OXFORD AQA

INTERNATIONAL QUALIFICATIONS

Please write clearly in block capitals.

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

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Forename(s) _____

Candidate signature _____

I declare this is my own work.

INTERNATIONAL AS

PHYSICS

Unit 2 Electricity, waves and particles

Tuesday 14 January 2025 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 A particle travels at a speed of 3.6×10^{6} m s^{-1}.
The de Broglie wavelength of the particle is 0.98 pm.

Calculate the mass of the particle.

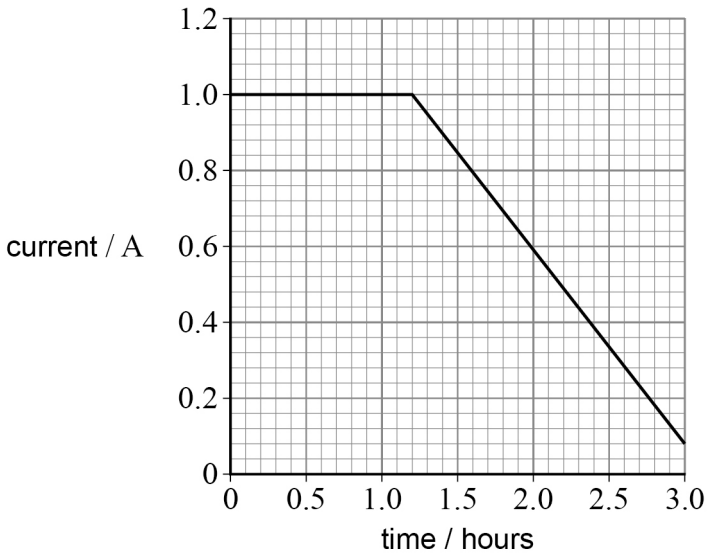
[2 marks]

mass of particle = _____ kg

2

0 2 A cell provides an electric current for 3.0 hours.
Figure 1 shows the variation of the current with time.

Figure 1



Determine, in C, the charge transferred by the cell in this time period of 3.0 hours.
[3 marks]

charge transferred = _____ C

3

Turn over for the next question

Do not write outside the box

0 3 **Figure 2** shows an experimental arrangement to investigate microwaves.

Figure 2

0 3 . 1 The transmitter produces microwaves of frequency 1.1×10^{10} Hz.

Calculate the wavelength of the microwaves.

[1 mark]

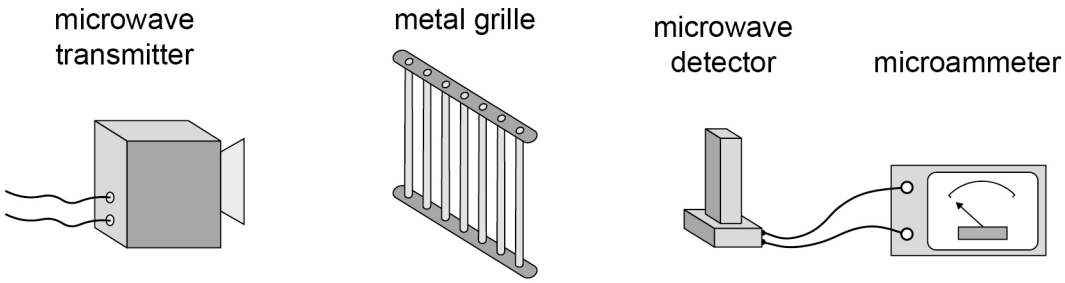
wavelength = _____ m

Do not write outside the box

0 3 . 2 A metal grille is placed between the microwave transmitter and the detector as shown in **Figure 3**.

As the grille is placed in position, the microammeter reading decreases to zero.

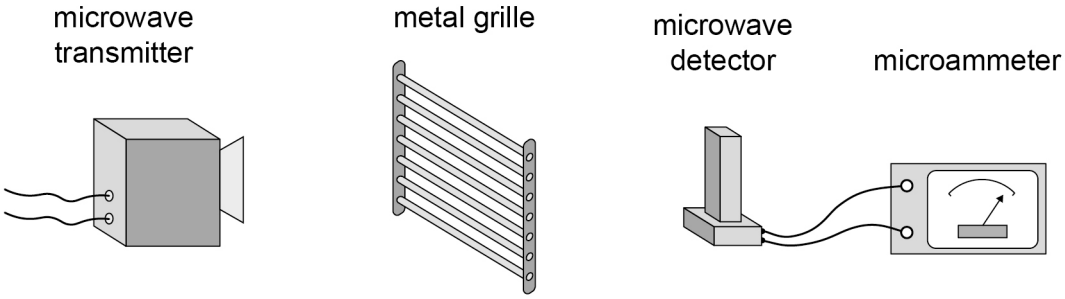
Figure 3



The grille is then rotated in the vertical plane by $90°$ as shown in **Figure 4**.

As the grille is rotated, the microammeter reading increases to a maximum.

Figure 4



The grille is rotated by a further $90°$ and the microammeter reading again decreases to zero.

State and explain how these observations provide evidence about the nature of microwaves.

