| Surname | Centre Number | Candidate Number |
|---|---|---|
| Other Names | | 2 |

# AS/A LEVEL

2420U20-1

S19-2420U20-1

## PHYSICS – AS unit 2
### Electricity and Light

FRIDAY, 17 MAY 2019 – MORNING

1 hour 30 minutes

| For Examiner's use only | | |
|---|---|---|
| **Question** | **Maximum Mark** | **Mark Awarded** |
| **1.** | **10** | |
| **2.** | **10** | |
| **3.** | **9** | |
| **4.** | **19** | |
| **5.** | **9** | |
| **6.** | **14** | |
| **7.** | **9** | |
| **Total** | **80** | |

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**ADDITIONAL MATERIALS**

In addition to this paper you will require a calculator, ruler 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 additional page 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 ***4(a)***.

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*Answer* **all** *questions.*

**1.** *(a)* (i) State Ohm's law. [1]

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(ii) What can be said about the *resistance* of a conductor that obeys Ohm's law? [1]

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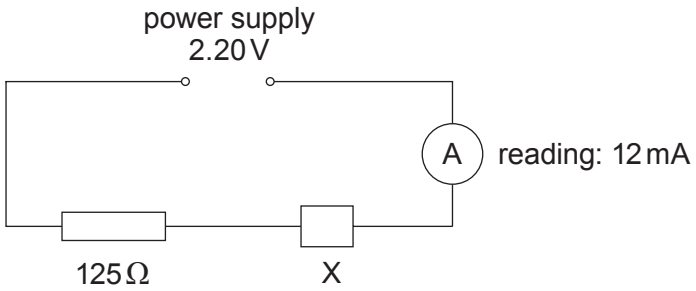
*(b)* (i) An electrical component, X, is included in the circuit shown. The internal resistance of the power supply is negligible.




Show that the resistance of X in this circuit is approximately 60 Ω. [2]

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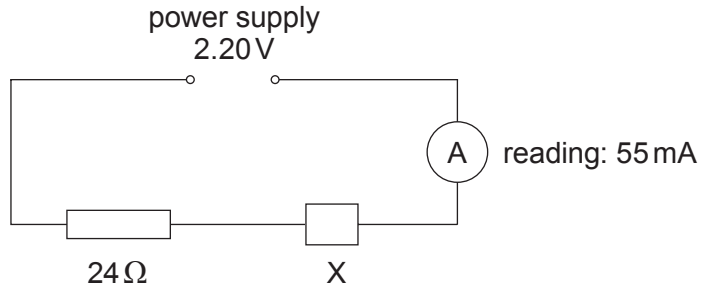
(ii) When the 125 Ω resistor in *(b)*(i) is replaced by a 24 Ω resistor, the reading on the ammeter increases, as shown below.




Evaluate whether or not X obeys Ohm's law, presenting your argument clearly. [2]

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(iii) State, giving a reason, whether or not X could be a filament lamp. [1]

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*(c)* A certain high temperature superconductor has a transition temperature of –188 °C. The boiling point of liquid nitrogen is –196 °C.

(i) State what is meant by the *transition temperature* of a superconductor. [1]

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(ii) Give one possible use for a high temperature superconductor and state why it would be an advantage for the transition temperature to be above the boiling point of liquid nitrogen. [2]

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**2.** *(a)* A battery does not *store* charge. State what a battery *does* do in relation to charge in an electric circuit. [1]

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*(b)* A battery consists of three cells, **each** of emf 1.60 V and internal resistance 0.10 Ω, connected in series. The battery is connected to an electromagnet of resistance 1.20 Ω.

