



CHAPTER

6

CARBON AND ITS COMPOUNDS

Coal, charcoal and graphite are black substances. Graphite is used for making pencils and dry cells. These substances are made up of carbon. Diamond is a bright, beautiful, hard and colourless substance which is used in jewellery. It is very rare and costly. Diamond is pure carbon. Carbon can exist in distinctly different forms which have quite different properties.

Many substances around us are made up of carbon. Clothes, foods, medicines, paper, plastic, cooking gas, electric cables and even transport vehicles and aeroplanes have components made up of carbon compounds. All living things have structures mainly based on carbon compounds.

The amount of carbon present in the earth's crust and in the atmosphere is quite low. Only about 0.02 % of carbon is present in the earth's crust as minerals in the form of carbonates, bicarbonates, coal and petroleum and about 0.03 % of the atmosphere is carbon dioxide. The importance of carbon is quite large in spite of its meagre abundance in the earth. In this chapter, we will discuss the uniqueness of carbon and its properties. This will illustrate the usefulness of carbon and its compounds.

6.1. Allotropes of Carbon

As seen above carbon occurs in nature, in physically distinct forms. However chemically they are the same. When heated strongly in air diamond and graphite leaves no residue but all are converted into carbon dioxide. Graphite is soft, slippery and greyish black in colour. It is a good conductor of electricity. However, diamond is transparent, very hard and is a non-conductor of electricity.

The difference between them lies in the manner in which the carbon atoms are bonded to one another. In diamond each carbon atom lies at the centre of a regular tetrahedron and is covalently bonded with four carbon atoms located at its four corners (Fig 6.1a). All the bonding electrons of the carbon atoms are thus used leaving no free electrons. This makes diamond an extremely

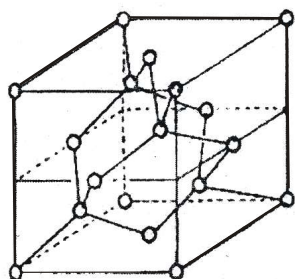


Fig. 6.1 (a) Structure of Diamond

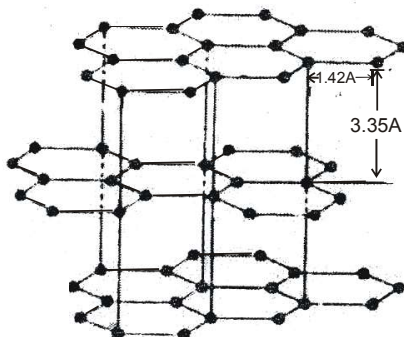


Fig. 6.1 (b) Structure of Graphite

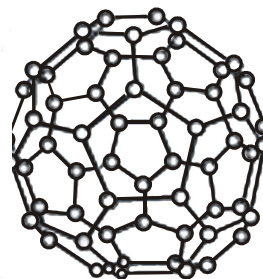


Fig. 6.1 (c) Structure of Fullerene

poor conductor of electricity. The tightly bonded three dimensional tetrahedral arrangement of carbon atoms produce a rigid network and makes diamond the hardest substance known. The melting point of diamond is 3500°C which is very high.

Each carbon in graphite is covalently bonded to only three neighbouring carbon atoms forming layers of hexagonal networks (Fig 6.1b), separated by a comparatively larger distance. Because of this distance between two successive layers, the possibility of a covalent bond being formed between carbon atoms lying in opposite layers is ruled out. The fourth valence electron thus remains almost free. This enable the easy flow of electrons through graphite and makes it a good conductor of electricity. These layers slide over one another. This makes graphite soft to feel, greasy to touch and thus graphite has lubricating properties. Thus powdered graphite is used as lubricants in machines where high temperature makes other lubricants unsuitable.

Graphite and diamond are the allotropes of carbon. Allotropism is the phenomenon of existence of an element in two or more physically different forms but with similar chemical properties and those forms are called **allotropes**.

Carbon also has another allotropic form known as fullerene (Fig 6.1c). It is a form in which sixty carbon atoms are arranged in the shape of a football. Since this looks like the geodesic dome designed by the US architect Buckminster Fuller, the molecule is named as **fullerene**.

Since carbon has four valence electrons, it is capable of bonding with four other carbon atoms or atoms of some other monovalent element. Such bonds are single bonds. Carbon forms compounds with hydrogen, oxygen,

nitrogen, sulphur, phosphorus, chlorine, bromine and many other elements giving rise to a large number of compounds. These compounds have specific properties which are characteristics of the elements rather than carbon present in the molecule.

6.2. Catenation – Unique property of Carbon

The number of carbon compounds whose formulas are known to us is about three million. The number of compounds formed by all the other elements put together is less than one lakh.

What makes the number of carbon compounds so large ?

Carbon has the unique property to form bonds with other carbon atoms to form long chains. This property of carbon is called **catenation**. The carbon chains may be straight, branched or even rings. The carbon atoms may be linked by double or triple bond in addition to single bonds. The carbon-carbon bond is very strong and hence stable.

The bonds that carbon forms with most other elements are very strong and therefore, these compounds are exceptionally stable. One reason for the formation of strong bonds by carbon is its small size. This enables the nucleus to hold on to the shared electron pairs strongly. Generally, the covalent bonds formed by elements having larger sizes are much weaker.

