Solutions

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

2.1

- a substance containing **radioactive nuclei** introduced into the body and **taken up** by the tissue being studied

2.2

- β^+ **(positron)** decay

2.3

- when a particle meets its **antiparticle**, they are destroyed
- and their **mass becomes energy** (electromagnetic radiation)

2.4

- 511 keV ($= m_e c^2$)

2.5

- fluorine-18 (in fluorodeoxyglucose, FDG)

3.1 B

- the two photons travel **in opposite directions**

3.2

- total rest energy $= 2m_e c^2$, shared by two photons, so each $E = m_e c^2$

$$E = m_e c^2 = (9.11 \times 10^{-31}\ \text{kg})(3.0 \times 10^8\ \frac{\text{m}}{\text{s}})^2 = \mathbf{8.2 \times 10^{-14}}\ \text{J}$$

(= 511 keV)

3.3

- momentum must be **conserved**
- the pair's total momentum is ≈ 0, so the photons must go in **opposite directions** with equal momentum (a single photon could not conserve momentum)

3.4

- both photons are detected (almost simultaneously) on **opposite sides** of the ring
- the annihilation lies on the **straight line** joining the two detectors – combining many such lines builds the image

3.5

- time elapsed: 09:00 to 12:40 is 220 minutes, which is $\dfrac{220}{110} = 2$ half-lives
- the activity halves each half-life: $A = A_0 \left(\frac{1}{2}\right)^n$

$$A = A_0 \left(\tfrac{1}{2}\right)^n = (400\ \text{MBq}) \left(\tfrac{1}{2}\right)^2 = \mathbf{100}\ \text{MBq}$$

3.6

- a short half-life gives a high enough activity for detection from a small amount, and the patient receives a low total dose because the activity soon falls
- the tracer decays quickly, so it must be made nearby (often in an on-site cyclotron) and used soon after production