# FIRST CHAPTER : CHEMICAL BONDS

A chemical bond is an interaction between several atoms, ions or molecules, at a distance allowing the stabilization of the system and the formation of an aggregate or a chemical substance.

The Octet rule may be defined as chemical tule followed by each atom or element in order to stabilize it. This rule states the ability of atoms to prefer to have eight electrons in their valence shell. But when an atom fails to possess 8 electrons in its valence shell, they tend to react and construct more stable compounds. This will only happen when an atom reacts with nearby atoms to give (lose electrons), receive (gain electros) or share electrons until it has a full outer shell. This process allows atoms to form bonds with other atoms and create stable compounds, fulfilling the octet rule and increasing overall stability.

## I. Strong chemical bonds

Strong chemical bonds are the *intramolecular* forces that hold atoms together in molecules. The types of strong bond differ due to the difference in electronegativity of the constituent elements.

- **Electronegativity**

Electronegativity is a chemical property that describes the tendency of an atom or a functional group to attract electrons toward itself. Elements having high electronegativity are incapable of transferring electrons, and elements having very low electron affinity cannot take up electrons. The presence of a bond between two elements can be determined by calculating the electronegative value between two atoms.

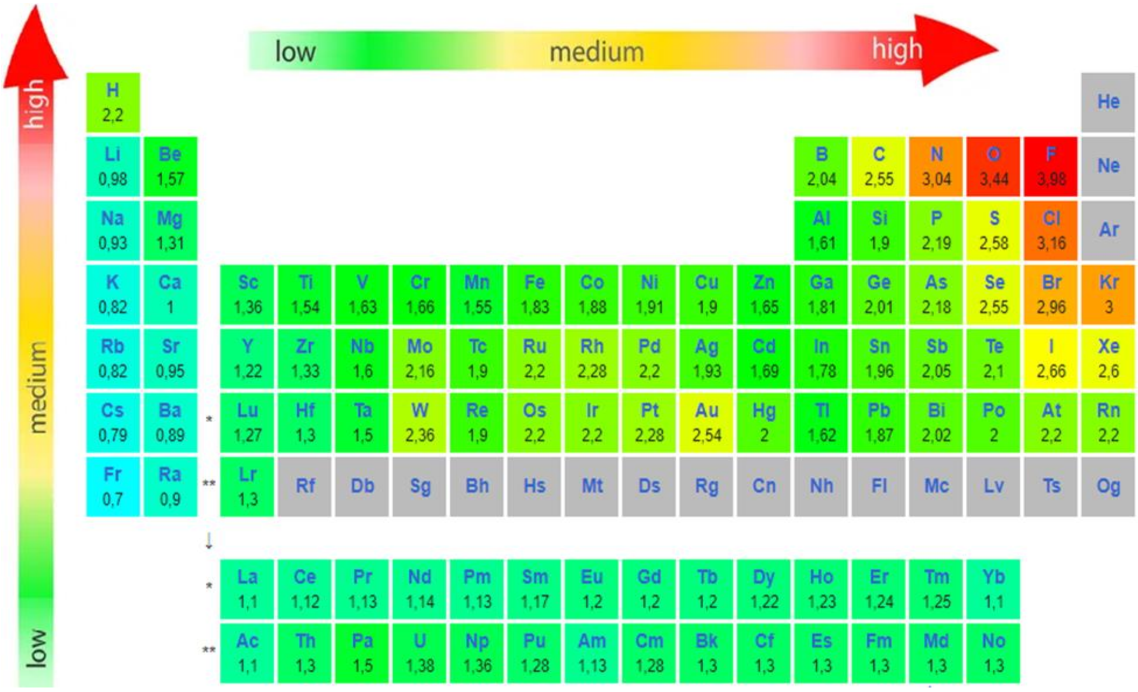



**Fig .1** periodic table

## I.1. Covalent bonds

A covalent bond occurs between two non-metallic atoms, it is formed by the equal sharing of electrons from both participating atoms. The pair of electrons participating in this type of bonding is called a shared pair or bonding pair. Covalent bonds are also called molecular bonds. Sharing of bonding pairs will ensure that the atoms achieve stability in their outer shell.

