



GCE AS/A LEVEL

2420U20 – 1

WEDNESDAY, 21 MAY 2025 – AFTERNOON

**PHYSICS – AS UNIT 2
ELECTRICITY AND LIGHT**

**1 hour 30 minutes plus your additional
time allowance**

Surname: _____

First name(s): _____

Centre Number: _____

Candidate Number: 2 _____

FOR EXAMINER'S USE ONLY		
Question	Maximum Mark	Mark Awarded
1.	11	
2.	13	
3.	7	
4.	11	
5.	12	
6.	13	
7.	8	
8.	5	
Total	80	

ADDITIONAL MATERIALS

In addition to this examination paper you will require a calculator and DATA BOOKLET.

ITEMS INCLUDED WITH QUESTION PAPER

A separate Diagram Booklet.

The Diagram Booklet MUST be handed in to the invigilators and sent for marking.

(Turn over)

INSTRUCTIONS TO CANDIDATES

Use black ink, black ball–point pen, black felt tip or your usual method.

Write your name, centre number and candidate number in the spaces on the front cover.

Answer ALL questions.

Write your answers in the spaces provided. If you run out of space, use the additional page(s) at the back of this booklet, taking care to number the question(s) correctly.

(Turn over)

INFORMATION FOR CANDIDATES

The total number of marks available for this paper is 80

The number of marks is given in brackets at the end of each question or part – question.

The assessment of the quality of extended response (QER) will take place in Question 2 (b).

(Turn over)

Answer ALL questions.

- 1. (a) Gwen provides the following incomplete derivation of the drift velocity equation**

$$***I = nAve.***$$

Refer to the diagram for Question 1 (a) in the separate Diagram Booklet for Gwen's incomplete derivation.

- (i) Gwen's statement regarding n is incomplete. Give the complete meaning of n .**

(Turn over)

[1 mark]

1. (a) (ii) Define 'electric current' AND
use your definition to finish
Gwen's derivation.

[2 marks]

continued on the next page . . .

(Turn over)

Question 1 continued

- 1. (b) Gwen and her friend Griff each construct a resistor made from constantan wire.**

Refer to the table provided separately in the Diagram Booklet. The table shows some of the values related to their wires.

- (i) Determine the length of Gwen's wire.**

(Turn over)

[4 marks]

continued on the next page . . .

(Turn over)

Question 1 (b) continued

- 1. (b) (ii) Refer to the diagram for Question 1 (b) (ii) in the separate Diagram Booklet. The two resistors are now arranged in series with a power supply of 12.0 V of negligible internal resistance, as shown in the diagram.**

I. ADD AN ARROW to the diagram to show the direction of ELECTRON FLOW.

[1 mark]

continued on the next page . . .

(Turn over)

Question 1 (b) (ii) continued

- 1. (b) (ii) II. Gwen and Griff make the following statements.**
- Gwen states that the current in Griff's wire will be less than in her wire because Griff's wire is thinner.**
 - Griff states that the drift velocity in his wire is less than in Gwen's wire.**

continued on the next page . . .

(Turn over)

Question 1 (b) (ii) II continued

Explain why both statements are incorrect.

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[3 marks]

(Total for Question 1 = 11 marks)

(Turn over)

2. Refer to the diagram for Question 2 in the separate Diagram Booklet.

A student investigates the $I - V$ characteristic of a filament lamp using the apparatus shown in the diagram.

Refer to the table for Question 2 provided separately in the Diagram Booklet. The table shows the student's results.

(a) Use data from the table to determine to what extent the filament lamp obeys Ohm's law.

(Turn over)

[3 marks]

continued on the next page . . .

(Turn over)

Question 2 continued

- 2. (b) Explain, making reference to free electrons, why the resistance of the filament in a lamp increases as the potential difference across it increases during the student's experiment.**

(Turn over)

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(Turn over)

[6 QER marks]

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(Turn over)

Question 2 continued

- 2. (c) Refer to the graph for Question 2 (c) in the separate Diagram Booklet. The graph shows how the resistance of a certain metal varies at low temperatures.**

Explain what is meant by the 'transition temperature' of a metal AND suggest a typical value for this temperature.

(Turn over)

[2 marks]

continued on the next page . . .

(Turn over)

Question 2 continued

- 2. (d) Whilst developing a new compound, a team of university students found evidence that the compound had room temperature superconducting properties and published their findings. It was later discovered that their experimental procedures had inaccuracies, and the compound did not behave as a room temperature superconductor.**

continued on the next page . . .

(Turn over)

Question 2 (d) continued

Describe how the team of students should have proceeded before publishing their findings.

[2 marks]

(Total for Question 2 = 13 marks)

(Turn over)

3. (a) Define the emf of a cell.

[2 marks]

continued on the next page . . .

(Turn over)

Question 3 continued

- 3. (b) Refer to the diagram for Question 3 (b) in the separate Diagram Booklet. Bryn connects a battery of emf 6.0 V and an unknown internal resistance, r , to an ammeter and a selection of different resistors ($1.0\ \Omega$, $2.0\ \Omega$, $4.0\ \Omega$ and $7.0\ \Omega$) as shown in the diagram.**

He produces a graph of current against resistance. Refer to the graph for Question 3 (b) in the separate Diagram Booklet.

continued on the next page . . .

(Turn over)

Question 3 continued

- 3. (b) (i) Show that the internal resistance, r , of the cell is $2.0\ \Omega$.**

[2 marks]

continued on the next page . . .

(Turn over)

Question 3 (b) continued

- 3. (b) (ii) Bryn states that the maximum power dissipation in the resistor, R , occurs when its resistance is equal to the internal resistance of the battery. Use the graph to justify his claim.**

(Turn over)

25

[3 marks]

(Total for Question 3 = 7 marks)

(Turn over)

4. Refer to the diagram for Question 4 (a) in the separate Diagram Booklet.

A group of students investigates stationary waves in an air column to determine the speed of sound using the apparatus shown in the diagram.

- (a) Describe how a stationary wave is produced in the air column.

[3 marks]

continued on the next page . . .

(Turn over)

Question 4 continued

- 4. (b) Refer to the diagram for Question 4 (b) in the separate Diagram Booklet. The loudspeaker produces a sound of frequency 495 Hz, and the length of the air column is adjusted to find two consecutive positions for maximum loudness as shown in the diagram.**

continued on the next page . . .

(Turn over)

Question 4 (b) continued

The distance between these positions, x , is measured with a ruler. This process is repeated and the results are tabulated in the table for Question 4 (b) provided separately in the Diagram Booklet.

continued on the next page . . .

(Turn over)

Question 4 (b) continued

- 4. (b) (i) Calculate the PERCENTAGE uncertainty of the mean value for X .**

(Turn over)

[2 marks]

continued on the next page . . .

(Turn over)

Question 4 (b) continued

- 4. (b) (ii) Show that the speed of sound, c , can be given by:**

$$c = 2fx$$

[2 marks]

continued on the next page . . .

(Turn over)

Question 4 (b) continued

- 4. (b) (iii) The uncertainty in the frequency is $\pm 2\%$**
- Calculate the speed of sound with its ABSOLUTE uncertainty. State your answers to a suitable number of significant figures.**

(Turn over)

[4 marks]

(Total for Question 4 = 11 marks)

(Turn over)

5. (a) Explain what is meant by diffraction.

