1a. $^{216}_{84} \rightarrow {}^{212}_{82}Pb$ α decay (1)

$^{212}_{82}Pb \rightarrow {}^{212}_{83}Bi$ β^- decay (1)

2

b. $N_1(t) = N_1(0)\, e^{-\lambda_1 t}$ (1)

$$N_2(t) = N_1(0)\, \lambda_1 \left[\frac{e^{-\lambda_1 t}}{\lambda_2 - \lambda_1} + \frac{e^{-\lambda_2 t}}{\lambda_1 - \lambda_2} \right]$$

$$= \frac{N_1(0)\, \lambda_1}{\lambda_2 - \lambda_1} \left[e^{-\lambda_1 t} - e^{-\lambda_2 t} \right]$$ (1)

$$N_3(t) = N_1(0)\, \lambda_1 \lambda_2 \left[\frac{e^{-\lambda_1 t}}{(\lambda_3 - \lambda_1)(\lambda_2 - \lambda_1)} + \frac{e^{-\lambda_2 t}}{(\lambda_1 - \lambda_2)(\lambda_3 - \lambda_2)} + \frac{e^{-\lambda_3 t}}{(\lambda_1 - \lambda_3)(\lambda_2 - \lambda_3)} \right]$$

(1)

But N_3 is stable so $\lambda_3 = 0$ (1)

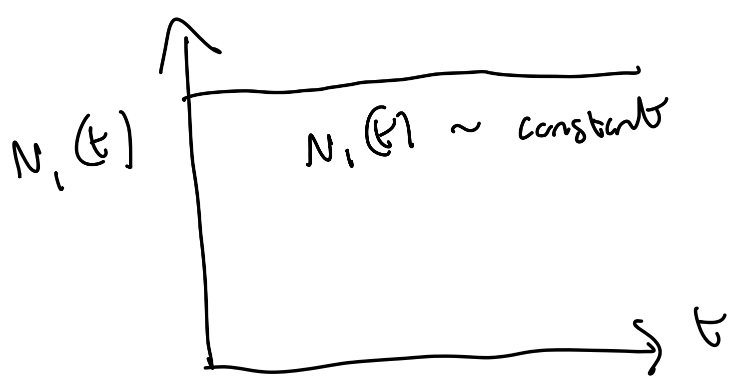
$$N_3(t) = N_1(0)\,\lambda_1 \lambda_2 \left[\frac{e^{-\lambda_1 t}}{\lambda_1(\lambda_1 - \lambda_2)} + \frac{e^{-\lambda_2 t}}{\lambda_2(\lambda_2 - \lambda_1)} + \frac{1}{\lambda_1 \lambda_2} \right]$$

$$= N_1(0) \left[1 - \frac{1}{\lambda_2 - \lambda_1} \left[\lambda_2 e^{-\lambda_1 t} - \lambda_1 e^{-\lambda_2 t} \right] \right]$$

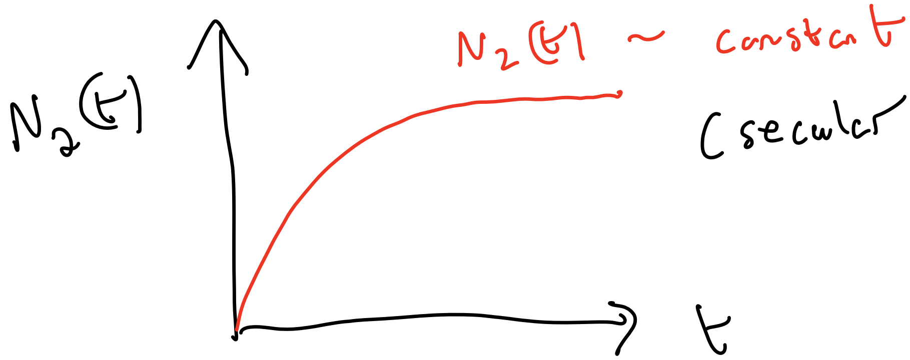
(1)

5

iii A.



