Please write clearly in block capitals.

Centre number | | | | | | Candidate number | | | | |

Surname _____

Forename(s) _____

Candidate signature _____

A-level PHYSICS A

Unit 5B Medical Physics
Section B

Tuesday 28 June 2016 Morning

Time allowed: The total time for both sections of this paper is 1 hour 45 minutes. You are advised to spend approximately 50 minutes on this section.

Materials

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

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.
- Do all rough work in this book. Cross through any work you do not want to be marked.
- Show all your working.

Information
- The marks for questions are shown in brackets.
- The maximum mark for this section is 35.
- You are expected to use a calculator where appropriate.
- A *Data and Formulae Booklet* is provided as a loose insert.
- You will be marked on your ability to:
  – use good English
  – organise information clearly
  – use specialist vocabulary where appropriate.

Do not write outside the box

Section B

The maximum mark for this section is 35. You are advised to spend approximately 50 minutes on this section.

1 (a) Two bright point sources of light are just resolved as individual images when viewed by a naked eye.

1 (a) (i) State the condition needed for the images to be resolved by the retina.

[1 mark]

_____

_____

_____

1 (a) (ii) The images are formed on the retina at the fovea.
Explain which type of receptor in the retina is being used to detect the images.

[1 mark]

_____

_____

_____

1 (a) (iii) The sources subtend an angle of 0.13 mrad at the naked eye. The eyeball may be assumed to be spherical with a diameter of 52 mm.
Calculate the maximum diameter of the receptor used.

[2 marks]

diameter of receptor = _____ m

Do not write outside the box

1 (b) (i) Describe the changes which occur in a normal eye when the eye changes from viewing a near object to viewing a distant object, both objects being viewed in bright light.

[2 marks]

1 (b) (ii) Describe the changes which occur in a normal eye as the eye changes from viewing an object in bright light to viewing the same object in very dim light.

[3 marks]

9

Turn over for the next question

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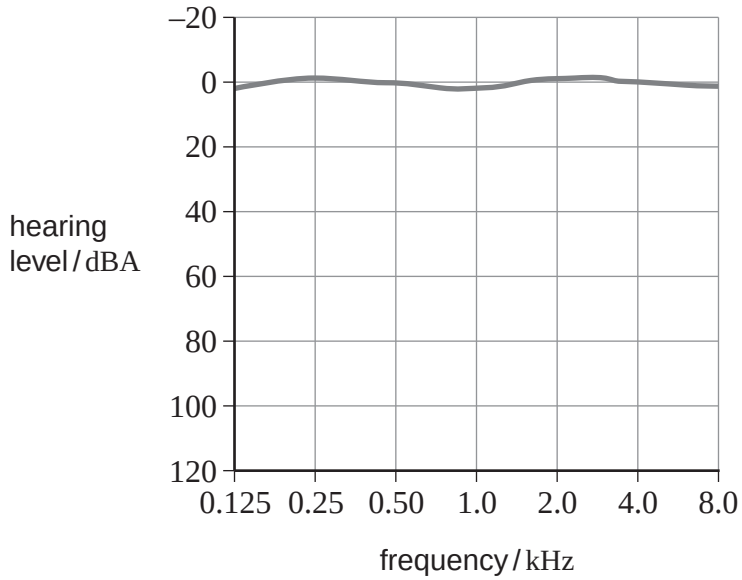
2 Three people were given routine hearing tests. One person was found to have normal hearing and the other two were found to have defective hearing.

2 (a) **Figure 1** shows the variation of hearing level with frequency for the person found to have normal hearing.

Figure 1



It is known that the ear of a person with normal hearing is much more sensitive at 3 kHz than at other frequencies.
Explain why the graph indicates little variation with frequency.

