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 Turning points in 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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Section B

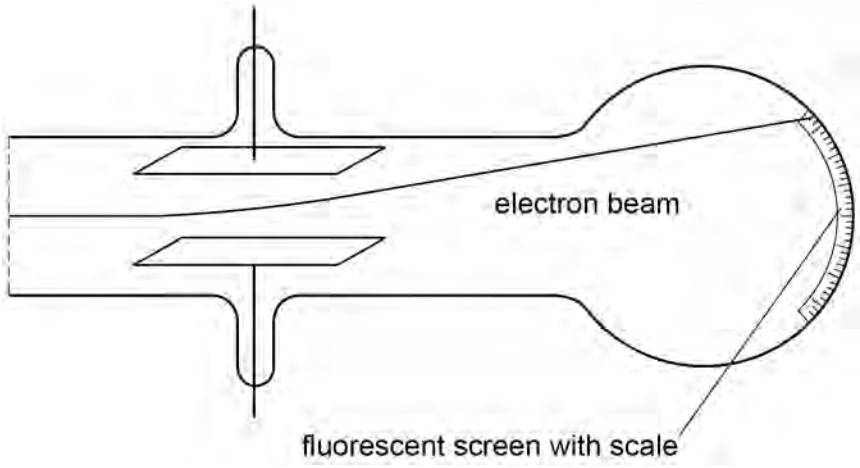
Answer **all** questions in this section.

0 1 This question is about Thomson's determination of the electron's specific charge.

You should **not** use the values of the electron charge, mass or specific charge from the data and formulae booklet in this question.

Figure 1 shows part of the apparatus that Thomson used to measure the specific charge of the electron.

Figure 1



0 1 . 1 A modern version of Thomson's apparatus uses thermionic emission in the production of the electron beam.

Suggest how the electron beam is produced in this modern version.
You should include a labelled diagram and suitable values for the power supplies used.

[3 marks]

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Question 1 continues on the next page

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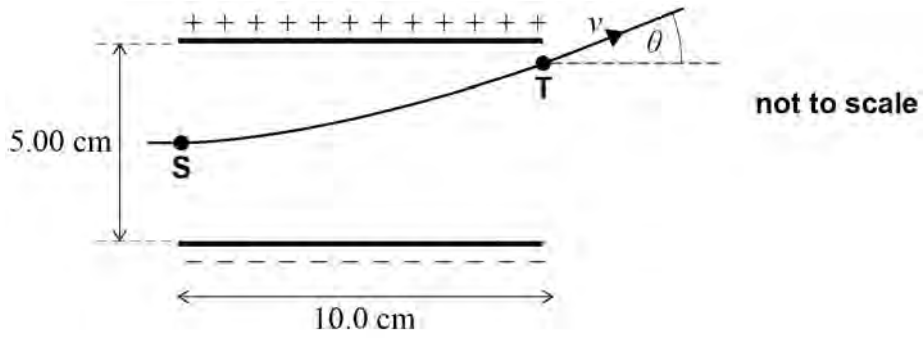
A potential difference (pd) of 750 V is applied between the horizontal parallel plates. **Figure 2** shows the plates and the path of the electrons.

Figure 2



The electrons enter the electric field between the plates at **S** and leave it at **T** with speed v. Beyond **T** the electrons travel in a straight line at an angle θ.
θ is read from a scale on a fluorescent screen.

The plates are of length 10.0 cm and are separated by a distance of 5.00 cm.

0 1 . 2 A uniform magnetic field of flux density 0.640 mT is now applied between the plates. This returns the electron beam to its undeflected position.

Show that the horizontal component of the velocity of the electrons is approximately 2.3×10^7 m s^{-1}.

[2 marks]

The magnetic field is switched off and θ is measured to be 25°.

0 1 . 3 Show that the vertical component of the velocity of the electrons at **T** is approximately 1.1×10^7 m s^{-1}.

[1 mark]

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0 1 . 4 Show that the vertical acceleration of the electrons between the plates is approximately $2.5 \times 10^{15}\ \text{m s}^{-2}$.

[2 marks]

0 1 . 5 Determine a value for the specific charge of the electron.

[3 marks]

specific charge = _____ C kg^{-1}

0 1 . 6 Explain the significance of the result of Thomson's determination.

[2 marks]

Question 1 continues on the next page

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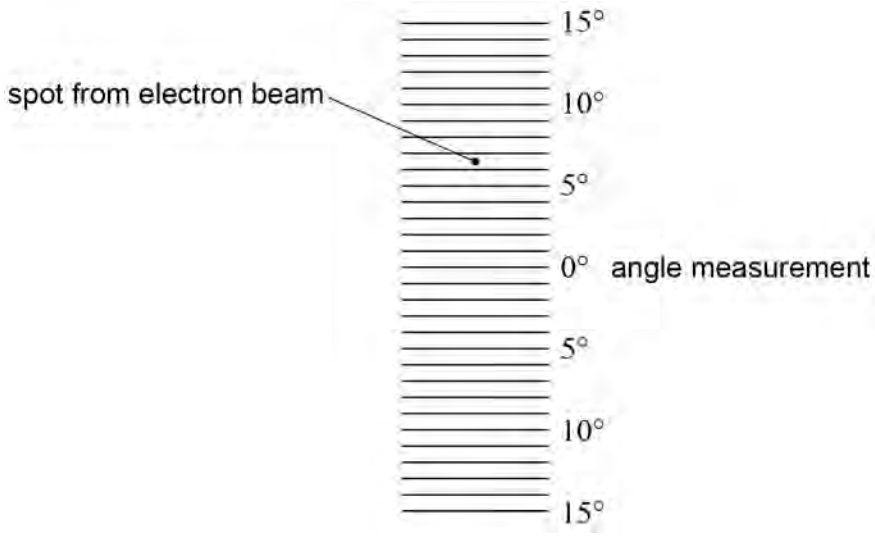
0 1 . 7 Some students are given a version of the apparatus to repeat Thomson's experiment.

