TD1: General Biochemistry

Review of Chemical Bonds

1- Different Types of Bonds

1.1. Strong Bonds

1.2. Weak Bonds

Chemical Bonds

A chemical bond is a force that holds atoms together in a molecule or crystal. Bonds form when atoms share or transfer electrons to achieve a more stable electron configuration.

1.Strong Bonds

This type of bond, also called intramolecular bond, depends on the difference in electronegativity. The greater the electronegativity difference, the more the electron is attracted to a particular atom, and the more ionic character the bond has. If the electronegativity difference is small, the bond is covalent.

1.1. Liaisons fortes

This type of bond, also known as an intramolecular bond, depends on the difference in electronegativity. The greater the electronegativity, the more the electron is attracted to a particular atom, and the bond has more ionic character. If the electronegativity is low, the bond is covalent

a. Ionic Bonds

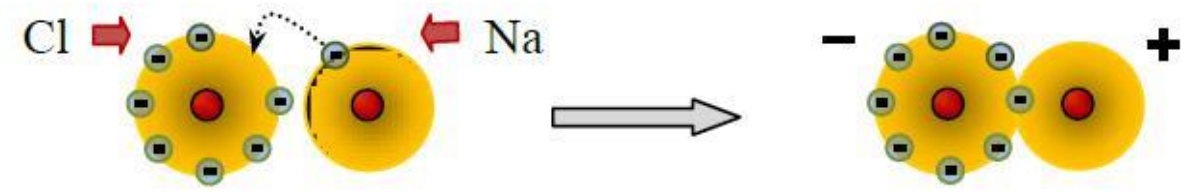
Characteristics:

There is no sharing of electrons. One atom (usually an alkali metal) donates its s^1 electron to the other atom.

- High melting and boiling points
- Good conductivity when dissolved
- Form crystalline structures
- Usually soluble in water

Thus, the two ions formed often acquire the noble gas configuration (they follow the octet rule) and the stability of the bond is ensured by the electrostatic interaction between the cation and anion.Therefore, the ionic bond results from the attraction between a positive species (cation) and a negative species (anion). The stability of the bond is ensured by electrostatic interaction. Example (NaCl, K2S).

Example: Sodium Chloride NaCl (Table Salt): $Na^+ + Cl^- \longrightarrow NaCl$

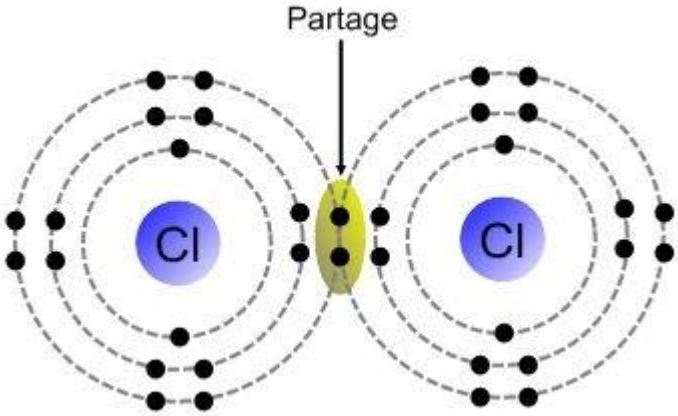


b. Covalent and Coordinate (Dative) Bonds

b1- Covalent Bond

The covalent bond between 2 non-metallic atoms A and B is the sharing of two electrons. Each atom provides one valence electron.

Example: Cl_2



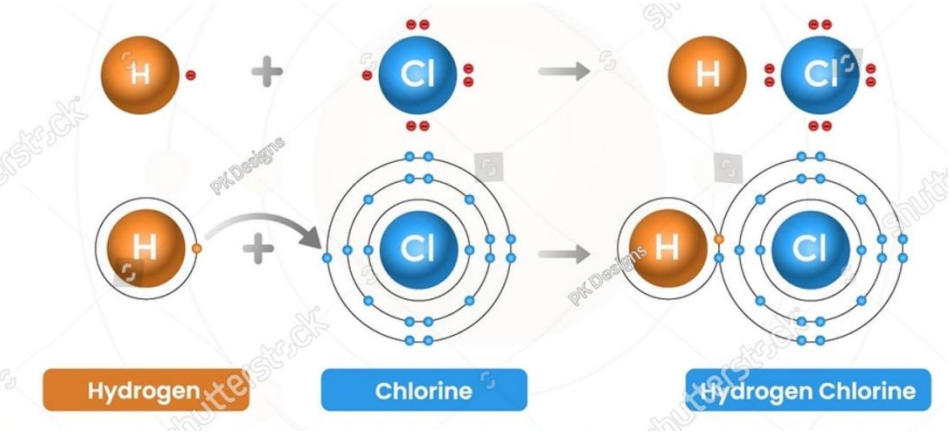
Covalent bonds are the strongest σ (sigma) bonds, and there can only be one σ bond between two atoms. If additional bonds are created (multiple bonds), they are weaker and are of the π (pi) type.

