JEE-MAIN+ADV.

TOPIC

SOLUTIONS

NUCLEAR PHYSICS

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Exercise-I

1. C

1 a.m.u. = $\frac{1}{12}$ [mass of one $_6c^{12}$]

For $C \Rightarrow A = 12$

2. B

Energy = BE of Products – BE of Reactants
(8.2 × 110 + 8.2 × 90) – 7.4 × 200
= 160 MeV

3. B

$^{A}X + {}^{A}X \rightarrow {}^{2A}Y$

$E_2 - 2E_1 = Q$

4. C

$$\begin{array}{ccc} 3B & \rightarrow & A + e \\ \downarrow & & \downarrow \\ E_b & & E_a \end{array}$$

$e = E_a - 3E_b \Rightarrow 3E_b = E_a - e$

5. C

BE/ Nucleon $\Rightarrow$

$^4_2He \Rightarrow \frac{28}{4} = 7\,MeV$

$^7_3Li \Rightarrow \frac{52}{7} = 7.4\,MeV$

$^{12}_6C \Rightarrow \frac{90}{12} = 7.5\,MeV$

$^{14}_7N \Rightarrow \frac{98}{14} = 7\,MeV$

Elements with more BE/nucleon is more stable.

6. B

Two smaller nuclei combining to form a larger nucleus is called a Fusion reaction.

7. D

The gamma photon corresponding to the energy difference will be captured so that energy on reactant and product side is equal.
(939 + 940 - 1876)
= 3 MeV (Captures)

8. B

$K.E_\alpha = \frac{A\,50\,Mev}{(A+4)}$ = 48 MeV

0.96 × 50 MeV = 48 MeV
A = 100

9. D

$M_x = e^0_{-1} + {}_0\gamma^0 + M_y$

$M_x = M_y$

10. C

$^{226}_{88}R_a \rightarrow {}^{206}_{82}P_b + x\alpha + y\beta$

226 = 206 + 4x
x = 5

11. B

$N_1 = N_0 e^{-10\lambda_0 t}$ $\qquad N_2 = N_0 e^{-\lambda_0 t}$

12. C

$A = \lambda N$

$A_1 = \frac{0.693}{2} N_0 e^{-\frac{0.693}{2}t}$

$A_2 = \frac{0.693}{4} N_0\, e^{\frac{-0.693}{4}t}$ $\qquad \frac{A_1}{A_2} = 2e^{\frac{0.693}{4}t - \frac{0.693}{2}t}$

$= 2e^{\frac{-0.693}{2}}$

13. C

$N_1 = N_0 e^{-\lambda t}$

$= N_0 e^{-1} = \frac{N_0}{e}$

14. B

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

$N = N_0 e^{-2\lambda t}$ $\qquad N = N_0 0.9 \times 0.9$

$N = 0.81\, N_0$

15. D

$R_1 = R_0 e^{-\lambda t_1}$

$R_2 = R_0 e^{-\lambda t_2}$ $\qquad$ $\frac{R_2}{R_1} = e^{-\lambda(t_2 - t_1)}$

16. A

$\lambda_1 : \lambda_2 = 1:2$

$\lambda_1 A_0 = \lambda_2 B_0$ $\qquad$ $A_0 = 2B_0$

17. C

$A_1 = A_0 e^{-\lambda t_1}$ $\qquad$ $A_2 = A_0 e^{-\lambda t_2}$

$A_2 = A_1 e^{(t_1 - t_2)\lambda} \Rightarrow A_2 = A_1 \; e^{\frac{(t_1-t_2)}{T}}$

18. A

$f_1 = 1 - e^{-\lambda \frac{1}{\lambda}}$ $\qquad$ $= 0.634$

$f_2 = 1 - e^{-\lambda \frac{Ln2}{\lambda}}$ $\qquad$ $= 1 - e^{\ln 2^{-1}}$

$= \left(1 - \frac{1}{2}\right) = \frac{1}{2}$

19. B

$R_1 = \lambda N_o e^{-\lambda T_1}$

$R_2 = \lambda N_o e^{-\lambda T_2}$

Atoms decayed N_1-N_2

$= \frac{R_1 - R_2}{\lambda} = R_1 - R_2$

20. A

As there is no further disintegration of product hence decay constant is Zero.

21. D

A given Nucleus may decay after t = 0 at any time.

22. A

$\lambda_1 : \lambda_2 = 1:2$

$\lambda_1 A_0 = \lambda_2 B_0$

$A_0 = 2B_0$

23. B

Initial = N_o

Total decayed in 10 years

$\frac{N_o}{2} + \frac{N_o}{2^2} = \frac{3}{4} N_o$

Prob = $= \frac{\frac{3}{4} N_o}{N_o}$ $\qquad$ Prob = 75%

24. A

Prob of decay by $\lambda_1 \Rightarrow \frac{dN_1}{N_1} = \lambda_1 t$

$\lambda_2 \Rightarrow \frac{dN_2}{N_2} = \lambda_2 t$

$\text{Total Prob} = \frac{dN}{N} = \lambda dt$

$\lambda dt = \lambda_1 dt + \lambda_2 dt$

$\lambda = \lambda_1 + \lambda_2$

25. E

$N = N_0 (1 - e^{-\lambda t})$

26. C

No effect of concentration on activity.

27. B

$\text{time} = \frac{3200 \times 10^3}{2000}$

$1600 \rightarrow 1600 \text{ sec}.$

Remaining after two half time

$\frac{N_o}{4} = \frac{10^8}{4} = 25 \times 10^6$

28. D

$13.6 z^2 = 13.6 \times 4 = 54.4$

Second electron = 54.4 + 24.6 = 79

29. A

It is difficult to over come attractive forces

30. A

The nucleus of Atom is positively charged So striking it with +ve proton or α particle would be relatively difficult

31. C

Photon thermal energy or excess energy is always liberated in the form of gamma radiation

32. D

Half of total number of nucleus are left after one half life.

Exercise-II

1. A
We know that
$R = R_0 A^{1/3}$
Surface area $\Rightarrow \pi R^2$
$= \pi(R_o A^{1/3})^2 \quad = \pi R_0^2 A^{2/3}$

2. A
$C^{13} \rightarrow C^{12} + n$
BE of reactants = 7.5 × 13 = 97.50
BE of products = 7.68 × 12 = 92.16
Energy Required = $(BE)_R - (BE)_P$
= 97.50 - 92.16 = 5.34 MeV

3. B
One fission = 200 MeV
Power = 200 x 10^6 x 1.6 x 10^{-19}
= 10^3J/S
1.5 x 10^{-19} J = 1eV.
Fission / sec = x
X x 3.2 x 10^{-11} = 10^3
x = 0.3125 x 10^{14}
x = 3.125 x 10^{13} .
$$\frac{1\times10^3}{200\times10^6\times1.6\times10^{-19}}$$
= 3.125 × 10^{13}

4. C
Total energy radiated by star is 10^{16}J/s
energy from one fission is of the order of
10^6 x 1.6x 10^{-19}J
No of reactions per sec = 10^{16} x 10^{13} / 1.6
= 10^{29} / 1.6
No of deutrons used/sec = 3 x 10^{29} / 1.6
Time to use 10^{40} deutrons = 10^{29} t
t = 10^{40} /$10^{29} \cong 10^{11}$
order about 10^{12} sec.

