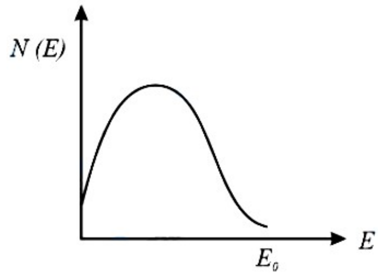
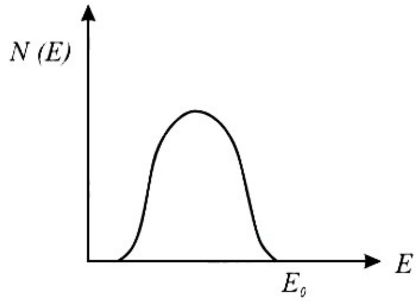
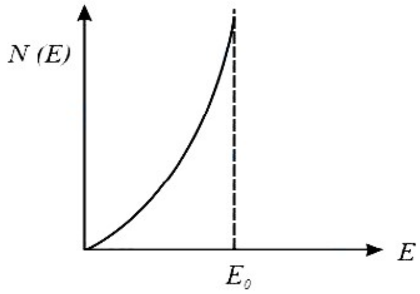
TOPIC : NUCLEAR PHYSICS (DPP)

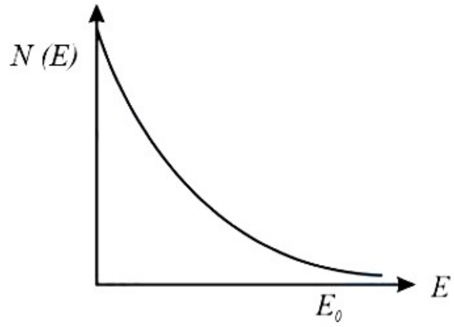
1. Half-life of radioactive substance is 3.20 h. What is the time taken for 75% of substance to be used?
   1) 6.4 h 2) 12 h 3) 4.18 days 4) 1.2 days

2. The energy spectrum of $\beta-$ particles [number N (E) as a function of $\beta-$energy E] emitted from a radioactive source is

1) 

2) 

3) 

4) 

3. The mean lives of a radioactive substance are 1620 years and 405 years for α and β emission respectively. If it is decaying by both α and β emission simultaneously, then the time during which three-fourths of the sample will decay is
   1) 643 years 2) 449 years 3) 528 years 4) 279 years

4. Two radioactive materials X_1 and X_2 have decay constants 10λ and λ respectively. If initially, they have the same number of nuclei, then the ratio of the number of nuclei of X_1 to that of X_2 will be $\frac{1}{e}$ after a time
   1) $\frac{1}{10\lambda}$ 2) $\frac{1}{11\lambda}$ 3) $\frac{11}{10\lambda}$ 4) $\frac{1}{9\lambda}$

5. There are two radioactive substances A and B. Decay constant of B is two times that of A. Initially, both have an equal number of nuclei. After n half lives of A, rate of disintegration of both are equal. The value of n is
   1) 4 2) 2 3) 1 4) 5

6. The binding energy per nucleon of deuterium and helium nuclei are 1.1 MeV and 7.0 MeV respectively. When two deuterium nuclei fuse together to form a helium nucleus, the energy released in the fusion is
   1) 2.2 MeV 2) 23. 6 MeV 3) 28.0 MeV 4) 30. 2 MeV

7. The ratio of the nuclear radius, of an atom with mass number A and ${}_2^4He$ is $(14)^{1/3}$. What is the value of A?
   1) 56 2) 80 3) 79 4) 30

8. After 280 days, the activity of a radioactive sample is 6000 dps. The activity reduces to 3000 dps after another 140 days. The initial activity of the sample (in dps) is
   1) 6000 2) 9000 3) 3000 4) 24000

9. The rate of disintegration of a radioactive substance falls from $\frac{40}{3}$ dps to $\frac{5}{3}$ dps in 6 hours. The half-life of the radioactive substance is

1) $\frac{6}{7}$ hours 2) 2 hours 3) 3 hours 4) 1 hour

10. ^{7}Li fuses with a proton according to the nuclear reaction given below:

$p+{}^{7}Li \rightarrow {}^{4}He+{}^{4}He$

Given that the atomic masses of ^{1}H, ^{4}He and ^{7}Li are 1. 007825 u, 4. 002603 u and 7.016004 u respectively, where $u = 931.5\ MeV/c^2$, then the Q − value of the reaction is

1) 17.35 MeV 2) 18.06 MeV 3) 177.35 MeV 4) 170.35 MeV

11. The β^- activity of a sample of CO_2 prepared from a contemporary wood gave a count rate of 25.5 counts per minute (cpm). The same mass of CO_2 from an ancient wooden statue gave a count rate of 20.5 cpm under the same conditions. If the half life of ^{14}C is 5770 years, then the age of the statue is close to [Take $\log_{10}\left(\frac{255}{205}\right) \approx 0.095$]

1) 1822 years 2) 182 years 3) 822 years 4) 18220 years

12. A 1.5×10^9 years old rock contains ^{238}U which disintegrates to form ^{206}Pb. Assume that there was no lead in the rock initially and it is the only stable product formed by the decay. Calculate the ratio of the number of nuclei of lead to that of uranium. [Given, half-life of $^{238}U = 4.5 \times 10^9$ years, $2^{1/3} \approx 1.26$]

1) 0.26 2) 0.36 3) 0.45 4) 1.26

13. If the nuclear fission, a piece of uranium of mass 6.0 g is lost, the energy obtained (in kWh) in $n \times 10^7$. Find the value of n.

1) $2.50 \times 10^9\ kWh$ 2) $1.25 \times 10^7\ kWh$ 3) $1.25 \times 10^3\ kWh$ 4) $1.25 \times 10^9\ kWh$

14. A proton is bombarded on a stationary lithium nucleus. As a result of the collision two $\alpha-$particles are produced. If the direction of motion of the $\alpha-$particles with the initial direction of motion makes an angle $\cos^{-1}(1/4)$, then the kinetic energy of the striking proton is [Given, binding energies per nucleon of $Li^7 = 5.60\ MeV$ and $He^4 = 7.60\ MeV$, $m_{\text{proton}} \approx m_{\text{neutron}}$]

1) 17.28 MeV 2) 17.36 MeV 3) 17.58 MeV 4) 17.44 MeV

15. A proton collides with a stationary deuteron to form a ^{3}He nucleus. For this reaction to take place, the proton must have a minimum kinetic energy K_0. If instead, a deuteron collides with a stationary proton to make a ^{3}He nucleus, then it must have minimum kinetic energy equal to

1) $2K_0$ 2) $1.5K_0$ 3) K_0 4) $\frac{K_0}{2}$

16. The fraction of atoms of a radioactive element that decays in 6 days is $\frac{7}{8}$. The fraction that decays in 10 days will be

1) $\frac{77}{80}$ 2) $\frac{71}{80}$ 3) $\frac{31}{32}$ 4) $\frac{15}{16}$

17. A heavy nucleus having mass number 200 gets disintegrated into smaller fragments of mass number 80 and 120. If binding energy per nucleon for parent atom is 6.5 eV and for daughter nuclei are 7 eV and 8 eV respectively and the energy released in the decay is given by $X \times 10^5\ eV$, then X will be

1) 4500 2) 1100 3) 2200 4) 3600

18. What is the disintegration constant of radon if the number of its atoms diminishes by 18% in 24 h? [Take ln (0.82) ≈ -0.2]

1) $2.3 \times 10^{-3} s^{-1}$ 2) $2.3 \times 10^{-4} s^{-1}$ 3) $2.3 \times 10^{-5} s^{-1}$ 4) $2.3 \times 10^{-6} s^{-1}$

19. When aluminium is bombarded with fast neutrons, it changes into sodium with emission of particle x according to the equation ${}_{13}^{27}Al + {}_{0}^{1}n \rightarrow {}_{11}^{24}Na + x$. What is x?

1) Electron 2) Proton 3) Neutron 4) Alpha-particle

20. In a sample initially, there are an equal number of atoms of two radioactive isotopes A and B. 3 days later, the number of atoms of A is twice of B. The half-life of B is 1.5 days. What is the half-life (in days) of isotope A?

1) 3 days 2) 6 days 3) 2 days 4) 4 days

21. For a radioactive sample, the initial activity of the material was 8 counts and after 3 h it becomes 1 count,. The half-life of the sample is

1) 2 h 2) 1 h 3) 3 h 4) 4 h

22. A radioactive sample contains 2.2 mg of pure ${}_{6}^{11}C$ which has a half-life period of 1224 seconds. Calculate the number of atoms present initially, and the activity when 5 μg of the sample will be left.

