

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	



Section AAnswer **all** questions in this section.**0 1**An electron is travelling at $1.29 \times 10^6 \text{ m s}^{-1}$.

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

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

Turn over ►



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.

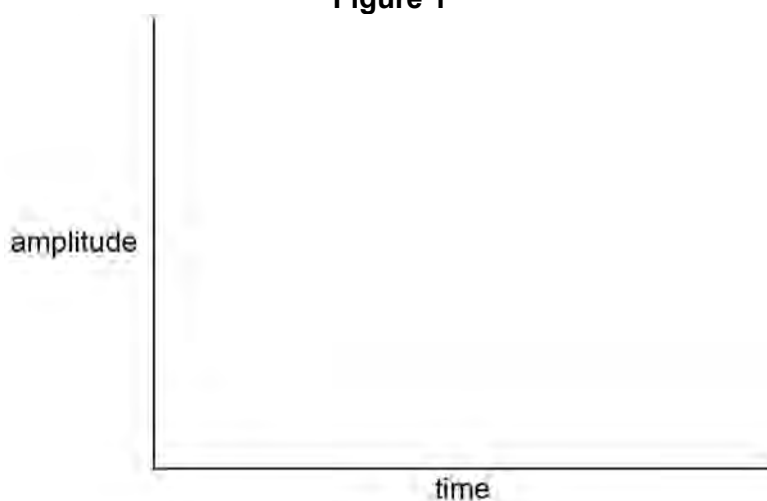
[3 marks]

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]



