OXFORD

INTERNATIONAL AQA EXAMINATIONS

Please write clearly in block capitals.

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

Surname _____

Forename(s) _____

Candidate signature _____

INTERNATIONAL AS
PHYSICS

Unit 2 Electricity, waves and particles

Monday 13 May 2019 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.

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	
11–24	
TOTAL	

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Section A

Answer **all** questions in this section.

0 1 An electron is travelling at 1.29×10^{6} m s^{-1}.

Calculate its de Broglie wavelength.

[2 marks]

wavelength = _____ m

2

0 2 Laser light is incident normally on a diffraction grating.
The diffraction grating has 250 slits per millimetre.
A third-order maximum is observed at an angle of 29° to the central maximum.

Calculate the frequency of the laser light.

[4 marks]

frequency = _____ Hz

4

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0 3 A student is provided with the following apparatus:

- a lamp
- a polarising filter
- a light meter that measures the intensity of incident light.

Describe how the student could use this apparatus to determine whether the light from the lamp is polarised.

[3 marks]

3

Turn over for the next question

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0 4 A washing machine is loaded unevenly. When the machine is turned on, the drum rotates with an increasing frequency. At one particular frequency the system vibrates with a large amplitude. As the frequency increases further, the amplitude of the vibrations decreases.

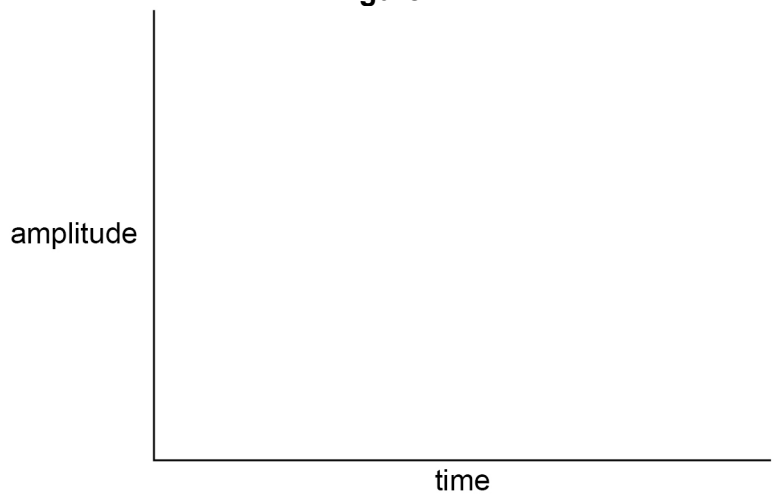
0 4 . 1 Explain why the large amplitude vibrations occur.

[3 marks]

0 4 . 2 Sketch on **Figure 1** the variation with time of the amplitude of vibrations as the frequency of the drum's rotation increases.

[1 mark]

Figure 1



0 4 . 3 Explain how increasing the damping of the system affects the graph you sketched in question **04.2**.

[2 marks]

6

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Turn over for the next question

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ANSWER IN THE SPACES PROVIDED

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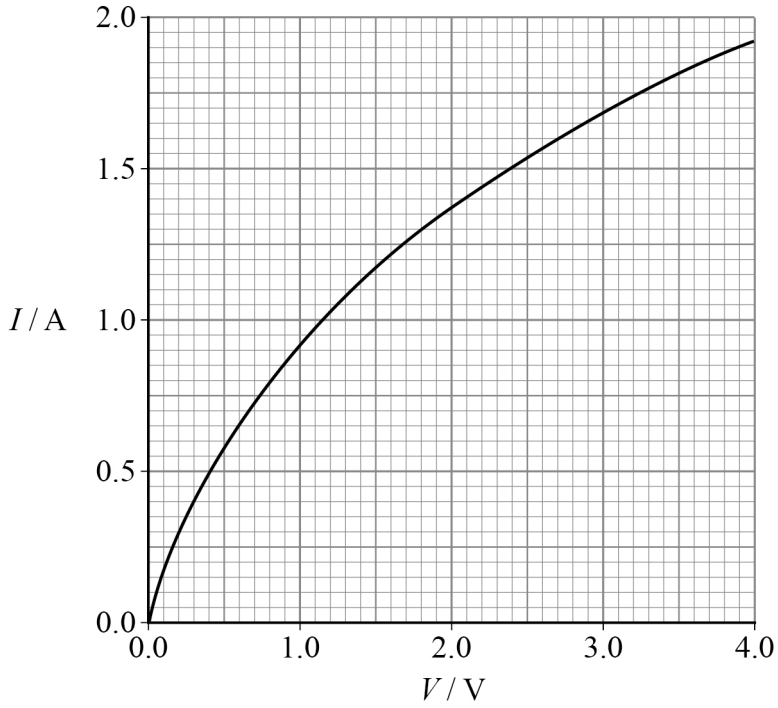
0 5 **Figure 2** shows the current-voltage (I-V) characteristic of a filament lamp.

Figure 2



0 5 . 1 Explain how **Figure 2** shows that the filament lamp is **not** an ohmic conductor.

[1 mark]

0 5 . 2 Explain, in terms of the particles in the filament, why the filament lamp is **not** an ohmic conductor.

