# 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 = $3 \times 10^{14}$.

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 '$\alpha$' particle be xu.
   '$\alpha$' particle contains 2 protons and 2 neutrons.
   $\therefore$ Binding energy = $(2 \times 1.007825\text{ u} \times 1 \times 1.00866\text{ u} - xu)C^2 = 28.2$ MeV (given).
   $\therefore x = 4.0016$ u.

4. $Li^7 + p \rightarrow I + \alpha + E$ ; $Li^7 = 7.016$u
   $\alpha = {}^4He = 4.0026$u ; $p = 1.007276$ 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. $B = (Zm_p + Nm_n - M)C^2$
   $Z = 79$ ; $N = 118$ ; $m_p = 1.007276$u ; $M = 196.96$ u ; $m_n = 1.008665$u
   $B = [(79 \times 1.007276 + 118 \times 1.008665)u - Mu]c^2$
   $= 198.597274 \times 931 - 196.96 \times 931 = 1524.302094$
   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.
   ${}^{223}R_a \rightarrow {}^{209}Pb + {}^{14}C$
   $\Delta m$ = 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. $P^{32} \rightarrow S^{32} + {}_0\overline{v}^0 + {}_1\beta^0$
    Energy of antineutrino and $\beta$-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 $\lambda$ = decay constant).
    Or $\lambda = 0.6931 / 14 \times 60 = 8.25 \times 10^{-4}$ S  [As half life = 14 min = 14 × 60 sec].
    Energy = $[M_n - (M_P + M_e)]u = [(M_{nu} - M_{pu}) - M_{pu}]c^2 = [0.00189u - 511\ KeV/c^2]$
    $= [1293159\ ev/c^2 - 511000\ ev/c^2]c^2 = 782159$ eV = 782 Kev.

12. ${}^{226}_{58}Ra \rightarrow {}^4_2\alpha + {}^{222}_{26}Rn$
    ${}^{19}_8O \rightarrow {}^{19}_9F + {}^0_n\beta + {}^0_0\overline{v}$
    ${}^{13}_{25}Al \rightarrow {}^{25}_{12}MG + {}^0_{-1}e + {}^0_0\overline{v}$

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

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 = $\frac{500 \times 1.6 \times 10^{-19}}{3 \times 10^8} \times 10^3$ J = $2.67 \times 10^{-22}$ kg m/s.

14. a) $_{19}K^{40} \rightarrow {}_{20}Ca^{40} + {}_{-1}e^0 + {}_0\bar{v}^0$

$_{19}K^{40} \rightarrow {}_{18}Ar^{40} + {}_{-1}e^0 + {}_0\bar{v}^0$

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

$_{19}K^{40} \rightarrow {}_{20}Ca^{40} + {}_{-1}e^0 + {}_0v^0$ .

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.

$_{19}K^{40} \rightarrow {}_{18}Ar^{40} + {}_{-1}e^0 + {}_0\bar{v}^0$

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

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

$Q_{value}$ = (39.964 – 39.9624)$uc^2$.

15. $^6_3Li + n \rightarrow {}^7_3Li$ ; $^7_3Li + r \rightarrow {}^8_3Li$

$^8_3Li \rightarrow {}^8_4Be + e^- + v^-$

$^8_4Be \rightarrow {}^4_2He + {}^4_2He$

16. $^{\prime\prime}C \rightarrow {}^{\prime\prime}B + \beta^+ + v$

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 $^{238Th}$ = 228.028726 u ; $^{224}Ra$ = 224.020196 u ; $\alpha = {}^4_2He \rightarrow$ 4.00260u

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

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

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

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

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

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

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

Net reaction : $^{12}N \rightarrow {}^{12}C + e^+ + v + v$(4.43 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) $t_{1/2} = 0.693 / \lambda$ [$\lambda \rightarrow$ Decay constant]

$\Rightarrow t_{1/2}$ = 3820 sec = 64 min.

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

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

20. a) 198 grams of Ag contains $\rightarrow N_0$ atoms.

1 μg of Ag contains $\rightarrow N_0/198 \times 1\ \mu g = \frac{6 \times 10^{23} \times 1 \times 10^{-6}}{198}$ atoms

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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 μ 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 $\mu$ Ci

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

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

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

$= 6.47 \times 10^3$ years.

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

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

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

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

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

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

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

$A'' = \dfrac{A_0}{2^{t/t_{1/2}}} \Rightarrow A'' = \dfrac{4 \times 10^6}{2^{100/10}} = 0.00390625 \times 10^6 = 3.9 \times 10^3$ 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 $= \dfrac{1}{297} \times 0.1$ mole of Ra $= \dfrac{0.1 \times 6.023 \times 10^{23}}{297} = 0.02027 \times 10^{22}$

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

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, $A_9 = \lambda N_9$

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

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

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

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

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, $A = A_0 e^{-\lambda t}$ [$\lambda = 0.693/14.3$]

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

28. According to the question, the emission rate of $\gamma$ 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 $\beta^+$ 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

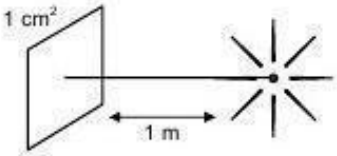
No. of atoms disintegrated $= (4 - 2.82)\times 10^{23} = 1.18\times 10^{23}$.