b2- Coordinating or dative covalent bond

It is the sharing of two electrons between two atoms A and B. One of the atoms provides the two electrons.

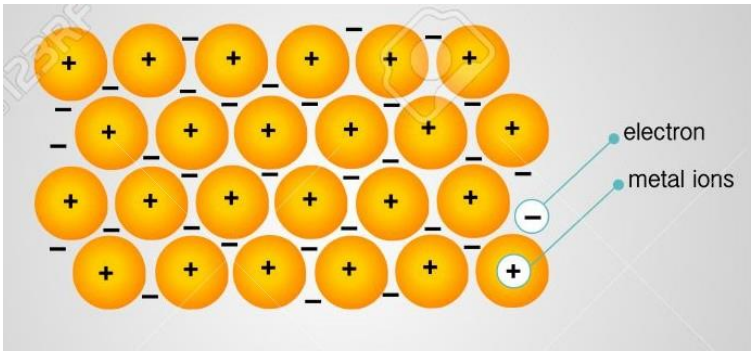
- The donor must have a lone pair.
- The acceptor must have an empty atomic orbital.

Example: HCl



c. The metallic bond,

- found only in metallic solids, is based on the mobility of electrons within a network, which makes metals excellent electrical and thermal conductors. The more valence electrons a metal atom shares, the stronger the bond, giving the metal greater hardness and higher melting and boiling points. A metal can be described as an assembly of positive ions in a "cloud" of mobile electrons, explaining its high conductivity.



1.1.1 Bond Polarity

The polarization of a bond is closely related to the difference in electronegativity between the bonded atoms. The greater the difference, the more polarized the bond.

a. **Polar and Nonpolar Bonds**

A bond is polar if the difference in electronegativity between the atoms forming the bond is non-zero, creating an asymmetry in the electron cloud. The more electronegative atom pulls the bonding pair toward itself, gaining a slight negative charge, noted as -δ, while the less electronegative atom acquires a slight positive charge, noted as +δ. The molecule as a whole, however, remains electrically neutral.

Example: H–O ; C–F ; N–O

A bond is nonpolar if the difference in electronegativity between the atoms forming the bond is zero, resulting in a symmetric electron cloud. This bond is purely covalent. (See appendix, page 147: electronegativity values)

