OCR RECOGNISING ACHIEVEMENT

SPECIMEN

Advanced Subsidiary GCE

PHYSICS A

Unit G482: Electrons, Waves and Photons

Specimen Paper

Candidates answer on the question paper.

Additional Materials:
Data and formulae sheet
Electronic calculator

G482 QP

Time: 1 hour 45 minutes

Candidate Name

Centre Number

Candidate Number

INSTRUCTIONS TO CANDIDATES

- Write your name, Centre number and Candidate number in the boxes above.
- Answer **all** the questions.
- Use blue or black ink. Pencil may be used for graphs and diagrams only.
- Read each question carefully and make sure you know what you have to do before starting your answer.
- Do **not** write in the bar code.
- Do **not** write outside the box bordering each page.
- WRITE YOUR ANSWER TO EACH QUESTION IN THE SPACE PROVIDED.

INFORMATION FOR CANDIDATES

- The number of marks is given in brackets [ ] at the end of each question or part question.
- ✎ Where you see this icon you will be awarded marks for the quality of written communication in your answer.
- You may use an electronic calculator.
- You are advised to show all the steps in any calculations.
- The total number of marks for this paper is **100**.

FOR EXAMINER'S USE		
Qu.	**Max.**	**Mark**
1	**11**	
2	**15**	
3	**14**	
4	**15**	
5	**12**	
6	**10**	
7	**11**	
8	**12**	
TOTAL	**100**	

This document consists of **18** printed pages and **2** blank pages.

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[Turn Over

Answer **all** the questions.

1 **(a)** Name the charge carriers responsible for electric current in a metal and in an electrolyte.

....

.... **[2]**

(b) **(i)** Define electrical *resistivity*.

....

....

....

.... **[2]**

(ii) Explain why the *resistivity* rather than the *resistance* of a material is given in tables of properties of materials.

....

....

.... **[1]**

(c)

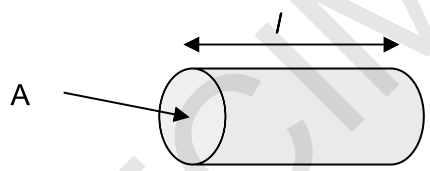

Fig. 1.1

Fig. 1.1. shows a copper rod of length l = 0.080m, having a cross-sectional area A = 3.0×10^{-4} m^2.

The resistivity of copper is 1.7×10^{-8} Ω m.

(i) Calculate the resistance between the ends of the copper rod.

resistance = ... Ω **[2]**

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(ii) The copper rod is used to transmit large currents. A charge of 650 C passes along the rod every 5.0 s. Calculate

1. the current in the rod

current = ...A **[2]**

2. the total number of electrons passing any point in the rod per second.

number = ... **[2]**

[Total: 11]

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2 (a) (i) Use energy considerations to distinguish between potential difference (p.d.) and electromotive force (e.m.f.).

....

....

....

.... **[2]**

(ii) Here is a list of possible units for e.m.f. or p.d.

$J\ s^{-1}$ $\qquad$ $J\ A^{-1}$ $\qquad$ $J\ C^{-1}$

State which one is a correct unit: .... **[1]**

(b) Kirchhoff's second law is based on the conservation of a quantity. State the law and the quantity that is conserved.

....

....

.... **[2]**

(c) A battery is being tested. Fig. 2.1 shows the battery connected to a variable resistor R and two meters.

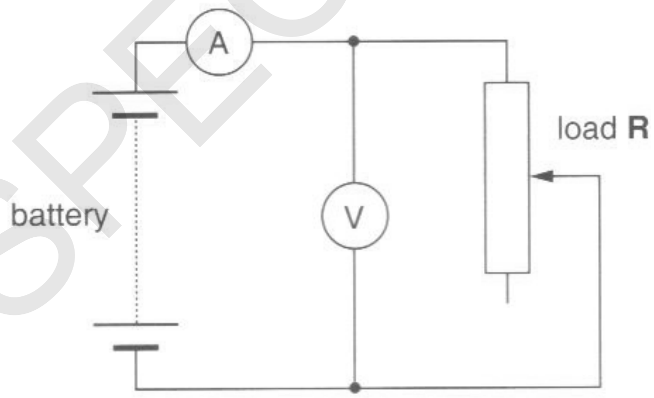

Fig. 2.1

The graph of Fig.2.2 shows the variation of the p.d. V across the battery with the current I as R is varied.

