Surname	Centre Number	Candidate Number
First name(s)		2

GCE AS

B420U20-1

S24-B420U20-1

WEDNESDAY, 22 MAY 2024 – AFTERNOON

PHYSICS – AS component 2
Electricity and Light

1 hour 30 minutes

For Examiner's use only		
Question	**Maximum Mark**	**Mark Awarded**
1.	**9**	
2.	**10**	
3.	**13**	
4.	**12**	
5.	**8**	
6.	**14**	
7.	**9**	
Total	**75**	

B420U201
01

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 75.

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

You are reminded to show all working. Credit is given for correct working even when the final answer is incorrect.

The assessment of the quality of extended response (QER) will take place in **4**(a).

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Answer **all** questions.

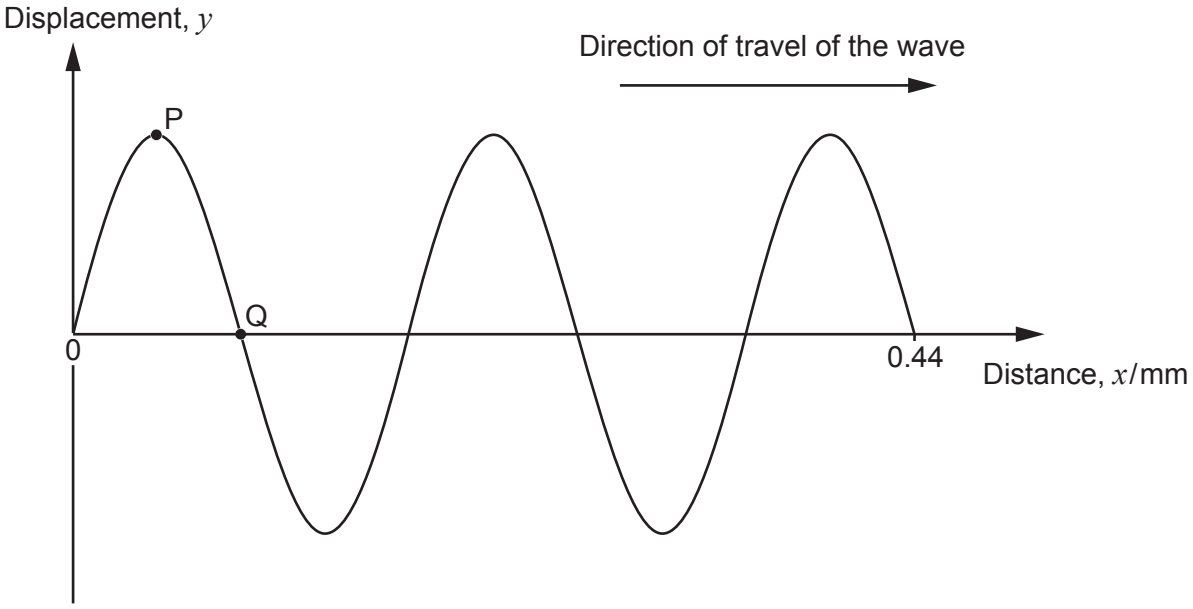
1. (a) Explain what is meant by a transverse wave. [2]

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(b) The following graph shows displacement against distance for a progressive wave.



(i) Explain what is meant by the amplitude of the wave. [1]

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(ii) Calculate the wavelength of the wave. [2]

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(iii) Determine the frequency of the wave if it travels with a speed of $340\,m\,s^{-1}$. [2]

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(c) Determine the phase difference between points labelled P and Q **and** state which point is leading. [2]

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2. A beam of monochromatic light is incident normally (at right angles) on a diffraction grating.

(a) Explain in clear steps why bright beams emerge from the grating at angles, θ, to the normal given by the equation: [4]

$$n\lambda = d\sin\theta$$

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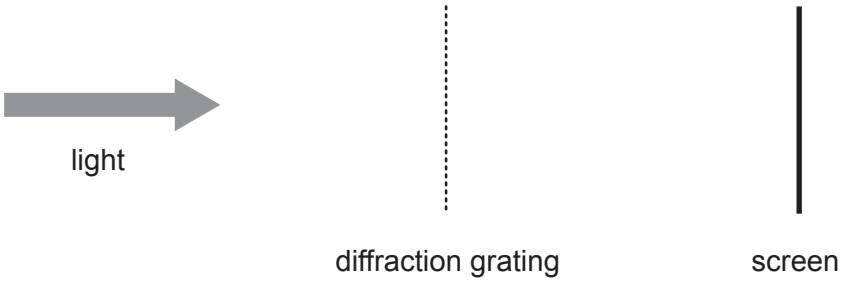
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(b) A diffraction grating has 8000 lines over a width of 20 mm. Light of wavelength 590 nm is incident on the grating.



(i) Calculate the angle to the normal for the first order beam. [3]

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(ii) Determine the maximum number of bright spots observed on the screen. [3]

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3. (a) State what is meant by the work function of a metal. [1]

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(b) The work function of sodium is 3.8×10^{-19} J.

