THE NUCLEUS
CHAPTER - 46

1. $M = Am_p$, $f = M/V$, $m_p = 1.007276$ u
$R = R_0A^{1/3} = 1.1 \times 10^{-15}\ A^{1/3}$, $u = 1.6605402 \times 10^{-27}$ kg

$$= \frac{A \times 1.007276 \times 1.6605402 \times 10^{-27}}{4/3 \times 3.14 \times R^3} = 0.300159 \times 10^{18} = 3 \times 10^{17}\ \text{kg/m}^3.$$

'f' in CGS = Specific gravity = 3×10^{14}.

2. $$f = \frac{M}{v} \Rightarrow V = \frac{M}{f} = \frac{4 \times 10^{30}}{2.4 \times 10^{17}} = \frac{1}{0.6} \times 10^{13} = \frac{1}{6} \times 10^{14}$$
$V = 4/3\ \pi R^3$.

$$\Rightarrow \frac{1}{6} \times 10^{14} = 4/3\ \pi \times R^3 \Rightarrow R^3 = \frac{1}{6} \times \frac{3}{4} \times \frac{1}{\pi} \times 10^{14}$$

$$\Rightarrow R^3 = \frac{1}{8} \times \frac{100}{\pi} \times 10^{12}$$

$\therefore R = ½ \times 10^4 \times 3.17 = 1.585 \times 10^4$ m = 15 km.

3. Let the mass of 'α' particle be xu.
'α' particle contains 2 protons and 2 neutrons.
$\therefore$ Binding energy = $(2 \times 1.007825\ u \times 1 \times 1.00866\ u - xu)C^2$ = 28.2 MeV (given).
$\therefore x = 4.0016$ u.

4. $Li^7 + p \rightarrow l + \alpha + E$; $Li^7 = 7.016u$
$\alpha = {}^4He = 4.0026u$; $p = 1.007276$ u
$E = Li^7 + P - 2\alpha = (7.016 + 1.007276)u - (2 \times 4.0026)u = 0.018076$ u.
$\Rightarrow 0.018076 \times 931 = 16.828 = 16.83$ MeV.

5. $B = (Zm_p + Nm_n - M)C^2$
$Z = 79$; $N = 118$; $m_p = 1.007276u$; $M = 196.96$ u ; $m_n = 1.008665u$
$B\ = [(79 \times 1.007276 + 118 \times 1.008665)u - Mu]c^2$
$= 198.597274 \times 931 - 196.96 \times 931 = 1524.302094$
so, Binding Energy per nucleon = 1524.3 / 197 = 7.737.

6. a) $U^{238}\ {}_2He^4 + Th^{234}$
$E = [M_u - (N_{HC} + M_{Th})]u = 238.0508 - (234.04363 + 4.00260)]u = 4.25487$ Mev = 4.255 Mev.
b) $E = U^{238} - [Th^{234} + 2n'_0 + 2p'_1]$
$= \{238.0508 - [234.64363 + 2(1.008665) + 2(1.007276)]\}u$
$= 0.024712u = 23.0068 = 23.007$ MeV.

7. ${}^{223}R_a = 223.018$ u ; ${}^{209}Pb = 208.981$ u ; ${}^{14}C = 14.003$ u.
${}^{223}R_a \rightarrow {}^{209}Pb + {}^{14}C$
Δm = mass ${}^{223}R_a$ – mass $({}^{209}Pb + {}^{14}C)$
$\Rightarrow\ = 223.018 - (208.981 + 14.003) = 0.034$.
Energy = $\Delta M \times u = 0.034 \times 931 = 31.65$ Me.

8. $E_{Z.N.} \rightarrow E_{Z-1}, N + P_1 \Rightarrow E_{Z.N.} \rightarrow E_{Z-1}, N + {}_1H^1$ [As hydrogen has no neutrons but protons only]
$\Delta E = (M_{Z-1,\ N} + N_H - M_{Z,N})c^2$

9. $E_2N = E_{Z,N-1} + {}^1_0n$.
Energy released = (Initial Mass of nucleus – Final mass of nucleus)$c^2 = (M_{Z.N-1} + M_0 - M_{ZN})c^2$.

10. $P^{32} \rightarrow S^{32} + {}_0\bar{v}^0 + {}_1\beta^0$
Energy of antineutrino and β-particle
$= (31.974 - 31.972)u = 0.002\ u = 0.002 \times 931 = 1.862$ MeV = 1.86.

