CARBON AND ITS COMPOUNDS

Concepts Covered

- Basic Concept of Carbon and its Compounds
- Concept of The Existence of Carbon, Its Allotropes and Hydrocarbons
- Concept of Physical and Chemical Properties of Compounds
- Structure and Nomenclature of Organic Compounds

Introduction

Nowadays materials like food, cosmetics, furniture, clothes, medicines, books and many other things contain the versatile element carbon. In addition, all living structures (human beings, animals, birds, insects, plant kingdom etc) are made up of carbon compounds (Such as fats, carbohydrates, proteins, vitamins, hormones, etc.)

The amount of carbon present in the earth's crust in the atmosphere is low. The earth's crust has 0.02% carbon form of salt, like carbonates, bicarbonates metallic cyanides, coal, petroleum, graphite etc. Earth's atmosphere has 0.03% of carbon dioxide.

Carbon is the fourth most abundant element in the universe by mass. It is also the second most abundant element in the human body after oxygen. Carbon was discovered in prehistory and it was known to the ancients. They used to manufacture charcoal by burning organic material. Carbon is a non-metal. It belongs to the fourteenth group or IV A group in the modern periodical table.

Bonding in Carbon Compound

We know that the reactivity of elements is explained as their tendency to attain a full filled outer shell, that is, attain noble gas configuration. Elements forming ionic compounds achieve this by either gaining or losing electrons from the outermost shell. In the case of carbon, it has four electrons in its outermost shell and needs to gain or lose four electrons to attain noble gas configuration.

If it gains four electrons forming C^{4-} anion. It would be difficult for the nucleus with six protons to hold on to ten electrons, means the attraction force of 6 electrons is not sufficient to hold 8 electrons in valence shell. If it loses four electrons forming C^{4+} cation. It would require a large amount of energy to remove four electrons from its valence shell that is not easily available in chemical reaction.

Carbon overcomes this problem by sharing its valence electrons with other atoms of carbon or with atoms of other elements. Not just carbon, but many other elements form molecules by sharing electrons in this manner. The shared electrons 'belong' to the outer shells of both the atoms and lead to both atoms attaining the noble gas configuration.

Covalent Bond

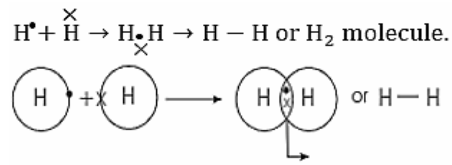
Bond formed by sharing of electrons is called covalent bond. Two of more atoms share electrons to make their configuration stable. In this type of bond, all the atoms have similar rights over shared electrons. Compounds which are formed because of covalent bond are called Covalent Compounds.

Single Covalent Bond

When one electron is shared from both atoms a single covalent bond is formed. This bond is indicated by a single line (-) between two bonding atoms. Formation of Hydrogen molecule. The atomic number (Z) of H is one. Electronic configuration 1H = K(1).

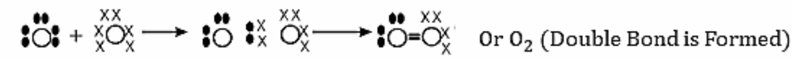
Double Covalent Bond

When two electrons from each atom are shared between two atoms a double covalent bond is formed. This bond is indicated by a double line (=) between two bonding atoms.



Formation of Oxygen Molecule

Atomic no. of $O(Z) = 8$ Electronic configuration of $O = K(2)$ L(6)



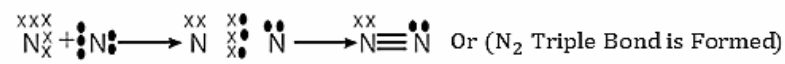
Other examples are CO_2, C_2H_4 etc.

Triple Covalent Bond

When three electrons from each atom are shared between two atoms a triple bond is formed some examples of triple covalent bond are C_2H_2 (acetylene), Hydrocyanic acid.

Formation of Nitrogen Molecule

At. no. of N(Z)= 7 Electronic configuration of N = K(2) L(5)



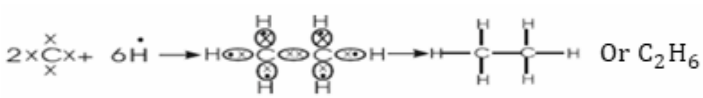
Some more examples of molecules having single, double and triple covalent bonds.