5. B
$_{92}U^{238} \rightarrow {}_{82}Pb^{206} + x\,{}_2He^4 + y\,{}_{-1}e^0 + Q$
A = 206 + 4x = 238
4x = 32 $\Rightarrow$ x = 8
2x - y + 82 = 92 $\Rightarrow$ 2x - y = 10
16 - y = 10 $\Rightarrow$ y = 6

6. C
$(BE)_W = 7.5 \times 120 = 900$
$(BE)_x = 8.0 \times 90 = 720$
$(BE)_y = 8.5 \times 60 = 510$
$(BE)_Z = 3.0 \times 5.0 = 150$
To release energy $\Rightarrow (BE)_{Products} > (BE)_{Reactants}$

7. C
$A_1 = A_0 e^{-\lambda t}$
$A_2 = 2A_0 e^{-\lambda(t-t^1)}$
$\frac{A_1}{A_2} = \frac{1}{2} e^{-\lambda t^1}$ $\qquad \log\frac{2A_1}{A_2} = -\lambda t^1$
$t' = \frac{T}{\log_2}\left|\log\frac{A_2}{A_1}\right|$

8. B
$\frac{A_0}{\sqrt{3}} = A_0 e^{-\lambda 1}$ $\qquad A' = A_0 e^{-\lambda 4}$
$A' = \frac{A_0}{9}$

9. B
Give $t_{1/2} = 1620$yr $\qquad t_{1/2} = \frac{0.693}{\lambda}$
$$\lambda = \frac{0.693}{1620\times365\times24\times60\times60}$$
No of mols (n) = $\frac{mass}{At.wt} = \frac{5}{223}$
$N_0 = n \times N_A = 6.023\times10^{23}$
At t = 5hr = 5 × 3600
N(t) = $N_0 e^{-\lambda t}$ $\Rightarrow$ N(t) = 3.23 ×10^{15}

10. C
$\xrightarrow{R} A \xrightarrow{\lambda} B$
$\frac{dN}{dt} = R - \lambda N$ N = be the number of at any time t
$$\int_0^N \frac{dN}{R-\lambda N} = \int_0^N dt$$
$$N = \frac{R(1-e^{-\lambda t})}{\lambda}$$
$2(1-e^{-\lambda t}) = 1$ $\qquad e^{-\lambda t} = \frac{1}{2}$
$\frac{t}{2} = \ln 2$ $\qquad t = 2 \times 0.693 = 1.386$

11. C
$$\frac{-dN_1'}{dt} = \lambda_1 N_1'$$
$$\frac{-dN_2'}{dt} = \lambda_2 N_2'$$
$$\frac{-dN}{dt} = \frac{-dN_1'}{dt} + \left(\frac{-dN_2'}{dt}\right)$$
$$= \lambda_1 N_1' + \lambda_2 N_2' = \lambda_1 N_1' e^{-\lambda_1 t} + \lambda_2 N_2' e^{-\lambda_2 t}$$

12. C
Probability $= \frac{favourable}{Total}$
Surviving Nucleus after 6 half lives in $\frac{N_o}{2^6}$
Total $\frac{N_o}{2^5}$
Prob = $\frac{N_o}{2^6} / \frac{N_o}{2^5} = \frac{1}{2}$

13. B

Let sample is x' x $\rightarrow$ Y
2% 14%

$x \rightarrow \frac{2x'}{100}$ $y \rightarrow \frac{14x'}{100}$ $\lambda = \frac{\ln 2}{45}$

$\text{Total} = \frac{16x'}{100}$

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

$\frac{2}{100}x' = \frac{16x'}{100}e^{-\lambda t} = 2^{-3}$

$\lambda t = 3\ln 2 = 45x3 = 135$

14. C

$\xrightarrow{1000} A \xrightarrow{\lambda} B$

$\frac{dN}{dt} = R - \lambda N = 0$ $R = \lambda N$

$1000 = \frac{1}{40 \times 60} N$ $N = 24 \times 10^5$

15. C

At t = 0

$N_o = 20 \times 10^5$ $N = N_o \frac{R}{\lambda}(1 - e^{-\lambda t})$

16. C

$v = \frac{kq}{r}$ $1 = \frac{9x10^9 q}{1.6x10^{-3}}$

$q = \frac{1.6}{9} x10^{-12}$ q = ne= n x 1.6 x 10^{-19}

$n = 6.25x10^{10} t$

Multiple Correct

17. (A) ${}_zX^A \rightarrow {}_{z-2}Y^{A-4} + {}_2He^4 + Q_1$

(B) ${}_zX^A \rightarrow {}_{z-1}Y^A + {}_{+1}e^0 + Q_2$

(C) ${}_zX^A \rightarrow {}_{z+1}Y^A + {}_{-1}e^0 + Q_3$

(D) ${}_zX^A \rightarrow {}_zY^A + {}_z\gamma^0 + Q_4$

18. AC

Initially

$A = m_p + m_n$

A = $\frac{m_p}{m_n} = 1$

$\frac{(B.E.)_1}{A_1} > \frac{(B.E.)_2}{A_2}$

A_1 is lesser initially then

$A_2 \uparrow$ $(B.E.)_2 \downarrow$

19. C

$m_1^1 = 10 \times m_p + (20-10)m_n$

$m_1^1 = 10m_p + 10m_n = 10(m_p + m_n)$ &

$m_2^1 = 20m_p + (40-20)m_n$

$m_2^1 = 20(m_p + m_n)$

$m_2^1 = 2m_1^1$

$M_{observed} < M_{expected}$

But observed relation $m_2 < 2m_1$

20. Rest mass $\Rightarrow$ E = mc^2

Stable nucleus has to release energy.

$A \Rightarrow B + C$

$E_1 < E_2 + E_3$.

$m_1 < (m_2 + m_3)$

21. $AB \rightarrow r\downarrow PE\uparrow$ due to electrostatic repulsion.

BC $\rightarrow$ nuclear force dominate & nuclear forces are always attractive in nature.

22. ${}_7^{14}N + n \rightarrow {}_3^7Li + He_2^4 + 4n + 2\beta$

${}_7^{14}N + n \rightarrow {}_3^7Li + 4p + 4n$

23. excess neutrons = α active and β^- active
excess proton = β^+ active

24. ${}_zX^A \rightarrow {}_{Z+1}Y^A + {}_+\beta^0 + E$

KE of β particle can not exceed E.

