OXFORD

INTERNATIONAL AQA EXAMINATIONS

Please write clearly in block capitals.

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

Surname _____

Forename(s) _____

Candidate signature _____

INTERNATIONAL AS

PHYSICS (9630)

Unit 2: Electricity, waves and particles

Thursday 25 May 2017 Morning Time allowed: 2 hours

Y

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.

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.
- 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 the spaces provided.

0 1 During a lightning strike, 9.4×10^{18} electrons move from a cloud to the ground in a time of $18\ \mu s$.

0 1 . 1 Calculate the current in the lightning strike due to the transfer of electrons.

[2 marks]

current = _____ A

0 1 . 2 State the direction of the conventional current during this lightning strike.

[1 mark]

_____

_____

3

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0 2 A student investigates a simple pendulum. The results of the investigation are shown in **Table 1**.

Table 1

Time for 10 oscillations / s			
Reading 1	**Reading 2**	**Reading 3**	**Reading 4**
14.4	13.0	14.6	14.2

0 2 . 1 Calculate the most appropriate value for the period of the pendulum.

[2 marks]

period = _____ s

0 2 . 2 Calculate the length of the simple pendulum.

[2 marks]

length = _____ m

4

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0 3 . 1 State **one** piece of evidence which supports the view that electrons can exhibit wave properties.

[1 mark]

0 3 . 2 An electron has a kinetic energy of 1.02×10^{-24} J.

Show that the speed of this electron is about 1500 m s^{-1}.

[2 marks]

0 3 . 3 Calculate the de Broglie wavelength of the electron in Question **03.2**.

[2 marks]

wavelength = _____ m

5

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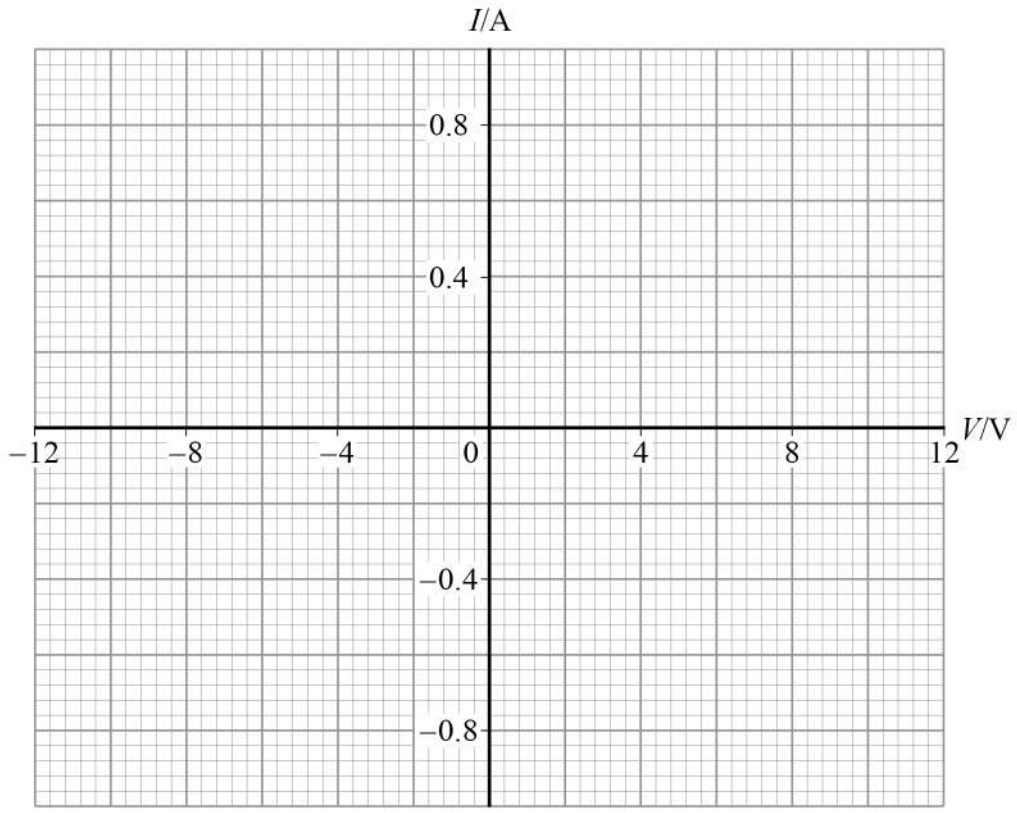
0 4 A filament lamp rated $12\ \text{V}, 0.8\ \text{A}$ has a resistance of $5.0\ \Omega$ when the current is very small.

