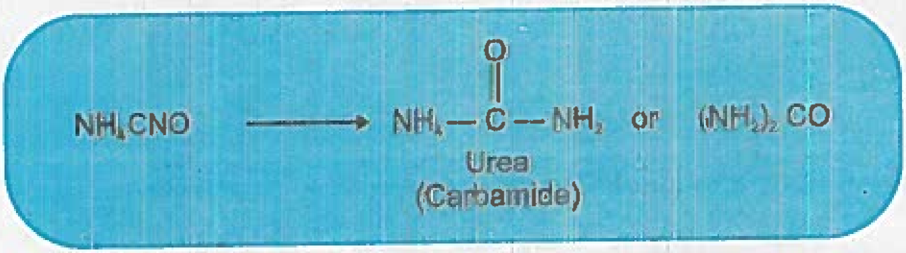
Introduction:

Organic chemistry is a branch of chemistry that deals with the scientific study of the structure, properties, composition, reactions and preparations of carbon based compounds i.e. hydrocarbons and their derivatives. An organic compound is any member of a large class of chemical compounds whose molecules contain carbon. Methane (CH_4) is one of the simplest organic compounds. These compounds may also contain any number of other elements, including hydrogen, nitrogen, oxygen, halogens, sulphur, phosphorous, silicon as well as metal atoms (organo-metallic compounds).

In past all the known compounds were classified according to their source from which they were obtained. Compounds obtained from living organisms (plants and animals), like sugar (plant source) and urea (animal source), were named as "organic" compounds as word "organic" means "life or living". On the other hand, the compounds obtained from mineral sources were named as "inorganic" compounds as the word "inorganic" means "lifeless" as they came from non-living source.

At that time it was believed that organic compounds can only be obtained from living organisms as they possess a super-natural force called vital force". This theory is called "vital force theory". According to this theory the vital force is possessed only by living organisms and such compounds cannot be obtained or synthesized in the laboratory from other compounds but can be made only by living organisms. Thus according to old concept, those compounds which were obtained from living organisms (plants and animals) were called organic compounds and the study of such compounds was named organic chemistry by Berzelius in 1807.

However, in 1828, a German chemist, Friedrick Wohler synthesized in the laboratory an organic compound, Urea, by heating an inorganic compound Ammonium cyanate.



Urea had long been considered to be an "Organic" compound being a constituent of urine, where it is formed from the breakdown of protein.

Wohler's experiments were followed by many other scientists, where increasingly complex organic substances were synthesized from inorganic ones without the involvement of any living organism and thus vital force theory was rejected.

When the composition of all the organic compounds was studied, they were found to contain carbon as a major element alongwith other elements like hydrogen, oxygen, nitrogen etc.

Thus organic compounds are the compounds containing carbon which are obtained from living things (plants and animals) as well as synthesized in the laboratory, while study of the chemistry of these carbon containing compounds is called organic chemistry.

Almost all the organic compounds contain carbon along with hydrogen. Such compounds are called hydrocarbons and the rest which also contain oxygen, nitrogen, halogens etc are considered to be their derivatives.

However, there is an exception to the above generalization. There are some compounds like carbon containing alloys (including steel), metal carbonates, bicarbonates, carbonyls, simple oxides of carbon (CO, CO_2), cyanides ($NaCN$), cyanates ($KOCN$, NH_4OCN), sulfides (CS_2) as well as the allotropes of carbon (diamond and graphite), which although contain carbon but are not organic compounds. They are inorganic in nature either by their source or properties or nature of bonding.

15.1 Sources:

Major sources of organic compounds are coal, natural gas and petroleum (fossil fuel).

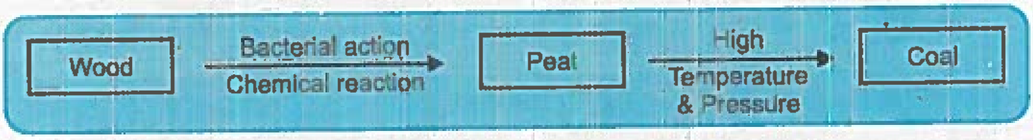
15.1.1 Fossil Remains:

Fossil fuels are formed by the anaerobic decomposition of buried plants and animals.

a. Coal:

Coal is an important solid fossil fuel of black or brownish–black colour normally occuring in rock strata in layers called coal beds.

Coal is mainly composed of carbon along with other elements like hydrogen, oxygen, sulphur and nitrogen. Coal is formed in nature from the decay of plant matter buried under the soil millions of years ago. Due to different bacterial and chemical reactions, it is first converted into a coal precursor called peat which under high pressure and temperature gets converted into coal.



