Radiation physics –practical Experimental No.1

Linear and mass absorption coefficients

Asst.Lec.Dumoaa Haider Shakir

1.1 The objectives of this experiment:

- 1) Verification of the absorption law of Gamma radiation.
- 2) Determination:

  a) The linear absorption coefficient (μ).

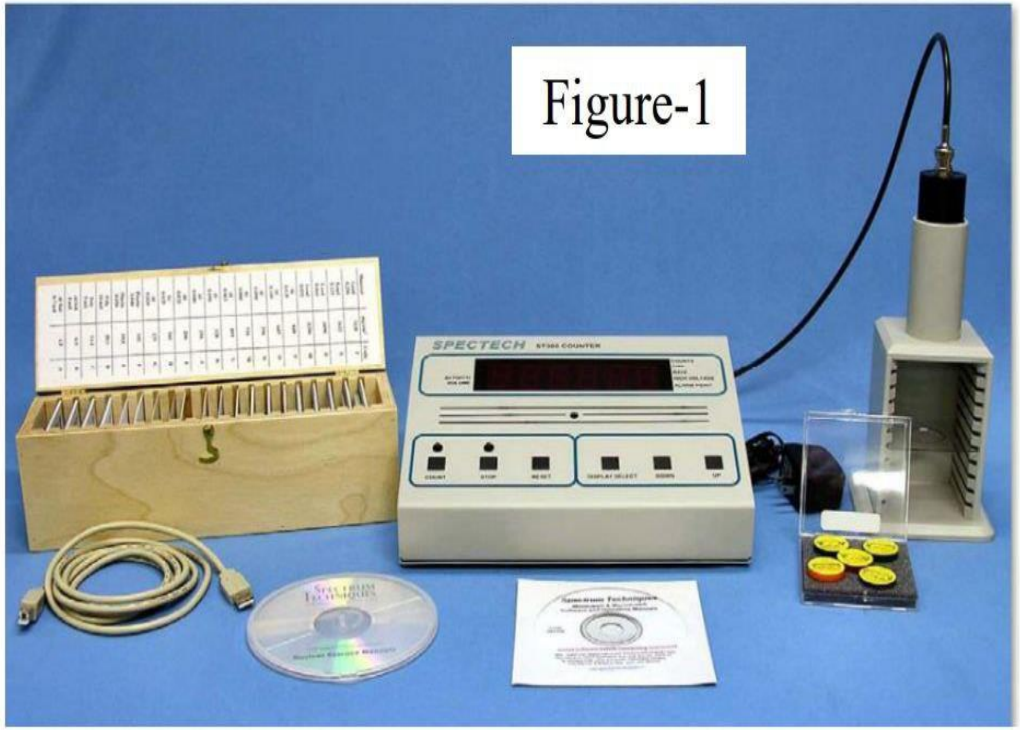
  b) The mass absorption coefficient µm .

  c) The half value thickness of the absorbing material ($X_{1/2}$)

1.2 Apparatus

- GM Tube and stand (Counter box, power supply – transformer, GM Tube, shelf stand, USB cable, and a source holder for the stand) – shown in Figure 1.
- Source of radiation.
- Sheets of different absorbing materials

(Aluminum and Lead).



1.3 Theory

- **When Gamma radiation passes through matter, it undergoes attenuation primarily by Compton, photoelectric and pair production interactions. The intensity of the radiation is thus decreased as a function of thickness of the absorbing material. The mathematical expression for intensity (I) is given by the following expression:**

$$I = I_0 e^{-\mu x} \quad \ldots\ldots\ldots\ldots\ldots (1)$$

where,

I_0 **the original intensity of the beam.**

I **is the intensity transmitted through an absorber thickness X.**

μ is the linear absorption coefficient for the absorbing material

- If we rearrange eq.(1) and take the natural logarithm of both sides, the expression becomes,

$$\ln \frac{I}{I_o} = -\mu X \text{ .... (2)}$$

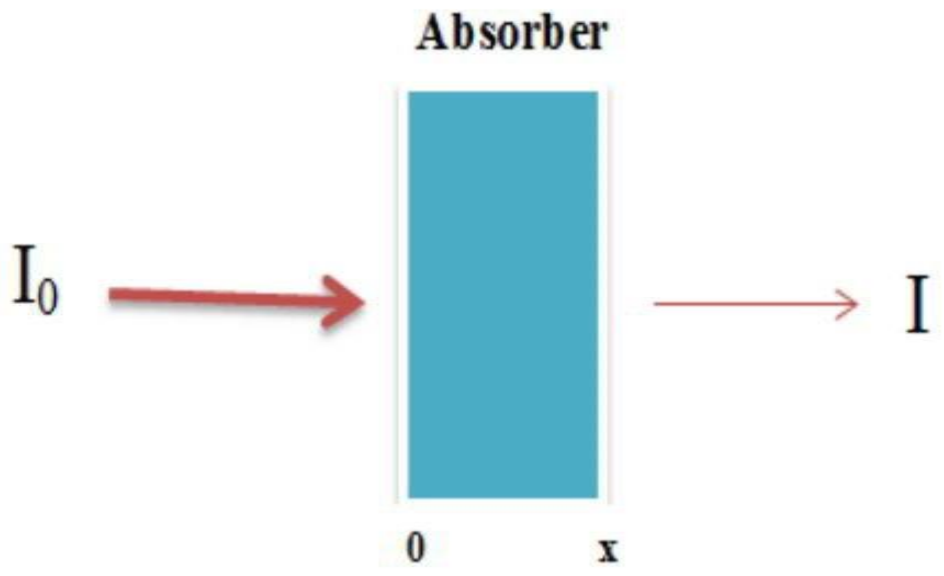
- The half value layer (HVL) of the absorbing material is defined as that thickness $X_{1/2}$ which will decrease the initial intensity by half. That is, I= $I_0/2$. If we substitute this into eq.(2) we get:

$$\ln(2) = \mu X_{1/2} \text{....(3)}$$

- Rearranging eq.(3) we get:

$$X_{1/2} = \ln(2)/\mu \text{ .... (4) Or } X_{1/2} = 0.693/\mu$$

- **<u>The factors which effects on the Linear and mass absorption coefficients</u>**
- **1. Effect of Atomic Number**
- **2. Effect of Density**
- **3. Effect of Thickness**
- **4. Effect of Gamma-Ray Energy**



- the mass absorption coefficient (μm) another useful concept is defined by dividing the linear absorption coefficient by the material density

$$\mu m = \mu / \rho \qquad .... (5)$$

Where

ρ is the density of the absorber material.

1.4 Procedure

- 1. Connect the plugs of the electric mains.
- 2. Set the timer to 60s and the operating voltage to 380 V
- 3. Record the count rate per one minute for the background ($I_{B.G}$).
- 4. Put the source in front of the GM tube.
- 5. Record the count rate (I_0).
- 6. Place (Al) sheet midway between the source and the GM tube.
- 7. Record the count rate (I_1 and I_2) and then find I_{Avg}.

- 8. Repeat steps 6 and 7 with increasing the thickness of the absorbing material.
- 9. Place (Pb) sheet and repeat steps 6,7 and 8.
- 10. Plot a graph between ln(I_0/I) and thickness X, if the relation is a straight line, then the absorption law is verified.
- 11. Find the slope from the graph, this is equal to the linear absorption (or Attenuation) coefficient.
- 12. Calculate the mass absorption (or Attenuation) coefficient.
- 13. Plot a graph between (I) and thickness (X), then find the value of the half thickness graphically.
- 14. Calculate the half thickness theoretically by using eq.(4).