AQA

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I declare this is my own work.

A-level PHYSICS

Paper 3
Section B Medical physics

Friday 5 June 2020 Afternoon

Time allowed: The total time for both sections of this paper is 2 hours. You are advised to spend approximately 50 minutes on this section.

Materials

For this paper you must have:
- a pencil and a ruler
- a scientific calculator
- a Data and Formulae Booklet.

Instructions
- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- If you need extra space for your answer(s), use the lined pages at the end of this book. Write the question number against your answer(s).
- Do all rough work in this book. Cross through any work you do not want to be marked.
- Show all your working.

For Examiner's Use	
Question	Mark
1	
2	
3	
4	
TOTAL	

Information
- The marks for questions are shown in brackets.
- The maximum mark for this paper is 35.
- You are expected to use a scientific calculator where appropriate.
- A Data and Formulae Booklet is provided as a loose insert.

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Section B

Answer **all** questions in this section.

0 1 . 1 State and explain **two** differences between the perceived image of a brightly coloured object in bright light and the perceived image of the same object when viewed in very dark conditions.

In your answer you should refer to the visual receptors in the eye.

[5 marks]

Difference 1

Difference 2

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According to some legends, in the 17th century a pirate with two healthy eyes covered one eye with a patch to keep the eye in the dark. The patch was removed when going from bright conditions outside to the very dark conditions below decks in an enemy ship.

It was necessary for the pirate to put the patch on about 45 minutes before going into the very dark conditions inside the ship.

0 1 . 2 What is the name of the process which occurs when the pirate's eye is covered by the patch?
Tick (✓) **one** box.

[1 mark]

aberration ☐

accommodation ☐

adaptation ☐

adjustment ☐

0 1 . 3 Discuss why it was necessary to wear the eye patch for 45 minutes before entering the ship.

[3 marks]

9

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0 2 A sound wave produces a maximum increase in pressure on an ear of 2.5×10^{-3} N m^{-2}.

This causes a maximum increase in pressure in the fluid of the inner ear of 5.0×10^{-2} N m^{-2}.

0 2 . 1 Explain how the ossicles contribute to this increase in pressure in the fluid of the inner ear.

[2 marks]

0 2 . 2 The ear's tympanic membrane can be assumed to be a circle of diameter 1.0 cm.

Calculate the area, in m^2, of the oval window.

[3 marks]

area = _____ m^2

5

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Turn over for the next question

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ANSWER IN THE SPACES PROVIDED

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0 3 X-ray photons can be used to treat cancerous tumours in radiotherapy.
Some photons are absorbed by healthy tissue before they reach the tumour.

Photons with a range of energies are generated in an X-ray machine.

Table 1 shows the linear attenuation coefficient of brain tissue for photons of energy 100 keV and 500 keV.

Table 1

Energy / keV	Linear attenuation coefficient of brain tissue / cm^{-1}
100	0.15
500	0.087

0 3 . 1 Deduce whether photons of energy 100 keV or 500 keV are better for treating a brain tumour at a depth of 11 cm.

[4 marks]

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0 3 . 2 Metal filters are used in X-ray machines to limit the damage to healthy tissues. **Table 2** gives data for possible filter materials.

Table 2

Energy / keV	Linear attenuation coefficient / cm^{-1}	
	Aluminium	**Copper**
100	0.44	3.8
500	0.23	0.73

Discuss whether it would be better to use aluminium or copper to filter the X-rays in Question **03.1**.
No calculations are required.

[2 marks]

0 3 . 3 State and explain **one** other method used to limit exposure of healthy cells during X-ray radiotherapy.

[2 marks]

Method _____

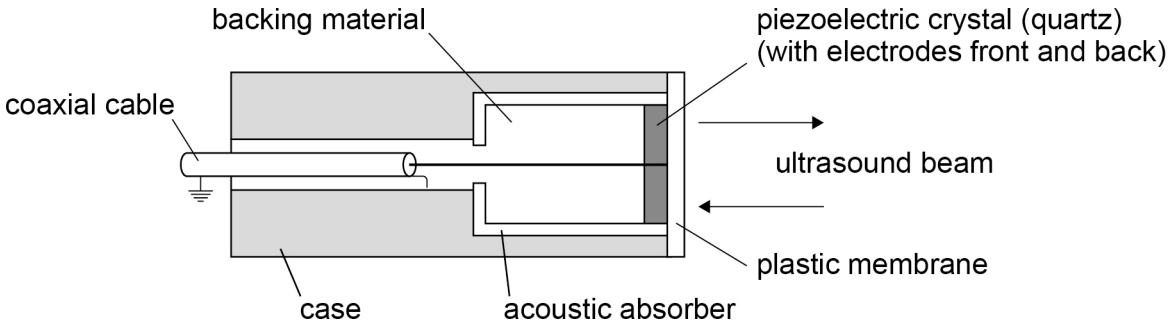
Explanation _____

8

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0 4 **Figure 1** shows an ultrasound transducer used to perform medical scans.

Figure 1



0 4 . 1 Explain how the transducer in **Figure 1** operates in medical diagnosis.

In your answer you should explain how

- an ultrasound pulse is produced by the transducer
- the reflected ultrasound pulse is detected by the transducer
- the transducer can both transmit a pulse and receive the reflected pulse.

[6 marks]

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0 4 . 2 Ultrasound of frequency $1.0\ \text{MHz}$ is used to scan a person's liver.

Estimate the resolution of the scan.

speed of sound in liver tissue = $1600\ \text{m s}^{-1}$

[1 mark]

resolution = _____ mm

Question 4 continues on the next page

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0 4 . 3 Ultrasound travels from a transducer through the chest wall to an air pocket inside the lung. From the air pocket, the ultrasound is then incident on lung tissue.

Calculate the percentage of the incident ultrasound intensity that is transmitted into the lung tissue.

speed of sound in lung tissue = $1580\ \text{m s}^{-1}$

density of lung tissue = $1075\ \text{kg m}^{-3}$

speed of sound in air = $330\ \text{m s}^{-1}$

density of air = $1.3\ \text{kg m}^{-3}$

[4 marks]

percentage = _____ %

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0 4 . 4 Discuss whether an ultrasound scan would be suitable to investigate a tumour inside a lung.

[2 marks]

13

END OF QUESTIONS

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