



GCE AS/A LEVEL

2420U20-1

WEDNESDAY, 24 MAY 2023 – 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.	13	
2.	11	
3.	12	
4.	10	
5.	10	
6.	8	
7.	7	
8.	9	
Total	80	

(Turn over)

ADDITIONAL MATERIALS

In addition to this paper you will require a calculator and a 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 pages at the back of the 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 3 (b).

(Turn over)

ANSWER ALL QUESTIONS.

- 1. (a) Look at Diagram 1 for Question 1 (a) in the separate Diagram Booklet.**

Diagram 1 shows a circuit.

Emily sets up the circuit in order to investigate how the resistance of a metal wire varies with length.

continued on the next page . . .

(Turn over)

Question 1 (a) continued

Emily connects one crocodile clip on the wire at the 0.0 cm mark while the other clip is moved along at suitable intervals to cover the whole range of the wire.

Look at Diagram 2 for Question 1 (a) in the separate Diagram Booklet.

Diagram 2 shows a graph.

She obtains results as shown in the graph.

continued on the next page . . .

(Turn over)

Question 1 (a) continued

1. (a) (i) Use the graph to obtain a value for the resistance at 0.0 cm and suggest the cause of this resistance.

[2 marks]

continued on the next page . . .

(Turn over)

Question 1 (a) continued

- 1. (a) (ii) Discuss to what extent Emily's results confirm that the variation of resistance of the wire with length is consistent with the equation:**

$$R = \frac{\rho l}{A}$$

(Turn over)

[3 marks]

continued on the next page . . .

(Turn over)

Question 1 (a) continued

1. (a) (iii) The wire used in the experiment has a mean DIAMETER of 0.23 mm. Name a measuring instrument that could have been used to take this reading AND state its likely resolution.

[2 marks]

continued on the next page . . .

(Turn over)

Question 1 (a) continued

1. (a) (iv) Use the graph and the mean diameter to determine the resistivity of the metal of the wire.

(Turn over)

[4 marks]

continued on the next page . . .

(Turn over)

Question 1 continued

1. (b) Emily used a 1.5 V cell in her experiment as she was concerned about the size of the electrical current in the wire. Suggest her reasons for using the 1.5 V cell.

(Turn over)

14

[2 marks]

(Total for Question 1 = 13 marks)

(Turn over)

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

[2 marks]

continued on the next page . . .

(Turn over)

Question 2 continued

2. (b) Look at the diagram for Question 2 (b) in the separate Diagram Booklet.

The diagram shows a circuit.

Four identical cells each having an emf of 1.50 V are connected in series to form a 6.00 V battery. The battery is connected across resistor X.

The reading on the ammeter is 0.30 A and the reading on the voltmeter is 5.40 V.

continued on the next page . . .

(Turn over)

Question 2 (b) continued

2. (b) (i) Show that the resistance of resistor X is 18 Ω .

[1 mark]

continued on the next page . . .

(Turn over)

[3 marks]

continued on the next page . . .

(Turn over)

Question 2 (b) continued

2. (b) (iv) Resistor X is now replaced with a different resistor, Y. Resistor Y has half the resistance of resistor X. Seren states ‘as the resistance is halved, the power dissipated in the internal resistance of the battery will be twice that with resistor X.’ Evaluate Seren’s claim.

(Turn over)

[3 marks]

(Total for Question 2 = 11 marks)

(Turn over)

- 3. (a) Look at the diagram for Question 3 (a) in the separate Diagram Booklet.**

A vibration generator attached to one end of a string produces a progressive wave on the string as shown in the diagram (for time $t = 0$).

The wavelength of the waves is 15.0 cm.

continued on the next page . . .

(Turn over)

Question 3 (a) continued

3. (a) (i) State what is meant by the amplitude of a progressive wave.

[1 mark]

continued on the next page . . .

(Turn over)

Question 3 (a) continued

3. (a) (ii) Look at the diagram for Question 3 (a) (ii) in the separate Diagram Booklet. The diagram is a graph.

The graph shows the displacement of point A, in the previous diagram, with respect to time.

Determine the speed of the wave.

(Turn over)

[3 marks]

continued on the next page . . .

(Turn over)

Question 3 (a) continued

**3. (a) (iii) Sketch the
displacement–time graph
of point B ON THE GRID
IN part (a) (ii).**

[2 marks]

continued on the next page . . .

(Turn over)

Question 3 continued

3. (b) The progressive wave set-up in part (a) can be modified in order to create a stationary wave pattern.

Explain how a stationary wave is formed AND describe the similarities and differences between a stationary wave and a progressive wave.

