Radiation protection –Theoretical Lec3.

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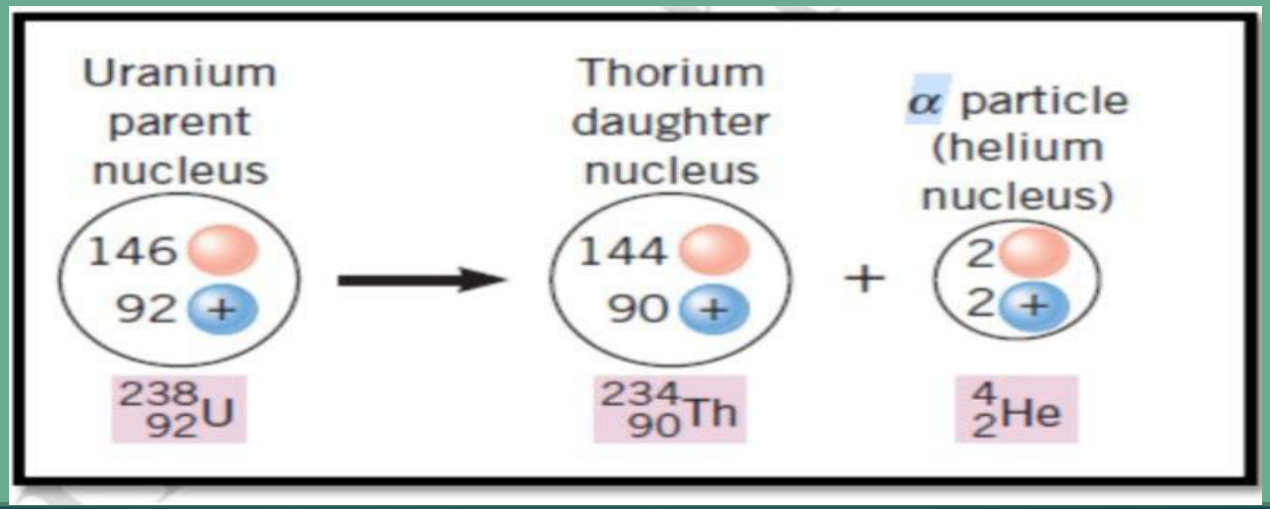
Particulate radiation

- Particulate radiation is the radiation of energy by means of fast-moving subatomic particles that has finite mass and may or may not carry a charge.
- Particulate radiation is primarily produced by disintegration of an unstable atom.
- Particulate radiation is of four forms:

- **Positively Charged alpha particle (a^+).**
- **Positively charged (Positrons) or negatively charged (Electron) beta particles (β + or β -).**
- **neutrons, subatomic particles which have no charge.**
- **photons (called a gamma ray γ, and x-ray)**

ALPHA PARTICLE

- **Alpha Particles: The alpha particle emitted from the nucleus of some radionuclides during a form of radioactive decay, called alpha-decay, giving off a particle (called an alpha particle).**
- **consisting of two protons and two neutrons (essentially the nucleus of a helium atom ,changing the originating atom to one of an element with an atomic number 2 less (Z-2) and atomic weight 4 less (A-4) than it started with.**

