Rewarding Learning

ADVANCED SUBSIDIARY (AS)
General Certificate of Education
2024

Centre Number

Candidate Number

Physics

Assessment Unit AS 3B (Theory)

assessing

Practical Techniques and Data Analysis

SPH32

[SPH32]

FRIDAY 31 MAY, MORNING

TIME

1 hour.

INSTRUCTIONS TO CANDIDATES

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.
You must answer the questions in the spaces provided.
Do not write outside the boxed area on each page or on blank pages.
Complete in black ink and use a dark HB pencil for drawings and graphs.
Do not write with a gel pen.
Answer **all five** questions.

INFORMATION FOR CANDIDATES

The total mark for this paper is 50.
Figures in brackets printed down the right-hand side of pages indicate the marks awarded to each question or part question.
You may use a scientific calculator.

1 A sample of methane gas at constant pressure was cooled. Values of temperature and volume were recorded as the gas cooled.

The values of temperature and volume of the gas are shown in **Table 1.1**.

Table 1.1

Temperature / °C	70	38	16	–23	–53	–105	–185
Volume / m^3	2.80×10^{-2}	2.54×10^{-2}	2.35×10^{-2}	2.08×10^{-2}	1.80×10^{-2}	1.45×10^{-2}	7.4×10^{-3}

On **Fig. 1.1**, plot a graph of volume against temperature and draw a line of best fit for the data.

Mark your points clearly using a ⊙ or a +. [8]

