## Introduction

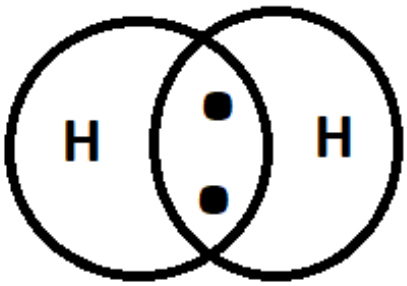
- All living and non- living things are based on carbon. For example, food, medicines, books, clothes and many others.
- Carbon is an element of immense importance both in its combined form as well as in elemental form.
- Earth crust contains 0.02% of carbon in the form of carbonates, coal petroleum and atmosphere contain only 0.03% carbon.

### Covalent bond in Carbon

- All elements that have less then 8 electrons in their outermost shell have a tendency to complete their octet to attain nearest noble gas configuration by gaining, losing or sharing electrons.
- Carbon has 4 electrons in its outermost shell and therefore requires 4 electrons more due to this it is called tetravalent.
- Carbon can attain octet in the following two ways:
    i. It can gain four electrons forming $C^{4-}$ anion. But it will be very difficult for the nucleus to hold 4 four extra electrons.
    ii. It can lose four electrons forming $C^{4+}$ cation. But large amount of energy will be required to remove four electrons leaving behind carbon cation with six protons in its nucleus holding on to just two electrons.
- To overcome this barrier, Carbon shares its valence electrons with other atoms of carbon or other elements.
- Carbon is said to form covalent bond because of this tendency of sharing its valence electrons with electrons of other elements.
- Compounds containing covalent bonds have low melting and boiling points because the intermolecular forces are not as strong as that of ionic compounds. However, the covalent bond is quite strong in nature.
- Covalent compounds are poor conductors of electricity because of absence of any charged particles or ions.

### Bonding in Hydrogen

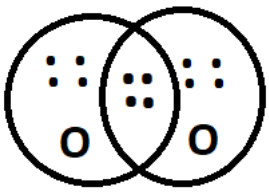
- The atomic number of hydrogen is 1. It has only one electron in the K shell and requires only one electron to fill the shell. Therefore, two hydrogen atom shares their electron to form a molecule $H_2$. In this way hydrogen attains the noble gas configuration of Helium.
- The shared paired of electron between the two atoms of hydrogen makes a covalent bond and is shown by a single line.

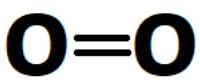




## Formation of Oxygen molecule

- The atomic number of Oxygen is 8, which means it has 6 electrons in its L shell.
- Oxygen requires two electrons to attain the noble gas configuration of Neon.
- This is achieved by sharing these two electrons with another Oxygen atom leading to the formation of Oxygen molecule.
- These two shared pair form a double bond between the two atoms and is represented by two parallel lines.

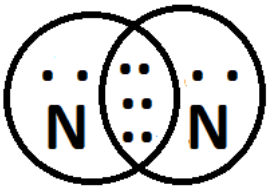


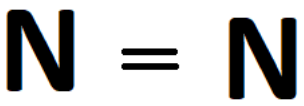




## Formation of Nitrogen

- The atomic number of Nitrogen is 7, so it has 5 electrons in its outermost shell.

- Nitrogen can either gain or lose 3 electrons to attain the noble gas configuration of Neon.
- So, two Nitrogen atoms share 3 electrons to complete the octet.
- These three shared pair form a triple bond between the two atoms and is represented by three parallel lines.



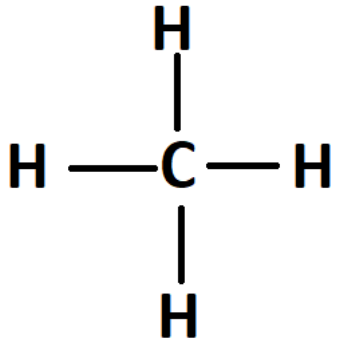

## Versatile Nature of Carbon

The versatile nature of carbon is due to its following properties:

- Carbon is tetravalent in nature; due to this it is capable of bonding with 4 atoms of carbon or any other monovalent element.
- Carbon possesses a unique property of bonding with other atoms of carbon giving rise to large molecules. This is called **catenation**.
- These may contain long chains of carbon, branched chain of carbon or carbon atoms arranged in ring and joined by single, double or triple bonds.
- Carbon can bond with oxygen, hydrogen, nitrogen, sulphur, chlorine and many other elements forming compounds with specific properties that depend on the elements other than carbon present in the molecule.
- Carbon forms strong bond making the compounds very stable, this is because of the small size of Carbon.

