicarbonates and cyanides are not included in the organic compounds.

The organic chemistry is an important branch of chemistry, this is because not only the organic compounds have interesting features but they are also very abundant. We deal with the organic compounds all times in our life,

our food stuff, cloths, medicines, the hydrocarbon fuels. Almost everything which we use in our daily life mostly consists of the organic compounds.

There are many types of organic compounds which are not made naturally and they are in laboratories and factories prepared artificially, e.g the plastics, paints, detergents, cosmetics, artificial fibers (rayon and nylon). These artificially prepared organic compounds also play important role in our life.

11.1 The Organic compounds

The organic compounds, that contain the element carbon as the major element in their framework. The first member of the series of organic compounds is the famous methane which is gas at normal temperature and pressure, and is used as a fuel. In methane a carbon atom is surrounded by 4 hydrogen atoms and forms a regular tetrahedron structure. The structure of CH_4 is shown here. You can see that the CH_4 molecule can be represented by a number of ways. The common method is to represent the molecule by classical 2-D (dimension) manner, as shown in the figure-11.1.

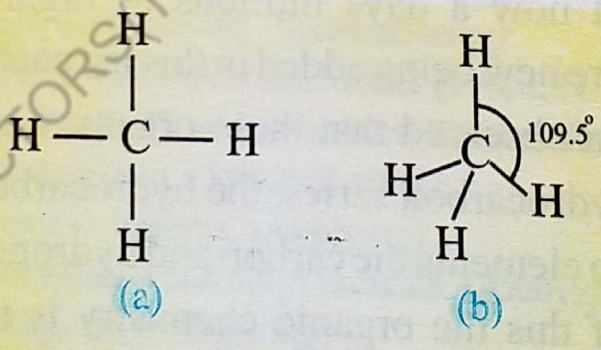


Fig. 11.1: Two dimensional representation of CH_4 molecule, (a) general representation, (b) Representation showing angles

The molecules are drawn mostly using some special signs, as shown in fig 11.2, this is because the three dimensional (3D) structure of these organic compound is of the interest of scientists and they use different signs to represent this actual 3-D structure. These signs are called Wedge and Dash, the wedge "◀" shows that the direction of the atom or the group that is represented by this is actually situated towards the viewer, and dash "||||"

shows that the atom or groups present at its end is actually opposite to the direction of viewer.

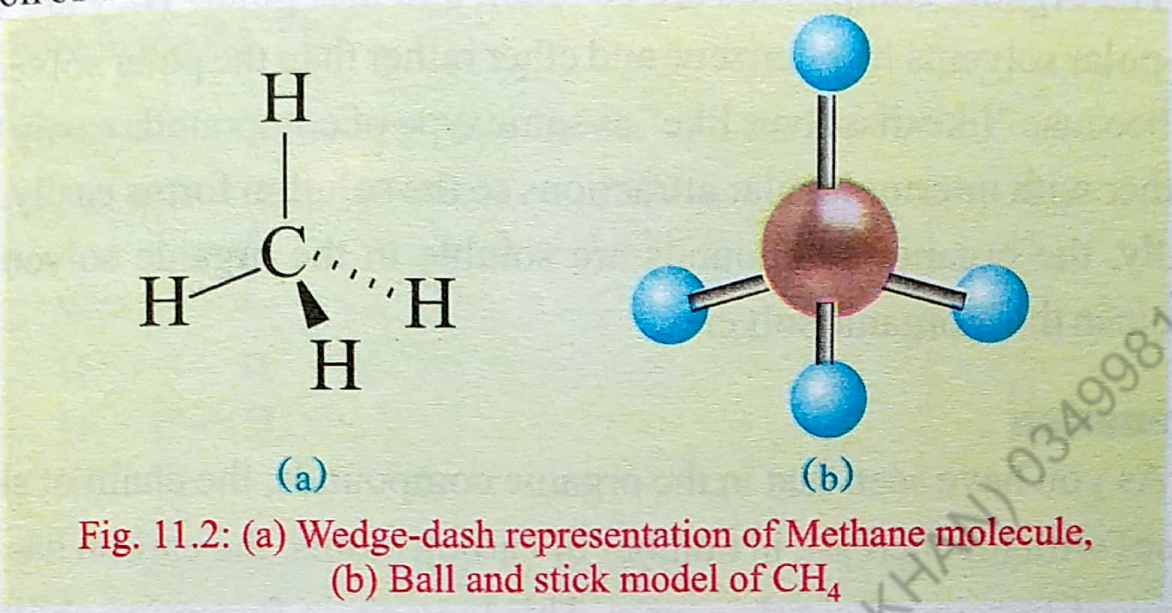


Fig. 11.2: (a) Wedge-dash representation of Methane molecule, (b) Ball and stick model of CH_4

As the number of carbon increase, the structure of organic compounds become more complex. So normally we use the simple 2-D structures of the molecules also we use the models and wedge-dash representation of the molecules in this book.

The second member of the series of the organic compounds is ethane, which contains 2 carbon atoms and 6 hydrogen atoms. This increases the complexity of the organic compound.

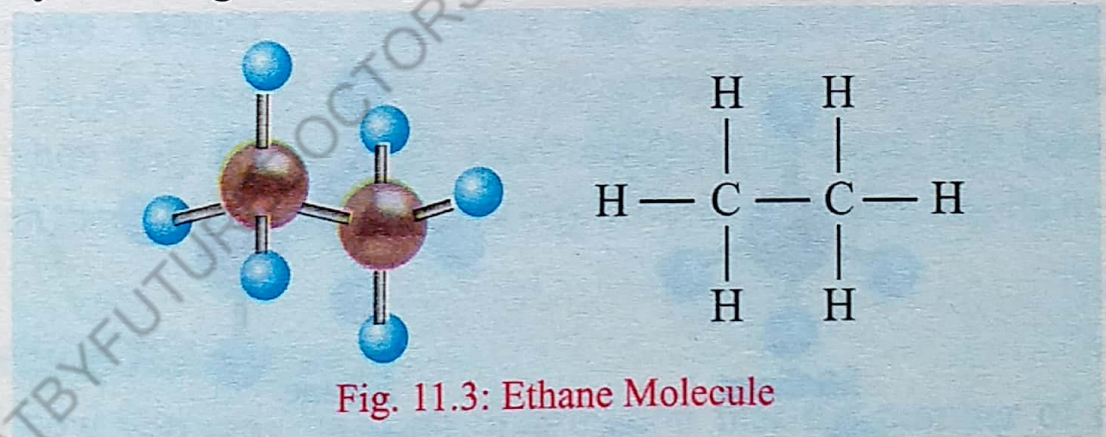


Fig. 11.3: Ethane Molecule

The organic compounds may have other elements of which O, N, S, P, Cl, and Br are important. Which make the nature of these organic compounds more complex. We will discuss such compounds later in this book.

11.1.1 General features of organic compounds

The organic compounds although show diverse characters and properties.

1. Solubility

The organic compounds are covalent and non-polar. They are soluble in non-polar solvents like benzene and ether rather than the polar solvents like water, because "like dissolves like" as same type of compounds easily bind to each other with intermolecular attractions so the solution forms easily. Hence generally, the organic compounds are soluble in the organic solvents, and inorganic in the inorganic solvents.

2. Catenation

As you have seen that in the organic compounds, the chain of skeleton increases with the increase in number of carbon atoms, the carbon has a great tendency of forming chain structures. This long chain formation ability of an element is called "catenation". As the organic compounds are primarily formed by the carbon element, which has ability of catenation. So the organic molecules may be very big and complex in which hundreds of atoms can be present, but we concentrate upon the simple ones to understand them satisfactorily. Some of the simple members of organic compounds are shown below.