[3 marks]

4

Turn over ►

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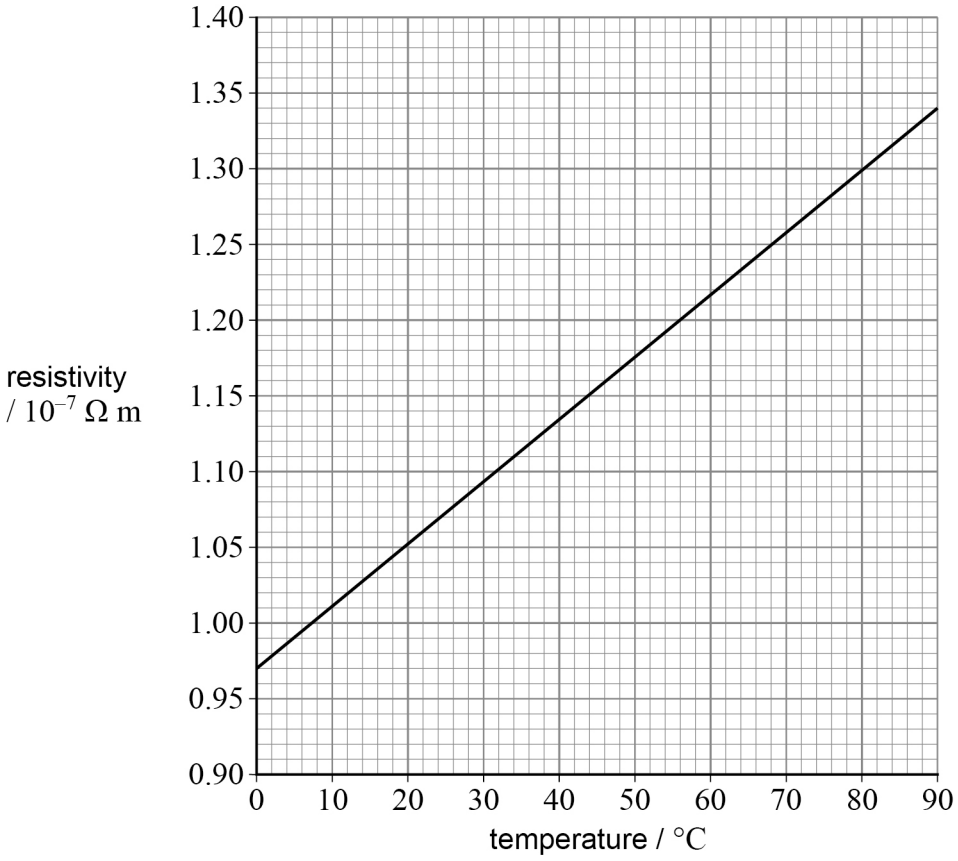
0 4 **Figure 5** shows how the resistivity of platinum metal varies linearly with temperature over the range shown.

Figure 5



0 4 . 1 A length of platinum wire at a temperature of $0.0\ °C$ has a resistance of $99\ \Omega$.
The diameter of the wire is 1.8×10^{-5} m.

Determine the length of the wire.

[3 marks]

length of wire = _____ m

Do not write outside the box

0 4 . 2 The linear variation of resistivity with temperature shown in **Figure 5** continues up to 200 °C.

Determine the resistivity of platinum when it is at a temperature of 190 °C.

[2 marks]

resistivity = _____ Ω m

5

Turn over for the next question

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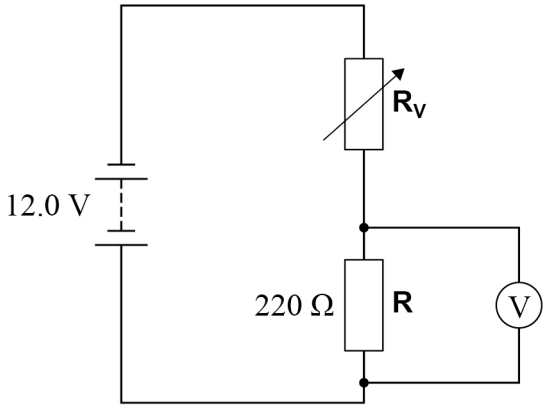
0 5 **Figure 6** shows a battery connected to a fixed resistor **R** of resistance 220 Ω and a variable resistor $\mathbf{R_V}$. The battery has an emf of 12.0 V and negligible internal resistance.

Figure 6



0 5 . 1 When the resistance of $\mathbf{R_V}$ is varied between zero and its maximum, the range of voltmeter readings is 3.0 V to 12.0 V.

Deduce the maximum resistance of $\mathbf{R_V}$.

[2 marks]

maximum resistance = _____ Ω

0 5 . 2 The battery develops a significant internal resistance.

Explain why a voltmeter reading of 12.0 V is no longer possible.

[2 marks]

_____

_____

_____

_____

_____

4

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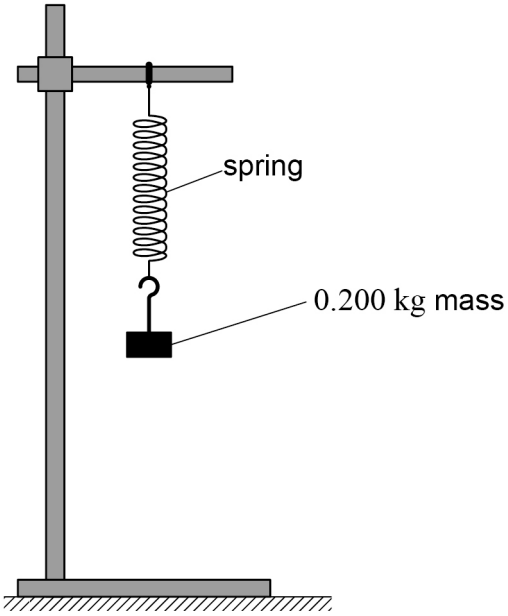
0 6 **Figure 7** shows a $0.200\ \text{kg}$ mass suspended from a spring. The top of the spring is fixed in place.

Figure 7



0 6 . 1 The mass is displaced vertically downwards and released. The mass–spring system oscillates with a frequency of $1.8\ \text{Hz}$.

Determine the spring constant of the spring.

