Surname	Centre Number	Candidate Number
First name(s)		2

GCE AS/A LEVEL

S25-2420U20-1

2420U20-1

WEDNESDAY, 21 MAY 2025 – AFTERNOON

PHYSICS – AS unit 2
Electricity and Light

1 hour 30 minutes

For Examiner's use only		
Question	**Maximum Mark**	**Mark Awarded**
1.	**11**	
2.	**13**	
3.	**7**	
4.	**11**	
5.	**12**	
6.	**13**	
7.	**8**	
8.	**5**	
Total	**80**	

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ADDITIONAL MATERIALS

In addition to this paper you will require a calculator and a **Data Booklet**.

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen. Do not use gel pen or correction fluid.

You may use a pencil for graphs and diagrams only.

Write your name, centre number and candidate number in the spaces at the top of this page.

Answer **all** questions.

Write your answers in the spaces provided in this booklet. If you run out of space, use the additional page(s) at the back of the booklet, taking care to number the question(s) correctly.

INFORMATION FOR CANDIDATES

The total number of marks available for this paper is 80.

The number of marks is given in brackets at the end of each question or part-question.

The assessment of the quality of extended response (QER) will take place in question **2**(b).

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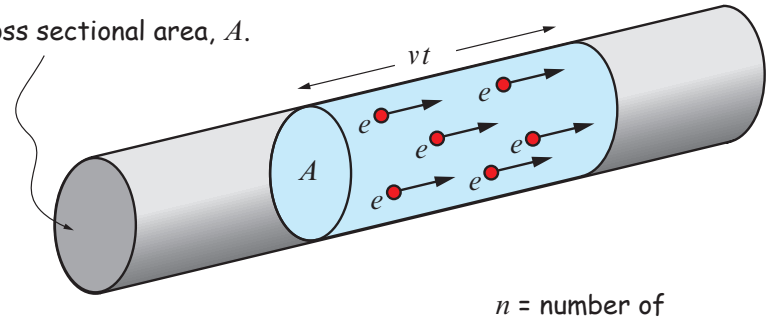
Answer **all** questions.

1. (a) Gwen provides the following incomplete derivation of the drift velocity equation $I = nAve$.

A pd is applied across either end of a wire.

Electrons move with drift velocity, v,

through a cross sectional area, A.



n = number of electrons per m^3

Volume of blue shaded portion of wire = Avt using cross sectional area × distance

Number of electrons = $nAvt$

Total charge = $nAvte$

(i) Gwen's statement regarding n is incomplete. Give the complete meaning of n. [1]

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(ii) Define 'electric current' **and** use your definition to finish Gwen's derivation. [2]

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(b) Gwen and her friend Griff each construct a resistor made from constantan wire.

The table shows some of the values related to their wires.

	Gwen's wire	Griff's wire
Resistance / Ω	9.0	18.0
Diameter / mm	0.508	0.254
Length / m	.....	1.861

(i) Determine the length of Gwen's wire. [4]

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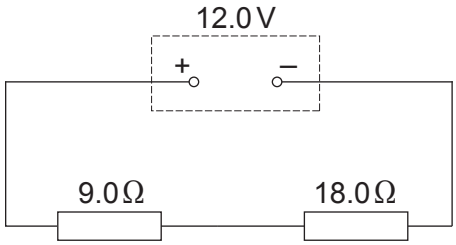
(ii) The two resistors are now arranged in series with a power supply of 12.0 V of negligible internal resistance.



I. **Add an arrow** to the diagram to show the direction of **electron flow**. [1]

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II. Gwen and Griff make the following statements.

- Gwen states that the current in Griff's wire will be less than in her wire because Griff's wire is thinner.
- Griff states that the drift velocity in his wire is less than in Gwen's wire.

Explain why both statements are incorrect. [3]

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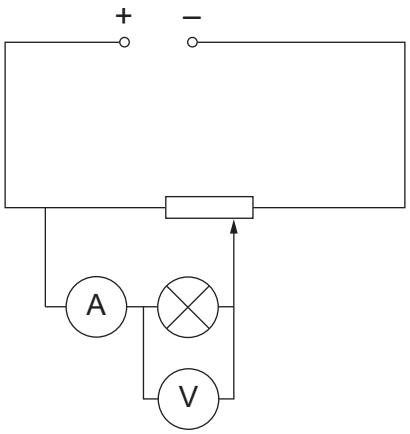
2. A student investigates the $I - V$ characteristic of a filament lamp using the apparatus below.



