tutorial #14 [nuclear physics and radioactivity].quiz

1) Two isotopes of a certain element have binding energies that differ by 5.03 MeV. The isotope with the larger binding energy contains one more neutron than the other isotope. Find the difference in atomic mass between the two isotopes.\[ (\Delta m_1 - \Delta m_2)^2 = 5.03 \text{ MeV} \]
\[ \Delta m_1 = (Z \text{mp} + Z n_n - Z n_1) \]
\[ \Delta m_2 = (Z \text{mp} + Z n_n - Z n_2) \]
\[ \rightarrow (m_1 - m_2)^2 = 5.03 \text{ MeV} \rightarrow m_1 - m_2 = m_n - (5.03 \text{ MeV})/c^2 \]
\[ = \frac{1.008665 \text{ u}}{931.5 \text{ MeV/uc}} \]

2) Radon $^{222}$Rn produces a daughter nucleus that is radioactive. The daughter, in turn, produces its own radioactive daughter, and so on. This process continues until lead $^{208}$Pb is reached. What are the total number $N_\alpha$ of $\alpha$ particles and the total number $N_\beta$ of $\beta^-$ particles that are generated in this series of radioactive decays? Assume that there is no $\beta^+$ particle generated.

3) The number of radioactive nuclei present at the start of an experiment is $4.60 \times 10^{15}$. The number present twenty days later is $8.14 \times 10^{14}$. What is the half-life (in days) of the nuclei?

$$N_t = N_0 e^{-\lambda t}$$

$$t = 20 \text{ days}; \quad N = 8.14 \times 10^{14} = N_0 e^{-\lambda \cdot 20 \text{ days}} \quad \Rightarrow \quad \ln \frac{N}{N_0} = -\lambda \cdot 20 \text{ days} \quad \Rightarrow \quad \lambda = \frac{1}{20 \text{ days}} \ln \frac{N_0}{N}$$

$$\frac{T_1}{2} = \frac{\ln 2}{\lambda} = \ln 2 \cdot 20 \text{ days} \cdot \frac{1}{\ln \frac{N_0}{N}} = 8.0 \text{ days}.$$