(Turn over)

[6 marks QER]

(Total for Question 3 = 12 marks)

(Turn over)

4. Look at the diagram for Question 4 in the separate Diagram Booklet.

The diagram shows the apparatus set up by some students to investigate the superposition of sound waves.

Two identical loudspeakers (S_1 and S_2) are connected to the same signal generator and act as coherent sources.

The students use an app on their mobile phones to measure the intensity of the sound signal at different positions in the classroom.

continued on the next page . . .

(Turn over)

Question 4 continued

Mobile phone A detects a maximum of intensity on the central line.

Mobile phone B detects the FIRST maximum away from the central maximum.

- 4. (a) Explain what is meant by coherent sources.**

[1 mark]

continued on the next page . . .

(Turn over)

Question 4 continued

4. (b) (i) The distance S_1B is 8.0 m and the distance S_2B is 7.4 m.

State what is meant by the term path difference AND hence explain why the wavelength of the sound wave must be 0.60 m.

(Turn over)

[2 marks]

continued on the next page . . .

(Turn over)

Question 4 (b) continued

4. (b) (ii) Mobile phone C detects a minimum intensity.

Determine TWO possible values of the distance $(S_2C - S_1C)$.

[2 marks]

(Turn over)

Question 4 continued

4. (c) (i) State the principle of superposition.

[2 marks]

continued on the next page . . .

(Turn over)

Question 4 (c) continued

4. (c) (ii) Loudspeaker S_2 develops a fault whose only effect is to reduce the amplitude of the sound waves it emits. Explain why the intensities at A and B decrease AND the intensity at C increases.

(Turn over)

[3 marks]

(Total for Question 4 = 10 marks)

(Turn over)

5. (a) Define the refractive index of a material.

[1 mark]

continued on the next page . . .

(Turn over)

Question 5 continued

- 5. (b) Look at the diagram for Question 5 (b) in the separate Diagram Booklet.**

The diagram shows material A of unknown refractive index, n , sandwiched between two rectangular blocks of different refractive indices.

A ray of light travels from the top block into material A as shown in the diagram.

continued on the next page . . .

(Turn over)

[3 marks]

continued on the next page . . .

(Turn over)

Question 5 (c) continued

5. (c) (ii) ON THE DIAGRAM for part (b) continue the path of the light ray inside material A.

[1 mark]

(Total for Question 5 = 10 marks)

(Turn over)

6. (a) State what is meant by the work function, ϕ , of a metal surface.

[1 mark]

continued on the next page . . .

(Turn over)

Question 6 continued

6. (b) Sodium will undergo the photoelectric effect when illuminated by visible light, but zinc requires ultraviolet radiation. EXPLAIN which material has the greater work function.

[1 mark]

continued on the next page . . .

(Turn over)

Question 6 continued

- 6. (c) (i) Use Einstein's photoelectric effect equation to show that the maximum wavelength, λ_{\max} for emission is given by the equation:**

$$\lambda_{\max} = \frac{hc}{\phi}$$

(Turn over)

[2 marks]

continued on the next page . . .

(Turn over)

Question 6 (c) continued

6. (c) (ii) A mixture of red ($\lambda = 650 \text{ nm}$), green ($\lambda = 550 \text{ nm}$) and blue ($\lambda = 450 \text{ nm}$) light is incident on a metal surface of work function of $3.7 \times 10^{-19} \text{ J}$.

Determine which wavelength or wavelengths of light will be UNABLE to release electrons from the metal surface.

(Turn over)

[2 marks]

continued on the next page . . .

(Turn over)

Question 6 (c) continued

6. (c) (iii) Explain, in terms of photons whether or not the intensity of the light will affect the maximum kinetic energy of the released electrons.

(Turn over)

[2 marks]

(Total for Question 6 = 8 marks)

(Turn over)

7. (a) Look at the diagram for Question 7 (a) in the separate Diagram Booklet.

The diagram shows a circuit.

Lewis uses the circuit in the diagram to find the minimum pd, V_{\min} across an LED at which light is emitted by the diode. He collects his data in a dark room where he varies the pd of the power supply until the LED lights.

continued on the next page . . .

(Turn over)

Question 7 (a) continued

Lewis measures the minimum pd, V_{\min} five times and his results are shown below.

V_{\min} / V	1.81	1.87	1.93	1.84	1.90
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- 7. (a) (i) Determine the mean value for V_{\min} along with its PERCENTAGE uncertainty.**

(Turn over)

[3 marks]

continued on the next page . . .

(Turn over)

Question 7 (a) continued

- 7. (a) (ii) Lewis uses the following equation to calculate the wavelength of the light expected to be produced by the LED:**

$$eV_{\min} = \frac{hc}{\lambda}$$

Calculate the mean value for λ and its ABSOLUTE uncertainty.