Coal exists in different forms like lignite (low %age of carbon) sub–bituminous coal, bituminous coal and anthracite (highest rank coal due to presence of high percentage of carbon more than 91.5 %).

Coal is suitable fuel for power generation to minimize the use of petroleum and natural gas for heating homes. Coal is mainly used as a fuel to produce electricity and heat through combustion. It is the largest source of energy for the generation of electricity world wide. Coal is a major source of a large number of organic compounds, especially aromatic compounds.

2. Petroleum:

The word petroleum is derived from latin words: "petra" means "rock" and "oleum" means "oil". Thus the word petroleum means "rock oil" as it is present in underground porous rocks. It is also sometimes called "mineral oil" or "crude oil" or "liquid gold" Petroleum exists as a viscous liquid having dark brown colour with a strong unpleasant smell.

Composition: Petroleum is a mixture of hydrocarbons. The hydrocarbons in petroleum are mostly alkanes, cycloalkanes and aromatic hydrocarbons, while some other organic compounds in trace amounts are found which contain nitrogen, oxygen, sulphur as well as trace amounts of metals such as nickel, copper and vanadium.

3. Natural Gas:

Natural gas is a gaseous form of fossil fuel which is a mixture of low boiling hydrocarbons, methane, ethane, propane and butane.

Natural gas, a source of organic compounds, is also formed by the dead decay of animal matter and is usually found above the underground deposits of petroleum.

In strict sense, petroleum includes only crude oil but in common usage, it includes both crude oil and natural gas. Under normal pressure and temperature the lighter hydrocarbons methane, ethane, propane and butane occur as gases while the heavier ones from butane onwards are in the form of liquids. Usually natural gas and petroleum deposits, are found in association with each other.

15.1.2 Plants and Natural Products Chemistry:

Plants and animals are the major sources of organic compounds. Those compounds which are produced by plants and animals are called natural compounds or natural products and the study of the chemistry of such compounds is called natural product chemistry. Plants have always been a rich source of a large number of organic compounds. Natural products may be extracted from tissues of plants. These compounds may be of medicinal importance and can be used in pharmaceutical drug discovery and drug design. Even today a large number of organic compounds are isolated from plants. Still the number of plants that have been extensively studied is very few and the vast majority has not been studied at all. Clinically, useful drugs which have been recently isolated from plants include the anticancer agent palliate (Taxol) from the yew tree, and the anti malarial agent artemisinin from Artemisia annual.

15.1.3 Partial and Total Synthesis:

According to modern concept, organic compounds can be isolated from living organisms as well as synthesized in the laboratory. The study of processes or chemical reactions by which organic compounds can be synthesized in the laboratory from a living or non living source is called synthetic organic chemistry and the compounds are called synthetic organic compounds or simply synthetic compounds.

Organic compounds can be synthesized either through partial synthesis, or through total synthesis. Mostly, organic reactions occur in many steps. Sometimes, an intermediate product of a reaction is used to synthesize a targeted product. This process is known as partial synthesis. Sometimes the starting material converts through many steps into targeted product. Such process is known as total synthesis. In other words, total synthesis is the process of finding new synthesis routes for a given compound. The first demonstration of total synthesis was Friedrich Wholer's synthesis of urea in 1828 and this process was commercialized for the first time by Gustaf Kompa from the synthesis of camphor (an organic compound) in 1903.

Partial and total synthesis are used to synthesize a large number of organic compounds.

15.1.4 Products of Biotechnology:

Biotechnology is a field of applied biology that involves the use of living organisms and bioprocesses in engineering, technology, medicine and other fields requiring bio-products. Most of products of biotechnology are organic compounds. One application of biotechnology is the direct use of organisms for the manufacturing of organic products. For example beer and milk products.

Chemicals which have been made using biotechnology include benzylpenicilin (an antibiotic), ethanol, ethylene glycol, insulin (a hormone), polyhydroxybutyrate (a biodegradable thermoplastic), rennin (an enzyme) and Chemosensory protein (CSP) etc.

15.2 Coal as a Source of Organic Compounds:

Coal is a rich source of organic compounds. It can be converted into many organic compounds by the following ways.

15.2.1 Destructive Distillation of Coal:

When coal is heated in the absence of air, it does not burn but produces many by-products. This process of heating coal in the absence of air is called destructive distillation of coal. The main products obtained by the destructive distillation of coal are:

i. Coke
ii. Coal Tar
iii. Ammoniacal Liquor
iv. Coal gas

I. Coke:

Coke is a fuel which is used in homes and factories but it is mainly used in industries as reducing agent for the extraction of metals from their ores.

