22.01 Introduction to Ionizing Radiation
Fall 2003
Problem Set #6

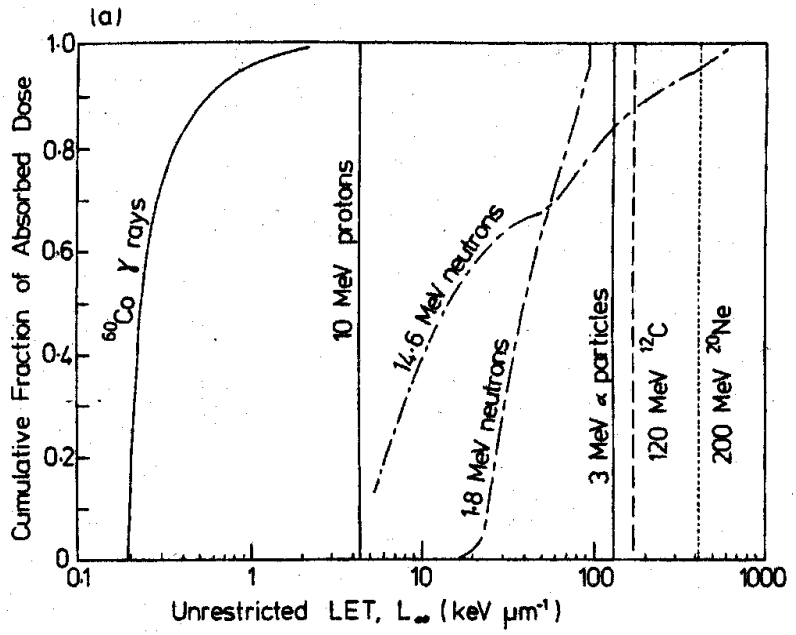
Due Date: Friday, October 24, 2003

Show all work. Provide units on all answers.

1. A 25-curie source of ^{32}P is placed in a lead shielding container just thick enough to stop all of the beta particles. Consider this a point source. State any assumptions you make.
   a) Calculate the bremsstrahlung photon fluence rate (photons/cm^2/sec) at a distance of 2 meters from the lead container.
   b) What would be the absorbed dose to a 70 kg person who stood 2 meters from the container for 10 minutes?
   c) What thickness of lead shielding (at 2 meters from the lead container) would be required to reduce the dose rate in air at 2 meters to 0.01 milliGy/hour?