Turn over for the next question

*Do not write
outside the
box*

**DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED**

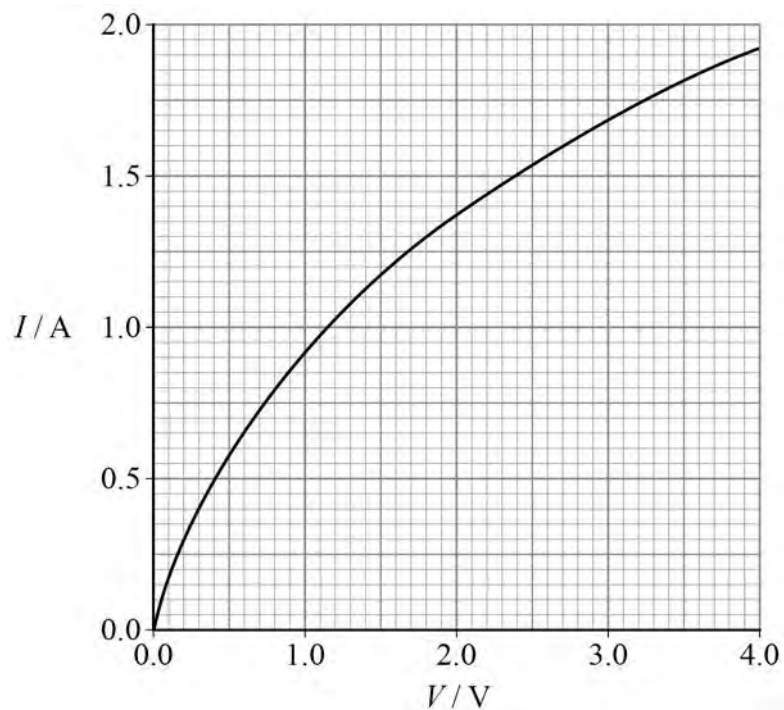
Turn over ►



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

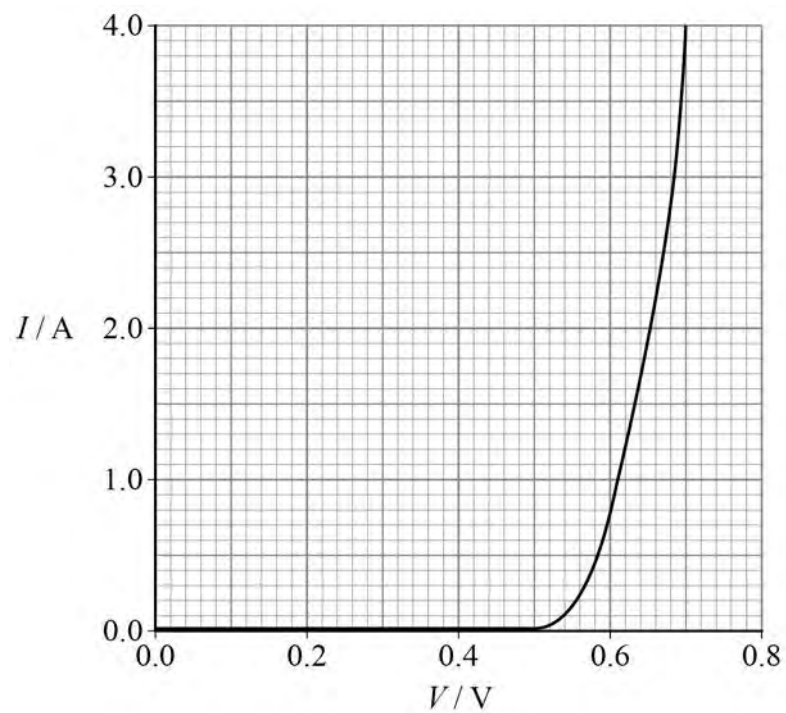
Explain, in terms of the particles in the filament, why the filament lamp is **not** an ohmic conductor.

[3 marks]



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

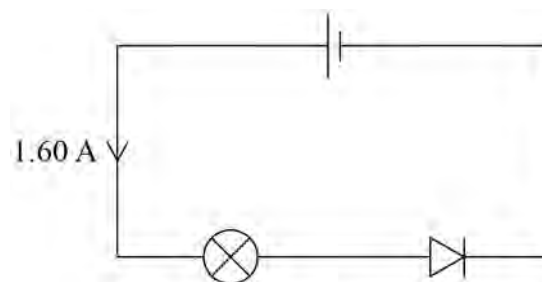
Figure 3



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 ►

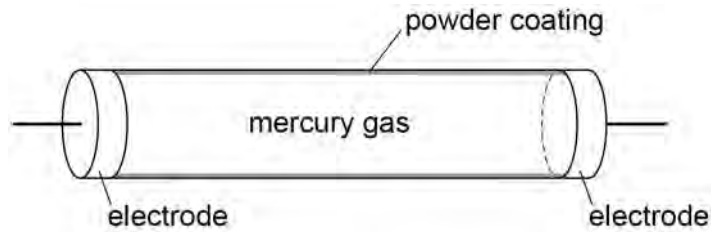


0 6

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.

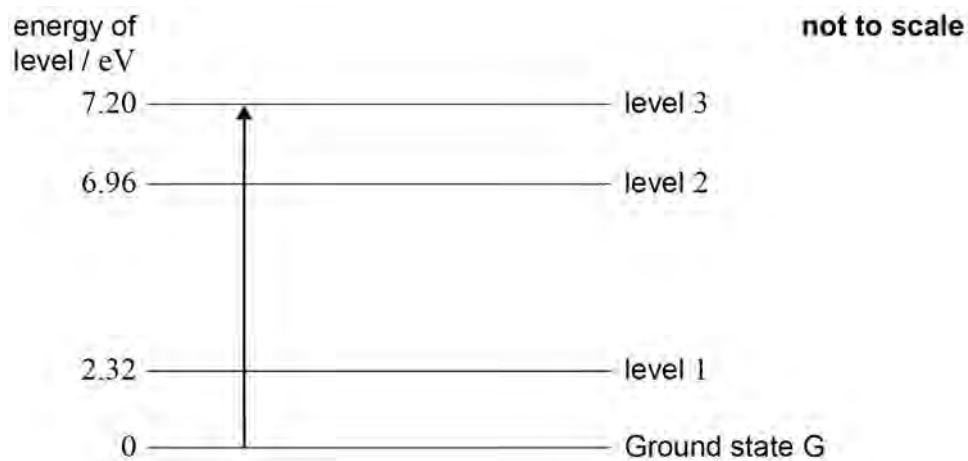
0 6 . 1

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



06.2

Explain how atoms in the powder become excited to the 7.20 eV energy level.