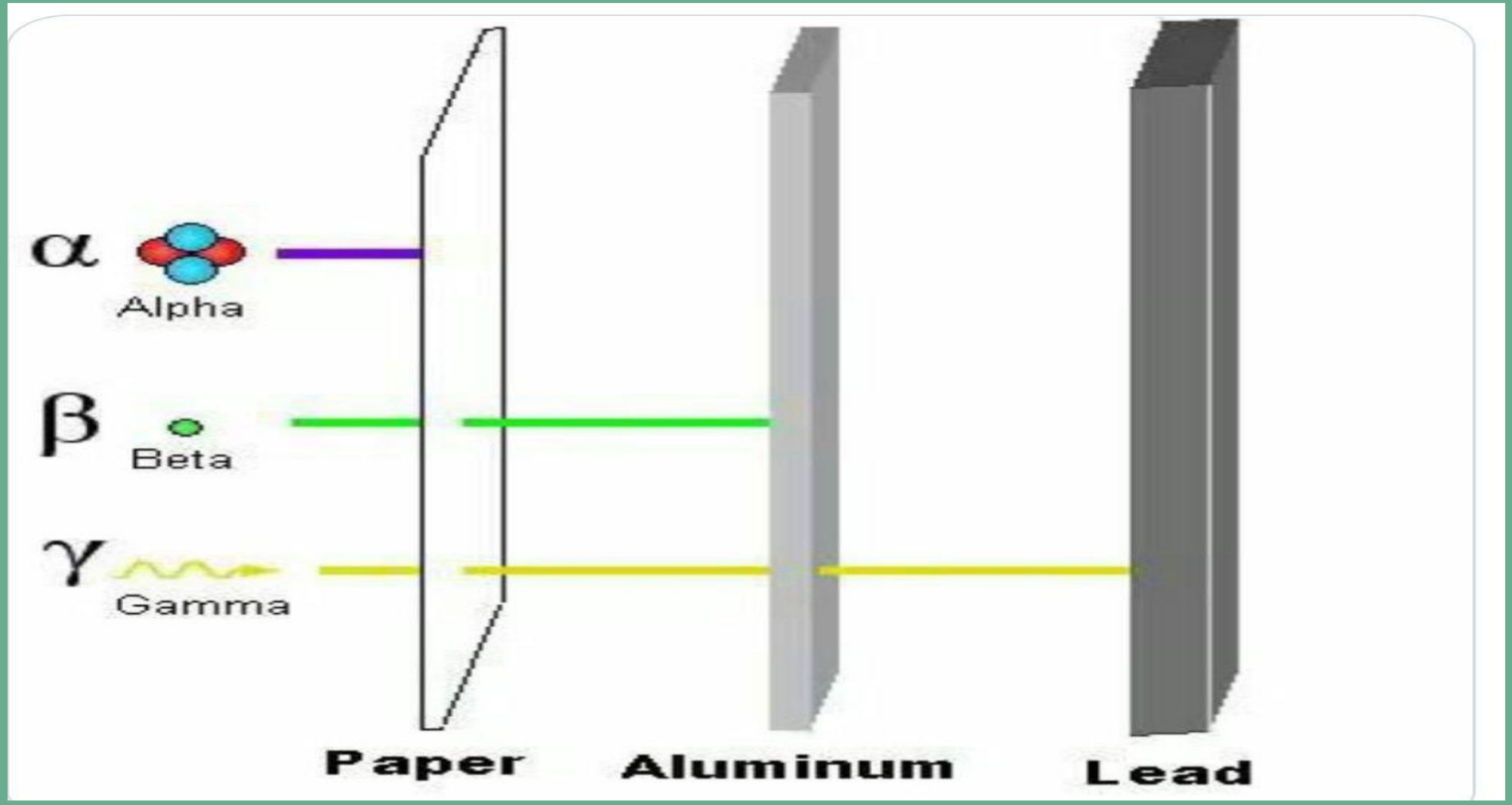


Properties of alpha particle:

- It's a helium nucleus containing two protons and two neutrons.
- It's emitted only from the nuclei of heavy elements. e.g. ^{226} Ra, ^{238} U, ^{239} Pu.
- It ionizes 40,000 atoms for every cm of travel through air.
- It has a very short rang, in air is 5cm, in soft tissue is less than 100 μm
- Its average kinetic energy is (4- 7 MeV)
- Its mass is 4 amu.
- Alpha emission occurs in nuclei have excess protons.
- Alpha decay is represented by:

$$^{A}_{Z}X \rightarrow {}^{A-4}_{Z-2}X + {}^{4}_{2}He$$

- Has very low penetration power and can be stopped by a thin sheet of paper. Alpha particles are unable to penetrate the outer layer of dead skin cells.



