OXFORD AQA

INTERNATIONAL QUALIFICATIONS

Please write clearly in block capitals.

Centre number | | | | | | Candidate number | | | | |

Surname _____

Forename(s) _____

Candidate signature _____

I declare this is my own work.

INTERNATIONAL AS

PHYSICS

Unit 2 Electricity, waves and particles

Wednesday 14 January 2026 07:00 UK Time Time allowed: 2 hours

Materials

For this paper you must have:

- a Data and Formulae Booklet as a loose insert
- a ruler with millimetre measurements
- a scientific calculator, which you are expected to use where appropriate
- a protractor.

Instructions

- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- 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.
- All working must be shown.
- 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.

Information

- The marks for questions are shown in brackets.
- The maximum mark for this paper is 80.

For Examiner's Use	
Question	Mark
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12–25	
TOTAL	

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Section A

Answer **all** questions in this section.

0 1 Light of wavelength 5.5×10^{-7} m is incident normally on a diffraction grating.
The grating has 250 lines mm^{-1}.

Calculate the angle between the central maximum and a second-order maximum.
[2 marks]

angle = _____ °

2

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0 2 A battery with a storage capacity of $1\ \text{A h}$ can supply $1\ \text{A}$ for one hour at its working potential difference.

A phone battery has a storage capacity of $4500\ \text{mA h}$.

0 2 . 1 Identify the SI unit for storage capacity.

Tick (✓) **one** box.

[1 mark]

A s^{-1} ☐

C ☐

J ☐

W ☐

0 2 . 2 Determine the storage capacity of the phone battery in the unit you chose in Question **02.1**.

[1 mark]

storage capacity = _____

2

Turn over for the next question

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0 3 An electron is accelerated from rest through a potential difference V.

The electron now has a de Broglie wavelength of $1.5\ \text{nm}$.

Calculate V.

[3 marks]

$V =$ _____ V

3

Do not write outside the box

0 4 An optical fibre has a core and cladding.

The refractive index of the core is 1.49

The critical angle for the core–cladding boundary is $62.4°$.

0 4 . 1 Calculate the refractive index of the cladding.

[1 mark]

refractive index = _____

0 4 . 2 An optical fibre with cladding is used to carry information using a series of pulses of monochromatic light.

This optical fibre has a larger critical angle than an optical fibre without cladding.

Explain the benefit of a larger critical angle in this optical fibre.

[2 marks]

_____

_____

_____

_____

_____

_____

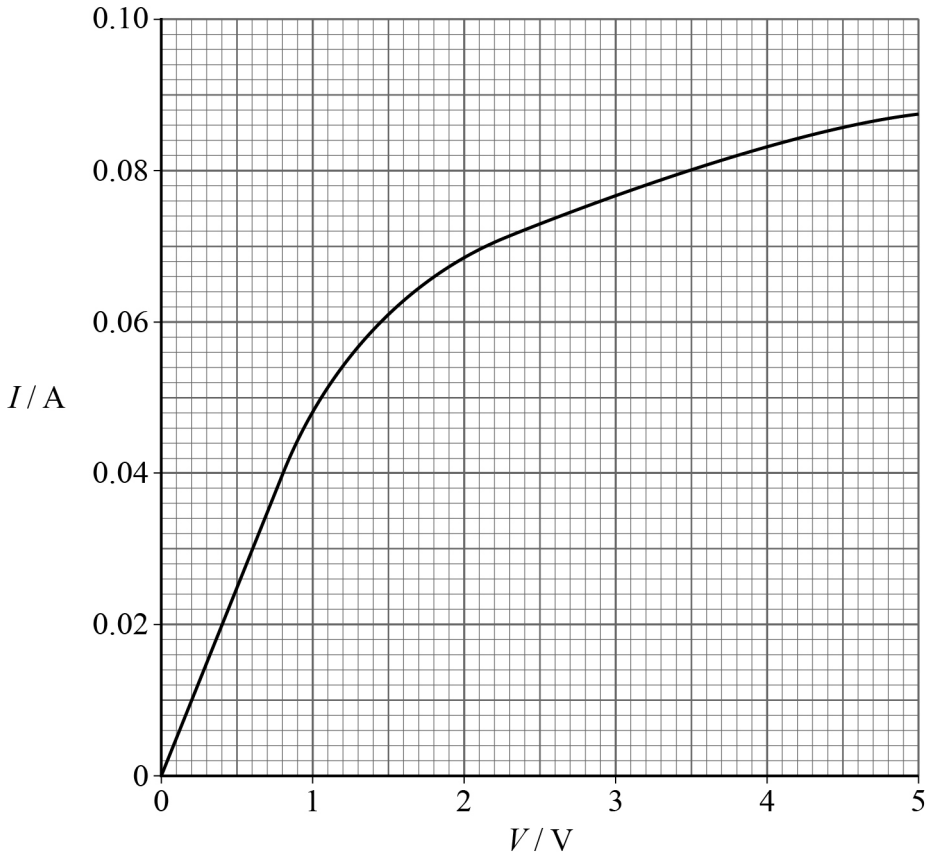
_____

3

Turn over for the next question

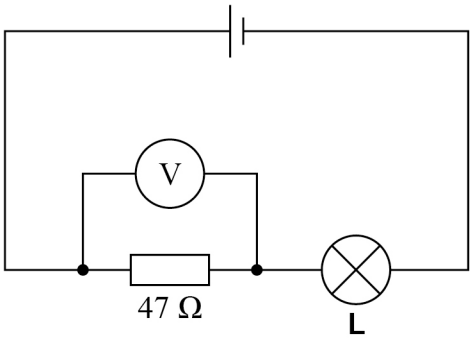
0 5 **Figure 1** shows the I–V characteristic of a filament lamp **L**.

