Please write clearly in block capitals.

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

Surname _____

Forename(s) _____

Candidate signature _____

I declare this is my own work.

A-level PHYSICS

Paper 3
Section B Medical physics

Tuesday 17 June 2025 Morning

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
- a protractor.

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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ANSWER IN THE SPACES PROVIDED

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Section B

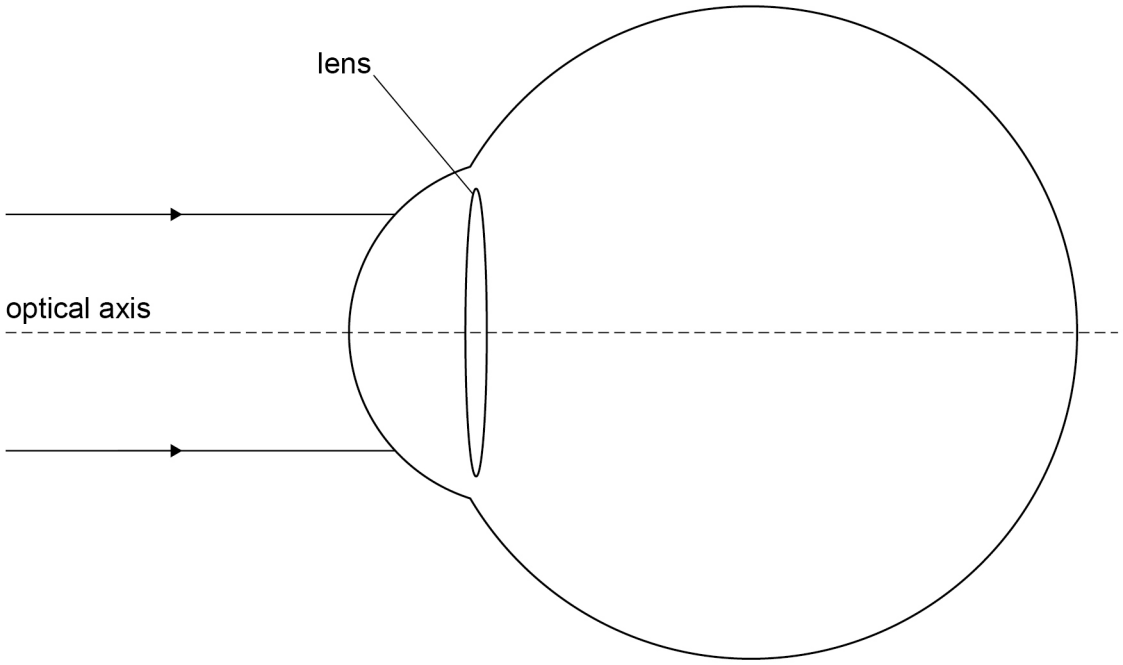
Answer **all** questions in this section.

0 1 . 1 **Figure 1** shows a simplified diagram of an eye that has no sight defects.
The eye is viewing a distant point object.

Complete, on **Figure 1**, the paths of the two rays to the back of the eye.

[2 marks]

Figure 1



0 1 . 2 Accommodation is the ability of the eye to change its optical power.

Which part of the eye enables accommodation?

Tick (✓) **one** box.

[1 mark]

cornea ☐

iris ☐

lens ☐

Question 1 continues on the next page

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The accommodation amplitude A, in dioptres, is given by

