Unit 24

Answers: Radioactivity and Nuclear Reactions

Quick checks

1 **c**

2 **c**

3 **c**

4 **b** A Z $^{226}_{89}$

5 **c**

6 **c** $n = 12/3 = 4$ $N = N_0\left(\frac{1}{2}\right)^4 = \frac{N_0}{16}$ $\frac{1}{4}$

7 **c** $\lambda = 0.693/6.93 = 0.100$ $\tau = 1/\lambda = 10.0$ $1.443 \times 6.93 = 10.0$

8 **b**

9 **b**

10 **c**

11 **b** $\dfrac{1.85 \times 10^{12}}{3.7 \times 10^{10}} = 50$

12 **a** $M\left(\frac{1}{2}\right)^6 = \frac{M}{64}$

13 **d** $10 \times \left(\frac{1}{2}\right)^5 = \frac{10}{32} = 0.3125$

14 **d**

15 **c**

16 **d**

17 **c** $\left(\frac{1}{2}\right)^4 = \frac{1}{16}$

18 **a** $N = \frac{10^{20}}{4} = 2.5 \times 10^{19}$

$$\lambda = \frac{0.693}{130 \times 86400} = 6.17 \times 10^{-8}$$

$$R = \lambda N = 6.17 \times 10^{-8} \times 2.5 \times 10^{19} = 1.54 \times 10^{12}$$

19 **d** $e^{-25\lambda} = 0.99 \quad \lambda = \dfrac{\ln(100/99)}{25} = \dfrac{0.01005}{25} = 4.02 \times 10^{-4}$

$$T_{1/2} = \frac{0.693}{4.02 \times 10^{-4}} = 1724$$

20 **a** $e^{-100\lambda} = 0.01 \quad \lambda = \dfrac{\ln 100}{100} = 0.0461 \qquad T_{1/2} = \dfrac{0.693}{0.0461} = 15.0$

$2^{6.6} \approx 100$

21 **c** $t = \dfrac{T_{1/2}}{0.693} \ln \dfrac{R_0}{R} = \dfrac{4.8}{0.693} \ln 20 = 6.93 \times 2.996 = 20.7$

12.

-
-
-

$$-\frac{dN}{dt} \propto N$$

λ

$$\lambda = -\frac{dN/dt}{N}$$

$\frac{dN}{dt} = -\lambda N$ $N = N_0 e^{-\lambda t}$ $t = T_{1/2}$ $N = \frac{N_0}{2}$

$$\frac{N_0}{2} = N_0 e^{-\lambda T_{1/2}} \;\Rightarrow\; e^{\lambda T_{1/2}} = 2 \;\Rightarrow\; \lambda T_{1/2} = \ln 2 \;\Rightarrow\; T_{1/2} = \frac{0.693}{\lambda}$$

$\lambda = \frac{0.693}{30} =$

$\frac{1}{4} = \left(\frac{1}{2}\right)^2$ $t = 2 \times 30 =$

$\frac{1}{\lambda} = 43.3$

13.

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

$T_{1/2}$

τ

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

t $t + dt$ $\lambda N_0 e^{-\lambda t}\, dt$ t

$$\tau = \frac{1}{N_0}\int_0^\infty t\, \lambda N_0 e^{-\lambda t}\, dt = \lambda \times \frac{1}{\lambda^2} = \frac{1}{\lambda}$$

$\frac{T_{1/2}}{\tau} = \frac{0.693/\lambda}{1/\lambda} = 0.693$ $T_{1/2} = 0.693\,\tau$

$e^{-7.5\lambda} = \frac{1}{10}$ $\lambda = \frac{\ln 10}{7.5} = \frac{2.303}{7.5} = 0.307$

$T_{1/2} = \frac{0.693}{0.307} =$

$2^{3.3} \approx 10$

14.

$$\frac{146}{92} = 1.587$$

$$\frac{144}{90} = 1.600$$

$\frac{3}{4}$ $\frac{1}{4} = \left(\frac{1}{2}\right)^2$

15. $\left(\frac{1}{2}\right)^5 = \frac{1}{32} = 0.03125$

$$0.0327 \times 1.6 \times 10^{-19} = 5.23 \times 10^{-21}$$

$$v = \sqrt{\frac{2E}{m}} = \sqrt{\frac{2 \times 5.23 \times 10^{-21}}{1.675 \times 10^{-27}}} = 2.50 \times 10^{3}$$

$$t = \frac{10}{2500} = 4.0 \times 10^{-3}$$

$$\lambda = \frac{0.693}{700} = 9.9 \times 10^{-4}$$

$$= 1 - e^{-\lambda t} \approx \lambda t = 9.9 \times 10^{-4} \times 4.0 \times 10^{-3} =$$

λt $e^{-\lambda t} \approx 1 - \lambda t$

16.

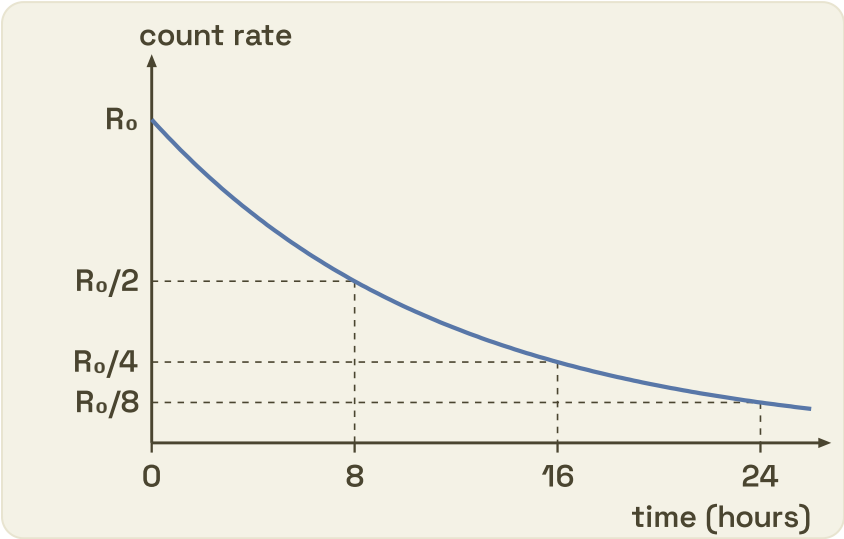
$$\lambda = \frac{0.693}{T_{1/2}} = \frac{0.693}{14} =$$

17.

$$T_{1/2} = \frac{106}{2} =$$

18.

Type of particle	Number of particles	Charge on a particle



$\frac{1}{4}$ $\left(\frac{1}{2}\right)^2$ $2 \times 8 =$

19.

$T_{1/2} \approx$

20.

$$180 \times \left(\tfrac{1}{2}\right)^{2} =$$