[2 marks]

06.3

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

[2 marks]

06.4

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

[1 mark]

06.5

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

[3 marks]

wavelength = _____ m

9

Turn over ►



0 7

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

Do not write
outside the
box

Figure 7

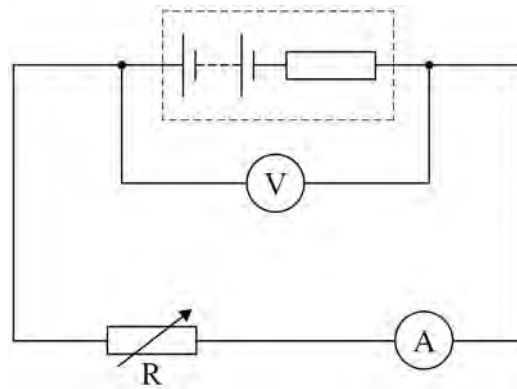
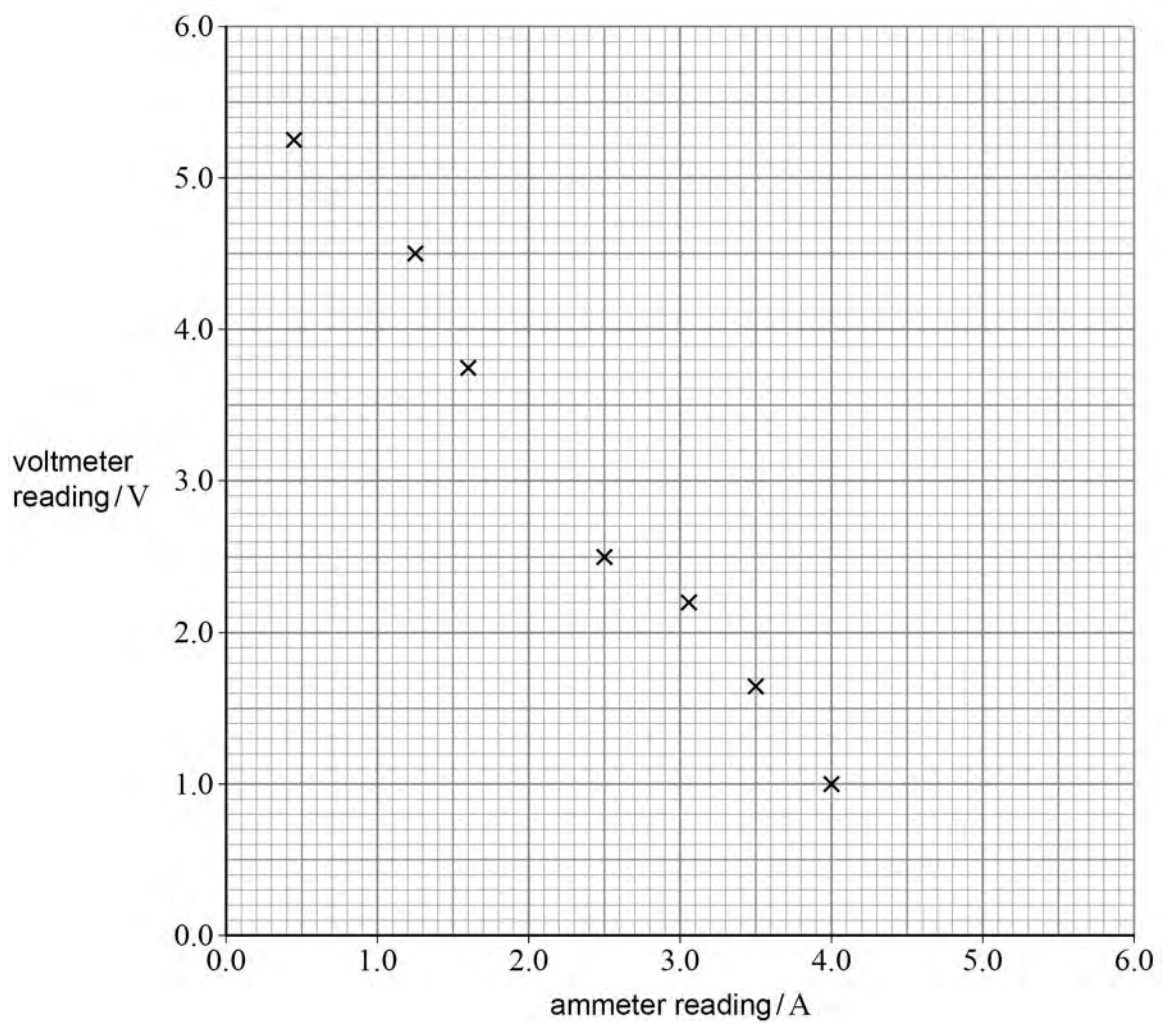


Figure 8 shows data from this experiment.