1) 2.1×10^{20} atoms, 3.3×10^{14} dps 2) 3.1×10^{19} atoms, 2.6×10^{13} dps.

3) 2.3×10^{19} atoms, 1.6×10^{13} dps 4) 1.2×10^{20} atoms, 1.55×10^{14} dps

23. The nuclei have mass number in the ratio 8 : 125. The ratio of their nuclei radii is :

1) 5 : 3 2) 3 : 5 3) 5 : 2 4) 2 : 5

24. Nucleus A decays into B with a decay constant λ_1 and B further decays into C with a decay constant λ_2. Initially, at t = 0, the number of nuclei of A and B were $3N_0$ and N_0 respectively. If at $t = t_0$ number of nuclei of B becomes constant and equal to $2N_0$, then

1) $t_0 = \frac{1}{\lambda_1} \ln\left[\frac{3\lambda_1}{2\lambda_2}\right]$ 2) $t_0 = \frac{1}{\lambda_1} \ln\left[\frac{\lambda_1}{\lambda_2}\right]$ 3) $t_0 = \frac{1}{\lambda_1} \ln\left[\frac{2\lambda_1}{3\lambda_2}\right]$ 4) $t_0 = \frac{1}{\lambda_2} \ln\left[\frac{3\lambda_1}{2\lambda_2}\right]$

25. The radius of germanium (Ge) nuclide is measured to be twice the radius of ${}_{4}^{9}Be$. The number of nucleons in Ge are

1) 73 2) 74 3) 75 4) 72

26. The atomic ratio between the uranium isotopes ${}^{238}U$ and ${}^{234}U$ in a mineral sample is found to be 1.8×10^4. The half life of ${}^{234}U$ is $T_{\frac{1}{2}}(234) = 2.5 \times 10^5$ years. The half-life of ${}^{238}U$ is -

1) 4.5×10^9 years 2) 5.4×10^9 years 3) 4.5 years 4) 5.4 years

27. Which, among the following, is a correct statement?

1) binding energy of a nucleus is always negative
2) binding energy of a nucleus may be positive
3) higher value of binding energy per nucleon means the nucleus is more unstable
4) higher value of binding energy per nucleon means the nucleus is more stable

28. A mixture consists of two radioactive materials A_1 and A_2 with half-lives of 20s and 10 s, respectively. Initially the mixture has 40 g of A_1 and 160 g of A_2. The amount of the two in the mixture will become equal after

1) 60 s 2) 80 s 3) 20 s 4) 40 s

29. If 200 MeV energy is released in the fission of a single nucleus of ${}_{92}U^{235}$. How many fissions must occur per second to produce a power of 1 kW?

1) 3.125×10^{13} 2) 6.250×10^{13} 3) 1.525×10^{13} 4) none of these

30. The radioactive isotope X with a half-life of 10^9 years decays to Y which is stable. A sample of rocks was found to contain both the elements X and Y in the ratio 1 : 7. Initially, the quantity of Y in the rock was zero, then the age of the rocks is

1) 2×10^9 years 2) 3×10^9 years 3) 6×10^9 years 4) 7×10^9 years

KEY

1 – 10	1	1	2	4	3	2	1	4	2	1
11 – 20	1	1	2	1	1	3	3	4	4	1
21 – 30	2	4	4	1	4	1	4	4	1	2

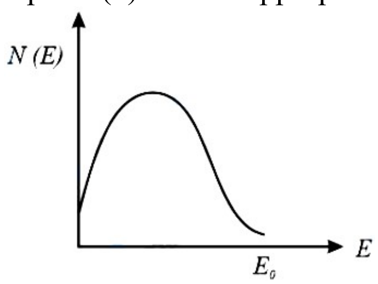
SOLUTIONS

1. $N_0 \xrightarrow[1]{} \frac{N_0}{2} \rightarrow \frac{N_0}{4}$

Remaining substance after two half lives is $\frac{N_0}{4}$ (or)

The substance used during this time $= N_0 - \frac{N_0}{4} = 3\frac{N_0}{4} = 75\% N_0$

