Carbon and it's Compound

- **Carbon is an element. It is a non-metal**
- **The amount of carbon present in the earth's crust and atmosphere is very small all the living things, plants and animals, are made up of carbon based compounds which are called organic compounds.**
- **A large number of things which we use in our daily life are made of carbon compounds. carbon element plays a very important role in our daily life.**
- **We can test the presence of carbon in a material on the basis of the fact that carbon and its compounds burn in air to give carbon dioxide gas which turns lime water milky.**
- **The electronic configuration of carbon is 2, 6.**
- **it is not possible to remove 4 electrons from a carbon atom**
- **It is also not possible to add as many as 4 electrons to a carbon atom**
- **Since carbon atoms can achieve the inert gas. electron arrangement only by the sharing of electrons, therefore, carbon always forms covalent bonds.**
- **Since one carbon atom requires 4 electrons to achieve the eight-electron inert gas structure, therefore, the valency of carbon is 4.**
- **The property of self combination of carbon atoms to form long chains is useful to us because it gives rise to an extremely large number of carbon compounds (or organic compounds)**
- **The formation of strong bonds by carbon atoms among themselves and with other elements makes the carbon compounds exceptionally stable.**
- **The various physical forms in which an element can exist are called allotropes of the element.**
- **Diamond and graphite are the two common allotropes of carbon which are known to us for centuries.**

- **Buckminsterfullerene is the new allotrope of carbon which has been discovered recently.**

- **Diamond is a colourless transparent substance having extraordinary brilliance**

- **Graphite is a greyish-black opaque substance.**

- **the two common allotropes of carbon, diamond and graphite, have entirely different physical properties.**

- **The difference in the physical properties of diamond and graphite arises because of the different arrangements of carbon atoms in them.**

Diamond

1. **The rigid structure of diamond makes it a very hard substance**

2. **Diamond is a non-conductor of electricity. Since there are 'no free electrons' in a diamond crystal, it does not conduct electricity**

3. **diamonds are used in cutting instruments like glass cutters, saw for cutting marble and in rock drilling equipment.**
4. **Diamonds are used for making jewellery**

5. **Diamonds can be made artificially by subjecting pure carbon to very high pressure and temperature.**

Graphite

1. **Due to the sheet like structure, graphite is a comparatively soft substance**

2. **Graphite is a good conductor of electricity. Due to the 'presence of free electrons' in a graphite crystal, it conducts electricity.**

3. **graphite is used as a lubricant for the fast moving parts of machinery it can be used for lubricating those machine parts which operate at very high temperatures .**

4. **graphite is used for making carbon electrodes or graphite electrodes in dry cells and electric arcs.**
5. **Graphite is used for making the cores of our pencils called 'pencil leads' and black paints.**

Buckminsterfullerene

- **Buckminsterfullerene is an allotrope of carbon containing clusters of 60 carbon atoms joined together to form spherical molecules.**
- **Buckminsterfullerene is a dark solid at room temperature.**
- **Buckminsterfullerene is neither very hard nor soft.**

- **The compounds of carbon are known as organic compounds.**
- **Carbon compounds (or organic compounds) are covalent compounds having low melting points and boiling points.**
- **Most of the carbon compounds are non-conductors of electricity.**
- **Organic compounds occur in all living things like plants and animals.**
- **oxides of carbon (like carbon monoxide and carbon dioxide), carbonates, hydrogen carbonates and carbides are also carbon compounds but they are not considered to be organic compounds.**
- **The study of carbon compounds (such as hydrocarbons and their derivatives) is called organic chemistry**

1. One reason for the existence of a large number of organic compounds or carbon compounds is that carbon atoms can link with one another by means of covalent bonds to form long chains (or rings) of carbon atoms

2. Another reason for the existence of a large number of organic compounds or carbon compounds is that the valency of carbon is 4 (which is quite large).