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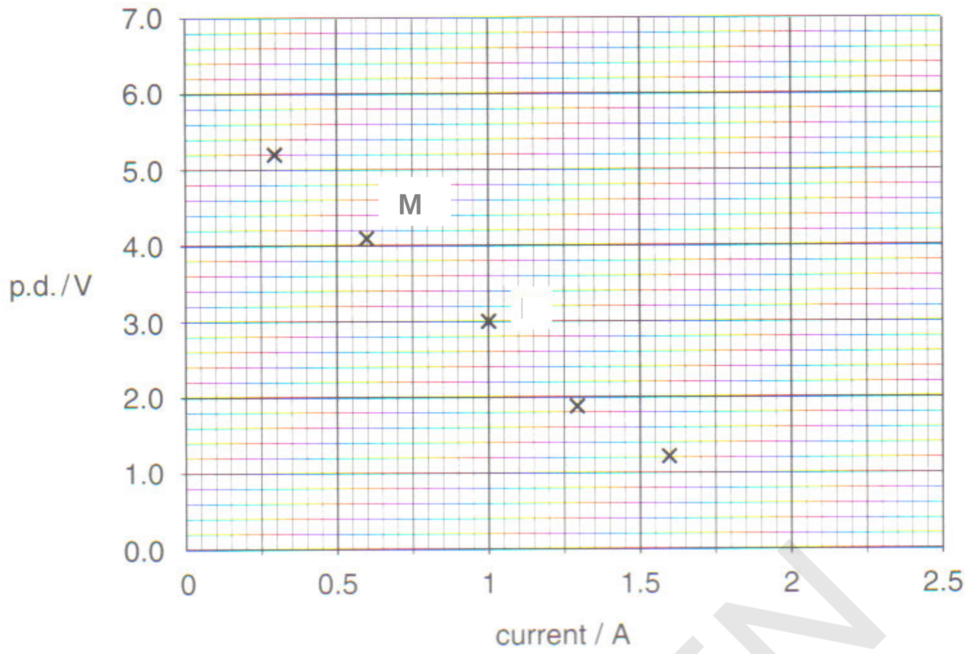

Fig. 2.2

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(i) Draw the line of best fit on Fig. 2.2. **[1]**

(ii) Use your line of best fit to determine

the e.m.f. *ε* of the battery

ε = ... V **[1]**

the internal resistance *r* of the battery. Show your working clearly.

r = ...Ω **[3]**

(d) The variable resistor R is adjusted to give the values at point M on Fig. 2.2.

Calculate

(i) the resistance of R at this point

R = ...Ω **[3]**

(ii) the power dissipated in R.

power = ... W **[2]**

[Total: 15]

3 Fig. 3.1 shows how the resistance of a thermistor varies with temperature.

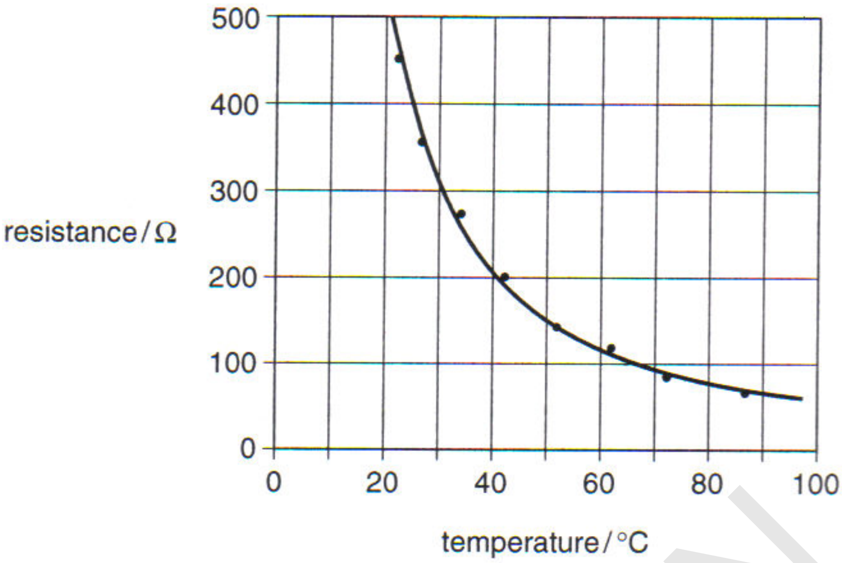

Fig. 3.1

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3 **(a)** **(i)** Describe qualitatively how the resistance of the thermistor changes as the temperature rises.

