OXFORD

INTERNATIONAL
AQA EXAMINATIONS

Please write clearly in block capitals.

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

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Candidate signature _____

I declare this is my own work.

INTERNATIONAL AS
PHYSICS

Unit 2 Electricity, waves and particles

Monday 9 January 2023 07:00 GMT 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 Describe the nature of transverse waves.

[2 marks]

2

0 2 Superconductors can be used in the electromagnets in some types of train.

0 2 . 1 Explain what is meant by a superconductor.

[2 marks]

0 2 . 2 Explain why superconductors are used in these electromagnets.

[2 marks]

4

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0 3 The critical angle for light travelling from diamond to air is 24°.
The critical angle for light travelling from glass to air is 42°.

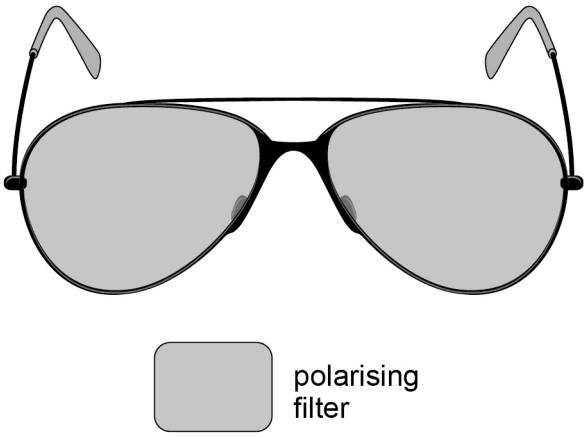
Explain what can be deduced about the relative values of the refractive index of diamond and the refractive index of glass.

[2 marks]

2

0 4 **Figure 1** shows sunglasses that have polarising lenses. The sunglasses are sold with a separate small polarising filter.

Figure 1



State and explain how the filter can be used to check that the lenses are polarising.

[3 marks]

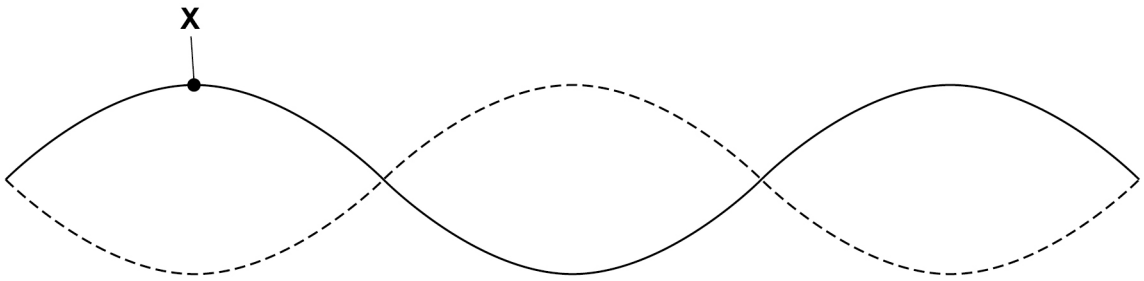
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0 5 **Figure 2** represents a stationary wave. **X** marks the position of an antinode.

Figure 2



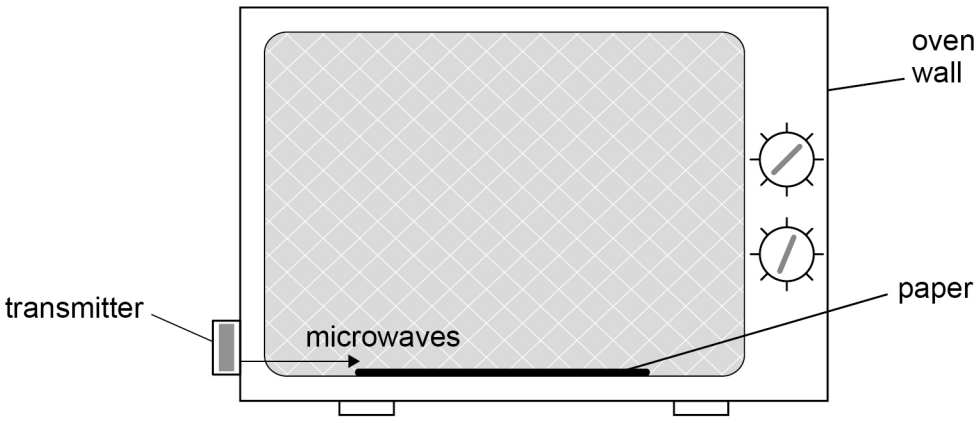
0 5 . 1 Explain how the antinode is produced.

[2 marks]

0 5 . 2 A student determines the speed of microwaves in a microwave oven from which the turntable has been removed. Stationary waves are formed in the oven.

The student has paper that changes colour above a certain temperature. The paper is placed on the floor of the oven as shown in **Figure 3**.

