Solution-12

Q1. The isotope carbon-14, C_6^{14}, is radioactive and has a half-life of 5730 years. If you start with a sample of 1000 carbon-14 nuclei, how many nuclei will still be undecayed in 25000 years?

$$n = \frac{25\,000 \text{ yr}}{5\,730 \text{ yr}} = 4.363$$

$$N = N_0\left(\tfrac{1}{2}\right)^n = 1\,000\left(\tfrac{1}{2}\right)^{4.363} = \boxed{49}$$

What time interval is required for the activity of a sample of the radioactive isotope $^{72}_{33}\text{As}$ to decrease by 90.0% from its original value? The half-life of $^{72}_{33}\text{As}$ is 26 h.

We use Equation 44.7 for the exponential decay rate of the sample, $R = R_0 e^{-\lambda t}$, where

$$\lambda = \frac{\ln 2}{26.0 \text{ h}} = 0.026\ 7 \text{ h}^{-1}$$

Since we require a 90% decrease in activity,

$$\frac{R}{R_0} = 0.100 = e^{-\lambda t} \quad \rightarrow \quad \ln(0.100) = -\lambda t$$

$$t = \frac{2.30}{0.026\ 7/\text{h}} = \boxed{86.4 \text{ h}}$$

22.3. Nuclear waste from power plants may contain ^{239}Pu, a plutonium isotope with a half-life of 24000 years. How long does it take for the stored waste to decay to 10% of its current activity level?

$A(t) = A_0 e^{-\lambda t} = A_0/10$ and $\lambda = \ln(2)/T_{1/2}$

$t = (\ln(10)/\ln(2)) \times T_{1/2}$

$t = 79726$ years

22.12. The activity of a radioisotope is found to decrease by 40% of its original value in 20 days. (a) Calculate the decay constant. (b) What is the half-life?

a) $A(t) = A_0 e^{-\lambda t}$ at $t = 20$ days, $A(t) = (6/10) \times A_0$

$\lambda = \ln(10/6)/t$

$\lambda = 2.95 \times 10^{-7}\ s^{-1}$

b) $T_{1/2} = \ln(2)/\lambda = 27.18$ days