CARBON & ITS COMPOUND

INTRODUCTION:

The compound obtained from 'Carbon' are widely used as clothes, medicines, books fertilizer, fuel etc. all living structures are carbon based.

The amount of carbon present in the earth's crust and in the atmosphere is quite merging. The earth's crust has only 0.02% carbon in the form of mineral (like carbonates, hydrogen-carbonates, coal and petroleum) and the importance has 0.03% of carbon dioxide. In spite of this small amount of carbon available in nature. the importance of carbon seems to be immense.

Carbon forms a large number of compounds with hydrogen which are known as hydrocarbons. In addition to hydrogen. Carbon compound may also contain some other element such as oxygen, halogen, nitrogen, phosphorus, sulphur etc.

The number of compounds of carbon is more than three million which is much larger than the compounds formed by all other element put together.

BONDING IN CARBON COMPOUNDS:

Carbon forms **covalent bonds** in its compounds with other atoms. In each compound the valency of carbon is four. That is, carbon has **tetravalent** character. But what is covalent bond and what is meaning of tetravalent?

Why does a carbon atom form only covalent bond?

- The atomic number of carbon is 6 and first shell contains just two electrons and second shell (Outermost shell).
  Contains four electrons.
- Carbon atom can attain the noble gas configuration by sharing its valence electrons with other atoms of carbon or with atoms of other elements and form covalent bond.

CONVALENT BOND:

A chemical bond formed between two atoms of the same element or two atoms of different elements by sharing of electron is called a **covalent bond.**

Necessary conditions of the formation of covalent bond:

- The combining atoms should have **nonmetallic** character.
- The combining atoms should contain **4 to 7 electron as** in their respective valence shell.
- In **hydrogen** there is only **1 valence electron,** but it also forms **covalent bond.**
- The combining atoms need **1, 2, 3, or 4 electrons** to complete their **octet (hydrogen completes its duplet)**
- The combining atoms should contribute equal number of electrons to form pair of electrons to be **shared.**
- After sharing the pair of electrons each combining atoms should attain stable electronic configuration like its nearest noble gas.

CLASSIFICATION OF COVALENT BOND:

On the basis of the number of electrons shared by two combining atoms, the covalent bonds are of three types.

- **Single Covalent Bond:** A single covalent bond is formed by the sharing of one pair of electrons between the two atoms. It is represented by one short line (—) between the two atoms.

Example: H—H, Cl—Cl, H—Cl, CH_3— CH_3.

- **Double Covalent Bond:** A double covalent bond is formed by the sharing of two pairs of electron between the two combining atoms. It is represented by putting (=) two short lines between the two bonded atoms.

  Examples: O = O (O_2), CO_2 (O = C = O), $H_2C = CH_2$
- **Triple covalent bond:** A triple bond is formed by the sharing of three pair of electrons between the two combining atoms. It is represented by putting three short line () between two bonded atom.
  Example: N_2(N≡N), CH≡CH.

FORMATION OF SINGLE CONVALENT COMPOUNDS:

- **Formation of hydrogen molecule (H_2):**

A molecule of hydrogen is composed to two H-atoms. The electronic configuration of H-atom is.

Shell - K
Electron-1 } incomplete duplet (unstable)

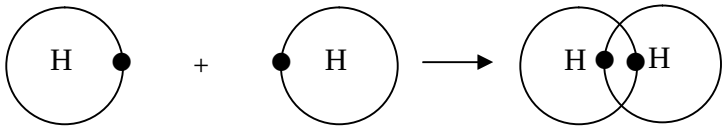
Electronic configuration of He atom

Shell - K
Electrons-2 } complete duplet (stable)

$H^{\cdot} + {}^{\cdot}H \longrightarrow H{:}H \longrightarrow H\text{-}H \longrightarrow H_2$

K(1) K(1) Atom Atom	Shared electron Pair	Covalent Bond	Hydrogen molecule

H – H Bond in terms of energy shells (orbits)



H Atom H Atom H_2 molecule

- **Formation of chlorine molecule** (Cl_2). The atomic number of chlorine is 17, thus there 17 electrons in an atom of chlorine.

Electronic configuration of Cl atom –

Shells	K	L	M'
Electrons	2	8	7

} Incomplete octet

Electronic configuration of Ar atom –

Shells	K	L	M
Electrons	2	8	8

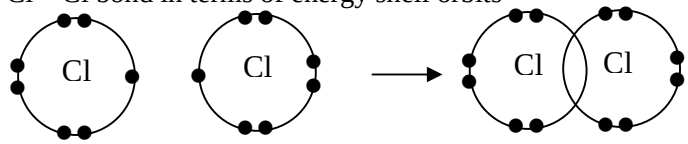
} Complete octet

Chlorine atom needs one electron more to complete its octet –

$:\ddot{\underset{\cdot\cdot}{Cl}}\bullet \quad + \quad \bullet\ddot{\underset{\cdot\cdot}{Cl}}: \longrightarrow :\ddot{\underset{\cdot\cdot}{Cl}}\cdot\cdot\ddot{\underset{\cdot\cdot}{Cl}}: \longrightarrow Cl - Cl \longrightarrow Cl_2$

Atom Atom Shared electrons Covalent Bond Chlorine molecule

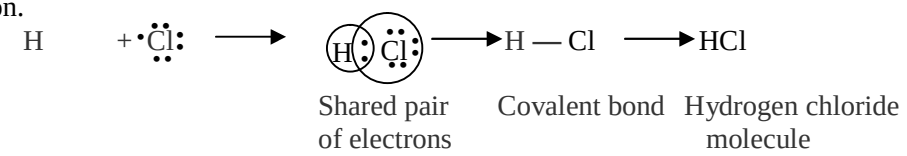
Cl – Cl bond in terms of energy shell orbits



Cl Atom Cl Atom Cl_2 Molecule

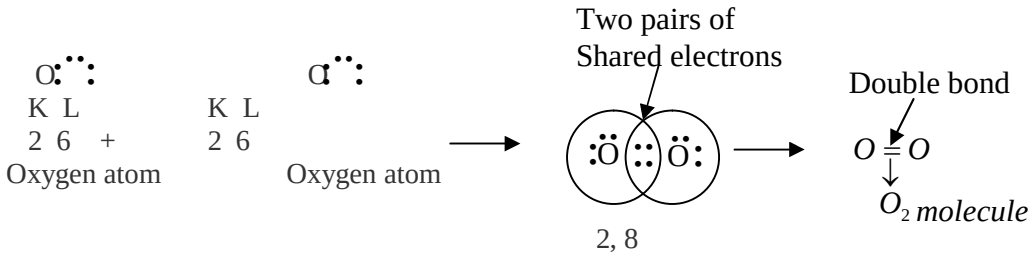
Formation of hydrochloric acid (HCl):

- H atom has one valence electron. It needs 1 electron more to complete its duplet and chlorine has 7 valence electrons. It need 1 electron more to complete its octet and acquire stable electronic configuration (2, 8, 8) like noble gas argon.



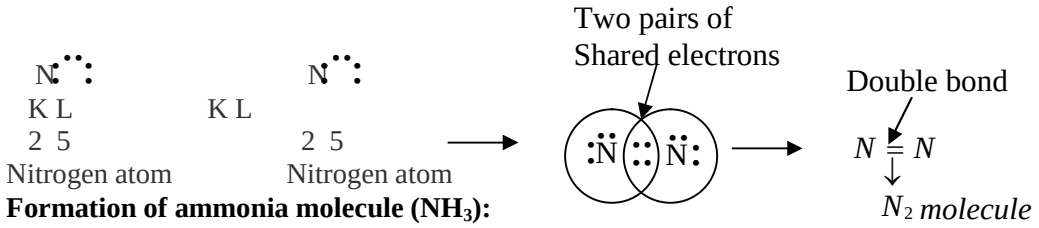
- **Formation of oxygen (O_2):**

The atomic number of O atom is 8. There are 6 electron in the valence shell of oxygen atom it needs 2 more electrons to attain the nearest stable inert gas Neon (2,8) configuration:



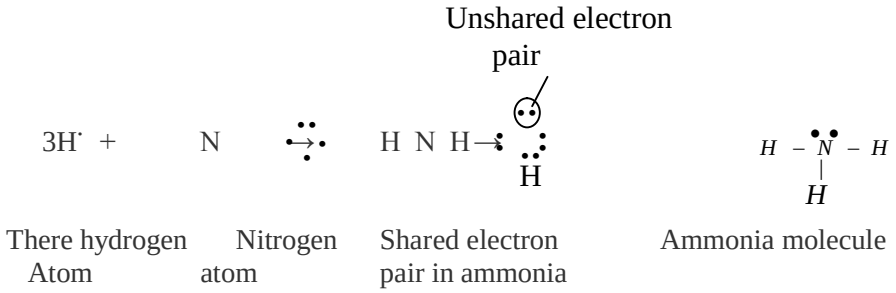
- **Formation of nitrogen molecule (N_2):**

The atomic number of nitrogen is 7 and its electronic configuration is K(2). L(5). It needs 3 electrons more to complete its octet like noble gas neon (2,8).

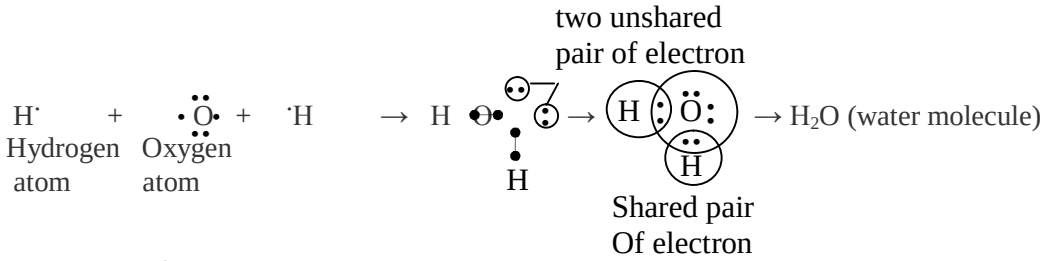


- **Formation of ammonia molecule (NH_3):**

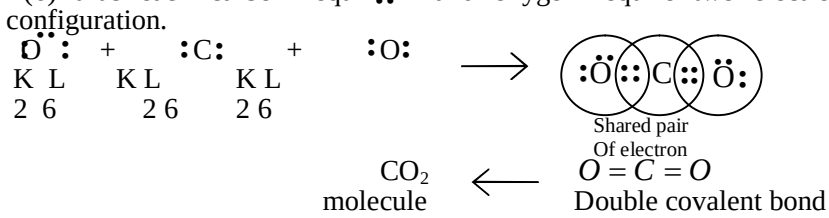
The atomic number of N is 7. It's electronic configuration is 2,5 there are 5 electrons in its valence shell. It needs 3 electrons more to complete its octet like noble gas neon (2,8).



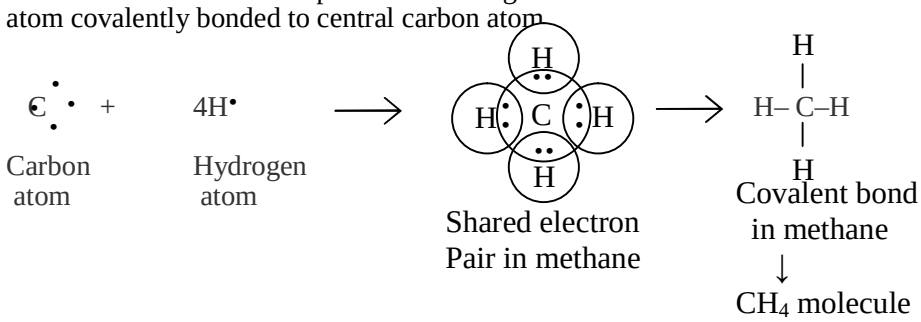
- **Formation of H_2O molecule:**
  The electronic configuration of hydrogen is K (1) and that of oxygen is K(2) L(6) thus each hydrogen require one and oxygen required two electrons to achieve the stable electronic configuration.



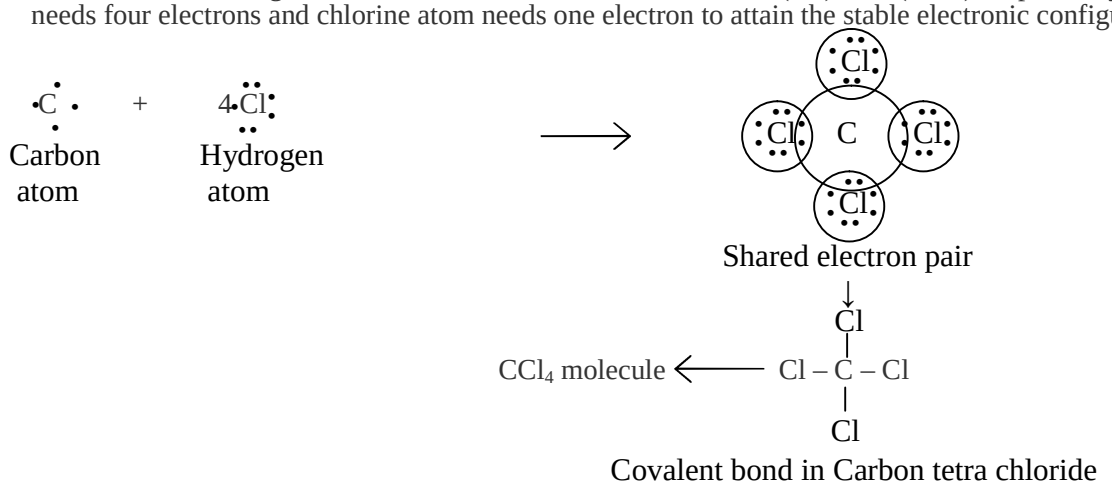
- **Formation of CO_2 molecule:**
  The atomic number of C is 6 and the electronic configuration of C is K(2). L(4) and that of oxygen is K(2), L(6) thus each carbon require 4 and oxygen require two electrons to achieve the stable electronic configuration.



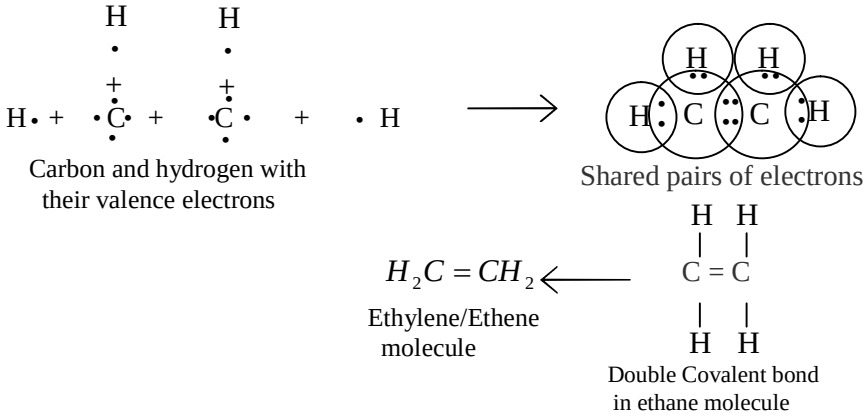
- **Formation of CH_4 molecule:**
  Methane is a covalent compound containing 4 covalent bond. It contains one carbon atom and four hydrogen atom covalently bonded to central carbon atom.



