ADVANCED SUBSIDIARY GCE

PHYSICS B (ADVANCING PHYSICS)

Physics in Action

G491

Candidates answer on the Question Paper

OCR Supplied Materials:
* Data, Formulae and Relationships Booklet

Other Materials Required:
* Electronic calculator
* Ruler (cm/mm)

Wednesday 12 January 2011
Morning

Duration: 1 hour

Candidate Forename		Candidate Surname	

Centre Number						Candidate Number					

INSTRUCTIONS TO CANDIDATES

* Write your name clearly in capital letters, your Centre Number and Candidate Number in the boxes above.
* Use black ink. Pencil may be used for graphs and diagrams only.
* Read each question carefully and make sure that you know what you have to do before starting your answer.
* Answer **all** the questions.
* Do **not** write in the bar codes.
* Write your answer to each question in the space provided. Additional paper may be used if necessary but you must clearly show your Candidate Number, Centre Number and question number(s).

INFORMATION FOR CANDIDATES

* The number of marks is given in brackets **[ ]** at the end of each question or part question.
* The total number of marks for this paper is **60**.
* You are advised to spend about 20 minutes on Section A and 40 minutes on Section B.
* The values of standard physical constants are given in the Data, Formulae and Relationships Booklet. Any additional data required are given in the appropriate question.
* Where you see this icon you will be awarded marks for the quality of written communication in your answer.
  This means, for example, you should
  * ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear;
  * organise information clearly and coherently, using specialist vocabulary when appropriate.
* This document consists of **16** pages. Any blank pages are indicated.

OCR is an exempt Charity

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Answer **all** the questions.

Section A

1   Here is a list of electrical units.

<div align="center">

A   **S**   **V**   Ω   **W**

</div>

State which of these units is correct for each of the following combinations of quantities:

(a) $\dfrac{\text{charge}}{\text{time}}$ ....

(b) $\dfrac{\text{energy}}{\text{charge}}$ ....

(c) $\dfrac{\text{current}}{\text{voltage}}$ ....   **[3]**

2   A student sets up a potential divider circuit with two 100 Ω resistors, intending to halve a potential difference of 10 V as shown in Fig. 2.1.
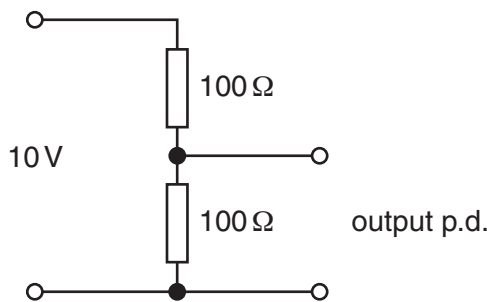
Fig. 2.1

The resistors are manufactured to a tolerance of ± 5%.

(a) State the smallest and largest possible values of each of the resistors that could be found within this tolerance.

   smallest .... Ω   largest .... Ω   **[1]**

(b) Calculate the smallest possible output p.d. from the circuit in Fig. 2.1.

   Make your method clear.

<div align="right">

output p.d. = ... V   **[2]**

</div>

3 Fig. 3.1 shows the frequency spectrum of signals labelled **A**, **B**, **C** and **D** detected by a radio receiver.
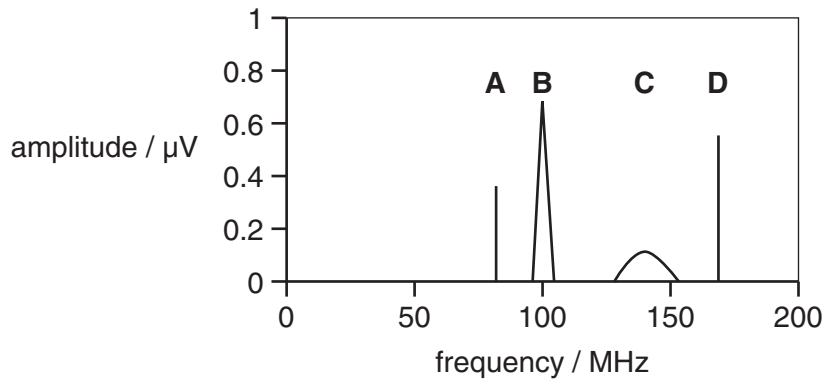

Fig. 3.1

State which signal has the largest

(a) wavelength   ....

