Medical imaging – 2021/20 GCE Physics A Component 02

1. Nov/2021/Paper_H556_02/No.14

A beam of ultrasound is incident normally at a boundary between two tissues **F** and **G**.

The table below shows some data on the two tissues.

	Tissue F	Tissue G
Density of tissue	ρ	1.2ρ
Speed of ultrasound in tissue	c	$1.5c$

What percentage of the intensity of the ultrasound is reflected at the boundary?

A 0.83%

B 8.2%

C 9.1%

D 29%

Your answer ☐ **[1]**

2. Nov/2021/Paper_H556_02/No.21

(a) A high-energy X-ray photon interacts with an electron of an atom through the **Compton effect**.

Describe this effect.

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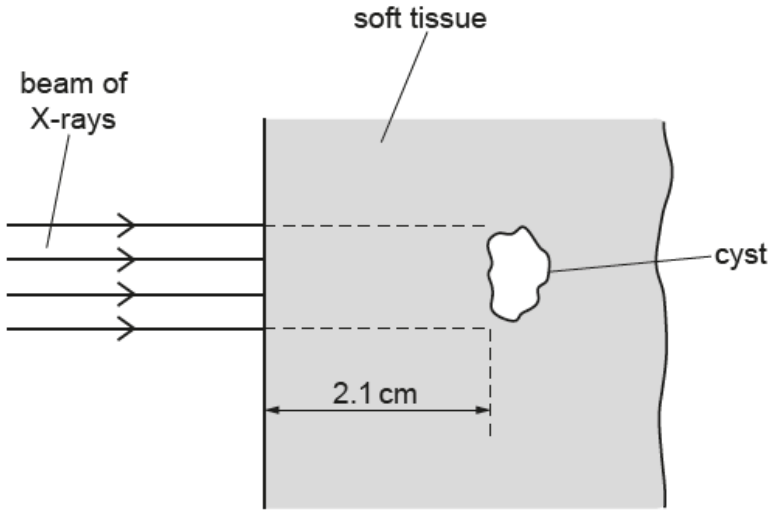
..... **[2]**

(b) The diagram below shows a beam of X-rays incident normally on some soft tissue.



The attenuation (absorption) constant of the soft tissue is $0.85\,cm^{-1}$.
The intensity of the beam is $4.6 \times 10^{3}\,W\,m^{-2}$.
There is a small cyst 2.1 cm from the surface of the soft tissue. The cross-sectional area of the cyst normal to the beam is $3.4 \times 10^{-4}\,m^{2}$.

The beam is switched on for 30 s.

Calculate the X-ray energy incident on the cyst in a period of 30 s.

energy = ... J **[4]**

(c) The attenuation coefficients of the cyst and the soft tissues in **(b)** were similar. This prevented imaging the cyst using a two-dimensional X-ray image.

Name a different X-ray technique that could be used to image the cyst. Explain the advantage of this technique.

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3. Nov/2021/Paper_H556_02/No.22

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.

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..... **[4]**

4. Nov/2020/Paper_H556_02/No.1

The Doppler effect is used to measure the speed of blood flow in arteries.

Which medical diagnostic method uses this technique?

A barium scan

B CAT scan

C PET scan

D ultrasound scan

Your answer ☐ **[1]**

5. Nov/2020/Paper_H556_02/No.16

This question is about the medical use of ultrasound.

(a) In ultrasound scanning, explain what is meant by **impedance (acoustic) matching** and how it may be achieved.

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(b) There are several different types of ultrasound scanning techniques.

Explain how an A-scan could be used to measure the thickness of a patient's eye lens. You may draw a diagram to help with your answer.

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6. Nov/2020/Paper_H556_02/No.24

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

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

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(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.

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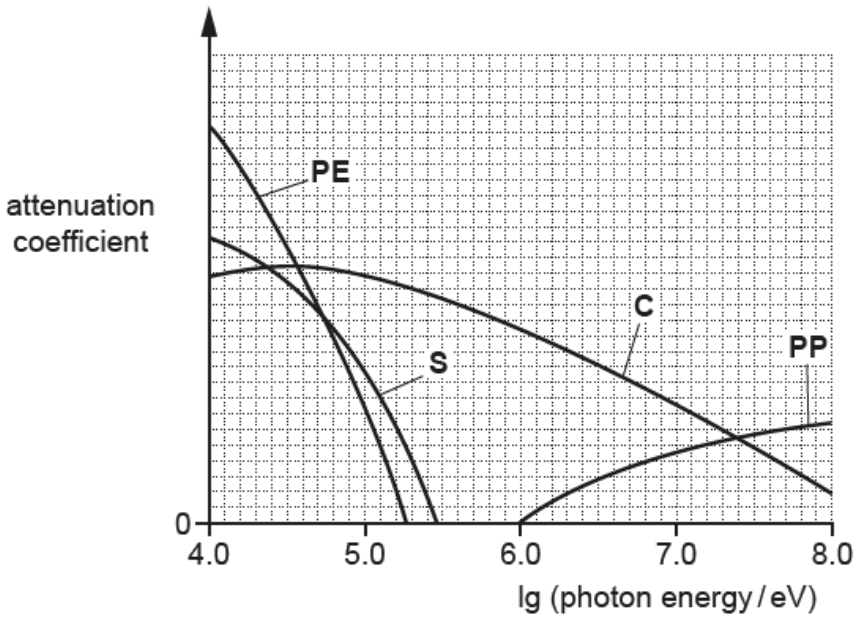
7. Nov/2020/Paper_H556_02/No.25

X-ray photons interact with atoms.

The attenuation coefficient against lg(photon energy) graphs for simple scattering (**S**), photoelectric effect (**PE**), Compton effect (**C**) and pair production (**PP**) are shown below.



(a) For the X-ray tubes used in hospital, the X-ray photons have energy of about 10^5 eV.

State the attenuation mechanisms for these photons.

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(b) With the help of a calculation, explain the minimum photon energy shown on the graph for pair production.

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