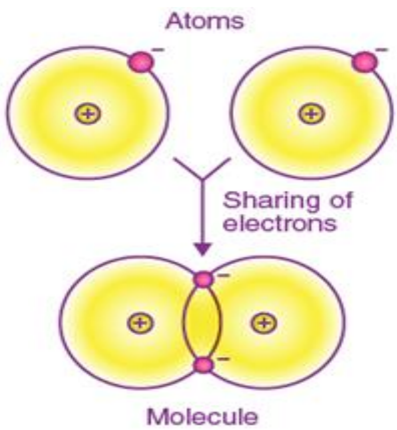
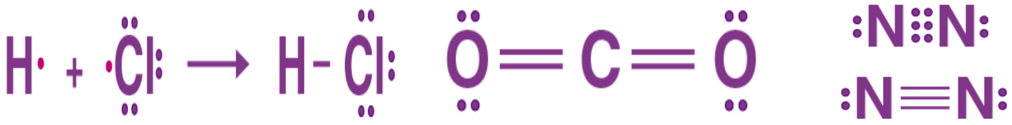



**Fig 2.** Formation of covalent bond.

Depending upon the number of shared electron pairs, the covalent bond can be classified into:

- Single covalent bond.

- Double covalent bond.
- Triple covalent bond.



(a) (b) (c)

**Fig. 3** Type of covalent bonds. **(a)** HCL molecule with single bond; **(b)** Double Bond in Ethylene Molecule; **(c)** Nitrogen Molecule with Triple Bond.

a) **Polar Covalent Bond**

This type of covalent bond exists where the unequal sharing of electrons occurs due to the difference in the electronegativity of combining atoms. More electronegative atoms will have a stronger pull for electrons. The electronegative difference between the atoms is greater than 0.5 and less than 0.79. As a result, the shared pair of electrons will be closer to that atom.

**b) Nonpolar Covalent Bond**

This type of covalent bond is formed whenever there is an equal share of electrons between atoms. The electronegativity difference between two atoms is close to zero (0 to 0.5). It occurs wherever the combining atoms have similar electron affinity.

