UNIT 12 CARBON AND ITS COMPOUNDS

Structure

12.1 INTRODUCTION

In the previous unit you have studied about the strategies of teaching about some metallic and non-metallic elements and some of their compounds. In the present unit we shall discuss the teaching of some exemplary concepts and subtopics related to carbon and its compounds. Here it is important to appreciate that carbon and organic compounds need to be dealt as separate from other elements and their compounds. As you go through this unit you would be familiarizing yourself with teaching of allotropic forms of carbon, hydrocarbons and other compounds of carbon and finally the man made materials obtained from carbon compounds.

This unit shows us that living bodies and their products contain a large quantity of carbon compounds in our daily life. Carbon compounds are used in plenty by man for their daily existence e.g. cereals, pulses, cooking gas, leather goods, cotton, synthetic fibres, dyes etc. are all made up of carbon compounds. This is easily illustrated by burning these substances, the black residue that is left is carbon. In short, compounds of carbon are widely distributed in nature. Carbon belongs to group 4 of periodic table along with silicon, germanium, tin and lead. It has 4 electrons in their outermost orbit, thereby giving it a valency of 4. Group 4 is basically non-metallic in nature, but sometimes shows the metallic characteristics (when atomic number increases).

Thus, this unit should enable you to stimulate the effective communication of the various concepts in organic chemistry to the students.

12.2 OBJECTIVES

After completing this unit, you should be able to :

- clarify the concept of allotropy and bring out the discrimination between diamond and graphite;
- discuss reasons for the occurrence of a large number of carbon compounds;
- explain the family of hydrocarbons highlighting some relevant concepts related to hydrocarbons;
- discuss that hydrocarbons are parent compounds from which many other types of compounds can be formed;
- clarify the concept of functional group and demonstrate the application of this concept in alcohols, carboxylic acids and esters;
- discuss the group of man made materials such as plastics, fibres and rubber etc. which are derived from carbon compounds; and
- explain the cleansing action of soaps and detergents.

12.3 ALLOTROPES OF CARBON

Main Teaching Points

- Definition of allotropy
- Structure of diamond and graphite
- Properties of diamond and graphite

Teaching Learning Process

What is allotropy?

Allotropes are elements which occur in more than one form in nature i.e. physically they may be different but have the same chemical properties. The most important example is carbon, which occurs in two forms.

- Diamond
- Graphite

This phenomenon is called allotropy. We all know that diamond is used in jewellery besides being used in various other activities, i.e. cutting of glass.

The other form of carbon is graphite which is also found in abundance in nature. The most common use of graphite is that it is used in pencils and in dry cells. We notice that though both diamond and graphite are forms of carbon but they have different appearances. If we burn them, both produce carbon dioxide and do not leave any residue, but this experiment cannot be shown in the laboratory as diamond is very expensive.

Now we know that although diamond and graphite appear different but chemically they are same. In other words, diamond and graphite have same chemical properties (both give out CO_2 on burning) but have different physical properties.

After polishing diamond shines brilliantly while graphite shines due to its internal structure. One is hard, other is soft yet they both are allotropes of carbon.

Physical properties of diamond and graphite is given below :

Properties	Diamond	Graphite
Appearance Hardness	Transparent, very hard	Black, shiny soft
Conductivity Thermal Electrical	Poor	Good
Density	3510 Kg/m^3	2250 Kg/m^3
Use	Jewellery, grinding, drilling	Dry cell, pencil lead, lubricant, electric arc

Structure of Diamond and Graphite

Structure of diamond and graphite can be explained though the ball and stick model. The two structures can be compared. Following characteristics may be pointed out :

i) Each carbon atom is bonded to many other carbon atoms in the models of graphite and diamond.

ii) Here the teacher may ask the students to draw the geometrical shape of the smallest unit in the two models.

- tetra hedron
- hexagon

The students would observe that in diamond each carbon atom is bonded to four other carbon atoms, giving rise to tetrahedron shape of the smallest unit in diamond. Hence diamond has tetrahedral structure. While in graphite, each carbon atom is bonded to three carbon atoms only. This leaves one electron free with each carbon atom, as carbon atoms has four electrons in the outermost shell. Carbon atoms in graphite link up to form hexagons. Hence graphite has hexagonal sheets which are joined to each other by weak forces due to free electrons between them.