$T_e = \frac{my}{m_e + m_y} Q < Q$

N/2 ratio becomes $\frac{N-1}{Z+1}$

25. ABC

Free neutron does not exist in nature hence it breaks into proton and electron but free proton is possible.

26. C,D

The nucleus agter gamma decay remains neutral as no change in proton and neutron take place. Gamma photons carry only energy with them. In K capture also the neutrality of nucleus do not get altered.

27. A,C

Given

$\lambda = 0.173(\text{year})^{-1}$

$t_{1/2} = \frac{0.693}{0.173}$ $N = N_0 e^{-0.173 \times \frac{1}{0.173}}$

(A) $N = \frac{N_0}{e} \Rightarrow N = 0.63\ N_0$

Exercise-III Level-I

1. $10^6 \times 28.2 = \Delta m.931\times10^6$
$\Delta m = 0.03029$
$\Delta m = 0.03029$ (Take)
$m_p = 1.007276 \quad \Rightarrow \quad m_n = 1.008005$
$(2\times m_p + 2\times m_n - \Delta m)$
m_α = 4.001592 A.M.U.

2. The no.of protons is ${}^{56}_{26}fe = 26$
The no. of neutrons = 56 - 26 = 30
B.E. = [26 × 1.00783 u + 30 × 1.00867 u - 55.9349u]c^2
= 492 MeV

3. Use energy conservation
$m({}^{238}P_U)C^2 = m({}^{234}U)C^2 + m({}^{4}He)C^2 + k$
k = $\left[m({}^{238}P_U) - m({}^{234}U) - m({}^{4}He)\right]c^2$
= (238.04955u - 234.04095u - 4.002603u)
$\frac{931MeV}{u}$ = 5.58 MeV

4. $[7.0160 + 1.00783 - (2x4.0026)]x931$
= 17.34 MeV

5. ${}^{32}P \rightarrow {}^{32}S + {}_{-}e + \vec{v}$
$\Delta m = 2\times10^{-3}$ A.M.U
E = 1.862 MeV

6. ${}^{40}_{19}K \rightarrow {}^{40}_{20}Ca + {}^{e}_{-1} + \bar{v}$
E = $\Delta m(931) = 1.3034$

7. $\Delta m 931 = E$
$\therefore$ α particle energy = E - 217 Kev

8. $\Delta m = 12.018613 - 12 - 2\times0.0005486$
$\therefore$ E = 16.3072
E e^+ = 16.3072 - 4.43 = 11.88 MeV

9. (a) The Q - Value of β^- decay is
$Q = \left[m({}^{19}0) - m({}^{19}F)\right]C^2$ = 4.816 MeV
(b) The Q - Value of β^1 decay is
$Q = \left[m({}^{23}Al) - m({}^{25}Mg) - 2mc\right]C^2$
= $\left[24.990432u - 24.985839u - 2\times0.511\frac{MeV}{C^2}\right]C^2$
= (0.004593)-(931 $^{Mev}/_{u}$)-1.022 MeV = 3.254 Mev

10. The kinetic energy available for the beta particle and the antinutreno is
$Q = \left[m({}^{175}Lu) - m({}^{176}Hf)\right]C^2$
= (175.942694 u - 175.941420 u) (931 $^{MeV}/_{u}$)
= 1.182 MeV
This energy is shared by the beta particle and the antinutreno.
So Max K.E. = 1.182 MeV when antineutrino do not get any share

11. If the product nucleus ^{198}Hg is formed is its ground state, the kinetic energy available to the e^- and antinutreno is
$Q = \left[m({}^{198}Au) - m({}^{198}Hg)\right]C^2$
As ^{198}Hg has energy 1.088 MeV more than ^{198}Hg is 9.5, K.E. actually available is
$Q = \left[m({}^{198}Au) - m({}^{198}Hg)\right]C^2 - 1.088$
= 0.2806 MeV (Max^m K.E. of the e^- emitted)

12. Rate = 300 MW = 300 x 10^6 J/s
Energy in one second = 300 x 10^6 J
Energy from one fisson = 200 x 10^6 x 1.6 x 10^{-19}s
No of fission = $\frac{3 x 1}{2 x 1.6 x 10^{-19}}$
= No of u-nucleus
Gm-moles n
= $\frac{1.5 x 10^{19}}{1.6 x 6.023 x 10^{23}} = 0.1556 x 10^{-4}$
amount = n M = 36.578 x 10^{-4} gm
$\Rightarrow 3.6578mg = 3.7mg$

13. Q value =
$[2(4.0026) - 8.0053]931 = -1 x 10^{-4} x 931$
$= -931 x 10^{-4} MeV x 10^3$
$= -93.1KeV$
Q value is energy released So because q value is -ve hence energy has to be given.

14. $B\left({}_1H^2\right) = 1.1MeV$
$B\left({}_2He^4\right)$ = 7.0 MeV
Energy release= 4(7.0) - 4(1.1)
= 28 - 4.4 = 23.6 MeV

15. Mass of ${}^{1}_{1}H = 1.67\times10^{-27}kg$
Now No. of ${}^{1}_{1}H$ atom is sun
= $\frac{1.7\times10^{50}}{1.67\times10^{-27}}$ atom
No. of ${}^{4}_{2}He$ from = $\frac{1.7\times10^{30}}{1.67\times10^{-27}\times4}$
Energy release
= $\frac{1.7\times10^{30}}{1.67\times10^{-27}\times4}\times26\times10^6\times1.6\times10^{-19}$ Joule
Time taken = $\frac{\text{Energy release}}{3.9\times10^{26}}$
= $\frac{1.7\times10^{30}\times26\times^6\times1.6\times10^{-19}}{1.7\times10^{-27}\times4\times3.9\times10^{26}} = \frac{8}{3}\times10^{18}$ s