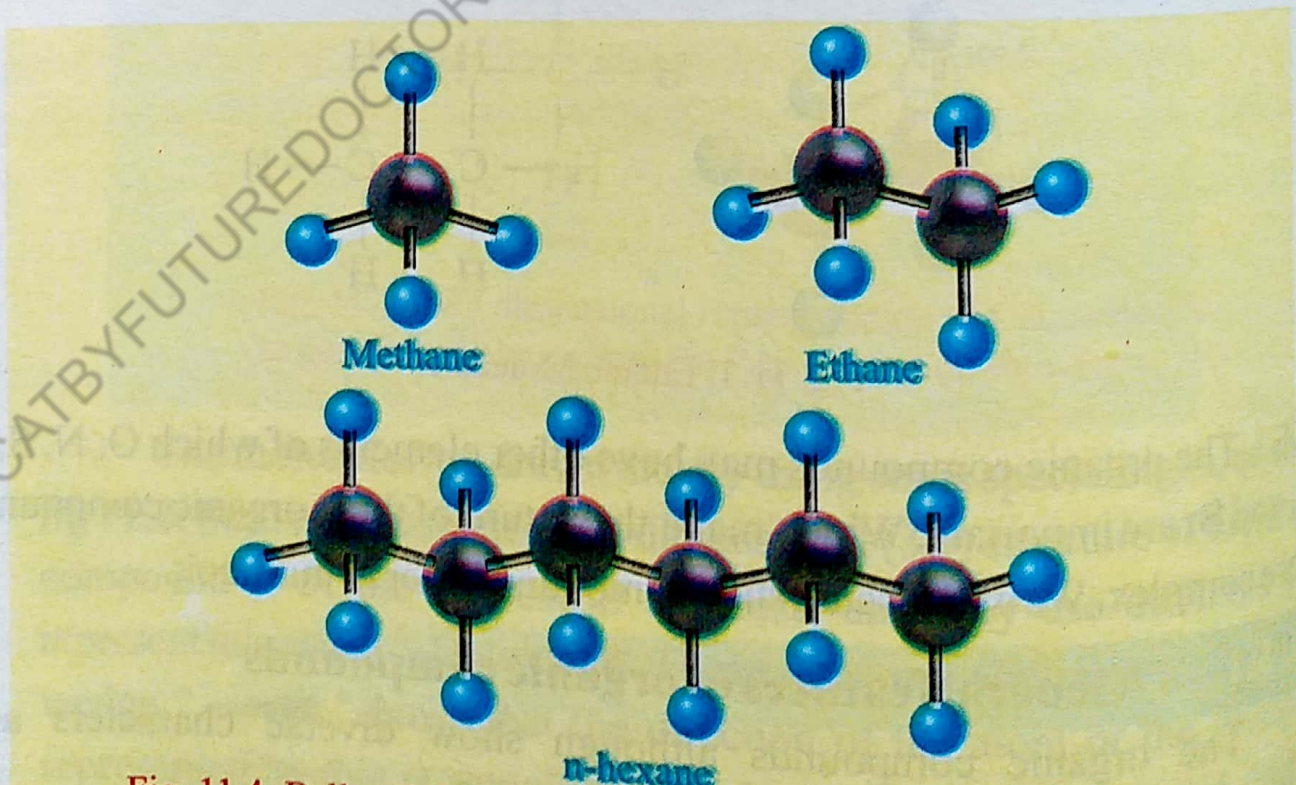


Fig. 11.4: Ball and Stick models of some simple organic molecules

The Carbon chain not only can increase in a single direction but to other directions too, e.g. in pentane, which has 5 carbon atoms, the linkage of atoms is shown here in the fig. 11.5.

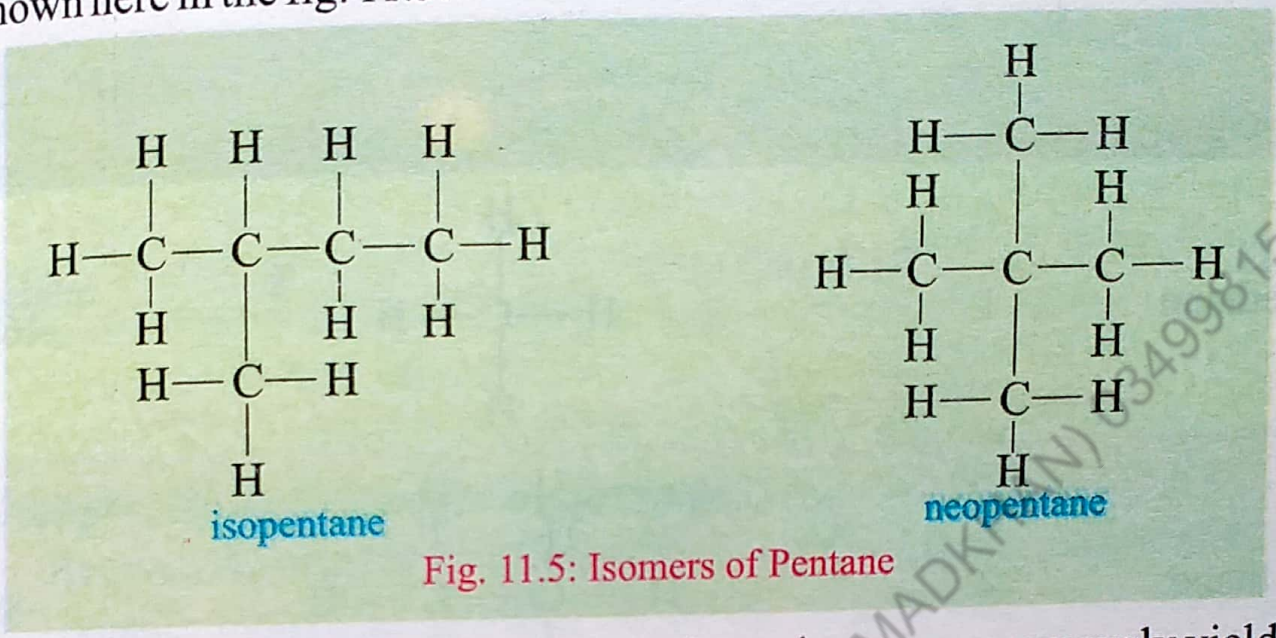


Fig. 11.5: Isomers of Pentane

The chain in the organic compounds can increase enormously yielding complex organic molecules like starch and glycogen due to this distinct catenation property of carbon element.

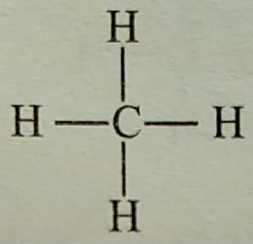
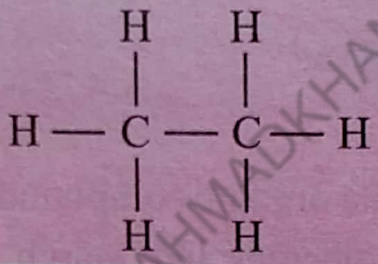
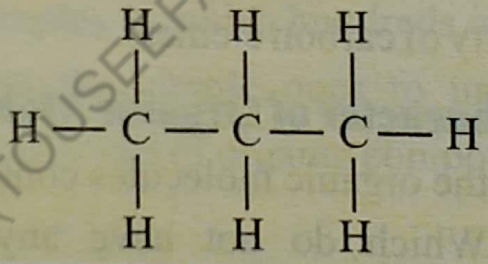
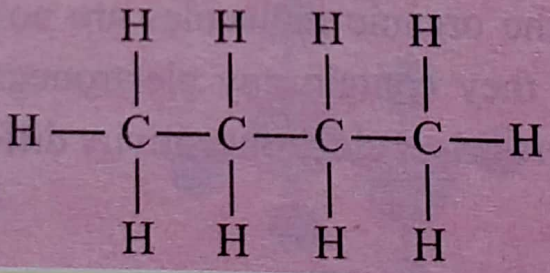
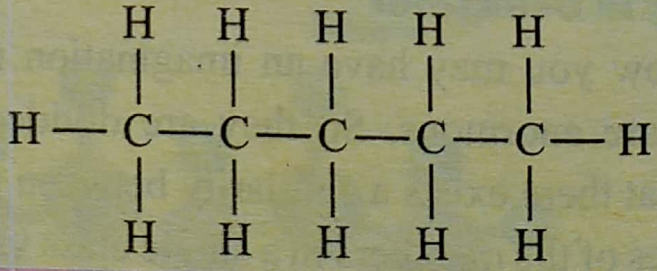
3. Non Polar Character of Organic Molecules

In general the organic molecules contain carbon and hydrogen as the only elements. Which do not have any appreciable electronegativity difference, so the organic molecules are normally non-polar in character, however when they contain any electronegative element like halogen or oxygen then there arises electronegativity difference, which results in a polar molecule.

4. Simlarity in Behaviour

Till now you may have an imagination that the number of organic compounds are enormous. So they are divided into various classes, but remember that there exists a similarity between the members of same class. The properties of the members in a single class vary in a regular manner with the increase in the "•CH_2•" units of the members. Thus a series is obtained where in every next member a "•CH_2•" unit increases, this series is called "homologous series". In a homologous series all the members show much

similarity in chemical behaviour, e.g. all the hydrocarbon behave same, and all alcohols behave same. Although they differ in physical characters in a regular manner. You can see this trend in the table below.

Name	No of C atoms in chain	Structural formula	Boiling point °C
Methane	1		-162
Ethane	2		-89
Propane	3		-42
Butane	4		0
Pentane	5		36
n-hexane	6	$CH_3(CH_2)_4CH_3$	69

Name	No of C atoms in chain	Structural formula	Boiling point °C
Heptane	7	$CH_3(CH_2)_5CH_3$	98
Octane	8	$CH_3(CH_2)_6CH_3$	126

Table 11.1 Some important characters of simple hydrocarbons

5. Complexity in Organic Compounds

Because the organic molecules may comprise a large number of atoms, so the organic molecules like that of starch, protein and other bioorganic molecules are very complex in nature. The complexity increases as the chain increases, and even becomes so complex that even now a days with the usage of advanced technology we find it hard to understand completely the bioorganic compounds.

