Covalent Bond

(Bonding by Mutual Sharing of Electrons)

Lewis Concept of Covalent Bond: Octet Rule of Covalent Bond

In 1916 G.N. Lewis, an American chemist, suggested that there are atoms which can combine with each other or with other atoms by sharing the unpaired electrons in their outermost shells. In this way the occupied orbitals of the outermost shell of each of the participating atoms are filled with two electrons which have opposite spins. Consequently *the paired electrons are shared by both the atoms* and circulate about the nuclei of both the atoms. The attractive force of the two nuclei for the shared pair of electrons holds the atoms together and gives rise to the formation of a bond which is called **covalent bond** or **electron pair bond** and the compounds containing covalent bonds are called **covalent compounds.** Thus :

The chemical bond between two atoms in which the electrons (in pairs) are shared by both the participating atoms is called covalent bond.

Each of the two combining atoms contributes one electron to the electron pair and has equal claim on the shared electron pair.

According to Lewis concept when two atoms form a covalent bond between them, each of the atoms attains the stable configuration of the nearest inert gas, by completing its *octet* (*i.e.* 8 electrons in the outermost shell) or *duplet* (*i.e.* 2 electrons in case of hydrogen). The covalent bond is established between the atoms of the same or different elements. Since a covalent bond between atoms

results by the interaction of their electrons which become common to both the atoms, it is also called an **atomic bond.**

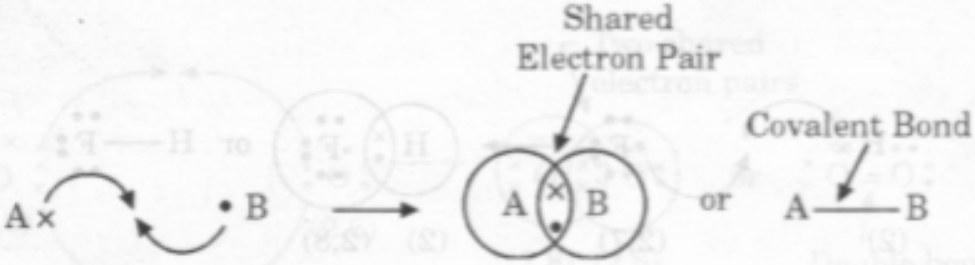
Types of Covalent Bond (*Single, double and triple covalent bonds*).

The covalent bond formed by the sharing of *one, two* or *three electron pairs* between the participating atoms is called *single, double* and *triple covalent bond* respectively. These bonds are represented as follows :

Type of bond	Represented by	No. of electron pairs involved	Examples
Single covalent bond	*Single dash* (–)	*1 pair = 1 × 2 = 2 electrons*	*H–H, Cl–Cl, H–Cl, H–O–H*
Double covalent bond	*Double dash* (=)	*2 pairs = 2 × 2 = 4 electrons*	*O = O*
Triple covalent bond	*Triple dash* (≡)	*3 pairs = 3 × 2 = 6 electrons*	*N ≡ N*

Double and triple covalent bonds are called **multiple covalent bonds.**

Illustration of the formation of covalent bond. How a covalent bond is formed between two atoms can be understood by considering a general case in which an atom A has one valence electron and another atom B has seven valence electrons. As these atoms approach nearer to each other, each atom contributes one electron and the resulting electron pair fills the outer shell of both the atoms. Thus atom A acquires 2 electrons and B, 8 electrons in their respective outer shells and the shared electron pair constitutes a covalent bond between A and B.



Writing the Electronic Formulae (Lewis Formulae) for Covalent Compounds (H_2, F_2, HF, H_2O, H_2S, NH_3, BF_3, CH_4, O_2, N_2, CO_2, C_2H_4, C_2H_2).

The method used for writing the electronic formulae of covalent compounds consists of the following steps :

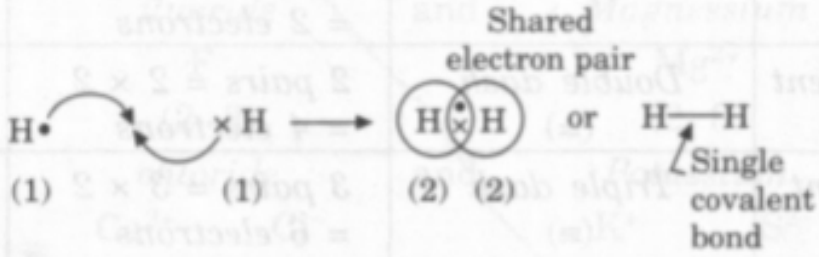
(*a*) Around the symbol of each atom in the formula, we place dots, crosses etc. equal to the number of electrons present in the valence-shell of the atom.

(*b*) The shared pair of electrons are indicated by electron signs like dots (•), crosses (×) etc which are placed between the symbols of the atoms.