[2 marks]

spring constant = _____ N m^{-1}

Question 6 continues on the next page

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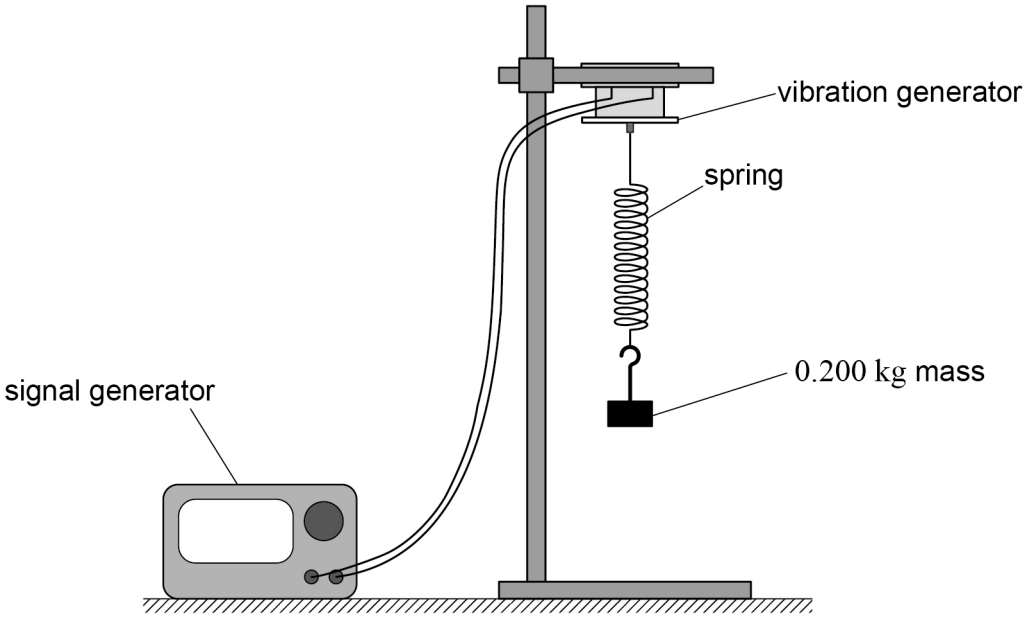
Figure 8 shows the spring suspended from a vibration generator. The vibration generator is powered by a signal generator.

Figure 8



0 6 . 2 The frequency of the signal generator is increased slowly from zero.
The amplitude of oscillation of the mass increases and then decreases.
The amplitude has a maximum value at a frequency of 1.8 Hz.

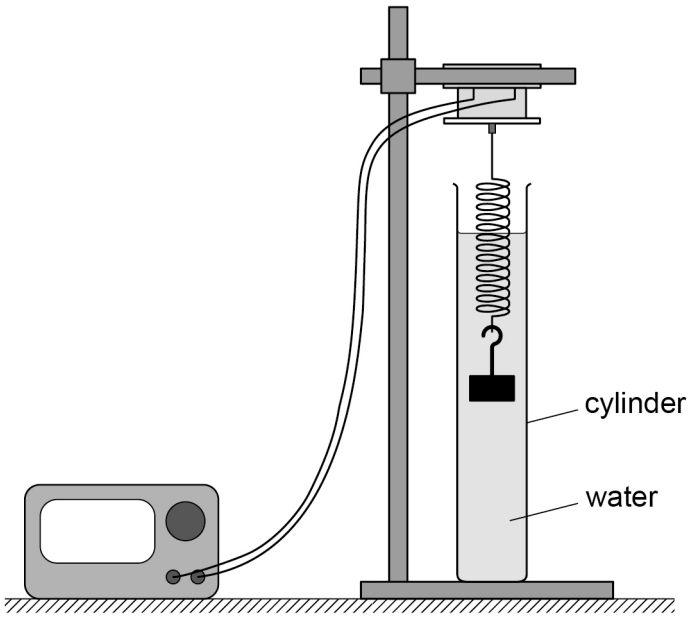
Explain why the amplitude varies in this way.

[2 marks]

Do not write outside the box

0 6 . 3 The experiment is repeated with the mass and spring suspended in a cylinder of water as shown in **Figure 9**.

Figure 9



The frequency is again increased slowly from zero.

Compare the behaviour of the oscillating systems in **Figure 8** and **Figure 9**.

[2 marks]

6

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0 7 Monochromatic light from a laser passes through the centre of a narrow single slit. The light forms a pattern on a screen.

0 7 . 1 Describe the appearance of the pattern.

You may support your answer with a labelled diagram.

[2 marks]

0 7 . 2 The width of the slit is decreased and a new pattern is observed on the screen.

Describe how this new pattern is different from the pattern in Question **07.1**.

[2 marks]

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0 7 . 3 The single slit is replaced with a diffraction grating that has 400 lines per mm.
The wavelength of the laser light is 530 nm.
A diffraction pattern is produced.

Calculate the maximum order of this diffraction pattern.

[2 marks]

maximum order = _____

6

Turn over for the next question

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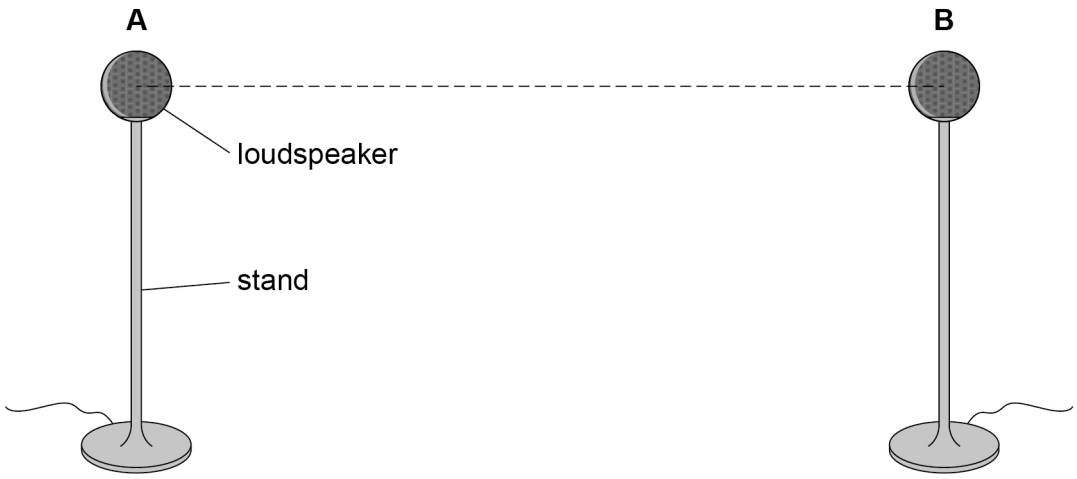
0 8 **Figure 10** shows two small loudspeakers **A** and **B** on stands.
A and **B** act as point sources of sound waves.

