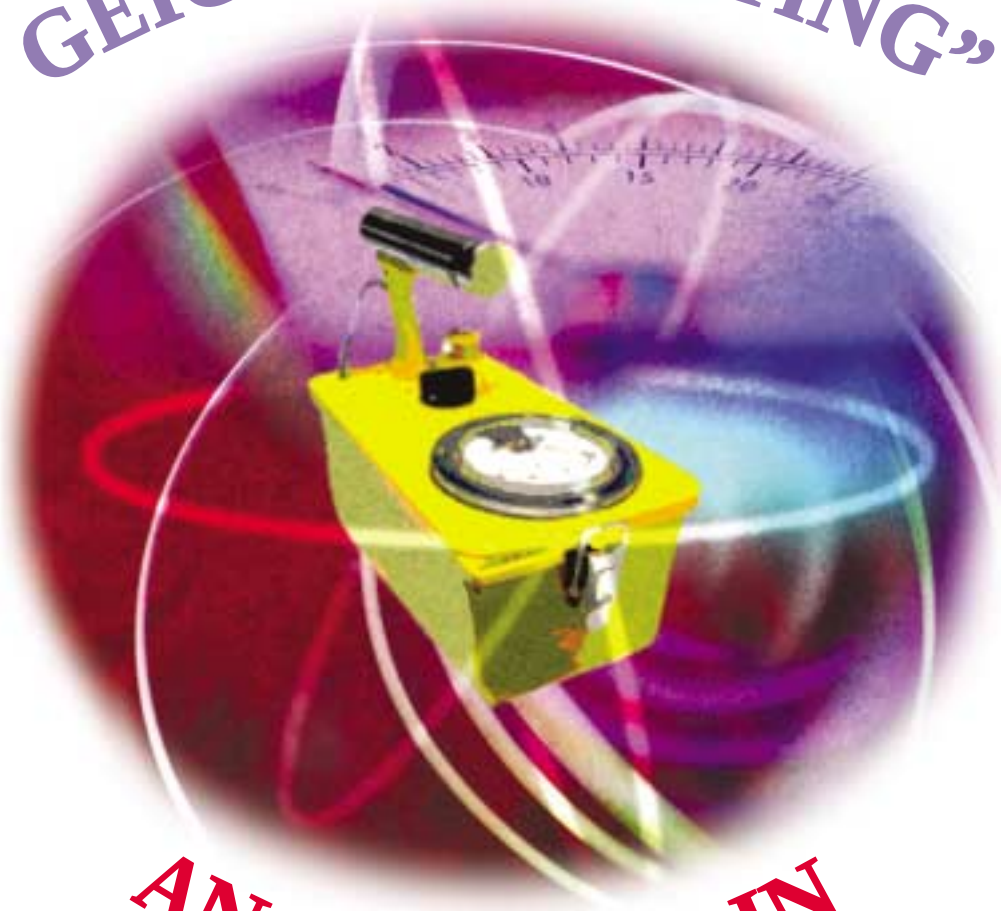
GEIGER "COUNTING"



AN EXERCISE IN RADIATION SHIELDING

GRADES 9 - 12

SOUTHERN COMPANY

Energy to Serve Your World®

GEIGER "COUNTING"

SNC - Plant Farley

LESSON PLAN

AN EXERCISE IN RADIATION SHIELDING

Lesson Title: Geiger "Counting" – An Exercise in Radiation Shielding

Lesson Description: After study of basic principles/concepts relating to radiation, students utilize a Geiger-Mueller Detector and unlicensed radiation sources to test various shielding materials. Students experiment to determine what type of material provides the best shielding. Students also determine the effect of distance upon radiation detection and plot the results of the experiment.

Grade Level: 9 - 12

Subject Area(s): Physical Science, Chemistry, Physics

Objectives: Students will:
- operate a GM detector properly
- observe/measure baseline radiation counts using a GM detector and several different unlicensed radiation sources
- use a variety of shielding materials and determine their effectiveness
- determine the effects upon distance between sources and GM probe
- collect and plot data as a graph
- analyze/discuss/report findings with other students
- formulate hypotheses related to efficiency of shielding materials
- relate findings to basic principles of radioactive decay

Materials:
- GM Detection Devices
- variety of unlicensed radiation sources such as gas lantern mantles, tungsten welding electrodes, smoke detectors, orange Fiesta Ware, Vaseline glass, salt substitute, sealed commercial sources, uranyl nitrate in sealed packages (NOT loose crystals)
- gloves
- 4" x 4" x 1/8" sheets of various shielding materials such as paper, cardboard, plastic, wood, aluminum, glass, lead, cloth, etc.
- metric rules
- activity sheets/handouts
- graph paper
- pencils

