Answer on Question 63530, Physics, Atomic and Nuclear Physics

Question:

Calculate how long it would take for the following to decay to an activity of 1 becquerel (Bq).

1) A sample of cobalt-60 (half-life - 5.27 years) whose original activity is 64 Bq.

2) A sample of iodine-131 (half-life - 8 days) whose original activity is 128 Bq.

3) A sample of polonium -210 (half-life - 138 days) whose original activity falls is 32 Bq.

Solution:

Let's use the famous formula for radioactive decay:

$$A = A_0 e^{-\lambda t},$$

here, A_0 is the original activity of the radioactive sample at time $t = 0$, A is the activity of the radioactive sample at time t, $\lambda = \frac{0.693}{T_{1/2}}$ is the decay constant, $T_{1/2}$ is the half-life of the radioactive sample, t is the time we are searching for.

From this formula we can find how long it would take for the following radioactive samples (cobalt-60, iodine-131, polonium-210) to decay to an activity of 1 Bq:

$$\frac{A}{A_0} = e^{-\lambda t},$$

$$\ln\left(\frac{A}{A_0}\right) = \ln\left(e^{-\lambda t}\right),$$

$$\ln\left(\frac{A}{A_0}\right) = -\frac{0.693}{T_{1/2}} t,$$

$$t = \left[\frac{\ln\left(\frac{A}{A_0}\right)}{(-0.693)}\right] T_{1/2}.$$

1) For the sample of cobalt-60:

$$t = \left[\frac{\ln\left(\frac{A}{A_0}\right)}{(-0.693)}\right] T_{1/2} = \left[\frac{\ln\left(\frac{1\ Bq}{64\ Bq}\right)}{(-0.693)}\right] \cdot 5.27\ years = 31.6\ years.$$

2) For the sample of iodine-131:

$$t = \left[\frac{\ln\left(\frac{A}{A_0}\right)}{(-0.693)}\right] T_{1/2} = \left[\frac{\ln\left(\frac{1\ Bq}{128\ Bq}\right)}{(-0.693)}\right] \cdot 8\ days = 56\ days.$$

3) For the sample of polonium-210:

$$t = \left[\frac{\ln\left(\frac{A}{A_0}\right)}{(-0.693)}\right] T_{1/2} = \left[\frac{\ln\left(\frac{1\ Bq}{32\ Bq}\right)}{(-0.693)}\right] \cdot 138\ days = 690\ days.$$

Answer:

1) $t = 31.6\ years.$

2) $t = 56\ days.$

3) $t = 690\ days.$