16. E = 2 x 0.5 = 1MeV

$$\frac{E}{2}=\frac{hc}{\lambda}=\frac{1.24\times10^{-12}MeVm}{\lambda}$$

$\lambda=2.48\times10^{-12}m \quad =2.48\times10^{-12}$ m

17. $2\,{}^2H_1 \rightarrow \quad {}_2He^4+23.6\,MeV$

$\downarrow \qquad \downarrow$

$1.1\times2\times2.2 \quad E-4.4$

E = 28 MeV

18. $\pi^+\rightarrow\mu^++\text{neutrino}$

$100\rightarrow100MeV$

$$50=\frac{1}{2}mv^2+\frac{hc}{\lambda}$$

$$mv=\frac{h}{\lambda}$$

$$50=\frac{1}{2}100\frac{v^2}{c^2}+100\frac{v}{c}$$

$x^2+2x-1=0$

$$x=0.41\Rightarrow\frac{v}{c}=0.41$$

$$\frac{1}{2}mv^2=\frac{1}{2}\frac{100x10^6 0.41\,x\,c^2}{C^2}=9\times10^6eV$$

19. Δm = (2.0141) -4.0024
= 0.0258 u
Q = 0.0258 x 931
= 24 Me

20. $A=A_0e^{-\lambda t}$ $\qquad$ 500 = $600e^{-\lambda t}$

$$\lambda=\frac{Ln6/5}{t}=\frac{Ln(5/6)}{40\ min}$$

Half life $t_{1/2}=\dfrac{\ln2}{\lambda}=\dfrac{\ln2}{\ln6/5}\times40=152$ min

21. $\lambda=\dfrac{\ln^2}{4.5\times10^9}$

No of U^{238} atoms = N_u $\qquad$ No of Pb^{206} atoms = N_{pb}

$N_u = N_{pb}$ $\qquad$ $N_u = N_oe^{-\lambda t}$

$e^{-\lambda t}$ = 1-$e^{-\lambda t}$ $\qquad$ λt = ln2

t = 4.5 x 10^9y

22.

From $N=N_0\left[1-e^{-\lambda t}\right]$

$1\times10^5=N_0\left[1-e^{-\lambda 36}\right]$ .... (1)

$1.11\times10^5=N_0\left[1-e^{-108\lambda}\right]$ .... (2)

From eq. (1) & (2)

$\lambda=\dfrac{2.27}{36}=0.0630$ $\quad t_{1/2}=\dfrac{0.693}{0.0638}$ = 10.89 Sec.

23. ${}^{40}_{19}K\rightarrow{}^{40}_{18}Ar+{}_{+1}e^0+\nu$

$\lambda=\dfrac{0.693}{1.4\times10^9}$ $\qquad N=N_0e^{-\lambda t}$

$1=8e^{-\lambda t}$ $\quad \lambda t=\ln(8)\Rightarrow\dfrac{2.079\times1.4\times10^9}{0.693}=t$

t = 4.2 × 10^9 years.

24. Given $R=R_0e^{-\lambda t}$

No of atom dissociated in time t
= 80%

$\Rightarrow \dfrac{80N_0}{100}=N_0\left[1-e^{-\lambda t}\right]$ $\quad 4=5-5e^{-\lambda t}$

$\Rightarrow 5e^{-\lambda t}=1\Rightarrow\ln5=\lambda t$

$$t=\frac{\ln5}{\lambda}=\left(\frac{\ln5}{\ln2}\right)\tau$$

25. $t_{1/2}$ = 8 days $\qquad A_0=20\,\mu ci$

$A=A_0e^{-\lambda t}$

26. Since the number o ^{206}Pb atoms equals the no. of ^{238}U atoms, half of the original ^{238}U atom have decayed. It takes one half life to decay half of the active mudei, Thus the sample is 4.5 × 10^9y old

27. $t=\dfrac{1}{\lambda}\ln\left(1+\dfrac{N_D}{N_c}\right)$ $\qquad t_1=\dfrac{1}{\lambda}\ln\left(1+\dfrac{1}{9}\right)$

$t_2=\dfrac{1}{\lambda}\ln(1+9)$ $\qquad t_1-t_2=24\,min$

28. $t=\dfrac{1}{\lambda}\ln\left(1+\dfrac{N_{pb}}{N_u}\right)$

$$t=\frac{4.47\times10^9}{\ln2}\left(1+\frac{\frac{0.6\times10^3}{286}}{\frac{2\times10^3}{238}}\right)$$

$$=\frac{4.47\times10^9}{\ln2}\ln(1.34660)$$

= 1.92 x 10^9 years

29. $\xrightarrow{\alpha} A \xrightarrow{\lambda} B$ $\qquad$ t = 0

$$N=N_oe^{-\lambda t}+\frac{R}{\lambda}(1-e^{-\lambda t})$$

$$N=\frac{1}{\lambda}\left[\alpha(1-e^{-\lambda t})+\lambda N_oe^{-\lambda/2}\right]$$

$\alpha=2N_ox$

$$N_{\lambda/2}=\frac{1}{\lambda}\left[2N_o\lambda\left(\frac{1}{2}\right)+\frac{\lambda N_o}{2}\right]$$

$=\dfrac{3N_o}{2}$ $\qquad N_\infty=\dfrac{1}{\lambda}\left[2N_o\lambda(1-0)+\lambda N_o\,x\,0\right]=2N_o$

Exercise-III Level-II

1. $T_\alpha = \frac{A-4}{A}Q$ $\therefore$ T_α = 4.78 MeV

A = 226

$4.78 \times 10^6 = \frac{226-4}{226} \times Q \Rightarrow Q = 4.86$ MeV

2. Intial Activity $R_1 = \lambda N_1$

Activity after time t $R_2 = \lambda N_2$

Now, $N_2 = N_1 e^{-\lambda t}$

Because only one α-particle out of 4000 induces a reaction we can find the number of radon atoms introduced into the source.

$$N' = nN_1 = \frac{nN_2}{e^{-\lambda t}} = nN_2 e^{\lambda t}$$

$\therefore$ mass of radon m

$$= \frac{AN'}{N_A} = \frac{A}{N_A} nN_2 e^{\lambda t} = \frac{Ane^{\lambda t}.R_2}{N_A \lambda}$$

Given that A = 222, n = 4000, T = 3.8 days

t = 7.6 days

$e^{\lambda t} = e^{\frac{0.693}{3.8} \times 5} = 2.49$, $R_2 = 1.2 \times 10^6$ sec

m = 3.3 μg

3. $\Delta m = (10.01167 + 1.00894 - m_{Li} - 4.00386)$

Q = 1.83 MeV

or Q = $\Delta m \times 931$ MeV

$\therefore$ $\Delta m = 0.001965$

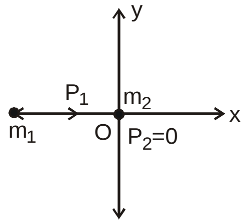
$m_{Li} = 7.01675 - 0.001965$

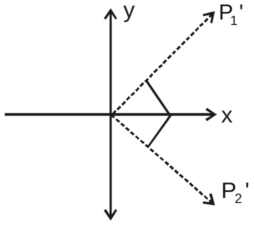
m_{Li} = 7.01478 a.m.u

4. Intially m_1 has a monmentum P_1 & m_2 is at rest ($P_2 = 0$) in the lab frame. The masses of the particular after collision are m_p & m_o.

