# Electrical nature of matter

Electric charge Is a physical property associated with matter that causes It to experience a force when placed in an electromagnetic field. There are two types of electric charges: positive charge and negative charge (often carried by protons and electrons, respectively). Like charges repel each other, unlike charges attract. A particle that lacks charge Is referred to as neutral The unit of electric charge according to the International System of Units Is the coulomb.

1. Atoms always contain electric charges, but we don't notice them until we make them move from their normal positions.

2. Atoms have equal numbers of protons and electrons.

3. Protons cannot move; electrons move.

4. Protons and electrons have the same amount of charge, but their charges are opposite.

5. When atoms become charged, **only the electrons move from atom to atom.**

6. In each atom the number of electrons surrounding the nucleus equals the number of protons and so a single atom is electrically neutral.

7. In some elements (e.g. copper - Cu) the nucleus has a weaker attraction to its electrons and the electrons are able to move freely from atom to atom.

8. In elements such as sulfur (S) the electrons are strongly bonded to the atom and do not move freely.

9. If an atom **gains an extra electron**, the overall (net) charge on the atom is

10. **negative** and the atom is called a **negative ion**.

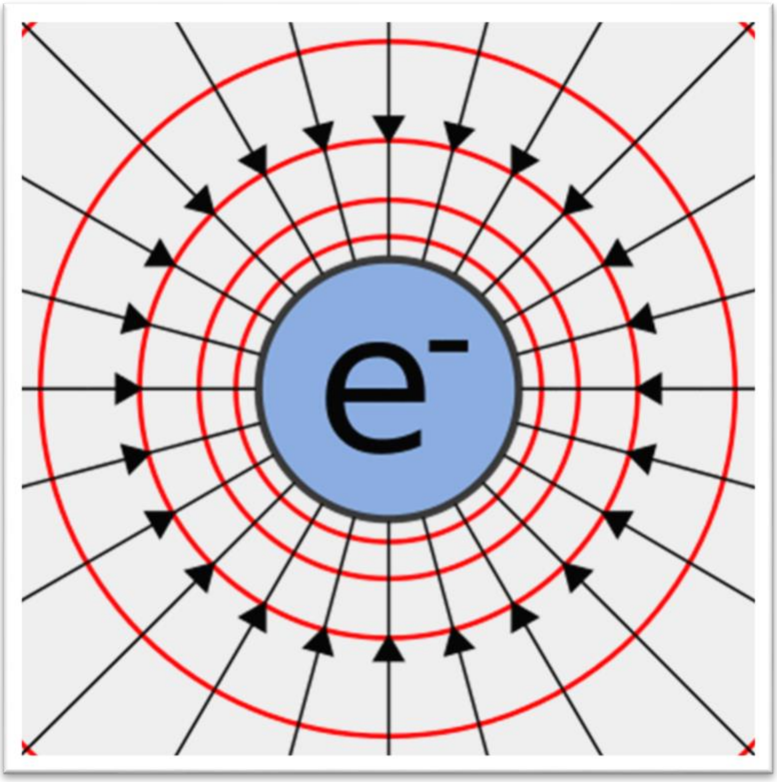
11. If the atom **loses an electron**, the overall charge is **positive** and the atom is called a **positive ion**.

**12. Like charges repel. Unlike charges attract.**

The study of charge separation (“static electricity”) is called electrostatics.

There are 3 ways to make an object have an electrical charge:

1. by friction
2. by contact and
3. by induction



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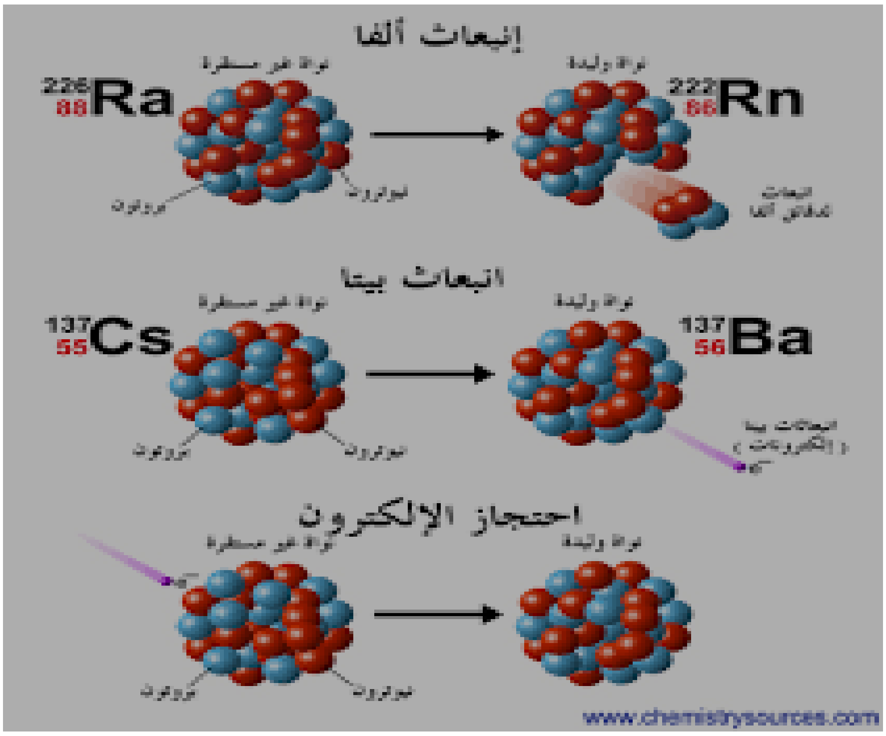
# Radioactivity

