Carbon & its Compounds
Introduction & Covalent Bonding in Carbon

❖ INTRODUCTION:

Materials like food, cosmetics, furnitures, clothes, medicines, books and many other things contain the versatile element **carbon**.

In addition, all living creatures (human beings, animals, birds, insects, plant kingdom etc.) are made up of **carbon compounds** (Such as fats, carbohydrates, proteins, vitamins, hormones, etc.)

The amount of carbon present in the earth's crust or in the atmosphere is low.

The earth's crust has **0.02% carbon** in the form of salts, like carbonates, bicarbonates, metallic cyanides, coal, petroleum, graphite etc.

Earth's atmosphere has **0.03% of carbon dioxide**.

❖ BONDING IN CARBON COMPOUND:

We know that the reactivity of elements is explained as their tendency to attain a fulfilled outer shell, that is, to attain a **noble gas electronic configuration**.

Elements forming ionic compounds achieve this by either gaining or losing electrons from the outermost shell.

In the case of carbon, Carbon has 6 protons, 6 neutrons and 6 electrons. Its chemical symbol is . Its electronic configuration is 2 electrons in the K-shell, and 4 electrons in the L-shell. It has four electrons in its outermost shell and needs to gain or lose four electrons to attain noble gas configuration.

(i) If it gains four electrons forming C^{4-} anion. It would be difficult for the nucleus with six protons to hold on to ten electrons, means attraction force of 6 protons is not sufficient to hold 8 electrons in valence shell.

(ii) If it loses four electrons forming C^{4+} cation. It would require a large amount of energy to remove four electrons from its valence shell that is not easily available in chemical reaction.

So it does not form ionic bond at all, Carbon shares its valence electrons with other atoms of carbon or with atoms of other elements. Not just carbon, but many other elements form molecules by sharing electrons in this manner.

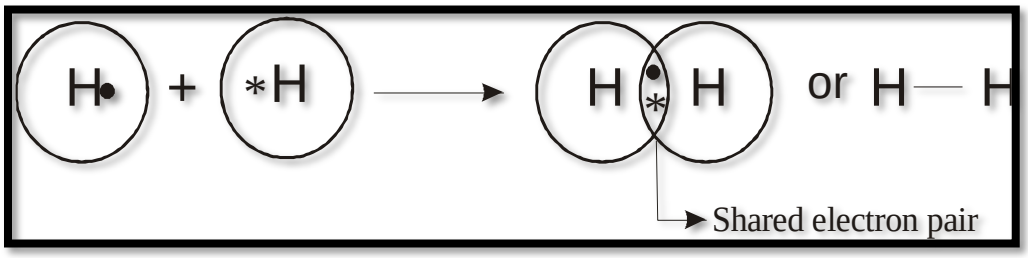
The shared electrons 'belong' to the outer shells of both the atoms and lead to both atoms attaining the noble gas configuration.

➢ **Covalent Bond :**

"A covalent bond, also called **molecular bond**, is a chemical bond that involves the sharing of electron pairs between atoms. These electron pairs are known as shared pairs or bonding pair, and the stable balance of attractive and repulsive forces between atoms, when they share electrons, is known as **covalent bonding**."

For example :

$$H\bullet + {}^{*}H \longrightarrow H{}^{\bullet}_{*}H \longrightarrow H-H$$ or H_2 molecule.



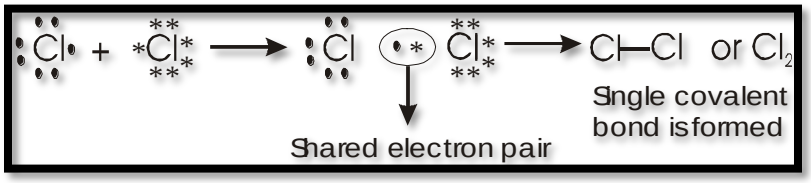
Some simple examples of covalent bonded compounds are:

➢ **Single Covalent Bond:**

When one electron is shared from both atoms a single covalent bond is formed. This bond is indicated by a single line (–) between two bonding atoms.

