Medical Physics Module
Semester 1

Session 8
Lecture 15

Physics of Nuclear Medicine

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Objectives

1. Physical of radioactive.

2. The basic equation for describing radioactive decay.

3. Application of nuclear in medicine (treatment & diagnosis).

4. Basic instrumentation & its clinical applications.

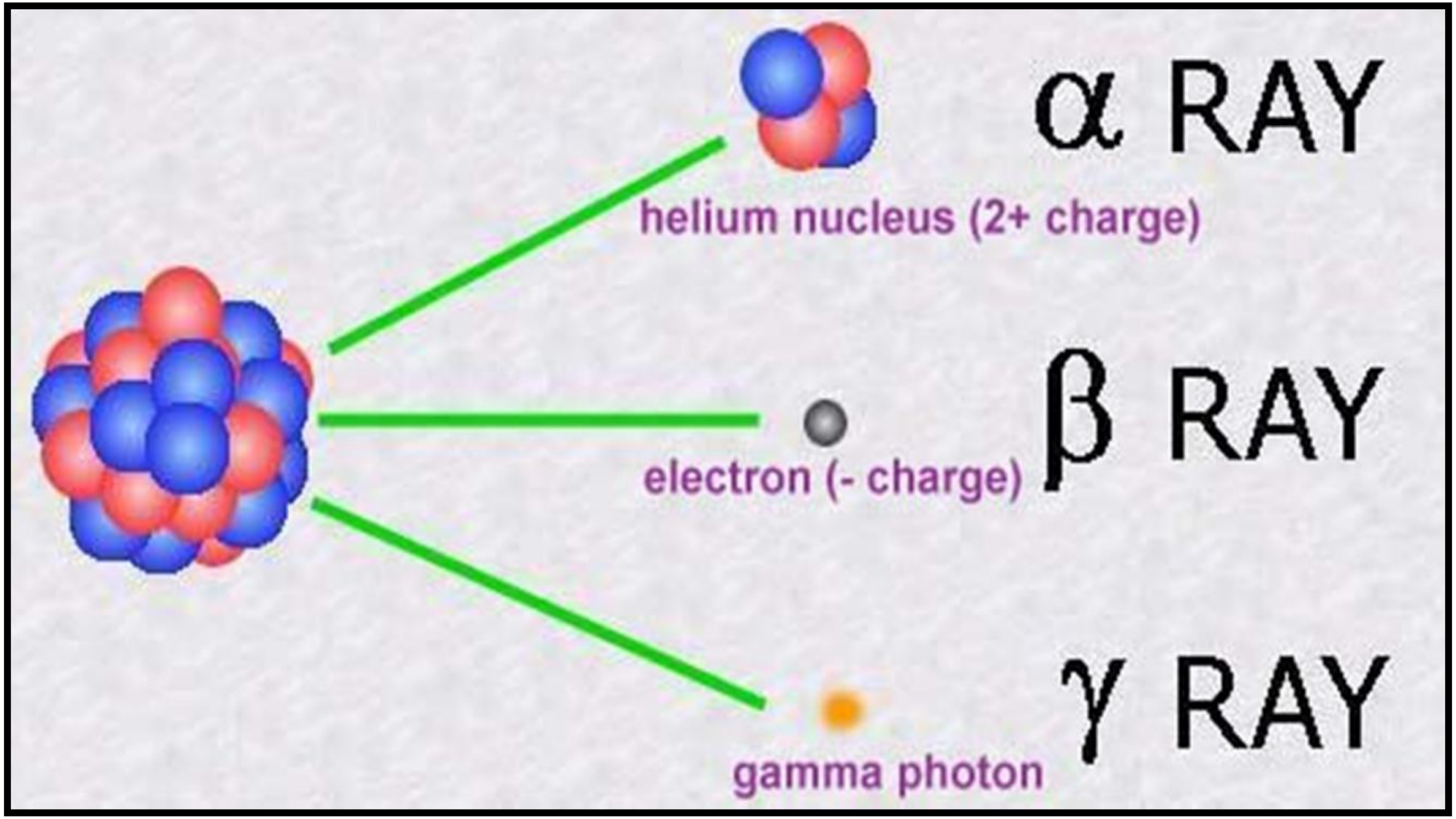
Obj.1

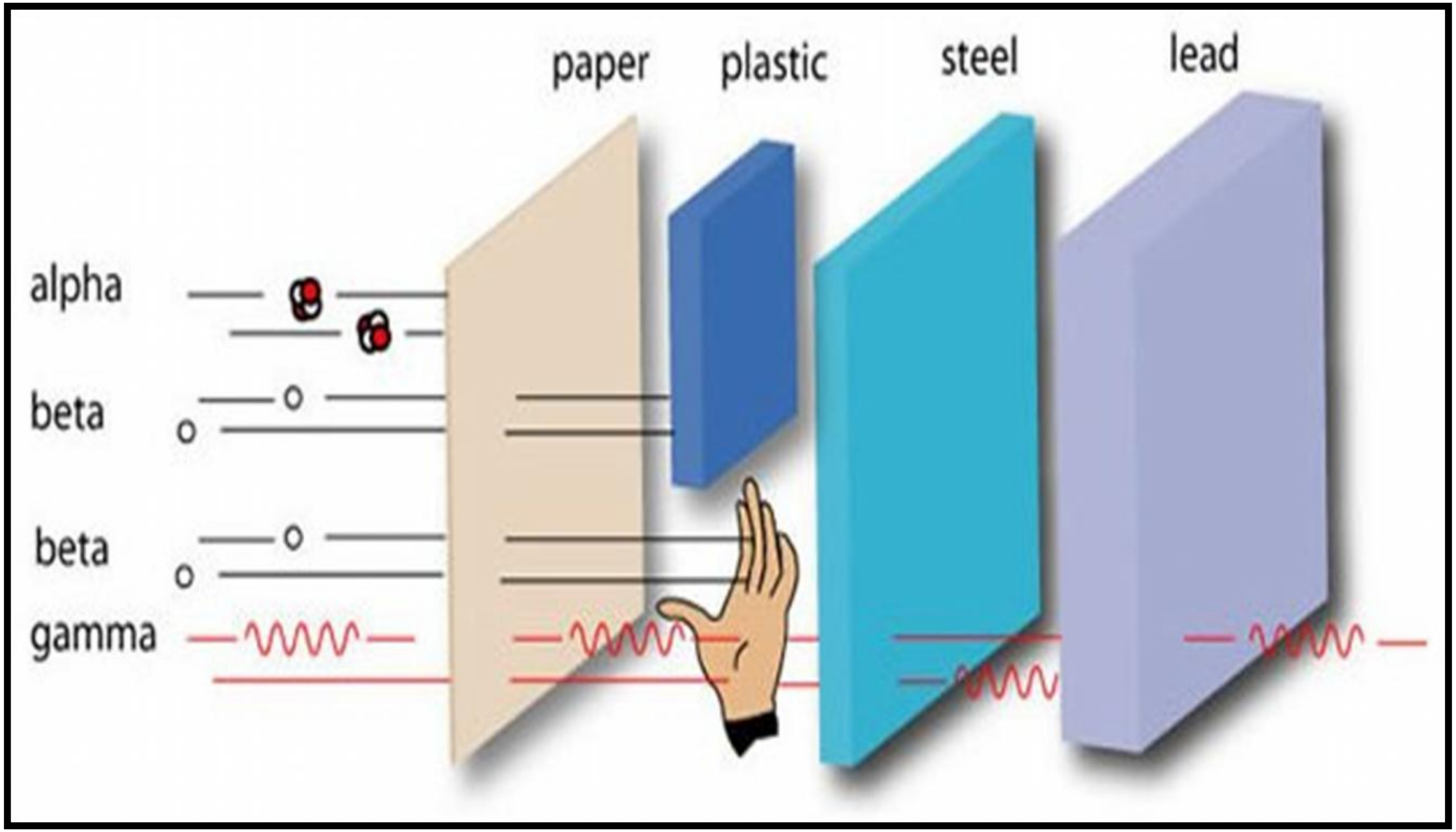
Radioactivity

A certain natural elements, heavy have unstable that disintegrate to emit various rays.

Alpha (α), Beta(β), Gamma(γ) rays.

