Doctor 022

Biochemistry

Sheet no. 1

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Chemical elements in our body:

Elements:

- **The human body is composed mainly of ~30 elements.**
- **Hydrogen, oxygen, carbon and nitrogen are the main elements (96.5% of the body's weight)**
- **• Calcium and phosphorus in our bones (2% of the body's weight), (that is 98.5% of Major Elements)**
- **Others exist in trace amounts but are essential, elements(mostly metals), but they are important such as: selenium and zinc.**

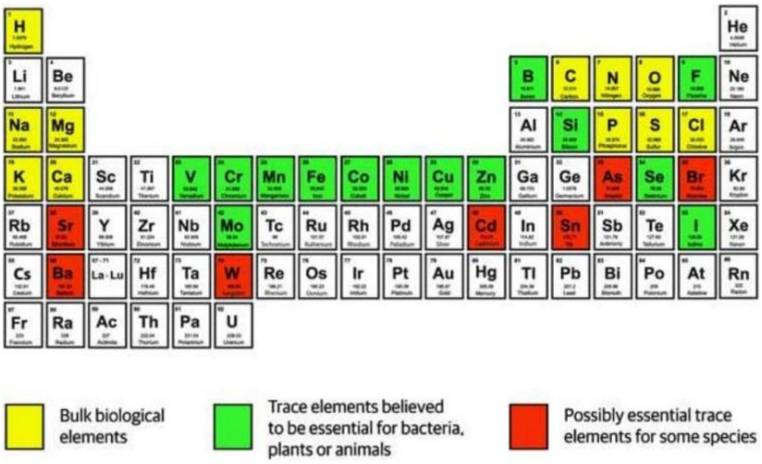


TABLE 2.1 Elements of the Human Body

Name	Symbol		Percentage of Body Weight
Major Elements (Total 98.5%)			
Oxygen	O		65.0
Carbon	C		18.0
Hydrogen	H		10.0
Nitrogen	N		3.0
Calcium	Ca		1.5
Phosphorus	P		1.0
Lesser Elements (Total 0.8%)			
Sulfur	S		0.25
Potassium	K		0.20
Sodium	Na		0.15
Chlorine	Cl		0.15
Magnesium	Mg		0.05
Iron	Fe		0.006
Trace Elements (Total 0.7%)			
Chromium	Cr	Molybdenum	Mo
Cobalt	Co	Selenium	Se
Copper	Cu	Silicon	Si
Fluorine	F	Tin	Sn
Iodine	I	Vanadium	V
Manganese	Mn	Zinc	Zn

Important terms:

Electronegativity: **the ability of an element or atom to attract electrons to its side.**

Some elements are considered highly electronegative such as oxygen and nitrogen. Other elements are less electronegative such as carbon and hydrogen.

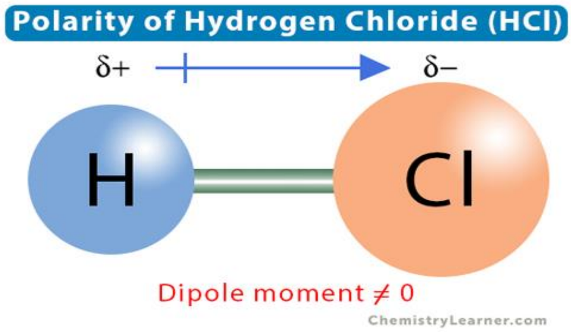
Polarity: **covalent bonds in which electrons are shared unequally. the difference in electronegativity between 2 elements will lead to polarity, it is a property that arises from a highly electronegative atom binding to a less electronegative atom. The highly electronegative atoms will attract electrons to their side, leading to the formation of a partial negative charge on the highly electronegative atom, and a partial positive charge will be formed on the less electronegative atom. Polar bonds are known as dipoles. Polarity**

could describe bonds or molecules (we must differentiate between these two)

examples:

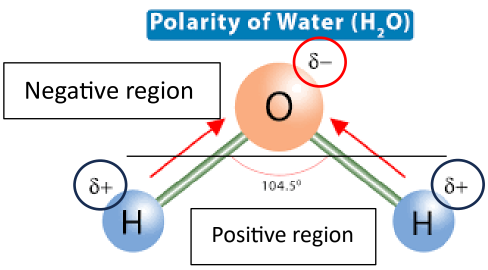
Oxygen-hydrogen bonds are polar.