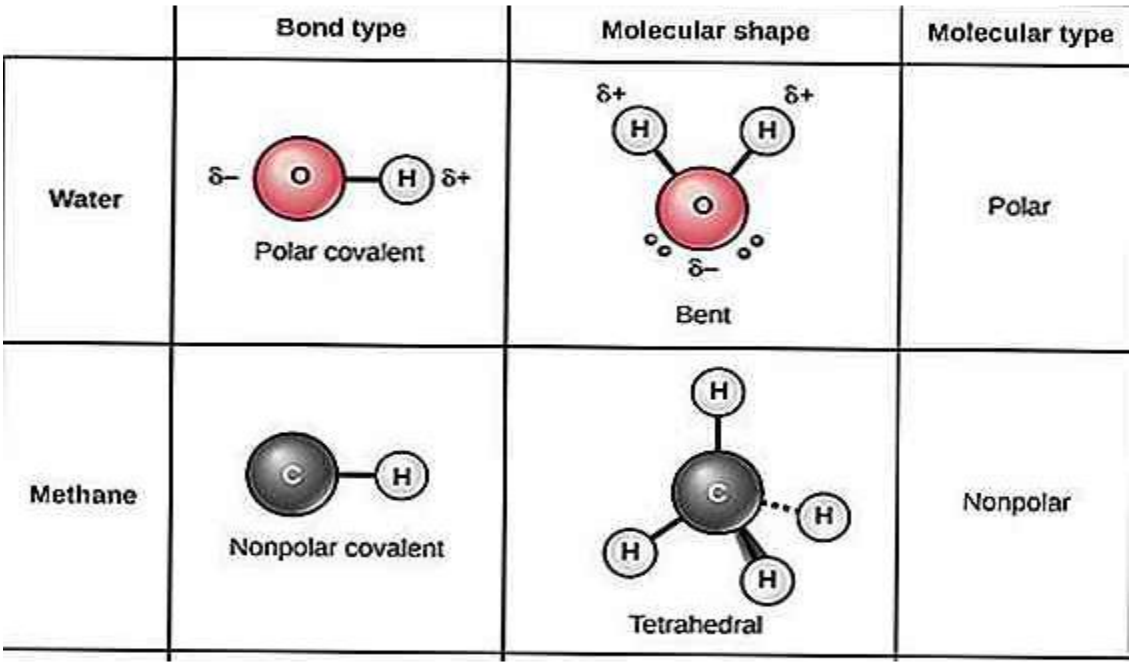



**Fig 4.** Type of covalent bond.

## I.2. Ionic bonds

Ionic bonding is a type of electrostatic interaction between atoms that have a large electronegativity difference. There is no precise value that distinguishes ionic from covalent bonding, but an electronegativity difference of over 1.79 is likely to be ionic while a difference of less than 1.79 is likely to be covalent. These bonds are different in their properties and structure. Covalent bonds include pairs of electrons by two atoms binding them in a fixed orientation, while a bond between two ions is called an ionic bond. Ionic bonding leads to separate positive and negative ions. Ionic charges are commonly between −3e to +3e.