II. Coal Tar

One of the products of coal is Coal tar, which is a mixture of organic compounds. These can be separated by fractional distillation. The compounds, so obtained can be used for making soap, fats, dyes, plastics, perfume, drugs, pesticides, explosives. On fractional distillation, coal tar gives important organic compounds like benzene, toluene, xylene, phenol, cresol, naphthalene, anthracene etc.

III. Ammoniacal liquor:

The other by product is ammonia solution called ammoniacal liquor which is used for making fertilizers like ammonium sulphate, ammonium super phosphate etc.

iv. Coal gas:

The coal gas, also called town gas, is a mixture of hydrogen, carbon monoxide, which is combustible, making the coal gas an excellent fuel.

15.2.2 Conversion of Coal to Petroleum:

Coal gas, obtained from the distructive distillation of coal can be converted into petroleum by a process known as Fischer–Tropsch (FT) process. The Fischer–Tropsch synthesis or process is a set of chemical reactions that convert a mixture of carbon monoxide and hydrogen into liquid hydrocarbons mainly alkanes.

$$(2n+1)H_2 + nCO \longrightarrow C_nH_{2n+2} + nH_2O$$

The conversion of CO to alkanes in presence of hydrogen involves hydrogenolysis of $C-O$ bond and the formation of $C-C$ bond. This process takes place in presence of transition metal catalysts (cobalt, iron, ruthenium and nickel) at a temperature range $150-300^\circ C$.

Fischer –Tropsch (FT) plants associated with coal (source of carbon) convert it into gaseous reactants i.e CO and H_2. This conversion is called gasification. Coal based FT plants can produce a petroleum substitute that is used as synthetic fuel and as synthetic lubricating oil.

15.3 Characteristics of Organic Compounds:

The Following are some of the important characteristic features of organic compounds.

1. *Unique Properties of Carbon:*

Carbon has the property of self linkage. It can link with hundreds and thousands of other carbon atoms to form long C–C chains or rings. This self–linkage of carbon atoms to form chains and ring compounds is called catenation. Carbon can also form stable single and multiple bonds with each other and other atoms like hydrogen, oxygen, nitrogen, halogens, sulphur etc.

2. *Isomerism:*

When two or more organic compounds have the same molecular formula but different structures, these are called isomers and this phenomenon is called isomerism.

3. *Non –Ionic Character:*

Majority of organic compounds mainly involve covalent bond between C—C and C—H, therefore, they are generally non–polar and have non–ionic characters.

4. *Solubility:*

Solubility depends upon the forces of attraction between the solute and solvent molecules. When these forces are stronger than the intermolecular forces of solute-solute and solvent-solvent, then solute dissolves easily. But the organic compounds are formed by covalent bonds i.e. non-ionic and almost non-polar, so most of the organic compounds are insoluble in water, while some are partially soluble but they are readily soluble in non–polar solvents like ether, benzene carbon tetrachloride etc.

5. *Rates of Organic Reactions:*

Bonds between atoms in organic molecules are formed by mutual sharing of electrons and reaction needs the breakage of these bonds. The organic reactions are slow because these involve breaking of certain bonds and formation of new bonds.

6. *Similar Structural features and behaviour:*

Mostly organic compounds have similar structural features and similar physical and chemical properties. Therefore they show similar beahaviour to various reactants. This similarity in behaviour has reduced the study of millions of organic compounds to a few homologous series.

15.4 Uses of Organic Compounds:

Life is a practical version of chemistry, especially organic chemistry. No field of science is so closely related to our daily life as is organic chemistry. The importance of organic compounds and products can hardly be overemphasized. Most of the things that we come across in our daily life are organic substances like, the food we eat (carbohydrates, proteins, vitamins, fats etc) and the clothes we wear (cotton, silk, nylon) are organic compounds. We have become dependent upon organic compounds for our food, medicines and clothing.

Similarly, the chemists have learnt to synthesize paper, rubber, ink, plastics, leather, fibres, fertilizers, shoe polishes, pesticides, cosmetics, paints, dyes, preservatives, detergents and medicines etc, that we use in our daily life. In fact, our own body is made of thousands of complex organic molecules like proteins, nucleic acids, enzymes, fats, lipids etc. that are called life molecules.

Almost all the chemical reactions that takes place in living systems, including our own body, are organic in nature.

