Lab 12 Radiation II

Introduction

General Radiation

Radioactive decays follow some curious rules that are a consequence of quantum mechanics. Regardless of when a particular nucleus was created, all nuclei of the same species (Uranium in this experiment) have exactly the same probability of decay. We might expect that the longer a nucleus has been around, the more likely it is to decay, but that is not what is observed. Even though the probability that a given nucleus will decay is fixed, there is no way to predict when it will decay. In this sense the decay process is completely random. Despite this randomness, a collection of many identical and independent nuclei will exhibit certain predictable behaviors, such as a consistent average decay rate when measured over a long time.

There are still variations in the average count rate when measured over a shorter time, however. Suppose we collect data on the number of decays during a five-second interval. We count decays for five seconds, and then another five, and so forth. If the average number of counts during each interval is n, then we will find that the standard deviation of the collection of measurements is on average $n^{1/2}$. The standard deviation is a measure of how far away, on average, a measurement is from the mean value. A histogram of the measurements of the number of decays detected each interval will show the characteristic distribution known as the *Poisson distribution*.

When the average number of decays each interval is small, such as one or two, then the Poisson distribution is not symmetric. An asymmetric distribution means that the most common value is different from the average value. If the average number of decays in each time interval is larger, such as more than twenty, the shape of the Poisson distribution approaches the shape of the Normal, or Gaussian, distribution. The Normal distribution is sometimes called the bell-shaped curve, although there are other distributions that also look like a bell! The Normal distribution is symmetric, with the average value being identical to the most common value.

In this experiment you will collect data from a source that exhibits an essentially constant decay rate. Because the lifetime of the source is so long, the average decay rate will not change during your experiment. The interval-to-interval count rate will vary, however, but in a way consistent with the Poisson distribution.

Your experiment

In this experiment you will be working with an extremely low quality uranium ore a.k.a. Uraninite. All uraninite minerals contain a small amount of radium as a radioactive decay product of uranium. Uraninite also always contains small amounts of the lead isotopes ^{206}Pb and ^{207}Pb, the end products of the decay series of the uranium isotopes ^{238}U and ^{235}U respectively.

The decay starts from ^{238}U and ^{235}U which each have a half life of 4.468 billion years and 703.8 million years respectively, since 235 has such a lower half life most of the remaining radioactivity comes from the 238 isotope.

The radiation you will be observing comes from a number of sources. The diagram below shows the full series of uranium decay which eventually leads to the three lead isotopes in the bottom left.
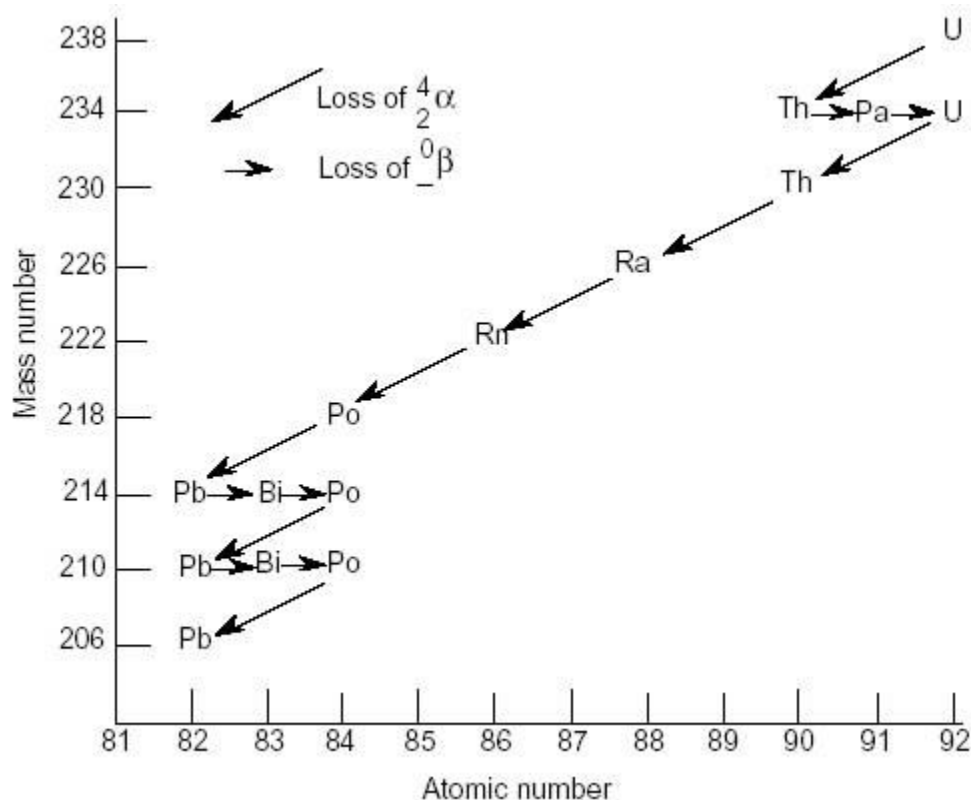
http://www.mhhe.com/physsci/chemistry/chang7/ssg/chap23_3sg.html

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Part I: Counting Statistics Procedure

A. Open the logger pro "Statistics" file.
   Open logger pro then follow **file->open->"Nuclear Radiation with vernier"-> "Statistics"**

B. Again go to the **experiment** tab and open **data collection.** Change the length of the experiment to 10 minutes, and the sample rate to 5/ minute. This should give you 50 total data points.

