

### Exercice 1

$$1) \lambda = \frac{\ln 2}{t_{1/2}} = \frac{\ln 2}{27,8 \times 365,25 \times 24 \times 3600}$$

$$= 7,63 \times 10^{-10} \text{ s}^{-1}$$

$$2) A_0 = \lambda N_0 = \lambda \frac{m_0}{M} N_A$$

$$= 5,1 \times 10^5 \text{ Bq} = 0,14 \text{ Ci}$$

$$3) N(t) = N_0 e^{-\lambda t}$$

$$\frac{m(t)}{M} N_A = \frac{m_0}{M} N_A e^{-\lambda t}$$

d'où:  $m(t) = m_0 e^{-\lambda t}$

$$\frac{m}{m_0} = \frac{0,25}{1} = \frac{1}{4} = e^{-\lambda t}$$

d'où  $-\ln 4 = -\lambda t$

et  $\lambda t = \lambda t_{1/2} \Rightarrow t = \frac{2 \ln 2}{\lambda}$

$$t = \frac{2 \ln 2}{\ln 2} \times t_{1/2} = 2 t_{1/2} = 57,6 \text{ a}$$

$$A = A_0 e^{-\lambda t} = A_0 e^{-\frac{\ln 2}{t_{1/2}} \times 2 t_{1/2}}$$

$$= A_0 e^{-\ln 4} = \frac{A_0}{4} = 1,27 \times 10^5 \text{ Bq}$$

$$= 0,034 \text{ Ci}$$

### Exercice 2

$$A = \lambda N = \frac{\ln 2}{t_{1/2}} \times \frac{m}{M} \times N_A$$

d'où:

$$t_{1/2} = \frac{\ln 2}{A} \times \frac{m}{M} \times N_A$$

$$= \frac{\ln 2}{89} \times \frac{0,151}{15936} \times 6,02 \times 10^{23}$$

$$= 4,71 \times 10^{11} \text{ s} = 1,4925 \times 10^{11} \text{ a}$$

### Exercice 3

$$A = \frac{15,3}{60} \times 70 \times 10^3 \times 0,19$$

$$= 3213 \text{ Bq}$$

### Exercice 6



$$Q = (m_{\text{Pu}} - m_{\text{U}} - m_{\alpha}) c^2$$

$$= 5,87 \text{ MeV} > 0$$

$\Rightarrow$  désintégration possible.

b) Nous avons:  $p_{\text{U}} = p_{\alpha}$

d'où:  $p_{\text{U}}^2 = p_{\alpha}^2$

Donc:  $2m_{\text{U}}T_{\text{U}} = 2m_{\alpha}T_{\alpha}$

et  $T_{\text{U}} = \frac{m_{\alpha}}{m_{\text{U}}} T_{\alpha}$

$$Q = T_{\text{U}} + T_{\alpha} = \left(\frac{m_{\alpha}}{m_{\text{U}}} + 1\right) T_{\alpha}$$

$$= \left(\frac{m_{\alpha} + m_{\text{U}}}{m_{\text{U}}}\right) T_{\alpha}$$

d'où:  $T_{\alpha} = \frac{m_{\text{U}}}{m_{\alpha} + m_{\text{U}}} Q$

$$= 5,77 \text{ MeV} \quad (98\%)$$

c)  $T_{\text{U}} = Q - T_{\alpha} = 0,01 \text{ MeV} \quad (2\%)$

### Exercice 6



$$Q = (m_{\text{He}} - m_{\text{Li}} - m_{\text{e}} - m_{\bar{\nu}_e}) c^2$$

$$\approx (m_{\text{He}} - m_{\text{Li}} - m_{\text{e}}) c^2$$

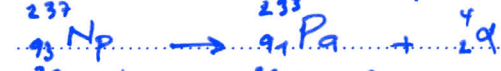
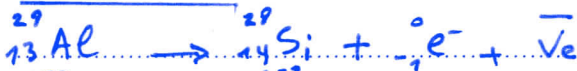
$$= T_{\text{Li}} + T_{\text{e}^-} + T_{\bar{\nu}_e} = T_{\text{e}^-}^{\text{max}}$$