[3 marks]

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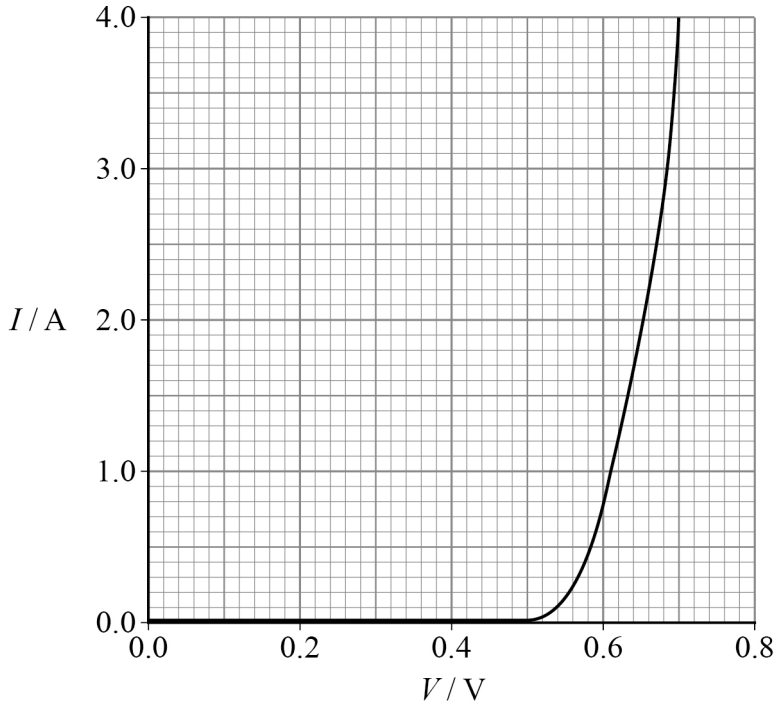
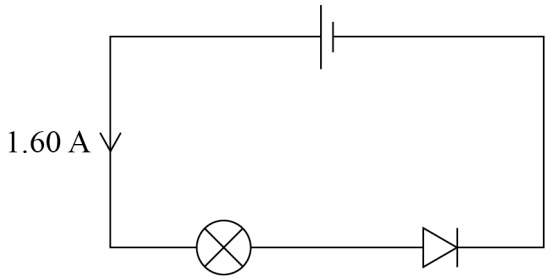
Figure 3 shows the I-V characteristic of a diode.

Figure 3



0 5 . 3 The filament lamp and the diode are connected in series with a cell of negligible internal resistance, as shown in **Figure 4**. The current in the circuit is 1.60 A.

Figure 4



Determine the emf of the cell.

[2 marks]

emf = _____ V

6

Turn over ►

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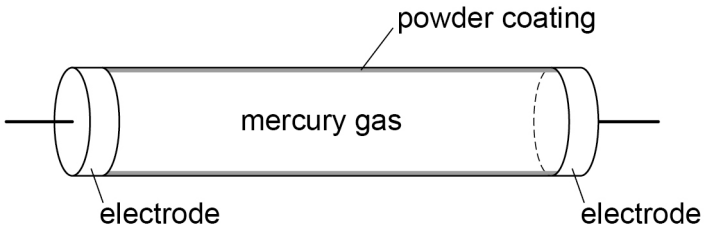
0 6 **Figure 5** shows a fluorescent tube. A fluorescent tube contains low-pressure mercury gas.
The inner surface of the tube is coated with a special powder as shown in **Figure 5**.

Figure 5



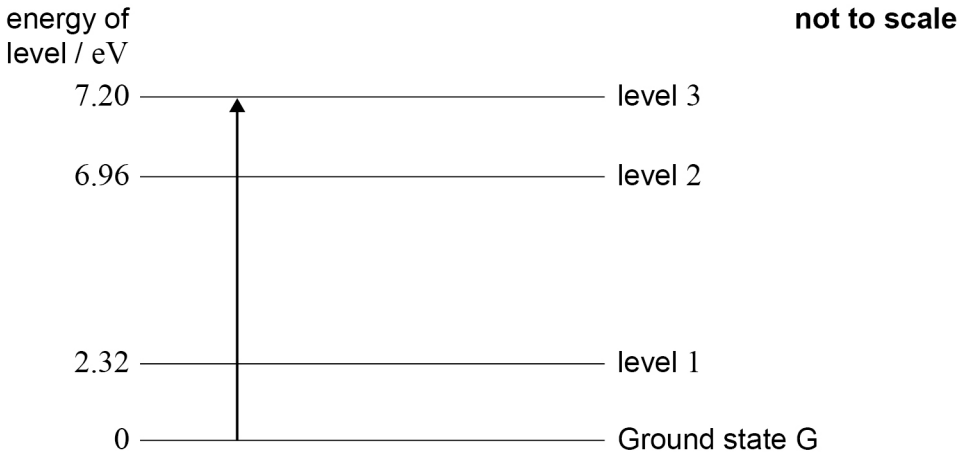
The mercury atoms are excited, and this eventually leads to the excitation of the atoms in the powder.

0 6 . 1 Explain how the mercury atoms are excited.

[1 mark]

Figure 6 shows the energy levels of one type of atom in the powder.

Figure 6



Do not write outside the box

0 6 . 2 Explain how atoms in the powder become excited to the $7.20\ \text{eV}$ energy level.

[2 marks]

0 6 . 3 With reference to **Figure 6**, explain how photons of visible light are emitted by the powder. Calculations are not required.