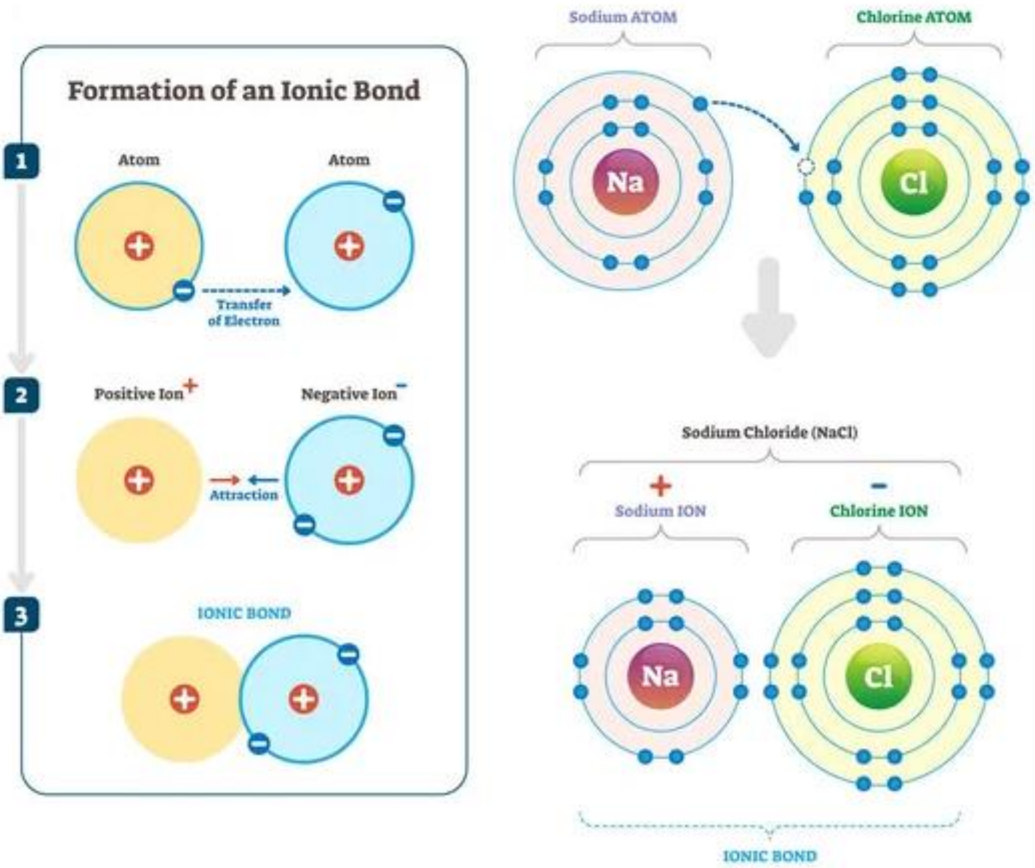



**Fig 5.** Ionic bond.

## I.3. Metallic bond

Force that holds atoms together in a metallic substance. Such a solid consists of closely packed atoms. In most cases, the outermost electron shell of each of the metal atoms overlaps with a large number of neighbouring atoms. As a consequence, the valence electrons continually move from one atom to another and are not associated with any specific pair of atoms. In short, the valence electrons in metals, unlike those in covalently bonded substances, are nonlocalized, capable of wandering relatively freely throughout the entire crystal. The atoms that the electrons leave behind become positive ions, and the interaction between such ions and valence electrons gives rise to the cohesive or binding force that holds the metallic crystal together.

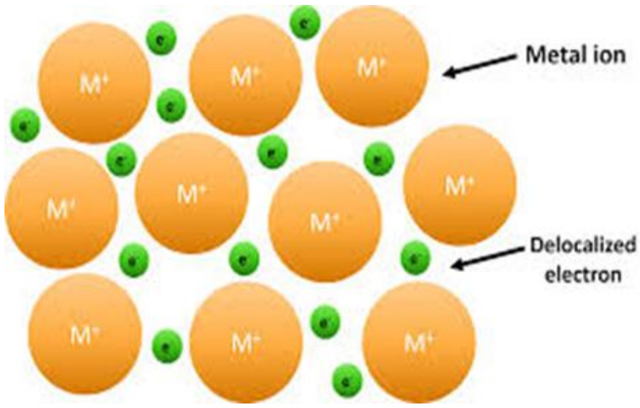



**Fig 6.** Metallic bond. https://www.expii.com/t/metallic-bond-formation-compounds-8645

## II. Noncovalent interactions in biomolecules (Weak interactions)

Weak, reversible bonds (noncovalent bonds or Intermolecular bonding) mediate interactions between biomolecules. Noncovalent bonds are "individually weak, but collectively strong" and together stabilize the complex structures of biomolecules such as proteins. However, non-covalent interactions allow reversible binding of molecules such as small bioactive compounds to enzymes and nucleic acids. Generally, noncovalent interactions are less than $1/10^{th}$ as strong as covalent bonds.

Four major types of noncovalent bonds or forces are involved in the structure and function of biomolecules. In addition to hydrogen bonds and hydrophobicity, there are; charge-charge interactions and van der Waals forces.

### II.1. Charge-charge interactions

Charge-charge interactions occur between oppositely charged functional groups or ions. These bonds are also known as ion pairing interactions and salt-bridges, they are potentially the strongest noncovalent forces and can extend over greater distances than other noncovalent interactions. Repulsive forces between like charges also can play an important role in biological processes.

**II.2. Hydrogen bonds.**

The hydrogen bonds that occur between water molecules are just one example of the many types found in biomolecules. In general, an hydrogen bond is defined as a dipolar attraction between the hydrogen atom attached to one electronegative atom, and a second electronegative atom. The H atom must be covalently bonded to an electronegative atom such as O or N to generate a molecular dipole. The atom with the covalently bound hydrogen atom is called the hydrogen donor, and the other atom is the hydrogen acceptor. The distance between the two electronegative atoms in an H-bond is ~0.3 nm (3 Å). Hydrogen bonds are very important in establishing specificity in molecular interactions, e.g., A-T and G-C base pairing in DNA.

