Surname	Centre Number	Candidate Number
Other Names		2

GCE AS/A LEVEL – NEW

2420U20-1

S17-2420U20-1

PHYSICS – AS unit 2
Electricity and Light

THURSDAY, 8 JUNE 2017 – AFTERNOON

1 hour 30 minutes

2420U201 01

For Examiner's use only		
Question	**Maximum Mark**	**Mark Awarded**
1.	**6**	
2.	**8**	
3.	**8**	
4.	**11**	
5.	**12**	
6.	**10**	
7.	**12**	
8.	**13**	
Total	**80**	

ADDITIONAL MATERIALS

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

INSTRUCTIONS TO CANDIDATES

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

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 continuation 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 **5**(*a*).

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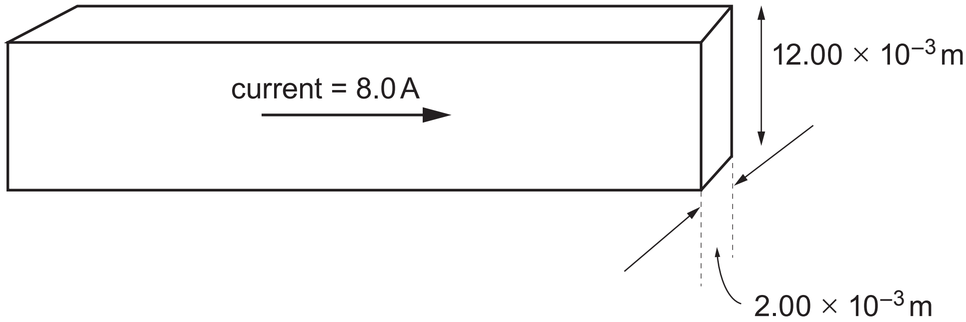
Answer **all** *questions.*

1. A strip of metal of rectangular cross-section is shown.



(a) Calculate the drift velocity of free electrons in the strip when there is a current of 8.0 A as shown. The free electron concentration, n, in the metal is $8.5 \times 10^{28}\,\text{m}^{-3}$. [3]

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(b) The resistance of the strip is 0.15 Ω from end to end. Calculate the energy transferred from electrical potential to thermal in the strip in a time of 20 s, for a current of 8.0 A, **and** briefly state how the transfer takes place. [3]

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2. A student is given wire cutters and a reel of metal wire, and asked to find the resistivity of the metal. She cuts off a piece of the wire and makes measurements on it. She takes repeat readings and obtains the same values each time.

Quantity	Measurement	Instrument	Resolution of instrument
length	812 mm	metre ruler	1 mm
diameter	0.48 mm	digital calipers	0.01 mm
resistance	2.2 Ω	digital multimeter	0.1 Ω

(a) (i) Calculate the resistivity of the metal of the wire. [3]

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(ii) Calculate the **absolute** uncertainty in the resistivity giving your value to an appropriate number of significant figures. [3]

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(b) Suggest **one** way in which the student could reduce the uncertainty in her value for the resistivity, using the same reel of wire and the same instruments as before. Explain briefly why the uncertainty would be reduced. [2]

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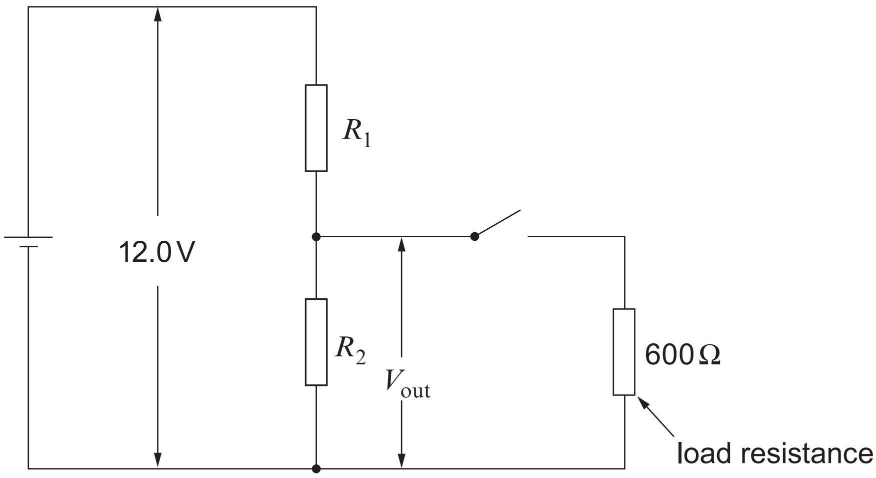
3. For the potential divider circuit shown a student is asked to select values for R_1 and R_2 so that the circuit meets certain requirements.



