FLINN SCIENTIFIC

Name____

Laboratory Report

Radiation Shielding: Number of Counts per Minute

Radiation	No Shielding			Shielding								
				Paper			Aluminum			Lead		
Background												
Alpha												
Beta												
Gamma												

Effects of Distance on Beta Radiation Intensity

Distance from radiation detector	2 cm			5 cm			10 cm			20 cm		
Activity (Counts per minute)												

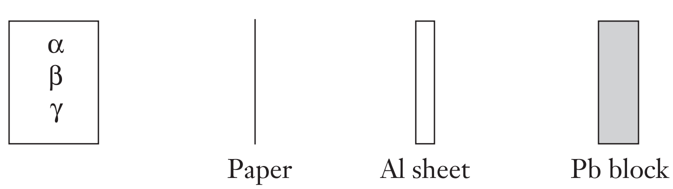
1. Compare the background activity (number of counts per minute of background radiation) versus that of the alpha, beta, and gamma sources with no shielding. Is it necessary to "correct" the activity of the α, β, and γ sources to take into account the level of background radiation? Explain.

2. What type(s) of shielding material can be used to absorb (a) alpha, (b) beta and (c) gamma radiation?

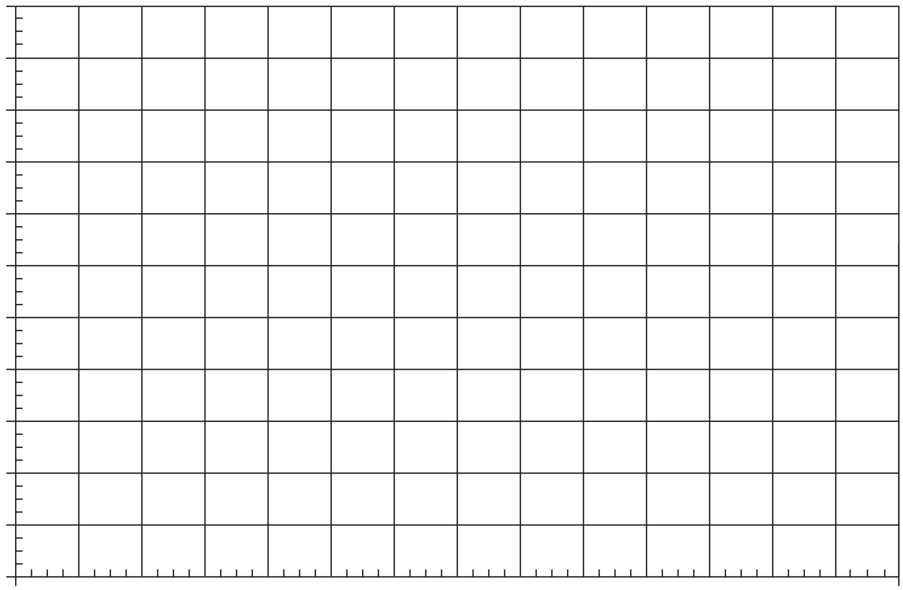
3. Which metal, aluminum or lead, is more effective in shielding against beta radiation? What is the reason for the difference in shielding ability of aluminum versus lead?

4. Is it possible to completely stop gamma radiation using a sheet of metal? Would increasing the thickness of the metal stop more gamma radiation? Why or why not?

5. Use arrows in the following diagram to show the ability of alpha, beta and gamma radiation to "penetrate" different types of shielding materials.



6. Prepare a graph of activity (counts per minute) on the y-axis versus the distance of the beta or gamma source from the detector on the x-axis.



7. Describe in words how the level of radiation from a radioactive source changes as the distance of the source from the detector increases.

8. Calculate the activity ratios at each of the following distances. Does the activity change by a constant amount when the distance from the source is doubled?

   (a) $\dfrac{1 \text{ cm}}{2 \text{ cm}}$ (b) $\dfrac{5 \text{ cm}}{10 \text{ cm}}$ (c) $\dfrac{10 \text{ cm}}{20 \text{ cm}}$

9. Based on the results obtained in Question 8, predict how the amount of radiation detected should change when the distance between the source and the detector is increased by a factor of four (e.g., from 5 cm to 20 cm). What was the actual activity ratio at 5 cm versus 20 cm?

10. Explain how distance and shielding can be used together to protect workers from the harmful effects of gamma radiation.

11. How can shielding be used to decide what type of radiation is emitted by an “unknown” radioactive source?

12. The following calculations illustrate the radiation exposure from working with the sealed radioactive sources in this experiment. The gamma source is cobalt-60, having an activity of 1.0 µCi, and the alpha source is polonium-210, with an activity of 0.1 µCi. Calculate the maximum radiation dose in millirems (mrems) for an average 150 lb (68 kg) individual working with the C0-60 source for one hour.

Source	Activity	Mode of Decay	Energy	RBE (mrems/mrads)
Po-210	0.1 µCi	α–radiation	5.30 MeV	20
Co-60	1.0 µCi	γ-rays	2.51 MeV	1

Sample dose calculation for polonium-210:

$$0.1 \times 10^{-6}\text{ Ci} \times \left(3.7 \times 10^{10}\,\frac{\text{disintegrations/sec}}{\text{Ci}}\right) \times \frac{5.30\text{ MeV}}{\text{disintegration}}$$

$$\times \frac{1\text{ J}}{6.24 \times 10^{12}\text{ MeV}} \times \frac{1\text{ rad}}{0.01\text{ J/kg}} \times \frac{1}{68\text{ kg}} \times \frac{60\text{ sec}}{1\text{ min}} \times \frac{60\text{ min}}{1\text{ hr}}$$

$$= 1.7 \times 10^{-5}\text{ rad/hr} \times \frac{10^{3}\text{ mrad}}{\text{rad}} = 1.7 \times 10^{-2}\text{ mrad/hr}$$

$$1.7 \times 10^{-2}\text{ mrad/hr} \times \frac{20\text{ mrem}}{1\text{ mrad}} = 0.33\text{ mrem/hr}$$

Complete the dose calculation for cobalt-60:

$$1.0 \times 10^{-6}\text{ Ci} \times \left(3.7 \times 10^{10}\,\frac{\text{disintegrations/sec}}{\text{Ci}}\right) \times \frac{\qquad\text{MeV}}{\text{disintegration}}$$

$$\times \frac{1\text{ J}}{\qquad\qquad\text{MeV}} \times \frac{1\text{ rad}}{0.01\text{ J/kg}} \times \frac{1}{68\text{ kg}} \times \frac{\qquad\text{sec}}{1\text{ min}} \times \frac{\qquad\text{min}}{1\text{ hr}}$$

$$= \qquad\qquad\text{rad/hr} \times \frac{10^{3}\text{ mrad}}{\text{rad}} = \qquad\qquad\text{mrad/hr}$$

$$\qquad\text{mrad/hr} \times \frac{\qquad}{1\text{ mrad}} = \qquad\qquad\text{mrem/hr}$$