Figure 1



L is connected in series with a resistor of resistance 47 Ω and a cell of negligible internal resistance, as shown in **Figure 2**.

Figure 2



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0 5 . 1 The voltmeter reading is $2.6\ \text{V}$.

Determine the emf of the cell.

[3 marks]

emf = _____ V

0 5 . 2 A student suggests that **L** shows ohmic behaviour within a voltage range V_1 to V_2.

Suggest an estimate for V_1 and for V_2.

Show on **Figure 1** how you obtain your answer.

[2 marks]

V_1 = _____ V

V_2 = _____ V

5

Do not write outside the box

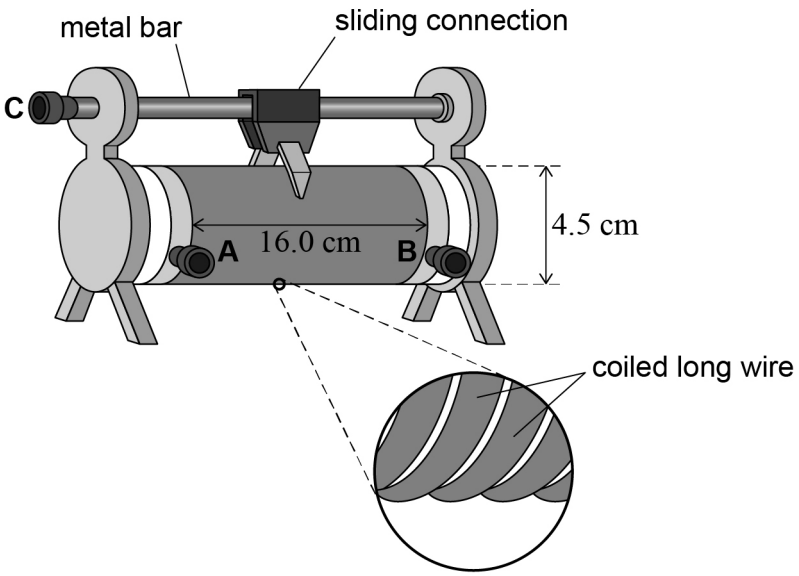
0 6 **Figure 3** shows a device that can be used as a variable resistor or in a potential divider circuit.

The device has a metal bar and a long thin wire coiled in circular turns around an insulated cylinder.

There are three terminals **A**, **B** and **C**. **A** and **B** are connected to the ends of the wire.

There is a sliding connection that moves along the bar and connects **C** to the wire.

Figure 3



0 6 . 1 The resistance of the metal bar is negligible.

Suggest how the properties of the metal bar and wire ensure that the metal bar has a much smaller resistance than the wire.

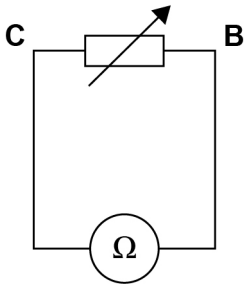
[2 marks]

Do not write outside the box

Terminals **B** and **C** are connected across an ohmmeter as shown in **Figure 4**.
In **Figure 4** the device acts as a variable resistor.

When the sliding connection is moved towards **C**, the resistance between **B** and **C** increases.

Figure 4



The maximum resistance measured by the ohmmeter is 18.3 Ω.

0 6 . 2 The coil of wire has a length of 16.0 cm and has 10.0 circular turns per cm.
The diameter of each turn is 4.5 cm.

The diameter of the wire is 0.91 mm.

Calculate an estimate for the resistivity of the metal in the wire.

[4 marks]

resistivity = _____ Ω m

Question 6 continues on the next page

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0 6 . 3 The resistance of the metal bar is negligible.

When the sliding connection is at **B**, the ohmmeter accurately measures a non-negligible resistance.

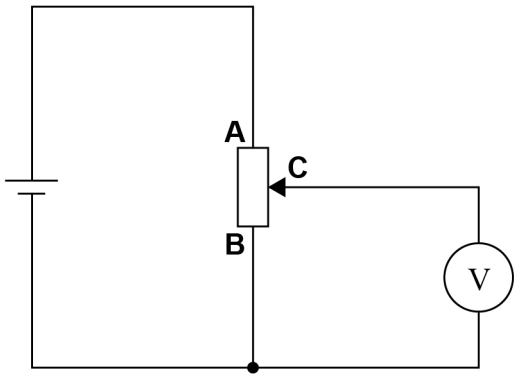
Suggest **one** reason why this resistance measured by the ohmmeter is **not** negligible.

[1 mark]

0 6 . 4 The device can also be used in a potential divider circuit as shown in **Figure 5**.

Terminals **A**, **B** and **C** are all used in this circuit.

Figure 5



The emf of the cell is $1.6\ \text{V}$ and the internal resistance of the cell is $0.95\ \Omega$.