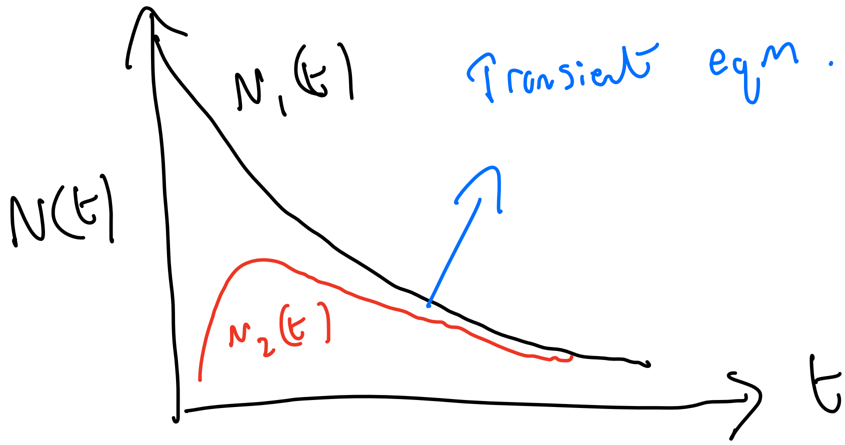
(1)



(secular eqm) (1)

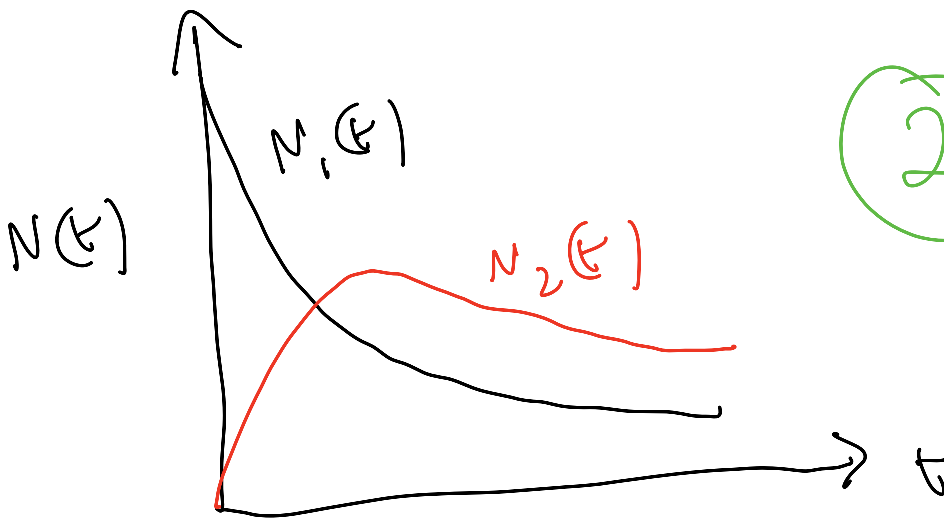
2

B.



2

C.



2

iii) T_1 very large so $d_1 \sim 0$ (1)

d_i very large for $i \neq m$ (1)

$$N_m(t) = N_1(0)\left[\frac{d_1 \cancel{d_2} \cdots \cancel{d_{m-1}}}{\cancel{d_2} \cdots \cancel{d_{m-1}}\, d_m}\right.$$ (1)

$$\left. - \frac{d_1 \cancel{d_2} \cdots \cancel{d_{m-1}}\, e^{-d_m t}}{(\cancel{d_1} - d_m)(\cancel{d_2 - d_m}) \cdots (\cancel{d_{m-1} - d_m})}\right]$$

$$\simeq N_1(0)\left[\frac{d_1}{d_m} - \frac{d_1}{d_m} e^{-d_m t}\right]$$

$$\simeq N_1(0)\frac{d_1}{d_m}\left[1 - e^{-d_m t}\right]$$ (1)

Eqm value at $N_1(0)\dfrac{d_1}{d_m}$ (1)

Reached when $0.75 = 1 - e^{-\lambda_m t}$

$$t = \frac{\ln 0.25}{-\ln 2} \text{ days}$$

$= 2$ days. (1) 6

iv) $$\frac{dN_1}{dt} = C - \lambda_1 N_1 \quad (1)$$

$$\frac{dN_1}{dt} + \lambda_1 N_1 = C$$

IF of $e^{\lambda_1 t}$

$$\frac{d(e^{\lambda_1 t} N_1)}{dt} = Ce^{\lambda_1 t}$$

(1)

$$e^{\lambda_1 t} N_1 = C \int_0^t e^{\lambda_1 t'} \, dt'$$

$$= \frac{C}{\lambda_1} \left[e^{\lambda_1 t} - 1 \right] \quad (1)$$

$$N_1 = \frac{C}{\lambda_1} \left[1 - e^{-\lambda_1 t} \right] \quad (1)$$

$$\lambda_1 = \frac{\ln 2}{T_1} = \frac{\ln 2}{5} \text{ mins}^{-1} \quad (1)$$

$$= 0.139 \text{ mins}^{-1}$$

$$N_1 = \frac{10^{10}}{0.139} \times \left[1 - e^{-0.139 \times 10} \right]$$

$$\text{min}^{-1}$$

$$= 3.24 \times 10^{12} \text{ decay} / s \quad (1)$$

$$(Bq) \quad 6$$