

Chapter 38 Problem 27 †

Given

$$t_{1/2} = 29 \text{ years}$$

Solution

a) Find the time for 99% of the strontium-90 to decay.

The rate of radioactive decay is calculated using the equation

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

Taking this equation and solving for time gives

$$\frac{N}{N_0} = e^{-\lambda t}$$

$$\ln\left(\frac{N}{N_0}\right) = -\lambda t$$

$$t = \frac{-1}{\lambda} \ln\left(\frac{N}{N_0}\right)$$

The relationship between half-life and the decay constant is

$$t_{1/2} = \frac{\ln 2}{\lambda}$$

Solving for the decay constant gives

$$\lambda = \frac{\ln 2}{t_{1/2}}$$

$$\lambda = \frac{\ln 2}{29 \text{ yr}} = 0.0239 \text{ yr}^{-1}$$

When 99% of the strontium-90 is decayed the ratio of present amount, N , to original amount, N_0 , is 0.01. The time for 99% decay is then

$$t = \frac{-1}{0.0239 \text{ yr}^{-1}} \ln(0.01) = 193 \text{ yr}$$

b) Find the time for 99.9% of the strontium-90 to decay.

Using the same development as part a, use a ratio of $N/N_0 = 0.001$.

$$t = \frac{-1}{0.0239 \text{ yr}^{-1}} \ln(0.001) = 289 \text{ yr}$$

†Problem from Essential University Physics, Wolfson