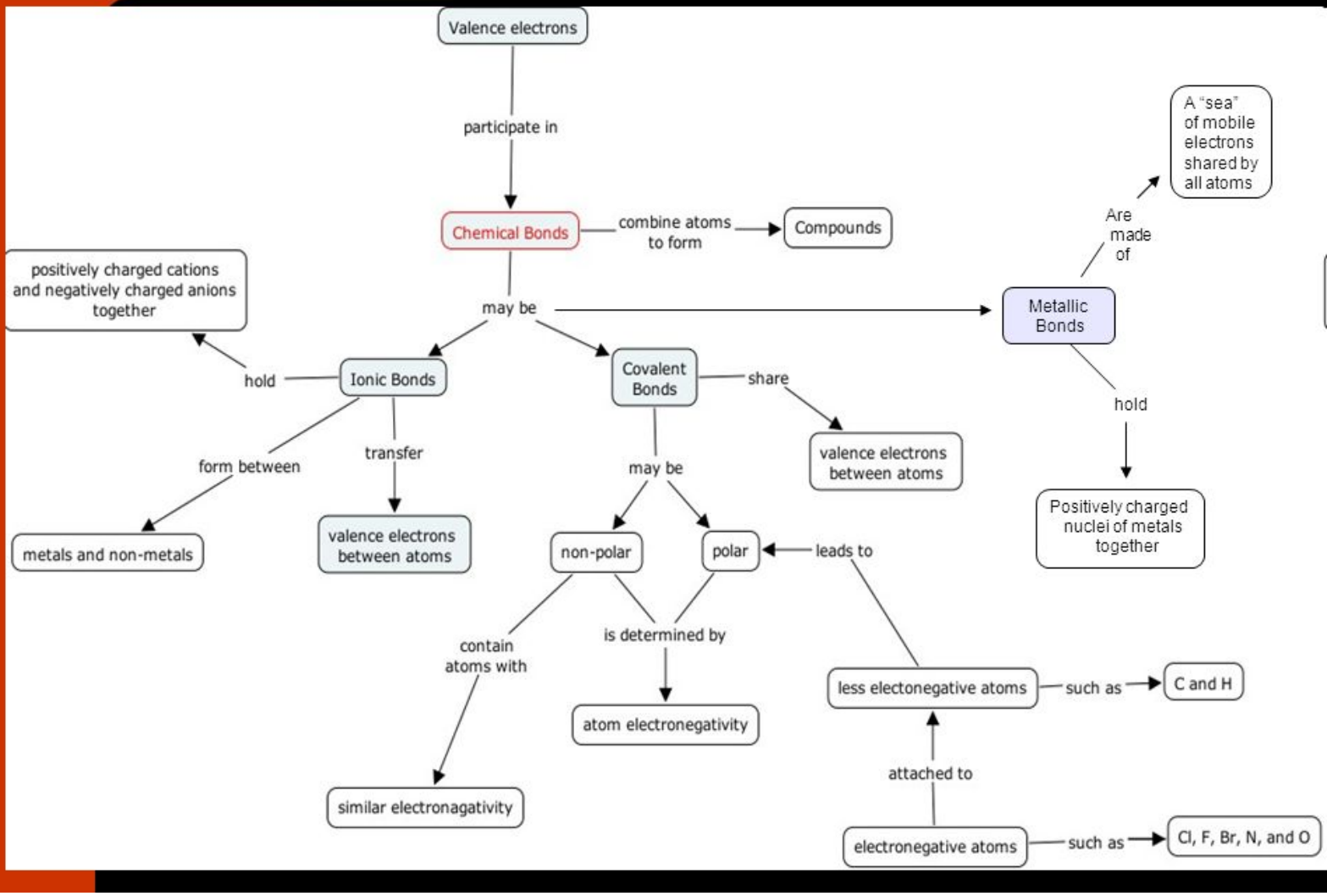
Bonding Concept Map



What is Chemical Bond ?

Atoms rarely occur in the free state at ordinary temperature. Except noble gases, which are chemically unreactive, atoms of all other elements have a tendency to combine either with each other or with the atoms of other elements to form cluster or aggregates of atoms with definite composition. A cluster formed may be either a molecule or an ion. The attraction between atoms forming the cluster is called a *chemical bond* or *valence bond*. Thus :

A chemical bond is defined as the attractive force that holds two or more atoms together in a molecule or an ion.

Our main concern in this chapter is to consider the interactions between atoms in the light of the structure of atom and find out the answers of the following questions

(*a*) *Why do atoms combine* ?

(*b*) *How do atoms combine together* ?

(*c*) *How can the properties of compounds be understood and determined in terms of the forces that keep the atoms together in molecules.*

Why Do Atoms Combine? (*Cause of Chemical Bonding*)

By a close study of atoms and molecules it has been found that atoms combine chemically for the following reasons :

1. Net attractive force between atoms. Atoms consist of strongly positive nucleus and negative electrons. When two atoms come closer to combine with each other to form a bond between them, the attractive and repulsive forces begin to operate between them. The attractive forces are between the electrons of one atom and the nucleus of the other atom while the repulsive forces are between the electrons or the nuclei of the two atoms (Fig. 7.1).

