



Surname _____

Forename(s) _____

Centre Number _____

Candidate Number _____

Candidate Signature _____

I declare this is my own work.

A-level

PHYSICS

Paper 3

Section B Turning points in physics

7408/3BD

Monday 17 June 2024 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.

[Turn over]



J U N 2 4 7 4 0 8 3 B D 0 1

BLANK PAGE



On the front of this book, write your surname and forename(s), your centre number, your candidate number and add your signature.

MATERIALS

For this paper you must have:

- **a pencil and a ruler**
- **a scientific calculator**
- **a Data and Formulae Booklet**
- **a protractor.**

[Turn over]



INSTRUCTIONS

- **Use black ink or black ball-point pen.**
- **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.**



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.**

DO NOT TURN OVER UNTIL TOLD TO DO SO



SECTION B

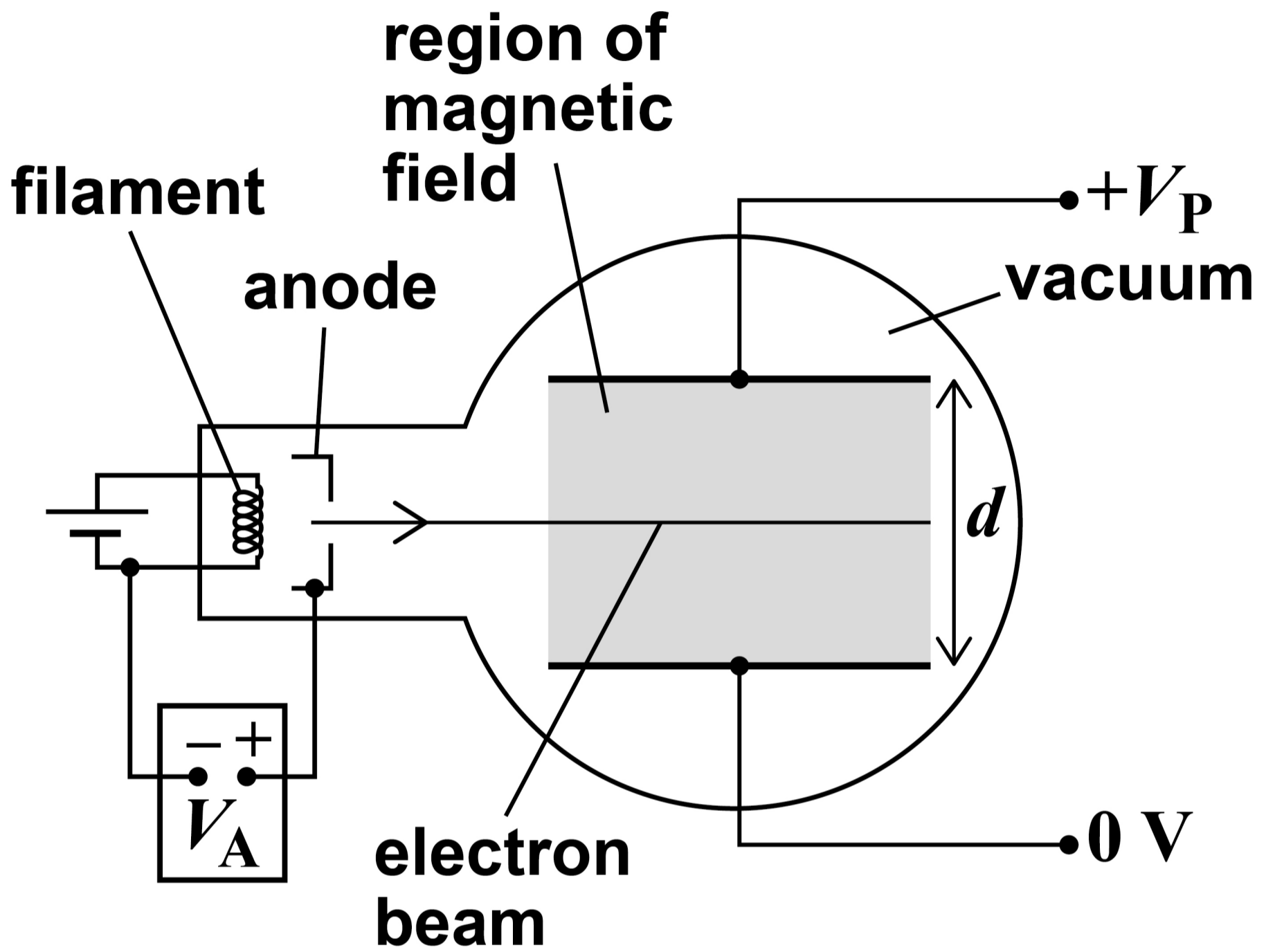
Answer ALL questions in this section.