Calculate the maximum possible reading on the voltmeter in this circuit.
Assume that the maximum resistance of the device is $18.3\ \Omega$.

[2 marks]

maximum reading = _____ V

9

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Turn over for the next question

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ANSWER IN THE SPACES PROVIDED

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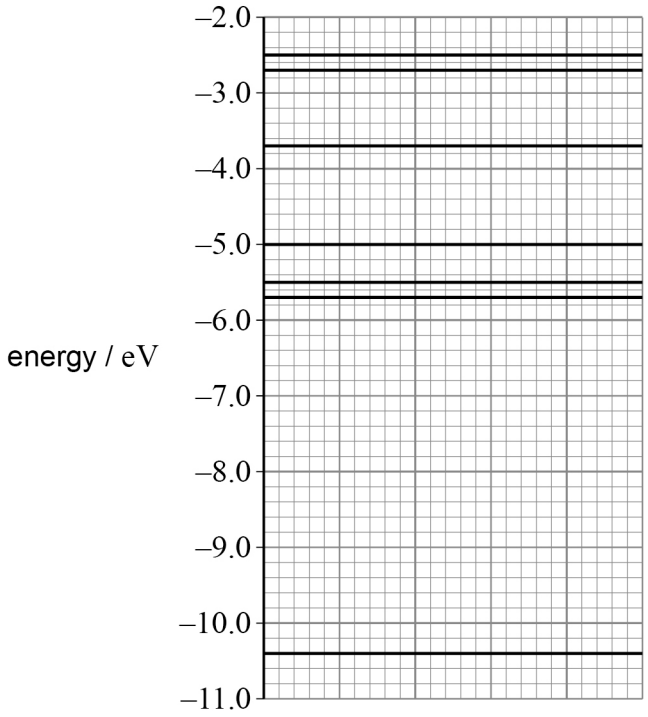
0 7 **Figure 6** shows some of the energy levels in an atom of mercury.

Figure 6



0 7 . 1 Explain why the energy levels are negative.

[2 marks]

0 7 . 2 Draw an arrow on **Figure 6** to represent the transition that leads to the emission of the **shortest** wavelength of light for these energy levels.

[1 mark]

Do not write outside the box

0 7 . 3 Calculate the wavelength that is consistent with the transition you chose in Question **07.2**.

[3 marks]

wavelength = _____ m

A fluorescent tube contains a low-pressure mercury gas.

0 7 . 4 Describe how the mercury atoms become excited in the fluorescent tube.

[2 marks]

0 7 . 5 Explain how the excitation of mercury atoms leads to the emission of white light from the fluorescent tube.

[3 marks]

11

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0 8 **Figure 7** shows two views of apparatus used to demonstrate double-slit interference using microwaves.

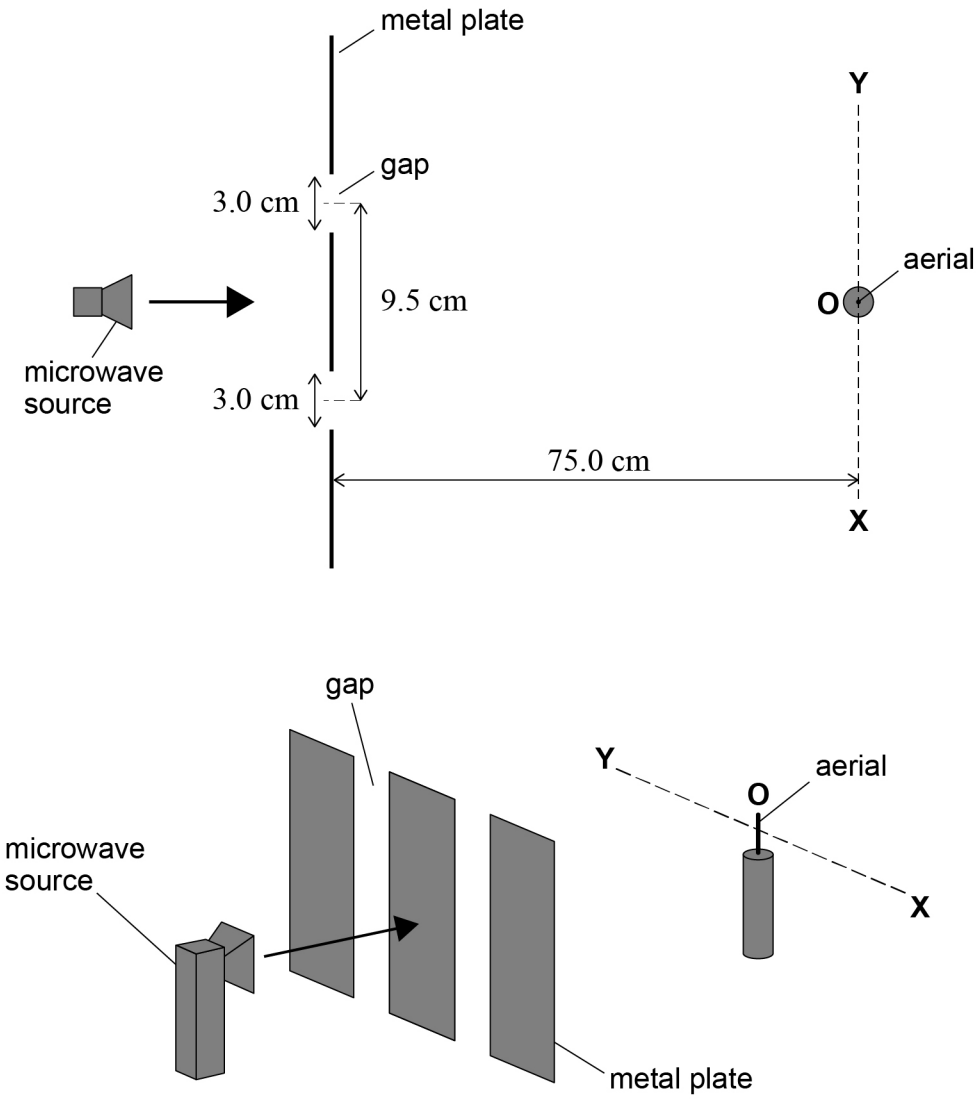
The apparatus includes a microwave source, three metal plates mounted vertically, and a rod-shaped aerial. The aerial is used to measure the intensity of microwaves.