Carbon-hydrogen bonds are NOT polar.



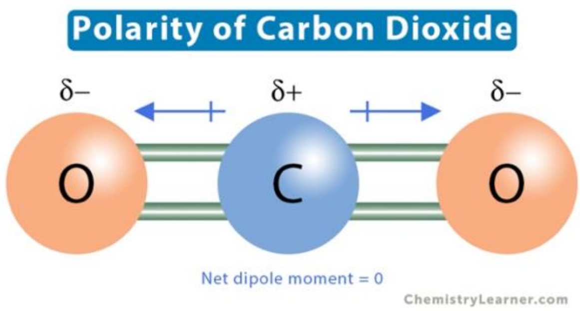
Polar bonds vs polar molecules:

- **An important note: even if the molecule has a polar bond (a highly electronegative atom binding to a less electronegative one) that does NOT necessitate that the molecule is polar, for example: CO_2 (although it has 2 polar covalent bonds, but it is not a polar molecule.**
- **To determine if a molecule is polar, we need to have a plane where we can divide the molecule into 2 regions: a region where partial positive charges are located and another region where partial negative charges are located.**



2 polar bonds,

polar molecule



2 polar bonds

Non-polar molecule

Terms related to bonds:

- **Bond strength: the amount of energy required to break the bond.**
- **Bond length: the distance between 2 nuclei.**

- Bond orientation: bond angles determining the geometry of the molecule.
- The three-dimensional structures of molecules are specified by the bond angles and bond lengths for each covalent linkage.

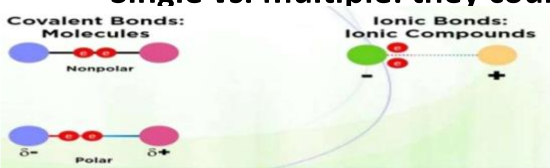
There is a relationship between bond length and bond strength: as bond strength increases, bond length decreases as the atoms are attracted more to each other.

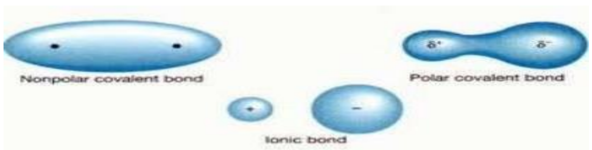
Bond	H—F	H—Cl	H—Br	H—I
Length	0.917 Å	1.275 Å	1.415 Å	1.609 Å
Strength	136 kcal/mol 571 kJ/mol	103 kcal/mol 432 kJ/mol	87 kcal/mol 366 kJ/mol	71 kcal/mol 298 kJ/mol

Types of bonds:

Covalent bonds:

- Covalent bond is stronger than non covalent.
- Polar vs. non-polar covalent bonds: covalent bonds are considered polar when one of the atoms is highly electronegative and the other is less electronegative.
- Single vs. multiple: they could be single, double, and triple bonds.





Covalent bonds in which the electrons are shared unequally in this way are

Known as polar covalent bonds. The bonds are known as "dipoles".

- Oxygen and nitrogen atoms are electronegative
- Oxygen and hydrogen
- Nitrogen and hydrogen
- Not carbon and hydrogen

Water is an excellent Example of polar Molecules, but not CO2

Non-covalent interactions:

General properties:

- They are reversible and relatively weak.
- Molecules interact and bind specifically.