Coherent waves of the same amplitude are emitted from **A** and **B**.

Figure 10



0 8 . 1 State what is meant by coherent waves.

[2 marks]

Do not write outside the box

A sound meter gives a maximum reading when placed at the centre of the line **AB**. When the meter is moved $5.0\ \text{cm}$ towards **B** along the line **AB**, the meter reading decreases to a minimum.

0 8 . 2 Explain why the meter gives a minimum reading at this new position.

[3 marks]

As the meter is moved further towards **B** another maximum is detected, followed by a regular pattern of minima and maxima.

0 8 . 3 State the distance between two adjacent minima.
Go on to explain your answer.

[2 marks]

distance = _____ m

0 8 . 4 As the meter gets closer to **B**, the amplitude of the minima increases.

Suggest why.

[2 marks]

9

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0 9 This question is about different methods of producing white light.

0 9 . 1 A fluorescent tube produces white light from ultraviolet (UV) light.

Explain how UV light is produced in a fluorescent tube.

[3 marks]

A type of light-emitting diode (LED) emits UV photons.
White light can be produced from these photons by fluorescence.

0 9 . 2 This LED emits UV radiation at a power of $42\ \text{mW}$.
The radiation consists of photons with a frequency of $7.6 \times 10^{14}\ \text{Hz}$.

Calculate the number of UV photons emitted each second from the LED.

[3 marks]

number of photons emitted each second = _____

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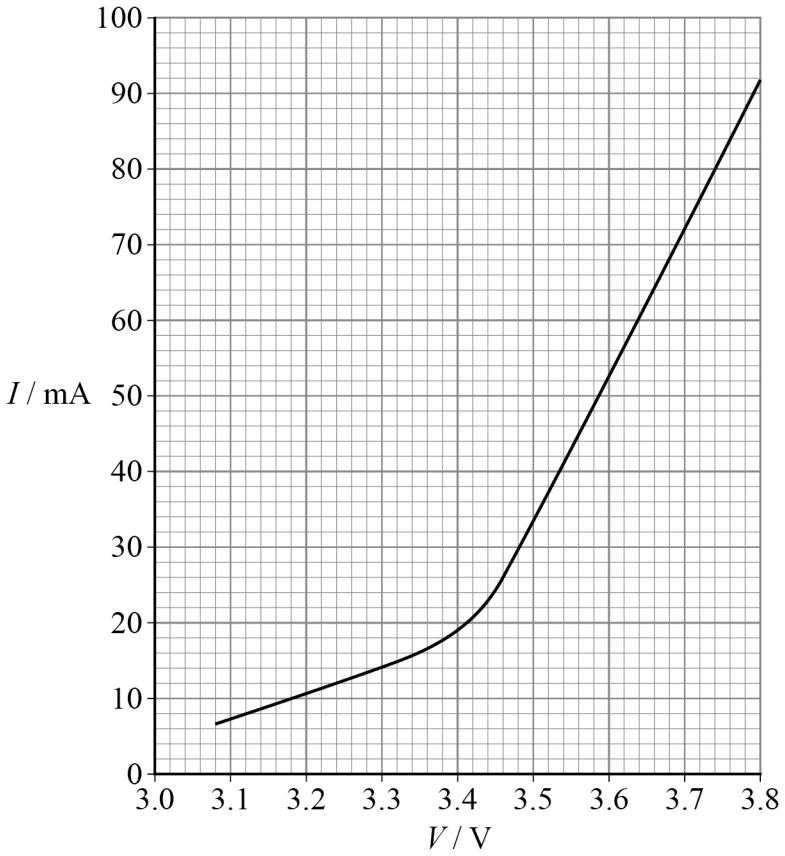
Figure 11 shows part of the I–V characteristic graph for the LED.

Figure 11



0 9 . 3 The pd across the LED is $3.4\ \text{V}$ when it emits UV radiation at a power of $42\ \text{mW}$.

Determine the efficiency of the production of UV radiation in the LED.

[2 marks]

efficiency = _____

Question 9 continues on the next page

0 9 . 4 A different source of white light uses a red LED, a green LED and a blue LED.

Figure 12 shows the I–V characteristic graph for each LED.