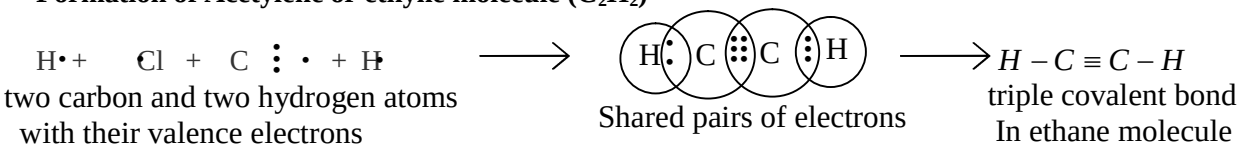
- **Formation of carbon tetrachloride molecule (CCl_4):**
  The electronic configuration of carbon and chlorine atoms are (2,4) and (2,8,7) respectively. Carbon atom needs four electrons and chlorine atom needs one electron to attain the stable electronic configuration.



- **Formation of ethylene or ethane molecule (C_2H_4):**
  The electronic configuration of carbon atom is 2,4. There are 4 valence electrons in one C atom. Each H atom contains 1 valence electron. Thus, there are 12 valence electrons present in ethane molecule.



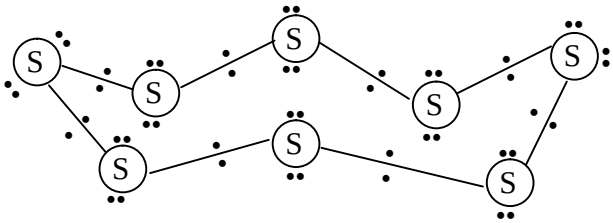
- **Formation of Acetylene or ethyne molecule (C_2H_2)**



Q. What would be the electron dot structure of carbon dioxide which has formula CO_2? **[NCERT]**

Q. What would be the electron dot structure of a molecule of sulphur which is made up of eight atoms of sulphur?

Ans. The eight atoms of sulphur are joined together in the form of a puckered ring. **[NCERT]**



Q. Explain the nature of the covalent bond using the bond formation in CH_3Cl. **[NCERT]**

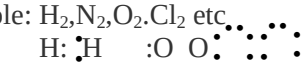
Q. Draw the electron dot structure for **[NCERT]**

(a) ethanoic acid (b) H_2S (c) propanone (d) F_2

NON POLAR AND POLAR COVALENT COMPOUNDS:

Non polar covalent bond:

A covalent bond formed between **two atoms** of the same element or same **electronegativity** is called a **non-polar covalent bond.** Example: H_2,N_2,O_2.Cl_2 etc.



the shared pair electron lies exactly midway between the two atoms

Polar covalent bond:

The covalent bond between the atoms of **two elements** having **different electronegativities** is called a **polar covalent bond.** Molecules in which the atom is bonded by a polar covalent bond are called **polar molecules.**

Note: In a polar covalent bond, the shared pair of electrons lies more toward the atom which is more electronegative.

Example: HCl, H_2O & NH_3

Shared pair of electrons lie nearer to Cl because Cl is more electronegative

Note: δ means partial

CHARACTERISTICS OF COVALENT BOND AND COVALENT COMPOUNDS:

Characteristics of covalent bond:

- Covalent bond are formed by mutual **sharing** of electrons
  Note: Shared pair of electrons is also called **bonding pair of electrons.**
- Covalent bond is directional in nature because shared pair of electrons remains localized in a definite space between the two atoms.

Characteristics of covalent compounds:

Physical Store: The covalent compounds are generally **gases or liquids.** but compounds with high molecular masses are **solids.**

Example: **Solid:** Urea, Glucose, Naphthalene.

Liquids: Water, ethanol, benzene.

Gases: Methane, chlorine, hydrogen, oxygen

- **Melting and boiling points:** Covalent compounds have **low melting** and **low boiling points** because **intermolecular forces** (cohesive forces) in covalent compounds **are weaker** than those in ionic compounds.

Note: Some exceptions like diamond and graphite which are covalent solids have very high M.P. & B.P.

- **Solubility:**

Covalent compounds generally dissolve readily in organic solvents but they are **less soluble in water.**

For example: Naphthalene which is an organic compound dissolves readily in organic solvents like ether but is insoluble in water. However some covalent compounds like urea, glucose, sugar etc. are soluble in water. Some polar covalent compounds like ammonia and hydrochloric acid are soluble in water.

- **Conductivity:**

Covalent compounds **do not conduct electricity** because they contain neither the ions nor free electrons necessary for conduction. So they do not conduct electricity

For example: Covalent compounds like glucose, alcohol. Carbon tetrachlorides do not conduct electricity.

Differences between ionic and covalent compounds:

S.N.	Electrovalent (Ionic) Compounds	Covalent Compounds
1	Formed by transfer of electrons, (only single bond network exist)	Formed by sharing of electrons, (single, double & triple are formed).
2	Usually crystalline solid	Usually gasses or liquid only a few of them are solid
3	Generally have high melting and boiling points	Generally have low M.P. and B.P.
4	Soluble in water but insoluble in organic solvents	Soluble in organic solvent but insoluble or soluble in water
5	Conduct electricity in solution or molten state	Usually non conductor of electricity
6	Highly polar and ionize in water eg. $NaCl \rightarrow Na^{+} + Cl^{-}$	Usually Non-polar and do not ionize in water but few compounds are polar in nature and ionise in water eg. $HCl \rightarrow H^{+} + Cl^{-}$

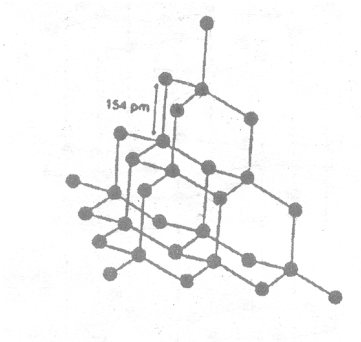
ORGANIC COMPOUNDS:

The chemical compounds which are present in living organisms (plant and animal) are called **organic compounds.** The belief that formation of organic compounds was possible only in plants and animals led the scientists of early days to propose that **Vital Force** was necessary for the formation of such compounds. But the experimental work of **Friedrich Wohler** (German chemist) denied the idea of vital force when he prepared urea in his laboratory. (Urea is an organic compound and waste product of urine).

Q. Name the organic compound which was prepared by Wohler in his laboratory. **[NCERT]**

Allotropy/ allotropes of carbon:

The phenomenon of existence of allotropic forms of an element is called allotropy. Allotropes are the different forms of the same element having different physical properties but almost similar chemical properties. There are three allotropes of carbon these are diamond, graphite and fullerene.
DIAMOND: Diamond is a **crystalline allotrope** of carbon. Its atomic symbol & empirical formula is 'C'.



Structure of Diamond

Structure: In diamond, each carbon atom is covalently bonded to four other carbon atoms in a tetrahedral arrangement. This tetrahedral arrangement of carbon atoms gives a rigid; three dimensional structure to diamond It is due to this rigid structure that diamond.

- Is very hard crystalline structure?
- Has high melting point.
- Is non conductor of heat and electricity?

Properties: Pure diamond is a transparent and colourless solid.

- Polished diamond sparkles brightly because it reflects most of the light (refractive index of diamond is 245)
- Diamond is not attacked by acids. Alkalis and solvents like water, ether, benzene or carbon tetrachloride but diamond is attacked by fluorine at 750^0C.

C (Diamond) + $2F_2 \xrightarrow{750^0 C} CF_4$

Carbon Fluorine carbon tetrafluoride

- The density of diamond is 3.51 g per cm^3 at 20^0C.

Uses:

- A saw fitted with diamond is used for sawing marbles.
- A chip diamond is used for glass cutting.
- Black diamonds are used in making drill.
- Diamonds are used for making dice for drawing very thin wires of harder metals.
- Diamonds are also used for making high precision tools for use in surgery such as, for the removal of cataract.
- Diamond are used for making precision thermometers and protective windows for space craft's.

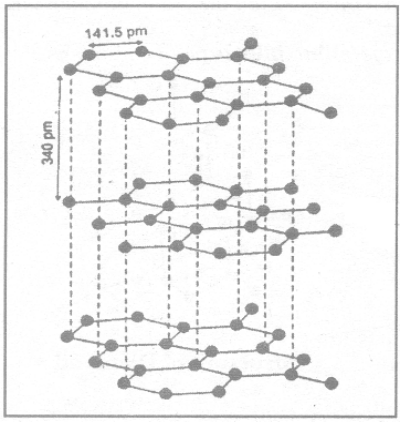
GRAPHITE:

Graphite is also known as **black lead** it marks paper work black. The name graphite has been taken from the greek word "**graphein**" (which means to write) in reference to its uses as 'lead' in lead pencils.

Structure:

Graphite is an opaque and dark grey solid. In a crystal of graphite the carbon atoms are arranged in hexagonal patterns in parallel planes. In a layer of graphite each carbon atom is strongly bonded to three carbon atoms by covalent bonds. Thus, one valence electron of each carbon atoms is free in every layer of graphite crystal. Thus free electron makes graphite a good conductor of electricity.

Each layer is bonded to the adjacent layers by weak forces. As a result, each layer can easily slide over the other.



Properties:

- Graphite is grayish-black, opaque material having metallic (shiny) **luster.**
- It is soft and has a **soapy** (slippery) touch.
- Graphite is lighter than diamond. The **density of graphite** is 2.26 g per cm^3 at 20^0C.
- Graphite is a **good conductor** of heat and electricity.
- Graphite has a very **high melting point.**
- Graphite is **insoluble** in all common solvent.

Uses:

- For making electrodes in dry cells and electric arc furnaces.
- Graphite is a **good dry lubricant** for those parts of machines where grease and oil cannot be used.
- For making crucibles for melting metals.
- For manufacturing lead pencils.
- Graphite is used as neutron moderator in nuclear reactors.
- For the manufacture of gramophone records and in electrotyping.
- For the manufacture of artificial diamond.

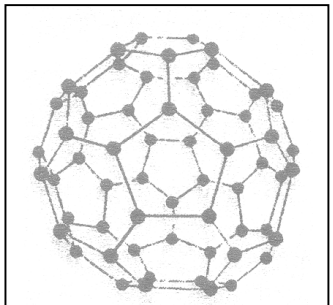
Fullerene:

- Fullerene was discovered in 1985 by Robert F. Curl Jr, Harold Kroto and Richard E.Smalley.
- This molecule containing sixty atoms of carbon has been named Buckminster fullerene. Fullerene has been named after American architect and engineer **R. Buckminster-fuller** whose geodesic domes follow similar building principles.

Type of fullerene:

C_{60},C_{70},C_{74} and C_{78} are the members of the fullerene family. But C_{60} is the most stable and most studied from of fullerenes.

Structure of fullerene:



Structure of fullerene

- Buckminster fullerene molecule (C_{60}) is nearly spherical.
- It consists of 12 pentagonal faces and 20 hexagonal faces giving it 60 corners. Thus, Buckminster fullerene has a hollow, cage-like structure.
- In figure, ball like molecules containing C atoms.

Preparation:

- By electrically heating a graphite rod in atmosphere of helium.
- By vaporising graphite by using laser.

Properties:

- Fullerene is soluble in benzene and forms deep violet colour solution.
- Crystalline fullerene has semiconductor properties.
- Compounds of fullerene with alkali metals are called fullerides and they are superconductors.

Uses:

- As a superconductor.
- As a semiconductor.
- As a lubricants and catalyst.
- As fibres to reinforce plastics.

VERSATILE NATURE OF CARBON:

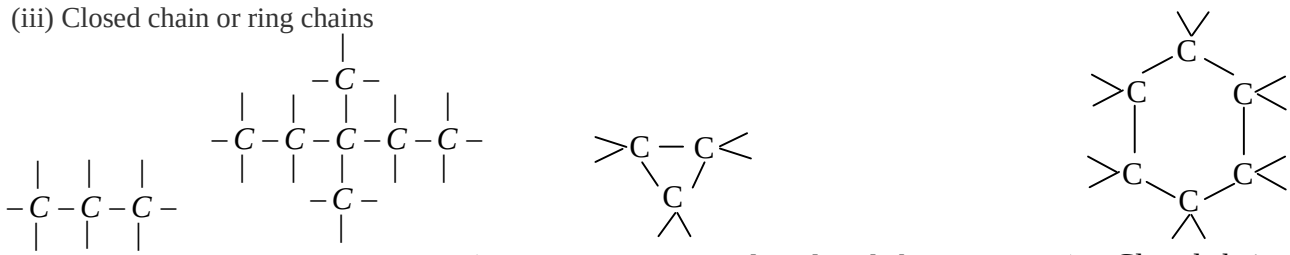
About three million (or thirty lakh) compounds of carbon are known. The existence of such a large number of organic compounds is due to the following characteristic features of carbon.

(1) CATENATION: Tendency to form Carbon-Carbon bond:

"The property of forming bonds with atoms of the same element is called **catenation".**

Carbon has the maximum tendency for catenation in the periodic table. This is because of strong carbon-carbon bonds as compared to other atoms.

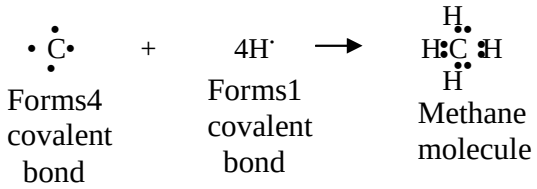
- When two or more carbon atoms combine with one another, they form different types of chain such as
  (i) Straight chains
  (ii) Branched chains
  (iii) Closed chain or ring chains



Straight chain Branched chain (Minimum 3C required in closed chain structure) Closed chain

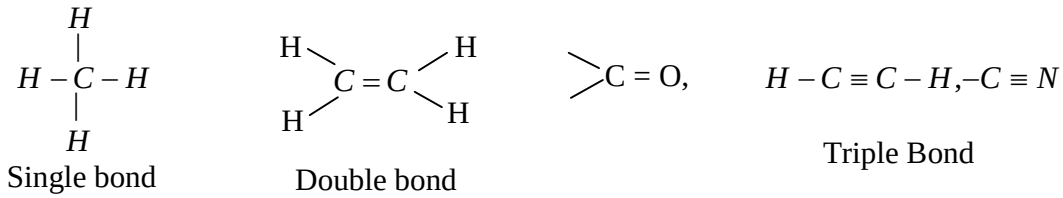
(2) Tetravalency of Carbon:

- The atomic number of carbon is **6.**
- The electronic configuration of carbon atom is **$1s^2, 2s^2, 2p^2$.**
- It has four electrons in the outermost shell, therefore its valency is four. Thus carbon forms four covalent bonds in its compounds.



(3) Tendency to form multiple bonds:

Due to small size, carbon can easily form double or triple bonds **(called multiple bonds)** with itself and with the atoms of other elements as nitrogen, oxygen, sulphur etc.