6. Isomerism in the Organic Compounds

One of the interesting features of the organic compounds is the sequence of atoms in a given molecule. The properties of organic molecule depends upon the sequence of the linkage between atoms rather than the type and number of atoms. So in many cases, two molecules although having same number and type of atoms, show different behaviours, e.g. ethyl alcohol and dimethyl ether both having same molecular formula C_2H_6O have totally

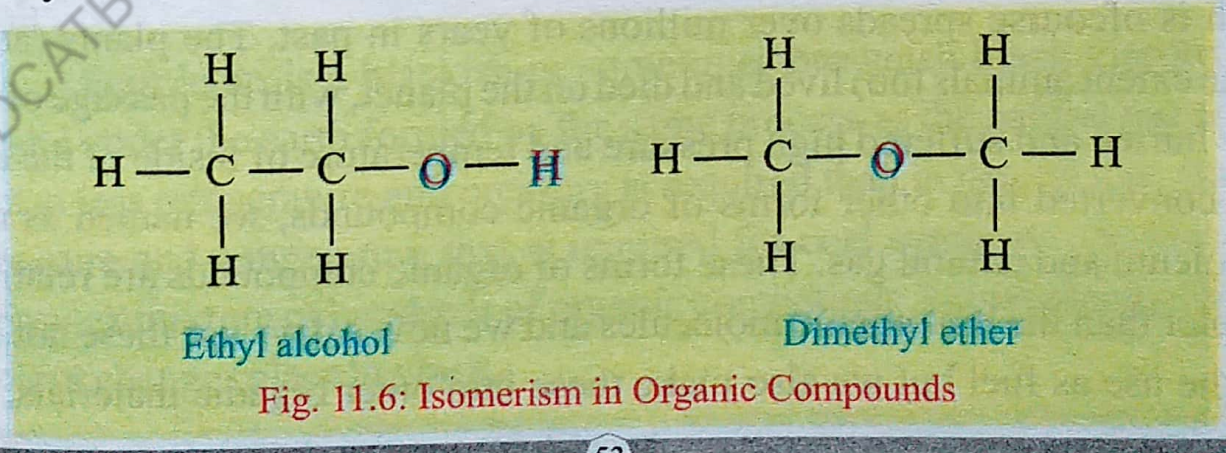


Fig. 11.6: Isomerism in Organic Compounds

different physical and chemical properties, as the atoms are linked in both in different sequence.

This phenomenon in which more than one structures of a compound having same molecular formula are possible is called Isomerism, and the compounds formed thus are called Isomers.

7. Rates of Organic Reactions

The organic compounds are generally non-ionic and non-polar, so the speed or rate of their reactions is slower than the inorganic compounds.

11.2 Sources of Organic compounds

The major sources of organic compounds are the living organisms, both the animal and the plant kingdoms. The plant kingdom, which of course is the main source, provides the chief source of organic compounds from which other sources derive the main components and change the organic matter through bio-chemical processes. Thus the basic and chief sources of the organic compounds are the plants.

The plants absorb the inorganic compounds CO_2 and the H_2O from surroundings and by using the energy of sun convert these inorganic compounds into organic compounds of which the carbohydrates are the major ones. The animals that depend upon the plants for their food requirements convert the eaten carbohydrates into complex organic compounds, i.e. to Proteins, Fats and others through complex biochemical reactions.

We have yet described the process of formation of organic compounds which is in progress in nature all the times. But the history of life on the planet earth is ofcourse spreads over millions of years in past. The plants (and to some extent animals too) lived and died on the planet, with the passage of time they buried and suffered high pressure and temperature of inside of the earth and converted into other forms of organic compounds, we named as coal, petroleum and natural gas. These forms of organic compounds are relatively simpler than the bio organic molecules and we now a days use these not only for the use as fuel but we also make these into other organic materials, like

plastics, synthetic rubber, artificial fibres and many others.

It is to be remembered that these different forms of organic compounds are produced due to the difference of pressure and temperature under the earth, more is the pressure and temperature, higher is the volatility of the fraction of organic compound.

Let's take a closer look on each of the fractions of these organic compound sources.

11.2.1 Coal

Coal is the readily combustible black or brownish-black solid form of the organic matter formed. Major use of coal is for fuel, and carbon is the chief element in coal which burns to yield energy.

The coal has been categorized according to the percentage of carbon content. Hence the top quality is the Anthracite which has more than 90% of carbon, then comes bituminous which has 80% carbon, this is used as domestic fuel in cold regions of Pakistan, lignite having 70% of carbon which is used in power stations for production of electricity. The most inferior type of coal is the Peat which is found near surface of earth and even above the surface, it has approximately 60% carbon content and high moisture content which makes less valuable for the use as good fuel. Peat is used as low cost furnace fuel, for example in brick making furnaces.

11.2.2 Petroleum

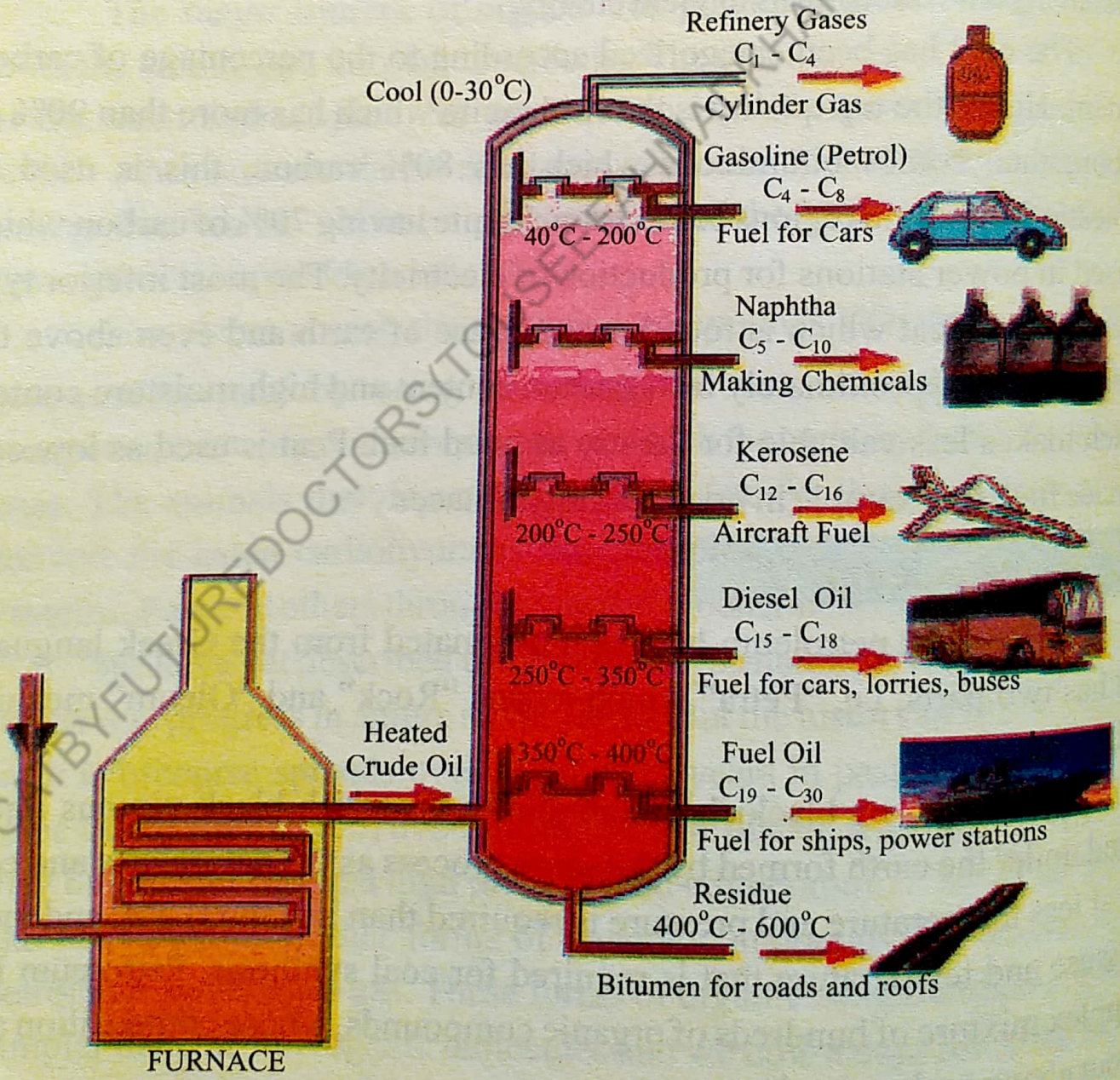
The word petroleum has been originated from the Greek language and has two parts, i.e. "Petra" which means "Rock" and "Oleum" meaning "Oil".