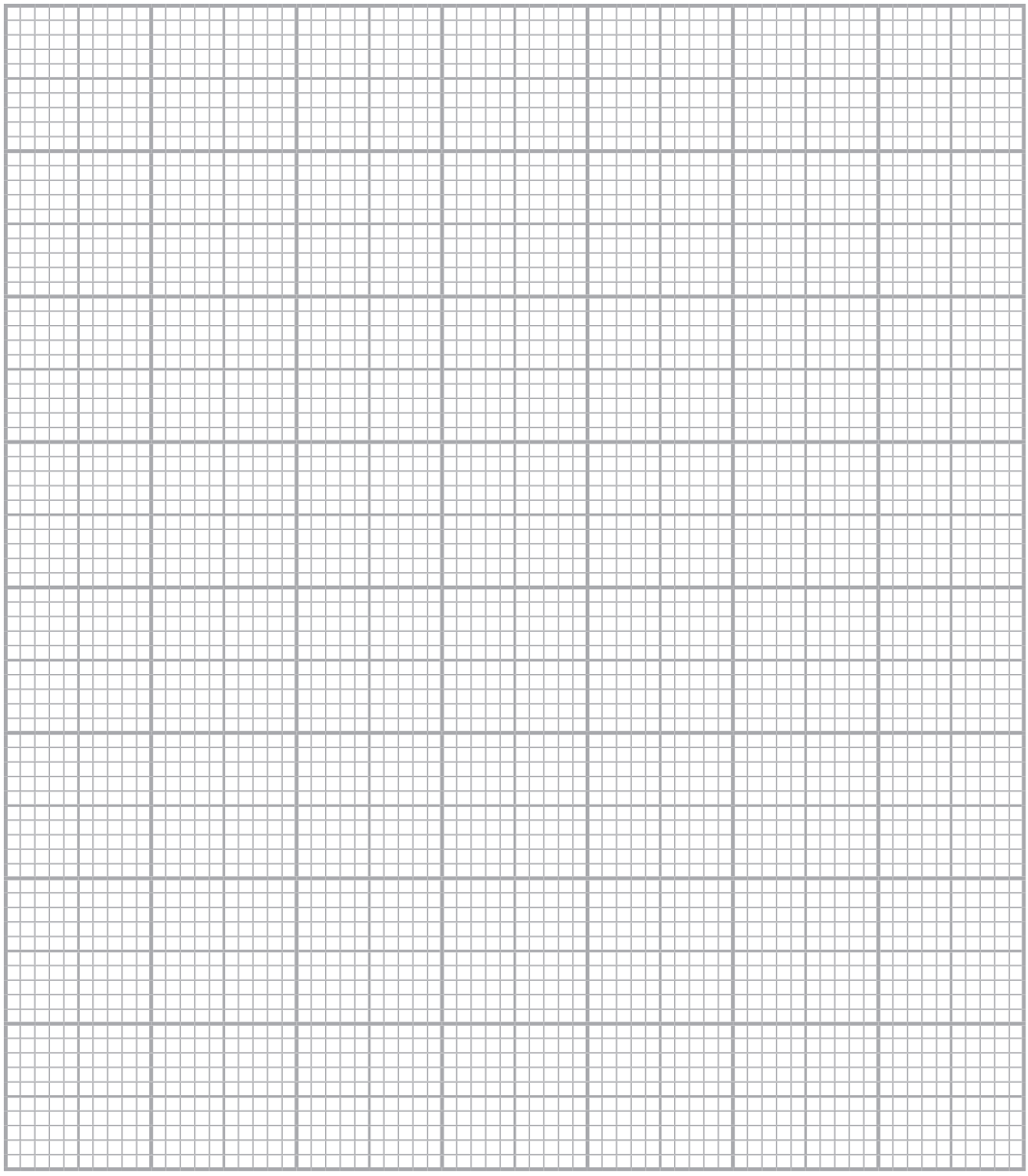

Fig. 1.1

[Turn over

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2 A student performs an experiment to determine the electromotive force E and internal resistance r of a torch cell. The student obtains the circuit current I and terminal voltage V for a range of different values of the variable load resistor.

Equation 2.1 provides the relationship between E and r.

$$E = V + Ir \qquad \textbf{Equation 2.1}$$

Fig. 2.1 shows an incomplete diagram of the circuit required to carry out this experiment.

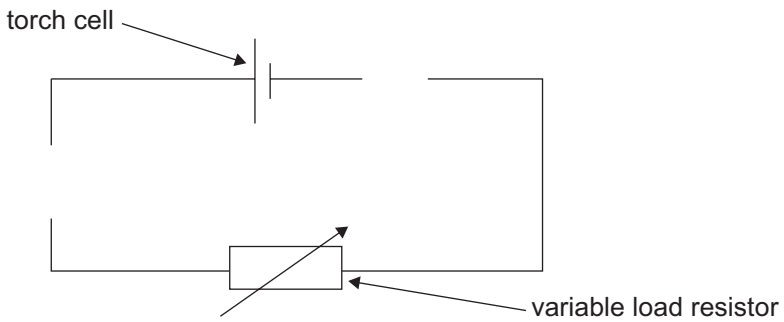

Fig. 2.1

(a) Complete **Fig. 2.1** by adding the equipment required to carry out the experiment. [3]

[Turn over

(b) Fig. 2.2 shows a graph of the values of V and I obtained in the experiment.