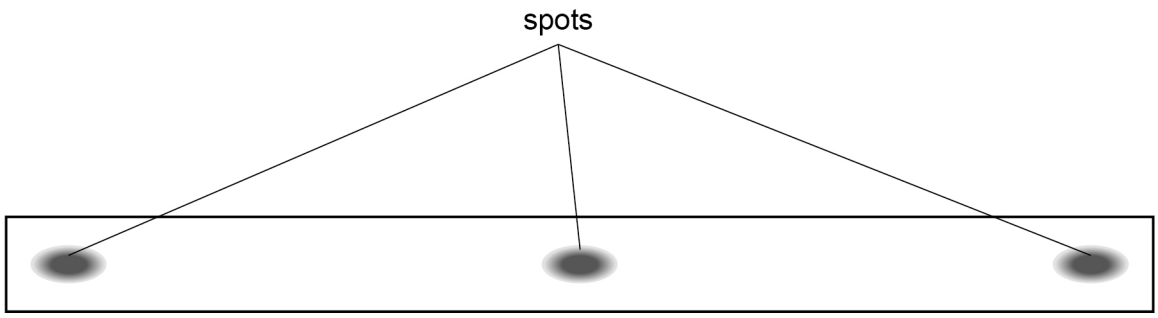
Figure 3



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The student switches on the oven for a short time and then removes the paper. **Figure 4** shows the paper at actual size. There are three spots where the paper has changed colour.

Figure 4



The frequency of the emitted microwaves is 2.45 GHz.

Determine the speed of the microwaves in the oven by taking measurements from **Figure 4**.

[3 marks]

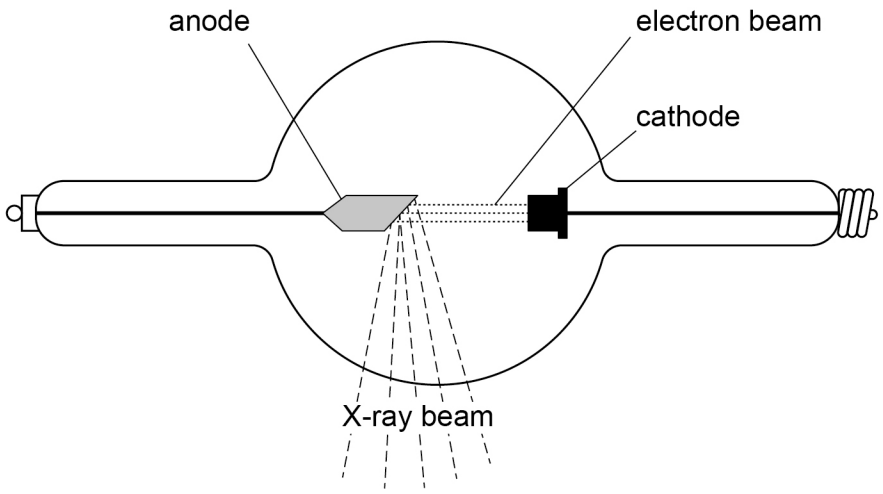
speed = _____ $m\ s^{-1}$

5

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0 6 **Figure 5** shows the main parts of an X-ray tube. Electrons are emitted at the cathode and accelerated onto the anode.

Figure 5



The operating voltage between the anode and the cathode is $80\ \text{kV}$.
The tube current is $100\ \text{mA}$.
The tube is switched on for an operating period of $5.0\ \text{ms}$.

0 6 . 1 Calculate the number of electrons that reach the anode during this operating period.
[2 marks]

number of electrons = _____

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0 6 . 2 Energy that is not emitted in the form of photons is transferred to internal energy. The efficiency of the X-ray tube is 2.0%.

Calculate the increase in internal energy of the anode.

[3 marks]

increase in internal energy = _____ J

0 6 . 3 The tube current is now increased. The operating voltage and the operating period are unchanged.

State and explain any effect that the increased tube current has on the X-rays produced.

[3 marks]

_____

_____

_____

_____

_____

_____

_____

8

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0 7 The following equation applies to the photoelectric effect:

$$hf = \phi + E_{k(max)}$$

0 7 . 1 State what quantities are represented by the terms hf and $E_{k(max)}$.

[2 marks]

hf _____

_____

$E_{k(max)}$ _____

_____

0 7 . 2 State and explain what is represented by the term ϕ.

[2 marks]

_____

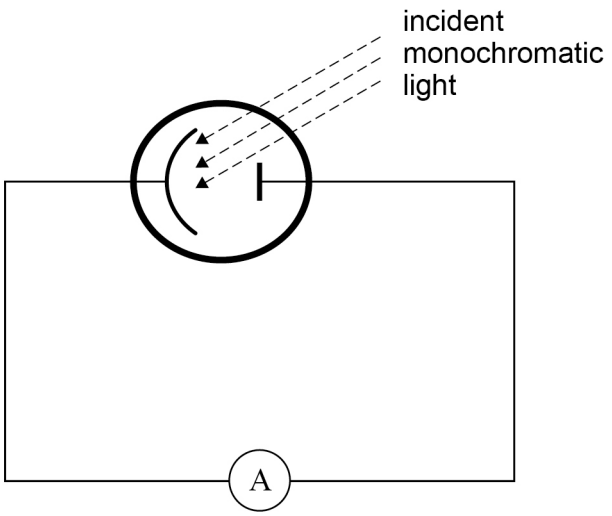
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Figure 6 shows a circuit used to investigate the photoelectric effect. The ammeter can measure very small currents.