Examples:

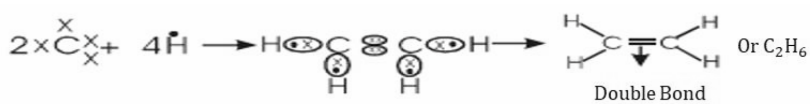
Formation of Ethane (C_2H_6):

At. no. of $C(Z) = 6$, Electronic configuration of $C = K(2)L(4)$

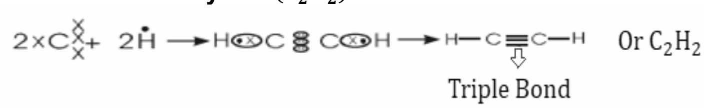
At. no. of $H(Z) = 1$, Electronic configuration of $H = K$ (1)



Formation of Acetylene (C_2H_4):



Formation of Acetylene (C_2H_2):



Properties of Covalent Bond

- The intermolecular force is smaller.
- Covalent bonds are weaker than ionic bonds. As a result, covalent compounds have low melting and boiling points.
- Covalent compounds are poor conductors of electricity as no charged particles are formed in covalent bonds.

Since carbon compounds are formed by the formation of covalent bond, so carbon compounds generally have low melting and boiling points and are poor conductors of electricity.

Allotropy

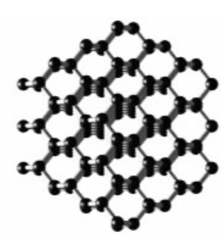
Allotropy is defined as the property by which an element can exist in more than one form that are physically different but chemically similar.

Allotropes of Carbon

- Carbon exists in three allotropic forms.
- They are Crystalline form (diamond and graphite), Amorphous form (coke, charcoal) and Fullerene.

Diamond

In diamond, each carbon atom is bonded to four other carbon atoms forming a rigid three-dimensional structure, accounting for its hardness and rigidity.



Structure of Diamond

Diamond

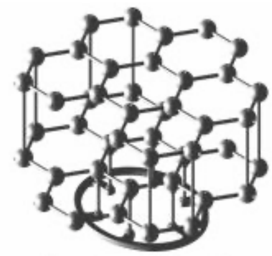
The General Properties of Diamonds are:

- It is a colourless transparent substance with extraordinary brilliance due to its high refractive index.
- It is quite heavy.

- It is extremely hard (a hardest natural substance known).
- It does not conduct electricity (because of the absence of free electrons).
- It has high thermal conductivity and high melting point.
- It burns on strong heating to form carbon dioxide.

Graphite

In graphite, each carbon atom is bonded to three other carbon atoms in the same plane giving hexagonal layers held together by weak vander Waals forces accounting for softness.



Structure of Graphite

Graphite

DID you KNOW

The word “graphite” stems from “graphein”, meaning “to write/draw” in ancient Greek.

General Properties of Graphite are:

- It is a greyish black opaque substance.
- It is lighter than diamond, feels soft and slippery to touch.
- It is a good conductor of electricity (due to the presence of free electrons) but bad conductor of heat.
- It burns on strong heating to form carbon dioxide.

Fullerenes

Fullerenes form another type of carbon allotrope. The first one was identified to contain 60 carbon atoms in the shape of a football. (C-60). Since this looks like the geodesic dome designed by the US architect Buck Minster Fuller, it is named as Buck Minster Fullerene.

Structure of Fullerenes

A soccer ball is a model of the C_{60} fullerene

DID you KNOW

Carbon nanotubes were first discovered and synthesized in 1991. After their discovery, minute quantities of fullerenes were found to be produced in sooty flames, and by lightning discharges in the atmosphere.

General Properties of Fullerenes are:

- These are dark solids at room temperature.
- These are neither too hard nor too soft.
- These are the purest allotropic forms of carbon because of the absence of free valencies or surface bonds.
- On burning, these produce only carbon dioxide gas.

DID you KNOW

The three forms of carbon found in nature are amorphous, graphite, and diamond. While each form has different properties, graphite is one of the softest. In contrast, the hardest known material is diamond which also came from carbon. Meanwhile, amorphous carbon is free, reactive carbon that does not have any crystalline structure.