$$A = \frac{1}{d_1} - \frac{1}{d_2}$$

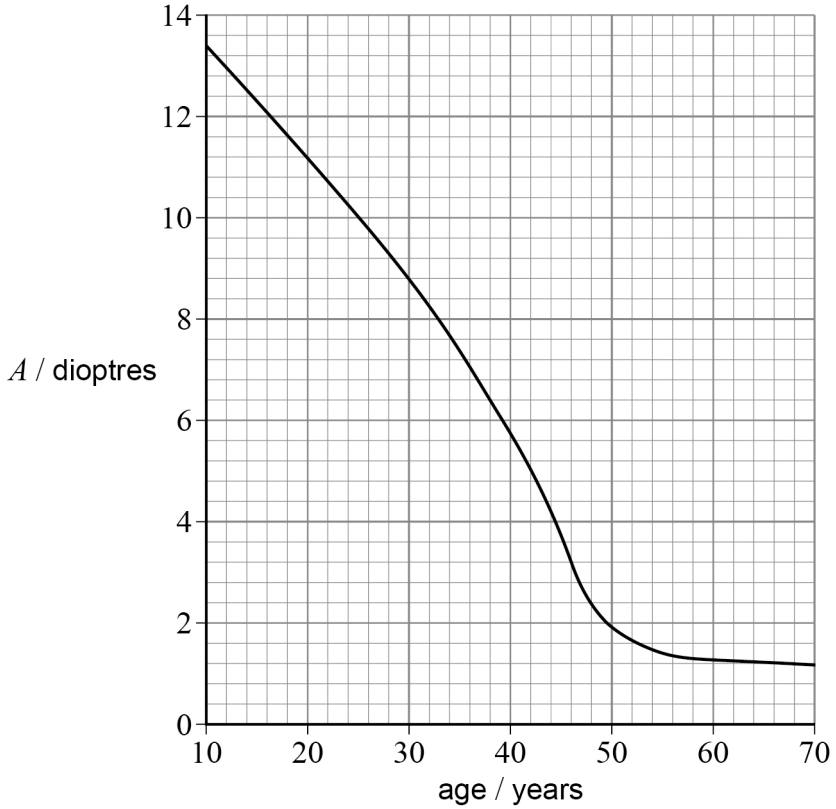
where

d_1 is the distance, in m, from the eye to its near point

d_2 is the distance, in m, from the eye to its far point.

Figure 2 shows how the value of A varies with age for a typical person.

Figure 2



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0 1 . 3 An eye of a typical 30-year-old person has a far point at infinity.
The focal length of the eye when viewing an object at its far point is 23 mm.

Calculate the focal length of the eye when viewing an object at its near point.

[4 marks]

focal length = _____ mm

0 1 . 4 For a typical person, the far point remains at infinity as the person's age increases.
Some studies suggest that hypermetropia increases with age.

Explain how **Figure 2** supports this suggestion.

[2 marks]

_____

_____

_____

_____

_____

_____

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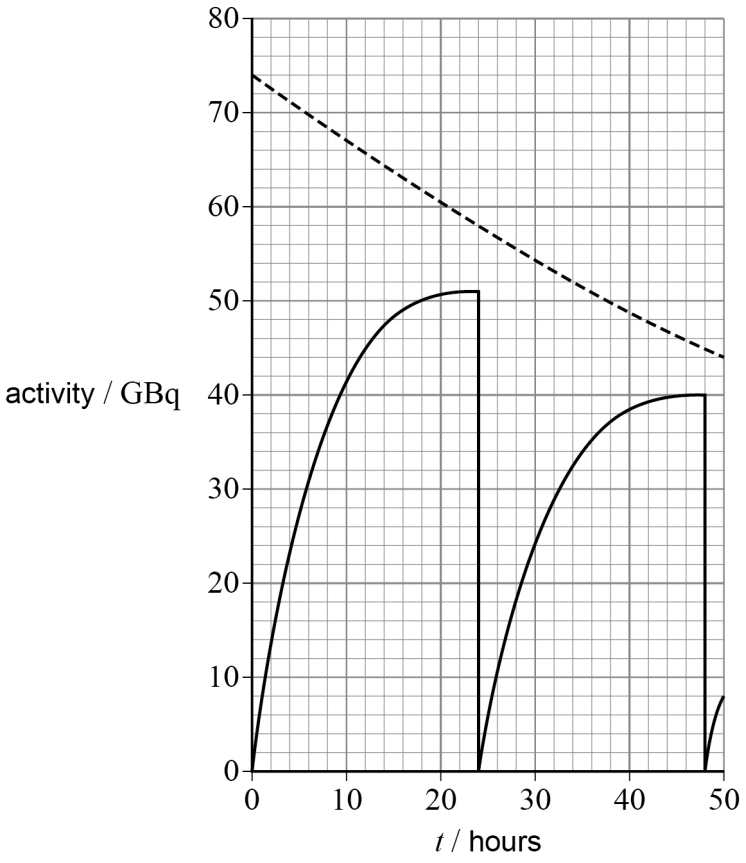
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0 2 Technetium-99_m (^{99m}Tc) is produced from the decay of molybdenum-99 (^{99}Mo).
In hospitals, ^{99m}Tc is extracted from a molybdenum-technetium generator.

^{99}Mo is put into the generator at time $t = 0$
As ^{99}Mo decays, the amount of ^{99m}Tc increases to a maximum at $t = 24$ hours.
^{99m}Tc is extracted from the generator at regular intervals.
At each extraction, the activity of ^{99m}Tc in the generator falls to zero and then increases again.

Figure 3 shows how the activities of ^{99}Mo and ^{99m}Tc in the generator vary with t when extractions are made at $t = 24$ hours and $t = 48$ hours.

