OCR
Oxford Cambridge and RSA

Thursday 4 June 2015 – Afternoon

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

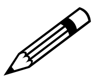
Candidate forename		Candidate surname	

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 page at the end of this booklet. The question numbers 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.

Turn over

Answer **all** the questions.

1 The maximum power input to a domestic fan heater is 2.6 kW when connected to the 230 V mains supply. The electric circuit of the fan heater consists of two heating elements (resistors) rated at 1.5 kW and 1.0 kW, a motor rated at 100 W and three switches.

(a) **(i)** Show that the resistance of the 1.5 kW heating element is about 35 Ω.

[2]

(ii) The 1.5 kW heating element is made from a wire of cross-sectional area 7.8×10^{-8} m^2 and resistivity 1.1×10^{-6} Ω m. Calculate the length of the wire.

length = ... m **[3]**

(b) With only the first switch closed, the fan rotates; closing the second switch gives the heater an output of 1.5 kW and closing the third switch increases the output to 2.5 kW. The elements will not heat up unless the fan is switched on. The heater cannot give an output of 1.0 kW.

Complete the circuit diagram of Fig. 1.1 to show the fan, the heating elements and the switches connected so that the heater will work as described. Label the switches and the elements.

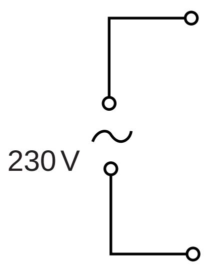


Fig. 1.1

[3]

(c) Both heating elements are made of wire of the same resistivity and length.

(i) Explain, without calculation, why the diameter *d* of the 1.0 kW heater wire must be less than the diameter *D* of the 1.5 kW heater wire, designed for use with a 230 V supply.

....

....

.... **[2]**

(ii) Show that *d* is approximately equal to 0.8 *D*.

[3]

(d) Circle the correct fuse for the plug of this appliance from the values below.

3 A **5 A** **10 A** **13 A**

Justify your choice.

....

....

.... **[2]**

(e) **(i)** Define the *kilowatt-hour*.

....

.... **[1]**

(ii) Calculate, to the nearest penny, the cost of using the heater for 4.0 hours with only **one** of the heating elements switched on. The cost of 1 kWh is 18 p.

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

2 This question is about the use of a thermistor fitted inside a domestic oven as a temperature sensor in a potential divider circuit.

Fig. 2.1 shows the potential divider circuit in which the component $\mathbf{R_2}$ is connected in parallel to the input of an electronic circuit that switches the mains supply to the heating element in the oven on or off.

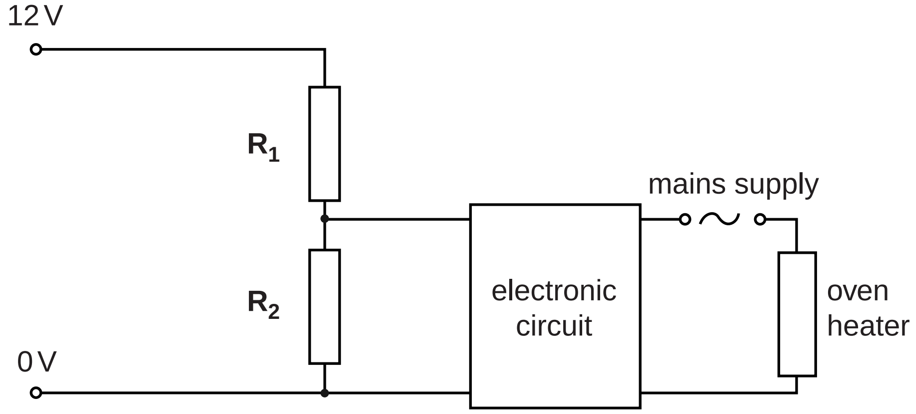


Fig. 2.1

(a) $\mathbf{R_1}$ is a variable resistor and $\mathbf{R_2}$ is the thermistor. The circuit symbols for $\mathbf{R_1}$ and $\mathbf{R_2}$ are incomplete. Complete these circuit symbols on Fig. 2.1. **[2]**

(b) It is required that the p.d. across the thermistor $\mathbf{R_2}$ is 7.0 V when at a temperature of 180 °C. The variation of resistance with temperature for $\mathbf{R_2}$ is shown in Fig. 2.2.

