

Lab N02: Radioactive Decay

My name _____ partner _____ block _____

Equipment and Cautions:

- In this lab, you'll be using a Radiation Monitor and LabPro interface attached to a computer. This allows the computer to count radioactive emissions that are detected in a Geiger-Mueller tube inside the Radiation Monitor. **In using the Radiation Monitor, be careful not to touch or bring anything close to the thin window on the top of the Monitor (this will be the bottom of your upside-down Monitor).** This window is very delicate. If broken, the tube will not function. The metal screen in front of the window will protect it somewhat, but beware of thin, pointed objects that could pierce the screen; also, never leave the Radiation Monitor with the screen side facing upward, since foreign objects could fall behind the screen and damage the equipment.
- The radioactive sources that you will be using are not active enough to be harmful. The beta and gamma sources are completely enclosed in plastic disks so that there is no danger of contacting or ingesting the radioactive materials. The alpha sources (and the alpha/gamma source ^{241}Am), while surrounded by plastic, are *not* covered and must only be handled by the plastic. **Whenever you finish with a radioactive source, place it back in the labelled box of sources.**

To get started.....plug the jack of the Radiation Monitor into the DIG/SONIC 1 port of the LabPro interface box. Notice the two switches on the Monitor. Set one of them to "x1"; set the other one to ON (or to AUDIO). Place a beta (or gamma) source near the Geiger tube (i.e. near the metal screen). You should notice that a red light on the Radiation Monitor is flashing. If you set the switch to AUDIO, you should hear clicks coming from the monitor. The needle on the Monitor should move to the right. These indicate that the tube is detecting radioactive emissions. In order to get the computer to count and time these emissions,

- Select Start, Programs, Vernier Software, Logger Pro 2.0. If you get a scan message, click Scan, then OK.
- Then go to Files, Open and navigate to the Probes and Sensors, then Radiation Monitor directories. Open the file "Count vs. time."
- Next go to Setup, data collection, then hit the sampling tab. Change the experiment time length to 20 seconds, and the count interval to 1 second. When you have finished click okay.

Part A: Effects of Source/Detector Positioning and Background Radiation

1. Place a source underneath the Geiger tube. Press the Collect button and observe the counts collected in each 1 second interval for a total of 20 seconds. Notice the location of the "window" on the end of the Geiger tube. What could you do with the source/detector combination to make a significant change in the count rate? Explain. Make the necessary adjustments to get the highest count rate you can (at least 50/second).

Once you have an acceptable count rate, mark the location of your source as follows: make sure there is at least $\frac{1}{2}$ cm of space between the source and detector (use a set of cardstock spacers to check this). Put a blank piece of scrap paper on the base of your ring stand and tape it, so that the paper is flat and will not move. Center the source as accurately as you can directly underneath the detector window. Trace the outline of your source on the paper, using a pen. In the remainder of the lab, do not move the detector, and make sure the source is always at the same location whenever you take data.

Record the average count rate (averaged over 20 seconds) with your source at this location. Use the STATISTICS option under ANALYSIS to find the median counts and the standard deviation of the count rate.

Count rate is _____/sec +/- _____/sec

2. Without moving the source or detector from their positions in number 1, change the interval time to 10 seconds, and repeat the data collection of the source in #1.

Count rate is _____/10sec +/- _____/10sec

Do you observe more or less variation in the counts per interval (think percentage here)? Why? Explain.

3. Now remove the source from under the Geiger tube. Make sure all radioactive sources are far away. Collect another sample the same way you did above in number 2, except for a longer total time. You have measured what is called the background rate. Record the average value for the background rate.

Background count rate is _____/10sec +/- _____/10sec

Why are counts registered even when the sources are removed? Are there other sources of radioactivity in the room? What might they be (give specific examples) ?

Part B: Effects of Intervening Objects on the Detection Rate of α , β , and γ rays

4. In the following section, follow the instructions for one alpha, one beta and one gamma source. You will only need one source at a time. Place a source under the Geiger counter. Make sure that a count rate significantly higher (at least 10 times higher) than the background is obtained; if not, use a different source. For an alpha source, make sure that the side of the source with the open hole is facing the Geiger counter. For a beta or gamma source, compare the count rates with different sides of the source facing the detector; use the side that gives a higher count rate.

Measure the count rate for your source over a 10 second interval. Next, use the materials indicated in the chart shown to try to "block" the radiation from the source. In other words, put a piece of the indicated material between the source of the radiation and the radiation detector. In the box that corresponds to the source and material being tested record how many counts/10sec you got and what fraction of the total that is. This is the % of transmission as shown below.

$$\% \text{ of transmission} = \frac{(\text{recorded counts with intervening material} - \text{background})}{(\text{recorded counts with no intervening material} - \text{background})} \times 100\%$$

	Alpha source		Beta source		Gamma Source	
	Number of Counts/()	Transmission (%)	Number of Counts/()	Transmission (%)	Number of Counts/()	Transmission (%)
Background (no source near detector)	+/-	N/A	+/-	N/A	+/-	N/A
Nothing (no material between source and detector)	+/-	N/A	+/-	N/A	+/-	N/A
1 sheet of Paper	+/-		+/-		+/-	
N sheets of paper (equal in thickness to a White Plastic)	+/-		+/-		+/-	
1 sheet of White Plastic	+/-		+/-		+/-	
4 sheets of Aluminum	+/-		+/-		+/-	
4 sheets of Copper	+/-		+/-		+/-	
1 sheet of Thick Lead	+/-		+/-		+/-	

5. How many sheets of paper, copper, lead, etc. does it take to fully block your gamma source? Describe your investigation of this and your results.

Analysis Questions (to be answered on separate paper)

6. Why were you instructed in step 3 to make sure all other sources were far from the tube? To what type of source does this instruction particularly apply (alpha, beta or gamma)?
7. Explain why the alpha source is not completely enclosed in plastic as are the beta and gamma sources.
8. Explain why the α 's are the least penetrating rays and why the γ 's are the most penetrating rays; Refer to specific properties of the individual rays and specific basic physics laws to do this. There are at least two separate reasons why alphas are the least penetrating radiation and gammas are the most penetrating.
9. Give two reasons (again using basic physics laws to support your reasons) that the lead sheet you used for shielding was more effective shielding than the copper sheet. (HINT: Why do these rays interact with matter?)
10. An important lesson from this lab has to do with radiation protection. List at least three factors (other than shielding and distance from source to you) that influence the total amount of radiation one's body might encounter from a radioactive source (i.e., the total number of decay particles that hit your body). Explain why each of the factors influences the amount of radiation you receive.