(Turn over)

[3 marks]

continued on the next page . . .

(Turn over)

Question 7 continued

7. (b) Lewis noted the value for V_{\min} when he noticed that the LED had turned on.

Suggest an improvement to his method.

[1 mark]

(Total for Question 7 = 7 marks)

(Turn over)

8. Look at the diagram for Question 8 in the separate Diagram Booklet.

The diagram shows the energy levels for the amplifying medium in a 4 – level gas laser.

(a) The laser transition between level U and level L produces stimulated photons of wavelength 1.06×10^{-6} m.

Determine the value of energy level L in eV.

(Turn over)

[3 marks]

continued on the next page . . .

(Turn over)

Question 8 continued

- 8. (b) When explaining the operation of this laser, a student writes the following:**

‘Pumping is required to move electrons from ground level to level P which is a metastable state. This creates a population inversion between P and ground which is needed for the laser to work.’

State TWO mistakes in the student’s explanation.

(Turn over)

[2 marks]

continued on the next page . . .

(Turn over)

Question 8 continued

8. (c) Semiconductor lasers are regularly used in DVD players and bar code scanners.

State TWO advantages that these semiconductor lasers have over gas lasers.

[2 marks]

(Turn over)

Question 8 continued

8. (d) As electronic technology advances, outdated electronic devices and their components are discarded. It has been estimated that 50 million tonnes of electronic waste is produced each year and roughly 80% of this is finding its way into landfill. Discuss the effects this electronic waste may have on society.

(Turn over)

[2 marks]

(Total for Question 8 = 9 marks)

END OF PAPER

TOTAL 80 MARKS

(Turn over)