HYDROCARBON

A compound made up of hydrogen and carbon only is called hydrocarbon
The most important natural source of hydrocarbons is petroleum (or crude oil)

Types of Hydrocarbons

A hydrocarbon in which the carbon atoms are connected by only single bonds is called a saturated hydrocarbon

ALKANE

An alkane is a hydrocarbon in which the carbon atoms are connected by only single covalent bonds (There are no double or triple bonds in an alkane).

- **The general formula of saturated hydrocarbons or alkanes is C nH 2n+2 where C, H is the number of carbon atoms in one molecule of the alkane.**

- **A hydrocarbon in which the two carbon atoms are connected by a 'double bond' or a 'triple bond' is called an unsaturated hydrocarbon.**

ALKENE

An unsaturated hydrocarbon in which the two carbon atoms are connected by a double bond is called an alkene.

- **The general formula of an alkene is CnH 2n where C, H is the number of carbon atoms in its one molecule.**

ALKYNE

An unsaturated hydrocarbon in which the two carbon atoms are connected by a triple bond is called an alkyne

- **The general formula of alkynes is CnH2n-2 where C, H is the number of carbon atoms in one molecule of the alkyne.**

ALKYL GROUP

The group formed by the removal of one hydrogen atom from an alkane molecule is called an alkyl group. General formula is C_nH_{2n+1}

ISOMERES

The organic compounds having the same molecular formula but different structures are known as isomers.

- **Isomerism is possible only with hydrocarbons having 4 or more carbon atoms no isomerism is possible in methane, ethane and propane because they contain only one, two or three carbon atoms respectively.**

HOMOLOGOUS SERIES

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

1. All the members of a homologous series can be represented by the same general formula

2. Any two adjacent homologues differ by 1 carbon atom and 2 hydrogen atoms in their molecular formulae

3. The difference in the molecular masses of any two adjacent homologues is 14 u

4. All the compounds of a homologous series show similar chemical properties.

5. The members of a homologous series show a gradual change in their physical properties with increase in molecular mass.

- **The organic compounds such as haloalkanes, alcohols, aldehydes, ketones and carboxylic acids (organic acids) also form the homologous series.**

- **In an organic compound, any atom other than carbon and hydrogen, is called a heteroatom.**

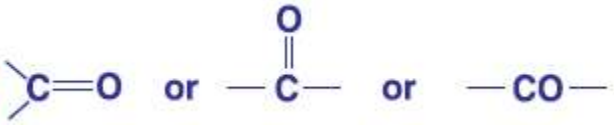
FUNCTIONAL GROUP

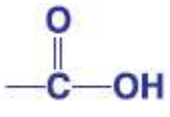
An 'atom' or 'a group of atoms' which makes a carbon compound (or organic compound) reactive and decides its properties (or functions) is called a functional group.

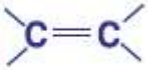
1. Halo Group : —X (X can be Cl, Br or I)

2. Alcohol Group : —OH

3. Aldehyde Group : —CHO or  **or**

4. Ketone Group :  or or —CO—

5. Carboxylic Acid Group : —COOH or 

6. Alkene Group : 

7. Alkyne Group : —C≡C—

FUNCTIONAL GROUP TABLE

S. No.	Functional Group	Prefix	Suffix
1.	Double bond (=)	–	ene
2.	Triple bond (≡)	–	yne
3.	Chlorine (—Cl)	Chloro	–
4.	Bromine (—Br)	Bromo	–
5.	Alcohol (-OH)	–	ol
6.	Aldehyde (-CHO)	–	al
7.	Ketone (-CO-)	–	one
8.	Carboxylic acid (-COOH)	–	oic acid