Now it is clear that in diamond all bonding electrons are engaged leaving no electrons thus making it a very poor conductor of electricity. The strong co-valent bond of electrons in tetra hedral arrangement makes it the hardest element known, whereas in graphite each atom is bonded to only three neighbouring carbon atoms. Thus, it forms a loose hexagonal network leaving 4th electron free to move within, hence making it a good conductor of electricity. The layers also have the facility to slide over each other hence giving it the quality of a lubricant.

It must be made clear that diamond has brilliant shine only after cutting and polishing. Originally when taken out of mines, diamond has no shine. This is so, because diamond has a very high refractive index and excellent cleavage along its intersecting planes. This implies that after cutting through different planes and polishing the raw diamond, the light falling on diamond would bend sharply and slight movement would give several rays of light and colour due to refraction. The graphite also has shiny appearance but due to different reason. It has free electrons which are constantly absorbing and emitting light giving it a shiny appearance.

Methodology used

- Concept of allotropy is discussed and explained.
- Structure of diamond and graphite is explained with the help of ball and stick model.
- Properties and uses of diamond and graphite are discussed.

Check Your Progress

Notes : a) Write your answers in the space given below.
b) Compare your answers with those given at the end of the unit.

1. Diamond and graphite are allotropes of carbon. How can this statement be justified?

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2. Discuss the various physical properties of Diamond and Graphite.

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12.4 WHY ARE THERE A LARGE NUMBER OF CARBON COMPOUNDS IN NATURE

Main Teaching Points

- Carbon compound in abundance in nature
- Definition of catenation
- Concept of isomers

Teaching Learning Process

Although carbon ranks seventeenth in the order of abundance in the earth's crust, it forms the largest number of compounds, next only to hydrogen. Carbon and its compounds are widely distributed in nature. Diamond and graphite are the two different forms of pure elemental carbon present in nature. Charcoal and coke are impure forms of carbon. They are obtained by strong heating of wood and coal respectively in the absence of air. In the combined state carbon is present as carbonate in many minerals. In air, carbon dioxide is present in small quantities.

All living systems contain carbon compounds. Life would be impossible today without them. Fossil fuels such as lignite coal and oil which are derived from living matter are all rich in carbon compounds.

Scientist Lavoisier showed by qualitative and quantitative analysis of numerous organic compounds that they were made up of relatively few elements and they all contained carbon. Later organic chemistry was established as the chemistry of carbon compounds generally containing carbon bonds. Organic compounds usually contain hydrogen and also, oxygen, nitrogen, sulphur, phosphorus and the halogens.

More than five million organic compounds are known and they comprise about 90% of all known compounds, the reason being the presence of carbon-carbon bond. The carbon-carbon bond are strong compared to carbon hydrogen or carbon oxygen bonds.

The second reason for the abundance of organic compounds is the phenomenon of isomerism.

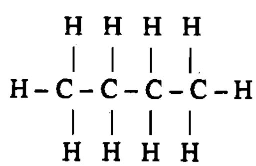
Organic compounds play an important part in our daily lives. All living systems obtain their energy from organic compounds like carbohydrates (sugar) and fats and grow using amino acids and proteins (again organic).

They transmit genetic information from one generation to the next via nucleic acids (also organic). The clothes we wear, be they of natural fibres like cotton, wool or silk or synthetic materials like polyster are organic compounds.

Most of the drugs and pharmaceuticals are also organic compounds. In agriculture too, organic chemistry is well represented. Fertilizers like urea, pesticides like D.D.T., metathion and gammaxene and plant growth regulators are all organic chemicals. Among our various energy sources, fossil fuels like lignite, petroleum and natural gas are of organic origin. Many commonly used polymers (natural and synthetic) like wood, rubber, paper and plastics are again organic compounds.

12.4.1 Catenation

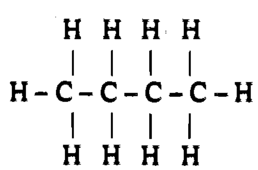
It is a phenomenon where atoms of elements join together to form chains of compounds.

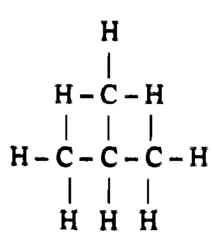


Organic compound have carbon–carbon bonds. No other element forms bonds with itself so easily. This phenomenon of an atom bonding to itself is known as catenation. This is one of the reasons that so many organic compounds are formed.

12.4.2 Isomerism

It is the property of those compound whose chemical structure can be arranged in more than one form for example :





This can be demonstrated with the help of ball and stick models.

These different forms of a compound are called 'Isomers' and this phenomenon is called Isomerism.