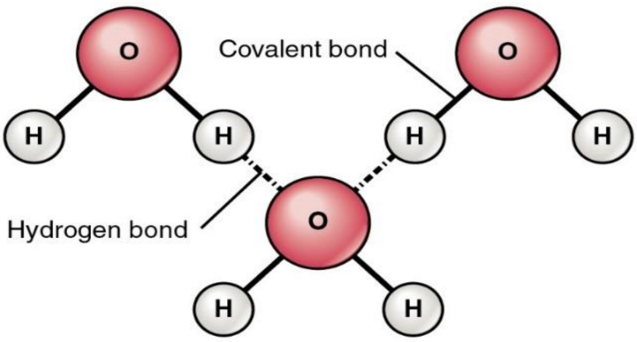



**Fig 7.** Hydrogen bond. Anatomy & Physiology, Connexions Website. http://cnx.org/content/col11496/1.6/, Jun 19, 2013.

**II.3. Van der Waals forces**

is a distance-dependent interaction between atoms or molecules. van der Waals forces typically are the weakest of the noncovalent interactions. However, they often are important in the packing of amino acids inside a folded protein and in the interactions between adjacent bases stacked within the DNA double helix. They also can mediate specific interactions because they become collectively strong if the interacting molecules have precisely complementary shapes and can approach one another closely.

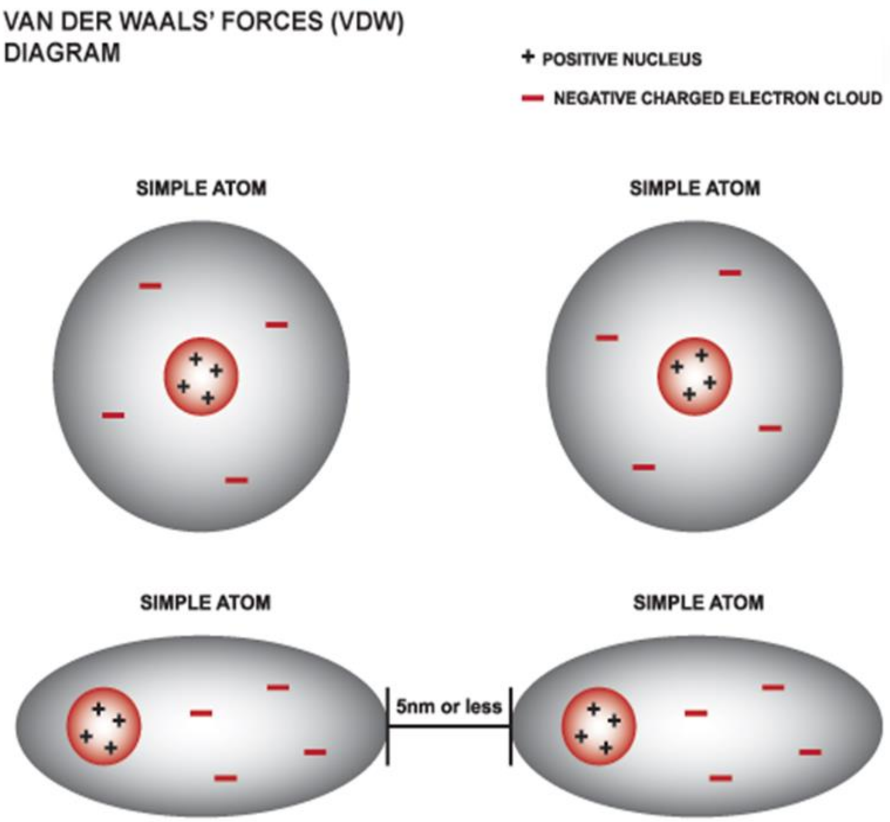



**Fig 8.** Van der Waals interactions.

## II.4. Hydrophilic interaction

Hydrophobic interactions describe the relations between water and hydrophobes (low water-soluble molecules). they arise from the inclination of non-polar hydrophobic molecules to cluster together and repel water molecules in a polar medium.