- **NAMING OF THE COMPOUND CAN BE DONE IN THE FOLLOWING MANNER**

PREFIX + WORD ROOT + SUFFIX

COAL AND PETROLEUM

- **When a fuel is burned, the energy is released mainly as heat**
- **Most of the fuels which we use today are obtained from coal, petroleum and natural gas.**
- **Coal is a complex mixture of compounds of carbon, hydrogen and oxygen, and some free carbon.**
- **Coal was formed by the decomposition of large land plants and trees buried under the earth millions of years ago.**
- **The crude oil petroleum is a complex mixture of several solid, liquid and gaseous hydrocarbons mixed with water, salt and earth particles.**
- **Petroleum oil (and natural gas) were formed by the decomposition of the remains of extremely small plants and animals buried under the sea millions of years ago.**
- **All the gaseous fuels burn with a flame but only those solid and liquid fuels which vaporise on heating (to form a gas), burn with a flame.**

➢ **Flames are of two types :**
Blue flame and yellow flame.

1. When the oxygen supply (or air supply) is sufficient, then the fuels burn completely producing a blue flame.

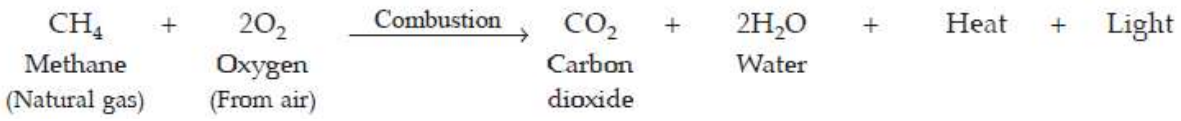
2. When the oxygen supply (or air supply) is insufficient, then the fuels burn incompletely producing mainly a yellow flame.

➢ **Those solid and liquid fuels which do not vaporise on heating, burn without producing a flame.**

CHEMICAL PROPERTIES OF CARBON COMPOUNDS

1. Combustion (or Burning)

The process of burning of a carbon compound in air to give carbon dioxide, water, heat and light, is known as combustion.



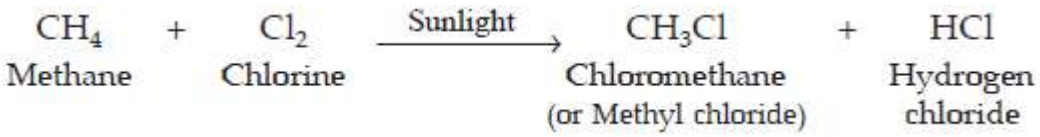
- **alkanes burn in air to produce a lot of heat due to which alkanes are excellent fuels.**
- **carbon and its compounds are used as fuels because they burn in air releasing a lot of heat energy.**
- **The saturated hydrocarbons (alkanes) generally burn in air with a blue, non-sooty flame.**
- **If, however, the supply of air (and hence oxygen) for burning is reduced (or limited), then incomplete combustion of even saturated hydrocarbons will take place and they will burn producing a sooty flame.**
- **The gas stove (and kerosene stove) used in our homes have tiny holes (or inlets) for air so that sufficient oxygen of air is available for the complete burning of fuel to produce a smokeless blue flame. if the bottom of the cooking utensils in our homes are getting blackened, it shows that the air holes of the gas stove (or kerosene stove) are getting blocked and the fuel is not burning completely**
- **The unsaturated hydrocarbons (alkenes and alkynes) burn in air with a yellow, sooty flame (producing black smoke).**
- **if unsaturated hydrocarbons are burned in pure oxygen, then they will burn completely producing a blue flame (without any smoke at all).**
- **A mixture of acetylene (ethyne) and air is not used for welding because burning of acetylene (ethyne) in air produces a sooty flame (due to incomplete combustion), which is not hot enough to melt metals for welding.**

2. Substitution Reactions

Saturated hydrocarbons, however, undergo substitution reactions with chlorine in the presence of sunlight.