Figure 8



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

Turn over ►

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 _____

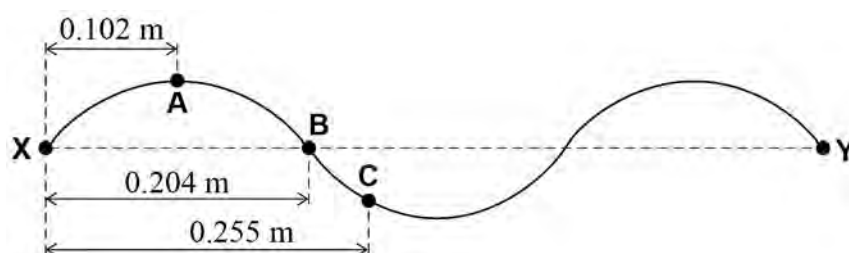
A string of mass 0.98 g vibrates between two fixed ends **X** and **Y**.

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



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

Turn over ►



Section B*Do not write
outside the
box*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° .

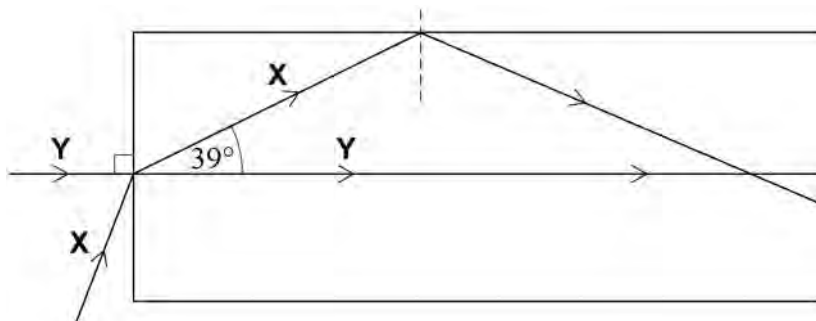
0 9 . 1

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

[2 marks]

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

Turn over ►



09.3

Modern optical fibres are made with cladding around the core.

Explain how using cladding reduces pulse broadening.

[2 marks]

8

Turn over for the next question

*Do not write
outside the
box*

**DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED**

Turn over ►



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

$10T / \text{s}$	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 $T =$ _____



1	0	.	3
---	---	---	---

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

Calculate the spring constant k .

[1 mark]

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

1	0	.	4
---	---	---	---

Calculate the percentage uncertainty in your answer for k .

[2 marks]

