Chapter = 20

Nuclear Radiation

Alpha Particle:

Introduction:

Alpha particles are helium atom with both of its electron removed. Their mass is approximately 4 times the mass of proton. Due to their heavy mass they have low penetrating power. When they pass close to an atom, the strong electrostatic force of attraction tears the electron off and ionize the atom. Their ionization power is greater than β- particles and γ- rays.

As Ionization Source:

As α particle is positively charged (has charge of +2e), when it passes near to an atom it takes off electron in its outer most shell by electrostatic attractive force between it and the electron, hence ionizes the atom.

Beta Particles:

Introduction:

Beta particles are fast moving electrons. Their mass is equal to the mass of electron. Their penetrating power is greater than that of α- particles. When they pass close to an atom, the strong electrostatic force of repulsion tears the electron off and ionize the atom. Their ionization power is less then β- particles and greater then γ- rays. Their velocity is greater than α particles but less than that of γ- rays.

As Ionization Source:

As β particle is negatively charged (has charge of -e), when it passes near to an atom it takes off electron in its outer most shell by electrostatic repulsive force between it and the electron, hence ionizes the atom.

Gamma Rays:

Introduction:

Gamma rays are electromagnetic radiations (frequency range: Greater than ~30 EHz). These are mass less photons. They have highest penetrating power. They usually ionize an atom by photoelectric effect or Compton's effect. They usually ionize an atom by photoelectric effect or Compton's effect. Their velocity is equal to the velocity of light, i-e **$3x10^8$ m/s.**

As Ionization Source:

γ- Rays can produce ionization in following three ways:

- It may lose all its energy in a single encounter with the electron of an atom **(Photoelectric Effect)**.
- It may lose only a part of its energy in an encounter **(Compton's Effect)**.
- Very few of high energy γ- ray's photons may impinge directly on heavy nuclei. Be stopped and annihilated giving rise to electron-positron pair **(The materialization of energy).**

Proton:

Introduction:

Proton is also a positively charged particle. It has mass 4 times less than an Alpha particle and charge equal to half of the charge on Alpha particle.

As Ionization Source:

As proton is positively charged (has charge of +1e), when it passes near to an atom it takes off electron in its outer most shell by electrostatic attractive force between it and the electron, hence ionizes the atom.

Neutron:

Introduction:

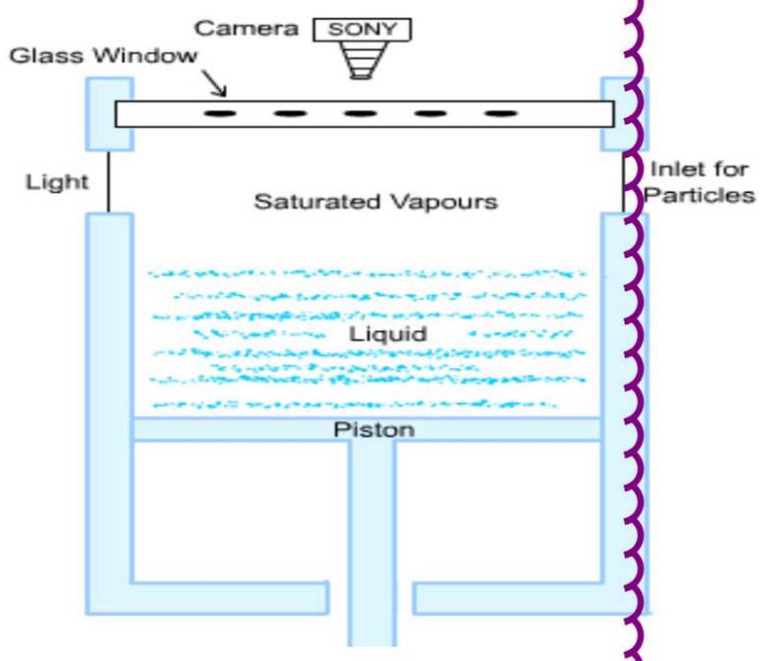
Neutron is also uncharged particle. It has mass 4 times less than an Alpha particle.

As Ionization Source:

Neutrons are neutral particles (having no charge). They can ionize an atom only by direct impact. When it hits an electron, it knocks it out and from the atom (ionization) with particularly no change in its own energy.

Wilson Cloud Chamber

Wilson Cloud Chamber is a device used to observe the path of ionizing particles. It helps to examine the mechanism of ionization of various ionizing radiations and the product of their interaction with material inside the chamber.