.... **[1]**

(ii) The change in resistance between 80 °C and 90 °C is about 15 Ω.

State the change in resistance between 30 °C and 40 °C.

.... **[1]**

(iii) Describe, giving a reason, how the sensitivity of temperature measurement using this circuit changes over the range of temperatures shown on Fig. 3.1.

....

....

.... **[2]**

(b) Fig 3.2 shows a temperature sensing potential divider circuit where this thermistor may be connected, between terminals A and B, in series with a resistor.

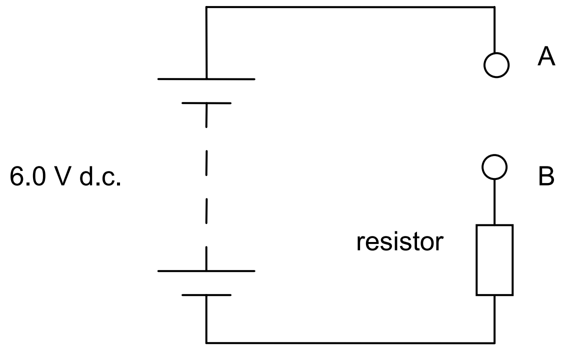

Fig. 3.2

(i) Draw the circuit symbol for a thermistor on Fig. 3.2 in the space between terminals **A** and **B**. **[1]**

(ii) A voltmeter is to be connected to the circuit to indicate an increasing p.d. when the thermistor detects an increasing temperature. On Fig. 3.2, draw the circuit connections for a voltmeter to measure a p.d. that rises with increasing temperature. **[1]**

(iii) The value of the resistor in Fig. 3.2 is 200 Ω. The thermistor is at 65 ^{o}C. Use data from Fig. 3.1 to show that the current in the circuit is about 0.02 A.

[3]

(iv) Calculate the p.d. across the 200 Ω resistor at 65 ^{o}C.

p.d. across resistor = ...V **[1]**

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(c) The graphs **X**, **Y** and **Z** in Fig 3.3. show how the p.d. across the resistor varies with temperature, for three different values of the resistor.

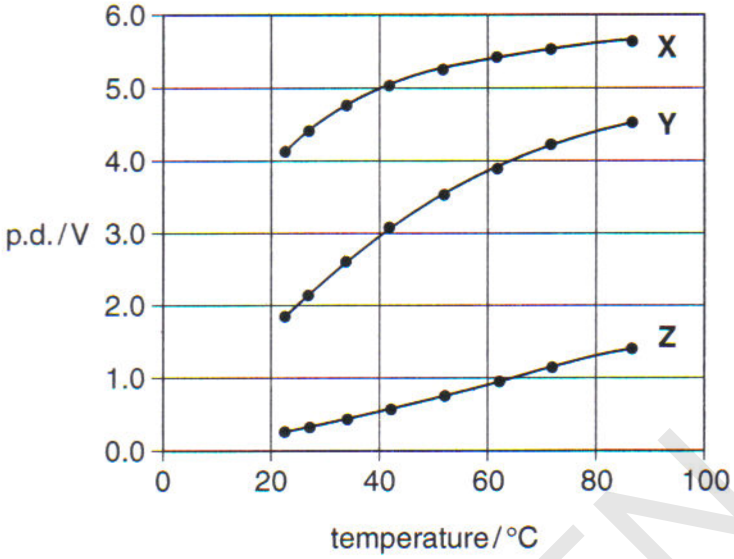

Fig. 3.3

(i) The values of resistance used are 20 Ω, 200 Ω and 1000 Ω.
State, explaining your reasoning clearly, which graph, **X**, **Y** or **Z,** is the curve for the 1000 Ω resistor.

....

....

....**[2]**

(ii) State **one** advantage and **one** disadvantage of using output **Z** for the temperature sensing circuit.

advantage ....

....

disadvantage ....