The aerial is moved parallel to the plates along the line **XY** and the microwave intensity at different positions is measured.

O is the position of the central maximum.

Figure 7

not to scale



The 3.0 cm gaps between the plates act as a double slit. The distance between the centres of the slits is 9.5 cm.

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The aerial is placed at **O**, a perpendicular distance of $75.0\ \text{cm}$ from the slits. The aerial measures a maximum intensity.

The frequency of the microwaves is $11\ \text{GHz}$.

A student attempts to predict the distance w along **XY** between **O** and the next maximum.

She uses the equation $w = \dfrac{\lambda D}{s}$ to calculate w.

0 8 . 1 Calculate w, using this equation.

[2 marks]

$w =$ _____ m

0 8 . 2 Suggest why the use of this equation does **not** give an accurate value for w in this demonstration.

[1 mark]

_____

_____

_____

Question 8 continues on the next page

Turn over ►

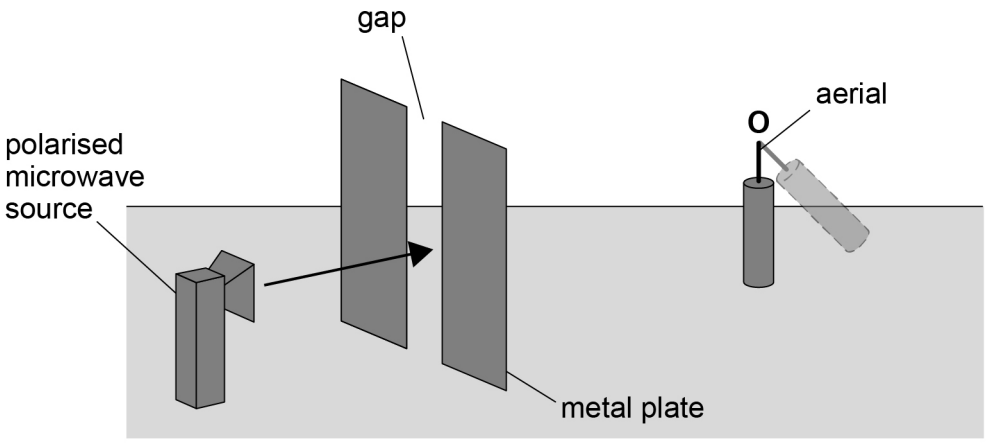
The same microwave source is used to demonstrate polarisation, as shown in **Figure 8**.

The source produces vertically polarised microwaves.

There is now just one gap between plates.

Figure 8

not to scale



The aerial is rotated at **O** in a plane parallel to the plates.
The intensity is measured at different angles of rotation from $0°$ to $360°$.

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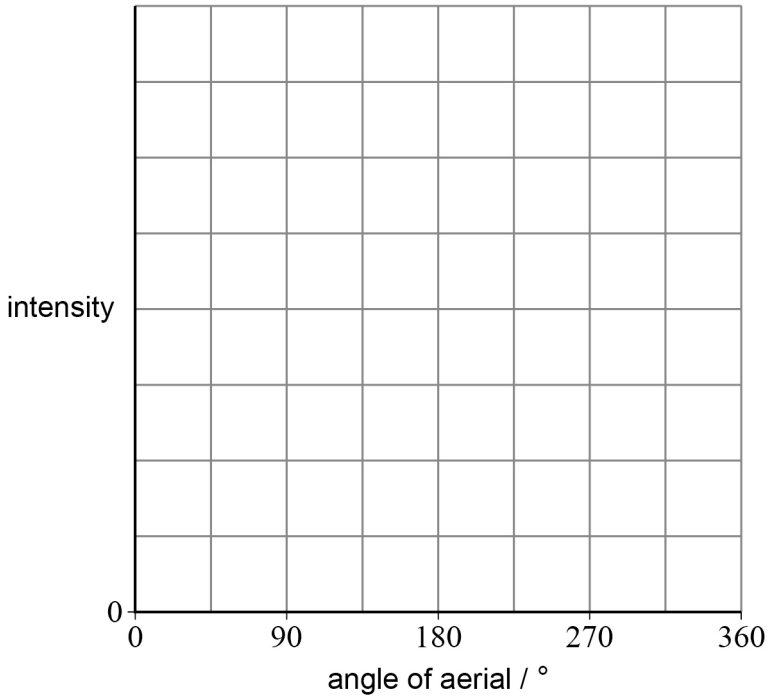
0 8 . 3 Sketch on **Figure 9** a line to show a relationship between the measured intensity and the angle of the aerial.