6.2.1. Hydrocarbons

Saturated hydrocarbons

Compounds of carbon and hydrogen only are called hydrocarbons. Methane, CH_4 is the simplest possible hydrocarbon. Carbon is tetravalent while hydrogen is monovalent. Each of the four valence electrons of carbon shares with one electron of hydrogen to acquire the noble gas configuration. Thus, methane is formed as shown in Fig. 6.2

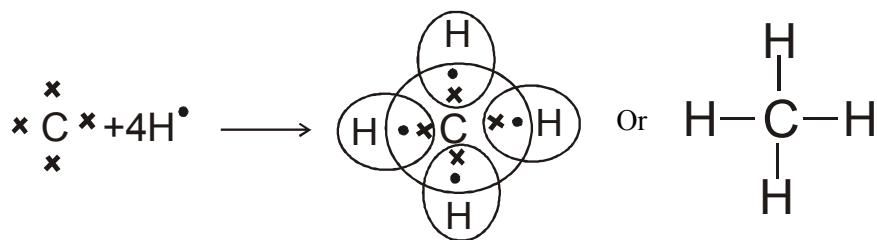


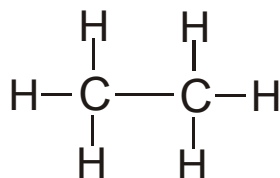
Fig. 6.2. Electron dot and cross structure of methane

Methane occurs in the nature in the form of gas. It is formed by the decay of plants and animals i.e., organic matters and is also known as marsh gas. Natural gas found in earth's crust is always associated with petroleum. Methane is widely used as fuel and is a major component of bio-gas and Compressed Natural Gas (CNG).

The next hydrocarbon after methane is ethane with the molecular formula C_2H_6 . To arrive at the structure first write the two carbon atoms linked by a single bond,



Then, in the second step, use the hydrogen atoms to satisfy the remaining three valencies of each carbon,



The electron dot structure of ethane is shown in the Fig 6.3

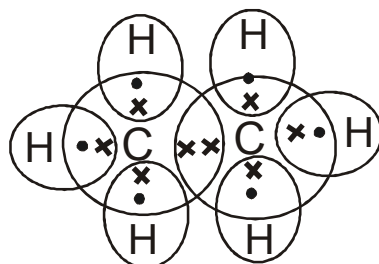


Fig 6.3. Electron dot structure of ethane molecule.

Now give answers for the following

1. Draw the structure of propane with the molecular formula C_3H_8 .
2. Draw the electron dot structure of chloromethane with the molecular formula CH_3Cl .

The hydrocarbons ethane C_2H_6 , propane C_3H_8 etc. contains carbon - carbon single bonds only. Such hydrocarbons along with methane CH_4 are known as **saturated hydrocarbons** or simply **alkanes**. They are **open chain** compounds.

Alkanes are represented by the general formula $C_n H_{2n+2}$ when $n = 1, 2, 3$ etc. Alkanes when arranged in order of increasing molecular mass constitute a series in which any two consecutive alkanes differ by $-CH_2-$. Such a series is called **homologous series**. The names and structures of a few alkanes are given in Table 6.1.

Table 6.1. Names and Structures of some Alkanes

Name	Formula	Straight chain formula
Methane	CH_4	$ \begin{array}{c} H \\ \\ H-C-H \\ \\ H \end{array} $
Ethane	C_2H_6	$ \begin{array}{c} H \quad H \\ \quad \\ H-C-C-H \\ \quad \\ H \quad H \end{array} $
Propane	C_3H_8	$ \begin{array}{c} H \quad H \quad H \\ \quad \quad \\ H-C-C-C-H \\ \quad \quad \\ H \quad H \quad H \end{array} $
Butane	C_4H_{10}	$ \begin{array}{c} H \quad H \quad H \quad H \\ \quad \quad \quad \\ H-C-C-C-C-H \\ \quad \quad \quad \\ H \quad H \quad H \quad H \end{array} $
Pentane	C_5H_{12}	$ \begin{array}{c} H \quad H \quad H \quad H \quad H \\ \quad \quad \quad \quad \\ H-C-C-C-C-C-H \\ \quad \quad \quad \quad \\ H \quad H \quad H \quad H \quad H \end{array} $
Hexane	C_6H_{14}	$ \begin{array}{c} H \quad H \quad H \quad H \quad H \quad H \\ \quad \quad \quad \quad \quad \\ H-C-C-C-C-C-C-H \\ \quad \quad \quad \quad \quad \\ H \quad H \quad H \quad H \quad H \quad H \end{array} $

Will it be possible to write structures of butane C_4H_{10} other than the straight chain structure given above ? We can write two different carbon skeletons of C_4H_{10} using the principle of carbon-carbon single bonds only. They are (Fig 6.4)

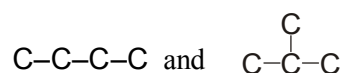


Fig 6.4 Two possible carbon skeletons of some C_4H_{10}

Satisfying the remaining valencies of carbon with hydrogen atoms we have the complete structures of the molecules of C_4H_{10} (Fig. 6.5).