Figure 12

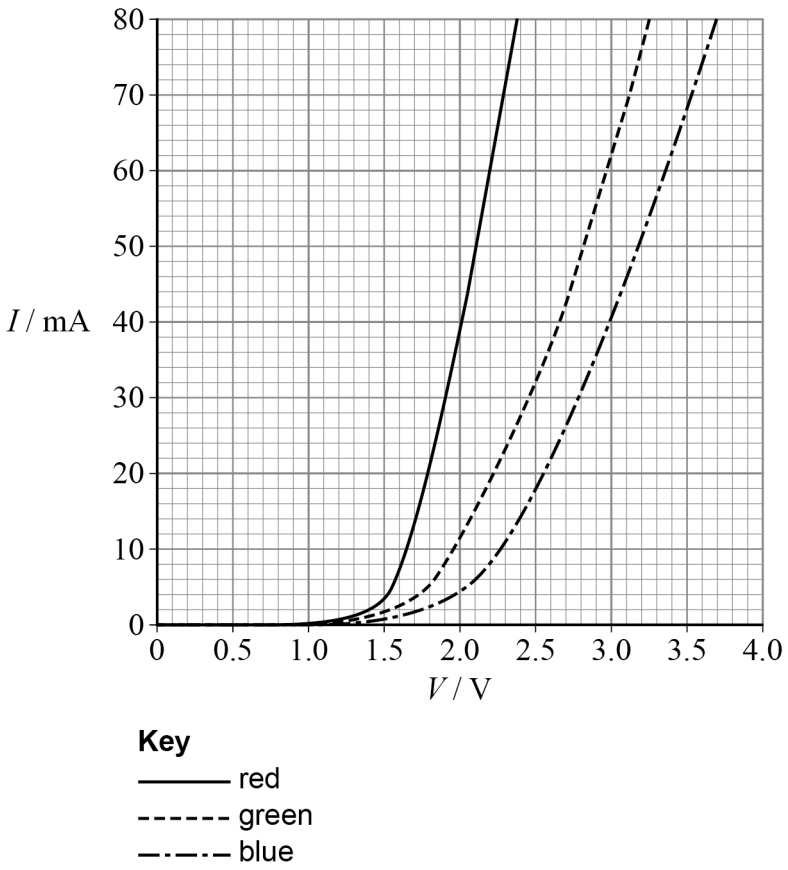


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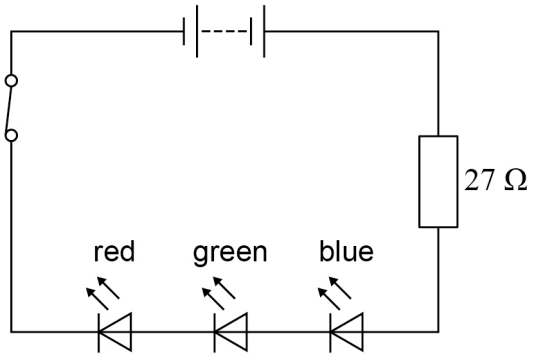
Figure 13 shows the LEDs connected in series to a $27\ \Omega$ resistor and a battery of negligible internal resistance.

Figure 13



The current in the circuit is $43\ \text{mA}$.

Determine the emf of the battery.

[3 marks]

emf = _____ V

11

END OF SECTION A

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Section B

Answer **all** questions in this section.

1 0 **Figure 14** shows the seed pod of a tree. The pod consists of two seeds and two wings. When the pod falls, the wings spin to produce an upward force so that the pod travels vertically downwards at a terminal speed.

Figure 14

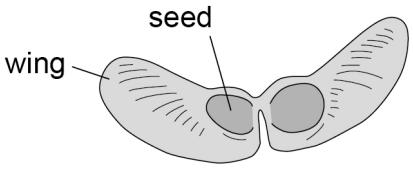
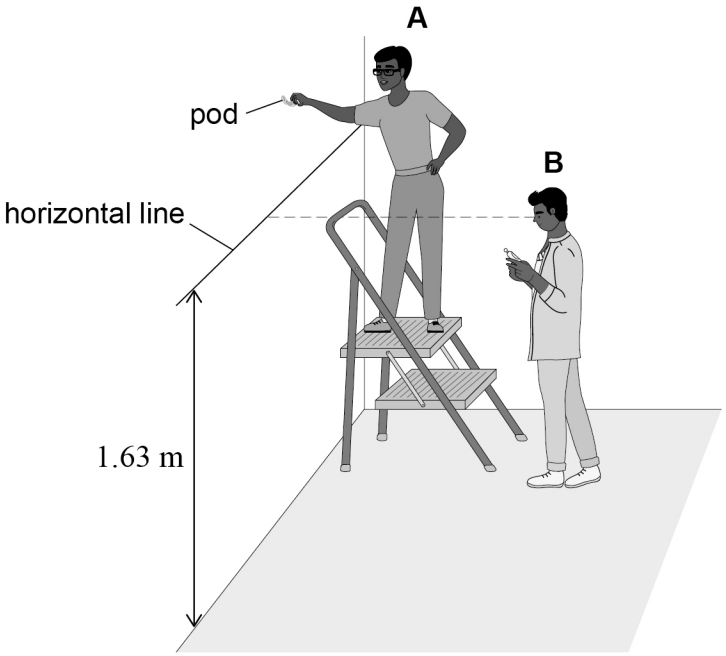


Figure 15 shows how two students **A** and **B** investigate how one pod falls.

Figure 15



Student **A** marks a horizontal line on the wall at a height of $1.63\ \text{m}$. The line is at the height of student **B**'s eyes when he stands facing the wall.

Student **A** releases the pod from a point higher than the line.
Student **B** measures the time t for the pod to travel at terminal speed between the line on the wall and the floor.

Do not write outside the box

The students make five valid measurements of t.
Table 1 shows four of the measurements and the mean value t_{mean} of all five measurements.

Table 1

t / s					
t_1	t_2	t_3	t_4	t_5	t_{mean}
0.84	0.75		0.94	0.77	0.83

1 0 . 1 Determine t_3.

[1 mark]

$t_3 =$ _____ s

1 0 . 2 Calculate the percentage uncertainty in t_{mean}.

[2 marks]

percentage uncertainty = _____

1 0 . 3 Determine the absolute uncertainty in the mean terminal speed of the pod.
Assume that the uncertainty in the height is negligible.

[2 marks]

absolute uncertainty = _____ m s^{-1}

Question 10 continues on the next page

Turn over ►

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1 0 . 4 The investigation is now repeated with student **B** dropping the pod and student **A** measuring the time.
Student **A** is taller than student **B**.

Suggest how the results are likely to be affected by this change.