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

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

Total counts radiated from the source = Total surface area × 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

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

Let the time passed be t,

We know $A = A_0e^{-\lambda t} - \frac{0.6931}{5730}\times t \Rightarrow 12.3 = 15.3\times e.$

$\Rightarrow t = 1804.3$ years.

34. The activity when the bottle was manufactured = $A_0$

Activity after 8 years = $A_0e^{\frac{-0.693}{12.5}\times 8}$

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

$A = A_0e^{\frac{-0.693}{12.5}\times t}$ ; A = Activity of the bottle found on the mountain.

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

$\Rightarrow A_0e^{\frac{-0.693}{12.5}} = A_0e^{\frac{-0.693}{12.5}\times 8}\times 0.015$

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

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

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

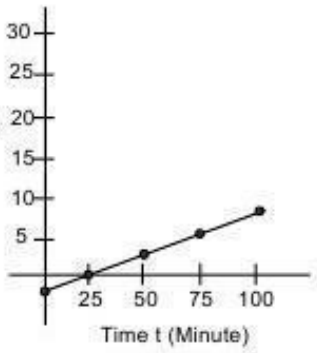
i) $\ln(R_0/R_1) = \ln\left(\frac{30\times10^9}{30\times10^9}\right) = 0$

ii) $\ln(R_0/R_2) = \ln\left(\frac{30\times10^9}{16\times10^9}\right) = 0.63$

iii) $\ln(R_0/R_3) = \ln\left(\frac{30\times10^9}{8\times10^9}\right) = 1.35$

iv) $\ln(R_0/R_4) = \ln\left(\frac{30\times10^9}{3.8\times10^9}\right) = 2.06$

v) $\ln(R_0/R_5) = \ln\left(\frac{30\times10^9}{2\times10^9}\right) = 2.7$




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

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

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

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

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

$\Rightarrow N = \frac{160\times1.30\times365\times86400\times10^9}{0.693} = 9.5 \times 10^{18}$

∴ $6.023 \times 10^{23}$ No. of present in 40 grams.

$6.023 \times 10^{23} = 40\ g \Rightarrow 1 = \frac{40}{6.023\times10^{23}}$

∴ $9.5 \times 10^{18}$ present in $= \frac{40\times9.5\times10^{18}}{6.023\times10^{23}} = 6.309 \times 10^{-4} = 0.00063.$

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

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

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

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

$\Rightarrow \lambda = \frac{3\times10^8}{14903.2\times10^{14}} = 2 \times 10^{-5} \times 10^{-6} = 2 \times 10^{-4}$ m = 20 pm.

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

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

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

∴ $R = (dN/dt)_{decay}$

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

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

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

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

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

∴ The no.of particles decay = $N_0 - N = N_0 - N_0e^{-\lambda t} = N_0\ (1 - e^{-\lambda t})$

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

From the above equation

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

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

t = 70 hours, dN/dt in root after time $t = \lambda N$

$-\frac{0.693\times70}{}$

$N = N_o e^{-\lambda t} = 6 \times 10^{23} \times e^{\frac{-0.693}{14.3 \times 24}} = 6 \times 10^{23} \times 0.868 = 5.209 \times 10^{23}$.

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

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

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

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

41. $V = 125\ cm^3 = 0.125$ L, P = 500 K pa = 5 atm.
$T = 300$ K, $t_{1/2} = 12.3$ years $= 3.82 \times 10^8$ sec. Activity $= \lambda \times N$

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

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

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

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

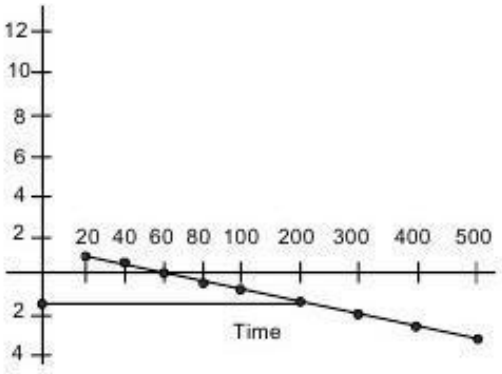
42. $^{212}_{83}Bi \rightarrow ^{208}_{81}Ti + ^{4}_{2}He(\alpha)$

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

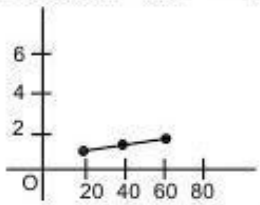
$t_{1/2} = 1$ h. Time elapsed = 1 hour
at t = 0 $Bi^{212}$ Present = 1 g
$\therefore$ at t = 1 $Bi^{212}$ Present = 0.5 g
Probability $\alpha$-decay and $\beta$-decay are in ratio 7/13.
$\therefore$ Tl remained = 0.175 g
$\therefore$ $P_0$ remained = 0.325 g

