(7.5) An acid solution of fresh fission products contains 0.8 g l^{-1} cerium as Ce^{4+}. 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 Ce^{3+} in 24 h? Assume the same *G*-value as in Figure 7.7.

As one reference value we can use the 0.66 MeV LET value in water (0.39 keV/μm) for ^{137}Cs in Table 6.2. Other data are available for ^{60}Co; 1.2-1.3 MeV. Use these values in a simple interpolation.

Begin as usual with some unit definitions:

$eV := 1.60217733 \cdot 10^{-19} \cdot joule$ $\quad keV := 1000 \cdot eV$ $\quad MeV := 1000 \cdot keV$

$\mu m := 10^{-6} \cdot m$ $\quad Å := 10^{-8} \cdot cm$ $\quad Bq := sec^{-1}$

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

$LET_{Cs} := 0.39 \cdot keV \cdot \mu m^{-1}$ $\quad LET_{Cs} = 6.248 \cdot 10^{-11} \cdot joule \cdot m^{-1}$

$LET_{Co} := 0.27 \cdot keV \cdot \mu m^{-1}$ $\quad LET_{Co} = 4.326 \cdot 10^{-11} \cdot joule \cdot m^{-1}$ $\quad (E_{mean} = 1.25\ MeV)$

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

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

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

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

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

$$C_0 := \frac{0.8 \cdot \frac{gm}{liter}}{140.12 \cdot \frac{gm}{mole}} \qquad C_0 = 5.709 \cdot 10^{-3} \cdot M$$

$t := 24 \cdot hr$ $\quad dC := dCdt \cdot t$ $\quad fraction := \frac{dC}{C_0}$ $\quad fraction = 0.11$

or

$fraction = 11 \cdot \%$