$$m_{\text{He}} = T_{\text{e}^-}^{\text{max}}/c^2 + m_{\text{Li}} + m_{\text{e}}$$

$$= \frac{1,983 + 0,511}{931,5} + 6,015121$$

$$= 6,017798 \text{ u}$$

### Exercice 7



### Exercice 8



a)  $\frac{dx}{dt} = -\lambda x$

d'où:  $\frac{dx}{x} = -\lambda dt$

et  $\ln x = -\lambda t + \ln k$

$$x(t) = k e^{-\lambda t}$$

$$\frac{dy}{dt} = -\lambda' y + \lambda x$$

$$\frac{dy}{dt} + \lambda' y = \lambda x_0 e^{-\lambda t} \dots (1)$$

$$* \frac{dy}{dt} + \lambda' y = 0$$

$$\frac{dy}{dt} = -\lambda' y \quad \text{et } y(t) = K_1 e^{-\lambda' t}$$

$$* y(t) = K_1(t) e^{-\lambda' t}$$

$$\frac{dy}{dt} = K_1' e^{-\lambda' t} - \lambda' K_1 e^{-\lambda' t} \rightarrow (1)$$

$$K_1' e^{-\lambda' t} - \lambda' K_1 e^{-\lambda' t} + \lambda' K_1 e^{-\lambda' t} = \lambda x_0 e^{-\lambda t}$$

$$K_1' e^{-\lambda' t} = \lambda x_0 e^{-\lambda t} \quad \text{d'où:}$$

$$K_1' = \lambda x_0 e^{(\lambda' - \lambda)t} \quad \text{d'où:}$$

$$K_1 = \frac{\lambda x_0}{\lambda' - \lambda} e^{(\lambda' - \lambda)t} + K_2$$

Donc:

$$y(t) = \frac{\lambda x_0}{\lambda' - \lambda} e^{-\lambda t} + K_2 e^{-\lambda' t}$$

$t \rightarrow \infty, y = 0$  d'où

$$K_2 = -\frac{\lambda x_0}{\lambda' - \lambda}$$

Enfin:

$$y(t) = \frac{\lambda x_0}{\lambda' - \lambda} (e^{-\lambda t} - e^{-\lambda' t})$$

$$b) \frac{M_{Ac}}{M_{Ac}} N_A = \frac{m_0}{M_{Ra}} N_A \frac{\lambda}{\lambda' - \lambda} (e^{-\lambda t} - e^{-\lambda' t})$$

$$M_{Ac} \approx M_{Ra}$$

$$m_{Ac} = m_0 \frac{\lambda}{\lambda' - \lambda} (e^{-\lambda t} - e^{-\lambda' t})$$

$$= m_0 \left( \frac{T_1}{T_1 - T_1'} \right) \left( e^{-\ln 2 \cdot \frac{t}{T_1}} - e^{-\ln 2 \cdot \frac{t}{T_1'}} \right)$$

$$= 1,65 \times 10^{-3} \text{ g} = 1,65 \text{ mg}$$

$$c) \frac{dE}{dt} = \lambda' y = \frac{\lambda' \lambda x_0}{\lambda' - \lambda} (e^{-\lambda t} - e^{-\lambda' t})$$

$$z(t) = \frac{\lambda' \lambda x_0}{\lambda' - \lambda} \int (e^{-\lambda t} - e^{-\lambda' t}) dt$$

$$= \frac{\lambda' \lambda x_0}{\lambda' - \lambda} \left( \frac{e^{-\lambda t}}{-\lambda} + \frac{e^{-\lambda' t}}{\lambda'} \right) + K_3$$