....**[2]**

[Total: 14]

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4 **(a)** Fig.4.1 shows the electromagnetic spectrum.

			visible			
A	X-rays	u.v.		**B**	microwaves	radiowaves

---→ increasing wavelength

Fig. 4.1

In the spaces in Fig. 4.2, identify the principal radiations **A** and **B** and for each suggest a typical value for the wavelength.

	principal radiation	λ/m
A		
B		

[4]

Fig. 4.2

(b) State **two** features common to all types of radiation in the electromagnetic spectrum.

....

....

.... **[2]**

(c) **(i)** Define the term *plane-polarisation* of visible light waves.

....

.... **[1]**

(ii) Explain why sound waves cannot be *plane-polarised*.

....

....

....

.... **[2]**

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(d) Fig. 4.3 shows a student observing a parallel beam of plane-polarised light that has passed through a polarising filter.

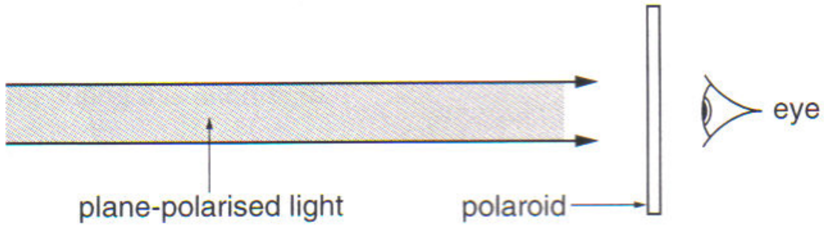

Fig. 4.3

(i) Fig. 4.4. shows how the intensity of the light reaching the student varies as the polarising filter is rotated through 360° in its own plane.

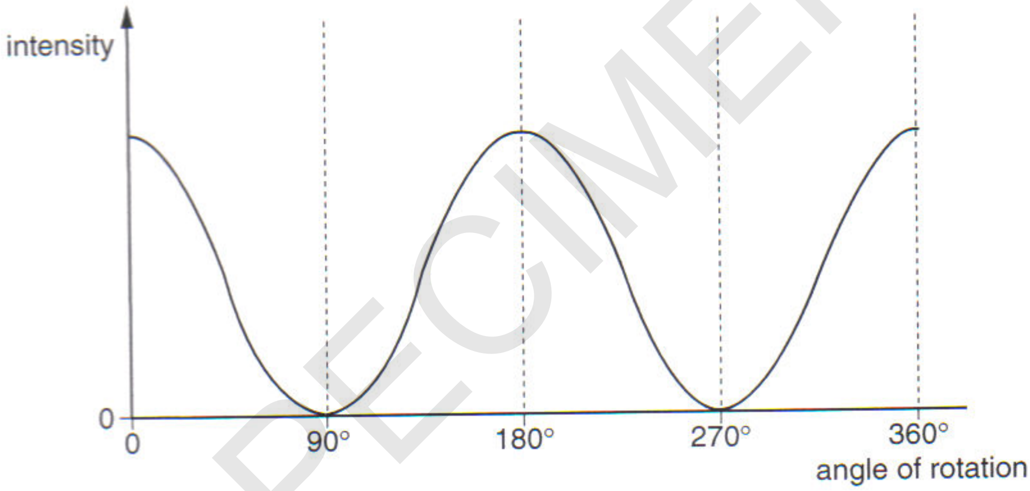

Fig. 4.4

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Suggest why there is a series of maxima and minima in the intensity.

....

....

....

....**[2]**

(ii) Hence explain how sunglasses using polarising filters reduce glare.

....

....

....

....

.... **[2]**

(e) State an example of plane-polarisation that does **not** involve visible light and state how the polarised wave may be detected.

....

....

....**[2]**

[Total: 15]

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5 (a) State and explain one difference between a progressive and a standing wave.

....

....

....

....

....**[2]**

(b) In an investigation of standing waves, a loudspeaker is positioned above a long pipe containing water, causing sound waves to be sent down the pipe. The waves are reflected by the water surface. The water level is lowered until a standing wave is set up in the air in the pipe as shown in Fig. 5.1. A loud note is heard. The water level is then lowered further until a loud sound is again obtained from the air in the pipe. See Fig. 5.2.

