PHYS 3650L - Modern Physics Laboratory

Laboratory Advanced Sheet

Absorption of beta particles

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1. Objectives. The objective of this laboratory is to investigate the absorption of beta particles.

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2. Theory.

Charged particles have a definite range in matter. The range of a charged particle in an absorber is the average depth of penetration of the charged particle into the absorber before it loses all of its kinetic energy and stops. The energy of the particle, which is a function of the mass of the particle and its velocity, and the electrical charge of the particle affect the range of the charged particle in a material. The atomic density (number of atoms per cubic centimeter) and the atomic number (Z) of the shielding material also affect range. Generally, the higher the electrical charge and the higher the mass, the shorter the range of the charged particle. Conversely, the lighter the mass and the smaller the electrical charge, the longer the range.

The factor that affects the range of a charged particle in any material is a unit called density-thickness. Density-thickness can be calculated by multiplying the density of a material in milligrams per cubic centimeter

(mg/cm^3) by the distance the particle traveled in that material in centimeters. The product is density-thickness
in units of milligrams per square centimeter (g/cm^2). Density-thickness can be considered a cross-sectional target
for a charged particle as it travels through the material. Although materials may have different densities and
thicknesses, if their density-thickness values are the same, they will attenuate beta radiation in a similar
manner. For example, a piece of Mylar used as a detector window with a density of 7 mg/cm^2 will attenuate
beta radiation similar to the outer layer of dead skin of the human body which has a density-thickness of 7
mg/cm^2. The density of soft human tissue is equal to 1,000 milligrams per cubic centimeter (mg/cm3).
Therefore, the density-thickness values for the skin, lens of the eye and whole body are 7 milligrams per square centimeter (mg/cm^2),
300 mg/cm^2 and 1,000 mg/cm^2.
Beta particles have a range in air of about 10 feet per MeV of kinetic energy. Beta particles can penetrate
the dead layer of skin if they possess more than 0.07 MeV of kinetic energy.

There exists an *approximate* empirical relationship between range and energy for low energy electrons:

$$r = \frac{0.412 \ g / cm^2}{\rho} (E)^{1.29}$$

where r is in cm, E is in MeV, and ρ is the density of the stopping material in g / cm^3.
Note that the density of Aluminum is 2.702 g / cm^3.

3. Apparatus and experimental procedures.

a. Equipment.

1) Geiger-Müller tube with sample holder.

2) Radiation counter.

3) Radioactive sources.

4) Absorber set.

b. Experimental setup. To be provided by the student.

c. Capabilities. To be provided by the student.

d. Procedures. Detailed instructions are provided in paragraph 4 below.

4. Requirements.

a. In the laboratory.

1) Your instructor will introduce you to the experiment.

2) Perform the background count measurement.

4) Perform the count measurements for different absorption thickness for two radioactive isotops.

b. After the laboratory. The items listed below will be turned in at the beginning of the next laboratory period. A complete laboratory report is **not** required for this experiment.

Para 3. Apparatus and experimental procedures.

1) Provide a figure of the experimental apparatus (para 3b).

2) Provide descriptions of the capabilities of equipment used in the experiment (para 3c).

Para 4. Data. Data tables are included at Annex A for recording measurements taken in the laboratory. A copy of these tables must be included with the lab report. Provide the items listed below in your report in the form a Microsoft Excel^{TM} spreadsheet showing data, calculations and graphs. The spreadsheet will include:

1) Operating potential, resolving time, and counting time for the absorption measurements.

2) Background count measurement (per 400 s).

3) A table with columns for absorber code, absorber thickness, corresponding uncorrected count, and corrected count for each isotope.

4) A graph of the counts vs. absorber thickness for each isotope.

5) Estimated value of a range of beta particles for each isotope.

Para. 5. Results and Conclusions.

a. Results.

1) A statement of the experimental and estimated range of beta particles for each isotope.

b. Conclusions.

1) Do your experimental results agree with the empirical formula? If not, what are the possible reasons?

Annex A
Data

Counting time: 50 s.

Operating potential: ______________________________ V

Resolving time:______________________________ s

Background count/ 400 s:______________________________

1. Absorption measurements. Isotope 1 __________________________

Absorber code	Absorber thickness (mg/cm^2)	counts/50 s	Absorber code	Absorber (mg
A			K	
B			L	
C			M	
D			N	
E			O	
F			P	
G			Q	
H			R	
I			S	
J			T	

2. Absorption measurements. Isotope 2 ____________________________

Absorber code	Absorber thickness (mg/cm^2)	counts/50 s	Absorber code	Absorber (mg
A			K	
B			L	

C			M	
D			N	
E			O	
F			P	
G			Q	
H			R	
I			S	
J			T	