SLE212: Biochemistry Lecture Notes

Week 1: Intro and Thermodynamics

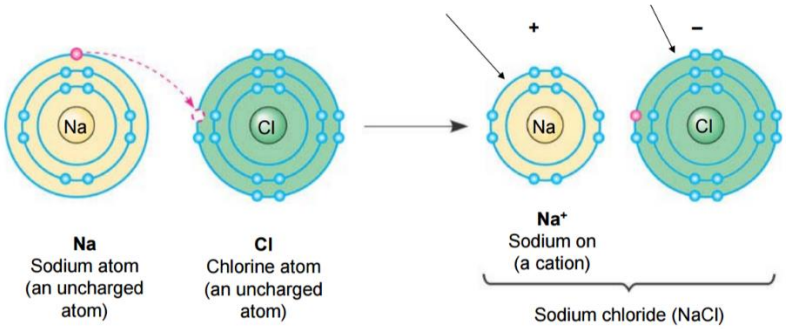
Essential elements of life

Organic matter makes up 25 out of 92 chemical elements.

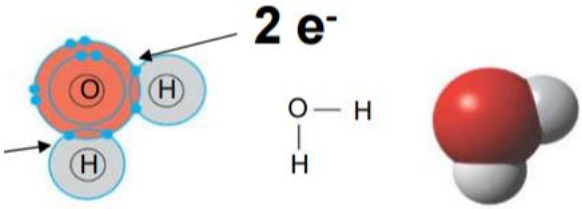
- 96% of this is Carbon (C), Oxygen (O), Nitrogen (N) and Hydrogen (H).
- The other 4% is Phosphorus (P), Sulphur (S), Calcium (Ca), Potassium (K) and Sodium (Na)
- Trace elements such as Iron (Fe) and Iodine (I) are also required in minute amounts

Bonds that are involved in life

1. Ionic bonds: Opposite attraction between cations and anions.
- Exists in salts, NaCl, KCl, $CaCl_2$ etc.
- *In vivo,* exist as disassociated ions with valence shell full



2. Covalent bonds: Sharing a pair of valence electrons.
- In contrast to ionic bonds, they covalent bonds share electrons rather than give them up
- Occur when atoms are not electronegative enough to rip an electron away from the other atom
- Very strong bonds. They are the reason that life exists.