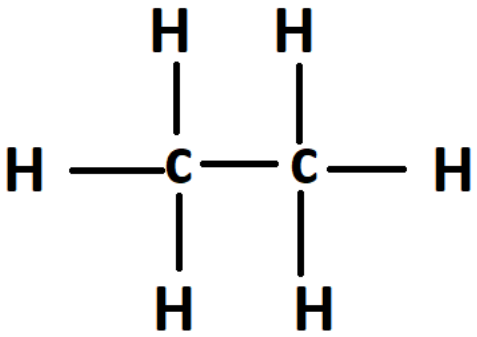
## Saturated Carbon Compounds

- Compounds which are formed by the linking of carbon atoms by single bonds are known as saturated compounds.
- All the other valencies are satisfied by Hydrogen atoms
- For example, Alkanes are saturated compounds. The simplest alkane is Methane with the formula $CH_4$.
- The valency of hydrogen is 1 and that of carbon is 4.
- Therefore, 4 carbon atoms share their outermost electrons with four individual hydrogen atoms bonded by a single bond.



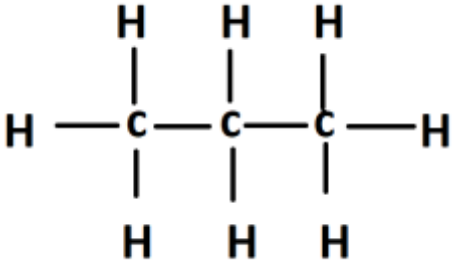
**Methane**

- The second compound in this series is **Ethane** $C_2H_6$.
- Its structure can be drawn by linking 2 carbon atoms and satisfying other 6 valencies by Hydrogen atoms.



**Ethane**

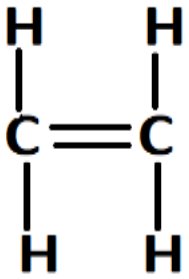
- The next compound in the series of saturated compounds is **Propane.**
- It contains 3 carbon atoms and rest Hydrogen atoms.



**Propane**

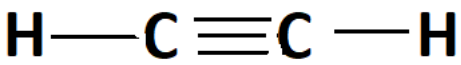
## Unsaturated Carbon Compounds

- Compounds formed by linking of carbon atoms by means of double or triple bond are called Unsaturated compounds.
- For example, In Ethene **$C_2H_4$** molecule two carbon atoms are joined by a double bond and rest of the valencies are satisfied by Hydrogen atoms.




**Ethene**

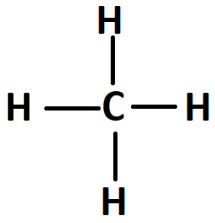
- **Ethyne** is an unsaturated compound in which two carbon atoms are bonded together by a triple bond and rest of the valencies are satisfied by Hydrogen atoms.



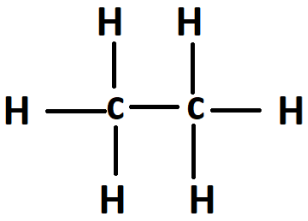

**Ethyne**

## Hydrocarbons

- Compounds containing carbon and hydrogen are called Hydrocarbons.
- Hydrocarbon are classified as saturated and unsaturated.
- Hydrocarbon containing single bonds are said to be saturated and those containing double or triple bond are called unsaturated hydrocarbon.
- Saturated hydrocarbons containing single bond are called alkanes. The general formula for alkanes is $C_nH_{2n+2}$ where n = 1,2,3,4,5,6,7,8 etc. For example, methane, ethane, propane.

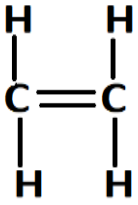


**Methane**

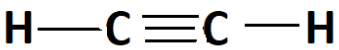


**Ethane**

- The unsaturated hydrocarbon containing one or more double bonds are called alkenes. The general formula for alkene is $C_nH_{2n.}$ where n = 2,3,4,5,6 etc. For example, ethene, propene, butene etc.



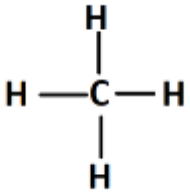
- The unsaturated hydrocarbons containing one or more triple bonds are called alkynes. The general formula for alkynes can be written as CnH2n-1, where n = 2, 3, 4,5 etc. For example, Ethyne, Propyne etc.