(b) bandwidth.   ....   **[2]**

4 Light reflected off the surface of water is partially polarised in the horizontal direction. The amount the light is polarised depends on the angle of reflection *r*, as shown in Fig. 4.1.
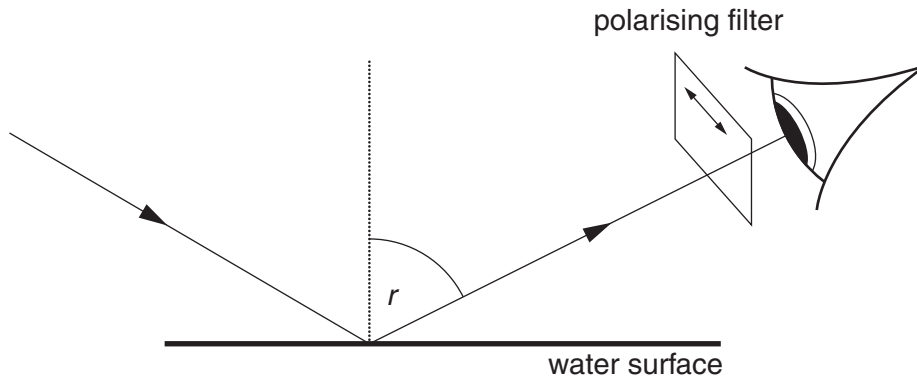

Fig. 4.1

Describe how students could use a polarising filter (sheet of Polaroid) to observe these effects. You may find it useful to refer to Fig. 4.1 in your answer.

✏️ *In your answer, you should organise your description clearly and coherently*.

[3]

5 Fig. 5.1 shows the calibration curve for the output potential difference (p.d.) for an electrical wind speed sensor.
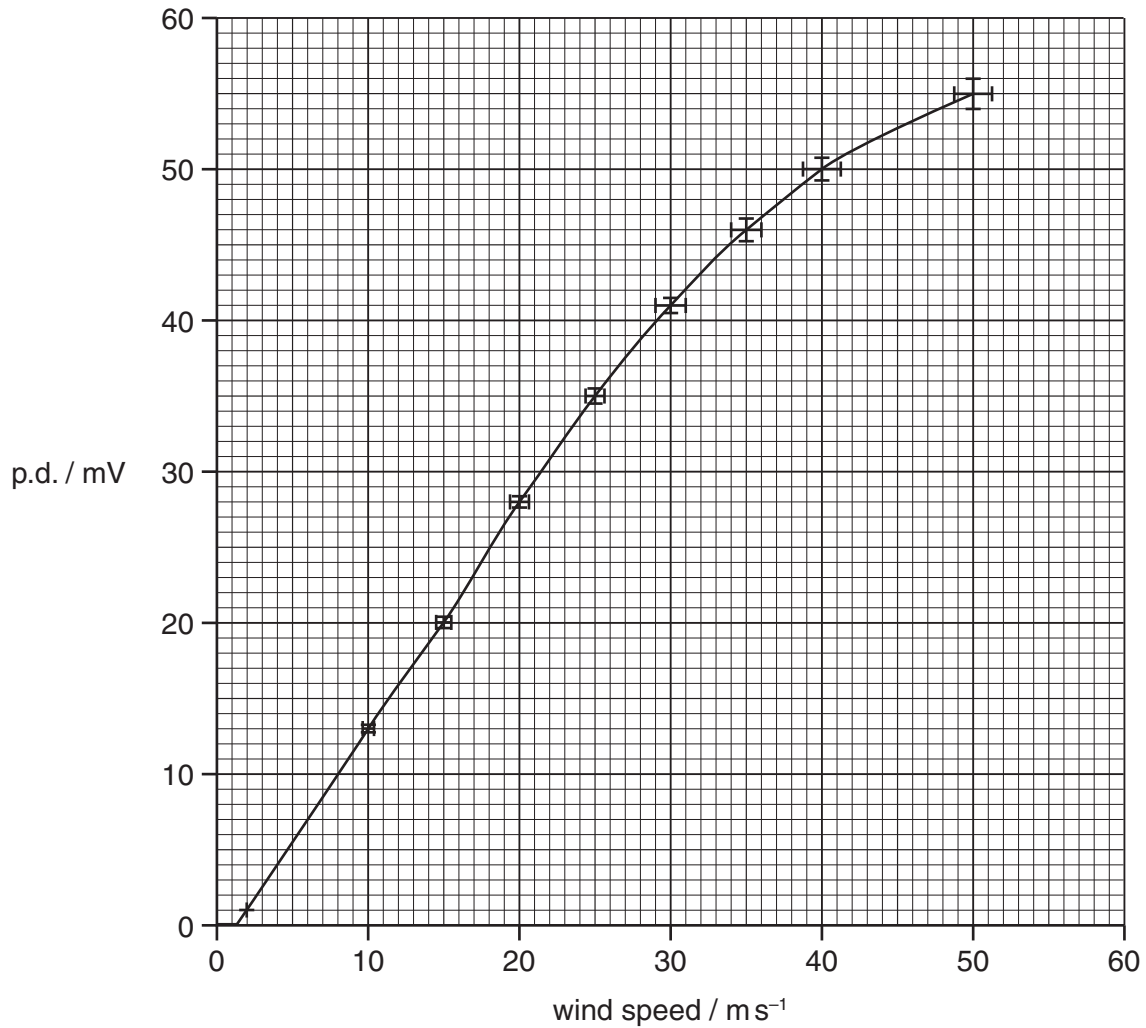