Versatile Nature of Carbon

The number of carbon compounds which are known today is approximately three million. This number for exceeds the total number of compounds formed by all other elements.
The five main reasons for this are as discussed below:

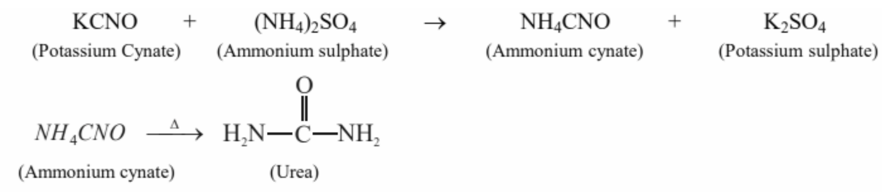
1. Catenation: The property of self-linking of carbon atoms through covalent bonds form long straight and branched chains and rings of different sizes is called catenation. The property of catenation is probably due to:
   (a) Small size
   (b) Great strength of carbon-carbon bonds.
2. Tetra Covalency of Carbon: Carbon has valency four. It is capable of bonding four other atoms of carbon or some other elements.
3. Tendency to Combine other hetero atoms: (like N, O, S, P, F, Cl, Br, I):- Due to the small size of carbon atom it can form very strong bonds with many elements such as O, N, S, F, Cl, Br, I, P etc.
4. Tendency to form multiple bonds: Due to its small size carbon also forms multiple (double, triple bonds, with other carbon atoms, oxygen, nitrogen etc.

5. Isomerism: Covalently bonded carbon compounds show isomerism. If a given molecular formula represents two are more structures having different properties is called isomerism and compounds are called isomers.
6. Compounds like urea, sugar, oils, fats, dyes, proteins, vitamins, hormones etc, which were isolated directly or indirectly from living organisms such as animals and plants are called organic compounds and the branch of chemistry which deals with the study of these compounds called organic chemistry.
7. Compounds like common salt (NaCl) blue vitriol ($CuSO_4.5H_2O$), green vitriol ($FeSO_4.7H_2O$) white vitriol ($ZnSO_4.7H_2O$), CaO, $Ca(OH)_2$ etc. which were isolated from non-living sources such as rocks and minerals are called inorganic compound and the branch of chemistry which study about those compounds is called inorganic chemistry.

Vital Force Theory: According to this theory organic compounds are produced only under the influence of some mysterious force existing in the living organisms. This mysterious force was called the vital force. This theory was proposed by Berzelius in 1815. Since such vital force can not be created artificially, so organic compounds cannot be prepared artificially in the laboratory.

Rejection of Vital force Theory: In 1828 Wholer accidentally prepared urea by heating Potassium cyanate and Ammonium sulphate .

This synthesis discarded the vital force theory and clearly demonstrated that no mysterious force was required in the formation of organic compounds in the laboratory.



Modern Definition of Organic Compound

All covalently bonded carbon compounds(except oxides of carbon (CO,CO_2), carbonates, bicarbonates are called organic compounds.

Check Your Concept - 1

(i) Name the scientist who disproved the 'vital force theory' for the formation of organic compounds.
(ii) Name the element whose allotropic form is graphite.
(iii) Name the hardest natural substance known.

Hydrocarbons

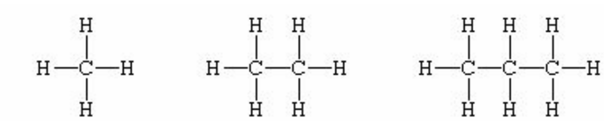
Compounds made up of carbon and hydrogen are called hydrocarbons and all other compounds may be regarded to have been derived from them by replacement of one or more of their hydrogen atoms by other atom or group of atoms.
These can be divided into two parts:

1. **Saturated Hydrocarbon**
   Compounds of carbon which have only single bonds between carbon atoms are called saturated compounds. These are also known as Alkanes. Example: Methane, Ethane, Propane etc.

2. **Unsaturated Hydrocarbon**
   Compounds of carbon which contain one or more double or triple bonds between C-C atoms are called unsaturated compounds. These compounds can be further divided into two parts:
   a. Alkene: If there is at least one double bond between (C = C) such hydrocarbons are known as Alkenes. Example of alkenes are Ethene (ethylene), Butene, Propene etc.
   b. Alkyne: If there is at least one triple bond between (C=C)such hydrocarbons are known as Alkynes. Examples of alkynes are Ethyne (acetylene), Butyne, Propyne etc. Open Chain Compound and closed Chain or Cyclic Compound

Open Chain Compounds

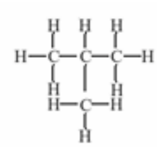
The organic compounds in which the carbon atoms are linked to each other in such a manner that the molecules having an open chain structure are called open chain or acyclic or aliphatic compounds. This may be of two types straight chain and Branched-chain compound.