Petroleum is a blackish or sometimes brownish black viscous liquid found under the earth formed by the same process as the natural gas and coal but at less temperature and pressure is required than in natural gas, and more pressure and temperature that is required for coal synthesis. Petroleum is a complex mixture of hundreds of organic compounds, whose composition and colour changes place to place.

Crude petroleum is purified in oil refineries to obtain a various fractions, which are used for various purposes in the energy production.

Interesting Information

The crude petroleum is purified in the oil refineries, the different fractions in the crude oil are separated on the basis of the differences in the boiling points of different fraction. Not only the components present in crude oil can be separated but also these fraction can be interconverted, all this separation and interconversion is done on the basis of demand of required fractions.



11.2.3 Natural gas

The natural gas is also believed to be formed by the same process as the coal forms, but here the pressure and heat are applied more than the coal, so it is found in depths than the coal. Huge reserves of natural gas have been found in the area of Sui Balochistan in 1952, that is why it is also called "Sui gas" in Pakistan. The natural gas has generally following constitution, but the constitution varies from place to place.

Methane	70-90%
Ethane	5-15%
Propane	<5%
Butane	1-2%
N_2, CO_2, H_2S	Remaining

Table 11.2 General composition of natural gas

The natural gas is a cheap source of energy in Pakistan, and is used in almost all industries along with the domestic use. It is also used as CNG (compressed natural gas), LPG (liquefied petroleum gas), but in LPG the proportion of propane and butane is kept higher than methane and ethane, which eases the liquification process.

The natural gas is also used for the preparation of many compounds like urea fertilizer.(this process of making urea is well explained in section 16.3 later in this book)

11.2.4 Synthesis of organic compounds in laboratories/factories

Although the major source of the organic compounds is the plant kingdom, but now a days there are a number of organic compounds which are prepared in laboratories and later on in factories on industrial scale to meet their requirements. For example, the important organic compounds prepared on large scale are various plastic products, used in almost every field of life, The fertilizers like urea are also prepared in large scale to meet the increasing

demands of food, many medicinal compounds are also required in large quantities e.g. the antibiotics, the antiulcerants, antipyretics etc, detergents, soaps and other cleansing agents, Paints and dyes, Artificial fibers and rubber, insecticides, pesticides and many other organic compounds are prepared in laboratories and in factories.

11.3 Uses of Organic compounds

Because of the catenation power of the carbon, the organic compounds comprise a tremendous list. There are so many types and varieties of organic compounds and each year more and more organic compounds are added in this list, so the use of these organic compounds is vast and in broad range. In fact they are used in almost every step of our daily life.

i) The organic compounds are the chief constituent of our food, and different food articles in the form of vegetables, fruits, meat, cereals etc are actually the organic compounds.

ii) The cloths we wear are also the organic compounds which are prepared from natural fibers i.e the cotton or wool, or from the artificial fibers i.e the rayon or other plastic threads are again actually the organic compounds.

iii) The medicines that comprise antipyretic, anti-inflammatory, antihistamines, antibiotics, anti ulcer, and others we take when we become sick are again mostly consists of organic compounds

iv) The fertilizers in the form of urea, and others we use to enhance the crops production are again the organic compounds.

v) The insecticide and fungicide preparations that are used to fight insect and fungus attack are again mostly organic in nature.

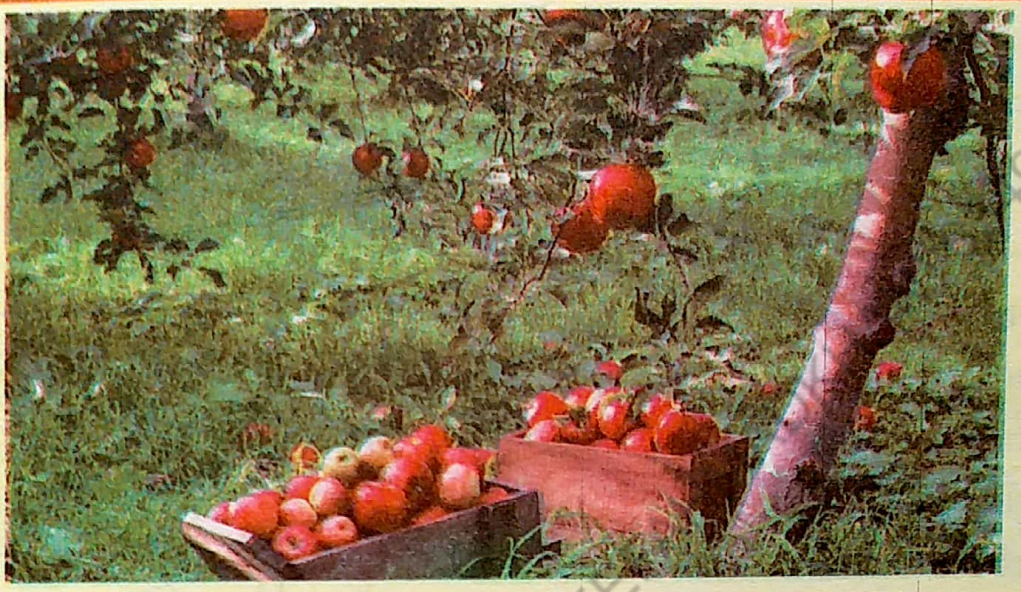
vi) The fuel as natural gas, petrol, kerosene oil. diesel, CNG, LPG, coal, wood (that we use to run our vehicles and in our home to cook the food that we eat) are all again organic in nature.

vii) The dyes that gives us a colourful life are again majorly comprise the organic compounds.

viii) Different types of plastics used in various fields of life are also the organic compounds.

These are just few categories of organic compounds and actually the organic compounds are very abundant and almost every place of our imagination involves the use of these organic compounds, so the impact of the organic chemistry is also very high and it affects our life too much.

11.4 Alkanes and Alkyl radicals



The paraffin wax coating that makes these apples so shiny is actually due to the mixture of alkanes

The Alkanes comprise the initial and simplest class of organic compounds, where the carbon is bonded with the other carbons by a single covalent bond, thus their general formula is C_nH_{2n+2} where n is the number of carbon atoms. The 1st member of the Alkane series is the methane, which has one carbon and all four bonds of carbon are with hydrogen, as shown figure-11.7.

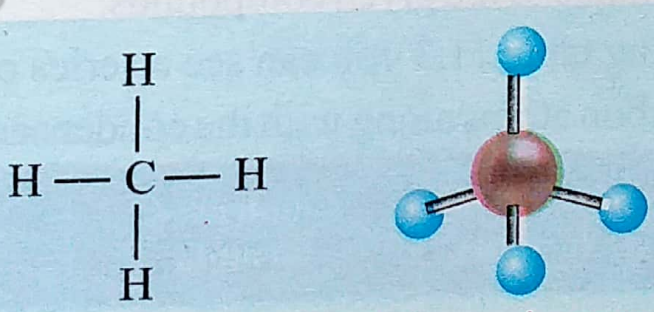


Fig. 11.7: Methane, the simplest organic compounds

The second member of this class of alkanes is the Ethane, which has two carbon atoms and '6' hydrogen atoms, its structure is shown in figure-11.8.

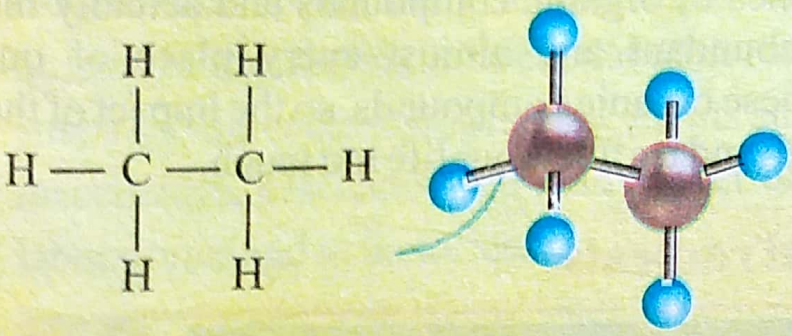


Fig. 11.8: Ethane, A two carbon containing organic compound

Activity 11.1

Draw "line structural formula" and "ball and stick structure" of Propane.

This series increases with the increase in the carbon atoms, and even the side branching can also appear, a branch is the area of chain where at least three other carbon atoms are attached with the carbon of chain, e.g. in figure-11.9.