(i) Calculate the frequency of radiation needed to eject electrons with a maximum kinetic energy of 1.5×10^{-19} J from a sodium surface. [2]

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(ii) Determine the minimum pd needed between the sodium surface and a nearby negatively charged electrode to stop these electrons. [2]

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(iii) The intensity of the radiation is increased by moving the radiation source closer to the sodium surface. Ronald states the minimum pd will also increase.
Explain whether Ronald is correct. [3]

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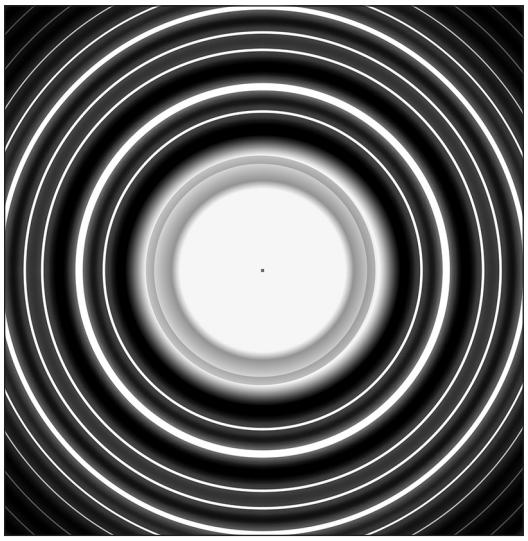
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(c) When fast moving electrons strike a thin graphite layer, the following pattern is observed on a fluorescent screen.



(i) State what this pattern tells us about the behaviour of electrons. [1]

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(ii) Explain how this pattern is formed. [2]

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(iii) Calculate the speed at which an electron must be moving to have a de Broglie wavelength of 1.7×10^{-11} m. [2]

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4. (a) Describe an experiment to measure the speed of sound in air using stationary waves in a resonance tube. Include details of graphical analysis in your answer. [6 QER]

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(b) (i) A large earthquake on the Earth's surface creates two types of waves that have speeds of 6.0 km s^{-1} and 3.5 km s^{-1}. The waves travel to a monitoring station. They arrive with a 60 s interval between them. Calculate the distance between the centre of the earthquake and the monitoring station. [4]

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(ii) Japan and Mexico have developed an earthquake early warning system costing billions of pounds. Discuss whether all countries should develop such a system. [2]

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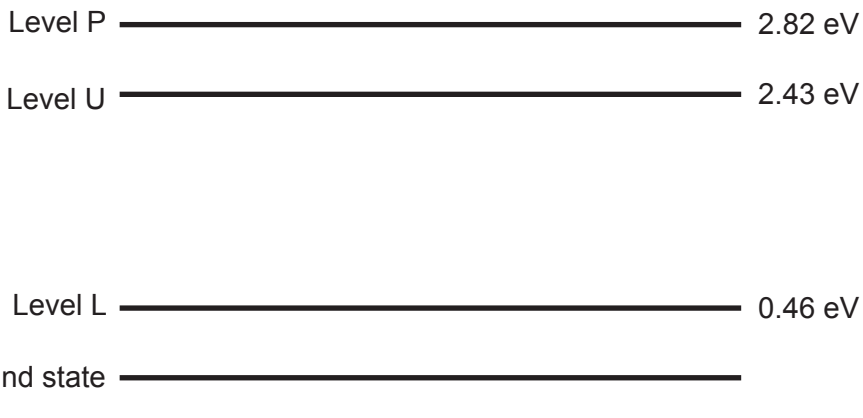
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5. A simplified energy level diagram for a four-level laser system is given below.



(a) (i) State the transition associated with pumping. [1]

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(ii) Explain why a population inversion is required for a laser to work. [3]

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(b) The manufacturer's label shows that the wavelength of the light from the laser is 630 nm. Determine whether this label is correct. [4]

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6. Beatrice carried out an investigation into how the resistance of a metal wire varies with the length of the wire.

(a) Beatrice used a voltmeter and an ammeter to determine the resistance. Draw a diagram of the circuit that she used to obtain her results. [2]