Methane(CH_4) Ethane(C_2H_6) Propane(C_3H_6)

Branched Chain Compounds

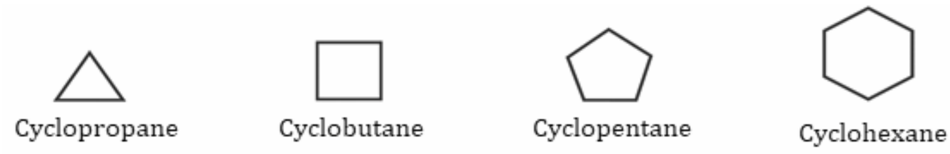
The carbon compounds in which at least one carbon of the chain is linked to three or four other carbon atoms are called branched-chain compounds.



C_4H_{10}(Iso butane)

Cyclic Compounds

Compounds of carbon in, which carbon atoms are arranged in a ring are called cyclic compounds.



Derivatives of Hydrocarbon

If hydrogen of a hydrocarbon is displaced from other atoms or group of atoms such compounds are known as derivative of hydrocarbons. Examples Alcohol, Ether, Aldehyde etc.

Such compounds can be divided into two parts:

1. Hydrocarbon Group (Radical): When one hydrogen is removed from hydrocarbon rest species is known as hydrocarbon radical. It determines the physical properties of an organic compound. It is donated by R.
On the basis of parent hydrocarbon it can be named as below:

Hydrocarbon	Formula	Name of radical	Formula
Alkane	C_nH_{2n+2}	Alkyl group	C_nH_{2n+1}
Alkene	C_nH_{2n}	Alkenyl group	C_nH_{2n-1}
Alkyne	C_nH_{2n-2}	Alkynyl group	C_nH_{2n-3}

2. Functional Groups: An atom or a group of atoms which displaces the hydrogen atom from hydrocarbon molecule is called a Functional Group. It determines the characteristic chemical properties of an organic compound. It is denoted by G. Some examples of functional group are given below:
All compounds with same functional group belong the same family.

General Formula	Functional Group	Functional Group Name
$R-X$	$-X(F, Cl, Br \text{ or } I)$	Alkyl halide or haloalkane
$R-OH$	$-OH$	Alcohol
$R-O-R$	$-O-$	Ether
$R-CHO$	$-CHO$	Aldehyde
$R-CO-R$	$-CO-$	Ketone
$R-COOH$	$-COOH$	Carboxylic acid
$R-COCl$	$-COCl$	Acid chloride
$R-COOR^1$	$-COOR^1$	Ester
$(RCO)_2O$	$-CO-O-CO-$	Anhydride
$R-NH$	$-NH_2$	Amine
$R-C\equiv N$	$-C\equiv N$	Cyanide
$R-N\equiv C$	$-N\equiv C$	Isocyanide
$R-O-N=O$	$-O-N=O$	Alkyl nitrile

Check Your Concept - 2

(i) What is meant by catenation? Name two elements which exhibit the property of catenation.

(ii) (a) What is buckminsterfullerene? How is it related to diamond and graphite?
(b) Why is diamond used for making cutting tools (like glass cutters) but graphite is not?

(iii) What are hydrocarbons? Explain with examples.

Homologous Series

A homologous series is a group or a class of organic compounds having similar structures and similar chemical properties in which the successive compounds differ by a CH_2 group.

Characteristics of Homologous Series:

1. Each member of the series differs from the proceeding or succeeding member by a common difference of CH_2 and by a molecular mass of 14 amu (amu = atomic mass unit).
2. All members of homologous series contain same elements and the same functional groups.
3. All members of homologous series have same general molecular formula.
For Example: Alkane = C_nH_{2n+2}, Alkene = C_nH_{2n}, Alkyne = C_nH_{2n-2}
4. The members in homologous series show a regular gradation in their physical properties with respect to increase in molecular mass.
5. The chemical properties of the members of the homologous series are similar.
6. All members of homologous series can be prepared by using same general method.