The table below shows the student's results.

V / V	I / A
0.0	0.00
1.0	0.04
2.0	0.08
3.0	0.10
4.0	0.12
5.0	0.13
6.0	0.15
7.0	0.16
8.0	0.17
9.0	0.18
10.0	0.19

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(a) Use data from the table to determine to what extent the filament lamp obeys Ohm's law. [3]

(b) Explain, making reference to free electrons, why the resistance of the filament in a lamp increases as the potential difference across it increases during the student's experiment. [6 QER]

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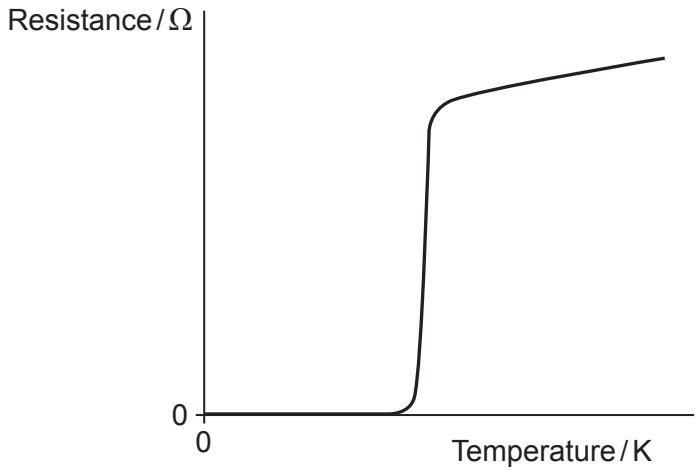
(c) The graph shows how the resistance of a certain metal varies at low temperatures.



Explain what is meant by the 'transition temperature' of a metal **and** suggest a typical value for this temperature. [2]

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(d) Whilst developing a new compound, a team of university students found evidence that the compound had room temperature superconducting properties and published their findings. It was later discovered that their experimental procedures had inaccuracies, and the compound did not behave as a room temperature superconductor.
Describe how the team of students should have proceeded before publishing their findings. [2]

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3. (a) Define the emf of a cell. [2]

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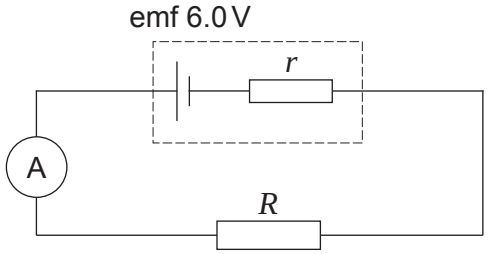
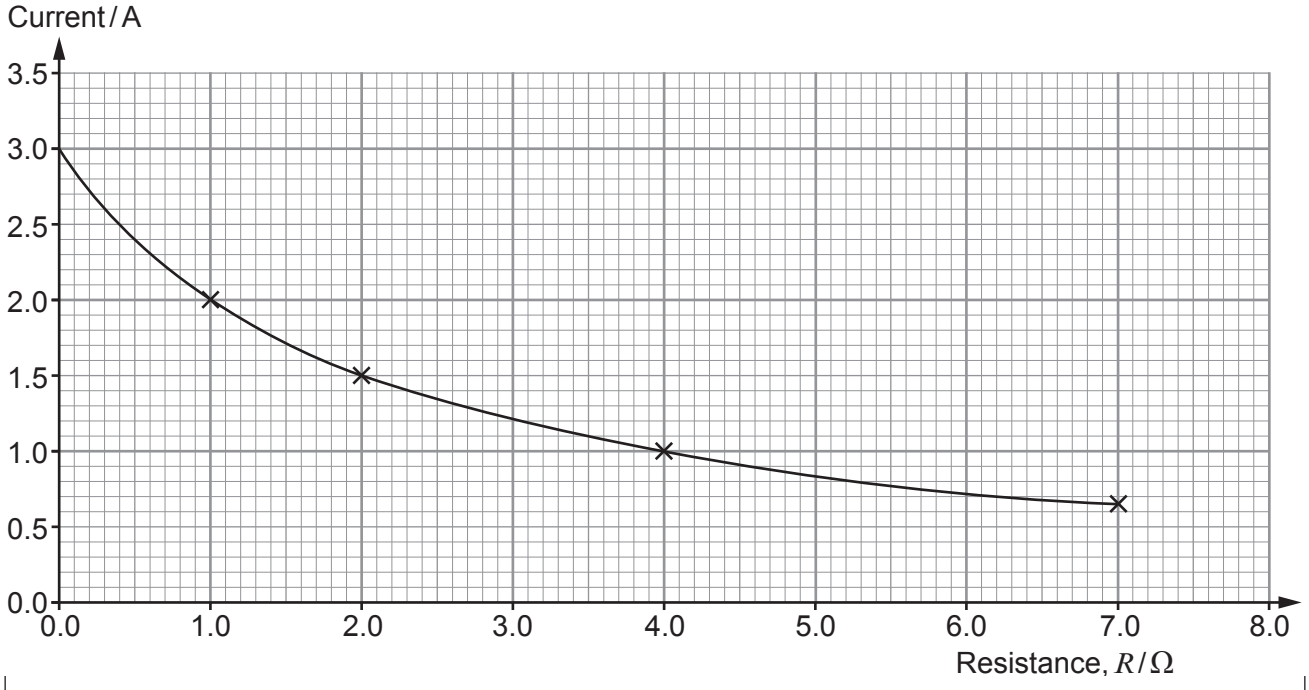
(b) Bryn connects a battery of emf 6.0 V and an unknown internal resistance, r, to an ammeter and a selection of different resistors (1.0 Ω, 2.0 Ω, 4.0 Ω and 7.0 Ω) as shown.