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ELECTRICITY AND LIGHT

**The Diagram Booklet MUST
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and sent for marking.**

Diagram Booklet

Surname: _____

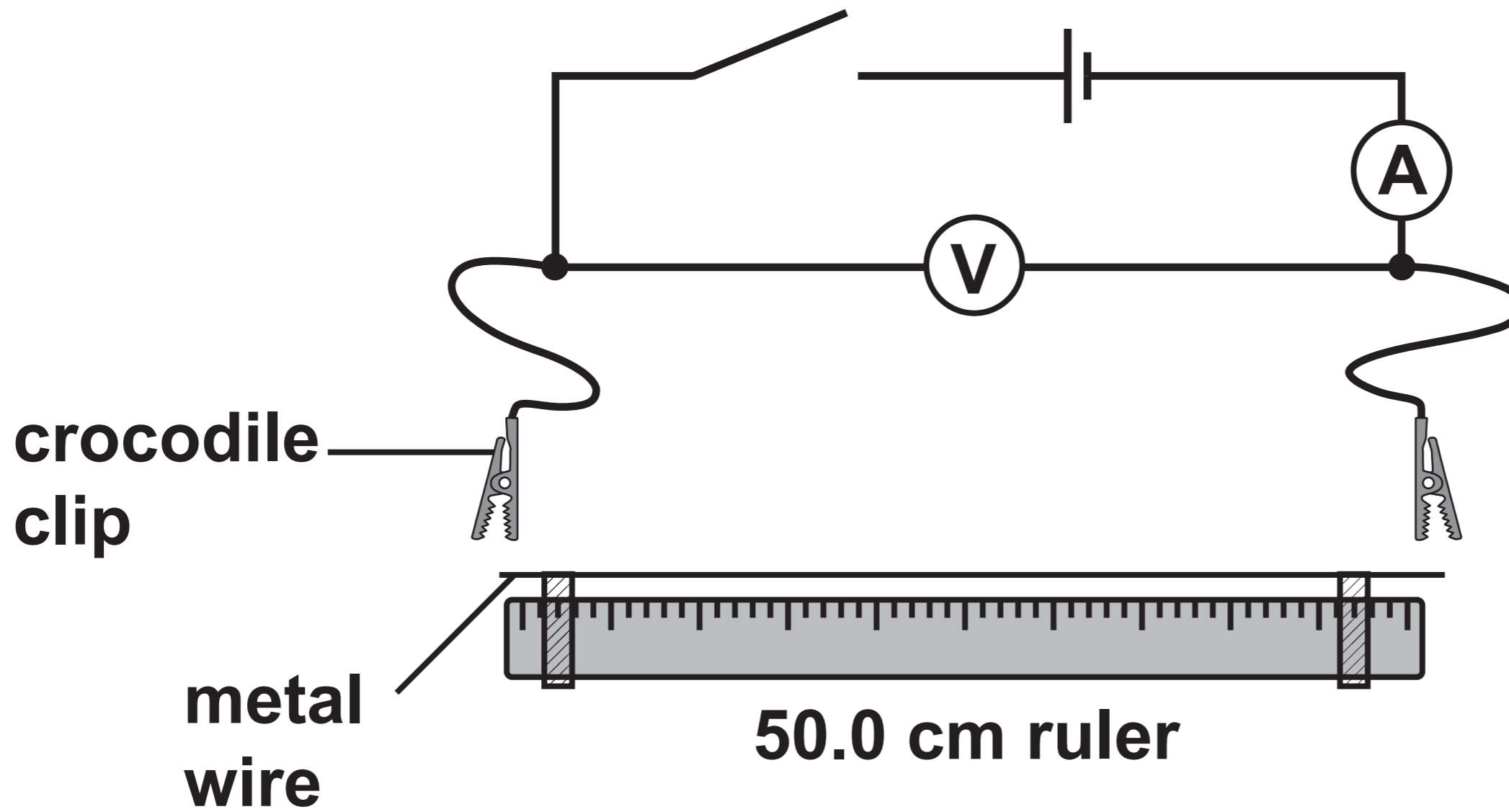
First name(s): _____

Centre Number: _____

Candidate Number: 2 _____

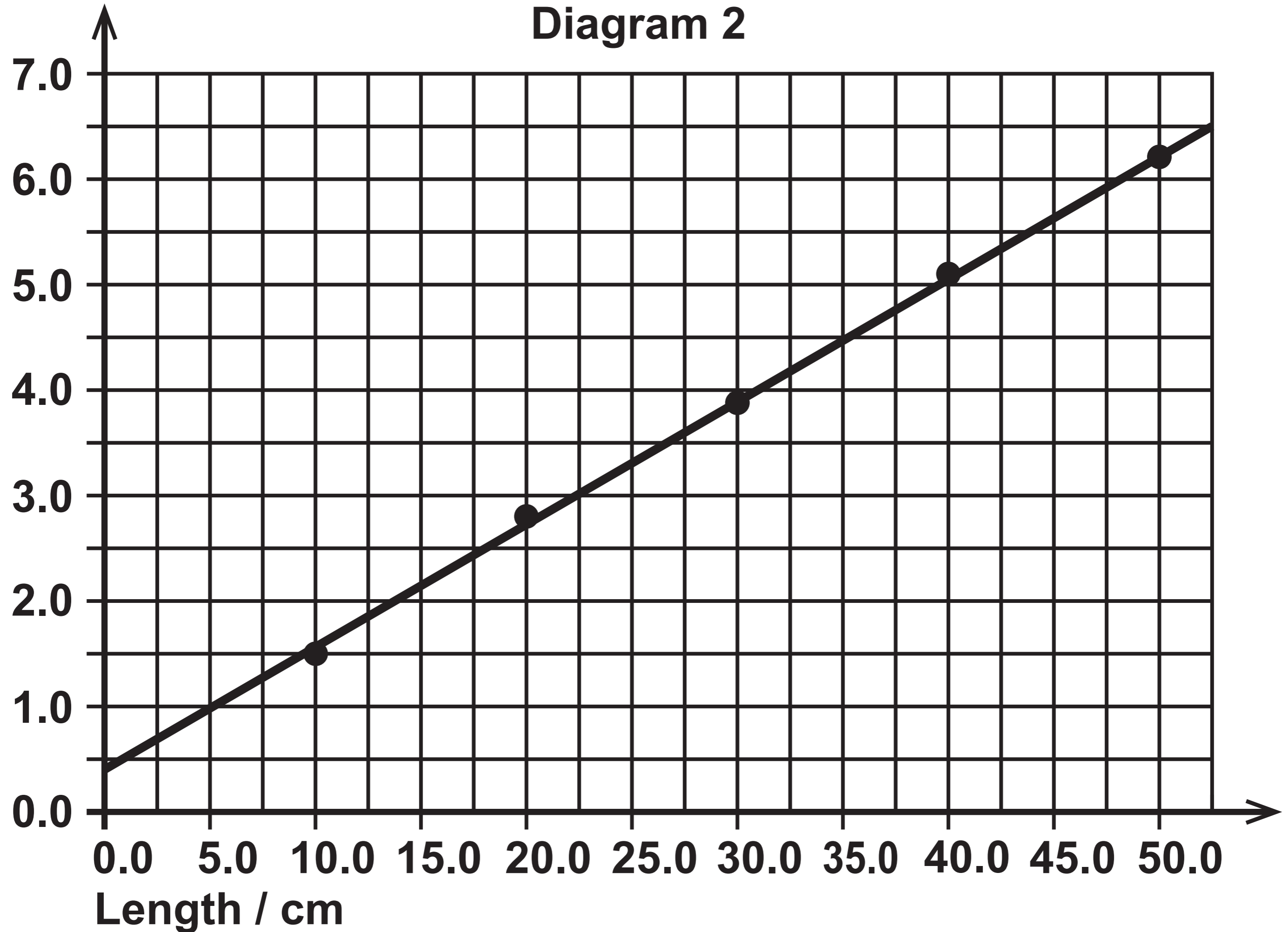
Question 1 (a)