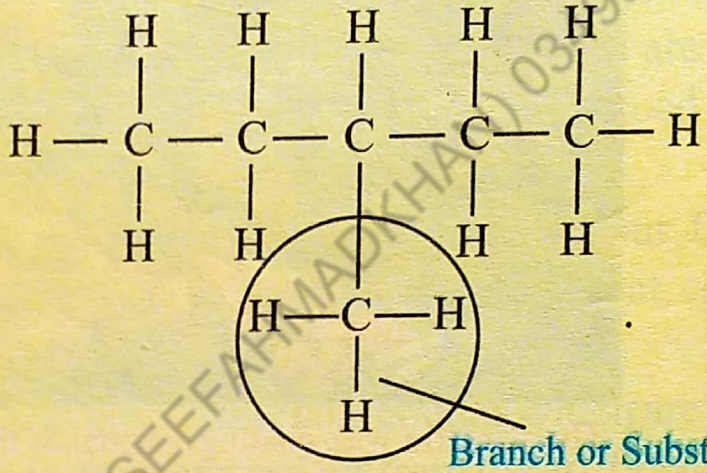
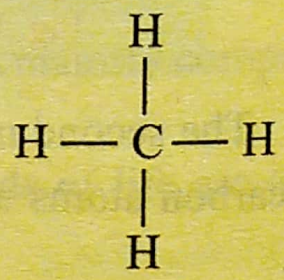


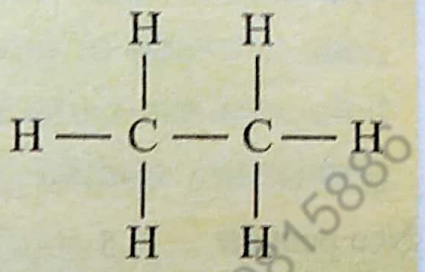
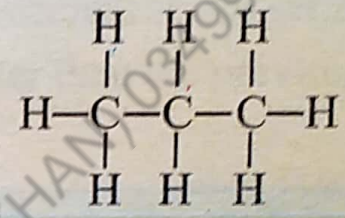
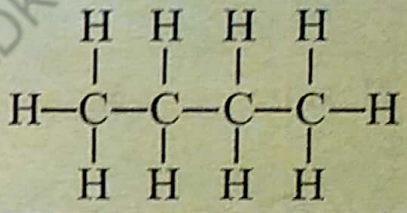
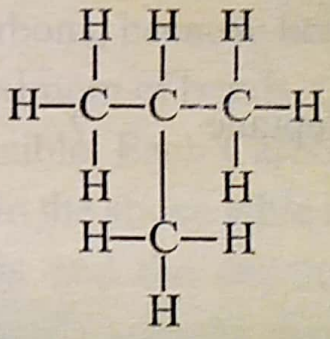
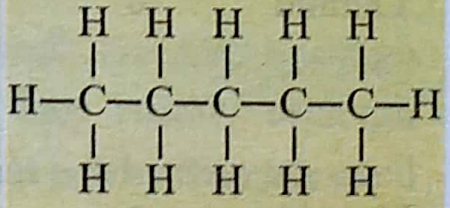
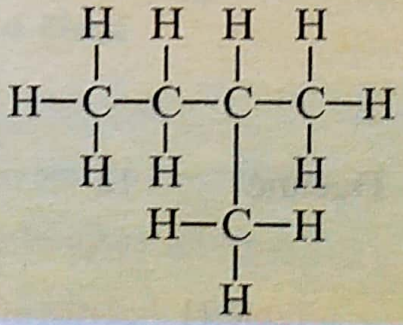
Fig 11.9 Branching in the organic compound

Note that in the fig11.9 the part of the chain having lesser number of carbon atoms is the branch or is also called a substituent.

As the number of carbon increases, the complexity in the organic compound also increases. It is not necessary that we always write full structure of the organic compound, and often we use some shortcuts like that of the condensed formulae of the given compounds.

In the following table 11.3 you can see a series of alkane class which comprise up to 10 carbon atoms along with the condensed formulae.

Name	No of C atoms in chain	Molecular formula	Condensed formula	Structural formula
Methane	1	CH_4	CH_4	

Name	No of C atoms in chain	Molecular formula	Condensed formula	Structural formula
Ethane	2	C_2H_6	CH_3CH_3	
Propane	3	C_3H_8	$CH_3CH_2CH_3$	
Butane	4	C_4H_{10}	$CH_3CH_2CH_2CH_3$ Or $CH_3(CH_2)_2CH_3$	
Isobutane	4	C_4H_{10}	$CH_3CH(CH_3)_2$	
Pentane	5	C_5H_{12}	$CH_3CH_2CH_2CH_2CH_3$ or $H_3C(CH_2)_3CH_3$	
Iso pentane	5	C_5H_{12}	$CH_3CH_2CH(CH_3)_2$	

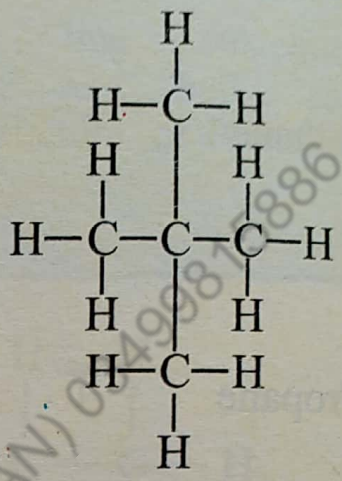
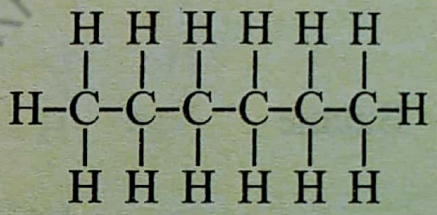
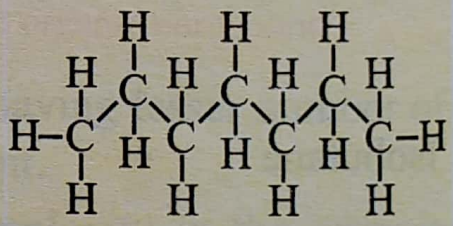
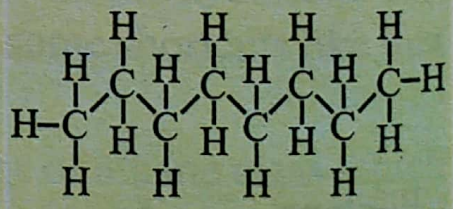
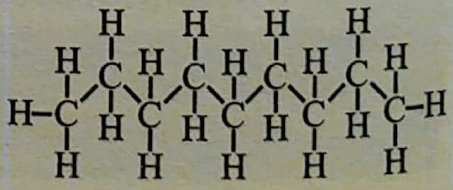
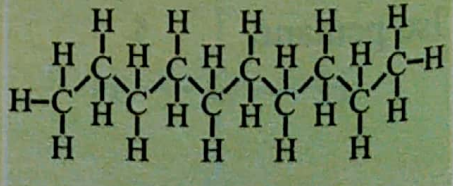
Name	No of C atoms in chain	Molecular formula	Condensed formula	Structural formula
Neo pentane	5	C_5H_{12}	$C(CH_3)_4$	
Hexane	6	C_6H_{14}	$CH_3(CH_2)_4CH_3$	
Heptane	7	C_7H_{16}	$CH_3(CH_2)_5CH_3$	
Octane	8	C_8H_{18}	$CH_3(CH_2)_6CH_3$	
Nonane	9	C_9H_{20}	$CH_3(CH_2)_7CH_3$	
Decane	10	$C_{10}H_{22}$	$CH_3(CH_2)_8CH_3$	

Table 11.3 Series of organic compounds composed of 1—10 carbon atoms.

This is notable that as the number of carbon atoms grows the complexity in the organic compound chain also increases, even the compounds having same number of carbon atoms can join in different ways yielding different type of compounds, e.g. in butane and in pentane, such compounds that have same number of atoms but different structures are called Isomers, this is clearly shown in case of '4' and '5' carbon containing compounds in table 11.3.

You can see in the above table that the individual members of this series of alkanes, each member contains one "$\bullet CH_2\bullet$" unit greater than the previous member, forming homologous series.

Activity 11.2

Write Condensed and structural formulae for the compounds
(a) n-Hexane (b) n-Octane

The Alkanes are also called the saturated hydrocarbons, because here the valency of "C" is fully satisfied, each 'C' forms its maximum of bonds, i.e '4' in number. and addition of any other atom is not possible. Each Carbon atom here is surrounded by 4 other atoms, as can be seen in the above table in their pictures. Alkanes are water insoluble compounds and the density, melting point and boiling point of these increases continuously with the chain length of carbon.

