PHYS 3650L - Modern Physics Laboratory

Laboratory Advanced Sheet
Half-Life

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1. Objectives. The objective of the lab is to experimentally determine the half-life of ^{137m}Ba.

2. Theory.

a. Radioactivity is the spontaneous change in the state of a nucleus with the release of energy. The decay of a sample of radioactive nuclei of the same type is given by:

$$N = N_0 e^{-\lambda t}$$

where

N is the number of nuclei present at time, t,
N_0 is the number of nuclei present at time, t = 0,
λ is the decay constant for the nucleus.

b. The decay constant is the probability per unit time that a single radioactive nucleus in the sample will decay. It has units of reciprocal time and is related to the half-life of the radioactive species, the time required for one-half of the nuclei in the sample to decay (or remain), by:

$$t_{1/2} = \ln(2) / \lambda$$

where

$t_{1/2}$ is the half-life.

c. The activity of a radioactive sample is the rate of decay of the sample. Activity is given by:

$$R = N \lambda$$

and as a result of this relationship:

$$R = R_0 e^{-\lambda t}$$

where

R_0 is the activity of the sample at time, t = 0.

3. <u>Apparatus and experimental procedures</u>.

a. Equipment.

1) Geiger-Mueller tube with counting stand.

2) Counter.

3) ^{137}Cs - ^{137m}Ba generator set.

4) 10 ml beaker.

5) Computer with radiation counting software

b. Experimental setup. The student will provide a diagram for the experimental set up.

c. Capabilities.

1) The Geiger-Mueller tube detects radiations emitted from radioactive sources.

2) The counter/timer and high voltage supply records counts detected by the GMT in a fixed time interval and provides the source of high voltage that allows the GMT to operate.

3) The counting stand allows radiation sources to be placed under the GMT in reproducible geometries.

4) ^{137}Cs - ^{137m}Ba generator set allows the chemical separation of ^{137m}Ba from ^{137}Cs.

5) The 10 ml beaker is used to position and hold the ^{137m}Ba source for the half-life determination experiment.

6) The computer with radiation counting software is used to control the operation of the counting system and record the results of counting measurements.

4. Requirements.

a. In the laboratory.

1) Determine the background count rate.

a) Place the holder of the counting stand at the highest position that will accommodate the 10 ml beaker under the detector.

b) With the empty beaker in this position, perform a five minute count of the background.

c) Calculate the background count rate in units of counts per minute.

2) Make measurements to allow determination the half-life of ^{137m}Ba.

a) With your instructor's assistance set up the counting system to provide eleven successive one minute counts.

b) Insure that the counting stand geometry is the same as was used for the background determination.

c) Take your 10 ml beaker to your instructor and obtain a sample of ^{137m}Ba. Your instructor will elute a liquid sample for you and place it in your beaker. The liquid sample is radioactive. Handle it carefully. Do not spill or drip the liquid. The ^{137m}Ba sample decays rapidly so get to work quickly when you receive your sample.

d) Place the beaker under the Geiger-Mueller tube and start the counting process. Record the counts detected in each one-minute interval in the table provide in Annex A.

e) Upon completing of your counting experiment, return the beaker with sample to your instructor.

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 laboratory.

Para 3. Apparatus and experimental procedures. Provide a diagram of the experimental set up.

Para 4. Data. Provide the following in a spreadsheet:

1) The data from your background count, and calculation of the background count rate in counts per minute.

2) A table of your decay experiment data that includes a column for:

a) the time at which each count was taken (set the time of the first count at 0 minutes),

b) the count rate recorded (source plus background) per minute,

c) the count rate for the source only, and

d) the natural logarithm of the source count rate.

3) A graph of the natural logarithm of the source count rate versus time of count. Include a regression line.

4) The half-life.

5) The percent discrepancy between the measured and accepted values of the half-life. The accepted value of the half-life of ^{137m}Ba is 2.552 minutes.

Para. 5. Results and conclusions.

a. Results.

1) Provide a statement of the value of the half-life of ^{137m}Ba.

2) Provide a statement of the percent discrepancy in the measured value of the half-life of ^{137m}Ba.

b. Conclusions.

1) List sources of random error in the experiment.

2) List sources of systematic error in the experiment.

Annex A
Data

1. Background measurement.

Background counts in 5 minutes: ______________________

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2. Decay data for ^{137m}Ba.

time of start of count (min)	counts in 1 min
0	
1	
2	
3	
4	
5	
6	
7	
8	

9	
10	

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