AQA

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]

JUN247408 3BD01

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.**

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

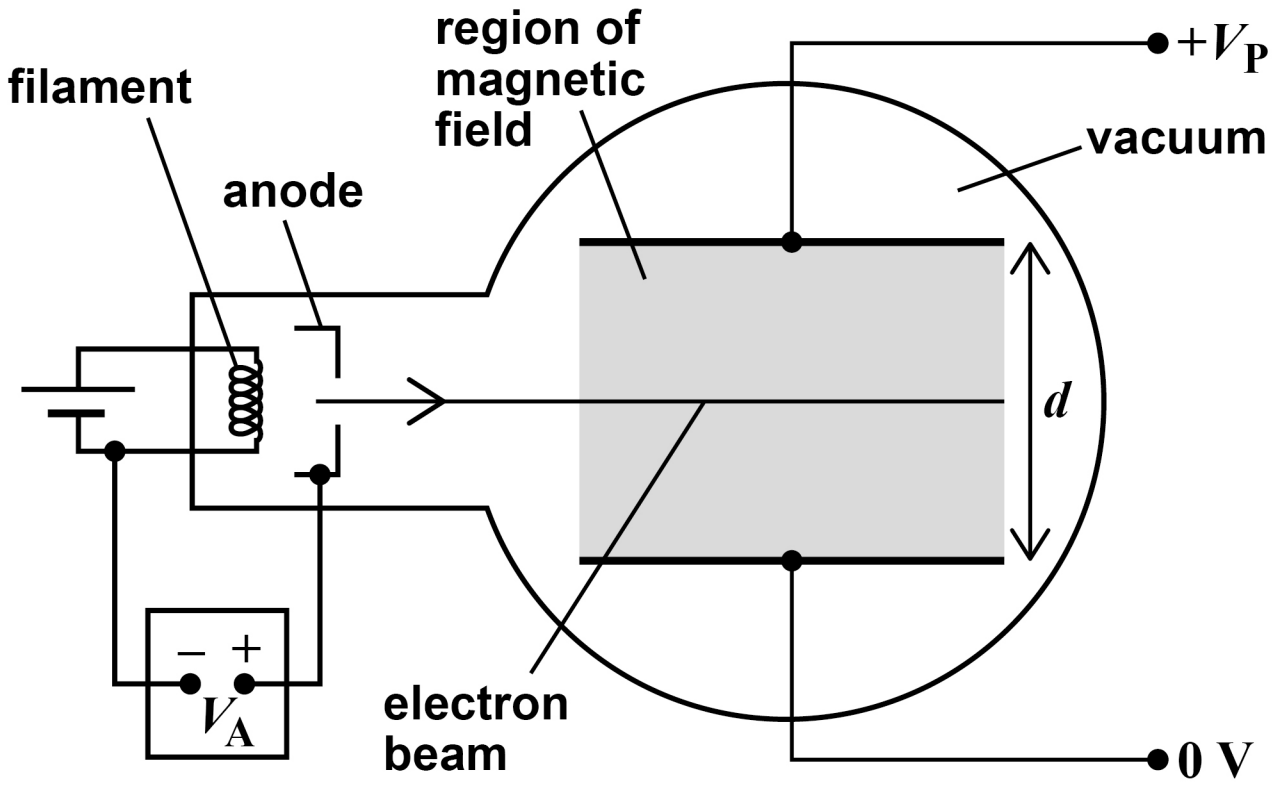
SECTION B

Answer ALL questions in this section.

0 1 . 1

FIGURE 1 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. 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]