- Alpha Rays (or Alpha particles) = nuclei of Helium atoms (2 protons, 2 neutrons)
- Beta Rays = electrons (created within the nucleus)
- Gamma Rays = high-energy photons (packets of energy)


α RAY
helium nucleus (2+ charge)
β RAY
electron (- charge)
γ RAY
gamma photon


paper
plastic
steel
lead
alpha
beta
beta
gamma

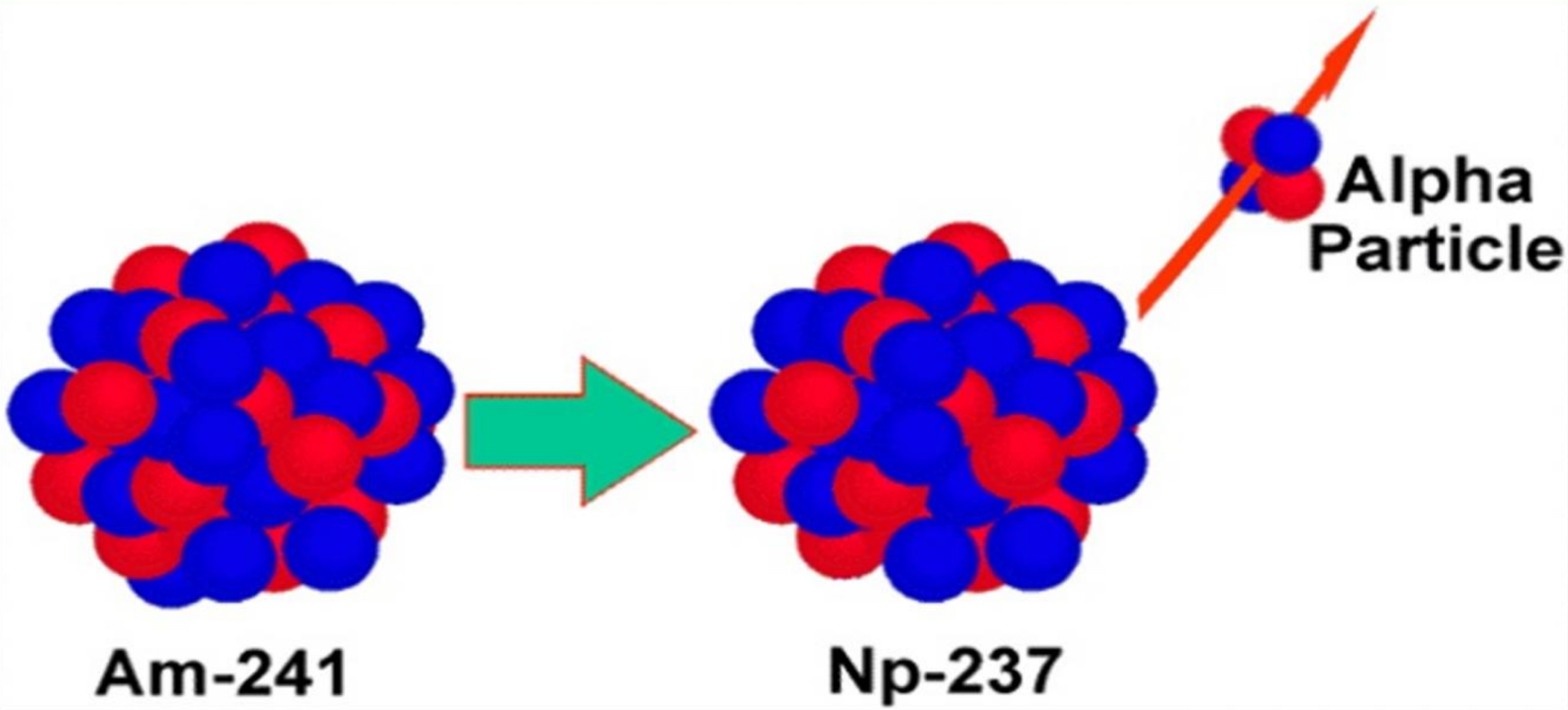
Alpha Decay

- The loss of 2 neutrons and 2 protons (the Helium nucleus) changes the atom.

