① $r = 1.2\times10^{-15} \times \sqrt[3]{238} = 7.4\times10^{-15}$ $\left(r = 1.2\times10^{-15}(A)^{\frac{1}{3}}\right)$

Additional: $V = \frac{4}{3}\pi r^3$, $d = 2r$ (مطلوب d)

② V_β / V_α

$V_\alpha = 5\% C \rightarrow 0.05\,C$

$V_\beta = 90\% C \rightarrow 0.9\,C$

$\frac{V_\beta}{V_\alpha} = \frac{0.9\,C}{0.05\,C} = 18 \Rightarrow V_\beta = 18 V_\alpha$

$\frac{V_\beta}{V_\alpha} = 18$

③ $\lambda = 9.8\times10^{-10}\ y^{-1}$

$\frac{9.8\times10^{-10}}{y} * \frac{1y}{365\,day} * \frac{1\,day}{24\,hour} * \frac{1\,hour}{3600\,s}$

$\lambda = 3.1\times10^{-17}\ s^{-1}$

a) $T_{\frac{1}{2}} = \frac{\ln 2}{\lambda} = \frac{\ln 2}{3.1\times10^{-17}} = 2.2\times10^{16}\,s$ $(7.07\times10^{8}\,yr)$

b) $N_0 \longrightarrow 1\times10^{-6}\,g$ (initially at $t=0$)

$N \longrightarrow 235\,g$

$N = 6.022\times10^{23}$

Atomic mass for ^{235}U is $A = 235$ so, $235\,g$ will contain 6.022×10^{23} nuclei (Avogadro number)

$N_0 = \frac{1\times10^{-6}\times6.022\times10^{23}}{235}$

$= 2.5\times10^{15}$

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

$\Rightarrow t = 10^{4}\,y * \frac{365\,day}{1\,y} * \frac{24\,hour}{1\,day} * \frac{3600\,s}{1\,hour}$

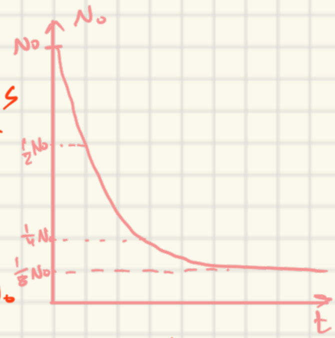
$t = 3.1\times10^{16}\,s$

$= 2.5\times10^{12}\times e^{-(3.1\times10^{16})(3.1\times10^{-17})}$

$= 9.56\times10^{11}$

④ $T_{\frac{1}{2}} = 10\,min * \frac{60\,s}{1\,min} \Rightarrow T_{\frac{1}{2}} = 600\,s$

$\lambda = \frac{\ln 2}{T_{\frac{1}{2}}} = 1.155\times10^{-3}\ s^{-1}$



Maximum possible number of $^{62}Cu = N_0$

90% of Maximum possible number $= 0.9\,N_0 = N$

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

$0.9 N_0 = N_0 e^{-\lambda t}$

$\ln 0.9 = -\lambda t \Rightarrow t = -\frac{\ln 0.9}{1.155\times10^{-3}} = 91.22\,s = 1.5\,min$

⑤ $Th \longrightarrow Ra + \alpha$

$T_{\frac{1}{2}} = 18.72\,day * \frac{24\,hour}{1\,day} * \frac{3600\,s}{1\,hour}$

$T_{\frac{1}{2}} = 1617408\,s$ (Th)

$\lambda_{(Th)} = \frac{\ln 2}{T_{\frac{1}{2}}} = 4.2\times10^{-7}$

$T_{\frac{1}{2}} = 11.43\,day * \frac{24\,hour}{1\,day} * \frac{3600\,seconds}{1\,hour}$

$T_{\frac{1}{2}} = 987552$ (Ra)

$\lambda_{(Ra)} = \frac{\ln 2}{T_{\frac{1}{2}}} = 7.01\times10^{-7}$

⑥ For $^{14}C \rightarrow T_{\frac{1}{2}} = 5730\,yr$ (معطى)

$\lambda = \frac{\ln 2}{T_{\frac{1}{2}}} = \frac{0.693}{5730\times3.15\times10^{7}} = 3.8\times10^{-12}\ s^{-1}$ (yr → s نحول)

$^{14}C \Rightarrow 14\,g \longrightarrow 6.02\times10^{23}$

$175\,g \longrightarrow N_0$

$N_0 = 75.25\times10^{23}$ Nuclei

(الـ R اللي موجود في الحسابات فقط يدل على الناقص)

$R = -\lambda N \Rightarrow N = \frac{R}{\lambda} = \frac{8.1}{3.8\times10^{-12}} = 2.112\times10^{12}$

$N = N_0 e^{-\lambda t} \Rightarrow \frac{N}{N_0} = e^{-\lambda t}$

$\ln \frac{2.112\times10^{12}}{75.25\times10^{23}} = -(3.8\times10^{-12})\,t$

$t = 7.536\times10^{12}\,s$ (238, 960.36 yr)

⑦ 350 rad from α radiation

1α particle $\longrightarrow$ 20 x-ray

$350\alpha \longrightarrow X$

$X = 7000$ rad

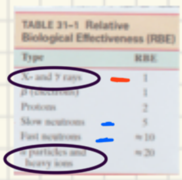


TABLE 31-1 Relative Biological Effectiveness (RBE)

Type	RBE
X- and γ rays	1
β (electrons)	1
Protons	2
Slow neutrons	5
Fast neutrons	≈10
α particles and heavy ions	≈20

The 350 rad of α particle radiation does the same damage as 7000 rad of x-ray

⑧ 4 S.V of γ ray

Effective dose (SV) = Dose (Gy) × RBE (from the table)

4 (SV) = Dose (Gy) × 1

Dose (Gy) = 4

∴ Number of sivert = Number of gray

⑨ 1 Fast neutron ⟶ 10 X-ray (from the table)

72 rads of fast neutrons ⟶ X

* 72 rads of fast neutrons cause biological damage equivalent to 720 rad of x-ray.

1 slow neutrons ⟶ 5 X-ray (from the table)

X rads of slow neutrons ⟶ 720 rads X-ray

* 144 of slow neutrons makes the same damage as 72 rads of fast neutrons.

⑩ 1 gray = 1 J/kg

4.5 Gray = Energy ⇒ Energy = 4.5 J/kg

For a body with mass of 65 kg ⇒ Energy = 4.5(65) = 292.5 J

$N_0(Th) = 10^6$, $N_0(Ra) = 0$ } at $t = 0$

After $t = 15\,d \longrightarrow t = 1296000$

For Th ⟶ $N = N_0 e^{-\lambda t}$

$= 10^6\, e^{-(4.2\times10^{-7})(1.296\times10^{6})}$

$= 0.574\times10^{6}$ Nuclei

For Ra ⟶ $N = N_0 e^{-\lambda t}$

$\frac{N}{N_0} = e^{-\lambda t} = e^{-(7.01\times10^{-7})(1.296\times10^{6})}$

$\frac{N}{N_0} = 0.403$, $N = 0.403\,N_0$ at $t = 15$ day