Fig. 5.1

(a) At 55 mV the wind speed is 50 m s^{-1}.
Use the graph to estimate the ± % uncertainty of this wind speed.

± % uncertainty = ...% **[1]**

(b) Describe **one** feature of the uncertainties indicated by the uncertainty bars.

[1]

(c) Fig. 5.1 shows that the sensor output increases with wind speed.

State **two** other features of how the sensor output varies with wind speed as shown by the graph.

[2]

6 An electronic display of a company logo is to be designed to fit into an array of 12 × 12 pixels. Each pixel is either ON or OFF (1 / 0).

(a) State how many bits will be needed to store the logo. .... bits **[1]**

(b) State the amount of information in the logo in bytes. .... bytes **[1]**

(c) Calculate the total possible number of alternative logos the designer could consider. Assume that a change to any pixel forms a different logo.

number of alternative logos = ... **[1]**

7 A long-sighted person needs a corrective lens of power + 5.5 D for reading. One corrective lens is rather thick and heavy. The optician suggests a lighter, less curved lens of a material with a higher refractive index, as shown in Fig. 7.1. The density of the materials for both lenses is the same.
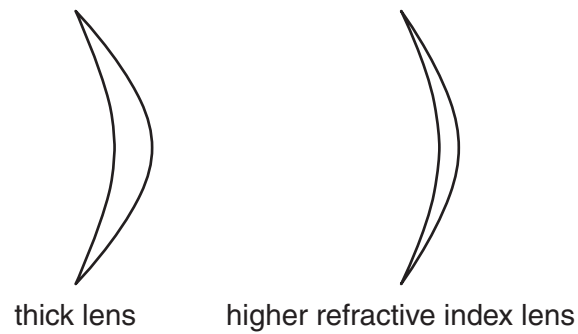

thick lens   higher refractive index lens

Fig. 7.1

Explain how the higher refractive index lens can

(a) be less heavy than the thick lens

[1]

(b) have the same power as the thick lens.

[1]

[Total Section A: 20]