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

A Radium-226 atom decays into a Radon-222 atom and a Helium nucleus

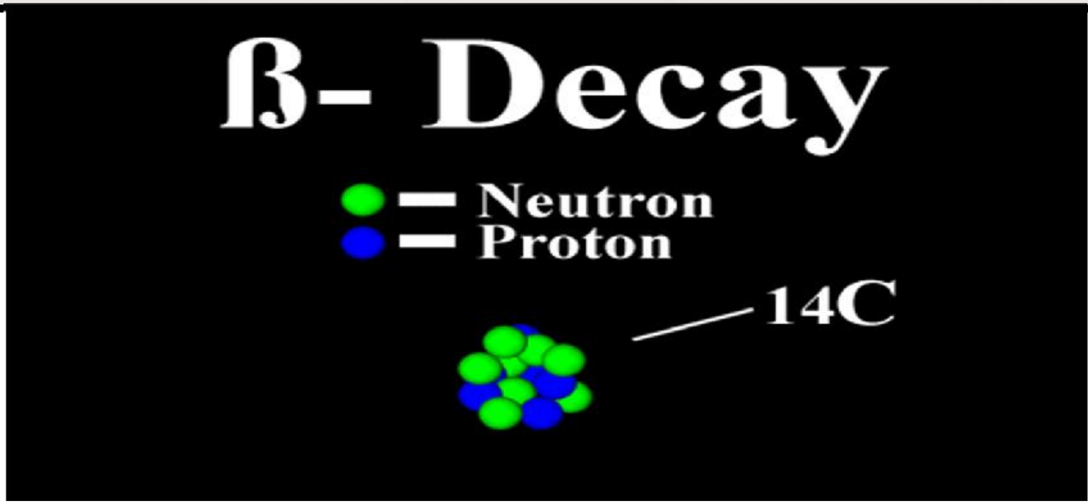
Alpha Decay



Beta Decay

- Beta decay occurs with the emission of an electron (e^-) or β^- particle.

$$^{14}_{6}C \rightarrow ^{14}_{7}N + e^{-} + a\ neutrino$$



Neutrino

A mass less, charge less, particle, Takes up the difference in energy between the actual beta energy and the maximum beta energy.

Positron Decay

$$ {}^{19}_{10}Ne \longrightarrow {}^{19}_{9}Fl + e^{+} + \nu $$

The e^{+} represents the positron and the ν represents the neutrino (Note it is without the bar over it).

So…

An antineutrino is emitted with an electron (β^{-})

and

An antielectron is emitted with a neutrino (β^{+})

Gamma Decay

$$^{12}_{6}C \longrightarrow ^{12}_{6}C + \gamma$$

A nucleus may remain in an excited state for some time before it emits a gamma ray. The nucleus is them said to be in a metastable state and is called an isomer.

Isotpes

Nuclei of a given element with different numbers of neutrons.

There are two types:

1-Stable isotopes if they are not radioactive.

Ex:(12 C, 13 C).

2-Radioisotopes if they are radioactive.

Ex: (11 C, 14 C, 15 C)

Radio- nuclides

Radio-nuclides:
Is used when several radioactive elements are involved. (Radioisotopes are used when referring to single element).

