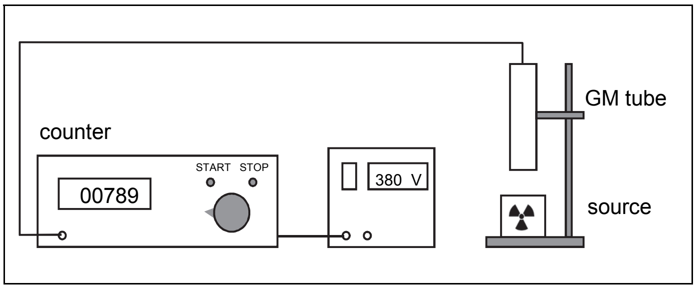
Experiment 6

Geiger-Müller Tube

Name: ……………………………………………...

Aim

To measure the operating voltage and counting efficiency of a Geiger-Müller tube.



Set-up

The set-up consists of a Geiger-Müller tube, a pulse counter with a variable high voltage supply for the GM tube, a voltmeter, and a source of strontium-90 (^{90}Sr).

Read the introduction on page 8 of the booklet *ISP Experiments* about the operation of a GM tube. See also the background information on the information sheet for this experiment.

This experiment consists of two parts: determining the *operating voltage* and the *counting efficiency* of the GM tube. Both parts contain measurements and assignments.

Part 1: Operating voltage

Measurements

1 After removing the cover, position the source underneath the GM tube.

2 Set the high voltage supply to 0 V. Turn the *time-interval button* to *off*. Start the counter, slowly turn up the voltage until the counter starts counting and record this value of the voltage.

3 Reduce the voltage by 50 V, relative to the value recorded in step 2. This is the starting point for the graph.

4 Set the *time-interval button* to 10 s. Measure the intensity *I* of the radiation (in pulses per 10 s) and record the result in the table below. Increase the voltage in steps of 50 V and record the intensity measured in the table below. **Note**: The voltage should not exceed **850 V**.

U (V)											
I (pulses/10s)											

5 Take the source out of the set-up and put the lid back on.

Assignments

1 Plot your measurements (intensity *I* as a function of voltage *U*) in the graph (right).

2 Explain the shape of the graph.
- Why doesn't a GM tube work at low voltages?
- Why does the value of the intensity increase at high voltages?

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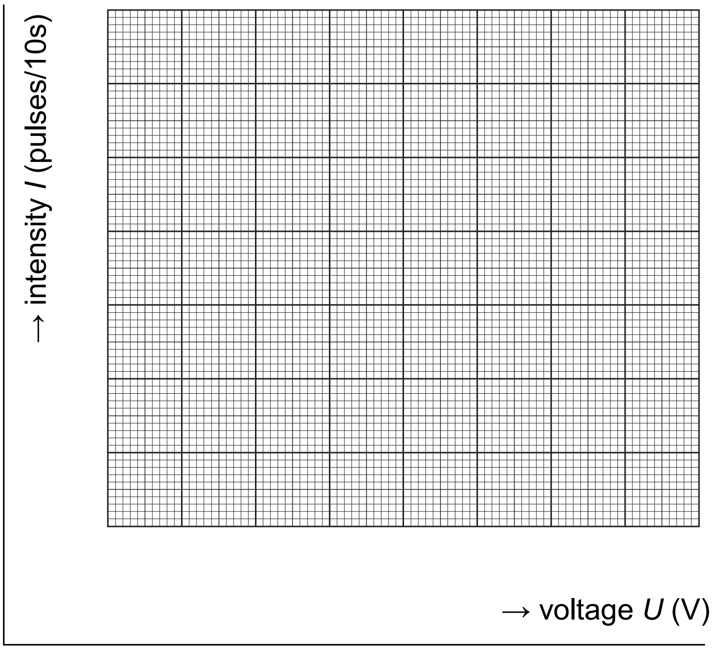


The graph drawn in assignment 1 has a part in which the measured intensity is almost constant, independent of the voltage. This part we call the *working voltage area* of the GM tube.

3 Determine the working voltage area from the graph. Then choose within this area an appropriate value for the working voltage.

Working voltage area: ……… to ……… V

Working voltage chosen: ……… V

Part 2: Counting efficiency

Measurements

1 After removing the cover, position the source underneath the GM tube.

2 Set the voltage to the working voltage chosen. Measure the intensity I of the radiation (in pulses per 10 s) four times and calculate the average intensity I_{avr} (in pulses per 10 s). Record the results in the table below.

I (pulses/10s)					I_{avr} (pulses/10s)	

3 Take the source out of the set-up and put the lid back on.

Assignments

Because of the decay of instable atomic nuclei a radioactive source sends out a number of particles per second. This is what we call the activity A of the source.

1 Explain why only a part of these particles will reach the GM tube.

………

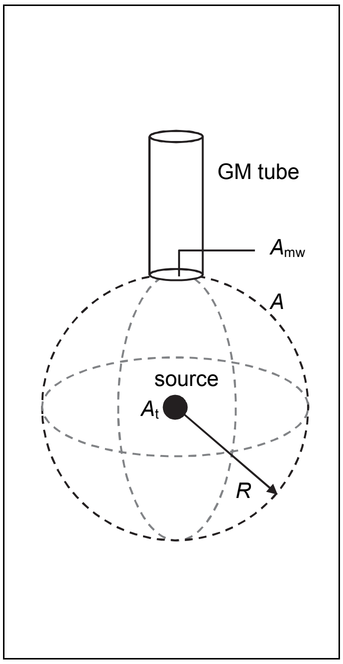
………

Of the particles that do reach the GM tube, only a part will be detected. The counting efficiency η of the GM tube indicates which part that is. In a formula:

$$\eta_{\text{tube}} = \frac{\text{number of detected particles}}{\text{number of incoming particles}} \times 100\%$$

Both numbers in the formula, of course, relate to the same time interval (for example, 1 s). The number of detected particles per second is easy to calculate from the measurements in the table above. This leaves the number of incoming particles, which depends on the activity of the source, and the geometry of the set-up.

2 Calculate the number of incoming particles per second by answering the following three questions:



- The original activity A_0 of the source was 185 kBq. The source is 25 years old. The half-life of ^{90}Sr is 28 years.

The current activity A_t of the source will then be ……… kBq.

Note: The activity A_t is given by $A_t = A_0 \cdot \left(\frac{1}{2}\right)^{t/t_{1/2}}$

- The distance R between the source and the measurement window of the GM tube is approximately 5 cm. The source emits the particles in all directions, and these particles are spread out evenly on an imaginary sphere with a radius of 5 cm.

The surface area A of this sphere will then be ……… cm^2.

Note: The surface area A of a sphere is given by $A = 4\pi \cdot R^2$.

- The measurement window of the GM tube is located on the sphere's surface. This measurement window has a surface area A_{mw} of 1.54 cm^2.

The number of particles per second reaching the measurement window will then be: ………

Note: For your calculation, use the current activity A_t of the source, the surface area A of the sphere and the surface area A_{mw} of the GM-tube's measurement window.

3 Calculate the counting efficiency of the GM-tube.

η_{tube} = ………. %