[2 marks]

0 6 . 4 Draw an arrow on **Figure 6** to represent the transition that leads to the emission of the longest wavelength of radiation.

[1 mark]

0 6 . 5 Calculate the **wavelength** of radiation emitted as a result of the transition you identified in question **06.4**.

[3 marks]

wavelength = _____ m

9

0 7 **Figure 7** shows a circuit used to determine the emf and internal resistance of a battery.

Figure 7

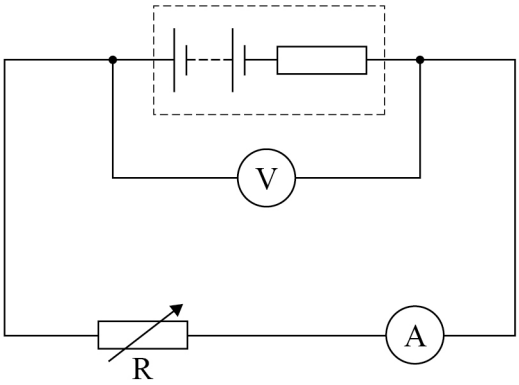
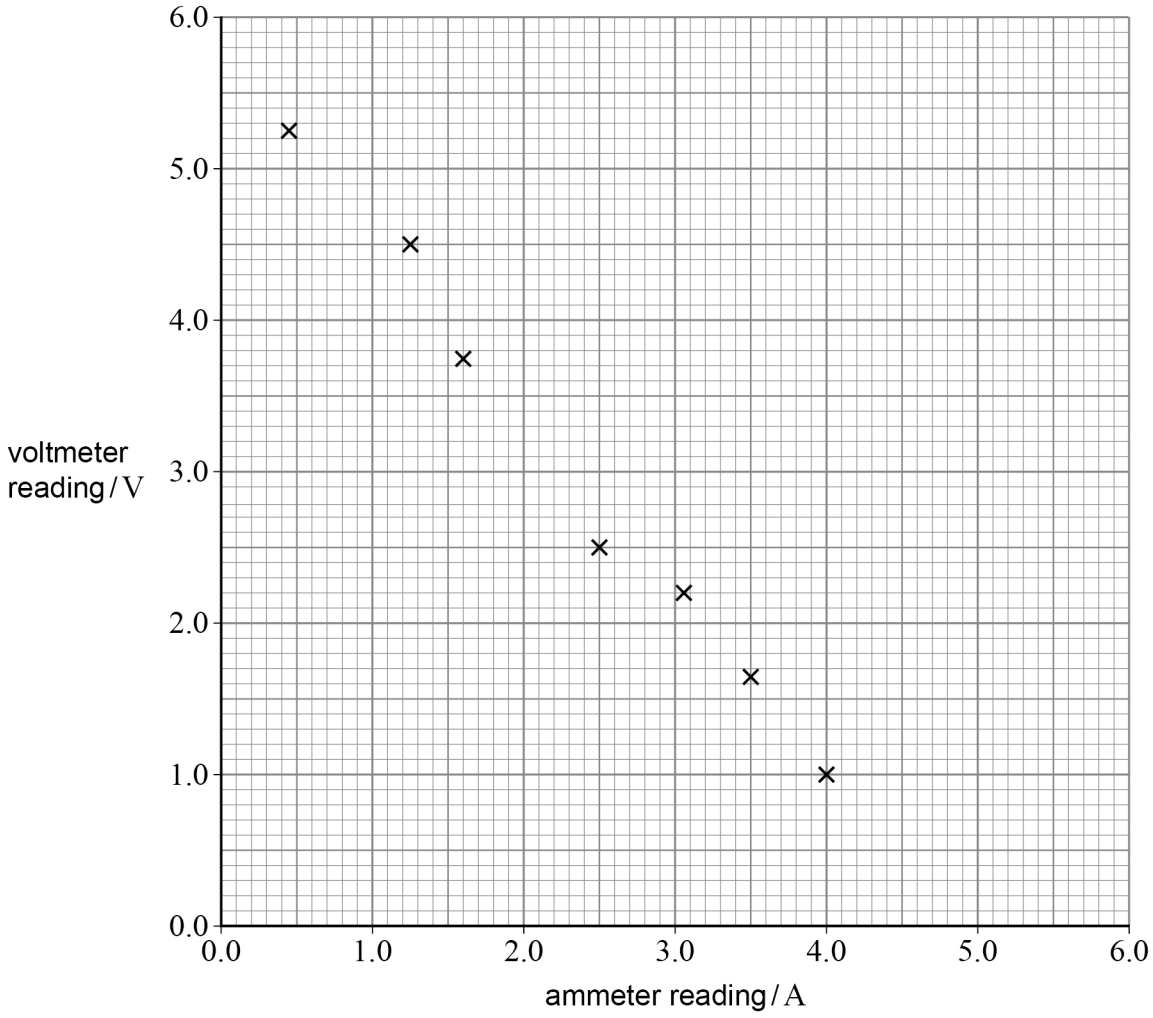


Figure 8 shows data from this experiment.

Figure 8



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0 7 . 1 Explain why the voltmeter reading decreases as the current increases.

[2 marks]

0 7 . 2 Determine the emf of the battery.

[2 marks]

emf = _____ V

0 7 . 3 Determine the internal resistance of the battery.

