Physics 222 CID _____

Homework 24

Score _____ / 30

1. (5 pts) Imagine that you have a chunk of radioactive material, and you plop it down in front of a Geiger counter. At time t=0 you measure a count rate of 102 decays per second. 30 days later you read a count rate of 38.7 counts per second. (a) What is the half-life of the material (in days)? (b) What will the count rate be at time t=50 days?

2. (6 pts) The book tells you that the mean lifetime $\bar{T}$ is equal to $1/\lambda$ without proof. But it is not hard to prove. (a) If I have N_0 of a particular type of nuclei with a decay constant λ at time $t = 0$, how many will decay from time t_a to t_b? (b) How many decay in a time dt? (c) Use this to calculate the mean lifetime. You should get $1/\lambda$.

3. (5 pts) From a tissue sample from a living elephant I find that the ratio of ^{14}C to ^{12}C only 1.02×10^{-12}. When I analyze the tissue of a mastodon which was found frozen in a glacier, I find that the ratio of ^{14}C to ^{12}C is 3.06×10^{-13}. How long ago did the mastodon die?

4. (4 pts) A $^{232}_{90}$Th nucleus, it is most likely to decay by α emission. (a) What is the daughter nucleus of this decay? (b) The next two steps in this series are β^- decays. What are the two daughters nuclei produced in these two steps? (c) Next comes an α decay. What daughter nucleus is produced?

5. (6 pts) Make a sketch similar to the one in figure 12.7 for the first part of the $^{232}_{90}$Th series which you studied in the last problem.

6. (4 pts) The longest-lived isotope of radon has a half-life of 3.824 days. So why is there still appreciable amounts of radon around?

Extra problems I recommend you work (not to be turned in)

- Neptunium-238 decays via β^- emission with a half life of 2.117 days. Plutonium-238 decays with a half life of 87.7 years. If I start with 10^{26} Neptunium-238 nuclei. How many Plutonium-238 nuclei will I have after (a) 4 days, (b) 40 years, (c) 100 years, and (d) 2000 years? What will the ratio of the number of Neptunium to Plutonium nuclei in my sample be after a very very long time?
- Calculate the (a) half-life and (b) mean lifetime of ^{226}Ra using the fact that 1 gram of radium has a disintegration rate of about 1 Ci. Give answers in years.

Useful Integrals

$$\int_0^\infty xe^{-x}dx = 1 \qquad \int_0^\infty x^2e^{-x}dx = 2 \qquad \int_0^\infty x^3e^{-x}dx = 6$$