(i) Show clearly that the current is approximately 3 A. [The space is for a diagram if required.] [3]

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(ii) Calculate the rate (in watts) at which:

I. energy is dissipated by the electromagnet; [1]

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II. the battery's chemical energy is being used. [1]

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(iii) The answer to *(b)*(ii)II. is expected to be greater than the answer to *(b)*(ii)I. Explain where the missing energy goes. [2]

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*(c)* A student wishes to maximise the current through the electromagnet. She has a spare cell of emf 1.50 V and internal resistance 0.50 Ω. Evaluate whether or not she should put it in series with the battery, giving your calculations and conclusion clearly. [2]

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**Turn over.**

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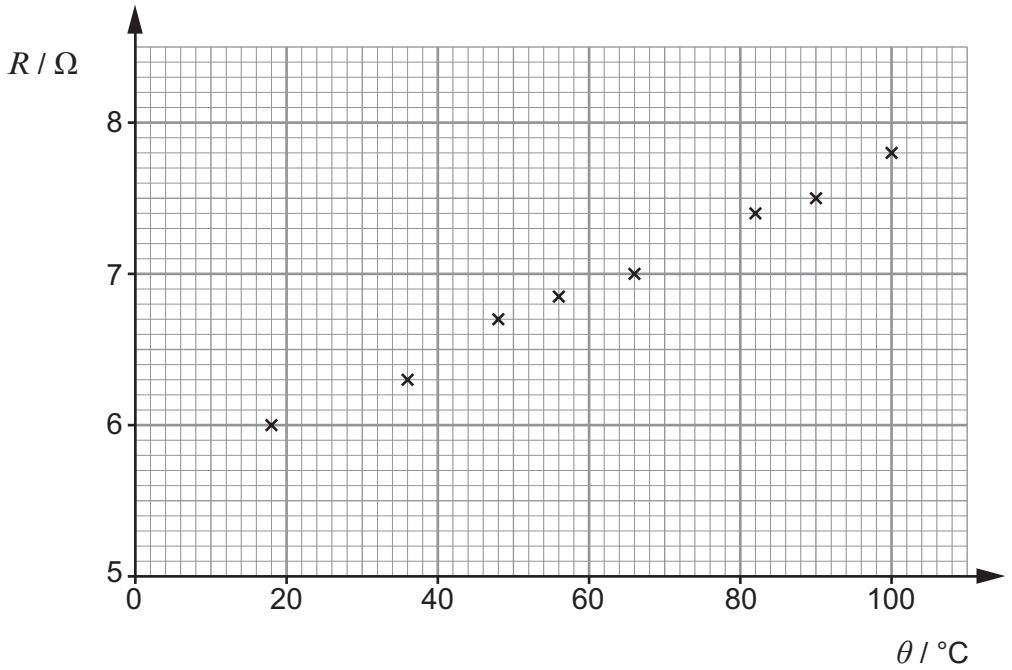
**3.** A student slowly heated a coil of insulated copper wire. He took readings of its temperature, $\theta$, and resistance, $R$, at intervals. The readings are plotted below.




*(a)* Bearing in mind the range of temperatures, suggest how the student heated the coil, and how he could have extended the range of temperatures down to just above 0 °C. [2]

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*(b)* Textbooks state that the resistance, $R$, of a metal wire is related to its celsius temperature, $\theta$, by an equation of the form:

$$R = R_0 \alpha \theta + R_0$$

in which $R_0$ and $\alpha$ are positive constants.

(i) Explain how the readings plotted support the equation. [3]

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(ii) Determine from the graph the values, with units, of:

I. $R_0$; [1]

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II. $\alpha$. [3]

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**4.** *(a)* Explain the conditions that are required of the light sources, for a two-source interference pattern to be observed. Include examples of when the requirements would and would not be met. [6 QER]



