NE-150 - Introduction to Nuclear Reactor Theory

Spring 2018

Homework 1 (Review)

Due February 6, 2018

1. What are the types of spontaneous decays of radionuclides? Give short description of each decay type. Is there a radioactive decay in which a neutron can be emitted (other than fission)?

2. The radioactive decay constant of ^{124}Sb is $1.33 \cdot 10^{-7}$ s^{-1}. How many years would be required for the activity of this isotope to decay to 0.1% of the initial value? How many half-lives does this represent?

3. How many grams of K are there in a 1 μCi source? (K natural composition: 93.26 atom% ^{39}K, 0.01 atom% ^{40}K, 6.73 atom% ^{41}K)

4. Name and complete the following reactions:
   (a) $^{16}_{8}O + n \rightarrow \ldots + p$
   (b) $^{238}_{92}U \rightarrow {}^{234}_{90}Th + \ldots$
   (c) $^{3}H \rightarrow \ldots + e^{-} + \overline{\nu}$
   (d) $^{240}_{94}Pu + n \rightarrow {}^{241}_{94}Pu + \ldots$

5. Determine the total binding energy and binding energy per nucleon for ^{11}B (mass = 11.009305 amu), ^{12}C and ^{14}N (mass = 14.003074 amu)).

6. The density of UO_2 is 10.41 g/cm^3. Uranium is enriched to 5 atom% in the isotope ^{235}U. Compute the atom densities of ^{235}U, ^{238}U and O.

7. Radio carbon dating is based on the absorption by living material of ^{14}C in the atmosphere, formed by cosmic rays. After death, absorption ceases and the ^{14}C decays. Estimate the age of a sample of wood found to have 75% of the ^{14}C concentration in living material.

8. Polonium-210 is alpha emitter with very high specific activity of 166500 TBq/kg (4500 Ci/g). Alpha particles energy is 5.3 MeV. How much energy in MeV and J will be deposited locally by one milligram of Po-210?

9. Which is the total energy released by a fission reaction (roughly)? Which is the average energy of neutrons born in a fission reaction?

10. The half-life of ^{238}U is about $4.5 \cdot 10^{9}$ years. The half-life of ^{235}U is about $7.1 \cdot 10^{8}$ years. Naturally-occurring uranium contains about 99.3 atom% ^{238}U and 0.7 atom% ^{235}U. Assuming no sources of either nuclide, what was the atomic fraction of ^{235}U 6 billion years ago? How long ago was the enrichment 4%?