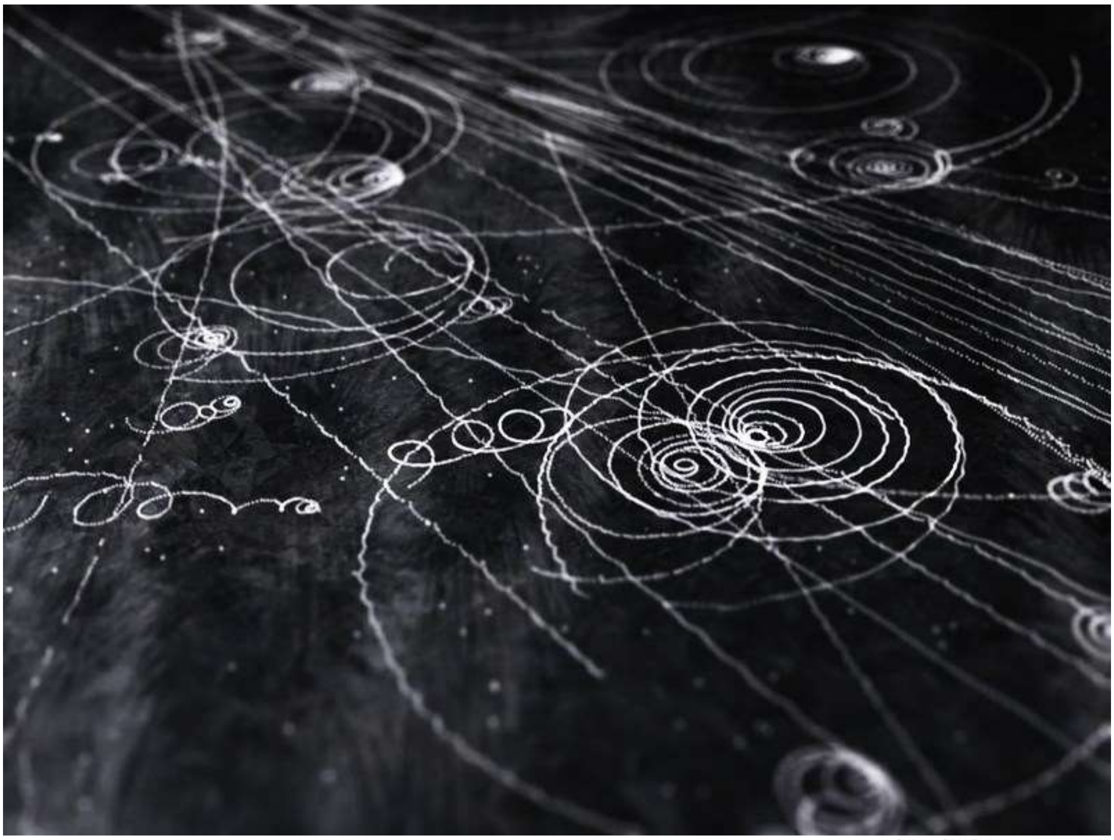

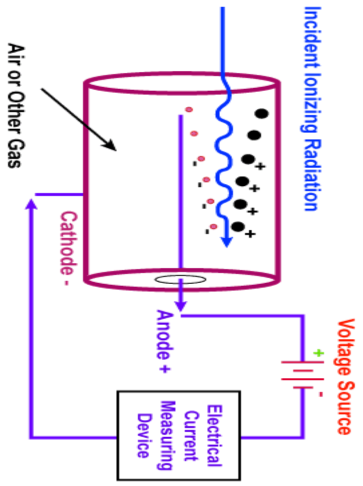

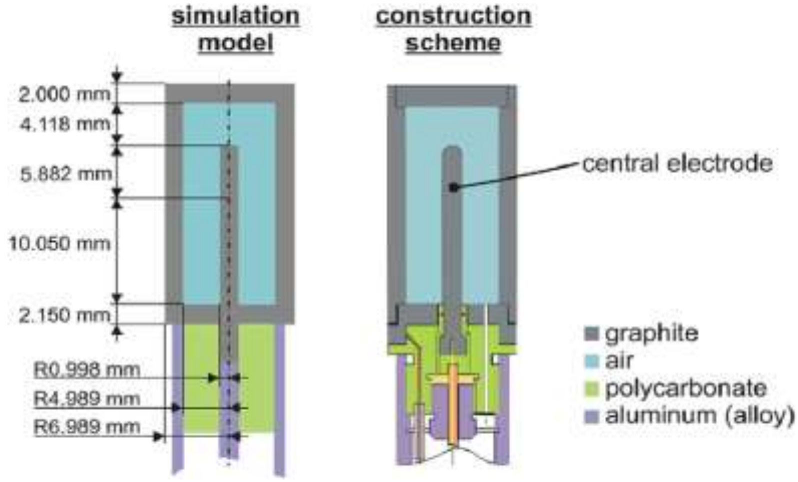

Radiation Detection and Measurement

Second Experiment (2)

First semester / Second year

By

Assist. Lec. ASAL AHMED

Ionization Chamber (Ion Chamber):

Characteristics of the Ion Chamber:

An Ionization chamber: is a type of radiation detection device; it's an electrical device that detects various types of ionizing radiation, such as alpha, beta particles, and gamma rays.