Two compounds are said to be Isomers if they have the same molecular formula but different arrangement of atoms.

Methodology used

- History of abundance of carbon compound is traced.
- With help of ball and stick model concept of catenation and isomerism is discussed.

Check Your Progress

Notes : a) Write your answers in the space given below.
b) Compare your answers with those given at the end of the unit.

3. Why are carbon compounds found in abundance in nature?

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4. Explain the term 'catenation' and 'isomerism'.

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12.5 HYDROCARBON

Main Teaching Points

- Concept of Hydrocarbons
- Saturated Hydrocarbons
- Unsaturated Hydrocarbons
- Homologous series

Teaching Learning Process

The concept of hydrocarbons may be introduced by taking the term 'Hydrocarbons' as compounds which are made up of carbon and hydrogen only. It can be made clear that while in allotropes like diamond each carbon atom was bonded to four carbon atoms, in hydrocarbons the carbon atom joins the hydrogen atoms. Carbon is chemically unique. Its atoms have the ability to combine with themselves to form long chains. The long chain in turn, can combine with atoms of other elements in various ways, thus giving rise to largest number of compounds (Carbon .Compounds) popularly known as hydrocarbons. The simplest of them is methane (CH_4).

$$\begin{array}{ccc} & H & \\ H & : \ddot{\underset{\cdot\cdot}{C}} : & H \\ & H & \end{array} \quad \longleftrightarrow \quad \begin{array}{ccccc} & & H & & \\ & & | & & \\ H & - & C & - & H \\ & & | & & \\ & & H & & \end{array}$$

Compare the model structures of ethane, ethene and ethyne. We notice the nature of carbon-carbon bond: single bond in ethane, double in ethene and triple in ethyne. Similarly the number of hydrogen atoms attached to the two carbon atoms as C_2H_6, C_2H_4 and C_2H_2. Hydro carbons basically form two types of compounds — Saturated and Unsaturated.

12.5.1 Saturated Compounds

Saturated hydrocarbons are those compounds where carbon and hydrogen atoms are joined together in single contact bonds fully saturating their chemical structure i.e. electrons in outer shell.

Saturated hydrocarbon are also known as alkanes.

Example

Methane

$$\begin{array}{ccccc} & & H & & \\ & & | & & \\ H & - & C & - & C \\ & & | & & \\ & & H & & \end{array} \longrightarrow CH_4$$

Ethane

$$\begin{array}{ccccccc} & & H & & H & & \\ & & | & & | & & \\ H & - & C & - & H & - & H \\ & & | & & | & & \\ & & H & & H & & \end{array} \longrightarrow C_2H_6$$

Here valency of carbon is satisfied (Saturated).

12.5.2 Unsaturated Compounds

Unsaturated compounds are those compounds where carbon and hydrogen atoms share more than one electron leaving room for further chemical reaction. They are susceptible to hydrogenation so as to complete the outer octet for stability. In other words, they easily combine with hydrogen to form stable compounds.

Unsaturated hydrocarbons can be further classified into alkenes and alkynes.

Alkenes

When two atoms are shared by carbon atoms in double contact bond, the compounds are called alkenes. e.g. ethene:

$$\begin{array}{ccccc} H & & H & & \\ | & & | & & \\ C & - & C & - & C_2H_4 \\ | & & | & & \\ H & & H & & \end{array}$$

With 4 or more carbon atoms they exist in the form of isomers C_4H_8.

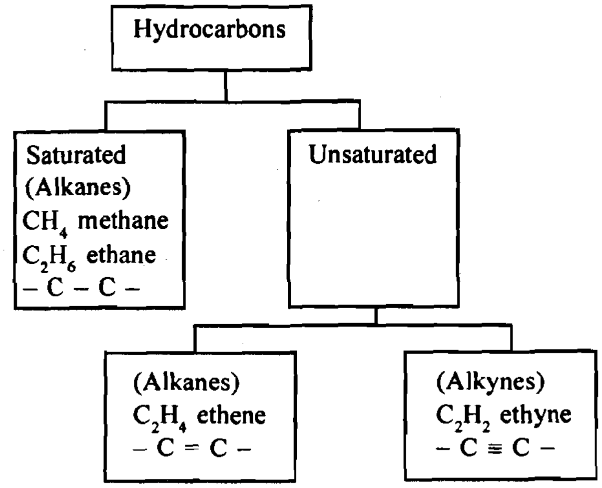

Fig. 12.1 : Classification of hydrocarbons

Hydrogenation

It is a process where unsaturated hydrocarbons combine with hydrogen atom to form a stable (saturated) hydrocarbon.

$$\text{Unsaturated hydrocarbons} \xrightarrow{\text{hydrogenation}} \text{Saturated hydrocarbons.}$$

Here the teacher may ask the students to compare the number of hydrogen molecules required to convert an alkene and an alkyne into the corresponding alkane.

