

836.

Problem 43.63E (HRW)

A 5.00 g charcoal sample from an ancient fire pit has a ^{14}C activity of 63.0 disintegrations per minute. A living tree has a ^{14}C activity of 15.3 disintegrations per minute per gram. The half-life of ^{14}C is 5730 y. We have to find how old the charcoal sample is.

Solution:



Let N_0 be the number of ^{14}C nuclides in a 5.00 g piece of wood before it became a piece of charcoal.

A living tree has a ^{14}C activity of 15.3 disintegrations per minute per gram. Therefore, the activity in 5.00 g piece of wood at time t earlier would have been

$$R_0 = 15.3 \times 5 \text{ disintegrations per minute.}$$

The present activity measured in the piece of charcoal, $R(t)$, is 63.0 disintegrations per minute.

We know that variation of disintegration rates with time is given as

$$R(t) = R_0 e^{-\lambda t}.$$

We therefore note that

$$-\lambda t = \ln\left(\frac{R(t)}{R_0}\right) = \ln\left(\frac{63.0}{15.3 \times 5}\right) = -0.194,$$

or

$$t = \frac{0.194}{\lambda}.$$

The half-life of ^{14}C is 5730 y. Its disintegration constant will be

$$\lambda = \frac{\ln 2}{5730 \text{ y}} = 1.209 \times 10^{-4} \text{ y}^{-1}.$$

Therefore, the age of the piece of charcoal will be

$$t = \frac{0.194}{1.209 \times 10^{-4}} \text{ y} = 1606 \text{ y}.$$