He produces a graph of current against resistance.



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(i) Show that the internal resistance, r, of the cell is $2.0\,\Omega$. [2]

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(ii) Bryn states that the maximum power dissipation in the resistor, R, occurs when its resistance is equal to the internal resistance of the battery. Use the graph to justify his claim. [3]

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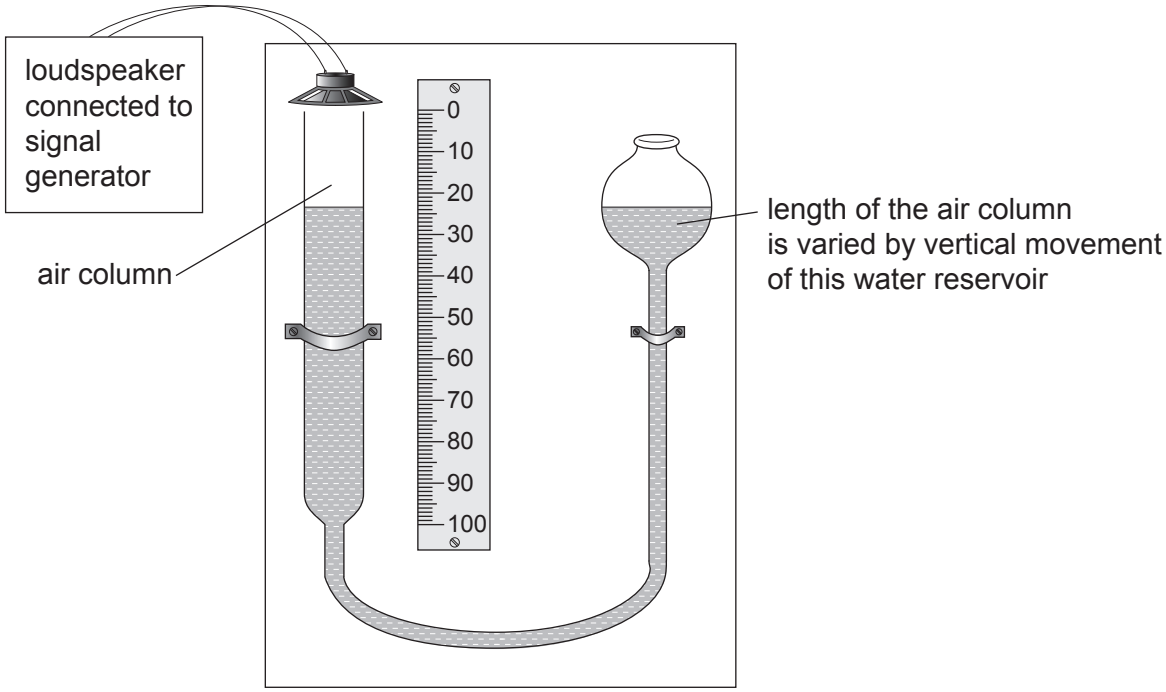
4. A group of students investigates stationary waves in an air column to determine the speed of sound.