12.5.3 Homologous Hydrocarbons

Unsaturated hydrocarbons, which after hydrogenation change into saturated hydrocarbon or saturated hydrocarbons after de-hydrogenation are changed into unstable, unsaturated hydrocarbons form the members of a Homologous series.

1. Alkanes → Alkenes → Alkynes
2. Alkynes → Alkenes → Alkanes

Hence we see that members of homologous series do not get converted into another compound directly but follow a set pattern. The hydrogen atoms are either joined in pairs or are separated in pairs.

$$\underset{\text{ethyne}}{C_2H_2} + H_2 \rightarrow \underset{\text{ethene}}{C_2H_4} + H_2 \rightarrow \underset{\text{ethane}}{C_2H_6}$$

$$\underset{\text{ethane}}{C_2H_6} - H_2 \rightarrow \underset{\text{ethene}}{C_2H_4} - H_2 \rightarrow \underset{\text{ethyne}}{C_2H_2}$$

These compounds are called homologous members.

Here it must be made clear that:

1. C – C Single bond in alkanes.
2. C = C Double bond in alkane.
3. C ■ Triple bond in alkynes.

Given below is the chart of homologous series.

Alkanes	**Alkenes**	**Alkynes**
CH_4		
C_2H_6	C_2H_4	C_2H_2
C_3H_8	C_3H_6	C_3H_4

C_4H_{10}	C_4H_8	C_4H_6
C_5H_{12}	C_5H_{10}	C_5H_8

What is the difference between successive member within a series here ? There is an addition of a $- CH_2$ at each successive stage.

It is clear that all the members within a series are characterised by the same type of bonds.

Methodology used : The concept of hydrocarbons was developed through lecture- demonstration method based on inductive and deductive reasoning. The homologous series and their characteristics were taken up through lecture discussion method based on inductive approach.

Check Your Progress

Notes : a) Write your answers in the space given below.
b) Compare your answers with those given at the end of the unit.

5. Define hydrocarbon.

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6. What makes hydrocarbons saturated and unsaturated?

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7. Explain Homologous series?

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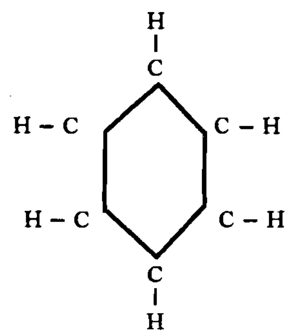
12.5.4 Aromatic Compounds (Arenes)

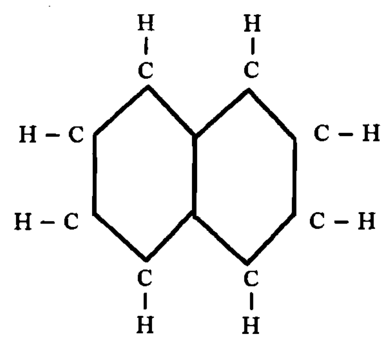
Aromatic compounds are also known as arenes. These are unsaturated hydrocarbons referred to as cyclic compounds. They are characterised by special ring structure and exudes aroma or smell. They behave differently than other alkenes and alkynes in chemical reactions.

