What are the specific activities of ^{90}Sr and ^{137}Cs in Bq g^{-1}?

Marks 8

For ^{90}Sr, the activity coefficient is given by

$\lambda = \ln 2 / t_{1/2} = \ln 2 / (28.9 \times 365 \times 24 \times 60 \times 60)\ s^{-1} = 7.61 \times 10^{-10}\ s^{-1}$

The number of nuclei, *N*, in a gram is

$N = (6.022 \times 10^{23} / 90) = 6.69 \times 10^{21}$

Hence, the activity, *A*, is

$A = \lambda N = (7.61 \times 10^{-10}) \times (6.69 \times 10^{21})\ Bq\ g^{-1} = 5.09 \times 10^{12}\ Bq\ g^{-1}$

For ^{137}Sr, the activity coefficient is given by

$\lambda = \ln 2 / t_{1/2} = \ln 2 / (30.23 \times 365 \times 24 \times 60 \times 60)\ s^{-1} = 7.271 \times 10^{-10}\ s^{-1}$

The number of nuclei, *N*, in a gram is

$N = (6.022 \times 10^{23} / 137) = 4.40 \times 10^{21}$

Hence, the activity, *A*, is

$A = \lambda N = (7.271 \times 10^{-10}) \times (4.40 \times 10^{21})\ Bq\ g^{-1} = 3.19 \times 10^{12}\ Bq\ g^{-1}$

^{90}Sr: **5.09×10^{12} Bq g^{-1}**	^{137}Cs: **3.19×10^{12} Bq g^{-1}**

Assuming the majority of the activity of a spent fuel rod to be due to these nuclides, what will be the activity of a 1 tonne fuel rod 100 years after placing it in the pond?

As ^{90}Sr represents 0.05% of the mass (from 2012-J-4) and has an activity of 5.09 × 10^{12} Bq g^{-1} (from above), its initial activity, A_0, is

$A_0 = (1 \times 10^6) \times (5.09 \times 10^{12}) \times (0.05 / 100)\ Bq$

Activity decays with time according to

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

Hence

$A_t = (1 \times 10^6) \times (5.09 \times 10^{12}) \times (0.05 / 100) \exp(-100 \times \ln 2 / 28.9)\ Bq$
$= 2.3 \times 10^{14}\ Bq$

As ^{137}Cs represents 0.11% of the mass (from 2012-J-4) and has an activity of 3.19 × 10^{12} Bq g^{-1} (from above), its initial activity, A_0, is

$A_0 = (1 \times 10^6) \times (3.19 \times 10^{12}) \times (0.11 / 100)\ Bq$

Hence

$A_t = (1 \times 10^6) \times (3.19 \times 10^{12}) \times (0.11 / 100) \exp(-100 \times \ln 2 / 30.23)\ Bq$
$= 3.5 \times 10^{14}\ Bq$

The total activity is therefore $(2.3 \times 10^{14} + 3.5 \times 10^{14})\ Bq = 6 \times 10^{14}\ Bq$

Answer: **6×10^{14} Bq**