Set of Exercises - 02

Chapter 02: Radioactivity

Useful data: $1uc^2 = 931.5[MeV]$; $m_p = 1.0073u$; $m_n = 1.0087u$

Exercise 01:

The helium isotope $^{6}_{2}He$ is unstable. If you know that instability is due to high neutrons energy level, what kind of decay would you expect it to undergo and what is the end product of this decay?

Exercise 02:

The activity of a sample of $^{55}_{24}Cr$ at the end of 5-min intervals is found to be 19.2, 7.13, 2.65, 2.65, 0.99, and 0.37 mCi.

What is the half-life of $^{55}_{24}Cr$?

Exercise 03:

1. How long does it take for 60 % of a sample of radon $^{222}_{86}Rn$ to decay? ($T_{1/2} = 3.82\ days$)
2. Find the activity of 1 mg of radon ($M = 222u$)
3. What will the activity of this radon sample be exactly one week later?

Exercise 04:

Calculate the activity of 1. Gram of radium $^{226}_{86}Ra$, whose half-life is 1622 years.

Exercise 05:

The atomic ratio between the uranium isotopes $^{238}_{92}U$ and $^{234}_{92}U$ in a mineral sample is found to be 1.8×10^4. The half-life of $^{234}_{92}U$ is: $T_{1/2} = 2.5 \times 10^5\ y$. Find the half-life of $^{238}_{92}U$.

Exercise 06:

The polonium isotope $^{210}_{84}Po$ is unstable and emits a 5.30 MeV alpha particle. The atomic mass of $^{210}_{84}Po$ is 209.9829 u and that of $^{4}_{2}He$ is 4.0026 u. Identify the daughter nuclide and find its atomic mass.

Exercise 07:

A free neutron is an instable particle with a half-life of 12.8 min. Over what distance in free space will the intensity of a 5eV neutron beam be reduced by a factor of one-half?

Exercise 08:

How much time is required for 5mg of $^{22}_{11}Na$ $(T_{1/2} = 2.6y)$ to reduce to 1mg?

Exercise 09:

In terms of the parent and daughter rest masses, determine the Q-values for β^-, β^+ and $E.C$.

Exercise 10:

Determine the energy of an antineutrino to produce the reaction:

$$\bar{\nu} + p \rightarrow n + e^+$$

Exercise 11:

A piece of wood from the ruins of an ancient dwelling was found to have a $^{14}_{6}C$ activity of 13 disintegrations per minute per gram of its carbon content. The $^{14}_{6}C$ activity of living wood is 16 disintegrations per minute per gram.

How long ago did the tree die from which the wood sample came? ($T_{1/2} = 5670\ y$)

Exercise 12:

The isotope $^{20}_{9}F$ decays to the ground state of $^{20}_{10}Ne$ as follows:

$$^{20}_{9}\mathrm{F} \rightarrow (^{20}_{10}\mathrm{Ne})^{*} + e^{-} + \bar{\nu}$$
$$\hookrightarrow {}^{20}_{10}\mathrm{Ne} + \gamma$$

Where $(^{20}_{10}Ne)^*$ is an excited state of $^{20}_{10}Ne$. If the maximum kinetic energy of the emitted electrons is 5.4MeVand the γ-rays energy is 1.6MeV, determine the mass of $^{20}_{9}F$. ($M_{Ne} = 19.992u$)