Correlations (NSES):
- Content Standard A – Science as Inquiry
  - develop abilities necessary to do scientific inquiry
  - develop understandings about scientific inquiry
- Content Standard B – Physical Science
  - develop an understanding of the structure and properties of matter
  - develop an understanding of motions and forces
  - develop an understanding of conservation of energy and increase in disorder
- Content Standard E – Science and Technology
  - develop understanding about science and technology
- Content Standard G – History and Nature of Science
  - develop an understanding of science as a human endeavor
  - develop an understanding of the nature of scientific knowledge

Curriculum Integration:

- Mathematics (measurement/graphing)
- Environmental Science
- Health

Process Skills:

- Observation
- Collection of data
- Comparison
- Measurement
- Counting
- Research
- Investigation/experimentation
- Inference
- Analysis of findings/data
- Plotting data
- Interpretation of data
- Communication of ideas
- Description of findings
- Prediction

Background Information:

- Main ideas
  - Principles of alpha, beta, and gamma decay; especially those relating to ionization, penetrating properties, mass and charge
  - Principles relating to GM Detector operation; specifically ionization within a gas-filled tube and reading the instrument
  - Concept of counts per minute, disintegrations per minute, and mR/hr
  - Different materials differ in the amount of shielding they provide; relate this ability to density of shielding materials
  - Different types of decay have different ionizing and penetrating abilities
  - Distance between radioactive sources and survey instrument probe affect readings
- Secondary ideas
  - Familiarity with some radionuclides and their emissions
  - Awareness of other types of instruments (e.g. scintillation devices, gamma spectroscopy, etc.) used to measure radioactivity/decay
  - Hazards of radiation exposure
  - Radiation sources in consumer products
  - Usage of radiation in our world

Teacher Activities:

- Assemble/organize all materials needed for activity
- Review operation/theory of GM devices (study manuals if needed and practice operation of GM device)
- Check all GM devices to make certain they are operational and calibrated to an acceptable standard
- Present background materials to students
- Divide class into small groups for lab activity (2-4 students per group
- Issue instructions to students regarding lab activity
- Issue and stress safety information:
  1) handle sources with gloves on
  2) do not open GM detectors due to electrical shock hazards (there is a high voltage source inside the GM detectors)
  3) some shielding materials will have sharp corners that can inflict cuts
  4) all students should wash their hands with soap and water after the exercises are completed

Teacher Activities (cont):
- Distribute Activity Sheets to students and issue instructions regarding their completion.
- Monitor/assist students as needed during exercises.
- After completion of lab activities, assemble students and have them share and compare data.
- Complete lesson by stressing main points and relating them to lab activities.
- Take up rad sources after the exercise. Count them to make certain you have collected them all. Store them properly.

Student Activities:
- Listen carefully to background information issued by teacher.
- Obtain materials needed for exercise.
- Follow instructions on Activity Sheets to conduct exercises.
- Observe, record, plot data on graph paper.
- Analyze/interpret data
- Complete Activity Sheets
- Compare data with that of other groups
- Participate in post-activity discussion

Evaluation:
- Direct observation
- Lab Activity Sheets
- Oral communication from students

Extension/Enrichment:
- Have students bring in their own shielding materials to test
- Obtain different radioactive sources
- Arrange a Field Trip to a nuclear facility
- Use an isogenerator (such as Cs137/Ba137m) and study half-life
- Construct cloud chambers and study the paths and linear energy transfer of alpha particles
- Assign reports on topics related to nuclear science (e.g. gamma sterilization, use of radiation to treat cancer, nuclear reactor designs, etc.)

Safety Considerations:
- Have students use gloves when handling all radioactive sources. Caution students against handling sources and placing their fingers in their mouths, noses, or eyes. Do not distribute loose uranyl nitrate or other radioactive chemicals – if you use these sources make certain that they are in sealed containers
- Do not use any radioactive liquids as sources
- GM Detectors step up voltage provided by the batteries. Do not allow students to take the covers off of GM devices as they may be exposed to a high voltage electrical source.
- Do not allow students to attempt to take the mylar coverings off of sealed sources
- Some of the materials used for shielding materials (e.g. hard plastic, glass plates, metal plates) may have sharp edges or corners that can inflict cuts
- Insist that all students wash their hands after completion of the lab
- Make certain that you take up all radiation sources and that you store them properly in a secure location.