The conservation of momentum given

$P_1' + P_2' = P_1$ or $P_2' = P_1 - P_1'$ ...(1)





After collision

Squaring above equation

$$P_2'^2 = (P_1 - P_1')^2 = P_1^2 + P_1'^2 - 2P_1.P_1' = P_1^2 + P_1'^2$$

$\{\because P_1.P_1' = 0\}$

$$\therefore Q = \frac{P_1'^2}{2m_p} + \frac{P_2'^2}{2m_0} - \frac{P_1^2}{2m_1}$$

$$\Rightarrow Q = \frac{1}{2}\left(\frac{1}{m_p} + \frac{1}{m_0}\right)P_1'^2 + \frac{1}{2}\left(\frac{1}{m_0} - \frac{1}{m_1}\right)P_1^2$$

$\therefore$ $E_k = \frac{P^2}{2m}$ Now

$$Q = K_p\left(1 + \frac{m_p}{m_0}\right) - K_1\left(1 + \frac{m_1}{m_0}\right)$$

5. $T_{1/2} = \frac{1}{\lambda}$

$\therefore$ $\frac{dN}{N}$ = fraction of body disintegrate in time dt

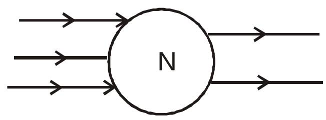
$\therefore$ $\frac{dN}{N} = \lambda dt$

or $\frac{dm}{m} = \lambda dt$ or $\frac{dv}{v} = \lambda dt$ $\Rightarrow$

$\int_0^v dv = \int_0^t u\lambda dt \Rightarrow$ v = uλ t

6.

Rate of decay = λN



Rate of formation = α

Let N be the no of radionucler any time t. Then net rate of form of nuclei at time t is

$\frac{dN}{dt} = \alpha - \lambda N$ or $\int_0^N \frac{dN}{\alpha - \lambda N} = \int_0^t dt$

$$N = \frac{\alpha}{\lambda}(1 - e^{-\lambda t})$$

Number of nuclei formed in time t = αt

& Number of nuclei left after time

$t = \frac{\alpha}{A}(1-e^{-\lambda t})$

$\therefore$ energy released till time

$t = E_0[\alpha t - \frac{\alpha}{\lambda}(1-e^{-\lambda t})]$

But only 20% of it is used in rasing the tamprature of water

So $0.2E_0[\alpha t - \frac{\alpha}{\lambda}(1-e^{-\lambda t})] = Q$

where Q = ms $\Delta\theta$

$\therefore$ $\Delta\theta$ = increase in temprature of water =

$\frac{Q}{ms} \Rightarrow \Delta\theta = \frac{0.2E_0[\alpha t - \frac{\alpha}{\lambda}(1-e^{-\lambda t})]}{ms}$

7. At the time of observation t = t

$\frac{m_1}{m_2} = \frac{140}{1} \quad \therefore \quad \frac{A_1}{A_2} = \frac{238}{235} = 1.01$

Number of atoms N = $\frac{m}{A}$

$\therefore \frac{N_1}{N_A} = \frac{m_1}{m_2} \times \frac{A_2}{A_1} = \frac{140}{1.01}$ ...(i)

Let N_0 be the no. of atoms of both isotopes at the time of formation the

$\frac{N_1}{N_2} = \frac{N_0 e^{-\lambda_1 t}}{N_0 e^{-\lambda_2 t}} = e^{(\lambda_2-\lambda_1)t}$ ...(ii)

Equation (i) & (ii) we have

$e^{(\lambda_2-\lambda_1)t} = \frac{140}{1.01}$

$(\lambda_2 - \lambda_1)t = \ell n\,(140) - \ell n\,(1.01)$

$t = \frac{4.9305}{\frac{0.693}{10^8}\left[\frac{45-7.13}{45\times 7.13}\right]} = 6.04 \times 10^9$ yrs

8. Given that Activity = 8.4 sec^{-1}

According to Avagadro hypothesis the no. of atoms in 2.5 mg.

$N = \frac{6.02\times 10^{23}}{230} \times 2.5 \times 10^{-3}$

$\Rightarrow$ N = 6.54 × 10^{18}

Now λN = 8.4 sec^{-1}

$\therefore \quad \lambda = \frac{8.4}{N} = \frac{8.4}{6.54\times 10^{18}}$

λ = 1.28 × 10^{-18} sec^{-1}

$\therefore \quad T = \frac{0.6931}{\lambda} = 1.7 \times 10^{10}$ year

9. From $t_{1/2} = \frac{0.693}{\lambda} \Rightarrow \lambda = \frac{0.693}{5730}$

Now A = $A_0\, e^{-\lambda t}$

A_0 = 50 × 12 = 600

A = 320

From above data t = 5196 years

10. Energy from one α deacy

${}^{248}_{96}cm \longrightarrow {}^{244}_{94}Pu + {}^{4}_{2}He$

Δm = 248. 072220 – 244.064100 – 4.002603

= 0.005 517

E = Δmx931

= 5. 136327 Mev.

Total energy

$= \left(\frac{8}{100}\times 200 + \frac{92}{100}\times 5.1366327\right)10^{20}$

= (20. 725421) Mev. × 10^{20}

Average cufe – 10^{13} sec.

Power output

$= \frac{20.725421\times 10^{20}\times 1.6\times 10^{-19}\times 10^{6}}{10^{13}}$

= 33.16 μW

11. $\lambda = \frac{len2}{15\times 3600}$

Activity of ^{24}Na after 5 hours

$\Rightarrow$ A = 1 × 10^{-6} × 3.7×10^{10}

1 $cm^3 \longrightarrow$ 296

x $cm^3 \longrightarrow$ 296 x

And 296 x = 3.7 × 10^4 × $e^{-ln2/3}$

x = 6 liters

12. $= \frac{25}{100}$ x $e^{-\lambda 10}$

$e^{-\lambda 10} = \frac{1}{2}$; $\quad \lambda = \frac{ln\,2}{10}$

$\frac{t_1}{2}$ = 10 sec. $\quad$ tan g = $\frac{10}{ln\,2}$

t = 40 sec.

Exercise - IV PREVIOUS YEAR QUESTIONS

LEVEL - I JEE MAIN

1. A

N_0 oLrq dh izkjfEHkd ek=kk gS vkSj N {k.k gksus ds ckn dh ek=kk gSA

blfy,, $N = N_o\left(\frac{1}{2}\right)^n$

n = v)Zvk;q dh la[;k $= \frac{t}{t_{1/2}} = \frac{15}{5} = 3$

blfy,, $N = N_o\left(\frac{1}{2}\right)^3 = \frac{N_o}{8}$

2. A

$E = -Z^2\frac{13.6}{n^2}\text{eV}$

igyh mÙksftr voLFkk ds fy,

$E_2 = -3^2 \times \frac{13.6}{4}$

Li^{2+} dh igyh mÙksftr voLFkk ds fy, vk;uhdj.k ÅtkZ 30.6 eV.