11. $In \rightarrow P + e^-$
We know : Half life = $0.6931 / \lambda$ (Where λ = decay constant).
Or $\lambda = 0.6931 / 14{\times}60 = 8.25 \times 10^{-4}$ S [As half life = 14 min = 14 × 60 sec].
Energy = $[M_n - (M_P + M_e)]u = [(M_{nu} - M_{pu}) - M_{pu}]c^2 = [0.00189u - 511\ \text{KeV}/c^2]$
$= [1293159\ \text{ev}/c^2 - 511000\ \text{ev}/c^2]c^2 = 782159$ eV = 782 Kev.

12. $^{226}_{58}\text{Ra} \to {}^{4}_{2}\alpha + {}^{222}_{26}\text{Rn}$

$^{19}_{8}\text{O} \to {}^{19}_{9}\text{F} + {}^{0}_{n}\beta + {}^{0}_{0}\overline{v}$

$^{13}_{25}\text{Al} \to {}^{25}_{12}\text{MG} + {}^{0}_{-1}e + {}^{0}_{0}\overline{v}$

13. $^{64}\text{Cu} \to {}^{64}\text{Ni} + e^{-} + v$

Emission of nutrino is along with a positron emission.

a) Energy of positron = 0.650 MeV.

Energy of Nutrino = 0.650 – KE of given position = 0.650 – 0.150 = 0.5 MeV = 500 Kev.

b) Momentum of Nutrino = $\dfrac{500 \times 1.6 \times 10^{-19}}{3 \times 10^{8}} \times 10^{3}$ J = 2.67×10^{-22} kg m/s.

14. a) ${}_{19}K^{40} \to {}_{20}Ca^{40} + {}_{-1}e^{0} + {}_{0}\overline{v}^{0}$

${}_{19}K^{40} \to {}_{18}Ar^{40} + {}_{-1}e^{0} + {}_{0}\overline{v}^{0}$

${}_{19}K^{40} + {}_{-1}e^{0} \to {}_{18}Ar^{40}$

${}_{19}K^{40} \to {}_{20}Ca^{40} + {}_{-1}e^{0} + {}_{0}v^{0}$.

b) Q = [Mass of reactants – Mass of products]c^2

= [39.964u – 39.9626u] = [39.964u – 39.9626]uc^2 = (39.964 – 39.9626) 931 Mev = 1.3034 Mev.

${}_{19}K^{40} \to {}_{18}Ar^{40} + {}_{-1}e^{0} + {}_{0}\overline{v}^{0}$

Q = (39.9640 – 39.9624)uc^2 = 1.4890 = 1.49 Mev.

${}_{19}K^{40} + {}_{-1}e^{0} \to {}_{18}Ar^{40}$

Q_{value} = (39.964 – 39.9624)uc^2.

15. $^{6}_{3}\text{Li} + n \to {}^{7}_{3}\text{Li}$; $^{7}_{3}\text{Li} + r \to {}^{8}_{3}\text{Li}$

$^{8}_{3}\text{Li} \to {}^{8}_{4}\text{Be} + e^{-} + v^{-}$

$^{8}_{4}\text{Be} \to {}^{4}_{2}\text{He} + {}^{4}_{2}\text{He}$

16. $''\text{C} \to {}''\text{B} + \beta^{+} + v$

mass of C″ = 11.014u ; mass of B″ = 11.0093u

Energy liberated = (11.014 – 11.0093)u = 29.5127 Mev.

For maximum K.E. of the positron energy of v may be assumed as 0.

∴ Maximum K.E. of the positron is 29.5127 Mev.

17. Mass $^{238\text{Th}}$ = 228.028726 u ; ^{224}Ra = 224.020196 u ; α = $^{4}_{2}\text{He}$ → 4.00260u

$^{238}\text{Th} \to {}^{224}\text{Ra}^{*} + \alpha$

$^{224}\text{Ra}^{*} \to {}^{224}\text{Ra} + v(217\text{ Kev})$

Now, Mass of $^{224}\text{Ra}^{*}$ = 224.020196 × 931 + 0.217 Mev = 208563.0195 Mev.

KE of α = E $^{226\text{Th}}$ – E($^{224}\text{Ra}^{*} + \alpha$)

= 228.028726 × 931 – [208563.0195 + 4.00260 × 931] = 5.30383 Mev= 5.304 Mev.