Beta Particles

- **The emission of a beta particle from the nucleus of an atom.**
- **Beta radiation takes the form of either an electron (β^-) or a positron (β^+) (a particle with the size and mass of an electron, but with a positive charge) being emitted from an atom.**
- **Beta particles are high energy, high speed electrons or positrons that are ejected from the nucleus by some radionuclides during a form of radioactive decay called beta-decay.**

- **The penetrating power of β rays is greater than that of α -rays; but can be stopped by thin aluminum. It can penetrate skin a few centimeters, posing somewhat of an external radiation hazard.**

Properties of Bata particle:

- It is emitted during the radioactive decay of some unstable atoms.
- It's emitted by the conversion of the proton into a neutron (or vice versa).
- Its cross (10-100cm) in air, and (1- 3 cm) in soft tissues. It can be stopped with a few centimeters of plastic or a few millimeters of metal.
- It's less ionizing than alpha radiation, but more than gamma.
- Its ionize several hundred atoms/cm
- Its atomic mass number = (0).
- Negative charge beta (electron) emitted as a result of the transformation of neutron into proton, electron and antiquark neutrino:

$$^{1}_{0}\mathrm{n} \longrightarrow {}^{1}_{1}p + {}^{0}_{-1}\mathrm{e} + \nu$$

- Positive beta charge (positron) emitted as a result of the transformation of the proton into neutron, electron and neutrino:

$$^{1}_{0}\mathrm{n} \longrightarrow {}^{1}_{1}p + {}^{0}_{+1}\mathrm{e} + \nu$$

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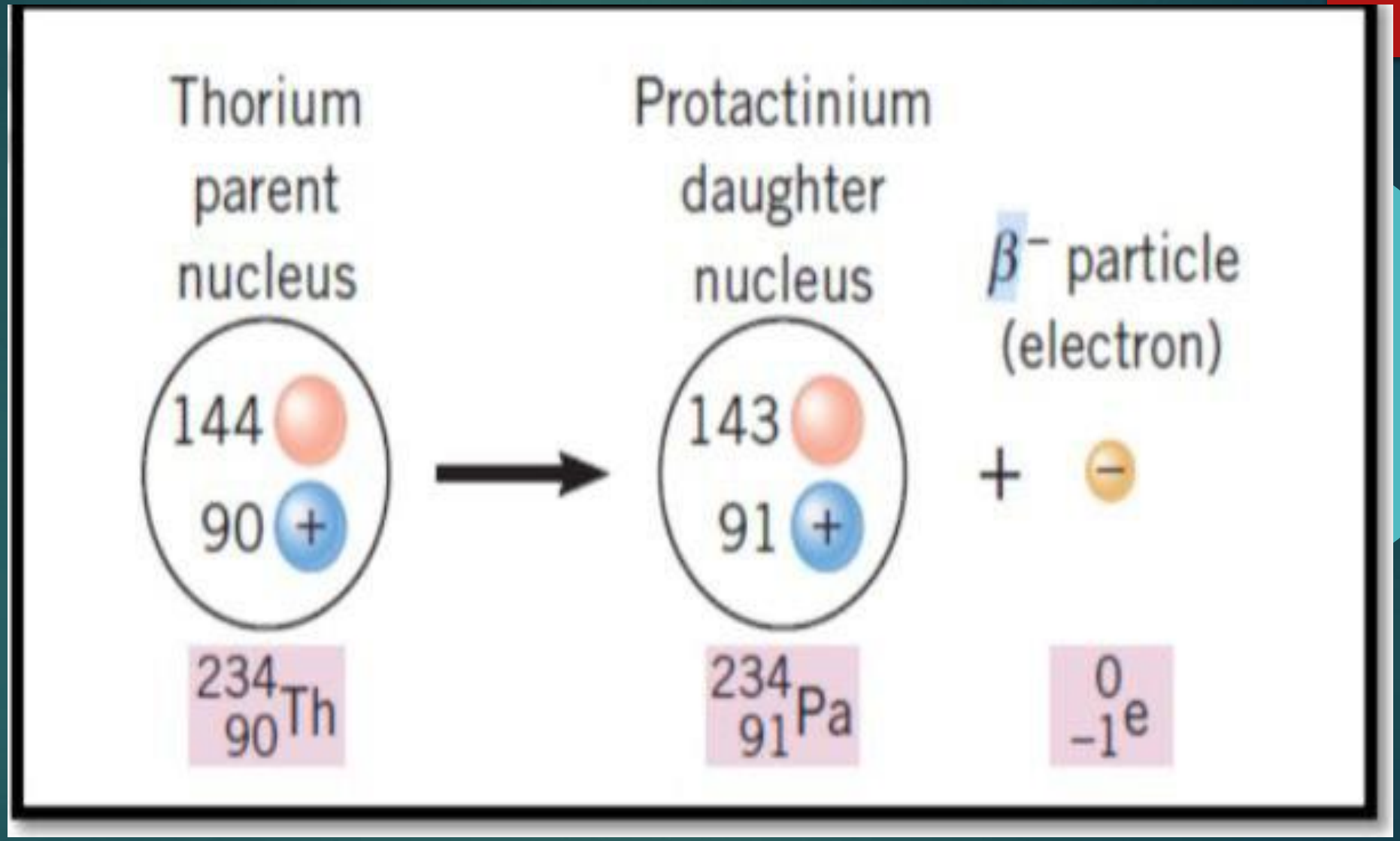
Thorium
parent
nucleus
144
90
+
Protactinium
daughter
nucleus
143
91
+
β⁻ particle
(electron)
+
−
234 90 Th
234 91 Pa
0 −1 e

