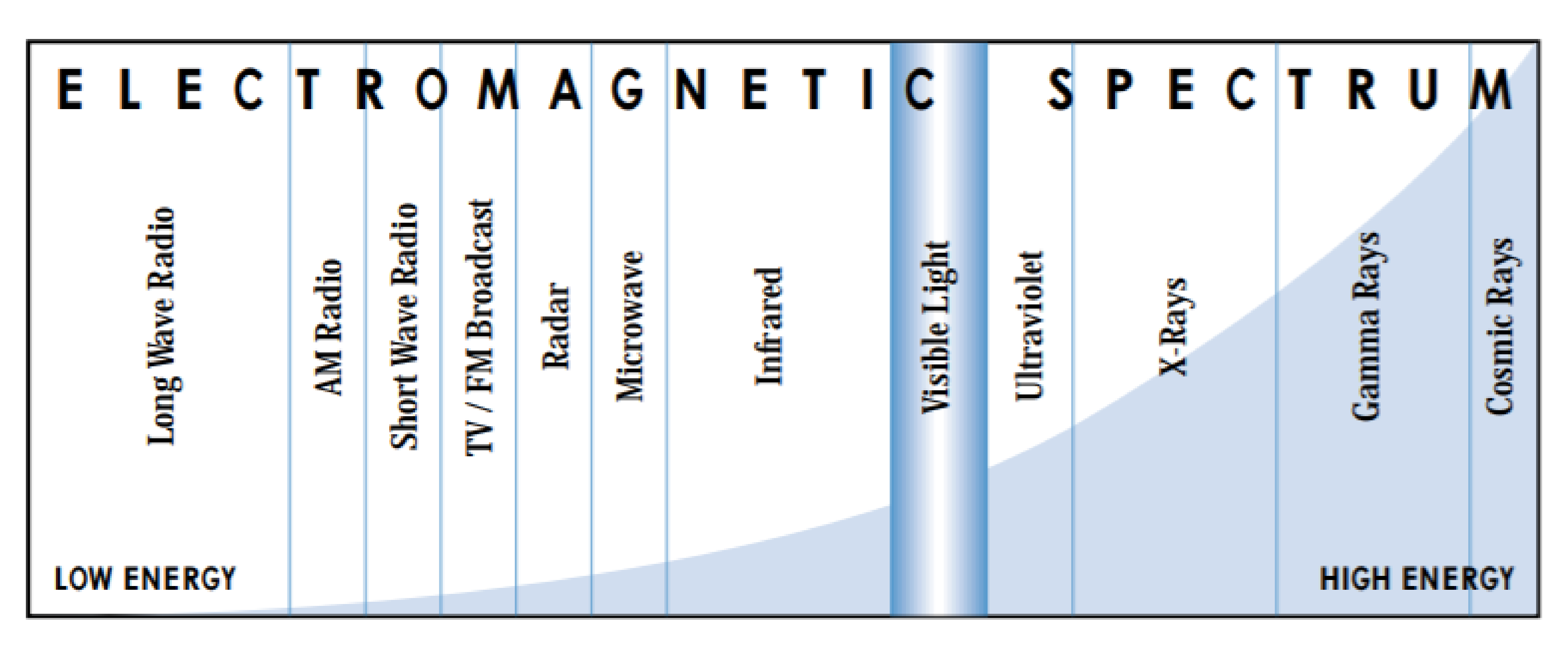
IONIZING RADIATION PART 1

Lecture for 2d gr students

What is ionizing radiation?



1. TYPES OF IONIZING RADIATION

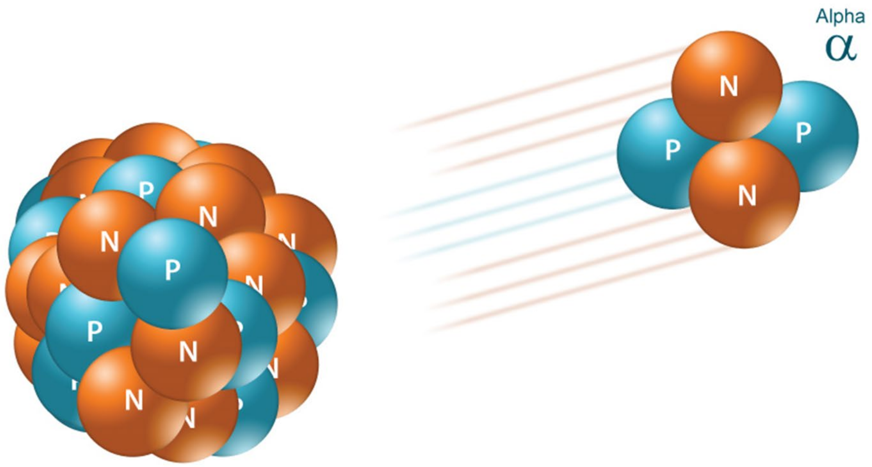
Ionizing radiation - is any type of particle or electromagnetic wave that carries enough energy to ionize or remove electrons from an atom

