# Atom

**Leukipos and Demokritos** - 2.5 thousand years ago, based on observations of natural phenomena, they expressed the theory that all substances that exist are composed of small, indestructible and indivisible particles - **atoms**.

Today's knowledge: **Atoms are the basic building blocks of chemical substances** with a radius of the order of $10^{-10}$m.

## The nucleus of an atom

**An atomic nucleus** consists of **nucleons** (determined by mass number A): **protons** (atomic number Z) and **neutrons** (neutron number N). A = Z + N applies. The number Z also indicates the number of electrons (the atom is electrically neutral).

## Radioactivity

The atomic nuclei of some elements are unstable and subject to **spontaneous transformation** (natural radioactivity), whereby there is a **emission of radiation** - ionizing radiation.

We recognize these components of radiation in natural radionuclides

- **α radiation**- a stream of helium atomic nuclei
- **β radiation**- formed by a stream of electrons;
- **γ radiation** - the most penetrating, with a short wavelength;
- **artificial radioactivity** is created, for example, by bombarding the nuclei of atoms with α particles, which creates an artificial radionuclide.

## Electron shell of an atom

It can contain one or more electrons.

### Electron

A microparticle and negative charge carrier labeled **e** or **$e^-$**. Electrons in an atom exist only in states with a certain energy.

Electrons can emit or receive energy only after certain quanta, when transitioning from one energy level to another. The energy of a quantum is given by the difference in energies that belong to certain energy levels in the shell of an atom.

The electron has a dual character – **wave** and **corpuscular**. This also corresponds to the **uncertainty principle** (it is impossible to determine where the electron is and at what speed it is moving). We can only determine the probability - the place with the greatest probability of an electron's occurrence is called an **orbital**.

#### Quantum numbers

The state of the electron in the shell of the atom is described by 4 quantum numbers (3 characterize the orbital and the fourth the spin projection of a particular electron in the orbital).

- **Principal quantum number (n)** - Expresses the energy of the orbital. It takes on values from 1 to 7 (or also referred to as K, L, M, N, O, P, Q).
- **Minor quantum number (l)** - Takes values from 0 to (n – 1). It indicates the spatial shape and energy difference of individual orbitals.
- **Magnetic quantum number (m)** - Indicates the directional orientation of the orbital in the magnetic field. It acquires values from -l...0...+l (secondary quantum number).
- **Spin quantum number (s)** - Takes values of +1/2 or −1/2. There can be a maximum of two electrons in one orbital, which have opposite spin and form an electron pair.

| electron layer | n | l | Type of orbital | m | number of orbitals | max. number of electrons |
|---|---|---|---|---|---|---|
| K | 1 | 0 | 1s | 0 | 1 | 2 |
| L | 2 | 0<br>1 | 2s<br>2p | 0<br>−1, 0, +1 | 1<br>3 | 8 |
| M | 3 | 0<br>1<br>2 | 3s<br>3p<br>3d | 0<br>−1, 0, +1<br>−2, −1, 0, +1, +2 | 1<br>3<br>5 | 18 |
| N | 4 | 0<br>1<br>2<br>3 | 4s<br>4p<br>4d<br>4f | 0<br>−1, 0, +1<br>−2, −1, 0, +1, +2<br>−3, −2, −1, 0, +1, +2, +3 | 1<br>3<br>5<br>7 | 32 |

# Rules for filling orbitals with electrons =

**Electron (ion) configuration**- distribution of electrons in individual orbitals on individual layers of the electron shell. It is possible to derive from it the ability of an atom (ion) to form a certain type of chemical bond. Successive occupancy is determined by the construction and Pauli principles and Hund's rule. **Construction principle** - minimum energy principle: An atom in the ground state strives to acquire the state with the lowest possible energy - occupying orbitals from those with the lowest energy: 1s-2s-2p-3s-3p-'*4s-3d*-***4p-5s-4d-5p-'*** **6s-4f**-5d-6p-7s-5f-6d-7p.

**Degenerate orbitals**- have the same energy (have the same major and minor quantum number, differ in magnetic).

**Pauli Principle** There are no two electrons in an atom that have all 4 quantum numbers the same (they must differ at least in terms of spin – shown by opposite arrows).

**Hund's Rule** Degenerate orbitals are filled so that there is the maximum possible number of unpaired electrons (with the same spin) in the degenerate orbitals, and only then do electron pairs begin to form.

# Links

## Related links

- Atomic nucleus
- Periodic table of elements
- Radioactivity

## References

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