The fuels like petroleum products, petrol, diesel oil, compressed natural gas (CNG), coal as well as natural gas (suigas) etc, are also mixtures of organic compounds that run our cars and industries.

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Just about every substance you pull out of plants or animals is made of mostly carbon atoms except water. The chemist uses plant and animal compounds to make new compounds not found in nature. Many farmers in USA grow Maize for enthanol rather than food. There are over hundred chemical substances, that have been derived from plants for use as medicines e.g. Quinine (Antimalaria) Asprine (Cardiac diseases, pain killer); Borneol (Anitinflametery), Benzyl benzoate (scabicide) and Galantamine hydrobromide (Alzheimer's disease)

15.5 New Allotrope of Carbon: Bucky Ball

Bucky ball is a member of a class of structures called carbon fullerenes. Fullerenes are molecules composed entirely of carbon in the form of a hollow sphere, ellipsoid or tube. Spherical fullerenes are known as bucky balls. Fullerenes are solid allotrope of the element carbon. The discovery of fullerenes significantly expanded the number of known allotropes of carbon, which were until recently limited to graphite, diamond and amorphous carbon like soot & coal. Bucky balls and other fullerenes are similar in structure to graphite, which consists of hexagonal rings made of carbon, but also pentagonal (or sometimes heptagonal rings). The first fullerene was discovered in **1985** by Herold Kroto, James Heath, Sean O'Brion , Robert Curl and Richard Smalley for which they were awarded Nobel prize in 1996. It was named Buckminster fullerene (or Bucky ball) that contained 60 carbons (C_{60}). The name is a tribute to Richard Buckminster Fuller, a known architecture, who popularized geodesic domes and the shape of C_{60} bucky ball is similar to that sort of dome.

In Bucky balls, the smallest member is C_{20} which is made of 20 carbon atoms while the most common one is C_{60}.

The existence of fullerenes is very rare in nature. Negligible amounts of C_{60}, C_{70}, C_{76}, C_{84} are found in nature. In 2010, fullerenes were also discovered in outer space.

15.6 Functional Groups and Homologous Series:

There are millions of organic compounds known so far and thousands are discovered and synthesized every year. As mentioned this diversity and such a large number of organic compounds is due to some peculiar behaviour of carbon. It is difficult to study the chemistry of each individual compound. Therefore, the organic compounds are classified into different groups, in order to make their study easy. One such classification is on the basis of structure of organic molecules and the other on the basis of functional groups.

a. *Classification on the basis of Structure: (old classification)*

This classification of organic compounds is based on the arrangement of carbon atoms in molecules. According to this classification organic compounds are broadly divided into the following groups.

i. Open Chain or Acyclic organic Compounds:

In these compounds carbon atoms are linked to each other in open chains, which may be a straight chain or a branched chain.

$CH_3-CH_2-CH_2-CH_3$

Butane (a straight chain compound)

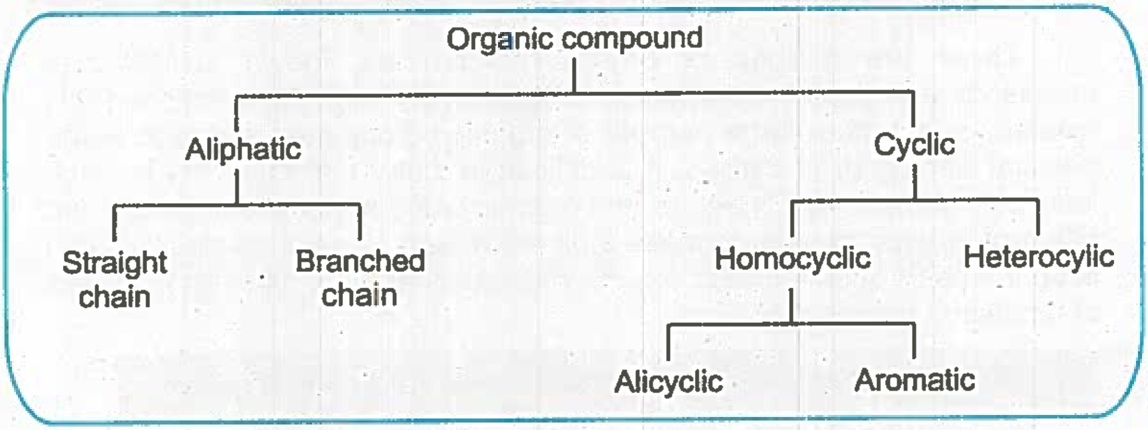
$$\begin{array}{c} CH_3-CH-CH_3 \\ | \\ CH_3 \end{array}$$

iso-butane (a branched compound)