Diagram 1

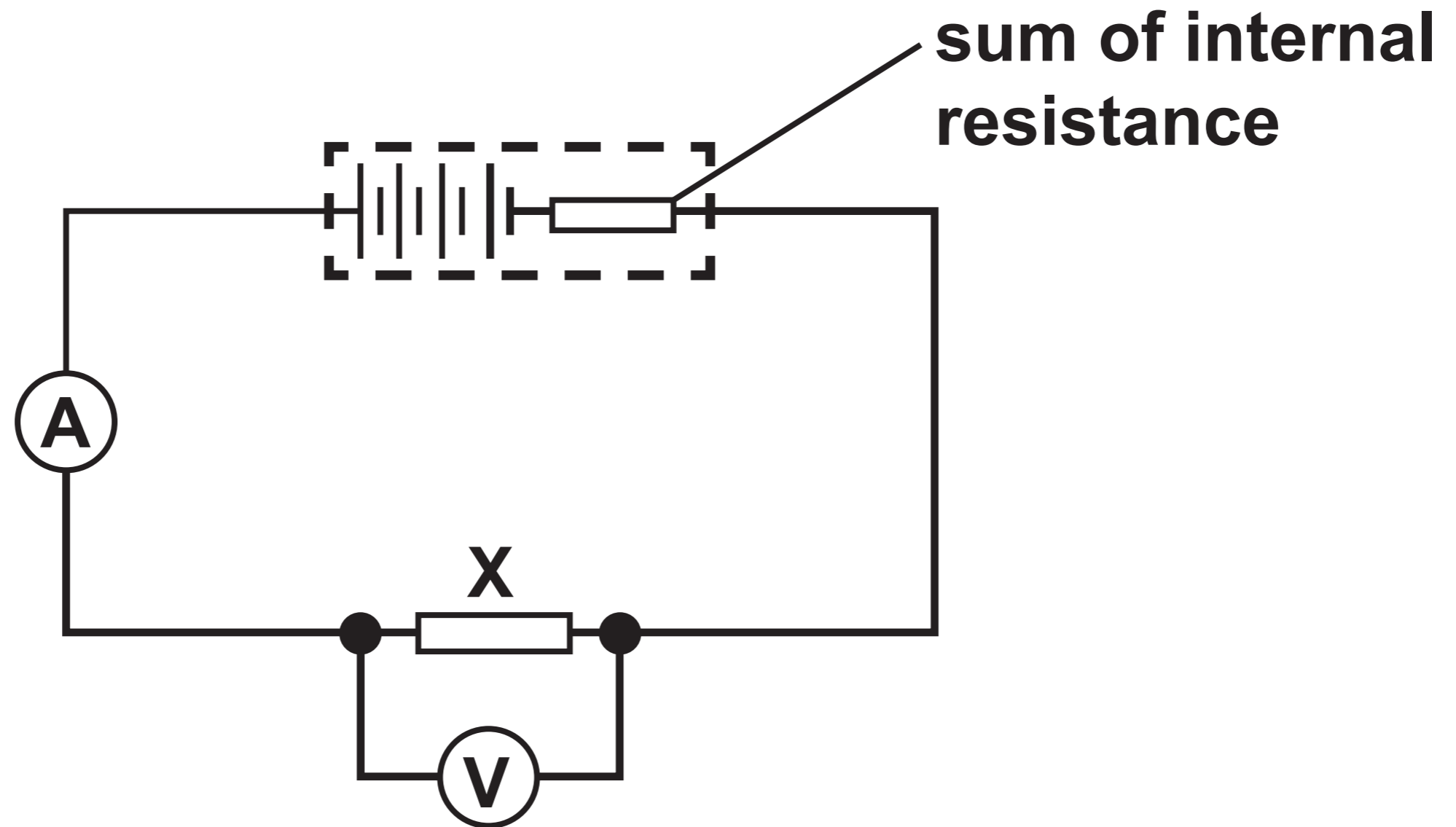


Resistance / Ω

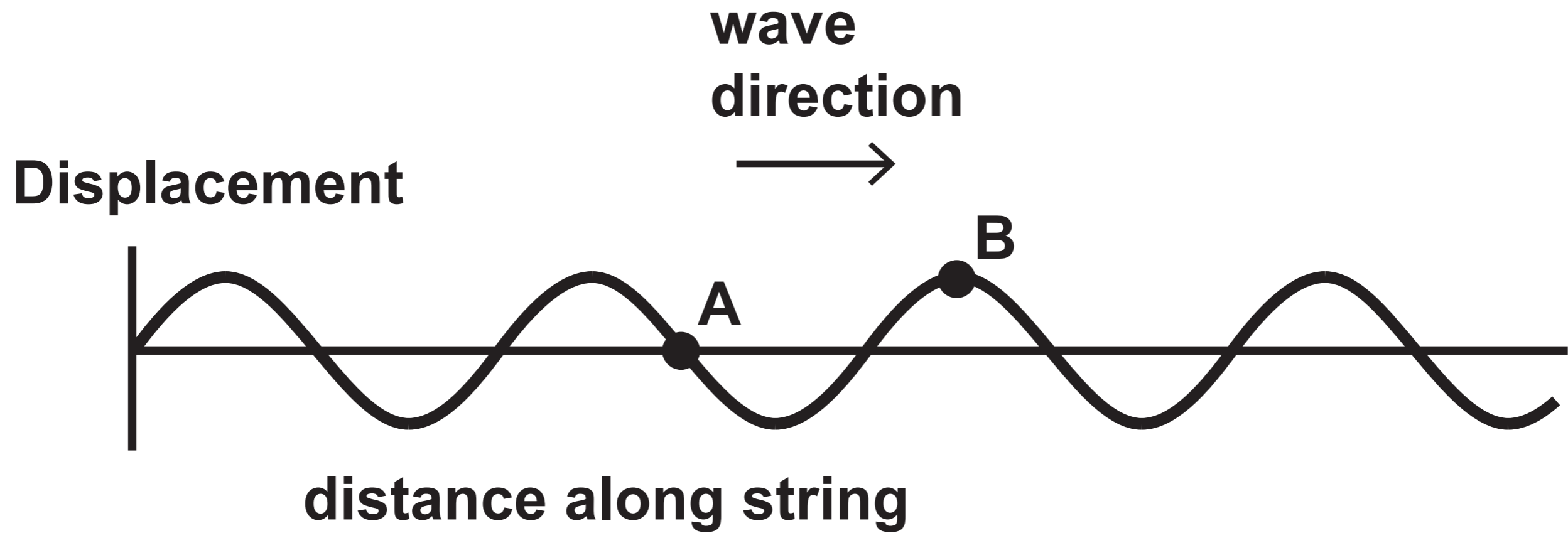