3. C

$\frac{1}{\lambda} = Rz^2\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$

$R \propto m$

nksuksa fLFkfr;ksa esa nzO;eku fHkUu gSA

4. D

$\frac{3}{2}kT = 7.7 \times 10^{-14}\,J$

;k $T = \frac{2 \times 7.7 \times 10^{-14}}{3 \times 1.38 \times 10^{-23}} = 3.7 \times 10^9 K$

5. A

jsfM;ks/kehZ inkFkZ ds }kjk izdkf'kr mudk {k.k.k gksus ds le; mRlftZr ugha gksrs gSA

6. B

blfy,] 8 α-d.k 4β- d.k vkSj 2β⁺- d.k mRlftZr gksrs gSA
blfy, u;k v.kq la[;k Z' = Z - 8 x 2 + 4 x 1-2x1 = 78

7. A

fn;k gS $N_o\lambda = 5000, N\lambda = 1250$

$N = N_o e^{-\lambda t} = N_o e^{-5\lambda}$

tgk¡ λ {k;kad gS rFkk t = 5 feuV

$N\lambda = N_o\,\lambda\,e^{-5\lambda}$

$\Rightarrow 1250 = N_o\lambda e^{-5\lambda}$

$\therefore\ \frac{N_o\lambda}{N_o\lambda e^{-5\lambda}} = \frac{5000}{1250} = 4$

;k $e^{5\lambda} = 4$

;k $5\lambda = 2\log_e 2$

;k $\lambda = 0.4\ln 2$

8. C

ÅtkZ laj{k.k ds fu;e ls α- d.k dh xfrt ÅtkZ = α- d.k dh LFkSfrt ÅtkZ U;wure nwjh ij

tSls $\frac{1}{2}mv^2 = \frac{1}{4\pi\varepsilon_o}\frac{q_1q_2}{r}$

$\therefore 5\text{MeV} = \frac{9 \times 10^9 \times (2e) \times (92e)}{r}$

$\left(\therefore \frac{1}{2}mv^2 = 5\text{MeV}\right)$

;k r = 5.3×10^{-14} m = 10^{-12} cm

9. C

tSlk fd fn;k gS

${}_1^2H + {}_1^2H \rightarrow {}_2^4He +$ ÅtkZ

M~;wVªku dh cU/ku ÅtkZ izfr U;wfDyvkWu ij $({}_1^2H)$ = 1.1 MeV

∴ ,d M~;wVªku dh ukfHkd dh dqy cU/ku ÅtkZ = 2 x 1.1 = 2.2 MeV

izfr ukfHkd] cU/ku ÅtkZ ghfy;e dh $({}_2^4He)$ = 7 MeV

∴ dqy cU/ku ÅtkZ = 4 x 7 = 28 MeV
blfy,] ÅtkZ ifjorZu izfØ;k esa eqDr dh tkrh gSA
= 28 - 2 x 2.2 = 28-4.4 = 23.6 MeV

10. D

laosx laj{k.k ds fu;e ls gesa izkIr gksrk gS&

$m_1v_1 = m_2v_2$

$\Rightarrow \frac{m_1}{m_2} = \frac{v_1}{v_2}$

ysfdu $m = \frac{4}{3}\pi r^3\rho$

;k $m \propto r^3$

$\therefore\ \frac{m_1}{m_2} = \frac{r_1^3}{r_2^3} = \frac{v_2}{v_1}$

$\Rightarrow \quad \frac{r_1}{r_2} = \left(\frac{1}{2}\right)^{1/3}$

;k $\quad r_1 : r_2 = 1 : 2^{1/3}$

11. B

${}^{A}_{Z}X + {}^{1}_{0}n \rightarrow {}^{7}_{3}Li + {}^{4}_{2}He$

bl dkerycgSfd, A + 1 = 7+4

$\Rightarrow \quad A = 10$

vkSjZ + 0 = 3+2

$\Rightarrow \quad Z = 5$

blfy, ,d cksjksu ${}^{10}_{5}B$ gSA

12. A

$R = R_o (A)^{1/3}$

$$\frac{R_{Al}}{R_{Te}} = \frac{R_o (A_{Al})^{1/3}}{R_o (A_{Te})^{1/3}}$$

;k $\frac{R_{Al}}{R_{Te}} = \frac{(A_{Al})^{1/3}}{(A_{Te})^{1/3}}$

;k $\frac{R_{Al}}{R_{Te}} = \frac{(27)^{1/3}}{(125)^{1/3}} = \frac{3}{5}$

;k$R_{Te} = \frac{5}{3} x 3.6 = 6$ QehZ

13. C

$N = N_o (1 - e^{-\lambda t})$

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

$\therefore \quad \frac{1}{8} = e^{-\lambda t}$

;k $\quad 8 = e^{\lambda t}$

;k $\quad 3 \ln 2 = \lambda t$

;k $\quad \lambda = \frac{3 x 0.693}{15}$

vk;qdky]

$t_{1/2} = \frac{0.693}{3 x 0.693} x 15 = 5$ fefuV

14. C

ukfHkdh; vfHkfØ;kfuEukuqlkj iznf'kZr dh tkrh gS&

$${}^{7}_{3}Li + {}^{1}_{1}H \rightarrow {}^{8}_{4}Be + {}^{A}_{Z}X$$

v.kq la[;k ¼ijek.kq la[;k½ ds laj{k.k ds vuqlkj

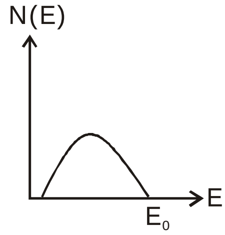
$$3 + 1 = 4 + Z \Rightarrow Z = 0$$

v.kqnzO;eku la[;k ds laj{k.k ds vuqlkj

$$7 + 1 = 8 + A \Rightarrow A = 0$$

blfy,] mRlftZr d.k γ-iQksVkWu gS (${}^{0}_{0}X$)

15. C



jsfM;ksa/kehZ ukfHkdksa ls mRlftZr Åtkz LisDVªe n'kkZ;k x;k gS&

16. B

iQksVksu dh Åtkz+ 7 x 5.60 = 2 x [4×7.06]

$\therefore$ iQksVksu dh Åtkz= 17.28 MeV.