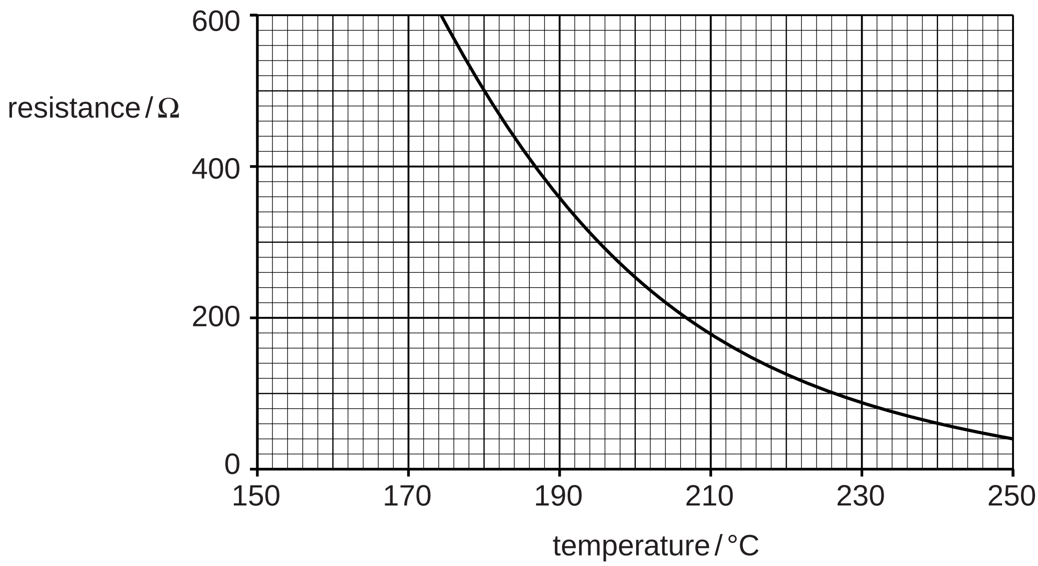


Fig. 2.2

(i) Use Fig. 2.2 to determine the resistance of $\mathbf{R_2}$ at a temperature of 180 °C.

resistance = ... Ω **[1]**

(ii) When the temperature is 180 °C the p.d. across $\mathbf{R_2}$ is 7.0 V. Calculate the current in $\mathbf{R_2}$.

current = ... A **[1]**

(iii) The electronic circuit draws a negligible current. Show that the resistance of the variable resistor $\mathbf{R_1}$ must be about 350 Ω.

[2]

(iv) $\mathbf{R_2}$ is heated slowly. Show that the p.d. across $\mathbf{R_2}$ must fall to about 5.0 V when the temperature of $\mathbf{R_2}$ reaches 200 °C.

[2]

(c) The thermistor $\mathbf{R_2}$ is fitted inside the oven. When the p.d. across $\mathbf{R_2}$ falls to 5.0 V the oven heater switches off. The oven cools until the p.d. across $\mathbf{R_2}$ rises to 7.0 V when the heater switches on again.

$\mathbf{R_1}$ is adjusted to 250 Ω. Calculate the temperatures at which the oven heater is switched on and off.

temperature on .... °C

temperature off .... °C **[4]**

3 **(a)** A battery charger contains a microprocessor circuit so that it can charge an AA rechargeable cell at a constant current of 450 mA. It takes 4 hours 40 minutes to charge a 1.5 V cell from a fully discharged state.

(i) Calculate the charge *Q* passing through the cell during the charging process.

Q = ... unit .... **[3]**

(ii) Fig. 3.1 shows the cell of internal resistance 0.90 Ω connected to the battery charger. Assume that the e.m.f. of the cell is 1.5 V.

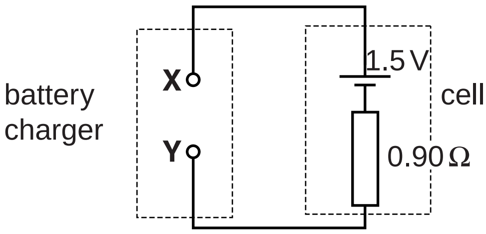


Fig. 3.1

1 State whether the terminal **X** of the battery charger is positive or negative.

....

2 Mark the direction of the current in the circuit on Fig. 3.1. Label your arrow *I*. Give a reason for your choice.

....

.... **[2]**

3 Calculate the terminal p.d. V_{XY} between **X** and **Y** during the charging process.

V_{XY} = ... V **[2]**

4 Show that the mean rate of increase of energy stored in the cell during the charging process is about 0.7 J s^{-1}.

[2]

(b) Explain how you would determine experimentally the e.m.f. E and internal resistance r of the charged cell. Include a circuit diagram with meters and a variable load resistor.