[3 marks]

internal resistance = _____ Ω

0 7 . 4 A second battery has half the emf and half the internal resistance of the first battery.

Draw a line on **Figure 8** to show the variation of voltmeter reading with ammeter reading for the second battery.

[2 marks]

9

Do not write outside the box

0 8 . 1 Progressive waves transfer energy along the wave; stationary waves do not.

Describe **two other** differences between stationary waves and progressive waves.

[2 marks]

Difference 1 _____

_____

_____

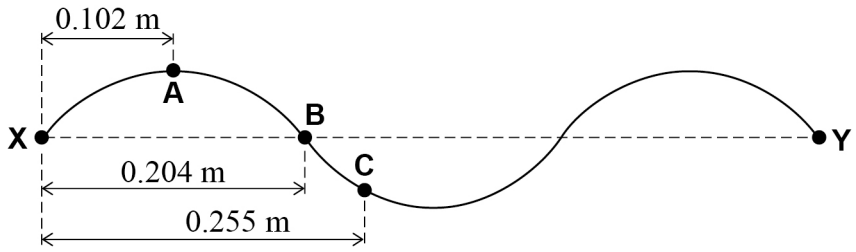
Difference 2 _____

_____

_____

A string of mass 0.98 g vibrates between two fixed ends **X** and **Y**.
The distance between **X** and **Y** is 0.612 m.
The tension in the string is 69 N.
Figure 9 shows one position of the string when vibrating at the third harmonic.

Figure 9



0 8 . 2 Determine the frequency of the third harmonic.

[4 marks]

frequency = _____ Hz

Do not write outside the box

0 8 . 3 Calculate the speed of the waves on the string.

[3 marks]

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

0 8 . 4 Point **B** is shown on **Figure 9**.

Describe the behaviour of the string at point **B**.

[1 mark]

_____

_____

0 8 . 5 Points **A** and **C** are shown on **Figure 9**.

State the phase difference between the motion of the string at points **A** and **C**.

[1 mark]

phase difference = _____ rad

11

END OF SECTION A

Do not write outside the box

Section B

Answer **all** questions in this section.

0 9 Light undergoes total internal reflection in an optical fibre with no cladding.
The critical angle of light in this fibre without cladding is $43.6°$.

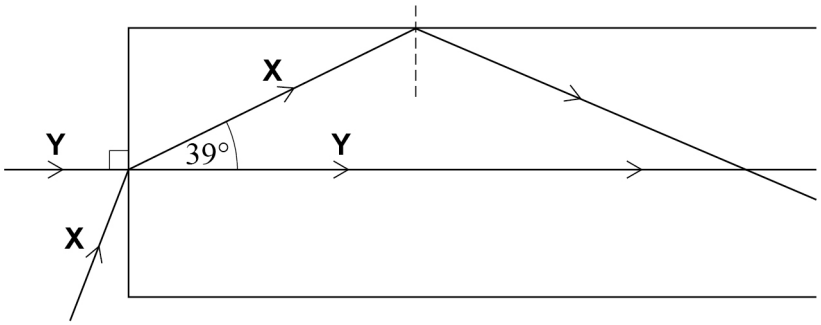
0 9 . 1 Show that the speed of light in the fibre is approximately $2.1 \times 10^8 \text{ m s}^{-1}$.

[2 marks]

Do not write outside the box

0 9 . 2 **Figure 10** shows the paths followed by two pulses of light, **X** and **Y**, entering the straight optical fibre at the same time. **X** travels through the fibre at $39°$ to the axis of the fibre. **Y** travels along the axis of the fibre.

Figure 10



The fibre is 320 m long.

Calculate the time delay between pulse **Y** leaving the fibre and pulse **X** leaving the fibre.

[4 marks]

time delay = _____ s

Question 9 continues on the next page

Do not write outside the box

0 9 . 3 Modern optical fibres are made with cladding around the core.

Explain how using cladding reduces pulse broadening.

[2 marks]

8

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Turn over for the next question

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ANSWER IN THE SPACES PROVIDED

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1 0 A student determines the period T of oscillation for a mass–spring system by measuring ten oscillations of the system. The measurements were repeated.

Table 1 shows these measurements.

Table 1

$\mathbf{10}T$ **/ s**	12.63	12.60	12.73	12.80	12.71

1 0 . 1 Calculate the mean value for T.

[1 mark]

mean value for T = _____

1 0 . 2 Calculate the percentage uncertainty in your mean value for T.

[1 mark]

percentage uncertainty in T = _____

Do not write outside the box

1 0 . 3 The mass m on the spring was (0.400 ± 0.008) kg.

Calculate the spring constant k.

[1 mark]

$k =$ _____ N m^{-1}

1 0 . 4 Calculate the percentage uncertainty in your answer for k.