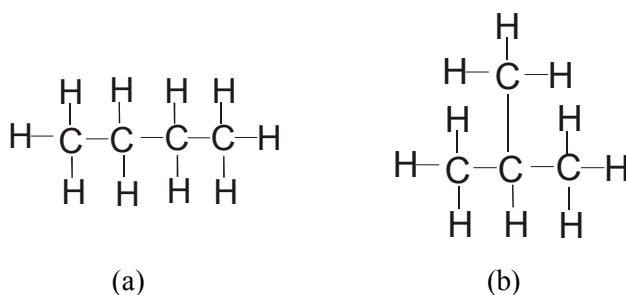
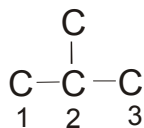


Fig. 6.5 Complete structure of C_4H_{10}

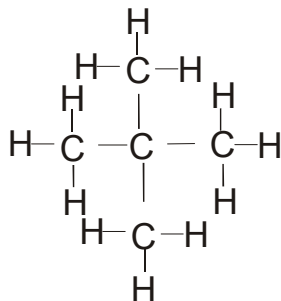
The structure (a) has all the four carbon atoms in a single line or chain. Its name is n-butane (read as normal butane). The structure (b) has three carbon atoms in a single chain and one carbon atom is branched. It is called iso-butane. If the carbon atoms in the longest chain are numbered as



then the structure (b) is also called as 2-Methyl propane. Why is it so?

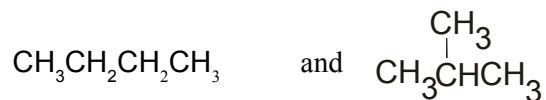
Let us answer these.

1. Give the name of



2. (a) Write the possible carbon skeletons of C_5H_{12} .
 (b) Then write the possible structures of C_5H_{12} .

The two structures of C_4H_{10} , although they have the same molecular formula, are different from each other. Such compounds with the same molecular formula but different structure are called **structural isomers**. They can be written in short as



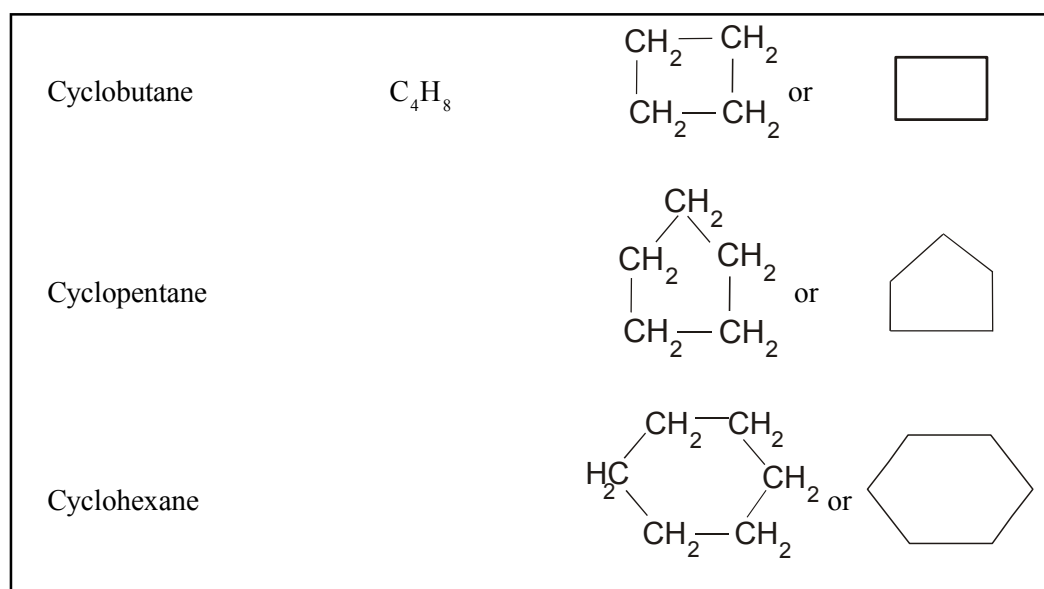
What is the relationship between the two structures ?

In addition to straight and branched chains, the same hydrocarbon may have carbon atoms in the form of a ring. Such hydrocarbons are called **cycloalkanes**. They have the general formula C_nH_{2n} i.e., they have two hydrogen atoms less than the corresponding saturated hydrocarbons.

Why is it so?

Examples of some cycloalkanes are given in Table 6.2

Table 6.2.		
NAME	FORMULA	STRUCTURE
Cyclopropane	C_3H_6	$\begin{array}{c} CH_2 \\ / \quad \backslash \\ CH_2-CH_2 \end{array}$ or



Unsaturated Hydrocarbons

In section 6.2 we have seen that carbon-carbon bonds may also be double or triple. Such open chain hydrocarbons containing double or triple bonds are called **unsaturated hydrocarbons**. They are so called as they have fewer number of hydrogen atoms when compared to the saturated hydrocarbons.

Alkenes are those unsaturated hydrocarbons which contain double bond. Such compounds have the general formula C_nH_{2n} (same as cycloalkanes). The first member of this group is ethene (or ethylene) which have the formula C_2H_4 . Let us write the electron dot structure of ethene, C_2H_4 . It is shown in Fig 6.6.



Fig. 6.6 (a) Electron dot structure of ethene (b) Structural formula

Table 6.3 Shows the homologues of ethene, name and the structural formulas.

Table 6.3

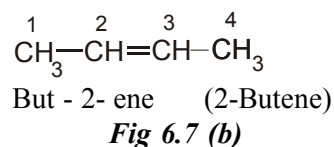
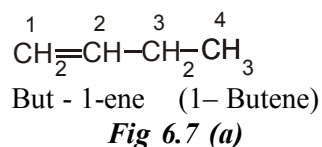
Molecular Formula	Structure	Name
C_2H_4	$CH_2 = CH_2$	Ethene
C_3H_6	$CH_3-CH=CH_2$	Propene
C_4H_8	(i) $CH_2=CH-CH_2-CH_3$	But-1-ene
	(ii) $CH_3-CH=CH-CH_3$	But-2-ene

Let us answer these.