0 1 . 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}

6

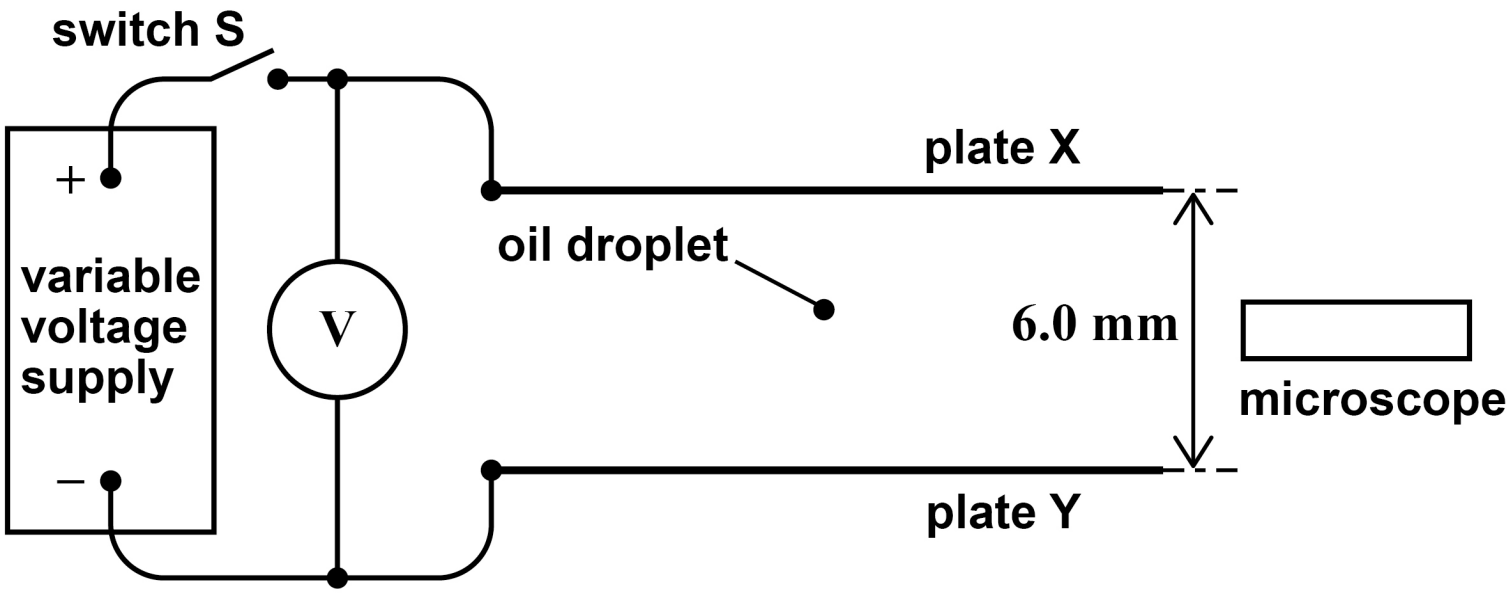
BLANK PAGE

[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



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.

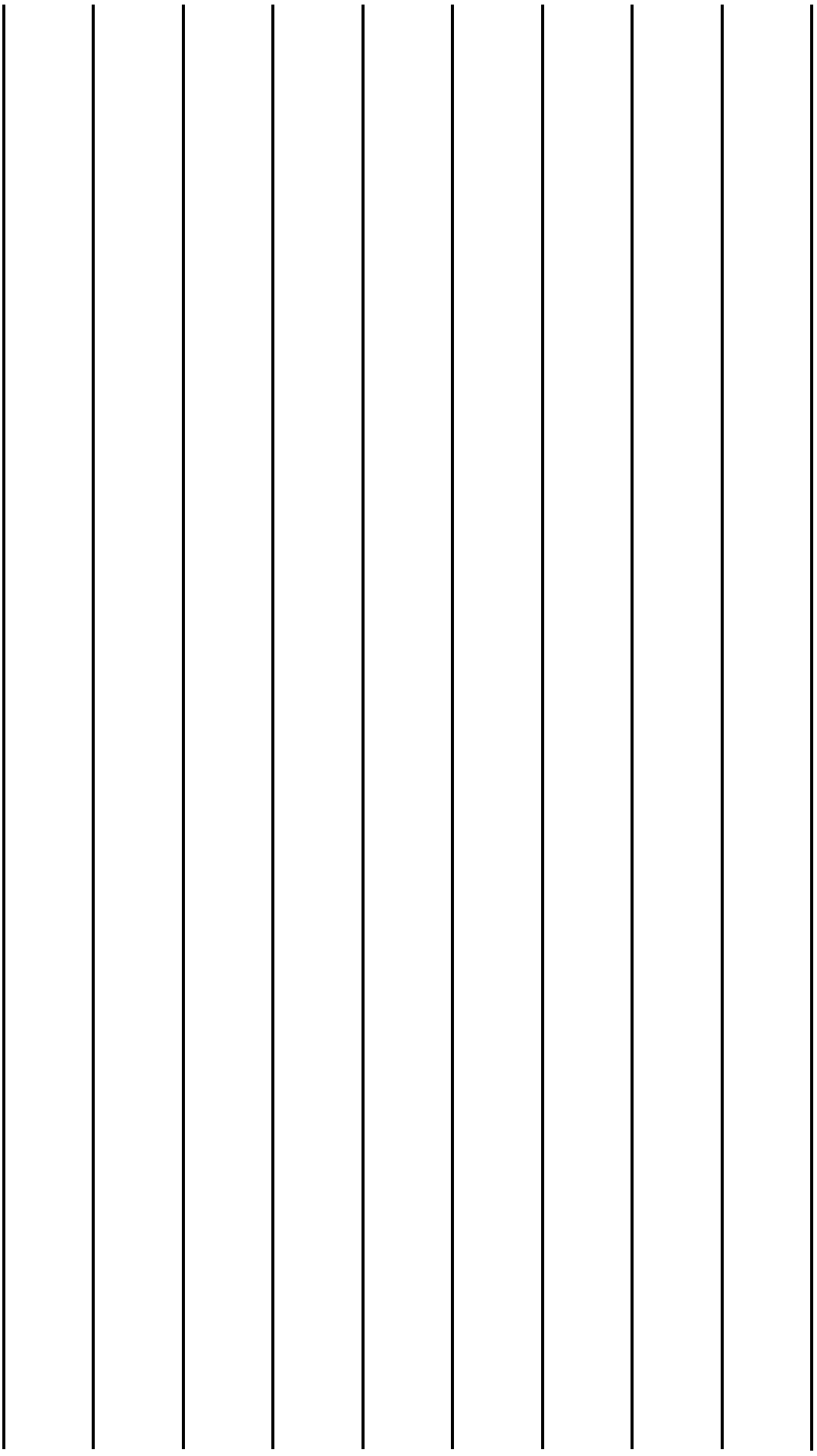
In your answer you should:

- **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]

[Turn over]

[Turn over]



[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]

BLANK PAGE

[Turn over]

0 2 . 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 14, 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]

12

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]

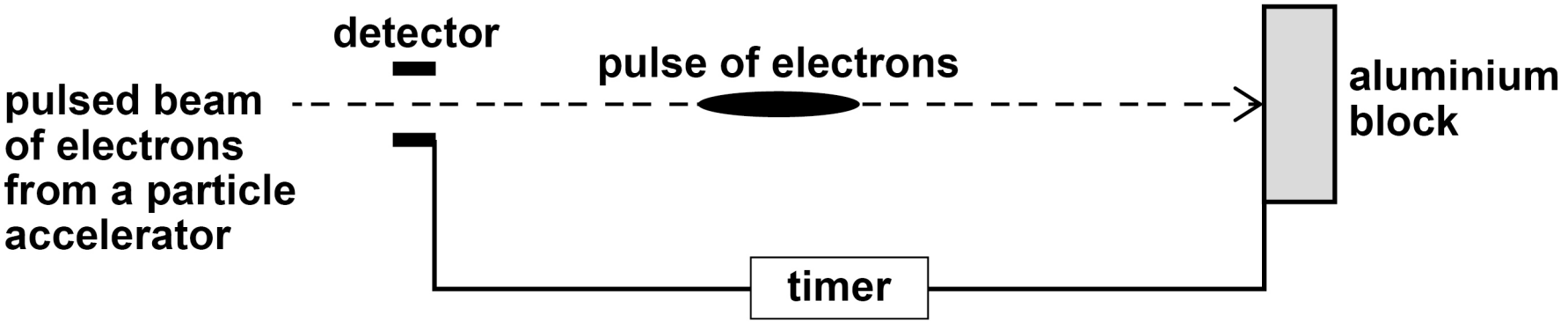
[Turn over]

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 $1.30\ \text{MV}$ is used to accelerate the electrons.

Show that each electron gains approximately $2 \times 10^{-13}\ \text{J}$ 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 J kg^{-1} K^{-1}

mass of aluminium block = 1.50 kg

[2 marks]

[Turn over]

0 4 . 3

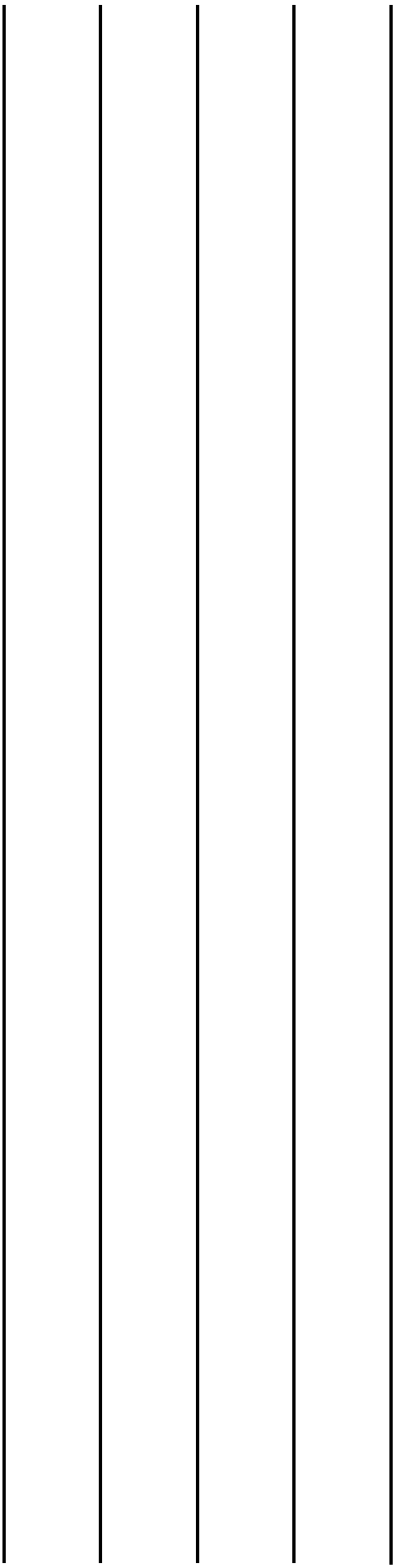
The speed of the electrons between the detector and the block is 2.88×10^8 m s^{-1}.

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]




3 0

0 4 . 4

The timer in FIGURE 3, on page 24, 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 24, 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]

END OF QUESTIONS

12

Additional page, if required.

Write the question numbers in the left-hand margin.

Additional page, if required.

Write the question numbers in the left-hand margin.

BLANK PAGE

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