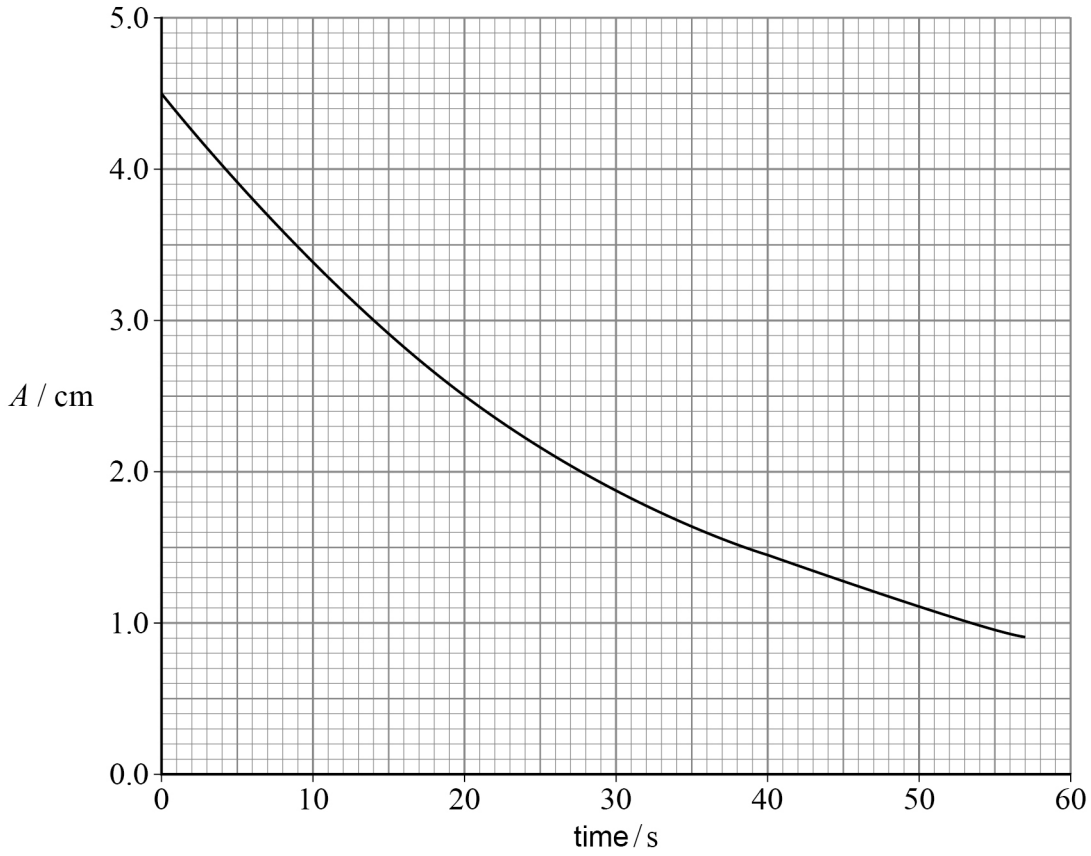
[2 marks]

percentage uncertainty in $k =$ _____

Question 10 continues on the next page

1 0 . 5 To investigate damping in the system, the amplitude A of the oscillations was measured until a total of fifty oscillations were completed.
Figure 11 shows the variation of amplitude with time.

Figure 11



The damping in the mass–spring system causes the amplitude to decrease. The time taken for the amplitude of this system to decrease by half is constant, and is called the half-life.

Determine a reliable value for the half-life of this system.

[3 marks]

half-life = _____ s

8

END OF SECTION B

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Turn over for the next question

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ANSWER IN THE SPACES PROVIDED

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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 

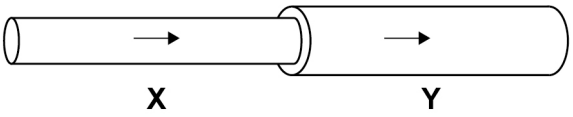
WRONG METHODS 

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 sheets for this working.

1 1 Two wires, **X** and **Y**, are connected in series.
X and **Y** are made of the same material and have the same length. The diameter of **Y** is larger than the diameter of **X**.



Which statement is correct?

[1 mark]

A The resistance of **X** is smaller than the resistance of **Y**. ⬭

B The current in **X** is smaller than the current in **Y**. ⬭

C The pd across **X** is equal to the pd across **Y**. ⬭

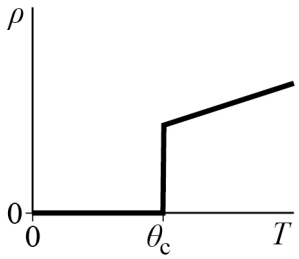
D The power dissipated by **X** is larger than the power dissipated by **Y**. ⬭

1 2 A superconductor has critical temperature θ_c.

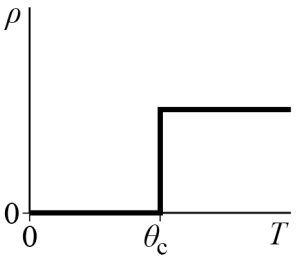
Which graph shows the variation of resistivity ρ with temperature T for this superconductor?

[1 mark]

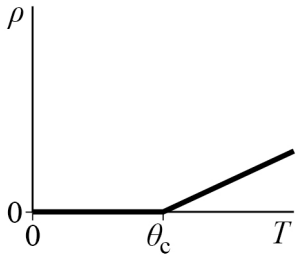
A



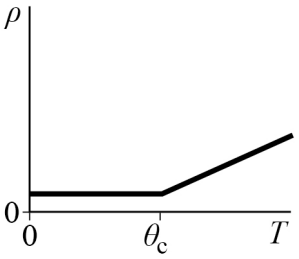
B



C



D



A ⬭

B ⬭

C ⬭

D ⬭

Turn over for the next question

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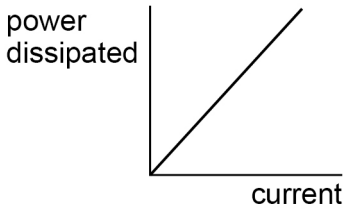
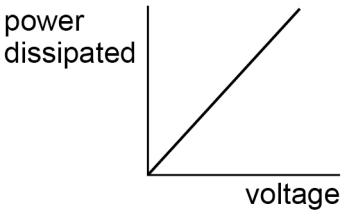
1 3 Which pair of graphs shows the variation of power dissipated with current, and the variation of power dissipated with voltage, for a resistor of constant resistance?