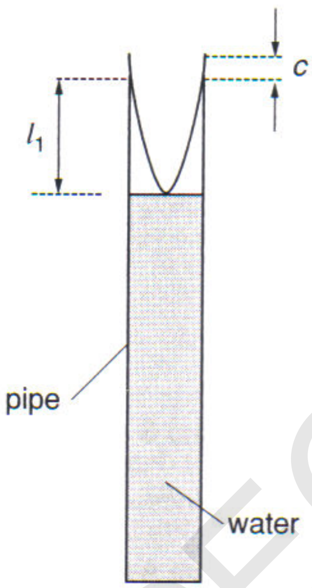

Fig 5.1

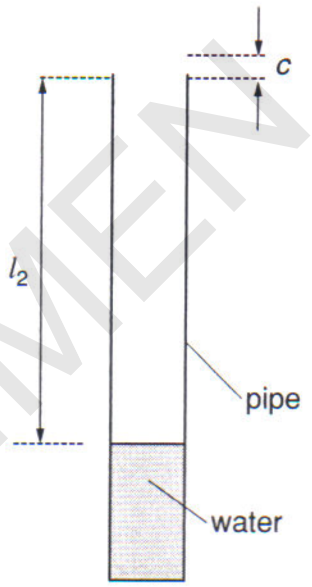

Fig. 5.2

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The air at the open end of of the pipe is free to move and this means that the antinode of the standing wave is actually a small distance *c* beyond the open end. This distance is called the end correction.

A student writes down the following equations relating the two situations shown.

$$l_1 + c = \lambda/4 \qquad l_2 + c = 3\lambda/4$$

(i) Draw the standing wave in the pipe shown in Fig. 5.2 which corresponds to the equation $l_2 + c = 3\lambda/4$. **[1]**

(ii) On your diagram, label the positions of any displacement nodes and antinodes with the letters N and A respectively. **[1]**

(iii) Use the two equations to show that $l_1 - l_2 = \lambda/2$. **[1]**

(iv) The following results were obtained in the experiment.

frequency of sound = 500Hz l_1 = 0.170 m l_2 = 0.506 m

Calculate the speed of sound in the pipe.

speed = ………………..m s^{-1} **[3]**

(c) The student repeats the experiment, but sets the frequency of the sound from the speaker at 5000 Hz.

Suggest and explain why these results are likely to give a far less accurate value for the speed of sound than those obtained in the first experiment.

In your answer, you should make clear the sequence of steps in your argument.

....

....

....

....

....

....**[4]**

[Total: 12]

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6 **(a)** Explain what is meant by the principle of superposition of two waves.

....

....

....

.... **[2]**

(b) In an experiment to try to produce an observable interference pattern, two monochromatic light sources, S1 and S2, are placed in front of a screen, as shown in Fig. 6.1.

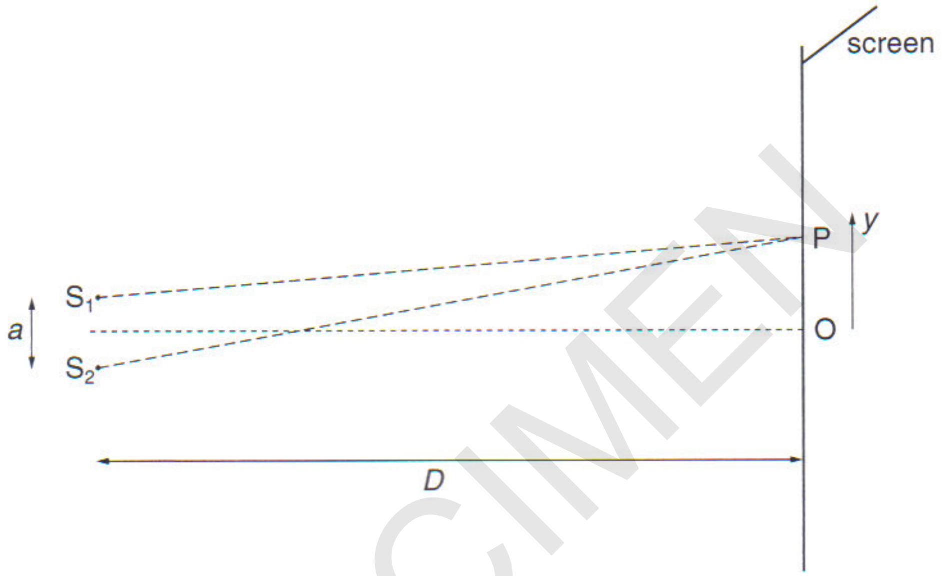

Fig. 6.1

(i) In order to produce a clear interference pattern on the screen, the light sources must be *coherent*. State what is meant by *coherent.*

....

