1 Modelli atomici e configurazione elettronica

Summing-up

The property of matter responsible for the electric force is the **electric charge** (***Q***); electric charge can be positive (+) or negative (–).

In general, forces between electric charges of the same type are repulsive, while those between electric charges of opposite sign are attractive. The magnitude of force established between electrically charged bodies is expressed by **Coulomb's law**. The magnitude of the Electrostatics force of interaction between two point charges is directly proportional to the scalar multiplication of the magnitudes of charges and inversely proportional to the square of the distances between them.

Normally objects do not carry electrical charge.

Numerous experiments involving the passing of electrical charges through tubes containing a gas at low pressure led to the discovery of the three types of elementary *sub-atomic particles* found in atoms: **electrons**, **protons** and **neutrons**.

The mass of protons and neutrons is about the same while, in comparison, the mass of the electron is much smaller (1/1836 the mass of a proton), and as such can be considered negligible.

The electric charge of electrons and protons is exactly the same but of opposite sign: negative for electrons (conventionally –1) and positive for protons (conventionally +1). Neutrons have no electric charge.

The *Rutherford atomic model* was the first major scientific theory to describe the arrangement of particles within the atom, on which the **model of the atomic nucleus** is based:

- the atom is represented as a sphere with a central core, called the *nucleus*, that is densely packed with all the protons and neutrons, while the electrons revolve around the nucleus;
- the size of the nucleus is very small compared to that of the atom and consequently the sphere is practically empty with the electrons located at relatively large distances from the nucleus;
- in neutral atoms the number of protons is equal to the number of electrons.

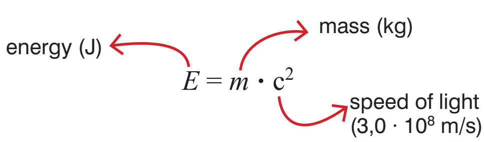
In chemical changes the nucleus remains unchanged and for this reason we can say that the chemical identity of an atom resides in its nucleus. Every atom contains a specific number of protons in the nucleus, called the **atomic number (Z).**

The total number of neutrons and protons in the nucleus determines the mass of the atom and is called the **mass number (A)**.

Isotopes are atoms of an element that have the same number of protons (same Z) but different numbers of neutrons (different A) in the nucleus.

Some isotopes, called *radioisotopes*, are unstable and because of this transform spontaneously into other, more stable, isotopes. The *half-life* indicates the time required for a given mass of radioisotope to halve.

In general, all transformations of matter affecting radioisotopes are called **nuclear reactions**. Nuclear reactions have the characteristic of producing very large (huge) amounts of energy as a part of the mass of all the particles involved in the reaction is transformed into energy (**mass defect**) according to Einstein's famous equation $E = m \cdot c^2$.



There are two types of nuclear reactions, the *fusion reaction* that occurs in the Sun, and the *fission reaction* that takes place in nuclear power plants.

According to **Bohr's atomic model**, electrons move around the nucleus without losing energy and occupy a specific number of stationary orbits; the passage of an electron from the ground state to an excited state is called *electron transition*; for this to take place the electron must absorb energy that it releases when it returns back to the ground state, emitting electromagnetic radiation.

Electromagnetic radiation is a form of radiant energy that can propagate in a vacuum at the speed of light: $3.0 \cdot 10^8$ m/s. As with all waves, electromagnetic radiation is characterized by a wavelength (λ) and a frequency (f). The wavelength is the distance between two consecutive points on the wave that are in the same phase. The frequency indicates the number of complete oscillations made in one second. It is also important to remember that, according to the Planck equation for energy associated with a radiation, the energy of the corresponding photon is directly proportional to the frequency of the radiation:

$$E = \mathrm{h} \cdot f$$

Confirmation of the existence of energy levels for the electrons arranged around the nucleus, as proposed by Bohr, comes from the discontinuous values of ionization energy.

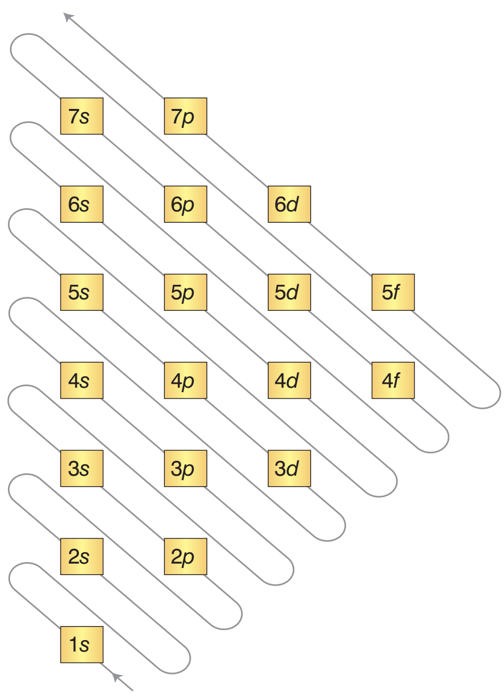
The **first ionization energy** (***Ei′***) is the energy required to remove an electron from an atom:

$$\mathrm{C} + Ei' \rightarrow \mathrm{C}^+ + \mathrm{e}^-$$

De Broglie's idea of associating the motion of an electron around the nucleus with a standing wave together with the Heisenberg uncertainty principle led the scientist Schrodinger to formulate the wave equation that forms the basis of the *quantum mechanics wave model* or **atomic orbitals model**.

Orbitals are solutions (Ψ) of wave equations: they are very complex functions which express the "condition" of each electron-wave present in the atom. To make the concept less abstract one can say that the square of the amplitude of the wave function Ψ is proportional to the probability of finding the electron in a specified small space around the nucleus.

According to the atomic orbital model, in order to determine the energy state of the electron it is necessary to specify a sequence of four numerical parameters for each electron called *quantum numbers*: the **principal quantum number** (***n***) is associated with the orbital size; the **secondary quantum number** (***l***) is related to the shape of the orbitals; the **magnetic quantum number** (***m***) describes the orientation in space of orbitals that belong to the same sub-level; and the fourth number, or **spin**, is associated with two possible electron magnetic moments.



The manner in which electrons are arranged around the nucleus can be represented by the **electronic structure** of an atom: the symbol of the element is followed by orbitals that are successively occupied by electrons, with the number of electrons present in each orbital written in superscript.

In the case of zinc (Z = 30), for example, the electron structure is written as:

$$\mathrm{Zn} \Rightarrow 1s^2\, 2s^2\, 2p^6\, 3s^2\, 3p^6\, 4s^2\, 3d^{10}$$

In certain cases **Hund's rule** must be taken into consideration: *electrons that arrange themselves into orbitals with the same energy tend to occupy the highest number in order to have the largest number of unpaired electrons*.

oxigen (Z = 8)