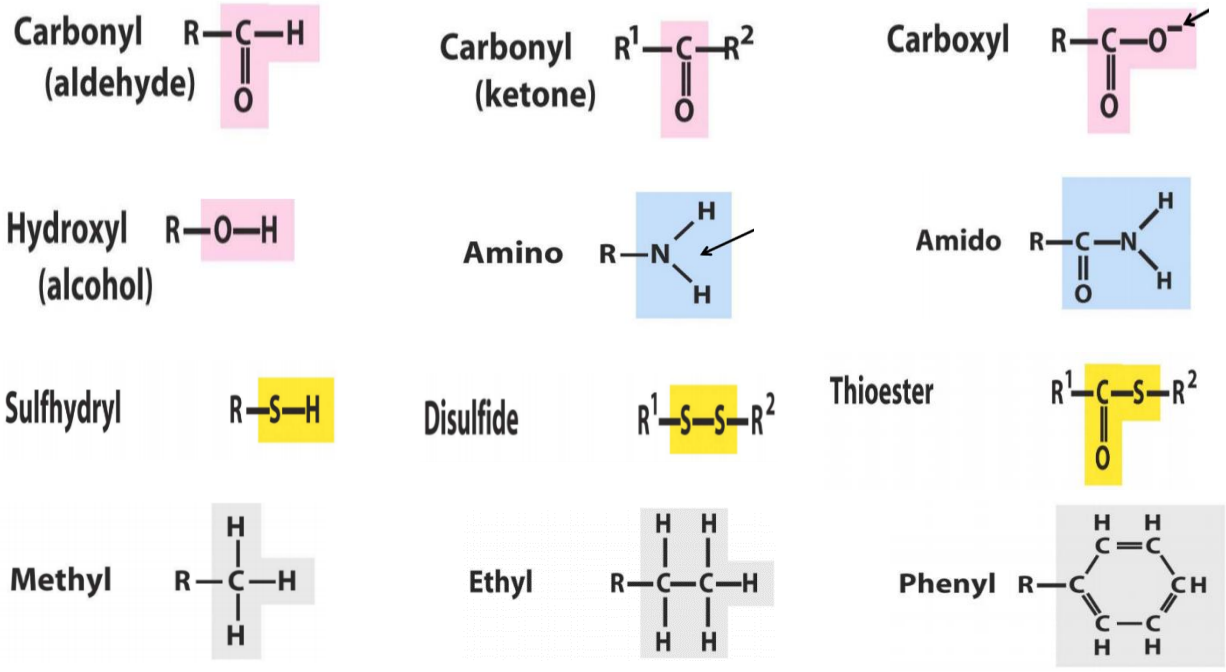


3. Hydrogen bonds: H atom bonded to an electronegative atom forms a δ+.
- The slightly positive charge (δ+) of a H atom, attracted to the slightly negative charge (δ-) of an electronegative atom.
- Must have three atoms in a straight line, with the H atom sandwiched in the middle.
4. Van der Waals interactions: Attraction between non polar molecules
- Weak interactions, occur when the molecules are very close
- The electrons move around, and for a split second where they congregate becomes an electron hotspot that becomes slightly negatively charged. These hotspots become transient dipoles.
- Van der Waals forces are responsible for allowing geckos to walk up walls.

Biomolecules

Consist of a C skeleton + other groups of atoms to form functional groups. Carbon skeletons exist at the centre of all biological molecules.

Common Functional Groups



Isomers

Isomers are two or more compounds with the same formula but a different arrangement of atoms in the molecule and different properties.

They are very important because certain molecules are only present in cells. Different isomers perform very different functions, eg. Form different metabolites in a metabolic pathway.

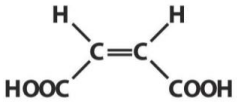
There are two types:

- Chiral
- Geometric

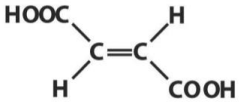
Geometric: Cis-trans isomers

Cis-trans isomers are geometric isomers with different arrangements.

- *Cis* = Carbons on the same side
- *Trans* = Carbons on opposite sides



Maleic acid (cis)



Fumaric acid (trans)

As seen in the diagram above, Cis and Trans isomers make different compounds with different chemical properties.

Chiral Centres

Chiral centres are carbon molecules with 4 different constituents. In chiral molecules, the rotated molecule cannot be superimposed on its mirror image.

- Mirror image chiral molecules are enantiomers
- Ones that can't be superimposed are diastereoisomers

THERMODYNAMICS **(Tells us whether certain processes are spontaneous)**

First Law of Thermodynamics (Principle of Conservation)

'Energy can be transferred and transformed, but it cannot be created or destroyed.'

For example, a plant can transform light energy into chemical energy. Then a deer might eat that plant and transform the chemical energy into kinetic energy.

Second Law of Thermodynamics

'During energy transfer, some of the energy becomes unavailable to do work.'

This means that some energy is wasted, usually as heat. Logically, such loss makes the universe more disordered. Energy transfer or transformation increases the entropy of the universe.

Entropy

Entropy is a measure of a system's disorder. It allows for an understanding of why a process will occur spontaneously.

Entropy always increases, because a spontaneous system will always move towards disorder rather than order.

Entropy and Spontaneity

The process will be spontaneous if it involves an increase in disorder (ie. An increase in entropy). It will not be spontaneous if it involves a decrease in disorder (ie. An increase in order).

An increase in order will only occur if energy is added to a system.

2nd law of thermodynamics alternative:

'For a process to occur spontaneously, it must increase the entropy of the universe'

Free Energy

Free energy is the portion of a system's energy that can perform work when temperature and pressure are constant. You can't estimate the amount of free energy itself, but you can estimate the change in free energy with the following formula:

$$\Delta G = \Delta H - T\Delta S$$

Where:

- ΔH = Change in enthalpy (or heat)
- $T\Delta S$ = Change in entropy (order of a system)