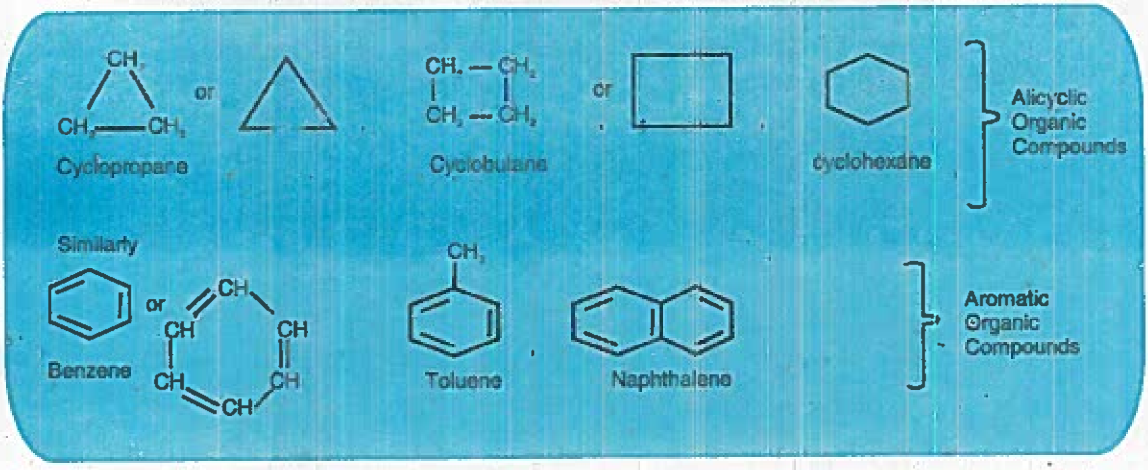
ii. Closed chain or cyclic organic Compounds:

In closed chain compounds carbon atoms are arranged in closed chain forms. They may be homocyclic or heterocyclic organic compounds.

Homocyclic, which are also known as carbocyclic organic compounds, are those in which cycle or ring is made only of carbon atoms. They are further divided into alicyclic having properties similar to open chain compounds and aromatic in which benzene ring is present.



On the other hand, heterocyclic organic compounds are those cyclic compounds in which the ring contains at least one atom other than carbon.



Pyridine Thiopene Furan Pyrole } Heterocyclic organic compounds

b. Classification on the basis of Functional group:

An atom or a group of atoms that gives certain characteristic properties to an organic compound is called a functional group.

It is called a functional group because it is the chemically active or functional part of a molecule. Each functional group represents a different class of organic compounds.

Organic compounds are divided into:

i. Hydrocarbons ii. Derivatives of hydrocarbons.

i. Hydrocarbons:

Hydrocarbons are those organic compounds which are made up of carbon and hydrogen only. They may be aliphatic or open chain hydrocarbons and cyclic or closed chain hydrocarbons.

In open chain hydrocarbons, carbon and hydrogen atoms are arranged in open chain forms. They are further subdivided into alkanes (saturated hydrocarbons) in which all the four valencies of carbon are fully satisfied through single bonds. Unsaturated hydrocarbons are those in which at least one double bond $(=)$ or a triple bond $(\equiv)$ is present between adjacent carbon atoms. The former is called alkene and the later is called alkyne.

The cyclic or closed chain hydrocarbons are either alicyclic or aromatic hydrocarbons.

ii.

The derivatives of hydrocarbons are organic compounds obtained by replacing alteast one hydrogen from hydrocarbons especially saturated hydrocarbons and aromatic hydrocarbons. i.e benzene ring. They are alkyl halides, alcohols and phenol, ethers, ketones, aldehyde, carboxylic acids and their derivatives.

Different classes of organic compounds, their functional groups and general formulae are summarized in the following table alongwith examples.

Table: 15.1 Classification of organic compounds based on Functional groups.

