



GCE

Physics A

Advanced Subsidiary GCE

Unit **G482**: Electrons, Waves and Photons

Mark Scheme for January 2013

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This mark scheme is published as an aid to teachers and students, to indicate the requirements of the examination. It shows the basis on which marks were awarded by examiners. It does not indicate the details of the discussions which took place at an examiners' meeting before marking commenced.

All examiners are instructed that alternative correct answers and unexpected approaches in candidates' scripts must be given marks that fairly reflect the relevant knowledge and skills demonstrated.

Mark schemes should be read in conjunction with the published question papers and the report on the examination.

OCR will not enter into any discussion or correspondence in connection with this mark scheme.

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Annotations

Available in Scoris

Annotation	Meaning
	Benefit of doubt given
	Contradiction
	Incorrect response
	Error carried forward
	Follow through
	Not answered question
	Benefit of doubt not given
	Power of 10 error
	Omission mark
	Rounding error or repeat error
	Error in number of significant figures
	Correct response
	Arithmetic error
	Wrong physics or equation

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Mark Scheme

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The abbreviations, annotations and conventions used in the detailed Mark Scheme are:

Annotation	Meaning
/	Alternative and acceptable answers for the same marking point
(1)	Separates marking points
reject	Answers which are not worthy of credit
not	Answers which are not worthy of credit
IGNORE	Statements which are irrelevant
ALLOW	Answers that can be accepted
()	Words which are not essential to gain credit
<u> </u>	Underlined words must be present in answer to score a mark
ecf	Error carried forward
AW	Alternative wording
ORA	Or reverse argument

Subject-specific Marking Instructions

CATEGORISATION OF MARKS

The marking scheme categorises marks on the MABC scheme

- B** marks: These are awarded as independent marks, which do not depend on other marks. For a **B**-mark to be scored, the point to which it refers must be seen specifically in the candidate's answer.
- M** marks: These are method marks upon which **A**-marks (accuracy marks) later depend. For an **M**-mark to be scored, the point to which it refers must be seen in the candidate's answer. If a candidate fails to score a particular **M**-mark, then none of the dependent **A**-marks can be scored.
- C** marks: These are compensatory method marks which can be scored even if the points to which they refer are not written down by the candidate, providing subsequent working gives evidence that they must have known it. For example, if an equation carries a **C**-mark and the candidate does not write down the actual equation but does correct working which shows that the candidate knew the equation, then the **C**-mark is given.
- A** marks: These are accuracy or answer marks, which either depend on an **M**-mark, or allow a **C**-mark to be scored.

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Note about significant figures:

If the data given in a question is to 2 SF, then allow answers to 2 or more SF.

If an answer is given to fewer than 2 SF, then penalise once only in the entire paper. **N.B.** Also penalise RE only once per paper.

Any exception to this rule will be mentioned in the Guidance.

Please put ticks and crosses against all sub-sections marked AAA (7 in total)

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Question		Answer	Marks	Guidance
1	(a)	V is not proportional to I the characteristic/line is a curve/not a straight line	B1 B1	accept statement of Ohm's law for 1 mark not resistance is not constant/AW
	(b) (i)	variable power supply or fixed supply + potential divider ammeter in series with and voltmeter in parallel with lamp	B1 B1	value of power supply not required accept cross or Ω in circle for lamp symbol penalise each extra component connected (up to two)
A A A	(ii)	vary p.d. (across lamp)/current (in circuit) by changing voltage supply/moving contact on the potential divider take/record set of values of V and I	B1 B1 B1	accept increase voltage in steps of 1 V/AW accept as ecf changing variable resistor in series in circuit QWC mark
	(c)	From Fig. 1.1 lamp $I_L = 0.25$ A for R $I_R = 6/20 = 0.30$ A so $I_P = 0.55$ (A)	C1 C1 A1	1 mark for each current; 1 mark for $I_R + I_L$ or $R_L = 6/0.25 = 24 \Omega$; R_s in // gives $R_{tot} = 10.9$; so $I_P = 6.0/10.9 = 0.55$ A
	(d) (i)	straight line through origin and 300,6	B1	
	(ii)	appreciation that p.d.s across both components add to 6 V attempt to find where current is the same in both components $I_S = 0.16$ to 0.17 (A) or $165 \pm 5 \times 10^{-3}$ A or 165 ± 5 mA	B1 B1 B1	accept answers in terms of lines drawn on fig.1.1 or description of using ruler horizontally on graph and adding squares across graph,etc. ecf (d)(i)
		Total	14	