$$\text{percentage uncertainty in } k = \text{_____}$$

Question 10 continues on the next page

Turn over ►

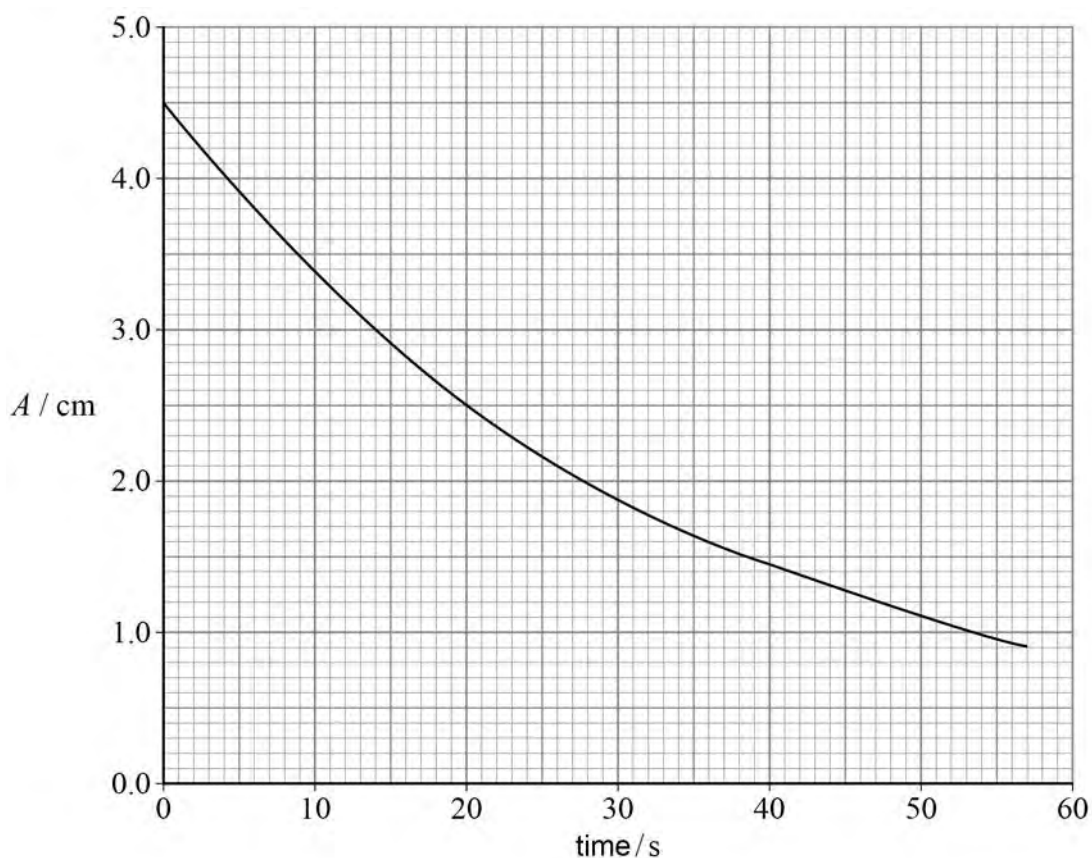


1 0 . 5

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

END OF SECTION B

Do not write
outside the
box

8



Turn over for the next question

*Do not write
outside the
box*

**DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED**

Turn over ►



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. 

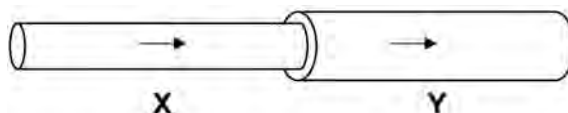
If you wish to return to an answer previously crossed out, ring the answer you now wish to select as shown. 

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**.

☐

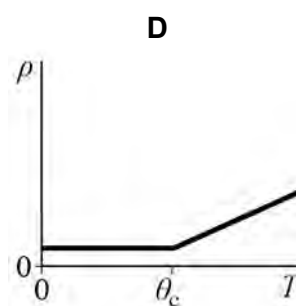
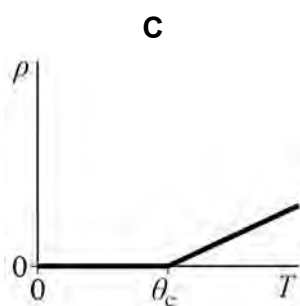
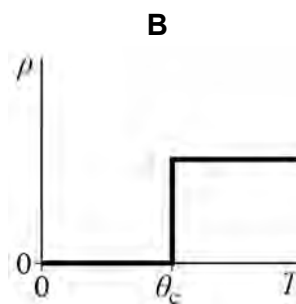
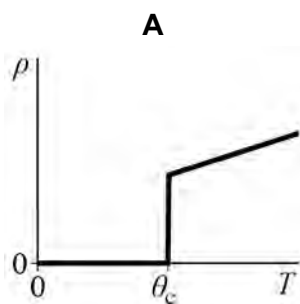
D The power dissipated by **X** is larger than the power dissipated by **Y**.

☐


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 ☐

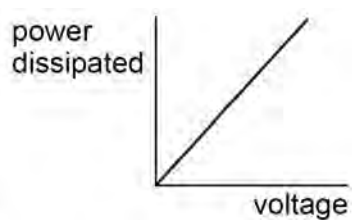
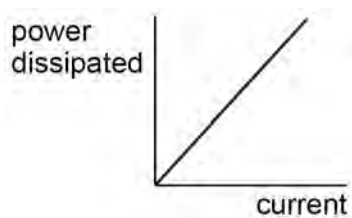
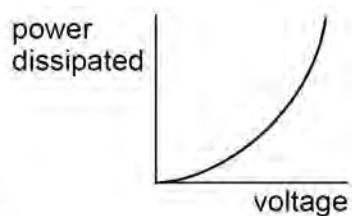
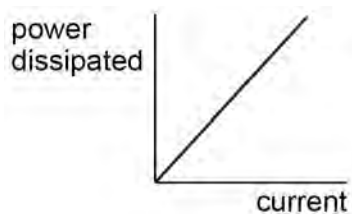
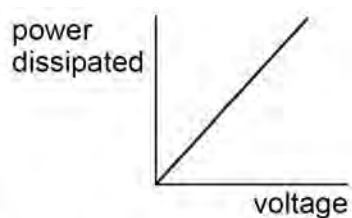
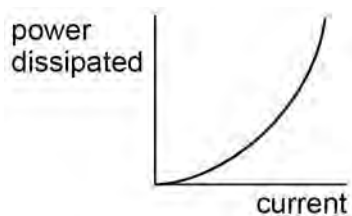
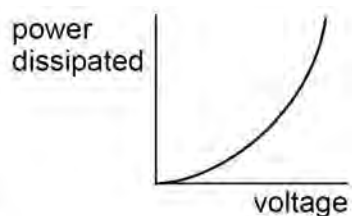
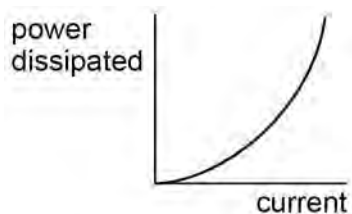
Turn over for the next question

