

Problem 1

Neutrons are placed in a magnetic field with magnitude 2.30 T.

- What is the energy difference between the states with the nuclear spin angular momentum components parallel and antiparallel to the field?
- Which state is lower in energy: the one with its spin component parallel to the field or the one with its spin component antiparallel to the field?
- The neutrons can make transitions from one of these states to the other by emitting or absorbing a photon with energy equal to the energy difference of the two states. Find the frequency and wavelength of such a photon.

Problem 2

The most common isotope of uranium ${}^{238}_{92}\text{U}$, has atomic mass 238.050783 u.

- Calculate the mass defect.
- Determine the binding energy (in MeV).
- Determine the binding energy per nucleon.

Problem 3

- Calculate the total binding energy of ${}^{12}_6\text{C}$.
- Calculate the binding energy per nucleon.
- What percent of the rest mass of this nucleus is its total binding energy?

Problem 4

The atomic mass of ${}^{14}_6\text{C}$ is 14.003242 u. Show that the β^- decay of ${}^{14}_6\text{C}$ is energetically possible, and calculate the energy released in the decay.

Problem 5

- Calculate the energy released by the electron-capture decay of ${}^{57}_{27}\text{Co}$.
- A negligible amount of this energy goes to the resulting atom ${}^{57}_{26}\text{Fe}$ as kinetic energy. About 90% of the time, the ${}^{57}_{26}\text{Fe}$ nucleus emits two successive gamma-ray photons after the electron-capture process, of energies 0.122 MeV and 0.014 MeV respectively, in decaying to its ground state. What is the energy of the neutrino emitted in this case?

Problem 6

The isotope ${}^{226}_{88}\text{Ra}$ undergoes α decay with a half life of 1620 years. What is the activity of 1.00 g of ${}^{226}_{88}\text{Ra}$? Express your answer in Bq and in Ci.

Problem 7

A 12.0 g sample of carbon from living matter decays at the rate of 180.0 decays/min due to the radioactive ${}^{14}_6\text{C}$ in it. What will be the decay rate of this sample in 1000 years? Note that the half life is 5730 yr.

Problem 8

A person exposed to fast neutrons receives a radiation dose of 200 rem on part of his hand, affecting 25 g of tissue. The RBE of these neutrons is 10.

- How many rad did he receive?
- How many joules of energy did this person receive?
- Suppose the person received the same rad dosage, but from beta rays with an RBE of 1.0 instead of neutrons. How many rem would he have received?

Problem 9

The second reaction in the proton-proton chain produces a ${}^3_2\text{He}$ nucleus. A nucleus produced in this way can combine with a ${}^4_2\text{He}$ nucleus, ${}^3_2\text{He} + {}^4_2\text{He} \rightarrow {}^7_4\text{Be} + \gamma$. Calculate the energy liberated in this process. (This is shared between the energy of the photon and the recoil kinetic energy of the beryllium nucleus.) The mass of a ${}^7_4\text{Be}$ atom is 7.016929 u.

Problem 10

Consider the nuclear reaction, ${}^4_2\text{He} + {}^7_3\text{Li} \rightarrow X + {}^1_0\text{n}$, where X is a nuclide. What are Z and A for the nuclide X?

Problem 11

The nucleus ${}^{15}_8\text{O}$ has a half life of 122.2 s. ${}^{19}_8\text{O}$ has a half life of 26.9 s. If at some time a sample contains equal amounts of ${}^{15}_8\text{O}$ and ${}^{19}_8\text{O}$, what is the ratio of ${}^{15}_8\text{O}$ to ${}^{19}_8\text{O}$ after 5.00 minutes?

Problem 12

A bone fragment found in a cave believed to have been inhabited by early humans contains 0.29 times as much ${}^{14}_6\text{C}$ as an equal amount of carbon in the atmosphere when the organism containing the bone died. Find the approximate age of the fragment.