Half-Life Measurement

The *activity* (in decays per second) of some radioactive samples varies in time in a particularly simple way. You will use a source called an isogenerator to produce a sample of radioactive barium. The isogenerator contains cesium-137, which decays to barium-137 and emits gamma photons. The barium nucleus is then stable, and does not emit further radiation. The isogenerator allows you to remove a sample of the cesium-barium mixture. It is the activity and lifetime of the Cs-137 you will measure and determine the half-life of Cs-137. The *half-life* of a radioactive species is also used to indicate the rate at which a sample will decay. A half-life is the time it takes for half of a sample to decay. That is equivalent to the time it takes for the activity to drop by one-half.

OBJECTIVES

- Use a radiation counter to measure the decay constant and half-life of cesium-137.
- Determine if the observed time-variation of radiation from a sample of cesium-137 is consistent with simple radioactive decay.

MATERIALS

computer
Vernier computer interface
Logger *Pro*
Vernier Radiation Monitor or
  Student Radiation Monitor
Cesium/Barium-137 Isogenerator
cut-off paper cup for Barium solution

PRELIMINARY QUESTIONS

1. Consider a candy jar, initially filled with 1000 candies. You walk past it once each hour. Since you don't want anyone to notice that you're taking candy, each time you take 10% of the candies remaining in the jar. Sketch a graph of the number of candies for a few hours.
2. How would the graph change if instead of removing 10% of the candies, you removed 20%? Sketch your new graph.

PROCEDURE

1. Connect the radiation monitor to DIG/SONIC 1 of the computer interface. Turn on the monitor.
2. Prepare the computer for data collection by opening the file "03 Lifetime" from the *Nuclear Radiation w Computers* folder of t:drive/neugebauert/experiments file. One graph is displayed: count rate *vs.* time. The vertical axis is scaled from 0 to 1200 counts/interval. The horizontal axis is time scaled from 0 to 30 minutes.
3. Your instructor will extract the cesium-137 radioactive solution into your prepared tin cup. **Work quickly between the time of solution extraction and the start of data collection in step 6, for the barium begins to decay immediately.** Take care not to spill the solution.
4. When your lab partner goes to do step 3 above, click [Collect] to begin collecting data.

5. Hold the radiation monitor above the cup so that the rate of flashing of the red LED is maximized. Please do not have it on audio, just on.

6. Logger *Pro* will begin counting the number of gamma photons that strike the detector during each 30 second count interval. Data collection will continue for 30 minutes or until you observe no change in decay rate (particle emission). **Do not move the detector or the barium cup during data collection – try to hold it steady.**

7. After data collection is complete, the [Collect] button will reappear or you will need to press stop. Set the radiation monitor aside, and dispose of the barium solution by rinsing it down the drain with water (use the sinks on the END of the lab stations) and use soap and water to clean the tin cup.

ANALYSIS

1. Inspect your graph. Does the count rate decrease in time?

2. Compare your graph to the graphs you sketched in the Preliminary Questions. How are they different? How are they similar? Why are they similar?

3. Fit an exponential function to the first fifteen minutes **of your data**. (Do not include the background radiation counts at the very beginning.) Select the "first" fifteen minutes of data, when the solution was in place,with the mouse. Then, click the curve fit button. Select Natural Exponential from the equation list. Notice that the Natural Exponential fit [y=A*exp(–Ct)+B] includes an additive term B. This term will account for the constant background counts due to non-barium sources, then click [Try Fit]. A best-fit curve will be displayed on the graph. If your data follow the exponential relationship, the curve should closely match the data. When you are satisfied with the fit, click [OK]

Save your graph to you My Documents folder by doing a SAVE AS, then print it. When you select print it will ask if you want to use a footer. You do! Put your names on the footer, Chemistry, and class period. Print a copy for you and your partner. You will need it to determine the half-life of Cesium-137.

4. Use your graph to determine the half-life of Cesium-137. What is the half-life? __________

5. What fraction of the initial activity of your barium sample would remain after 25 minutes?

6. Was it a good assumption that the counts in the last five minutes would be due entirely to non-barium sources?

7. If the last several minutes of counts was not due to your barium source (Cs-137), then where is the radiation coming from?

Name ______________________ Class ______________ Date ______________