Lab 12

Neutron Activation

What You Need To Know:

The Physics   This lab is a "dry" lab, meaning that all of the data will be given to you. All you have to do is understand what you are doing and crunch the numbers. The reason you do not have to collect data is that this lab deals with radioactivity and it would be too dangerous to do so with the actual materials.

Silver occurs naturally in two stable isotopes: Ag-109 and Ag-107. These isotopes can be made unstable when the nuclei of the isotopes capture slow moving neutrons. This process is called *neutron activation*. When this occurs, the two stable isotopes, Ag-109 and Ag-107, increase their mass number by one (i.e. adding/capturing one neutron). We then have two new isotopes, Ag-110 and Ag-108, which are unstable, or *radioactive*. This means that the isotopes want to *decay* into a more stable isotope. The time it takes for half of the amount of isotopes to decay is called the *half-life*. Each of the radioactive isotopes will decay according to their own half-lives. Your job is to calculate the half-life of each of the two radioactive isotopes. The following two equations will be used in this lab to measure the half-lives for the silver isotopes.

The *activity*, or the number of decays per minute, can be calculated by using the following equation …

$$A = A_o e^{-\lambda t}$$

A is the activity of the sample at time, t (in decays/min.)
A_o is the activity at time, $t = 0$ (in decays/min.)
λ is the decay constant (in 1/sec.)
t is the time (in sec.)

The decay constant can be calculated using the following equation…

$$\lambda = \frac{\ln 2}{T_{1/2}}$$

$T_{1/2}$ is the half-life, in seconds.
λ is the decay constant, in 1/sec.

Log Review   You will be using logarithmic graph paper for this lab. Graphing the data using log paper will allow you to get a linear plot on your graph. This is similar to the "forcing-the-line" method that you've become familiar with in both the 211 lab and the 212 lab. Graphing on log paper will "force" the line for you. In other words, you will not have to make separate calculations for a secondary graph.

There are many different kinds of log paper. One has both of the axes "logged" and the other has only one axis "logged" (semi-log paper). In this lab you will be using semi-log paper. There are also different kinds of semi-log paper. The type of semi-log paper is determined by examining your data. As an example, let's say that you

x	y
1	3
2	9
3	34
4	65
5	89
6	457
7	988

FIGURE 1
Example data

have some arbitrary data for a **y** vs. **x** graph. See **Figure 1**. The **y** data has numbers that are in the *ones*, *tens*, and *hundreds* digits. You would say that the **y** data has three *decades* of numbers and would therefore need 3 *cycle* semi-log paper. See **Figure 2**.

Now you have to define the divisions on the axes. In **Figure 2** you see an example of a piece of 3 cycle semi-log paper. Each cycle on the y axis will have its own decade of numbers. In the case of the example data you will have a ones decade, a tens decade, and a hundreds decade. The numbers for the ones decade would list as 1, 2, 3, … 9, the tens decade would list as 10, 20, 30, … 90, and the hundreds decade would list as 100, 200, 300, … 900. Usually the first digit is printed on the graph paper and you just have to fill in the zeros. You are ready to graph.
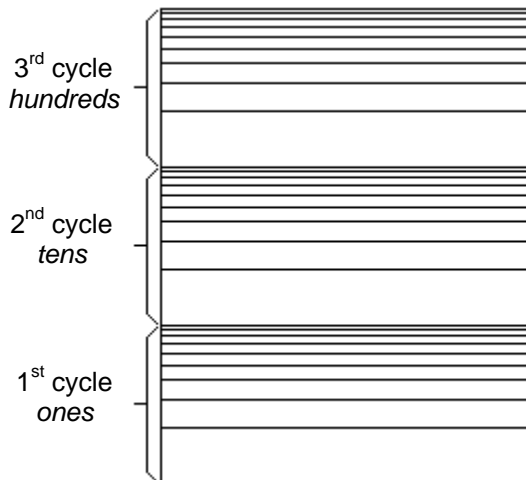
3rd cycle
hundreds

2nd cycle
tens

1st cycle
ones

FIGURE 2 – Semi-Log graph paper

What You Need To Do:

Part 1 - The Data and Graphing The data you'll be using is given in **Chart 1**. Make a copy of the chart including the data in your lab report. The data was collected by measuring the activity for a **mixed** sample of the radioactive isotopes, Ag-110 and Ag-108.

A) Based on the given data for the activity, determine which type of graph paper you need to use. (The Mixed Activity data will be on the log axis.) Collect this graph paper from the front of the lab room.