Example

1. Benzene C_6H_6 (Homocyclic)



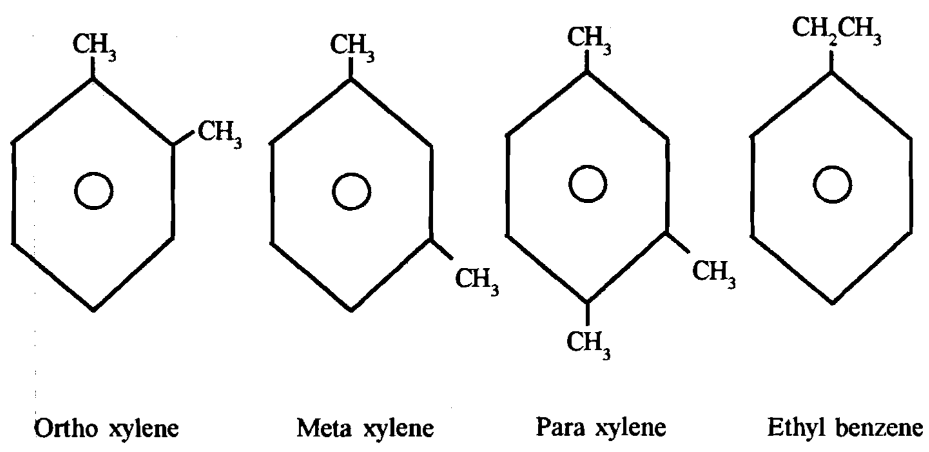
2. Naphthalene $C_{10}H_8$



3. Authracene

Characteristic properties of arenes

1. They are unsaturated hydrocarbons.
2. Six carbon atoms are arranged cyclically to form a ring which is diagrammatically represented in the form of a hexagon.
3. They exhibit positional isomerism. That is to say that all mono substituted benzene are single isomers, but three different di-subsituted benzene are possible too.



Ortho xylene Meta xylene Para xylene Ethyl benzene

Methodology used : Characteristics of aromatic compounds are explained and with the help of diagram positional isomerism is made clear.

12.6 SOME OTHER ORGANIC COMPOUNDS

Main Teaching Points

1. Other compounds of hydrocarbons
2. Functional group
3. Formation of alcohols
4. Formation of carboxylic acids
5. Esters

12.6.1 Hydrocarbon as Parent Compound

Hydrocarbons also join with other elements to form other compounds. When hydrocarbons combine with oxygen, they form alcohols, organic acids and esters.

When they combine with chlorine, bromine etc., they form chloroethene and bromoethene etc.

12.6.2 Functional Groups

In large number of carbon compounds we find a) similarities within the members of a homologous series and b) difference in the properties among the homogenous series. Organic compounds (except hydrocarbons, where the properties are due to presence of single, double or triple carbon-carbon bonds) contain atoms or groups of atoms which give the compounds their characteristic properties. In other words, these atoms/group of atoms are responsible to make the compound function or show its properties, therefore, these atoms or groups of atoms are called the functional groups.

The following table clarifies the relationships :

Compounds	CH_3OH	CH_3COOH	CH_3COOCH_3
Functional group associated	– OH	– COOH	– COOR where $R = CH_3$, C_2H_5 etc.
Homologous series	Alcohols	Carboxylic Acids	Esters

Thus, a functional group is an atom or group of atoms bonded together in a unique fashion and having characteristic chemical properties.

12.6.3 Alcohols

Alcohols are compounds containing carbon, hydrogen and oxygen and are characterised by the presence of hydroxyl (OH) group. Here, one atom of hydrogen gets replaced by (OH) group.

Hydroxyl group, on attaching with methane, convert it to methanol. Similarly, ethane is converted to ethanol, when hydroxyl group attaches to it.

Alcohols also form a homologous series.

General Properties

1. Alcohols are mostly in liquid form.
2. They react with sodium to form hydrogen.
3. Alcohols are highly inflammable
4. Alcohols are non-conductors of electricity.

Main Alcohols

Methanol : Chemical formula CH_3OH

It is formed when wood is heated in the absence of air. It is poisonous if consumed; and is used for making perfumes, solvents and synthetic fibres.

Ethanol : Chemical formula C_2H_5 OH

It is prepared by fermentation of starch or sugar with enzymes releasing CO_2. The process is carried out at 20-30°C in a vessel which doesn't allow air but provides for the escape of CO_2. It is then distilled to get pure ethanol.

Synthetic ethanol is produced by reacting ethene with water in the presence of Phosphoric acid

$$C_2H_4+H_2O \xrightarrow{H_3PO_4} C_2H_5OH$$

Uses

1. Alcohols are used to sterilize wounds and syringes.
2. Used as antifreeze mixture in radiators of vehicles in cold countries.
3. Alcohols are capable of intoxication and so, are used as liquors.
4. They are used as fuels and solvents.

Chemical Properties

1. It forms carbon dioxide and water on reacting with oxygen.

   $$C_2H_5OH + 3O_2 \longrightarrow 2CO_2 + 3H_2O$$

2. It also forms ethanoic acid on reacting with oxygen.

   $$C_2H_5OH + O_2 \longrightarrow CH_3COOH + H_2O$$

12.6.4 Carboxylic Acids

When alcohols undergo process of oxidation, they form carboxylic acids, which are characterised by the presence of (COOH) group known as carboxylic group.

