Radiation and Life 99.102-801 Laboratory 4: Detector Efficiency, Spring 2008

Name: ____________________

Introduction:

During the third lab, you learned that the Geiger-Mueller counter can be used to measure the number of particles or photons per unit time that a radioactive source is emitting (activity). In this experiment you will learn that a GM counter doesn't actually measure all of the radiation that a particular source emits; that is, it has an *efficiency* of less then 100%. A calculation using the detector's efficiency must be performed to translate measured counts into an actual source activity.

The efficiency of the GM detector is stated as counts per decay (c/d). For example, consider a particular detector with an efficiency of 25%. For every four decays of the radioactive source, the detector only registers one count. If the efficiency is only 1% (not uncommon), then for every 100 decays of the radioactive source, only one count will be registered.

Efficiency (E) is computed by dividing the measured *net* counting rate* in counts per minute (CPM) by the sample's activity in decays per minute (DPM). This will yield a fraction that is less than 1; the detector only counts some of the radiation that is given off by the source.

The counting efficiency of the GM detector depends on several factors, including the type of radiation to be detected. For beta particles, the efficiency can be high (approaching 50% under the right circumstances). That is, the detector actually counts 50% of the beta particles that are emitted by a radioactive source. For alpha particles (which have very short ranges), the counting efficiency depends on how thick the window of the detector is, and may be well below 1%. The thicker the window, the more likely it will be to absorb the alpha particle, thus making it undetectable. This absorption lowers the efficiency. The counting efficiency for gamma rays depends on two factors:

1) the probability that the incident gamma ray interacts in the wall and produces a secondary electron, and
2) the probability that the secondary electron reaches the fill gas before the end of its track.

The energy of the incident radiation will also influence the GM counter's efficiency. This effect will not be investigated.

*Note: the net counting rate is the actual count rate as read on the counter's display minus the background radiation in the room. Recall "Discussion" question 4) from the third lab.

Procedure:

You will count background and the radiation emitted by alpha, beta, and gamma sources.

1) Count background (no source present) for 5 minutes and record the number of counts. Be sure that no sources (especially the gamma source) are near the detector while counting background.

2) Count the radiation emitted by the alpha source (Po-210) for two minutes with the source in the top shelf position. Please note: there are only two alpha sources available for use, so some of the groups will have to wait until an alpha source becomes available to complete this step.

3) Repeat step 2) for three other shelf positions.

4) Count the radiation emitted by the beta source (Sr-90) for two minutes with the source in the top shelf position.

5) Repeat step 4) for three other shelf positions. Ensure that these are the same three shelf positions used in step 3).

6) Count the radiation emitted by the gamma source (Co-60) for two minutes with the source in the top shelf position.

7) Repeat step 6) for three other shelf positions. Ensure that these are the same three shelf positions used in steps 3) and 5).

8) Record each of the three source activities (for alpha, beta, and gamma).

9) Count the alpha source (Po-210) with unknown activity for two minutes in any one of the shelf positions you used in steps 2) and 3), above.

Data:

Perform the following calculations.

1) Background counting rate = background counts / background counting time

2) Gross counting rate = measured counts / counting time (2 minutes for each source count).

3) Net source counting rate = gross counting rate – background counting rate

4) Efficiency = net source counting rate / source activity (you will have to convert the source activities from curies to decays per minute to calculate the efficiencies).

5) Calculate the activity of the alpha source with unknown activity. You will have to use the formula for efficiency in step 4), above, and solve it algebraically for source activity. Once you have done this, plug into the formula the activity you measured for the unknown source and the alpha particle counting efficiency for the tray in which you counted the unknown source.

Ensure that the data you enter in your lab notebook is examined by the TA (and initialed) before you leave.

Discussion:

1) The type of radiation being counted obviously influenced the detector's efficiency. For what type of radiation did the detector have its best efficiency? Did you expect this? Explain.

2) What effect did the distance between the detector's window and the shelf have on the efficiency? Did you expect this? Explain.