1. Why is the first member of alkene C_2H_4 ?
2. Why does butene have two names ?

Isomerism in alkene

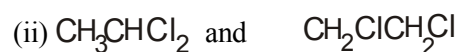
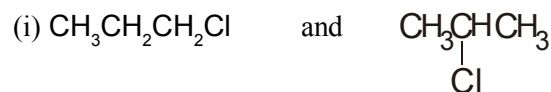
The two structures of butene C_4H_8 have the same carbon chain but differ in the position of carbon-carbon double bond. The carbon atoms in the chain are numbered starting from the end which is nearer to the double bond. Thus



In Fig 6.7 (a) the double bond lies between the C_1 and C_2 and therefore it is called **But-1-ene**. This indicates that the position of double bond is between C_1 and C_2 . In Fig 6.7 (b) the double bond lies between C_2 and C_3 and therefore it is called **But-2-ene**. This indicates that double bond lies between C_2 and C_3 .

Such compounds having the same carbon chain but differ in the position of double bond (which is a characteristic property) are called **position isomers**. Let us answer the following.

1. Write the position isomers of pentene C_5H_{10} .
2. Identify the relationship between



Examine the structures given in Fig 6.8 (a) and 6.8 (b)

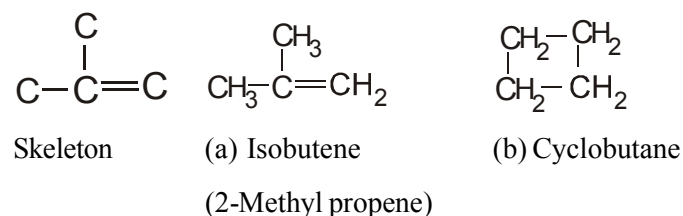


Fig 6.8 Different structures of C_4H_8

They have the same molecular formula C_4H_8 as butenes shown in Figs 6.7. But the structure of carbon chains are all different. Thus the relationship between But-1-ene or But-2-ene with isobutene (2-Methyl propene) or cyclobutane is structural isomerism. Thus butene can show both **structural** and **position isomerisms**.

Alkynes:

Hydrocarbons with carbon-carbon triple bond are called alkynes. They have the general formula $\text{C}_n\text{H}_{2n-2}$. The first member of the series is ethyne (or acetylene) with the formula C_2H_2 . Let us draw the structure of this molecule.



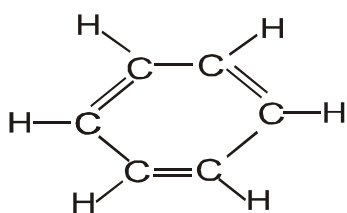
Some of the compounds of the family are

Formula	Structure	Name
C_2H_2	$\text{H}-\text{C}\equiv\text{C}-\text{H}$	Ethyne
C_3H_4	$\text{CH}_3-\text{C}\equiv\text{C}-\text{H}$	Propyne
C_4H_6	(i) $\text{H}-\text{C}\equiv\text{C}-\text{CH}_2-\text{CH}_3$	But-1-yne
	(ii) $\text{CH}_3-\text{C}\equiv\text{C}-\text{CH}_3$	But-2-yne

- Question :** (i) Why does Butyne has two isomers ?
(ii) Is there any other structural isomer of Butyne ?

Alkenes and alkynes are highly reactive organic compounds. They are used for making many useful chemicals and other substances like plastic, rubbers etc.

Yet there is another type of hydrocarbons which are known as **arenes** or **benzene** and its **derivatives**. They are cyclic and contain at least one benzene ring. Benzene itself is C_6H_6 . The simplest representation of benzene is



Arenes are known as aromatic hydrocarbons. They are very stable hydrocarbons inspite of their general formula C_nH_{2n-6} .

We are familiar with cooking gas, motor spirit, petrol, diesel, kerosene, lubricating oil. They are all hydrocarbons and their source is petroleum which is a black liquid found in the crust of the earth.

6.3. Petroleum (Mineral Oil)

Petroleum is a dark coloured viscous liquid found deep in the earth's crust. Chemically it is a mixture of various types of hydrocarbons along with some oxygen, sulphur and nitrogen containing compounds.

Petroleum is believed to be formed by the decay and decomposition of marine animals as well as that of plant materials of the prehistoric forests. In other words, petroleum is of animal and plant origin. It is thought that due to some upheavals like earthquake, volcanic eruptions etc, these prehistoric forests, and sea animals get buried under the earth's crust. Due to prolonged action of

high pressure and high temperature in the interior of the earth for ages, the organic matter decomposed into petroleum.

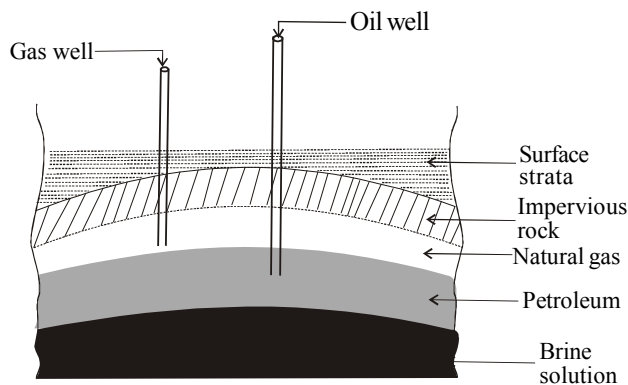


Fig. 6.9. Mining of Petroleum

A diagrammatic representation of the occurrence and mining of petroleum is given in Fig 6.9. Petroleum is pumped out through the deep wells bored into the crust.