Sketch, on the axes below, the current–voltage (I–V) characteristic for this lamp.

[4 marks]



4

Turn over for the next question

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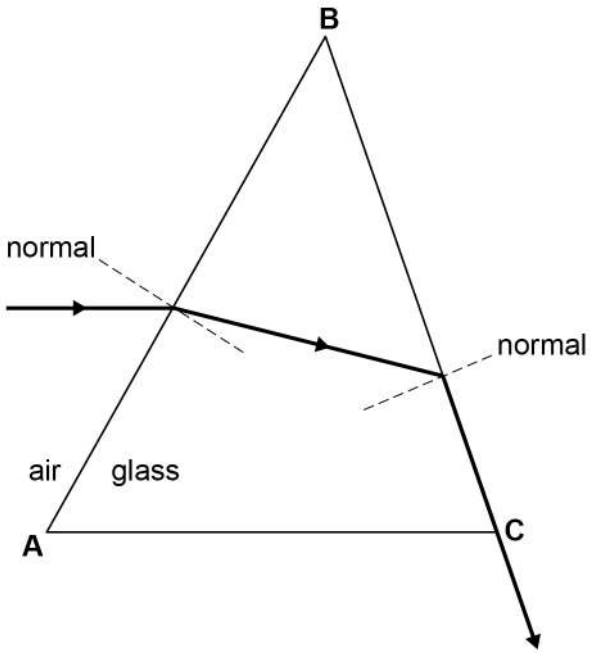
0 5 **Figure 1** shows a ray of light passing from air into a glass prism. The ray emerges from face **BC**.

The refractive index of the glass is 1.55

Figure 1



0 5 . 1 Mark, with the symbol θ_c, the critical angle on **Figure 1**.

[1 mark]

0 5 . 2 Calculate θ_c.

[2 marks]

θ_c = _____ degrees

Do not write outside the box

0 5 . 3 Calculate the speed of light in the glass prism.

[2 marks]

speed = _____ m s^{-1}

5

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0 6 **Figure 2** shows a simplified circuit for the main lights on a car. The battery has an emf of 12 V and no internal resistance.

Figure 2

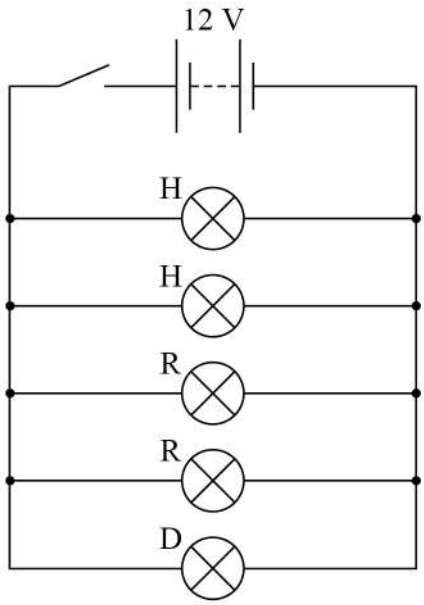

Table 2 gives data about the lamps used in the circuit. The resistance values are correct when each lamp is at its operating voltage.

Table 2

Lamp	Operating voltage / V	Resistance / Ω
H, headlight lamp	12	3.5
R, rear lamp	12	5.8
D, dashboard lamp	12	74

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0 6 . 1 Calculate the power of a single headlight lamp when operating at 12 V.

[2 marks]

power = _____ W

0 6 . 2 Calculate the resistance of the combination of lamps when operating at 12 V.

[3 marks]

resistance = _____ Ω

5

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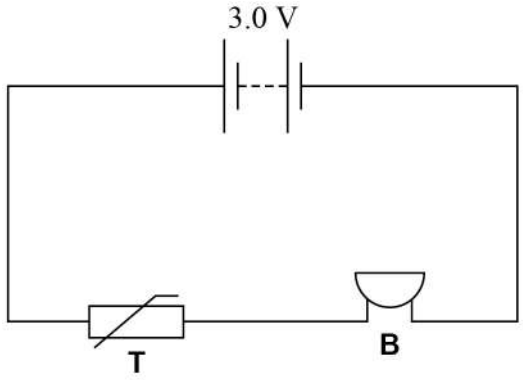
0 7 **Figure 3** shows a thermistor **T** used in an alarm circuit for a refrigerator. The alarm is designed to sound a buzzer **B** when the temperature exceeds a threshold value. **B** has a constant resistance of $123\ \Omega$.