Figure 6



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Monochromatic red light is incident on the metal surface of the cathode and the current in the ammeter is zero.

The red light is replaced with monochromatic blue light and there is a current in the ammeter.

0 7 . 3 Explain why there is a current with blue light but not with red light.

[2 marks]

0 7 . 4 The intensity of the monochromatic blue light is increased and the experiment is repeated.

State and explain any change in the current.

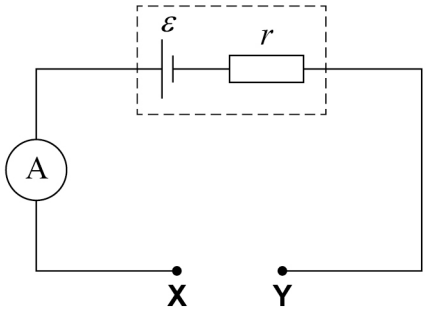
[3 marks]

9

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0 8 **Figure 7** shows a circuit used by a student to determine the emf ε and internal resistance r of a cell.

Figure 7

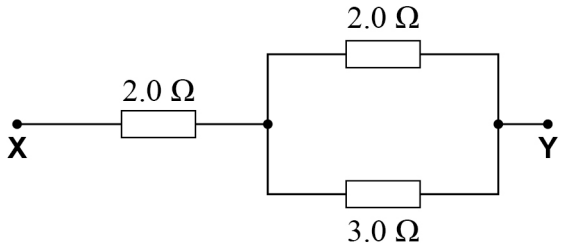


An external resistance R can be connected between **X** and **Y**. Its value can be changed by using different combinations of resistors.

She uses a combination of resistors to make a network with resistances ranging from $1.0\ \Omega$ to $8.0\ \Omega$.

Figure 8 shows one of these networks inserted between **X** and **Y** in the circuit.

Figure 8



0 8 . 1 Calculate the resistance between **X** and **Y** in **Figure 8**.

[2 marks]

resistance = _____ Ω

Do not write outside the box

The student measures the current I in the ammeter for each value of R and plots a graph of $\frac{1}{I}$ against R.

0 8 . 2 Show that

$$\frac{1}{I} = \frac{R}{\varepsilon} + \frac{r}{\varepsilon}$$

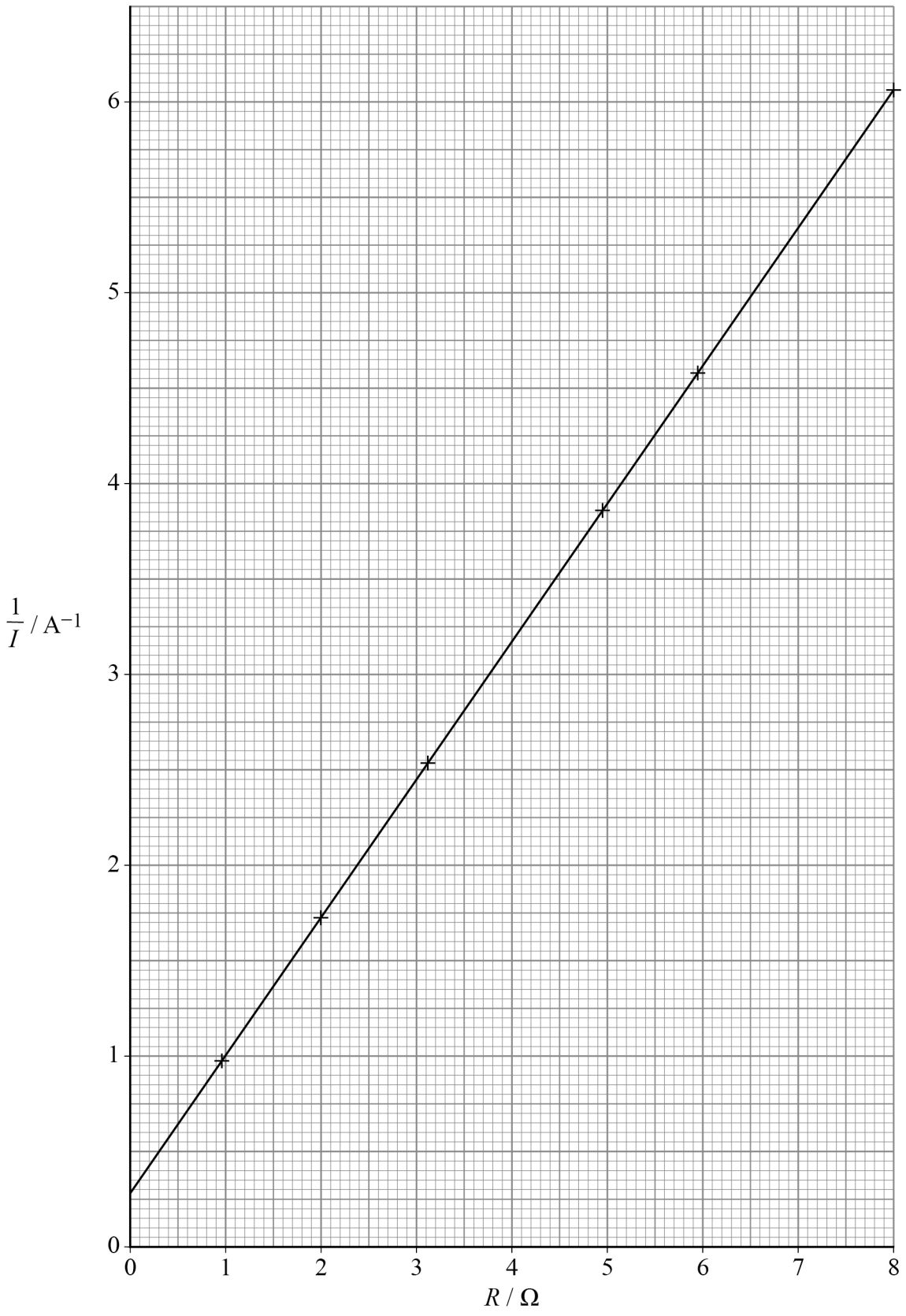
[1 mark]