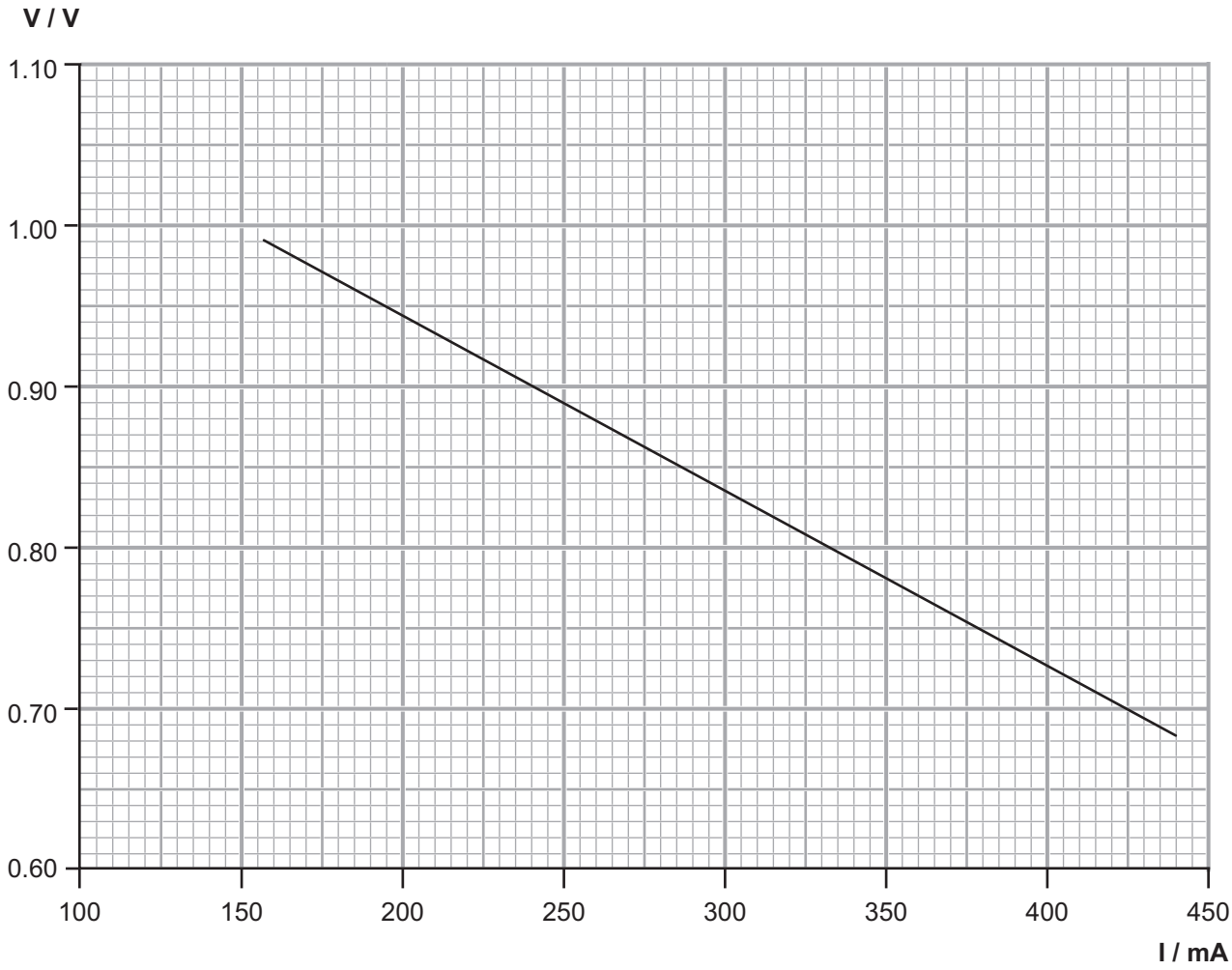

Fig. 2.2

(i) The general equation for a straight line is $y = mx + c$. Rewrite **Equation 2.1** in this form identifying clearly the terms y, m, x and c.

[2]

(ii) Calculate the gradient of the graph shown in **Fig. 2.2**. Include a unit with your answer.

Gradient = _____ Unit = _____ [5]

(iii) Use your answer to **(b)(ii)** and **Fig. 2.2** to determine the electromotive force E of the torch cell.

E = _____ V [2]

[Turn over

3 Electrons can be accelerated across a potential difference in an evacuated tube. The graph in **Fig. 3.1** shows the relationship between the associated wavelength λ of an electron and the potential difference V across which the electron is accelerated.