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Section B

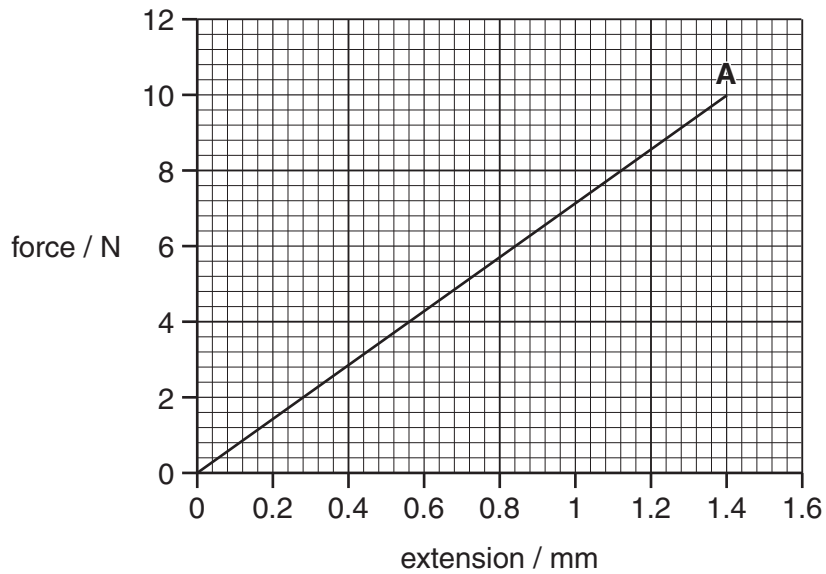8   Fig. 8.1 shows the graph of force against extension for a metal wire **A**.

Fig. 8.1

(a) (i) Draw on Fig. 8.1 the graph you would expect for a wire of the same material and diameter as **A**, but of **twice** the original length. Label this graph **B**.

[1]

(ii) Draw on Fig. 8.1 the graph you would expect for a wire of the same material and length as **A**, but of **double** the original diameter. Label this graph **C**.

[1]

(b) (i) State **one** piece of evidence from the graph which suggests that the stretching of the wire (by a force of 10 N) is elastic.

[1]

(ii) Wire **A** has a cross-sectional area of $7.8 \times 10^{-8} \ m^2$ and an original length of 2.00 m.

Calculate the Young modulus of the material of the wire.

Young modulus = ...Pa   **[3]**

(c) Describe metallic bonding on the atomic scale. Include in your description an explanation of how metals such as wire **A** can show elastic behaviour.

In your explanation, you should make clear how the bonding between atoms can account for the large-scale elastic behaviour of the material.

🖉   *You should use appropriate technical terms in your answer. You may wish to use diagrams*.

[4]

[Total: 10]

Turn over

9 This question is about some uses of a piezoelectric crystal. A potential difference develops across the piezoelectric crystal when put under stress. A crystal microphone contains a piezoelectric crystal. It produces the electrical signal shown in Fig. 9.1 when stressed by the pressure changes in a sound wave.
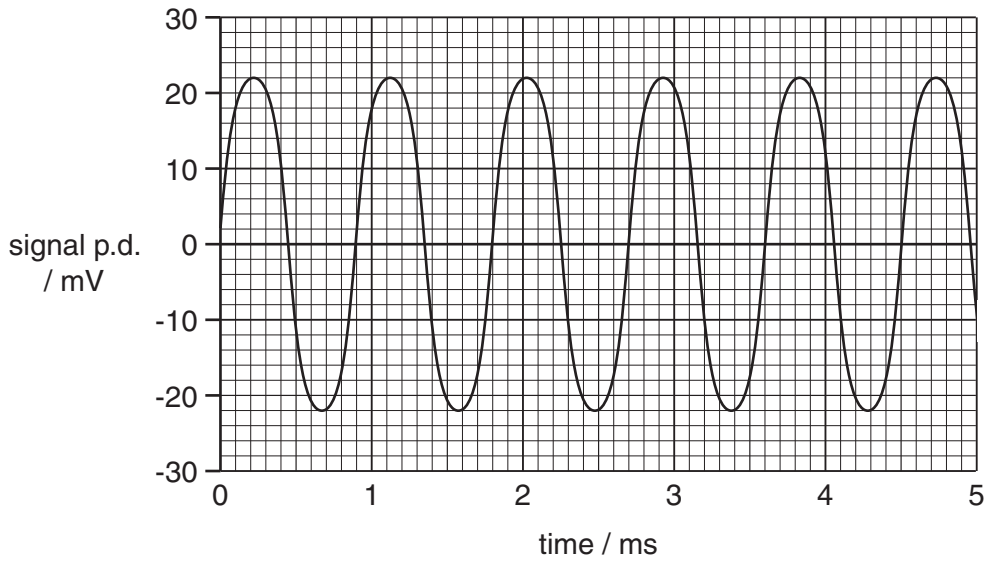

Fig. 9.1

(a) Write down the amplitude of the electrical signal.   .... mV   **[1]**

(b) Calculate the frequency of the electrical signal. Make your method clear.

frequency = ... Hz   **[3]**

(c) The amplitude of the pressure wave that produces the stress in the crystal is 2.0 Pa.