Figure 3 shows a section of the measuring scale on the fluorescent screen and the spot from the electron beam.

Figure 3



The students consider two methods for minimising the percentage uncertainty in the measurement of the angle.

Method 1:

- choose a magnetic flux density B
- then set the magnetic flux density to B with no pd
- then adjust only the pd until the beam is horizontal
- then switch off the magnetic field and measure the angle θ.

Method 2:

- choose an angle θ
- then set the pd so that the spot from the electron beam is at θ with no magnetic field
- then adjust only the magnetic field until the beam is horizontal.

Discuss both of these methods with reference to the percentage uncertainty in θ that they will produce.
In your answer, suggest which method will minimise the percentage uncertainty.
No calculations are required.

[3 marks]

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16

Turn over for the next question

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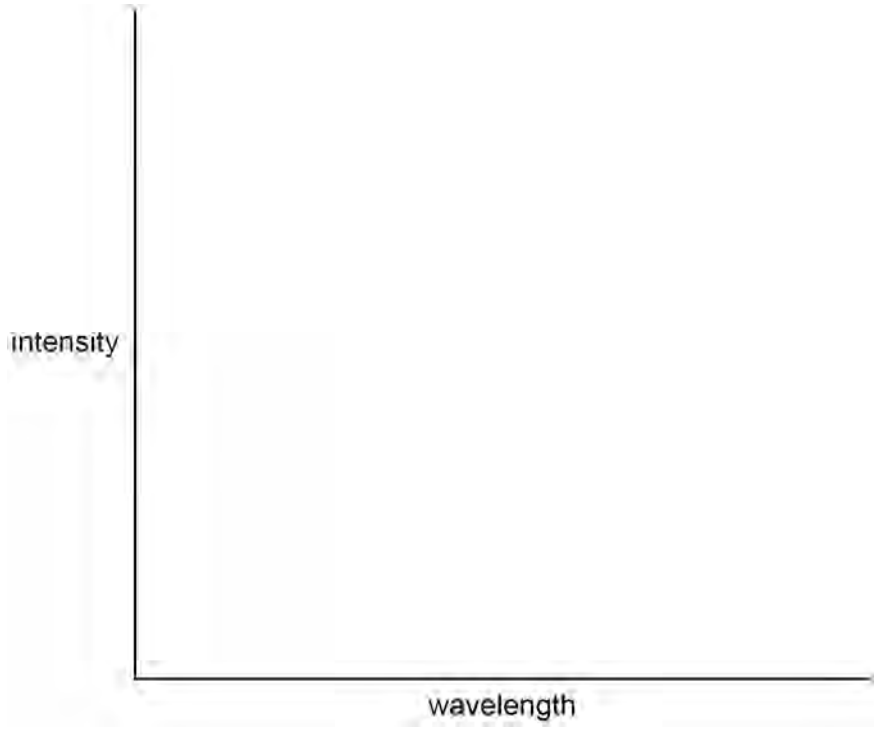
0 2 In the early 1900s a contradiction between experimental results and theoretical predictions was termed the ultraviolet catastrophe.

0 2 . 1 Compare these experimental results and theoretical predictions.
You may sketch and label a graph or graphs on **Figure 4** as part of your answer.

[3 marks]

Figure 4



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0 2 . 2 A proposal was made that allowed a resolution of the contradiction.

Outline this proposal.

[1 mark]

4

Turn over for the next question

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0 3 The work of Fizeau, Foucault, Hertz and Maxwell contributed to our understanding of the nature of light.

Fizeau measured the speed of light in air.
Foucault confirmed that light travels faster in air than in water.
Hertz measured the speed of radio waves in air.
Maxwell developed a theory that was used to obtain the speed of light.

Discuss how the work of these four scientists contributed to our understanding of the nature of light.

In your answer you should refer to:

- the two pre-1800 models for the nature of light
- the predictions that these models made about the speed of light
- Maxwell's theory
- the significance of the measurements made by Fizeau, Foucault and Hertz.

Do **not** include any experimental details in your answer.

[6 marks]

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6

Turn over for the next question

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0 4 In a science-fiction novel, spaceship **A** transports cargo from planet **O** to planet **P**.

A travels at a constant speed of $0.50c$ in the reference frame of an observer on **P**.

0 4 . 1 The observer on **P** measures the distance from **O** to **P** as 1.4×10^{14} m.
Some of the cargo is food and must experience a journey time of no more than 10 days.

Determine whether **A** is able to deliver the cargo within this time.

[4 marks]

0 4 . 2 The observer on **P** measures the length of a cargo at rest on **P** to be 210 m.
There is a cargo hold along the full length of **A**.
The observer on **P** measures the length of **A** to be 200 m in the direction of travel while the spaceship is moving at $0.50c$.

Determine whether the cargo will fit into the cargo hold of **A**.

[4 marks]

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0 4 . 3 Spaceships **A** and **B** are travelling towards each other along the same straight line. The speed of **B** is $0.30c$ with respect to **P**.

Figure 5 shows the situation.

Figure 5

B sends a radio signal to **A**.

What is the speed of the radio signal measured by **A**?

Tick (✓) **one** box.

[1 mark]

$0.20c$ ☐

$0.40c$ ☐

$0.80c$ ☐

c ☐

$1.8c$ ☐

9

END OF QUESTIONS

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ANSWER IN THE SPACES PROVIDED

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