The battery has a negligible internal resistance.

Figure 3



The buzzer sounds when the potential difference across it is greater than $1.8\ \text{V}$.

0 7 . 1 Explain why the potential difference across the buzzer increases when the temperature increases.

[3 marks]

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0 7 . 2 Show that, when the potential difference across the buzzer is $1.8\ \text{V}$, the resistance of the thermistor is about $80\ \Omega$.

[2 marks]

Question 7 continues on the next page

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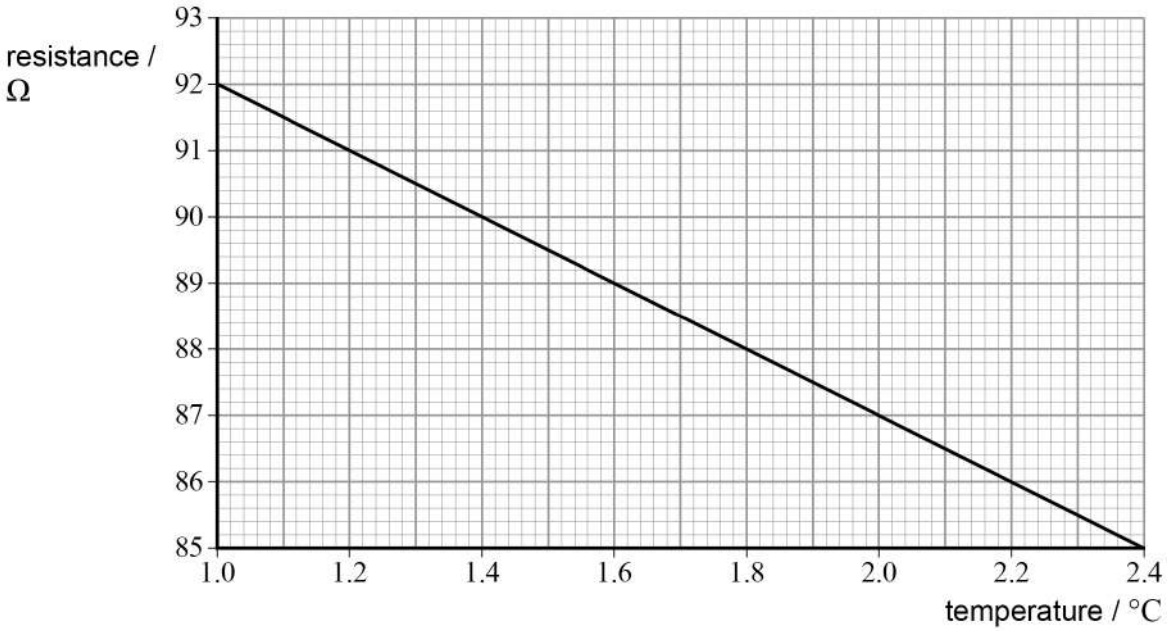
Figure 4 shows how the resistance of the thermistor varies with temperature over a small range of temperatures.

Figure 4



0 7 . 3 Calculate the gradient of the graph.

[2 marks]

gradient = _____ $\Omega\ K^{-1}$

0 7 . 4 Determine the temperature at which the buzzer will start to sound.
Assume that the gradient of the graph remains constant when the temperature rises above 2.4 °C.

[1 mark]

temperature = _____ °C

8

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ANSWER IN THE SPACES PROVIDED

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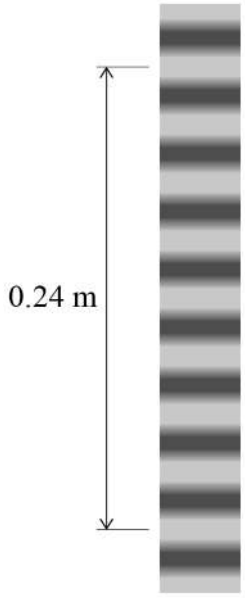
0 8 The interference of light can be observed on a screen when a set of double slits is illuminated using a suitable light source.

Figure 5 shows the interference pattern observed on the screen.

Figure 5



0 8 . 1 Explain how the interference pattern shown in **Figure 5** is formed.

[3 marks]

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0 8 . 2 The distance from the double slits to the screen is $3.5\ \text{m}$. The spacing of the double slits is $7.3 \times 10^{-5}\ \text{m}$.

Calculate the wavelength of the light used to illuminate the slits.