The Young modulus of the piezoelectric crystal is 72 GPa.

Show that the peak strain in the crystal caused by this stress is about 3×10^{-11}.

[2]

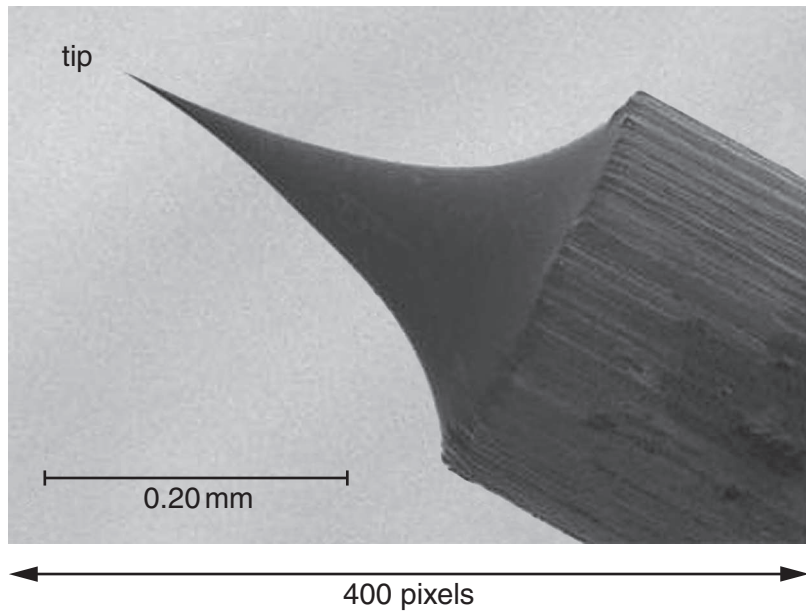**(d)** Fig. 9.2 shows an image of the tip of a Scanning Tunnelling Microscope (STM).

Fig. 9.2

The image is 400 pixels wide. Calculate the resolution of this image.

resolution = ... m **[1]**

(e) The STM tip is attached to a piezoelectric crystal, to make a nano-manipulator. When a p.d. is applied across the crystal a strain is produced which moves the tip through a molecular sized distance. The strain ε in the crystal is proportional to the p.d. V applied across it, with a constant of $1.3 \times 10^{-9}\,V^{-1}$.

$$\varepsilon = 1.3 \times 10^{-9}\,V$$

(i) Calculate the extension of a crystal that is 8.0 mm in length when a p.d. of 900 V is applied across it. Make your method clear.

extension = ... m **[3]**

(ii) Calculate the number of atomic diameters that the crystal extends when the 900 V is applied. Take an atomic diameter to be 260 pm.

number of diameters = ... **[1]**

[Total: 11]

10 This question is about the operation of a gas-filled pixel in a plasma TV screen. A plasma is a conducting ionised gas. It is formed by a high voltage pulse across a pair of electrodes in the pixel as shown in Fig. 10.1.
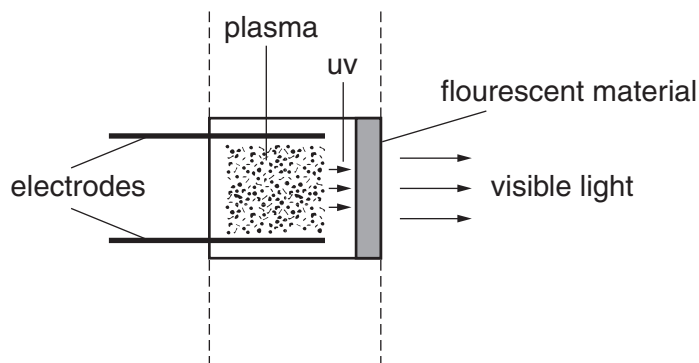

Fig. 10.1 (schematic diagram of a pixel in plasma display)

(a) Describe what is meant by an ionised gas.

[2]

(b) Plasma emits uv radiation at a frequency of 2.9×10^{15} Hz.