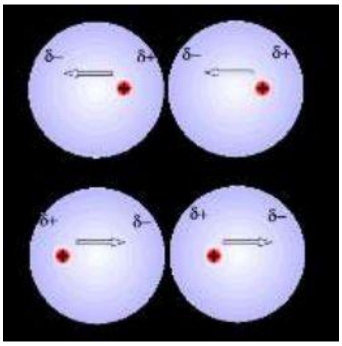
- Noncovalent forces significantly contribute to the structure, stability, and functional competence of macromolecules in living cells.
- Can be either attractive or repulsive.
- Involve interactions both within the biomolecule and between it and other molecules of the surrounding environment.

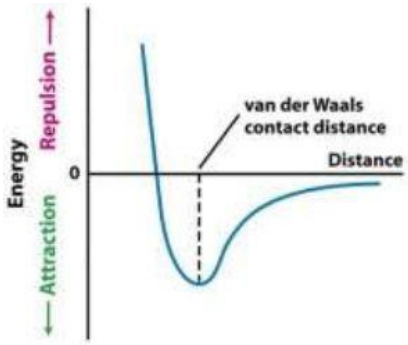
• hydrogen bonds (donor and acceptor): when a partially positive hydrogen is attracted to a relatively electronegative atom such as oxygen or nitrogen (they are mainly intermolecular "between two different molecules" but they can also be intramolecular). The hydrogen atom and the atom that is attached to the hydrogen atom with a covalent bond are always considered as a donor, while the other electronegative atom is considered as an acceptor.

• electrostatic interactions: Between two atoms with real and partial charges, these forces are quite strong in the absence of water. for example: NaCl.

-Dipole-dipole is a special case of electrostatic interactions.

•Van der Waals interactions occur when there is an uneven distribution of electrons in its orbitals, resulting in weak interactions and they are easily broken as molecules are moving rapidly.However, large number of them cannot be neglected.Additionally, these interactions are influenced by the distance between the two atoms.A greater number of interactions leads to increase stability, while rapid changes indicate decreased stability.Furthermore, when the distance between atoms form van der waals interactions within the same molecule is reduced ,there is higher repulsion energ .Refer to the figure bellow





-When 2 molecules are
far away from each other—>There is very minimal interaction.
close to each other—> Attraction
very close to each other—> Repulsion

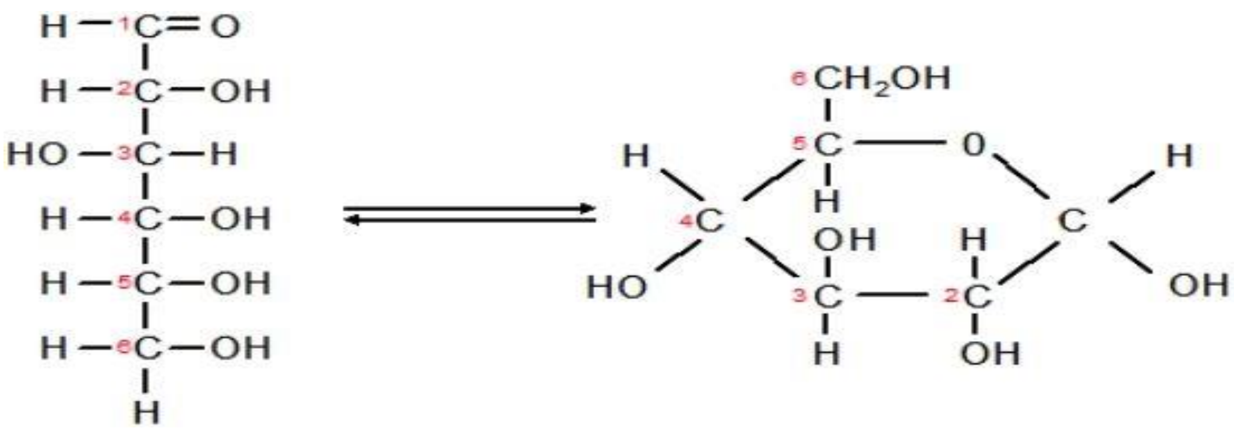
- Hydrophobic interactions: Self-association of nonpolar compounds in an aqueous environment. These interactions minimize unfavourable interactions between nonpolar groups and water. (The same as phospholipid bilayer when the lipids self-assemble to avoid the interaction of water with the hydrophobic tails).