**Question 1 (a)
Diagram 2**



Question 2 (b)

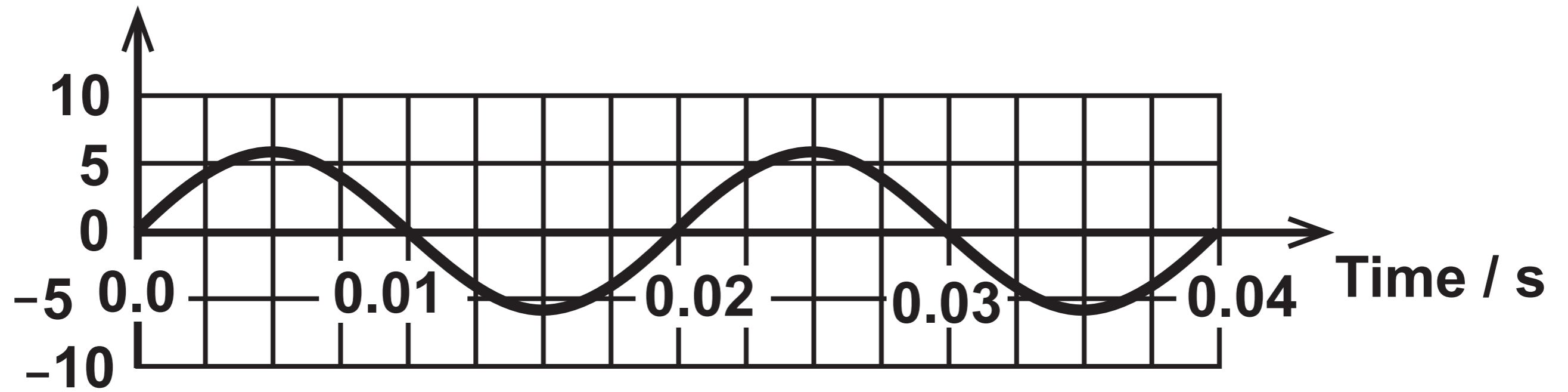


Question 3 (a)



