OCR
RECOGNISING ACHIEVEMENT

Friday 18 January 2013 – Morning

AS GCE PHYSICS A

G482/01 Electrons, Waves and Photons

Candidates answer on the Question Paper.

OCR supplied materials:
- Data, Formulae and Relationships Booklet (sent with general stationery)

Other materials required:
- Electronic calculator

Duration: 1 hour 45 minutes

Candidate forename		Candidate surname	

Centre number						Candidate number				

INSTRUCTIONS TO CANDIDATES

- Write your name, centre number and candidate number in the boxes above. Please write clearly and in capital letters.
- Use black ink. HB pencil may be used for graphs and diagrams only.
- Answer **all** the questions.
- Read each question carefully. Make sure you know what you have to do before starting your answer.
- Write your answer to each question in the space provided. If additional space is required, you should use the lined pages at the end of this booklet. The question number(s) must be clearly shown.
- Do **not** write in the bar codes.

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 **100**.
- You may use an electronic calculator.
- You are advised to show all the steps in any calculations.
- 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 **20** pages. Any blank pages are indicated.

Answer **all** the questions.

1 Fig. 1.1 shows the I–V characteristic of a filament lamp.

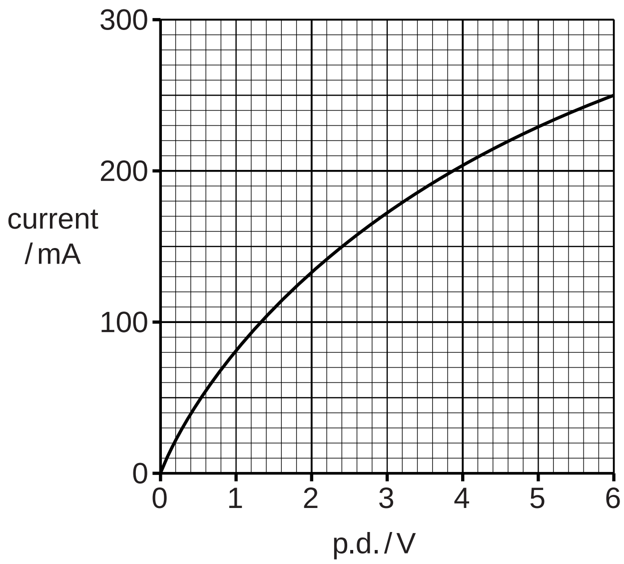

Fig. 1.1

(a) Explain how the graph of Fig. 1.1 shows that the filament lamp does not obey Ohm's law.

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.... **[2]**

(b) You are to carry out an experiment to obtain the I–V characteristic shown in Fig. 1.1.

(i) Draw a suitable circuit diagram for your experiment in the space below. **[2]**

(ii) Describe how you would carry out the experiment.

In your answer you should make clear how you make the measurements to obtain the data for the characteristic.

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.... **[3]**

(c) The lamp is connected in **parallel** with a resistor of resistance 20 Ω to a 6.0 V d.c. supply of negligible internal resistance. Use Fig. 1.1 to calculate the current I_P drawn from the supply.

I_P = ... A **[3]**

(d) The circuit is rearranged with the lamp connected in **series** with the 20 Ω resistor to the same 6.0 V supply.

(i) On Fig. 1.1 draw the $I–V$ characteristic of the resistor. **[1]**

(ii) Use your answer to **(i)** and Fig. 1.1 to determine the current I_S drawn from the supply. Explain your method.

I_S = ... A **[3]**

[Total: 14]

2 An electric heater has a constant resistance of 42.5 Ω. It is connected to the 230 V mains supply by wires of total resistance 2.50 Ω. See Fig. 2.1.