[3 marks]

wavelength = _____ m

Question 8 continues on the next page

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0 8 . 3 Describe how you would perform an experiment to make an accurate measurement of the wavelength of monochromatic light. Your experiment should be based on a double-slit interference technique. Your answer should discuss:

- the choice of apparatus
- the experimental setup
- how the apparatus is used.

[4 marks]

10

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0 9 A fuse wire is a short piece of wire in series with a component in a circuit. The fuse wire is designed to melt and act as a circuit breaker when the current exceeds a safe level. A lighting technician needs to choose a fuse wire for a spotlight that normally operates at $11\ \text{A}$. He can choose from two types of fuse wire, **A** and **B**, shown in **Table 3**. Each fuse wire is $1.2\ \text{cm}$ long.

Table 3

Fuse wire	Metal	Resistivity / …….	Cross-sectional area / m^2	Power required to melt fuse wire / W
A	Zinc	5.5×10^{-8}	1.8×10^{-8}	2.4
B	Silver	1.6×10^{-8}	9.5×10^{-9}	2.7

0 9 . 1 Complete **Table 3** with the SI unit of resistivity.

[1 mark]

0 9 . 2 Determine which fuse wire should be used for the spotlight.

[4 marks]

fuse wire = _____

0 9 . 3 Suggest **one** other factor that might influence the technician's choice.

[1 mark]

_____

_____

6

Turn over ►

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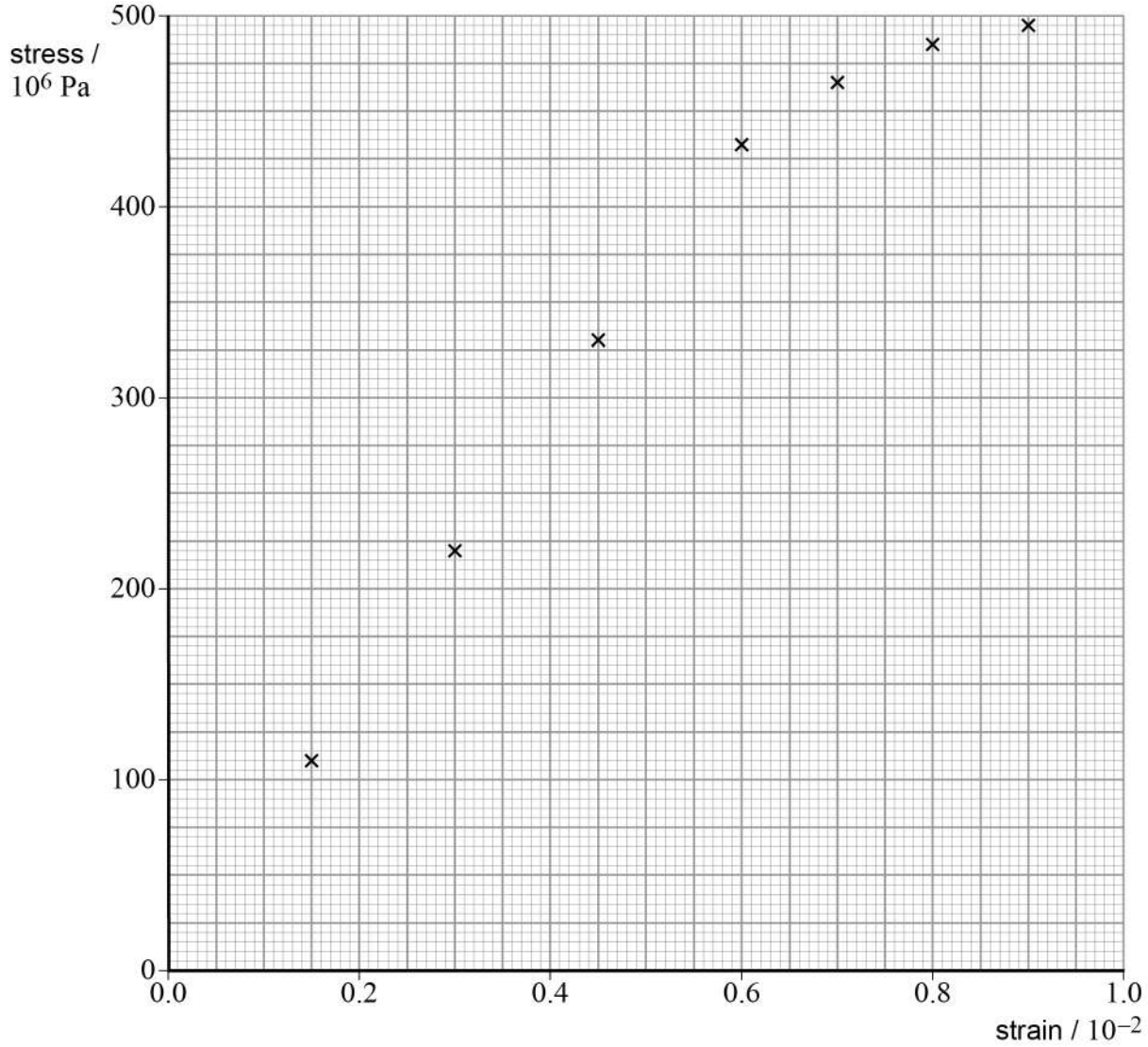
Section B