Turn over ►



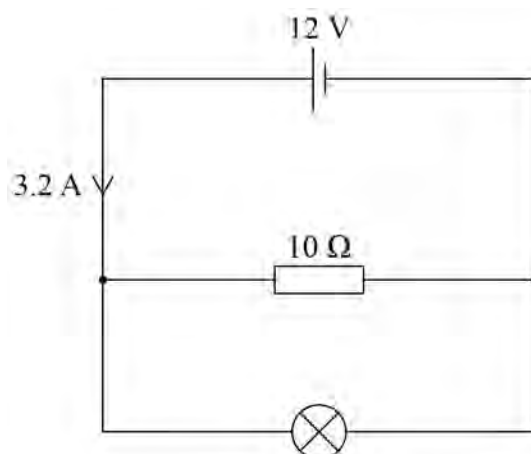
1 3

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
☐


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

☐

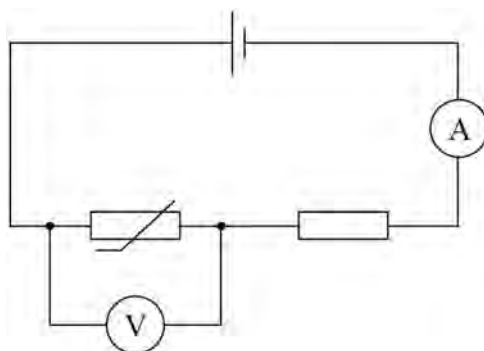
Turn over for the next question

Turn over ►



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	<input type="checkbox"/>
B	decreases	increases	<input type="checkbox"/>
C	increases	decreases	<input type="checkbox"/>
D	increases	increases	<input type="checkbox"/>



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. ☐

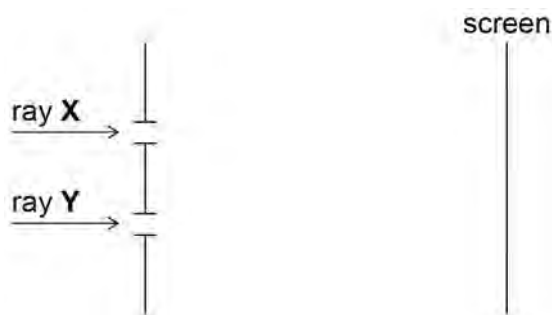
Turn over for the next question

Turn over ►



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.

☐

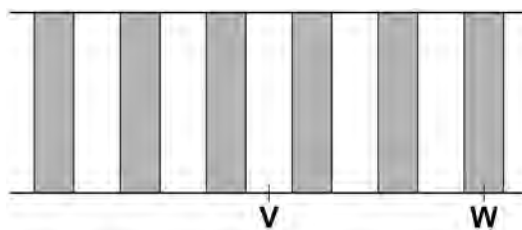
C **X** and **Y** are too bright.