The acids are named after the respective alcohols replacing the last letter of 'ol' by 'OIC' acid.

Example

Methanol	HCOOH	Methanoic acid
	CH_3COOH	Ethanoic acid
	C_2H_5COOH	Propanoic acid

These are also known as organic acids, these are mostly in liquid form but when found in solid form are called fatty acids. They are used as mild acids in food products, cold drinks, drugs, soap and perfumes.

12.6.5 Esters

Esters are produced when organic acids react with alcohols in the presence of sulphuric acid. They are characterised by the presence of COO group and water as its by product.

$$CH_3COOH + C_2H_5OH — H_2SO_4 \longrightarrow CH_3COO\ C_2H_5 + H_2O$$

Esters have a pleasant smell and are used in ice creams, sweets, perfumes etc. They are responsible for the characteristic flavour of fruits.

In short, esters are alkyl derivatives of carboxylic acids. An ester is named on the basis of the corresponding acid by changing "oic"— to 'oate' and preceding this with the name of akyl group attached to oxygen atom.

Example

$HCOOC_2H_5$ ethyl methanoate

Methodology used : Concept of hydrocarbon as the parents of other compounds is discussed.

The concept of a functional group is a little difficult to communicate hence, the lesson was introduced through analogy.

Different groups of alcohol, carboxylic acid and esters are taken up separately.

Check Your Progress

Notes : a) Write your answers in the space given below.

b) Compare your answers with those given at the end of the unit.

8. What are functional groups? Explain.

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9. Describe the uses of alcohol.

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10. What are carboxylic acids?

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12.7 MAN MADE MATERIALS FROM CARBON COMPOUNDS

Carbon compounds play an important part in our daily lives. The clothes we wear, be they made from natural fibres or synthetic materials are organic or carbon compounds. Most of the drugs or pharmaceuticals are also carbon compounds. Fertilizers like urea, detergents, soaps, plasticware, all are made up of carbon compounds. Many commonly used polymers like wood, rubber, paper are again carbon compounds.

Main Teaching Points

1. Polymers – Fibres, plastics, rubber.
2. Soaps and detergents.
3. Cleansing action of soaps and detergents.

Teaching Learning Process

12.7.1 Polymers – Fibres, Plastics, Rubber

A polymer is a compound capable of undergoing the process of 'polymerisation' or reacting with itself without any actual change in its empirical formula. In simpler words, several molecules of same compounds combine together to form a complex molecule with same empirical formula but greater molecular weight. 'Poly' means many and 'mer' is repeating units.

Example

Cellulose is a naturally occurring polymer. The cell wall of plants is made up of cellulose, Cotton, jute are natural fibres made of cellulose in its purified form.

Synthetic polymer rayon is purified cellulose in the form of long fibres.

Nylon is formed due to polymerisation of small organic molecules not found naturally. The material thus made is moulded and spun into fibres. These are polymers containing amino group (NH – CO), Nylon was first manufactured in 1935 and commercially sold in 1939 as stockings for women.

Polyester : It was developed by reacting carbon compounds with 2 hydroxyl (–OH) group with a compound containing 2 carboxylic (– COO) group reacting in the formation of ester group and hence the name polyester. It is used in the manufacturing of textiles, water hoses etc.

Plastics :They are polymers which can be easily moulded into desired shapes and are produced by replacing one or more hydrogen atoms in ethene and then polymerising the basic unit called monomer. This, when heated, can be moulded into desired shape and on cooling it maintains the shape. This property is used in the manufacture of PVC pipes, stiyro foam etc.

Polymers which do not further change, their shape after obtaining it, or once they are set are called irreversible polymers or thermo setting polymer.

E.g. Backelite, Melamine, Formica tables tops etc.

Rubber : It is a natural polymer obtained as latex from rubber trees. It has long chain of 7 molecules in double bonds. It is a polymer of monomer isoprene. Products made out of it can be easily deformed which can regain their shape after stress is removed. It retains its shape after it is mixed with sulphur and warmed and then set into a particular shape.

Rubber is made synthetically also. Chemically, synthetic rubber is called thiokol which is made by reacting dichloro ethane with sodium polysulphide.

$$n.Cl-CH_2-CH_2-Cl+nNa-\overset{\overset{\displaystyle S}{\|}}{S}-\overset{\overset{\displaystyle S}{\|}}{S}-Na+nClCH_2-CH_2-Cl$$

$$[CH_2-CH_2-\overset{\overset{\displaystyle S}{\|}}{S}-\overset{\overset{\displaystyle S}{\|}}{S}-CH_2-CH_2]\,n+2n.NaCl$$

It is used in the manufacture of chemicals, solvents, storage tanks, hoses and solid fuel in rocket engines.