Answer **all** questions in this section.

1 0 **Figure 6** shows some results from an experiment in which a metal wire was stretched.

Figure 6



1 0 . 1 Draw a line of best fit for these results.

[1 mark]

Do not write outside the box

1 0 . 2 Determine the Young modulus of the metal used to make the wire.

[3 marks]

Young modulus = _____ Pa

1 0 . 3 It is necessary to measure the diameter of the metal wire to be able to calculate its stress.

State the measuring instrument you would use and describe how you would obtain an accurate value for the diameter of the wire.

[2 marks]

Measuring instrument _____

Description _____

_____

_____

_____

1 0 . 4 It is necessary to measure the length of the metal wire to be able to calculate its strain.

State and explain how you would obtain an accurate value for the length.

[2 marks]

Method _____

_____

Explanation _____

_____

_____

8

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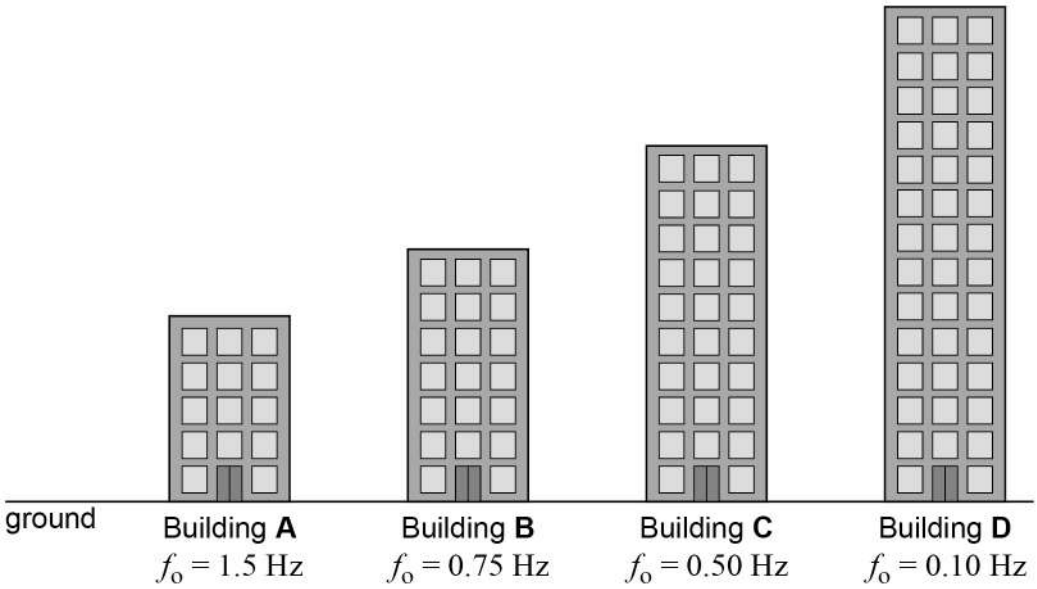
1 1 An earthquake generates seismic waves some of which are transverse.

1 1 . 1 State what is meant by a transverse wave.

[1 mark]

Earthquakes make the ground vibrate, sometimes causing buildings to collapse. Buildings of a particular height are most likely to collapse. The taller the building the lower its natural frequency of vibration f_o as shown in **Figure 7**.

Figure 7



In one earthquake the ground vibrated horizontally for 24 s and completed 12 oscillations.

1 1 . 2 Calculate the frequency of the vibrations produced in the four buildings in **Figure 7**.

[1 mark]

frequency = _____ Hz

Do not write outside the box

1 1 . 3 Explain which building in **Figure 7** vibrated with the largest amplitude.

[2 marks]

1 1 . 4 A building can be modelled as a mass–spring system allowing vibration testing.