In your answer you should state how the data collected is used to determine the values of E and r.

....

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....

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....

....

.... **[5]**

(c) A 6.0 V 2.0 W filament lamp has a resistance of 18 Ω when lit to normal brightness. It is connected in series to four 1.5 V cells each of internal resistance 0.90 Ω.

(i) Explain, using calculations, why the lamp does not light to normal brightness.

[3]

(ii) It is found that by adding more cells in series it is possible to make the lamp light to normal brightness. Calculate the total number of cells needed in the circuit for this to occur. Show your working clearly.

number of cells = ... **[2]**

4 (a) Fig. 4.1 shows a section of a uniform string under tension at one instant of time. A progressive wave of wavelength 80 cm is moving along the string from left to right. At the instant shown, the displacement of the string is zero at the point opposite the zero mark on the scale beneath the string.

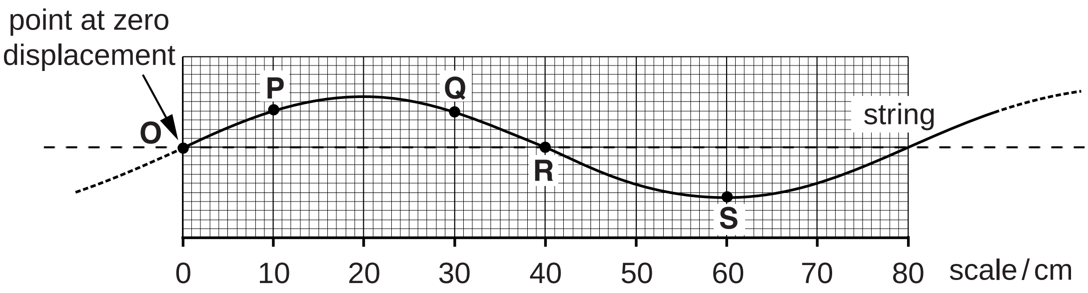

Fig. 4.1

Four points **P**, **Q**, **R** and **S** at 10, 30, 40 and 60 cm respectively, are marked on the string. The oscillatory motion of each point can be described in terms of amplitude, frequency and phase difference from **O**.

(i) State the meaning of each of the terms

1 *amplitude*

....

....

2 *frequency*

....

....

3 *phase difference*.

....

.... **[3]**

(ii) Describe using these three terms how the motion of points **P**, **Q**, **R** and **S**

1 is similar,

....

....

2 is different.

....

.... **[2]**

(b) Fig. 4.2 shows the same section of string now held under tension between a clamp and a pulley, 80 cm apart. A mechanical oscillator is attached to the string close to the clamped end. The frequency of the mechanical oscillator is varied until the stationary wave shown is set up between the clamp and the pulley. The same four points as in Fig. 4.1 are marked on the string.

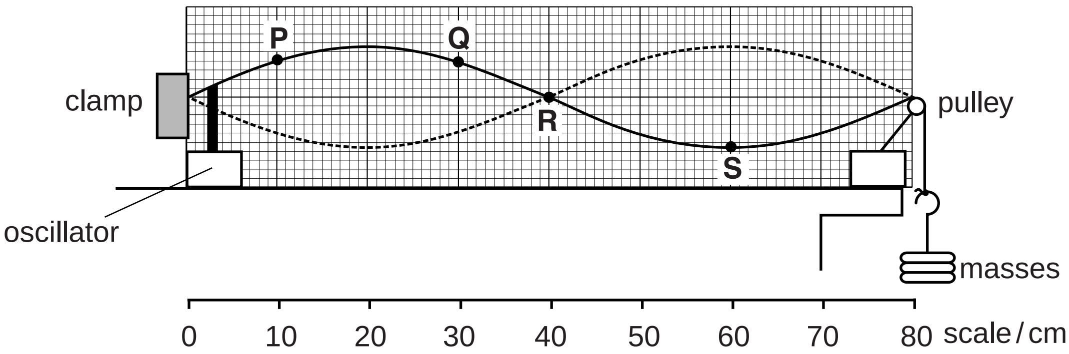

Fig. 4.2

(i) Describe how a stationary wave is different from a progressive wave.

....

....

....

....

.... **[2]**

(ii) Explain how the stationary wave is formed on this string.

....

....

....

....

....

.... **[3]**

(iii) Describe, using the terms amplitude, frequency and phase difference, how the motions of the points **P**, **Q** and **S**

1 are similar,

....