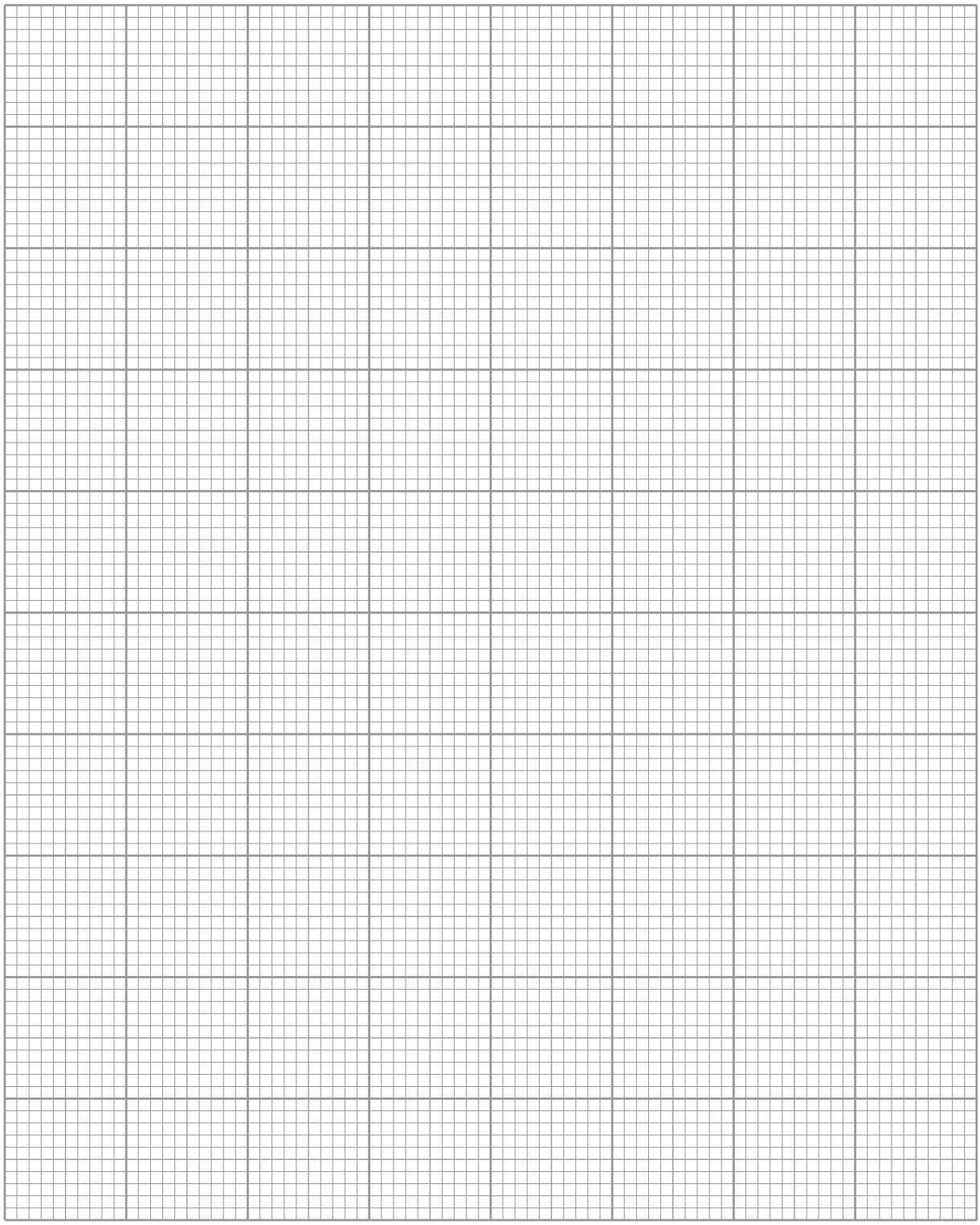
(b) Beatrice's results are given in the table.

Length, l / m	Resistance, R / Ω
0.100	1.2
0.200	2.5
0.300	3.7
0.400	5.0
0.500	6.2
0.600	7.4

Plot a graph with R on the y-axis and l on the x–axis. Draw a line of best fit through the data. [4]

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(c) Beatrice measures the diameter of the wire and obtains the following values.

Diameter, d / mm	0.30	0.33	0.32	0.32

(i) Determine the resistivity of the wire. [6]

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(ii) Beatrice's value for the resistivity has a percentage uncertainty of $\pm 18\%$.
A data source gives the value of the resistivity of nichrome as $110 \times 10^{-8}\,\Omega\,\text{m}$.
Determine whether the material of the wire that Beatrice used could be nichrome. [2]

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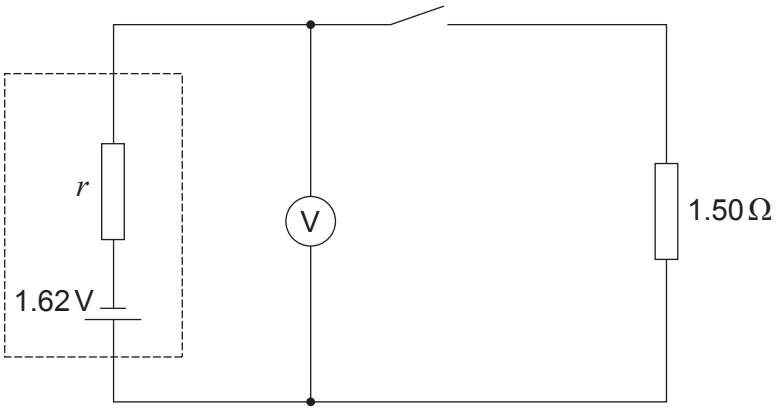
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7. A circuit with a cell of emf 1.62 V and internal resistance, r, is set up as shown.



(a) (i) State the expected reading on the voltmeter when the switch is open. [1]

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(ii) With the switch closed the voltmeter reads 1.38 V. Determine the internal resistance, r, of the cell. [3]

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(iii) The switch is closed for a period of time and 550 J of the cell's energy is dissipated. Calculate the time for which the switch is closed. [2]

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(b) Calculate the voltmeter reading when the 1.50 Ω resistor is replaced by a 0.56 Ω resistor and the switch is closed. [3]

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END OF PAPER

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