

## 22.01 “Introduction to Ionizing Radiation”

Fall 2006

### Problem Set #4

*Due Date: Thursday, October 19, 2006*

Show all work. Provide units on all answers.

(Make use of graphs and tables in the Text whenever possible.)

1. Which can transfer more energy to an electron in a single collision – a proton or an alpha particle? Explain.
2. A proton and an alpha particle with the same velocity are incident on a water target. Which will penetrate to a greater depth? Explain.
3. Astatine-211 is an alpha-emitting isotope that is used in radiation therapy by attaching it to a monoclonal antibody. The energy of the  $^{211}\text{At}$  alpha particle is 6.87 MeV.
  - (a) What is the stopping power ( $-dE/dx$ ) of water for the  $^{211}\text{At}$  alpha?
  - (b) What is the range in water?
4. What thickness of Lucite (density  $1.19\text{ g cm}^{-3}$ ) would be required to completely shield the beta radiation from phosphorus-32 (1.7 MeV maximum energy).
5.  $^{239}\text{Pu}$  emits a 5.16-MeV alpha particle. What is its range in cm in
  - (a) muscle,
  - (b) bone of density  $1.9\text{ g cm}^{-3}$ ,
  - (c) air at 22 degrees C and 750 mm Hg?
6. You have at your disposal an accelerator capable of accelerating any ion up to a maximum energy of 500 MeV *per nucleon*. You want to do a cell irradiation experiment with  $^{12}_6\text{C}$  and with protons, **both having the same stopping power** ( $-dE/dx$ ). You can pick any stopping power you want, but both ions must be able to penetrate the cell target, i.e., have a range of  $> 10$  micrometers in water. Is this experiment possible? Why or why not?
7. An electron emerges normally from a 7-mm-thick Lucite slab (density  $1.19\text{ g cm}^{-3}$ ) with an energy of 1.2 MeV. What was its energy when it entered the slab?
8. Consider two particles: a 1.2 MeV proton and a 30.5 MeV alpha particle.
  - (a) Calculate the stopping powers ( $-dE/dx$ ) of water for both particles.
  - (b) What are the ranges of these particles in water?
  - (c) Calculate the maximum energy transferred by each in a collision with an orbital electron (assume that the electron is free and at rest).
  - (d) What are the ranges in water of these delta ray electrons?