Figure 3



- - - - - - - - activity of ^{99}Mo
———— activity of ^{99m}Tc

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0 2 . 1 Show that about 6×10^{15} nuclei of ^{99}Mo decay between $t = 0$ and $t = 24$ hours.

decay constant for $^{99}\text{Mo} = 2.8 \times 10^{-6}\ \text{s}^{-1}$

[2 marks]

0 2 . 2 90% of the ^{99}Mo nuclei decay to form $^{99\text{m}}\text{Tc}$ nuclei. The other 10% decay to form different nuclei.

Estimate the number of $^{99\text{m}}\text{Tc}$ nuclei that are extracted from the generator at $t = 24$ hours.

[3 marks]

number = _____

Question 2 continues on the next page

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0 2 . 3 Information about heart function can be obtained from a multi-gated acquisition (MUGA) scan or from a transthoracic echocardiogram (TTE) scan.
Heart specialists use these scans to diagnose a range of heart conditions.

In a MUGA scan, a patient is injected with a compound containing ^{99m}Tc which binds to red blood cells.
Using images of the red blood cells, a precise reading can be made of blood flow rate through the heart.

A TTE is an ultrasound scan of the heart.
Images of the heart are seen on a monitor as a transducer is moved across the surface of the patient's chest.

Compare the MUGA method of investigating heart function with the TTE method of investigating heart function.

In your answer you should:
- outline how an image of the red blood cells is obtained during a MUGA scan
- explain the advantages that a MUGA scan and a TTE scan have in common
- compare the strengths and weaknesses of a MUGA scan and a TTE scan.

[6 marks]

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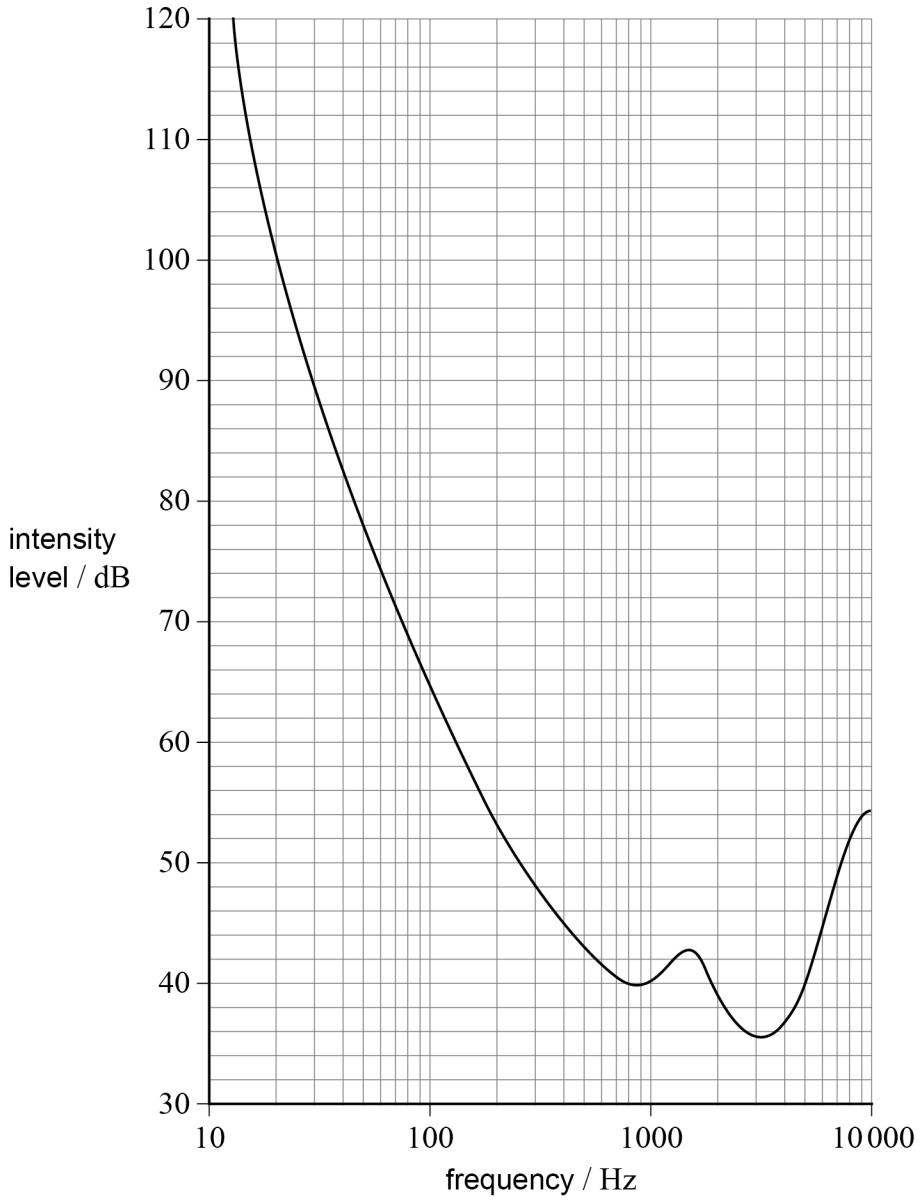
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0 3 . 1 State what is meant by the threshold of hearing for a person with good hearing.

