LAB 13
Radioactivity

OBJECTIVES
(1) Observe alpha, beta and gamma emissions from radioactive nuclei and measure some of their physical properties.
(2) Measure the half-life of a short-lived radioisotope.

EQUIPMENT
Geiger counter, radioactive samples, shielding and “minigenerator” isotope.

PROCEDURE
CAUTION—even the low activity radioactive samples we will use in this lab can be dangerous if handled carelessly or improperly. Pay strict attention to the following special rules and procedures:

- Do not eat, drink, smoke or use cosmetics.
- Wash your hands thoroughly before leaving.
- Report spills or wounds immediately.
- Return all samples to the instructor at the end of lab.

Part 1: Determining the proper operating voltage for your Geiger tube

(1) Insert a radioactive β - source, set the "high voltage" to zero, and turn on the Geiger counter. Push the reset button to clear the display, then push the count button to start counting. Note that since there is no voltage being applied to the Geiger tube, the counter does not detect any activity.

(2) Increase the voltage until the counter begins to count - this is the "threshold voltage" - the minimum voltage at which the Geiger tube will operate.

(3) Repeat this procedure for a second sample to convince yourself that the threshold voltage is essentially the same for alpha, beta or gamma radiation - it depends only on the Geiger tube itself.

(4) For proper operation of the counter (i.e. no missed counts) set the voltage about 75-100 volts higher than threshold voltage.
Part 2: Measure the background radiation activity

(5) Remove all radioactive sources from your table.

(6) Set the time selector to 30 seconds, stop the counter, reset the display, and then push the count button. The counter will now count the "background radiation" for 30 seconds and stop automatically.

(7) Record the activity (# counts / 30 s) and repeat a total of five times.

- Why does the activity seem to vary so much?
- What is the source of this background radiation?

(8) Determine the average background radiation activity from your measurements.

Part 3: Experiment with a radioactive sample

(9) Get one of the sources and answer the following questions:

- What isotope is it?
- What type of radiation does it produce?
- What daughter results from its decay?
- What is its half-life?

(10) Measure the activity three times for 30 seconds and subtract the background from your counts to get the true activity of the sample.

- Do the measurements vary as much or as little as you expect?
- How different would the activity have been, say, three years ago?

(11) Insert an absorbing material between the sample and the Geiger tube and observe the effect on the counting rate. What type and thickness is required to absorb half of the radiation (that is, to cut the count-rate in half)?

(12) Repeat steps 9 – 11 for the other two types of radioactive sources.

- Which type of radiation penetrates the most?
- Which type of radiation is easiest to shield?
- Any ideas why?
Part 4: Measure the half-life of a “minigenerator” isotope

(13) With the instructors help, elute the short half-life isotope from the minigenerator.

(14) Measure the activity of your sample once every minute for 30 seconds at a time. Continue the measurements for 10-12 minutes, or until they become statistically indistinguishable from the background.

(15) Subtract the background from each of your measurements and plot the resulting activity versus time on ordinary graph paper that is provided.

(16) Draw a smooth curve through the data points on your graph.

- Does the curve approximate an exponential decay?
- Estimate the half-life of the isotope (i.e. the time at which the activity falls to half its initial value).
- Compare your results to the accepted value, which the instructor will help you find. If your result is within 3%, you win a prize!
- Does the activity fall to 1/4 its initial value after two half-lives?
- Does it fall to 1/8 its initial value after three half-lives?
- How accurate do you think your half-life measurement is?