Measurement of Half value thickness (HVT) of Aluminium for a β source

The Aim of the Experiment

This experiment uses the same strontium 90 collimated beta source as the first year radioactivity experiment. However, in this case absorption by Aluminium is studied and a quantity known as the half value thickness found.

PLEASE RE-READ THE FOLLOWING SAFETY NOTE:

The College's radioactive sources are not strong and if treated with care will not harm you. It is worth remembering that the effective range of a β source is only about 50 cm. Hence the best safety precaution is to KEEP YOUR DISTANCE!

It is a Health and Safety requirement that a lab coat be worn whenever you are working with a radioactive source. You need to log out the source from the prep. room.

Care must be taken when handling the source . It should be moved around with tongs at all times and pointed away from the body. DO NOT touch the source and DO NOT point the source at anyone else. If possible work at a side bench with the source facing the window . Otherwise, ensure that the source is not directed at a person working opposite you.

When you have finished with any source put it back in the storage box immediately and make sure that the tin in which the sources are kept is properly closed. This must then be stored in the appropriate cupboard and the log book signed - ask a technician if you are unsure about this.

Having used the source you should wash your hands thoroughly.

Apparatus

Scalar timer
Strontium-90 source
Baseboard
Geiger-Muller tube HANDLE WITH CARE
Scalar to Geiger-Muller tube connector
Geiger-Muller tube holder with brass hoop
Rubber tipped tongs
Numbered sheets of Aluminium
Micrometer screw gauge

The set up is basically the same as in the first year – ask your teacher if you need help.

Theory

Half value thickness (HVT) is a similar concept to half life and arises because the count rate falls off exponentially with thickness of material.

The count rate, A of radiation decreases with thickness, x according to the equation: $A = A_0 e^{-\mu x}$
Where μ is the total linear attenuation coefficient.

Taking the natural logarithm of both sides gives: $\ln A = \ln A_0 - \mu x$

A graph of ln A against x should therefore be a straight line with a negative gradient of magnitude μ.

Having found μ from the graph, the half value thickness(HVT), $x_{1/2}$ can be calculated from: $x_{1/2} = \ln 2 / \mu$

Method

Keep the distance between the source and the detector *small* and *constant.* Use the counter in "frequency rate" mode such that it records the average count rate over 10 second intervals. Use the numbered sheets of aluminium in the radioactivity kit and repeat each reading *at least* once - radioactive decay is a random process, so random errors are unavoidable. Remember that "background radiation" is always present, so your readings will never become zero. Measure the thickness of each sheet of aluminium with the micrometer screw gauge. When you have finished the experiment, make sure you return the source to the locked cabinet, sign the log book and wash your hands.

Analysis

Record your repeat values of count rate and corresponding thicknesses in a table and calculate the average values. Also subtract the average background count rate from all the count rate values – this may seem negligible, but becomes significant for the smaller values once logged.

Tabulate natural log values for your corrected average count rate readings and plot a graph of $\ln(A/s^{-1})$ against x.

Measure the gradient of your graph and use this to calculate the half value thickness.

Does your value for the half value thickness seem to be a sensible order of magnitude?

A web resource gives the half value 'thickness' of Al for strontium 90 as 112 mg / cm^2. Clearly this is not a unit of length! By thinking about the units of the quantities involved, you should be able to see that by dividing this number by the density of Aluminium a quantity with the units of length is produced.

Use the above value (converted into SI units) and the density of Aluminium (2700 kg m^{-3}) to calculate an expected value for the half value thickness in metres and compare it with your result.