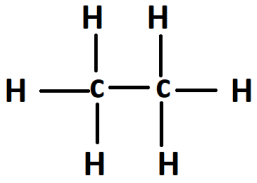
**Ethyne**

## Homologous Series

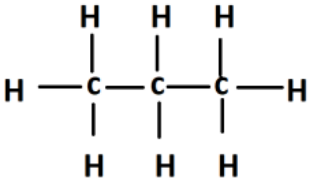
- A series of compounds in which the same functional group substitutes for one or more hydrogen atoms in a carbon chain is called a homologous series.
- The members of a homologous series have same chemical properties irrespective of the length of carbon chain.
- For example, series of alkanes i.e., Methane, Ethane, Propane, Butane etc.



**Methane**



**Ethane**



**Propane**

- The homologous series of compound containing alcoholic group OH is methanol, ethanol, propanol etc. these compounds are called **Alcohols**.
- In the Homologous series as the molecular mass increases, some gradation is seen in the physical properties but the chemical properties remain same.

## Nomenclature of Carbon Compounds

- **Step I –** Identify the number of carbon compounds.

| No. of carbon atoms | Term used |
|---|---|
| 1 | **Meth** |
| **2** | **Eth** |
| **3** | **Prop** |
| **4** | **But** |
| **5** | **Pent** |
| **6** | **Hex** |
| **7** | **Hept** |
| **8** | **Oct** |
| **9** | **Non** |
| **10** | **Dec** |

- **Step II –** The functional group present in the compound is indicated either by a prefix or a suffix.

| Functional Group | Prefix / Suffix | Example |
|---|---|---|
| Halogen/ Haloalkane | Prefix- chloro, bromo etc. | Chloropropane, bromopropane |
| Alcohol | Suffix - ol | Ethanol, propanol |
| Aldehyde | Suffix - al | Propanal, butanal |
| Ketone | Suffix - one | Pentanone, butanone |
| Carboxylic acid | Suffix – oic acid | Butanoic acid, methanoic acid |
| alkenes | Suffix - ene | Pentene, hexene |
| Alkynes | Suffix - yne | Butyne, hexyne |

- **Step III -** The functional group present in the compound is denoted as suffix by removing the e at the end and adding the appropriate suffix as given in the table. For example, a three-carbon chain with an Aldehyde group would be named as: - propan – 'e' = propan + 'one' = propanone.

- **Step IV** - If the carbon chain is unsaturated the final 'ane' in the name of the carbon chain is substituted by 'ene' for double bond or 'yne' for triple bond.

## Chemical Properties of Carbon Compounds

### Combustion

- Carbon burns in the presence of oxygen to produce carbon dioxide along with evolution of heat and light.
- The chemical equations for combustion of carbon compounds are as follows:

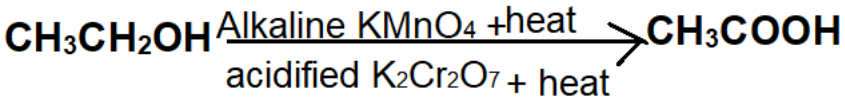
$$\mathbf{C + O_2 \rightarrow CO_2 + heat\ and\ light}$$

$$\mathbf{CH_4 + O_2 \rightarrow CO_2 + H_2O + heat\ and\ light}$$

$$\mathbf{CH_3CH_2OH + O_2 \rightarrow CO_2 + H_2O + heat\ and\ light}$$

### Oxidation

- Carbon compounds gets easily oxidised on combustion. The following equation shows the conversion of alcohols to carboxylic acid.



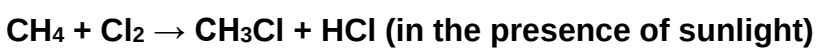

- Substance that are capable of adding oxygen to other are called oxidising agents.
- Alkaline potassium permanganate or acidified potassium dichromate used in the above reaction are oxidising agents.

## Addition Reaction

- During addition reaction an unsaturated hydrocarbon adds hydrogen in the presence of catalysts to produce a saturated hydrocarbon.
- Catalysts such as palladium or nickel are used as catalyst in the above reaction.
- Catalysts are substances that makes a reaction to proceed at a different rate without affecting the reaction itself.

## Substitution Reaction

- A reaction in which one functional group or atom is replaced by another functional group or atom is called substitution reaction.
- In the presence of sunlight, chlorine adds on to hydrocarbons in a very rapidly. Chlorine has the ability to replace the hydrogen atoms one by one.
- It is called a substitution reaction because one type of atom or a group of atoms is replaced or substituted by another. A number of products are usually formed with the higher homologues of alkanes.




