Past-paper walk-through

PET scanning ▪ 24.3

eXercise

Questions in this set

- 9702/44 N25 Q8 ▪ 15 marks

Reading the mark scheme

- **B1** a mark that stands on its own – the point is either made or not.
- **M1** a *method* mark: the right approach, even if the number is wrong.
- **A1** an *answer* mark, and it usually needs its M mark first.
- **C1** a working mark on the way to the answer.
- // separates answers the examiner accepts equally.
- **ecf** = error carried forward: a later part is marked on your own earlier answer.
- **owtte** = "or words to that effect" – the wording need not match.

Question 8

9702/44 N25 ▪ Q8 ▪ 15 marks

Oxygen-15 ($^{15}_{8}$O) is radioactive and has a half-life of 2.04 minutes.
The decay of oxygen-15 produces positrons. For this reason, oxygen-15 is sometimes used as a tracer in positron emission tomography (PET scanning).

(a) State what is meant by a tracer. **[2]**

(b)(i) State the values of the integers *P*, *Q*, *R* and *S*. **[2]**

(b)(ii) State the name of particle Z. **[1]**

(c)(i) Define the activity of a sample. **[1]**

(c)(ii) Calculate the decay constant of oxygen-15. Give a unit with your answer. **[2]**

(c)(iii) Determine the rate at which positrons are produced in a sample of oxygen-15 that has a mass of 2.85×10^{-6} kg. **[4]**

(d)(i) State the name of the particles that are detected. **[1]**

(d)(ii) Explain how these particles are formed inside the body. **[2]**

Solution 8

(a)

Mark scheme

- (radioactive) substance introduced into the body **B1**
- substance absorbed by the tissues being studied **B1**

Solution 8

(b)(i)

Mark scheme

- P = 15 and R = 0 **A1**
- Q = 7 and S = (+)1 **A1**

(b)(ii)

Mark scheme

- (electron) neutrino **B1**

Solution 8

(c)(i)

Mark scheme

- number of nuclear disintegrations per unit time **B1**

Solution 8

(c)(ii) Worked steps

- $\lambda = \dfrac{\ln 2}{t_{1/2}}$, with the half-life in **seconds**: 2.04 min $= 122.4$ s.
- $\lambda = \dfrac{0.693}{122.4}$
- $\lambda = 5.66 \times 10^{-3}$ s^{-1}

Solution 8

The unit is asked for, and it is per second — a decay constant is a probability per unit time, never a plain number.

Mark scheme

- decay constant = ln 2 / (2.04 × 60) C1
- = 5.66 × 10–3 s–1 A1

Solution 8

(c)(iii) Worked steps

Two steps: how many nuclei there are, then how fast they decay.

- Mass of one oxygen-15 nucleus $= 15 \times 1.66 \times 10^{-27}$ kg.
- $N = \dfrac{2.85 \times 10^{-6}}{15 \times 1.66 \times 10^{-27}} = 1.14 \times 10^{20}$
- Activity $A = \lambda N = 5.66 \times 10^{-3} \times 1.14 \times 10^{20}$
- $A = 6.48 \times 10^{17}$ s^{-1}

Solution 8

Each decay of oxygen-15 emits one positron, so that activity **is** the rate at which positrons are produced.

Mark scheme

- N = (2.85 × 10–6) / (15 × 1.66 × 10–27) C1
- A = λN C1
- rate = (5.66 × 10–3) × (2.85 × 10–6) / (15 × 1.66 × 10–27) C1
- = 6.48 × 1017 s–1 A1

Solution 8

(d)(i)

Mark scheme

- gamma photons **B1**

(d)(ii)

Mark scheme

- positron collides with electron (in body) **B1**
- annihilation results in their masses becoming photon energy **B1**