C. After data collection is complete, click the Counts vs. Time graph to make it active, and then click on the statistics button to calculate statistics for the data. Record the average and standard deviation for part E. Rescale your graph if needed.

D. Print your screen, being sure to include both the graph and histogram by selecting Print from the File menu, or through any method, you will paste this in your lab.

E. List the following: (The earlier steps tell you how to find them)

   Mean value:
   Standard Deviation:

F. The standard deviation is a measure of how far away, on average, a typical measurement (of counts during each interval) is from the average of all the measurements. The interval defined by (average ± one standard deviation) should contain most of the measurements (about 68% of them.

   Now find the mean + and – the standard deviation, this should give you a range from

   [mean-1stddev, mean+1stddev]

   and count the number of values within this range (this doesn't have to be too precise). Take the fraction of this number to the total, 50.

**Part II Questions:**

Question 1.)
The way standard deviation is defined in a very long experiment 68% of values should fall within the first std deviation, 95% within the second, and 99.7% within the third standard deviation as shown below. **Compare the fractional number you found to this rule for the first std deviation.**

Question 2.)
If this data was completely randomized the curve would form a "bell" or normal distribution as shown below in the first figure. In fact if given enough time you would see such a normal distribution from our radioactive material.

However for small samples sometimes the data may skew in one direction or another, giving one of the curves shown in the second figure.

a.) Is your histogram normal, positive skewed, or negative skewed?

b.) What may have caused it to be skewed? (answer this even if yours isn't)

Negative Skew

Positive Skew
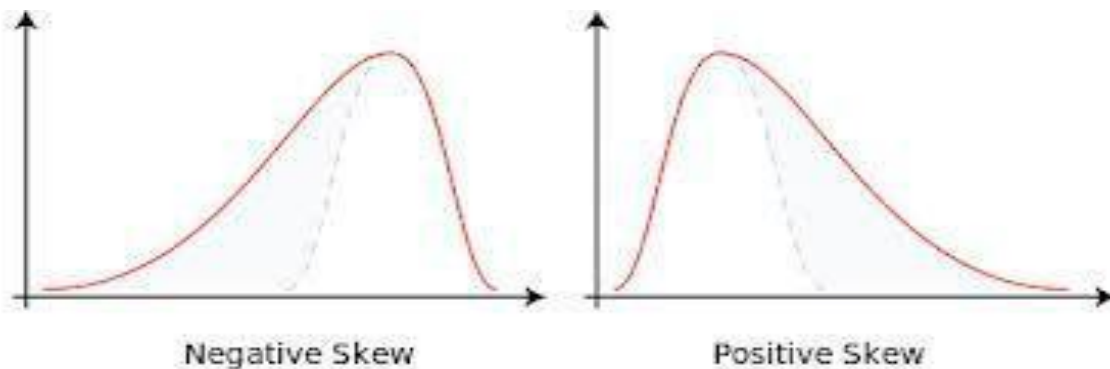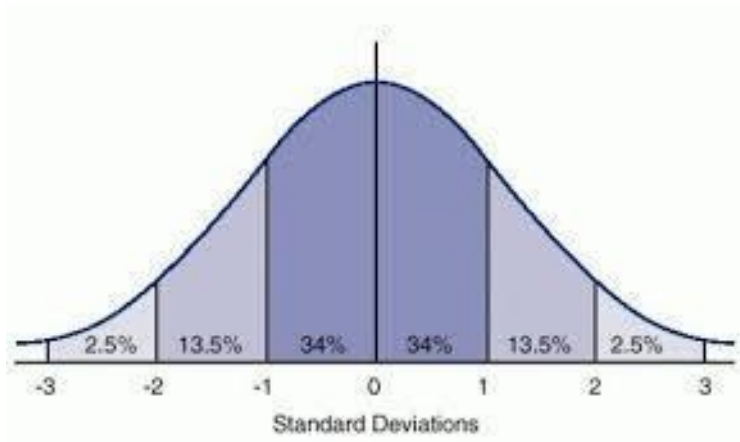
Question 3.)
Right click on your histogram and select histogram options. Go to the second tab and change the bin size, try 1, 2, 5, and 10. How does this affect your histogram? Is the symmetry affected?

At the end of the experiment you should have one image, a mean and standard deviation, and three answered questions recorded in your lab report.