The process of separating crude petroleum into useful

fractions by fractional distillation is known as refining. Fractions condensing at different boiling points are collected separately and are called products of petroleum. They are— gas, gasoline or petrol, kerosene, gas oil, diesel oil, lubricating oil, vaseline, paraffin, wax and asphalt.

Uses

Gas is used as a fuel, gasoline as a motor fuel, kerosene as household fuel and lighting purpose, gas oil and diesel oil as furnace fuel and for diesel engines, lubricating oil and grease for lubrication, vaseline for softening skin, paraffin wax for making candles, and asphalt for road surfacing. LPG (liquefied petroleum gas) is widely used for cooking.

6.4. Some compounds of carbon other than hydrocarbons

Carbon can form covalent bonds with many other elements like oxygen, sulphur, halogens— fluorine, chlorine, bromine, iodine etc. In a hydrocarbon one or more hydrogens can be replaced by these elements to form stable compounds. These hetero atoms may also be present as a group combined with other atoms.

Functional Groups

The heteroatoms and the group attached to the hydrocarbon part forming a stable molecule characterise the specific properties of the compound irrespective of the nature and length of the carbon chain. Hence these heteroatoms and groups are called **functional groups**. Example of some of these functional groups are given in Tables 6.4.

Table 6.4 Some functional groups of Carbon compounds

Heteroatoms	Functional group	Formula	Compound examples,	Name
Cl / Br / I Oxygen	Halo-(Chloro/Bromo/Iodo)	-Cl, -Br, -I	CH ₃ Cl	Chloromethane
			CH ₃ Br	Bromomethane
			CH ₃ CH ₂ I	Iodoethane
	1. Alcohol (-ol) (hydroxyl) 2. Aldehyde (-al) (formyl or aldehydic)	-OH -CHO	CH ₃ OH	Methanol
			C ₂ H ₅ OH	Ethanol
			HCHO	Methanal
			CH ₃ CHO	Ethanal

3. Ketone (–one)	–CO–	CH ₃ –CO–CH ₃	Propanone
4. Carboxylic acid (–oic acid)	–COOH	HCOOH	Methanoic acid
		CH ₃ COOH	Ethanoic acid (Acetic acid)

Alcohols are a family of carbon compounds which contain the functional group –OH attached to a saturated carbon as $\begin{array}{c} | \\ \text{—C—OH} \\ | \end{array}$. These compounds have similar chemical properties inspite of the differences in the number of carbon chain. They are represented by the general formula C_nH_{2n+1}OH.

Let us answer the following.

1. Write the homologous series of alcohols upto four carbon atoms.
2. Write any two isomers of C₄H₉OH.

6.5. Nomenclature of Carbon Compounds

The name of an organic compound essentially consists of the following three parts.

1. Word root
2. Suffix
- and
3. Prefix.

Word root : It is the basic unit of the name. It denotes the number of carbon atoms present in the **main chain** (the longest possible continuous chain of carbon atoms including the functional group and carbon-carbon multiple bonds) of the molecules. For molecules upto four carbon atoms special word root are used but for chains of five or more carbon atoms Greek roots are used as given below :

Chain length	Word Root
C ₁	Meth –
C ₂	Eth –
C ₃	Prop –
C ₄	But –
C ₅	Pent –
C ₆	Hex –
C ₇	Hept–
C ₈	Oct–
C ₉	Non–
C ₁₀	Dec–

The general name of the word root for any carbon chain is **alk–**.

Suffix : There are two types of suffixes.

(a) Primary suffix

A primary suffix is added to the word root to indicate whether the carbon chain is of single bonds only (saturated) or contains carbon - carbon multiple bonds (unsaturated). The three basic primary suffixes are:

Nature of carbon chain	Primary suffix	General Name
i) Saturated	– ane	Alkane
ii) Unsaturated with a double bond	– ene	Alkene
iii) Unsaturated with a triple bond	– yne	Alkyne

It is illustrated as in the following example.

Organic compound	Word Root	Primary Suffix	Name
$\text{CH}_3\text{CH}_2\text{CH}_3$	Prop	– ane	Propane
$\text{CH}_3\text{CH}=\text{CH}_2$	Prop	– ene	Propene
$\text{CH}_3-\text{C}\equiv\text{CH}$	Prop	– yne	Propyne

b) Secondary Suffix

A secondary suffix is added to the primary suffix to indicate the nature of the functional group present in the molecule. Some secondary suffixes are given below:

Family of compound	Functional group	Secondary suffix
Alcohols	– OH	– ol
Aldehydes	– CHO	– al
Ketones	– CO –	– one
Carboxylic acids	– COOH	– oic acid

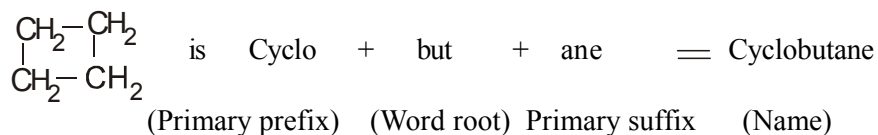
The examples given below illustrate the use of word root, primary suffix and secondary suffix while naming an organic compound.