$t \rightarrow \infty, z = 0$  d'où:

$$K_3 = -\frac{\lambda' \lambda x_0}{\lambda' - \lambda} \left( -\frac{1}{\lambda} + \frac{1}{\lambda'} \right) = x_0$$

$$z(t) = x_0 + \frac{\lambda' \lambda x_0}{\lambda' - \lambda} \left( \frac{e^{-\lambda t}}{\lambda} - \frac{e^{-\lambda' t}}{\lambda'} \right)$$

$$d) x + y + z =$$

$$x_0 e^{-\lambda t} + \frac{\lambda x_0}{\lambda' - \lambda} (e^{-\lambda t} + e^{-\lambda' t})$$

$$+ x_0 + \frac{\lambda' \lambda x_0}{\lambda' - \lambda} \left( \frac{e^{-\lambda t}}{\lambda} - \frac{e^{-\lambda' t}}{\lambda'} \right)$$

$$= x_0 e^{-\lambda t} + \frac{\lambda x_0}{\lambda' - \lambda} e^{-\lambda t} - \frac{\lambda' \lambda x_0}{\lambda' - \lambda} e^{-\lambda' t}$$

$$+ x_0 + \frac{\lambda' \lambda x_0 e^{-\lambda t}}{\lambda' - \lambda} - \frac{\lambda' \lambda x_0}{\lambda' - \lambda} e^{-\lambda' t}$$

$$= x_0 e^{-\lambda t} - x_0 e^{-\lambda' t} + x_0 = x_0$$

### Exercice 4

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

$$\frac{A(t)}{A_0} = e^{-\lambda t} \quad \text{et } \lambda t = \ln \frac{A_0}{A}$$

$$t = \frac{1}{\lambda} \ln \frac{A_0}{A} = \frac{t_{1/2}}{\ln 2} \times \ln \frac{A_0}{A}$$

$$= 12,279 \text{ a}$$

### Exercice 9

$$a) A_0 = \lambda N_0 = \frac{\ln 2}{t_{1/2}} \times \frac{m_0}{M} N_A$$

$$m_0 = \frac{A_0 \cdot t_{1/2} \cdot M}{\ln 2 \times N_A} = \frac{40 \times 10^6 \times 3,7 \times 10^4 \times 238}{\ln 2 \times 6,02 \times 10^{23}}$$

$$\frac{8,04 \times 24 \times 3600 \times 131}{1} = 2,7 \times 10^{-11} \text{ g}$$

$$b) A = \lambda N \times 0,35 = 0,35 \lambda N_0 e^{-\lambda t}$$

$$= 0,35 \times A_0 \times e^{-\ln 2 \cdot t / t_{1/2}} = 10,65 \mu\text{Ci}$$

$$c) \frac{dD}{dt} = \frac{1}{m} \frac{dE}{dt} = \frac{E_0}{m t} \frac{dN}{dt} = \frac{0,35 E_0}{m t} \times \lambda N(t)$$

$$= \frac{0,35 E_0}{m t} \lambda N_0 e^{-\lambda t} = \frac{0,35 A_0 E_0}{m t} e^{-\lambda t}$$

$$D = \frac{0,35 A_0 E_0}{m t} \int_0^t e^{-\lambda t} dt = \frac{0,35 A_0 E_0}{m t \lambda} (1 - e^{-\lambda t})$$

$$= \frac{0,35 \times 40 \times 238 \times 6,6 \times 10^{-14}}{m \times \ln 2} (1 - e^{-\ln 2 \cdot t / t_{1/2}}) = 0,19 \text{ Jy}$$

$$\rightarrow H = 0,19 \text{ Sv}$$

$$d) (-dN)_{\text{eff}} = (-dN)_r + (-dN)_b$$

$$\frac{1}{T_{\text{eff}}} = \frac{1}{T_r} + \frac{1}{T_b} \Rightarrow T_b = \frac{T_r T_{\text{eff}}}{T_r - T_{\text{eff}}}$$

$$= \frac{8,04 \times 5}{8,04 - 3} = 13,2 \text{ j}$$