0 1 . 1

FIGURE 1, on the opposite page, shows apparatus used in an experiment to measure the specific charge of the electron.



FIGURE 1



Electrons are accelerated by the potential difference V_A .

The electrons then enter the region between two parallel metal plates, shown shaded in FIGURE 1, on page 7. The parallel metal plates are separated by a distance d with a potential difference V_P across them. In the same region there is a uniform magnetic field of flux density B into the plane of the diagram.

Explain why the electron beam is undeflected in the shaded region shown in FIGURE 1. [2 marks]



[Turn over]



01.2

Determine, using the following data, a value for the specific charge of the electron.

$$***B* = 1.59 \text{ mT}**$$

$$***V*_P = 1.51 \text{ kV}**$$

$$***d* = 5.0 \text{ cm}**$$

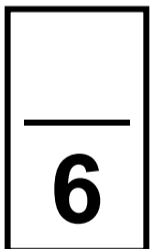
$$***V*_A = 1.00 \text{ kV}**$$

[4 marks]



specific charge = _____ C kg⁻¹

[Turn over]

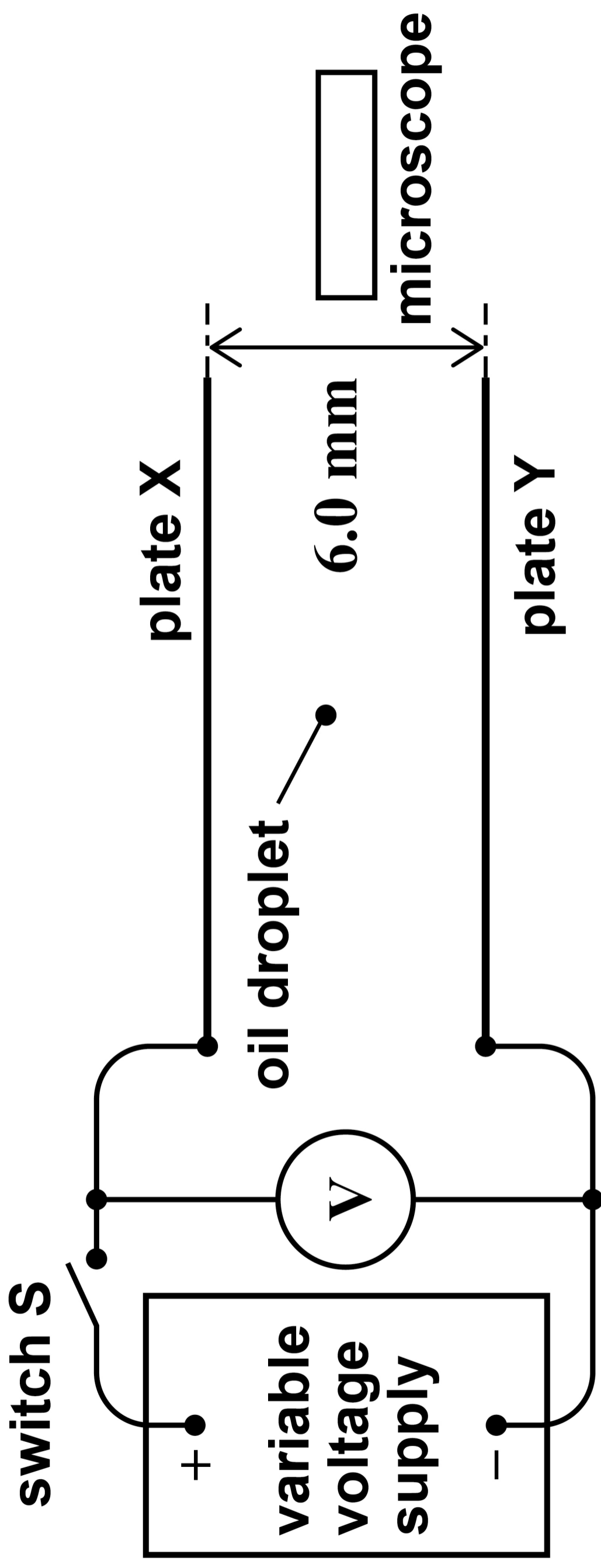




0 2 . 1

FIGURE 2 shows a cross-sectional view of the arrangement that Millikan used to determine the charge on the electron.

FIGURE 2





BLANK PAGE

[Turn over]



Millikan's initial step was to determine the radius of the oil droplet.

Explain how Millikan used this apparatus to determine the radius of the oil droplet.

In your answer you should:

- describe the procedure used, the measurements taken and any additional data required**
- describe how the radius was determined from the measurements**
- state the physical principles and assumptions involved in the determination of the radius.**

[6 marks]