[2 marks]

7

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Turn over for the next question

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ANSWER IN THE SPACES PROVIDED

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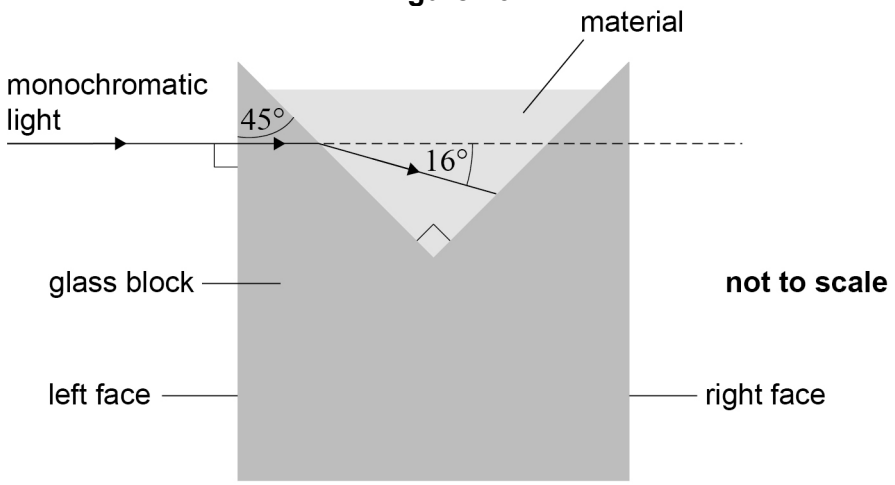
1 1 **Figure 16** shows apparatus used to determine the refractive index of a material.

The material is placed between two internal faces of a glass block. The angle between the two internal faces is $90°$. The angle between the vertical face and the angled face of the block is $45°$.
A horizontal ray of monochromatic light travelling in air is incident at $90°$ to the left face of the block.
The refractive index of the glass is 1.52

Figure 16



1 1 . 1 Calculate the change in the speed of light as it passes from air to the glass.

[2 marks]

change in speed of light = _____ $m\ s^{-1}$

1 1 . 2 The light deviates by $16°$ from the horizontal as it passes from the glass to the material, as shown in **Figure 16**.

Calculate the refractive index of the material.

[3 marks]

refractive index = _____

Do not write outside the box

This apparatus cannot be used to determine refractive indices smaller than a minimum value n_{min}.

1 1 . 3 Determine, by considering the critical angle, the value of n_{min}.

[1 mark]

$n_{min} =$ _____

1 1 . 4 Explain why refractive indices smaller than n_{min} cannot be measured with this apparatus.

[3 marks]

_____

_____

_____

_____

_____

_____

_____

_____

9

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 

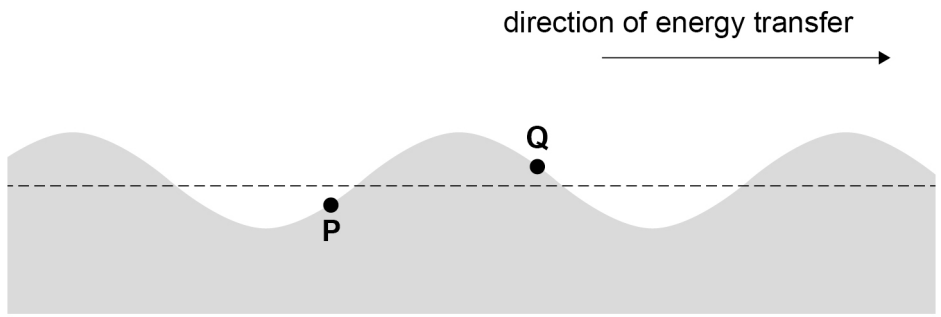
WRONG METHODS 

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 The diagram shows a progressive transverse wave at one instant.
The direction of energy transfer is to the right.



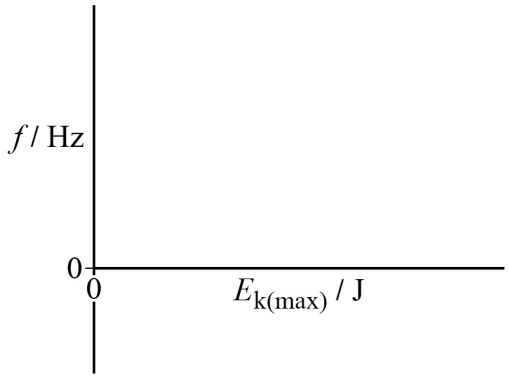
What are the directions of movement of **P** and **Q** at this instant?

[1 mark]

	Direction of movement of **P**	Direction of movement of **Q**	
A	down	down	⬭
B	down	up	⬭
C	up	down	⬭
D	up	up	⬭

Do not write outside the box

1 3 Light of frequency f is incident on a metal surface.
Photoelectrons with maximum kinetic energy $E_{k(max)}$ are emitted.
A graph showing the variation of f with $E_{k(max)}$ is plotted using the axes below.



Which row shows how the Planck constant and the work function of the metal surface are determined?

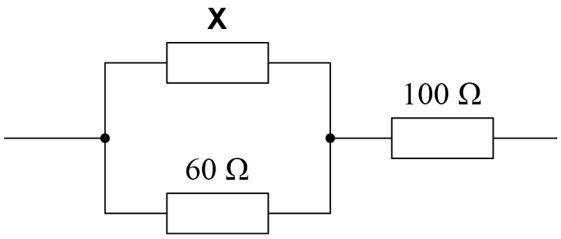
[1 mark]

	Planck constant	Work function	
A	gradient	$\frac{f \text{ intercept}}{\text{gradient}}$	⬭
B	gradient	f intercept × gradient	⬭
C	$\frac{1}{\text{gradient}}$	$\frac{f \text{ intercept}}{\text{gradient}}$	⬭
D	$\frac{1}{\text{gradient}}$	f intercept × gradient	⬭

Turn over for the next question

Do not write outside the box

1 4 The diagram shows a network of resistors.



The equivalent resistance of the network is 120 Ω.

What is the resistance of **X**?

[1 mark]

A 60 Ω ⬭

B 40 Ω ⬭

C 30 Ω ⬭

D 20 Ω ⬭

1 5 An atom is in its ground state.