There are officially two types of ionizing radiation:

- Corpuscular (Alpha, beta, and neutron particles)
- Electromagnetic. (X-rays and gamma-rays, and sometimes they have the same energy.) Gamma radiation is produced by interactions within the nucleus, while X-rays are produced outside of the nucleus by electrons.

Corpuscular ionizing radiation. Alpha particle radiation (alpha radiation)

- The alpha particle is composed of two protons and two neutrons, or a helium $^{4}_{2}\mathrm{He}^{2+}$
- Alpha particles are composed of two neutrons with no charge and two positively charged protons, traveling at very high speed. When alpha particles penetrate solid material, they interact with many atoms within a very short distance. They create ions and use up all their energy in that short distance. Most alpha particles will use up their energy while traveling through a single sheet of ordinary notebook paper. The primary health concern associated with alpha particles is that when alpha-emitting materials are ingested or inhaled, energy from the alpha particles is deposited in internal tissues such as the lungs.



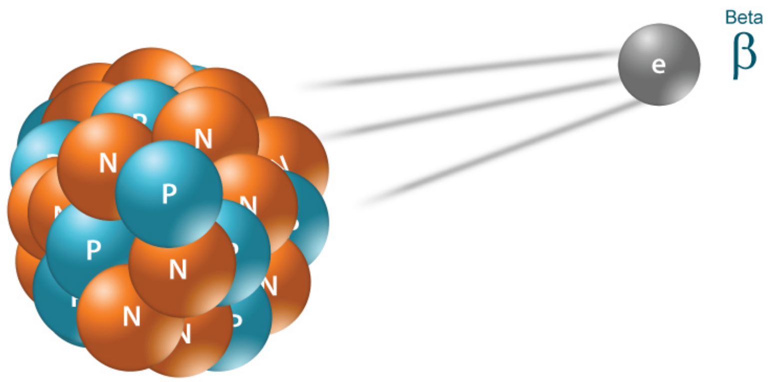
Alpha decay

- Alpha decay: a nucleus ejects an alpha particle which is identical to an ionized helium nucleus

- **Alpha radiation: The emission of an alpha particle from the nucleus of an atom**

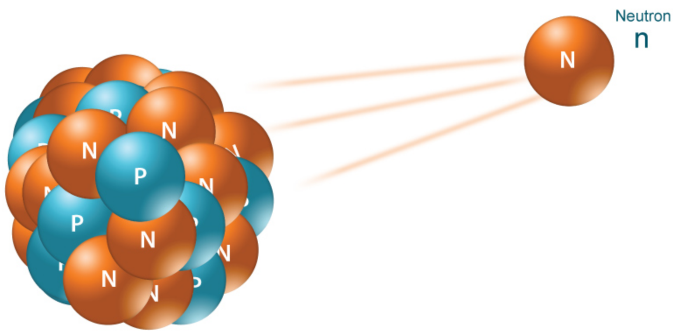
Beta Radiation

- Beta particles are high-speed electrons that are not attached to atoms. They are small - over 7,000 times lighter than alpha particles. The beta particles travel farther through solid material than alpha particles. For example, a very high-energy beta particle will travel about half an inch through plastic before it uses up all its energy. Like alpha particles, beta particles lose energy with every interaction and no longer produce ions once all their energy is spent. Health concerns associated with beta particles arise primarily when beta - emitting materials are ingested or inhaled.



Beta decay

- **Beta radiation: The emission of a beta particle from the nucleus of an atom**
- Beta radiation takes the form of either an electron or a positron (a particle with the size and mass of an electron, but with a positive charge) being emitted from an atom.