A series of 12 vertical lines spanning the page, creating 11 columns for writing.



[Turn over]



Vertical lines for writing.





1 9

BLANK PAGE

[Turn over]

0 2 . 2

On one occasion, the radius of a droplet was determined to be 1.20×10^{-6} m.

When the droplet was stationary, the voltmeter reading was 467 V.

Show that the charge on the droplet was approximately 8×10^{-19} C.

density of oil = 880 kg m^{-3}

[3 marks]



[Turn over]



02.3

TABLE 1 shows the percentage uncertainty in each quantity.

TABLE 1

QUANTITY	PERCENTAGE UNCERTAINTY
radius of oil droplet	4%
density of oil	1%
gravitational field strength	0.1%
potential difference	0.2%
distance between the plates	2%



Show that the absolute uncertainty in your answer to Question 02.2, on page 20, is approximately $\pm 1 \times 10^{-19}$ C.

Go on to discuss whether this uncertainty allows your answer to Question 02.2 to be used to support the quantisation of electric charge.

[3 marks]

[Turn over]



BLANK PAGE

[Turn over]



0	3
---	---

Hertz did an experiment to determine the speed of radio waves.

Describe this experiment.

In your answer you should:

- **include a labelled diagram**
- **state the measurements that were taken**
- **describe how the data were used to determine the speed of radio waves.**

[5 marks]



[Turn over]



[Turn over]

5

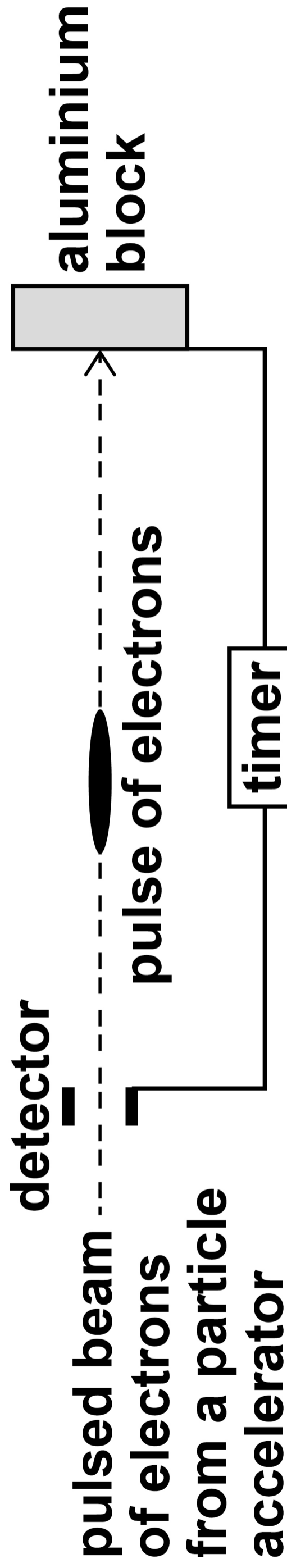




0 4

FIGURE 3 shows a modern version of Bertozzi's experiment to measure the kinetic energy of high-speed electrons. A timer is used to measure the time taken for a pulse of electrons to travel from the detector to the aluminium block.

