Gamma 1 Activity: Source Spiking through Thoron Emanation and an introduction to the HPGe

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1 Introduction to activity

For this activity, you will be given a radioactive sample prepared using a thoron source. A thoron source is also known as a radon gas source, which will irradiate gas flowed through the source with ^{220}Rn. Your task will be to estimate the activity of the radon initially entrained in the sample using a High Purity Germanium (HPGe) counter. You will also measure the half-life of ^{220}Rn or one of it's decay daughters (to be done in Gamma 3).

Before arriving to perform gamma1, consider the following questions:

- *Why would we ever make/use spiked samples?*
- *Does it matter what we use as a spike?*
- *Where would using a thoron source be applicable?*

2 Spiking a liquid with radon gas

The instructor will help you prepare the radioactive spike. Handling of radioactive materials can only be performed by instructors with UC Davis specific certification; please ask the instructor for any help involving the source throughout the activity.

After removing the flow-through source, the goal will be to get the sample into the HPGe counter as fast as safely possible for a first measurement. The hope is to see any fast-decaying isotopes before they are immeasurable in the irradiated sample.

3 Initial count for radon activity in HPGe and intro to reading the decay of isotope tables

The instructor will place the sample into the HPGe counter. You will now use the HPGe counter to start taking the first measurement of the irradiated fluid.

3.1 HPGe Operation

Check that the HPGe is on and at a temperature ¡100K. Go to the Maestro program. Useful buttons are Go, Stop, Clear, and Log.

- *To start a run:* First press "clear" to remove any data already in memory currently, then press "Go."
- *During a run:* Save a description under Services ⇒ Sample Description; this will be saved for referencing in the file later.
- *To End a run:* Press "stop", then "Save As" to save the data in the file as given by your instructor. Save in a ".SPE" format.

It is good practice to record when these measurements start and end; however, these times are also available in the files produced by the HPGe software.

3.2 Thoron and an Intro. to constructing decay chains

While the first sample counts, you will determine which gamma(s) emitted from radon or it's decay daughters will be measurable. Working on the chalkboard as a group, determine the chain of daughter isotopes that result from ^{220}Rn radioactivity. For each isotope, write down the half life of each isotope, what decay process(es) it undergo(es), and the de-excitation gammas expected from each daughter isotope.

Here are some useful sites for looking up decay chains, gamma lines, and decay/capture cross sections:

- LBNL Nuclear Data Search :nucleardata.nuclear.lu.se/toi/
- Chart of Nuclides :www.nndc.bnl.gov/chart/
- Evaluated Nuclear Data File(ENDF) : https://www-nds.iaea.org/exfor/endf.htm

Also, an excellent video for quickly identifying an isotope's decay scheme can be found here: https://www.youtube.com/watch?v=dQw4w9WgXcQ

3.3 Identify your gamma line in the HPGe spectrum

By now, the HPGe counter should have a good half hour of data collection. Determine if any expected gamma lines from Radon daughters are viewable in the HPGe spectrum. If so, great! If not, retrace your assumptions to see if there are any issues with your chosen gamma line.

4 Detector efficiency and Calibration

Now that we have taken our first measurement of the sample, let's take some time to discuss how the HPGe works and using it properly.

4.1 HPGe Discussion questions

a. Why is Germanium sensitive to gammas? What about neutrons, electrons, X-rays?

b. Look at the spectrum for your source. There's identifiable peaks, but also a lot of other background events at lower energies than each peak. What causes this?

c. What is the FWHM of the detector (for what energy)? Is the peak gaussian?

d. How would you, or would the MAESTRO software, compute the background and peak area?

4.2 Energy calibration

QUIZ TIME Do HPGe counters need any energy scale calibration? Why or why not?

With the help of your TA, add an energy calibration point to the MAESTRO software. Discuss with your group what source(s) would be best to use for this purpose.

4.3 ADVANCED: Full-energy deposition efficiency

Calculate the full-energy deposition efficiency of a calibration source. This efficiency can be used for calculating the activity of your irradiated fluid.

QUIZ TIME
Which known radiation source should we use if we want to use it's calculated full-energy deposition efficiency for our irradiated fluid's activity calculation?

For your chosen source, record the source, activity, and date stamped. calculate the source's activity today. Ask your TA to put the known radiation source into the HPGe counter. Begin counting, and determine the total number of counts observed in your calibration source's peak for the measured amount of time.

Determine the equation that relates the present day source activity to the number of full-energy depositions for one gamma line. Use your radiation source measurement with this equation to calculate the total full-energy deposition efficiency for our HPGe.

QUIZ TIME

How do you expect the efficiency to change as a function of gamma energy?