The ionisation energy of the atom is the minimum energy required to:

[1 mark]

A remove an electron from the atom. ⬭

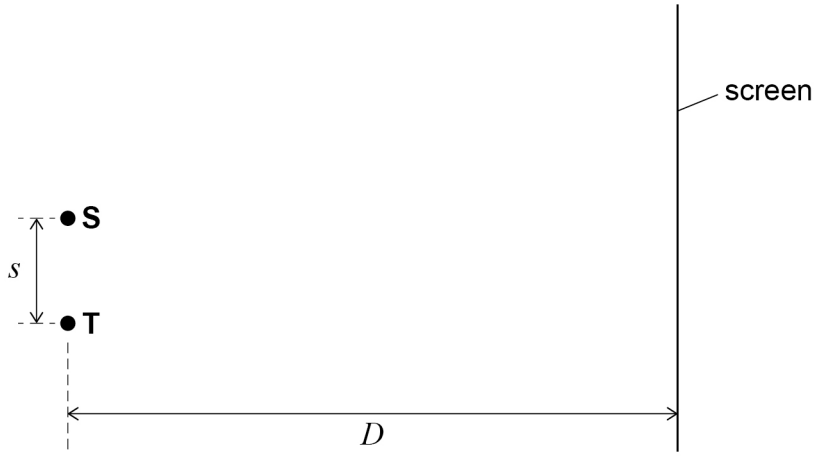
B remove all electrons from the atom. ⬭

C add an electron to the atom. ⬭

D move an electron within the atom so that the atom's energy level increases. ⬭

Do not write outside the box

1 6 Two coherent sources **S** and **T** emit light of wavelength λ.
S and **T** are separated by a distance s.
A screen lies at a distance D from a line connecting **S** and **T**.
In this arrangement $s << D$.



The distance between the 5th and 7th bright fringes is:

[1 mark]

A $\frac{\lambda D}{2s}$ ⬭

B $\frac{2\lambda D}{s}$ ⬭

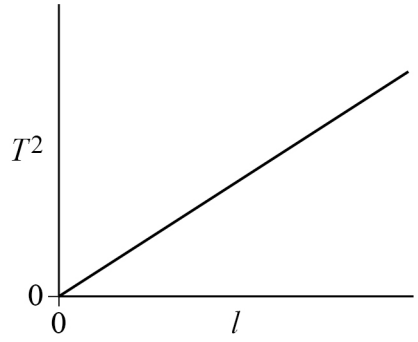
C $\frac{3s\lambda}{D}$ ⬭

D $\frac{3\lambda D}{s}$ ⬭

Turn over for the next question

Do not write outside the box

1 7 A simple pendulum is used to find a value for the acceleration g due to gravity.
The period of oscillation T is measured for different lengths l of the pendulum.
A graph of T^2 against l is a straight line with gradient S. The graph goes through the origin.



What is g?

[1 mark]

A $\frac{2\pi}{S}$ ⬭

B $2\pi S$ ⬭

C $\frac{4\pi^2}{S}$ ⬭

D $\frac{S}{4\pi^2}$ ⬭

1 8 Monochromatic light has a wavelength λ.
Each photon of the light has an energy E.

Which row shows what happens to λ and E as the light enters a glass block from air?

[1 mark]

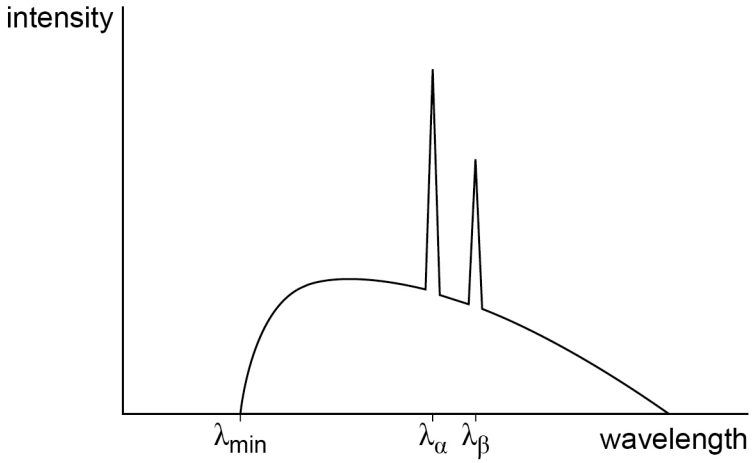
	λ	E	
A	decreases	remains the same	⬭
B	decreases	increases	⬭
C	increases	remains the same	⬭
D	increases	decreases	⬭

Do not write outside the box

1 9 The graph shows the emission spectrum for an X-ray tube operating at $80\ \mathrm{kV}$.

Characteristic lines occur at wavelengths λ_α and λ_β.

The shortest wavelength in the emission spectrum is λ_{min}.



The same X-ray tube is now operated at $40\ \mathrm{kV}$.

What happens to λ_α, λ_β and λ_{min}?

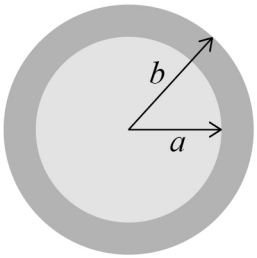
[1 mark]

	λ_α	λ_β	λ_{min}	
A	doubled	doubled	doubled	⬭
B	halved	halved	halved	⬭
C	unchanged	unchanged	halved	⬭
D	unchanged	unchanged	doubled	⬭

Turn over for the next question

Do not write outside the box

2 0 A step-index optical fibre has a core of radius a and a cladding of maximum radius b.

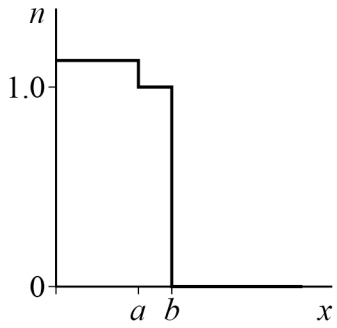


The fibre is in air.