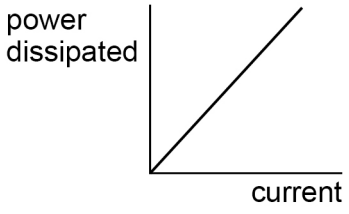
[1 mark]

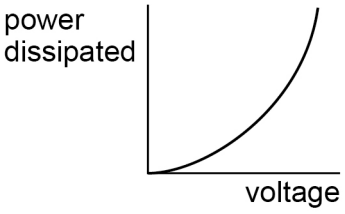
A



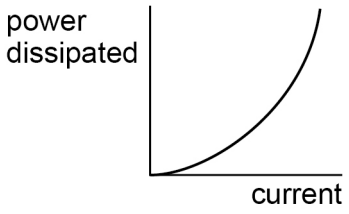


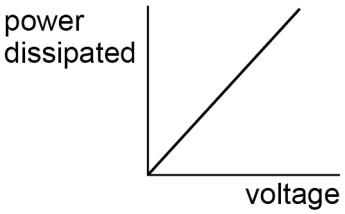
B



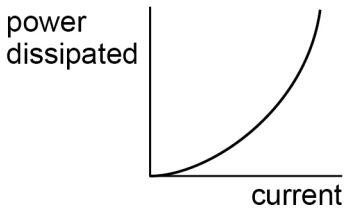


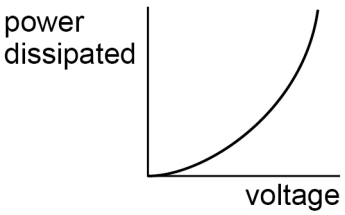
C





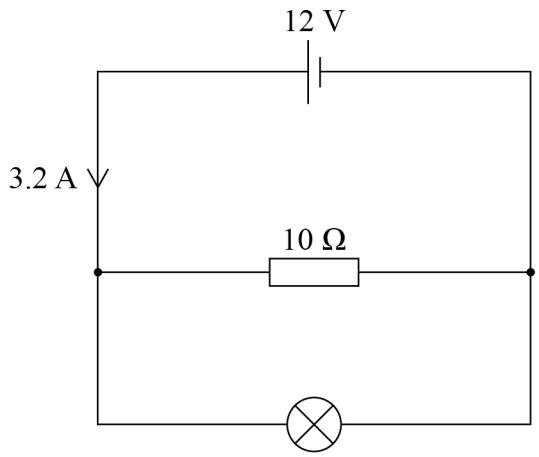
D





Do not write outside the box

1 4 A cell of negligible internal resistance is connected to a resistor and a lamp in parallel as shown.



What is the power dissipated by the lamp?

[1 mark]

A 14 W ⬭

B 16 W ⬭

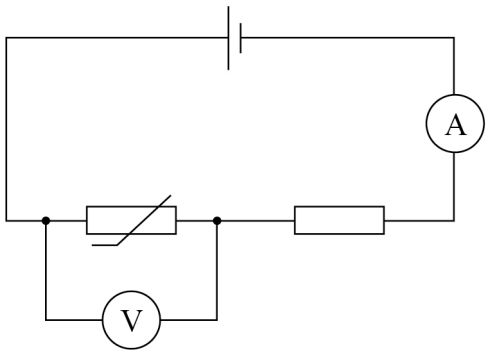
C 24 W ⬭

D 38 W ⬭

Turn over for the next question

Do not write outside the box

1 5 A negative temperature coefficient thermistor is connected to a resistor and a cell as shown.



The temperature of the thermistor increases.

What are the changes in the ammeter reading and the voltmeter reading?

[1 mark]

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

Do not write outside the box

1 6 A pendulum of length l oscillates at frequency f.

Which length of pendulum oscillates at frequency $2f$?

[1 mark]

A $\frac{l}{4}$ ⬭

B $\frac{l}{2}$ ⬭

C $\frac{l}{\sqrt{2}}$ ⬭

D $l\sqrt{2}$ ⬭

1 7 A stationary wave forms on a string when progressive waves are reflected at the fixed ends. For a real string, energy is transferred from the progressive waves when they are reflected at the fixed ends.

The effect of this energy transfer on the stationary wave is that

[1 mark]

A the antinodes and nodes no longer form. ⬭

B the nodes are not positions of zero amplitude. ⬭

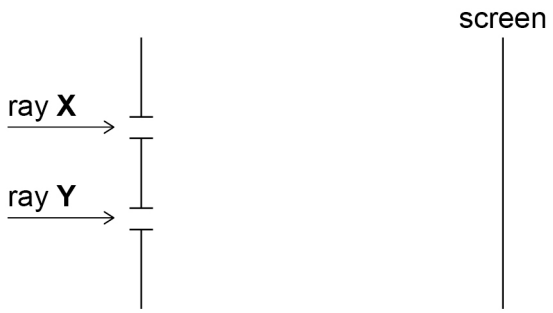
C the distance between antinodes increases. ⬭

D the speed of the waves on the string is decreased. ⬭

Turn over for the next question

Do not write outside the box

1 8 Ray **X** is incident on one slit and ray **Y** is incident on another slit of a double slit arrangement as shown below.