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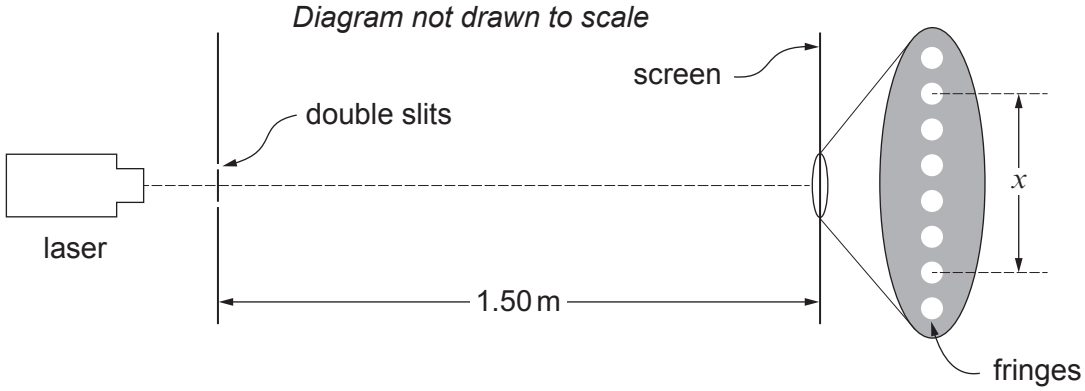
*(b)* A Young's fringes experiment is set up as shown.




(i) Six students measure the distance $x$, obtaining these results:

6.5 mm 6.3 mm 6.9 mm 6.9 mm 6.7 mm 6.4 mm

Calculate the mean value for fringe separation (the separation of the centres of **neighbouring** bright fringes), together with its **percentage** uncertainty. [4]

(ii) The uncertainty in the distance of 1.50 m shown in the diagram is negligible. The separation between the centres of the slits is given by the makers of the double slit as 0.60 mm ± 5 %. Calculate a value for the wavelength of the light from the laser, along with its **percentage** uncertainty. [3]

**QUESTION CONTINUES ON NEXT PAGE**





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*(c)* The laser beam is now shone normally on to a diffraction grating with centres of slits separated by 1 500 nm. Second order beams emerge at angles of 45° to the normal.

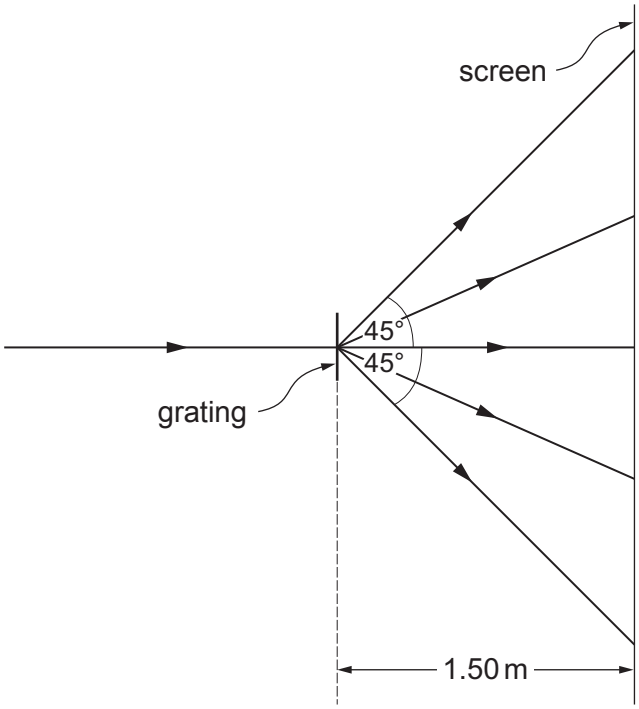


*Diagram not drawn to scale*

(i) Determine a value for the wavelength of the laser light from the data. [2]

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(ii) The beams from the grating strike the screen as shown opposite. The pattern on the screen may be compared with the pattern of fringes in part *(b)* (Young's experiment). There are fewer bright spots in the case of the grating. State two other differences between the patterns **and** state briefly why each difference occurs. [4]

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**5.** *(a)* Define the *work function* of a metal. [1]