[1 mark]

continued on the next page . . .

(Turn over)

Question 5 continued

- 5. (b) Refer to the diagram for Question 5 (b) in the separate Diagram Booklet. The diagram shows plane water waves approaching a gap in a barrier in a ripple tank. The wavefronts are separated by one wavelength, λ .**

- (i) ADD TO THE DIAGRAM the next four wavefronts to the right of those shown.**

[2 marks]

continued on the next page . . .

(Turn over)

Question 5 (b) continued

- 5. (b) (ii) Describe the shape of the wavefronts if the gap in the barrier is made less than λ .**

[1 mark]

continued on the next page . . .

(Turn over)

Question 5 continued

5. (c) Interference patterns are produced by sources of waves that have a constant phase relationship.

(i) State the term used to describe sources that have a constant phase relationship.

[1 mark]

continued on the next page . . .

(Turn over)

Question 5 (c) continued

5. (c) (ii) Refer to the diagram for Question 5 (c) (ii) in the separate Diagram Booklet.

The ripple tank is also used to investigate two – source interference. Two spherical dippers attached to the same vibrating block act as in – phase sources and produce an interference pattern as shown in the diagram.

The wavefronts are separated by one wavelength.

continued on the next page . . .

(Turn over)

Question 5 (c) (ii) continued

Explain, making reference to path difference, what type of interference occurs at points A and B.

(Turn over)

[4 marks]

continued on the next page . . .

(Turn over)

Question 5 (c) continued

5. (c) (iii) A technician wants to use light sources in order to demonstrate a two – source interference pattern.

He considers the following options:

- Red laser light directed through a double slit onto a screen.**
- Light from a sodium lamp directed through a double slit onto a screen.**

continued on the next page . . .

(Turn over)

Question 5 (c) (iii) continued

- **Light from a red laser and a blue laser directed at the same point on a screen.**

Explain whether each option is suitable in demonstrating two – source interference.

(Turn over)

[3 marks]

(Total for Question 5 = 12 marks)

(Turn over)

6. Refer to the diagram for Question 6 in the separate Diagram Booklet. A beam of laser light travels from air ($n_{\text{air}} = 1.00$) through a plastic bottle ($n_{\text{plastic}} = 1.57$) containing water ($n_{\text{water}} = 1.33$). A hole created in the bottle allows water to flow as a continuous stream as shown in the diagram.

(a) (i) Using calculated values, describe how the speed of the laser light varies as it follows the path shown.

[3 marks]

continued on the next page . . .

(Turn over)

Question 6 continued

- 6. (a) (ii) When the beam enters the stream of water, it follows the path as shown.**

Explain this process, making reference to the critical angle of the water – air boundary and giving suitable calculations.

(Turn over)

[4 marks]

continued on the next page . . .

(Turn over)

Question 6 continued

6. (b) The laser has a power output of 1.0 mW , and its stimulated emission wavelength is 550 nm .

(i) Explain what is meant by stimulated emission.

(Turn over)

[3 marks]

continued on the next page . . .

(Turn over)

Question 6 (b) continued

6. (b) (ii) Determine the number of photons per second emitted by the laser.

[3 marks]

(Total for Question 6 = 13 marks)

(Turn over)

7. Refer to the diagram for Question 7 (a) in the separate Diagram Booklet. The diagram shows part of a simplified energy level diagram for a sodium atom.

(a) Determine the wavelength of the electromagnetic radiation emitted when an electron drops from the 1st excited state to the ground state.

(Turn over)

[3 marks]

continued on the next page . . .

(Turn over)

Question 7 continued

- 7. (b) A sodium discharge tube is observed in a dark room through a diffraction grating. A line EMISSION spectrum is observed. Describe the appearance of this spectrum.**

[2 marks]

continued on the next page . . .

(Turn over)

Question 7 continued

- 7. (c) Refer to the diagram for Question 7 (c) in the separate Diagram Booklet. A technician demonstrates the absorption spectrum of sodium using the apparatus shown in the diagram. The light is projected onto a screen.**

Explain why there is a black line in the spectrum. Make reference to the energy level diagram.

(Turn over)

[3 marks]

(Total for Question 7 = 8 marks)

(Turn over)

8. Refer to the diagram for Question 8 in the separate Diagram Booklet.

Fast-moving electrons are incident upon a powdered graphite target as shown in the diagram.

(a) A pattern appears on the fluorescent screen. Describe the pattern AND explain the significance of this experiment.

(Turn over)

[2 marks]

continued on the next page . . .

(Turn over)

Question 8 continued

- 8. (b) The electrons emitted from the electron gun have a speed of $1.8 \times 10^7 \text{ m s}^{-1}$**

Calculate their (de Broglie) wavelength IN pm.

(HINT: Momentum is the product of mass and velocity).

(Turn over)

60

[3 marks]

(Total for Question 8 = 5 marks)

TOTAL FOR PAPER = 80 MARKS

END OF PAPER

(Turn over)

Question number	Additional pages, if required. Write the question number(s) in the left – hand margin.

(Turn over)

Question number	Additional pages, if required. Write the question number(s) in the left – hand margin.

(Turn over)

[illegible]



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ELECTRICITY AND LIGHT**

Diagram Booklet

**The Diagram Booklet MUST be handed in
to the invigilators and sent for marking.**

Surname: _____

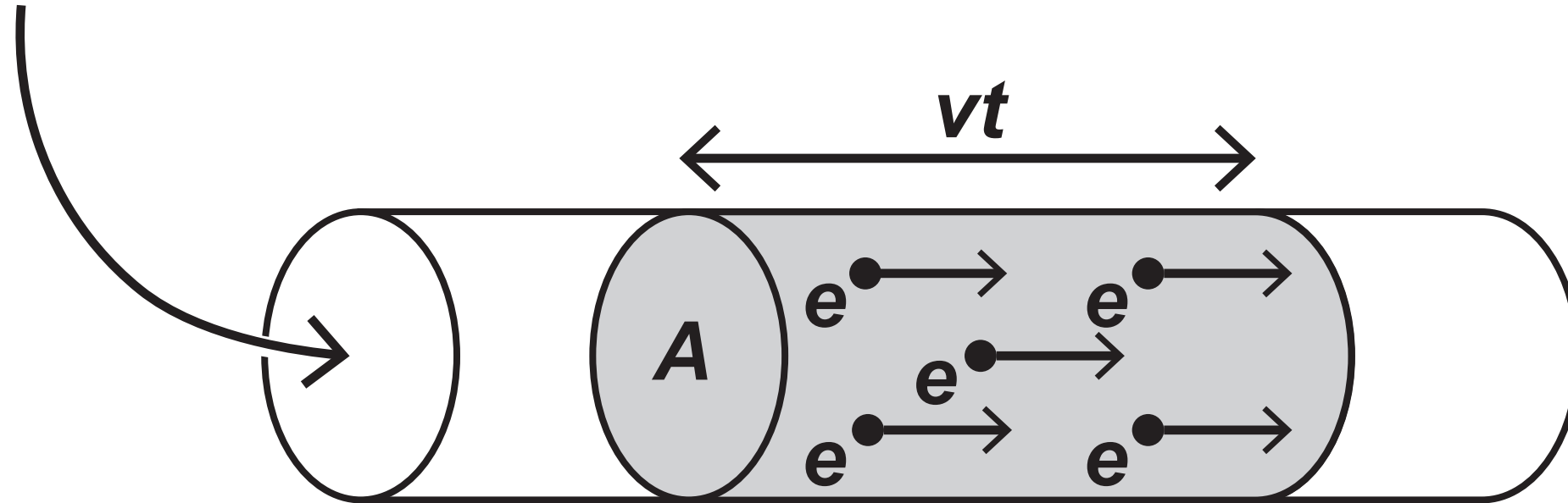
First name(s): _____

Centre Number: _____

Candidate Number: 2 _____

Question 1 (a)