A fringe pattern is **not** observed on the screen.

What is a possible explanation?

[1 mark]

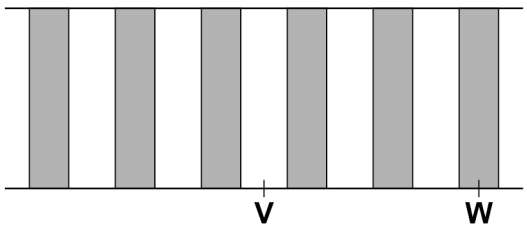
A **X** and **Y** are not incident at $90°$ to the slits. ⬭

B **X** and **Y** do not have the same wavelength. ⬭

C **X** and **Y** are too bright. ⬭

D **X** and **Y** are out of phase at the position of the slits. ⬭

1 9 Light of wavelength $500\ \text{nm}$ is incident on a double slit and the resulting fringe pattern is shown below. **V** is the central bright fringe and the dark fringes are shown shaded.



What is the path difference that results in fringe **W**?

[1 mark]

A $1250\ \text{nm}$ ⬭

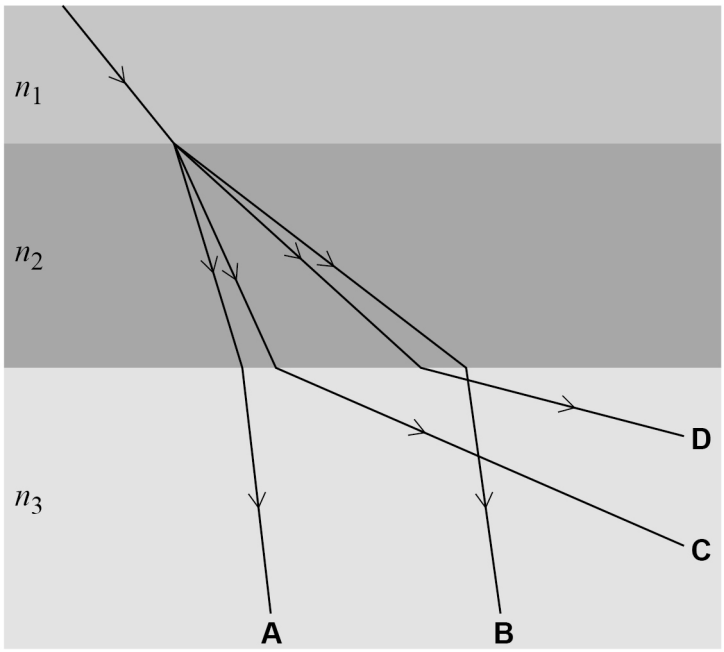
B $1000\ \text{nm}$ ⬭

C $750\ \text{nm}$ ⬭

D $500\ \text{nm}$ ⬭

Do not write outside the box

2 0 A ray of light travels through three materials, with refractive indices n_1, n_2 and n_3, where $n_3 < n_1 < n_2$.



Which is a possible path for the ray?

[1 mark]

A ⬭

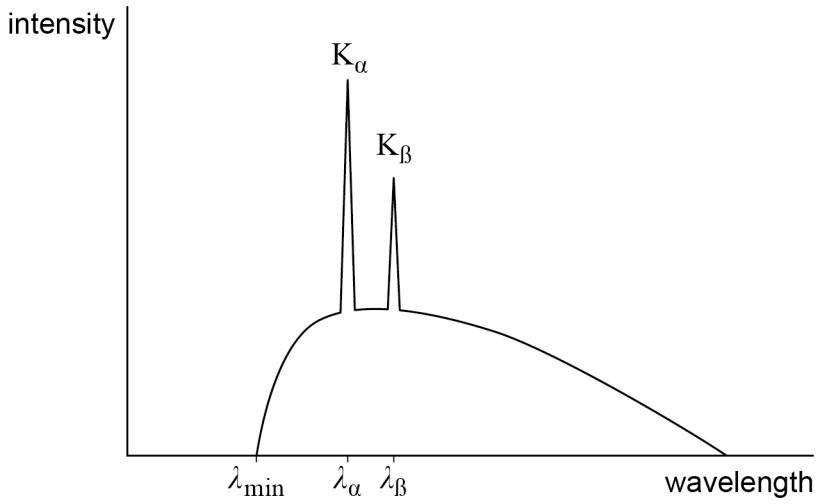
B ⬭

C ⬭

D ⬭

Turn over for the next question

2 1 The graph shows the X-ray spectrum emitted by an X-ray tube with a tungsten target, operated at $50\ \text{kV}$.



The same X-ray tube, with the same tungsten target, is now operated at $100\ \text{kV}$.

What happens to the minimum wavelength λ_{min} of the spectrum and the wavelengths λ_α and λ_β of the characteristic K-lines K_α and K_β?