2. In $\beta-$decay, energy emission is continuous and energy is shared between $\beta-$particle and daughter nuclei. Thus certain $\beta-$particles have zero energy and certain have maximum energy.
Option (1) is most appropriate



3. $\lambda = \lambda_\alpha + \lambda_\beta$

$= \frac{1}{T_\alpha} + \frac{1}{T_\beta}\left[\because\ \lambda = \frac{1}{T}\right]$

$= \frac{1}{1620} + \frac{1}{405}$ [given, $T_\alpha = 1620\ yr$ and $T_\beta = 405\ yr$]

$= \frac{5}{1620}\ yr^{-1}$

$\frac{3}{4}th$ sample will decay, i.e., remaining $\frac{1}{4}th$

$N = N_0\left(\frac{1}{2}\right)^n$

$\frac{N_0}{4} = N_0\left(\frac{1}{2}\right)^n$

$\Rightarrow n = 2$

$\therefore\ t = nT_{\frac{1}{2}} = n\frac{\ln 2}{\lambda}$

$= 2 \times \frac{0.693}{\frac{5}{1620}} = 499\ yr$

4. $\frac{1}{9\lambda}$

Here, $\frac{N_{x_1}(t)}{N_{x_2}(t)} = \frac{1}{e}$

Or $\frac{N_0 e^{-10\lambda t}}{N_0 e^{-\lambda t}} = \frac{1}{e}$

(Because initially, both have the same number of nuclei, N_0)

Or $e = \frac{e^{-\lambda t}}{e^{-10\lambda t}} = e^{9\lambda t}$

$9\lambda t = 1$

$t = \frac{1}{9\lambda}$

5. Let $\lambda_A = \lambda \therefore \lambda_B = 2\lambda$

If N_0 is total number of atoms in A and B at $t = 0$, then initial rate of disintegration of $A = \lambda N_0$, and initial rate of disintegration of $B = 2\lambda N_0$

As $\lambda_B = 2\lambda_A$

$\therefore\ T_B = \frac{1}{2} T_A$

i.e., half-life of B is half the half-life of A.

After one half-life of A

$\left(-\frac{dN}{dt}\right)_A = \frac{\lambda N_0}{2}$

Equivalently, after two half lives of B

$\left(-\frac{dN}{dt}\right)_B = \frac{2\lambda N_0}{4} = \frac{\lambda N_0}{2}$

Clearly, $\left(-\frac{dN}{dt}\right)_A = -\left(\frac{dN}{dt}\right)_B$

After $n = 1$ i.e, one half-life of A

6. The fusion reaction is a given below :

${}_1H^2 + {}_1H^2 \rightarrow {}_2He^4 + Q$

The binding energy of the reacting nuclei

$= 1.1 \times 2 + 1.1 \times 2 = 4.4\, MeV$

The binding energy of the product nuclei

$= 7.0 \times 4 = 28.0\ MeV$

Hence, the energy released in the fusion reaction,

$Q = 28.0 - 4.4 = 23.6\ MeV$

7. From the relation $r \propto A^{1/3}$,

We have, $\frac{r_2}{r_1} = \left(\frac{A_2}{A_1}\right)^{1/3}$

Or $\left(\frac{A_2}{4}\right)^{1/3} = (14)^{1/3}$

Therefor, $A_2 = 56$

8. Activity reduces from 6000 dps to 3000 dps in 140 days. It implies that half-life of the radioactive sample is 140 days. In 280 days (or two half-lives) activity will remain $\frac{1}{4}$th of the initial activity. Hence the initial activity of the sample is

$4 \times 6000\, dps = 24000\ dps$

9. $A = A_0 e^{-\lambda t}$

$\Rightarrow 100 = 800\, e^{-\lambda(6 \times 60)}$

$$\Rightarrow e^{-350x} = \frac{1}{8}$$

$$\Rightarrow -360\lambda = \ln\left(\frac{1}{8}\right) = -\ln 8$$

$$\Rightarrow \lambda = \frac{\ln\left(2^3\right)}{360} = \frac{\ln 2}{120}$$

$$\Rightarrow T_{1/2} = \frac{\ln 2}{\lambda} = \frac{\ln 2}{\left(\ln 2/120\right)} = 120 \text{ minutes}$$