(a) Describe how a stationary wave is produced in the air column. [3]

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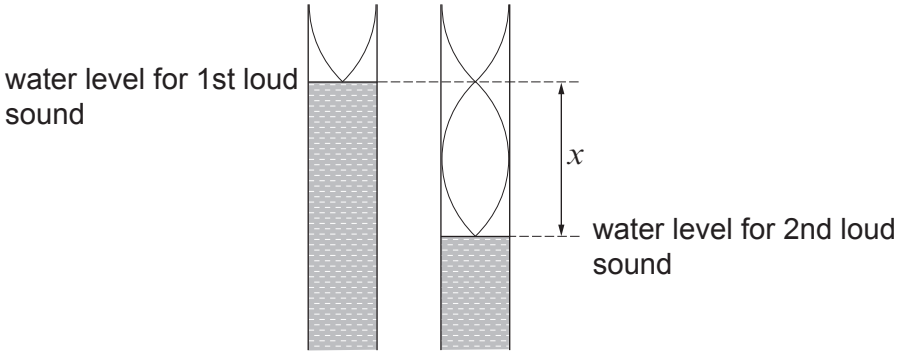
(b) The loudspeaker produces a sound of frequency 495 Hz, and the length of the air column is adjusted to find two consecutive positions for maximum loudness as shown below.



The distance between these positions, x, is measured with a ruler. This process is repeated and the results are tabulated below.

Frequency / Hz	x / m				
	Measurement 1	Measurement 2	Measurement 3	Measurement 4	Mean
495	0.332	0.338	0.342	0.348	0.340

(i) Calculate the **percentage** uncertainty of the mean value for x. [2]

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(ii) Show that the speed of sound, c, can be given by:

$$c = 2fx$$

[2]

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(iii) The uncertainty in the frequency is ± 2%. Calculate the speed of sound with its **absolute** uncertainty. State your answers to a suitable number of significant figures. [4]

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5. (a) Explain what is meant by diffraction. [1]

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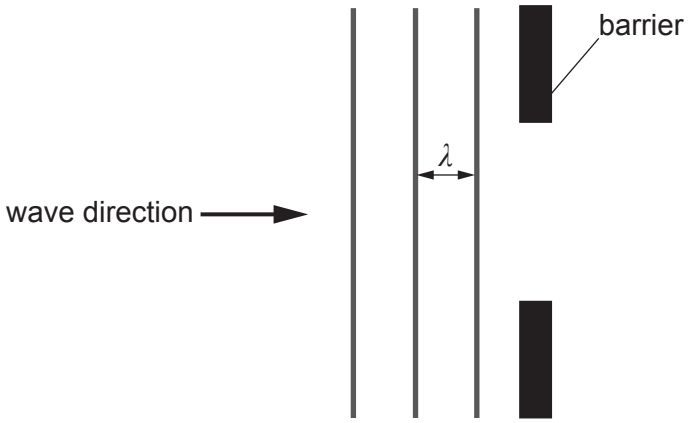
(b) The diagram below shows plane water waves approaching a gap in a barrier in a ripple tank. The wavefronts are separated by one wavelength, λ.



(i) **Add to the diagram** the next four wavefronts to the right of those shown. [2]

(ii) Describe the shape of the wavefronts if the gap in the barrier is made less than λ. [1]

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(c) Interference patterns are produced by sources of waves that have a constant phase relationship.

(i) State the term used to describe sources that have a constant phase relationship. [1]