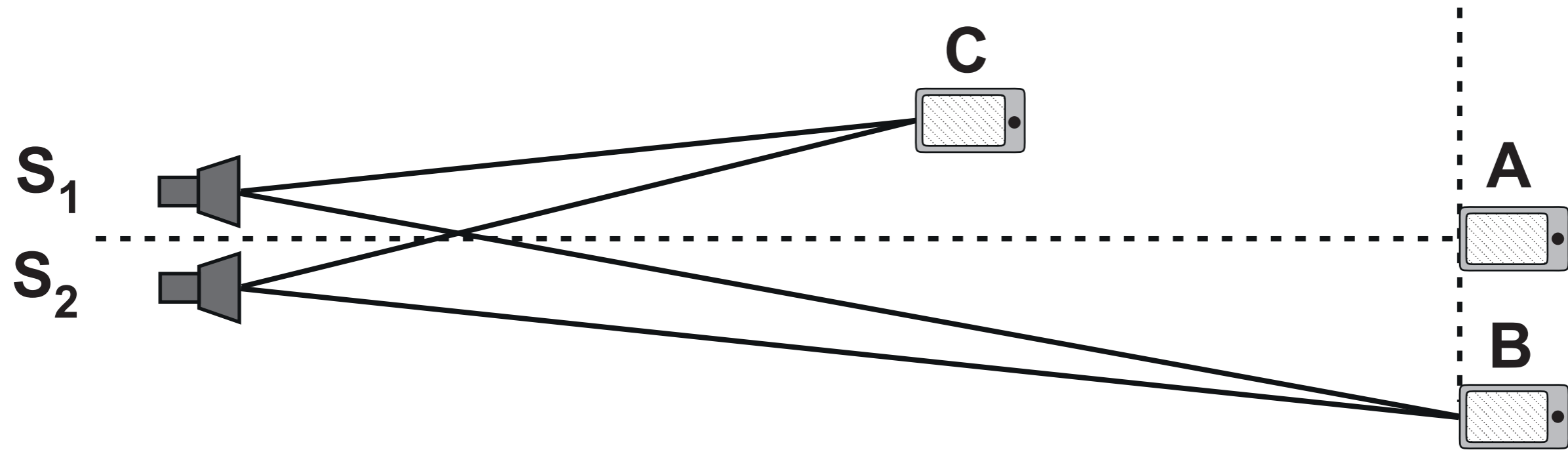
Question 3 (a) (ii)