☐

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

☐
1 9

Light of wavelength 500 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 nm

☐

B 1000 nm

☐

C 750 nm

☐

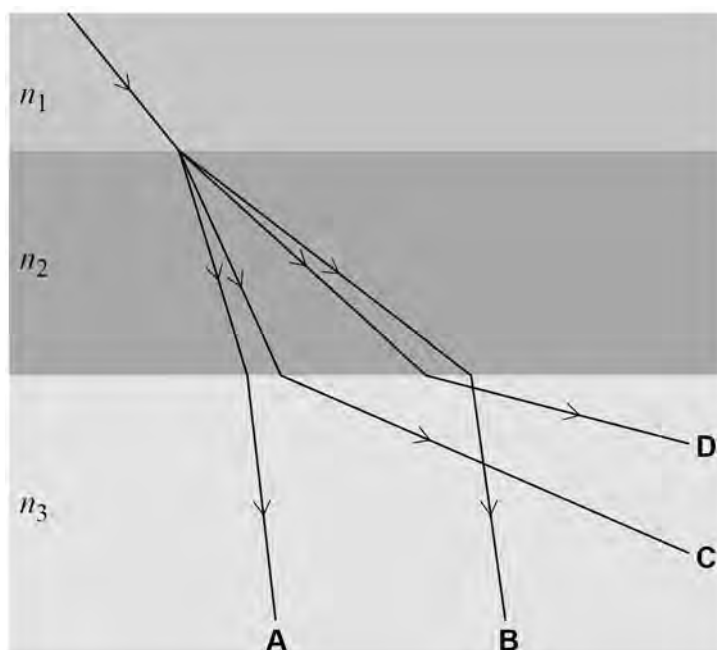
D 500 nm

☐


2 0

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

Do not write
outside the
box



Which is a possible path for the ray?

[1 mark]

- | | |
|----------|--------------------------|
| A | <input type="checkbox"/> |
| B | <input type="checkbox"/> |
| C | <input type="checkbox"/> |
| D | <input type="checkbox"/> |

Turn over for the next question

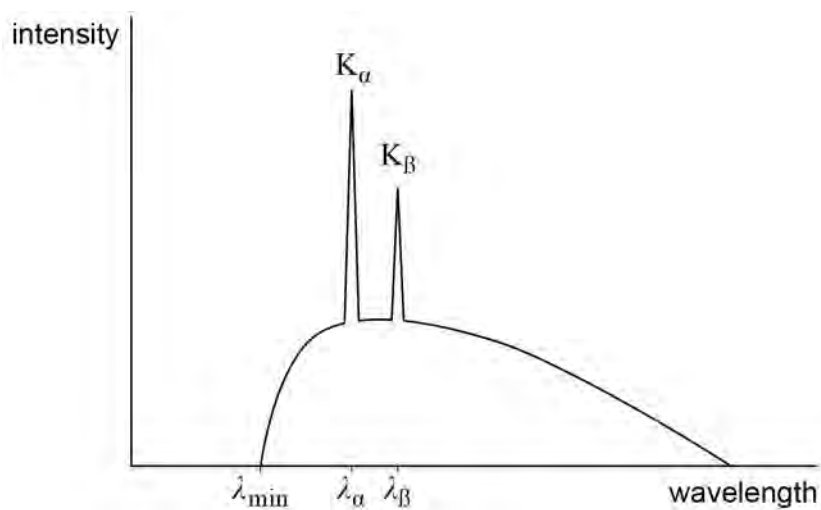
Turn over ►



2 1

The graph shows the X-ray spectrum emitted by an X-ray tube with a tungsten target, operated at 50 kV.

Do not write
outside the
box



The same X-ray tube, with the same tungsten target, is now operated at 100 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	<input type="radio"/>
B	doubles	doubles	doubles	<input type="radio"/>
C	halves	unchanged	unchanged	<input type="radio"/>
D	doubles	unchanged	unchanged	<input type="radio"/>