The time period T of the vibration is given by $T = 2\pi\sqrt{\frac{M}{k}}$

where M is the mass of the building and k is a constant for the building.

Calculate k for a building of mass 5.0×10^7 kg and f_o = 0.92 Hz.

[2 marks]

k = _____ N m^{-1}

Question 11 continues on the next page

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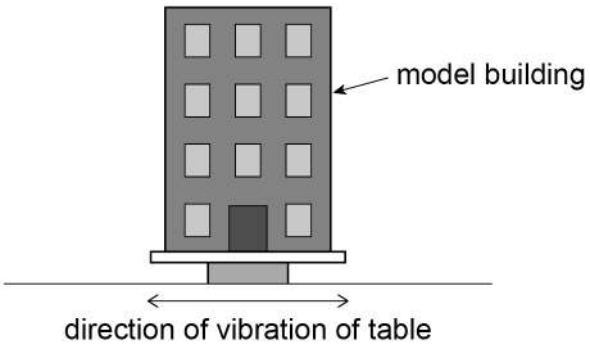
Model buildings are used to simulate the behaviour of real buildings in an earthquake. One arrangement, as shown in **Figure 8**, involves placing the model building on a table. The frequency of vibration f of the table in the horizontal direction can be varied, and the amplitude of vibration of the model building can be measured.

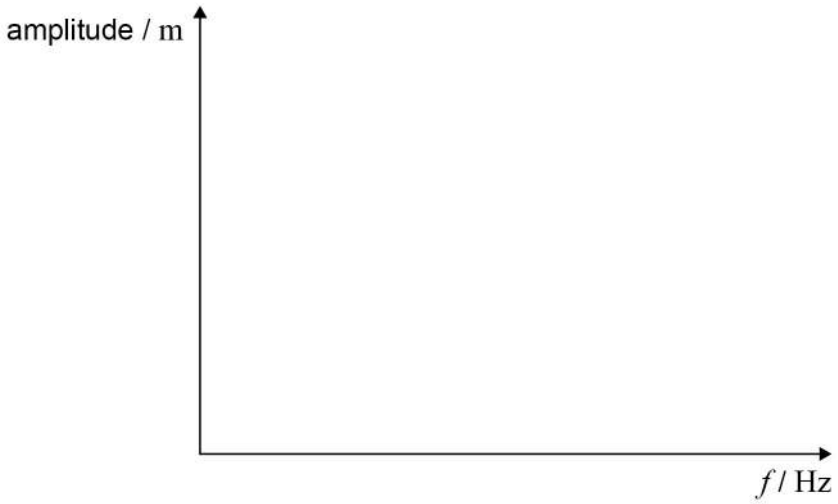
Figure 8



1 1 . 5 Sketch, on the axes, a graph to show how the amplitude of vibration of the model building varies with f.

Label this graph **A**.

[1 mark]



1 1 . 6 Sketch, on the same axes, a second graph to show the difference when a damping system was fitted to the model building.

Label this graph **B**.

[1 mark]

8

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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 answer 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. 

1 2 Which combination of units is equivalent to a unit of energy?

[1 mark]

A $\mathrm{A\ V}$ ⬭

B $\mathrm{C\ V}$ ⬭

C $\mathrm{A^2\ \Omega\ s^{-1}}$ ⬭

D $\mathrm{V^2\ \Omega\ s}$ ⬭

1 3 A metal surface is illuminated with ultraviolet radiation. The number of photoelectrons emitted from the surface per unit time and the maximum kinetic energy of the photoelectrons are both measured. The illumination is now changed by increasing the frequency of radiation and decreasing the number of photons incident on the metal surface per unit time.

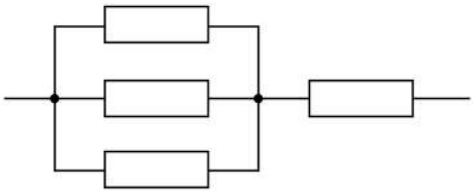
Which row correctly describes the observed changes?

[1 mark]

	Number of electrons emitted per unit time	**Maximum kinetic energy of emitted electrons**	
A	Decreased	Increased	⬭
B	Decreased	No change	⬭
C	Increased	Decreased	⬭
D	Increased	No change	⬭

Do not write outside the box

1 4 Four resistors each of resistance X are connected in a network as shown.



What is the total resistance of this network?

