A Level · OCR · Physics

28 mins 4 questions

Structured Questions

Diagnostic Methods in Medicine

Medical Tracers / Gamma Camera / PET Scans

Easy (1 question)	/5
Medium (3 questions)	/23
Total Marks	**/28**

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Easy Questions

1 (a) The medical tracer technetium-99m is used in imaging organs such as the brain.

Explain the advantages of using technetium-99m for this purpose.

[2]

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(2 marks)

(b) A gamma-camera uses powerful computers and sophisticated software to produce three- dimensional images of the patient's organ.

Name and describe the remaining three main components of the gamma camera.

[3]

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(3 marks)

Medium Questions

1 (a) Fluorine-18 is a common radioactive isotope used in positron emission tomography (PET). Fluorine-18 emits positrons. A patient is injected with a radiopharmaceutical containing fluorine-18.

Describe how a PET scanner is used to locate an area of increased activity within the patient.

[4]

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(4 marks)

(b) The half-life of fluorine-18 is 110 minutes.

Calculate the time *t* in minutes for the activity of the radiopharmaceutical to decrease to 30% of its initial activity.

t = ... minutes **[3]**

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(3 marks)

(c) PET scanners are not available in all hospitals. This is because fluorine-18 requires expensive on-site particle accelerators and fluorine-18 has a very small 'shelf-life'. Suggest the impact this may have on the treatment and diagnosis of patients in the country.

[1]

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(1 mark)

2 The medical tracer fluorine-18 is used in positron emission tomography (PET). Fluorine-18 is a beta-plus emitter with a short half-life.

Describe how the fluorine-18 nuclei are located in a patient using a PET scanner.

[4]

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(4 marks)

3 (a) The nuclear reaction below shows how the isotope of fluorine-18 ($^{18}_{9}\text{F}$) is made from the isotope of oxygen-18 ($^{18}_{8}\text{O}$).

$$^{18}_{8}\text{O} + {}^{1}_{1}\text{p} \rightarrow {}^{18}_{9}\text{F} + {}^{1}_{0}\text{n} + \gamma$$

The oxygen-18 nucleus is **stationary** and the proton has kinetic energy of 0.25×10^{-11} J. The binding energy of the $^{18}_{8}\text{O}$ nucleus is 2.24×10^{-11} J and the binding energy of the $^{18}_{9}\text{F}$ nucleus is 2.20×10^{-11} J. The proton and the neutron have zero binding energy.

i) Explain why a high-speed proton is necessary to trigger the nuclear reaction shown above.

[2]

ii) Estimate the minimum wavelength λ of the gamma ray photon (γ).

λ = ... m **[3]**

iii) Fluorine-18 is a positron emitter. Name a medical imaging technique that uses fluorine-18 and state one benefit of the technique.

[2]

(7 marks)

(b) Describe how the components of a computerised axial tomography (CAT) scanner can produce high-quality images of the internal structures of a patient.

[4]

(4 marks)