Importance of Homologous Series:

1. It helps to predict the properties of the members of the series that are yet to be prepared.
2. Knowledge of homologous series gives a systematic study of the members.
3. The nature of any member of the family can be ascertained if the properties of the first member are known.

Nomenclature of Organic Compound

The naming of organic compounds is called nomenclature.
There are two main systems of Nomenclature:

1. **Trivial system or common names:**
   These name were given after the source from which the organic compounds were first isolated.
   Example: Acetic acid (CH_3COOH) got its name from acetum (means vinegar) because it is present in vinegar. Formic acid ($HCOOH$) got its name from formica (means red ant) because it is present in Red ants. Marsh gas (CH_4) got its name because it is obtained from marshy land.

2. **IUPAC name:**
   International union of pure and applied chemistry has given certain rules to systematize nomenclature of organic compounds. This is simple, systematic, and scientific method for nomenclature of organic compounds. IUPAC name is unique.
   The IUPAC name of any organic compound can be derived by using the following rules.
   It mainly consists of three parts:
   A. Word Root
   B. Suffix
   C. Prefix

A. Word Root

The number of carbon atoms present in the linear continuous chain (main chain or present chain) of the molecule is denoted by word Root. It is generally indicated as “Alk”.

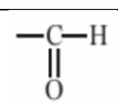
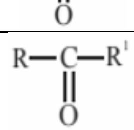
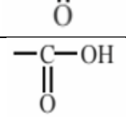
Chain length		Word Root (Alk)
One carbon	(C_1)	Meth
Two Carbon	(C_2)	Eth
Three Carbon	(C_3)	Prop
Four Carbon	(C_4)	But
Five Carbon	(C_5)	Pent
Six Carbon	(C_6)	Hex
Seven Carbon	(C_7)	Hept
Eight Carbon	(C_8)	Oct
Nine Carbon	(C_9)	Non
Ten Carbon	(C_{10})	Dec

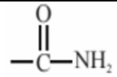
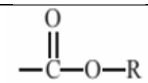
B. Suffix

1. **Primary Suffix:** Primary suffix is always added after the word root to indicate whether carbon chain is saturated or unsaturated.

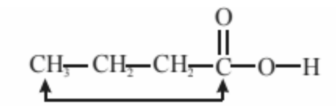
	Nature of Carbon Chain	Primary suffix	Name
(i)	Saturated i.e. Contain $C-C$ single covalent bond only	ane	Alkane
(ii)	Unsaturated i.e. Contains at least one $C=C$ double covalent bond	ene	Alkene
(iii)	Unsaturated i.e. Contain at least one $C\equiv C$ triple covalent bond	yne	Alkyne

2. **Secondary Suffix:** Secondary suffix is added after primary suffix to indicate the presence of particular functional group in the carbon chain. While adding secondary suffix to the primary suffix, the terminal ‘e’ of the primary suffix (i.e. ane, ene, yne) is dropped if secondary suffix begins with vowels (a,e,i,o,u) but it is retained if the secondary suffix begins with consonant.

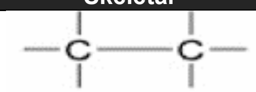
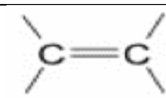
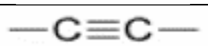
Family	Functional Group	Secondary Suffix	IUPAC Name
Alcohol		−ol	Alkane-ol=Alkanol
Adehyde		−al	Alkane-al = Alkanal
Ketone		−one	Alkane-one = Alkanone
Carboxylic acid		−oic acid	Alkane-oic acid = Alkanoic acid

Amine	$-NH_2$	−amine	Alkane-amine = Alkanamine
Amide		−amide	Alkane-amide = Alkanamide
Cyanides	$-C \equiv N$	nitrile	Alkane + nitrile = Alkane nitrile
Ester		Alkyl-oate	Alkyl/Alkane-oate = Alkyl alkanoate

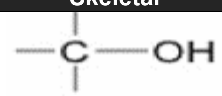
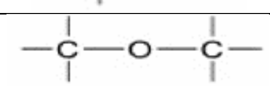
Linear Continuous Chain
Family-Carboxylic acid
Word Root = 4, Carbon atom i.e. But primary Suffix - ane
Functional group-ane
Functional group i.e. secondary.
suffix = oic acid
Hence name is:
But + ane −e + oic acid = Butanoic acid



