Modern physics Chapter 11-12. Solutions to Exercises.

11.1.1 After one half-life there are ½ of the nuclei left. After still one half-life there are ¼ left, after still one half-life there are 1/8 left and finally after on more there are 1/16 left. We have totally 4 half-lives, which means 4 x 0.30 μs = 1.2 μs.

11.1.2 The number of nuclei in 1.0 g of Po is $N = \frac{1}{226} \times 6.026 \times 10^{23} = 2.26 \times 10^{21}$ nuclei.

11.1.3 The activity of a radioactive substance is given by $R = \lambda N$. The decay constant λ can be written as a function of the half-life as $\lambda = ln2/T_{1/2}$.

$$R = \lambda N = \frac{\ln 2}{T_{1/2}} N = \frac{\ln 2}{1620 \times 365 \times 24 \times 3600} 2.26 \times 10^{21} \approx 37 \times 10^{10}$$ decays per second.

This was earlier the unit for activity, i.e. 1 Ci = 1 Curie

11.1.4 Measured activity $R = 735/60$ decay/s. $R = (ln2/T_{1/2})N$ where $N = \frac{m}{M} N_0$

The half-life: $T_{1/2} = \frac{\ln 2}{R} \times \frac{m}{M} N_0 = \frac{\ln 2}{735/60} \times \frac{1.0 \times 10^{-3}}{238} \times 6.023 \times 10^{23} s \approx$ 4,5x10^9 ears

(We have divided by 365x24x60x60 s/year)

11.2.1 M_{Po210}= 209. 982 876 u. M_{Pb206} = 205. 974 455 u. m_{He4} = 4.00260 u.
Q-value is given by: $Q = M_{Po210} c^2 - (M_{Pb206} c^2 + m_{He4}c^2) - K =$
(209. 982 876 – 205. 974 455 – 4.00260) x 931.4 – 5.3 MeV =
O.005821x931.4 MeV – 5.3 MeV = 5.4216794 – 5.3 MeV =
0.122 MeV

11.3.1 $m_n = m_p + m_e + \frac{E_{K\max}}{c_2} = M_H + \frac{E_{K\max}}{c_2} =$
1.007825 + (0.782 MeV)(1/931.5 u/MeV) = 1.008665 u

11.4.1 The power $P = n \; x \; hf = N\lambda \; hf =$

$$\frac{1}{60} \times 6.023 \times 10^{23} \frac{\ln 2 \times (1.173 + 1.333)}{5.3 \times 365 \times 24 \times 3600} 0.99 MeV/c \approx 16.5W$$

11.4.2 The activity/g = S = 0.415 decay/(minutes,g). We get the equation $0.415 = 14 \times e^{-0.693t/5730}$. Take the logarithm and we gets $t = 2.91x10^4$ years.

11.5.1 The reaction becomes: $^2H + ^3H \rightarrow ^4He + ^1n$
$Q = (M_{before} - M_{after}) c^2 =$
(3.016 050 + 2.014 102 – 4.002 603 – 1.008 665)x931.5 MeV =
17.6MeV

11.6.1 The reaction becomes: $^{235}U + ^1n \rightarrow ^{236}U$
$Q = (M_{before} - M_{after}) c^2$ = *(235.1170 + 1.008 665 – 236.1191) x 931.5 MeV =*
= 6.1153 MeV. The potential barrier is only *5.3 MeV* why it is enough with slow thermal neutrons.