AM   Sort Q4 !!   4 (d) error – work in years!

Radioactivity – 2 (questions)   4 (d) A = 25/min !!   A Physics

Avogadro's number $N_A = 6 \times 10^{23}$

1. A small volume of solution containing radioactive Na-24 with an activity of 12×10^3 counts/min., and half life of 15 hours is injected into a patient's blood stream.
After 30 hours $1.0\ cm^3$ of blood is removed, and has an activity of 0.5 counts per minute.

(a) What is initial activity of Na-24 in Bq? – of all Na-24 (1)
(b) what is the samples activity after 30 hours.? – total sample (2)
(c) What is the volume of blood in the patient's body? (2)
(d) Why wait 30 hours? (2)

[7]

2. A small volume of a solution containing Na-24 with activity of 1.6×10^4 Bq, half life 15 hours, is mixed with the water in a house central heating system.
After 15 hours, ~~a~~ 100 cm^3 ~~sample~~ of the water has an activity of 4 Bq.

(a) How much water is in the central heating system? (3)
(b) What is the decay constant of Na-24? (2)
(c) What would be the activity of all the Na-24 (initially 1.6×10^4 Bq) after 7.5 hours? (3)

[8]

(0.4 mg)

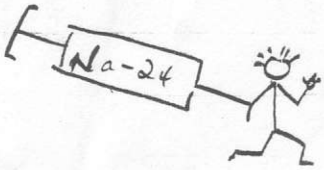
3. A sample of U-235 has a count rate of 35 Bq.
The background count rate is 1.7 Bq.
Calculate ... (a) the number of moles of U-235 (2)
(b) the number of U-235 atoms in the sample (2)
(c) the activity of U-235 (1)
(d) the decay constant of U-235 (2) λ in sec^{-1} and $years^{-1}$
(e) the half life of U-235 in (i) seconds (ii) years (3)

[10]

4. In a piece of living wood, 1×10^{-10} % of the total mass is C-14 (half life 5700 years.); most of the carbon is (of course) C-12.
a) Calculate the half life in sec, and decay constant (in sec^{-1}). (3
b) Calculate the no. of C-14 atoms in 2g of living wood (2
c) Calculate the count you would expect in 1 minute if the background count was 10 per minute. (3   25 !!
d). The total count rate from 2g of ancient wood is ~~30~~ per minute
Calculate the age of the ancient wood in years. (3) [11]

TN 4.99.

Radioactivity ② answers — A Physics



1 a) $12 \times 10^3 \text{ min}^{-1} = \underline{200 \text{ Bq}}$ (1

b) $30 \text{ h} = 2 \times t_{1/2}$ ①

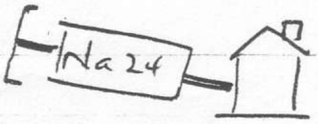
So $A = 200 \div 2 \div 2 = \underline{50 \text{ Bq}}$ ①

c) work in min or sec ...

Activity of 1 cm^3 blood $= \frac{0.5}{60} = 0.0083$ ① Bq (or $\frac{3000}{0.5} = 6000$ in min.)

So Blood volume $= \frac{50}{0.0083} = \underline{6000 \text{ cm}^3}$ ①

d) 30 h = time for all blood to mix
= 2 half lives (convenient) $\boxed{7}$

2. 

a) activity of Na-24 after 15 h = $\underline{0.8 \times 10^4 \text{ Bq}}$

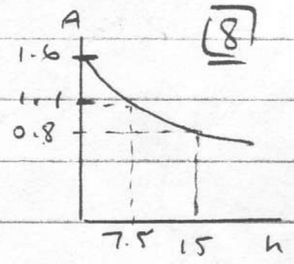
So volume of water $= \frac{0.8 \times 10^4}{4}$ ① $= 2000 \times 100 \text{ cm}^3$
$= 200$ litres
$= 2 \times 10^5 \text{ cm}^3$ ①

b) $\ln 2 = \lambda t_{1/2}$ ① $\rightarrow \lambda = \ln 2 / t_{1/2} = 0.046 \text{ h}^{-1} = 12.8 \times 10^{-6} \text{ s}^{-1}$ ①

c) use $A_t = A_0 e^{-\lambda t}$ ① $= 1.6 \times 10^4 \times e^{-0.046 \times 7.5}$ ① (both in hours!)

$= 1.1 \times 10^4$ ① Bq. $\boxed{8}$

(sketch A/t curve + check answer is sensible →



3. a) moles $= 0.4 \times 10^{-3} \text{ (g)} / 235$ ① $= \underline{1.7 \times 10^{-6} \text{ moles}}$ ①

b) No. atoms $= 1.7 \times 10^{-6} \times 6 \times 10^{23} = \underline{1.02 \times 10^{18} \text{ atoms}}$

c) Activity $= A_U - A_{Background} = 35 - 1.7 = 33.3$ Bq ①

d) use $A = -\lambda N$ ① $\rightarrow \lambda = A/N = 33.3 / 1.02 \times 10^{18} = \underline{3.26 \times 10^{-17} \text{ s}^{-1}}$ ①

e) $t_{1/2}$ ... use $\ln 2 = \lambda t_{1/2}$ ① $\rightarrow t_{1/2} = \ln 2 / \lambda = \underline{2.12 \times 10^{16} \text{ sec}}$ ①
$= \underline{6.7 \times 10^8 \text{ years}}$ ① $\boxed{10}$

4. a) $t_{1/2} = 5700 \times 365 \times 24 \times 60 \times 60 = 1.798 \times 10^{11}$ s. ①

So, since $\ln 2 = \lambda t_{1/2}$ ①, $\rightarrow \lambda = \ln 2 / t_{1/2} = \underline{3.86 \times 10^{-12} \text{ s}^{-1}}$ ① $= 1.22 \times 10^{-4} \text{ y}^{-1}$

b) 2g living wood ... 1×10^{-10} % of 2g $= 2 \times 1 \times 10^{-12}$ g $= \underline{2 \times 10^{-12} \text{ g}}$ ① of C-14

this is $2 \times 10^{-12} / 14 = \underline{1.43 \times 10^{-13}}$ moles
$= 1.43 \times 10^{-13} \times 6 \times 10^{23} = \underline{8.57 \times 10^{10}}$ ① C-14 atoms

c) $A = -\lambda N$ ① $= 3.86 \times 10^{-12} \text{ (s}^{-1}) \times 8.57 \times 10^{10} = 0.331$ ① counts/sec

So in 1 minute Total count $= A_{C-14} + A_{background} = 19.9 + 10 = 29.9 \text{ min}^{-1}$ ①

TN d) Ancient wood: ... count rate = 25/min − 10 Background = 15/min from C-14

4.99. use $\ln\left(\frac{A_0}{A_t}\right) = \lambda t = \ln\left(\frac{19.9}{15}\right) = 0.283 = \lambda t \rightarrow t = 7.3 \times 10^{10}$ s
$= \underline{2320 \text{ years}}$

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