18. $^{12}\text{N} \to {}^{12}\text{C}^{*} + e^{+} + v$

$^{12}\text{C}^{*} \to {}^{12}\text{C} + v(4.43\text{ Mev})$

Net reaction : $^{12}\text{N} \to {}^{12}\text{C} + e^{+} + v + v(4.43\text{ Mev})$

Energy of $(e^{+} + v) = N^{12} - (c^{12} + v)$

= 12.018613u – (12)u – 4.43 = 0.018613 u – 4.43 = 17.328 – 4.43 = 12.89 Mev.

Maximum energy of electron (assuming 0 energy for v) = 12.89 Mev.

19. a) $t_{1/2} = 0.693 / \lambda$ [λ → Decay constant]

⇒ $t_{1/2}$ = 3820 sec = 64 min.

b) Average life = $t_{1/2}$ / 0.693 = 92 min.

c) $0.75 = 1\, e^{-\lambda t} \Rightarrow \text{In } 0.75 = -\lambda t \Rightarrow t = \text{In } 0.75 / -0.00018 = 1598.23$ sec.

20. a) 198 grams of Ag contains → N_0 atoms.

1 μg of Ag contains → $N_0/198 \times 1$ μg = $\dfrac{6 \times 10^{23} \times 1 \times 10^{-6}}{198}$ atoms

Activity = $\lambda N = \frac{0.963}{t_{1/2}} \times N = \frac{0.693 \times 6 \times 10^{17}}{198 \times 2.7}$ disintegrations/day.

$= \frac{0.693 \times 6 \times 10^{17}}{198 \times 2.7 \times 3600 \times 24}$ disintegration/sec $= \frac{0.693 \times 6 \times 10^{17}}{198 \times 2.7 \times 36 \times 24 \times 3.7 \times 10^{10}}$ curie = 0.244 Curie.

b) $A = \frac{A_0}{2t_{1/2}} = \frac{0.244}{2 \times \frac{7}{2.7}}$ = 0.0405 = 0.040 Curie.

21. $t_{1/2}$ = 8.0 days ; $A_0 = 20\ \mu$ CI

a) t = 4.0 days ; $\lambda = 0.693/8$

$A = A_0 e^{-\lambda t} = 20 \times 10^{-6} \times e^{(-0.693/8) \times 4} = 1.41 \times 10^{-5}$ Ci = 14 μ Ci

b) $\lambda = \frac{0.693}{8 \times 24 \times 3600} = 1.0026 \times 10^{-6}$.

22. $\lambda = 4.9 \times 10^{-18}\ s^{-1}$

a) Avg. life of $^{238}U = \frac{1}{\lambda} = \frac{1}{4.9 \times 10^{-18}} = \frac{1}{4.9} \times 10^{-18}$ sec.

$= 6.47 \times 10^3$ years.

b) Half life of uranium $= \frac{0.693}{\lambda} = \frac{0.693}{4.9 \times 10^{-18}} = 4.5 \times 10^9$ years.

c) $A = \frac{A_0}{2^{t/t_{1/2}}} \Rightarrow \frac{A_0}{A} = 2^{t/t_{1/2}} = 2^2 = 4$.

23. A = 200, A_0 = 500, t = 50 min

$A = A_0 e^{-\lambda t}$ or $200 = 500 \times e^{-50 \times 60 \times \lambda}$

$\Rightarrow \lambda = 3.05 \times 10^{-4}$ s.

b) $t_{1/2} = \frac{0.693}{\lambda} = \frac{0.693}{0.000305}$ = 2272.13 sec = 38 min.

24. $A_0 = 4 \times 10^5$ disintegration / sec

$A' = 1 \times 10^6$ dis/sec ; t = 20 hours.

$A' = \frac{A_0}{2^{t/t_{1/2}}} \Rightarrow 2^{t/t_{1/2}} = \frac{A_0}{A'} \Rightarrow 2^{t/t_{1/2}} = 4$

$\Rightarrow t/t_{1/2} = 2 \Rightarrow t^{1/2} = t/2$ = 20 hours / 2 = 10 hours.

$A'' = \frac{A_0}{2^{t/t_{1/2}}} \Rightarrow A'' = \frac{4 \times 10^6}{2^{100/10}} = 0.00390625 \times 10^6 = 3.9 \times 10^3$ dintegrations/sec.

25. $t_{1/2}$ = 1602 Y ; Ra = 226 g/mole ; Cl = 35.5 g/mole.

1 mole $RaCl_2$ = 226 + 71 = 297 g

297g = 1 mole of Ra.