The Alkanes are relatively less reactive compounds, and they undergo reactions under extreme conditions only, although they readily undergo oxidation reactions yielding high amount of energy, that is why they are used as fuels.

$$C_nH_{2n+2} + xO_2 \longrightarrow yCO_2 + zH_2O + Heat$$

e.g Methane burns yielding following products.

$$CH_{4(g)} + 2O_{2(g)} \longrightarrow CO_{2(g)} + 2H_2O_{(g)} + 891KJ/mol$$ (at standard conditions)

Higher alkanes which have more carbon atoms yield more energy, e.g.

$$C_3H_{8(g)} + 5O_{2(g)} \longrightarrow 3CO_{2(g)} + 4H_2O_{(g)} + 2220KJ/mol$$

This production of high energy is the reason the alkanes are used as fuel.

Alkanes having more than 20 atoms of carbon per mole are also used as low cost lubricants for engines and automobiles.

Paraffin wax which is a mixture of alkanes having generally 20—40 carbon atoms per molecule is usually used in candle making, in lubricants, water repellent and in skin cream preparations.

Activity 11.3

The Alkanes are used as low cost easy handling fuel, what products will you expect to form when kerosene oil (having 12 carbon atoms) is burnt.

11.4.1 Alkyl radical

As described earlier in this chapter that in a class of organic compounds different members that differ in ($\bullet CH_2 \bullet$) unit comprise a homologous series, in such series the members differ in their properties in a gradual manner, e.g the boiling points in above series of alkanes increases in a rhythm. But the chemical properties in a class are almost same. So, in a class of an organic series the number of carbon atoms has not so value, as in the above alkanes, all the members in a class have almost similar chemical properties (although the physical properties differ in a regular rhythm), so, there is no need to write the number of carbon atoms, but instead, they are described by a general symbol "R". This "R" group is called Alkyl group. In alkanes the class is written as **"R-H"**, where "R" represents the alkyl chain of carbon atoms. So, removing a hydrogen atom from the parent hydrocarbon leaves behind the alkyl group (which also has an unpaired electron). Thus removing one hydrogen from methane, CH_4 gives a group of atoms $\bullet CH_3$, and is called methyl group or methyl radical. Similarly, from ethane (C_2H_6) the group $\bullet C_2H_5$ (called ethyl from ethane), is obtained.

$$CH_3 — CH_3 \longrightarrow \bullet CH_2 — CH_3 + \dot{H}$$

The dot written there represents unpaired electron which forms further bond with other species. In general, any alkane can be used to generate alkyl

groups. The Alkyl groups are the key to naming organic molecules.

Here is chart that shows some common alkyl radicals with their names.

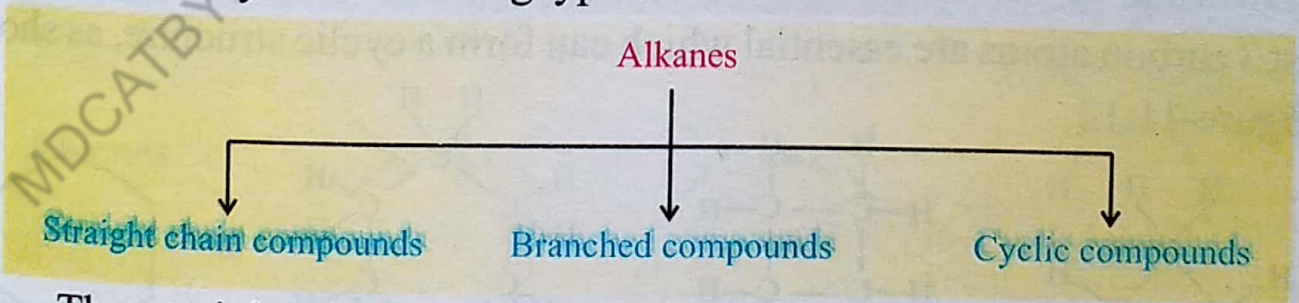
No of Carbon atom	Name	Structural representation
1	Methyl	$\bullet CH_3$
2	Ethyl	$\bullet CH_2CH_3$
3	n-propyl	$\bullet CH_2CH_2CH_3$
3	Isopropyl or sec.propyl	$H_3C - \dot{C}H - CH_3$
4	n-butyl	$\bullet CH_2 - CH_2 - CH_2 - CH_3$
4	isobutyl	$\bullet CH_2 - CH(CH_3) - CH_3$

Table 11.4 Some Alkyl radicals

It is to be noted that the line present above at starting of radical shows the point from where the bond forms with any other substrate species, and in naming a radical the suffix 'ane' from the parent chain is replaced by the 'yl' in the given radical.

Classification of Alkanes

The alkanes which are the simplest organic compounds can be classified broadly into following types.



The straight chain compounds are those in which each carbon is bonded to maximum of 2 other carbon atoms (such chain is called normal chain), as shown in the following.

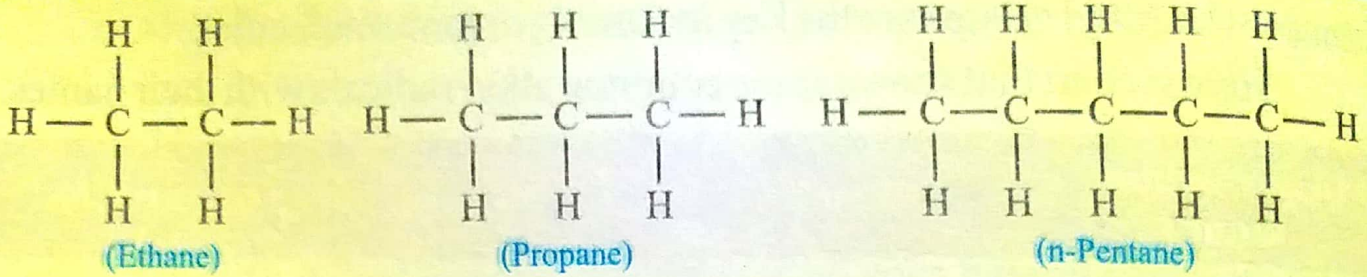


Fig. 11.10: Some straight chain Hydrocarbons

The branched organic compounds are those where at least one of the carbon atom present in the chain is bonded to 3 carbon atoms. There may be four different types of carbon atoms in the carbon chain. They are called primary, secondary, tertiary and quaternary carbon atoms. The primary carbon atom is that which is linked with only one carbon atom at its one of four bonds, the secondary carbon atom is linked with two other carbon atoms, the tertiary is linked with three carbon atoms and quaternary carbon atom is that which is linked with four other carbon atoms at its all four sides. This is further explained by the help of figure-11.11.

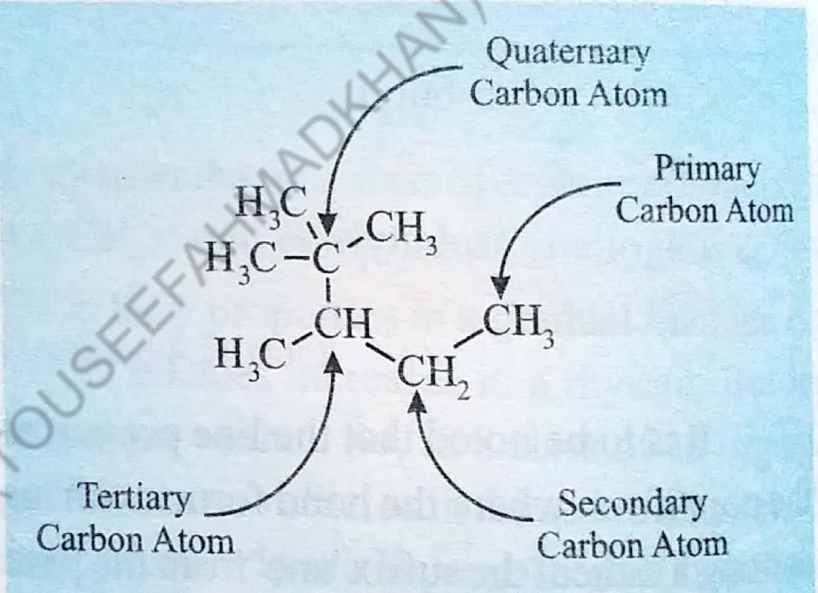


Fig. 11.11: A chain of hydrocarbon showing primary, secondary, tertiary and quaternary carbon atoms

In the cyclic compounds the carbon that forms the chain is bonded to other carbon atoms in a manner that a closed structure is resulted, for this at least 3 carbon atoms are essential which can form a cyclic structure, as shown in figure-11.12.

