Health Physics Society
Specialists in Radiation Safety

Investigating Properties of Radiation
What Can Absorb Radiation?

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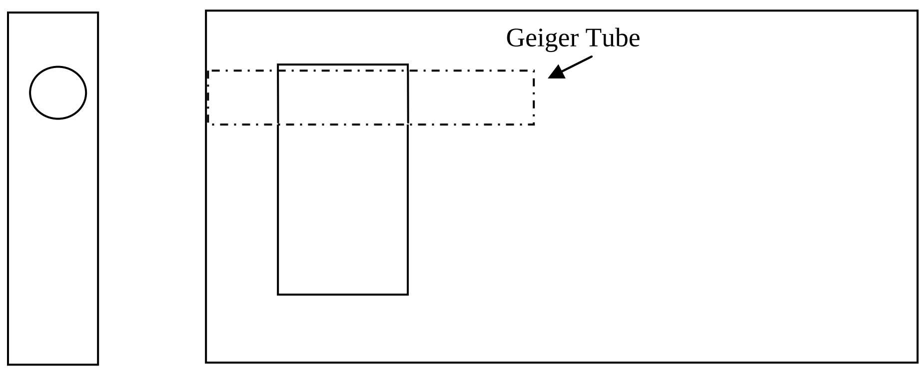
Radiation is present in everyday life; this is called background radiation. It comes from the rocks and soil in the earth, from outer space as cosmic radiation, and from radioactive materials in our own bodies. The dose received from these radiations is small and safe. However, other sources of radiation, either human-produced or natural, may produce radiation levels that are harmful. Your job is to determine some properties of radiation and what kind of materials and what thicknesses best stop different kinds of radiation. Note: all the radiation sources used in this experiment are safe to handle. However, because it is best to avoid any unnecessary radiation, do not put these sources in a pocket.

Your teacher will explain how to turn on the detector and explain the function of the switches. The actual detection of radiation takes place in a sealed Geiger tube that is located inside the detector. This tube is cylindrical in shape, with one end appearing at the end of the detector. This exposed end has a thin cover with a screen to protect it. DO NOT POKE ANYTHING (like a pencil tip) THROUGH THE SCREEN; breaking the thin cover will ruin the detector (and maybe your grade!).



You will have a radiation detector and various materials to use. To proceed with your quest:

1. Experiment with the detector and the different radioactive sources to determine what arrangement will detect the different kinds of radiation and produce the maximum number of counts on the detector.

2. Determine what happens to the radiation detected by the detector as you change distances between the source and detector.

3. Once you have made these determinations, devise an experiment to measure the thickness of some material (this can be in numbers of pieces of paper, cardboard, or aluminum) that will totally stop each kind of radiation. Remember that the detector will always detect background radiation. Discuss your plans with your teacher before proceeding to take data. Record your data on the Data Sheet.

Explanations of observations

1. Write a summary of what you found when you experimented with the detector and sources. Be specific about each kind of radiation. What happened to the count rate as you moved the detector away from the source? Can you offer an explanation for what you observed?

2. For each kind of radiation, list what materials are needed to stop the radiation and list the number of pieces for each. Also discuss the ability of the absorbers to stop ALL the radiation.

Alpha:

Beta:

Gamma:

Data Sheet

Alpha:

Absorber material: ______________

Number of absorbers	Counts per minute
1	
2	
3	
4	

Beta:

Absorber material: ______________

Number of absorbers	Counts per minute
1	
2	
3	
4	
5	
6	
7	

Gamma:

Absorber material: ______________

Number of absorbers	Counts per minute
1	
2	
3	
4	
5	
6	
7	

Teacher Notes

Materials: This activity requires three sources: alpha (^{210}Po), beta (^{204}Tl), and gamma (^{137}Cs). The alpha source has a half-life of 138 days, so you need to order a new source each year; preferably a month or so before the laboratory exercise. The ^{204}Tl source has a half life of 3.78 years, so it will last several (about 5) years; get a 10 μCi source. The ^{137}Cs source (which also will emit some beta radiation) has a half-life of 30 years, so it will last a career; get a 10 μCi source.

This experiment also requires a detector that can detect alpha particles (e.g., Vernier). Unfortunately, a civil defense meter will not work for alpha radiation. However, it will work for beta and gamma, as long as the beta shield is open for the beta experiment. Other items needed are paper, pieces of cardboard, thin aluminum pieces, and thick pieces of aluminum or steel. The thin aluminum should be about 1/32 inches thick; check a local home center for this. The thick aluminum or steel can be made by students in metal shop; just cut squares (about 2 inches on a side) of ½-inch aluminum or steel. About 6 are needed for this experiment.

Teacher's instructions: This experiment is an inquiry-based activity. Therefore, you will need to guide the students to find an acceptable solution.

The students should work in groups of three to six so they can discuss ideas with others and, as a group, formulate what they want to do. Therefore, you will need several sets of sources. However, one alpha source could be sufficient for the class if they share it.

As a safety measure, you may want to assign one student in each group to be the "radiation safety officer (RSO)." The RSO will be responsible for the sources to assure all sources are returned at the end of class.

1. Detector arrangements:

Alpha: The students should find that the only way to detect alpha particles is to put the sensitive area of the detector (the open area with the screen) very close to the source. The alphas do not penetrate the side of the detector and are absorbed by 1 cm of air, so the only way to detect them is with the source very close to the end of the detector. They should also find that if they very slowly pull the detector away from the source, the count rate will decrease a little, then at about 1 cm drop off to zero quickly.

Beta: Because beta particles can penetrate more than alphas, the students should find that they can detect them with the detector just close to the source; some will pass through the side of the detector. However, if the end of the detector is facing the source, this gives a maximum count rate.

Gamma: Gamma rays have the maximum penetration of all the radiation types, so the detector will detect gammas in any configuration. Placing the detector facing the source will give the maximum count rate, but not significantly higher than if the source faces the side.

2. Number of absorbers:

For the beta and gamma exercises, the distance between the source and detector must be kept constant; as the students should have noted, increasing the distance will decrease the count rate independent of the absorption.

<u>Alpha:</u> One piece of paper will do the job. The students should put the detector screen on the alpha source and then slip a piece of paper between the detector and source. The count rate will drop to background.

<u>Beta:</u> This will require several (about 4 to 6, depending on the cardboard thickness) pieces of cardboard or two or three pieces of aluminum. You can have the students examine one or the other, or both. The count rate will decrease gradually with each added piece of cardboard or aluminum until it gets to the background rate. The actual number may be hard to determine exactly, but the students just need to realize that it takes more material to absorb betas than alphas.

<u>Gamma:</u> Gamma radiation is very penetrating and its absorption is exponential in nature, so no absorber thickness actually absorbs all the gamma radiation. However, several pieces of thick aluminum or steel will reduce the count rate noticeably (half the gamma radiation will be stopped by about 2 inches of aluminum or by slightly less than an inch of steel).