Compound	Word Root	Primary Suffix	Secondary Suffix	Name
CH_3OH	Meth	an (e)*	ol	Methanol
$\text{CH}_3\text{CH}_2\text{OH}$	Eth	an (e)*	ol	Ethanol
$\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$	Prop	an (e)*	ol	Propanol (Propan-1-ol)
CH_3COOH	Eth	an (e)*	oic acid	Ethanoic acid

* The terminal 'e' from the primary suffix has been dropped because the secondary suffix begins with a vowel.

Prefix: There are two types of prefixes. They are

a) Primary prefix: It is used to distinguish open chain compounds from ring compounds (closed chain compounds). For example, in the case of cyclic (ring) compounds, a primary prefix, **Cyclo** is used immediately before the word root. Thus the name of the compound is



If the prefix 'Cyclo' is not used, it simply indicates open chain (acyclic) compound.

b) Secondary prefix: Certain groups are not considered as functional groups but are treated as substituents. These are called secondary prefixes. These prefixes are added immediately before the word root or primary prefix in **alphabetical order**. Some important secondary prefixes are given below

Group	Secondary prefix	Example	Name
- F	Fluoro	CH_3F	Fluoromethane
- Cl	Chloro	$\text{CH}_3\text{CH}_2\text{Cl}$	Chloromethane
- CH_3	Methyl	$ \begin{array}{c} \text{CH}_3 \\ \\ \text{CH}_3 - \text{CH} - \text{CH}_3 \end{array} $	2-Methyl propane

Note : *Fluoromethane, chloroethane are single word name.*

Thus, the complete name of an organic compound in the IUPAC system (International Union of Pure and Applied Chemistry) consists of the following parts :

Secondary prefix + primary prefix + word root + primary suffix + secondary suffix .

Questions

1. Let us name the following compounds :

- (a) $\text{CH}_3\text{CH}_2\text{CH}_2\text{Br}$ b) $\begin{array}{c} \text{CH}_3\text{CHCH}_3 \\ | \\ \text{Br} \end{array}$
- (c) $\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$ d) $\begin{array}{c} \text{CH}_3\text{CHCH}_3 \\ | \\ \text{OH} \end{array}$
- (e) CH_3CHO f) $\text{CH}_3\text{CH}_2\text{COOH}$

2. Draw the structures of

- a) 1-Bromobutane b) 2-bromobutane c) Ethanoic acid
d) Propanone f) Butanal

6.6. Chemical Properties Of Carbon Compounds

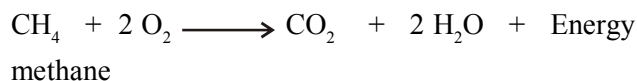
Let us try to understand some of the properties of carbon compounds. Carbon and its compounds are combustible substances.

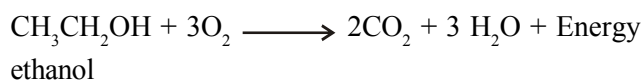
6.6.1. Combustion

All the allotropic forms of carbon burn in oxygen to form carbon dioxide producing large amounts of heat and light (energy).



Some fuels like coal, charcoal and wood burn leaving some residue. But fuels like LPG, kerosene, alcohol etc. burn without leaving any residue. Some of the carbon compounds burn with sooty flame while some others burn with clean flames. All compounds of carbon burn to form carbon dioxide and water. Thus



**Activity 6.1**

- ☞ Hold a metal scale or plate over the flame of a burning candle and observe. Is there any deposit of soot ?
- ☞ Repeat the above step using a spirit lamp.
- ☞ Repeat again using a diesel oil lamp
- ☞ Record your observation and draw a conclusion.

Saturated hydrocarbons usually burn with a clear flame whereas unsaturated hydrocarbons burn with coloured (yellow to orange) flame with a lot of soots. Can you explain why is it so ?

When the supply of air (oxygen) is limited even the saturated hydrocarbons burn with a sooty flame. Why ? The gas and kerosene stoves used at home have air inlets to mix with the fuel to burn them completely. If the bottoms of the cooking vessels become black , it means that air holes are blocked and the fuel is wasted (incomplete burn). Fuel such as coal, petrol and diesel contain some compounds of sulphur and nitrogen. Their combustion produces oxides of sulphur and nitrogen. These oxides are the major pollutants of air. Besides fine particles of carbon often missed combustion and are released in the air as particulates. These particulates cause pollution.

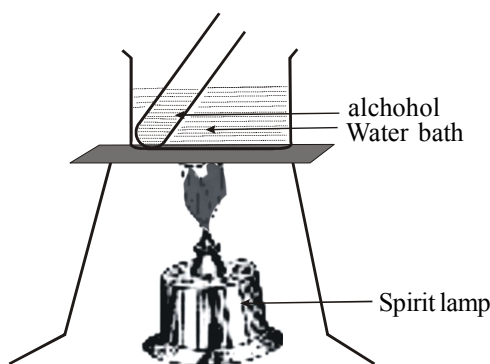


Fig. 6.10 Oxidation of ethanol

6.6.2. Oxidation

Combustion is also an oxidation process. The final product of oxidation of an organic compound is carbon dioxide and water. Many organic compounds may form intermediate products when reacted with oxygen or any other oxidising agent. Oxidation, in its simplest sense, may be defined as the addition of oxygen or removal of hydrogen from a carbon compound.

Activity 6.2.