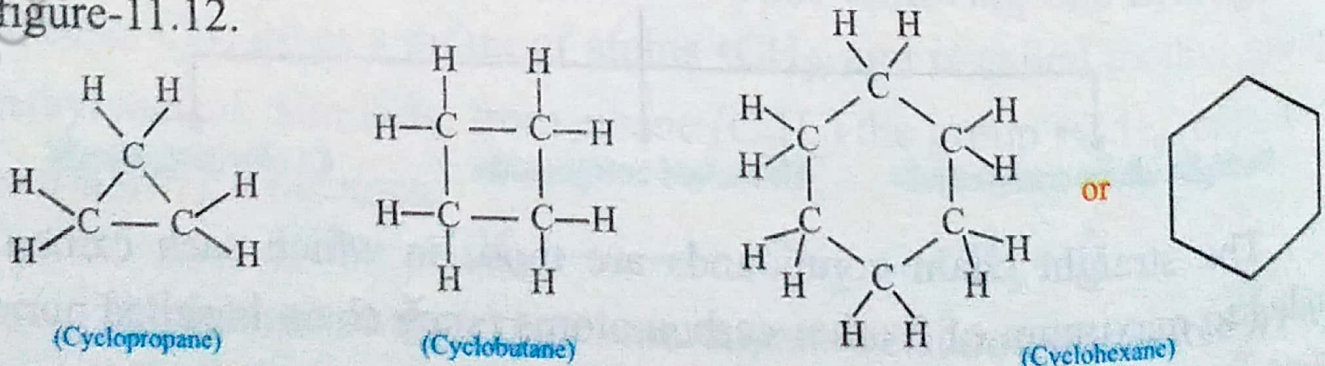


Fig. 11.12: Some example of Cyclic organic compounds

Notice that these cyclic compounds have been drawn here in different ways, this is how the organic compounds are written at different times and all these methods are correct, for ease we generally write the Carbon skeleton by lines and omit the 'C' symbol, as you can see in the case of Cyclohexane in above.

11.5 The Functional Groups

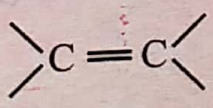
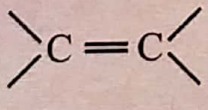
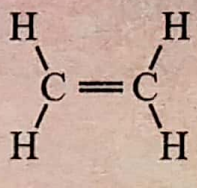
Although the organic compounds contain just a few elements, (carbon, hydrogen, oxygen, nitrogen, sulphur, and halogens), but they show vast diversity in their characters. This diversity is due to the difference in the linkages or sequence of atoms present in the molecule. This special linkages which constitute a class is called a functional group. The functional group can also be defined as the group of atom(s) upon which the functions or the properties of an organic compound depends.

The functional groups can further be divided on the basis of the types of atoms present in these compounds; thus the important divisions among these are:

- Functional groups having double and triple bonds
- Functional groups having C, H, and Halogens
- Functional groups having C, H, and N
- Functional groups having C, H and O

Following is table that shows these functional groups along with their sequence of atoms, an example of each is also given.

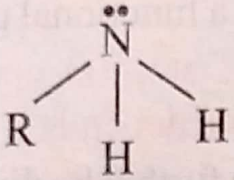
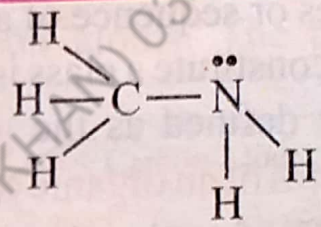
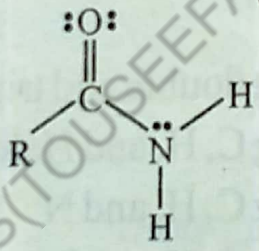
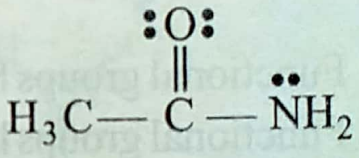
Functional groups having Double and triple bonds

Functional group	Formula	Structural formula	Example
Alkenes			 Ethene
Alkynes	—C≡C—	—C≡C—	H—C≡C—H Ethyne

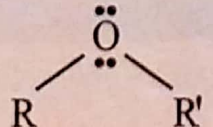
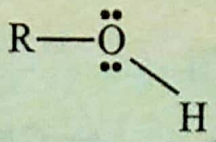
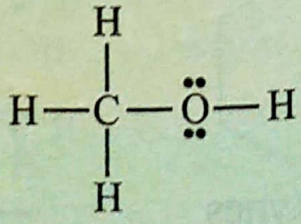
Functional groups having Carbon, Hydrogen and Halogens

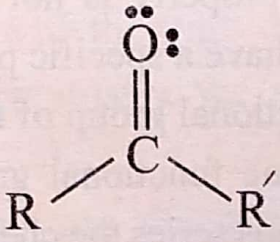
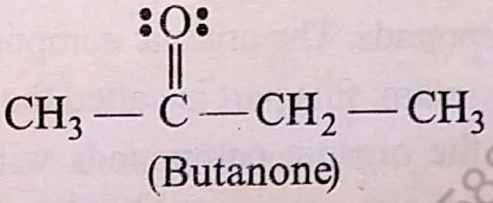
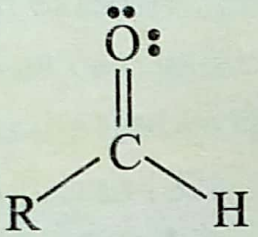
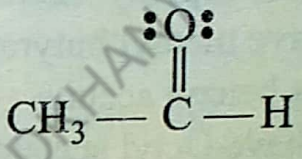
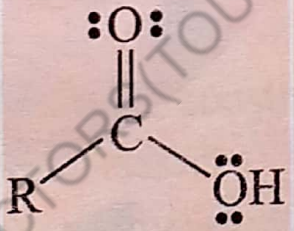
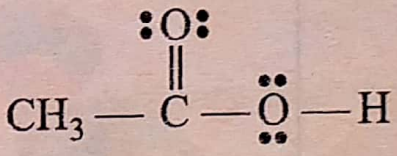
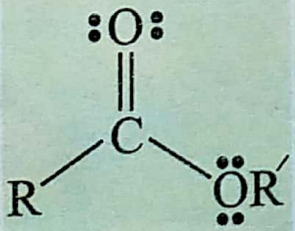
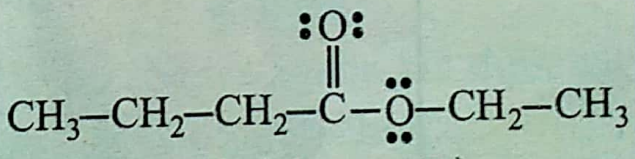
Functional group	Formula	Structural formula	Example
Alkyl Halides	RX	R — X	$H_3C — CH_2 — Cl$ (Chloroethane)

Functional groups having Carbon, Hydrogen and Nitrogen

Functional group	Formula	Structural formula	Example
Amines	$R\text{-}\ddot{N}H_2$		 (Methyl amine)
Amides	$RCONH_2$ or $RCONR_2$		 (Ethanamide)

Functional groups having Carbon, Hydrogen and Oxygen

Functional group	Formula	Structural formula	Example
Ethers	$R\ddot{O}R'$		$H_3C–CH_2–\ddot{O}–CH_2–CH_3$ (Diethyl ether)
Alcohols	$R\ddot{O}H$		 (Methanol)

Functional group	Formula	Structural formula	Example
Ketone	RCOR'		 (Butanone)
Aldehyde	RCHO		 (Ethanal)
Carboxylic acid	RCOOH		 (Ethanoic acid)
Esters	RCOOR'		 (Ethyl butanoate)

You can see that in all these functional groups the atoms (mostly of same type) are linked in a special, characteristic and unique way that is why these organic compounds show so much diversity in their characters.

Interesting Information

One of the special features of the organic compounds is the property of having the homologous series; this property is not present in the inorganic compounds. The organic compounds have a specific part where the reactivity is maximum; this part is called the Functional group of that particular compound. All the organic compounds with same functional group fall under the same homologous series, and in a homologous series the chemical properties are same while physical properties vary in a regular manner; e.g. the distinct fragrance of most of the fruits is due to the presence of ester linkage in the homologous series.

Banana has Isopentyl acetate
Apples have methyl butyrate
Peach has benzyl acetate
Oranges have Octyl acetate
Pear has n-propyl acetate
Honey has Ethyl phenyl acetate

Summary of the Chapter

- Organic chemistry is one of the important branches of chemistry, this branch deals with the study of organic matter.
- In the organic chemistry we study the hydrocarbons and their derivatives.
- The hydrocarbons are the chemical compounds that have only carbon and hydrogen elements.
- In the organic compounds carbon is the chief element.
- The carbon has an extensive property of forming long chains; this property is termed as 'catenation'.
- Urea is regarded as the first synthetic organic compound, which was synthesized by Wohler in 1828.
- Methane is the first member of hydrocarbon series and simplest organic compound having molecular formula CH_4.
- The organic compounds are generally non-polar and water insoluble compounds.
- The organic compounds constitute a vast category and they are classified into several classes.
- In a class of organic compounds, the members differ by CH_2 units, the series formed by such is termed as the homologous series.
- As the number of carbon atoms increases, the organic compounds become more complex.
- The organic compounds can have same composition but different structures; such compounds are called isomers of each other.
- The major sources of organic compounds are the petroleum, natural gas and coal, and plant kingdom. Certain organic compounds are also synthesized artificially and these do not exist naturally, the important examples of such artificially synthesized compounds include different types of plastics.