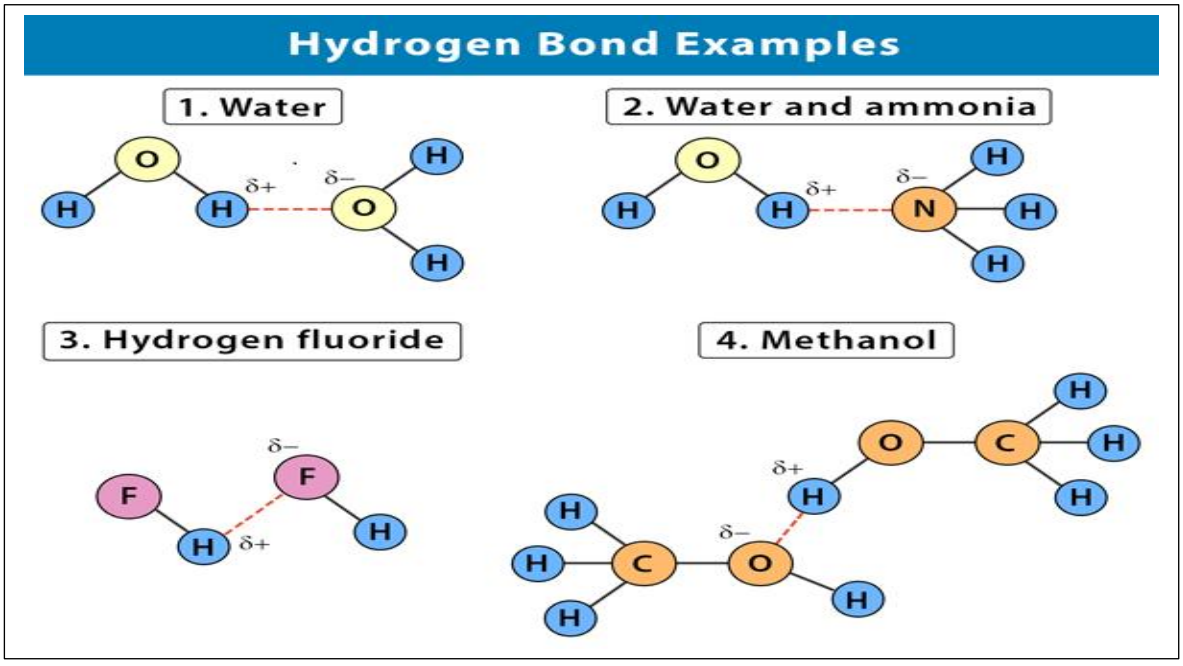
Examples: H–H, Cl–Cl, C–I, N–Cl

1-2 Weak Bonds

An intermolecular bond is a bond that unites molecules. It is defined as a weak residual electrostatic force established between molecular dipoles. There are three types of interactions or forces between molecules.

a. Liaison hydrogène :

Cette liaison est souvent présente dans toute la chimie de la vie. Par définition Les liaisons hydrogène sont des interactions dipôle-dipôle qui peuvent s'établir entre un atome d'hydrogène lié par covalence à un atome très électronégatif porteur d'un doublet non liant.



b. Van der Waals Forces

Van der Waals forces arise from the interaction between the electron clouds of atoms or molecules that are very close to each other. The negative charge of an electron cloud is not "fixed"; it fluctuates at any moment and is only statistical, allowing for attractions between a positively charged nucleus and the electron cloud of a neighboring atom. Van der Waals interactions include

dipole-dipole interactions, whose interaction energy decreases over distance. These interactions are also referred to as London forces.

Three types of attractive forces can be distinguished:

- Keesom forces: between polar molecules
- Debye forces: between a polar molecule and a nonpolar molecule
- London dispersion forces: between two nonpolar molecules

c. Hydrophobic Interactions:

Hydrophobic interactions result from the strong tendency of water molecules to exclude nonpolar groups and molecules. These interactions do not stem primarily from a particular affinity between nonpolar substances but rather from the strong interactions between water molecules, which are much stronger than those with nonpolar molecules.

Since the strongest possible interactions between two molecules prevail over others, the formation of hydrogen bonds between polar water molecules excludes nonpolar molecules and groups. The exclusion of hydrophobic substances from an aqueous solution and the tendency of nonpolar molecules to cluster together are consequences of the preferential interactions of water molecules. This is why the nonpolar regions of biological macromolecules are often buried inside the molecules.

References & Bibliography

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QCM :(Cocher une seule réponse)

Q1 : Les Forces de Van der Waals prennent lieu avec les fluctuations de la charge électriques entre deux atomes proches?

- ✓ OUI /Explication : Forces de Van der Waals : fluctuations de la charge électriques
  Non

Q2 : les interactions hydrophobes correspondent a des liaisons hydrogène?

  OUI

- ✓ Non /Explication : liaison hydrophobe entre deux groupes hydrophobes

Q3 : les liaisons ioniques sont des liaisons covalentes?

  OUI

- ✓ Non /Explication : liaisons ioniques : L faibles / L covalentes

Q4 : Laquelle des caractéristiques suivantes est valable pour les liaisons ioniques?

- ✓ Les liaisons ioniques deviennent faibles avec les sels /Explication : liaisons ioniques rendues faibles avec les sels
  Les liaisons ioniques sont plus fortes en solution aqueuse

Q5 : Les ponts disulfures sont des liaisons covalentes?

- ✓ Oui /Explication : Ponts S-S sont des liaisons covalentes
  Non

Q6 : Quel est le résultat de l'interaction de l'acide acétique **(CH3-COOH)** et l'eau?

  Interaction hydrophobe

  Liaisons ionique

- ✓ Liaison hydrogène