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 $\phi = hf + V_s e$

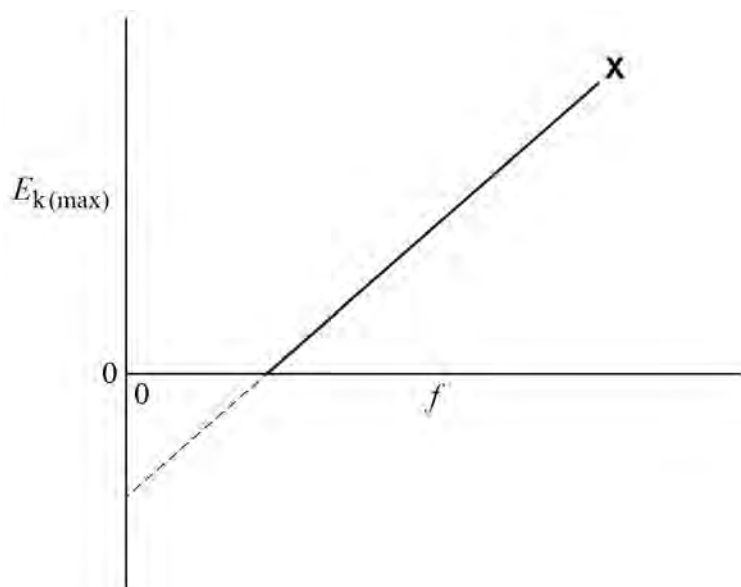
☐

Turn over for the next question

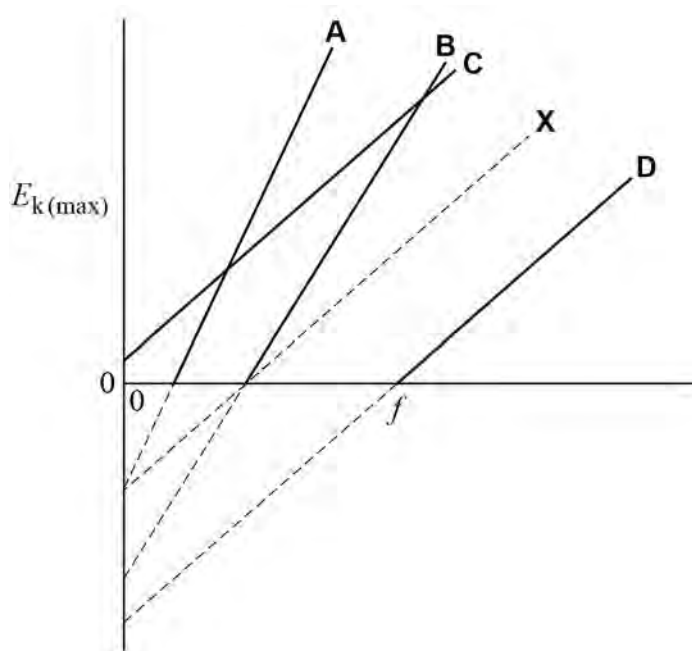
Turn over ►

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.

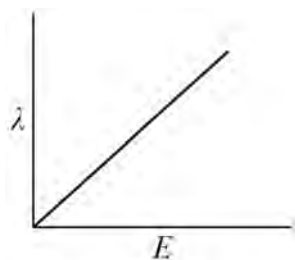
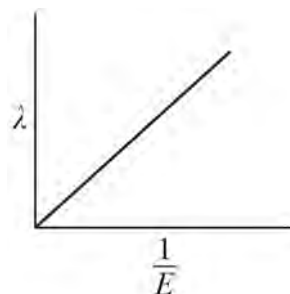
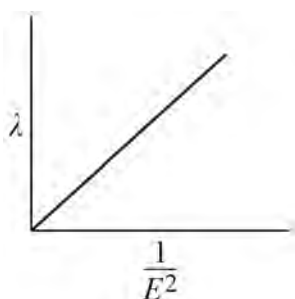
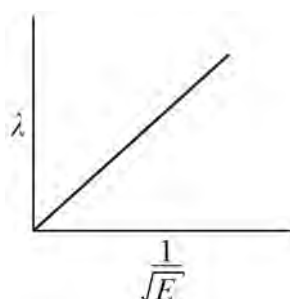


Which line shows the variation of $E_{k(\max)}$ with f for a different material?

[1 mark]**A**
☐
B
☐
C
☐
D
☐


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
☐

Do not write
outside the
box

14**END OF QUESTIONS**

There are no questions printed on this page

*Do not write
outside the
box*

**DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED**



[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

There are no questions printed on this page

*Do not write
outside the
box*

**DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED**

Copyright information

For confidentiality purposes, acknowledgements of third-party copyright material are published in a separate booklet rather than including them on the examination paper or support materials. This booklet is published after each examination series and is available for free download from www.oxfordaqaexams.org.uk after the live examination series.

Permission to reproduce all copyright material has been applied for. In some cases, efforts to contact copyright-holders may have been unsuccessful and Oxford International AQA Examinations will be happy to rectify any omissions of acknowledgements. If you have any queries please contact the Copyright Team, AQA, Stag Hill House, Guildford, GU2 7XJ.

Copyright © 2019 Oxford International AQA Examinations and its licensors. All rights reserved.