0.1 g $= \frac{1}{297} \times 0.1$ mole of Ra $= \frac{0.1 \times 6.023 \times 10^{23}}{297} = 0.02027 \times 10^{22}$

$\lambda = 0.693 / t_{1/2} = 1.371 \times 10^{-11}$.

Activity = $\lambda N = 1.371 \times 10^{-11} \times 2.027 \times 10^{20} = 2.779 \times 10^9 = 2.8 \times 10^9$ disintegrations/second.

26. $t_{1/2}$ = 10 hours, A_0 = 1 ci

Activity after 9 hours = $A_0 e^{-\lambda t} = 1 \times e^{\frac{-0.693}{10} \times 9}$ = 0.5359 = 0.536 Ci.

No. of atoms left after 9th hour, $A_9 = \lambda N_9$

$\Rightarrow N_9 = \frac{A_9}{\lambda} = \frac{0.536 \times 10 \times 3.7 \times 10^{10} \times 3600}{0.693} = 28.6176 \times 10^{10} \times 3600 = 103.023 \times 10^{13}$.

Activity after 10 hours = $A_0 e^{-\lambda t} = 1 \times e^{\frac{-0.693}{10} \times 9}$ = 0.5 Ci.

No. of atoms left after 10th hour

$A_{10} = \lambda N_{10}$

$\Rightarrow$ $N_{10} = \frac{A_{10}}{\lambda} = \frac{0.5 \times 3.7 \times 10^{10} \times 3600}{0.693/10} = 26.37 \times 10^{10} \times 3600 = 96.103 \times 10^{13}$.

No.of disintegrations = $(103.023 - 96.103) \times 10^{13} = 6.92 \times 10^{13}$.

27. $t_{1/2} = 14.3$ days ; t = 30 days = 1 month

As, the selling rate is decided by the activity, hence $A_0 = 800$ disintegration/sec.

We know, $A = A_0e^{-\lambda t}$ $[\lambda = 0.693/14.3]$

$A = 800 \times 0.233669 = 186.935 = 187$ rupees.

28. According to the question, the emission rate of γ rays will drop to half when the $\beta+$ decays to half of its original amount. And for this the sample would take 270 days.

$\therefore$ The required time is 270 days.

29. a) $P \rightarrow n + e^+ + v$ Hence it is a β^+ decay.

b) Let the total no. of atoms be $100\ N_0$.

	Carbon	Boron
Initially	$90\ N_0$	$10\ N_0$
Finally	$10\ N_0$	$90\ N_0$

Now, $10\ N_0 = 90\ N_0\ e^{-\lambda t} \Rightarrow 1/9 = e^{\frac{-0.693}{20.3} \times t}$ [because $t_{1/2} = 20.3$ min]

$\Rightarrow$ $\ln \frac{1}{9} = \frac{-0.693}{20.3} t \Rightarrow t = \frac{2.1972 \times 20.3}{0.693} = 64.36 = 64$ min.

30. $N = 4 \times 10^{23}$; $t_{1/2} = 12.3$ years.

a) Activity = $\frac{dN}{dt} = \lambda n = \frac{0.693}{t_{1/2}} N = \frac{0.693}{12.3} \times 4 \times 10^{23}$ dis/year.

$= 7.146 \times 10^{14}$ dis/sec.

b) $\frac{dN}{dt} = 7.146 \times 10^{14}$

No.of decays in next 10 hours = $7.146 \times 10^{14} \times 10 \times 36.. = 257.256 \times 10^{17} = 2.57 \times 10^{19}$.

c) $N = N_0\ e^{-\lambda t} = 4 \times 10^{23} \times e^{\frac{-0.693}{20.3} \times 6.16} = 2.82 \times 10^{23}$ = No.of atoms remained

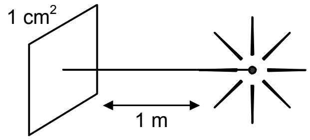
No. of atoms disintegrated = $(4 - 2.82) \times 10^{23} = 1.18 \times 10^{23}$.

31. Counts received per cm^2 = 50000 Counts/sec.

$N = N_3o$ of active nucleic = 6×10^{16}

Total counts radiated from the source = Total surface area $\times$ 50000 counts/cm^2

$= 4 \times 3.14 \times 1 \times 10^4 \times 5 \times 10^4 = 6.28 \times 10^9$ Counts = dN/dt



We know, $\frac{dN}{dt} = \lambda N$

Or $\lambda = \frac{6.28 \times 10^9}{6 \times 10^{16}} = 1.0467 \times 10^{-7} = 1.05 \times 10^{-7}\ s^{-1}$.