(4) Isomerism:

Compounds having same molecular formula but different structural formulae are known as Isomers and the phenomenon of existence of isomers is termed as **isomerism.**

Example:

C_2H_6O(Same Molecular Formulae)

Two Isomers

- C_2H_5OH Ethyl alcohol
- CH_3-O-CH_3 Dimethyl ether

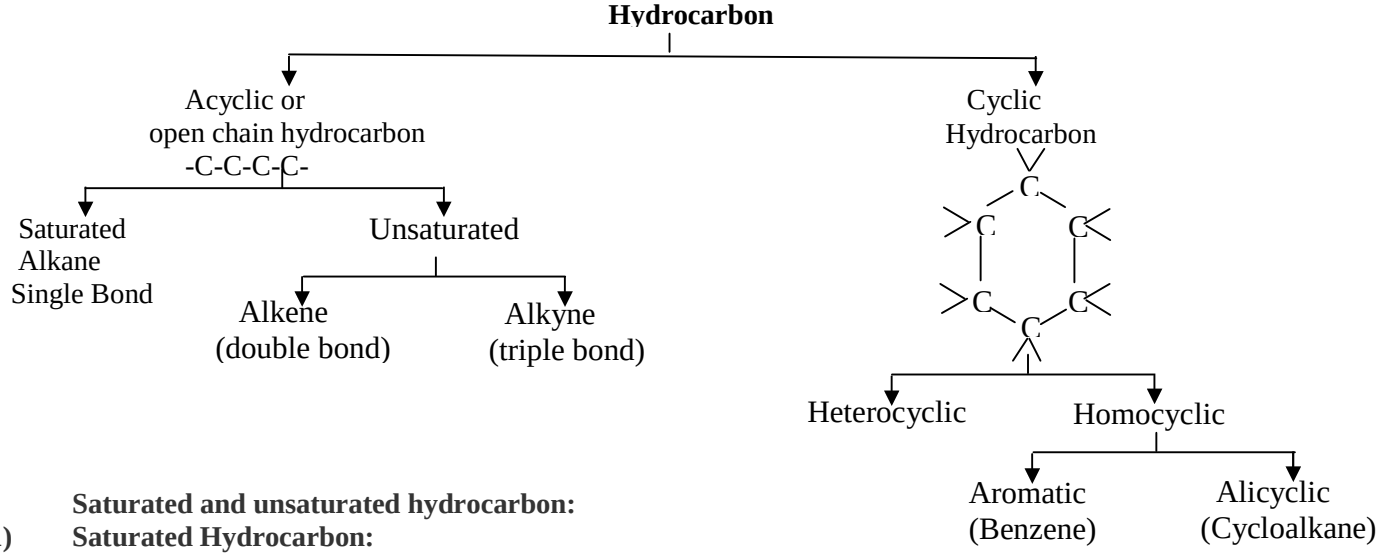
C_5H_{12}(Pentane)

Three Isomers

- CH_3-CH_2-CH_2-CH_2-CH_3 n-pentane
- CH_3-CH(CH_3)-CH_2-CH_3 Iso-pentane
- H_3C-C(CH_3)$_2$-CH_3 Neo-pentane

HYDROCARBON:

Compounds formed from combination of carbon and hydrogen is known as hydrocarbon. Hydrocarbon the basis of chain is mainly classified into two parts.

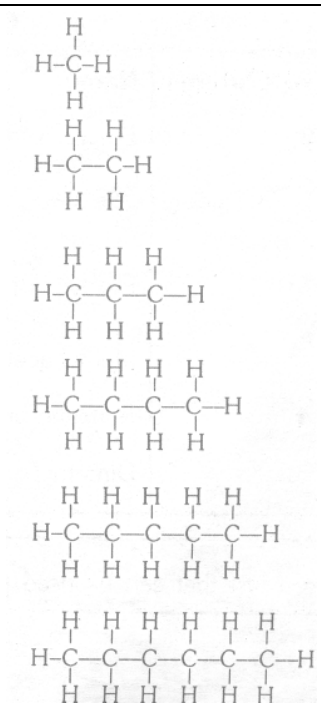


Saturated and unsaturated hydrocarbon:

(1) Saturated Hydrocarbon:

- The hydrocarbons which contain only single carbon-carbon covalent bonds are called **saturated hydrocarbons.**
- They are also called **alkanes.**
- General formula for alkanes is C_nH_{2n+2} where 'n' is the number of carbon atoms.

General formula of saturated hydrocarbon (C_nH_{2n+2})

No. of 'C' atoms	Name	Formula	Structure
1	Methane	CH_4	
2	Ethane	C_2H_6	
3	Propane	C_3H_8	
4	Butane	C_4H_{10}	
5	Pentane	C_5H_{12}	
6	Hexane	C_6H_{14}	

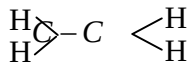
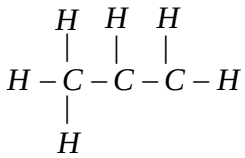
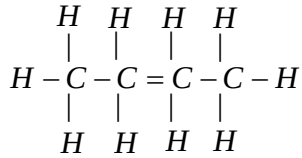
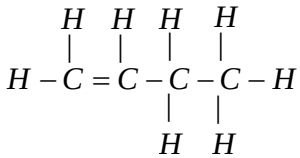
(2) Unsaturated hydrocarbons:
The hydrocarbon in which two carbon atoms are bonded to each other by a double (=) or a triple (≡) bond is called an unsaturated hydrocarbon.

- Unsaturated hydrocarbons are of two types viz. alkenes and alkynes.

$$(-\overset{|}{C}=\overset{|}{C}-)$$

(1) Alkenes:
- The hydrocarbon in which the two carbon atoms are bonded by a double bond are called **alkenes.**
- Their general formula is C_nH_{2n} where "n" is the number of carbon atoms.

General formula of alkenes : C_nH_{2n}

No. of C atoms	Name	Formula	Structure
2.	Ethene or Ethylene	C_2H_4 $CH_2=CH_2$	
3.	Propene or Propylene	C_3H_6 $CH_3\text{-}CH=CH_2$	
4.	Butene or Butylene	C_4H_8 $CH_3\text{-}CH=CH\text{-}CH_3$ or $CH_2=CH\text{-}CH_2\text{-}CH_3$	 or 

(II) Alkyne $(-C\equiv C-)$
- The hydrocarbon in which two carbon atoms are bonded by a triple bond are called **alkyne.**
- Their general formula is C_nH_{2n-2} where 'n' is the number of carbon atoms.

General formula of alkynes: C_nH_{2n-2}			
No. of 'C' atoms	**Name**	**Formula**	**Structure**
2	Ethyne or Acetylene	C_2H_2 or $HC \equiv CH$	$H-C\equiv C-H$
3	Propyne or	C_3H_4 or	$H-\underset{H}{\overset{H}{C}}-C\equiv C-H$
	Methyl acetylene	$H_3C-C\equiv C-H$	
4	Butylene or	C_4H_6 or	$H-\underset{H}{\overset{H}{C}}-C\equiv C-\underset{H}{\overset{H}{C}}-H$
	Dimethyl acetylene	$H_3C-C\equiv C-CH_3$	

Q. Give a test that can be used to differentiate chemically between butter and cooking oil. **[NCERT]**

CHAINS, BRANCHES AND RINGS:

The hydrocarbon may also have branched, closed chains or ring or cyclic structures.

Branched structure:

The alkanes containing three or less carbon atoms do not form branches.

CH_4	CH_3-CH_3	CH_3-CH_2-CH_3
Methane	Ethane	Propane

- The alkane containing four carbon atoms (C_4H_{10}) has two types of arrangement of carbon atoms.

$H_3C-CH_2-CH_2-CH_2$ — Continuous chain

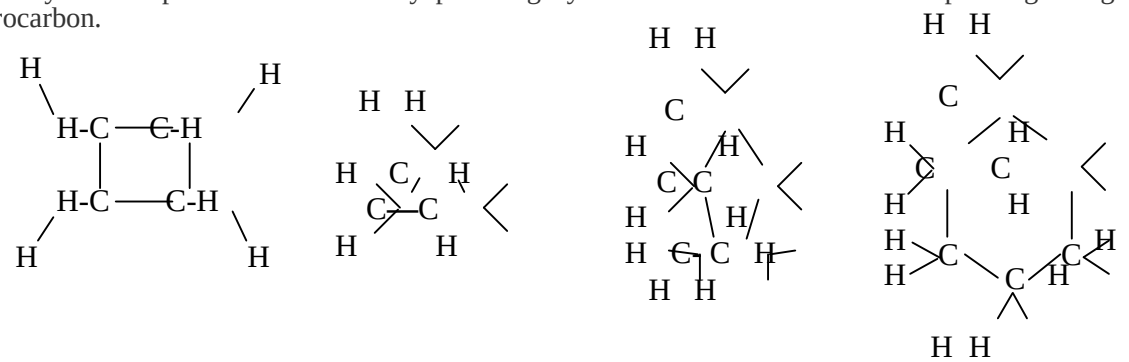
$H_3C-CH(CH_3)-CH_3$ — Branched chain

- **Closed chains or cyclic hydrocarbon:** Isomers

These hydrocarbons contain closed chain or rings of atoms in their molecules. These are of two types:

(A) Alicyclic hydrocarbon:

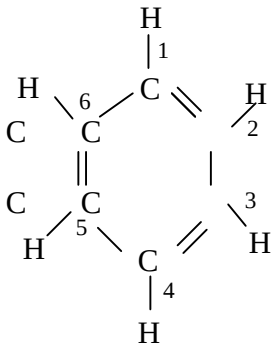
- These hydrocarbons contain a ring chain of three or more carbon atoms.
- These cyclic compounds are named by prefixing cyclo before the name of corresponding straight chain hydrocarbon.



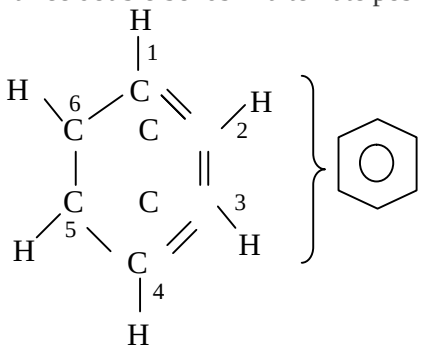
Cyclobutane (C_4H_8) Cyclopropane (C_3H_6) Cyclopentane (C_5H_{10}) Cyclohexane (C_6H_{12})

(B) Aromatic hydrocarbon:

- These have at least one benzene ring in their molecules.
- It is a special type of ring of six carbon atoms with three double bonds in alternate positions.



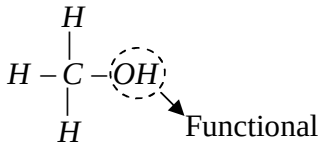
or



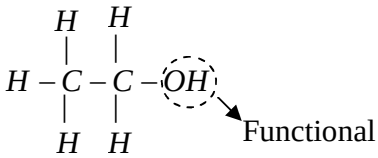
Will you be my friend? (Functional group):

- Carbon forms many compounds with hydrogen. But carbon also forms bonds with other atoms such as halogen, oxygen, nitrogen and sulphur. Therefore, carbon is said to be very friendly element.
  These compounds are obtained by replacing one or more hydrogen atoms by other atoms such that the valency of carbon remains satisfied. The atom replacing the hydrogen atom is called **heteroatom** or **Functional** group.
- Different organic compounds having same functional group have almost same properties these are called **families.**

Example:



Methanol



Ethanol

- Properties of CH_3-OH and CH_3-CH_2OH are similar and it is due to the presence of –OH (hydroxyl) group.
- This group is known as **alcoholic group.**
- Family of compounds having –OH group is called **alcohols.**

SOME FUNCTIONAL GROUPS IN CARBON COMPOUNDS

Hetero atom	Functional Group	Formula of Functional Group
Halogen atom	Halo	-X
(F, Cl, Br, I)	(Fluoro,Chloro,Bromo,Iodo)	(-F,-Cl,-Br,-I)
Oxygen	1. Alcohol	-OH
	2. Aldehydes	$-C\overset{H}{}_{\diagup}\!\!=\!\!O$ or $-CHO$

	3. Ketones	$>C=O$ or $-\overset{\vert}{C}O$
	4.Carboxylic acid	$-\overset{O}{\overset{\Vert}{C}}-OH$ or $-COOH$
Nitrogen	1. Nitro	$-NO_2$
	2. Amines	$-NH_2$

HOMOLOGOUS SERIES:

"A series of organic compounds having similar structures and similar chemical properties in which the successive members differ in their molecular formula by $-CH_2$ group".

The different members of the series are called **homologous.**

Characteristics of Homologous Series:

- All the member of a homologous series can be described by a common general formula.
  Example: All alkane can be described by the general formula $\mathbf{C_nH_{2n+2}}$.
- Each member of a homologous series differs from its higher and lowers neighbouring members by a common difference of $-CH_2$ group.
- Molecular masses of the two adjacent homologues differ by 14 mass units, because molecular mass of $-CH_2$ group is 12 + 2 = 14.

- All the members of a homologous series show similar chemical properties.
- All the members of the series can be prepared by similar methods known as the general method of preparation.

Table: Some members of alkane, alkene and alkyne homologous series.

Alkane		**Alkene**		**Alkyne**	
C_nH_{2n+2}		C_nH_{2n}		C_nH_{2n+2}	
Homologous series		Homologous series		Homologous series	
Name	**Formula**	**Name**	**Formula**	**Name**	**Formula**
Methane	CH_4	-	-	-	-
Ethane	C_2H_6	Ethene	C_2H_4	Ethyne	C_2H_2
Propane	C_3H_8	Propene	C_3H_6	Propyne	C_3H_4
Butane	C_4H_{10}	Butene	C_4H_8	Butyne	C_4H_6
Pentane	C_5H_{12}	Pentene	C_5H_{10}	Pentyne	C_5H_8
Hexane	C_6H_{14}	Hexene	C_6H_{12}	Hexyne	C_6H_{10}

Activity: Calculate the difference in the formulae and molecular masses for (a) CH_3OH and C_2H_5OH (b) C_2H_5OH and C_3H_7OH and (c) C_3H_7OH and C_4H_9OH

Q. It there any similarity in these three? **[NCERT]**

Q. Arrange these alcohols in the order of increasing carbon atoms to get a family. Can we call this family a homologous series? **[NCERT]**

Q. What is homologous series? Explain with an example. **[NCERT]**

Solution:

Formula	**Molecular Mass (Calculated)**	**Difference In**	
		Formula	**Molecular mass**
(a) CH_3OH	12 + 3 + 16 + 1 = 32	$-CH_2$	14
C_2H_5OH	24 + 5 + 16 + 1 = 46		
(b) C_2H_5OH	24 + 5 + 16 + 1 = 46	$-CH_2$	14
C_3H_7OH	36 + 7 + 16 + 1 = 60		
(c) C_3H_7OH	36 + 7 + 16 + 1 = 60	$-CH_2$	14
C_4H_9OH	49 + 9 + 16 + 1 = 74		

Conclusion:
(i) Yes, all these compounds are the members of a homologous series for alcohols.
(ii) CH_3OH, C_2H_5OH, C_3H_7OH and C_4H_9OH –increasing carbon atoms. These four compounds from a homologous series.

HOMOLOGOUS SERIES CONTAINING FUNCTIONAL GROUPS.

- **Aldehydes**:
  HCHO, CH_3CHO, CH_3CH_2CHO, $CH_3CH_2CH_2CHO$
- **Carboxylic acids:** HCOOH, CH_3COOH, CH_3CH_2COOH, $CH_3CH_2CH_2COOH$
- **Amines:** CH_3NH_2, $CH_3CH_2NH_2$,$CH_3CH_2CH_2NH_2$.
- **Ketones:** CH_3COCH_3,$CH_3COCH_2CH_3$,$CH_3COCH_2CH_2CH_3$
- **Haloalkanes:** CH_3X,CH_3CH_2X,$CH_3CH_2CH_2X$,$CH_3CH_2CH_2$-CH_2X

How do physical properties change in a homologous series of hydrocarbons.
The physical properties of the various members of a homologous series change regularly with an increases in the molecular mass.

