DPP – 3

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Q 1. Two radioactive sources X and Y of half-lives 1h and 2h respectively initially contain the same number of radioactive atoms. At the end of 2h, their rates of disintegration are in the ratio of :

(a) 4 : 3 (b) 3 : 4
(c) 1 : 1 (d) 2 : 1

Q 2. The half-life period of radium is 1600 years. Its average life time will be nearly

(a) 3200 years (b) 4800 years
(c) 2308 years (d) 4217 years

Q 3. The decay constant of a radioactive sample is γ. Its half-life is $T_{1/2}$ and mean life is T.

(a) $T_{1/2}=\frac{1}{\gamma}, T=\frac{\ln 2}{\gamma}$ (b) $T_{1/2}=\frac{\ln 2}{\gamma}, T=\frac{1}{\gamma}$
(c) $T_{1/2}=\gamma\ln 2, T=\frac{1}{\gamma}$ (d) $T_{1/2}=\frac{\gamma}{\ln 2}, T=\frac{\ln 2}{\gamma}$

Q 4. If the half - lives of a radioactive element for α - decay and β - decay are 4 year and 12 year respectively. What percent would its total activity be of its initial activity after 12 years?

(a) 50 % (b) 25 %
(c) 12.25 % (d) 6.25 %

Q 5. The fraction of the original number of a radioactive atom having a mean life of 10 days, that decays during the 5th day is:
[Given: $e^{-0.4}=0.66, e^{-0.5}=0.6$]

(a) 0.15 (b) 0.30
(c) 0.015 (d) 0.06

Q.6 A radioactive substance emits 100 beta particles in the first 2 seconds and 50 beta particles in the next 2 seconds. The mean life of the sample is.

(a) 4 sec (b) 2 sec
(c) $\frac{2}{0.693}$ sec (d) 2×0.693 sec

Q 7. Calculate the time required for 60% of a sample of radon to undergo decay. (Given $T_{1/2}$ of radon = 3.8 days, and $\ln(0.4)=-0.916$)

(a) 4.5 days (b) 5.05 days
(c) 2.35 days (d) 7.16 days

Q 8. 75 atoms of radio active species are decayed in 2 half lives ($t_{1/2} = 1$ hr) if 100 atoms are taken initially. Number of atoms remained in two hours, if 200 atoms are taken initially

(a) 75 (b) 150
(c) 50 (d) 200

Q 9. A radioactive material decays by simultaneous emission of two particles with half-lives 1620 year and 810 year respectively. The time in years after which one-fourth of material remains, is :

(a) 1080 year (b) 2340 year
(c) 4860 year (d) 3240 year

Q 10. The activity of a radioactive sample is measured as N_o counts per minute at t = 0 and $\frac{N_o}{e}$ counts per minute at t = 5 min. The time, (in minute) at which the activity reduces to half its value, is :

(a) $\ln\frac{2}{5}$ (b) $\frac{5}{\ln 2}$
(c) $5\log_{10} 2$ (d) $5\ln 2$

Q 11. The half life of a radioactive material is 5 years. The probability of disintegration for a nucleus within 10 years is

(a) 0.50 (b) 0.25
(c) 0.60 (d) 0.75

Q 12. Samples of two radioactive nuclides, X and Y, each have equal activity A_o at time t = 0. X has a half-life of 24 years and Y a half-life of 16 years. The samples are mixed together. What will be the total activity of the mixture at t = 48 years?

