NUCLEAR RADIATION

Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**INTRODUCTION**

Nuclear radiation can be broadly classified into three categories. These three categories are labeled with the first three letters of the Greek alphabet:  (alpha),  (beta) and  (gamma). Alpha radiation consists of a stream of fast-moving helium nuclei (two protons and two neutrons). As such, an alpha particle is relatively heavy and carries two positive electrical charges. Beta radiation consists of fast-moving electrons or positrons (an antimatter electron).
A beta particle is much lighter than an alpha, and carries one unit of charge. Gamma radiation consists of photons, which are without mass and carry no charge. X-rays are also photons, but carry less energy than gammas.

After being emitted from a decaying nucleus, the alpha, beta or gamma radiation may pass through matter, or it may be absorbed by the matter. Alpha, beta, gamma, and X-rays can pass through matter, but can also be absorbed or scattered in varying degrees depending on the material and on the type and energy of the radiation. Medical X-ray images are possible because bones absorb X-rays more so than do soft tissues. Strongly radioactive sources are often stored in heavy lead boxes to shield the local environment from the radiation.

Some materials absorb beta rays. A sheet of common cardboard will absorb some of the betas, but will allow most to pass through. You can measure this absorption by fixing a beta source and a radiation monitor so their positions do not change, and then inserting layers of cardboard between them.

When an absorber is in the path of beta rays, it will allow a certain fraction, *f*, to pass through. The fraction, *f*, depends on the density and thickness of the absorber, but will be a constant for identical absorbers and fixed beta ray energy. If the number of counts detected in a count interval is *N*0 when no absorber is in place, then the counts, *N*, with the absorber is *N* = *f N*0.

However, scientists and health care workers using intense radiation sources are often told that the best protection is distance; that is, the best way to minimize exposure to radiation is to stay far away from the radiation source. Why is that?

In this experiment, you will examine how the amount of radiation is affected by various methods of shielding and distance from the source.

### Procedure

**PART A – Radiation**

1. Connect the radiation monitor to DIG 1 of the LabQuest.

2. Turn on the LabQuest.

3. Prepare the LabQuest for this experiment.

a. Select Sensors from the main screen.

b. Select Sensor Setup from the Sensors menu.

c. Select Radiation Monitor from the DIG 1 menu.

d. Press and release ok.

e. Press and release the Length Menu on the right of the screen. Change the Interval and Length 30 seconds each.

f. Select OK.

4. Place the source near the Geiger tube window on the underside of the Radiation

Monitor, and when using an absorber, place the absorber between the source and

the window. In either case, use approximately the same position for the sources

each time, with and without an absorber. The sources are usually mounted in small

plastic discs, with the most radiation emitted from the underside of the disc. Begin

with no source, to determine the background count rate.

a. Move all sources away from the monitor.

b. Select START from the main screen to begin collecting data.

c. Wait 30 seconds for the calculator to complete the data collection interval.

Record the number of counts/interval in the no-source row of the data table, no

shielding.

5. Using no absorber (shield material), place the beta source near the appropriate region of your

radiation monitor, with the underside of the disc facing the monitor. As you did

before, press the play button to begin collecting data. Wait 30 seconds for the LabQuest to

complete the data collection interval. Record the number of counts/interval in the

beta row of the data table, no shielding.

6. Place a single sheet of paper between the beta source and the monitor, and measure

the counts as before. Take care to keep the source in the same position with respect

to the radiation monitor. Record the count rate in the appropriate place.

7. In a similar manner, record the counts for the following used as absorbers for each

of the three sources:

a. a single sheet of paper

b. a single sheet of aluminum

c. a single sheet of lead

8. Record each count rate in your data table.

**PART B – Shielding**

1. Obtain a Beta radiation source.

2. Confirm that the source and monitor are positioned so they will not move, and so

that there is enough space between them for ten layers of cardboard.

3. Remove all cardboard from between the source and monitor.

4. Press the play button to begin collecting data. The LabQuest will begin counting the

number of beta particles that strike the detector during each 30-second count

interval.

6. Record the number of counts that are recorded next to the box containing 0 cardboard sheets.

7. Insert one layer of cardboard between the source and detector. Be sure that the

cardboard completely covers the source’s “view” of the Geiger tube in the detector.

8. Press play to collect more data, and wait 30 seconds.

9. Enter the number of layers of cardboard and counts on your data table.

10. Without moving the source or the monitor, and adding an additional layer of

cardboard each time, repeat steps 9and 10 until you have completed data collection

for ten layers..

12. Use a computer to prepare a shielding vs. counts graph according to your teachers instructions.

**PART C – Distance**

2. Obtain a gamma radiation source.

3. Place a ruler on the lab bench next to the wire screen on the detector.

4. Place the gamma source against the wire screen such that the back of the source is facing the screen.

5. Confirm that the back of the source is also aligned with 0 cm on the ruler.

6. Press the play button to begin collecting data. The LabQuest will begin counting the

number of gamma particles that strike the detector during each 30-second count

interval.

7. Record the number of counts on your data table next to 0.00 cm.

8. Move the source so that its back is 2.00 cm from the screen on the detector.

9. Press play to collect more data, and wait 30 seconds.

10. Enter the distance from the detector.

11. Without moving the ruler, and adding moving the source an additional 2.00 cm each time, repeat steps

8 – 10 until you have recorded distances up to 24.00 cm.

12. Use a computer to prepare a distance vs. counts graph according to your teachers instructions.

**DATA**

**Part A**

|  |
| --- |
| Counts in 30-second interval |
|  | No Shielding | Shielding |
| source |  | Paper | Aluminum | Lead |
| none |  |  |  |  |
| alpha |  |  |  |  |
| beta |  |  |  |  |
| gamma |  |  |  |  |

**Part B**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Cardboard Sheets | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Number of Counts |  |  |  |  |  |  |  |  |  |  |  |

**Part C**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Distance (cm) | 0 | 2.00 | 4.00 | 6.00 | 8.00 | 10.00 | 12.00 | 14.00 | 16.00 | 18.00 | 20.00 | 22.00 | 24.00 |
| Number of counts |  |  |  |  |  |  |  |  |  |  |  |  |  |

**Questions**

1. Compare the no-source, or background, count with the no-absorber counts for the sources. Is the background count number a significant fraction of the counts from the sources? Do you need to consider a correction for the background counts?
2. If you were presented with a safe, but unknown, radiation source, and if it emitted only one type of radiation, devise a test that would allow you to tentatively identify the type of radiation as primarily alpha, beta, or gamma. Write instructions for another student to follow in performing the test.
3. X-rays are photons, just like gamma rays. X-rays carry lower energy, however, and so historically received a different name. If you have had an X-ray film picture of your teeth taken by a dentist, the dentist probably placed a lead-lined apron on your chest and lap before making the X-ray. What is the function of the lead apron? Support any assertion you make from your experimental data.