- The petroleum, coal, and natural gas are also believed to be formed by decayed burried plants.
- The petroleum products play an important role in provision of energy rich compounds that run all the machineries of planet earth.
- The petroleum is refined in oil refineries on the basis that different fractions in petroleum have different boiling points; this technique of purification is called fractional distillation.
- Alkanes comprise saturated class of organic compounds having general formula C_nH_{2n+2}, where 'n' is the number of carbon atoms in the compound.
- Another important class of organic compounds constitutes the unsaturated hydrocarbon series, they are called 'alkenes' and 'alkynes'.
- Alkenes contain at least one double bond in their structure, while alkynes have one or more triple bond in their structure.
- The organic compounds also constitutes a cyclic structure where the carbon atoms are linked in a manner that a ring is formed, such compounds are classified as cyclic compounds.
- There exists a specific linkage of atoms in the organic compounds called 'functional group'; this functional group determines all the properties of organic compounds.

Exercise

Q1: Fill in the blanks with suitable words.

i) Organic chemistry deals with the study of .....

ii) Wohler was the first Scientist who prepared an organic compound named .....

iii) The long chain formation ability of carbon is termed as .....

iv) Alkanes are ..... hydrocarbons.

v) A ..... is the group of atoms, which determines the properties of organic compounds.

vi) General representation of the Alcohol is.....

vii) Ketone has the general formula.....

viii) The functional group present in Acetic acid is.....

ix) The % of Carbon in .....coal is 80%.

x) The general formula of ether is .....

Q2: Choose the correct answer.

i) $NaHCO_3$ is categorized as:

(a) Organic compound
(b) Inorganic compound
(c) Some time organic, some time inorganic
(d) Bio-organic compound

ii) The Hydrocarbons are soluble in the:

(a) Organic solvents (b) Water
(c) Both of above (d) Non of above

iii) When two molecules have same molecular formula but different structures, the phenomenon is called:

(a) Catenation (b) Alkylation
(c) Isomerization (d) Sublimation

iv) Organic compounds undergo chemical reactions with the

(a) Very fast rate (b) Very slow rate

(c) Neither fast nor slow (d) They do not react

v) The important source of organic compounds is

(a) Coal (b) Petroleum

(c) Natural gas (d) All of these

vi) Major compound present in the natural gas is

(a) Methane (b) Ethane

(c) Propane (d) Butane

vii) When one 'H' atom is removed from an alkane, it forms:

(a) Saturated hydrocarbon (b) Unsaturated hydrocarbon

(c) Alkyl radical (d) Alkene

viii) The fraction of petroleum that contains Carbon atoms from 4—8 is called:

(a) Gasoline (b) Kerosene

(c) Diesel (d) Wax

ix) The fragrance of fruits is due to the presence of functional group called:

(a) Amines (b) Ethers

(c) Esters (d) Carboxyllic acid

x) On combustion the hydrocarbons produce

(a) CO_2 only (b) H_2O only

(c) Both CO_2 and H_2O (d) Oxygen

Q3: Answer the following questions briefly.

i) Define organic chemistry.

ii) What do you understand by the term "Catenation"?

iii) What is a homologous series?

iv) Write the names and uses of different types of coals.

v) Comment that the plants are main source of organic compounds.

vi) How organic chemistry is important to study?

vii) Define the functional group.

viii) Draw structures of the isomers of a hydrocarbon having 5 carbon atoms?

ix) What is an "alkyl group"?

x) Why peat is inferior quality coal?

Q4: Answer the following questions with reasoning.

i) What are the main differences between organic and Inorganic compounds?

ii) Why hydrocarbons do not dissolve in water?

iii) Why writing structural formulae of the organic compounds is important instead of the molecular formulae?

iv) Does catenation is shown by the carbon element only?

v) In the LPG, the fraction of propane and butane is more than the Methane gas.

Q5: Discuss the organic chemistry evolution. How Wohler broke the concept of vitalism?

Q6: How the organic chemistry helps the mankind?

Q7: What are the general characteristics of the organic compounds?

Q8: How crude oil is purified in the oil refineries?

Q9: Write a note on classification of alkane hydrocarbons?

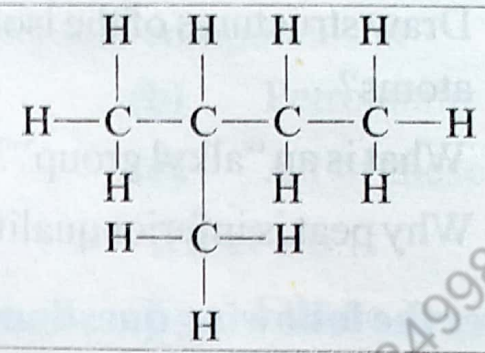
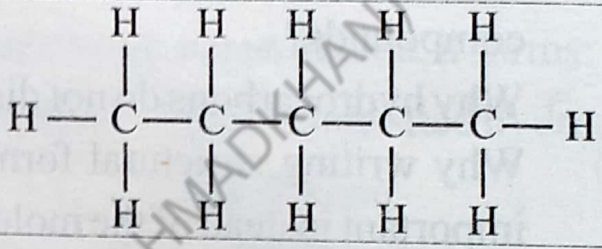
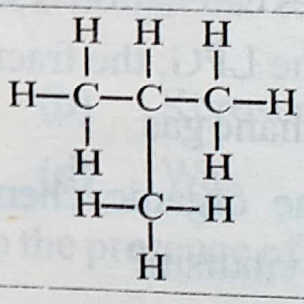
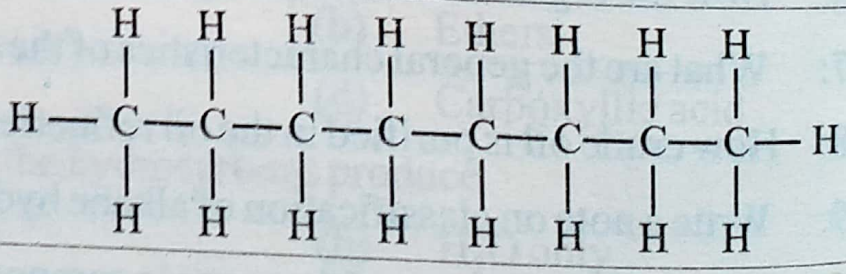
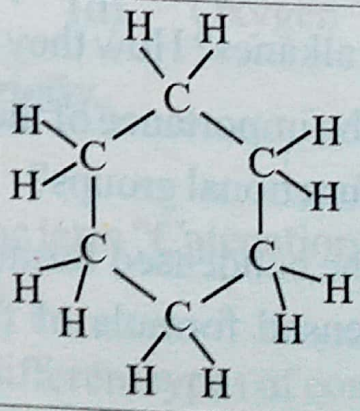
Q10: What are the sources of the organic compounds?

Q11: What are alkanes? How they are important to us?

Q12: Discuss the importance of the functional groups? What are the different types of functional groups?

Q13: What is the condensed formula used for the organic compound? Draw the condensed formula of first ten straight chain alkanes with their names.

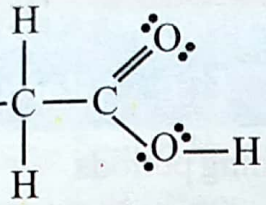
Q14: Complete the table.

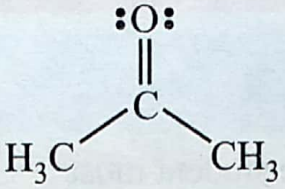
Name	Structure
Propane	
isohexane	
neohexane	
Cyclopentane	
neopentane	

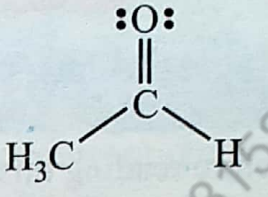
Q15: What do you know about the Alkyl radicals? Explain with examples.

Q16: Identify the functional group in the given organic compound.

1. CH_3CHO
2. $CH_3—CO—CH_3$
3. CH_3COOH
4. $CH_3CO_2CH_3$
5. $CH_3—\ddot{N}H_2$
6. $CH_3CH=CH_2$

7. 

8. 

9. 

10. $H_3C—CH_2—\ddot{O}H$