Nuclides and Isotopes

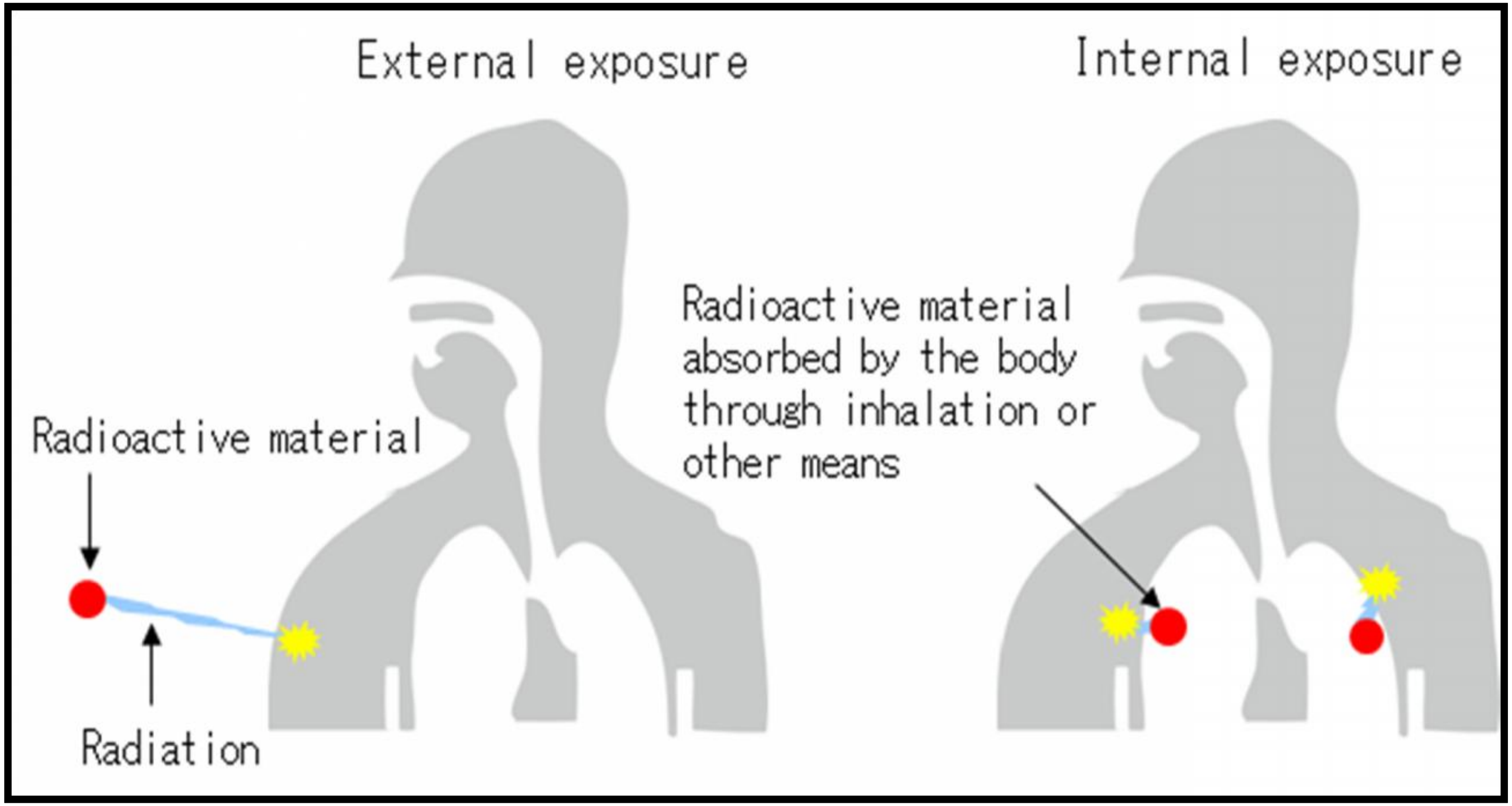
The composition of any nucleus is defined by two numbers.

- The atomic number is the number of protons in the nucleus.
  - This defines the chemical nature of the atom.
  - It is equal to the total charge on the nucleus.
- The mass number is the total number of nucleons (protons and neutrons) in the nucleus.

E.g. $^{12}_{6}C$ has an atomic number of 6 and a mass number of 12.

- A nuclide is an atom with a particular mass number and atomic number.

- Nuclei with the same atomic number but different mass numbers are called isotopes.