(i) **Melting and boiling points:** Melting point and boiling of hydrocarbon in a homologous series increases with an increase in molecular mass.

(ii) **Physical State:**

- Hydrocarbons containing lesser number of carbon atoms are **gases.**
- Hydrocarbons containing large number of carbon are **solids.**
- Hydrocarbon containing intermediate number of carbon atoms are **liquid.**

Example: Hydrocarbon containing 1-4 carbon atoms are gases, these containing 5-13 carbon atoms are liquid and those containing more than 14 carbon atoms are solids,

Nomenclature of carbon compounds:
Carbon compounds can be called by their common names, but, then remembering millions of compounds by their individual names may be very difficult. Due to this reason, **the International Union of Pure and Applied chemistry (IUPAC)** has devised a very systematic method of naming these compounds.
Naming a carbon compound can be done by the following methods.

- The number of carbon atoms in the molecule of a hydrocarbon is indicated by the following stems.

No. of carbon atom:	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Stem	Meth	Eth	Prop	But	Pent	Hex	Hept	Oct	Non	Dec.

Example; Saturated hydrocarbon.
Alkane → Meth +ane = Methane
Unsaturated hydrocarbon
Alkene → Eth + ene = Ethene
Alkyne → Eth + yne = Ethyne

- In case of functional group is present, it is indicated in the name of compound with either a prefix or a suffix.
- Identify the longest continuous chain of carbon atoms. This gives the name of parent hydrocarbon.
- In the case of any substituent appropriate prefix is added before the name of parent hydrocarbon.
- In the case of a functional group. the ending ‘e’ in the name of the parent hydrocarbon is replaced by the appropriate suffix.

Functional Group:
“Functional group may be defined as an atom or a group of atoms which is responsible for most of the characteristic chemical properties of an organic compound”.

The prefixes and suffixes of some substituents/functional group

Substituents/ Functional group	Prefix	Suffix	Example	
			Structure	**Name**
1. Halogen: Chlorine	Chloro	-	$CH_3CH_2-CH_2-Cl$	Chloropropane
Bromine	Bromo	-	$CH_3-CH_2-CH_2-Br$	Bromopropane
Iodine	Iodo	-	$CH_3-CH_2-CH_2-I$	Iodo propane
2. Alcohol	-	ol	$CH_3-CH_2-CH_2-OH$	propanol
3. Aldehyde	-	al	$CH_3-CH_2-\overset{\overset{H}{\vert}}{C}=O$	propanal
4. Ketone	-	one	$H_3C-\underset{\underset{O}{\Vert}}{C}-CH_3$	Propanone
5. Carboxylic acid	-	oic acid	$H_3C-CH_2-\overset{\overset{O}{\Vert}}{C}-OH$	Propanoic acid
6. Single bond (alkane)	-	ane	$CH_3-CH_2-CH_3$	Propane
7. Double bond (Alkene)	-	ene	$CH_3-CH=CH_2$	Propene
8. Triple bond (Alkyne)	-	yne	$CH_3-CH\equiv CH$	Propyne

Q. How many structure isomers can you draw for pentane?
Q. What will be the formula and electron dot structure of cyclopentane?
Q. Draw the structure for the following compounds:
(i) Ethanoic acid (ii) Bromopentane (iii) Butanone (iv) Hexanal
Q. Draw the possible structural isomers for bromopentane.
Q. How would you name the following compounds?

(i) CH_3-CH_2-Br (ii) $H-\overset{\overset{H}{\vert}}{C}=O$

(ii) $$H-\underset{\underset{H}{\vert}}{\overset{\overset{H}{\vert}}{C}}-\underset{\underset{H}{\vert}}{\overset{\overset{H}{\vert}}{C}}-\underset{\underset{H}{\vert}}{\overset{\overset{H}{\vert}}{C}}-\underset{\underset{H}{\vert}}{\overset{\overset{H}{\vert}}{C}}-C\equiv C-H$$

CHEMICAL PROPERTIES OF CARBON COMPOUND:

All carbon compounds show more common characteristic properties. As most of the fuels we use are either carbons 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 substance:

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

$$C(s) + O_2(g) \xrightarrow{Combusion} CO_2(g) + Heat + light$$

Carbon Oxygen Carbon dioxide

Q. Why carbon and its compounds are used as fuels for most application?

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

$$CH_4(g) + O_2(g) \xrightarrow{Combusion} CO_2(g) + H_2O(g) + Heat + Light$$

Methane

Note: Natural gas and biogas contain methane. So, burning of natural gas and biogas are also combustion reactions.

Burning of LPG (Butane) produces CO2, H2O heat and light.

$$C_4H_{10}(g) + \frac{13}{2}O_2(g) \xrightarrow{Combustion} 4CO_2(g) + 5H_2O(g) + Heat + Light$$

Butane/LPG

- **COMBUSTION OF CELLULOSE:**

Combustion of cellulose (like wood, cotton cloth and paper) gives CO_2, H_2O heat and light. Cellulose is a carbohydrate and can be described by the formula $(C_6H_{10}O_5)_n$.

$$(C_6H_{10}O_5)_n(s) + 6nO_2(g) \xrightarrow{burn} 6nCO_2(g) + 5nH_2O(g) + Heat + light$$

Cellulose

- Combustion of alcohol:

$$C_2H_5OH(l) + 3O_2(g) \xrightarrow{burn} 2CO_2(g) + 3H_2O(g) + Heat + light$$

Ethanol oxygen (in air)

Activity: To observe the combustion of given organic compounds.
Materials: Benzene, naphthalene, Camphor, alcohol (ethanol). Spirit, acetone.

Procedure:
1. Take each compound on iron spatula and burn them in Bunsen burner.
2. Record the type of flame produced.
3. Put a metal plate above the flame and observe whether or not there in black carbon deposition.

Observation:

Compound used	Flame Produced	Deposit
Benzene	Smoky flame	Carbon deposited
Naphthalene	Smoky flame	Carbon deposited
Camphor	Smoky flame	Carbon deposited
Alcohol	Non-Luminous flame	No Carbon deposited
Spirit	Non-Luminous flame	No Carbon deposited
Acetone	Non-Luminous flame	No Carbon deposited

Conclusion:

Benzene, naphthalene, camphor burn with smoky flame and carbon particles get deposited they undergo incomplete combustion due to excess of carbon content.

- Alcohol, spirit and acetone burn with non-Luminous flame and no carbon gets deposited. They under go complete combustion, therefore produce more heat.

Activity: To study the different types of flames/presence of smoke.

Material required: Bunsen burner.

Procedure:
1. Light the Bunsen burner.
2. Close the air hole and observe the colour of the flame.
3. Put a metal plate over it and observe the nature of deposit.
4. Open the air regulator to allow flow of air.
5. Observe the colour of flame.
6. Put a metal plate and observe the nature of deposit.

Observation:

Air Regulator	Colour of flame	Nature of deposit	Nature of flame	Temperature
Closed	Yellow sooty flame	Black carbon deposited	Reducing flame	low
Open	Bluish flame	No black carbon deposited	Oxidising flame	High

Conclusion: Keep the air regulator open to get oxidizing, non-sooty flame which has high temperature and does not lead to black deposits.

COMBUSTION AND THE NATURE FO FLAME:

(i) Saturated hydrocarbon such as, methane, ethane, propane, butane and natural gas and LPG burn with a blue flame in the presence of sufficient/excess of air/oxygen.

(ii) In the presence of limited amount/of air/oxygen, saturated hydrocarbon, such as, methane, butane, etc give smoky flame.

(iii) Unsaturated hydrocarbon such as ethane, ethyne etc. burn with a luminous/yellow smoky flame.

(iv) The gas/kerosene stove used at home has inlets for air so that a sufficiently oxygen rich mixture is burnt to give a clean blue flame. If you carefully observe the bottoms of vessels getting blackened, it is clear indication that the air holes are blocked and the fuel is getting wasted.

(v) Fuels, such as coal and petroleum, have some amount of nitrogen and sulphur in them. Combustion of coal and petroleum results in formation of oxides of sulphur and nitrogen (such as sulphur dioxide, nitric oxide, nitrogen peroxide) which are major pollutants in the environment.

FORMATION OF COAL AND PETROLEUM:

Coal and petroleum have been formed from biomass which has been subjected to various biological can geological processes.

Coal is a naturally occurring black mineral and is a mixture of free carbon and compounds of carbon containing hydrogen, oxygen, nitrogen and sulphur. It is not only a good fuel but is also a source of many organic compounds.
It is found in coal mines deep under the surface of earth.

Coal is believed to be formed from fossils which got buried inside the earth during earthquakes and volcanoes which occurred about 300 million years ago. Due to huge pressure and temperature inside the earth and in the absence of air the fossils fuels (vegetable matter or wood, etc.) were converted into coal. The slow chemical processes of the conversion of wood into coal is called **carbonization.** Since coal is formed by slow carbonisation. of plants and fossils, it produces many important carbonisation products like peat, lignite, bituminous and anthracite etc. and is itself known as **fossil fuel.** Coal is also a **non-renewable source** of energy.

Petroleum is complex mixture containing various hydrocarbons (compounds of carbon and hydrogen) in addition to small amounts of other organic compounds containing oxygen, nitrogen, and sulphur. It is a dark coloured. viscous and foul smelling crude oil. The name petroleum is derived from Latin words: **"Petra"** meaning rock and **"oleum"** meaning oil. Since petroleum is found trapped between various rocks, it is also known as **rock oil.**

OXYDATION:

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

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

$$2C(s) + O_2(g) \rightarrow 2CO(g)$$

Carbon Oxygen(limited) Carbon monoxide

- $$C(s) + O_2(g) \rightarrow CO_2(g)$$

(excess) Carbon dioxide

- Hydrocarbon when oxidised give different product as follows:

$$CH_4(g) + 2O_2(g) \xrightarrow{Complete\ oxidation} CO_2(g) + 2H_2O(g)$$

Methane Oxygen(excess)

- $$2CH_4(g) + 3O_2(g) \xrightarrow{Incomplete\ oxidation} 2CO\ (g) + 4H_2O(g)$$

Methane Oxygen (Limited)

- Alcohols also give different products on oxidation depending upon the reaction conditions.

Example:
Alcohols on oxidation with certain oxidising agents such as chromic anhydride in acetic acid, yield corresponding aldehydes, whereas on oxidation with alkaline potassium permanganate (or acidified potassium dichromate) corresponding carboxylic acid is formed, as given below:

$$CH_3CH_2OH(l) + [O] \xrightarrow[CH_3COOH]{CrO_3in} CH_3CHO + H_2O$$

Ethanol Nascent oxygen Ethanal (an aldehyde)

$$CH_3CH_2OH(l) + 2[O] \xrightarrow[KMnO_4, Heat]{Alkaline} CH_3COOH + H_2O$$

Ethanoic acid

Activity: To study the reaction of ethanol with alkaline potassium permanganate:

Material required: Ethanol, alkaline $KMnO_4$, test tube.

Procedure:

- Take about 3 ml of ethanol in a test tube.
- Add 5% solution of alkaline $KMnO_4$ drop by drop into this solution.
- Observe the colour of alkaline $KMnO_4$ after adding initially as well as finally.

Observation: The colour of $KMnO_4$ gets discharged in the beginning. When excess of $KMnO_4$ is added, the colour of $KMnO_4$ does not disappear because whole of ethanol gets oxidised to ethanoic acid.

$$CH_3CH_2OH \xrightarrow[or\ K_2Cr_2O_7 / H_2SO_4, Heat)]{Alkaline, KMnO_4, Heat} CH_3COOH + H_2O$$

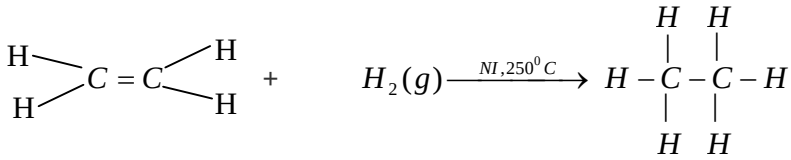
ADDITION REACTION:

All unsaturated hydrocarbons (unsaturated carbon compounds) react with a molecule like H2. X2. H2O 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.

Note: Catalysts are substance that cause a reaction to occur or proceed at a different rate without the reaction it say being affected.

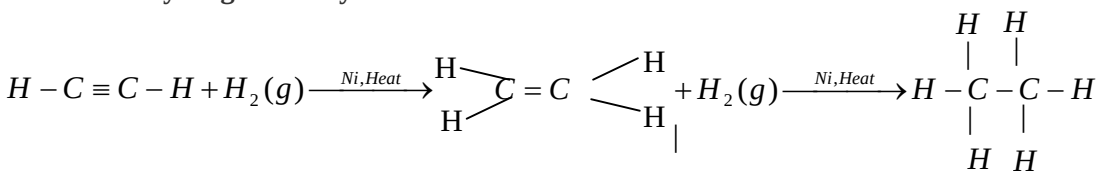
- **Addition of hydrogen to ethene:**



Ethene (Double bond containing unsaturated carbon compound) — Ethane (Saturated hydrocarbon)

Q. Which of the following hydrocarbons undergo addition reactions: C_2H_6, C_3H_8, C_3H_6, C_2H_2 and CH_4. **[NCERT]**

- **Addition of hydrogen to ethyne:**



Ethyne (acetylene) — Ethene (ethylene) — Ethane

- Addition of hydrogen to a unsaturated carbon compound is called **hydrogenation reaction.**
Certain vegetable oils such as ground nut oil, cotton seed oil and mustard oil, contain double bonds (C = C) 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 $\xrightarrow{Ni, Heat}$ Vanaspati Ghee (Saturated ghee)

Q. What is hydrogenation? What is its industrial application? **[NCERT]**

Q. If a molecule Y contain two –C = C- double bonds, then how many moles of H_2 are required for completed hydrogenation of one mole of Y? **[NCERT]**

Q. Write the industrial application of hydrogenation. **[NCERT]**

SUBTITUTION REACTION:

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

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

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

Chloromethane

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

Dichloromethane

$$CH_2Cl_2(g) + Cl_2(g) \xrightarrow{Sunlight} CHCl_3(g) + HCl(g)$$

Trichloromethane(chloroform)

$$CHCl_3(g) + Cl_2(g) \xrightarrow{Sunlight} CCl_4(l) + HCl(g)$$

Tetra chloromethane
(carbon tetra chloride)

Q.	Why is the conversion of ethanol to ethanoic acid an oxidation reaction?	**[NCERT]**
Q.	A mixture of oxygen and ethyne is burnt for welding. Can you tell why a mixture of ethyne and air is not used?	**[NCERT]**

SOME IMPORTANT CARBON COMPOUNDS:

ETHANOL (ETHYL ALCOHOL. C_2H_5OH):
Ethanol is the second member of the homologous series of alcohols.

Preparation: By the fermentation of carbohydrates (sugar or starch).