FIGURE 3





0 4 . 1

A potential difference (pd) of 1.30 MV is used to accelerate the electrons.

Show that each electron gains approximately 2×10^{-13} J of kinetic energy. [1 mark]

[Turn over]



0 4 . 2

These electrons cause the temperature of the aluminium block to increase by 68.0 K.

The number of electrons that cause this increase in temperature is 4.50×10^{17}

Deduce whether this increase in temperature is consistent with an accelerating pd of 1.30 MV.

**specific heat capacity of aluminium = $903 \text{ J kg}^{-1} \text{ K}^{-1}$
mass of aluminium block = 1.50 kg [2 marks]**



[Turn over]



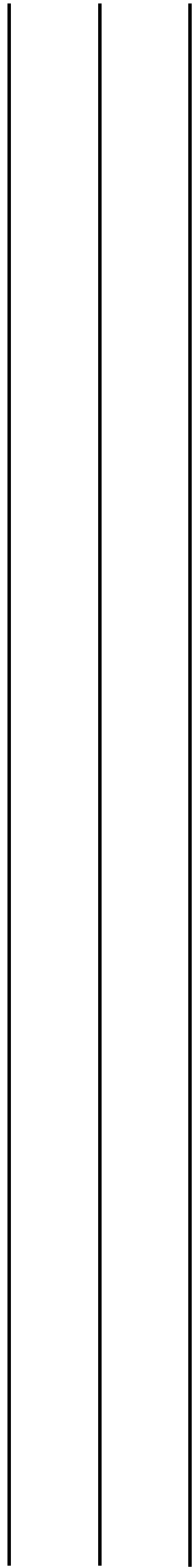
0	4	.	3
---	---	---	---

The speed of the electrons between the detector and the block is $2.88 \times 10^8 \text{ m s}^{-1}$.

Student A suggests that the non-relativistic equation for kinetic energy could be used.

Student B suggests that the relativistic equation for kinetic energy is required in this situation.

Evaluate the suggestions of student A and student B. Support your answer with calculations. [4 marks]



[Turn over]



Five vertical lines forming a template for writing.





0 4 . 4

The timer in FIGURE 3, on page 30, records a time of 29.8 ns.

What is the proper time interval for an electron travelling from the detector to the aluminium block? [1 mark]

Tick (✓) ONE box.

< 29.8 ns

29.8 ns

> 29.8 ns

[Turn over]



0 4 . 5

The electrons in FIGURE 3, on page 30, were accelerated from rest in 13 stages.

In each stage the electrons were accelerated by a pd of 100 kV.

As a result, an electron increases its speed and kinetic energy during each stage.

Compare, for an electron,

- its increase in speed for the first stage with that for the last stage
- its increase in kinetic energy for the first stage with that for the last stage.



Justify your answer.

No further calculations are required. [4 marks]

39

<hr/> 12

END OF QUESTIONS

BLANK PAGE

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

Copyright information

For confidentiality purposes, all acknowledgements of third-party copyright material are published in a separate booklet. This booklet is published after each live examination series and is available for free download from www.aqa.org.uk.

Permission to reproduce all copyright material has been applied for. In some cases, efforts to contact copyright-holders may have been unsuccessful and AQA will be happy to rectify any omissions of acknowledgements. If you have any queries please contact the Copyright Team.

Copyright © 2024 AQA and its licensors. All rights reserved.

WP/M/DL/Jun24/7408/3BD/V3

4 2



2 4 6 A 7 4 0 8 / 3 B D