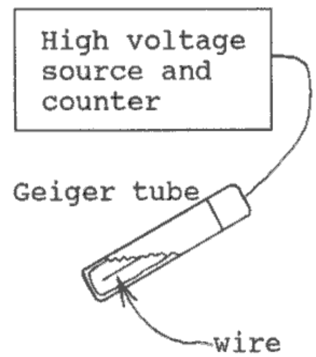
Experiment13: Radioactivity

OBJECT: To study radioactivity, measuring background radiation, looking at radiation shielding and performing radioactive dating.

We detect radiation with a Geiger tube. In the center of the tube is a wire charged to a high electric potential. An alpha, beta, or gamma ray entering the tube can break apart atoms of gas or atoms in the walls of the tube, into free electrons and ions. The electrons rush toward the charged wire, ionizing more gas atoms on the way by hitting them, so that an avalanche of electrons crashes into the wire. The electrical pulse produced is counted by an electronic device, a computer in our case. The number of pulses registered in some time interval measures the amount of radiation entering the Geiger tube.



CAUTION: The radiation sources used in parts 2 and 3 are weak enough to handle without special precautions, but avoid unnecessary contact. Don't play with them. Don't put them in your pocket.

Setup:

1. Mount the Geiger-Muller Counter on a ring stand, with the bottom of the tube about one centimeter above the table. Do NOT remove the cap from the end of the tube or you will expose a delicate, easily broken part.

2. Plug the counter into channel 1 of the interface. Connect the interface to the computer and turn them both on. Open PASCO Capstone. (Traditional Geiger counters click every time they register ionizing radiation. This one makes an annoying beep instead. The only way to stop it is to pull the plug out of channel 1 when not in use.)

3. Click Hardware Setup at the upper left. Click channel 1 on the picture of the interface. Click Geiger Counter on the menu. Click Hardware Setup again to get that out of the way.

4. Double click "Digits" about halfway down on the right. Click <Select measurement> at the upper left. Click Geiger Counts (counts/ sample).

5. It probably says 1.0 Hz at the bottom of the screen. With the down arrow, change it to 1.00 min.

Part 1. Background radiation.

With no radioactive disk nearby, click Record near the bottom left. Nothing will appear for a minute, then it will show the number of pulses it counted. Write it down and leave the counter running. At 2.00 minutes, it will display the number it counted during the second minute. Record that and also the number of pulses during the third minute. Click Stop. Average.

The efficiency of a Geiger tube varies for different kinds of radiation. It can be as low as 1% . Your body is thick and dense enough to absorb a much higher percentage. Also, you are quite a bit larger than the tube. Multiply the average number of counts per minute by 100 to compensate for the 1% efficiency. Multiply by 100 again because your cross sectional area is roughly 100 times the tube's. You now have a crude estimate of the number of times per minute that natural radiation, from radioisotopes in the environment and cosmic rays, interacts with your body. (This does not include the many muons and neutrinos which pass right through you; just rays which are actually causing ionization.) Kinda scary, isn't it?

Part 2. Penetration and shielding.

1. Obtain a beta ray source (Sr-90 in a green disk) and place it below the detector. If one is not available, go on to step 5 or to part three, and someone will be done with one soon.

2. Temporarily change from 1 minute to 10 seconds at the bottom of the screen. Make short data runs to see if you get a stronger signal from the disk when the side with writing on it is up or down. (They aren't all the same.) Use it the way that gives a stronger signal.

3. Make four 30 s runs. Add and divide by 2 to get average counts per minute.

Notice that the decay rate goes up and down at random. The shorter the time interval, the more significant the variation is. This is why you need to collect data for a couple of minutes each time, to average this out. Now that you have seen this, just do 2 minute runs and divide by 2.

4. Measure the counting rate with two pieces of lead stacked between the source and detector. Repeat with the same thickness of aluminum, and then cardboard.

5. Replace the beta source with a gamma source (Cobalt-60, orange disk). Do not use one that says "old"; that's for part three. It makes less difference which side of the disk is up. Let's go with writing side on the bottom. Repeat what you did with the beta source.

6. Conclusions:

   a. Compare the penetrating ability of beta to gamma rays. That is, for which kind of rays does a larger fraction of the rays get through a material?

   b. Compare the effectiveness of these three materials in blocking out radiation.

Part 3. Radioactive dating.

You will determine the age of an old Co-60 sample by comparing its activity to the newer one you just measured.

1. Put the old gamma ray source under the tube. Have it the same way you had the other one: Manufacturer's label on the bottom, handwritten paper tag on top.

2. Determine the counts per minute, as before.

3. The half-life of Co-60 is printed on the disk. Calculate the time it would take for the newer sample to decay down to the activity of the older sample. (The samples were not made very precisely; some were more radioactive than others when new. So, which ones you happened to pick up can affect your answer. What you get may differ from other groups by a few years.)

4. The year the newer one was made is printed on it. According to your measurements, in what year was the old one made?

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Part 1. Background radiation.

__________, __________, __________ average = ____________ counts per minute.

Find your exposure:

Part 2. Beta source:

Nothing between ________, ________, ________, ________, average = ________ c.p.m.

Lead: ____________ ÷ 2 = ____________ counts per minute

Aluminum: ____________ ÷ 2 = ____________ counts per minute

Cardboard: ____________ ÷ 2 = ____________ counts per minute

Gamma source:

Nothing between ____________ ÷ 2 = ____________ counts per minute

Lead: ____________ ÷ 2 = ____________ counts per minute

Aluminum: ____________ ÷ 2 = ____________ counts per minute

Cardboard: ____________ ÷ 2 = ____________ counts per minute

Part 3. Older sample: ____________ ÷ 2 = ____________ counts per minute

Calculate what year the older one was made. (Continue on back if necessary):