22.01 "Introduction to Ionizing Radiation"
Fall 2006
Problem Set #5

Due Date: Thursday, October 26, 2006

Show all work. Provide units on all answers.
(Make use of graphs and tables in the Text whenever possible.)

1) A narrow beam of 10^8 photons per second is normally incident on a 6 mm aluminum sheet. The beam consists of equal numbers of 200 keV photons and 2 MeV photons.

a) Calculate the number of photons per second of each energy that are transmitted without interaction through the sheet.
b) Calculate the transmitted intensities for the same two photon beams striking a lead sheet of the same thickness.
c) Calculate the atomic cross sections of aluminum and lead for the 200 keV and the 2 MeV photons.

2) A narrow beam of 200 keV photons strikes a target consisting of a 1.4-cm-thick sheet of aluminum followed by a 2-mm-thick sheet of lead.
(a) What fraction of the incident photons penetrates both sheets without interacting?
(b) Would there be any difference if the photons came from the other direction, entering the lead first and then the aluminum?

3) Food irradiation is carried out with very intense ^{60}Co sources. Calculate the dose rate in air (Gy/sec) at distances of 1 meter and 10 meters from a 50,000 Ci source of ^{60}Co.

4) A gold foil weighing 3.500 mg is irradiated with thermal neutrons for exactly 10 minutes. Forty-eight hours after the end of the irradiation, the foil is placed in a gamma spectrometer with 100% counting efficiency and an activity of 2750 Bq is recorded.
(A) What was the thermal neutron flux (neutrons/cm^2/sec) to which the foil was exposed?
(B) What would be the saturation activity of this gold foil when exposed to this neutron flux?

Given:
^{197}Au (100% abundance)
thermal neutron capture cross section, $\sigma = 98.8$ barns
$^{197}Au + n \rightarrow {}^{198}Au$
^{198}Au $t_{1/2} = 2.7$ days

5) A narrow beam of 100 MeV neutrons, with a fluence of 10^5 n/cm^2/sec, is normally incident on an aluminum [$^{27}_{13}Al$] plate. The elastic scattering cross section of aluminum for 100 MeV neutrons is 0.95 barns. The density of aluminum is 2.7 g/cm^3.

(a) How thick must the aluminum plate be in order to reduce the number of unscattered neutrons emerging from the plate by three orders of magnitude?

(b) How much would this plate attenuate a narrow beam of 100 MeV **photons**?

6) A 1 mCi source of ^{60}Co is placed in the center of a cylindrical water-filled tank with an inside diameter of 20 cm and a depth of 100 cm. The tank is made of iron with a wall thickness of 1 cm. What is the uncollided energy fluence rate at the outer surface of the tank nearest the source?

7) A 1-MeV photon is Compton scattered at an angle of 55°. Calculate

(a) the energy of the scattered photon,
(b) the change in wavelength,
(c) the recoil energy of the electron.

8) A 4-MeV photon creates an electron-positron pair in the field of a nucleus. What is the total kinetic energy of the pair?

9) An experiment is carried out with monoenergetic photons in "good" geometry. The relative count rate of the detector is measured with different thicknesses *x* of tin (Sn) used as absorber. The following data are measured:

x(cm)	0	0.50	1.0	1.5	2.0	3.0	5.0
Relative count rate	1.00	0.861	0.735	0.621	0.538	0.399	0.210

(a) What is the value of the linear attenuation coefficient?
(b) What is the value of the mass attenuation coefficient?
(c) What is the atomic cross section?
(d) What is the photon energy?

10) A sample containing 62 grams of ^{31}P (100% abundant) is exposed to 2 x 10^{11} thermal neutrons cm^{-2} sec^{-1}. If the thermal neutron absorption cross section is 0.19 barns, for how long must the sample be irradiated to produce 3.7 x 10^{10} Bq of ^{32}P?