[2 marks]

In a hearing test, a person is found to have good hearing.
Figure 4 shows the equal loudness curve produced in the test.

Figure 4



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0 3 . 2 The eardrum of the person being tested has a cross-sectional area of $60\ \text{mm}^2$.

Calculate the power that is incident on the eardrum when the frequency is $50\ \text{Hz}$.

[3 marks]

power = _____ W

0 3 . 3 Sketch, on **Figure 4**, an equal loudness curve that passes through $100\ \text{dB}$ at $1\ \text{kHz}$.

[2 marks]

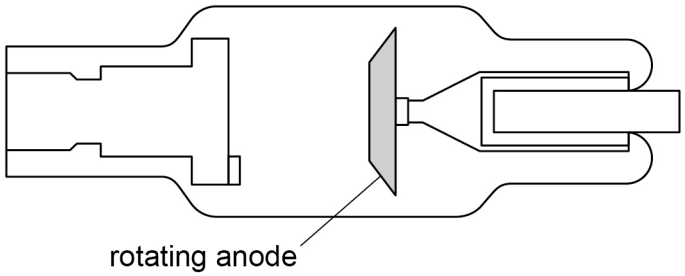
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Turn over for the next question

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0 4 **Figure 5** shows a rotating-anode X-ray tube used to produce an image of a bone.

Figure 5



0 4 . 1 X-rays originate from a region on the rotating anode known as the focal spot.

Explain:
- one advantage of using a small focal spot
- why the focal spot should not be too small.

[2 marks]

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0 4 . 2 State and explain **three** methods used to limit exposure of the patient's healthy cells to X-rays during a diagnostic procedure.

[3 marks]

1 _____

2 _____

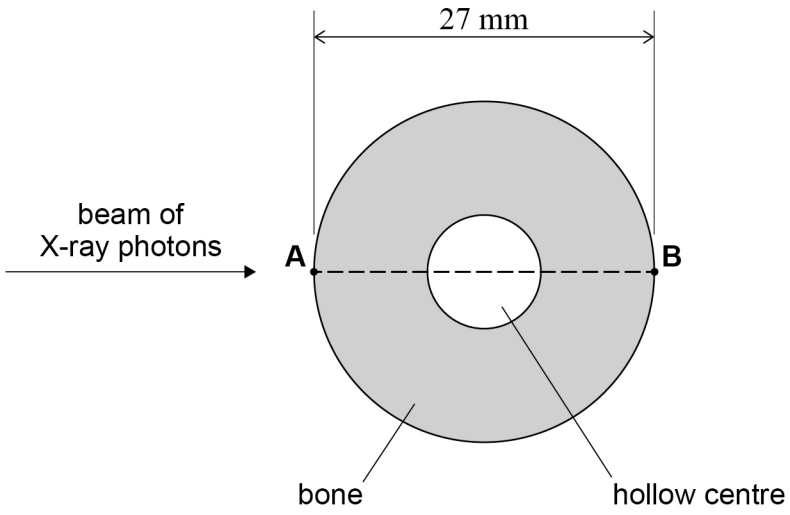
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0 4 . 3 **Figure 6** shows a scale diagram of a cross-section through a human bone called a femur.

Figure 6



A dashed line has been drawn from point **A** to point **B** through the centre of the femur.
Along **AB** the femur has a circular cross-section with an external diameter of 27 mm.
The femur has a hollow centre.

A beam of X-ray photons is incident on the femur at **A** in the direction **AB**.
For these photons, the half-value thickness of bone is 15 mm.

Determine, using the scale diagram in **Figure 6**, the percentage of the X-ray photons incident on **A** that emerge at **B**.

[3 marks]

percentage = _____ %

8

END OF QUESTIONS

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