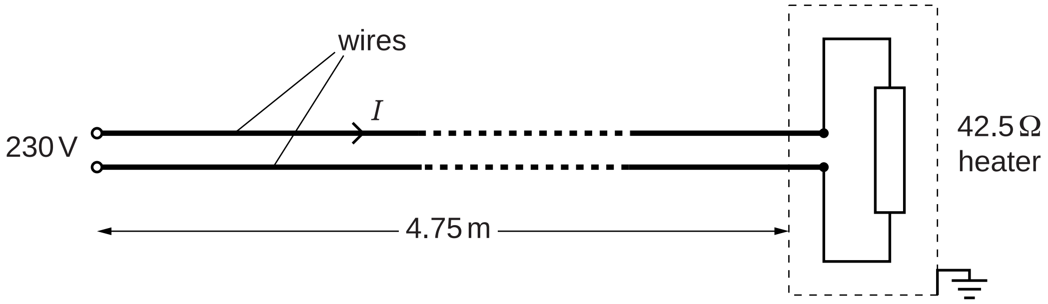

Fig. 2.1

(a) (i) Show that the current I in the wires is about 5 A.

[2]

(ii) Calculate the total power P dissipated in the heater and wires. Give your answer to three significant figures.

P = ... W **[3]**

(iii) Suggest a suitable value for the fuse in the plug connecting the cable to the mains supply.

fuse value = ... A **[1]**

(b) Calculate the cost, to the nearest penny, of using this heater for 4.0 hours, when 1 kW h costs 21p.

cost = ... p **[2]**

(c) The wires used to connect the heater to the supply have a total length of 9.50 m. The wires are made of copper. The resistivity of copper is $1.70 \times 10^{-8}\,\Omega\,\text{m}$.

Calculate the cross-sectional area *A* of the wire.

A = ... m^2 **[3]**

(d) Suggest and explain **one** disadvantage of connecting the heater to the mains supply using thinner copper wires.

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.... **[3]**

[Total: 14]

3 Fig. 3.1 shows a circuit consisting of a battery of electromotive force 16.0V and negligible internal resistance, two resistors and a thermistor.

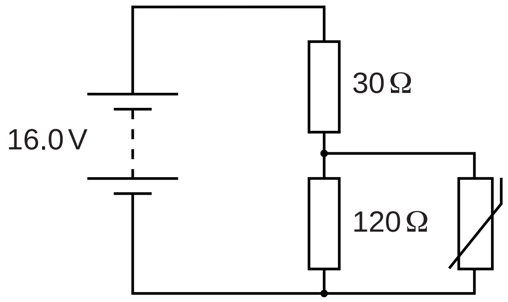

Fig. 3.1

(a) (i) Define the term *electromotive force* (*e.m.f.*).

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.... **[2]**

(ii) Explain the meaning of the term *internal resistance*.

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.... **[1]**

(b) The thermistor has a resistance of 360Ω at 20°C. Calculate

(i) the total resistance *R* of the thermistor and the resistor of resistance 120Ω at 20°C

R = ... Ω **[2]**

(ii) the potential difference *V* across the thermistor.

V = ... V **[3]**

(iii) It is suggested that the thermistor in the circuit of Fig. 3.1 is used to monitor temperatures between 20 °C and 200 °C. Describe how the potential difference across the thermistor and the current in it will vary as the temperature increases above 20 °C.

In your answer you should explain why the potential difference and current vary as the temperature increases.

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.... **[4]**

(c) The battery in Fig. 3.1 is rechargeable.

(i) Calculate the charge stored in the battery when it is charged for 8.0 hours at a constant current of 1.2 A.

charge = …………………… unit ……….. **[3]**

(ii) After charging, the battery loses energy at a constant rate of 1.4 $J\,s^{-1}$. The e.m.f. of the battery remains constant at 16.0 V. Calculate how many hours it takes for the battery to discharge.

discharge time = ... h **[3]**

[Total: 18]

4 Fig. 4.1 shows the variation with time t of the displacement y of the air at a point **P** in front of a loudspeaker emitting a sound wave of a single frequency.