17. B

blfy,] ;gk¡ ukfHkd Hkkjh gS, g lEiw.kZ ekuk tkrk gS fd ;g fLFkj gS vkSj dwykWe vkd"kZ.k cy dh otg ls xfr ugha djsxkA U;wure nwjh ij] nksuksa d.kksa dh vkisf{kr xfr 'kwU; gS, ;gk¡ y{; dks LFkSfrd ekuk gS blfy, α- d.k dh lEiw.kZ xfrt Åtkz ds fLFkfr tU; Åtkz esa cny tkrh gS

$$0 - \frac{mv^2}{2} = -\frac{1}{4\pi\varepsilon_o} \frac{Ze \times 2e}{r}$$

$\Rightarrow r \propto \frac{1}{m}$

or $\quad r \propto \frac{1}{v^2}$

or $\quad r \propto Ze^2$

18. B

ekukfd j.k dsmRltZu ij ukfHkd ls Åtkz eqDr gksrh gS blfy, ukfHkd LFkk;h gks tkrk gSA

19. B

cU/ku Åtkz

BE = (M_{ukfHkd} - $M_{U;wfDyvkWu}$)c^2

= (M_0-8M_P-9M_n)c^2

20. B

$T_{1/2}(X) = \tau(Y)$

$\Rightarrow \frac{0.693}{\lambda_X} = \frac{1}{\lambda_Y}$

or $\quad \lambda_Y = \frac{\lambda_X}{0.693}$

$\Rightarrow \lambda_Y > \lambda_X$

blfy, Y, X dh rqyuk esa tYnh {kf;r gksxkA

21. B

i gykd Fku l R; gS vkjS n wl jk d Fku xyr gS kfd cãk u Åt kZ@U; wfDy; ku ,d t S k ugha gksrkA

22. A

i gyh vfHkdfØ;k l y; u gS vkjS pr qFkZ vfHkfØ;k fo[k.Mu dh gSA

23. B

/kukRed ch Vk d s {k; gk us ea i kt hW<ku] U;wVªkWu ea cny t krk gS vkjS ok W b M a V mRl ft Z r gk s k gSA U;wVªkWu dh l a[;k c<+ t krh gSA

$p^+ \rightarrow n^0 + e^+$

{k; gk us ds ckn U;wVªkWu dh l a[;k Number of neutrons initially was A-Z

{k; gk us ds ckn U;wVªkWu dh l a[;k (A-Z)-3 × 2 (α d.k dh ot g l s) + 2 × 1 (+β ds {k; gk us dh ot g l s) i kt hW<ku dh l a[;k 8 de gk sxh

[t Sl s fd 3 × 2 (α d.k dh ot g l s) + 2 (+β ds {k; gk us dh ot g l s)]

bl fy, v.kq l a[;k 8 de gks xh

bl fy, U;wVªkWu dk vuqikr] i kt hW<ku ds fy,

$$= \frac{A - Z - 4}{Z - 8}$$

24. C

{k; gk us ds ckn] i qe h ukfHkd vf/kd fLFkj gk sxh] cãk u Åt kZ i R;s d ukfHkd After decay, the daughter nuclei will be more stable hence, binding every per nucleon will be more than that of their parent nucleus.

25. B

Conserving the momentum

$$0 = \frac{M}{2}v_1 - \frac{M}{2}v_2$$

$$v_1 = v_2 \qquad \ldots(i)$$

$$\Delta mc^2 = \frac{1}{2}.\frac{M}{2}v_1^2 + \frac{1}{2}.\frac{M}{2}v_2^2 \qquad \ldots(ii)$$

$$\Delta mc^2 = \frac{M}{2}v_1^2$$

$$\frac{2\Delta mc^2}{M} = v_1^2$$

$$v_1 = c\sqrt{\frac{2\Delta m}{M}}$$

26. B

$$N_1 = N_o - \frac{1}{3}N_o = \frac{2}{3}N_o$$

$$N_2 = N_o - \frac{2}{3}N_o = \frac{1}{3}N_o$$

$$\frac{N_1}{N_2} = \left(\frac{1}{2}\right)^n \qquad \Rightarrow n = 1$$

$\therefore \quad t_2 - t_1 = \text{one half life} = 20 \text{ min.}$

27. C

In particle situation, at least three particles take place in transformation, so energy of β-particle + energy of third particle = E_1-E_2

Hence, energy of β-particle $\le E_1 - E_2$

28. D

For damped harmonic motion,

$$ma = -kx - mbv$$

or $\quad ma + mbv + kx = 0$

Solution to above equation is

$$x = A_o e^{-\frac{bt}{2}} \sin\omega t; \text{ with } \omega^2 = \frac{k}{m} - \frac{b^2}{4}$$

Where amplitude drops exponentially with time.

i.e., $A_\tau = A_o e^{-\frac{b\tau}{2}}$

Average time τ is that duration when amplitude drops by 63% i.e., becomes A_0/e.

Thus, $A_\tau = \frac{A_o}{e} = A_o e^{-\frac{b\tau}{2}}$

Exercise-IV Level-II

1. Since $\frac{1}{16} = \frac{1}{2^4}$, it follows that the time taken for the radioactivity to decay to $\frac{1}{16}$ of its initial value.
= four times the half – life of the sample
= $4\ t_{1/2} = 4 \times 100 = 400\ \mu s$

2. During the emission of a gamma radiation, both the mass no. & atomic no. remain the same. Hence the answer is C.

3. If m_p = mass of proton
& A = atomic no. of uranium
then the mass of uranium nucleus is
$m = m_p A$
& the volume of uranium nucleus is

$$v = 4/3\pi r^3 = 4/3\pi(r_0A^{1/3})^3 = 4/3\pi r_0^3 A$$

$$\frac{m}{v} = \frac{m_pA}{\frac{4}{3}\pi r_0^3 A} = \frac{3m_p}{4\pi r_0^3} \quad \text{Thus} \qquad m \propto V$$

4. K. E = $\frac{(\text{momentum})^2}{2 \times \text{mass}}$
mass no. of $\propto$ particle = 4 units
mass no. of daughter nucleus = 220 – 4 = 216
If P & p $\rightarrow$ denote the momenta of daughter nucleus, then

$$Q = \frac{P^2}{2M} + \frac{p^2}{2m}$$

Since momentum is conserved

$$Q = \frac{P^2}{2}\left(\frac{1}{M}+\frac{1}{m}\right) = \frac{P^2}{2m}\left(\frac{m}{M}+1\right)$$

Now $\frac{P^2}{2m}$ = K.E. of particle – α = E_α

$$Q = E_\alpha\left(\frac{m+M}{m}\right) \quad \text{or} \quad E_\alpha = \frac{QM}{(m+M)}$$

5. Let n_0 be the number of radioactive nuclei at time t = 0. Number of nuclei decayed in time t are given $n_0(1-e^{-2\lambda})$, which is also equal to the number of betal particles emitted the same interval of time. For the given condition,

$$n = n_0(1-e^{-2\lambda}) \qquad ..(i)$$

$$(n+0.75n) = n_0(1-e^{-4\lambda}) \qquad ..(ii)$$

Dividing (ii) by (i) we get

$1.75 = \frac{1-e^{-4\lambda}}{1-e^{-2\lambda}}$ or $1.75 - 1.75\ e^{-2\lambda} = 1 - e^{-4\lambda}$