32. Half life period can be a single for all the process. It is the time taken for 1/2 of the uranium to convert to lead.

No. of atoms of $U^{238} = \frac{6 \times 10^{23} \times 2 \times 10^{-3}}{238} = \frac{12}{238} \times 10^{20} = 0.05042 \times 10^{20}$

No. of atoms in Pb = $\frac{6 \times 10^{23} \times 0.6 \times 10^{-3}}{206} = \frac{3.6}{206} \times 10^{20}$

Initially total no. of uranium atoms = $\left(\frac{12}{235} + \frac{3.6}{206}\right) \times 10^{20} = 0.06789$

$N = N_0\ e^{-\lambda t} \Rightarrow N = N_0\ e^{\frac{-0.693}{t/t_{1/2}}} \Rightarrow 0.05042 = 0.06789\ e^{\frac{-0.693}{4.47 \times 10^9}}$

$\Rightarrow$ $\log\left(\frac{0.05042}{0.06789}\right) = \frac{-0.693t}{4.47 \times 10^9}$

$\Rightarrow t = 1.92 \times 10^9$ years.

33. $A_0 = 15.3$; $A = 12.3$; $t_{1/2} = 5730$ year

$$\lambda = \frac{0.6931}{T_{1/2}} = \frac{0.6931}{5730}\text{yr}^{-1}$$

Let the time passed be t,

We know $A = A_0 e^{-\lambda t} - \frac{0.6931}{5730} \times t \Rightarrow 12.3 = 15.3 \times e.$

$\Rightarrow$ t = 1804.3 years.

34. The activity when the bottle was manufactured = A_0

Activity after 8 years = $A_0 e^{\frac{-0.693}{12.5} \times 8}$

Let the time of the mountaineering = t years from the present

$A = A_0 e^{\frac{-0.693}{12.5} \times t}$; A = Activity of the bottle found on the mountain.

A = (Activity of the bottle manufactured 8 years before) × 1.5%

$$\Rightarrow A_0 e^{\frac{-0.693}{12.5}} = A_0 e^{\frac{-0.693}{12.5} \times 8} \times 0.015$$

$$\Rightarrow \frac{-0.693}{12.5} t = \frac{-0.693 \times 8}{12.5} + \ln[0.015]$$

$\Rightarrow 0.05544\,t = 0.44352 + 4.1997 \Rightarrow t = 83.75$ years.

35. a) Here we should take R_0 at time is $t_0 = 30 \times 10^9\ s^{-1}$

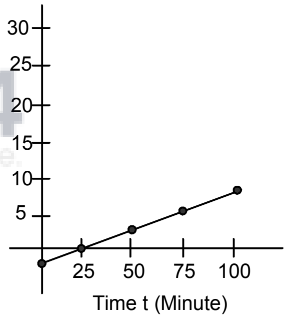
i) $\ln(R_0/R_1) = \ln\left(\frac{30 \times 10^9}{30 \times 10^9}\right) = 0$

ii) $\ln(R_0/R_2) = \ln\left(\frac{30 \times 10^9}{16 \times 10^9}\right) = 0.63$

iii) $\ln(R_0/R_3) = \ln\left(\frac{30 \times 10^9}{8 \times 10^9}\right) = 1.35$

iv) $\ln(R_0/R_4) = \ln\left(\frac{30 \times 10^9}{3.8 \times 10^9}\right) = 2.06$

v) $\ln(R_0/R_5) = \ln\left(\frac{30 \times 10^9}{2 \times 10^9}\right) = 2.7$



b) ∴ The decay constant $\lambda = 0.028\ \text{min}^{-1}$

c) ∴ The half life period = $t_{1/2}$.

$$t_{1/2} = \frac{0.693}{\lambda} = \frac{0.693}{0.028} = 25 \text{ min.}$$

36. Given : Half life period $t_{1/2} = 1.30 \times 10^9$ year , A = 160 count/s = $1.30 \times 10^9 \times 365 \times 86400$

$$\therefore A = \lambda N \Rightarrow 160 = \frac{0.693}{t_{1/2}} N$$

$$\Rightarrow N = \frac{160 \times 1.30 \times 365 \times 86400 \times 10^9}{0.693} = 9.5 \times 10^{18}$$

∴ 6.023×10^{23} No. of present in 40 grams.