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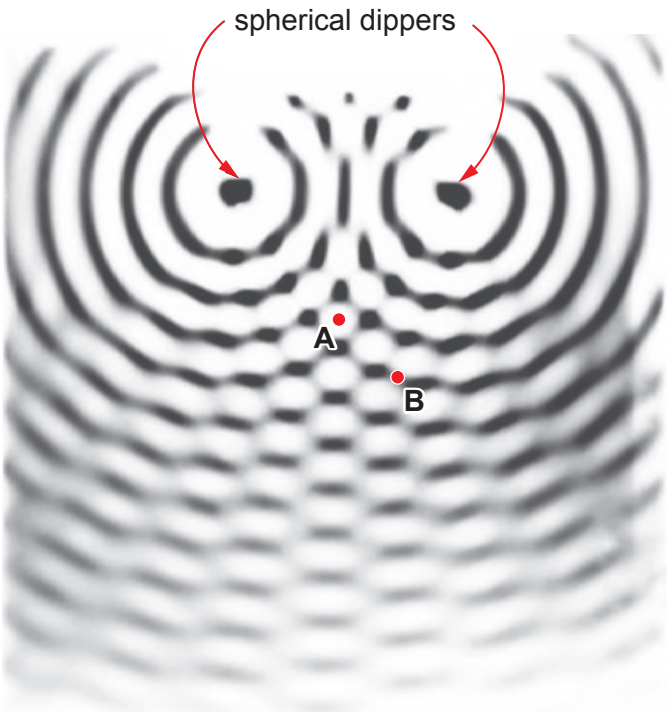
(ii) The ripple tank is also used to investigate two-source interference. Two spherical dippers attached to the same vibrating block act as in-phase sources and produce an interference pattern as shown. The wavefronts are separated by one wavelength.



Explain, making reference to path difference, what type of interference occurs at points **A** and **B**. [4]

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(iii) A technician wants to use light sources in order to demonstrate a two-source interference pattern. He considers the following options:

- Red laser light directed through a double slit onto a screen.
- Light from a sodium lamp directed through a double slit onto a screen.
- Light from a red laser and a blue laser directed at the same point on a screen.

Explain whether each option is suitable in demonstrating two-source interference. [3]

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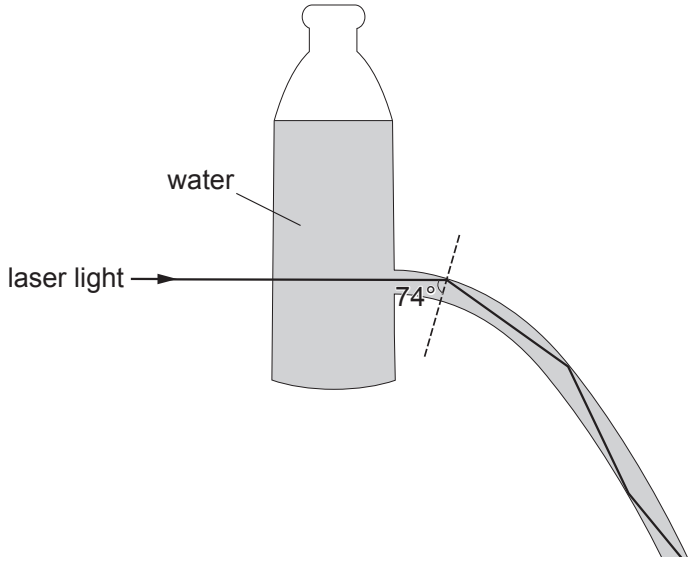
6. A beam of laser light travels from air (n_{air} = 1.00) through a plastic bottle ($n_{plastic}$ = 1.57) containing water (n_{water} = 1.33). A hole created in the bottle allows water to flow as a continuous stream as shown.



(a) (i) Using calculated values, describe how the speed of the laser light varies as it follows the path above. [3]

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(ii) When the beam enters the stream of water, it follows the path as shown above. Explain this process, making reference to the critical angle of the water–air boundary and giving suitable calculations. [4]

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(b) The laser has a power output of 1.0 mW, and its stimulated emission wavelength is 550 nm.

(i) Explain what is meant by stimulated emission. [3]

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(ii) Determine the number of photons per second emitted by the laser. [3]