Question 8 continues on the next page

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Figure 9 shows the student's graph.

Figure 9



Do not write outside the box

0 8 . 3 Determine ε.

[3 marks]

$\varepsilon =$ _____ V

0 8 . 4 Determine r.

[3 marks]

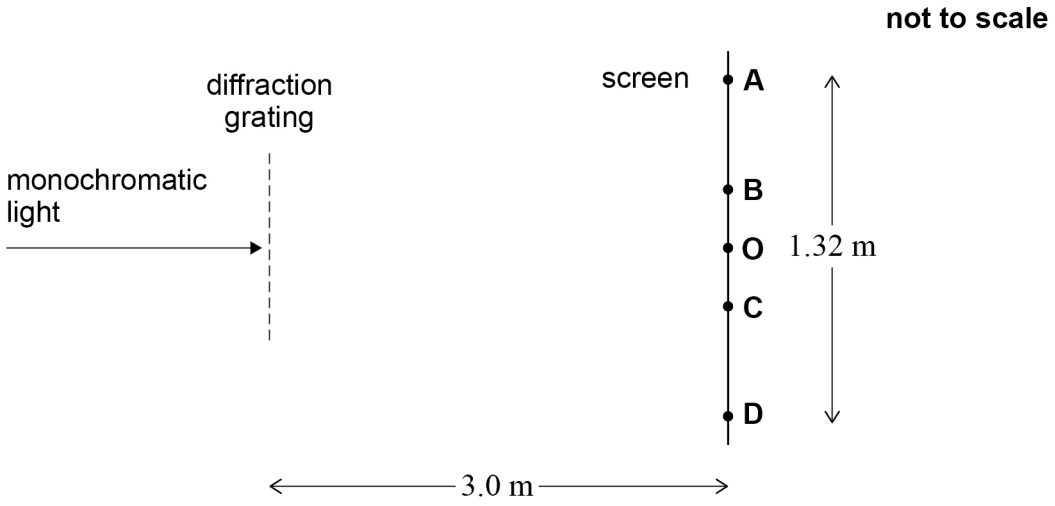
$r =$ _____ Ω

9

Do not write outside the box

0 9 A screen is placed $3.0\ \text{m}$ from a diffraction grating as shown in **Figure 10**. The screen and grating are parallel.

Figure 10



Monochromatic light of wavelength $540\ \text{nm}$ is incident normally on the diffraction grating. The central maximum appears on the screen at **O**. The first-order and second-order maxima on each side of **O** are seen at positions **A**, **B**, **C** and **D**.

The distance between **A** and **D** is $1.32\ \text{m}$.

0 9 . 1 Show that the angle between the two second-order maxima is approximately $25°$.

[2 marks]

Do not write outside the box

0 9 . 2 Calculate the number of lines per mm on the grating.

[3 marks]

number of lines per mm = _____

0 9 . 3 The incident light is now replaced with monochromatic light of a different wavelength.

More maxima are observed on the screen.

State and explain any other change in the appearance of the pattern on the screen.

[3 marks]

_____

_____

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8

END OF SECTION A

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ANSWER IN THE SPACES PROVIDED

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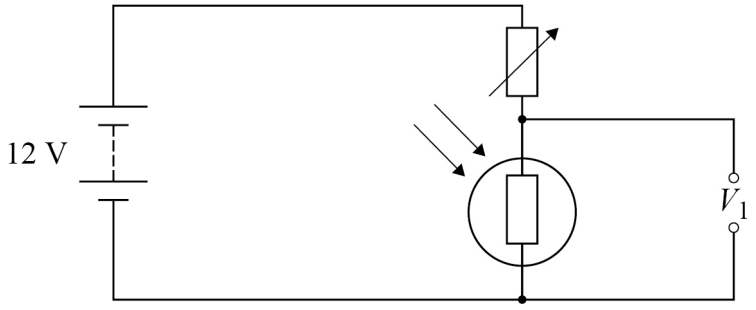
Section B

Answer **all** questions in this section.