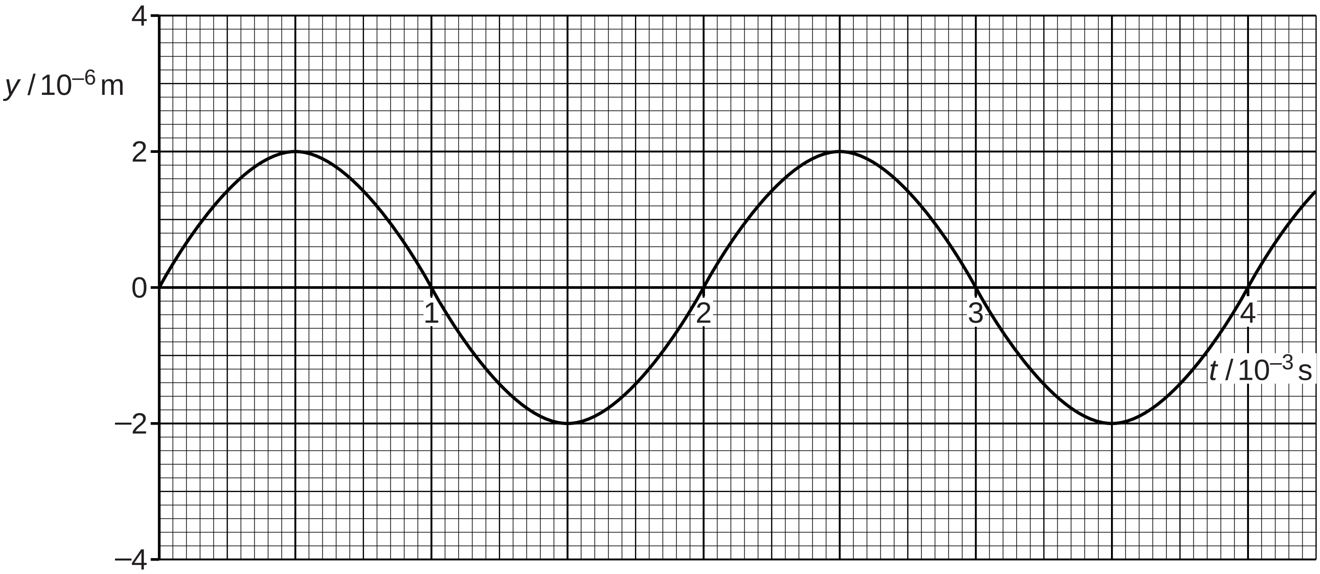

Fig. 4.1

(a) Calculate

(i) the frequency f of oscillation of the air at **P**

f = ... Hz **[2]**

(ii) the wavelength λ of the wave which is travelling at $340\,\mathrm{m\,s^{-1}}$.

λ = ... m **[2]**

(b) Draw on Fig. 4.1 the variation with time of the displacement of the air at a point **Q** a distance of one quarter of a wavelength λ/4 beyond **P**. Label this curve **Q.** **[2]**

(c) Explain the meaning of the term *phase difference*. Illustrate your answer by stating the phase difference between the displacements of the air at the points **P** and **Q**.

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.... **[3]**

(d) The amplitude of vibration of the loudspeaker is increased to produce a wave at the original frequency, but of twice the **intensity**. Sketch on Fig. 4.1 the new displacement against time graph, for $t = 0$ to $t = 2 \times 10^{-3}$ s, at point **P**. Label this curve **P**. Explain your reasoning.

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.... **[3]**

TURN OVER FOR PART (e) OF QUESTION 4

(e) An open tube is placed in front of the loudspeaker such that its far end is at point **Q**. See Fig. 4.2.

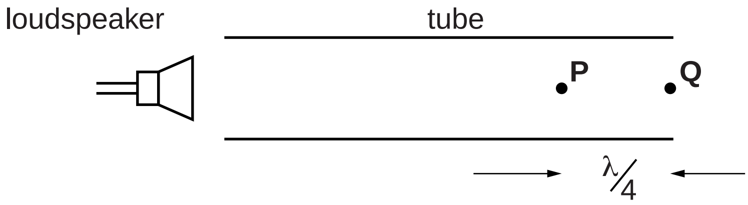

Fig. 4.2

(i) Explain how and under what conditions a stationary sound wave is formed in the tube.

