

Radioisotopes

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- Number of **protons** in the nucleus of an atom – **atomic number**.
- **Total number of protons and neutrons** in the nucleus – **atomic weight**.
- Atoms of the same element have **different atomic weights due to difference in the number of neutrons in the nucleus**. Such atoms with same atomic number but different atomic weight are called **isotopes**.

- Depending on the stability of the neutrons present in the nucleus, isotopes are classified as: Stable isotopes (do not decay into other elements), radioactive isotopes (decay).
- Radioactivity is the result of spontaneous and uncontrolled breakdown of nuclei (atoms having atomic number > 82) resulting in emission of radiations.

- Nuclear instabilities happen:

Due to **excess of neutrons** in the nucleus

Due to **shortage of neutrons** in the
nucleus

Due to **excess of protons** in the nucleus

- Decay of radioisotopes is irreversible.
- Depending upon their deflection in an electrical field, these radiations are classified as α (deflected towards cathode) β rays (deflected towards anode) and γ rays (neutral).

Half life period

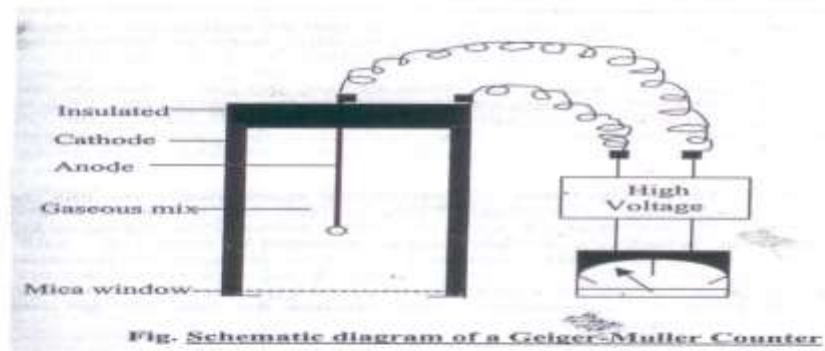
- ^3H -- 12.3 year
- ^{14}C -- 5730 year
- ^{35}S -- 87.4 days
- ^{32}P -- 14.3 days
- ^{125}I -- 60 days
- Time required for the radioactivity to be reduced to one half of its original value.

Measurement of radioactivity

- X-ray film method
- Ionization method
- Scintillation method

Ionization method

- Based on the fact that **radiations** (high energy β particles) cause **ionization** of other particles with which they collide.
- **Geiger-Muller counter** is based upon this principle.
- GM counter is useful for **hard β emitters** such as ^{32}P labels. Soft emitters such as ^3H cannot pass through the thin mica window whereas **gamma** rays may **pass through the mica window** but do **not cause ionization of the gas molecules** and hence cannot be counted using GM counter.



- GM counter consists of a thick cylindrical metallic tube sealed on one side with an insulated material and the other side by a thin mica window. The metallic surface act as a cathode whereas the anode wire is placed at the centre of the tube. The tube is filled with an inert gas like argon, neon (which ionize the radioactive rays pass through them) and also a small amount of a quenching agent such as propane, ethanol etc.,

- The quenching agent prevent continuous ionization of the gas molecules.
- The radioactive material is taken in a small metal disc and placed under the GM tube. The radiations enter through the mica window and ionize the gas molecules to positively charged argons and negatively charged electrons. These ion pairs rush to their respective electrodes.

- During this movement they collide with other gas molecules and ionize them too. Thus large number of ions are collected at their respective electrodes. This neutralizes the potential difference between the two electrodes which is registered as an electrical pulse.
- Each pulse is registered as a count by using a suitable circuitry.

- The GM counter should be operated only in the voltage region “Geiger Muller region”. It is the voltage range where a small increase or decrease in voltage does not affect the counting rate.

Scintillation counting

- Based - certain chemical substances emit flashes of light on exposure to radiation. The measurement of these flashes of light is the basis of the scintillation counting.
- Depending on the type of scintillator used for counting the radioactivity, they are classified into :
 - Solid
 - Liquid

Solid Sc

- Gamma emitters
- The counter consist of a large crystal of sodium iodide containing small amount of thallium iodide and photomultiplier, preamplifier, a source of high voltage .
- The radioactive sample is placed into a well-shaped opening drilled into the crystal surface.

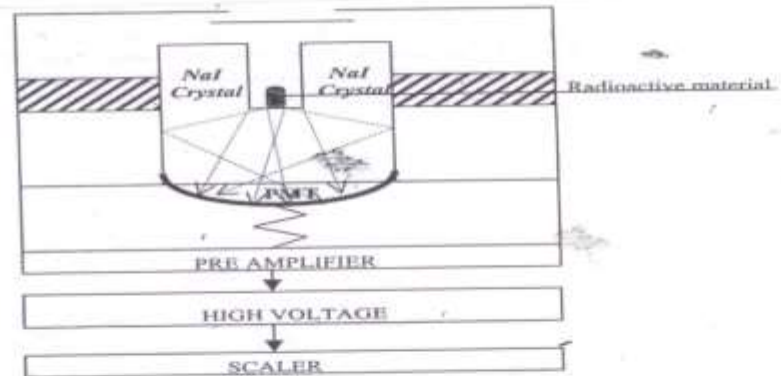


Fig. Schematic diagram of a solid scintillation counter

- The crystal absorbs the energy of gamma rays which causes excitation of electrons of the atoms.
- The excited electrons rise to higher energy orbital.
- Electrons return to normal level, the absorbed energy is discharged as flashes of light or scintillation.

- The light is converted into electrical signals by the photomultiplier tube, amplified and registered as counts.

Liquid SC

- Used in measuring soft β emitters such as ^3H , ^{35}S , ^{14}C .
- Consist of two photomultiplier tubes one on either side of a scintillation vial and enclosed in a light tight lead shield. The PMT is connected to a scaler through a high voltage power supply

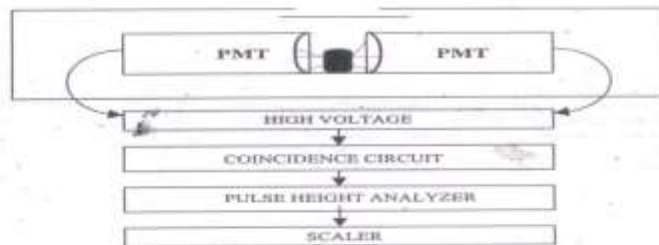


Fig. Schematic diagram of a liquid scintillation counter

- The radioactive sample is mixed in a glass or plastic vial with scintillation fluid. The scintillation fluid contains three components:
- An organic solvent
- Primary fluor
- Secondary fluor.

- The energy of the beta particle is first transferred to the organic solvent which causes excitation of solvent molecules.
- The excited solvent molecules returned to the ground state.
- Energy is transferred to the primary fluor causing excitation
- On returning to the ground state the primary fluor emits photons in the UV region.

- The photocathodes of the PMT are not sensitive to capture these photons.
- Hence secondary flour is used to absorb the energy from the primary flour and reemit the light of longer wavelength.
- The size of the electrical pulse produced by the photomultiplier tube is proportional to energy of beta particle absorbed by the scintillation fluid.

- Radiactivity is measured in terms of disintegrations per second (dps) or dpm (minute)
- 1 Curie (Ci) = 2.22×10^{12} dpm or 3.7×10^{10} dps.

- Use ion biological research as tracers
- Follow biosynthetic and degradative pathways in biological systems.
- Use to localize specific molecules in the cell