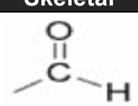
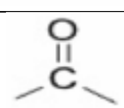
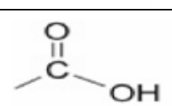
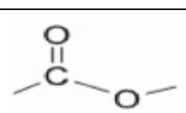
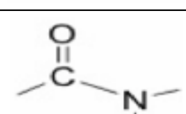
Hydrocarbons

Functional	Skeletal	Example	IUPAC Name	Nomenclature/Suffix
Alkane		CH_3CH_3	**Ethane**	**−ane**
Alkene		$H_2C = CH_2$	**Ethene**	**−ene**
Alkyne		$HC \equiv CH$	**Ethyne**	**−yne**

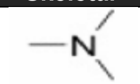
Simple Oxygen Heteratomics

Functional	Skeletal	Example	IUPAC Name	Nomenclature/Suffix
Alcohol		CH_3CH_2OH	**Ethanol**	**-ol**
Ether		$CH_3CH_2OCH_2CH_3$	**Diethyl Ether**	**<alkyl>ether**

Carbonyl Compounds

Functional	Skeletal	Example	IUPAC Name	Nomenclature/Suffix
Aldehyde		$CH_3C(O)H$	**Ethanal**	**-al**
Ketone		$CH_3C(O)CH_3$	**Propanone**	**-one**
Carboxylic Acid		$CH_3C(O)OH$	**Ethanoic Acid**	**-oic acid**
Ester		CH_3COOCH_3	**Methyl Ethanoate**	**<alkyl>-oate**
Amide		CH_3CONH_2	**Ethanamide**	**-amide**

Nitrogen-Based

Functional	Skeletal	Example	IUPAC Name	Nomenclature/Suffix
Amine		$CH_3CH_2NH_2$	**Ethanamine**	**-amine**
Nitrile	$-C\equiv N$	CH_3CN	**Ethanenitrile**	**-nitrile**

Prefix

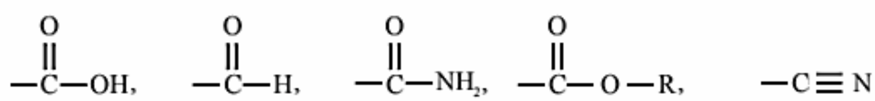
Prefix is added before word root to indicate side chains or substituents group present in the linear carbon chain of the molecule. In IUPAC system certain groups are treated as substituent (Prefix) instead of functional groups.

Group	Prefix
$-F$	Fluoro
$-Cl$	Chloro
$-Br$	Bromo
$-I$	Iodo
$-NO_2$	Nitro
$-O-R[R_3(CH_3, C_2H_5$ etc. $)]$	Alkoxy (Methoxy $(O-CH_3)$ Ethoxy $(O_2C_2H_5)$
$R-(CH_3, -C_2H_5)$	Alkyl [Methyl, (CH_3), Ethyl (C_2H_5)].
$-NO$	Nitroso
$-C_6H_5$	Phenyl

Numbering of Linear Chain

The numbering of liner carbon chain is done from one end of carbon chain in such a manner to give lowest possible numerical prefix. (i.e. called locant) $1, 2, 3, 4, 5$ ......tc to functional group, first then to double bond and triple bond.

Priority order is:
Functional group $> C=C <, -C\equiv C-$ Substituent

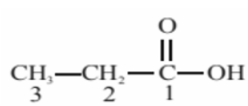


Functional group containing carbon always get number one during carbon chain numbering, hence their location is not required to write in the IUPAC.

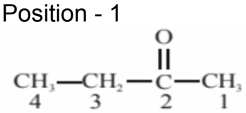
Examples:

Give IUPAC name of the following compounds.
W.R. = Word root, P.S. = Primary suffix, S.S. = Secondary suffix
$H_3C-CH_2-CH_2-OH$
Word root - Prop.
Primary suffix - ane
Functional group (Secondary suffix) =1-position of OH group in carbon chain

Hence IUPAC Name is:
1- Prop + ane $-e + ol$ = 1-propanol
$CH_3-CH_2-CH=CH_2$
Word Root but Primary Suffix = ene Position - 1
Name: 1-Butene



W.R. - Prop, P.S. = ane Secondary Suffix= Oic acid
Position - 1 Name: Propanoic Acid



W.R. = But. P.S. = ane Secondary Suffix= One
Position - 2 Name: 2-Butanone

Isomerism

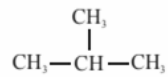
Compounds having same molecular formula show different physical and chemical properties are called isomers and the phenomenon is called isomerism. The difference in properties of isomers is due to the difference in the relative arrangements of various atoms present in their molecules.