....

.... **[2]**

(ii) In Fig 6.1, the central point O is a point of maximum intensity. Point P is the position of **minimum** intensity nearest to O. State, in terms of the wavelength λ, the magnitude of the path difference S_1P and S_2P.

.... **[1]**

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(c) In another experiment, a beam of laser light of wavelength 6.4×10^{-7} m is incident on a double slit which acts as the two sources in Fig. 6.1.

(i) Calculate the slit separation *a*, given that the distance *D* to the screen is 1.5 m and the distance between P and O is 4.0 mm.

a = ... m **[3]**

(ii) Sketch on the axes of Fig. 6.2 the variation of the intensity of the light on the screen with distance y from O. **[2]**

Fig. 6.2

[Total:10]

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7 **(a)** The concept of the photon was important in the development of physics throughout the last century. Explain what is meant by a photon.

....

.... **[1]**

(b) A laser emits a short pulse of ultraviolet radiation. The energy of each photon in the beam is 5.60×10^{-19} J.

(i) Calculate the frequency of an ultraviolet photon of the laser light.

frequency = ... Hz **[2]**

(ii) A photon of the laser light strikes the clean surface of a sheet of metal. This causes an electron to be emitted from the metal surface.

1. The work function energy of the metal is 4.80×10^{-19} J. Define the term *work* function energy.

....

.... **[1]**

2. Show that the maximum kinetic energy of the emitted electron is 8.0×10^{-20} J.

....

.... **[1]**

(iii) Show that the maximum speed of emission of an electron is about 4×10^{5} m s^{-1}.

[2]

(c) **(i)** State the de Broglie equation. Define any symbols used.

....

....

.... **[2]**

(ii) Calculate the minimum de Broglie wavelength associated with an electron emitted in **(b)** above.

wavelength = ... m **[2]**

[Total: 11]

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8 The concept of energy is important in many branches of physics. Energy is usually measured in joules, but sometimes the *kilowatt-hour* (kW h) and the *electron volt* (eV) are more convenient units of energy.

Define the *kilowatt-hour* and the *electron volt* and determine their values in joules.

Suggest why the *kilowatt-hour* and *electron volt* may be more convenient than joules.

✎ *In your answer you should make clear how your suggestions link with the evidence.*

Illustrate your answer by determining the energy dissipated by a 100 W filament lamp left on for 12 hours and the kinetic energy of an electron accelerated through a p.d. of 1.0 MV in a particle accelerator.

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[Total: 12]

Paper Total [100]

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Advanced Subsidiary GCE

PHYSICS A G482 MS

Unit G482: Electrons, Waves and Photons

Specimen Mark Scheme

The maximum mark for this paper is **100**.

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This document consists of **7** printed pages and **1** blank page.

Question Number	Answer	Max Mark
1(a)(i)	Electrons in a metal	[B1]
(ii)	Ion in an electrolyte	[B1]
(b)(i)	Correctly selected and re-arranged: $\rho = RA/L$; symbols defined: A = cross-sectional area, R = resistance, L = length	[M1] [A1]
(ii)	ρ is independent of dimensions of the specimen of the material/AW	[B1]
(c)(i)	$R = 1.7 \times 10^{-8} \times 0.08/3.0 \times 10^{-4}$ $R = 4.5(3)\ 10^{-6}$ (Ω)	[C1] [A1]
(ii) 1	$I = Q/t$ / $I = 650/5$ $I = 130$ (A)	[C1] [A1]
(ii) 2	$n = I/e = 130/1.6 \times 10^{-19}$ $n = 8.1 \times 10^{20}$	[C1] [A1]
2(a)(i)	p.d.: energy transferred per unit charge from electrical form (into other forms, e.g. light/heat) e.m.f.: energy transferred per unit charge into electrical form (from other forms, e.g. chemical/mechanical)	[B1] [B1]
(ii)	J C^{-1}	[B1]
(b)	(Sum of) e.m.f.s = sum /total of p.d.s/sum of voltages (in a loop) energy is conserved	[B1] [B1]
(c) (i)	any straight line of best fit judged by eye	[B1]
(ii) 1	6.0 ± 0.2 (V) /consistent with the y-intercept of their graph	[B1]
(ii) 2	r = gradient / $(\varepsilon - V)/I$ / V_{lost}/I e.g. r = (6.0 – 0)/2.0 r = 3.0 Ω	[B1] [M1] [A1]
(d)(i)	$I = 0.6$ A and V = 4.2 V $R = V/I = 7.0$ (Ω)	[B1] [C1]
(ii)	$R = 7.0$ (Ω) $P = IV = 4.2 \times 0.6$ $P = 2.5$ W	[A1] [C1] [A1]