The Theoretical Part:

Figure 1 shows the ionization chamber. In an ionization chamber, two opposing electrodes are placed in a container filled with gas, and a high voltage is applied. As the charged particles (radiation) pass through the gas, the gas molecules are ionized to produce ions and electrons. The voltage of the detector is adjusted so that the conditions correspond to the ionization region, and the voltage is insufficient to produce gas amplification (secondary ionization).

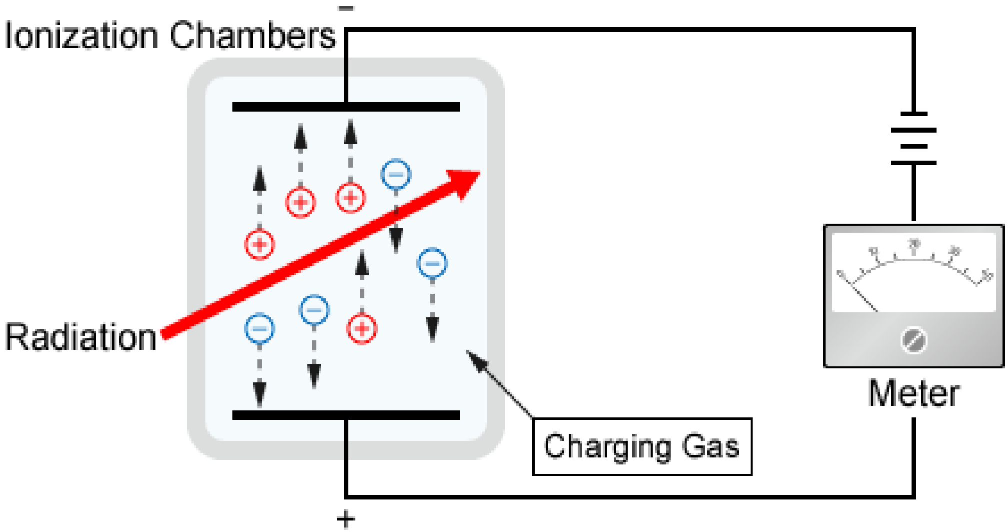

Figure (1): Shows the Ionization Chamber.

The charge collected (the output signal) is independent of the applied voltage. Single minimum-ionizing particles tend to be quite small and usually require special low-noise amplifiers for efficient operating performance. Ionization chambers are preferred for high radiation dose rates because they have no **"dead time"**, a phenomenon that affects the accuracy of the Geiger-Mueller tube at high dose rates. This is because there is no inherent amplification of signal in the operating medium; therefore, these counters do not require much time to recover from large currents. In addition, because there is no amplification, they provide excellent energy resolution.

Ionization Chambers for:

1. Alpha and heavy-charged particles:

Since the penetrating ability of alpha particles and other heavy-charged particles is small, these particles are completely absorbed into the wall of the chamber and do not pass through. Therefore, a thin window must be made in the wall of the room to allow these particles to enter through it.

The window is generally made of a light material, such as beryllium or light organic materials, and is in the form of a very thin membrane so that the membrane does not absorb a large portion of the energy of the particles. Also, the membrane bears the pressure difference that is applied to it, resulting from the difference in gas pressure inside the room and the atmospheric pressure outside it.