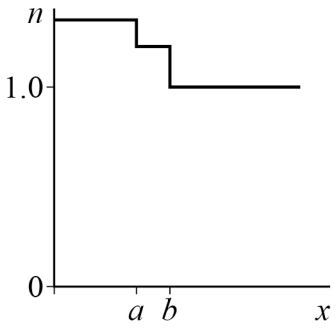
Which graph shows how the refractive index n varies with distance x from the centre of the fibre?

[1 mark]

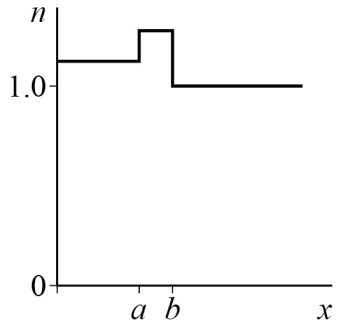
A



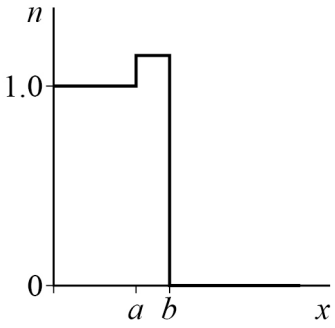
B



C



D



A ⬭

B ⬭

C ⬭

D ⬭

Do not write outside the box

2 1 A stretched wire vibrates between two fixed points.
The frequency of the first harmonic of the vibrating wire is 400 Hz.
The tension in the wire is T.

The tension in the wire is now increased.
Changes to the length and the mass per unit length of the wire are negligible.

The frequency of the first harmonic is now 600 Hz.

What is the new tension in the wire?

[1 mark]

A $\sqrt{\frac{3T}{2}}$ ⬭

B $\sqrt{\frac{3}{2}}\,T$ ⬭

C $\frac{3T}{2}$ ⬭

D $\frac{9T}{4}$ ⬭

2 2 The phase difference between two points on a wave is 0.56 rad.

What is the phase difference in degrees?

[1 mark]

A $32°$ ⬭

B $64°$ ⬭

C $101°$ ⬭

D $202°$ ⬭

Turn over ►

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2 3 The energy storage capacity of a battery is rated in ampere hour (A h).
A battery with a storage capacity of 1 A h can provide 1 A for one hour at its working pd.

One battery has a capacity of 2700 mA h at a working pd of 4.2 V.

What is the energy that can be transferred by this battery?

[1 mark]

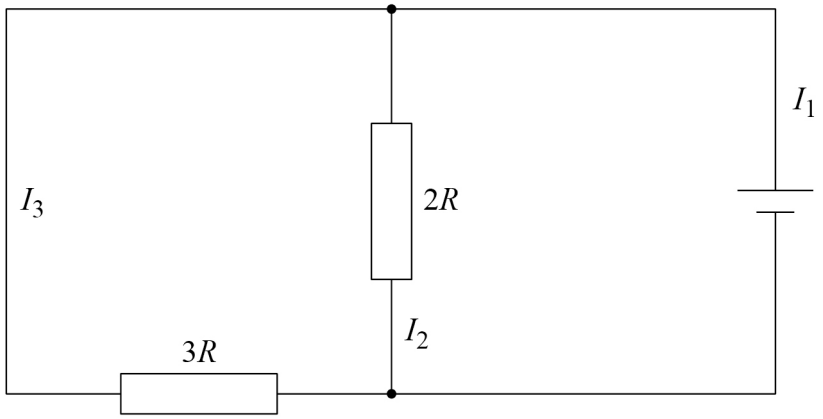
A 11 kJ ⬭

B 41 kJ ⬭

C 680 kJ ⬭

D 41 MJ ⬭

2 4 Two resistors are connected to a cell that has negligible internal resistance.
The resistances and currents are shown on the diagram.



Which relationship, for this circuit, is **not** correct?

[1 mark]

A $3I_1 = 5I_2$ ⬭

B $2I_1 = 5I_3$ ⬭

C $2I_2 = 3I_3$ ⬭

D $5I_1 = 3I_2 + 2I_3$ ⬭

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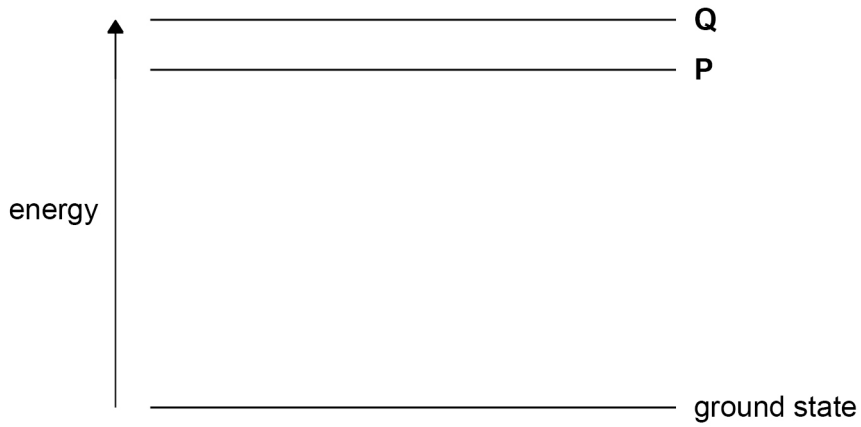
2 5 The diagram shows the ground state of an atom and two excited states **P** and **Q**.

The transition of an electron from **P** to the ground state produces a photon of wavelength 502 nm.
The transition of an electron from **Q** to the ground state produces a photon of wavelength 448 nm.



The energy difference between **P** and **Q** is:

[1 mark]

A 4.8×10^{-20} J ⬭

B 4.0×10^{-19} J ⬭

C 4.4×10^{-19} J ⬭

D 3.7×10^{-18} J ⬭

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END OF QUESTIONS

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