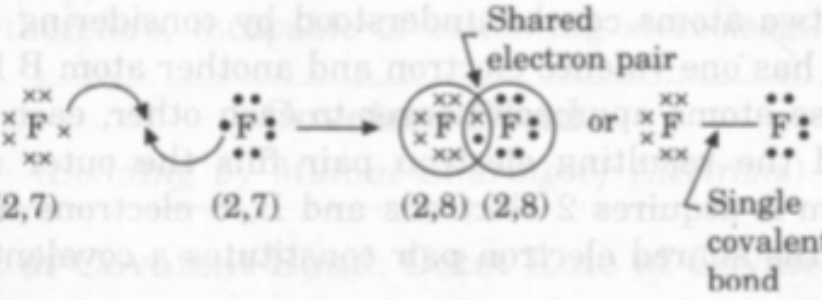
(*c*) Symbol of each atom and its octet is enclosed in a circle so that the two circles overlap the shared electrons. Thus each circle now has *eight* electrons (except *two* in case of H atom).

This method of writing the structure of covalent compounds can be illustrated by the following examples. For the differentiation of electrons, they have been shown by dots (•) and crosses (×). The structures obtained are called **Lewis structures** or **electron dot structures.**

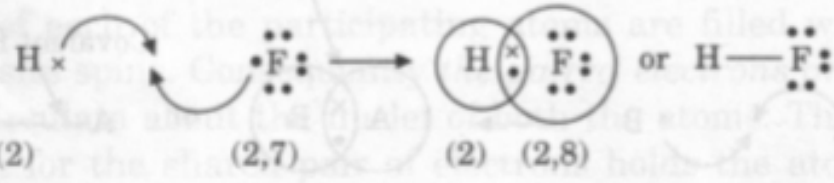
1. *H_2, F_2 and HF molecules.* (*a*) H_2 molecule is composed of two H atoms, each having one valence electron. Each contributes an electron to the shared pair and both atoms acquire stable helium configuration. Thus stable H_2 molecule results.



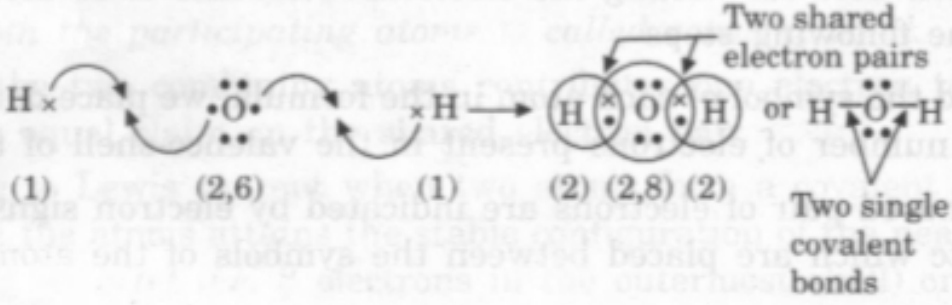
(*b*) In F_2 molecule each F atom (2, 7) has seven valence electrons. The two F atoms achieve a stable electron octet by sharing a pair of electrons.



(*c*) In HF molecule H atom attains a doublet while F atom achieves an octet of electrons.

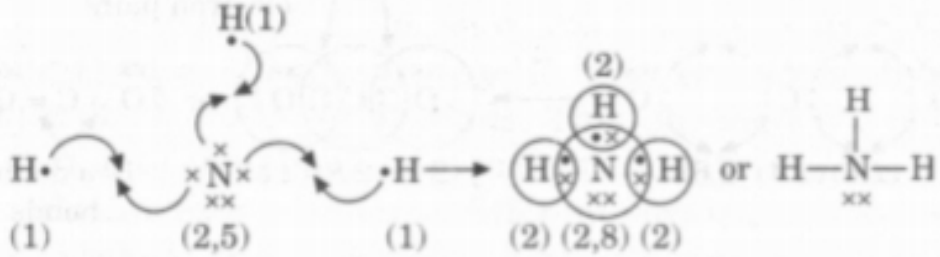


2. *H_2O and H_2S molecules.* (*a*) Oxygen atom (2, 6) has six valence electrons and achieves the stable octet by sharing two electrons, one with each H atom. Thus Lewis structure of water can be written as :



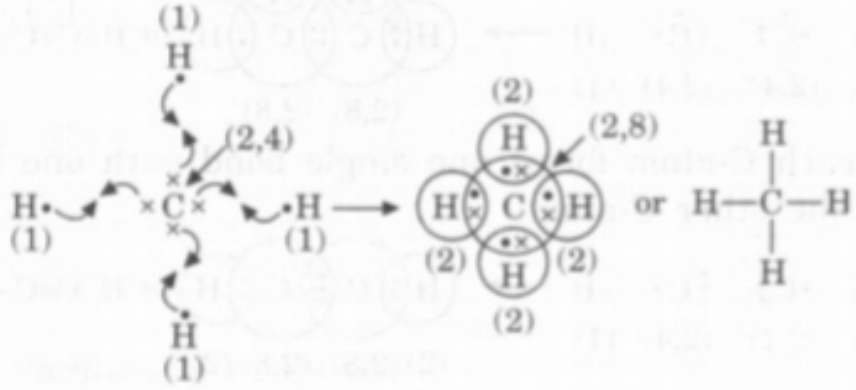
(*b*) On the same lines of argument Lewis structure of H_2S can also be written. (S→2, 8, 6).