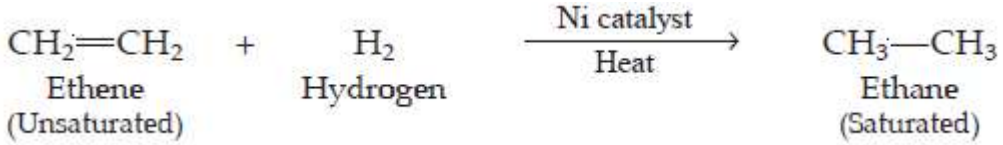
- **The reaction in which one (or more) hydrogen atoms of a hydrocarbon are replaced by some other atoms (like chlorine), is called a substitution reaction. substitution reactions (like chlorination) are a characteristic property of saturated hydrocarbons or alkanes**

- **Substitution Reaction of Methane with Chlorine.**



3. Addition Reactions

- **Addition reactions (like the addition of hydrogen, chlorine or bromine) are a characteristic property of unsaturated hydrocarbons. addition reactions are given by all the alkenes and alkynes.**



- **The addition of hydrogen to an unsaturated hydrocarbon to obtain a saturated hydrocarbon is called hydrogenation.**
- **The process of hydrogenation has an important industrial application : It is used to prepare ghee from vegetable oils.**
- **Vegetable oils containing unsaturated fatty acids are good for our health.**
- **The saturated fats like vegetable obtained by the hydrogenation of oils, are not good for health.**
- **The animal fats are also saturated fats containing saturated fatty acids which are said to be harmful for health.**
- **Bromine water has a red-brown colour due to the presence of bromine in it. if an organic compound decolourises bromine water, then it will be an unsaturated compound (containing a double bond or a triple bond).**
- **All the unsaturated compounds (alkenes and alkynes, etc.) decolourise bromine water but saturated compounds (alkanes) don't decolourise bromine water.**
- **We can distinguish chemically between a cooking oil and butter by the bromine water test.**

SOME IMPORTANT CARBON COMPOUNDS

- **ETHANOL (OR ETHYL ALCOHOL)**

- **The common name of ethanol is ethyl alcohol. it is a neutral compound.**

- **ethanol has no effect on any litmus solution.**

- **During combustion, the organic compound reacts rapidly with oxygen and breaks up completely to form carbon dioxide and water vapour, and a lot of heat and light are also produced .**

$$\underset{\text{Ethanol (Ethyl alcohol)}}{C_2H_5OH} + \underset{\text{Oxygen (From air)}}{3O_2} \xrightarrow[\text{(Burning)}]{\text{Combustion}} \underset{\text{Carbon dioxide}}{2CO_2} + \underset{\text{Water vapour}}{3H_2O} + \text{Heat} + \text{Light}$$

- **During oxidation, the organic compound combines with oxygen (provided by an oxidising agent) to form a new compound.**

- **Since ethanol burns with a clear flame giving a lot of heat, therefore, it is used as a fuel.**

- **ethanol is used as an additive in petrol.**

- **After the crystallisation of sugar from concentrated sugar cane juice, a thick, dark brown liquid called molasses is left behind. Ethanol is produced by the fermentation (breakdown by enzymes) of the cane sugar present in molasses.**

- **An aqueous solution of potassium permanganate containing sodium hydroxide is called alkaline potassium permanganate solution.**

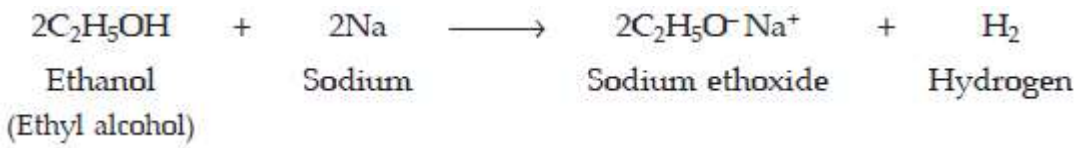
- **The potassium dichromate solution containing sulphuric acid is called acidified potassium dichromate solution.**

- **Alkaline potassium permanganate and acidified potassium dichromate are strong oxidising agents**