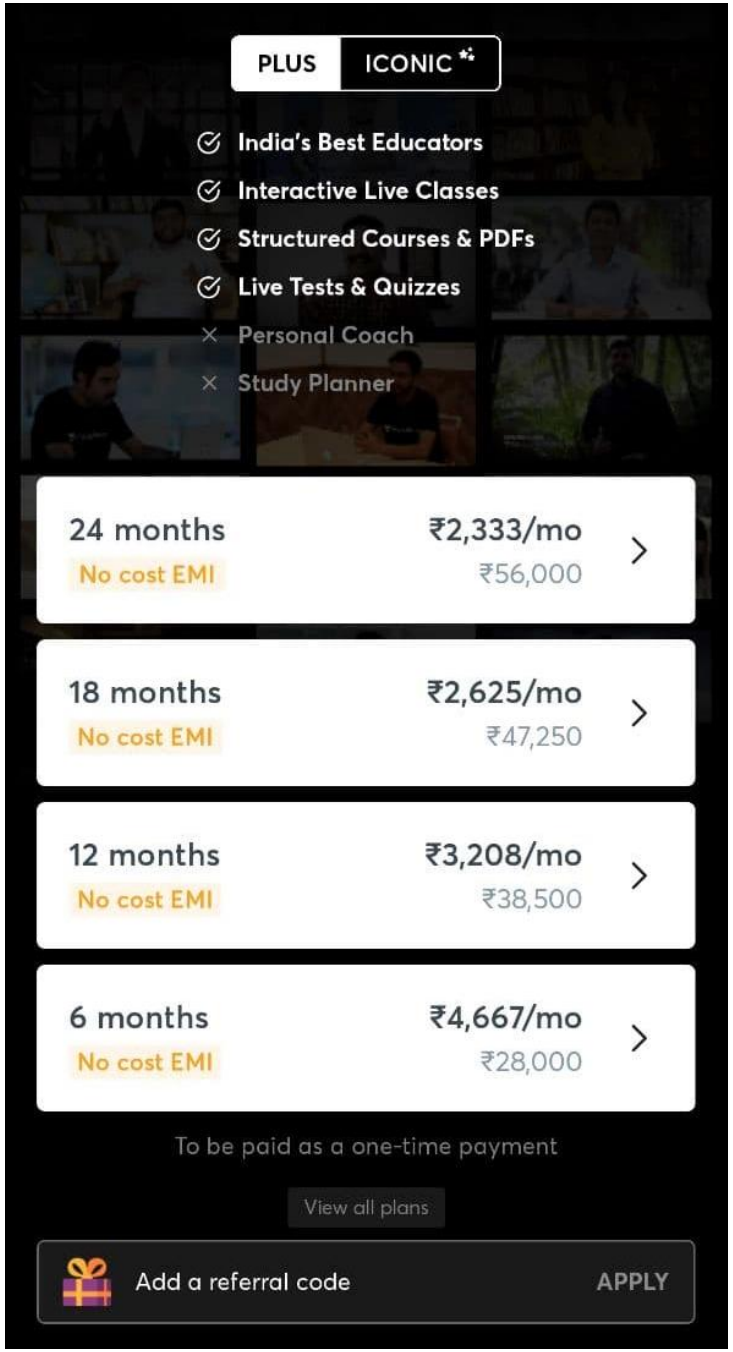
(a) $\frac{A_o}{2}$ (b) $\frac{A_o}{4}$
(c) $\frac{3A_o}{16}$ (d) $\frac{3A_o}{8}$

Q 13. The disintegration rate of a certain radioactive sample at any instant is 4750 dpm (disintegration per minute). Five minutes later, the rate becomes 2700 dpm. Calculate half-life of sample. [Given, $\ln(1.759) = 0.5647$)

(a) 6.1 min (b) 3.6 min
(c) 9.3 min (d) 1.2 min

Answer Key

Q.1 c	Q.2 c	Q.3 b	Q.4 d	Q.5 d
Q.6 c	Q.7 b	Q.8 c	Q.9 a	Q.10 d
Q.11 d	Q.12 d	Q.13 a		