[1 mark]

	λ_{min}	λ_α	λ_β	
A	halves	halves	halves	⬭
B	doubles	doubles	doubles	⬭
C	halves	unchanged	unchanged	⬭
D	doubles	unchanged	unchanged	⬭

2 2 In the photoelectric effect, what is the relationship between the work function ϕ of a material and its stopping potential V_s?

[1 mark]

A $\phi = hf - V_s e$ ⬭

B $\phi = V_s h$ ⬭

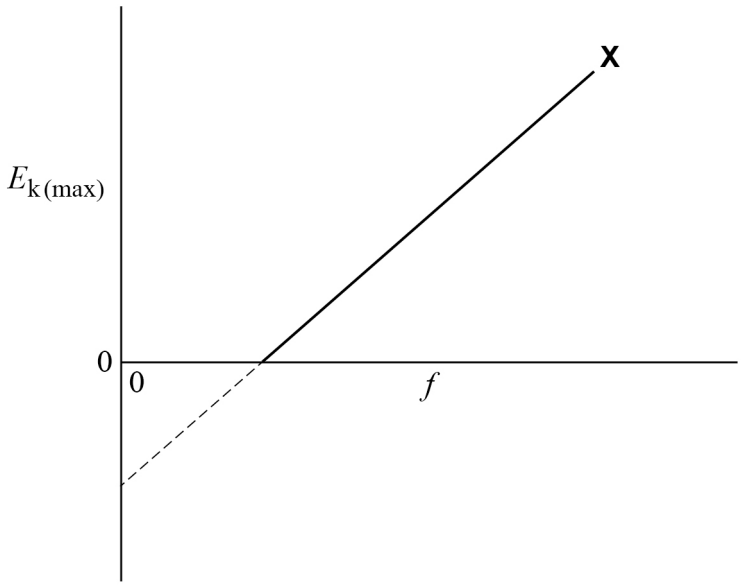
C $\phi = \frac{hc}{V_s}$ ⬭

D $\phi = hf + V_s e$ ⬭

Turn over for the next question

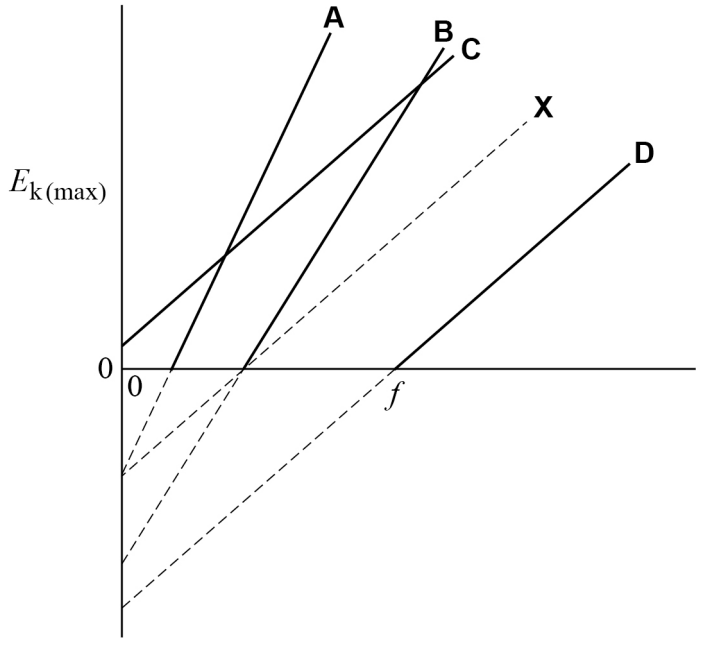
Do not write outside the box

2 3 The graph shows the relationship between the maximum kinetic energy $E_{k(max)}$ of photoelectrons emitted from material **X**, and the frequency f of incident light.



Which line shows the variation of $E_{k(max)}$ with f for a different material?

[1 mark]



A ⬭

B ⬭

C ⬭

D ⬭

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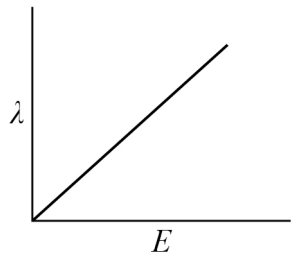
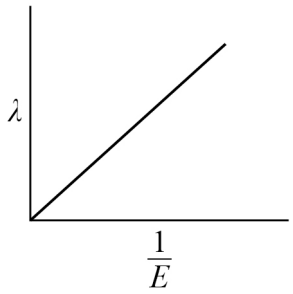
2 4 Which graph shows the relationship between the de Broglie wavelength λ of an electron and its kinetic energy E?

[1 mark]

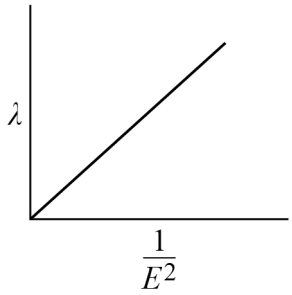
A



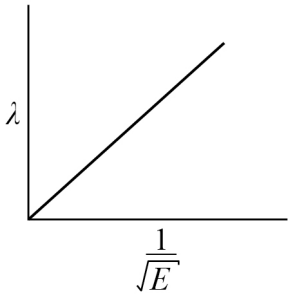
B



C



D



A ⬭

B ⬭

C ⬭

D ⬭

14

END OF QUESTIONS

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