Oxidation

$$\underset{\text{Ethanol (Ethyl alcohol)}}{CH_3CH_2OH} + \underset{\text{Nascent oxygen (From oxidising agent)}}{2[O]} \xrightarrow[\text{(or Acidified } K_2Cr_2O_7)]{\text{Alkaline } KMnO_4 \text{ ; Heat}} \underset{\text{Ethanoic acid (Acetic acid)}}{CH_3COOH} + \underset{\text{Water}}{H_2O}$$

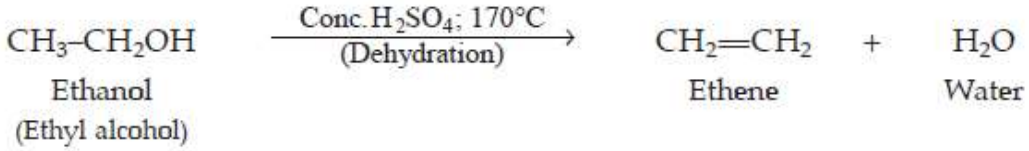
3. Reaction with Sodium Metal. Ethanol reacts with sodium to form sodium ethoxide and hydrogen gas



- **This reaction is used as a test for ethanol.**

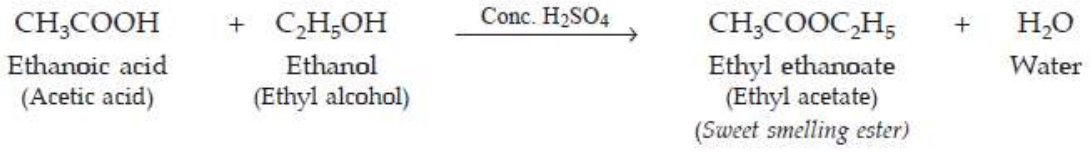
4. Dehydration. Dehydration of an alcohol means removal of water molecule from it. When ethanol is heated with excess of concentrated sulphuric acid at 170°C (443 K), it gets dehydrated to form ethene (which is an unsaturated hydrocarbon).

- **Concentrated sulphuric acid acts as a dehydrating agent.**



- **Reaction with Ethanoic Acid (Formation of Ester).**

- **The reaction in which a carboxylic acid combines with an alcohol to form an ester is called esterification.**



- **Methanol damages the optic nerve causing permanent blindness in a person.**

- **Denatured alcohol is ethyl alcohol which has been made unfit for drinking purposes by adding small amounts of poisonous substances like methanol, pyridine, copper sulphate, etc.**

➢ ETHANOIC ACID (OR ACETIC ACID)

1. Action on Litmus.

- **The common name of ethanoic acid is acetic acid. It turns blue litmus to red.**
- **Dilute ethanoic acid turns universal indicator paper to orange, showing that its pH is about 4.**
- **ethanoic acid is a weak acid.**
- **dilute hydrochloric acid turns universal indicator paper to red, showing that its pH is about 1.**
- **hydrochloric acid is a strong acid. the comparison of pH with universal indicator tells us that ethanoic acid and hydrochloric acid are not equally strong.**

2. Reaction with Carbonates and Hydrogen carbonates.

(*i*) Reaction with Sodium Carbonate. Ethanoic acid reacts with sodium carbonate to form sodium ethanoate and carbon dioxide gas.

$$2CH_3COOH + Na_2CO_3 \longrightarrow 2CH_3COONa + CO_2 + H_2O$$

Ethanoic acid (Acetic acid) | Sodium carbonate | Sodium ethanoate (Sodium acetate) | Carbon dioxide | Water

(*ii*) Reaction with Sodium Hydrogen carbonate. Ethanoic acid reacts with sodium Hydrogen carbonate to evolve brisk effervescence of carbon dioxide gas.