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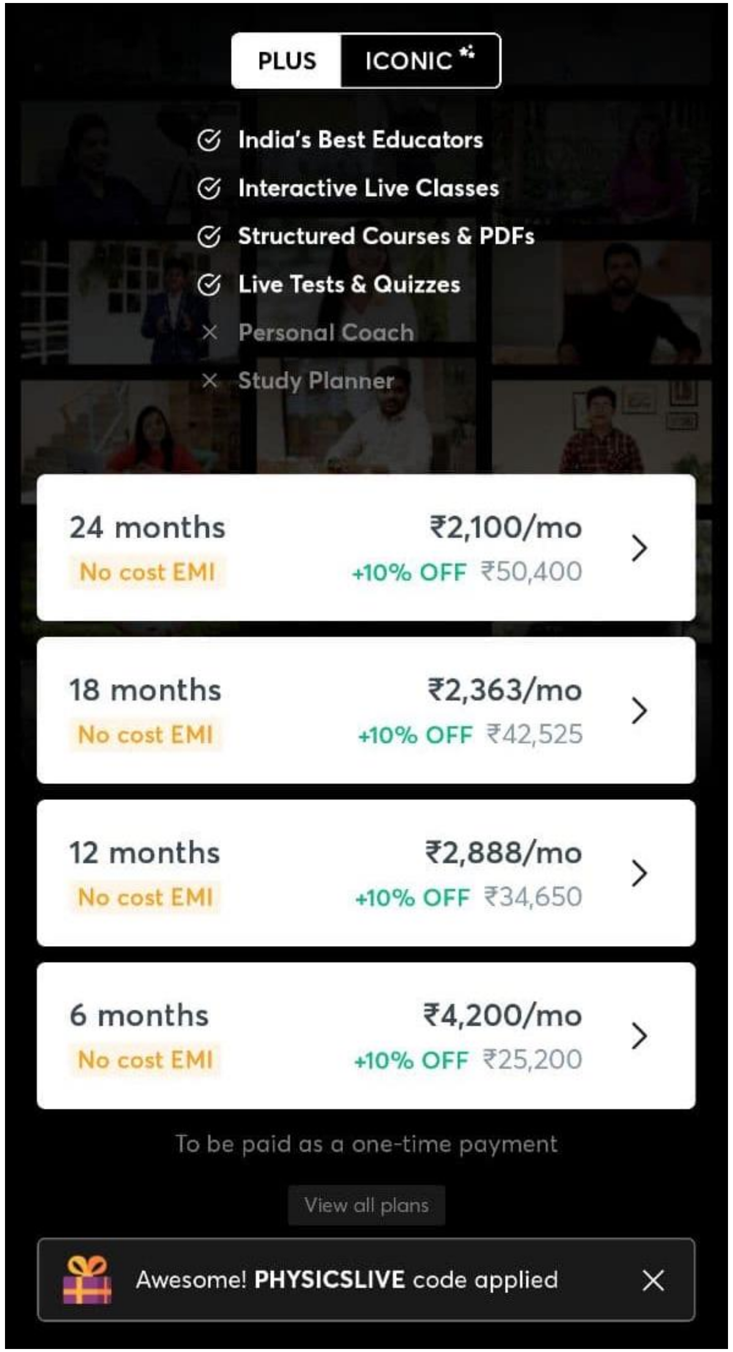

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Written Solution

DPP-3 Nuclear Physics: Radioactivity

By Physicsaholics Team

Solution: 1

for X ; $T_{1/2} = 1$ hr $\Rightarrow \lambda_x = \frac{\ln 2}{1}$

for Y ; $T_{1/2} = 2$ hr $\Rightarrow \lambda_y = \frac{\ln 2}{2}$

$\because N = N_0 e^{-\lambda t}$

or $N = N_0 \left(\frac{1}{2}\right)^n$; $n = \frac{t}{T_{1/2}}$

after ; t = 2 hr.

for x ; $n = \frac{2}{1} = 2$ for y ; $n = \frac{2}{2} = 1$

$\frac{N_x}{N_0} = \left(\frac{1}{2}\right)^2$ — ① $\frac{N_y}{N_0} = \left(\frac{1}{2}\right)^1$ — ②

$\frac{①}{②} \Rightarrow \frac{N_x/N_0}{N_y/N_0} = \frac{\left(\frac{1}{2}\right)^2}{\left(\frac{1}{2}\right)^1}$

$\frac{N_x}{N_y} = \left(\frac{1}{2}\right)^1$

$$\boxed{\frac{N_x}{N_y} = \frac{1}{2}}$$

$\left(\frac{dN}{dt}\right)_x = \lambda_x N_x$; $\left(\frac{dN}{dt}\right)_y = \lambda_y N_y$

$\frac{\left(\frac{dN}{dt}\right)_x}{\left(\frac{dN}{dt}\right)_y} = \frac{\lambda_x N_x}{\lambda_y N_y} = \frac{\left(\frac{\ln 2}{1}\right)}{\left(\frac{\ln 2}{2}\right)} \times \frac{1}{2}$

$= \frac{2}{1} \times \frac{1}{2}$

$= \frac{1}{1}$

$$\boxed{\frac{A_x}{A_y} = \frac{1}{1}}$$ Ans.

