Marks 8

- Calculate the activity (in Bq) of a 1.00 g sample of $^{137}Cs^{131}I$, if the half lives of the caesium and iodine are 30.17 years and 8.02 days respectively.

**The molar mass of $^{137}Cs^{131}I$ is (137 + 131) g mol$^{-1}$ = 268 g mol$^{-1}$. As each mole of $^{137}Cs^{131}I$ contains one mole of $^{137}Cs$ and one moles of $^{131}I$:**

**number of moles of $^{137}Cs$ = number of moles of $^{131}I$ = mass / molar mass**
**= 1.00 g / 268 g mol$^{-1}$ = 0.00373 mol**

**Each mole contains Avogadro's number of nuclei so:**

**number of nuclei of $^{137}Cs$ = number of nuclei of $^{131}I$ = number of moles × $N_A$**
**= 0.00373 mol × 6.022 × 10$^{23}$ mol$^{-1}$**
**= 2.25 × 10$^{25}$**

**The activity coefficient, $\lambda$, is related to the half life, $t_{1/2}$, through $\lambda = \ln 2 / t_{1/2}$. Hence:**

**$\lambda$ ($^{137}Cs$) = ln 2 / (30.17 × 365 × 24 × 60 × 60 s) = 7.28 × 10$^{-10}$ s$^{-1}$**
**$\lambda$ ($^{131}I$) = ln 2 / (8.02 × 24 × 60 × 60 s) = 1.00 × 10$^{-6}$ s$^{-1}$**

**The activity, $A$, is related to the number of nuclei, $N$, through $A = \lambda N$ and so:**

**$A$ ($^{137}Cs$) = (7.28 × 10$^{-10}$ s$^{-1}$) × (2.25 × 10$^{25}$ nuclei) = 1.64 × 10$^{12}$ Bq**
**$A$ ($^{131}I$) = (1.00 × 10$^{-6}$ s$^{-1}$) × (2.25 × 10$^{25}$ nuclei) = 2.25 × 10$^{15}$ Bq**

**As might have been anticipated from the relative sizes of the half lives, the activity is completely dominated by $^{131}I$:**

**Overall activity = $A$ ($^{137}Cs$) + $A$ ($^{131}I$) = 2.25 × 10$^{15}$ Bq**

Answer: **2.25 × 10$^{15}$ Bq**

Both nuclides in $^{137}Cs^{131}I$ are beta emitters, and the daughter nuclides are stable. Describe the sample after it has been melted and allowed to resolidify after (a) 3 months and (b) 300 years.

**The products formed by beta emission are:**

$$^{137}_{55}Cs \rightarrow {}^{137}_{56}Ba + {}^{0}_{-1}\beta \qquad {}^{131}_{53}I \rightarrow {}^{131}_{54}Xe + {}^{0}_{-1}\beta$$

**The $^{131}I$ decays to $^{131}Xe$ which, being a gas, escapes on melting.**

**(a) As the half life of $^{131}I$ is only 8.02 days, after 3 months most of it will have decayed. As the half life of $^{137}Cs$ is 30.17 years, after 3 months little will have decay. The sample will be mainly $^{137}Cs$ with a little $^{137}Ba$.**

**(b) After 300 years, the sample will be mainly $^{137}Ba$ with a little bit of $^{137}Cs$ remaining.**