Marks 3

How long does it take 1.0 g of ^{231}Th to decay to the same activity as 1.0 g of ^{232}Th?

The half life of ^{231}Th is *very* short compared to that of ^{232}Th. *All* of the ^{231}Th will decay to ^{231}Pa in the time it takes for the ^{231}Th decay. Thus, the activity of 1.0 g of ^{231}Th will actually correspond to the activity of ^{231}Pa.

From 2010-J-4, the activity of 1.0 g of ^{232}Th is 4.1 × 10^3 Bq and the activity of 1.0 g of ^{231}Pa is 1.8 × 10^9 Bq. The time, *t*, it takes for the activity of ^{231}Pa to fall from 1.8 × 10^9 (A_0) to 4.1 × 10^3 Bq (A_t) needs to be calculated.

The number of nuclei varies with time according to $\ln(N_0/N_t) = \lambda t$. As activity is directly proportional to the number of nuclei, this can be rewritten in terms of activities:

$$\ln(A_0/A_t) = \lambda t = (\ln 2/t_{1/2}) \times t$$

Thus,

$$\ln(1.8 \times 10^9 / 4.1 \times 10^3) = \ln 2/(3.27 \times 10^4 \times 365.25 \times 60 \times 60 \text{ s}) \times t$$

$$t = 1.93 \times 10^{13} \text{ s} = 6.1 \times 10^5 \text{ years}$$

Answer: **6.1 × 10^5 years**