Ethanol is prepared on commercial scale by fermentation of sugar Fermentation is allowed to take place at 298-303 K in the absence of air. This is ethanol (ethyl alcohol) gets oxidised to ethanoic acid (acetic acid) in the presence of air.

$$C_{12}H_{22}O_{11} + H_2O \xrightarrow{Invertase} C_6H_{12}O_6 + C_6H_{12}O_6$$

Sucrose Glucose Fructose

$$C_6H_{12}O_6 \xrightarrow{Zymase} 2C_2H_5OH + 2CO_2(g)$$

Glucose/Fructose Ethanol (ethyl alcohol) Carbon dioxide

PHYSICAL PROPERTIES:

- Physical state /colour and odour: Pure ethanol is a colourless liquid having a pleasant smell and a burning taste.
- **Boiling and Freezing points:** It is a volatile liquid with a boiling point of 78.1^0C, and freezing point is -118^0C.
- **Density:** Ethanol is lighter than water as its density is 0.79 g ml^{-1} at 293 K.
- **Solubility:** Ethanol is miscible with water in all proportion, due to the formation of hydrogen bonds with water molecules.
- **Conductivity:** Ethanol is a covalent compound and does not ionise easily in water. Hence it is a neutral compound.
- **Action on Litmus:** Ethanol is a neutral compound So, it has no effect on the colour of litmus.

CHEMICAL PROPERTIES OF ETHANOL:

- **Combustion (or burning):** Ethanol is highly inflammable liquid and readily burn in air with blue flame to form water vapour, carbon dioxide and evolving heat. Thus, combustion of ethanol is an exothermic reaction.

$$C_6H_5OH(l) + 3O_2(g) \xrightarrow{Combustion} 2CO_2(g) + 3H_2O(g) + Heat$$

Q.	Carbon and its compounds are used as fuels. Give its main reason.	**[NCERT]**

- **Reaction with sodium metal:** Ethanol reacts with sodium metal to produce sodium ethoxide and hydrogen gas is evolved.

$$2C_2H_5OH(l) + 2Na(s) \rightarrow 2C_2H_5ONa + H_2(g)$$

Ethanol Sodium metal Sodium ethoxide Hydrogen

Activity: To study the reaction of ethanol with sodium metal.
Materials: Ethanol, dry piece of sodium metal test tube.

Procedure:

- Take ethanol in a test tube.
- Add a dry piece of sodium metal.
- Bring a burning matchstick near the gas evolved to test it and record observation.

Observation: The gas burns in air with a pop sound which is the characteristics of hydrogen gas.
Conclusion: Alcohol reacts with sodium metal to liberate hydrogen gas.

- **Reaction with ethanoic acid (Esterification reaction):**

The reaction in which an alcohol reacts with acetic acid in the presence of conc. H2SO4 to form an ester is called esterification.

$$CH_3COOH(l) + C_2H_5OH(l) \underset{}{\overset{\text{Conc. } H_2SO_4\text{, Heat}}{\rightleftharpoons}} CH_3COOC_2H_5(l) + H_2O(l)$$

ethanoic acid (acetic acid) ethanol ethyl ethanoate (ethyl acetate) Sweet smelling compound

Note: Ester is sweet-smelling compounds and is used for making perfumes.

- **Reaction with conc. sulphuric acid (Dehydration):**

Ethanol when heated with excess of concentrated sulphuric acid at 443 K, gets dehydrated to give ethene.

$$C_2H_5OH(l) + H_2SO_4(Conc.) \xrightarrow{443K} H_2C = CH_2(g) + H_2O(l)$$

ethanol excess ethene

Note: The concentrated sulphuric acid can be regarded as a dehydrating agent who removes water from ethanol.

Use of ethanol:

- Ethanol is present in alcoholic beverages such as beer, wine, and whisky.
- As a solvent for paints, varnishes-dyes, cosmetics, perfumes, soaps and synthetic rubber etc.
- Ethanol is used in cough syrups, digestive syrups and tonics.
- A mixture of 80% rectified spirit and 20% petrol is called **power alcohol.** It is used as fuel in cars and aeroplanes.
- A mixture of ethanol and water has lower freezing point than water this mixture is known as **antifreezing** and is used in radiators of vehicles in cold countries and at hill stations.
- As an antiseptic to sterilize wounds and syringes in hospitals.
- For the manufacture of terylene and polythene.
- As a preservative for biological specimens.
- Ethyl alcohol is used as hypnotic (induces-sleep).

Harmful effects of Alcohols:

- Consumption of small quantities of dilute ethanol causes drunkenness. Even though this practice is condemned, it is a socially widespread practice. However, intake of even a small quantity of pure ethanol (called **absolute alcohol**) can be lethal. Also long-term consumption of alcohol leads to many health problems.
- When large quantities of ethanol are consumed, it tends to slow metabolic processes and to depress the central nervous system. This results in lack of coordination, mental confusion, drowsiness, lowering of normal inhibitions and finally stupor (unconscious state of wild)
- Drinking of alcohol over a long period of time damages liver.

Denatured Alcohol:

Ethanol to which certain poisonous and nauseating substances like methyl alcohol, pyridine etc. have been added is termed **denatured alcohol.**

Note: To prevent the misuse of ethanol (Alcohol), industrial alcohol is coloured blue to that it can be recognized easily.

Harmful effects of denatured alcohol:

- Methanol is highly poisonous compounds for human beings. Methanol when taken, even in small amount, can cause death.
- Methanol gets oxidised to methanal in the liver, which causes coagulation of protoplasm.
- Methanol also effects the optic nerve and cause blindness.

ETHANOIC ACID (ACETIC ACID) CH_3COOH:

- Ethanoic acid is commonly called acetic acid and belongs to the homologous series of carboxylic acid and is represented as CH_3COOH.
- 5-8% solution of acetic acid in water is called **vinegar** and is used for preservation foods like sausage, pickles. **Physical properties:**
- At ordinary temperature, ethanoic acid is a colourless liquid with a strong pungent smell and sour taste.
- Its boiling point is 391 K and its density at 273 K is 1.08 (heavier than water).
- It is miscible with water due to the formation of hydrogen bonds with water molecules.
- On cooling at 289.6K, it turns in ice-like crystals, hence named as glacial acetic acid.
- It dissolves sulphur, iodine and many other organic compounds.
- It dimerise when dissolved in benzene.
- $2CH_3COOH \rightleftharpoons (CH_3COOH)_2$

  Ethanoic acid Dimer

Activity: To determine pH of acetic acid and hydrochloric acid.
Material: Acetic acid (1M).HCl (1M), blue litmus paper, universal indicator.
Procedure: Take two strips of blue litmus paper.

- Put a few drops of HCl on one of them and few drops of acetic acid on the other.
- Observe the change in colour.
- Take 1 ml of acetic acid in a test tube and add a few drops of universal indicator.
- Take 1ml of HCl in a test tube and add few drops of universal indicator.

Observation: Both acetic acid and HCl turn blue litmus red showing that they are acidic in nature. pH of acetic acid and HCl are not equal.

Conclusion: HCl is strong acid than CH_3COOH, therefore, pH of HCl will be lower than that of acetic acid.

CHEMICAL PROPERTIES:

- **Reaction with alcohols (Esterification reaction):**

Ethanoic acid reacts with ethanol in the presence of cons. H_2SO_4 to form ethyl ethanoate which is an ester.

$$CH_3COOH(l) \quad + \quad C_2H_5OH(l) \xrightarrow{Conc, H_2SO_4, heat} CH_3COOC_2H_5 \quad + \quad H_2O$$

Ethanoic acid Ethanol Ethyl ethanoate (ester)

The reaction of carboxylic acid with an alcohol to form an ester is called **"esterification".**

Note: Ester can be hydrolysed in the presence of an acid or a base to give back the parent carboxylic acid and the alcohol.

Example:

(i) Ethyl ethanoate on acid hydrolysis gives ethanoic acid and ethanol.

$$CH_3COOC_2H_5(l) \quad + \quad H_2O(l) \quad \rightarrow \quad CH_3COOH(aq.) \; + \; C_2H_5OH$$

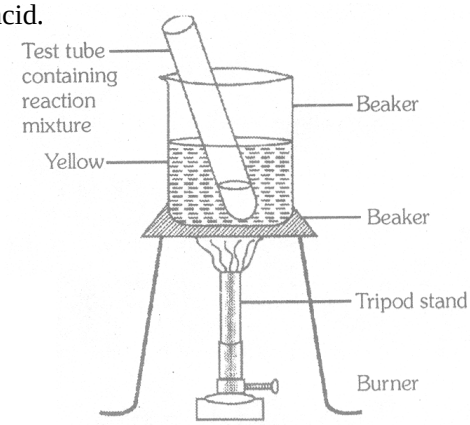
(ii) Hydrolysis of ester in the presence of base (alkali) is called **"Saponification reactions".**

$$CH_3COOC_2H_5(l) \quad + \quad NaOH(aq) \rightarrow CH_3COONa \quad + \; C_2H_5OH$$

Ethyl ethanoate Sodium Hydroxide Sodium ethanoate Ethanol

Note: Alkaline hydrolysis of higher esters is used in the manufacture of soaps.

Activity: To study the esterification process using ethanol and acetic acid.



Materials: Beaker, water, test tube, ethanol, acetic acid. Conc. H_2SO_4 etc.

Procedure: Take 2ml of ethanol in a test tube.

- Add 2ml of ethanoic acid (acetic acid) in to it.
- Add few drops of conc. H_2SO_4.
- Warm it in a beaker containing water.

Observation: Pleasant fruity smelling compound (called ester) is formed.

Conclusion: Acetic acid reacts with alcohol in presence of conc. H2SO4 which act as a dehydrating agent to form ester.

Reaction with sodium carbonate and sodium hydrogen carbonate:

Ethanoic acid decomposes sodium hydrogen carbonate and sodium carbonate with a rapid evaluation of carbon dioxide gas.

$$NaHCO_3(aq) + CH_3COOH(aq) \rightarrow CH_3COONa(aq) + H_2O(l) + CO_2(g)$$

Sodium Hydrogen carbonate ethnic acid Sodium ethanoate

$$Na_2CO_3(aq) + 2CH_3COOH(aq) \rightarrow 2CH_3COONa(aq) + H_2O + CO_2(g)$$

Sodium carbonate Ethanoic acid Sodium ethanoate

Note: Reactions of ethanoic acid with NaOH, NaHCO3, Na2CO3 and active metals show that the hydrogen present in the carboxy (-COOH) group is acidic in nature.

Activity: To study the reaction of carboxylic acid with sodium carbonate and sodium hydrogen carbonate.

Material: Ethanoic acid, Sodium carbonate, Sodium hydrogen carbonate.

Procedure:

- Take 1g of Na2CO3 and 2ml of ethanoic acid into it.
- Pass the gas formed through lime water and note down the observation.
- Repeat the same procedure with sodium hydrogen carbonate and record observation.

Observation: Brisk effervescence due to carbon dioxide formed which turns lime water milky.

Conclusion: Acetic acid reacts with Na_2CO_3 and $NaHCO_3$ to liberate CO_2 gas.

USES OF ETHANOIC ACID:

- Ethanoic acid is used in the manufacture of various dyes, perfumes and rayon.
- It is used for making vinegar.
- It is used for making white lead [$2PbCO_3$. Pb $(OH)_2$]which is used in white paints.
- Its 5% solution is bactericidal (destroys bacteria).
- It is used in preparation of cellulose acetate which is used for making photographic film.
- It is used for coagulation of the latex.
- It is used for preparation of 2,4-dichloro phenoxy ethanoic acid which is used as **herbicide.**
- Aluminium acetate and chromium acetate are used as mordants in dyeing and water proofing of fabrics.

Q. How would you distinguish experimentally between an alcohol and a carboxylic acid? **[NCERT]**

Q. What are oxidizing agents? **[NCERT]**

Q. How can ethanol and ethanoic acid be differentiated on the basis of their physical and chemical properties? **[NCERT]**

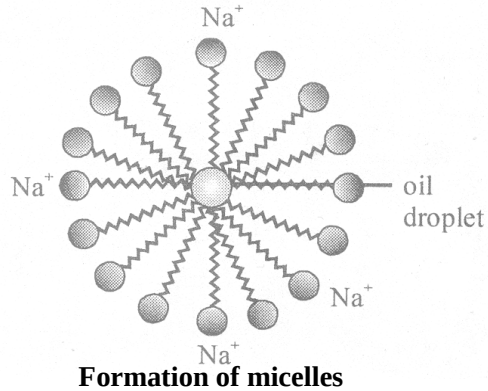
SOAP AND DETERGENTS:

Soap and detergents are substances which are used for cleaning. There are two types of detergents:

1. Soap 2. Synthetic detergents

Soap: A soap is the sodium or potassium salt of a long-chain fatty acids (carboxylic acid or glycerol).

Activity:



Formation of micelles

Take about 10mL of water each in two test tubes.
Add a drop of oil (cooking oil) to both the test tubes and label them as A and B.
To test tube B, add a few drops of soap solution. Now shake both the test tubes vigorously for the same period of time.
Can you see the oil and water layers separately in both the test tubes immediately after you stop shaking them. Leave the test tubes undisturbed for some time add observe. Does the oil layer separate out? In which test tube does this happen first?
This activity demonstrate effect of soap in cleansing as we know that most of the dirt is oily in nature and oil does it dissolve in water.
But know the question arise what are soap? What is the detergent which one is more effect? How the work.
Soap is sodium or potassium salt a long change fatty acid (Carboxylic acid or Glycerol)

Soap has large non ionic hydrocarbon group and an ionic group. COONa.

Ex. of soap is:

(1) Sodium stearate ($C_{17}H_{35}COONa$)

(2) Sodium palmitate ($C_{15}H_{31}COONa$)

Soap is basic in nature so soap solution turns red litmus to blue.

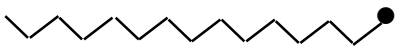
Preparation of Soap:

The soap is prepared by heating animal fats or vegetable oils (olive oils, castor oil or palm oil) with sodium hydroxide or potassium hydroxide.
The process of formation of soap by the hydrolysis of fat or oil with alkali is called saponification.
Oil or Fat + Sodium hydroxide → Soap + glycerol

Structure:

- A soap molecule contains two parts that interact differently with water. One part is a long hydrocarbon (non-polari) chain, and other belongs to the-COONa group (Hydrophilic).

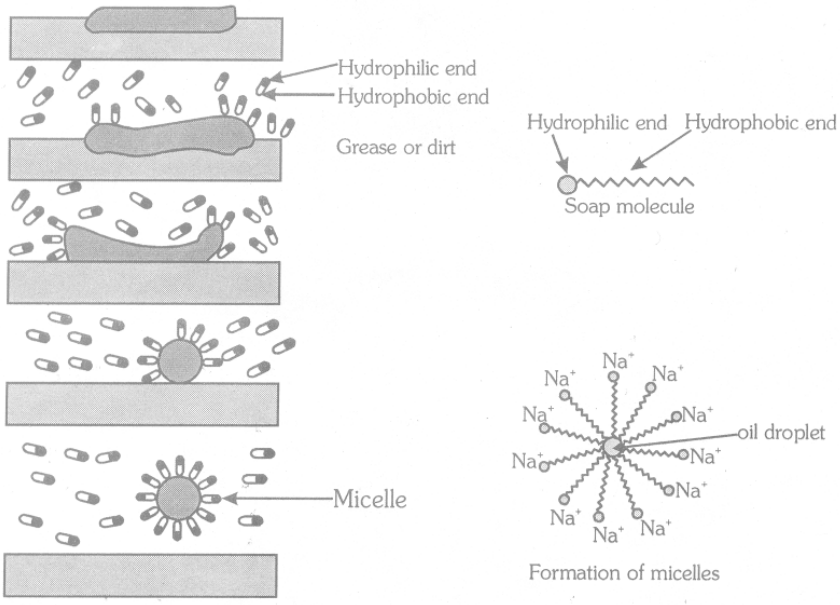
A soap molecule may be represented as:



$$R-\underset{\underset{O}{\|}}{C}-O^{-}\,Na^{+}$$

Cleansing action of soap:

The molecules of soap are sodium or potassium salts of long chain carboxylic acids, the ionic end of soap dissolves in water while the carbon chain dissolves in oil. The soap molecules thus form structures called micelles where one end of the molecules is towards the oil droplet while the ionic end faces outside. This form and emulsion in water. The soap micelle thus helps in dissolving the dirt in water and we can wash out clothes clean.