Calculate the wavelength of this radiation.

speed of light $= 3.0 \times 10^8 \, \text{m s}^{-1}$

wavelength = ... m **[1]**

(c) Gas atoms can be ionised by collision with fast-moving electrons. The p.d. between the electrodes provides energy for these electrons.

Calculate the energy gained by an electron of charge 1.6×10^{-19} C when it passes through a p.d. of 240 V.

energy = ...J **[2]**

(d) Once started by a high voltage pulse the plasma in a pixel can be maintained at a lower voltage. The plasma can be ended by switching off the voltage. Fig. 10.2 shows how the current in the gas in a pixel changes as the p.d. is raised to 290 V and lowered back to 0 V.
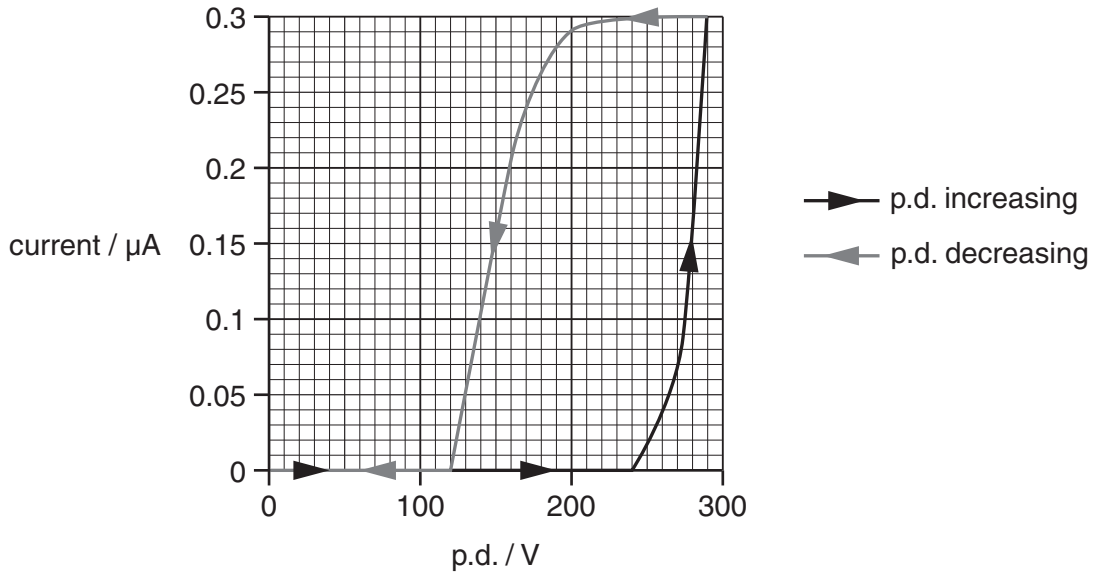

Fig. 10.2

   (i) 1   State the voltage at which ionisation starts.   V

   2   State the voltage at which ionisation stops.   V   **[2]**

   (ii)   There are 6.2×10^6 pixels in the display. When emitting visible light pixels operate at 180 V.

   Use data from Fig. 10.2 to calculate the total operating power of the display with all the pixels on.

