

# Medical imaging

## Question Paper 2

Level	A Level
Subject	Physics
Exam Board	OCR
Topic	Particles and medical physics
Sub-Topic	Medical imaging
Booklet	Question Paper 2

**Time Allowed:** 54 minutes

**Score:** / 45

**Percentage:** /100

**Grade Boundaries:**

A*	A	B	C	D	E	U
>85%	'77.5%	70%	62.5%	57.5%	45%	<45%

1 (a) State **two** main properties of X-ray photons.

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.....  
..... [2]

(b) Fig. 7.1 shows an X-ray photon interacting with an atom to produce an electron-positron pair in a process known as pair production.

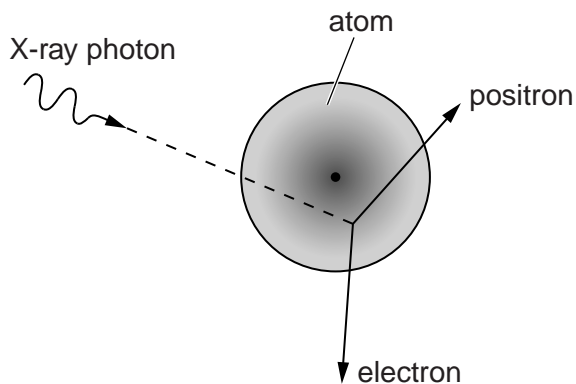


Fig. 7.1

Calculate the maximum wavelength of X-rays that can produce an electron-positron pair.

wavelength = ..... m [3]

(c) Name an element used as a contrast material in X-ray imaging. Explain why contrast materials are used in the diagnosis of stomach problems.

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..... [3]

- 2 Technetium-99m is a common medical tracer injected into patients before they have a scan with a gamma camera. Technetium-99m is a gamma emitter with a half-life of about 6 hours. Each gamma ray photon has energy  $2.2 \times 10^{-14}$  J.

A patient is given a dose with an initial activity of 500 MBq.

- (a) Explain what is meant by *activity*.

.....  
..... [1]

- (b) Calculate the initial rate of energy emission from the dose of technetium-99m.

rate of energy emission = .....  $\text{Js}^{-1}$  [2]



3 (a) State **two** main properties of ultrasound.

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..... [2]

(b) Describe how the piezoelectric effect is used in an ultrasound transducer both to emit and receive ultrasound.

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..... [2]

(c) Explain why a gel is used between the ultrasound transducer and the patient's skin during a scan.

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..... [2]

(d) Explain a method using ultrasound to determine the speed of blood in an artery in the arm.

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..... [4]

4 (a) State two properties of X-rays.

- 1. ....  
.....
- 2. ....  
..... [2]

(b) Explain what is meant by the *Compton effect*.

- .....  
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.....  
..... [2]

(c) The intensity  $I$  of a collimated beam of X-rays decreases exponentially with thickness  $x$  of the material through which the beam passes according to the equation  $I = I_0 e^{-\mu x}$ . The attenuation (absorption) coefficient  $\mu$  depends on the material.

(i) State what  $I_0$  represents in this equation.  
..... [1]

(ii) Bone has an attenuation coefficient of  $3.3\text{cm}^{-1}$ . Calculate the thickness in cm of bone that will reduce the X-ray intensity by half.

thickness = ..... cm [3]







- (b)** Discuss the major differences between an MRI scan and a positron emission tomography (PET) scan of the brain.

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**[2]**

**[Total: 9]**