GEIGER "COUNTING"

ACTIVITY SHEET ONE

AN EXERCISE IN RADIATION SHIELDING

(READ THIS ENTIRE SHEET BEFORE BEGINNING THE EXERCISE)

Introduction

In this exercise you will use a Geiger-Mueller (GM) Detection device to measure rates of radioactive decay emitted from a variety of radioactive sources. You will be testing a number of different materials for their shielding properties and recording the results in a table.

In addition, you will experiment to see what effect the distance between a source and the GM detection probes has upon measurement and detection of decay. You will record this data and plot it on graph paper to compare the distances and rate of decay.

Follow the directions on this Activity Sheet and record your data carefully. If you need help or have questions ask your teacher for assistance. The rad sources utilized in this exercise are very weak and do not present radiation hazards when utilized for short periods of time. Even so, always wear gloves when handling the sources and keep your hands away from your mouth, nose, and eyes.

Your GM Device reads out in Counts Per Minute (CPM) and/or mR/hr. The CPM indicates the number of nuclear events detected by the GM each minute. Bear in mind that the instrument has only a 10% efficiency rate and does not detect all the events – there are many more actually taking place. Disintegrations Per Minute (DPM) is the actual number of events taking place. To determine DPM, take the CPM reading and multiply it by a factor of 10. (Efficiency Factor of 10 x CPM = DPM).

Procedure

- Obtain the following materials as directed by your instructor:
  - GM Detector (See Fig. 1 & 2)
  - variety of radioactive sources (see Fig. 3)
  - gloves
  - metric rule
  - graph paper
  - variety of shielding materials
  - pencils
  - masking tape
  - handouts
- Listen carefully to the background information and instructions issued by your teacher
- Practice using the GM Detector as demonstrated by your teacher; remember that the instrument has a delicate probe with a window that must be opened; use the diagrams of the GM Detector for reference (Figures 1 and 2)
- When handling radioactive sources, always wear gloves
- Do not handle any loose (unpackaged) radioactive chemicals such as uranyl nitrate; make sure that they are in a plastic container prior to handling
- Use the scissors to cut the aluminum foil into two small strips about 4 inches wide and about 1 inch long.
- Open up the paper clip and straighten one end so that you have a hook; see Figure 1.

Procedure (cont)

- Insert the straightened end of the paper clip into the small end of the cork; push it all the way through so that a small part of the clip projects through the cork top; see Figures 2 and 4.
- Stack the two small strips of foil atop one another and then punch a small hole through both strips about 1/16” from one end; see Figure 3.
- Thread both strips onto the hook; the two strips should be close together on the hook but not quite touching; see Figure 4
- Answer questions 3 and 4 on Activity Sheet 2.
- Inflate the balloon and rub it gently with the wool cloth; then bring the balloon very close to the paper clip on the electroscope without touching it; observe what happens.
- Now go ahead and touch the balloon gently to the tip of the clip on the electroscope; observe what happens.
- Answer question 5 on Activity Sheet 2.
- Repeat this process using the nylon comb or rod and make observations.

Shielding Materials	Rad Source #1			Rad Source #2			Rad Source #3		
	CPM	DPM	mR/hr	CPM	DPM	mR/hr	CPM	DPM	mR/hr
Paper									
Cardboard									
Plastic									
Aluminum Foil									
Wood									
Other:									
Other:									
Other:									
Other:									
Other:									

Table 1

GEIGER "COUNTING"

ACTIVITY SHEET ONE

AN EXERCISE IN RADIATION SHIELDING

Questions regarding Table 1:

1. Which source produced the highest radiation readings? Which emitted the lowest amount of radiation?

2. Which source produced the radiation with the highest level of penetration?

3. Which source produced the lowest amount of penetration?

4. Which type of shielding was the most effective for source #1?

5. Which type of shielding was the most effective for source #2?

6. Which shielding was the most effective for source #3?

7. Based upon your shielding test results, predict the types (alpha, beta, gamma) of radiation emitted by each of your sources. List the data below.

AFTER COMPLETING THESE QUESTIONS, GO ON TO ACTIVITY SHEET TWO.

GEIGER "COUNTING"

ACTIVITY SHEET TWO

AN EXERCISE IN RADIATION SHIELDING

(READ THIS ENTIRE SHEET BEFORE BEGINNING THE EXERCISE)

Introduction

In this exercise, you will determine the effect of distance between the radiation source and the GM probe. You will use the same materials as for the previous exercise.