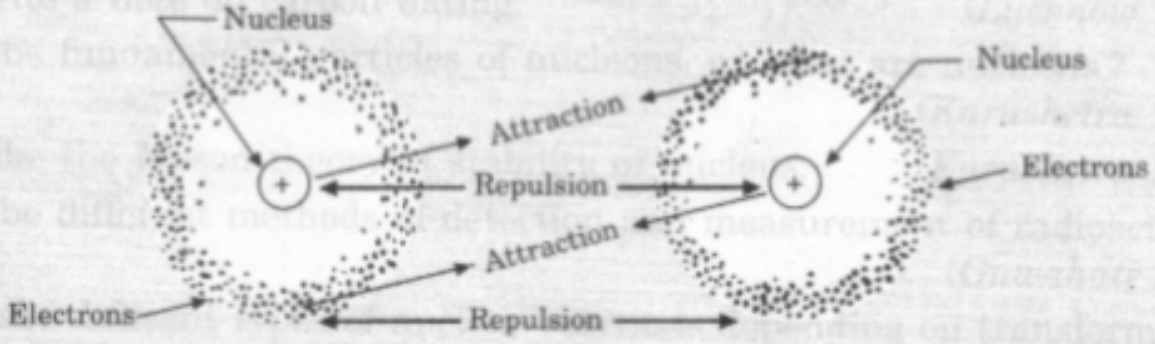


Fig. 7.1. Attractive and repulsive forces operating between two atoms when they come closer to each other.

When the two atoms approach closer to each other, these forces counteract each other. The net result of these forces may be either *attraction* or *repulsion* between the atoms. If the attractive forces become dominant over the repulsive forces, the net result is the attraction between the atoms and hence they combine together to form a chemical bond between them. On the other hand if the repulsive forces become dominant over the attractive forces, the atoms do not combine and hence no chemical bond is established between them. For example in case of hydrogen atoms, the net result is *attraction and hence two H-atoms combine together to form* H_2 *molecule.* On the other hand in case of helium atoms, the net result is *repulsion and hence two He-atoms do not combine together to form* He_2 *molecule.*

2. Octet rule or rule of eight. (*Electronic Theory of valency or octet theory of valency*). Lewis, Kossel and Longmuir (1916) tried, for the first time, to explain *why atoms combine together* on the basis of the electronic configuration of noble gases as given below.

Noble gas	At. No.	Electronic configuration
He	2	2
Ne	10	2, 8
Ar	18	2, 8, 8
Kr	36	2, 8, 18, 8
Xe	54	2, 8, 18, 18, 8
Rn	86	2, 8, 18, 32, 18, 8

They assumed that since the atoms of noble gases do not normally react with other atoms to form compounds, it is reasonable to assume that the outermost shell configuration of the atoms of noble gases is a stable configuration of 8 electrons which they called an *octet*. They also concluded that the two electrons in case of helium (called *duplet*) is also as stable as an octet present in other noble gases. *Since the octet of electrons is so stable in the gases, one can reasonably assume that when atoms of other elements combine to form a molecule, the electrons in their outermost orbits are arranged between themselves in such a way that they achieve an octet of electrons which is stable and thus a chemical bond is established between the atoms.*

The tendency of the atoms to have eight electrons in their outermost shell is known as **octet rule** or **rule of eight.** Since helium atom has only two electrons, this rule is called **doublet rule** or **rule of two** in case of helium. Octet rule was given in the form of a theory which is known as *octet theory of valency or electronic theory of valency* which states that :

In the formation of a chemical bond atoms interact with each other by losing, gaining or sharing of electrons so as to acquire a stable outer-shell of eight electrons.

The main points of this theory can be summarised as follows :

(*i*) Atom with 8 electrons in the outer most shell (2 in case of helium) are chemically stable and hence are incapable of chemical combination.

(*ii*) An atom having less than 8 electrons it its outer-most shell is chemically active and hence has a tendency to combine with other atoms. The atoms possessing less than 4 electrons in their ultimate shell usually tend to lose them, while those having more the 4 electrons in the outermost shell tend to gain the electrons during the chemical combination or bond formation to attain stable configuration of the nearest inert gas.

(*iii*) Atoms combine chemically as a result of transferring of electrons from the outer-most shell of one atom to that of the other or by sharing one, two or three electron pairs between the valence-shell of both the combining atoms. The transfer of electrons or sharing of electron pairs gives a stable configuration of 8 electrons to the valence-shell of both the atoms.

(*iv*) The tendency of an atom for transference or sharing its electron pairs is a measure of its chemical activity.

3. Lowering of energy of combining atoms. When two atoms combine together to form a bond, there is an over all decrease in the potential energy of the combining atoms, *i.e.,* a system having bonded atoms has lower energy than that having the unbonded atoms. This implies that the system of bonded atoms having lower energy is more stable than that of unbonded atoms having higher energy. *From this it, therefore, follows that the process of chemical bonding between the atoms decreases the energy of the combining atoms and gives rise to the formation of a system which has lower energy and hence has greater stability.*

How Do Atoms Combine ?