1 0 Many cars have headlamps that switch on automatically when light levels become too low.

Figure 11 is a circuit diagram showing a light dependent resistor (LDR) being used as a light-detecting sensor. The output voltage V_1 from the circuit is used to control the headlamps.

Figure 11



The resistance of the variable resistor can be adjusted to change the light level at which the headlamps switch on.

The system is set to switch the headlamps on when the power of the light incident on the LDR is less than or equal to $12\ \text{mW}$.

1 0 . 1 The wavelength of the photons incident on the LDR is $550\ \text{nm}$.

Calculate the number of photons incident on the LDR in one second when the headlamps just switch on.

[3 marks]

number of photons in one second = _____

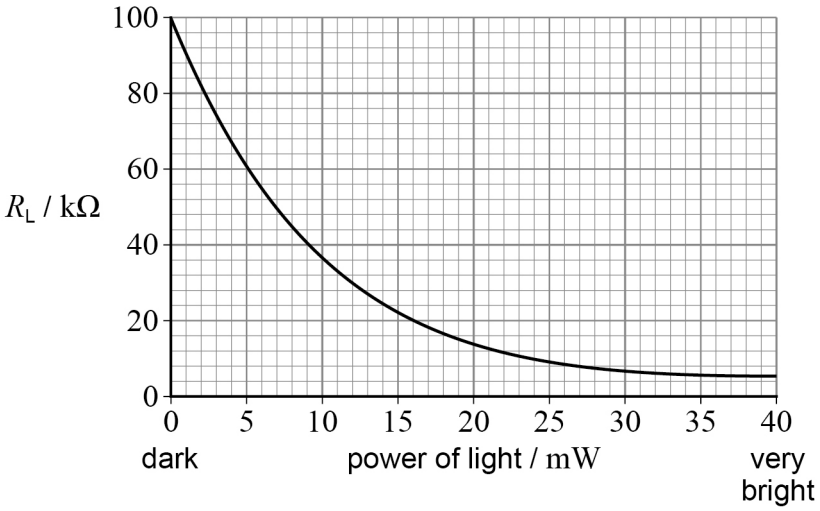
Question 10 continues on the next page

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Figure 12 shows how the resistance R_L of the LDR varies with the power of the light incident on it.

Figure 12



1 0 . 2 V_1 must be at least 8.0 V for the headlamps to switch on.

Determine the resistance of the variable resistor for the headlamps to switch on when the power of the light is 12 mW.

[2 marks]

resistance = _____ Ω

Do not write outside the box

1 0 . 3 An engineer wants to adjust the circuit so that the headlamps switch on when the light levels are greater.

State and explain what adjustment is necessary.

[3 marks]

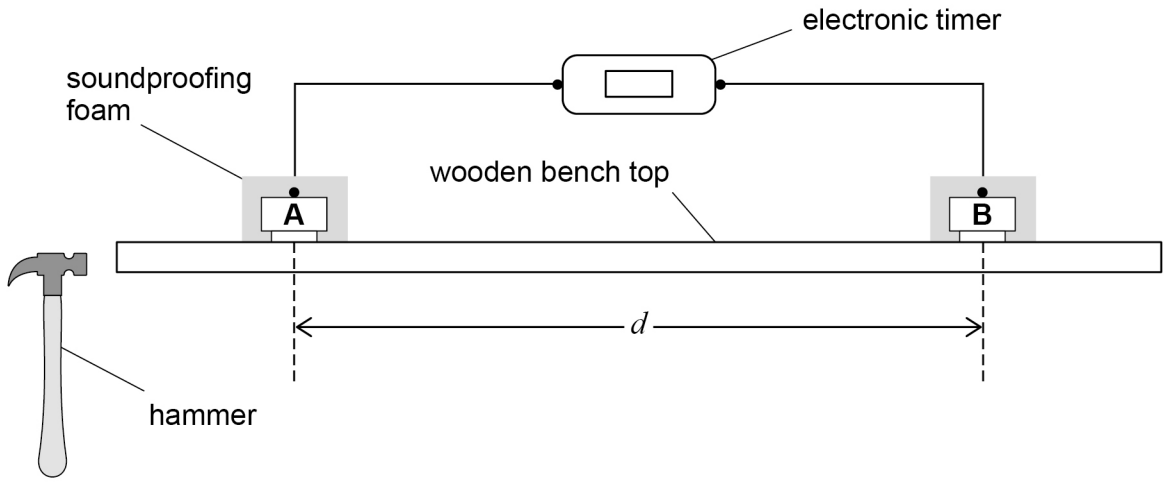
8

Turn over for the next question

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1 1 **Figure 13** shows the apparatus used in an experiment to measure the speed v of sound in wood.

Figure 13



Two microphones **A** and **B**, separated by distance d, are firmly clamped face-down to the wooden bench top.

The microphones are covered with soundproofing foam and connected to an electronic timer.

The end of the bench top is struck sharply with the hammer to produce a pulse of sound which travels through the wood. The timer starts when this pulse is detected by **A**. The timer stops when the same pulse is detected by **B**.