$$\Rightarrow \mathrm{T}_{1/2} = 2 \text{ hours}$$

10. The total mass of the initial particles

$m_i = 1.007825 + 7.016004$

$m_i = 8.023829\,u$

And the total mass of final particles

$m_f = 2 \times 4.002603 = 8.005206\ u$

Difference between the initial and final mass of particles

$= m_i - m_f = 8.023829 - 8.005206$

$= 0.018623u$

The Q value is given by

$Q = (\Delta m)c^2$

$= 0.018623 \times 931.5 = 17.35\ MeV$

11. $r = 20.5\ cpm,\ r_0 = 25.5\ cpm$

$\because\ r_0 \propto N_0$ and $r \propto N$

$$\therefore \frac{r_0}{r} = \frac{N_0}{N}$$

Also, $t = \dfrac{2.303}{\lambda}\log\left(\dfrac{N_0}{N}\right) = \dfrac{2.303}{\lambda}\log\left(\dfrac{r_0}{r}\right)$

$$t = \frac{2.303 \times 5770}{0.693}\log\left(\frac{25.5}{20.5}\right) = 1822 \text{ years}$$

12. Let N_0 be the initial number of uranium nuclei. After time t, let N_U be the number of uranium nuclei and N_{Pb} be the number of lead nuclei.

The number of half-lives passed is

$$n = \frac{t}{T_{half}} = \frac{1.5 \times 10^9}{4.5 \times 10^9} = \frac{1}{3}$$

$$N_U = N_0\left(\frac{1}{2}\right)^n = N_0\left(\frac{1}{2}\right)^{\frac{1}{3}}$$

$$N_{Pb} = N_0 - N_0\left(\frac{1}{2}\right)^{\frac{1}{3}}$$

$$\frac{N_{Pb}}{N_U} = 2^{\frac{1}{3}} - 1 = 0.26$$

13. $E = \Delta mc^2$

$= 0.5 \times 10^{-3} \times \left(3 \times 10^8\right)^2$

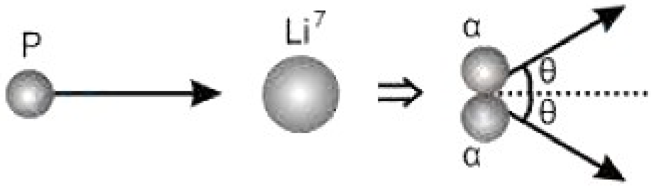
$= 4.5 \times 10^{13}\,\mathrm{J}$

$$E = \frac{4.5 \times 10^{13}}{3.6 \times 10^{6}} \text{ kWh}$$

$$= 1.25 \times 10^{7}\ kWh$$

14. Q value of reaction is,

$$Q = (2 \times 4 \times 7.06 - 7 \times 5.6)\,MeV = 17.28\ MeV$$



Applying conservation of energy for collision,

$$K_p + Q = 2K_\alpha \qquad \ldots(i)$$

(Here, K_p and K_α are the kinetic energies of proton and $\alpha -$ particle respectively)

From the conservation of linear momentum (As there is no external force) …(ii)

[Here $P = \sqrt{2\ mk}$]

$$\Rightarrow K_p = 16K_\alpha \cos^2\theta = (16K_\alpha)\left(\frac{1}{4}\right)^2 \qquad (\text{as } m_\alpha = 4m_p)$$

$$\therefore \qquad K_\alpha = K_p \qquad \ldots(iii)$$

Solving eqs. (i) and (iii) with $Q = 17.28\ MeV$

We get $K_p = 17.28\ MeV$

15. In case 1 :

Conservation of linear momentum : $mv_0 = 3mv$

$$\Rightarrow v = \frac{v_0}{3}$$

Conservation of mechanical energy : $\frac{1}{2}mv_0^2 + \frac{1}{2}3m\left(\frac{v_0}{3}\right)^2 + U_0$

Here U_0 is the minimum energy required for the reaction to happen

$$\Rightarrow U_0 = K_0 - \frac{K_0}{3} = \frac{2K_0}{3}$$

In case 2 :

Conservation of linear momentum : $2mv_0' = 3mv' \ \Rightarrow v' = \frac{2}{3}v_0'$