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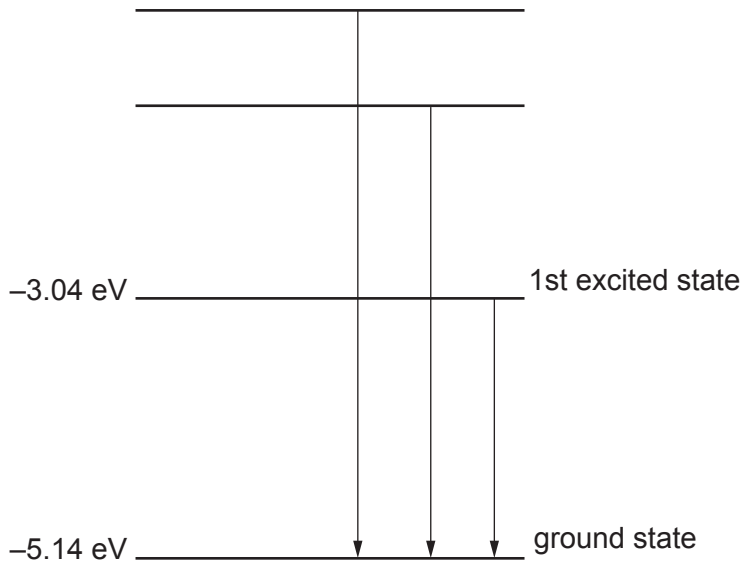
7. Part of a simplified energy level diagram for a sodium atom is shown below.



(a) Determine the wavelength of the electromagnetic radiation emitted when an electron drops from the 1st excited state to the ground state. [3]

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(b) A sodium discharge tube is observed in a dark room through a diffraction grating. A line **emission** spectrum is observed. Describe the appearance of this spectrum. [2]

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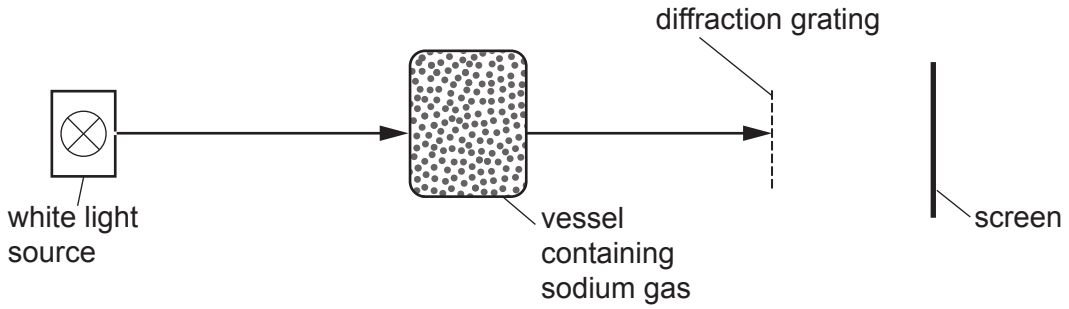
(c) A technician demonstrates the **absorption** spectrum of sodium using the apparatus shown in the diagram. The light is projected onto a screen.



Explain why there is a black line in the spectrum. Make reference to the energy level diagram. [3]

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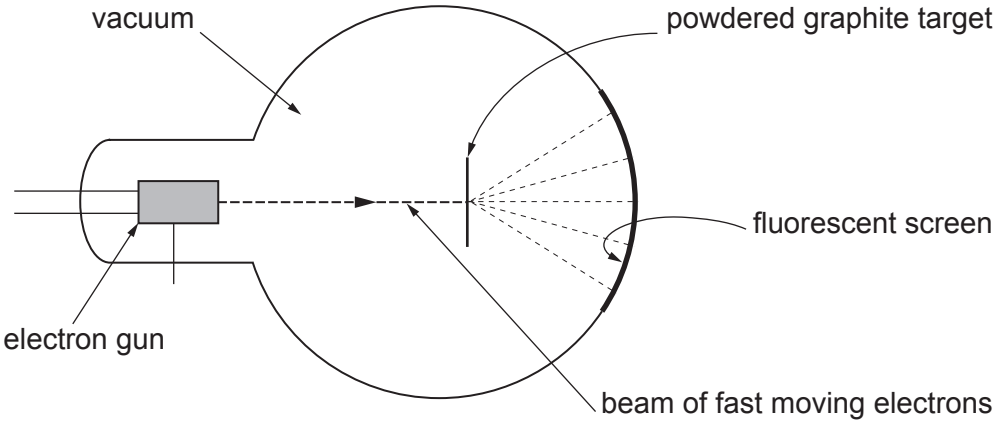
8. Fast-moving electrons are incident upon a powdered graphite target as shown.



(a) A pattern appears on the fluorescent screen. Describe the pattern **and** explain the significance of this experiment. [2]

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(b) The electrons emitted from the electron gun have a speed of $1.8 \times 10^7\,m\,s^{-1}$. Calculate their (de Broglie) wavelength **in pm**.
(HINT: Momentum is the product of mass and velocity). [3]

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END OF PAPER

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