[1 mark]

A $\frac{X}{4}$ ⬭

B $\frac{X^2+3}{X}$ ⬭

C $4X$ ⬭

D $\frac{4X}{3}$ ⬭

1 5 Two simple pendulums of frequency 0.5 Hz and 0.4 Hz respectively are set into simple harmonic motion simultaneously and are initially in phase.

What is the minimum time to elapse before they are again instantaneously in phase?

[1 mark]

A 2 s ⬭

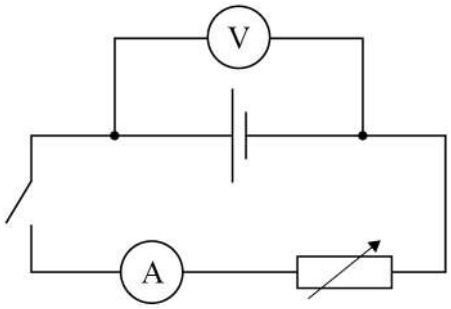
B 5 s ⬭

C 10 s ⬭

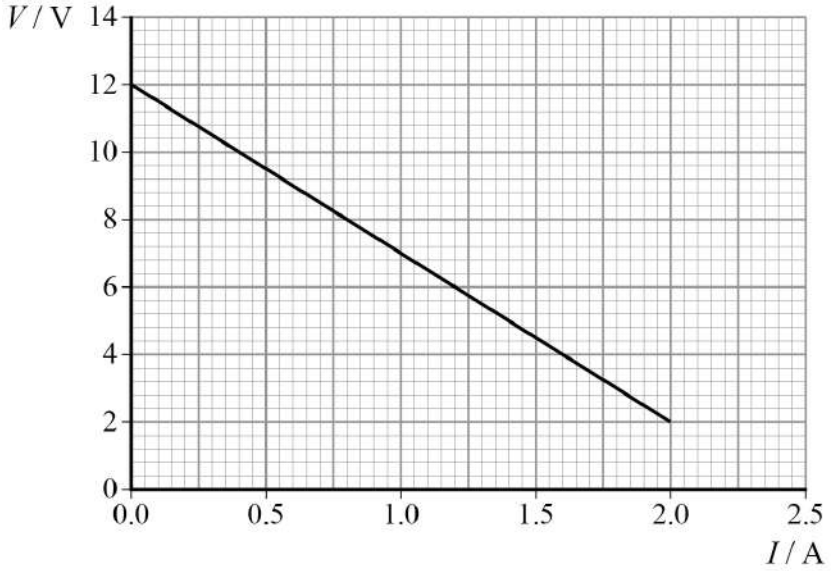
D 20 s ⬭

Do not write outside the box

1 6 A student sets up the circuit shown.



She varies the resistance of the circuit. The graph shows the results obtained.



Which statement is true?

[1 mark]

A The cell has negligible internal resistance ⬭

B The cell's internal resistance increases as the current increases. ⬭

C The maximum energy transferred to the external circuit by the cell occurs when the voltmeter reads 12 V. ⬭

D The internal resistance of the cell is 5 Ω. ⬭

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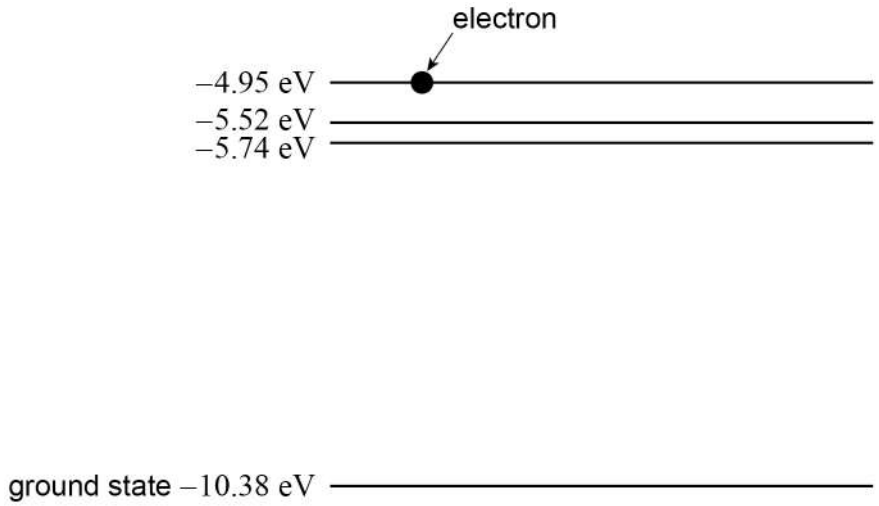
The diagram shows energy levels for an atom. **Questions 17** and **18** refer to this diagram.