$6.023 \times 10^{23} = 40\text{ g} \Rightarrow 1 = \frac{40}{6.023 \times 10^{23}}$

$\therefore 9.5 \times 10^{18}$ present in $= \frac{40 \times 9.5 \times 10^{18}}{6.023 \times 10^{23}} = 6.309 \times 10^{-4} = 0.00063.$

∴ The relative abundance at 40 k in natural potassium = $(2 \times 0.00063 \times 100)\% = 0.12\%$.

37. a) P + e → n + v neutrino [$a \to 4.95 \times 10^7\ s^{-1/2}$; $b \to 1$]

b) $\sqrt{f} = a(z - b)$

$\Rightarrow \sqrt{c/\lambda} = 4.95 \times 10^7 (79 - 1) = 4.95 \times 10^7 \times 78 \Rightarrow C/\lambda = (4.95 \times 78)^2 \times 10^{14}$

$\Rightarrow \lambda = \dfrac{3 \times 10^8}{14903.2 \times 10^{14}} = 2 \times 10^{-5} \times 10^{-6} = 2 \times 10^{-4}$ m = 20 pm.

38. Given : Half life period = $t_{1/2}$, Rate of radio active decay = $\dfrac{dN}{dt} = R \Rightarrow R = \dfrac{dN}{dt}$

Given after time $t >> t_{1/2}$, the number of active nuclei will become constant.

i.e. $(dN/dt)_{present} = R = (dN/dt)_{decay}$

$\therefore R = (dN/dt)_{decay}$

$\Rightarrow R = \lambda N$ [where, λ = Radioactive decay constant, N = constant number]

$\Rightarrow R = \dfrac{0.693}{t_{1/2}}(N) \Rightarrow Rt_{1/2} = 0.693\ N \Rightarrow N = \dfrac{Rt_{1/2}}{0.693}$.

39. Let N_0 = No. of radioactive particle present at time t = 0

N = No. of radio active particle present at time t.

$\therefore N = N_0\, e^{-\lambda t}$ [λ - Radioactive decay constant]

$\therefore$ The no.of particles decay = $N_0 - N = N_0 - N_0 e^{-\lambda t} = N_0 (1 - e^{-\lambda t})$

We know, $A_0 = \lambda N_0$; $R = \lambda N_0$; $N_0 = R/\lambda$

From the above equation

$N = N_0 (1 - e^{-\lambda t}) = \dfrac{R}{\lambda}(1 - e^{-\lambda t})$ (substituting the value of N_0)

40. n = 1 mole = 6×10^{23} atoms, $t_{1/2}$ = 14.3 days

t = 70 hours, dN/dt in root after time t = λN

$N = No\, e^{-\lambda t} = 6 \times 10^{23} \times e^{\frac{-0.693 \times 70}{14.3 \times 24}} = 6 \times 10^{23} \times 0.868 = 5.209 \times 10^{23}$.

$5.209 \times 10^{23} \times \dfrac{-0.693}{14.3 \times 24} = \dfrac{0.0105 \times 10^{23}}{3600}$ dis/hour.

$= 2.9 \times 10^{-6} \times 10^{23}$ dis/sec $= 2.9 \times 10^{17}$ dis/sec.

Fraction of activity transmitted = $\left(\dfrac{1\mu ci}{2.9 \times 10^{17}}\right) \times 100\%$

$\Rightarrow \left(\dfrac{1 \times 3.7 \times 10^8}{2.9 \times 10^{11}} \times 100\right)\% = 1.275 \times 10^{-11}\ \%$.

41. V = 125 cm^3 = 0.125 L, P = 500 K pa = 5 atm.

T = 300 K, $t_{1/2}$ = 12.3 years = 3.82×10^8 sec. Activity = $\lambda \times N$

$N = n \times 6.023 \times 10^{23} = \dfrac{5 \times 0.125}{8.2 \times 10^{-2} \times 3 \times 10^2} \times 6.023 \times 10^{23} = 1.5 \times 10^{22}$ atoms.

$\lambda = \dfrac{0.693}{3.82 \times 10^8} = 0.1814 \times 10^{-8} = 1.81 \times 10^{-9}\ s^{-1}$

Activity = $\lambda N = 1.81 \times 10^{-9} \times 1.5 \times 10^{22} = 2.7 \times 10^3$ disintegration/sec

$= \dfrac{2.7 \times 10^{13}}{3.7 \times 10^{10}}$ Ci = 729 Ci.