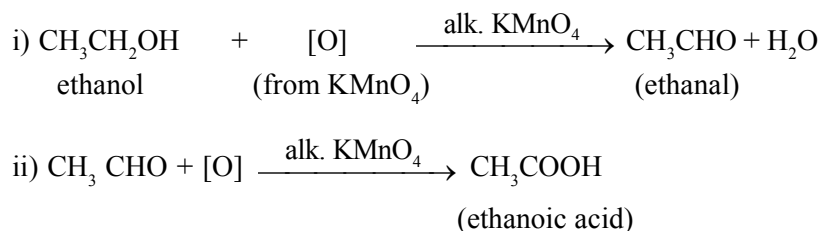
- ☞ Take about 3 mL of ethanol in a test tube and warm it gently on a water bath as in Fig 6.10.
- ☞ Add drop by drop a solution of 1% alkaline KMnO_4 (potassium permanganate).
- ☞ Note the change in the colour of KMnO_4 solution.
- ☞ Why does not the colour of potassium permanganate disappear when added in excess?

Note

The above activity may be performed by using acidic potassium dichromate solution ($\text{K}_2\text{Cr}_2\text{O}_7 + \text{Conc H}_2\text{SO}_4$). However, precaution must be taken not to touch this solution by hand.

Alkaline KMnO_4 or acidified $\text{K}_2\text{Cr}_2\text{O}_7$ are oxidising agents i.e. they can supply oxygen atoms which can be added to organic compounds.

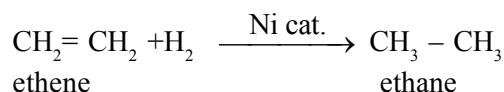
The reaction between ethanol and alkaline KMnO_4 produces an aldehyde which in turn is oxidised further to acid. The reaction occurs in the two steps



Nascent oxygens (oxygen atoms) are released within the reaction medium (*in situ*). The first step is oxidation of ethanol by the removal of two hydrogens, and the second step is the oxidation by adding oxygen atom to the intermediate product ethanal. Intermediate product is readily converted to ethanoic acid.

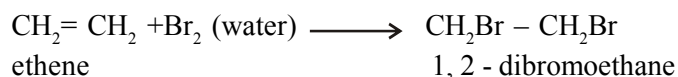
6.6.3. Addition Reactions

- (i) **Hydrogenation (addition of hydrogen):** Unsaturated hydrocarbons add hydrogen in presence of catalyst like palladium, platinum, nickel etc. to form saturated hydrocarbons. Thus, ethene adds a molecule of hydrogen to form ethane.



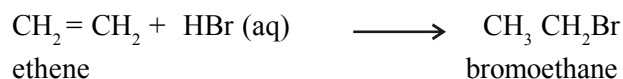
This reaction is commonly used in the hydrogenation of vegetable oils which contain unsaturated carbon chains. On hydrogenation vegetable oils give vegetable ghee.

- (ii) **Bromination (Halogenation) :** On treatment with bromine water, ethene adds a molecule of bromine to form dibromoethane. (Orange colour of bromine water is discharged during the reaction).

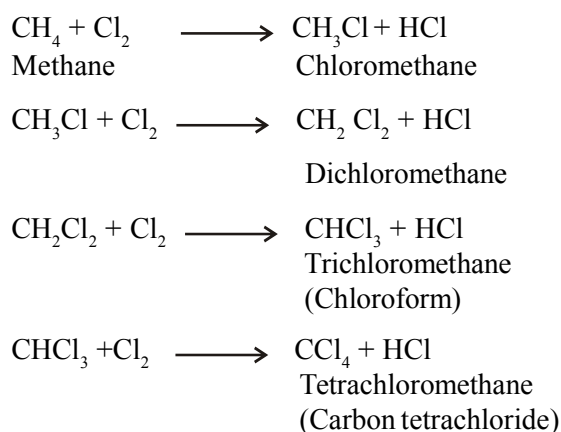


This reaction is used as a test for the unsaturated organic compounds (presence of double or triple bonds)

- (iii) **Addition of Hydrobromic acid :** Ethene readily reacts with hydrobromic acid HBr to produce bromoethane



6.6.4.Substitution Reaction: Saturated hydrocarbons are very stable and unreactive towards most reagents. But, in the presence of diffused sunlight (indirect light), chlorine can react with methane to produce various products. One or all the hydrogens of CH_4 can be replaced by chlorine atoms. Such a reaction is known as **substitution reaction**.



However, the reaction is very complex and very fast.

6.7. Properties of ethanol $\text{CH}_3\text{CH}_2\text{OH}$

Ethanol (ethyl alcohol) is one of the important compounds of carbon. Let us see some of its properties.

Ethyl alcohol is a colourless volatile liquid with a boiling point of 78°C . It has a typical pleasant smell. It is inflammable and burns with a blue flame. It is miscible with water in all proportions. It is also miscible with many organic solvents. Ethanol mixed with petrol, is used as a fuel for internal combustion engines. It is also used as the solvent for lacquers.

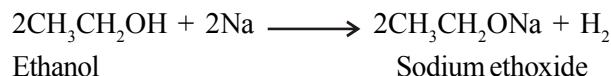
Ethyl alcohol is the active ingredient of all alcoholic drinks. Depending upon the type of drinks the alcohol content ranges from 3 – 50%. When consumed, the alcohol is oxidised and supplies energy which in turn stimulates the human system. However alcohol affects Central Nervous System (CNS) as it is neurodepressant. When taken in small amounts, apparent excitation and euphoria are experienced. Hesitation, caution, self-respect and restraint are lost first. Mood and feelings are altered. When taken in larger amounts it causes disorganization of thought, impairment of memory and other faculties and drowsiness.

Alcohol has been believed to produce CNS depression by a generalized membrane action by altering the state of membrane lipids. A person, therefore, loses control over his body after drinking alcohol.