Class of Compounds	Functional group	Name of Functional group	General Formula	Example
Alkane	$-\overset{\vert}{\underset{\vert}{C}}-\overset{\vert}{\underset{\vert}{C}}-$	Single bond	C_nH_{2n+2} n = 1, 2, 3 ..... shows member of carbon atoms	CH_4, CH_3-CH_3 Methane Ethane or C_2H_6
Alkene	$>C=C<$	Double bond	C_nH_{2n}	C_2H_4 or $CH_2=CH_2$ Ethene
Alkyne	$-C\equiv C-$	Triple bond	C_nH_{2n-2}	$HC\equiv CH$ or C_2H_2 (ethyne)
Alkyl halide	$-X$ (F, Cℓ, Br, I)	Halo (Flouro, Chloro, Bromo)	$R-X$ or $C_nH_{2n+1}X$	$CH_3-C\ell$ Methyl chloride C_2H_5-I Ethyl Iodide
Alcohol or alkanol	$-OH$	Hydroxyl	$R-OH$ or $C_nH_{2n+1}OH$	CH_3-OH Methylalcohol (Methanol)

Amine	$-NH_2$	Amino	$R-NH_2$ or $C_nH_{2n+1}NH_2$	CH_3-NH_2 Methylamine
Ether	$-O-$	Oxygen	$R-O-R$ or $(C_nH_{2n+1})_2O$	CH_3-O-CH_3 Dimethylether
Ketone	$-\overset{\overset{O}{\parallel}}{C}-$	Carbonyl (Keto group)	$(C_nH_{2n+1})_2CO$	$CH_3-\overset{\overset{O}{\parallel}}{C}-CH_3$ Dimethyl ketone (acetone)
Aldehyde	$-\overset{\overset{O}{\parallel}}{C}-H$ or $-CHO$	Formyl	$R-\overset{\overset{O}{\parallel}}{C}-H$ or $C_nH_{2n+1}CHO$	$CH_3-\overset{\overset{O}{\parallel}}{C}-H$ (acetaldehyde)
Carboxylic acid	$-\overset{\overset{O}{\parallel}}{C}-OH$ or $-COOH$	Carboxyl	$R-\overset{\overset{O}{\parallel}}{C}-OH$ or $C_nH_{2n+1}COOH$	$CH_3-\overset{\overset{O}{\parallel}}{C}-OH$ (acetic acid)
Acid halide	$-\overset{\overset{O}{\parallel}}{C}-X$ or $-COX$	Acyl	$R-\overset{\overset{O}{\parallel}}{C}-X$ or $C_nH_{2n+1}COX$	$CH_3-\overset{\overset{O}{\parallel}}{C}-C\ell$ (acetyl chloride)
Acid amide	$-\overset{\overset{O}{\parallel}}{C}-NH_2$ or $-CONH_2$	Amide	$R-\overset{\overset{O}{\parallel}}{C}-NH_2$ or $(C_nH_{2n+1}CONH_2)$	$CH_3-\overset{\overset{O}{\parallel}}{C}-NH_2$ (Acetamide)

Ester	$-\overset{O}{\overset{\Vert}{C}}-OR'$ or $-COOR$	Ester	$R-\overset{O}{\overset{\Vert}{C}}-O-R$ or ($C_nH_{2n+1}COOC_nH_{2n+1}$)	$CH_3-\overset{O}{\overset{\Vert}{C}}-OCH_3$ (Methyl acetate)
Alkyl cyanide or Nitrile	$-C\equiv N$	Cyano	$R-CN$ or $C_nH_{2n+1}CN$	CH_3CN Methyl cyanide

Homologous Series:

A series of organic compounds in which all members possess similar structural features and similar chemical characteristics, but each member is different from the next member by a methylene $(-CH_2-)$ group is called homologous series. All the members that differ from each other by metheylene are called homologues. Each class of organic compounds has its own homologous series which can be represented by a general formula. For example, alkanes (saturated hydrocarbons) form a series of compounds. It can be represented by a general formula C_nH_{2n+2} where 'n' shows the number of carbon atoms in the corresponding alkane.

Table 15.2 Alkane Homologoues Series

No. of C atoms	Molecular formula (C_nH_{2n+2})	Name with suffix (-ane)	Structural formula
1	CH_4	Methane	CH_4
2	C_2H_6	Ethane	CH_3CH_3

3	C_3H_8	Propane	$CH_3CH_2CH_3$
4	C_4H_{10}	Butane	$CH_3CH_2CH_2CH_3$
5	C_5H_{12}	Pentane	$CH_3CH_2CH_2CH_2CH_3$
6	C_6H_{14}	Hexane	$CH_3CH_2CH_2CH_2CH_2CH_3$
7	C_7H_{16}	Heptane	$CH_3CH_2CH_2CH_2CH_2CH_2CH_3$
8	C_8H_{18}	Octane	$CH_3CH_2CH_2CH_2CH_2CH_2CH_2CH_3$
9	C_9H_{20}	Nonane	$CH_3CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_3$
10	$C_{10}H_{22}$	Decane	$CH_3CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_3$

As it is clear from alkane homologous series that each member is different from the adjacent member by CH_2. Similarly this series can be expanded beyond C_{10} to higher alkanes. Similar homologous series can be developed for alkenes, alkynes, alcohols, ethers, amines, carboxylic acids, carbonyl compounds etc.