Ans. c

Solution: 2

$$T_{1/2} = \frac{\ln 2}{\lambda}$$

$$\lambda = \frac{\ln 2}{T_{1/2}}$$

and avg life $T_{avg} = \frac{1}{\lambda}$

$$T_{avg} = \frac{T_{1/2}}{\ln 2}$$

$$= \frac{1600}{0.693}$$

$$T_{avg} = 2308 \text{ years}$$

$$\boxed{T_{avg} = 2308 \text{ years}}$$ Ans

Ans. c

Solution: 3

Half life: $T_{1/2} = \frac{\ln 2}{\lambda} = \frac{ln2}{\gamma}$,

Mean life: $T = \frac{1}{\lambda} = \frac{1}{\gamma}$

Ans. b

Solution: 4

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

$$\frac{\ln 2}{T_{1/2}} = \frac{\ln 2}{(T_{1/2})_1} + \frac{\ln 2}{(T_{1/2})_2}$$

$$\frac{1}{T_{1/2}} = \frac{1}{(T_{1/2})_1} + \frac{1}{(T_{1/2})_2}$$

$$\frac{1}{T_{1/2}} = \frac{1}{4} + \frac{1}{12}$$

$$\boxed{T_{1/2} = 3 \text{ years}}$$

$$n = \frac{t}{T_{1/2}} = \frac{12}{3} = 4$$

$$\frac{R}{R_0} = \left(\frac{1}{2}\right)^n$$

$$\frac{R}{R_0} = \left(\frac{1}{2}\right)^4 = \frac{1}{16}$$

$$\frac{R}{R_0} = \frac{1}{16} \times 100\%$$

$$\boxed{\frac{R}{R_0}\% = 6.25\%}$$ Ans

Ans. d

Solution: 5

decay on 5th day N_5^{th} = Remaining after 4 days − Remaining after 5 days.

$$N_5^{th} = N_4 - N_5$$

$$= N_0 e^{-\lambda(4)} - N_0 e^{-\lambda(5)}$$

$$N_5^{th} = N_0 \left[e^{-4\lambda} - e^{-5\lambda} \right]$$

$$\frac{N_5^{th}}{N_0} = \left[e^{-4\lambda} - e^{-5\lambda} \right]$$

$$\lambda = \frac{1}{\tau} = \frac{1}{10}$$

$$\Rightarrow \frac{N_5^{th}}{N_0} = e^{-4\frac{1}{10}} - e^{-5\frac{1}{10}}$$

$$= e^{-2/5} - e^{-1/2}$$

$$= e^{-2/5} - e^{-1/2}$$

$$= \left(\frac{1}{e}\right)^{2/5} - \left(\frac{1}{e}\right)^{1/2}$$

$$= 0.66 - 0.60$$

$$\boxed{\frac{N_5^{th}}{N_0} \simeq 0.06}$$ Ans

Ans. d

Solution: 6

so; $T_{1/2} = 2$ sec.

but $T_{avg} = \frac{1}{\lambda} = \frac{1}{\left(\frac{\ln 2}{T_{1/2}}\right)}$

$T_{avg} = \frac{T_{1/2}}{\ln 2}$

$$T_{avg} = \frac{2}{0.693} \text{ sec}$$

Ans. c

Solution: 7

to decay 60 %

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

N → decayed amount.

$\frac{60}{100} \times N_0 = N_0(1-e^{-\lambda t})$

$0.6 = 1-e^{-\lambda t}$

$e^{-\lambda t} = 0.4$

$-\lambda t = \ln(0.4)$

$t = -\frac{\ln(0.4)}{\lambda} = -\frac{\ln(0.4)}{\ln 2}(T_{1/2})$

$t = -\left[\frac{-0.916}{0.693}\right] \times 3.8$

$\boxed{t = 5.05 \text{ days}}$ Ans

Ans. b

Solution: 8

$100 \xrightarrow{t_{1/2}} 50 \xrightarrow{t_{1/2}} 25$

75 decayed & 25 remaining after two half lives.

for $t = 2$ hr.

$\because t_{1/2} = 1$ hr

mes $n = \frac{2}{1} = 2$ (2 half lives)

$200 \xrightarrow{t_{1/2}} 100 \xrightarrow{t_{1/2}} 50$

if 200 is taken initially then 50 atoms are remaining after 2 hrs.