A pd is applied across either end of a wire.
Electrons move with drift velocity, v ,
through a cross sectional area, A .



n = number of electrons per m^3

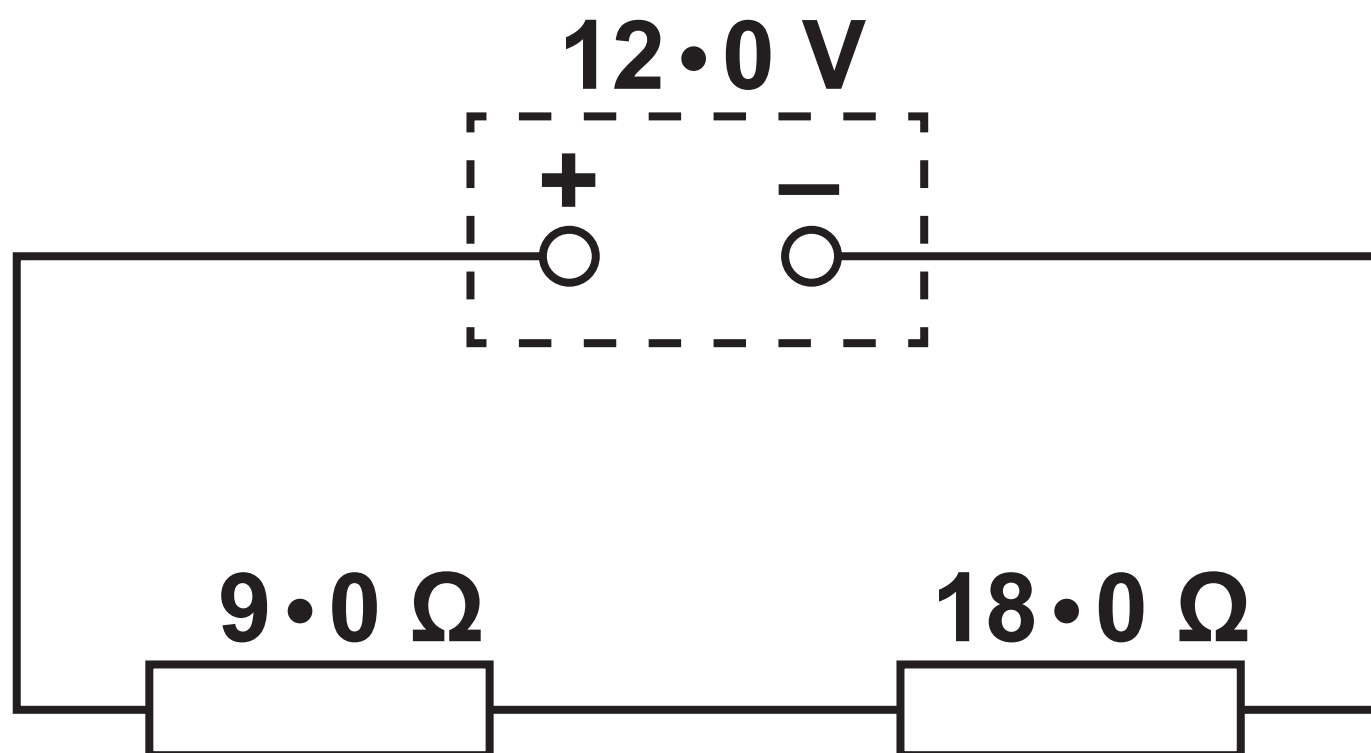
Volume of shaded portion of wire
= Avt using cross sectional area $\times$ distance
Number of electrons = $nAvt$
Total charge = $nAvte$

Question 1 (b)

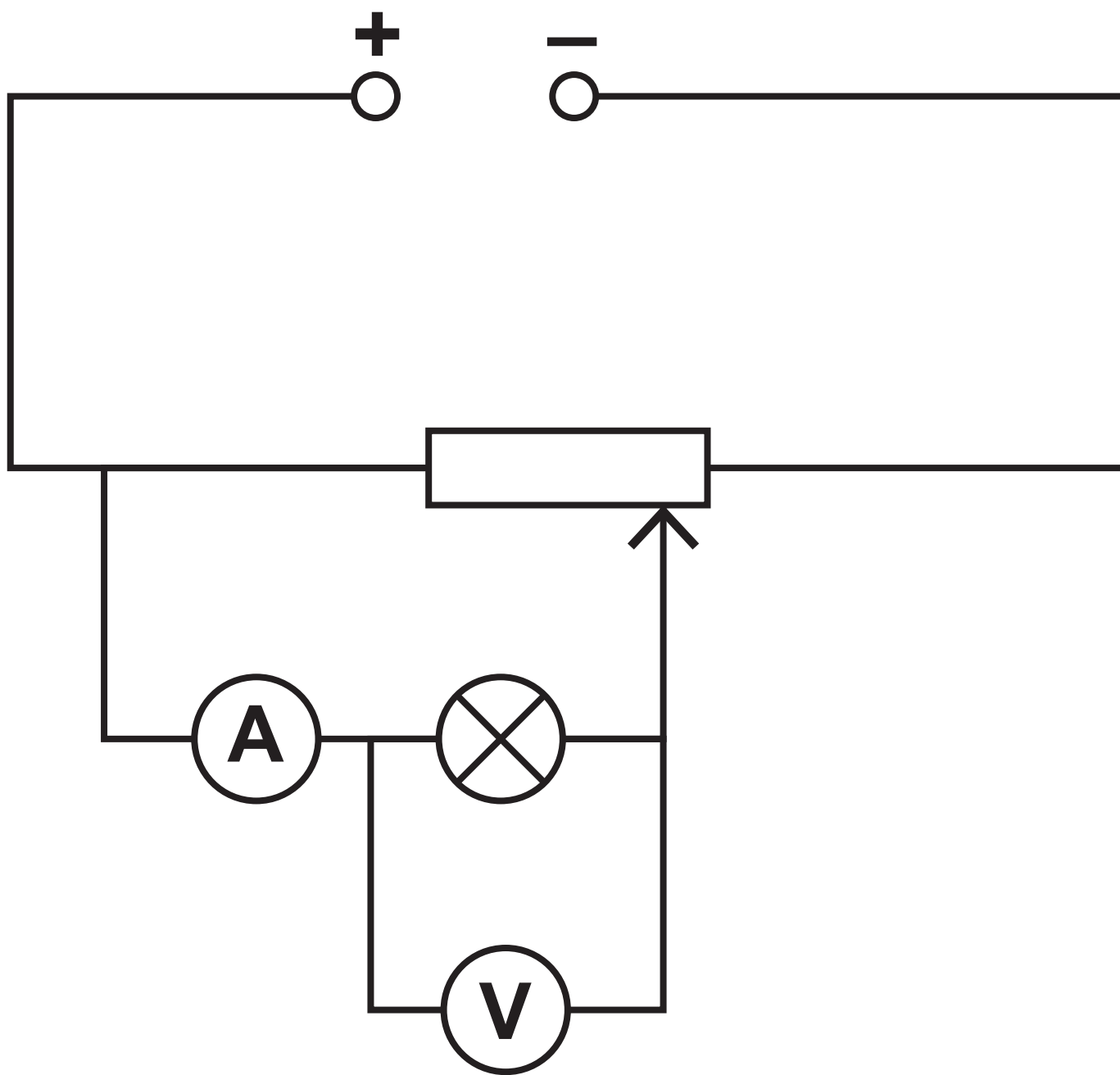
Table

	Gwen's wire	Griff's wire
Resistance (Ω)	9•0	18•0
Diameter (mm)	0•508	0•254
Length (m)		1•861