Characteristics of homologous Series:

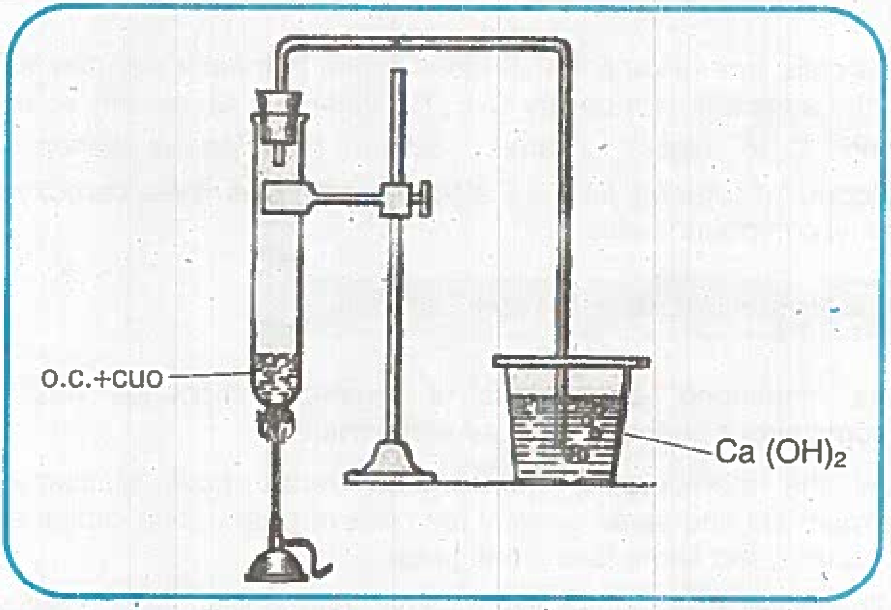
- As mentioned, each class of organic compounds has its own homologous series having general formula.
- All the members of homologous series have similar chemical properties and same general methods of preparation similar structural features and same functional group.
- The physical properties like melting point, boiling points, densities etc increases down the series due to increase in their molecular masses.

15.7 Detection of elements in Organic Compounds:

The main elements present in organic compounds are carbon and hydrogen as well as oxygen, nitrogen, sulphur and halogens. Following methods can be used to detect these elements, in the organic compound.

Detection of Carbon:

As carbon is always present in all the organic compounds, there is no need to test for it. The test is performed only to establish whether a given compound is organic or not. The organic substance is mixed with dry copper oxide in 1:3 ratio and heated in a test tube fitted with a delivery tube. The other end of which is dipped into lime water, Ca $(OH)_2$. Carbon converts to carbon dioxide which reacts with lime water and turn it milky due to formation of calium carbonate.



Detection of Hydrogen:

If hydrogen is present in the compound, it oxidizes to water vapours which condenses in small droplets on the cooler end of the test tube. The water formation is further confirmed by passing the issuing gases (water vapours) from anhydrous copper sulphate (white) that is turned blue as copper sulphate converts to hydrated form ($CuSO_4 5H_2O$).

Detection of Nitrogen, Sulphur and Halogens: (12)

Nitrogen, sulphur and halogens can be detected in organic compounds by extract sodium test or lassaign's test. For this, sodium extract or lassaign's solution is prepared first. The substance is heated strongly with sodium metal in a fusion tube till the tube becomes red hot which is dipped in water in a china dish and filtered after boiling the contents of china dish. The filtrate is called lassaign's solution or sodium extract.

Detection of Nitrogen: (13)

Take a part of lassaign's solution in a test tube and add to it few drops of sodium hydroxide and then few millilitres of freshly prepared ferrous sulphate ($FeSO_4$) solution and boil it. After cooling, add few drops of ferric chloride ($FeCl_3$) solution and excess of concentrated acid (HCl or H_2SO_4). The formation of Prussian blue or green colouration confirms the presence of nitrogen.

Detection of Sulphur: (14)

To another portion of sodium extract add some acetic acid first and then lead acetate solution. Black precipitate of lead sulphide will be formed which confirms the presence of sulphur.