- There are two substances that are essential for life that we are going to discuss: carbon and water.

Carbon:

Properties of carbon:

- The most important thing that carbon provides for us is diversity:
- They can form 4 bonds: and they can form single, double, or even triple bonds. And these bonds are stable (strength of bond: triple > double > single).
- They can form either chains or ring, and they can serve as backbones.



- They can rotate around single bonds producing different shapes.
- The electronegativity of carbon is between other atoms. It can form polar and non-polar molecules.
- Pure carbon is not water soluble, but when carbon forms covalent bonds with electronegative elements like O or N, the molecule becomes soluble.
- Carbon bonds have angles giving molecules three-dimensional structures.

-water

-Properties of water:

-water forms 60% of human's weight.

• Water is a polar molecule as a whole because of:

• the different electronegativities between Hydrogen and oxygen

• It is angular.

• Water is highly cohesive.

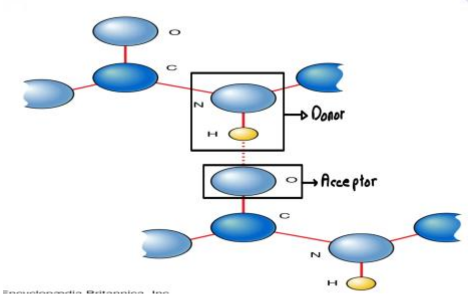
• Water molecules produce a network.

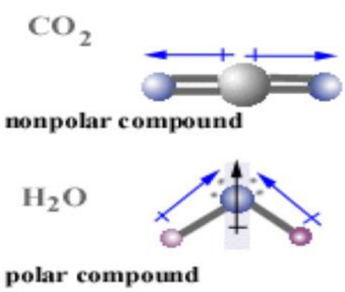
• Water is an excellent solvent because:

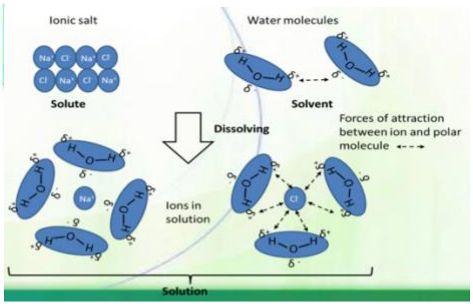
1)it is small.

2)it weakens electrostatic forces and hydrogen bonds among polar molecules.

-Water is an excellent solvent because it forms dipole-dipole interactions and hydrogen bonds with other molecules, disrupting the intermolecular forces.

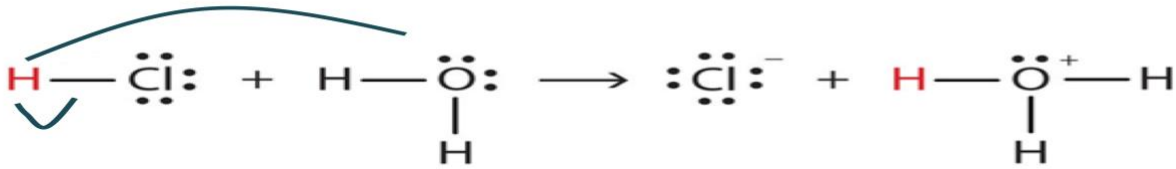




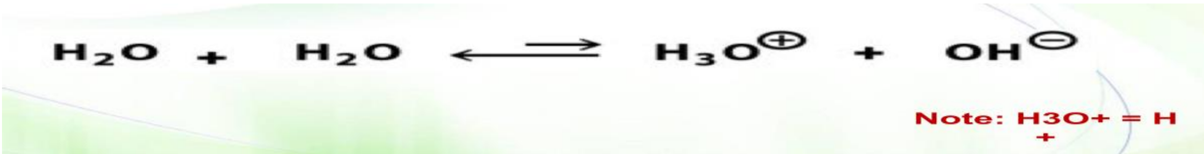


• **It is reactive because it is a nucleophile.**

• **A nucleophile is an electron-rich molecule that is attracted to positively- charged or electron-deficient species (electrophiles).**