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

Ethanoic acid | Sodium hydrogencarbonate | Sodium ethanoate | Carbon | Water

- **This reaction is used as a test for ethanoic acid (or acetic acid)**

3. Reaction with Sodium Hydroxide.

$$CH_3COOH + NaOH \longrightarrow CH_3COONa + H_2O$$

Ethanoic acid | Sodium hydroxide | Sodium ethanoate | Water

4. Reaction with Alcohols : Formation of Esters.

$$\underset{\text{Ethanoic acid (Acetic acid)}}{CH_3COOH} + \underset{\text{Ethanol (Ethyl alcohol)}}{C_2H_5OH} \xrightarrow{\text{Conc. } H_2SO_4} \underset{\text{Ethyl ethanoate (Ethyl acetate) (Sweet smell)}}{CH_3COOC_2H_5} + \underset{\text{Water}}{H_2O}$$

- **Esters are usually volatile liquids having sweet smell or pleasant smell.**
- **One of the most important reactions of esters is that they can be hydrolysed back to the alcohol and carboxylic acid (from which they are originally formed).**
- **The alkaline hydrolysis of esters (using alkali like sodium hydroxide) is known as saponification (soap making).**

Hydrolysis of Esters.

$$\underset{\text{Ethyl ethanoate (Ethyl acetate)}}{CH_3COOC_2H_5} + \underset{\text{Sodium hydroxide}}{NaOH} \xrightarrow{\text{Heat}} \underset{\text{Sodium ethanoate (Sodium acetate)}}{CH_3COONa} + \underset{\text{Ethanol (Ethyl alcohol)}}{C_2H_5OH}$$

SOAPS AND DETERGENTS

Any substance which has cleansing action in water is called a detergent.

SOAPS

A soap is the sodium salt (or potassium salt) of a long chain carboxylic acid (fatty acid) which has cleansing properties in water.

(*i*) Sodium Stearate, $C_{17}H_{35}COO^-Na^+$.

(*ii*) Sodium Palmitate, $C_{15}H_{31}COO^-Na^+$.

- **a soap solution turns red litmus paper to blue**
- **Soap is made by heating animal fat or vegetable oil with concentrated sodium hydroxide solution(caustic soda solution).**

$$\underset{\text{(An ester)}}{\text{Fat or Oil}} + \underset{\text{(An alkali)}}{\text{Sodium hydroxide}} \xrightarrow{\text{Heat}} \underset{\text{(Sodium salt of fatty acid)}}{\text{Soap}} + \underset{\text{(An alcohol)}}{\text{Glycerol}}$$

- **The process of making soap by the hydrolysis of fats and oils with alkalis is called saponification.**

- **Common salt is added to precipitate out all the soap from the aqueous solution.**

- **The soap which is used for washing clothes (or bathing) works by making the oil and grease particles dissolve in water (because normally the oil and grease are insoluble in water) the hydrocarbon part of the soap molecule is soluble in oil or grease, so it can attach to the oil and grease particles present on dirty clothes the short ionic part of the soap molecule (having negative charge) is soluble in water, so it can attach to the water particles (in which the soap is dissolved and dirty cloth is dipped)**

- **A 'spherical aggregate of soap molecules' in the soap solution in water is called a 'micelle'.**

- **Soap is not suitable for washing clothes with hard water**

DETERGENTS

- **Detergents are also called 'soap-less soaps' because though they act like a soap in having the cleansing properties, they do not contain the usual 'soaps' like sodium stearate, etc.**

- **we would not be able to check whether a sample of water is hard by using a detergent (because a detergent forms lather easily even with hard water).**

- **A detergent is the sodium salt of a long chain benzene sulphonic acid (or the sodium salt of a long chain alkyl hydrogensulphate) which has cleansing properties in water.**

- **The cleansing action of a detergent is similar to that of a soap**

- **Detergents have a number of advantages over soaps due to which they are replacing soaps as washing agents.**

- **An important disadvantage of detergents over soaps is that some ofthe detergents are not biodegradable, that is, they cannot be decomposed by micro-organisms like bacteria and hence cause water pollution in lakes and rivers.**