Question 1 (b) (ii)



Question 2

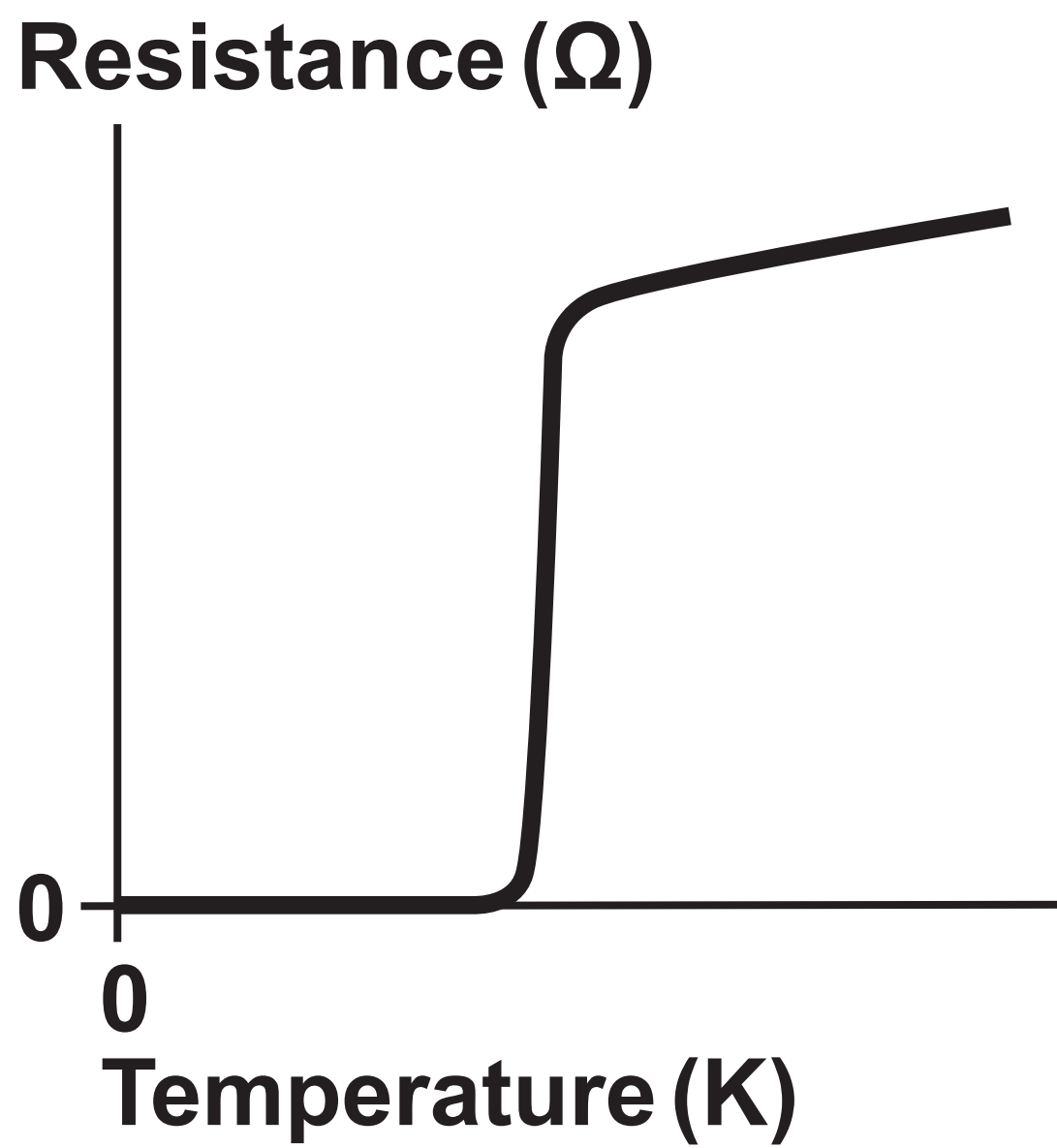


Question 2

Table

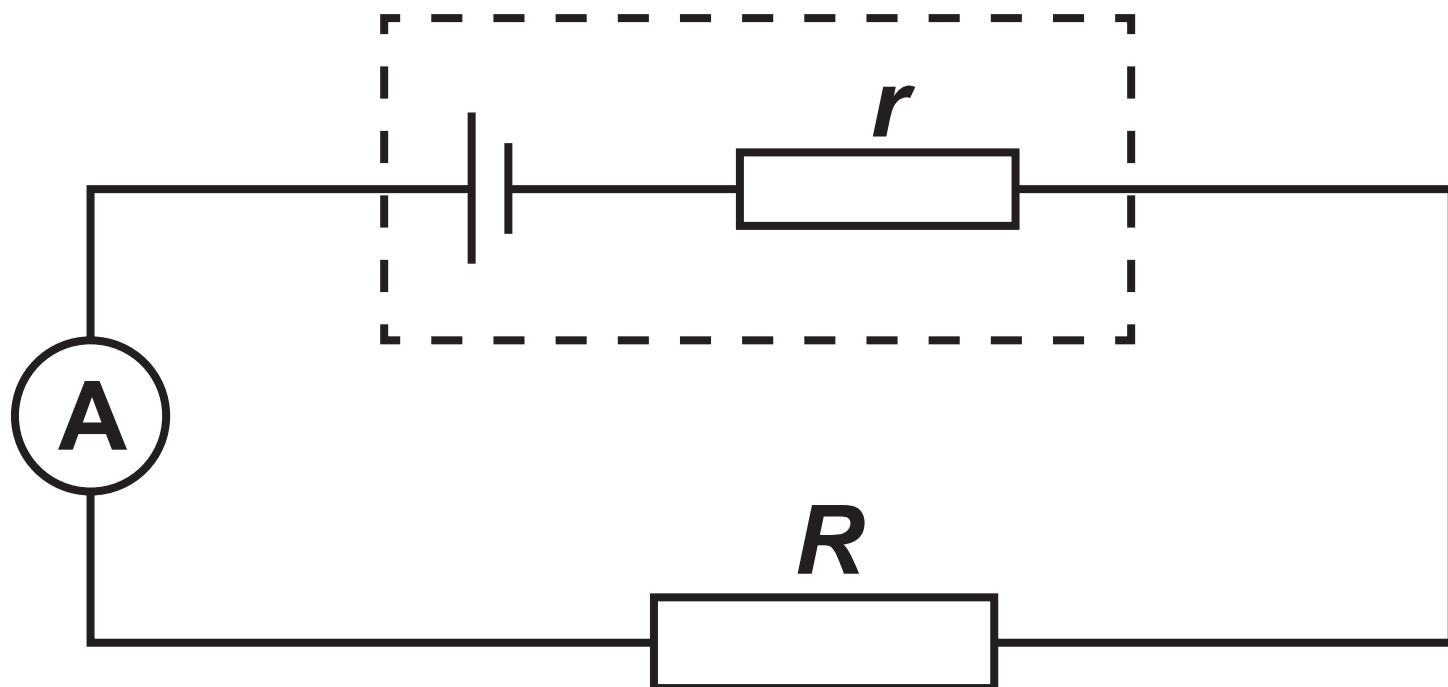
<i>V</i> (V)	<i>I</i> (A)
0•0	0•00
1•0	0•04
2•0	0•08
3•0	0•10
4•0	0•12
5•0	0•13
6•0	0•15
7•0	0•16
8•0	0•17
9•0	0•18
10•0	0•19