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.... **[3]**

(ii) Assume that the conditions are met for a stationary wave to be set up in the tube. The distance between the points **P** and **Q** is $\lambda/4$.

Describe the motion of the air molecules

1 at point **Q**

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2 at point **P**.

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.... **[3]**

[Total: 18]

5 (a) State the principle of superposition of waves.

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.... **[2]**

(b) Coherent red light of wavelength 6.00×10^{-7} m is incident normally on a pair of narrow slits $\mathbf{S_1}$ and $\mathbf{S_2}$. A pattern of bright and dark lines, called fringes, appears close to point **P** on a distant viewing screen.

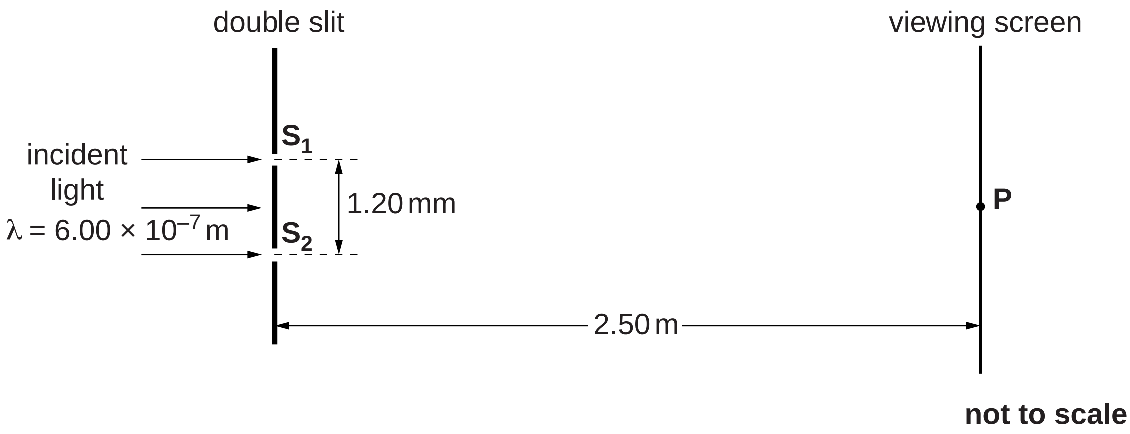

Fig. 5.1

(i) Explain the term *coherent*.

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.... **[1]**

(ii) State a value of the path difference between the light waves from slits $\mathbf{S_1}$ and $\mathbf{S_2}$ to the screen to produce a **dark** fringe on the screen.

path difference = ... m **[1]**

(iii) Calculate the separation of adjacent dark fringes on the screen near to point **P**.

Use the following data: slit separation $\mathbf{S_1S_2}$ = 1.20 mm
distance between slits and screen = 2.50 m

separation = ... m **[3]**

(iv) State and explain the effect, if any, on the **position** of the bright fringes on the screen when each of the following changes is made, separately, to the apparatus.

1 The light source is changed from a red to a yellow light source.

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.... **[2]**

2 Slit $\mathbf{S_1}$ is made wider than slit $\mathbf{S_2}$ but their centres remain the same distance apart.

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.... **[2]**

3 The viewing screen is moved closer to the slits.

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.... **[2]**

[Total: 13]

6 This question is about the light from low energy compact fluorescent lamps which are replacing filament lamps in the home.

(a) The light from a compact fluorescent lamp is analysed by passing it through a diffraction grating. Fig. 6.1 shows the angular positions of the three major lines in the first order spectrum and the bright central beam.