Ans. c

Solution: 9

half life = T

$T_1 = 1620$ year

$T_2 = 810$ year

$\because \lambda = \lambda_1 + \lambda_2$

$$\frac{\ln 2}{T} = \frac{\ln 2}{T_1} + \frac{\ln 2}{T_2}$$

$$\frac{1}{T} = \frac{1}{1620} + \frac{1}{810}$$

$$T = \frac{1620}{3} \text{ year}$$

$$\boxed{T = 540 \text{ year}}$$

If material is $\frac{1}{4}$th remaining

then; $N = \frac{1}{4} N_0$

$$N_0 \xrightarrow{t_{1/2}} \frac{N_0}{2} \xrightarrow{t_{1/2}} \frac{N_0}{4}$$

So; time = 2 - Half lives

$t = 2 \times T$

$= 2 \times 540$

$$\boxed{t = 1080 \text{ years}}$$ Ans.

Ans. a

Solution: 10

Activity;

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

so; initially; $A_0 = N_0$

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

at $t = 5$ min

$$\frac{N_0}{e} = N_0 e^{-\lambda(5)} \quad \text{--- (1)}$$

for $N = \frac{N_0}{2}$

$$\frac{N_0}{2} = N_0 e^{-\lambda t} \quad \text{--- (2)}$$

From eq^n-1

$$\frac{N_0}{e} = N_0 e^{-\lambda(5)} \Rightarrow \frac{1}{e} = e^{-5\lambda}$$

$$\frac{1}{e} = \frac{1}{e^{5\lambda}} \Rightarrow 5\lambda = 1$$

$$\boxed{\lambda = \frac{1}{5}}$$

Now put λ in eq^n (2)

$$\frac{N_0}{2} = N_0 e^{-\left(\frac{1}{5}t\right)}$$

$$\frac{1}{2} = e^{-t/5} \Rightarrow \ln 2^{-1} = \ln e^{-t/5}$$

$$-\ln 2 = -t/5$$

$$\boxed{t = 5 \ln 2 \text{ minutes}}$$ Ans.

Ans. d

Solution: 11

$T_{1/2} = 5$ year

$t = 10$ years $= 2 \times T_{1/2}$

so; $N_0 \xrightarrow{T_{1/2}} \frac{N_0}{2} \xrightarrow{T_{1/2}} \frac{N_0}{4}$

remaining atoms after 10 years $= \frac{N_0}{4}$

decayed atoms in 10 years $= \frac{3N_0}{4}$

So; Probability to decay in 10 years $= \frac{3N_0/4}{N_0}$

$= \frac{3}{4}$

$= \underline{0.75}$ Ans.

Ans. d

Solution: 12

for 'x';

initial activity = A_0

$T_{1/2} = 24$ year

for 'y';

initial activity = A_0

$T_{1/2} = 16$ years

after $t = 48$ years

$n = \frac{48}{24} = 2$

$n = \frac{48}{16} = 3$

Activity; $A_x = \frac{A_0}{2^n} = \frac{A_0}{2^2} = \frac{A_0}{4}$

Activity; $A_y = \frac{A_0}{2^n} = \frac{A_0}{2^3} = \frac{A_0}{8}$

so, Activity of mixture

$A_{mix} = A_x + A_y = \frac{A_0}{4} + \frac{A_0}{8} = \frac{3A_0}{8}$

$$\boxed{A_{mix} = \frac{3A_0}{8}}$$ Ans

Ans. d

Solution: 13

$$T_{1/2} = \frac{\ln 2}{\lambda}$$

$\lambda = ?$

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

$$2700 = 4750\, e^{-\lambda(5)}$$

$$\frac{2700}{4750} = e^{-5\lambda}$$

$$e^{5\lambda} = \frac{4750}{2700}$$

$$5\lambda = \ln\left(\frac{4750}{2700}\right)$$

$$\lambda = \frac{1}{5}\ln(1.759)$$

$$\lambda = \frac{1}{5} \times 0.5647$$

$$\boxed{\lambda = 0.113 \text{ min}^{-1}}$$

So; $T_{1/2} = \frac{\ln 2}{\lambda}$

$$T_{1/2} = \frac{0.693}{0.113}$$

$$T_{1/2} = \frac{693}{113} \text{ min}$$

$$\boxed{T_{1/2} = 6.13 \text{ min}}$$ Ans

Ans. a

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Chalo Niklo