Solutions

Each answer shows the steps, then the **result**.

2.1

- it is **spontaneous** (unaffected by external conditions)
- and **random** (cannot predict which nucleus decays when)

2.2

- **activity** — the number of decays per unit time
- **decay constant** — the probability per unit time that a nucleus decays

2.3

- the time for **half** the undecayed nuclei (or the activity) to decay

2.4

- $A = \lambda N$

3.1 B

- half-life is the time for **half the undecayed nuclei to decay**

3.2

- $t_{1/2} = 0.693/\lambda$

$$t_{1/2} = \frac{0.693}{0.040\ \text{s}^{-1}} = \mathbf{17}\ \text{s}$$

3.3

- $A = \lambda N$

$$A = (1.5 \times 10^{-9}\ \text{s}^{-1})(2.0 \times 10^{20}) = \mathbf{3.0 \times 10^{11}}\ \text{Bq}$$

3.4

- 18 h = 3 half-lives
- fraction $= (1/2)^3 = \mathbf{1/8}$

3.5

- $\lambda = 0.693/t_{1/2}$

$$\lambda = \frac{0.693}{8.0\ \text{day}} = 0.0866\ \text{day}^{-1}$$

- $t = -(1/\lambda)\ln(A/A_0)$

$$t = -\frac{1}{0.0866\ \text{day}^{-1}}\ln(0.20) = \mathbf{18.6}\ \text{days}$$

3.6

(a) a radioactive substance introduced into a system

- whose progress can be followed from outside by detecting the radiation it emits

(b) $P = 15$, $Q = 7$, $R = 0$, $S = +1$

- Z is a **positron**

(c) the **rate of decay** — the number of nuclei decaying per unit time

(d) $\lambda = \ln 2 / t_{1/2}$

$$\lambda = \frac{0.693}{122 \text{ s}} = \mathbf{5.7 \times 10^{-3}} \text{ s}^{\mathbf{-1}}$$

(e) $A = \lambda N$

$$A = (5.68 \times 10^{-3} \text{ s}^{-1})(4.8 \times 10^{14}) = \mathbf{2.7 \times 10^{12}} \text{ Bq}$$

(f) 10 minutes is 600 s

$$A = A_0 e^{-\lambda t} = (2.73 \times 10^{12} \text{ Bq})\, e^{-(5.68 \times 10^{-3} \text{ s}^{-1})(600 \text{ s})} = \mathbf{9.1 \times 10^{10}} \text{ Bq}$$

- about five half-lives, so roughly 1/32 of the start

(g) the patient would keep receiving **ionising radiation** long after the scan is over, raising the dose and the risk of cell damage

- the tracer should decay away soon after the measurement, which a half-life of minutes achieves and one of days does not