B) You will be graphing the data as Mixed Activity vs. Time. Set up the divisions on your graph paper accordingly. **NOTE: There are 10 boxes that separate all of the major divisions EXCEPT between 1 and 2 on the log axis where there are 20 boxes.**

Time (sec)	Mixed Activity (decays/min)	Ag-110 Activity (decays/min)
0	5000	
10	4267	
20	3691	
30	3235	
40	2870	
50	2575	
60	2333	
120	1490	
180	1070	-------
240	794	-------
300	594	-------
360	445	-------
420	334	-------
480	250	-------

CHART 1

C) Once you have your axis labeled and you are ready to plot you might want to check with your TA to make sure it is correct, otherwise you might have to do it over.

D) Plot the data.

Part 2 - Analyzing The Graph In examining the graph, you'll notice that there are two distinct parts to it. See **Figure 3**. The reason for this is that the data is a mixture of the activities for both of the isotopes. However, we can separate out the data to measure the half-life for each isotope.
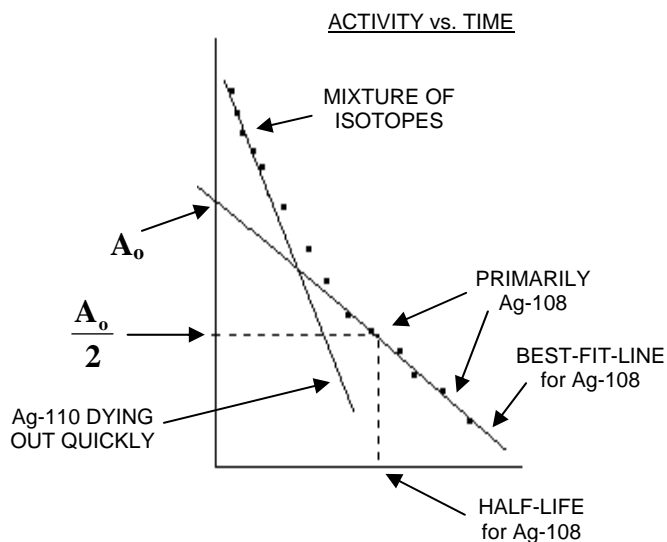

FIGURE 3 – Graph of isotope activity

Ag-110 has a smaller half-life and therefore decays more quickly than Ag-108. See **Figure 3**. The first five or so data points are a mixture of both isotopes. When the time gets up to about 200 seconds, the Ag-110 has pretty much all decayed away. So, the last six data points should be primarily data from the Ag-108 sample.

A) Using only the last six data points, draw a best-fit-line that extends all the way back through the y-axis (t = 0). See **Figure 3**. Read from the graph the value where the line crosses the y-axis. This will be the A_o value for Ag-108.

B) From your graph, find the value of time that corresponds to the activity, $A_o/2$. This time value will be the half-life, $T_{1/2}$, for Ag-108. See the horizontal and vertical dashed lines in **Figure 3**.

Now you need to calculate the half-life for Ag-110. To do this we need to separate out the data for Ag-108 from the mixed data. First you will calculate what the activity would be for Ag-108 by itself. Then you will subtract these values from the first 8 pieces of mixed data. This should leave you with data that is purely for Ag-110. The following will guide you through this.

EQUATION

$$\lambda = \frac{ln2}{T_{1/2}}$$

C) Plug the half-life for Ag-108 that you got from your graph into the decay constant equation and calculate λ. (You can use the equation on the left.)

EQUATION

$$A = A_o e^{-\lambda t}$$

D) Using your λ value, calculate the activity, **A**, (equation on the left) for the Ag-108 sample at the following times: 0, 10, 20, 30, 40, 50, 60, and 120 seconds. Subtract these values from the corresponding mixed activity values from the original data to get the activities of Ag-110 at these times. Show one sample calculation. Put all of your calculated values in the Chart.

E) You are now going to plot another graph using the values from **Part D).** Determine the appropriately cycled semi-log graph paper you need in order to plot this data and get it from the front of the lab room.

F) Plot the activity vs. time for Ag-110. Draw a best-fit-line. Using the procedure in **Parts A** and **B**, find the half-life for Ag-110.

G) Compare, using a percent error, the half-life values you measured to the real values: Ag-108 – 138 seconds, Ag-110 – 24 seconds. If your percent error is greater than 10% then you must go back and find your mistake.

What You Need To Turn in:

Turn in both graphs. Do not use a computer. (This is also an exercise in using log paper.) Turn in all of your calculations as well as the Chart.