24. Medical Physics

24.3 PET scanning

Paper 4

Question Paper

1 Fluorine-18 ($^{18}_{9}F$) decays by beta-plus (β^+) emission with a half-life of 110 minutes.

(a) **(i)** State the name of the beta-plus particle.

..... [1]

(b) A small sample of fluorine-18 injected into the body acts as a tracer for use in medical imaging.

(i) Describe how the interaction of a β^+ particle with an electron in the body enables the formation of an image.

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..... [3]

(ii) Suggest why 110 minutes is a suitable half-life for a nuclide used as a tracer in medical diagnosis.

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..... [2]

2 Fluorine-18 ($^{18}_{9}F$) is a radioactive nuclide that is used as a tracer in positron emission tomography (PET scanning). Fluorine-18 decays to a nuclide of oxygen (O) according to

$$^{18}_{9}F \longrightarrow {}^{Q}_{P}X + {}^{R}_{8}O.$$

(a) (i) State what is meant by a tracer.

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..... [1]

(b) (i) Explain how the radioactive decay of fluorine-18 results in the emission from the body of the gamma-ray photons that are detected during a PET scan.

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..... [2]

(ii) Explain how the detection of the gamma-ray photons is used to produce an image of the tissue being examined.

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..... [2]

3 **(c)** Positronium is highly unstable, and after a very short period of time it becomes gamma radiation.

(i) Describe how gamma radiation is formed from the two particles in positronium.

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..... [3]

(ii) State **one** medical application of the process described in **(c)(i)**.

..... [1]

4 Positron emission tomography (PET scanning) involves the detection of gamma-radiation in order to identify the position of origin of positrons in the body.

(a) (i) Positrons are not naturally present in the body.

Explain how positrons come to be present in the body during PET scanning.

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(ii) Explain how positrons cause the emission of gamma-radiation from the body during PET scanning.

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..... [3]

(b) Show that the wavelength of the gamma-radiation that is detected during PET scanning is approximately 2.4 pm. Explain your reasoning.

[4]

5 An electron, at rest, has mass m_e and charge $-q$.

A positron is a particle that, at rest, has mass m_e and charge $+q$.

A positron interacts with an electron. The electron and the positron may be considered to be at rest.
The outcome of this interaction is that the electron and the positron become two gamma-ray (γ-ray) photons, each having the same energy.

(b) State and explain the direction, relative to each other, in which the γ-ray photons are emitted.

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..... [2]