**Quadrant II – Transcript and Related Materials**

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**Notes**

Geiger-Muller counter

Hi everyone! Welcome to my lecture on Physical Chemistry. Today I am going to discuss nuclear detectors. One of the very important nuclear detectors is a Geiger-Muller counter or a GM counter.

So let's begin, what is a GM counter? GM counter is a kind of a nuclear detector which is capable of detecting different kinds of nuclear radiation like Alpha and Beta particles and Gamma radiation.

Now the principle on which this kind of a GM counter is based upon is very interesting.

But before we deal with it, let's first talk about the construction of this counter. It is a simple device which mainly consists of the Geiger-Muller tube which is nothing but a hollow metallic cylinder containing mixture of gases like Argon and Alcohol. A fine tungsten wire about 0.05 mm thick which acts as anode is suspended in the cylinder at the center.

Principle:

Now what is the working mechanism of this kind of setup? It is very simple, when the external nuclear particle like an Alpha or a Beta particle enters the GM tube containing gases it induces ionisation and leads to the creation of a positive ion and the free electron. The voltage applied across the electrodes is a huge and hence the electron will experience a high acceleration towards the central wire and the positive ion will move in the opposite direction i.e. towards the walls of the metallic tube.

Now what happens is that, once the electron is accelerated towards this positive anode, it is capable of causing further ionisation. This electron which moves downwards towards the central wire and since the potential is extremely high, the electron will gain very high velocity and this will result into more ion pairs formation thus producing secondary and tertiary ionisation. This will lead to a chain reaction and the effect that you see is called Avalanche effect and the huge number of electrons will gather all along the central wire so this kind of a phenomenon is known as **avalanche effect or Townsend avalanche**. This is the principle of a **GM counter.** This kind of avalanche effect leads to a complete discharge of the entire Geiger Muller tube.

Now when electron ionised the gaseous atoms, it can also interact with the potential field of the nucleus and experience deceleration and hence it can lose energy and lead to the creation of a photon. This effect is known as a bram stroulling effect. During this process, the electron is getting decelerated and ultraviolet radiation gets emitted. This ultraviolet radiation can travel to other corners of the counter tube and create their own avalanche effect in those places. So what you end up getting is even with a formation of a single electron, it leads to an avalanche effect all along the entire central electrode of the GM tube. This internal amplification is as high as 108 and the number of ion-pairs produced is independent of primary ionisation. Now these electrons complete the circuit and come back to the metallic surface by passing through the load resistance where the counter will record the count for the existence of nuclear particle. Now these electrons meet the positive ions and re-combines with it to create neutral molecules thus bringing the entire setup back to its original state.

Now this entire process takes a little bit of time so when the electron is created, it leads to an avalanche effect then electrons travel along the circuit and again it recombines with the positive ions. During this process no further external particle can be detected by the nuclear detector. So during this time period, the detector becomes inefficient and cannot detect any further nuclear particles as long as this process does not get completed and the instrument comes back to its origin state so this time period is known as **dead time**. So during this dead time period the GM counter becomes inefficient and incapable of detecting each further nuclear particles entering the tube. The dead time is usually of the order of 200 to 400 microseconds.

Now there is another topic associated with it, which is known as **quenching.** when the electron completes the circuit and recombines with the positive ions, it comes back to one of its shells to form the neutral atom. This process might lead to the emission of a photon. This photon is also capable of producing another avalanche effect. But the count has already been made and we only want counts associated with external nuclear particles so when this kind of photon can give extra avalanche effect which would basically increase the dead time and make the counter ineffective. So to prevent this from happening certain measures are taken. These measures are known as **quenching**. So one of the methods is chemical quenching in which the alcohol vapours are taken along with Argon gas which help in absorbing the photon formed in the recombination process. This alcohol absorbs the energy in the form of either vibrational energy or rotational energy, thus preventing some kind of an extravagant effects which might lead to increase the dead time. There is another quenching method which is called external quenching that is whenever electrons complete the circuit, the GM counter basically shuts down for a very small time, the voltage almost becomes near about 0. This will delay the formation of photon which might not lead to avalanche effect.

So these methods which prevents any kind of delay in the dead time during recombination of electron with an ion is known as quenching.

To summarize the whole thing, the principle of a Geiger Muller counter is based upon Townsend avalanche effect. The Townsend avalanche effect is quite simple when an external nuclear particle enters the tube containing mixture of gases, it ionises the gas to form positive ion and the free electron and when they experience a huge amount of electric field, electrons gets accelerated and cause further ionisation. This process continues and cause an avalanche effect along the entire central electrode.

Electrons formed travels externally to the cathode through RL and output signal is given to the counter and these electrons meet the positive ions in the tube by completing the circuit.

Dead time is the time during which the counter becomes insensitive and incapable of counting any new nuclear particles.

When electron recombines with the ion, the energy is liberated in the form of a photon which can induce unwanted avalanche effect.

To prevent the above effect, quenching is required.

-Internal quenching is achieved by taking alcohol in the GM tube.

-External quenching is achieved by using external load resistance

in series with the tube.

The disadvantages are; it cannot be used for extremely high counting rates. it can only be used for low counting rates. If there are a large number of nuclear particles coming in, it might not be able to count every single one of them.

High energetic and low energetic particles will lead to complete discharge of the GM counter. Since the current output for both particles is exactly the same and it cannot distinguish between different energies of the particles.

So that is all related to this discussion.

Thank you very much.