Label this line **A**.

Values are not required on the y-axis.

[1 mark]

Figure 9



0 8 . 4 Explain your answer to Question **08.3**.

[2 marks]

0 8 . 5 The microwave source is replaced with a new microwave source that produces unpolarised microwaves. These microwaves have the same intensity as those produced in **Figure 8**.
The experiment is then repeated.

Sketch on **Figure 9** a line to show the relationship between the measured intensity and the angle of the aerial for this experiment.

Label this line **B**.

[2 marks]

8

Turn over ►

Do not write outside the box

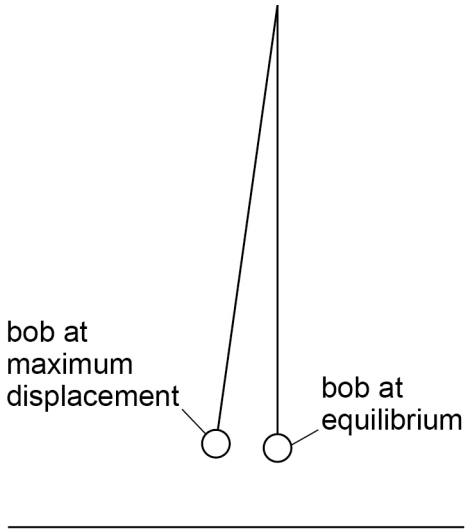
0 9 **Figure 10** shows a simple pendulum used by a student to determine the acceleration g due to gravity.

The pendulum is displaced and allowed to swing freely. The time taken for one oscillation is T.

The student intends to use a stopwatch to measure $10T$, the time for 10 oscillations, for several different lengths of pendulum.

The positions of the pendulum bob at equilibrium and at maximum displacement are shown.

Figure 10



0 9 . 1 Explain why the amplitude of the oscillation decreases with time.

[1 mark]

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0 9 . 2 The student uses a fiduciary marker to help him measure $10T$.

Annotate **Figure 10** with an **X** to show a suitable position for the fiduciary marker.

Go on to explain your choice of position.

[2 marks]

0 9 . 3 Explain the advantage of measuring $10T$ rather than directly measuring T.

[2 marks]

0 9 . 4 The student makes a mistake. He measures the time taken for 9 oscillations for each length, but records these times as $10T$.

Deduce the value of g obtained by the student.

[2 marks]

value of g = _____ m s^{-2}

7

END OF SECTION A

Turn over ►

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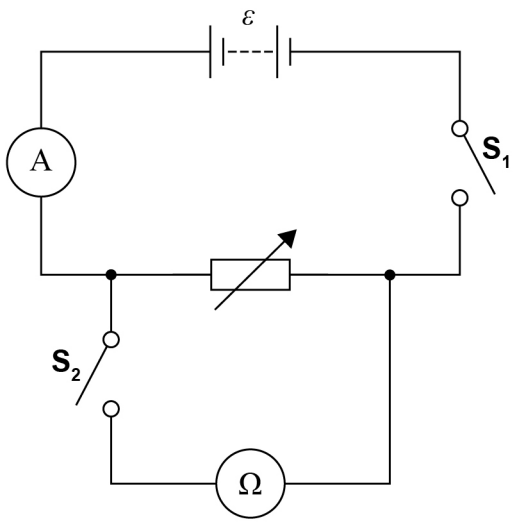
Section B

Answer **all** questions in this section.

1 0 A student uses the circuit shown in **Figure 11** to determine the emf ε and the internal resistance r of a battery.

Figure 11



A variable resistor is used as the load resistance R in the circuit. It is adjusted to obtain different values of R.

With S_1 open and S_2 closed, the value of R is set and measured using the ohmmeter. S_2 is now opened and then S_1 is closed, and the current I is recorded. This is repeated for different values of R.

Table 1 shows some of the student's data.