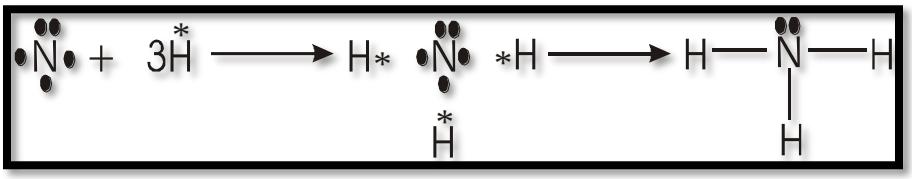
Formation of chlorine molecule :

At.no. (Z) of Cl = 17 Electronic configuration = K(2) L(8) M(7)



Formation of Ammonia:

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

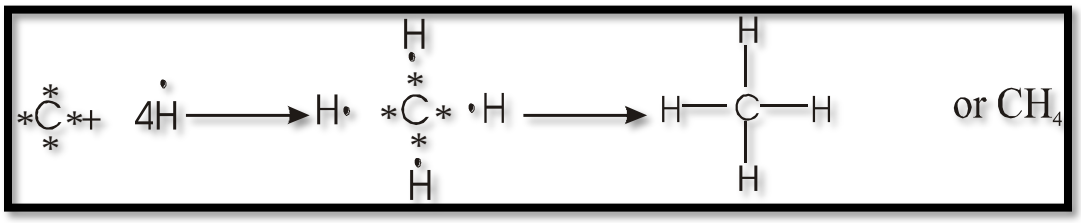


or NH_3 (Three single bond are formed)

Formation of methane (CH_4)

At. no. of C(Z) = 6 At. no. of H(Z) = 1

E.C. of C = K(2) L(4) E.C. of H = K (1)

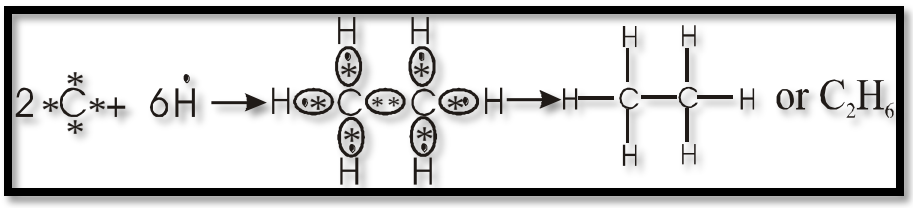


Note : **Methane is the simplest hydrocarbon and is known as marsh gas.**

Formation of Ethane (C_2H_6)

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

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

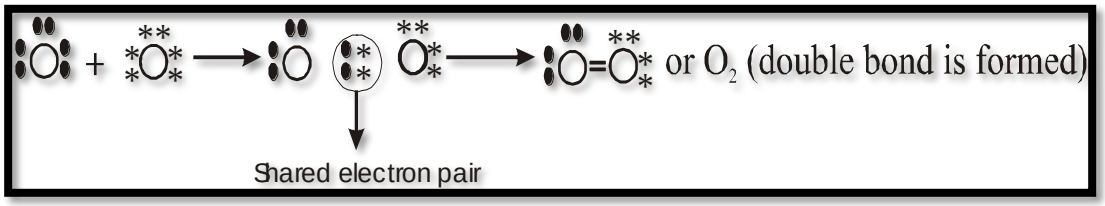


➢ **Double Covalent Bond:**

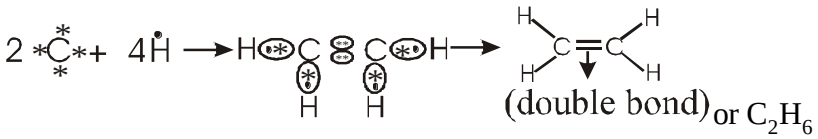
When two electrons from each atom are shared between two atoms a double covalent bond is formed. This bond is indicated by a double line (=) between two bonding atoms.

Formation of oxygen molecules :

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



Formation of Acetylene (C_2H_4):

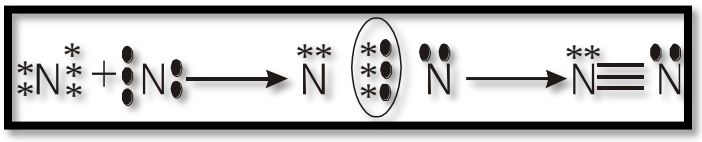


or C_2H_6

➢**Triple Covalent Bond:**

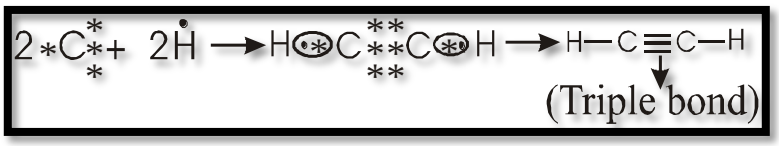
When three electrons from each atom are shared between two atom a triple bond is formed. Some examples of triple covalent bond are C_2H_2 (acetylene), Hydrocyanic acid. **Formation of Nitrogen molecule:**

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



or (N_2 triple bond is formed)

Formation of Acetylene (C_2H_2):



or C_2H_2

Covalency : Covalency of an element may be defined as :

The number of electrons which an atom of the element shares with other atoms in the formation of covalent molecule.

