

Chapter from Chemistry 1

Theory of Atom. Proton and neutrons. Electron configuration. Atomic orbitals. Pauli exclusion principle. Hund's rule. Aufbau principle. Chemical symbols.

The protons and neutrons of an atom are arranged in atomic nucleus. Electrons are arranged outside the core (nuclei). Each atom has one nucleus surrounded by enough electrons to balance the positive charge of the nucleus. The proton has a charge of $1+$, the electron's charge is $1-$, and the neutron is electrically neutral. The **atomic number** is the number of protons or electrons, respectively. Only protons and neutrons contribute to an atom's mass (both 1.67×10^{-24} g). Electron mass is 9.1×10^{-28} g. **Mass number** of an isotope is the sum of the protons and neutrons in one of its atom. **Isotope of element** is component of an element whose atoms have different numbers of neutrons but same number of protons. Consequently an element's atomic mass is the average mass of its atoms taking into consideration representation of individual isotopes in the element.

The electrons in an atom are placed in particular energy shells outside the nucleus. The arrangement of electrons about a nucleus is called **electron configuration**. The first scientist who determined positions of electrons outside the nucleus was Niels Bohr. He worked out so called "solar model". The electron move on the specific levels with given energy and any transfer to another level is connected with change of energy (radiation or absorption energy). The first energy level (shell) has the lowest energy. As soon as atoms have become excited (get energy), the electrons begin to shift back to the lower states, and difference in energy between the excited state and the lower state is emitted as light. The quantity of energy that is emitted in this process is called **quantum of energy**, and sometimes a **photon of energy**.

But location of an electron and its energy are not precisely known at same instant. Therefore the location of electrons are described in terms of probabilities of their being at certain places. The specific energy states in which electrons can be organized, we name the **principal energy levels** marked with small letter **n**. Thus $n=1$ has the lowest energy level.

There are limits on the numbers of electrons in the Principal energy levels. Up to the principal level $n=4$ we can calculate number of electrons in according to formula: maximum of electrons = $2n^2$. Then in the 5th principal energy level, the maximum of electrons are 32, 6th 18 and 7th 8 electrons.

The principal energy levels have subshells which are formed by the regions called atomic orbitals. To specify the location of electron, we must name its main energy shell, its subshell, and its orbital. An orbital can keep only two electrons and their spinning must be opposite.

Pauli Exclusion Principle : An orbital can hold as many as two electrons, but only if they opposite spins.

The energy of electron: all in nature tends to change in whichever direction results in more stable, lower energy arrangement of things (if it can). The lowest content of energy, the most stable arrangement.

The electrons of an atom fill into the lowest energy atomic orbitals available, spreading out among orbitals of the same energy.

Hund's Rule : Electrons at the same subshell spread out among the subshell's orbitals as much as possible.

This rule explains that the electrons, which all have the same negative charge, tend to be as far from each other as possible, if in this space is the same content of energy (they have then the same spins).

Electron configuration.

Aufbau principle is the system of the construction of electron configuration. As each proton is located in an atomic nucleus, an electron enters whichever of the available orbitals corresponds to the lowest energy. Hund's rule and Pauli exclusion principle govern the term "available orbitals of lowest energy".

Examples :

Hydrogen H $1s^1$

Helium He $1s^2$

Lithium Li $1s^2 2s^1$

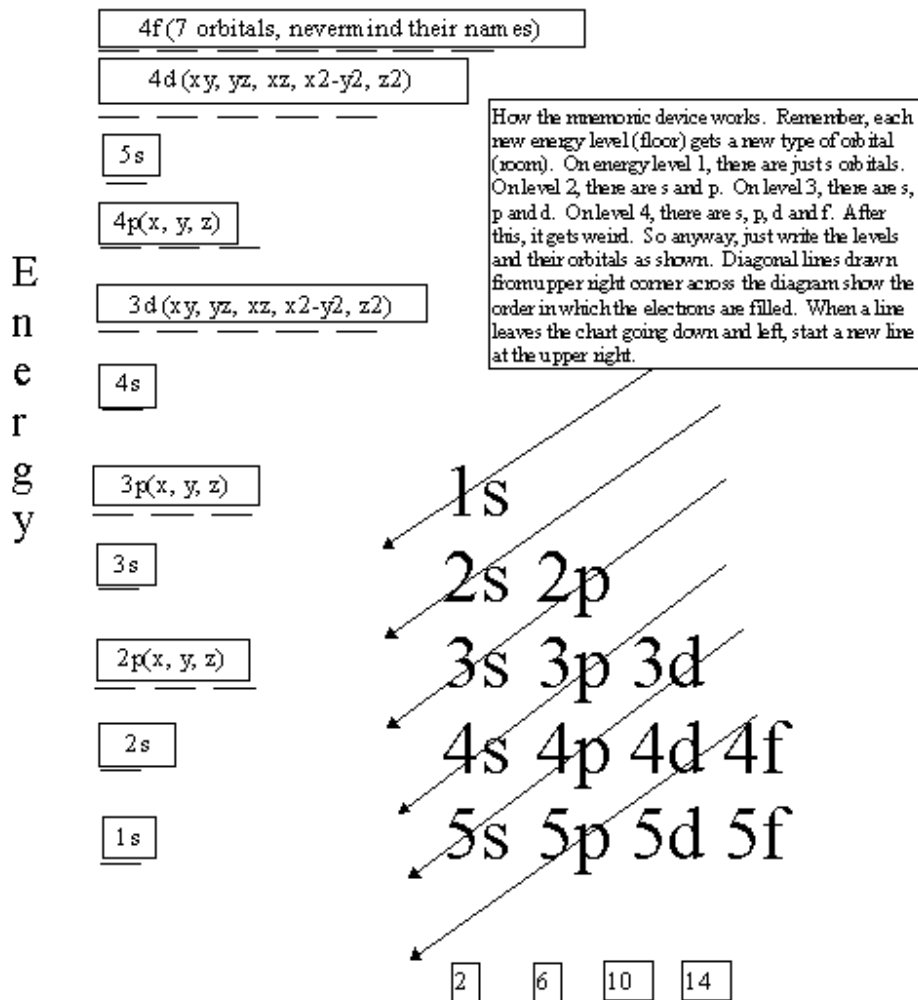
Carbon C $1s^2 2s^2 2p_x^1 2p_y^1$

Nitrogen N $1s^2 2s^2 2p_x^1 2p_y^1 2p_z^1$

Oxygen O $1s^2 2s^2 2p_x^2 2p_y^1 2p_z^1$

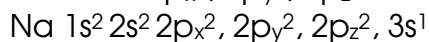
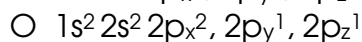
Note :

As you know, two of the subatomic particles proton and electron carry electrical charges. Do not forget that **Opposite charges attract** and **Like charges repel**.

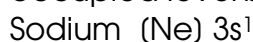


Beginning with the filling of orbitals at the 3d subshell and higher, energy subshell does not correlate well with the value of n. The 4s subshell is used before any electrons are put into any orbitals of the 3D subshell, because the energy of the 4s is lower than of the 3d.

Electron configuration of nitrogen :



Electron configuration can be also represented by the element of highest occupied level before the principal level which is not occupied. Examples :



Calcium (Ar) $4s^2$