Experiment – 2

Objective : Study of γ absorption in matter by γ-ray source.

Sources : γ-ray source

Scope of Expt :

i. Keep the source in the holder and at different values of the voltage record the number of counting and hence plot a graph between the count rate and the applied voltage.
ii. Now take the background reading for about 10 min without the source.
iii. Now put the source and then the absorbers (Pb, Al, Fe sheets) in different combinations and determine the count rate at different thickness.
iv. Calculate the linear attenuation coefficient, mass attenuation coefficient and half value thickness.
v. Prove the inverse square law of radiation.

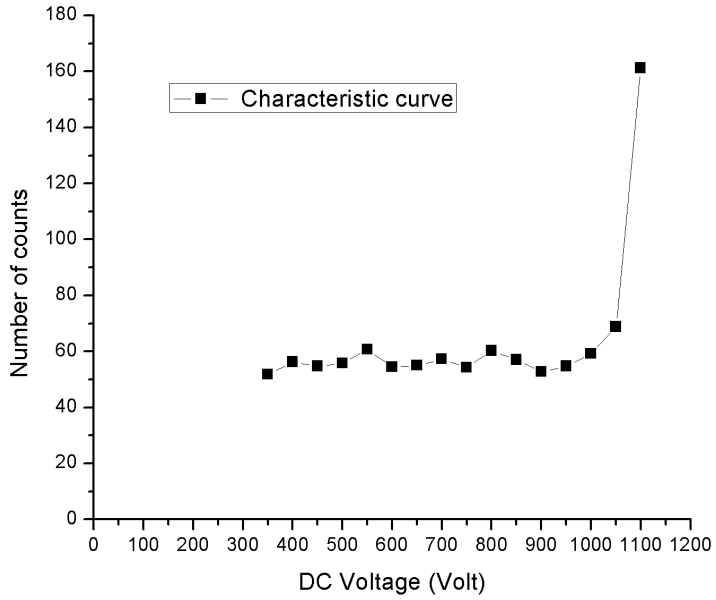
Theory : Write about GM counter in details. Describe about mass attenuation coefficient and inverse square law of radiation.

(A) Draw the operational characteristics curve of the counter and decide on the operating voltage.

(i) Set counting time for 20 or 30 sec. Set no. of run as 1.
(ii) Set your source in slot 4.
(iii) Set your HV to 0 by turning the HV Pot and then RUN. Note your counts. This is RUN-1
(iv) Repeat the same for RUN-2 and note down your counts.
(v) Increase your HV in a step of 50 and take RUN-1 and RUN-2. Note it down.
(vi) Repeat (v) in a step of 50 [from 0 to 250], step of 20 [from 250 to 350], step of 50 [from 350 t 950], and step of 20 [from 950 to 1100].
(vii) Make proper table and draw the graph.

HV	No of Counts		Average Counts		HV	No of Counts		Average Counts
	Run-1	Run-2				Run-1	Run-2	
0					650			
50					700			
100					750			
200					850			
250					900			
270					950			
290					970			
310					990			
330					1010			
350					1030			
400					1050			
450					1070			

Characteristic Graph :



Now decide the operating voltage from the above graph *i.e* may be 618 V

(B) Determination of background readings for long time (may be 10 minutes) without sources:

Background reading without sources			
Time(sec)	counts	Avg. count	Count rate(count/s)
600	653		
600	484	568.5	0.95

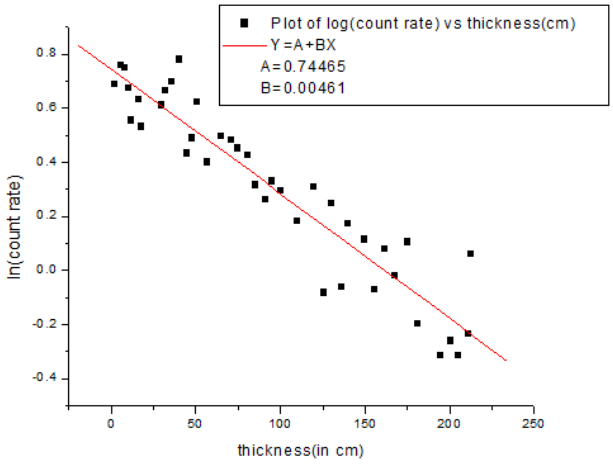
(C) Determination of count rate after putting the absorber with source:

Reading for count rate after putting the absorber						
Voltage(V)	Time(sec)	Thickness(mm)	Count	Average Count	Count rate(count/sec)	Corrected rate(count/sec)
			96			
			105			
618	30	0.2	95	98.67	3.29	1.99
			102			
			95			
618	30	0.6	112	103.00	3.43	2.13
			96			
			108			
618	30	0.8	103	102.33	3.41	2.11

Keep the thickness (in mm) as follows : 0.2, 0.6, 0.8, 1.0, 1.2, 1.6, 1.8, 3.0, 3.2, 3.6, 4.0, 4.5, 4.8, 5.1, 5.7, 6.5, 7.1, 7.5, 8.1, 8.5, 9.1, 9.5, 10.0, 11.0, 12.0, 12.6, 13, 13.6, 14.0, 15.0, 15.6, 16.2, 16.8, 17.5, 18.1, 19.5, 20.1, 20.5, 21.1 and 21.3 (this is just an example, use your slabs for thickness)

You can take two (2) RUN. Time can be more (60 sec). You decide your No of RUN and Time.

Graph : Plot of *log*(count rate) **vs** *thickness* (in mm)



Absorber mass thickness

In terms of mass attenuation coefficient, the attenuation law for gamma rays takes the form

$$I/I_0 = e^{-(\mu/\rho)\,\rho t}$$

I = intensity that comes out
I_0=Incident intensity
μ= linear attenution coefficient
ρ= density of the absorber

t = thickness

(μ / ρ) = the mass attenuation coefficient

Half value thickness

Half value thickness is the thickness of the absorber at which the value of the incident intensity attenuated to half of its initial value.

Calculation :

From graph 2 we have μ=linear attenuation coefficient=0.0461 mm^{-1}

Now as $\rho_{aluminium}$ = 2.7 g/cm^3 or 2.7 mg/mm^3

We have mass attenuation coefficient

$\mu / \rho = 0.0461/2.7\ mm^2mg^{-1} = 1.7074x10^{-2}\ mm^2mg^{-1}$

Calculating half value thickness

At half value thickness $\log(I/I_0)=\ln(1/2)= -0.693= -\mu t$

$$\rightarrow t = -0.693/-0.0461 = 15.0325 = 1.5033$$

Note: All the numerical value (except $\rho_{aluminium} = 2.7\ g/cm^3$) are just examples and not real value of expt. Put your own experimental value and find the true value.

(D) Inverse square law for gamma radiation :

Gamma radiation obeys an inverse square law in air since absorption is negligible. (Radiation spreads out over an increasing sphere. Area of a sphere = $4\ \pi\ r^2$, so as *r* gets larger, intensity will decrease as $1/r^2$. The effect of absorption by the air will be relatively small.

Fix the GM Tube and move the source and take reading. Repeat 2 or 3 times and take average of the same. Do background subtraction for correct reading. Then plot counts vs $1/r^2$ (straight line fitting) or counts vs *ln r*. You should get a coefficient of -2 in counts vs *ln r* graph.

Due to the absorption and scattering of radiations by air molecules, inverse square law deviates slightly from ideal behavior. Error associated with isotropy also contributed in the deviation of inverse square law.

Result :

The threshold voltage of the GM counter was found to be 367 volts.

The linear attenuation coefficient of aluminum was found to be 0.0461 mm^{-1}

The mass attenuation coefficient = $1.7074x10^{-2}\ mm^2mg^{-1}$

The half value thickness = 15.0325 mm

Error :

Write possible errors.