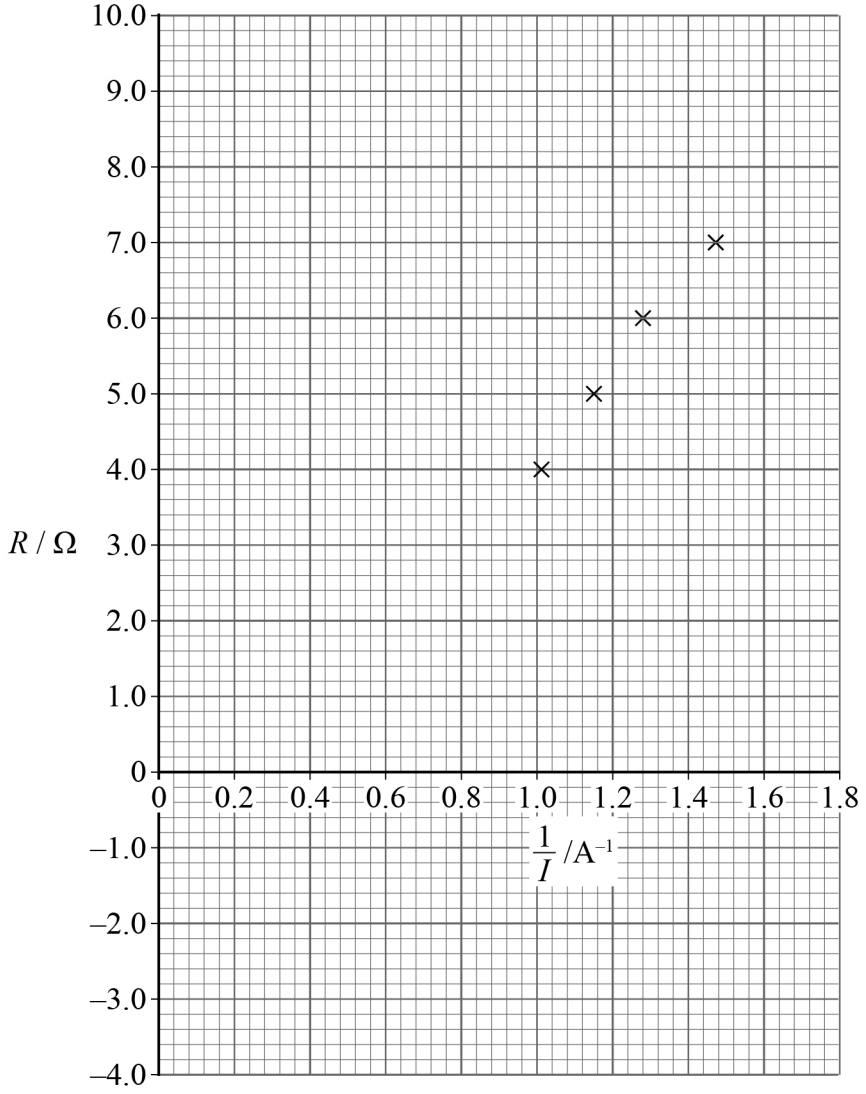
Table 1

R / Ω	I / A	$\frac{1}{I}$ / A^{-1}
4.0	0.991	1.01
5.0	0.872	1.15
6.0	0.781	1.28
7.0	0.680	1.47
8.0	0.611	
9.0	0.560	

Do not write outside the box

Figure 12 shows the first four points of a graph of R against $\frac{1}{I}$.

Figure 12



1 0 . 1 Complete **Table 1**.

Go on to plot the last two points on **Figure 12**.

[2 marks]

1 0 . 2 Draw on **Figure 12** a line of best fit.

You should extend your line to the y-axis.

[1 mark]

Question 10 continues on the next page

Do not write outside the box

1 0 . 3 Show algebraically that:

- gradient = ε
- y-intercept = $-r$.

[2 marks]

1 0 . 4 Determine ε and r.

[3 marks]

$\varepsilon =$ _____ V

$r =$ _____ Ω

8

Do not write outside the box

1 1 . 1 Explain how antinodes are formed in a stationary wave.

[3 marks]

Question 11 continues on the next page

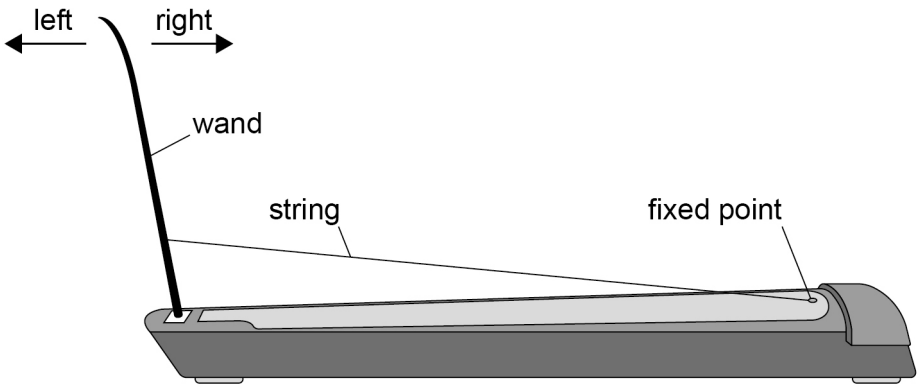
Do not write outside the box

Figure 13 shows a single-stringed musical instrument.

The string is fixed at one end and the other end of the string is attached to a long wooden rod called the wand.

The wand can be moved slightly to the left or right and the string is plucked (pulled quickly and then released) to make a sound.

Figure 13



When the wand is in its equilibrium position, and the middle of the string is plucked, the string vibrates at its first harmonic.

The frequency of the first harmonic is $131\ \text{Hz}$.

The length of the string is $0.84\ \text{m}$.

The mass per unit length of the string is $0.015\ \text{g cm}^{-1}$.

1 1 . 2 Calculate the tension in the string when the wand is in the equilibrium position.

[2 marks]

tension = _____ N

Do not write outside the box

1 1 . 3 When the string is plucked at a certain position, it creates an antinode at that position on the string.

When the string is plucked at a distance x from the wand, the second harmonic is heard.

Calculate x.

[1 mark]

$x =$ _____ m

1 1 . 4 The wand is pulled to the left and held. This produces a very small increase in the length of the string.