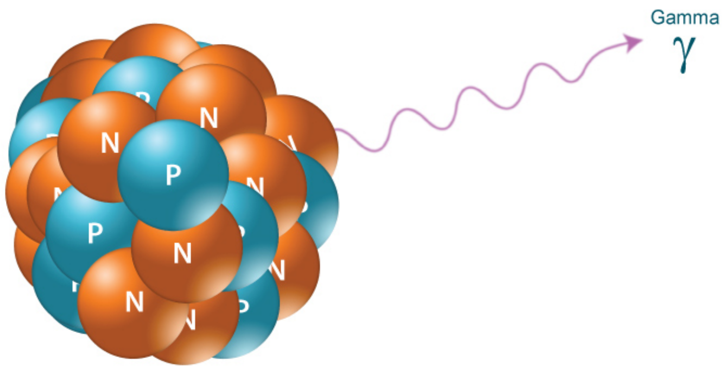


Neutron ionizing radiation

- **Neutron radiation: The emission of a neutron from the nucleus of an atom**
- Neutron radiation consists of a free neutron, usually emitted as a result of spontaneous or induced nuclear fission. Able to travel hundreds or even thousands of meters in air, they are however able to be effectively stopped if blocked by a hydrogen-rich material, such as concrete or water. Neutrons are, in fact, the only type of radiation that is able to turn other materials radioactive.

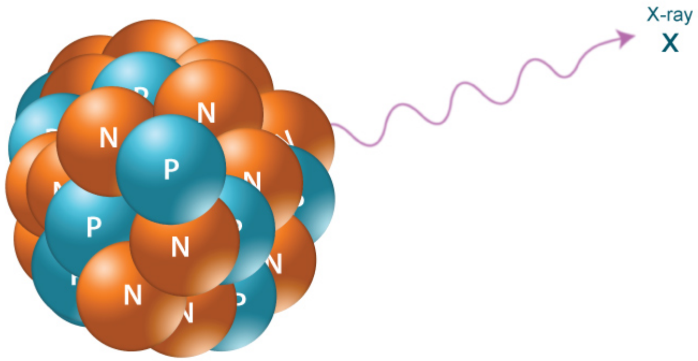
Electromagnetic ionizing radiation

- Gamma radiation
- X-rays



Gamma radiation

- **The emission of an high-energy wave from the nucleus of an atom**
- Gamma radiation, unlike alpha or beta, does not consist of any particles, instead consisting of a photon of energy being emitted from an unstable nucleus. Having no mass or charge, gamma radiation can travel much farther through air than alpha or beta, losing (on average) half its energy for every 500 feet. Gamma waves can be stopped by a thick or dense enough layer material, with high atomic number materials such as lead or depleted uranium being the most effective form of shielding.



X-Rays

- **The emission of a high energy wave from the electron cloud of an atom**
- X-rays are similar to gamma radiation, with the primary difference being that they originate from the electron cloud. This is generally caused by energy changes in an electron, such as moving from a higher energy level to a lower one, causing the excess energy to be released. X-Rays are longer-wavelength and (usually) lower energy than gamma radiation, as well.

2. Doses

- The system of dosimetric quantities:

1) Physical quantities (the impact of ionizing radiation on the material)
2) Normalized quantities (the hazard of ionizing radiation)

Physical quantities

- 1) Exposure ionizing radiation dose (radiation exposure)
- 2) Absorbed dose

Physical quantities. Radiation exposure

Exposure ionizing radiation dose (radiation exposure) - is a measure of the ionization of the air due to ionizing radiation from photons; that is, gamma rays and X-rays.

The SI unit of exposure is the coulomb per kilogram (C/kg), which has largely replaced the roentgen (R). One roentgen equals 0.000258 C/kg; an exposure of one coulomb per kilogram is equivalent to 3876 roentgens.

As a measure of **radiation damage exposure** has been superseded by the concept of **absorbed dose** which takes into account the absorption characteristic of the target material.

Physical quantities. Absorbed dose

- **Absorbed dose** is a dose quantity which is the measure of the energy deposited in matter by ionizing radiation per unit mass. Absorbed dose is used in the calculation of dose uptake in living tissue in both radiation protection (reduction of harmful effects), and radiology (potential beneficial effects for example in cancer treatment).
- The SI unit of measure is gray (Gy), which is defined as one Joule of energy absorbed per kilogram of matter. The older, non-SI unit is rad (sometimes also used)

Normalized quantities

- For biological effects assessment of ionizing radiation
- Specifically for radiological protection purposes

- **1) Equivalent Dose**
- **2) Effective Dose**

- **Equivalent dose** is calculated for individual organs.
- It is based on the absorbed dose to an organ, adjusted to account for the effectiveness of the type of radiation.
- Equivalent dose is expressed in millisieverts (mSv) to an organ.

- **Effective dose** is calculated for the whole body. It is sometimes called whole-body dose.
- It is the addition of equivalent doses to all organs, each adjusted to account for the sensitivity of the organ to radiation.
- Effective dose is expressed in millisieverts (mSv).