Question 2 (c)



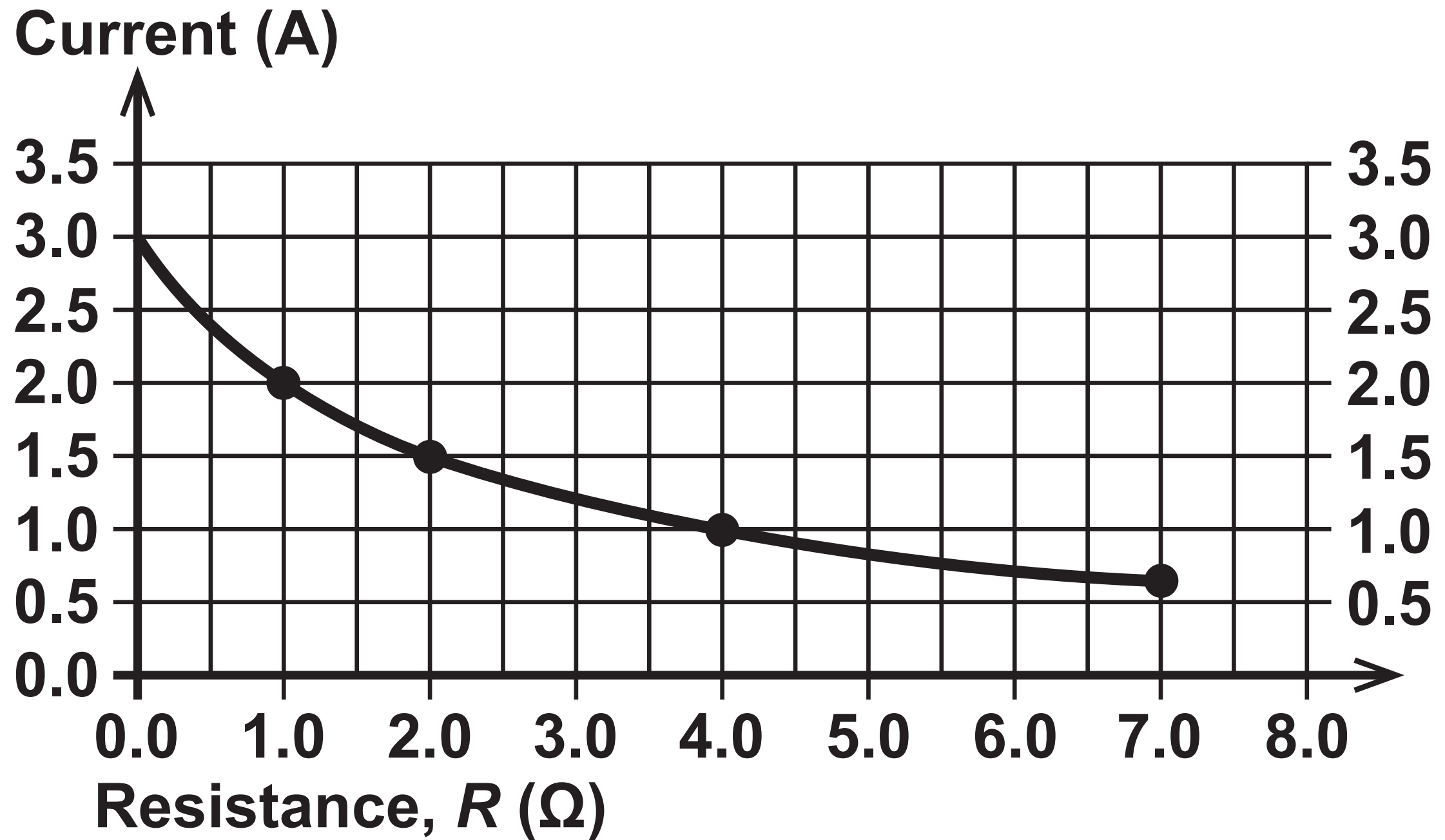
Question 3 (b)