Organic compound show following types of structural isomerism on the basis of their difference in structural arrangement of atoms.

Chain Isomerism

Organic compounds having same molecular formula but difference in the nature of length carbon chain are called chain isomers. For example, Let us consider the molecular formula of an alkane C_4H_{10}.

$CH_3-CH_2-CH_2-CH_3$
(Butane)

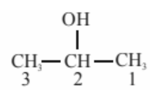

(2-Methylpropane)

(Here linear chain contains 4 carbon atom) (Here the linear chain contains 3 carbon atom)

Position Isomerism

Compounds having same molecular formula but differ in the position of, functional group, double bond or triple bond in the carbon chain are called position isomers. This type of isomerism is shown by Alkene, Alkyne, Alcohol, Amine, Haloalkane etc.
Let us consider the molecular formula of an alcohol ($C_nH_{2n+2}O$) are differ in the position of double bond in the linear carbon chain.

C_3H_8O $CH_3—CH_2—CH_2—OH$
(1-Propanol)


(2-Propanol)

Functional Isomerism

Compounds having same molecular formula but differ in nature of functional group are called functional isomers.

Examples:

(1) Alcohol and ether have same molecular formula ($C_nH_{2n+2}O$) but have different functional groups hence showing functional isomerism.

Answer:

C_2H_6O $CH_3—CH_2—OH$ (Ethanol) $CH_3—O—CH_3$ (Methoxy Methane)

(2) Give position isomers of the following compounds
(A) I-Butene (B) 1-Butyne

Answer:
(A) $CH_3-CH_2-C\equiv CH$ (1-Butyne) $CH_3-C\equiv C-CH_3$ (2-Butyne)
(B) $CH_3-CH_2-CH=CH_2$ (1-Butene) $CH_3-CH=CH-CH_3$ (2-Butene)

Chemical Properties of Carbon Compound

All carbon compounds show some common characteristic properties. As most of the fuels we use are either carbon or its compounds. Some such properties are described here:

Combustion

Combustion is a chemical process in which heat and light (in the form of flame) are given out
The process of combustion, is a rapid oxidation reaction of any substance in which heat and light are produced.

Combustion of Some Common Substances

1. **Combustion of Carbon: Carbon (or charcoal) burn in air or oxygen to give CO_2 producing heat and light.**

$$\underset{\text{Carbon}}{C(s)} + O_2(g) \xrightarrow{\text{Combustion}} \underset{\text{Carbon dioxide}}{CO_2(g)} + \text{Heat} + \text{light}$$

2. **Combustion of Hydro Carbon: Hydrocarbons burn to produce carbon dioxide (CO_2), water (H_2O) and heat and light.**

$$\underset{\text{Methane}}{CH_4(g)} + O_2(g) \xrightarrow{\text{Combustion}} \underset{\text{Carbon dioxide}}{CO_2(g)} + \text{Heat} + \text{light}$$

3. **Combustion of Alcohol:**

$$\underset{\text{Ethanol}}{C_2H_5OH(\ell)} + 3O_2(g) \xrightarrow{\text{Burn}} \underset{\text{Carbon dioxide}}{2CO_2(g)} + 3H_2O(g) + \text{Heat} + \text{light}$$

Oxidation

Carbon and its compounds can be easily oxidized on combustion (or burning). During combustion / burning, the compounds gets oxidised completely to different products, depending upon the nature of the oxidising agents.

Carbon gives carbon monoxide or carbon dioxide depending upon the oxygen available.

$$\underset{\text{Carbon}}{2C(s)} + \underset{\text{oxygen(limited)}}{O_2(g)} \rightarrow \underset{\text{Carbon monoxide}}{2CO_2(g)}$$

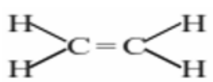
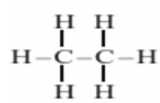
$$\underset{}{2C(s)} + \underset{\text{oxygen(Excess)}}{O_2(g)} \rightarrow \underset{\text{Carbon dioxide}}{CO_2(g)}$$

The term carbon footprint refers to the amount of greenhouse gas emissions caused by a country, organization, and humans. Thus, the carbon footprint is a tool to understand the impact of personal behavior on global warming.