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Question Number	Answer	Max Mark
3(a)(i)	resistance decreases/falls/drops (with increase in temperature)	**[B1]**
(ii)	100 ± 10 Ω	**[B1]**
(iii)	for low temps ΔR is large for $\Delta\theta$ and at high temps ΔR is small for same $\Delta\theta$; so sensitivity decreases (continuously)from low to high temperatures	**[B1]** **[B1]**
(b)(i)	correct circuit symbol	**[B1]**
(ii)	connections in parallel with fixed resistor	**[B1]**
(iii)	R_{th} = 100 to 105 Ω $R_{tot} = 200 + R_{th}$ $I = V/R_{tot} = 6/R_{tot}$ (= 0.02 A)	**[B1]** **[M1]** **[A1]**
(iv)	(V = IR = 0.02 x 200) = 4.0 (V)	**[A1]**
(c)(i)	basic potential divider argument detail, e.g.with R_{th} about 100 Ω at 70°C then R must be 1000 Ω to achieve 0.5 V to 5.5 V ratio/AW	**[B1]** **[B1]**
(ii)	advantage: (approx.) constant sensitivity/ linear (output) disadvantage: less sensitive (over most of range)/range of voltages is small/battery lasts for less time	**[B1]** **[B1]**
4(a)	A: gamma / γ (ray/radiation/wave) $\lambda = 10^{-16}$ to 10^{-10} (m) B: infrared / IR / i.r. $\lambda = 7 \times 10^{-7}$ to 10^{-3} (m)	**[B1]** **[B1]** **[B1]** **[B1]**
(b)	Any **two** from: travel at the speed of light/3×10^8 (m s^{-1}) (in a vacuum) can travel in a vacuum consists of oscillating E- <u>and</u> B-fields transverse waves/can be polarised can be diffracted/reflected/refracted	**[B1x2]**
(c)(i)	plane polarised light vibrates (travels) <u>in one plane only</u> (look for reference to one plane of oscillation)	**[B1]**
(ii)	only transverse waves can be polarised/AW sound waves are longitudinal/not transverse/AW	**[B1]** **[B1]**

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Question Number	Answer	Max Mark
(d)(i)	evidence of knowledge of: full/max transmission when the (transmission axis of) polarising sheet is parallel to the light's plane of polarisation/vibrations no transmission when the (transmission axis of) polarising sheet is at right angles to light's plane of polarisation/vibrations	[B1] [B1]
(ii)	reflected light from surface is partially plane polarised polarising sheet is placed at right angles to reflected light's polarisation plane/AW	[B1] [B1]
(e)	any valid example: e.g. radio waves, microwaves valid method of detection: e.g. aerial (allow microwave detector)	[M1] [A1]
5(a)	possible differences in amplitude/wavelength/phase/waveform/energy: As described for progressive wave As described for standing wave	[A1] [A1]
(b)(i)	correct standing wave drawn to top of end correction	[B1]
(ii)	all A and N labelled correctly	[B1]
(iii)	clear method showing $L_1 - L_2 = \lambda/2$	[B1]
(iv)	$0.506 - 0.170 = \lambda/2$; $\lambda = 0.67(2)$ (m) v = 500 x 0.672 v = 336 (m s^{-1}) (only accept 340 m s^{-1} if working shown)	[C1] [C1] [A1]
(c)	smaller wavelength means smaller distances to measure so less accuracy <u>in the measurements</u> /AW Candidate's response shows steps in a logical order as above.	[C1] [M1] [A1] [1]
6(a)	when two waves meet/interfere (at a point) the resultant displacement is the <u>sum</u> of individual <u>displacements</u> (allow the resultant amplitude is the vector/phasor sum of the individual amplitudes)	[B1] [B1]
(b)(i)	constant phase difference (allow 1 mark for same phase difference or same frequency/wavelength)	[B2]
(ii)	path difference = $\lambda/2$	[B1]
(c)(i)	evidence shown that fringe width x = 8.0 mm $a = \lambda D/x = 6.4 \times 10^{-7} \times 1.5/8.0 \times 10^{-3} = 1.2 \times 10^{-4}$ m (give 2 marks for using x = 4.0 mm giving $a = 2.4 \times 10^{-4}$ m)	[B1] [C1] [A1]