The middle of the string is plucked and the first harmonic is produced. The first harmonic now has a significantly higher frequency than 131 Hz.

Explain why a very small increase in the length of the string leads to a large increase in the frequency of the sound.

[2 marks]

_____

_____

_____

_____

_____

8

END OF SECTION B

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Section C

Each of the questions in this section is followed by four responses, **A**, **B**, **C** and **D**.

For each question select the best response.

Only **one** answer per question is allowed.
For each question, completely fill in the circle alongside the appropriate answer.

CORRECT METHOD 

WRONG METHODS 

If you want to change your answer you must cross out your original answer as shown. 

If you wish to return to an answer previously crossed out, ring the answer you now wish to select as shown. 

You may do your working in the blank space around each question but this will not be marked. Do **not** use additional pages for this working.

1 2 Superconducting wires can transport large currents without any loss of energy. Power transmission systems do **not** yet use superconducting wires.

This is because it is too expensive to:

[1 mark]

A cool the superconducting wires. ⬭

B generate the large currents. ⬭

C manufacture the superconducting wires. ⬭

D recycle the copper wires that are replaced. ⬭

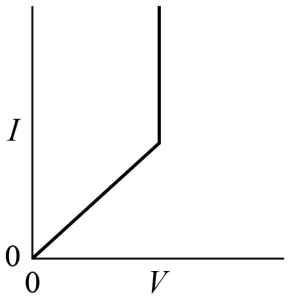
Do not write outside the box

1 3 An ideal semiconductor diode is connected in series with an ohmic resistor. A voltage is applied across the combination in the direction that allows current to flow.

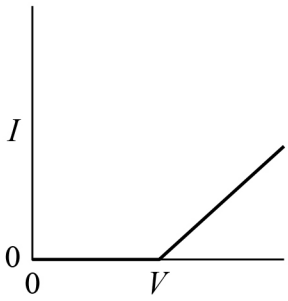
What is the variation of current I with applied voltage V for the combination?

[1 mark]

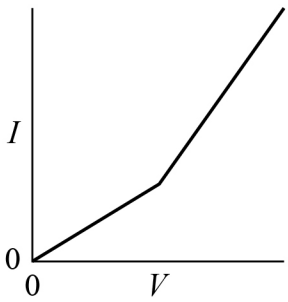
A



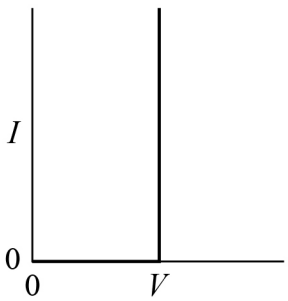
B



C



D



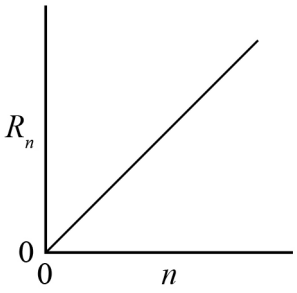
Do not write outside the box

1 4 A number n of identical resistors are connected in parallel. The overall resistance of the combination is R_n.

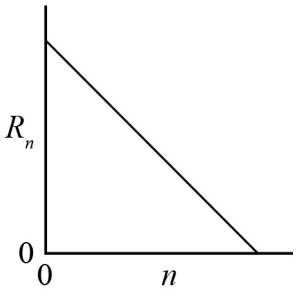
Which graph shows the variation of R_n with n?

[1 mark]

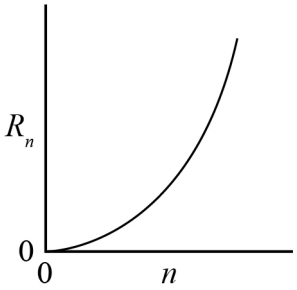
A



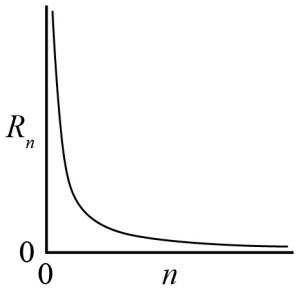
B



C



D



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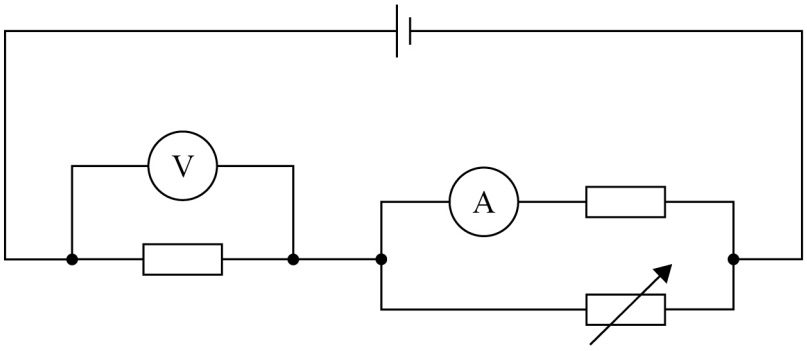
1 5 The circuit shown contains two fixed resistors, a variable resistor, and a cell with negligible internal resistance.



The resistance of the variable resistor is increased.

Which row shows what happens to the voltmeter reading and the ammeter reading?

