

22.01 "Introduction to Ionizing Radiation"

Fall 2006

Problem Set #6

Due Date: Thursday, November 2, 2006

Show all work. Provide units on all answers.

- 1) Assume that the W values for protons and carbon-recoil nuclei are both 30 eV ip^{-1} in C_2H_4 gas. What is the maximum number of ion pairs that can be produced by a 3-MeV neutron interacting elastically with (a) H or (b) C?
- 2) A ^{210}Po source is placed in an air ionization chamber and a saturation current of $8 \times 10^{-12} \text{ A}$ is observed. Assume all ionizations are due to 5.3 MeV alpha particles stopping completely in the chamber. How many particles per second are stopped in the chamber?
- 3) A saturation current of $2.70 \times 10^{-14} \text{ A}$ is measured with a parallel-plate ionization chamber in a radiation field. The chamber contains air ($W = 34 \text{ eV ip}^{-1}$) at 20°C and 752 torr.
 - (a) What is the rate of the energy absorption in the chamber?
 - (b) If the chamber has a sensitive volume of 750 cm^3 , what is the dose rate in the air in $\text{J kg}^{-1} \text{ s}^{-1}$ ($= \text{Gy s}^{-1}$)?
- 4) A 1.27-MeV photon loses 540 keV and 210 keV in successive Compton scattering events in the sensitive volume of a Ge detector before escaping.
 - (a) Estimate the total number of secondary electrons produced by the events.
 - (b) Would the device register the passage of the photon as a single event or as two events?
- 5) A 1.17-MeV gamma ray is Compton scattered once at an angle of 48° in a scintillator and again at an angle of 112° before escaping.
 - (a) What (average) pulse height is registered?
 - (b) If the photon were scattered once at 48° and then photoelectrically absorbed, what pulse height would be registered
- 6) A free-air ionization chamber operating under saturation conditions has a sensitive volume of 12 cm^3 . Exposed to a beam of X rays, it gives a reading of $5 \times 10^{-6} \text{ mA}$. The temperature is 18°C and the pressure is 756 torr. What is the exposure rate?
- 7) When ^{38}S decays, a single 1.88-MeV gamma photon is emitted in 95% of the transformations. Estimate the exposure rate at a distance of 3 m from a point source of ^{38}S having an activity of $2.7 \times 10^{12} \text{ Bq}$.
- 8) A 100-cm^3 sample of water is exposed to $1500 \text{ thermal neutrons cm}^{-2} \text{ s}^{-1}$. How many photons are emitted per second as a result of neutron capture by hydrogen? The cross section for the $^1\text{H}(n,\gamma)^2\text{H}$ reaction is $3.3 \times 10^{-25} \text{ cm}^2$.
- 9) Define energy straggling. Does energy straggling cause range straggling?