Construction:

- It consists of a closed cylindrical chamber with transparent glass top **(T)**.
- On the sides near the top the cylindrical is provided with a glass window for light **(L)**.
- An inlet **(I)** for the ionizing particles or radiations.

- A movable piston on the bottom. The piston can be moved up or down by a lever attached to it.

Before making the enclosed space above the piston aright, enough quantity of a low boiling point liquid such as water or alcohol is introduced in the space to produce its saturated vapors. A small quantity of liquid stays on the piston.

Working:

- The pressure of the liquid is lowered by pulling piston down which results in producing vapors of the liquid.
- When an ionizing particle enters the tube under this condition it produces ionization along its track.
- The condensation of vapors takes place on ion in the form of tiny droplets of fog, which can be photographed.

Results:

α − Particle:

An α-particle is highly ionizing the ions produced are so numerous that its trade is a thick and continuous line.

β − Particle:

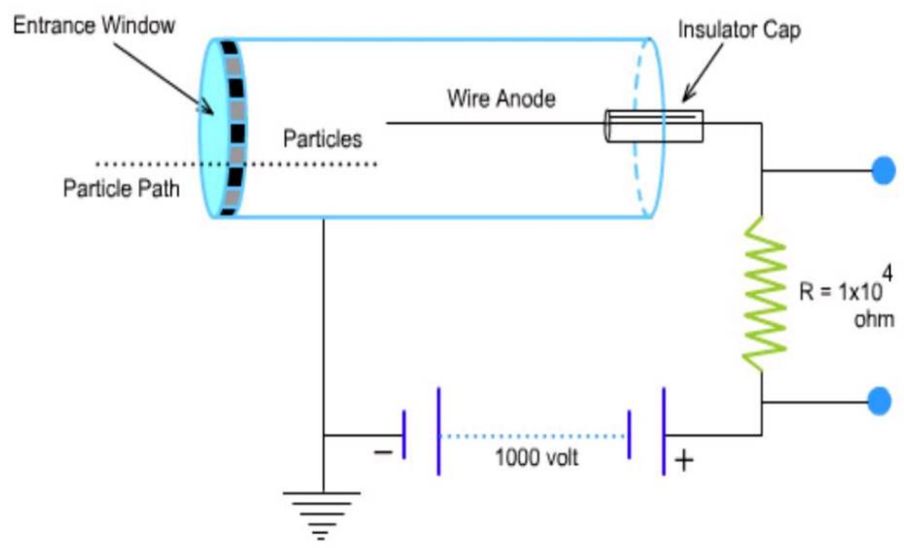
β-Particle is much less ionizing its track is therefore, a thin and broken line.

γ − Rays:

γ - Rays are photons emitted in a widening cone of some angle. They produce ionization by photoelectric effect distributed on a wide space. Some of the photoelectrons ejected by them give tiny line tracks in directions like the β- Particles and scattered dots are produced. The γ - rays not produce well-defined line track.

Geiger counter

Geiger counter is a portable device which is widely used for the detection of ionizing particles or radiations.



Construction:

It consists of:

- A hollow metal cylinder, one end of which is closed by an insulating cap.
- At the center of the cap is fixed a stiff straight wire along the axis of the cylinder.
- A thin mica or glass disc closes the other end which also serves as an entrance window for the ionizing particles or radiations.
- The sealed tube usually contains a special mixture (air, argon, alcohol etc.) at a low pressure of 50 to 100 millimeters of mercury.
- A potential difference of the order of one thousand volts is applied between the metal cylinder and difference is only slightly less than, necessary to start a discharge between the wire and a cylinder.

Working:

When an energetic charged particle or gamma-ray photon enters the tube through a thin window at one end, some of the gas atoms are ionized. The electrons removed from these atoms are attracted toward the wire electrode, and in the process, they ionize other atoms in their path. This sequential ionization results in an avalanche of electrons that produces a current pulse. After the pulse has been amplified, it can either be used to trigger an electronic counter or delivered to a loudspeaker that clicks each time a particle is detected. Although a Geiger counter reliably detects the presence and quantity of radiation, it cannot be used to measure the energy of the detected radiation.

Solid State Detectors:

Solid state detectors use semiconductor PN-junction diodes. When it is reversed biased no current is passed through junction diode. But when energy is provided to the junction that is when radiations or ionizing particles passed through junction diode current passed through it. The reverse current passed through junction diode on ionization of atoms of junction due to ionizing radiations. This results in producing small voltage. Resistance "R" is connected in series with diode & battery. Potential is amplified by amplifier & is connected with counting device to register the presence of radiations.