

(8.5) An acid solution of fresh fission products contains 0.8 g l⁻¹ cerium as Ce⁴⁺. The γ -flux in the solution corresponds to 520 GBq l⁻¹ of an average energy of 0.7 MeV. If half of the flux is absorbed in the solution, what fraction of cerium is reduced to Ce³⁺ in 24 h? Assume the same G-value as in Figure 8.7.

As one reference value we can use the 0.66 MeV LET value in water (0.39 keV/ μ m) for ¹³⁷Cs in Table 7.2. Other data are available for ⁶⁰Co; 1.2-1.3 MeV. Use these values in a simple interpolation.

Begin as usual with some unit definitions:

$$\begin{aligned} eV &:= 1.60217733 \cdot 10^{-19} \cdot \text{joule} & keV &:= 1000 \cdot eV & MeV &:= 1000 \cdot keV \\ \mu m &:= 10^{-6} \cdot m & \text{Å} &:= 10^{-8} \cdot cm & Bq &:= sec^{-1} \end{aligned}$$

Then the LET value at 0.7 MeV has to be calculated as follows:

$$\begin{aligned} LET_{Cs} &:= 0.39 \cdot keV \cdot \mu m^{-1} & LET_{Cs} &= 6.248 \cdot 10^{-11} \cdot \text{joule} \cdot m^{-1} \\ LET_{Co} &:= 0.27 \cdot keV \cdot \mu m^{-1} & LET_{Co} &= 4.326 \cdot 10^{-11} \cdot \text{joule} \cdot m^{-1} & (E_{\text{mean}} = 1.25 \text{ MeV}) \end{aligned}$$

$$LET_{0.7} := LET_{Cs} + (LET_{Co} - LET_{Cs}) \cdot \frac{0.7 - 0.66}{1.25 - 0.66} \quad (\text{linear interpolation})$$

$$LET_{0.7} = 6.118 \cdot 10^{-11} \cdot \text{joule} \cdot m^{-1} \quad \text{This corresponds to:} \quad G := 2.5 \cdot 10^{-7} \cdot \frac{\text{mole}}{\text{joule}}$$

However, only 50% (i.e. 1/2) of the energy (0.7 MeV) is absorbed in the solution.

$$A := 520 \cdot 10^9 \cdot Bq \cdot \text{liter}^{-1} \quad E_{\gamma} := 0.7 \cdot MeV \quad M := \frac{\text{mole}}{\text{liter}} \quad (\text{definition of } M)$$

$$P := A \cdot \frac{E_{\gamma}}{2} \quad P = 0.029 \cdot \frac{\text{watt}}{\text{liter}} \quad dCdt := P \cdot G \quad \text{mole/sec}$$

$$C_0 := \frac{0.8 \cdot \frac{\text{gm}}{\text{liter}}}{140.12 \cdot \frac{\text{gm}}{\text{mole}}} \quad C_0 = 0.006 \cdot M$$

$$t := 24 \cdot \text{hr} \quad dC := dCdt \cdot t \quad \text{fraction} := \frac{dC}{C_0} \quad \text{fraction} = 0.11 \quad (11\%)$$