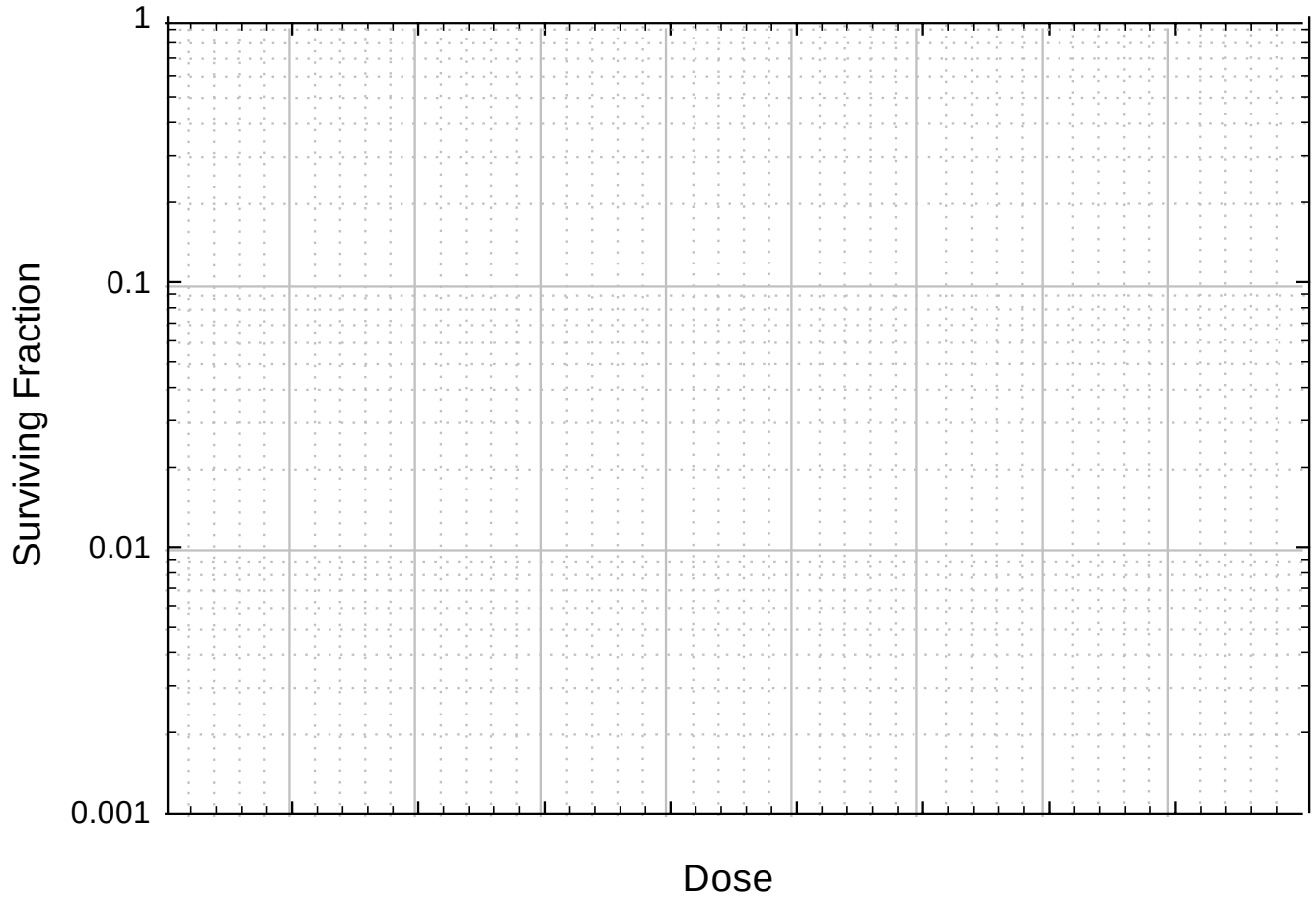
2. A dose of 1.5 Gy from a beam of 56,000 MeV ^{56}Fe particles reduces the survival of cells to 1%. Irradiation of the same cells with 1.0 Gy of 100 keV x rays results in the same level of cell survival. Explain. Discuss the RBE of the ^{56}Fe particles.

3. Refer to the figure below. Explain ***(in detail, with calculations)*** why the lines for gamma rays and neutrons are curved and the rest are straight. (Ignore Bragg peak effects at the ends of the particle tracks.) Hint: You do not need to calculate absorbed doses, just explain why there is a distribution of absorbed doses in some cases and not in others.



4. Refer to the cell survival data given in the Table below.
a) Graph the survival data for alpha particles and x rays on the blank graph paper below.
b) Calculate the RBE of the alpha particles.
c) What is the D_0 for the alpha particles?
d) What would happen if this experiment were repeated after bubbling nitrogen gas (N_2) through the cell culture medium to drive out all of the oxygen?
e) Sketch on the same graph below approximately where the N_2 survival curves would appear for both x rays and alpha particles.

Surviving Fraction	**Alpha particle dose (Gy)**	**Surviving Fraction**	**X ray dose (Gy)**
0.3	0.2	0.7	0.5
0.1	0.4	0.4	1.0
0.05	0.5	0.2	1.4
0.01	0.8	0.1	1.8
0.0025	1.0	0.03	2.3
		0.01	2.7



5. Does the Chatterjee formula for heavy particle track penumbra radius (in the "LET, RBE…." handout) give the same results as a calculation of the maximum range of a delta electron using the Turner (Chap. 5.2) formula for maximum energy transfer to an electron? Test this with several different Z particles and different energies (you pick the particles and the energies).

6. Iodine-131 is used to treat thyroid tumors. ^{131}I decay produces (primarily) a 630 keV beta particle and a 364 keV gamma ray. Assume that the thyroid tumor weighs 10 grams, and that 50% of the injected iodine binds to the tumor. Calculate the total, initial dose rate to the thyroid tumor after injection of 50 mCi of ^{131}I. State any assumptions that you need to make. Ignore the half-life of ^{131}I).