$\therefore\ 1.75\,e^{-2\lambda} - e^{-4\lambda} = \frac{3}{4}$ ...(iii)

Let us take $e^{-2\lambda} = x$
Then the above equation is,

$$x^2 - 1.75\ x + 0.75 = 0$$

or $x = \frac{1/75\ \sqrt{(1.75)^2-(4)(0.75)}}{2}$ or

x = 1 and $\frac{3}{4}$
$\therefore$ From equation (iii) either

$e^{-2\lambda} = 1$ or $e^{-2\lambda} = \frac{3}{4}$

but $e^{-2\lambda} = 1$ is not accepted because which means $\lambda = 0$. Hence

$$e^{-2\lambda} = \frac{3}{4}$$

or $-2\lambda\ \ln(e) = \ln(3) - \ln(4) = \ln(3) - 2\ln(2)$

$\therefore\ \lambda = \ln(2) - \frac{1}{2}\ln(3)$
Substituting the given values,

$\lambda = 0.6931 - \frac{1}{2} \times (1.0986) = 0.14395\ s^{-1}$

$\therefore$ Mean life $t_{means} = \frac{1}{\lambda} = 6.947$ sec

6. $\frac{A}{A_0} = \left(\frac{1}{2}\right)^n$, where A = Activity, n = number of half lives.

7. $\frac{0.3010}{T} = \frac{1}{t}\log\frac{a}{a_0}$
a = Number of atoms
= 0.259

8. $4({}_2He^4) = {}_8O^{16}$
Mass defect
$\Delta m = \{4(4.0026) - 15.834\} = 0.011$ amu.
Energy released per oxygen nuclei = (0.011) (931.48) MeV = 10.24 MeV

9. **B**

10. After two half lives $1/4^{th}$ fraction of nuclei will remain undecayed. or $3/4^{th}$ will decay. Hence the propability that a nucleus decays in two half lives is 3/4.

11. **(A) $\rightarrow$ P, Q ; (B) $\rightarrow$ P, R ; (C) $\rightarrow$ S, P ; (D) $\rightarrow$ P, Q, R**

12. **A**
Rest mass of parent nuclus should be greater than the rest mass of daughter nuclei
thus (A)

13. The series in U- V region is lymen series.

Longest wavelength corresponds to minimum energy which occurs in transition from n = 2 to n = 1.

$$122 = \frac{1/R}{(1/1^2 - 1/2^2)} \quad ..(i)$$

The smallest wavelength in the infrared region corresponds to max. energy of Paschen series.

$$\lambda = \frac{1/R}{(1/32 - 1/\infty)} \quad ..(ii)$$

from (i) & (ii)

λ = 823 nm

14. (A) $\rightarrow$ P,R ; (B) $\rightarrow$ Q,S ; (C) $\rightarrow$ P ; (D) $\rightarrow$ Q

15. B,D

In fusion two or more lighter nuclei combine to make a comparability heavier nucleus.
In fission, a heavy nucleus breaks into two or more comparatively lighter nuclei further, energy will be released in a nuclear process if total binding energy increases.

16. A

$$5\mu Ci = \frac{\ln 2}{T_1}(2N_0) \Rightarrow 10\mu Ci = \frac{\ln 2}{T_2}(N_0)$$

Dividing we get $T_1 = 4T_2$

17. D

The high temperature maintained inside the reactor core

18. A

$$2 \times 15KT = \frac{Ke^2}{r} \Rightarrow T \approx 1 \times 10^9$$

19. B

deuteron density = 8.0×10^{14} cm^{-3}, confinement time = 9.0×10^{-1} s

20.

$$\ell n\left(\frac{dN}{dt}\right) = \ell n\lambda N_0 - \lambda t$$

By Graph $\lambda = \frac{1}{2}$ $\quad \therefore$ T = $nt_{1/2}$

$4.16 = n \times \frac{0.693}{\lambda}$ $\qquad$ n = 3

$N = \frac{N_0}{P} = \frac{N_0}{2^n} \Rightarrow P = 2^3 \Rightarrow \quad P = 8$

21. 0001

$\frac{dN}{dt} = \lambda N \Rightarrow 10^{10} = \frac{1}{10^9} N$

$N = 10^{19}$

Total mass = $10^{19} \times 10^{-25} = 10^{-6}$ kg

$\Rightarrow M = 10^{-6} \times 1000 \times 10^3 = 1$ mg

22. C

The Kinetic energy is shared by both electron and anti neutrino. Hence maximum KE of antineutrino will also be nearly 0.8×10^6 eV.

23. D

The KE of elctron will lie in the range 0 to 0.8×10^6 eV.

24. 0004

Fraction in % = $\frac{N_0(1 - e^{-\lambda t})}{N_0}$

$= (1 - e^{-\lambda t}) = (1 - e^{-.04}) \approx 4\%$

25. C

${}_3^6Li \rightarrow 6.015123$ u

${}_2^4He \rightarrow 4.002603$ u

${}_1^2H \rightarrow 2.014102$ u

$\underbrace{{}_3^6Li}_{\text{less mass}} \longrightarrow \underbrace{{}_1^2H + {}_2^4He}_{\text{more mass}}$ (Not possible)

$\underbrace{{}_{84}^{210}Po}_{\text{less mass}} \longrightarrow \underbrace{{}_1^1H + {}_{83}^{209}Bi}_{\text{more mass}}$ (Not possible)

$\underbrace{{}_1^2H + {}_2^4He}_{\text{more mass}} \longrightarrow \underbrace{{}_3^6Li}_{\text{less mass}}$ (Possible)

$\underbrace{{}_{30}^{70}Zn + {}_{34}^{82}Se}_{\text{less mass}} \longrightarrow \underbrace{{}_{64}^{152}Gd}_{\text{more mass}}$ (Not possible)

26. D

${}_{84}^{210}Po \longrightarrow {}_{82}^{206}Pb + {}_2^4He$

Δ M = 0.005818 u

$(\Delta M)c^2$ = 5.419467 MeV $\simeq$ 5420 KeV

$K_{(Alpha)} = \frac{206}{210}(5420)$

= 5316 KeV $\simeq$ 5319 KeV

27. C

(P) Alpha Decay

$u_{92}^{238} \longrightarrow {}_{90}^{234} Th + He_2^4$ (2)

(Q) B^+ decay

${}_8^{15}O \longrightarrow {}_7^{15} N + {}_{+1}\beta^0$ $\qquad$ (1)

(R) Fission

${}_{94}^{239}Pu \longrightarrow {}_{57}^{140} La + {}_{37}^{99}$ $\qquad$ (4)

$\left(\frac{n}{p} > 1.5\right)$ unstable

(S) Proton Emission

${}_{83}^{185}Bi \longrightarrow {}_{82}^{184} Pb$ + Proton (3)