42. ${}^{212}_{83}Bi \to {}^{208}_{81}Ti + {}^{4}_{2}He(\alpha)$

${}^{212}_{83}Bi \to {}^{212}_{84}Bi \to {}^{212}_{84}P_0 + e^-$

$t_{1/2}$ = 1 h. Time elapsed = 1 hour

at t = 0 Bi^{212} Present = 1 g

$\therefore$ at t = 1 Bi^{212} Present = 0.5 g

Probability α-decay and β-decay are in ratio 7/13.

$\therefore$ Tl remained = 0.175 g

$\therefore P_0$ remained = 0.325 g

43. Activities of sample containing ^{108}Ag and ^{110}Ag isotopes = 8.0×10^8 disintegration/sec.

a) Here we take A = 8×10^8 dis./sec

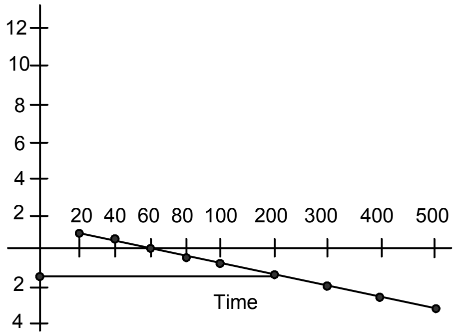
∴ i) $\text{In}(A_1/A_{0_1}) = \text{In}(11.794/8) = 0.389$

ii) $\text{In}(A_2/A_{0_2}) = \text{In}(9.1680/8) = 0.1362$

iii) $\text{In}(A_3/A_{0_3}) = \text{In}(7.4492/8) = -0.072$

iv) $\text{In}(A_4/A_{0_4}) = \text{In}(6.2684/8) = -0.244$

v) $\text{In}(5.4115/8) = -0.391$
vi) $\text{In}(3.0828/8) = -0.954$
vii) $\text{In}(1.8899/8) = -1.443$
viii) $\text{In}(1.167/8) = -1.93$
ix) $\text{In}(0.7212/8) = -2.406$



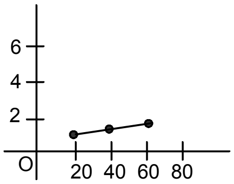
b) The half life of 110 Ag from this part of the plot is 24.4 s.

c) Half life of ^{110}Ag = 24.4 s.

∴ decay constant $\lambda = 0.693/24.4 = 0.0284 \Rightarrow t = 50$ sec,

The activity $A = A_0e^{-\lambda t} = 8 \times 10^8 \times e^{-0.0284\times50} = 1.93 \times 10^8$

d)



e) The half life period of ^{108}Ag from the graph is 144 s.

44. $t_{1/2} = 24$ h

∴ $t_{1/2} = \frac{t_1t_2}{t_1+t_2} = \frac{24\times6}{24+6} = 4.8$ h.

A_0 = 6 rci ; A = 3 rci

∴ $A = \frac{A_0}{2^{t/t_{1/2}}} \Rightarrow 3\text{ rci} = \frac{6\text{ rci}}{2^{t/4.8h}} \Rightarrow \frac{t}{24.8h} = 2 \Rightarrow t = 4.8$ h.

45. $Q = qe^{-t/CR}$; $A = A_0e^{-\lambda t}$

$$\frac{\text{Energy}}{\text{Activity}} = \frac{1q^2 \times e^{-2t/cR}}{2\,CA_0e^{-\lambda t}}$$

Since the term is independent of time, so their coefficients can be equated,

So, $\frac{2t}{CR} = \lambda t$ or, $\lambda = \frac{2}{CR}$ or, $\frac{1}{\tau} = \frac{2}{CR}$ or, $R = 2\frac{\tau}{C}$ (Proved)

46. R = 100 Ω ; L = 100 mH

After time t, $i = i_0(1-e^{-t/Lr})$ $N = N_0(e^{-\lambda t})$

$\frac{i}{N} = \frac{i_0(1-e^{-tR/L})}{N_0e^{-\lambda t}}$ i/N is constant i.e. independent of time.

Coefficients of t are equal $-R/L = -\lambda \Rightarrow R/L = 0.693/t_{1/2}$

$= t_{1/2} = 0.693 \times 10^{-3} = 6.93 \times 10^{-4}$ sec.

47. 1 g of 'I' contain 0.007 g U^{235} So, 235 g contains 6.023×10^{23} atoms.

