Investigate the Absorption of Gamma Radiation by Lead

AIm:
The goal of this investigation is to determine how the count rate of a gamma source is affected by the thickness of a lead absorber

Variables:

- Independent: The thickness of the lead sheets used as shielding.
- Dependent: The count rate
- Control:
    - The specific gamma radiation source used.
    - The distance between the source and the GM tube.
    - The laboratory location to ensure a consistent background radiation level.

Apparatus:

- Gamma radiation source (e.g., Cobalt-60 or Caesium-137)
- Geiger-Müller tube and counter
- Set of lead sheets of varying thicknesses
- Vernier calipers
- Ruler
- Tweezers or tongs
- Lead-lined storage container

Resolution of Instruments

- Ruler: 1 mm
- Geiger-Müller Tube: 0.01 μS/hr
- Vernier Calipers: 0.01 mm

Procedure

1. Background Measurement: With the radioactive source safely stored away, use the GM tube to measure the background radiation count for 5 minutes. Calculate and record the average count per minute.
2. Measure Absorbers: Using the Vernier calipers, measure the thickness of each lead sheet at three different points. Calculate and record the average thickness for each sheet.
3. Setup: Position the gamma source exactly 10 cm from the window of the GM tube.
4. Initial Reading (No Shielding): Without any lead in place, record the count rate over a 1-minute interval. Repeat this measurement two more times to get a total of three readings.
5. Begin Testing with Shielding: Place the thinnest lead sheet between the source and the GM tube, ensuring it is directly in the path of the radiation.
6. Take Data with Shielding: Record the count rate over one minute. Repeat this twice more so you have three readings for this thickness.
7. Repeat: Carefully replace the lead sheet with the next thickest one. Again, take three separate 1-minute count rate readings. Continue this process for all the lead sheets.

How to Analyze the Data

1. For each thickness (including zero), calculate the mean count rate from your three repeats.

2. Subtract the average background count rate from each of your mean values to find the corrected count rate.

3. The count rate will drop according to the equation: $C = C_0 e^{-\mu x}$
4. Taking logs of both sides gives: $\ln C = -\mu x + \ln C_0$

5. Plot a suitable graph to get μ from the gradient

6. What is the half-thickness of lead? (The thickness of lead to reduce the count rate by a half)

Considering Potential Errors

- Reducing Systematic Errors:
    - Store the source in its lead container when not in use to prevent accidental exposure affecting the setup.
    - Perform the entire experiment in one session and in the same spot to avoid variations in background radiation.
- Minimizing Random Errors:
    - Using a source with a long half-life ensures its activity doesn't decay significantly during the experiment.
    - Taking multiple readings at each thickness and calculating a mean improves reliability.

Safety Protocol

- Storage: The radioactive source must be kept in its lead-lined container whenever it is not being used for measurements.
- Handling: Always use tweezers or tongs to handle the source. Never touch it with your hands. When placing it, point it away from your body and others.
- Distance: Maintain a safe distance (at least 1 meter) from the exposed source during data collection.
- Aftercare: Wash your hands thoroughly after completing the experiment, even if you used tools.