Some simple reaction of ethanol

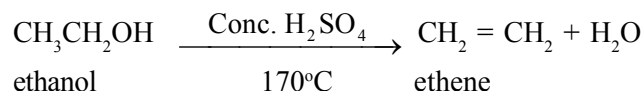
(i) Reaction with sodium metal

Ethanol reacts with sodium metal to produce sodium ethoxide and hydrogen gas.



(ii) Dehydration of ethanol

Ethanol on heating with concentrated sulphuric acid, H_2SO_4 at 170°C , loses a water molecule giving ethene.



(iii) Oxidation of ethanol : Oxidation of ethanol with alkaline KMnO_4 gives ethanoic acid which is called acetic acid (Refer to 6.10)

6.8. Properties of Ethanoic acid

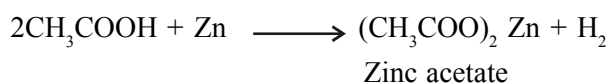


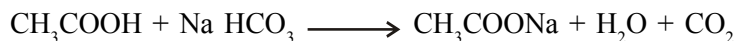
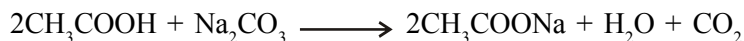
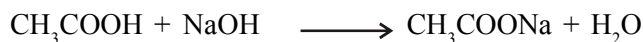
Fig. 6.11 Formation of ester

- ☞ Take about 2ml of ethanol and equal volume of glacial acetic acid in a test tube,. Add 2–3 drops of concentrated sulphuric acid.
- ☞ Heat the test tube on a water bath as shown in the Fig. 6.11. for about 5 minutes
- ☞ Pour the contents of the tube in about 20 ml cold water taken in a beaker and smell the mixture.

What is your observation ?

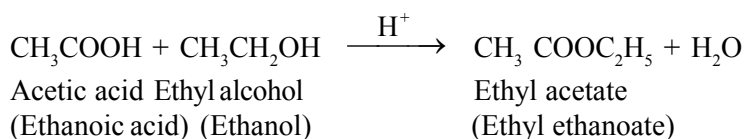
- $$\begin{array}{ccc} 2\text{CH}_3\text{COOH} + 2\text{Na} & \longrightarrow & 2\text{CH}_3\text{COONa} + \text{H}_2 \\ \text{Acetic acid} & & \text{Sodium acetate} \end{array}$$





(ii) Reaction with alcohol (Esterification reaction)

Acetic acid reacts with ethyl alcohol in presence of an acid catalyst to form ester, ethyl acetate,



Ethyl acetate (ester) is a sweet-smelling liquid. It is used in making perfumes and as flavouring agents.

SUMMARY

- Graphite, Diamond and Fullerene are the allotropes of carbon.
- Carbon forms largest number of compounds.
- Graphite is a good conductor of electricity whereas diamond is a non-conductor.
- Carbon can bond with other carbon atoms. This property of carbon is called catenation.
- Compounds of carbon and hydrogen are called hydrocarbons.
- Hydrocarbons with C–C single bonds only are called saturated hydrocarbons.
- Unsaturated hydrocarbons contain C–C multiple bonds.
- Isomers are compounds with the same molecular formula but having different structures.
- Any two successive members of a homologous series differ by a $-\text{CH}_2-$ unit.
- Hydrocarbons may be of straight chain or ring structures.
- Cycloalkanes have the same general formula C_nH_{2n} as alkenes.
- Butene shows position isomerism.
- Petroleum is the major source of hydrocarbons.
- Asphalt is used for road surfacing.

- ✱ Complete burning of organic compounds produce carbon dioxide as the end product.
- ✱ Saturated hydrocarbons burn with a clean flame.
- ✱ Unsaturated hydrocarbons usually burn with a sooty flame.
- ✱ Oxidation of ethyl alcohol with alkaline KMnO_4 or acidic $\text{K}_2\text{Cr}_2\text{O}_7$ produces acetic acid.
- ✱ Hydrogenation of vegetable oils give, vegetable ghee.
- ✱ Saturated hydrocarbons undergo substitution reaction with chlorine in presence of indirect sunlight.
- ✱ Ethanol produces depression of Central Nervous System.
- ✱ Ethanol on dehydration with conc H_2SO_4 produces ethene.
- ✱ Vinegar is dilute aqueous solution of acetic acid.
- ✱ Vapours of acetic acid cause damage to lungs.
- ✱ Acetic acid reacts with ethanol to give sweet smelling ester ethyl acetate.

EXERCISES

1. Why does graphite conduct electricity ?
2. Why is diamond so hard ?
3. What is CNG ? Give an use of it.
4. Draw the electron dot structure of ethane and count the number of covalent bond in a molecule of it.
5. Draw the structure of propane and find out the number of hydrogens which have similar properties.
6. Draw the structure of 2-methyl propane. How many types of carbon and hydrogens are there ?
7. What is the general formula of cycloalkanes ?
8. Can you write But-3-ene? If not why ?
9. Draw the structure of benzene molecule.
10. What are important fractions obtained from petroleum ? Mention their important uses.
11. Define functional groups. Write the functional groups of alcohol , aldehyde and carboxylic acids.
12. What is a word root ?

13. What are primary and secondary prefixes?
14. What are primary and secondary suffixes ?
15. How is oxidation different from combustion ?
16. Write equation for esterification reaction.
17. What is the formula of chloroform ?
Mention one use of chloroform.

★★★★★★