Answer on Question #49453-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 60co 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 60co 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 60co 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

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

The mass of the source when it was manufactured was

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

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

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

The source is barely usable.