Before you complete any of the activities for this exercise, answer question number 1 on the next page of this Activity Sheet. After completing question 1, proceed with the exercise as directed below. Remember to wear gloves when handling rad sources.

Procedure

- Tape metric rule and GM device as in for exercise
- Place source one 12 cm from the probe and obtain reading; record data in Table 2
- Move source to 11 cm from probe, obtain reading and record data in Table 2
- Repeat process with same source until it touches the end of probe; record readings at each location
- Repeat same process with other sources; record data in Table 2
- After completing exercise with all sources, take data in Table 2 and plot it on graph paper
- After plotting data, answer remainder of questions on Activity Sheet 2
- After answering all questions, compare your results with those of others in your class. Report your results to your teacher and classmates.
- Wash your hands after completion of all lab activities

POSITION	SOURCE #1			SOURCE #2			SOURCE #3		
	CPM	DPM	mR/hr	CPM	DPM	mR/hr	CPM	DPM	mR/hr
12 cm									
11 cm									
10 cm									
09 cm									
08 cm									
07 cm									
06 cm									
05 cm									
04 cm									
03 cm									
02 cm									
01 cm									
00 cm									

Table 2

GEIGER "COUNTING"

ACTIVITY SHEET TWO

AN EXERCISE IN RADIATION SHIELDING

1. Do you think the distance between a radioactive source and the GM probe will have an effect upon detection readings? Describe the effect(s) you predict and explain why you believe the predicted effect will occur.

2. How did distance affect readings with source #1?

3. Did it affect readings for sources 2 & 3 in the same manner? Why do you think you got these results?

4. Compare the data you plotted on graph paper. How would you interpret what is shown?

5. Use the data in Table 2 and the graphs to formulate a mathematical equation illustrating the effects of distance and radiation detected for each source.

6. Does this equation work for each source? Why or why not?

7. Look at your predictions you wrote for question 1. Were they accurate? If not, how did your results different from your predictions?