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43. Activities of sample containing $^{108}Ag$ and $^{110}Ag$ isotopes $= 8.0 \times 10^8$ disintegration/sec.
a) Here we take $A = 8 \times 10^8$ dis./sec
$\therefore$ i) $\ln (A_1/A_{0_1})$ $= \ln (11.794/8) = 0.389$
ii) $\ln (A_2/A_{0_2}) = \ln(9.1680/8) = 0.1362$
iii) $\ln (A_3/A_{0_3}) = \ln(7.4492/8) = -0.072$
iv) $\ln (A_4/A_{0_4}) = \ln(6.2684/8) = -0.244$
v) $\ln(5.4115/8) = -0.391$
vi) $\ln(3.0828/8) = -0.954$
vii) $\ln(1.8899/8) = -1.443$
viii) $\ln(1.167/8) = -1.93$
ix) $\ln(0.7212/8) = -2.406$




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.
$\therefore$ decay constant $\lambda = 0.693/24.4 = 0.0284 \Rightarrow t = 50$ sec,
The activity $A = A_0 e^{-\lambda t} = 8 \times 10^8 \times e^{-0.0284 \times 50} = 1.93 \times 10^8$
d)




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

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

$\therefore t_{1/2} = \frac{t_1 t_2}{t_1 + t_2} = \frac{24 \times 6}{24 + 6} = 4.8$ h.

$A_0 = 6$ rci ; A = 3 rci

$\therefore A = \frac{A_0}{2^{t/t_{1/2}}} \Rightarrow 3\ rci = \frac{6\ rci}{2^{t/4.8h}} \Rightarrow \frac{t}{24.8h} = 2 \Rightarrow t = 4.8$ 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. $R = 100\ \Omega$ ; $L = 100$ 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 $6.023 \times 10^{23}$ 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 $= 5.74 \times 10^{-8}$ 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 $= 300 \times 10^6$ Watt = Power

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

$\Rightarrow n = \frac{3}{2\times1.6} \times 10^{19} = \frac{3}{3.2} \times 10^{19}$

$6 \times 10^{23}$ atoms are present in 238 grams

$\frac{3}{3.2} \times 10^{19}$ atoms are present in $\frac{238\times3\times10^{19}}{6\times10^{23}\times3.2} = 3.7 \times 10^{-4}$ g = 3.7 mg.

49. a) Energy radiated per fission $= 2 \times 10^8$ 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 $= \frac{3\times10^8}{5\times1.6\times10^{-12}} = 0.375 \times 10^{20}$

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 $= 3.24 \times 10^{24}$

We have, $6.023 \times 10^{23}$ atoms for 235 g

for $3.24 \times 10^{24}$ atom $= \frac{235}{6.023\times10^{23}} \times 3.24 \times 10^{24}$ g = 1264 g/day = 1.264 kg/day.

50. a) ${}_1^2H + {}_1^2H \rightarrow {}_1^3H + {}_1^1H$

Q value $= 2M({}_1^2H) = [M({}_1^3H) + M({}_1^3H)]$

$= [2 \times 2.014102 - (3.016049 + 1.007825)]u = 4.0275$ Mev $= 4.05$ Mev.

b) ${}_1^2H + {}_1^2H \rightarrow {}_2^3H + n$

Q value $= 2[M({}_1^2H) - M({}_2^3He) + M_n]$

$= [2 \times 2.014102 - (3.016049 + 1.008665)]u = 3.26$ Mev $= 3.25$ Mev.

c) ${}_1^2H + {}_1^3H \rightarrow {}_2^4H + n$

Q value $= [M({}_1^2H) + M({}_1^3He) - M({}_2^4He) + M_n]$

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

51. $PE = \frac{Kq_1q_2}{r} = \frac{9\times10^9\times(2\times1.6\times10^{-19})^2}{r}$ ...(1)

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

Equating (1) and (2) $1.5 \times 1.38 \times 10^{-23} \times T = \frac{9\times10^9\times10.24\times10^{-38}}{}$

$2\times10^{-15}$

$\Rightarrow T = \dfrac{9\times10^{9}\times10.24\times10^{-38}}{2\times10^{-15}\times1.5\times1.38\times10^{-23}} = 22.26087\times10^{9}\ K = 2.23\times10^{10}\ K.$

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

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

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

Q value = $[2\ M(^{2}H) - M(^{8}Be)] = (2\times4.0026 - 8.0053)\ u$

$= -0.0001\ u = -0.0931\ Mev = -93.1\ Kev.$

53. In 18 g of $N_0$ of molecule = $6.023\times10^{23}$

In 100 g of $N_0$ of molecule = $\dfrac{6.023\times10^{26}}{18} = 3.346\times10^{25}$

$\therefore$ % of Deuterium = $3.346\times10^{26}\times99.985$

Energy of Deuterium = $30.4486\times10^{25} = (4.028204 - 3.016044)\times93$

$= 942.32\ ev = 1507\times10^{5}\ J = 1507\ mJ$