Experiment 22

Coefficients of Absorption of Aluminium for Gamma Radiation

Name:
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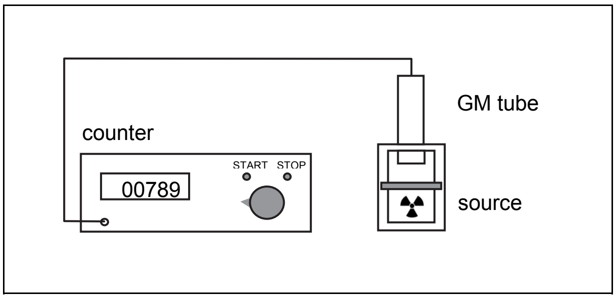
Aim

To measure the coefficients of absorption of aluminium for high-energetic and low-energetic γ radiation.

Set-up

The set-up consists of a Geiger-Müller tube, a pulse counter, a source of americium-241 (^{241}Am), and a number of aluminium sheets of different thickness.



Read the introduction on page 26 of the booklet *ISP Experiments* about the difference between absorption of high-energetic and low-energetic γ radiation in materials.

Measurements

1 Measure the intensity I_b of the background radiation (in pulses per 10 s) five times, and record the results 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 Remove the lid from the source, and position the source in the equipment set-up.

3 Insert the sheet of aluminium with thickness 0.06 mm in the equipment set-up. Measure the intensity I of the transmitted radiation (in pulses per 50 s). Do this by counting the number of pulses per 10 s five times, without resetting the counter. Record your measurements in the table below. Repeat these measurements with sheets of aluminium of different thickness d as indicated in the table below.

4 For each of the sheets of aluminium, calculate the average intensity I_{avr} (in pulses per 10 s), and correct for the background radiation: $I_{cor} = I_{avr} - I_{b,avr}$. Record the results in the table below.

d (mm)	I (pulses/50s)	I_{avr} (pulses/10s)	I_{cor} (pulses/10s)
0.06			
0.24			
0.37			
0.52			
0.69			
0.92			
1.13			
1.59			
1.99			
2.57			
3.29			

5 Take the source out of the equipment set-up, put the lid back on, and store it at approximately 1 m distance.

Assignments

1 Plot your measurements (intensity I_{cor} as a function of thickness d) on a separate sheet of single logarithmic graph paper. See the booklet *ISP Experiments* (pages 31-32) for the reasons of using single logarithmic graph paper.

2 In the right-hand part of the graph, draw a straight line that corresponds as well as possible to the plotted points, and extrapolate this line until the thickness d = 0 mm. This line indicates the absorption of the high-energetic γ radiation with an energy of 60 keV (line b in the diagram on page 26 of the booklet *ISP Experiments*).

Subtract the extrapolated line from the measured curve as plotted in Assignment 2 (curve a in the diagram on page 26 of the booklet *ISP Experiments*). Do this by reading the intensity of the transmitted radiation on the extrapolated line and the measured curve at a number of values of the thickness d, and then calculating the difference between both intensities. Then plot the calculated intensity differences as a function of thickness d, and draw a straight line that corresponds as well as possible to the plotted points. This line indicates the absorption of the low-energetic γ radiation with an energy of 27 keV (line c in the diagram on page 26 of the booklet *ISP Experiments*).

3 From the graph, determine the half-value thickness $d_{1/2}$ of aluminium for the low-energetic as well as the high-energetic γ radiation. or – if this is not possible – calculate this half-value thickness with the formula for the intensity I_d of the transmitted radiation:

$$I_d = I_0 \cdot \left(\tfrac{1}{2}\right)^{d / d_{1/2}}$$

In this formula, I_d is the intensity of the transmitted radiation, I_0 is the intensity of the incident radiation, d is the thickness, and $d_{1/2}$ is the half-value thickness of the absorbing material. Hint: If necessary, use the intersect function on the graphic calculator in doing this calculation.

Half-value thickness for E_f = 27 keV: $d_{1/2}$ = ……… mm

Half-value thickness for E_f = 60 keV: $d_{1/2}$ = ……… mm

4 The formula for the intensity I_d of the transmitted radiation can also be written as an exponential function with the help of the coefficient of absorption μ of the absorbing material:

$$I_d = I_0 \cdot e^{-\mu \cdot d}$$

Combining the two formulas for the intensity I_d of the transmitted radiation results in a relation between half-value thickness $d_{1/2}$ and coefficient of absorption μ:

$$I_0 \cdot e^{-\mu \cdot d} = I_0 \cdot \left(\tfrac{1}{2}\right)^{d/d_{1/2}} \rightarrow \ln\left(e^{-\mu \cdot d}\right) = \ln\left(2^{-d/d_{1/2}}\right) \rightarrow -\mu \cdot d = -\left(d/d_{1/2}\right) \cdot \ln 2 \rightarrow \mu = \frac{\ln 2}{d_{1/2}} = \frac{0,693}{d_{1/2}}$$

Calculate the coefficient of absorption μ of aluminium for the low-energetic as well as the high-energetic γ radiation.

Coefficient of absorption for E_f = 27 keV: μ = ……… mm^{-1}

Coefficient of absorption for E_f = 60 keV: μ = ……… mm^{-1}

5 The source contains the radioactive nuclide ^{241}Am. The decay of this nuclide is described by the equation below.

$$^{241}_{95}\text{Am} \xrightarrow{\dots} {}^{237}_{93}\text{Np (unstable)}$$**F**

Write the kind of radiation emitted in this decay above the arrow.

Explain why this source, despite the kind of radiation emitted, can be used for measuring the coefficients of absorption of aluminium for γ radiation.

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