Worksheet Solution

(Chapter 3 Radioactivity)

MCQ (Multiple Choice Questions)

Ans. 1: (a)

Solution: $\lambda=\frac{1}{t}\ln\left(\frac{R_0}{R}\right)=\frac{1}{30}\ln\left(\frac{R_0}{1/4R_0}\right)=\frac{1}{30}\ln(4)=\frac{1}{30}(1.4)=\frac{1.4}{30}=0.04$

$$T_{1/2}=\frac{0.693}{\lambda}=\frac{0.693}{0.047}=14 \text{ day.}$$

Ans. 2: (a)

Solution: $R_A=10\,mCi, R_B=20\,mCi, N_A=2N_B$

$$R_A/R_B=\lambda_A N_A/\lambda_B/N_B=\left[(T_{1/2})_B/(T_{1/2})_A\right]\times\left[N_A/N_B\right]$$

$$\left(\frac{1}{2}\right)=\left[(T_{1/2})_B/(T_{1/2})_A\right]\times 2\Rightarrow(T_{1/2})_A=4(T_{1/2})_B$$

Ans. 3: (a)

Solution: According to the law of radioactivity, the count rate at t = 8 seconds is

$$N_1=N_0e^{-\lambda t}$$

$$dN/dt=\lambda N_0e^0=\lambda N_0\Rightarrow 100=\lambda N_0e^{-8\lambda}=1600\,e^{-8\lambda}$$

$$e^{8\lambda}=16=24\Rightarrow e^{2\lambda}=2$$

$$t=6\,\text{sec}$$

$$(dN/dt)=\lambda N_0e^{-6\lambda}=1600\times\left(e^{-2\lambda}\right)^3=1600\times\left(\frac{1}{8}\right)=200$$

Ans. 4: (a)

Solution: $N=N_0e^{-\lambda t}$

So, $N_1=N_0e^{-10\lambda t}$

$$N_2=N_0e^{-\lambda t}\Rightarrow(1/e)=(N_1/N_2)=\left(N_0e^{-10\lambda t}\right)/\left(N_0e^{-\lambda t}\right)$$

$$\Rightarrow(1/e)=e^{-9\lambda t}=e^{-1}=e^{-9\lambda t}$$

$$\Rightarrow 1=9\lambda t\Rightarrow t=1/9\lambda$$

Ans. 5: (c)

Solution: By the law of radioactivity $N=N_0e^{\lambda t}$

For nuclei A,

$N_A = N_{0A}e^{-\lambda t}$

or $\left(N_A / N_{0A}\right) = \left(1/2\right)^n = \left(1/2\right)^{t/10} = \left(1/2\right)^6$ (i)

$N_A = N_{0A}/2^6$

For nuclei B,

$\left(N_B / N_{0B}\right) = \left(1/2\right)^n = \left(1/2\right)^{t/20} = \left(1/2\right)^3$

$\Rightarrow N_B = \left(N_{0B}\right)/2^3$

Ratio of nuclei decayed will be

$\left(N'_A / N'_B\right) = \left(N_{0A} - N_A\right)/\left(N_{0B} - N_B\right) = \left(N_{0A}/N_{0B}\right)\left[1-\left(1/2\right)^6/1-\left(1/2\right)^3\right] = 9/8$

Ans. 6: (d)

Solution: The number of undecayed nuclei at any time t,

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

As $N_{0A} = N_{0B}$ (given)

So, for nuclei A and B

$\left(N_A / N_B\right) = e^{(-\lambda_A + \lambda_B)t}$

$t = \left[1/\lambda_B - \lambda_A\right]\ln\left(N_A / N_B\right) = 1/\left(\lambda - 5\lambda\right)\ln\left(1/e^2\right) = 1/2\lambda$

Ans. 7: (c)

Solution: $T_{1/2}$, half-life of $X = T_{mean}$, mean life of Y

Or $0.693/\lambda_X = 1/\lambda_Y$

$\lambda_X = 0.693\lambda_Y$

$\lambda_X < \lambda_Y$

Rate of decay $= \lambda N$

Initially, number of atoms (N) of both are equal but since $\lambda_X < \lambda_Y$, therefore Y will decay at a faster rate than X

NAT (Numerical Answer Type)

Ans. 8: 97

Solution: $N = N_0\left(\frac{1}{2}\right)^{t/T_{1/2}} = N_0\left(\frac{1}{2}\right)^{15/3} = \frac{N_0}{32}$

In 15 days the probability of decay $= \frac{N_0 - N}{N_0}\times 100 = \frac{N_0 - \frac{N_0}{32}}{N_0}\times 100 = \frac{31}{32}\times 100 = 97\%$

Ans. 9: 1.23

Solution: $t_{1/2} = 4.5\times 10^9 \times 365\times 3600 = 1.42\times 10^{17}$ sec

$1g$ of U_{92}^{238} contain $\frac{1}{238\times 10^{-3}} kmol\times 6.025\times 10^{26} atom/kmol = 25.3\times 10^{20} atom$

Activity $A = \frac{dN}{dt} = \lambda N = \frac{0.693}{t_{1/2}}\times N = \frac{0.693}{1.42\times 10^{17}}\times 25\times 10^{20} = 1.23\times 10^4 \sec^{-1}$

Ans. 10: 5.72

Solution: $\lambda = \frac{0.693}{t_{1/2}} = \frac{0.693}{3.8\times 86,400 \sec/day} = 2.11\times 10^{-6}$

$N = \frac{1\times 10^{-6}}{222u\times 1.66kg/u} = 2.71 atom$

Activity $A = \frac{dN}{dt} = \lambda N = \frac{0.693}{t_{1/2}}\times N = \left(2.11\times 10^{-6}\right)\sec^{-1}\left(2.71\times 10^{18}\right) = 5.72\times 10^{12} decays/\sec$

Ans. 11: 690

Solution: $\frac{N}{N_0} = 0.92 \Rightarrow N = N_0 \exp(-\lambda t)$ $\lambda = \frac{0.693}{t_{1/2}}$

$t = -\frac{1}{\lambda}\ln\frac{N}{N_0} = -\frac{5730}{0.693}\ln 0.92 = 690$ year