Effect of soap in cleaning

Q.	Why does micelle formation take place when soap is added to water? Will a micelle be formed in other solvents such as ethanol also? **[NCERT]**
Q.	Explain the mechanism of the cleaning action of soaps. **[NCERT]**

Activity: Take two clean test tubes and label them as 'A' and 'B'. Now put 10ml hard water in each of the two test tubes. Add five drops of soap solution in test tube 'A' and five drops of detergent solution in test tube 'B' Shake the two test tubes for the same period and observe if both observe if both the test tubes have the same amount of foam. Find out in which of the two test tubes a curdy white mass is formed.

In which test due do you get more form?

We get more foams in test tube……..

A white curdy precipitate is formed in test tube…….

Result (Conclusion): Soaps are not effective in acidic medium.

When soaps is used for washing clothes with hard water, a large amount of soap is wasted in reacting with the calcium and magnesium ions of hard water to form an insoluble precipitate called scum, before it can be used for the real purpose of washing soap. A large amount of soap is needed for washing clothes. When the water is hard.

Activity:

Take two test tubes with a about 10 mL of hard water in each.
Add five drops of soap solution to one and five drops of detergent solution to the other.
Shake both test tubes for the same period
Do both test tubes have the same amount of foam?
In which test tube is a curdy solid formed?

Observation:

Test tube in which ……..is present contain more amount of foam.
Curdy solids is form in the test tube containing…….

Conclusion: Detergents have better cleansing action than soap. Detergents are generally ammonium or sulphonate salts of long chain carboxylic acids. The charged ends of these compounds do not form insoluble precipitates with the calcium and magnesium ions in hard water. Thus, they remain effective in hard water. Detergents are usually used to make shampoos and products for cleaning clothes.

Q. What change will you observe if you test soap with litmus paper (red and blue)? **[NCERT]**
Q. Would you be able to check if water is hard by using a detergent?
Q. People use a variety to methods to wash clothes. Usually after adding the soap, they 'beat' the clothes on a stone, or beat it with a paddle, scrub with a brush or the mixture is agitated in a washing machine. Why is agitation necessary to get clean clothes?

DIFFERENCES BETWEEN SOAPS AND SYNTHETIC DETERGENTS:

Soaps	**Synthetic detergents**
1. Soaps are sodium salts of long chain fatty acid (carboxylic acids)	**1.** Synthetic detergents are the sodium salts or long-chain benzene sulphonic acids or the sodium salt of a long. chain alkyl hydrogen sulphate
2. The ionic part of soap is $-COO^{-}Na^{+}$	**2.** The ionic part in a synthetic detergents is $-SO_3H-Na^{+}$
3. They are prepared from animal fats or plant based oils.	**3.** The are prepared from hydrocarbons extracted from coal or petroleum.
4. Their efficiency decreases in hard water	**4.** Their efficiency is unaffected in hard water.
5. Soaps take more time to dissolve in water.	**5.** Synthetic detergents dissolve faster than soaps in water
6. They are biodegradable	**6.** Some synthetic detergents are not biodegradable.
7. Examples: Sodium state, sodium palmitate	**7. Example:** Sodium lauryl sulphate, sodium dodecyl benzene sulphonate.

SOAP:

$$\begin{array}{l} C_{17}H_{35}COO-CH_2 \\ \qquad\qquad\qquad | \\ C_{17}H_{35}COO-CH \\ \qquad\qquad\qquad | \\ C_{17}H_{35}COO-CH_2 \end{array} + 3NaOH \rightarrow 3C_{17}H_{35}COONa$$

Glycerol stearate (fatty acid) + Sodium hydroxide → Sodium stearate(soap)

Structure:

- The hydrocarbon chain is non-polar and water-hating (hydrophobic), while the other part is polar or water loving (hydrophilic).
- Hydrophilic part makes the soap soluble in water and hydrophobic part makes the soap insoluble.

$$\underbrace{CH_3CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2}_{\text{Hydrophobic "Tail" (Non-polar part)}}\ \underbrace{-\overset{\overset{O}{\|}}{C}-O-Na^+}_{\text{Hydrophilic "head" (Polar part)}}$$

- When soap is added to water, the soap molecules assume a configuration which increases the interaction of the water loving heads with the water molecules, and decreases the interaction between the water hating tails with the water molecules.
- The hydrophobic part of the soap molecules traps the dirt and the hydrophilic part makes the entire molecules soluble in water. Thus, the dirt gets washed away with the soap.
- The water-hating, non polar tails clump together in a radial fashion with the water-loving. Polar heads remaining at the periphery of the clump, these clumps or droplets of soap molecules are called micelles.

Disadvantage of soap:

- **Soaps are not effective in hard water:** Hard water contains calcium ions (Ca^{2+}) and magnesium ions (Mg^{2+}) These ions react with the carboxylate ions (RCCO-) of the soap forming an insoluble precipitate called scum, For example, soap like sodium stearate (C17H35COONa) reacts with calcium and magnesium ions as per the following chemical equation.

$$2C_{17}H_{35}COONa + Ca^{2+}(aq) \rightarrow (C_{17}H_{35}COO)_2Ca \downarrow + 2Na^+(aq)$$

Sodium stearate (In hard water) Calcium stearate Sodium ion

$$2C_{17}H_{35}COONa + Mg^{2+}(aq) \rightarrow (C_{17}H_{35}COO)_2Mg \downarrow + 2Na^+(aq)$$

Sodium stearate (In hard water) Magnesium stearate (scum) Sodium ion

The scum gets attached to the clothes, utensils and even skin and thus, interferes with the cleansing ability of the additional soap and makes the cleansing of clothes difficult. Moreover, large amount of soap is wasted in reacting with calcium and magnesium ions present in hard water.

Q.	Explain the formation of scum when hard water is treated with soap.	**[NCERT]**

- **Soaps are not effective in acidic medium:** In presence of hydrogen ions (H ions), i.e. in acidic medium, the carboxylate ions of soap ($RCOO^-$ion)interact with hydrogen ions (H^+) to form undissociated (free) fatty acid as represented below:

$$C_{17}H_{35}COO^-(aq) + H^+ \rightleftharpoons C_{17}H_{35}COOH$$

carboxylate ion Carboxylic acid (Unionised)

As the fatty are weak acids, so they do not get ionised and hence, micelle formation is hindered, thus, adversely affecting the cleansing property of soaps.

You will observe that the amount of foam in the two test tubes in different. The foam is formed to a greater extent in test tube 'B' (containing detergent solution), while formation of a curdy white mass will be observed in test tube 'A'. This activity clearly indicates that detergents can be used for cleansing purpose, even with hard water.

SYNTHETIC DETERGENTS:

- Synthetic detergents are called soapless soap because they are not prepared from **fatty acid** and **alkali.**

- Synthetic detergents are sodium salts of sulphonic acids, i.e. detergents contain a sulphonic acid group (-SO_3H). instead of a carboxylic acid group (-COOH), on one end of the hydrocarbon chain.

$$CH_3CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2C_6H_4 - \underset{\underset{O}{|}}{\overset{\overset{O}{|}}{S}} - O^- - Na^+$$

Hydrophobic "Tail"
(Non-polar part)

Hydrophilic "head"
(Polar part)

Properties of synthetic detergents:

- Synthetic detergents do not react with the ions present in hard water. Hence synthetic detergents have no problem in forming lather with hard water, i.e. their efficiency is not affected by hard water.

- Synthetic detergents can be used even in acidic solution and sea water, whereas soap cannot be used in the acidic solution (due to precipitation of free acids)

- Synthetic detergents do not form insoluble salts of calcium or magnesium with hard water. Hence, lesser amounts of synthetic detergents are required for washing.

Washing powder:

- Washing powders used for washing clothes contain only about 15 to 30 percent detergents by mass. The remaining part is made of the following.

  (1) Sodium sulphate and sodium silicate which keep the power dry,

  (ii) Sodium tripolyphosphate or sodium carbonate which maintains alkalinity for removing dirt.

  (iii) carboxymethyl cellulose (CM- cellulose) which keep the dirt particle suspended in water.

  (iv) Sodium perborate (a mild bleaching agent) which impart whiteness to the materials (clothes, etc.) being washed.

PREVIOUS YEARS' BOARD QUESTIONS:

1. An organic compound 'A' has molecular formula $C_2H_4O_2$ and is acidic in nature. On heating with alcohol and conc. sulphuric acid, vapours with pleasant or fruity smell are given out, what is this chemical compound 'A' and what is the chemical equation involved in the reaction? **(CBSE ALL India 1999)**

Ans. The compound 'A' with molecular formula $C_2H_4O_2$ is ethanoic acid (acetic acid). Upon heating with ethanol (ethyl alcohol) and concentrated sulphuric acid, ethyl ethanoate (ethyl acetate) is formed as the product. It is an ester with pleasant or fruity smell. The reaction is known as esterification reaction.

$$CH_3COOH + C_2H_5OH \xrightarrow{H_2SO_4(conc.)} CH_3COOC_2H_5 + H_2O$$

Ethanoic acid (A) Ethanol Ethyl ethanoate (Ester)

2. An organic compound 'A' is a constituent of antifreeze and has the molecular formula C_2H_5O. Upon reaction with alkaline $KMnO_4$, the compound 'A' is oxidised to another compound 'B' with formula C_2H_6O, Identify the compounds 'A' and 'B'. Write the chemical equation for the reaction which leads to the formation of 'B'. **(CBSE ALL India 2000 Comptt.)**

Ans. The compound 'A' is ethanol and with alkaline KMnO4, it is oxidised to ethanoic acid 'B'. The chemical equation for the reaction is:

$$C_2H_5OH \xrightarrow[KMnO_4]{Alkaline} CH_3COOH$$

Ethanol (A) Ethanoic acid (B)

3. Name the functional groups present in the following compounds:

(i) $CH_3-CH_2-CH_2-OH$ (ii) $CH_2-CH_2-CH_2-COOH$

(iii) CH_3-CH_2-CHO (iv) $CH_3-CO-CH_2-CH_3$

Ans. (i) $-OH(ol)$ (ii) $-COON(oic\ acid)$ (iii) $-CHO(al)$ (iv) $-CO-(one)$

4. Write the formulae of the compounds and name the functional groups present in each of them

(i) Ethanoic acid (ii) Propanone (iii) Nitromethane **(C.B.S.E. Delhi 2005)**

Ans. (i) Ethanoic acid : CH_3COOH (oic acid)

(ii) Propanone : CH_3COCH_3 (one)

(iii) Nitromethane: CH_3NO_2 (nitro)

5. Name the enzyme which converts:

(i) milk into curd (yogurt)

(ii) cane sugar into glucose and fructose

(iii) glucose into ethanol.

Ans. (i) Lactase converts milk into curd

(ii) Invertase converts cane sugar (sucrose) into glucose and fructose

(iii) Zymase converts glucose into ethanol. **(C.B.S.E. Foreign 2005)**

6. (i) Name the gas evolved during fermentation process. **(C.B.S.E. Delhi 2006)**

(ii) List the two products formed when enzyme invertase acts on sugar present in molasses.

Ans. (i) CO_2 gas is evolved accompanied by brisk effervescence.

(ii) Glucose and fructose are the products when enzyme invertase acts on sucrose ($C_{12}H_{22}O_{11}$) present in molasses.

7. Complete the following equations and write the names of the products formed. **(C.B.S.E. Delhi 2007)**

(i) $CH_3COOH + NaOH \xrightarrow{Heat}$ (ii) $C_2H_5OH + O_2 \xrightarrow[KMnO_4]{Alkaline}$

(iii) $CH_3COOH + C_2H_5OH \xrightarrow{conc.H_2SO_4}$

Ans. (i) $CH_3COOH + NaOH \xrightarrow{Heat} CH_3COOH + H_2O$

Ethanoic acid Sod. ethanoate

(ii) $C_2H_5OH + O_2 \xrightarrow[KMnO_4]{Alkaline} CH_3COOH + H_2O$

Ethanol Ethanoic acid

(iii) $CH_3COOH + C_2H_5OH \xrightarrow{conc.H_2SO_4} CH_3COOC_2H_5 + H_2O$

Ethanoic acid Ethanol Ethyl ethanoate

8. Name the organic compound present in vinegar. Write a chemical equation which represents the commercial method for the preparation of this compound from methanol. **(C.B.S.E. All India 2007)**

Ans. The organic compound present in vinegar is ethanoic acid also called acetic acid. For its commercial preparation.

9. (a) Why does carbon form compounds by covalent bonding?

(b) An organic acid 'X' is a liquid which often freezes during winter time in cold countries. It has the molecular formula $C_2H_4O_2$. On warming with ethanol in the presence of a few drops of sulphuric acid, a compound 'Y' with sweet smell is formed.

(i) Identify X and 'Y'. (ii) Write chemical equation for the reaction involved. **(C.B.S.E. Delhi 2008)**

Ans. (a) Carbon forms a large number of organic compounds due to the self linking property known as catenation.

(b) The available information suggests that the organic acid X with molecular formula C2H4O2 is ethanoic acid (CH_3COOH). It reacts with ethanol in the presence of a few drops of sulphuric acid on warming to give ethyl ethanoate ester with a pleasant smell.

$$CH_3COOH + C_2H_5OH \xrightarrow[Warm]{H_2SO_4(Conc.)} CH_3COOC_2H_5 + H_2O$$

($C_2H_4O_2$) Warm Ethyl ethanoate (Y)

Ethanoic acid (X)

10. Why do covalent compounds have low melting and boiling points? **(C.B.S.E. All India 2008)**

Ans. In covalent compounds, the atoms are linked by covalent bonds formed by electron sharing. Since no ions are present in these, the attractive forces are quite weak. As a result, the covalent compounds have low melting and boiling points.

11. (i) How are carboxylic acids different from mineral acids from ionisaton point of view?

(ii) Describe an activity to find how ethanoic acid reacts with sodium carbonate. Name the gas evolved. How can it be tested? **(C.B.S.E All India 2008)**

Ans. (i) Carboxylic acids (organic acids) are less ionised in solution as compared to mineral acids (HCl, HNO3, H2SO4 etc.) Due to this reason, these are weaker acids than the mineral acids.