For example :

- In the molecules of H_2 and Cl_2, both the atoms have covalency of one.
- In the molecule of O_2, oxygen has covalency of two while in the molecules of N_2, nitrogen is trivalent.
- In the molecule of H_2O; oxygen has covalency of two while hydrogens is monovalent.

VERSATILE NATURE OF CARBON

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

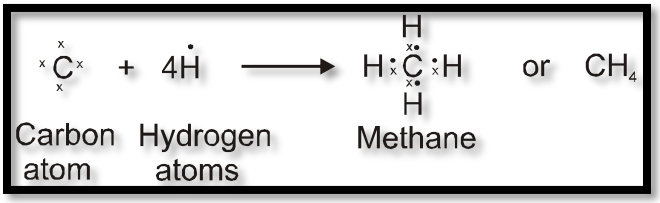
(i) **Catenation:** The property of self linking of carbon atoms through covalent bonds form long straight and branched chains and rings of different sizes is called **catenation**.

The property of catenation is probably due to :

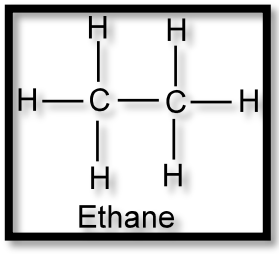
(a) Small size

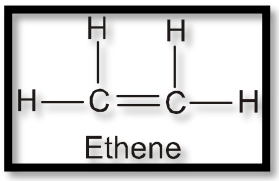
(b) Great strength of carbon-carbon bonds.

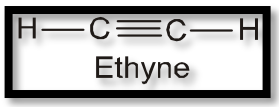
(ii) **Tetravalency of carbon :** Carbon belongs to group 14 of the periodic table. Since the atomic number of carbon is 6, the electronic configuration of carbon atom is 2,4. It has four electrons in the outermost shell. Therefore, its valency is four. Thus, carbon forms four covalent bonds in its compounds. A methane molecule (CH_4) is formed when four electrons of carbon are shared with four hydrogen atoms as shown below.



(iii) **Tendency to form multiple bonds :** Due to small size of carbon it has a strong tendency to form multiple bonds (double & triple bonds) by sharing more than one electron pair. As a result, it can form a variety of compounds. For example -







,

(iv) Isomerism: Covalently bonded carbon compounds show isomerism. If a given molecular formula represents two or more structures having different properties is called **isomerism** and compounds are called **isomers**.

(v) Tendency to Combine other hetero atom: (like N, O, S, P, F, Cl, Br, I etc) :- Due to small size of carbon atom it can form very strong bonds with many elements such as O, N, S, F, Cl, Br, I, P etc.

ORGANIC COMPOUNDS

Compounds like urea, sugar, oils, fats, dyes, proteins, vitamin, hormones etc, which were isolated directly or indirectly from living organisms such as animals and plants are called **Organic compounds** and the branch of chemistry which deals with the study of these compounds called **Organic chemistry.**

Compounds like common salt (NaCl) blue vitriol , green vitriol ($FeSO_4.7H_2O$) white vitriol ($ZnSO_4.7H_2O$), CaO, $Ca(OH)_2$ etc. which were isolated from non-living sources such as rocks and minerals are called **Inorganic compound** and the branch of chemistry which study about those compounds is called **Inorganic chemistry**.

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

- **Rejection of Vital force Theory :** In 1828 Wholer accidentlaly prepared urea by heating Potassium cyanate and Ammonium sulphate

$$\underset{\text{(Potassium Cyanate)}}{KCNO} + \underset{\text{(Ammonium sulphate)}}{(NH_4)_2SO_4} \longrightarrow \underset{\text{(Ammonium cyanate)}}{NH_4CNO} + \underset{\text{(Potassium sulphate)}}{K_2SO_4}$$

$$\underset{\text{(Potassium Cyanate)}}{KCNO} + \underset{\text{(Ammonium chloride)}}{NH_4Cl} \longrightarrow \underset{\text{(Ammonium cyanate)}}{NH_4CNO} + KCl$$

$$\underset{\text{(Ammonium cyanate)}}{NH_4CNO} \xrightarrow{\Delta} \underset{\text{(Urea)}}{H_2N-\overset{\overset{O}{\|}}{C}-NH_2}$$

(Inorganic Compound) (Organic Compound)

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

- **Modern definition of organic compound**: All covalent bonded carbon compounds (except oxides of carbon (CO, CO_2), carbonates, bicarbonates, (Metal Cyanides & carbides) are called **organic compound**.

CLASSIFICATION OF ORGANIC COMPOUNDS