The timer records the time t taken by the sound pulse to travel from **A** to **B**.

1 1 . 1 Explain why soundproofing foam is used to cover the microphones.

[1 mark]

Do not write outside the box

The measurement of t is repeated several times. **Table 1** shows the recorded values of t.

Table 1

t / µs	174	196	201	179	204

1 1 . 2 Calculate the mean value of t.

[1 mark]

mean value of t = _____ µs

1 1 . 3 Estimate the absolute uncertainty in your mean value of t.

[1 mark]

absolute uncertainty in t = _____ µs

1 1 . 4 The distance d is 0.75 m.

Calculate v.

[1 mark]

v = _____ m s^{-1}

Question 11 continues on the next page

Do not write outside the box

1 1 . 5 The absolute uncertainty in d is $\pm\ 0.01\ \text{m}$.

Estimate the percentage uncertainty in v.

[2 marks]

percentage uncertainty in v = _____

1 1 . 6 An increase in the value of d reduces the percentage uncertainty in its measurement. This increase in d also increases the value of t.

Suggest why increasing d may **not** lead to a more accurate measurement of v.

[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 Light of wavelength $480\ \text{nm}$ travels as a pulse in air.
The duration of the pulse is $10\ \mu\text{s}$.

How many complete waves does the pulse contain?

[1 mark]

A 6.25×10^{9} ⬭

B 6.25×10^{12} ⬭

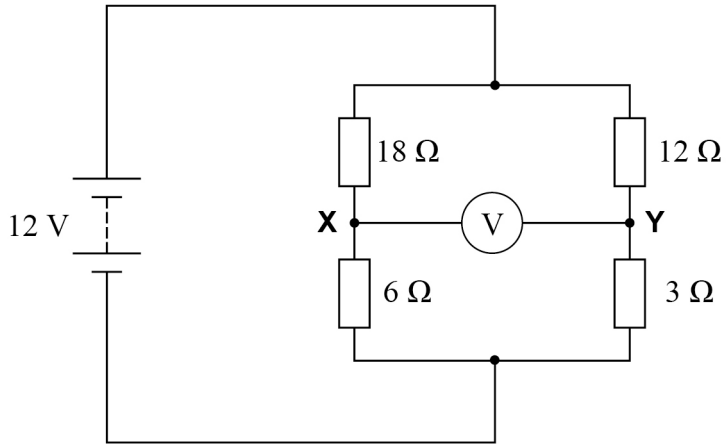
C 6.25×10^{14} ⬭

D 6.25×10^{19} ⬭

Turn over for the next question

Do not write outside the box

1 3 The diagram shows a battery of emf 12 V and negligible internal resistance connected across a network of resistors.



When a voltmeter is connected across **X** and **Y** the reading is

[1 mark]

A 0.6 V. ⬭

B 6.0 V. ⬭

C 9.0 V. ⬭

D 9.6 V. ⬭

1 4 A mass on a spring oscillates freely at frequency f.

What is the frequency when the mass on the spring is doubled?

[1 mark]

A $0.5f$ ⬭

B $0.7f$ ⬭

C $1.4f$ ⬭

D $2.0f$ ⬭

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1 5 The cladding in optical fibres

[1 mark]

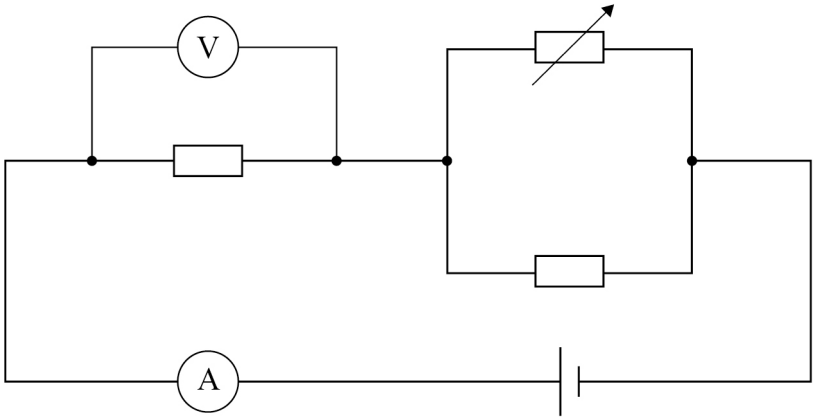
A has a higher refractive index than the core. ⬭

B reduces material dispersion inside the core. ⬭

C increases modal dispersion inside the core. ⬭

D increases the critical angle at the surface of the core. ⬭

1 6 A student notes the readings on the ammeter and voltmeter.



The resistance of the variable resistor is then decreased.

Which row shows the changes to the readings on the ammeter and the voltmeter?

[1 mark]

	Ammeter reading	Voltmeter reading	
A	decreases	decreases	⬭
B	increases	increases	⬭
C	increases	decreases	⬭
D	decreases	increases	⬭

Do not write outside the box

1 7 A metal wire **X** has a resistance R.
A second wire **Y** of the same metal has twice the length and half the diameter of **X**.

What is the resistance of **Y**?