(ii) Take a small volume of ethanoic acid in a tube. Add a few drops of sodium carbonate (Na2CO3) solution prepared in water to the tube. A colourless gas with brisk effervescence will evolve. When the gas is passed through lime water, it will become milky.

$$Na_2CO_3(aq) + CH_3COOH(aq) \rightarrow CH_3COONa(aq) + H_2O(l) + CO_2(g)$$

$$Ca(OH)_2(aq) + CO_2(g)) \rightarrow CaCO_3(s) + H_2O(l)$$

Lime water (Milky)

12. (a) What is a functional group in a carbon compound? Identify the functional group present in CH_3COOH and C_2H_5OH.

(b) State the principle on which the cleansing action of soap is based. **(C.B.S.E. Foreign 2008)**

Ans. (a) Functional group may be defined as an atom or group of atoms upon which the properties of a particular organic compound are based. Different families differ in the functional groups.

Functional group in $CH_3COOH : (-COOH)$

Functional group in $C_2H_5OH : (-OH)$

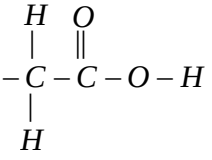
(b) The cleansing action of soap is based on its tendency to act as a bridge between water and oil drops containing dirt particles. As a result, oil and water get mixed. They form a stable emulsion also called micelle. This helps in removing oil drops containing dirt particles from clothes. The clothes become clean.

13. (a) Draw the structure of the following compounds

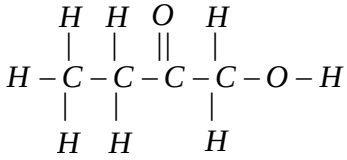
(i) Ethanoic acid (ii) Butanone.

(b) Why is conversion of ethanol to ethanoic acid considered an oxidation reaction? **(C.B.S.C. Foreign 2008)**

Ans. (a)



Ethanoic acid



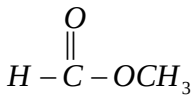
Butanone

(b) When ethanol (C2H5OH) changes with ethanoic acid (CH3COOH)

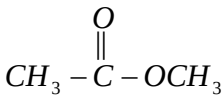
- There is a decrease in the number of hydrogen atoms by two.
- There is an increase in the number of oxygen atoms by one. Therefore, the conversion represents an oxidation reaction.

14. (a) What are esters? How are they formed? (b) Write two uses of ester? **(CBSE Foreign 2008)**

Ans. (a) Esters are the group of organic compounds which contain the function group ($-COOR$) called ester group. The value of R may change as $-CH_3$, $-C_2H_5$, $-C_3H_7$ etc. A few example of esters are:



Methyl methanoate



Methyl ethanoate

Esters are formed as a result of chemical reaction called esterification.

Uses of esters

(i) Esters have pleasant smell. These are used as flavouring agents and also in perfumes.

(ii) Esters of glycerol known as triglycerides are used in the manufacture of soaps. This reaction is called saponification reaction.

15. Distinguish between esterification and saponification reactions of organic compounds.

(C.B.S.E. All India 2008)

Ans. (a) In the esterification reaction an acid reacts with alcohol in the pressure of conc. H2SO4 to form an ester with a pleasant or fruity smell. For example,

$$CH_3COOH + C_2H_5OH \xrightarrow{H_2SO_4(Con.)} CH_3COOC_2H_5 + H_2O$$

Ethanoic acid Ethanol Ethyl ethanoate (ester)

Saponification is quite different from esterification because in this case an ester reacts with an alkali (NaOH or KOH) to form salt of acid and alcohol. For example,

$$C_3COOC_2H_5 + NaOH \rightarrow CH_3COONa + C_2H_5OH$$

Ethyl ethanoate Sod. ethanoate Ethanol

16. (a) In organic compounds, which part largely determines the physical and chemical properties.

(CBSE All India, 2008)

(b) Write chemical equation to represent the reaction of ethanol with acidified solution of potassium dichromate.

Ans. (a) In organic compounds, it is the functional group which largely determines the physical and chemical properties of compounds. Actually, and organic compound is made up of two parts. These are alkyl group and the functional group. Whereas the alkyl group remains the same (size may change) but the functional groups change. These are responsible for the characteristics of the compounds. For example, the properties of alkanols ($-OH$ is the functional group) are different from those of alkanoic acid ($-COONa$ is the functional group). For more details, consult text part.

(b) Acidified solution of potassium dichromate ($K_2O_2O_7$) forms chromic acid (H_2CrO_4). It releases oxygen to bring about the oxidation of ethanol first to ethanal and then to ethanoic acid.

$$\underset{\text{Ethanol}}{CH_3-CH_2-OH} \xrightarrow[-H_2O]{(O)} \underset{\text{Ethanal}}{CH_3-\overset{\overset{H}{|}}{C}=O} \xrightarrow{(O)} \underset{\text{Ethanoic acid}}{CH_2-\overset{\overset{OH}{|}}{C}=O}$$

17. Give reason for the following:

(a) Air holes of the gas burners have to be adjusted when heated vessels get blackened by the flame.

(b) Use of synthetic detergents causes pollution problems. **(C.B.S.E. Delhi, 2009)**

Ans. (a) In case the vessel where cooking is done get blackened from outside, this means that combustion is incomplete. As a result, the carbon particles in the form of soot get deposited and the vessel becomes black from outside. In order to check this, oxygen or air supply must be increased. This can be done only by adjusting the air holes of the gas burner.

(b) The pollution problems caused by the synthetic detergents is due to their non-biodegradable nature. These are actually long chain organic compounds which do not break or decompose in water. Naturally, this will result in pollution problems. Some of the detergents are even of toxic nature and will make water unfit for drinking.

- Carbon is versatile element that forms the basis of all living things.
- Carbon can from a vast variety of compounds because of its tetravalency and the property of catenation.
- Covalent bonds are formed between two similar or different atoms by sharing electron in their valence shell, Such that both of them can achieve the structure of nearest noble gas.
- Carbon forms covalent bonds with itself as well as atoms of hydrogen, oxygen, nitrogen, sulphur and halogens.
- Carbon can form compounds having a straight chain between carbon atoms with a single bond, or double bond or triple bond. It can also form compounds with branched chains and closed chains.
- Homologous series of carbon compounds is a group of carbon compounds having the same functional group with the same general formula.
- The functional groups such as alcohols, aldehydes, ketones, carboxylic acids and halogens impart characteristic properties to the carbon compounds.
- Carbon and its compounds are the major sources of fuels.
- Ethanol and ethanoic acid are most important compounds of carbon in our daily life.
- The soaps and detergents have cleansing action, because of the presence of hydrophobic and hydrophilic groups in their molecules, which help in emulsifying oil, and hence, in the removal of dirt.

EXERCISE #1 CARBON &ITS COMPOUNDS

1. Ethane, with the molecular formula C_2H_6 has (NCERT)
(A) 6 covalent bonds (B) 7 covalent bonds (C) 8 covalent bonds (D) 9 covalent bonds

2. Butanone is a four-carbon compound with the functional group (NCERT)
(A) Carboxylic acid (B) aldehyde (C) ketone (D) alcohol

3. While cooking. If the bottom of the vessel is getting blackened on the outside, it means that (NCERT)
(A) the food is not cooked completely (B) the fuel is not burning completely
(C) the fuel is wet (D) the fuel is burning completely

4. A covalent bond is formed by
(A) complete transfer of electrons (B) one sided sharing of electron
(C) mutual sharing of electron (D) all of the three above.

5. Which of the following compounds does not contain a multiple bond?
(A) Ethane (B) Ethene (C) Ethyne (D) Benzene

6. Which of the following is not a saturated hydrocarbon?
(A) Cyclohexane (B) Benzene (C) Butane (D) Isobutane

7. Benzene with molecular formula, C_6H_6, has
(A) 6 single bonds and 6 double bonds (B) 12 single bonds and 3 double bonds
(C) 18 single bonds only (D) 12 double bonds only

8. The functional group in methanol and methanol and methanal respectively are:
(A) $-OH, -CHO$ (B) $-CHO, -OH$ (C) $-OH, -COOH$ (D) $-CHO, -COOH$

9. Which of the following is not an allotropic form of carbon?
(A) Coal (B) Fullerene (C) Diamond (D)Graphite

10. Graphite is a soft lubricant extremely difficult to melt. The reason for this anomalous behaviour is that graphite
(A) has carbon atoms arranged in large plates of rings of strongly bound carbon atoms with weak centerplate bonds.
(B) is a non-crystalline substance
(C) is an allotropic form of carbon
(D) has only single bonds between carbon atoms

11. Which of the following represent the correct order of unsaturation?
(A) Alkanes, alkenes, alkynes (B) Alkanes, alkynes, alkenes
(C) Alkenes, alkynes, alkenes (D) Alkynes, alkanes, alkenes

12. The general formula of alcohol is
(A) $C_nH_{2n+2}OH$ (B) $C_nH_{2n+1}OH$ (C) C_nH_{2n-1} OH) (D) $C_nH_{2n+4}OH$

13. Wine contains
(A) CH_3OH (B) C_6H_5OH (C) C_2H_5OH (D) CH_3COOH

14. The acid present in vinegar is
(A) CH_3COOH (B) HCOOH
(C) CH_3CH_2COOH (D) $CH_3CH_2CH_2COOH$

15. The reaction $2C_2H_5OH + 2Na \rightarrow 2C_2H_5ONa + H_2$ suggests that ethanol is
(A) Acidic in nature (B) Basic in nature (C) Amphoteric (D) Neutral

16. Which of the following substance is added to denature ethanol?
(A) Methanol (B) Benzene (C) Copper nitrate (D) Poison

17. Which of the following substances cannot be used to distinguish ethanol from ethanoic acid?
(A) Na metal (B) $NaHCO_3$
(C) hot alkaline $KMnO_4$ (D) hot acidified $K_2Cr_2O_7$ solution

18. An example of soap is
(A) CH_3COONa (B) CH3ONa (C) $C_{17}H_{35}COONa$ (D) $C_{17}H_{35}COOC_2H_5$

19. Detergents are sodium or potassium salts of long chain
(A) aldehydes (B) ketones (C) carboxylic acids (D) sulphonic acids

20. Which of the following salts when dissolved in water produce hard water?
(A) Calcium sulphate (B) Magnesium bicarbonate
(C) Calcium chloride (D) Any of the above

21. Which of the following represents Lewis structure of N_2 molecule?

(A) $^{\times}_{\times}N \equiv N^{\times}_{\times}$ (B) $^{\times\times}_{\times}N \equiv N^{\times\times}_{\times}$ (C) $^{\times\times}_{\times}N - N^{\times\times}_{\times}$ (D) $^{\times\times}_{\times}N = N^{\times\times}_{\times}$

22. Which of the following has the shortest carbon-carbon bond length?
(A) C_2H_2 (B) C_2H_4
(C) C_2H_6 (D) All have the same bond length

23. Which of the following has the weakest carbon-carbon bond strength?
(A) C_2H_2 (B) C_2H_4
(C) C_2H_6 (D) All have the same bond length

24. The hydrocarbon with the general formula C_nH_{2n+n} is an-

(A) Alkane (B) Alkene
(C) Alkyne (D) unsaturated compounds

25. Which of the following is an alkyne?

(A) C_6H_6 (B) C_6H_{12} (C) C_6H_{10} (D) C_6H_{14}

EXERCISE #2 CARBON &ITS COMPOUNDS

1. Which of the following will not decolourise bromine water?
(A) C_4H_8 (B) C_3H_4 (C) C_3H_8 (D) C_4H_6

2. Compounds made up of carbon and hydrogen only are called
(A) Alkanes (B) Alkenes (C) Alkynes (D) Hydrocarbons

3. Open-chain saturated hydrocarbons are called
(A) Paraffins (B) Alkenes (C) Alkynes (D) Alkyl groups

4. The characteristic reaction of alkanes is
(A) Addition (B) Substitution (C) Pollymerization (D) Isomerization

5. The major constituent of biogas is
(A) Propane (B) Acetylen (C) Methane (D) Benzene

6. n-butane and isobutane are
(A) Alkenes (B) Alkynes (C) Isomers (D) None of these

7. Methane is a major constituent of
(A) Coal gas (B) Water gas (C) Petroleum (D) Biogas

8. The major constituent of natural gas is
(A) Butane (B) Methane (C) Propane (D) Ethane

9. Ethanol on oxidation gives
(A) Ethane (B) Formalin (C) Ethanoic acid (D) Methane

10. The functional group present in carboxylic acids is
(A) –OH (B) –CHO (C) –COOH (D) –CO

11. A dilute solution of ethanoic acid in water is called
(A) Tincture of iodine (B) Fehling's solution (C) Vinegar (D) Tollen's reagent

12. Which of the following will undergo addition reactions?
(A) C_2H_4 (B) C_2H_6 (C) CH_4 (D) C_3H_8

13. Which of the following formula represent alkenes?
(A) C_nH_{2n} (B) C_nH_{2n+2} (C) C_nH_{2n-2} (D) C_nH_{2n+1}

14. The general formula of cyclic alkanes is

(A) C_nH_{2n+2} (B) C_nH_{2n-2} (C) C_nH_{2n-1} (D) C_nH_{2n}

15. A carboxylic group is present in

(A) Ethylene (B) Methanoic acid (C) Formaldehyde (D) Ethanol

16. The functional group in an alcohol is

(A) $-\overset{\overset{O}{\|}}{C}-O-$ (B) $-\overset{\overset{O}{\|}}{C}-OH$ (C) $-OH$ (D) $-\overset{\overset{H}{|}}{C}=O$

17. Which of the following will react with sodium metal?

(A) Ethanol (B)Ethanal (C) Ethene (D) Ethane

18. Which of the following will give a pleasant smell of ester when heated with ethanol and a small quantity of sulphuric acid?

(A) CH_3COOH (B) CH_2CH_2OH (C) CH_3OH (D) CH_3CHO

19. The functional group in aldehydes is

(A) $-CHO$ (B) $-\overset{|}{C}=O$ (C) $-COOH$ (D) $-COOR$

20. Ethanol on complete oxidation gives

(A) CO_2 and water (B) Acetaldehyde (C) Acetic acid (D) Acetone

21. Which class of organic compounds gives effervescence with $NaHCO_3$ solution?

(A) Esters (B) Alcohols (C) Carboxylic acids (D) Aldehydes

22. Carboxylic acids are obtained from alcohols by -

(A) Oxidation (B) Reduction (C) Hydrolysis (D) Pyrolysis

23. Soaps are prepared by alkaline hydrolysis of-

(A) Carboxylic acids (B) Lower esters (C) Higher esters (D) None of these

EXERCISE #3 CARBON &ITS COMPOUNDS

FILL IN THE BLANKS TYPE QUESTION:

1. The ability of carbon atom to link with other carbon atom is known as ……

2. The hydrocarbons containing only single bonds are known as ……

3. Aliphatic hydrocarbons have been classified as alkanes, …… and alkynes.

4. …….. hydrocarbons undergo addition reaction.