## Properties of Ethanol

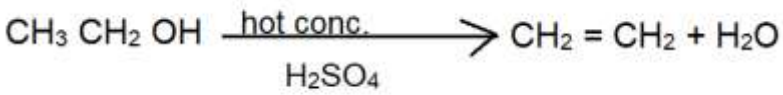
- Ethanol which is commonly called alcohol is a liquid at room temperature.
- Ethanol is the active ingredient of all alcoholic drinks.

- It is also used in medicines such as tincture iodine, cough syrups, and many tonics because it is a good solvent.
- Ethanol is also soluble in water in all proportions.
- Consumption of small quantities of dilute ethanol causes drunkenness.
- Intake of even a small quantity of pure ethanol (called absolute alcohol) can be lethal.
- **Chemical reactions of ethanol:**
    1. **Reaction with Sodium:** ethanol reacts with sodium to produce hydrogen gas and sodium ethoxide.

$$2Na + 2CH_3CH_2OH \rightarrow 2CH_3CH_2O{-}Na^+ + H_2$$

(Sodium ethoxide)

    2. **Reaction to give unsaturated hydrocarbon:** Dehydration of ethanol takes place when it is at 443 K with excess concentrated sulphuric acid.




Concentrated sulphuric acid acts as a dehydrating agent in this reaction.

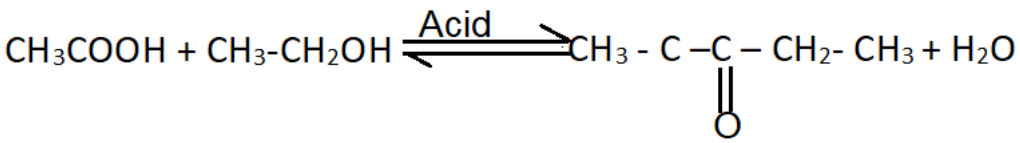
## Properties of Ethanoic Acid

- Ethanoic acid commonly known as acetic acid belongs to a group of acids called carboxylic acids.
- 5-8% solution of acetic acid in water which is called vinegar is widely used as a preservative in pickles.
- The melting point of pure ethanoic acid is 290 K and hence it often freezes during winter in cold climates. Because of this property it is also called glacial acetic acid.
- The carboxylic acids are acidic nature similar to other acids. However, unlike mineral acids like HCl, which are completely ionised, carboxylic acids are weak acids.

## Reactions of Ethanoic Acid

- **Esterification reaction:** Esters are formed by the reaction between an acid and an alcohol.

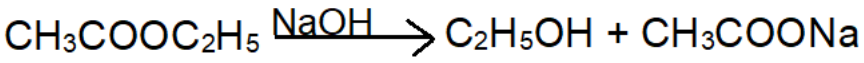
- Ethanoic acid reacts with absolute ethanol in the presence of an acid catalyst to produce an ester –



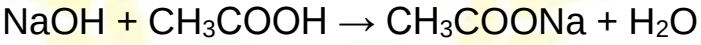

Ethanoic acid Ethanol Ester

Esters are sweet-smelling substances which are used in making perfumes and as flavouring agents.

When treated with sodium hydroxide, the ester gets converted back to alcohol and sodium salt of carboxylic acid. This reaction is known as saponification and is used in the manufacture of soap. Soaps are sodium or potassium salts of long chain carboxylic acid.




- Reaction with a base: Ethanoic acid reacts with a base like sodium hydroxide to produce a salt (sodium ethanoate or commonly called sodium acetate) and water.




## Soaps

- Most dirt is oily in nature and oil does not dissolve in water. The Soaps that we use are sodium or potassium salts of long-chain carboxylic acids.
- The ionic-end of soap reacts with water(hydrophilic) and the carbon chain (hydrophobic) reacts with oil. This leads to the formation of structures called Micelles.
- One end of the micelle is towards the oil droplet while the ionic-end is towards outside. This forms an emulsion in water. The soap micelle thus helps in pulling out the dirt in water and we can wash our clothes clean.

## Detergents

- Detergents are sodium salts of sulphonic acids or ammonium salts having long hydrocarbon chain.
- The charged ends of these compounds do not form insoluble precipitates with the calcium and magnesium ions in hard water. Therefore, they are effective in hard water also.
- Detergents are usually used for making shampoos and products for cleaning clothes.