1 7 How many different photon frequencies could be emitted when the atom returns to its ground state from these energy levels?

[1 mark]

A 3 ⬭

B 4 ⬭

C 6 ⬭

D 9 ⬭

1 8 What is the maximum possible wavelength of a photon emitted as the atom returns to the ground state?

[1 mark]

A 2.25×10^{-7}m ⬭

B 2.29×10^{-7}m ⬭

C 2.18×10^{-6}m ⬭

D 5.65×10^{-6}m ⬭

Do not write outside the box

1 9 Mercury atoms in a fluorescent tube emit photons when they de-excite. Some of the photons cause fluorescence in the inner coating of the tube.

What is the region of the electromagnetic spectrum to which these photons belong?

[1 mark]

A Ultraviolet ⬭

B Visible light ⬭

C Microwave ⬭

D Infrared ⬭

2 0 When radiation is incident on a platinum surface, electrons with a maximum kinetic energy of 8.20×10^{-19} J are emitted. The work function of platinum is 6.35 eV.

What is the frequency of the incident photons?

[1 mark]

A 1.24×10^{15} Hz ⬭

B 1.53×10^{15} Hz ⬭

C 2.77×10^{15} Hz ⬭

D 2.96×10^{15} Hz ⬭

2 1 Which row correctly describes the wave properties that can be demonstrated by light waves and sound waves?

[1 mark]

	Light waves	**Sound waves**	
A	Can be polarised	Can be polarised	⬭
B	Can form a stationary wave	Can form a stationary wave	⬭
C	Cannot be polarised	Cannot be polarised	⬭
D	Cannot form a stationary wave	Cannot be polarised	⬭

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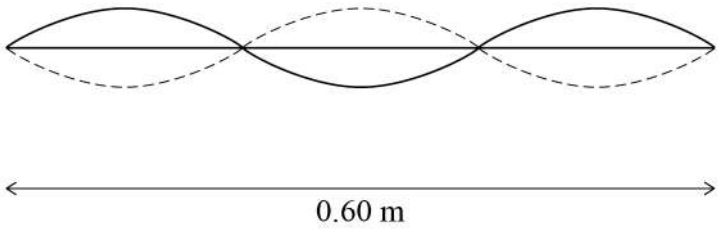
2 2 The diagram shows a **stationary** wave formed on a string of length $0.60\ \text{m}$.



Two points on the string are separated by a horizontal distance of $0.30\ \text{m}$.

What is a possible phase difference between these two points?

[1 mark]

A $\frac{\pi}{6}$ rad ⬭

B $\frac{\pi}{3}$ rad ⬭

C $\frac{\pi}{2}$ rad ⬭

D π rad ⬭

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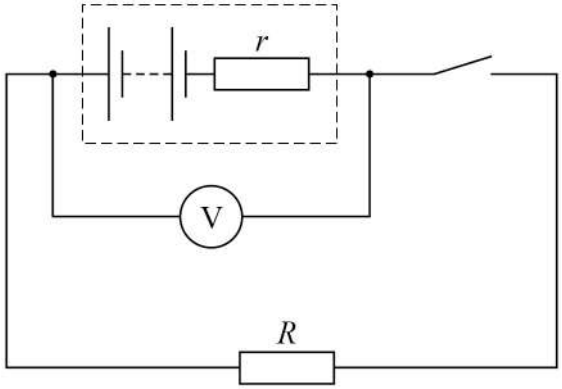
2 3 The diagram shows a $12\ \text{V}$ battery connected to a resistor of resistance R.
The voltmeter reads $10\ \text{V}$ when the switch is closed.



What is the internal resistance r of the battery?

[1 mark]

A $\frac{R}{6}$ ⬭

B $\frac{R}{5}$ ⬭

C $5R$ ⬭

D $6R$ ⬭

Turn over for the next question

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2 4 A 45 g mass suspended from a vertical spring performs simple harmonic motion.

What mass must be added to the system to double the period of oscillation?

[1 mark]

A 45 g ⬭

B 90 g ⬭

C 135 g ⬭

D 180 g ⬭

2 5 A string of length 90 cm is under tension T. A second string is 30 cm long and has the same mass per unit length.

What is the tension in the second string when both strings vibrate with the same frequency for the first harmonic?

[1 mark]

A $\frac{T}{9}$ ⬭

B $\frac{T}{3}$ ⬭

C $3T$ ⬭

D $9T$ ⬭

14

END OF QUESTIONS

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