TYPICAL GM DEVICE

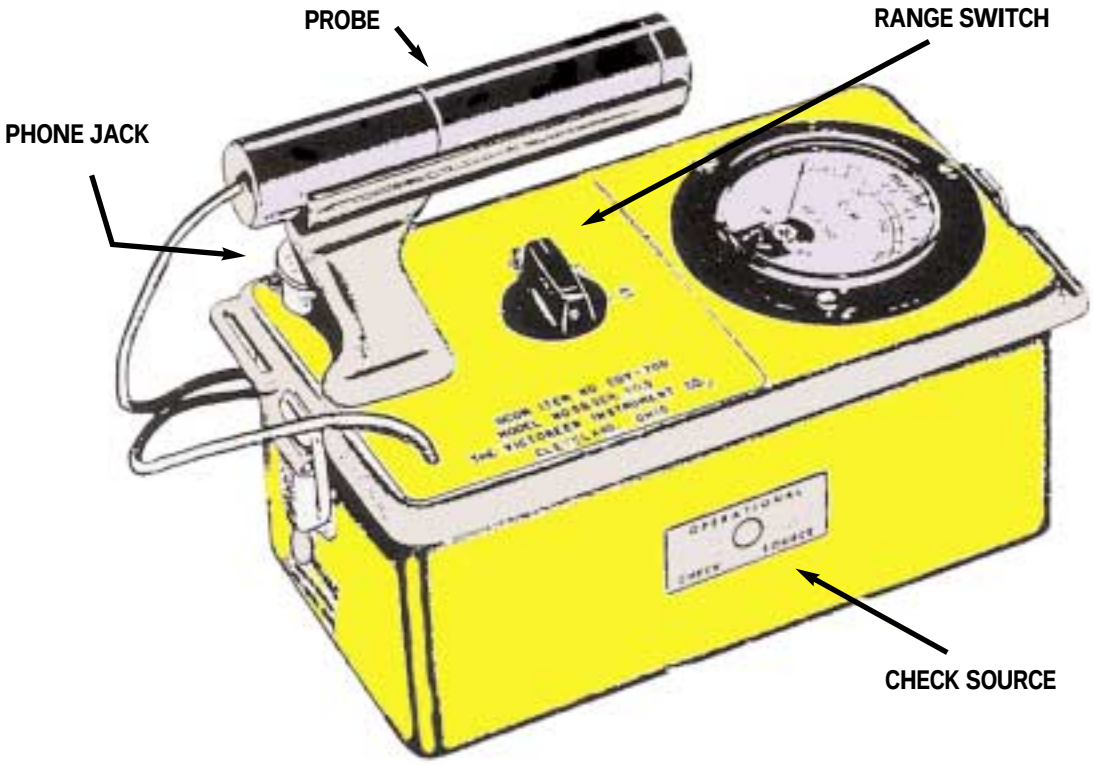


Figure 1

TYPICAL GM PROBE

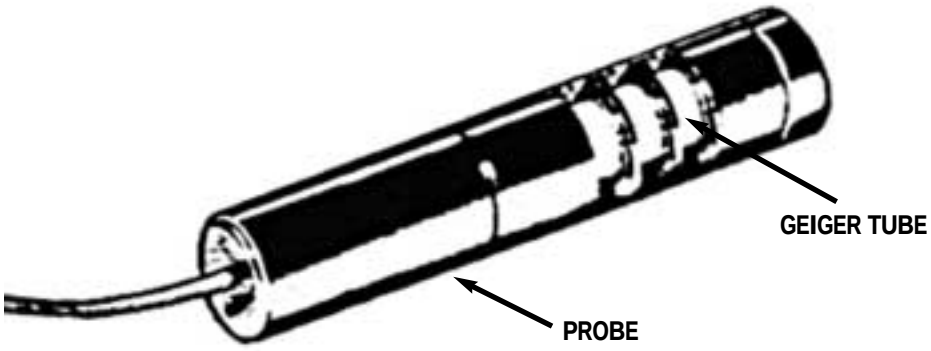


Figure 2

TYPICAL GM PROBE

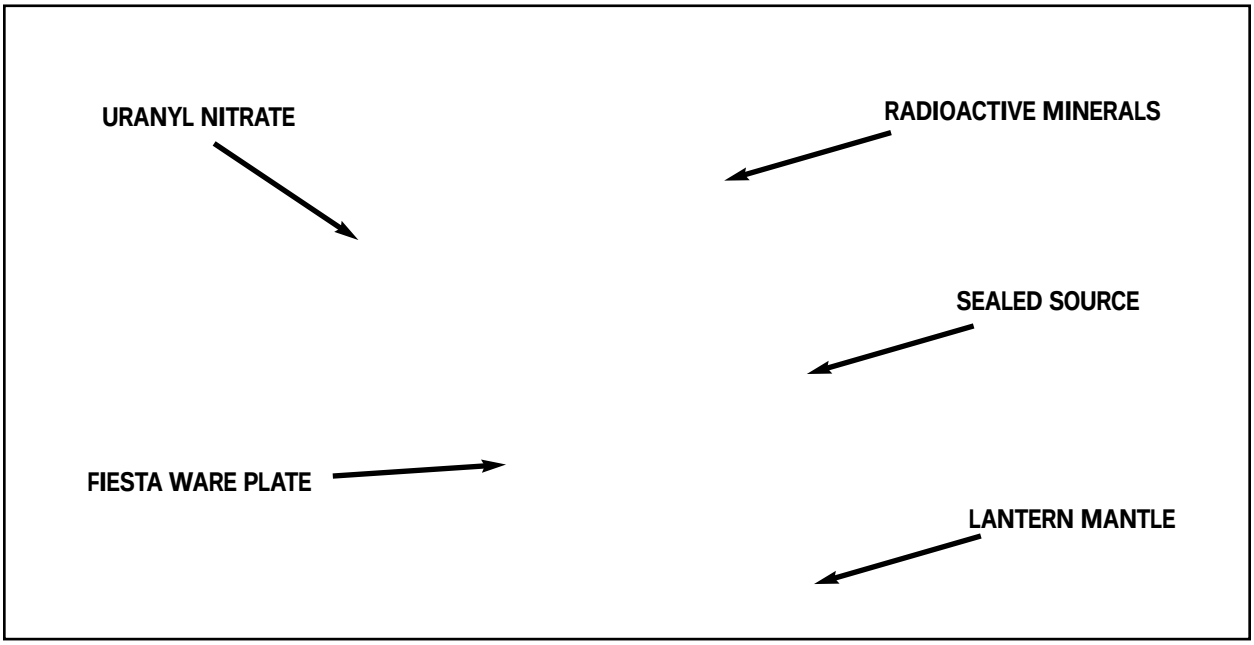


Figure 3