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Question Number	Answer	Max Mark
(ii)	maximum intensity when y = 0 AND minima at +4 and -4 correct repeat distance, i.e. 8.0 mm with at least 2 full cycles drawn	[B1] [B1]
7(a)	quantum of energy / radiation / packet of energy	[B1]
(b)(i)	f = E/h = $5.60 \times 10^{-19} / 6.63 \times 10^{-34}$ f = 8.45×10^{14} (Hz)	[C1] [A1]
(ii) 1	minimum energy to release an electron from the surface (of the metal)	[B1]
(ii) 2	$5.60 \times 10^{-19} - 4.80 \times 10^{-19}$ (= 8.0×10^{-20} J)	[B1]
(iii)	$8.0 \times 10^{-20} = ½(9.1 \times 10^{-31})v^2$ giving v = 4.2×10^5 (m s^{-1})	[M1] [A1]
(c)(i)	Correct selection of: $\lambda = h/p$ or $\lambda = h/mv$ where all symbols are defined	[M1] [A1]
(ii)	$\lambda = 6.6 \times 10^{-34} / (9.1 \times 10^{-31} \times 4.2 \times 10^5)$ $\lambda = 1.7 \times 10^{-9}$ (m)	[C1] [A1]
8	Any **Eleven** from: 1 kW h is the <u>energy</u> (transformed by) 1 kW (device) in a time of 1 hour reference to E = Pt/1 kW h = 1000 X 3600 1 kW h = 3.6×10^6 (J) 1 eV is the <u>energy</u> (transformed by an) electron travelling through a p.d. of 1 V reference to E = VQ 1 eV = 1.6×10^{-19} (J) kilowatt hour is useful when considering large amounts of energy/AW electronvolt is useful when considering small amounts of energy/AW eV for photons/in atomic physics/in nuclear physics kW h for domestic use/electrical bills energy of electron **or** lamp in <u>joules</u> (1.6×10^{-13} J and 4.3×10^6 J) (mark to be awarded only if E = Pt or E = VQ not credited) filament lamp: 1.2 <u>kW h</u> electron: 1.0 <u>MeV</u> # Candidate must make specific links to how the size of these answers compare with the Joule.	[B1] [B1] [B1] [B1] [B1] [B1] [B1] [B1] [B1] [B1] [B1] [B1] [B1] [B1] [1]
	Paper Total	**[100]**

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Assessment Objectives Grid (includes QWC)

Question	AO1	AO2	AO3	Total
1(a)	2			2
1(b)(i)	2			2
1(b)(ii)		1		1
1(c)(i)		2		2
1(c)(ii)		4		4
2(a)(i)	2			2
2(a)(ii)	1			1
2(b)	2			2
2(c)(i)			1	1
2(c)(ii)			4	4
2(d)(i)		3		3
2(d)(ii)		2		2
3(a)(i)			1	1
3(a)(ii)			1	1
3(a)(iii)		2		2
3(b)(i)	1			1
3(b)(ii)	1			1
3(b)(iii)		3		3
3(b)(iv)		1		1
3(c)(i)		2		2
3(c)(ii)		2		2
4(a)	4			4
4(b)	2			2
4(c)(i)	1			1
4(c)(ii)	2			2
4(d)(i)	2			2
4(d)(ii)		2		2
4(e)	2			2
5(a)	2			2
5(b)(i)	1			1
5(b)(ii)		1		1
5(b)(iii)		1		1
5(b)(iv)		3		3
5(c)			4	4
6(a)	2			2
6(b)(i)	2			2
6(b)(ii)		1		1
6(c)(i)		3		3
6(c)(ii)		2		2
7(a)	1			1

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7(b)(i)		2		**2**
7(b)(ii)		2		**2**
7(b)(iii)	2			**2**
7(c)(i)	2			**2**
7(c)(ii)		2		**2**
8	6	6		**12**
Totals	**42**	**47**	**11**	**100**

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