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Question		Answer	Marks	Guidance
2	(a) (i)	$I = 230/(42.5 + 2.5)$ $I = 5.11 \text{ (A)}$	C1 A1	accept 5.1 A
	(ii)	$P = I^2R = 5.11^2 \times 45$ $= 1175.0 \text{ W}$ or use $P = VI$ or $P = V^2/R$ answer given to 3 SF i.e. 1180 (W)	C1 A1 B1	ecf(a)(i) and allow $5.00^2 \times 45 = 1125 \text{ W}$ $5.1^2 \times 45 = 1170 \text{ W}$ give 1 mark for 65.3 W (wires only) or 1110 W (heater only) any follow through answer given to 3 SF gains third mark
	(iii)	6 to 10 A (integer values only)	B1	ecf(a)(i) ; allow 13 A
	(b)	$1180 \times 21 \times 4/1000$ $= 99 \text{ p}$	C1 A1	ecf(a)(ii) allow 99.1(2) or 100 p
	(c)	$R = \rho l/A$ $A = 1.70 \times 10^{-8} \times 9.50/2.50$ $A = 6.46 \times 10^{-8} \text{ (m}^2\text{)}$	C1 C1 A1	select formula mark correct substitution allow correct answer to 2 SF, i.e. $6.5 \times 10^{-8} \text{ (m}^2\text{)}$ special case 2/3 marks for: $l = 4.75 \text{ m}$; $A = 3.23 \times 10^{-8} \text{ (m}^2\text{)}$
A A A	(d)	resistance of wires increases so smaller current (in heater) power dissipation in <u>heater</u> less	B1 B1 B1	N.B. wires can be implied by e.g. A reduces so R increases or lower voltage across heater/greater voltage across wires or power dissipation in wires greater/wires get hotter/melt N.B. any statement implying constant or increased current invalidates second and third marking points
	•	Total	14	

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Question		Answer	Marks	Guidance
3	(a)	(i)	M1 A1	allow chemical
		(ii)	B1	allow any description which uses $E = V + Ir$ with symbols defined but not just the formula alone or e.g. statement about 'lost volts'/current
	(b)	(i)	C1 A1	1/R = 1/90 or 0.011 correct answer
		(ii)	C1 C1 A1	ecf (b)(i) accept $V_{out} = (90/120) \times 16 = 12$ V for full marks N.B. beware of false ratios, e.g. $360/(120 + 360)$ giving correct answer; give first marking point only
A A A		(iii)	B1 M1 A1 M1 A1	max 4 marks QWC mark is either of the M marks
	(c)	(i)	C1 A1 B1	accept 3.5 or 3.46×10^4 allow 1 mark for answer of 9.6 or 576 allow C, kC, A s; N.B. 9.6 A h or 576 A min score 3/3
		(ii)	C1 C1 A1	ecf (c)(i) allow full marks for $1.2 \times 8 \times 16/1.4 = 110$ h allow 111 h when using 3.5×10^4 C
Total			18	

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Question		Answer	Marks	Guidance
4	(a) (i)	$f = 1000/2$ $f = 500$ (Hz)	C1 A1	give 1 mark for $\frac{1}{2}$ (POT error)
	(ii)	$v = f\lambda$ giving $340 = 500 \times \lambda$ $\lambda = 0.68$ (m)	C1 A1	ecf(a)(i)
	(b)	sinusoidal curve of same frequency and amplitude \pm cosine curve	B1 B1	must be drawn for <u>2 full cycles</u> to score this mark allow drawn as sine curve from $t = 0.5$ ms
A A A	(c)	relates to the <u>oscillation</u> of two points on the (same) wave how far 'out of step' one oscillation is from the other/AW $\lambda/4$ means a phase difference of 90° or $\pi/2$ (rad)	B1 B1 B1	accept vibration N.B. statements about oscillations of two waves can only score the third marking point
	(d)	sine wave of same frequency with increased amplitude realisation that intensity is proportional to (amplitude) ² giving amplitude increase by $\sqrt{2}$, i.e. 2.8 mm	B1 B1 B1	
A A A	(e) (i)	the wave <u>reflected</u> at the end of the pipe <u>interferes/superposes</u> with the incident wave to produce a resultant wave with nodes and antinodes both ends must be antinodes the pipe must be $n\lambda/2$ in length for this to happen	B1 B1 B1 B1	max 3 marks
	(ii) 1	air molecules <u>oscillate</u> along the axis of the tube with maximum <u>amplitude</u>	B1 B1 B1	max 2 marks; allow vibrate; if transverse wave is clearly implied then can only score third marking point
	(ii) 2	no motion/nodal point	B1	allow zero displacement/amplitude
Total			18	
SCAN DOWN TO CHECK NO ANSWERS ON PAGE 11				