[2 marks]

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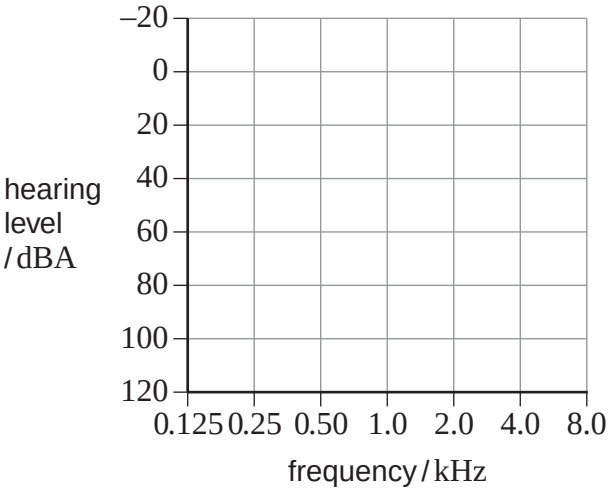
2 (b) Of the other two people, one was found to be suffering from age-related hearing loss and the other was found to be suffering from noise-related hearing loss.

2 (b) (i) Sketch on **Figure 2** the curve you would expect to see for the person suffering from age-related hearing loss.

[1 mark]

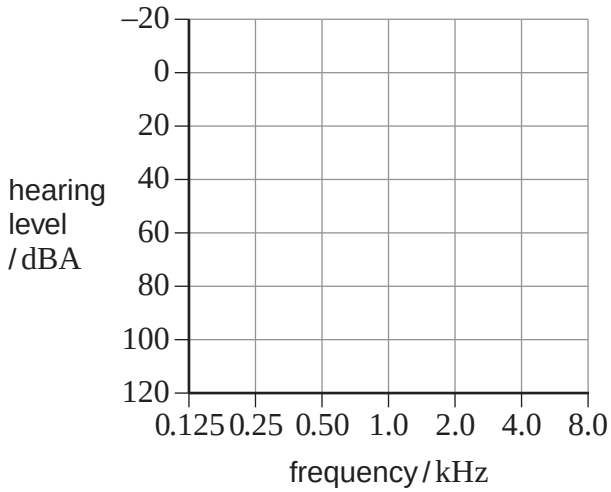
Figure 2



2 (b) (ii) Sketch on **Figure 3** the curve you would expect to see for the person suffering from noise-related hearing loss.

[2 marks]

Figure 3



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2 (c) A foghorn at the top of a cliff produces a sound. A sound meter on the deck of a ship $400\ \text{m}$ away from the cliff gives a reading of $92\ \text{dB}$.

2 (c) (i) Calculate the intensity of the sound incident on the sound meter.

[2 marks]

$I_0 = 1.0 \times 10^{-12}\ \text{W m}^{-2}$

intensity = _____ W m^{-2}

2 (c) (ii) The sound from the foghorn is emitted equally in all directions. Assume that the sound is not reflected at the surface of the sea and that there is no attenuation of the sound.

Estimate the power emitted by the foghorn

[2 marks]

power = _____ W

9

Turn over for the next question

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ANSWER IN THE SPACES PROVIDED

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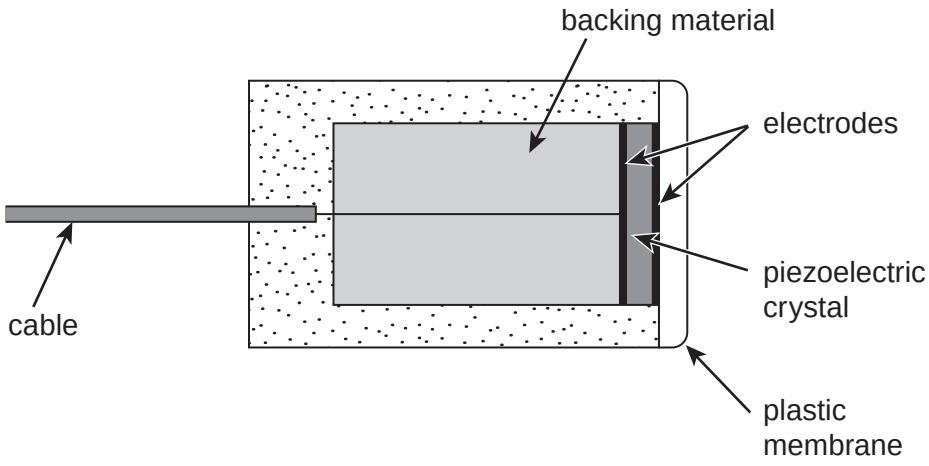
3 **Figure 4** shows a cross-section through an ultrasound transducer.

