(8.3) A freshly prepared small source of ^{24}Ne had a measured decay rate of 1 GBq 1 s after its preparation. The source is shielded by 10 cm of Pb. ^{24}Ne emits γ-rays; 8% with 0.878 MeV and 100% with 0.478 MeV. Estimate the total integrated dose received at 2 m distance during its life-time after preparation. Neglect build-up factors.

$Bq := sec^{-1}$ $\quad Gy := joule \cdot kg^{-1}$

$t_{half} := 3.38 \cdot min$ $\quad t_0 := 1 \cdot sec$ $\quad R_1 := 1 \cdot 10^9 \cdot Bq$

$\lambda := \frac{ln(2)}{t_{half}}$ $\quad R_0 := R_1 \cdot exp(t_0 \cdot \lambda)$ Bq at t=0 $\quad R_0 = 1.003 \cdot 10^9 \cdot Bq$ at t=0

$\rho := 11.34 \cdot gm \cdot cm^{-3}$ $\quad d := 10 \cdot cm$ $\quad x := 2 \cdot m$

$\mu_{m1} := 0.075 \cdot cm^2 \cdot gm^{-1}$ $\quad \mu_1 := \mu_{m1} \cdot \rho$ $\quad I_1 := 8 \cdot \%$ For the 0.878 MeV γ-rays

$\mu_{m2} := 0.16 \cdot cm^2 \cdot gm^{-1}$ $\quad \mu_2 := \mu_{m2} \cdot \rho$ $\quad I_2 := 100 \cdot \%$ For the 0.478 MeV γ-rays

$k_1 := 3.2 \cdot 10^{-18} \cdot Gy \cdot m^2 \cdot Bq^{-1} \cdot sec^{-1}$ From Fig. 8.2 for 0.878 MeV

$k_2 := 2.7 \cdot 10^{-18} \cdot Gy \cdot m^2 \cdot Bq^{-1} \cdot sec^{-1}$ From Fig. 8.2 for 0.478 MeV

$D_{rate} := \left(I_1 \cdot exp(-\mu_1 \cdot d) \cdot k_1 + I_2 \cdot exp(-\mu_2 \cdot d) \cdot k_2\right) \cdot \left(\frac{1}{x^2}\right) \cdot R_0$ Gy/s

We can calculate the number of decays in two ways:

First by integrating over time (100000 seconds is practically infinity)

$D_{cy} := \int_{0 \cdot sec}^{100000 \cdot sec} exp(-\lambda \cdot t)\, dt$ $\quad D := D_{rate} \cdot D_{cy}$ $\quad D = 3.807 \cdot 10^{-12} \cdot Gy$

Alternatively by assuming all atoms decay simultaneously at their average lifetime.

$N_0 := \frac{1}{\lambda}$ and then $\quad D_{cy} := N_0$ $\quad D := D_{rate} \cdot D_{cy}$ $\quad D = 3.807 \cdot 10^{-12} \cdot Gy$

(This is one case where the use of lifetime instead of half-life results in a very simple calculation)