So, 0.7 g contains $\frac{6.023\times10^{23}}{235} \times 0.007$ atom

1 atom given 200 Mev. So, 0.7 g contains $\frac{6.023\times10^{23}\times0.007\times200\times10^{6}\times1.6\times10^{-19}}{235}$ J = 5.74×10^{-8} J.

48. Let n atoms disintegrate per second

Total energy emitted/sec = $(n \times 200 \times 10^6 \times 1.6 \times 10^{-19})$ J = Power

300 MW = 300×10^6 Watt = Power

$300 \times 10^6 = n \times 200 \times 10^6 \times 1.6 \times 10^{-19}$

$\Rightarrow n = \dfrac{3}{2 \times 1.6} \times 10^{19} = \dfrac{3}{3.2} \times 10^{19}$

6×10^{23} atoms are present in 238 grams

$\dfrac{3}{3.2} \times 10^{19}$ atoms are present in $\dfrac{238 \times 3 \times 10^{19}}{6 \times 10^{23} \times 3.2} = 3.7 \times 10^{-4}$ g = 3.7 mg.

49. a) Energy radiated per fission = 2×10^8 ev

Usable energy = $2 \times 10^8 \times 25/100 = 5 \times 10^7$ ev $= 5 \times 1.6 \times 10^{-12}$

Total energy needed = $300 \times 10^8 = 3 \times 10^8$ J/s

No. of fission per second = $\dfrac{3 \times 10^8}{5 \times 1.6 \times 10^{-12}} = 0.375 \times 10^{20}$

No. of fission per day = $0.375 \times 10^{20} \times 3600 \times 24 = 3.24 \times 10^{24}$ fissions.

b) From 'a' No. of atoms disintegrated per day = 3.24×10^{24}

We have, 6.023×10^{23} atoms for 235 g

for 3.24×10^{24} atom = $\dfrac{235}{6.023 \times 10^{23}} \times 3.24 \times 10^{24}$ g = 1264 g/day = 1.264 kg/day.

50. a) ${}^2_1H + {}^2_1H \rightarrow {}^3_1H + {}^1_1H$

Q value = $2M({}^2_1H) = [M({}^3_1H) + M({}^3_1H)]$

= [2 × 2.014102 – (3.016049 + 1.007825)]u = 4.0275 Mev = 4.05 Mev.

b) ${}^2_1H + {}^2_1H \rightarrow {}^3_2H + n$

Q value = $2[M({}^2_1H) - M({}^3_2He) + M_n]$

= [2 × 2.014102 – (3.016049 + 1.008665)]u = 3.26 Mev = 3.25 Mev.

c) ${}^2_1H + {}^3_1H \rightarrow {}^4_2H + n$

Q value = $[M({}^2_1H) + M({}^3_1He) - M({}^4_2He) + M_n]$

= (2.014102 + 3.016049) – (4.002603 + 1.008665)]u = 17.58 Mev = 17.57 Mev.

51. PE = $\dfrac{Kq_1q_2}{r} = \dfrac{9 \times 10^9 \times (2 \times 1.6 \times 10^{-19})^2}{r}$ …(1)

$1.5\ KT = 1.5 \times 1.38 \times 10^{-23} \times T$ …(2)

Equating (1) and (2) $1.5 \times 1.38 \times 10^{-23} \times T = \dfrac{9 \times 10^9 \times 10.24 \times 10^{-38}}{2 \times 10^{-15}}$

$\Rightarrow T = \dfrac{9 \times 10^9 \times 10.24 \times 10^{-38}}{2 \times 10^{-15} \times 1.5 \times 1.38 \times 10^{-23}} = 22.26087 \times 10^9\ K = 2.23 \times 10^{10}\ K$.

52. ${}^4H + {}^4H \rightarrow {}^8Be$

$M({}^2H) \rightarrow 4.0026$ u

$M({}^8Be) \rightarrow 8.0053$ u

Q value = $[2\ M({}^2H) - M({}^8Be)] = (2 \times 4.0026 - 8.0053)$ u

= –0.0001 u = –0.0931 Mev = –93.1 Kev.

53. In 18 g of N_0 of molecule = 6.023×10^{23}

In 100 g of N_0 of molecule = $\dfrac{6.023 \times 10^{26}}{18} = 3.346 \times 10^{25}$

∴ % of Deuterium = $3.346 \times 10^{26} \times 99.985$

Energy of Deuterium = $30.4486 \times 10^{25} = (4.028204 - 3.016044) \times 93$

= 942.32 ev = 1507×10^5 J = 1507 mJ

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