emf 6.0 V

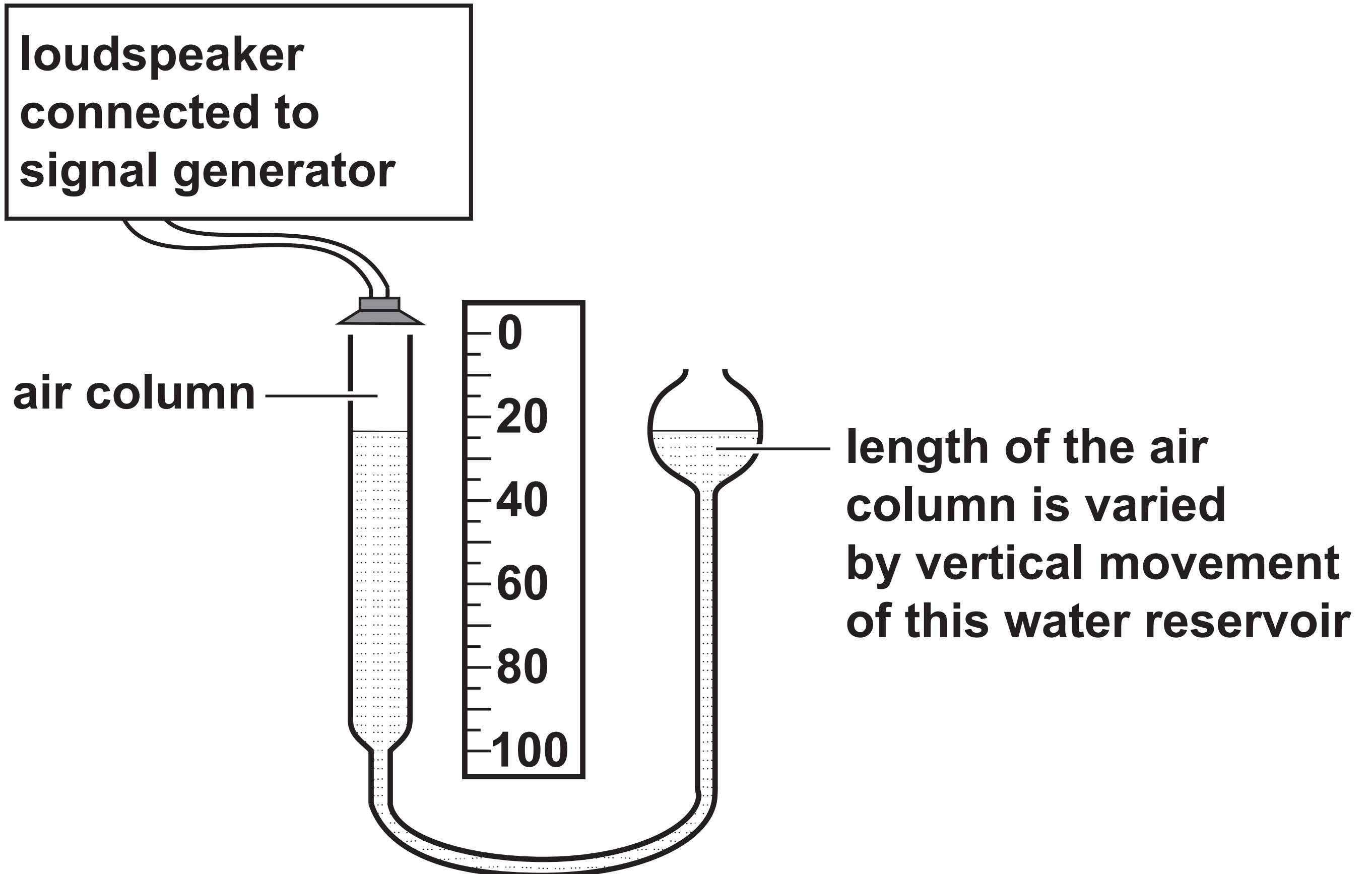


Question 3 (b)

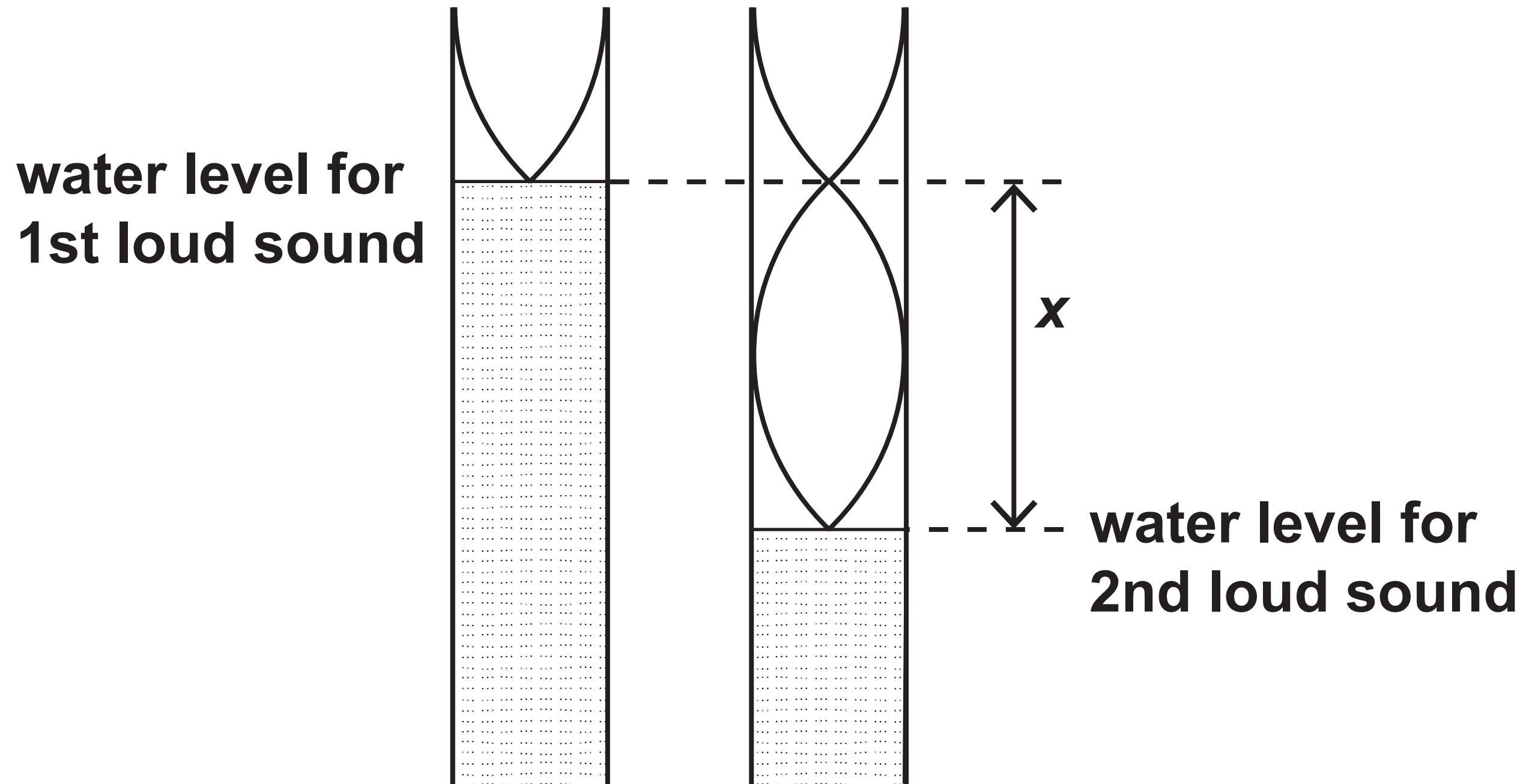
Graph



Question 4 (a)



Question 4 (b)

