

ALPHA, BETA AND GAMMA RADIATION LAB

Nuclear radiation can be broadly classified into three categories. These three categories are labeled with the first three letters of the Greek alphabet: α (alpha), β (beta) and γ (gamma). Alpha radiation consists of a stream of fast-moving helium nuclei (two protons and two neutrons). As such, an alpha particle is relatively heavy and carries two positive electrical charges. Beta radiation consists of fast-moving electrons or positrons (an antimatter electron).

A beta particle is much lighter than an alpha, and carries one unit of charge. Gamma radiation consists of photons, which have no mass and carry no charge. X-rays are also photons, but carry less energy than gammas.

After being emitted from a decaying nucleus, the alpha, beta or gamma radiation may pass through matter, or it may be absorbed by the matter. You will arrange for the three classes of radiation to pass through nothing but a thin layer of air, a sheet of paper, and an aluminum sheet. Will the different types of radiation be absorbed differently by the air, paper and aluminum? The question can be answered by considering which radiation type will interact more strongly with matter, and then tested by experiment. In this experiment you will use a small sources of alpha, beta, and gamma radiation. *Follow all local procedures for handling radioactive materials.*

OBJECTIVES:

Develop a model for the relative absorption of alpha, beta, and gamma radiation by matter.

Use a radiation counter to measure the absorption of alpha, beta, and gamma radiation by various materials

Analyze count rate data to test for consistency with your model.

MATERIALS:

Windows PC, LabPro Lab Interface

Polonium-210 0.1 μ C alpha source

Strontium-90 0.1 μ C beta source

Logger *Pro* Vernier Radiation Monitor


Cobalt-60 1 μ C gamma source, paper, cardboard, aluminum (Al) sheet-about 2 mm thick, and lead (Pb) sheet-about 2 mm thick


PRELIMINARY QUESTIONS:

1. Most nuclear radiation carries energy in the range of a few million electron volts, or MeV ($1 \text{ MeV} = 10^6 \text{ eV} = 1.6 \times 10^{-13} \text{ J}$), regardless of its type (alpha, beta, or gamma). This means that more massive particles generally travel more slowly than light particles. Make a preliminary guess as to which radiation type will in general interact most strongly with matter, and therefore would be most strongly absorbed as it passes through matter. Consider electrical charge, mass and speed. Explain your reasons.
2. Which radiation type do you predict would interact, in general, least strongly with matter, and so be less absorbed than others? Why?
3. Which radiation type do you predict would have an intermediate level of interaction with matter? Why?
4. You will be using paper and aluminum sheet metal as absorbers for the radiation. Which material has the greatest area density (that is, a density per unit area, which could be measured in g/cm²), and so would present more matter to the passing radiation? Which material would have less?
5. Is your radiation monitor sensitive to all three types of radiation? How can you tell? Devise a test and carry it out. If your radiation monitor does not detect one form of radiation, then you will be able to compare the absorption of the remaining two types.

PROCEDURE:

1. Connect the radiation monitor to DIG/SONIC 1 of the LabPro Interface.
2. Prepare the computer for data collection by opening "Exp 01 Alpha Beta Gamma" from the *Nuclear Radiation w Computers* experiment files of Logger *Pro*. One Meter Window and one data table are displayed. They will show the number of counts detected in one 50-second count interval.
3. Place the source near the metal screen on the Counter, and when using an absorber, place the absorber between the source and the screen. Use the same position for the sources each time, with or without an absorber. The sources are in small plastic discs, with the most radiation emitted from the bottom of the disc or opening (alpha)towards the screen.

Begin with no source, to determine the background count rate. Move all sources away from the monitor. Click  or return on computer to begin collecting data. Record the number of counts with no source. (*Check Set Up to make sure you have the correct connection, DIG/SONIC 1 or DIG/SONIC 2, to the LabPro if you appear not to be able to collect data.*)

- Using no shielding, place the alpha source near the appropriate region of your radiation monitor, with the underside of the disc facing the monitor. Click  to begin collecting data. Wait for Logger Pro to complete data collection. Record the number of counts in the alpha row of the data table, no shielding.
- Place a single sheet of paper between the alpha source and the monitor, and measure the counts as before. Take care to keep the source in the same position with respect to the radiation monitor. Record the count rate.
- In a similar manner, record the counts for the following used as absorbers for each of the three sources:
 - a single sheet of paper
 - a single sheet of cardboard
 - a single sheet of aluminum
 - a single sheet of lead

DATA TABLE:

Counts in 50-s interval					
	no shielding	shielding			
source		paper	cardboard	Al sheet	Pb sheet
none					
alpha					
beta					
gamma					

NUCLEAR LAB QUESTIONS:

- What is background radiation?
- Compare the no-source, or background, count with the no shielding counts for the sources. Is the background count number a significant fraction of the counts from the sources? Do you need to consider a correction for the background counts?
- Inspect your data. Does the count rate appear to follow your initial guesses for the relative absorption of the various types of radiation by matter? Be specific, considering which source should be the most penetrating (least interacting), and which shielding is more difficult to penetrate.
- Nuclear Equations: Complete the following:

Emission	Actual Lab Source	Write the Nuclear Equation for this Emission
Alpha (α)		
Beta (β)		
Gamma (γ)		

- X-rays are photons, just like gamma rays. X-rays carry lower energy, however, and so historically received a different name. If you have had an X-ray film picture of your teeth taken by a dentist, the dentist probably placed a lead-lined apron on your chest and lap before making the X-ray. What is the function of the lead apron? Support your response directly from your own experimental data.
- Based on your data identify which type of emission was specific to the following sources (*if available*):

object	Emission Type, α, β or γ
smoke detector	
marble	
ore of uranium	
Submarine gauge	
lantern mantle	

- Identify the California Content Standard in Chemistry that specifically addresses this laboratory activity.

EXTENSION:

- If you were presented with a safe, but unknown, radiation source, and assuming that it emitted only one type of radiation, devise a test that would allow you to tentatively identify the type of radiation as primarily alpha, beta, or gamma. Write instructions for another student to follow in performing the test.
- Your monitor detected some radiation even without a source present. Devise a method to correct for this background radiation. Do the corrected data still agree with your prediction?