Displacement / mm

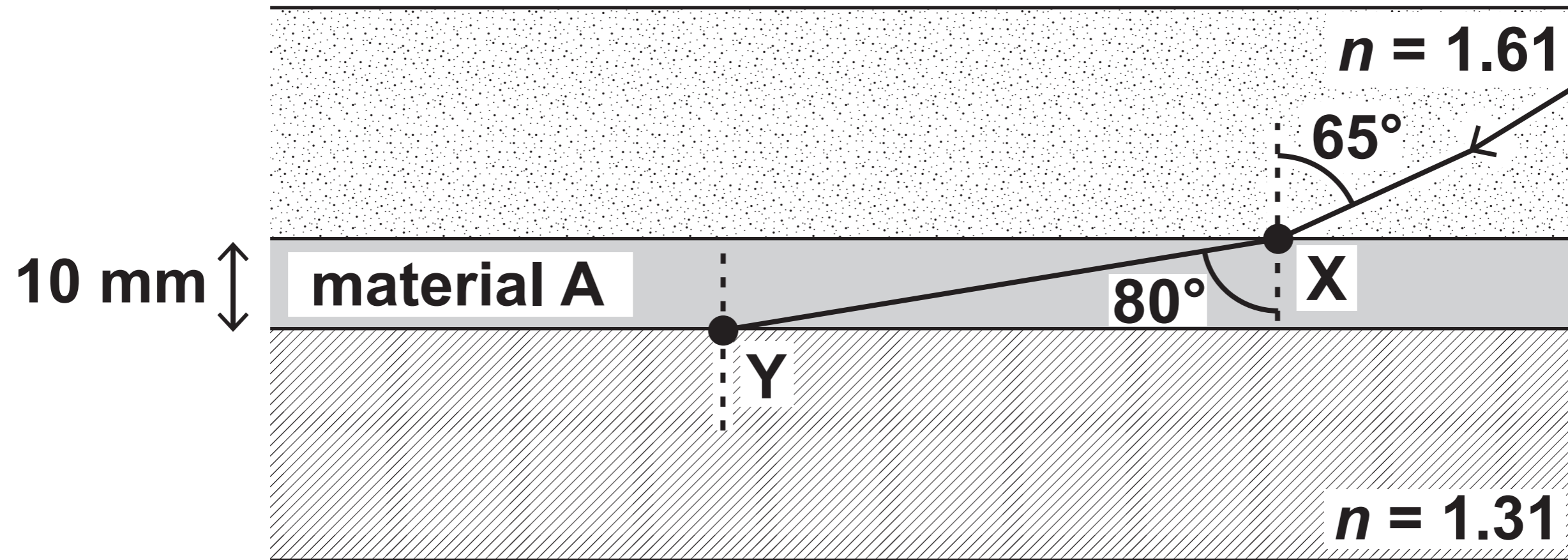


Question 4

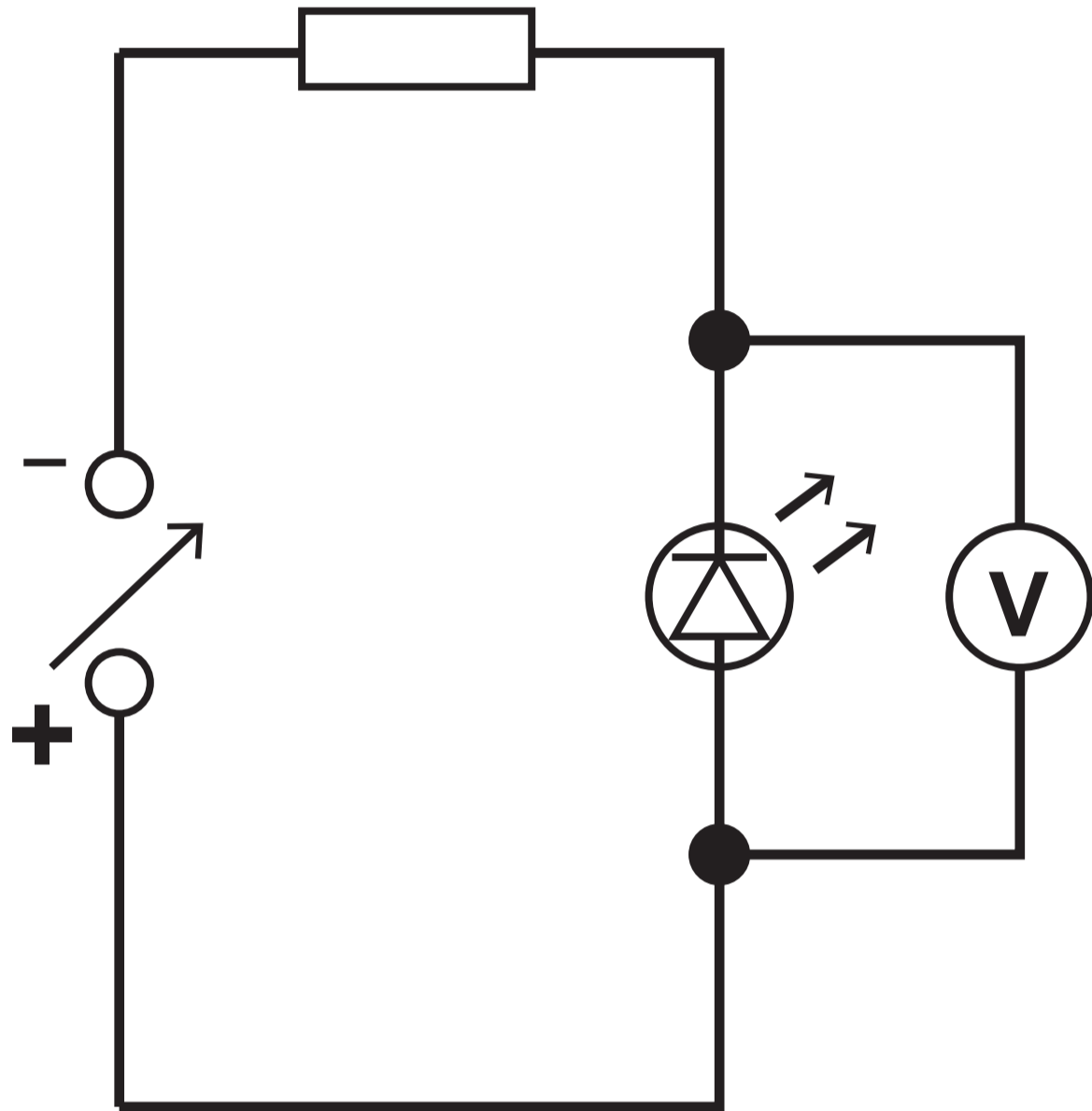
Diagram NOT drawn to scale



Question 5 (b)



Question 7 (a)



Question 8