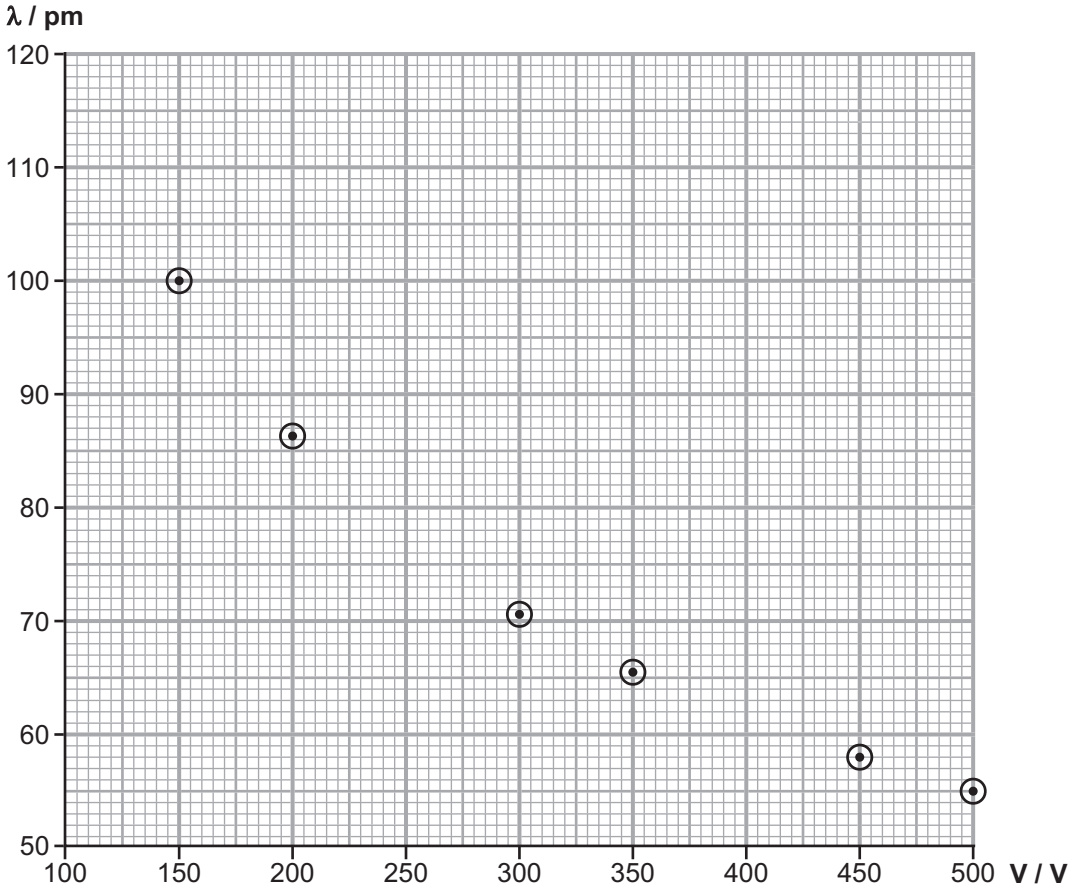

Fig. 3.1

(a) (i) Complete **Fig. 3.1** by drawing the line of best fit for the plotted points. [1]

(ii) Use the graph to estimate the associated wavelength of an electron which has been accelerated across a potential difference of 380 V.
Give your answer in metres.

Wavelength = _____ m [2]

(b) The relationship between wavelength λ and potential difference V is given by **Equation 3.1**.

$$\lambda = \frac{k}{\sqrt{V}} \qquad \textbf{Equation 3.1}$$

where k is a constant.

(i) What is the SI unit of k?

Unit = _____ [1]

(ii) A value of k can be determined by drawing a graph of V against $\frac{1}{\lambda^2}$.
Describe how k can be determined from the graph.

_____

_____

_____

_____ [2]

[Turn over

4 A student performed an experiment to determine a value for the refractive index of glass. A diagram of the experimental set-up is shown in **Fig. 4.1**.