Conservation of mechanical energy : $\frac{1}{2}2m(v_0')^2 = \frac{1}{2}3m\left(\frac{2}{3}v_0'\right)^2 + \frac{2K_0}{3}$

$$\Rightarrow mv_0'^2 - \frac{2}{3}mv_0'^2 = \frac{2K_0}{3}$$

$$\Rightarrow \frac{1}{3}mv_0'^2 - \frac{2K_0}{3}$$

$$\Rightarrow \frac{1}{2}2mv_0'^2 = 2K_0$$

16. $\frac{7}{8}$ fraction decays in 6 days

$\frac{1}{8}$ fraction is active after 6 days

By using, $N = N_0\left(\frac{1}{2}\right)^{t/T_{1/2}}$

$N = \frac{N_0}{2^n}$

$\frac{N_0}{8} = \frac{N_0}{2^n}$

$n = 3$

6 days = half lives

$t_{\frac{1}{2}} = 2$ days

10 days $= 5t_{1/2}$

$N = \frac{N_0}{2^5} = \frac{N_0}{32}$

So decay $= N_0 - \frac{N_0}{32} = \frac{31}{32}N_0$

17. $^{200}_{6.5}X \to {}^{80}_{7}Y + {}^{120}_{8}Z$

Energy released $= 80 \times 7 + 120 \times 8 - 200 \times 6.5$

$= 220\ MeV$

$= 2200 \times 10^5\ eV$

18. Undisintegrated part

$\frac{N}{N_0} = (100 - 18)\% = 82\%$

Using relation $N = N_0\left(e^{-\lambda t}\right)$

$\frac{82}{100} = e^{-(24 \times 60 \times 60\lambda)}$

$\therefore 24 \times 60 \times 60 \times \lambda = \log\left(\frac{100}{82}\right)$

Or $\lambda = 2.3 \times 10^{-6} s^{-1}$

19. The mass number of $x = 27 + 1 - 24 = 4$ and its atomic number $= 13 + 0 - 11 = 2$
Hence particle x is the helium nucleus, which is called an alpha particle

20.

	A	B
$t = 0$	N_0	N_0
$t_0 = 3$ days	2N	N

$2N = N_0(0.5)^{t_0/\tau_1}$

$N = N_0(0.5)^{t_0/\tau_2}$

$2 = (0.5)^{t_0\left(\frac{1}{\tau_1} - \frac{1}{\tau_2}\right)}$

$0.5^{-1} = (0.5)^{\left(\frac{3}{\tau_1} - 2\right)}$

$\Rightarrow -1 = \frac{3}{\tau_1} - 2$

$\therefore \tau_1 = 3$ days

21. Here $A_0 = 8$ counts, $A = 1$ count and $t = 3h$

$\frac{A}{A_0} = \left(\frac{1}{2}\right)^n$

$\Rightarrow \frac{1}{8} = \left(\frac{1}{2}\right)^n$

or $\left(\frac{1}{2}\right)^3 = \left(\frac{1}{2}\right)^n \Rightarrow n = 3$

So, $T_{1/2} = \frac{t}{n} = \frac{3}{3} = 1h$

22. Number of atoms present initially

$= \frac{6.023 \times 10^{23} \times 2.2 \times 10^{-3}}{11}$

$= 1.2 \times 10^{20}$ atoms

No. of atoms present in $5\,\mu g$ of the sample

$N = \frac{6.023 \times 10^{23} \times 5 \times 10^{-6}}{11} = 2.74 \times 10^{17}$ atoms

Activity of the sample $= \lambda N$

$= \frac{0.693}{T_{\frac{1}{2}}} \times N$

$= \frac{0.693 \times 2.74 \times 10^{17}}{1224}$

$= 1.55 \times 10^{14}$ disintegrations/second

23. Here,

$R = R_0 A^{1/3}$

Since, $R = R_0 A^{1/3}$

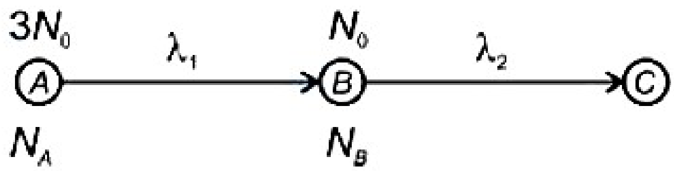
$\therefore \frac{R_1}{R_2} = \frac{A_1^{1/3}}{A_2^{1/3}} = \left(\frac{A_1}{A_2}\right)^{\frac{1}{3}}$

$= \left(\frac{8}{125}\right)^{1/3}$

$= \frac{2}{5}$

$\therefore$ The ratio of their radii $= 2:5$

24.



