TEACHERS' GUIDE

RADIATION CONCEPTS

Nuclear radiation. There are many types of radiation. This lab involves nuclear (or ionizing) radiation, which is at higher energies than most other types of radiation. It is energetic enough to ionize molecules in its path. It consists of alpha, beta, gamma, x-rays, etc. Alphas are heavy particles and only travel short distances (they are not easily measured by a geiger counter.) Betas are free electrons and travel about a foot in air. Gammas and x-rays are high energy photons, and are the most penetrating.

Geiger counter. The CV-700 probe contains a hollow chamber that has inner electrodes at high voltage. A ray of radiation hitting the probe, ionizes the gas in the chamber, and discharges the electrodes. The discharge creates an electronic pulse (heard as a click,) and is called a count. The instrument scale reads "counts per minute," the rate at which it detects radiation. If the detector probe has a rotating shield, turn it so the gray (or yellow) geiger tube is visible. The shield is used on Experiment #4.

On the side of the geiger counter is a "check source," made of a tiny amount of uranium. It is used to check the operation of the detector. The meter dial should respond when the probe is held close to the check source. Keep the check source side of the counter pointing away from any experiments. Otherwise it may interfere with the experiment. The check source is safe to touch. However, if it is gouged or cut open, place the counter in a plastic bag and do not use.

Radiation dose. The scale may also read millirem per hour (mR/hr or mrem/hr). This is a unit of dose rate. Dose is the amount of radiation absorbed by tissue (similar to chemical dose.) A geiger counter measures dose rate, not total dose. This measurement relates to safety—low doses are safe, high doses can be harmful. All doses measured in these experiments are safe.

Experiment #1 BACKGROUND RADIATION

TASK: Measure beta/gamma radiation background fields at various locations in the room with the geiger counter. Record the values for background. Answer the question " Where is background radiation coming from?"

Supplies: 1 geiger counter

Insights: The 2 main sources of background beta/gamma radiation are cosmic rays from above and the radioactive earth from below. Radioactive elements in the earth's crust include uranium, radium, thorium and potassium. Are these found in the human body? Radon gas is produced by radioactive decay of radium. Radon will be attracted to TV screens, while they're on. (Wipe the screen with a small piece of cloth, and check it with a geiger counter. You can measure its half-life *by checking the cloth every 5 minutes.) With earphones, clicks can be easily counted over one minute.*

TEACHERS' GUIDE

Experiment #2 TIME AND RADIATION EXPOSURE

<u>TASK</u>: Your Grandfather just gave you an old watch that contains radium "glow in the dark" paint (unknown to him). Measure the radiation field at 5 inches from the watch. Record the value. You place the watch on your headboard 5 inches from your pillow on your bed. If you leave it there for 1 year (365 days) and we assume that you sleep in your bed 8 hours every night, what will be the radiation dose to your head after 1 year?

Radiation Dose (millirem)=365 days/yr x 8 hrs/day sleep x _______mR/hr
(at 5" off the watch)= _______________ millirem to your head!

<u>Supplies:</u>
- 1 geiger counter
- Radium dial watch (or other radioactive item)
- ruler
- calculator

<u>Insights:</u> "The dose makes the poison." Large dose means large risk. Small dose means small risk. What is a safe dose? A medical x-ray delivers less than 50 millirem. Radiation workers (x-ray technicians, for example) can receive up to 5,000 millirem per year. Check the Web site, below, for more on safety and dose.

Experiment #3 DISTANCE AND RADIATION EXPOSURE

<u>TASK</u>: Measure the beta/gamma radiation from a piece of pottery with radioactive uranium glaze (Fiestaware) at 2 inches, 6 inches and 12 inches from the pottery. Record the values. Answer the question "How does distance affect radiation?"

<u>Supplies:</u>
- 1 geiger counter
- 1 Fiestaware pottery, uranium rock (or other radioactive item)
- ruler

<u>Insights:</u> Radiation levels drop off according to the square of the distance. This is based simply on geometry. Try plotting the data. Remember to subtract background from the readings.

Experiment #4 SHIELDING FOR BETA/GAMMA RADIATION

<u>TASK</u>: Measure the beta/gamma radiation from the surface of a radium dial watch. Record the value. Put a piece of paper over the watch and measure the beta/gamma radiation field. Repeat with plastic and then a piece of lead or metal. Record the values. How did the different types of shielding change the radiation field?

Supplies: 1 geiger counter
1 radium dial watch (or other radioactive item)
1 piece paper, plastic and lead (or metal)

Insights: First note that some geiger counters have a rotating shield over the detector. This can be used for the lead (or metal) shield. With the shield turned "off" you can see the gray or yellow geiger tube. Compare shielding of beta/gamma radiation to shielding of light (also a radiation.) All radiations are "energy in motion." To shield them, you need to dissipate their energy, which is done by the shield. Shield material does not become radioactive after stopping gamma rays. Note that most betas are stopped by the plastic, but not so with gammas, which are the most penetrating..

Experiment #5 WHICH ITEMS ARE RADIOACTIVE?

TASK: Using the geiger counter, determine which numbered items are radioactive and which aren't. Record the items that are radioactive.

Supplies: 1 geiger counter
numbered items - natural forms of radiation, consumer products (i.e., "NoSalt" [KCl,] Fiestaware, welding rods, old [thorium-coated] lenses, smoke detector, static eliminator, old cut fluorescent glass, old uranium glaze jewelry, cloisonné jewelry, uranium rock, some cloth mantles for camping lanterns, etc.) and non-radioactive items (i.e., computer disk, battery, light bulb, etc.)

Insights: Radioactive items listed contain either uranium, thorium, radium or potassium. Uranium ore also contains radium. This table can spin off a discussion of safety (see Experiment #2.) A rock collection works well for this. Also, students can determine the types of radiation given off by each item. Use shielding to see if betas are present (easily stopped,) or if gammas are present. Natural radioactivity will have both betas and gammas. (Alphas, while present, are hard to detect with a geiger counter. Their range in air is only about an inch.)

ADDITIONAL INFORMATION

Health Physics Society: 510-268-1571, or on the Web at http://www.radwaste.org/teacher.htm . More at http://www.umich.edu/~radinfo/ - Click on "Educational Resources."

There are many myths about radiation (Spiderman, the Hulk, two-headed babies—the list goes on.) Unfortunately, these are often viewed as actual. Students can research some of these, and shed some light on these myths.

Experiment #4a SHIELDING FOR BETA RADIATION

TEACHERS' GUIDE

This is a high school physics level experiment. The counter needs an earphone or speaker. "No Salt" can be obtained in any market. Knowledge of curve-fitting is helpful.

TASK: Measure the attenuation of beta radiation from the Potassium-40 isotope in KCl salt (available as "No Salt"). K-40 comprises 0.7% of all potassium (the rest is K-39). It emits a beta ray (1.3 MeV) and an occasional gamma ray (1.4 MeV). The first half value layer (thickness to reduce radiation by 1/2) is about 0.3 mm of aluminum-- 2 mm will stop all the betas at this energy.

Here are some typical results. The regression was done by MSExcel, by creating a line chart, points only, then clicking on Add Trendline, Linear, Show equation, etc. The true correlation is exponential, but linear works fine for this exercise.

IMPORTANT: Keep the same distance between the salt and detector. Small changes in distance will change the count rate, and disturb the effect of adding foils. Remove the cover on the detector by unscrewing. The tube exterior is not at high voltage, and is safe to touch. If punctured however, it may not work.
Remember to subtract background radiation *(step #2) from each measurement.*