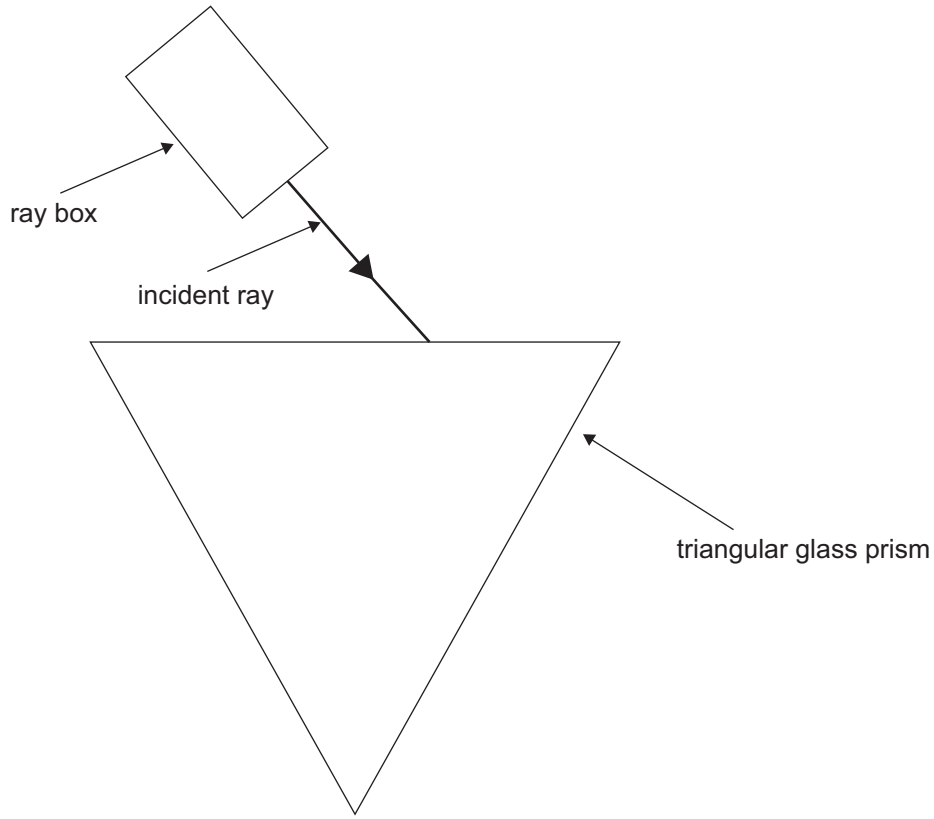

Fig. 4.1

(a) On **Fig. 4.1**, complete the path of the ray of monochromatic light inside the glass prism. Mark and label the angle of incidence i and angle of refraction r which were measured to determine the refractive index of glass. [3]

(b) (i) A set of results were taken using a protractor and recorded in **Table 4.1**. Complete **Table 4.1** by adding the headings for the values that would allow the refractive index **n** of glass to be determined graphically. [1]

Table 4.1

i / °	**r / °**		
15	10		
20	13		
30	19		
25	16		

(ii) Complete the row in **Table 4.1** for the angle of incidence of 15°. [2]

You do not need to complete the table for any of the other values.

(iii) How could the recording of results in **Table 4.1** be improved?

_____ [1]

(iv) Without changing the apparatus used, suggest two improvements that could be made to this experiment in order to obtain a more accurate value of **n**.

1. _____

2. _____ [2]

[Turn over

(c) **Fig. 4.2** shows a linear graph plotted using the data collected in the original experiment. The gradient of this graph is the refractive index.

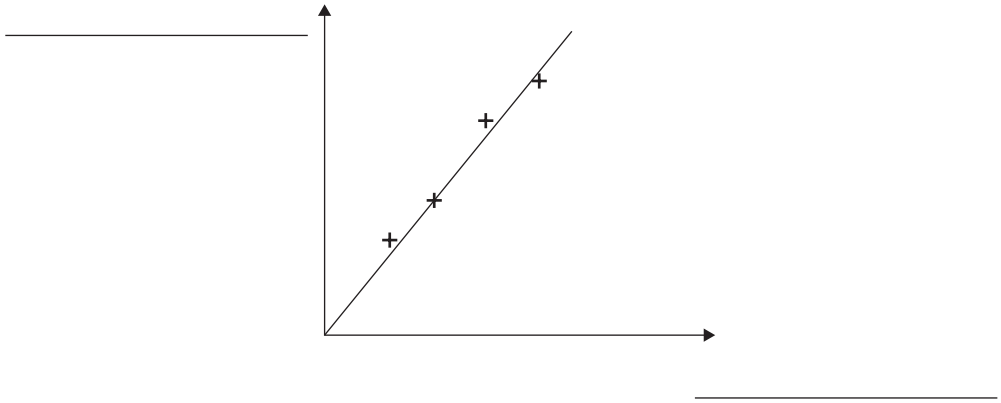

Fig. 4.2

(i) Label the x and y axes on **Fig. 4.2**. [1]

(ii) **Describe** how the percentage uncertainty in refractive index can be determined from **Fig. 4.2**.

