Dr.Ahmad Al-Qawasmi

Biochemistry

Introduction to biochemistry

❖ Introduction to Biochemistry

- It is the study of chemistry in the living systems (cells & organisms)
  - ➢ It studies the structure, organization, interactions, reactions and functions of biological molecules
  - ➢ Studying the flow of energy in the cells and its transformation from one type to another (which is called bioenergetics)

- We use biochemistry in medicine in:
  - ➢ Diagnosing, monitoring & understanding the molecular bases of diseases
  - ➢ Designing drugs (new antibiotics, chemotherapy agents)

❖ Chemical elements

- Living organisms on Earth are composed mainly of about 30 elements
  - ➢ **Major elements** (98.5%) are:
    - ✓ **4 Primary elements → Carbon, Hydrogen, Oxygen & Nitrogen** which form 96.5% of an organism's weight (the most abundant)
    - ✓ Then **calcium and phosphorus**
  - ➢ Then **lesser and trace elements** (about 2%), they are mainly metals
    - ✓ They are minor, but they are also vital (important)

❖ Bonds and interactions

- Bond are classified into covalent and non-covalent:

1) Covalent bonds

- bonds that involve **sharing electrons** between atoms, and they are formed during chemical reactions
- Covalent bonds can be either Polar or non-polar:

> - Electronegativity is the strength and ability of atoms to pull electrons
> - The most electronegative atoms are F, O and N

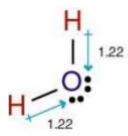
A) Polar

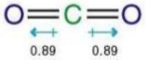
- ➢ They are covalent bonds where electrons are shared unequally between the atoms
- ➢ The unequal share is due to the difference in the electronegativity between atoms
- ➢ These bonds are also called dipoles, having a **partially positive** pole and **partially negative** pole
- ➢ The atom with higher electronegativity is partially negative and the other one is partially positive
- ➢ **Examples** on polar bonds: N-O, H-O, H-N

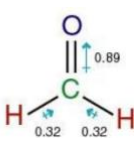
B) Non-polar

- ➢ Covalent bonds in which electrons are shared equally
- ➢ Electronegativity is almost similar between the atoms forming the bond
- ➢ **Example** on non-polar bonds: H-C

- A molecule can be polar or non polar
  - ➢ Polar molecules contain one or more polar covalent bonds which are not 180° opposite to each other such as water molecule and H_2CO





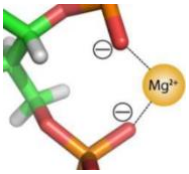


- Non-polar molecules doesn't contain polar covalent bonds or could have 2 or more polar covalent bonds which are opposite to each other (such as CO_2) so they cancel each other

2) Non-Covalent Bonds

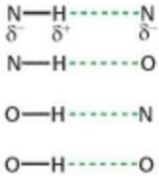
- They are reversible and relatively weak
  - They are weak but their significance is due to their large number
- They are important for the structure, function and stability of macromolecules
- They include many types of interactions:

A) Electrostatic (Ionic, Charge-charge) interactions



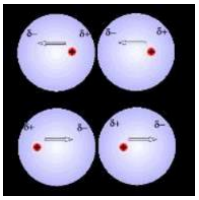
- Occur between charged particles either partially or fully charged particles
- These forces are quite strong in the absence of water

B) Hydrogen bonds



- It is considered a special type of electrostatic bonds
- A hydrogen atom is shared between 2 highly electronegative atoms (donor and acceptor)

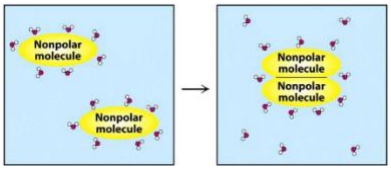
C) Van Der Waals interactions



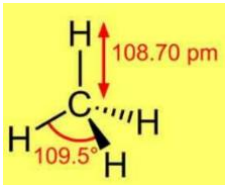
- They are instant (transient) interactions caused by the unequal distribution of electrons around an atom and they are the weakest interactions
- The strength of these interaction highly affected by distance

D) Hydrophobic interactions

- They are the forces that cause the self-association of nonpolar compounds in an aqueous environment
- They minimize the unfavorable interactions between nonpolar groups and water (increase stability)
- Help in the formation of **micelle**



❖ Properties of bonds

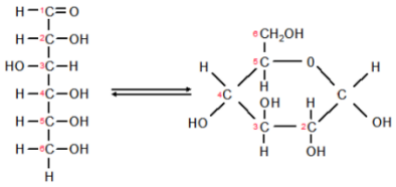


- **Bond strength:** It is the amount of energy that must be supplied to break a bond
- **Bond length:** The distance between two nuclei
  - Bonds strength and length are **inversely related**
- **Bond orientation:** Bond angles determining the overall geometry of molecules
  - It depends on the environment of the molecules
  - The three-dimensional structures of molecules are specified by the bond angles (orientation) and bond lengths for each covalent linkage

❖ Carbon

- It can form 4 bonds which can be single, double or triple bonds where each bond is very stable

- The strength of the bonds: Triple > Double > Single



- C atoms form the backbones of macromolecules which can be linear chains and rings
  - Carbon backbone contribute in the **stability** of the molecule
  - Angels between them contribute to the 3D structure of the molecules
  - In a carbon backbone, some carbon atoms **rotate** around a single covalent bond producing molecules of different shapes causing **diversity** between molecules
- Carbon can form polar (H_2CO) or nonpolar (coal) molecules due to its intermediate electronegativity
- Pure carbon is not water soluble but when carbon bind covalently with other highly electronegative elements (O, N) forming water-soluble

Past papers

1. **All of these are non-covalent interaction, EXCEPT:**
   A. Hydrophobic interactions
   B. Ionic interactions
   C. Hydrogen bonds
   D. Van der Waals
   E. None of the above

2. **Hydrogen bonds can form between electronegative atoms such as oxygen and nitrogen and a hydrogen atom bonded to:**
   A. Only oxygen
   B. Hydrogen
   C. Only nitrogen
   D. Any electronegative atom