3. *NH_3 and BF_3 molecules.* (*a*) N atom (2, 5) has five valence electrons and can achieve the octet by sharing three electrons, one each with three H atoms. This gives the following Lewis structure to NH_3 molecule.

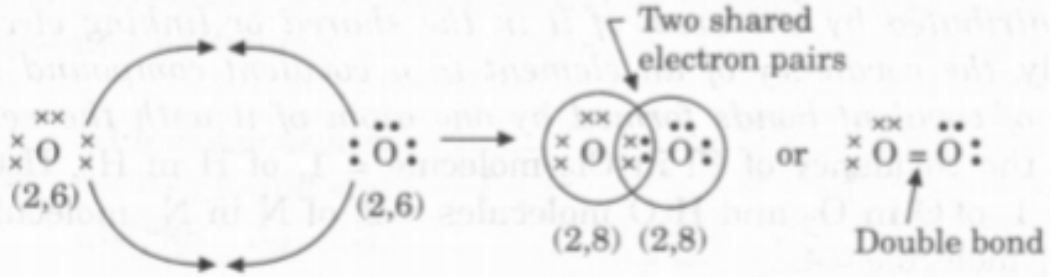


(*b*) On the same lines of agrument Lewis structure of BF_3 can also be written (B→2, 3 ; F→2, 7).

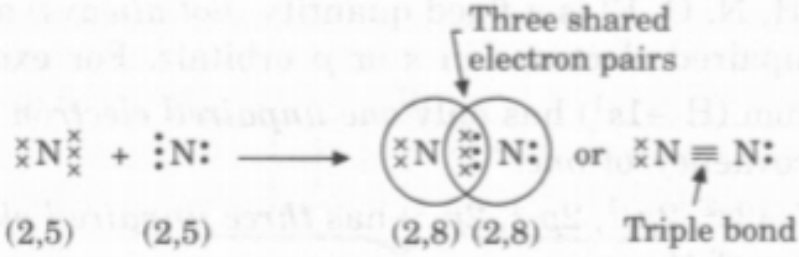
4. *Methane molecule (CH_4).* Carbon atom (2, 4) has four electrons in the valence shell. It can achieve the stable octet by sharing these electrons with H atoms, one with each H atom. Thus the Lewis structure of CH_4 can be written as :



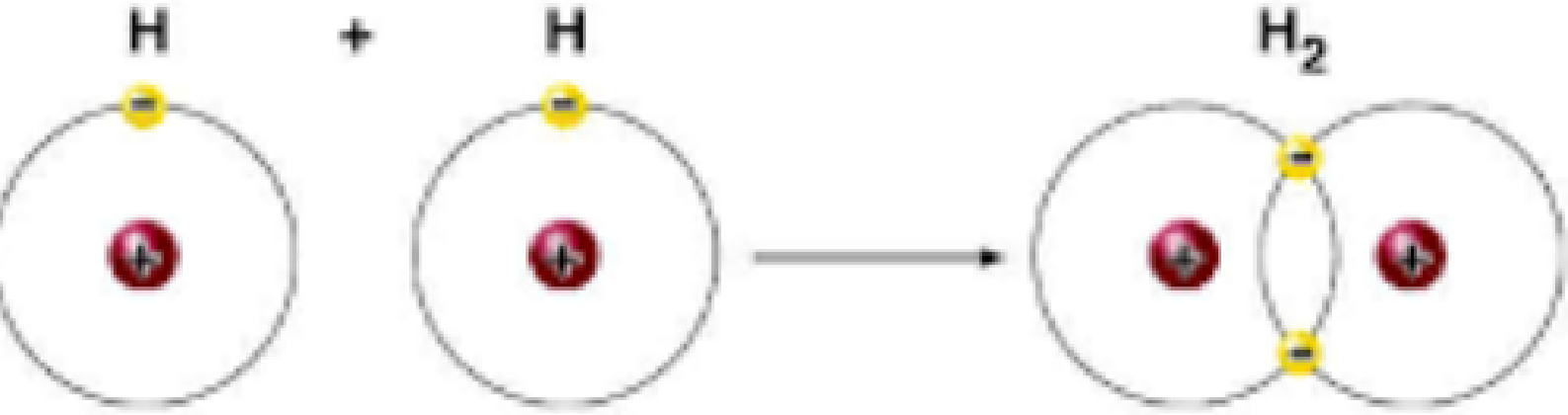
5. *O_2 molecule.* The conventional Lewis structure of O_2 molecules is written by sharing two pairs of electrons between two O-atoms (2, 6). In this way both O-atoms achieve the octet and both O-atoms are linked by a double bond.



6. *N_2 molecule.* The two N atoms (2, 5), each having five electrons in the valence shell, achieve the octet by sharing three electron pairs between them.



Covalent Bond



Hydrogen atom + Hydrogen atom

Hydrogen molecule