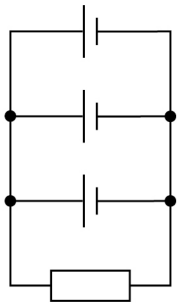
[1 mark]

	Voltmeter reading	**Ammeter reading**	
A	increases	stays the same	⬭
B	increases	increases	⬭
C	decreases	stays the same	⬭
D	decreases	increases	⬭

Turn over for the next question

Do not write outside the box

1 6 A resistor of resistance R and three identical cells of emf ε and internal resistance r are connected together as shown.



What is the potential difference across the resistor?

[1 mark]

A $\dfrac{\varepsilon R}{R+3r}$ ⬭

B $\dfrac{\varepsilon R}{3R+r}$ ⬭

C $\dfrac{3\varepsilon R}{R+3r}$ ⬭

D $\dfrac{3\varepsilon R}{3R+r}$ ⬭

1 7 A mass–spring system oscillates with frequency f.

The mass is increased by 21%.

What is the frequency of the new oscillation?

[1 mark]

A $0.83f$ ⬭

B $0.79f$ ⬭

C $0.91f$ ⬭

D $1.1f$ ⬭

Do not write outside the box

1 8 A spring of length $4.0\ \text{m}$ is used to demonstrate a longitudinal wave.

One end of the spring is moved back and forth. One oscillation is completed in a time of $0.40\ \text{s}$.
A compression produced by this movement takes $2.0\ \text{s}$ to travel the complete length of the spring.

What is the wavelength of the wave?

[1 mark]

A $0.40\ \text{m}$ ⬭

B $0.80\ \text{m}$ ⬭

C $1.6\ \text{m}$ ⬭

D $2.0\ \text{m}$ ⬭

1 9 A student is using a laser to investigate diffraction in a school laboratory.

Which procedure would **not** be suitable for this experiment?

[1 mark]

A using a laser with a wavelength in the visible part of the spectrum ⬭

B directing the lasers so that patterns are produced at eye level ⬭

C taking a photograph of the fringes next to a ruler ⬭

D projecting the laser light onto a wall ⬭

2 0 Two loudspeakers are used to demonstrate sound wave interference.

So that regions of maximum and minimum loudness are observed, the sounds from both speakers **must**:

[1 mark]

A be directed towards each other. ⬭

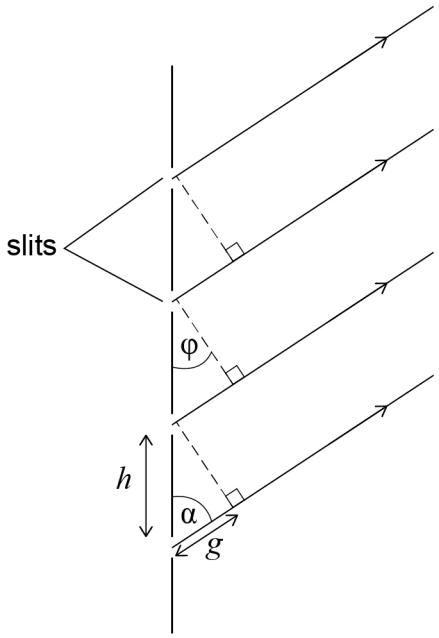
B have the same amplitude as each other. ⬭

C be coherent with each other. ⬭

D be directed parallel to each other. ⬭

Do not write outside the box

2 1 In the derivation of the diffraction grating equation $n\lambda = d \sin\theta$, a diagram is drawn similar to the one below. The arrows show the rays that meet to form the first-order maximum.



Which row shows the angle that is equal to θ and the distance that is equal to λ?

[1 mark]

	Angle equal to θ	Distance equal to λ	
A	φ	g	⬭
B	α	h	⬭
C	α	g	⬭
D	φ	h	⬭

Do not write outside the box

2 2 Electrons are accelerated through a potential difference of $6\ \mathrm{kV}$ and then directed at a metal target.

Which is **not** a possible consequence of the electrons hitting the target?

[1 mark]

A X-rays are produced. ⬭

B Photoelectrons are emitted. ⬭

C The temperature of the target increases. ⬭

D Photons are emitted. ⬭

2 3 Which can ionise an atom?

[1 mark]

A fast-moving electrons ⬭

B infrared radiation ⬭

C microwaves ⬭

D neutrinos ⬭

Turn over for the next question

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2 4 Monochromatic light from a source **L1** is shone on a metal surface, causing electrons to be emitted.

The light has frequency f and the power of **L1** is P.

The stopping potential of the electrons and the rate of emission of the electrons are measured.

L1 is replaced with a different monochromatic light source **L2**. The stopping potential of the electrons is unchanged and the rate of emission of the electrons doubles.

Which row is correct?

[1 mark]

	Frequency of light from L2	**Power of L2**	
A	f	$2P$	⬭
B	$2f$	P	⬭
C	$2f$	$2P$	⬭
D	$\frac{f}{2}$	P	⬭

2 5 Which statement is correct?

[1 mark]

A The photoelectric effect demonstrates the wave-like behaviour of electrons. ⬭

B The photoelectric effect demonstrates the particle-like behaviour of light. ⬭

C The diffraction of electrons demonstrates the particle-like behaviour of electrons. ⬭

D The diffraction of electrons demonstrates the wave-like behaviour of light. ⬭

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END OF QUESTIONS

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