The process by which the atoms of the elements rearrange their outer-most shell electrons to get eight-electron outer-most shell configuration which is a stable configuration takes place in the following ways :

(*i*) In this way the transfer of one or more electrons from the valence-shell of an atom to the valence-shell of another atom takes place (*Formation of ionic bond*).

(*ii*) In this way one, two or three electron pairs of the valence- shell of both the combining atoms are shared between them. The shared electron pairs may be contributed equally by both the atoms (*Formation of covalent bond*) or may be contributed by only one of the combining atoms (*Formation of co-ordinate bond*).

Types of Bonds

Corresponding to the above two ways by which the two atoms rearrange their outer-most shell electrons to get an eight-electron outer-most shell

configuration, we have the following four types of bonds (or linkages) which hold the atoms together in a molecule.

(*i*) *Ionic or Electrovalent Bond*. This type of bond is established by the transfer of one or more valence electrons from one atom to the other.

(*ii*) *Covalent Bond*. This type of bond is established by the sharing of one, two or three electron pairs between the combining atoms. Each of the two bonded atoms contributes one electron to make the shared electron pair and has equal claim on the shared electron pair, *i.e.*, the resulting electron pair fills the outer-shell of both the atoms and thus both the atoms attain the stable configuration of the nearest inert gas.

(*iii*) *Co-ordinate Bond*. A covalent bond in which both electrons of the shared electron pair come from one of the two atoms is called a coordinate bond.

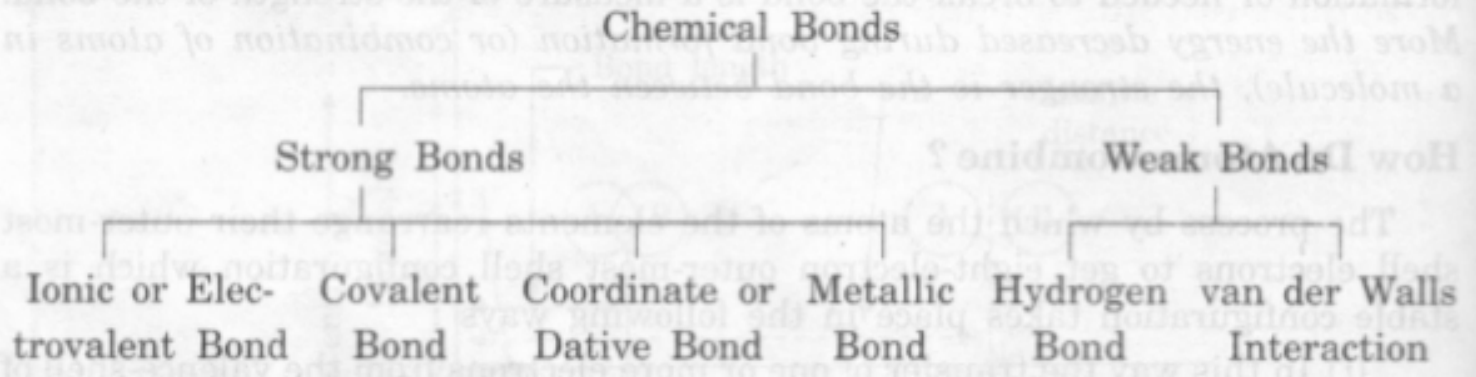
(*iv*) *Metallic Bond*. It is a typical bond and is formed in metals. In this bond a variable number of electrons are shared simultaneously by a variable number of atoms of the metal. This bond is altogether different from the three bonds mentioned above. This bond will be described in detail in subsequent pages of this chapter.

All these four bonds are called **strong bonds.** There are, however, attractive interactions between the atoms which are comparatively weaker than the bonds mentioned above. These weaker interactions are called **weaker bonds.** In these bonds the bonding atoms do not lose their identity. These weaker bonds are of the following types.

(*i*) *Hydrogen Bond*. This bond involves the bonding of a hydrogen atom with two strongly electronegative atoms (*e.g.* N, O and F) simultaneously.

(*ii*) *van der Walls Interaction*. This bond involves the interaction between atoms or molecules having inert gas configuration.

Thus the classification of bonds can be illustrated as follows :



Definitions

1. **Chemical bond: -** The attractive force that holds atoms together in a compound is called chemical bond.

2. **Ionic or electrovalent bond: -** It is defined as the electrostatic force of attraction between positive and negative ions.

3. **Covalent bond: -** Achemical bond that involves the sharing of electrons is called covalent bond.

4. **Single covalent bond (—): -**such a bond is formed when one electron is contributed from each atom making one shared pair. E.g. Cl_2

5. **Double covalent bond: -**in such a covalent bond each of the two atoms contribute two electrons as in O_2

6. **Triple covalent bond: -**in triple covalent bond each atom contributes three electrons as in N_2

7. **Co-ordinate or dative covalent bond: -**a covalent bond in witch one of the bonded atoms furnishes both of the shared electrons.

8. **Hydrogen bond: -** it is an electrostatic force of attraction between a partially positive hydrogen atom of one molecule and the electronegative atom of the other molecule