Experiment 21

Age of Radioactive Sources

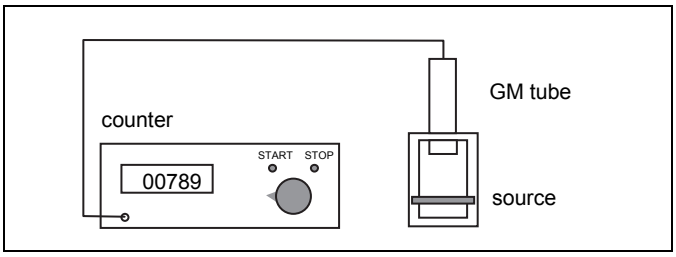
Name:
……..

Aim

To measure the age of a number of radioactive sources.

Set-up

The set-up consists of a Geiger-Müller tube, a pulse counter and a number of sources with cobalt-60 (^{60}Co).
The GM tube is mounted in a holder. The sources have the form of a sheet that can be inserted in the holder.



Read the introduction on page 25 of the booklet *ISP Experiments* about the way in which the age of radioactive sources can be measured.

Measurements

1 Measure the intensity I_b of the background radiation (in pulses per 10 s) five times, and record your measurements in the table below. Calculate the average intensity $I_{b,avr}$ of the background radiation (in pulses per 10 s), and record the result in the table below.

I_b (pulses/10s)						$I_{b,avr}$	

2 Position source 1 in the holder underneath the GM tube. Measure the radiation intensity I (in pulses per 10 s) five times, and record your measurements in the table below. Repeat these measurements for the five other sources.

source	I (pulses/10s)					I_{avr}	I_{cor}
1							
2							
3							
4							
5							
6							

3 Calculate the average radiation intensity I_{avr} (in pulses per 10 s) of each of the six sources, and make a correction for the background radiation: $I_{cor} = I_{avr} - I_{b,avr}$. Record the results in the table above.

Assignments

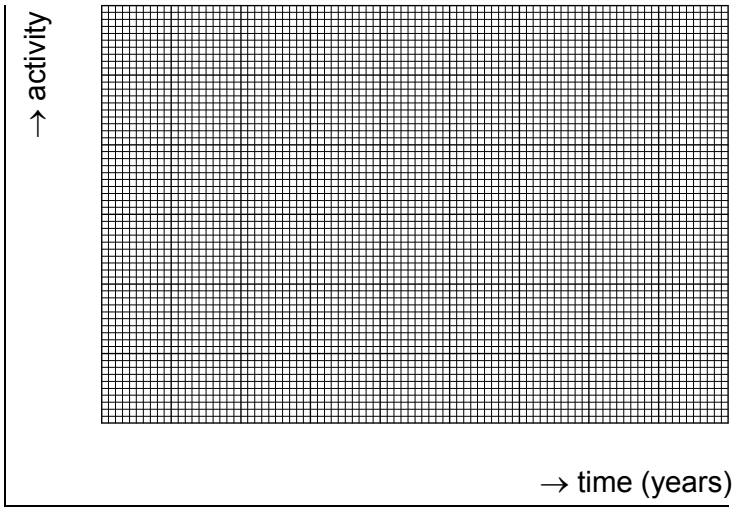
To determine the age of a radioactive source we will use its current activity, combined with its orginal activity and the known half-life of the nuclide in the source. However, the measured radiation intensity I is not equal to the activity A of the source. This is because the GM tube detects just a small part of the particles or photons emitted by the source. Which part that is, depends on the GM tube and on the distance between tube and source. However, these conditions are the same of each of the six sources in this experiment. Therefore, the radiation intensity I can be used as a measure for the activity A of the sources. For the sake of simplicity, when mutually comparing the sources to determine their age, we assume that the measured radiation intensity (after correction for the background radiation) represents the current activity of the sources.

The measurements show that the current activity of the sources clearly differs. However, the original activity of the sources has been the same. This implicates that the sources are of different age.

1 The youngest source is 5.0 years old. Record this age in the table below underneath the appropriate source.

2 The half-life of ^{60}Co is 5.3 years. By using the measurement results, estimate the age of the other five sources. Record the results in the table below.

Hint: One of the ways to estimate the ages of the five other sources is to draw the decay curve of the source of which the age is known. The measured current activity of that source, combined with its known half-life and age, results in an estimate of the original activity of the source. The decay curve of this source can then be drawn on the graph paper. Now, think about the following questions: why is this decay curve also valid for the other sources, and how are the approximate ages of these sources to be read from this decay curve?



source	1	2	3	4	5	6
age (years)						

Explain how you arrived at these estimated ages of the sources.

……

……

……

……

3 Check whether the estimated ages of the sources are correct by calculating these ages with the formula for the activity A_t of a radioactive source:

$A_t = A_0 \cdot \left(\frac{1}{2}\right)^{t/t_{1/2}}$

In this formula, A_t is the current activity and A_0 the original activity of the source, t is the age of the source and $t_{1/2}$ is the half-life of the source's nuclide.

Record the results of your calculations in the table below. Hint: If necessary, use the intersect function on the graphic calculator in doing these calculations.

source	1	2	3	4	5	6
age (years)						

4 Compare the results of Assignments 2 and 3: Are the ages of the sources in Assignment 2 estimated correctly?

……

……

……