12.7.2 Soaps and Detergents

These are made from oil (fat) or esters of fatty acids.

Glycerol is an alcohol containing 3 hydroxyl groups and fatty acid contains chains of many carbon atoms.

Stearic acid is an example of fatty acid.

$$\begin{array}{lcl} C_{15}H_{31}COO-CH_2 & & CH_2OH \\ \quad\quad\quad\quad\quad | & & \;| \\ C_{15}H_{31}COO-CH + 3NaOH & \longrightarrow & CHOH + 3C_5H_{31}COONa \\ \quad\quad\quad\quad\quad | & & \;| \quad\quad \text{Sodium stearate} \\ C_{15}H_{31}COO-CH_2 & & CH_2OH \\ \text{Stearic acid} & & \text{Glycerol} \end{array}$$

When oil/fats are heated with sodium hydroxide, they break down into sodium salts of fatty acids and glycerol. This process is called saponification and it produces soap which is separated from the solution by adding common salt to it, the salt decreases the solubility of soap and it floats on the solution. The soap is skimmed off and mixed with desired colouring agent and perfume and cast into various shapes for use.

Molecule of soap is made up of two compounds. One is hydrocarbon and other is (– COO Na) group. Hydrocarbons are water repelling, dust and grease present on cloth attach themselves to hydrocarbon compound and (– COO Na) group which is attracted to water attach itself to water molecule. Thus, the dirt is pulled away from the surface thereby cleaning the clothes, and gets away in the wash water.

Synthetic detergents have similar structure, the only difference being that hydrocarbons are obtained from coal and other petro products. The water repelling agents are hydrocarbon molecules and water attracting part is constituted by sulphate of sulphonate group (SONa) / ($-SO_3Na$).

Synthetic detergents can be used with hard water and they do not form insoluble calcium or magnesium salt with hard water.

Sodium sulphate and sodium silicate are added to dry washing powder.

Sodium poly phosphate or sodium carbonate is added to keep its abrasive property which is helpful in removing dust. A mild bleaching agent such as sodium perborate is added to produce whiteness.

However, widespread use of synthetic detergents has caused environmental pollution e.g. detergent containing phosphate can cause rapid growth of algae thereby depleting water bodies of the life giving oxygen needed by fish and animals.

Methodology used : The presence of carbon compounds is an integral part of our daily life. This is made clear through various uses of carbon compounds. Role of polymers, soaps and detergents is discussed in detail.

Check Your Progress

Notes : a) Write your answers in the space given below.

b) Compare your answers with those given at the end of the unit.

11. What roles do man made carbon compounds play in our daily life?

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12.8 LET US SUM UP

Carbon and its compounds form a major part of the earth crust. Most of organic matter on decomposition release carbon compounds. Grains, pulses, leather goods, cotton and most of the man made articles are derivatives of carbon compounds.

Concept of allotropes is made clear i.e. elements which occur in more than one form with different physical properties but same chemical properties. Diamond and graphite are two allotropes of carbon.

Carbon compounds are found in abundance in nature due to its two qualities–catenation and isomerism.

Hydrocarbons–these are compounds formed out of carbon and hydrogen and alongwith C – C bond, they have C – H bond. Hydrocarbon has two forms - Saturated and Unsaturated. This has been made clear.

By virtue of similar characteristics, are hydrocarbons categorises into various homologous groups. Saturated hydrocarbon change into unsaturated hydrocarbon and vice-versa in the process of hydrogenation and dehydrogenation. It is made clear through alkanes-alkenes and alkynes.

Other type of organic compounds apart from hydrocarbons are discussed. They consist of functional groups which is further categorised into alcohols, carboxylic acids and esters.

We already know about different types of man made carbon compounds. Polymer, fibres, plastics and rubbers are part of day to day life. Soap, detergents, pharmaceuticals are integral part of human activities.

12.9 UNIT-END EXERCISES

1. What is allotropy? Name at least two allotropes of carbon.
2. Name the various allotropic forms of carbon? Which of these forms are crystalline?
3. Why is diamond the hardest element known?
4. What is the difference between diamond and graphite?
5. What are isomers? Elaborate.
6. Explain how ethane, ethene and ethyne belong to the same family.
7. What is relationship between the number of carbon and hydrogen atoms present in alkanes, alkenes and alkynes?
8. What is the difference between each successive member within a homologous series?
9. How is ethanol prepared in laboratory? Write its chemical properties.
10. Define saturated hydrocarbon. How does it differ from unsaturated hydrocarbons.