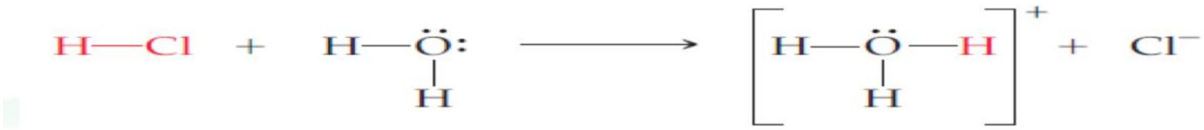


• **Water molecules are ionized to become a positively-charged hydronium ion (or proton), and a hydroxide ion:**

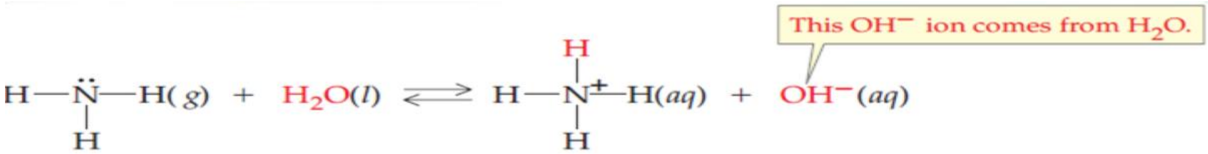


-Acids and bases:

• **Acid: a substance that produces H+ when dissolved in water • H+ Reacts with water producing hydronium ion (H3O+).**



• **Base(as Alkali): a substance that produces OH- when dissolved in water.**



-Types of acids and bases

• **The Brønsted-Lowry acid: any substance (proton donor) able to give a hydrogen ion or a proton (H+) to another molecule.**

• **Monoprotic acid: HCl, HNO3, CH3COOH**

• **Diprotic acid: H2SO4**

• **Triprotic acid: H3PO3**

• **Brønsted-Lowry base: any substance that accepts a proton (H+) from an acid.**

• **NaOH, NH3, KOH**

-Acid/base strength

• Acids differ in their ability to release protons.

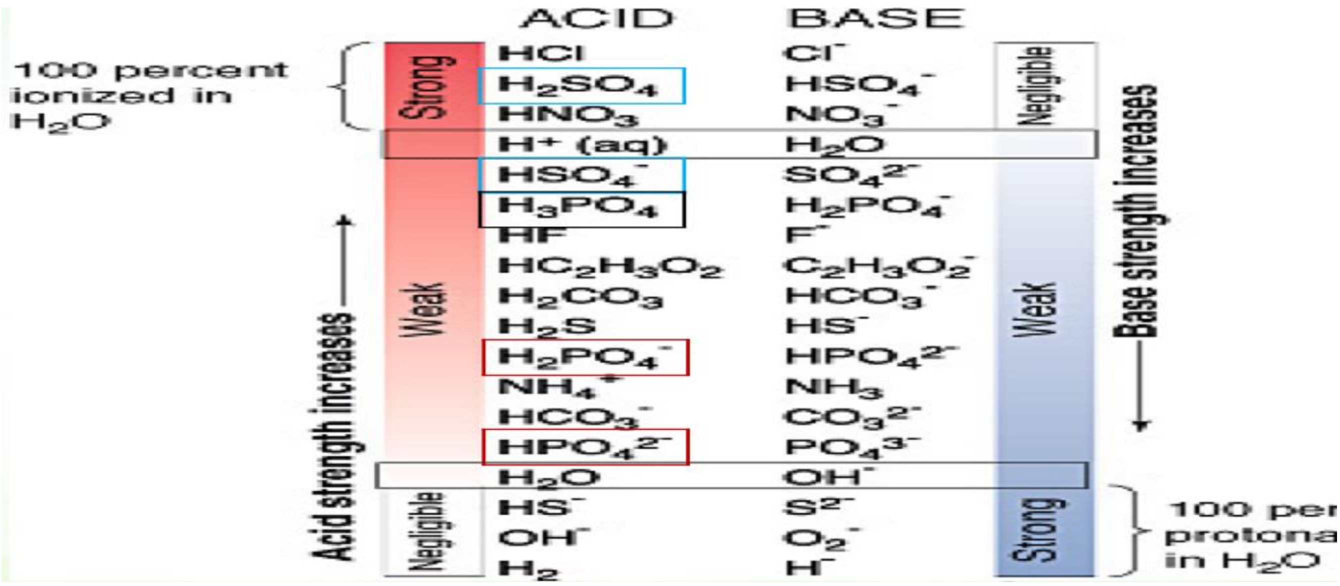
• Strong acids dissociate 100%.

