830.

Problem 54.32 (RHK)

A 1.00-g *sample of samarium emits* α *particles at a rate of* 120 *particles per second.* $^{147}\mathrm{Sm}$, *whose natural abundance in bulk samarium is* 15.0%, *is the responsible isotope. We have to calculate the half-life of this isotope.*

Solution:

The molar mass of samarium, $\mathrm{M_{Sa}} = 150.35\ \mathrm{g\ mol^{-1}}$.

Therefore, the number of atoms in 1.00 g sample of samarium will be $6.02\times10^{23}/150.35 = 4.00\times10^{21}$.

It is given that the natural abundance of $^{147}\mathrm{Sm}$ in bulk samarium is 15.0%.

Therefore, 1.00 g of natural samarium will contain $6.0\times10^{20}\ {}^{147}\mathrm{Sm}$ nuclides. As the observed decay rate of α particles in 1.00 g of samarium is 120 per second, the decay constant of $^{147}\mathrm{Sm}$ will be

$$\lambda = \frac{120}{6.00\times10^{20}}\ \mathrm{s^{-1}} = 2.0\times10^{-19}\ \mathrm{s^{-1}}.$$

The half-life of α particle decay of $^{147}\mathrm{Sm}$ will therefore be $t_{1/2} = \left(\ln 2 / 2.0\times10^{-19}\right)\ \mathrm{s} = 3.46\times10^{18}\ \mathrm{s}$.

As $1\ \mathrm{y} = 3.156\times10^{7}\ \mathrm{s}$, the half-life of α particle decay of $^{147}\mathrm{Sm}$ will be $1.09\times10^{11}\ \mathrm{y}$.