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Question		Answer	Marks	Guidance
5	(a)	when two(or more) waves meet/cross/interact (at a point) the (resultant) <u>displacement</u> is the (vector) sum of the (individual) <u>displacements</u>	B1 B1	do not allow for two waves travelling in opposite directions allow as a special case: the <u>resultant wave</u> is.....
	(b)	(i) <u>constant phase difference/relationship</u> (between the waves)	B1	allow fixed
		(ii) $6 \times (2n + 1)/2 \times 10^{-7}$ (m) where $n = 0, 1, 2, \text{ etc.}$	B1	expect 3×10^{-7} ; next values: 9×10^{-7} , 15×10^{-7} allow 300 nm, etc
		(iii) select $\lambda = ax/D$ $6.00 \times 10^{-7} = 1.20 \times 10^{-3} x/2.50$ $x = 1.25 \times 10^{-3}$ (m)	C1 C1 A1	
	(iv) 1	fringes move closer together a smaller distance is required between the rays from the slits to produce $\lambda/2 / \pi$ phase change	B1 B1	allow (use of formula) $x \propto \lambda$ as (a and D fixed) and λ decreases
	(iv) 2	fringes same distance apart paths of rays unchanged/slit centres same distance apart	B1 B1	allow (use of formula) x unchanged as a (λ and D) fixed
	(iv) 3	fringes move closer together the angle at which the dark fringes appear from the slits is the same, but the distance to the screen is much less	B1 B1	allow (use of formula) $x \propto D$ (as λ and a fixed)
Total			13	

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Question			Answer	Marks	Guidance
6	(a)	(i)	3 correct labels	B1	
		(ii)	the (three) colours add up/superpose to give white light or no dispersion/diffraction of incident white light/AW	B1	allow use of formula $d \sin \theta = n\lambda$ so constructive interference at $\theta = 0$ for all λ
		(iii)	select $\lambda = d \sin \theta$ $\lambda = 1.67 \times 10^{-6} \sin 19.1$ $\lambda = 546 \times 10^{-9}$ (m)	C1 C1 A1	allow 547×10^{-9} as answer is 546.46×10^{-9} do not allow 550×10^{-9} unless SF mark already deducted
	(b)		select $E = hc/\lambda$ $E = 6.63 \times 10^{-34} \times 3.0 \times 10^8/436 \times 10^{-9}$ $E = 4.56 \times 10^{-19}$ (J)	C1 C1 A1	do not allow 4.6×10^{-19} unless SF mark already deducted
	(c)	(i)	1 arrow correctly labelled 2 more arrows correctly labelled	B1 B1	
			Total	10	

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Question		Answer	Marks	Guidance
7	(a)	the energy of an electron✓ equals the energy of the (emitted) photon✓	B1 B1	alt: the electron energy✓ is converted into the energy of the emitted photon✓ or the minimum energy✓ of an electron required to produce a photon✓/AW
A A A	(b)	Adjust the potential divider to low/zero voltage connect flying lead to one LED increase voltage until LED just lights/strikes repeat several times and average to find V_{\min} repeat for each LED shield LED inside opaque tube to judge strike more accurately	B1 B1 B1 B1 B1	max 3 marks
A A A	(c) (i)	values of $1/\lambda$ calculated correctly: 2.14 and 2.43 2 points plotted correctly line of best fit drawn through origin gradient = 1.24×10^{-6} (V m)	B1 B1 B1 B1	not 2.13 unless this is second rounding error in paper ecf calculated values in table working must be shown to score the mark allow ecf for correct gradient from line drawn
	(ii)	gradient of line = $V \lambda$ from $eV = hc/\lambda$ $V\lambda = hc/e$	B1 B1	must have clear indication that $V \lambda$ is gradient of graph
	(iii)	$1.24 \times 10^{-6} = hc/e$ $h = 1.24 \times 10^{-6} \times 1.6 \times 10^{-19} / 3.0 \times 10^8$ $h = 6.6(1) \times 10^{-34}$ (J s)	M1 A1	ecf (c)(i) correct substitution into equation mark ans = 5.3 x grad (ignoring all powers of 10)
Total			13	
SCAN DOWN TO CHECK NO ANSWERS ON PAGE 18				

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