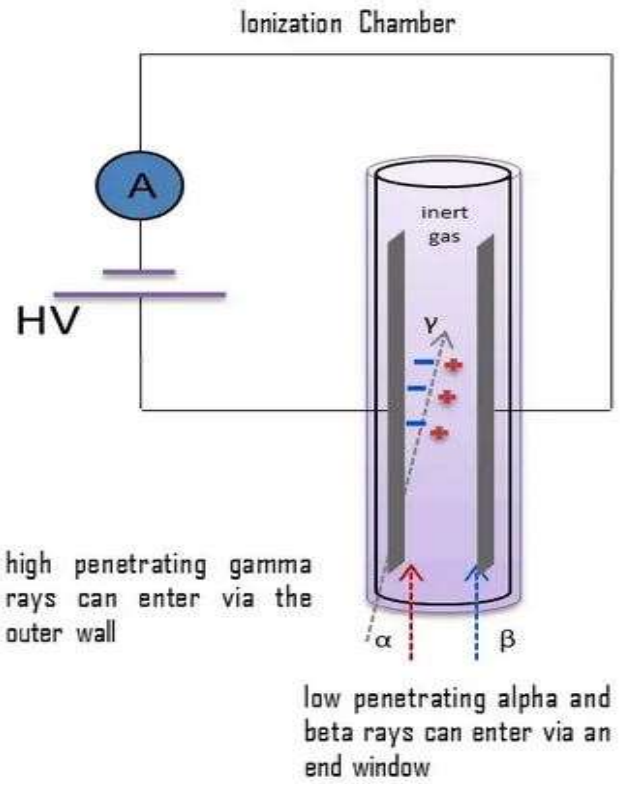

Figure (2): Shows the ability of the ionizing radiation to penetrate the ionization chamber.

This type of chamber is used to detect alpha particles, especially those resulting from contamination of the surfaces of devices and equipment with substances that emit alpha particles, as shown in figure 2. These rooms are distinguished by their sensitivity, as they can detect weak contamination whose radioactivity does not exceed one particle per minute.

Calculations:

A gaseous ionization chamber whose smallest scale ranges from 0 to 500 particles per minute. If you know that its window absorbs 20% of the energies of alpha particles, and if the energy of these particles is 5 MeV, calculate the amount of current generated by them when the pointer is in the middle of the scale in 35 minutes.

The solution:

When the indicator is **in the middle** of the scale, the number of alpha particles is $\frac{500}{2} = 250$ particles per minute.

The amount of energy lost in the window from each particle is:

$$AE = \frac{5 \times 20}{100} = 1 \text{ MeV}$$

The amount of energy lost in ionizing the gas per particle is:

$$E = 5 - 1 = 4 \text{ MeV}$$

The resulting current I is the charge generated divided by its generation time (1 minute = 60 seconds), which is:

$$I = \frac{dQ}{dt}$$

$$I = \frac{250 \times 4 \times 10^{6} \times 1.6 \times 10^{-19}}{35 \times 60}$$

I = 7.6×10^{-14} Ampere, I = 7.6×10^{-2} Pico Ampere.

2. Beta particles:

It is known that the ability of beta particles to penetrate is great, as their range in atmospheric air reaches several meters (about 5 meters) when their spectrum covers an energy range starting from zero up to about 1 MeV. Therefore, the gas pressure inside the room must be great in order for these particles to completely stop inside the room. For the same reason, windows of greater thickness are used to resist the pressure difference inside and outside the room.

3. Gamma Radiation:

Due to the superior penetrating ability of gamma radiation, it is not necessary to have a window to detect this radiation. Given the small probability of the occurrence of the Photoelectric Effect and the Compton Effect or Pairs Production inside the gas, the inner surface of the chamber is lined with a thin layer of lead to increase the possibility of any of these processes occurring, and the release of electron to ionize the gas. However, the thickness of this layer must be small; otherwise, the electrons emitted by the three processes will be absorbed into it. A small portion of gamma radiation is what leads to the release of these electrons, the other part passes through the room without leaving any traces and is not recorded. Therefore, all types of gamma radiation detectors are characterized by detector self-efficiency.

H.W:

1. A gaseous ionization chamber whose smallest scale ranges from 0 to 600 particles per minute. If you know that its window absorbs 35% of the energies of alpha particles, and if the energy of these particles is 4.9 MeV, calculate the amount of current generated by them when the pointer is in **the end** of the scale in 40 minutes. **Answer: I = 12.7 $\times 10^{-2}$ Pico Ampere.**

2. Calculate the number of particles per minute in a gaseous ionization chamber when the pointer is **in the middle** of the scale if the amount of energy of these particles is 11.5 MeV and the amount of current generated by them is 2.1×10^{-14} Ampere. If you know that its window absorbs 15% of the energies of alpha particles in 8 minutes. **Answer: N = 323 particle per minute.**

3. A gas ionization chamber whose smallest scale ranges from 0 to 550 particles per minute. If you know that its window absorbs 50% of the energies of alpha particles, and if the amount of current is 5.01×10^{-14} Ampere, calculate the amount of energy generated by them when the pointer is in **the end** of the scale in 8 minutes. **Answer: E= 30.7 MeV.**

4. What are the advantages and disadvantages of the ionization chamber?

5. What is more efficient ionization chamber or G.M tube?

6. What are the photoelectric Effect, the Compton Effect, and the production of pairs?