22.01 Introduction to Ionizing Radiation
Fall 2003
Problem Set #2

Due Date: Wednesday, September 24, 2003

Show all work. Provide units on all answers.

1. Show that $^{55}_{26}Fe$, which decays to $^{55}_{25}Mn$ by electron capture, cannot decay by positron emission.

2. A parent nuclide decays by beta-particle emission into a stable daughter. The major radiations, energies (MeV), and frequencies are:

   β⁻: 3.92 max (7%), 3.10 max (5%), 1,60 max (88%)
   γ: 2.32 (34%), 1.50 (54%), 0.820 (49%)
   e⁻: 0.818, 0.805

   (a) Draw the decay scheme.
   (b) What is the maximum energy that the antineutrino can receive in this decay?
   (c) What is the value of the internal-conversion coefficient?
   (d) Estimate the L-shell electron binding energy of the daughter nuclide.
   (e) Would daughter x-rays be expected also? Why or why not?

3. (a) Calculate the Q value for K orbital-electron capture by the $^{37}_{18}Ar$ nucleus, neglecting the electron binding energy.
(b) Repeat (a), including the binding energy, 3.20 keV, of the K-shell electron in argon.
(c) What becomes of the energy released as a result of this reaction?

4. The activity of a radioisotope is found to decrease to 45% of its original value in 30 days.
   (a) What is the decay constant?
   (b) What is the half-life?

5. How long will it take for each of the following radioisotopes to decrease to 0.0001% of its initial activity?

   (a) ^{64} Copper
   (b) ^{41} Scandium
   (c) ^{99} Technetium
   (d) ^{99m} Technetium

6. A 6.2-mg sample of ^{90}Sr is in secular equilibrium with its daughter ^{90}Y.
      (a) How many Bq of ^{90}Sr are present?
      (b) How many Bq of ^{90}Y are present?
      (c) What is the mass of the ^{90}Y present?
      (d) What will the activity of the ^{90}Y be after 100 y?

7. Carbon-14 has a half-life of 5730 years.
      (a) If you start with one mole of ^{14}C and wait 1500 years, how much is left?
      (b) What would be the activity (Bq) of the ^{14}C sample at 1500 years?

8. Three rock samples are being dated by the ^{40}K/^{40}Ar method. The following data are obtained for the number of parent atoms (^{40}K) and daughter atoms (^{40}Ar) in each. What are the ages of rock samples A, B and C?

Sample	^{40}K atoms present	^{40}Ar atoms present
A	7497	1071
B	11480	3827
C	839	2517

9. Calculate the number of grams contained in a 1.0 Ci source of the following nuclides:
      (a) ^{18}F
      (b) ^{14}C
      (c) ^{222}Rn
      (d) ^{235}U

10. Assume that the equilibrium specific activity of ^{14}C is 15 Bq per gram total carbon. A sample of wood from an archaeological site is analyzed and found to contain a ^{14}C activity of 6.1 Bq/g. What is the date you would assign to this site? [You can ignore corrections to the ^{14}C/^{12}C ratio.]