Lab E3: ***The Number of Atoms in a Radioactive Source***

4/7/03

Prelab:

Read Walker 32(3). Read the entire lab carefully as you may only have 10 minutes to collect the data.

Introduction:

In the previous radioactivity labs, you investigated some of the basic properties of radioactivity and the effects of shielding on α, β and γ sources. In this lab, you will determine the number of atoms in a particular radioactive source.

In this lab, it is preferable to use a gamma (γ) source, because gamma rays are least stopped by matter intervening between the source and the Geiger counter. In any event, record the radioactive isotope and the decay equation. Half-life can be found in the text or at www2.bnl.gov/ton/

Make sure that every number (meaning data value) in your lab write-up is preceded by an appropriate label/symbol and an equal sign!

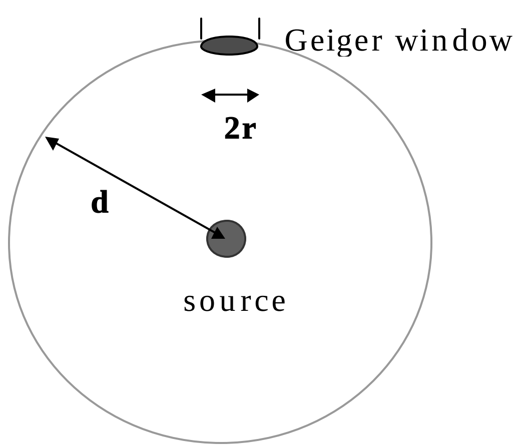
Data Collection and Analysis:

1) Carefully invert your Geiger counter and examine the window. You will see a square screened area that is covering the window to the Geiger counter. Peer through the screen at the window; the window is a very thin disk of material a couple of millimeters beyond the screen.

Measure and record the diameter and radius of the circular window. Remember that this window is very fragile; do not try to touch it or get anything close to it!

2) Next, a geometry problem. It should be clear that the Geiger counter is detecting only a fraction of the decays that are actually occurring. Assume that the radioactive source is emitting isotropically, i.e., equally in all directions.

Determine the fraction of emitted particles that enter the Geiger counter, in terms of the radius, ***r***, of the detector window and the distance, ***d***, between the detector window and the source (symbols only, no actual data!). Include a labeled picture (showing the radius of the detector and the separation of the counter and source) in your step-by-step explanation. Hint: While your labeled picture is 2-dimensional, you will have to think in 3 dimensions to derive the proper expression.



3) Adjust the separation of the source and the Geiger counter so that the latter records a significant count rate (at least 25 cps). Measure accurately and record the separation of the source and counter detecting area. If the separation distance is not at least 5cm, GET ANOTHER SOURCE (one with a higher activity).

4) Calculate the fraction of the particles emitted from the source that enter the Geiger counter.

Why is it important that the detector be at least 5 cm from the source?

5) Determine the average number of counts detected per second for a 2-minute period. You have used the Geiger counter in a number of different measuring modes in the previous labs. Decide what measuring mode is most appropriate for determining the most accurate value for the average count rate. Describe the measuring mode that you used, and show how you determined the average number of counts per second over a 5-minute period from your measurements.

6) Not every gamma ray that enters the Geiger counter will be detected by the counter. Explain this fact, using your knowledge of the properties of gamma rays and how a Geiger counter works. A typical Geiger counter only detects about 1% of the gamma rays that enter it. This percentage is called the efficiency of the detector. Assuming that the efficiency of your Geiger counter is 1%, determine the number of gamma rays per second that actually entered your detector.

7) Now correct your count rate in the previous part by the appropriate geometric factor (part 4) in order to determine the total number of nuclei decaying per second in your source.

8) Use this decay rate and the known half-life of your source nuclei to determine the number of radioactive nuclei in your source.

9) Determine how many decaying nuclei will be present in your source exactly one year from the time your measurement was made in part 5.

10) Determine the decay rate of the source one year from the time your measurement was made in part 5.

Conclusion/summary