Detection of Halogens: (15)

Boil a portion of sodium extract with concentrated nitric acid and then add to it silver nitrate solution. The formation of white precipitate soluble in ammonium hydroxide solution indicates chlorine, pale yellow precipitate slightly soluble in NH_4OH indicates bromine and deep yellow precipitate insoluble in ammonia solution shows the presence of iodine in the organic compound.

Detection of Oxygen:

Oxygen can not be detected by any direct method but for its detection following indirect methods can be employed.

i. The substance is heated alone in a dry test tube usually in nitrogen atmosphere. Formation of water droplets on the cooler part of the test tube obviously show the presence of oxygen.

ii. Different tests are applied for oxygen containing functional groups like alcohol, (OH) carbonyl compounds like

$\underset{}{-\overset{\overset{O}{\|}}{C}-}$ (Ketone), $-\overset{\overset{O}{\|}}{C}-H$ (aldehyde) and carboxylic acids

(COOH). If any one is detected, the presence of oxygen is confirmed.

iii. The most important test for presence of oxygen is combustion analysis in which the percentages of C and H are determined. If their sum is less than 100 then the remaining percentage is that of oxygen.

KEY POINTS

Key Points:

- Generally all the compounds were classified on the basis of their origin. The compounds that were having living source (plants and animals) were called organic and those coming from non living sources (minerals) were called inorganic.
- According to vital force theory, organic compounds can only be obtained from organism and could not be synthesized in the laboratory from inorganic sources.
- The study of the chemistry of the carbon containing compounds (organic compounds) is called organic chemistry.
- The Major sources of organic compounds are plants and animals as well as fossil fuels.
- The abundance of organic compounds is due to unique behaviour of carbon as well as due to some special characteristics of these compounds themselves.
- Organic chemistry have applications in almost all fields and the importance of organic compounds can hardly be over emphasized.
- The discovery of fullerenes (bucky balls) have significantly expanded the number of known allotropes of carbon.
- Functional group is the active part of organic compounds which greatly effect the chemistry of organic compounds.
- Organic compounds can be classified on the basis of structure as well as on the basis of functional group.
- Each class of organic compounds have their own homologous series that can be represented by a general formula.

Exercise

Q.1 Multiple Choice questions. Choose the correct answer from the given choices in each case.

i. The first organic compound prepared in the laboratory was.

a. Peat b. Urea c. Sugar d. Alcohol

ii. All the substances are organic except.

a. Graphite b. Urea c. Methane d. Acetic acid

iii. The final stage of conversion of decaying plants into coal is

a. Anthracite b. Lignite c. Peat d. Bituminous

iv. Petroleum is mainly a mixture of

a. Heterocyclic compounds b. Aromatic Hydrocarbons

c. Saturated hydrocarbons d. Unsaturated hydrocarbons

v. The major component of natural gas is

a. Butane b. Ethane c. Propane d. Methane

vi. All of the following fractions are obtained by destructive distillation of coal except.

a. Coal tar b. Refinery Gas c. Coal gas d. Coke

vii. Coal can be converted to petroleum by

a. Haber process b. destructive distillation

c. Fischer –Tropsch process d. Fractional distillation

viii. Pyridine belongs to which class of organic compounds.

a. Heterocyclic b. Hydrocarbon c. Alicyclic d. Homocyclic

ix. Which of the following represents the functional group of amides.

a. $-COOR$ b. $-NH_2$ c. $-C\equiv N$ d. $-CONH_2$

x. Which of the following elements can not be detected in a given organic compound directly.

a. Chlorine b. Phosphorous c. Nitrogen d. Oxygen

Q. 2 Briefly answer the following questions.

i. What is meant by organic compounds and organic chemistry?

ii. Why dil.HNO_3 is added to the sodium extract before detection of halogens in organic compound.

iii. Explain the significance of Wohler's work in the development of organic chemistry.

iv. Although bucky ball is an allotropic form of carbon, but it is included in organic chemistry.

v. What are those compounds which although contain carbon but are not considered organic?

vi. Differentiate between partial and total synthesis?

vii. How coal can be converted into petroleum?

viii. Discuss the reasons for the presence of large number of organic compounds?

ix. Differentiate between acyclic and cyclic organic compounds.

Q.3 What are fossil fuels? Discuss different types of fossil fuels.

Q.4 Elaborate the detection of various elements in organic compound.

Q.5 What are the different fraction obtained by the destructive distillation of coal. Give their importance.

Q.6 Explain some of the important characteristics of organic compounds.

Q.7 Define functional group. How organic compounds are classified on the basis of functional group.

Q.8 Give old classification of organic compounds based on arrangement of carbon atoms in the molecule.