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*(b)* The work function of caesium is $3.2 \times 10^{-19}$ J. Show that the frequency of light that will eject electrons from a caesium surface with a maximum kinetic energy of $1.5 \times 10^{-19}$ J is approximately $7 \times 10^{14}$ Hz. [2]

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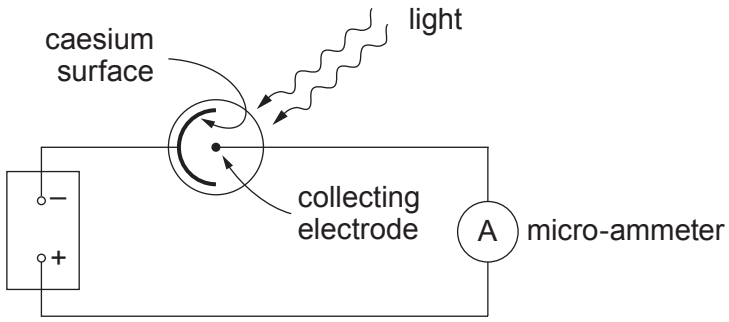
*(c)* The **same frequency** of light is shone on to the caesium surface in a vacuum photocell in the circuit shown.




The light energy falling each second on the caesium surface is 0.30 J.

(i) Show that the number of photons striking the caesium surface each second is approximately $6 \times 10^{17}$. [2]

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(ii) The current indicated by the ammeter is 0.80 μA. Calculate the number of electrons per second emitted from the caesium surface, stating your assumption. [3]

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(iii) Hence calculate the *probability* of a photon of this frequency ejecting an electron from a caesium surface. [1]

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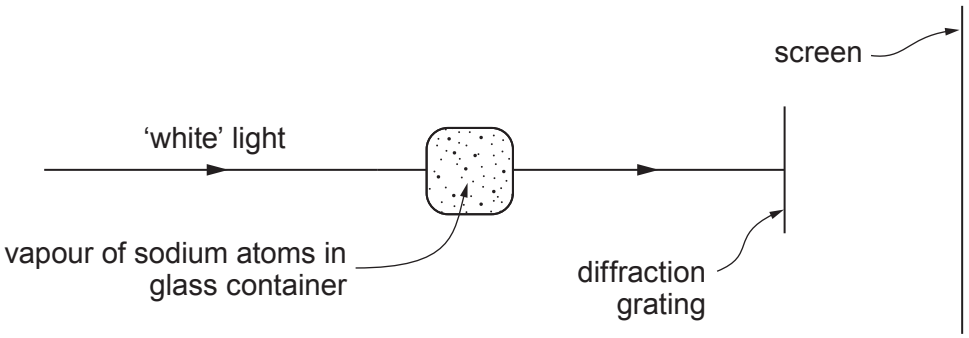
**6.** *(a)* The diagram shows how the *absorption spectrum* of sodium atoms may be produced.




Describe the appearance of the absorption spectrum, comparing it with the *emission spectrum* of sodium atoms. [3]

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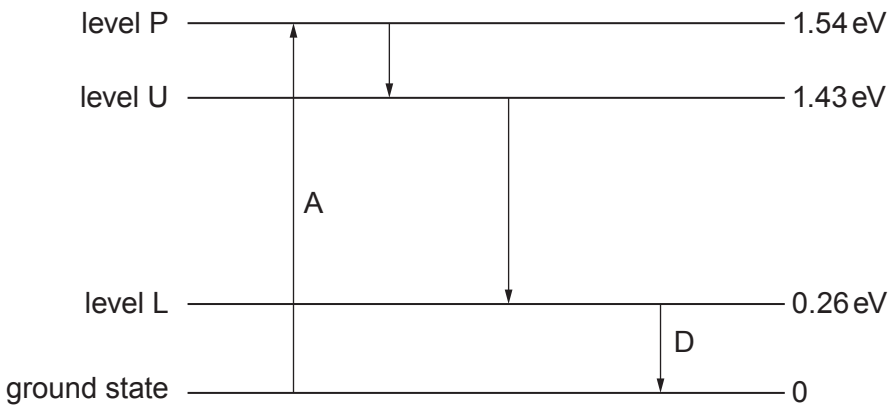
*(b)* A simplified energy level diagram for the amplifying medium of a 4 level laser is given.