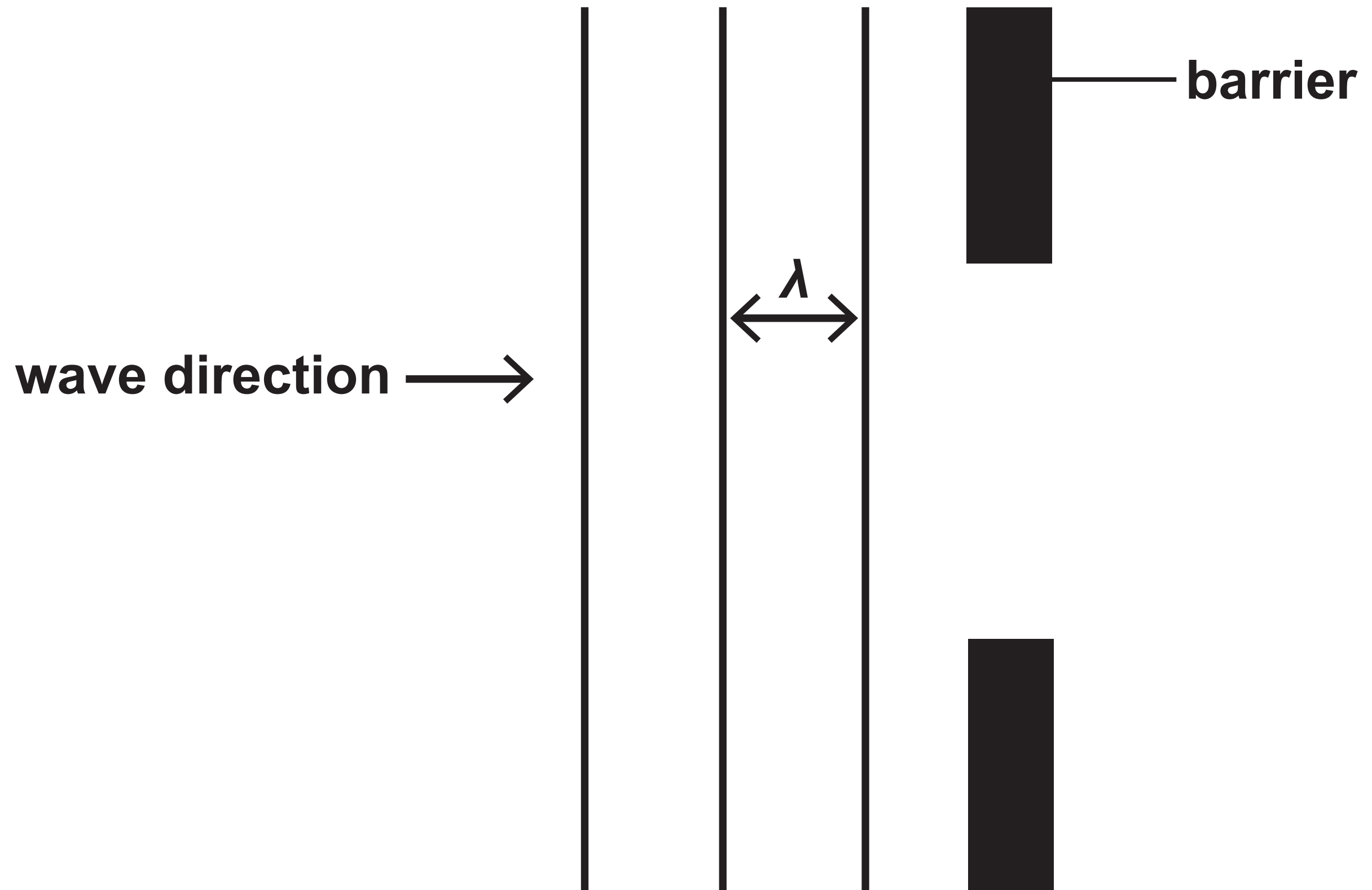


Question 4 (b)

Table

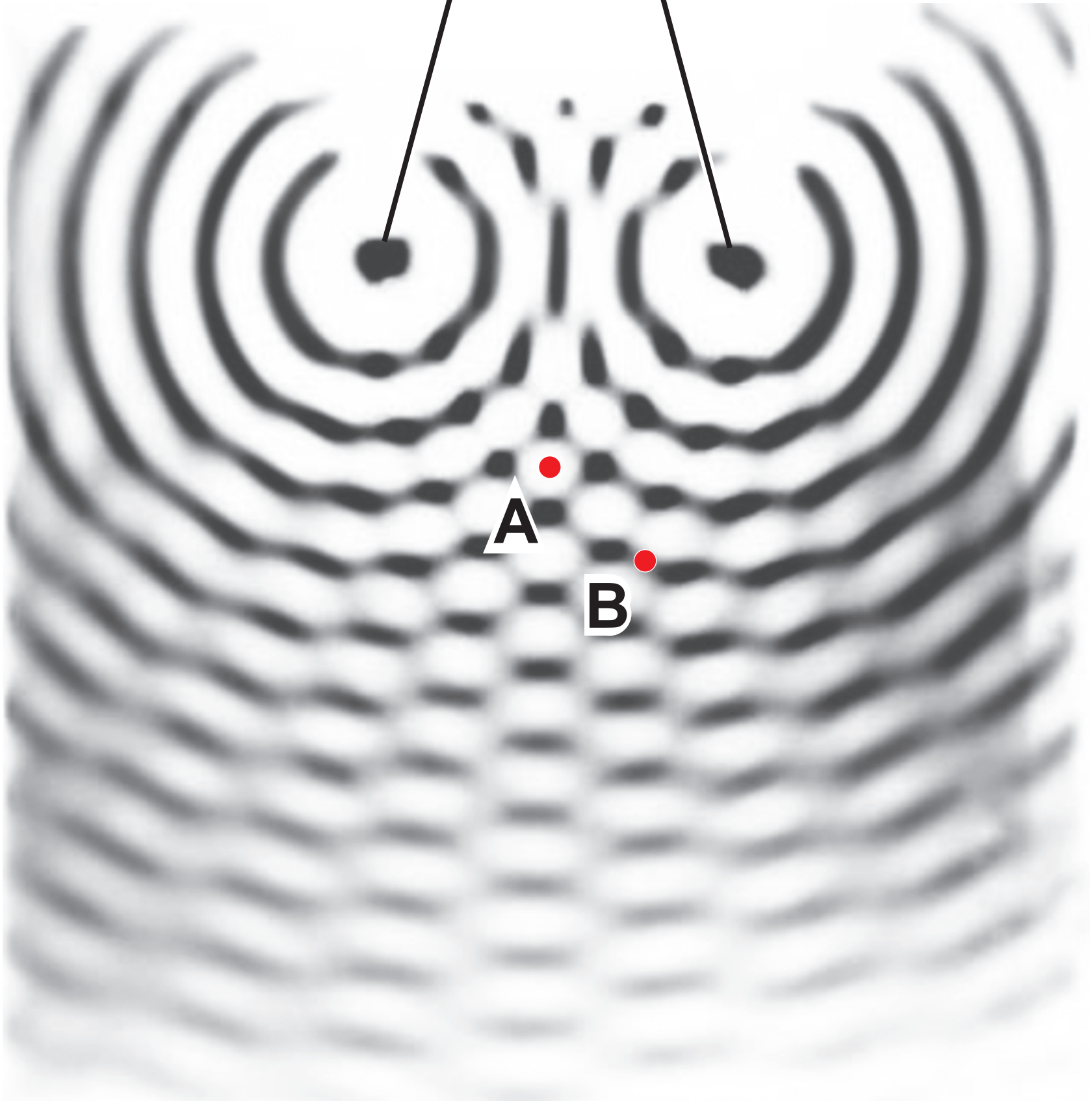
Frequency (Hz)	Measurement, x (m)				
	1	2	3	4	Mean
495	0.332	0.338	0.342	0.348	0.340

Question 5 (b)

