Physics 111
Experiment # 7
Radioactive Decay

Introduction

There is no simple way to influence the random decays of radioactive nuclei. Heating or cooling, changing the pressure, etc., all have no effect. The rate at which the nuclei decay is determined by the nuclear structure. If we know the number of nuclei present and the rate of decay, we can predict how many nuclei will remain at some future time (at least within some statistical uncertainty).

The number of radioactive decays per second (the ***activity*** of the sample of nuclei) may be plotted as a function of time. As the number of remaining nuclei decrease, so will the activity.

The equation relating the activity to time is

$$\Delta N/\Delta t = (\Delta N/\Delta t)_o \, e^{-\lambda t}$$

A plot of the natural log of the activity versus time will yield the decay constant, λ, or the half-life, $t_{1/2}$. The half-life, the time for the number of remaining nuclei to equal ½ of the original number, equals $0.693/\lambda$. Your job is to determine the half-life of the sample provided.

Procedure

You will receive a drop of radioactive material on a piece of an index card. Place the sample on a holder under the Geiger counter, which will read the number of decays during a time interval which you select. For our experiment, you may set the counters for 10 seconds.

Start the counter. It will count for 10 seconds and read the total number of detected decays for the 10 seconds. Divide by ten and you have approximately the count rate, or number of counts per second, at t = 5 seconds. (*Before you start the actual measurements with the sample, you will need to determine the wait time between successive measurements.*) Repeat this procedure for roughly 5 minutes.

You can now plot the activity versus time and determine the half-life. You can also take natural logs of both sides of the above equation and make an appropriate plot to determine the half-life. Compare the two determinations and comment on which is probably more reliable.

The last thing you will do before you leave the lab is to measure the count rate again and to compare it to the count rate when there is no sample in the holder. This will enable you to

compare the final count rate to that from the "background". You should comment on the comparison.

Note: Your sample comes from a simple device which provides short-lived nuclides suitable for half-life experiments. A solution (0.04 N HCl and 0.9% NaCl) is passed through Cesium-137 to create Barium-137m which has the half life you are measuring. The radioactive barium decays by emitting 662 KeV gamma rays that you count with the Geiger counter.