Experiment: Radiation

OBJECTIVES

- Measure the intensity of the transmitted beta radiation through cardboard layers
- Find the half-distance for cardboard (the thickness of the cardboard layer that cuts the intensity of the transmitted radiation in half)
- Measure the intensity (in events/min) of a radioactive (beta) source at different distances from the source
- To measure the background radiation

MATERIALS

- Radioactive source (β and γ)
- Radiation detector
- Cardboard sheets
- Vernier software
- Ruler

INTRODUCTION

Radioactive elements can emit particles or energy during nuclear reactions. These reactions result in more stable daughter nuclei. The decay process is random, governed by the probability of decay, and follows an exponential law.

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

Where

N=number of nuclei at moment t

N_o=initial number of nuclei

λ= decay constant (inverse of decay probability)

The time elapsed for the number of nuclei to become half of the initial number is called half-life ($t_{1/2}$)

The intensity of the radiation reduces when the beam travels through matter (due to the interaction of the emitted particles with atoms of the substance). The intensity of the transmitted radiation decreases with the thickness of the material it passes through. The intensity of radiation can be expressed in number of decays/time (or events/time) as measured using radiation detectors.

The measured intensity depends on the distance of the detector from the source. Assuming that the source emits evenly in all directions (isotropically), the number of particles entering the window of a radiation monitor will decrease with the distance from the source.

Also note, the Earth is constantly bombarded by the cosmic radiation. Some of this radiation is absorbed in the upper layers of the atmosphere (ozone layer), but part of it reaches the surface of the Earth. This naturally occurring radiation is called background radiation.

PRELIMINARY QUESTIONS

1. As the distance between a radioactive source and a detector increases, how would you expect the intensity to change? Sketch a predicted graph for Intensity vs distance

2. As more sheets of Aluminum are placed between the source and the detector (for a constant distance), how would you expect the intensity to change? Sketch a predicted graph (Intensity) vs. (Number of sheets)

PART I : BACKGROUND RADIATION

1. Place the detector on the table. Turn the detector on the " On" position and select the lower amplification scale (X1)
2. Connect the Radiaton Monitor to the LabPro interface
3. Start up LoggerPro and the experiment "File/Experiments/Probes and Sensors/Radiation Monitor/Counts Shielding"
4. Without any radioactive source nearby, collect readings 20 seconds. The radiation count will be displayed in the window at the bottom of your screen. Record the reading below:

Background radiation=**__________________________________**

PART II: SHIELDING

You will study how aluminum can shield the beta radiation emitted by your Cesium source. The source also generates gamma radiation, but only the beta radiation will be measured with this set-up. The intensity is measured in counts over a 20-second period.

Using the periodic table, write the equation for the beta decay of Cs-137:

PROCEDURE

1. Place the radioactive source at roughly 10 cm from the monitor, facing the monitor window.
2. Click "Collect". After 20 seconds, the window will display the Radiation Count. Click "Keep" and enter the number of Cardboard layers (zero for the first run) then click "Collect".

3. A new dialogue box will appear, prompting you to adjust your set-up. Place 1 cardboard layer in front of the window, then click “Continue”. The computer will collect data for another 20 seconds.

4. Repeat the steps 2 & 3 above for 2, 4, 6, 8, and 10 sheets.

ANALYSIS:

1. How did the intensity of radiation change with the number of Al sheets?

2. Was your graph linear? What kind of function do you think will best fit your data?

3. Check your prediction by trying different curve fit equations (Analyze/Curve fit). Which one best matched your data?

4. Print out the graph with the best fit equation

5. From your graph, estimate the distance (expressed in numbers of cardboard sheets) that would shield half of the incident beta radiation

Half distance = _______________

6. If a certain quantity decreases exponentially, then its natural log should display a linear decrease. Create a “New Calculated Column” to calculate the natural log of the radiation counts.

7. Create a graph of the natural log of the radiation count vs. # of Cardboard layers.

8. What is the shape of this new graph?

9. Using the fit equation of the new graph, find a way to calculate the half-distance. Enter your result below and compare it to the estimated value in step 5.

Half distance = ______________ **% Error = _________________**

PART III: INTENSITY OF RADIATION VS. DISTANCE

PROCEDURE:

1. Place the detector on the table. Turn the detector on the " On" position and select the lower amplification scale (X1)
2. Open a new experiment file: "Counts vs. Distance"
3. Place the radioactive source 60 cm from the detector, facing the detector window.
4. Collect data for 20 seconds. The window will display the Radiation Count. Click "Keep" and enter the distance then click "Collect".
5. A new dialogue box will appear, prompting you to adjust your set-up. Leaving the source in place, place the detector 50 cm from the source, then click "Continue".
6. Repeat the steps 4-5 above for 40, 35, 30, 25, 20, 15 and 10 cm

ANALYSIS:

1. How did the intensity of radiation change with the distance?
2. Was your graph linear? What kind of function do you think will best fit your data?
3. Check your prediction by trying different curve fit equations. Which one best matched your data?
4. Print out the graph with the best fit equation