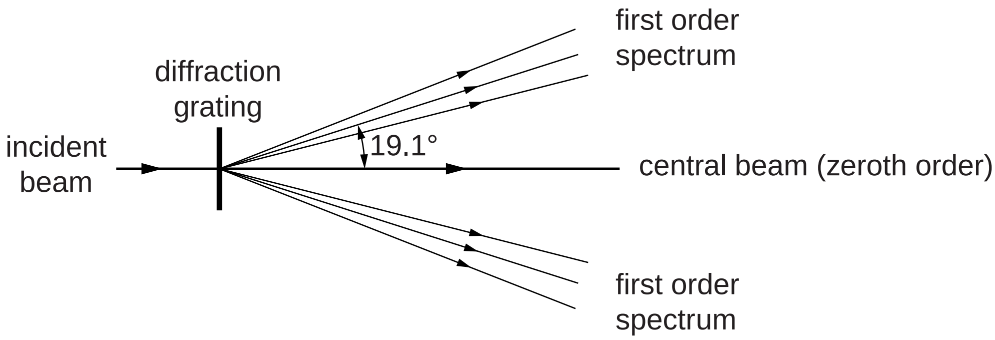

Fig. 6.1

(i) On Fig. 6.1 label one set of the lines in the first order spectrum **R**, **G** and **V** to indicate which is red, green and violet. **[1]**

(ii) Explain why the bright central beam appears white.

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.... **[1]**

(iii) The line separation d on the grating is 1.67×10^{-6} m.

Calculate the wavelength λ of the light producing the first order line at an angle of 19.1° to the central bright beam.

λ = ... m **[3]**

(b) The wavelength of the violet light is 436 nm. Calculate the energy of a photon of this wavelength.

energy = ... J **[3]**

(c) The energy level diagram of Fig. 6.2 is for the atoms emitting light in the lamp. The three electron transitions between the four levels **A**, **B**, **C** and **D** shown produce the photons of red, green and violet light. The energy *E* of an electron bound to an atom is negative. The ionisation level, not shown on the diagram, defines the zero of the vertical energy scale.

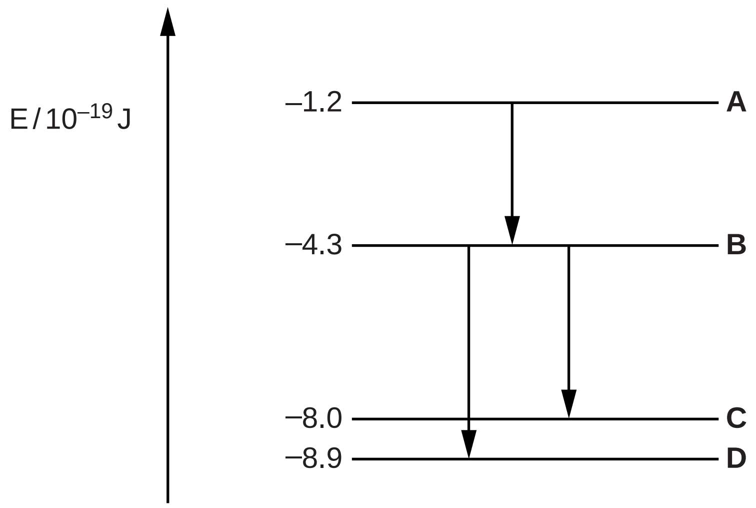

Fig. 6.2

Label the arrows on Fig. 6.2 **R**, **G** and **V** to indicate which results in the red, green and violet photons. **[2]**

[Total: 10]

7 This question is about an experiment to measure the Planck constant *h* using light-emitting diodes (LEDs).

(a) Each LED used in the experiment emits monochromatic light. The wavelength λ of the emitted photons is determined during the manufacturing process.

When the p.d. across the LED reaches a specific minimum value V_{min} the LED suddenly switches on emitting photons of light of wavelength λ. V_{min} and λ are related by the equation $eV_{min} = hc/\lambda$.

Explain the meaning of this equation in words.