12.10 ANSWERS TO CHECK YOUR PROGRESS

1. On burning diamond and graphite, both produce carbon dioxide and leave no other residue. It shows that both, though different in appearance, have same chemical properties i.e. made up of carbon only. Elements which occur in more than one form in nature, physically they may be different but have same chemical properties are called **allotropes** and this phenomenon is called **allotrophy**. Thus, it is clear that diamond and graphite are allotropes of carbon.
2. Diamond is very hard while graphite is so soft that it leaves a mark on paper. This is so because diamond has a strong co-valent bond in tetrahedral arrangement while graphite has hexagonal layer structure and the layers held by weak forces, therefore giving it a slippery nature.

Diamond is a poor conductor of electricity while graphite is good conductor of electricity, reason being that in diamond all the four atoms are involved in forming C–C bond leaving no free electron to move, which in graphite, free electrons are available to move the electric current.

3. Most of the organic matter found in nature have traces of carbon in them. Carbon - carbon bond present in the compounds makes strong bonds which form long chain this phenomenon is known as caternation. Due to catenation, carbon compounds are found in abundance in nature. The phenomenon of isomerism is also responsible for the abundant occurrence of hydrocarbons in nature.

4. **Catenation:** The phenomenon of an atom bonding to itself is known as caternation e.g.:

   Isomerism: This is a phenomenon where chemical structure of a compounds can be arranged in more than one form, wherein chemical formula remain the same.

$$
\begin{array}{ccccccccc}
 & & H & & H & & H & & H & & \\
 & & | & & | & & | & & | & & \\
H & - & C & - & C & - & C & - & C & - & H \\
 & & | & & | & & | & & | & & \\
 & & H & & H & & H & & H & &
\end{array}
$$

5. Compounds which are made up of carbon and hydrogen only are called hydrocarbon compounds.
   Carbon atoms have the ability to combine with themselves to form long chains. When it combines with atoms of hydrogen it forms hydrocarbons.

   The most common example is CH_4.

$$
\begin{array}{ccccc}
 & & H & & \\
 & & \cdot\cdot & & \\
H & : & C & : & H \\
 & & \cdot\cdot & & \\
 & & H & &
\end{array}
$$

6. When carbon atom joins hydrogen atom in single contact bond its chemical structure is fully saturated. The compounds formed thus are also known by the term alkanes e.g. ethane C_2H_6 and methane CH_4.

   Whereas in the case of unsaturated hydrocarbons, atoms of hydrogen and carbon share more than one electron, leaving room for further chemical reaction. Alkene and alkyne are examples of unsaturated hydrocarbons.

7. Unsaturated hydrocarbon, after hydrogenation change into saturated. Saturated hydrocarbon after dehydrogenation, change into unstable unsaturated hydrocarbon. They also becomes the member of a series called homologous series.

   Alkane $\longrightarrow$ Alkenes $\longrightarrow$ Alkynes

   Alkynes $\longrightarrow$ Alkenes $\longrightarrow$ Alkanes

8. Hydrocarbon in their characterities differ due to the presence of single, double or triple carbon–carbon bonds. These groups of atoms are responsible to make the compounds function in a particular way or show its properties, therefore these atoms or group of atoms are called functional groups.

   Presence of – OH makes it alcohol in nature

   COOH is carboxylic group .

   COOR where $R = CH_3$, C_2H_6 etc. esters.

9. Alcohols are used for making perfumes, solvents and synthetic fibres. They are also used to sterilise wounds and syringes. Alcohol is used as anti freeze mixture in radiators of vehicles in cold countries.

10. When alcohols under go the process of oxidation, they form carboxylic acid which are characterised by the process of COOH group known as carboxylic group.

11. Carbon compounds most of which are altered to suit man's day to day requirement are soap, washing detergents, clothes whether cotton or synthetic are all made of carbon compounds. From growing of crops to the treatment of various diseases man is dependant on carbon compounds. Wood, rubber, paper are again carbon compounds Man-made carbon compounds is used as solid fuel in rocket engines. However, widespread use of synthetic detergents has caused environmental pollution yet man is helpless because he cannot do without them.

12.11 SUGGESTED READINGS

Teaching of Science, NCERT Publication.

Teaching of Chemistry, Newburry.

Teaching of Chemistry, Waddingtion.