Addition Reaction

All unsaturated hydrocarbons (unsaturated carbon compounds) react with a molecule like H_2. X_2. H_2O etc. to form another saturated compounds are called addition reactions.

Unsaturated hydrocarbons add hydrogen, in the presence of catalysts, such as nickel or palladium to give saturated hydrocarbons.


+ $H_{2(g)} \xrightarrow{\text{Ni,250°C}}$


Ethene (Double bond containing unsaturated carbon compound)

Ethane (Saturated hydrocarbon)

The addition of hydrogen to a unsaturated carbon compound is called a hydrogenation reaction. Certain vegetable oils such as ground nut oil, cotton seed oil and mustard oil, contain double bonds (C = C) and are liquids at room temperature. Because of the unsaturation, the vegetable oils undergo hydrogenation, like alkenes, to from saturated products called vanaspati ghee. Which is semi-solid at room temperature.

Vegetable oils (Unsaturated oil) + Hydrogen $\xrightarrow{\text{Ni,Heat}}$ Vanaspati Ghee (Saturated ghee)

Carbon can be used to determine the age of organic material using a process called carbon dating.

Substitution Reactions

The reactions in which one or more hydrogen atoms of a hydrocarbon are replaced by some other atoms or groups are called substitution reactions.

Methane reacts with chlorine (or bromine) in the presence of sunlight and undergoes a substitution reaction. It is called photochemical reaction because it takes place in presence of sunlight.

Examples:

$$CH_4(g) + Cl_2(g) \xrightarrow{\text{Sunlight}} \underset{\text{Chloromethane}}{CH_3Cl(g)} + HCl(g)$$

$$CH_3Cl(g) + Cl_2(g) \xrightarrow{\text{Sunlight}} \underset{\text{Dichloromethane}}{CH_2Cl_2(g)} + HCl(g)$$

$$CH_2Cl_2(g) + Cl_2(g) \xrightarrow{\text{Sunlight}} \underset{\text{Trichloromethane (chloroform)}}{CHCl_3(g)} + HCl(g)$$

$$CHCl_3(g) + Cl_2(g) \xrightarrow{\text{Sunlight}} \underset{\text{Tetra Chloromethane (Carbon tetra chloride)}}{CCl_4(\ell)} + HCl(g)$$

Exercise

OBJECTIVE TYPE QUESTIONS

(1) The first compound to be prepared in the laboratory was
(A) Methane (B) Ethyl alcohol
(C) Acetic acid (D) Urea

(2) Diamond is not a good conductor of electricity because
(A) It is very hard.
(B) Its structure is very compact.
(C) It is not water soluble.
(D) Is has no free electrons to conduct electric current.

(3) Which of the following is a saturated hydrocarbon?
(A) C_2H_6 (B) C_2H_4
(C) C_2H_5 (D) All of these

(4) Which of the following compound contain single covalent bond?
(A) Oxygen (B) Nitrogen
(C) Methane (D) Carbon dioxide

(5) What is the general formula of Alkene?
(A) C_nH_{2n+2} (B) $C_nH_{2n-1}OH$
(C) C_nH_{2n} (D) C_nH_{2n-2}

(6) Select the alkyne form the following
(A) C_4H_8 (B) C_5H_8
(C) C_7H_{19} (D) None of these

(7) Which of the following is not an open chain compound?
(A) Methane (B) Ethane
(C) Toluene (D) Butyne

(8) Covalent compounds are
(A) Good conductors of electricity (B) Bad conductors of electricity
(C) Semiconductors of electricity (D) None of these

(9) Which of the following is not an open chain compound?
(A) Methane (B) CycloButane
(C) Toluene (D) Benzene

(10) The functional group, present in $CH_3COOC_2H_5$ is
(A) Ketonic (B) Aldehydic
(C) Ester (D) Carboxylic

Answer Key

OBJECTIVE TYPE QUESTIONS

(1)	(D)	**(6)**	(B)
(2)	(D)	**(7)**	(C)
(3)	(A)	**(8)**	(B)
(4)	(C)	**(9)**	(C)
(5)	(C)	**(10)**	(C)