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.... **[2]**

(b) Describe the experiment that uses the circuit of Fig. 7.1 to generate the data shown in the table. The wavelength value for each LED is provided by the manufacturer.

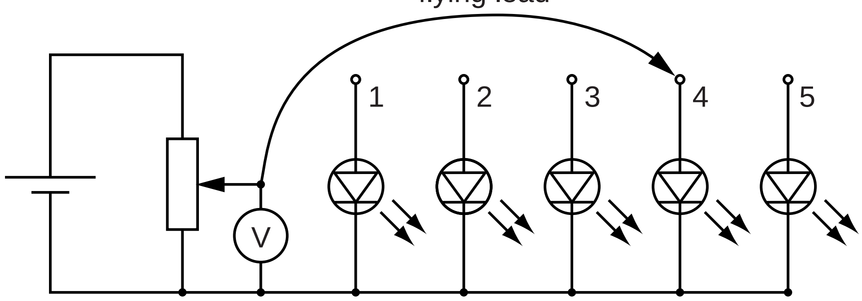

Fig. 7.1

LED	λ/nm	$1/\lambda$ /10^6 m^{-1}	average V_{min}/ V
1 red	627	1.59	1.98
2 yellow	590	1.69	2.10
3 green	546	1.83	2.27
4 blue	468		2.66
5 violet	411		3.02

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.... **[3]**

(c) (i) Complete the table and use the data to complete the graph of Fig. 7.2. Three of the points have been plotted for you.

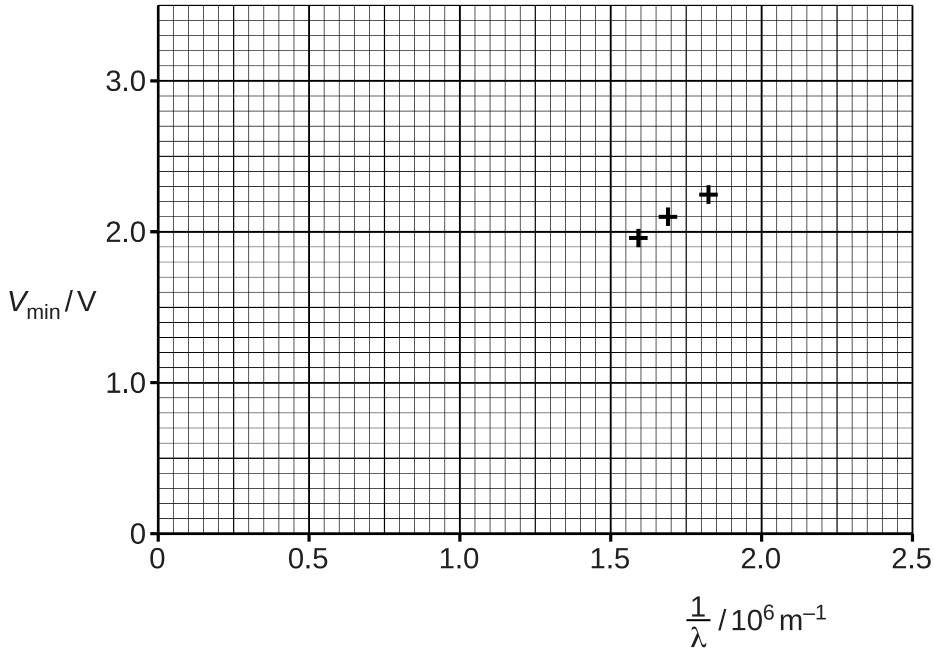

Fig. 7.2

Draw the line of best fit. Show that the gradient is about 1.2×10^{-6} V m.
Show your working clearly.

gradient = ... V m **[4]**

(ii) Use the equation given in **(a)** to show that the gradient of the line in Fig. 7.2 is equal to hc/e.

[2]

(iii) Calculate a value for the Planck constant using your value in **(i)** for the gradient of the graph. Show your working.

h = ... J s **[2]**

[Total: 13]

END OF QUESTION PAPER