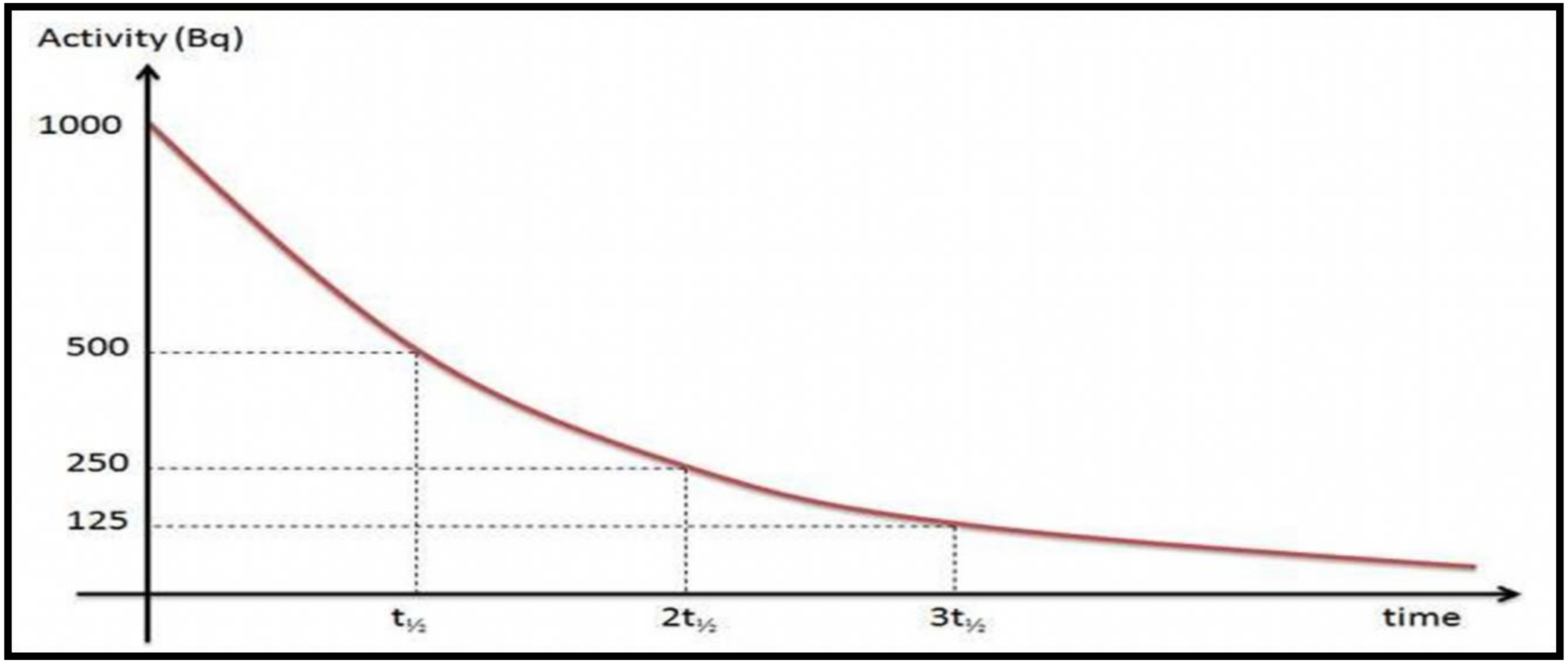

External exposure
Internal exposure
Radioactive material
Radiation
Radioactive material absorbed by the body through inhalation or other means

Activity of radioactive materials

- ✓ half-life.
- ✓ mean life.
- ✓ decay constant
- ✓ background

Half life (T1/2):

The time needed for half of the radioactive nuclei to decay.



- The half life and decay constant have an inverse relationship to one another; the longer the half life, the lower the decay constant (the more slowly it decays). The precise relationship is

$$T_{\frac{1}{2}} = \frac{0.693}{\lambda}$$

$$A = A_0 e^{-\lambda t} \quad \ldots\ldots\ldots\ldots (1)$$

A : activity in disintegration per second after time(t).

A_0 : initial activity.

λ : decay constant (sec $^{-1}$,hour $^{-1}$,year $^{-1}$)

t : time since activity (sec, hour, year)

$A = \lambda N$ ………… (2)

N is the number of radioactive atoms

$T1/2 = 0.693 / \lambda$ ………. (3)

The unite of radioactivity the curie (ci)

$Ci = 3.7 * 10^{10}$ disintegration per second

Detecting Radiation

Radioactive particles are far too small to be detected by our senses; it is for this reason that scientists have created a variety of ways to detect the alpha, beta, and gamma decays of nuclei.

1. Geiger counter
2. Scintillation counter
3. Liquid scintillators
4. Semiconductor detector

Geiger Muller Counter

Obj.4 Clinical applications

The gamma camera has been used for thyroid, brain and kidney scanning and its immediate and potential uses after further modification are indicated.
The machine will enable dynamic events to be studied and short-lived isotopes to be used, neither of which are practicable with mechanical scanning machines.


Thank you