Figure 4



3 (a) Explain how the transducer produces a pulse of ultrasound.

[3 marks]

Do not write outside the box

3 (b) Why does the ultrasound pulse produced need to be short?
Place a tick (✓) in the right-hand column to show the correct answer.

[1 mark]

	✓ if correct
To reduce pulse spreading	
To stop the probe overheating	
To allow the probe to act as a receiver	
To reduce damage to cells in the patient	

3 (c) A coupling gel is needed when performing an ultrasound scan.
Explain how and why a coupling gel is used.

[3 marks]

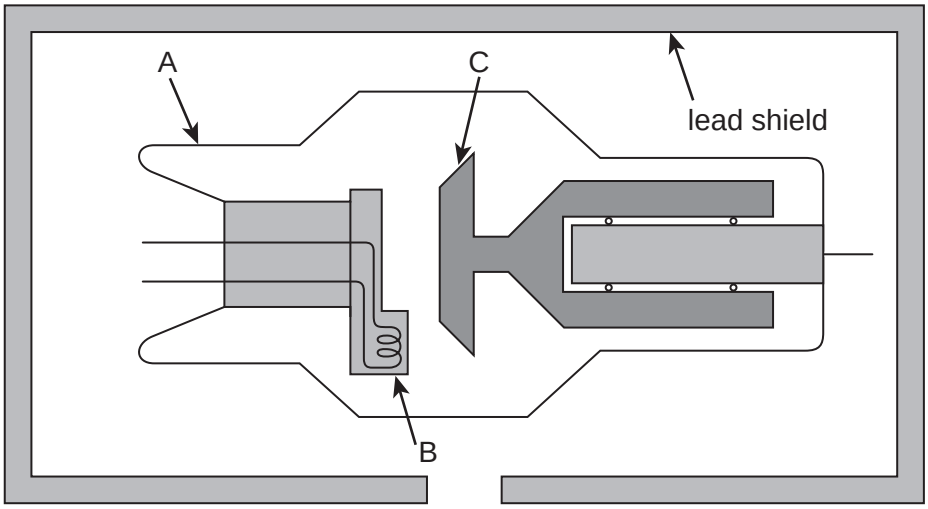
7

Turn over for the next question

Do not write outside the box

4 (a) **Figure 5** shows a simplified modern X-ray tube with a rotating anode.

Figure 5



Explain the design and operation of the X-ray tube and the purposes of the components labelled on the diagram.

In your answer you should include:

- reference to the components labelled A, B, C and the lead shield
- an explanation of the physical processes by which X-rays are produced.

The quality of your written communication will be assessed in your answer.

[6 marks]

Question 4 continues on the next page

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4 (b) The X-ray tube produces photons of energy $50\ \text{keV}$. The half-value thickness of bone for photons of this energy is $15\ \text{mm}$.

4 (b) (i) Explain what is meant by half-value thickness.

[1 mark]

_____

_____

_____

4 (b) (ii) Show that for $50\ \text{keV}$ X-ray photons, the attenuation coefficient of bone μ is $0.046\ \text{mm}^{-1}$.

[1 mark]

4 (b) (iii) A beam of $50\ \text{keV}$ X-ray photons is incident on a bone of thickness $12\ \text{mm}$. Calculate the percentage of the incident photons that leave the far side of the bone.

[2 marks]

percentage of incident photons = _____ %

10

END OF QUESTIONS