$N_A = 3N_0 e^{-\lambda_1 t}$

$\frac{dN_A}{dt} = -3\lambda_1 N_0 e^{-\lambda_1 t}$

$\frac{dN_B}{dt} = 3\lambda_1 N_0 e^{-\lambda_1 t} - \lambda_2 N_B$

At $t = t_0$, $\frac{dN_B}{dt} = 0$

$\Rightarrow 3\lambda_1 N_0 e^{-\lambda t} - \lambda_2 N_B = 0$

$\Rightarrow 3\lambda_1 N_0 e^{-\lambda t} = \lambda_2 (2N_0)$

$$e^{\lambda_1 t_0} = \frac{3\lambda_1}{2\lambda_1}$$

$$\Rightarrow t_0 = \frac{1}{\lambda_1}\ln\left[\frac{3\lambda_1}{2\lambda_2}\right]$$

25. Let the radius of ${}_4^9Be$ nucleus be r. Then, radius of germanium (Ge) nucleus will be 2r.

Radius of nucleus is given by

$$R = R_0 A^{1/3}$$

$$\therefore \frac{R_1}{R_2} = \left(\frac{A_1}{A_2}\right)^{1/3}$$

$$\Rightarrow \frac{r}{2r} = \left(\frac{9}{A_2}\right)^{1/3} \qquad (\because A_1 = 9)$$

$$\Rightarrow \left(\frac{1}{2}\right)^3 = \frac{9}{A_2}$$

Hence, $A_2 = 9 \times (2)^3 = 9 \times 8 = 72$

Thus, in germanium (Ge) nucleus number of nucleons is 72.

26. In radioactive equilibrium

$$\lambda_1 N_1 = \lambda_2 N_2$$

$$\frac{N_1}{T_1} = \frac{N_2}{T_2}$$

$$T_2 = \frac{N_2}{N_1} \times T_1$$

$$T_2 = 1.8 \times 10^4 \times 2.5 \times 10^5$$

$$T_2 = 4.5 \times 10^9 \text{ years}$$

27. It has been observed that total mass of nucleus is always less than the sum of the masses of its nucleons. The energy difference between the nucleus and its constituent particles due to their mass difference is termed as the binding energy of the nucleus.

In other words, we can say that to break the nucleus into its constituent particles, some energy is needed to be supplied. This energy is termed as binding energy of the nucleus. More is the binding energy per nucleon, more is the energy to break the nucleus and hence we can say the more stable the nucleus is.

28. Let after time $t\,s$, A_1 and A_2 will become equal in the mixture.

As $N = N_0\left(\frac{1}{2}\right)^n$

Where n is the number of half-lives

For A_1, $N_1 = N_{01}\left(\frac{1}{2}\right)^{t/20}$

For A_2, $N_2 = N_{01}\left(\frac{1}{2}\right)^{t/10}$

According to question, $N_1 = N_2$

$$\frac{40}{2^{t/20}} = \frac{160}{2^{t/10}}$$

$$2^{t/10} = 4\left(2^{t/20}\right) \text{ or } 2^{t/10} = 2^2 2^{t/20}$$

$$2^{t/10} = 2^{\left(\frac{t}{20}+2\right)}$$

$$\frac{t}{10} = \frac{t}{20} + 2 \text{ or } \frac{t}{10} - \frac{t}{20} = 2$$

Or $\frac{t}{20} = 2$ or $t = 40\ s$

29. We know that $1\ kW = 1 \times 10^3\ Js^{-1}$

Also, $1.6 \times 10^{-9}\ J = 1\ eV$

$\therefore 200\ MeV = 200 \times 1.6 \times 10^{-19} \times 10^6\ J$

$$\text{Number of fissions} = \frac{\text{Power}}{\text{Energy released}}$$

$$= \frac{10^3}{200 \times 1.6 \times 10^{-13}} = 3.125 \times 10^{13}$$

30. 3×10^9 years

$$\frac{N}{N_0} = \frac{1}{1+7} = \frac{1}{8}$$

$$\frac{N}{N_0} = \left(\frac{1}{2}\right)^n = \frac{1}{8}$$

$\therefore n = 3$

$t = nT = 3 \times 10^9$ years