

Answer on Question #49457-Physics-Nuclear Physics

Radioactive isotopes used in cancer therapy have a "shelf- life," like pharmaceuticals used in chemotherapy. Just after it has been manufactured in a nuclear reactor, the activity of a sample of ^{60}Co is 5000 Ci. When its activity falls below 3500 Ci, it is considered too weak a source to use in treatment. You work in the radiology department of a large hospital. One of these ^{60}Co sources in your inventory was manufactured on October 6, 2004. It is now April 6, 2007. Is the source still usable? The half-life of ^{60}Co is 5.271 years.

a) What is the mass of the source when it was manufactured?

b) Is this source still useable?

Solution

a) The number of isotopes was

$$N_0 = \frac{\frac{dN}{dt}}{\lambda} = \frac{\frac{dN}{dt} T_{1/2}}{\ln 2}.$$

The mass of the source when it was manufactured was

$$\begin{aligned} m = M_{^{60}\text{Co}} N_0 &= \frac{5000 \cdot 3.7 \cdot 10^{10} \text{ nuclei} \cdot \text{s}^{-1} \cdot 5.271 \cdot 31557600 \text{ s}}{\ln 2} \cdot \left(60 \cdot 1.66 \cdot 10^{-27} \frac{\text{kg}}{\text{nucleos}} \right) \\ &= 4.4 \cdot 10^{-3} \text{ kg} = 4.4 \text{ g}. \end{aligned}$$

b) The activity is

$$\frac{dN}{dt} = \lambda N.$$

Therefore

$$\frac{\frac{dN}{dt}}{\frac{dN_0}{dt}} = \frac{N}{N_0}.$$

$$N = N_0 2^{-\frac{t}{T_{1/2}}}.$$

The amount of elapsed time since the source was created is roughly 2.5 years. Thus, we expect the current activity to be

$$N = (5000 \text{ Ci}) 2^{-\frac{2.5 \text{ yr}}{5.271 \text{ yr}}} = 3600 \text{ Ci}.$$

The source is barely usable.