

Medical imaging

Question Paper 4

Level	A Level
Subject	Physics
Exam Board	OCR
Topic	Particles and medical physics
Sub-Topic	Medical imaging
Booklet	Question Paper 4

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) Describe briefly how X-rays are produced in an X-ray tube.

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..... [2]

(b) Describe the Compton Effect in terms of an X-ray photon.

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..... [2]

(c) A beam of X-rays of intensity $3.0 \times 10^9 \text{ W m}^{-2}$ is used to target a tumour in a patient. The tumour is situated at a depth of 1.7 cm in soft tissue. The attenuation (absorption) coefficient μ of soft-tissues is 6.5 cm^{-1} .

(i) Show that the intensity of the X-rays at the tumour is about $5 \times 10^4 \text{ W m}^{-2}$.

[2]

(ii) The cross-sectional area of the X-ray beam at the tumour is 5 mm^2 . The energy required to destroy the malignant cells of the tumour is 200J. The tumour absorbs 10% of the energy from the X-rays. Calculate the total exposure time required to destroy the tumour.

time = s [3]

- (b)** An MRI scan can take a long time and it does produce an unpleasant loud noise. State one other disadvantage and one advantage of an MRI scan.

disadvantage

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advantage

..... [2]

[Total: 8]

- 3 (a) Describe in simple terms how X-ray photons are produced in a hospital X-ray machine.

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..... [2]

- (b) Fig. 7.1 shows a simple X-ray intensifier screen.

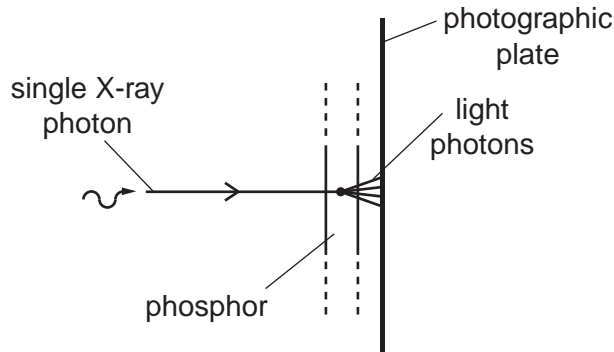


Fig. 7.1

A bright X-ray image can be produced using an image intensifier. A single X-ray photon incident on the phosphor produces about a thousand photons of visible light. The photons of visible light produce an image on a photographic plate.

- (i) Explain what is meant by a *photon*.

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..... [1]

- (ii) Explain why an X-ray photon has greater energy than a photon of visible light.

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..... [1]

- (c) In an X-ray machine, accelerated electrons hit a metal target. Most of the kinetic energy of the electrons is converted into heat, but a small amount is converted into X-ray photons. Electrons having maximum kinetic energy create the shortest wavelength X-ray photons. Calculate the shortest wavelength of X-ray photons emitted from an X-ray machine operating at 120 kV.

wavelength = m [3]

- (d) X-ray photons interact with matter. One of the interaction mechanisms of the X-ray photons with atoms is known as the **photoelectric effect**. State another interaction mechanism. Describe what happens to the X-ray photon interacting with a single atom using the mechanism you have stated.

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..... [2]

[Total: 9]

(d) Fig. 8.1 shows an ultrasound transducer placed above an artery.

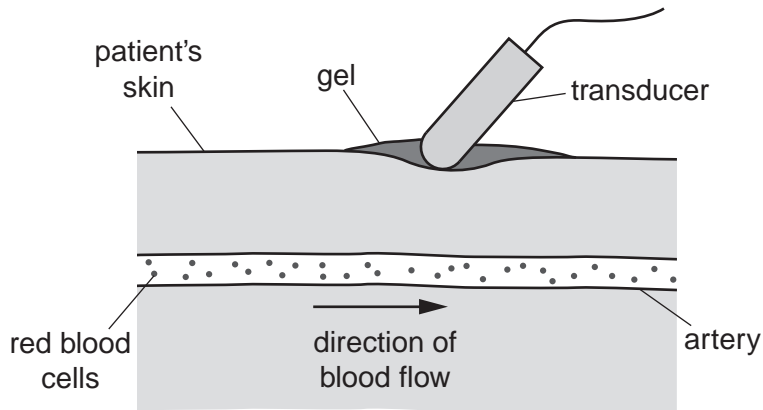


Fig. 8.1

(i) The speed of ultrasound in blood is 1500 m s^{-1} . Calculate the wavelength of the ultrasound of frequency $2.0 \times 10^6 \text{ Hz}$.

wavelength = m [2]

(ii) Describe how the ultrasound is used to determine the speed of the blood in the artery.

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..... [3]

[Total: 14]