....

2 are different.

....

.... **[3]**

(iv) In Fig. 4.2 the frequency of oscillation is 30 Hz. State, with a reason, the lowest frequency of oscillation of the string at which the motions of all of the points **P**, **Q**, **R** and **S** are

1 in phase,

....

....

2 all at rest.

....

.... **[4]**

5 Fig. 5.1 shows two microwave transmitters **A** and **B** 0.20 m apart. The transmitters emit microwaves of frequency 10 GHz, of equal amplitude and in phase. A microwave detector is placed at **O** a distance of 4.0 m from **AB**.

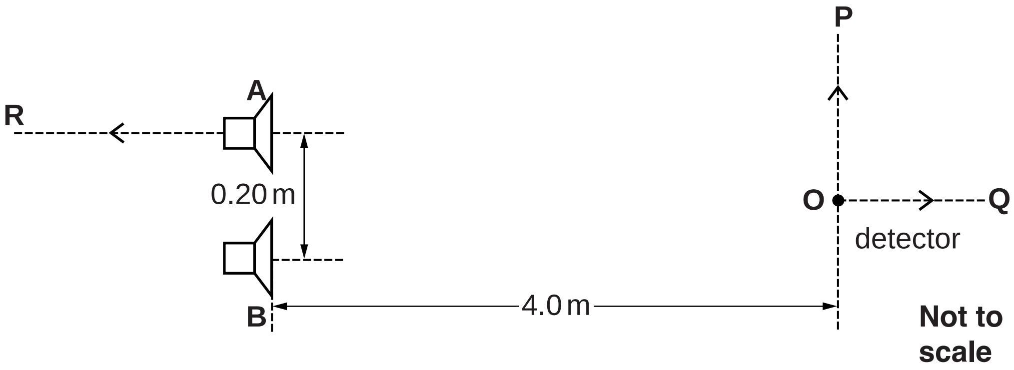

Fig. 5.1

(a) Interference of the waves from the two transmitters is detected only when the transmitters are coherent. Explain the meaning of

(i) *interference*

....

....

.... **[2]**

(ii) *coherent.*

....

.... **[1]**

(b) The length of the detector aerial is half a wavelength. Calculate the length of the aerial.

Show your working.

aerial length = ... m **[2]**

(c) (i) 1 Explain why the amplitude of the detected signal changes when the detector is moved in the direction **OP**.

....

....

....

.... **[2]**

2 Calculate the distance between adjacent **maximum** and **minimum** signals.

distance = ... m **[2]**

(ii) Explain why the amplitude of the detected signal changes when the detector is moved in the direction **OQ**.

....

....

....

.... **[2]**

(iii) Explain why the amplitude of the detected signal decreases to a minimum before increasing again as transmitter **A** is moved a small distance in the direction **AR** with the detector fixed at **O**. Calculate the distance **A** is moved to cause this minimum signal at **O**.

....

....

....

....

....

....

distance = ... m **[2]**

(d) State, with a reason, the effect on the intensity of the signal detected at **O** when each of the following changes is made.

(i) The amplitude of the waves emitted from **A** and **B** is doubled.

....

....

.... **[2]**

(ii) The detector **O** is rotated 90° about the axis through **OQ**.

....

....

....

....

.... **[3]**

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Question 6 begins on page 16

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6 In an experiment it is observed that when blue light is shone on a clean metal surface electrons are emitted, but with red light there is no electron emission.

(a) State the name of the effect observed in this experiment.

.... **[1]**

(b) Describe Einstein's theory to explain these observations.

In your answer you should include technical terms to explain how the physics of quantum behaviour is used to explain the observations.

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.... **[4]**

(c) The longest wavelength of light incident on the metal surface which causes electrons to be emitted is 480 nm.

(i) Show that the work function of the metal is about 4×10^{-19} J.

[3]

(ii) Calculate the maximum speed of an emitted electron when a photon of energy 5.2×10^{-19} J is incident on the metal surface.

speed = ... $m\,s^{-1}$ **[3]**

(d) **(i)** Describe briefly one piece of evidence for believing that electrons sometimes behave like waves.

....

....

....

.... **[2]**

(ii) Calculate the de Broglie wavelength of an electron moving at $500\,km\,s^{-1}$.

wavelength = ... m **[3]**

END OF QUESTION PAPER

ADDITIONAL ANSWER SPACE

If additional answer space is required, you should use the following lined page(s). The question number(s) must be clearly shown in the margins.

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