Requirements

A an output pd, V_{out}, of 3.0 V when unloaded (switch open),
B a power dissipation of less than 0.50 W in R_1 when unloaded (switch open),
C a **decrease** of less than 0.40 V in V_{out} when the switch is closed.

Showing your working clearly, determine whether or not the circuit meets the requirements when R_1 = 450 Ω and R_2 = 150 Ω.

(a) Requirement **A**: an output pd, V_{out}, of 3.0 V when unloaded (switch open). [2]

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(b) Requirement **B**: a power dissipation of less than 0.50 W in R_1 when unloaded (switch open). [2]

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(c) Requirement **C**: a **decrease** of less than 0.40 V in V_{out} when the switch is closed. [4]

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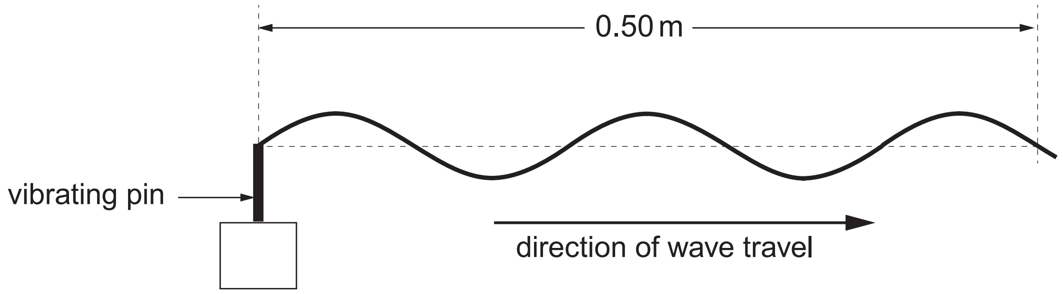
4. *(a)* A **progressive** wave generated by a vibrating pin is travelling on a long string. The periodic time is 0.040 s. The diagram shows a part of the string at time t = 0.



(i) Calculate the distance that the wave travels in a time of 0.34 s. [3]

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(ii) Carefully sketch **on the diagram above** the same part of the string at time t = 0.34 s. (The periodic time is 0.040 s.) [1]

(b) If the string above is clamped rigidly a little way to the right of the part shown, a **stationary** wave may be observed.

(i) State what is meant by a **node** in a stationary wave, and state how far apart the nodes will be in *this* stationary wave. [2]

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(ii) State how, if at all, the *phase* of the oscillations of the particles of the string varies with distance along the string, for a stationary wave. [2]

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(iii) Explain, in terms of *interference*, how the stationary wave is produced for this stationary wave on the string. [2]

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(iv) Stationary waves may also be observed on the string when the wave source is set to higher frequencies. State **one** way, apart from having a different frequency, in which the stationary waves will be different from the original stationary waves. [1]

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5. *(a)* Describe in detail how you would determine the wavelength of light from a (low-power) laser, given an opaque plate with two parallel slits. (The distance between the centres of the slits is less than 1 mm and has already been measured.) [6 QER]

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(b) A diffraction grating is used with a laser as shown, and a line of bright spots is seen on the screen as shown.

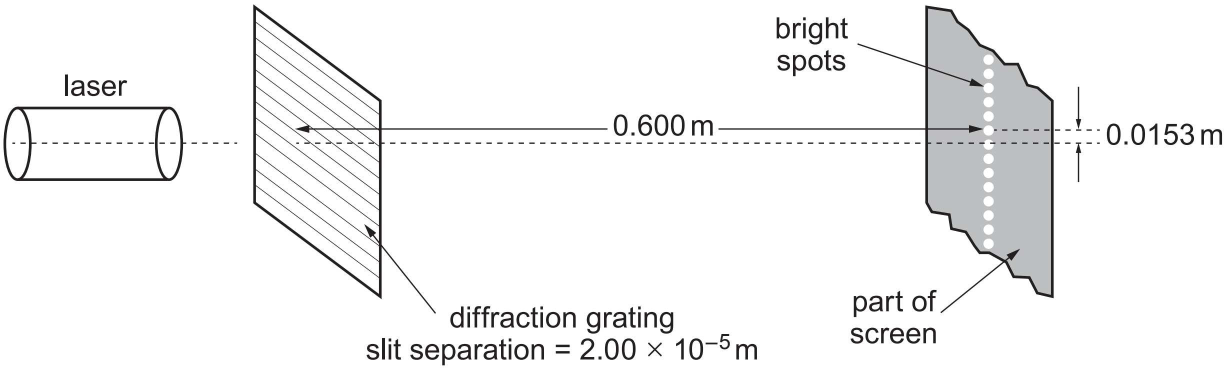

DIAGRAM NOT TO SCALE

(i) Using a labelled sketch of a relevant triangle (in the space below), explain why, to a very good approximation:

$$\sin\theta_1 = \frac{0.0153}{0.600}$$

in which θ_1 is the angle between the zeroth order and first order beams. [2]

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(ii) Determine the wavelength of light from the laser. [2]

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(iii) Calculate the highest **order** produced by this grating for this wavelength, and suggest why so many orders are produced by this grating. [2]

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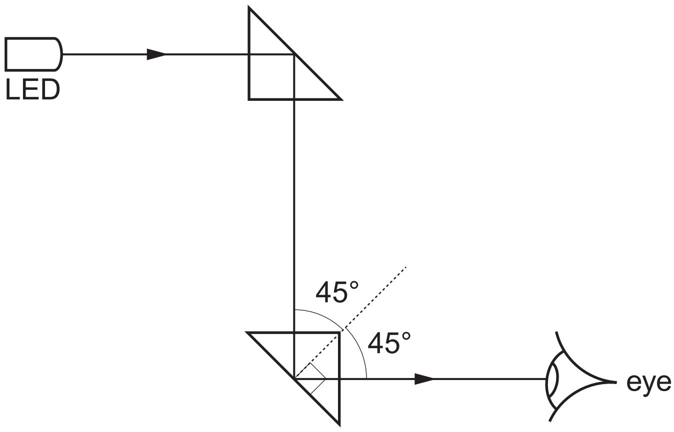
6. *(a)* A student sets up a simple periscope consisting of two glass prisms (n_{glass} = 1.52). She tests it by using it to view a light emitting diode (LED) as shown.



(i) Give the full name of the process by which the light changes direction in the prisms. [1]

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(ii) The student wonders whether the periscope will still work properly if the lower prism is surrounded by water (n_{water} = 1.33). Determine whether or not it will, giving your reasoning clearly. [3]

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(b) (i) A particular monomode fibre has a core of refractive index 1.515. Calculate the time it takes for a pulse of light to travel through 1.50 km of the fibre. [3]

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(ii) Explain the advantage of a monomode fibre over a fibre with a much thicker core, for the transmission of a rapid stream of data. [3]

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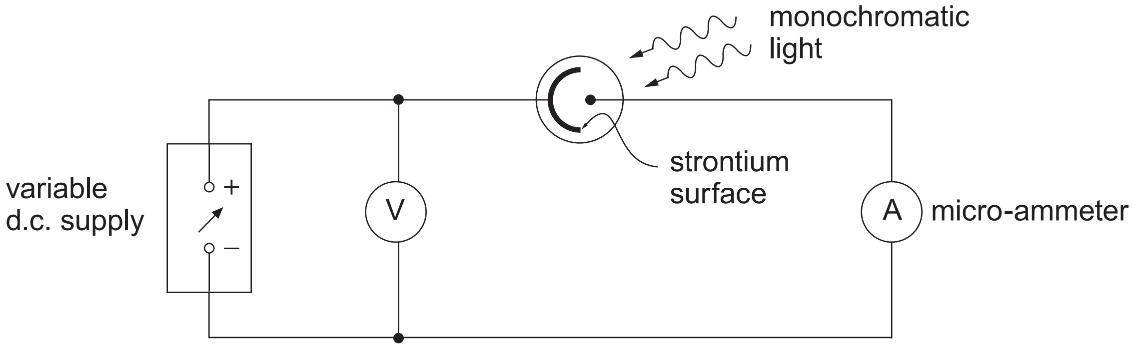
7. *(a)* A student uses the apparatus shown in the diagram to determine the maximum kinetic energy, $E_{k\,max}$, of electrons ejected from a strontium surface by light of wavelength 405 nm.



He records that $E_{k\,max}$ = 0.480 eV.

(i) Describe briefly how he used the apparatus to obtain this result. [2]

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(ii) Determine a value for the work function of strontium from this result. [3]

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Turn over.