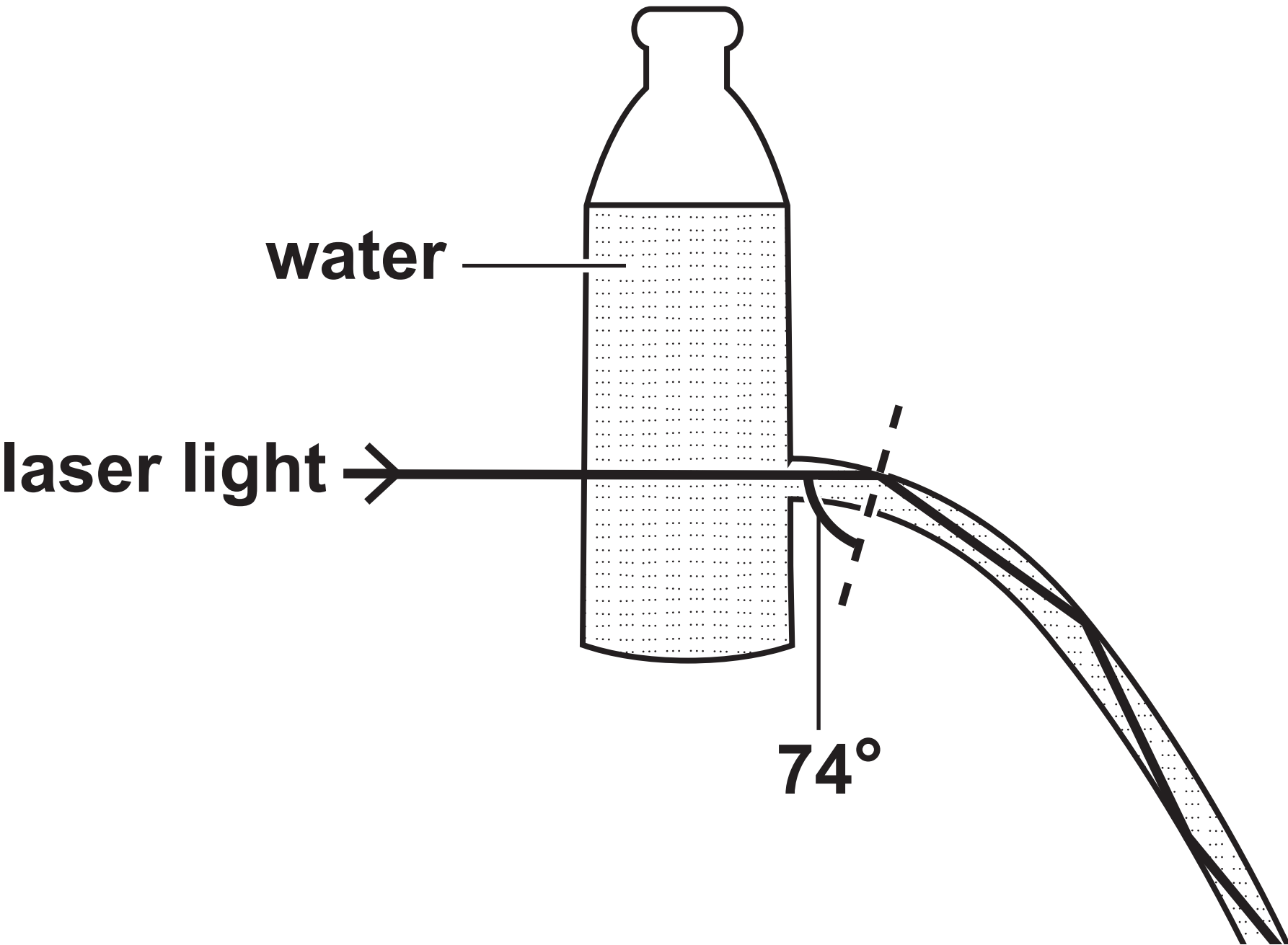


Question 5 (c) (ii)

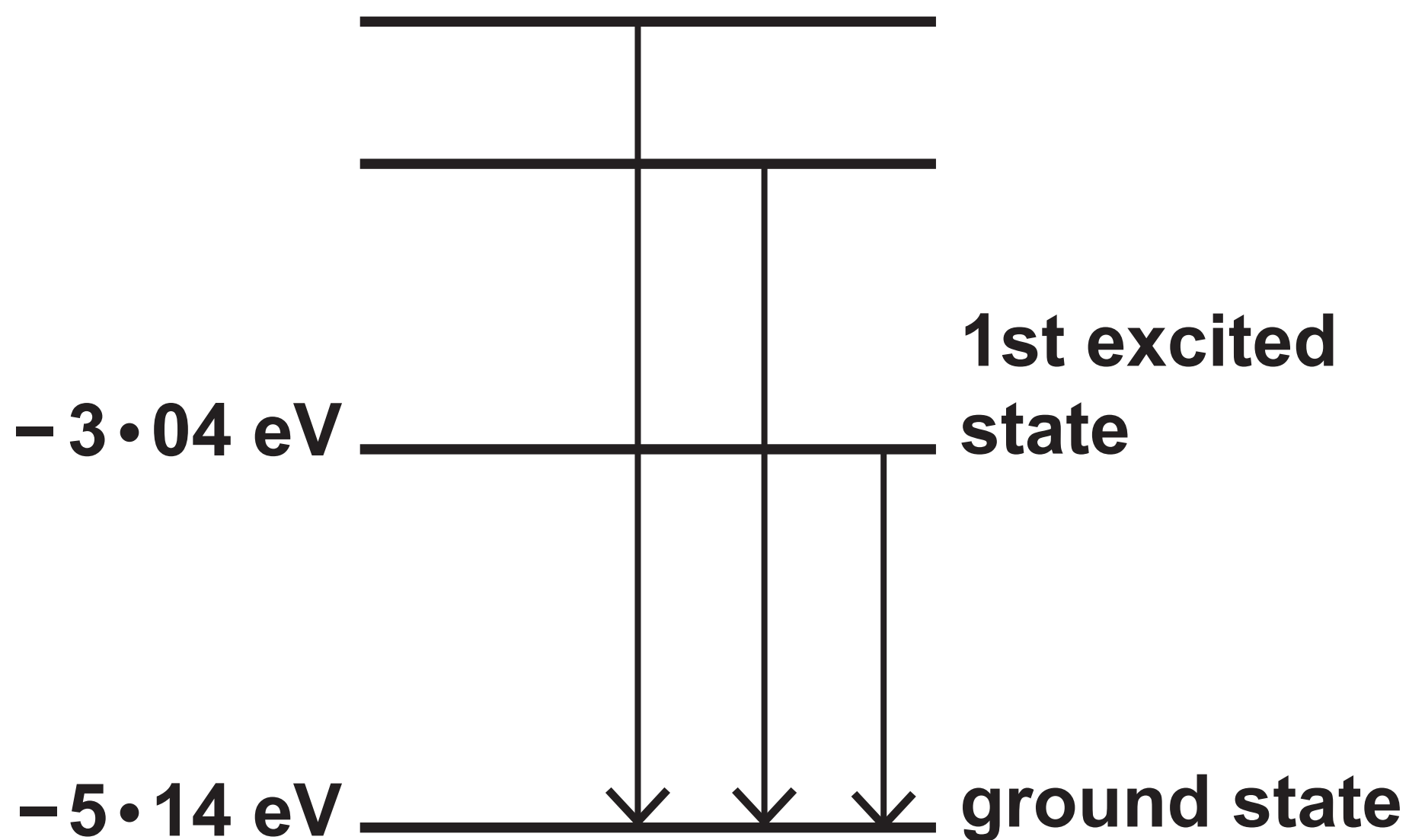
spherical dippers



Question 6

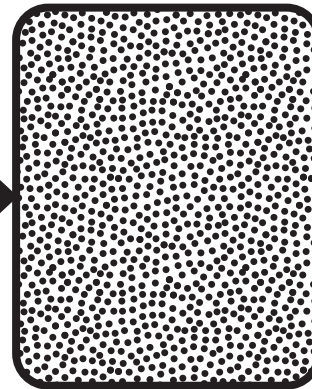
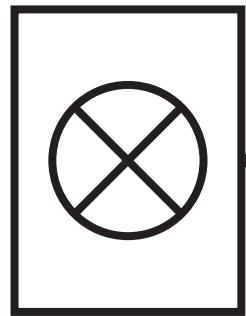


Question 7 (a)



Question 7 (c)

**white light
source**



**diffraction
grating**



screen



**vessel containing
sodium gas**

absorption spectrum of sodium



Question 8

