The University of Jordan/Physics Department

Chapter 30, Nuclear Physics and Radioactivity

Solutions to Suggested Problems / $7^{th}$ edition

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2] $R = 1.2\, A^{1/3} = 1.2(4)^{1/3} \simeq 1.9 \text{ fm}$

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37] a) $\lambda = \dfrac{\ln 2}{t_{1/2}} = \dfrac{\ln 2}{4.5 \times 10^{9} \times 365 \times 24 \times 60 \times 60}$

$\lambda \simeq 4.88 \times 10^{-18} \text{ s}^{-1}$

$\Rightarrow$ probability of decay is extremely small, which is obvious from the extremely long half-life of $4.5 \times 10^{9}$ years.

b) $t_{1/2} = \dfrac{\ln 2}{\lambda} = \dfrac{\ln 2}{3.2 \times 10^{-5} \text{ s}^{-1}} = 21660.8 \text{ s}$.



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42] For ${}^{131}_{53}I$, $t_{1/2} \simeq 8.0252$ days.

1 mole of ${}^{131}I$ has a mass of 131 grams.

$\Rightarrow$ number of ingested moles is

$$n = \frac{782 \times 10^{-6} \text{ grams}}{131 \text{ grams/mole}} \simeq 5.969466 \times 10^{-6} \text{ mole}$$

$\Rightarrow$ number of ingested ${}^{131}I$ nuclei by patient is

$$N_0 = n N_A$$

where $N_A = 6.02 \times 10^{23}$ is Avogadro's number.

L2

a) immediately $\rightarrow$ $t=0$ i.e initial activity.

$$A = A_0 e^{-\lambda t} = N_0 \lambda e^{-\lambda t}$$

$$A_0 = N_0 \lambda = (n N_A)\left(\frac{\ln 2}{t_{1/2}}\right)$$

$$= (3.59362 \times 10^{18})\left(\frac{\ln 2}{8.0252 \times 24 \times 60 \times 60}\right)$$

$$\approx 3.59 \times 10^{12} \text{ decays/s}$$

$$= 3.59 \times 10^{12} \text{ Bq} = \frac{3.59 \times 10^{12}}{3.7 \times 10^{10}} \text{ Ci}$$

$$\simeq 97 \text{ Ci}$$

b) $A = A_0 e^{-\frac{\ln 2}{t_{1/2}} t} = 3.59 \times 10^{12} e^{-(9.997 \times 10^{-7})(1.5 \times 60 \times 60)}$

$$A = 3.59 \times 10^{12} e^{-(9.997 \times 10^{-7} s^{-1})(5400 s)}$$

$$A = 3.571 \times 10^{12} \text{ Bq} = 96.5 \text{ Ci}$$

c) $A = A_0 e^{-\frac{\ln 2}{t_{1/2}}(3 \times 30 \times 24 \times 60 \times 60)}$

$$= 3.59 \times 10^{12} e^{-7.7737}$$

$$= 1.51 \times 10^{9} \text{ Bq}$$

$$= 0.041 \text{ Ci}$$

43] $A = \lambda N \Rightarrow N = \frac{A}{\lambda}$

$$\lambda = \frac{\ln 2}{t_{1/2}} = \frac{\ln 2}{4.5\times10^{9}\times365\times24\times60\times60} \simeq 4.88\times10^{-18}\ s^{-1}$$

$$\therefore N = \frac{420\ s^{-1}}{4.88\times10^{-18}\ s^{-1}} = 8.61\times10^{19} \text{ nuclei}$$

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46] $A = \lambda N \Rightarrow N = \frac{A}{\lambda} = \frac{2.4\times10^{5}\ s^{-1}}{\left(\frac{\ln 2}{t_{1/2}}\right)}$

$N = 1.362\times10^{22}$

number of moles $= \frac{1.362\times10^{22}}{N_A}$

$\therefore n = 0.0226$ moles.

$\therefore$ mass $= 0.0226\ \cancel{\text{mole}} \times 40 \frac{\text{grams}}{\cancel{\text{mole}}}$

$= 0.904$ grams.

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49] $A = A_0 e^{-\lambda t} \Rightarrow \frac{A}{A_0} = e^{-\frac{\ln 2}{t_{1/2}} t} = \frac{1}{6}$.

$\ln\frac{1}{6} = -\frac{\ln 2}{t_{1/2}} t$ [remember $y = e^{-x} \Rightarrow \ln y = \ln e^{-x} = -x$]

$\therefore -\ln\frac{1}{6} = \ln 6 = \frac{\ln 2}{t_{1/2}} t$

$\Rightarrow t_{1/2} = \frac{\ln 2}{\ln 6} t = \frac{\ln 2}{\ln 6}(9.4 \text{ min}) \approx 3.64$ min.