[1 mark]

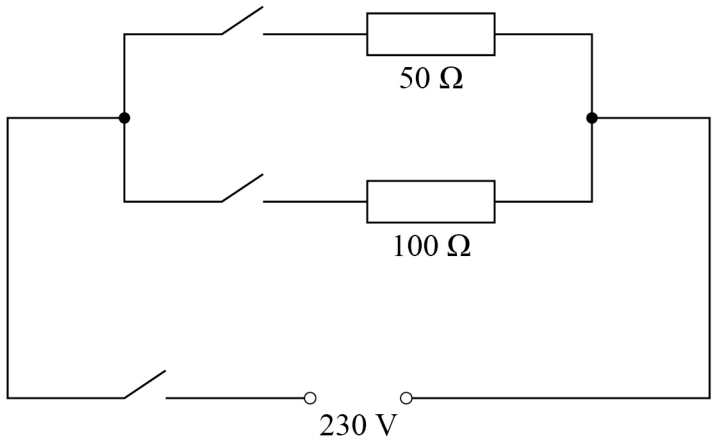
A R ⬭

B $2R$ ⬭

C $4R$ ⬭

D $8R$ ⬭

1 8 A heater consists of two resistors, one with a resistance of $50\ \Omega$ and the other with a resistance of $100\ \Omega$. The resistors are connected in parallel across a $230\ \text{V}$ supply. Each resistor can be switched on or off independently.



What is the maximum power available from the heater?

[1 mark]

A 530 W ⬭

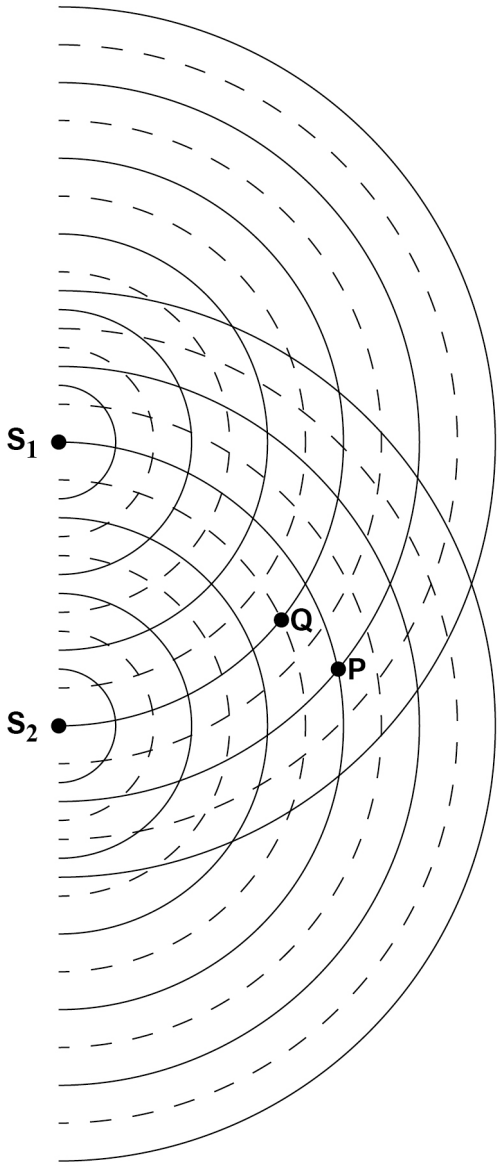
B 1100 W ⬭

C 1600 W ⬭

D 2100 W ⬭

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1 9 The diagram shows wave fronts from two sources S_1 and S_2.
The peaks of the waves are represented by dashed lines – – – – –.
The troughs of the waves are represented by continuous lines ——— .



P and **Q** show two points where the waves superpose.

Which is correct?

[1 mark]

A The waves arrive in phase at **Q**. ⬭

B The waves interfere destructively at **P**. ⬭

C The amplitude is a minimum at **Q**. ⬭

D The path difference is an odd number of wavelengths at **Q**. ⬭

Turn over ►

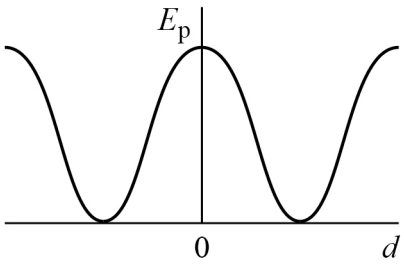
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2 0 A simple pendulum is displaced and allowed to oscillate freely.

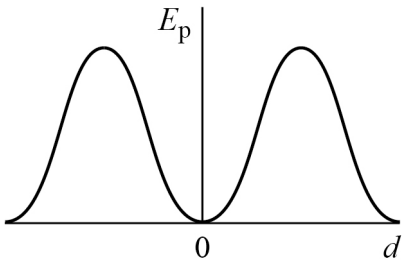
Which graph shows how the potential energy E_p varies with displacement d from the pendulum's equilibrium position?