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(i) Referring to *populations*, explain the part played in the operation of the laser by:

I. transition A; [2]

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II. transition D. [2]

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(ii) Calculate the wavelength of the radiation emitted by stimulated emission from the laser, and name the region of the electromagnetic spectrum in which it lies. [4]

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*(c)* Most laser pointers produce polarised light. Discuss whether or not students attending a lecture in which a laser pointer is used should be given spectacles fitted with polarising filters (polaroids) to wear for safety during the lecture. [3]

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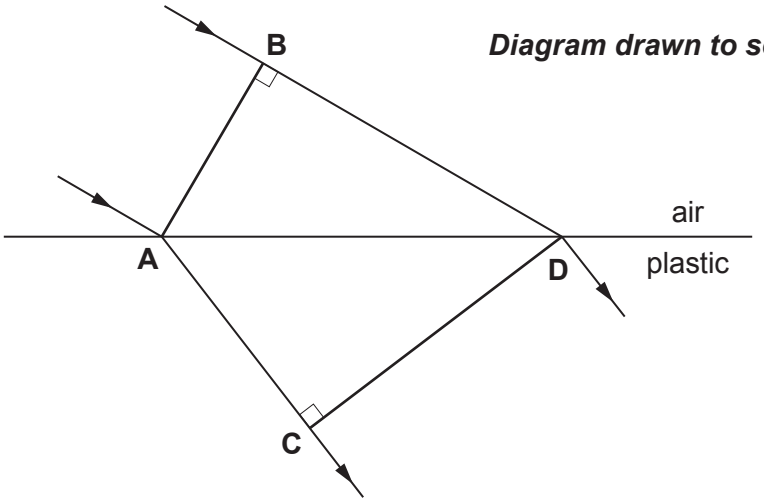
**7.** *(a)* The diagram (**real size**) shows a beam of light passing from air into a clear plastic. AB is a wavefront about to enter the plastic, and CD is its position a short time later.




(i) Determine the speed of light in the plastic **using measurements made with a ruler** from the diagram, and taking the speed of light in air to be equal to its speed in a vacuum. Show your working clearly. [3]

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(ii) Calculate the refractive index of the plastic. [1]

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*(b)* In a multimode fibre of length 120.00 m, the length of the longest possible (zig-zag) route for light to travel successfully is 120.90 m. The refractive index of the fibre core is 1.520. Very short pulses of light are sent into one end of the fibre at intervals of 4.0 ns.

(i) Evaluate whether or not overlap (or overtaking) of pulses will occur before the pulses have reached the other end of the fibre. [3]

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(ii) Part of the longest possible successful zig-zag route is shown below.

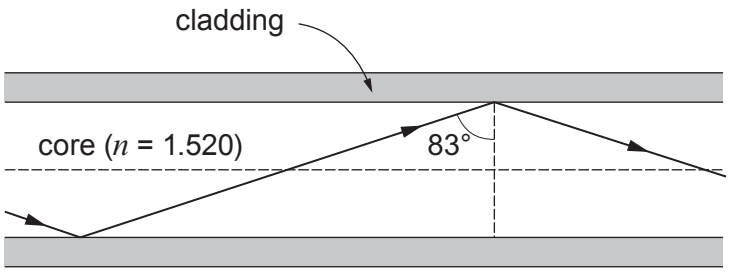


*Diagram not drawn to scale*

Calculate the refractive index of the cladding. [2]

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| Question number | Additional page, if required. Write the question number(s) in the left-hand margin. |
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