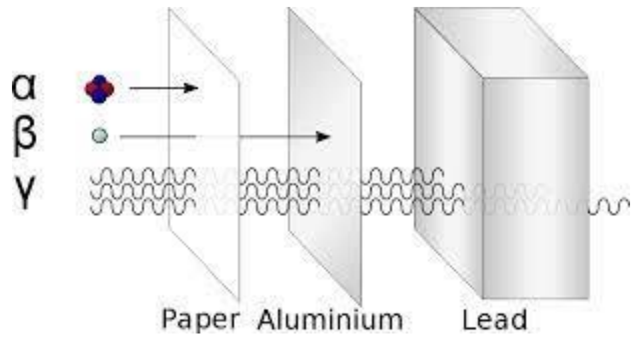
*radioactivity* is the act of emitting radiation spontaneously. This is done by an atomic nucleus that, for some reason, is unstable; it "wants" to give up some energy in order to shift to a more stable configuration.




## Radioactive rays were observed to be of three types:

1. Alpha rays, which could barely penetrate a piece of paper.
2. Beta rays, which could penetrate 3 mm of aluminum .
3. Gamma rays, which could penetrate several centimeters of lead.

We now know that alpha rays are helium nuclei, beta rays are electrons, and gamma rays are electromagnetic radiation.



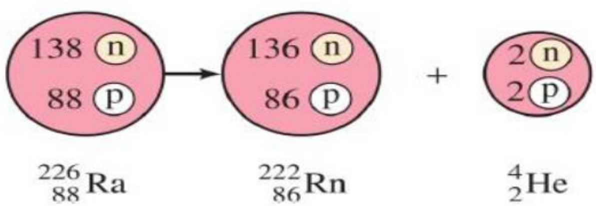

## Alpha Decay

In alpha decay, an energetic helium ion (alpha particle) is ejected, leaving a daughter nucleus of atomic number two less than the parent and of atomic mass number four less than the parent. An example is the decay (symbolized by an arrow) of the abundant isotope of uranium, 238U, to a thorium daughter plus an alpha particle:

$$^{238}_{92}\mathrm{U} \longrightarrow {}^{234}_{90}\mathrm{Th} + {}^{4}_{2}\mathrm{He} \qquad Q_\alpha = 4.268 \text{ MeV}, \quad t_{1/2} = 4.51 \times 10^9 \text{ years}$$

Radium-226 will alpha decay to radon-222:

$$^{226}_{88}\mathrm{Ra} \rightarrow {}^{222}_{86}\mathrm{Rn} + {}^{4}_{2}\mathrm{He}$$




α **decay :**

$$^{A}_{Z}\mathrm{N} \rightarrow {}^{A-4}_{Z-2}\mathrm{N}' + {}^{4}_{2}\mathrm{He}.$$

## Beta-minus decay

In beta-minus decay, an energetic negative electron is emitted, producing a daughter nucleus of one higher atomic number and the same mass number. An example is the decay of the uranium daughter product thorium-234 into protactinium-234:

$$^{234}_{90}\mathrm{Th} \longrightarrow {}^{234}_{91}\mathrm{Pa} + e^- + \bar{\nu} \qquad Q_{\beta^+} = .263\ \mathrm{MeV} \qquad t_{1/2} = 24.1\ \mathrm{days}$$

## Gamma Decay

Gamma rays are very high-energy photons. They are emitted when a nucleus decays from an excited state to a lower state, just as photons are emitted by electrons returning to a  lower state.

$$^{234m}_{91}\mathrm{Pa} \longrightarrow {}^{234}_{91}\mathrm{Pa} + \gamma \qquad Q_{\gamma} = 0.0698\ \mathrm{MeV} \qquad t_{1/2} = 1.17\ \mathrm{min}$$