• Bases differ in their ability to accept protons.

• Strong bases have a strong affinity to accept protons.

• For multi-protic acids (H2SO4, H3PO4), each proton is donated at different strengths.

-(HSO4-) is weaker than H2SO4



-If the acid is dissociated, the acid becomes in its ionic form.

-Rule:

• The stronger the acid, the weaker the conjugate base.

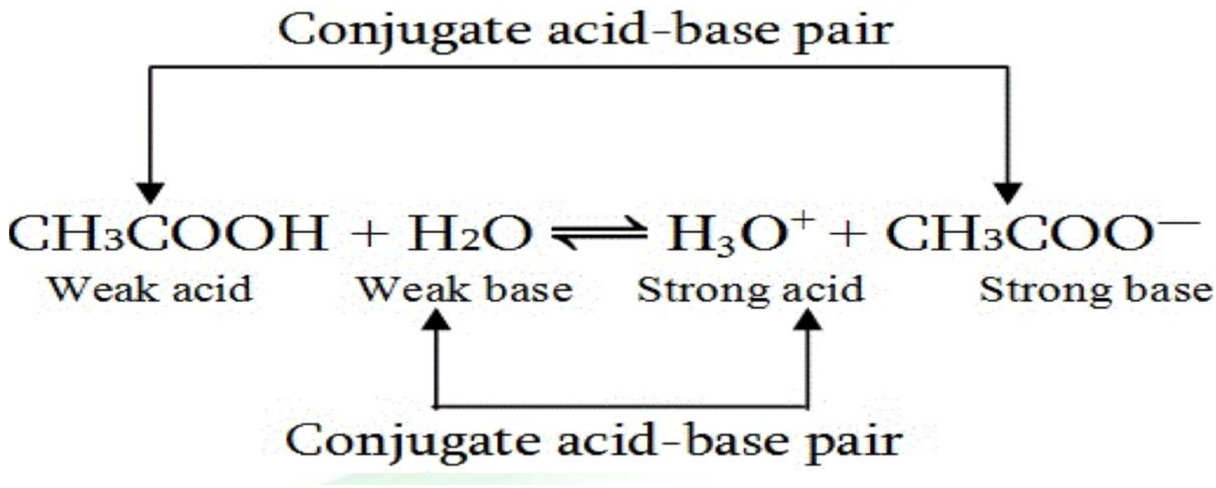
• Strong vs. weak acids and bases

• Strong acids and bases are one-way reactions HCl → H+ + Cl-

NaOH → Na+ + OH-

• Weak acids and bases do not ionize completely

HC2H3O2 ↔ H+ + C2H3O2- NH3 + H2O ↔ NH4+ + OH-



اللهمّ أجرنا من نار جهنم، هذا حرّ الدّنيا فكيف بحرّ الآخرة؟ نسأل الله العفو و العافية

GOOD LUCK

V2