_____

_____

_____

_____ [4]

5 A student completes an experiment to determine the relationship between the mass m added to a wire and the frequency f for the third mode of vibration of the wire. A diagram of the experimental apparatus is shown in **Fig. 5.1**.

One end of the wire is attached to a vibration generator and the other end is placed over a pulley. A 100 g mass is attached to the wire. The vibration generator is connected to a signal generator.

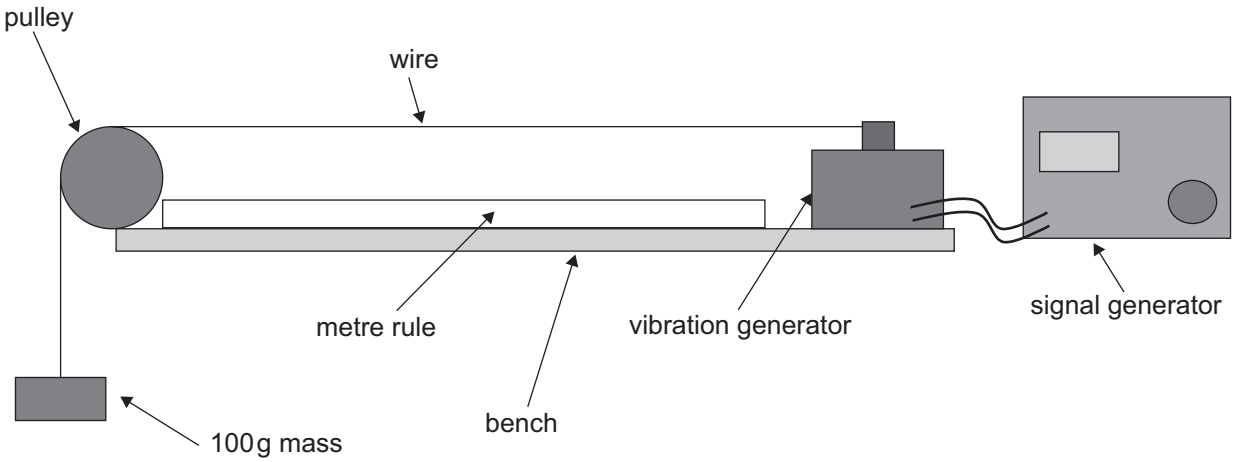

Fig. 5.1

The signal generator is switched on and the frequency is slowly increased.

(a) (i) How will the student know when the third mode of vibration is reached?

_____ [1]

[Turn over

The student records the frequency at which the third mode of vibration is observed for the 100 g mass. The experiment is repeated for a mass of 300 g. **Table 5.1** shows the frequency of the signal generator for the third mode of vibration for the 100 g and 300 g masses.

Table 5.1

m / kg	f / Hz
0.100	25.0
0.300	43.3

(ii) The relationship between mass m and frequency f is given by one of the three equations below.

$m = Bf^{-1}$ ☐

$m = Bf$ ☐

$m^{\frac{1}{2}} = Bf$ ☐

The quantity B is a constant.

Choose the equation which best represents the data in **Table 5.1**.
Indicate your choice by placing a tick (✓) in the appropriate box above.

Explain why the two equations you have not indicated do not correctly show the relationship.

_____

_____

_____

_____

_____

_____ [3]

(iii) Use the results from **Table 5.1** and your answer to **(ii)** to calculate a reliable value for the constant B. Include the unit of B if any.

B = _____ Unit = _____ [4]

(b) Using the apparatus shown in **Fig. 5.1**, describe how the student could determine a value for the speed of the wave travelling along the wire when the mass of 100 g is added to the wire and the third mode of vibration is observed.

_____

_____

_____

_____ [2]

THIS IS THE END OF THE QUESTION PAPER

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For Examiner's use only	
Question Number	**Marks**
1	
2	
3	
4	
5	
Total Marks	

Examiner Number