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(iii) The student next attempts to measure $E_{k\,max}$ for the same surface, but with light of wavelength 650 nm. He is surprised to find that the micro-ammeter reads zero for **all** applied pds – even when he makes the light brighter. Explain in terms of photons why he should not be surprised, justifying your answer with a calculation. [3]

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(b) (i) Calculate the speed at which an electron must be moving to have a de Broglie wavelength of 5.0×10^{-11} m. [2]

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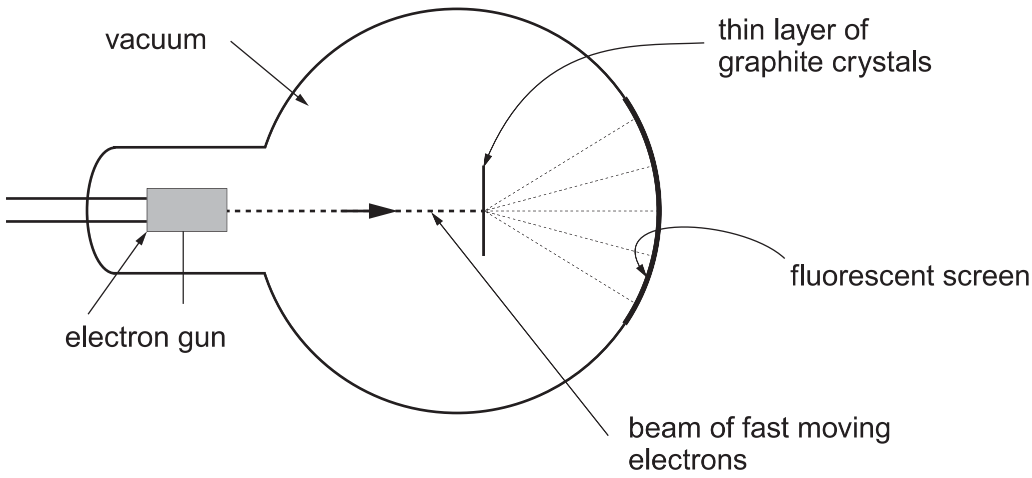
(ii) The diagram shows one way in which an aspect of the nature of electrons may be demonstrated by experiment.



Several bright concentric circles, caused by the impact of electrons on the fluorescent screen are seen. Explain briefly how the pattern of circles arises. [2]

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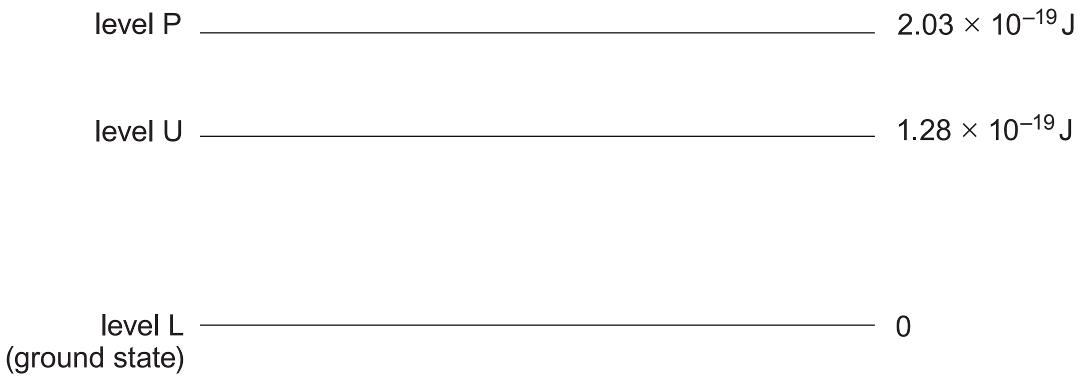
8. *(a)* A simplified energy level diagram for a 3-level laser system is given.



(i) Calculate the wavelength of photons which can take part in transitions between levels U and L. [2]

(ii) Describe the processes of *absorption* and *stimulated emission* involving levels U and L. [4]

absorption:

stimulated emission:

(iii) If the relative populations of levels P, U and L are 0.2%, 54.0% and 45.8%, state with a reason whether absorption or stimulated emission is the more likely event for a photon of the wavelength calculated in *(a)*(i). [1]

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(iv) The laser is pumped by promoting electrons from the ground state to level P. Explain why electrons must spend only a very short time in level P, but a relatively long time in level U. [2]

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(b) It has been suggested that energy should be carried across the country as high power light beams from lasers. Discuss whether or not this might be a good alternative to using electrical power lines. [4]

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END OF PAPER

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