5. Isomers have some molecular formula but different …….. formula.

6. Hydrocarbons are insoluble in ……..

7. The next homologue of ethene is ……..

8. During the formation of hydrogen molecule from its atoms, energy is ……

9. Bond between hydrogen and chlorine in HCl is ……

10. $CH_2 = CH_2 + H_2 \rightarrow CH_3 - CH_3$

11. The general formula of the homologous series of alcohols is …….

12. The functional group present in ethanol is ……..

13. When ethanol is warmed with alkaline potassium permanganate, the product formed is ……..

14. When a piece of sodium metal is added to ethanol, the gas formed with effervescence is ……..

15. Ethene and ethyene are examples of …… hydrocarbons.

16. The …….. group in a soap molecule is hydrophilic.

TRUE & FALSE:

1. Methane belongs to the homologous series of alkanes.

2. The compound having the molecular formula C_4H_{10} does not show isomerism.

3. The methane molecule has a phyrmidal shape.

4. Methane undergoes substitution reaction.

5. The consumption of ethanol increases the activity of the body.

6. Ethanoic acid is used in the manufacture of textiles.

7. Alkenes as well as alkynes decolourise bromine water.

8. Vanaspati ghee is obtained by the hydrogenation of vegetable oil.

9. Alkanes undergo substitution reactions.

10. Alkenes and alkynes are unsaturated compounds.

11. Ethanol is oxidised by alkaline $KMnO_4$ to oxalic acid.

12. Detergents give scum with hard water.

13. The polar end in soap is called hydrophilic end.

14. Methanol is safe to be used for drinking purpose.

15. The reaction of ethanol with conc. H_2SO_4 gives ethane.

16. Carboxylic acids react with alcohols to form esters.

VERY SHORT ANSWER TYPE QUESTIONS:

1. Name an allotrope of carbon which has 60 carbon atoms.

2. What is combustion?

3. What is the nature of substances that produce a flame?

4. The molecular formula of a compound is C_2H_6O. Name its homologous series.

5. What type of reactions are given by alkanes?

6. What is the composition of natural has used for cooking?

7. Which of the following open chain compounds can have a double bond?

8. Name an allotrope of carbon which contains both single and double bonds between carbon atoms.

9. Write the name and molecular formula of alcohol derived from butane.

10. What is rectified spirit?

11. Give the name and structural formula of one homologue of HCOOH.

12. Why does hard water not produce foam with soap easily?

13. Name the hydrophobic and hydrophilic ends of soap.

14. What is a detergent?

15. An organic compound burns with a sooty flame. Is it saturated or unsaturated compound?

SHORT ANSWER TYPE QUESTION:

1. Name any four substance obtained from organic compounds which are used in our daily life.

2. Hydrogen and chlorine react to form hydrochloric acid. Will they form and ionic or covalent bond?

3. How many electrons a carbon atom shared with other carbon atom in the formation of acetylene molecule?

4. Give examples of covalent compounds which contain:

(a) one unshared pair of electron(b) two unshared pairs of electrons.

5. What is meant by the term functional group?

6. What is meant by homologous series? Give its three important characteristics.

7. Name the functional group present in: (i) CH_3CH_2OH, and (ii) HCOOH.

8. The molecular formula of a hydrocarbon is C_5H_{10}. Name its homologous series.

9. Write structural formulae of the following compounds.

(i) Ethyl alcohol (ii) Acetaldehyde (iii) Propionic acid (iv) Butanone

10. What is the IUPAC name of fourth member of alcohol series? Draw its two structural isomers.

11. Write the general formulae of the following homologous series.

(i) Aldehydes (ii) Ketones (iii) Alkyne

12. How do alcohols differ structurally from alkanes?

13. Give the common and IUPAC names of the following alcohols:
(i) CH_3OH (ii) CH_3CH_2OH (iii) $CH_3CHOHCH_3$

14. Identify the functional group in CH_3CH_2OH . Give IUPAC name of the compound.

15. Ethanol can be oxidised to ethanoic acid. Write the equation involved in the reaction.

16. Name the oxidising agent which can oxidize:

(i) Ethanol to enthanal (ii) Ethanol to ethanoic acid.

17. How would you distinguish experimentally between an alcohol and a carboxylic acid?

18. A neutral organic compound 'A' having molecular formula C_2H_6O,undergoes oxidation with acidified potassium permanganate to give an acidic compound 'B'. The organic compound 'A' reacts with compound 'B' on warming and in the presence of concentrated sulphuric acid to form a sweet-smelling substance 'C'. Identify A, B and C.

19. An organic compound 'A' having molecular formula $C_2H_6O_2$ turns blue litmus red and gives brisk effervescence with sodium hydrogencarbonate. Give the name and formula of 'A'.

20. What happens when (Give equations of the chemical reaction)

(i) Sodium ethanoate is heated with soda lime.

(ii) Ethanoic acid is warmed with methanol in presence of concentrated sulphuric acid.

(iii) A pinch of sodium hydrogencarbonate is added to ethanoic acid.

(iv) Ethanol is oxidised with acidified potassium dichromate.

LONG ANSWER TYPE QUESTION:

1. What is covalent bond? Draw electron dot structure for the following:

(i) Methane (ii) Carbon dioxide (iii) Ammonia (iv) Water

2. Explain the following reaction with one example each:

(i) Substitution reactions (ii) Addition reactions

(iii) Combustion reactions (iv) Oxidation reactions

3. (i) What are alcohols? What is functional group?
(ii) Write names and formulae of first four members of alcohols family.
(iii) How does the second member of alcohol family react with?
(i) Sodium metal (ii) Ethanoic acid

4. What are soaps and synthetic detergents? How do they differ? Discuss their cleaning actions.

5. Which properties of carbon make it a versatile element? Discuss its bonding in saturated and unsaturated hydrocarbon.

6. What are harmful effects of drinking alcohol?

7. Write short not on:

(i) Catenation (ii) Glacial acetic acid (iii) Power alcohol (iv) Saponification

8. Give chemical test to detect the presence of (i) ethanol. (ii) ethanoic acid and (iii) and ester.

9. Discuss briefly two physical and three chemical properties of ethanol.

10. Discuss briefly the physical and chemical properties of ehtanoic acid.

CARBON & COMPOUND | **ANSWER KEY** | ALL EXERCISE

EXERCISE # 1

- ***Objective type questions***

Qus.	1	2	3	4	5	6	7	8	9	10
Ans.	B	C	B	C	A	B	B	A	A	A
Qus.	11	12	13	14	15	16	17	18	19	20
Ans.	A	B	C	A	A	A	A	C	D	D
Qus.	21	22	23	24	25					
Ans	A	A	C	A	C					

EXERCISE # 2

Qus.	1	2	3	4	5	6	7	8	9	10
Ans.	C	D	A	B	C	C	D	B	C	C
Qus.	11	12	13	14	15	16	17	18	19	20
Ans.	C	A	A	D	B	C	A	A	A	A
Qus.	21	22	23							
Ans	C	A	C							

EXERCISE # 3

- ***Fill in the blanks***

1. Catenation **2.** Alkanes/saturated hydrocarbon **3.** Alkenes
4. Unsaturated **5.** Structural **6.** Water **7.** Propene
8. Released **9.** Covalent **10.** Ni catalyst **11.** $C_nH_{2n+1}OH$.
12. Hydroxy **13.** Ethanoic acid **14.** Hydrogen **15.** Unsaturated
16. Polar/$COONa^+$

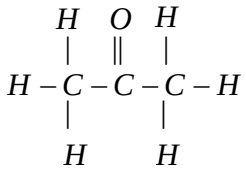
- ***True or False***

1. T **2.** F **3.** F **4.** T
5. F **6.** T **7.** T **8.** T
9. T **10.** T **11.** F **12.** F
13. T **14.** F **15.** F **16.** T

NCERT SOLVED QUESTIONS

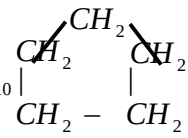
1. Write the chemical formula of simplest ketone.

Ans.



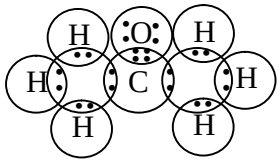
2. What will be formula and electron dot structure of cyclopentane?

Ans. Formula for cylopentane is C5H10. Its electron door structure can be represented as C_5H_{10}



3. Propanone.

Ans. Propanone



4. What will happen if a piece of diamond is dropped in fire? Write chemical equation for the reaction.

Ans. Diamond will burn in fire because it is an allotrope of carbon. On combustion, it will produce carbon dioxide.

$$C + O_2 \longrightarrow CO_2$$

Diamond Oxygen Carbon dioxide

5. Write two main differences between the nature of diamond and graphite.

Ans. Two main difference between diamond and graphite are

(i) Diamond is very hard whereas graphite is a soft substance.

(ii) Diamond is a poor conductor of electricity whereas graphite is a good conductor of electricity.

6. Write the formulae for the given compounds and name the functional groups present in each of them.

(i) Ethanoic acid (ii) Propanone

Ans. (i) Compound: Ethanoic acid

Formula: $CH_3 - COOH$

Functional group: $-\overset{\overset{O}{\|}}{C}-OH$

(Carboxylic acid group)

(ii) Compound: Propanone

Formula: $CH_3-\overset{\overset{O}{\|}}{C}-CH_3$

Functional group: $-\overset{\overset{O}{\|}}{C}-$

(Ketone group)

7. Mention any two test which can be used of defect carboxylic acid group in an organic compound.

Ans. **(i) Litmus test:-** Carboxylic acids turn blue litmus paper red.

(ii) Sodium bicarbonate test: Carboxylic acids give brisk effervescence due to the formation of carbon dioxide, when treated with sodium bicarbonate solution.

$$CH_3COOH + NaHCO_3 \rightarrow H_2O + CO_2 + CH_3COONa$$

8. What is hydrogenation? What is its industrial application?

Ans. Unsaturated hydrocarbons add hydrogen in the presence of palladium or nickel. This reaction is called hydrogenation.

$$C=C \quad + H_2 \xrightarrow{Pd\ or\ Ni} R-\underset{R}{\overset{H}{C}}-\underset{R}{\overset{H}{C}}-R$$

This reaction is industrially used in the conservation of vegetable oils into vegetable ghee.

9. Define the following giving one example of each:

(i) Esterification

(ii) Addition reaction

Ans. (i) The reaction of carboxylic acid with an alcohol in presence of sulphuric acid yields esters and the reaction is known as esterification.

$$CH_3-\overset{O}{\overset{\|}{C}}-OH + CH_3-CH_2-OH \xrightarrow[heat]{H_2SO_4}$$

(ii) Reactions in which two or more atoms are added across a double or triple bond, are called addition reactions.

$$CH_3=CH_2 + H_2 \xrightarrow{Pd.Pt\ or\ Ni} CH_3-CH_3$$

10. An organic compound 'X' is a constituent of wine. This compound on heating with acidified potassium dichromate forms another compound 'Y'. Name the compound 'X' and 'Y' and write the chemical equation of the reaction involved.

Ans. Compound 'Y' is ethanol.

Compound 'Y' is ethanoic acid.

$$\underset{\text{Ethanol}}{CH_3CH_2OH} \xrightarrow[heat]{K_2Cr_2O_7} \underset{\text{Ethanoic acid}}{CH_3-\overset{O}{\overset{\|}{C}}-OH}$$

11. (a) Identify the compounds A and B in the following reaction:

(i) $C_2H_5OH + CH_3COOH \xrightarrow{H_2SO_4}$ (ii) $CH_3COOC_2H_5 + NaOH \rightarrow B + C_2H_5OH$

(b) Name the type of reaction taking place in the above cases.

Ans. (a) (i) $CH_3-\overset{\overset{\displaystyle O}{\|}}{C}-O-CH_2-CH_3$ Ethyl ethanoate (ii) $CH_3-\overset{\overset{\displaystyle O}{\|}}{C}-ONa$ Sodium ethanoate

(b) (i) Esterification

12. Differentiate between a soap and a detergent on the basis of their chemical constituents. For cleansing action why is a detergent preferred to soap?

Ans. Soaps are sodium salts of long chain fatty acids whereas detergents are sodium salts of alkyl benezenesulphonic acids. Basically, the structure soap is  COONa whereas that of detergents is  SO_3Na. If water is hard i.e., it contains calcium or magnesium chlorides then detergent is preferred to a soap.

13. Why does micelle formation take place when soap is added to water? Will a micelle be formed in other solvents like ethanol also?

Ans. A molecule of soap has two dissimilar ends. At one end is the hydrocarbon chain which is water repellent. At the other end carboxylate anion is present which is water soluble end. 'When soap is dissolved in water, many molecules come together and form a group called micelle, these micelles are formed because their hydrocarbon chains come together and the polar ends are projected outward. Micelle formation in ethanol will not occur because the hydrocarbon chain end of the soap will also dissolve in ethanol.

14. Explain the formation of scum when hard water is treated with soap.

Ans. Hard water contains calcium and magnesium ions. When soap comes in contact with hard water these ions form calcium and magnesium salts of fatty acids which are insoluble in water. These calcium or magnesium salts precipitate out in the form of scum.

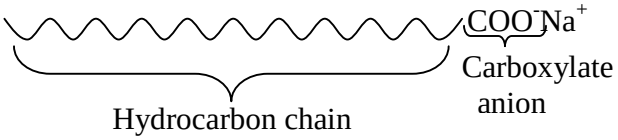
15. How can ethanol and ethanoic acid be differentiated on the basis of their physical and chemical properties?

Ans.

	Property	**Ethanol**	**Ethanoic acid**
(i)	Melting point	156 K	290 K
(ii)	Action on litmus	No action	Turns blue litmus into red
(iii)	Reaction with $NaHCO_3$ solution	No reaction	Effervescence due to the formation of CO_2

16. Explain the mechanism of the cleansing action of soaps.

Ans. A molecule of soap has two dissimilar ends. At one end is the hydrocarbon, chain which is water repellent and the other and is carboxylate anion which is polar end.



When soap is dissolved in water, many molecules come together and from a group called micelle. These micelles are formed because their hydrocarbon chains come together and the polar ends are projected outward.

When a cloth with a spot of oil soaked into a soap solution. Soap dissolves tiny oil droplets by the hydrophytic end in the middle of the micelle. Due to the outer polar ends, these micelles dissolve in water and are washed away- In this way cloth gets cleaned.

17. What is soap? How would you make soap in the laboratory? State one advantage and one disadvantage of soap over synthetic detergents.

Ans. Soaps are sodium or potassium salts of long chain fatty acids Soap can be prepared in laboratory by heating the naturally occurring. Oil or fat with sodium hydroxide. On heating, sodium salt of the fatty acid soap is formed along with glycerol. This process is known as saponification.

$$Oil\ or\ fat + NaOH \rightarrow Soap + Glycerol$$

The soap is precipitated by adding common salt to the above solution. Soap being lighter, floats on water and is filtered. It is cooled and then cut into pieces.

Soaps have the advantage over detergents that they are biodegradable and do not cause water pollution.
The disadvantage of soaps over detergents is that, they cannot be used in hard water.

18. What happens when a small piece of sodium metal is dropped into ethanol.

Ans. Hydrogen gas is evolved when a piece of sodium metal is dropped into ethanol.

$$C_2H_5OH + Na \rightarrow C_2H_5ONa + \frac{1}{2}H_2$$

19. Give reasons for the following observations:

Ans. (a) The element forms a very number of compounds.
(b) Air holes of a gas burner have to be adjusted when heated vessels get blackened by the flame.
(c) Use of synthetic detergents causes pollution of water.

Ans. (a]) The two main properties of carbon responsible for a large number of compounds are catenation and tetravalency of carbon.
(b) When the heated vessel is blackened by the flame, it shows that complete combustion of the gas is not occurring due to the less supply of oxygen or air. So air holes adjusted to increase the supply of air.
(c) Use of synthetic detergents causes pollution of water because most of them are non-biodegradable.