[1 mark]

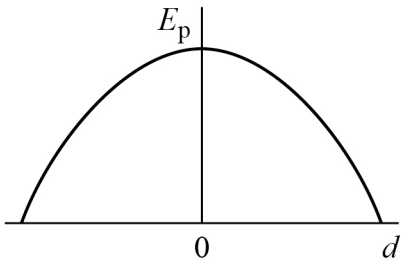
A



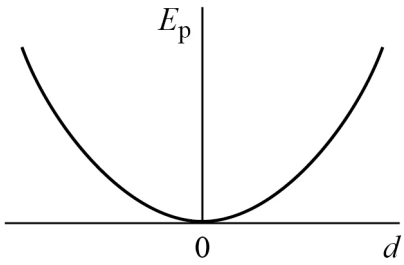
B



C



D



A ⬭

B ⬭

C ⬭

D ⬭

2 1 Which is **not** a unit for potential difference?

[1 mark]

A $\mathrm{J\,C^{-1}}$ ⬭

B $\mathrm{J\,s^{-1}\,A^{-1}}$ ⬭

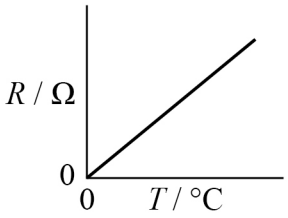
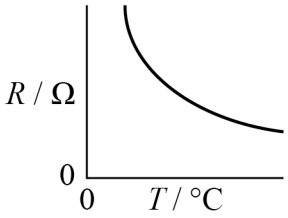
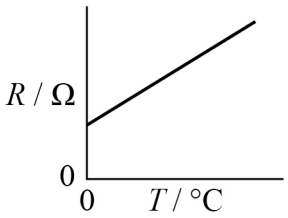
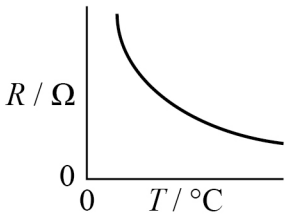
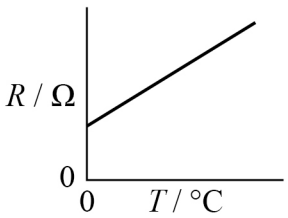
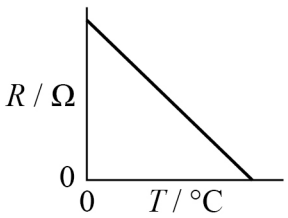
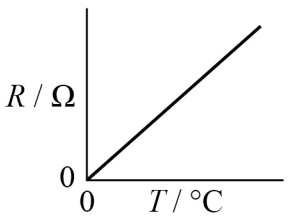
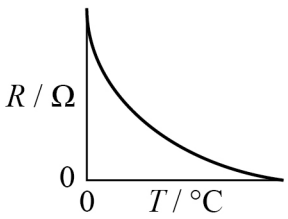
C $\mathrm{A\,\Omega}$ ⬭

D $\mathrm{C\,\Omega\,s}$ ⬭

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2 2 Which pair of graphs shows the variation of resistance R with temperature T for a metal wire and for a thermistor?

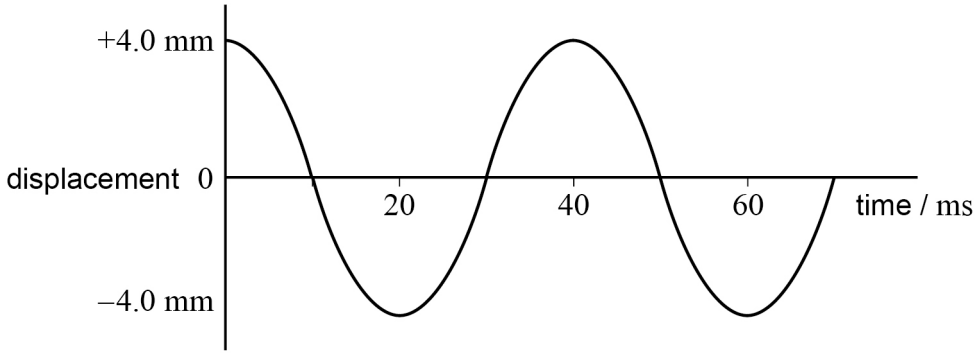
[1 mark]

	metal wire	thermistor	
A			⬭
B			⬭
C			⬭
D			⬭

Turn over for the next question

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2 3 The diagram shows how the displacement of a particle in a progressive wave varies with time.



Which row gives the amplitude and frequency of the wave?

[1 mark]

	Amplitude / mm	Frequency / Hz	
A	4.0	25	⬭
B	8.0	25	⬭
C	4.0	40	⬭
D	8.0	40	⬭

2 4 A pendulum has length L and period T.
When L is increased by 1.5 m the period becomes $2T$.

What is L?

[1 mark]

A 0.30 m ⬭

B 0.38 m ⬭

C 0.50 m ⬭

D 0.75 m ⬭

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2 5 An alpha particle moving at a speed v has de Broglie wavelength λ.

What is the de Broglie wavelength of a proton moving at a speed $2v$?

[1 mark]

A $\frac{\lambda}{4}$ ⬭

B $\frac{\lambda}{2}$ ⬭

C 2λ ⬭

D 4λ ⬭

14

END OF QUESTIONS

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