Neutron

- It 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.
- Not typically able to ionize an atom directly due to their lack of a charge, neutrons most commonly are indirectly ionizing (secondary radiation hazard),
- Neutrons are, in fact, the only type of radiation that is able to turn other materials radioactive.

Gamma rays

- **Gamma rays are a type of electromagnetic radiation with the highest frequency and shortest wavelength in the electromagnetic spectrum.**

- **Gamma rays are typically emitted during nuclear reactions, such as those occurring in stars, nuclear power plants, and nuclear explosions. They can also be emitted by certain radioactive materials, such as uranium and plutonium.**

- Gamma rays are highly ionizing, meaning they can remove tightly bound electrons from atoms, leading to the creation of charged particles (ions). This characteristic can be hazardous to living organisms as it can cause cellular damage and DNA mutations.

- These rays are highly energetic and penetrating Power, it have excellent penetrating power and can easily pass through materials such as paper, skin, and even dense metals. This property makes them useful in various applications, including medical imaging and industrial inspections.

The risks of radiological examination

- **The risks of radiological examination. Radiography examination involves exposing the patient to ionizing radiation in order to create images of the internal structures of the body. The risk from radiation examinations depends on several factors, including the type of exam, the number of exams performed, the age and sex of the patient, and the part of the body being examined. The risk is generally considered to be higher for children, pregnant women, and individuals who have had many previous radiation exams. While radiography is generally considered safe, there are some risks associated with the procedure.**

These risks include :

- **Allergic reactions:** Some patients may have an allergic reaction to the contrast dye that is sometimes used in radiography exams. This can cause symptoms such as irritation, itching, and difficulty breathing.
- **Pregnancy risks:** Pregnant women who undergo radiography exams may expose their developing fetus to radiation, which can increase the risk of birth defects and other health problems .
- **Misdiagnosis:** In some cases, radiography images may not provide a clear or accurate diagnosis. This can lead to misdiagnosis and incorrect treatment .
- **Overuse:** In some cases, radiography exams may be ordered unnecessarily or used too frequently, which can increase the risk of radiation exposure and other health problems .
- **Equipment malfunction:** Radiography equipment can sometimes malfunction, which can lead to incorrect or unusable images .