   power = ... W   **[3]**

11   Fig. 11.1 shows the variation of p.d. against current for two circuit components **X** and **Y**.
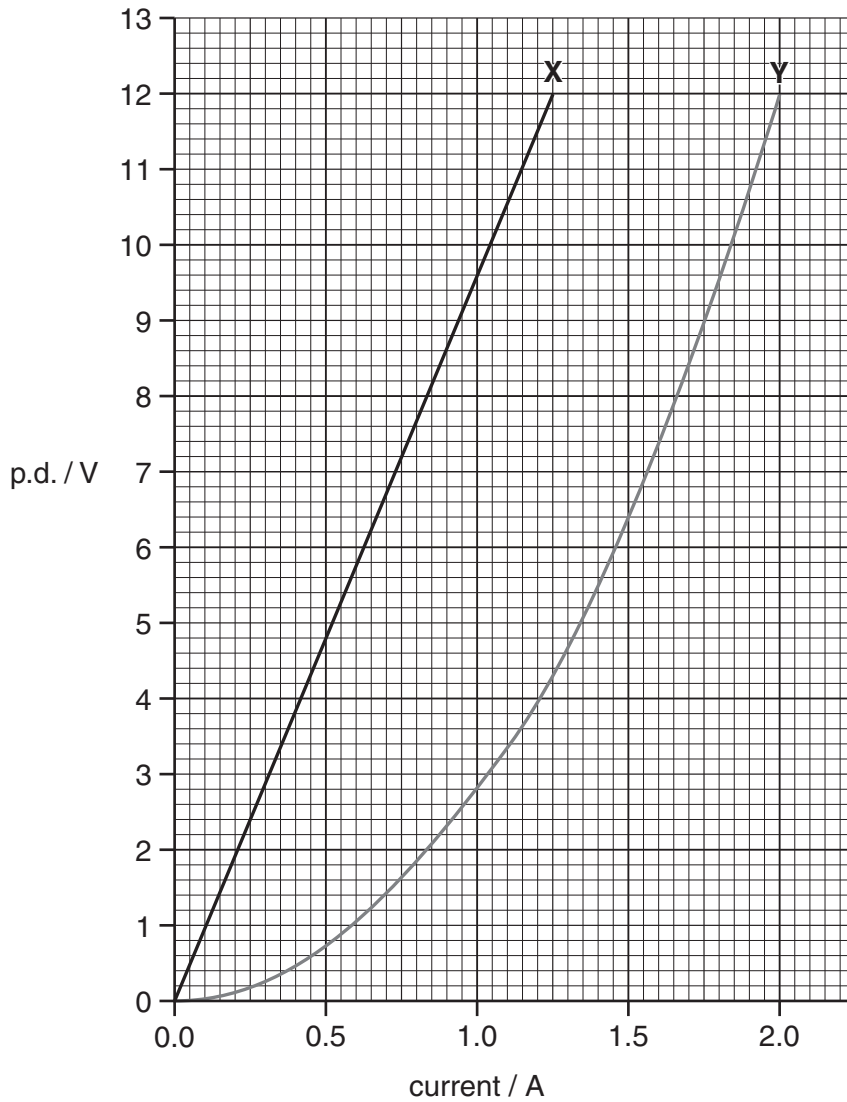   **X** is a variable resistor set to its maximum value, **Y** is a filament lamp.

Fig. 11.1

 (a)   (i)   Calculate the resistance of resistor **X** at this setting.

                                                   resistance of **X** = ...Ω   **[1]**

 (ii)   Describe how the graph indicates that **Y** is a filament lamp.

                                                                                                                                       [1]

(b) The variable resistor **X** is used to control the power dissipated in lamp **Y**, as shown in Fig. 11.2. The power supply is 12 V and has negligible internal resistance.
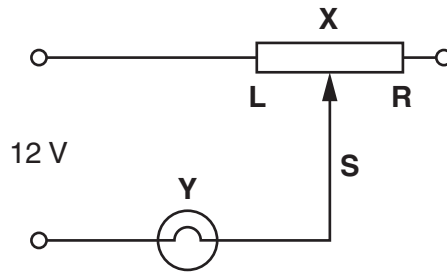
Fig. 11.2

(i) Explain how the variable resistor **X** controls the power dissipated in lamp **Y**.

[2]

(ii) Complete the following table showing the current in the circuit and the power dissipated in lamp **Y** for the positions of the variable contact **S** labelled in Fig. 11.2. You will need to use data from Fig. 11.1 to calculate the values, one value has been inserted already.

position of **S** on **X**	current / A	power in **Y** / W
at **L**		
at **R**	0.90	

[3]

TURN OVER FOR PART (c)

Turn over

(c) Another way of controlling the power dissipated in lamp **Y** is to use the variable resistor **X** as a potential divider as shown in Fig. 11.3.
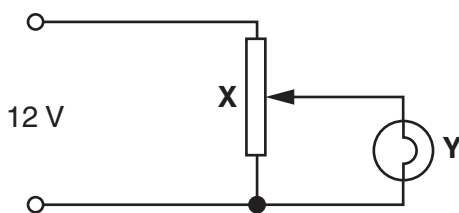
Fig. 11.3

Explain clearly **one** advantage of this potential divider circuit compared to the series resistor circuit of Fig. 11.2.

[2]

[Total: 9]

[Total Section B: 40]

END OF QUESTION PAPER