RECOGNISING ACHIEVEMENT

GCE

Physics A

Advanced Subsidiary GCE

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

Mark Scheme for June 2013

Oxford Cambridge and RSA Examinations

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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.

1. **Annotations**

Annotation	**Meaning**
BOD	Benefit of doubt given
CON	Contradiction
✗	Incorrect response
ECF	Error carried forward
FT	Follow through
NAQ	Not answered question
NBOD	Benefit of doubt not given
POT	Power of 10 error
^	Omission mark
RE	Rounding error or repeated error
SF	Error in number of significant figures
✓	Correct response
AE	Arithmetic error
?	Wrong physics or equation

Abbreviations, annotations and conventions used in the detailed Mark Scheme (to include abbreviations and subject–specific conventions).

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
__	Underlined words must be present in answer to score a mark
ecf	Error carried forward
AW	Alternative wording
ORA	Or reverse argument

Highlighting is also available to highlight any particular points on the script.

2. **Subject-specific Marking Instructions**

CATEGORISATION OF MARKS

The marking scheme categorises marks on the MABC scheme

B marks: These are awarded as <u>independent</u> 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 <u>method</u> 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 <u>compensatory</u> 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 <u>accuracy</u> or <u>answer</u> marks, which either depend on an **M**-mark, or allow a **C**-mark to be scored.

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 and annotate with SF.
Any exception to this rule will be mentioned in the Guidance.

Note about rounding errors

Only penalise rounding errors once in the entire paper and annotate with RE.

Please put ticks and crosses against all sub-sections marked AAA (9 in total) in the body of the text where the mark is given

Question			Answer	Marks	Guidance
1	**(a)**	**(i)**	potential difference (across a component)/current (in it)	B1	**allow** symbols if symbols defined; voltage or p.d.; **allow** per **not** over
		(ii)	read 10 V from graph (R = V/I =) 10/ 0.04 = 250 (Ω)	C1 M1 A0	**allow** 9.8 or 9.9 **ecf** reading from graph
	(b)		R = ρl/A **or** ρ =RA/l ρ = 250 x 1.2 x 10^{-3} ρ = 0.30 (Ω m)	C1 C1 A1	select formula mark **ecf(a)(ii)**; a correct substitution correct answer **allow** 0.3
A **A** **A**	**(c)**		(graph curves so) R changes qualification: I increases faster than V **increased temperature is caused by (larger) <u>current</u> in slice** qualification: P = I^2R as R decreases ρ decreases	B1 B1 B1 B1 B1	**allow** R increases or decreases **allow**: by calculating two values of R **do not allow** either of the first two marking points if reference made linking gradient and R value **QWC mark; allow** heating effect is caused by.... **allow** 'R decreases' already stated earlier in answer **max** 3 out of 4 + QWC mark
			Total	**10**	

Question			Answer	Marks	Guidance
2	**(a)**	**(i)**	energy transfer per unit charge from chemical/other to electrical form	B1 B1	**allow** energy per unit charge
		(ii)	(Q = It =) 200 x 4 x 60 x 60 = 2.9 x 10^6 (C)	M1 A1	**accept** 200 x 14400 **accept** 2.88 x 10^6
		(iii)	E = QV = 2.88 x 10^6 x 24 = 6.9 x 10^7 (J)	C1 A1	 **accept** 72 MJ if using 3 MC or 69.6 or 70 if using 2.9 MC
	(b)	**(i)**	correct symbol and polarity connected to X and Y	B1	**allow** one cell or more or two cells with dotted lines between
A **A** **A**		**(ii)**	V = 30 – 24 = 6 V R = V/I = 6/120 = 0.05 (Ω)	M1 M1 A0	evidence of the V subtraction needed **do not allow** use of E = V + I**r**; it must be I**R**
		(iii)	P = VI = 6 x 120 = 720 (J s^{-1})	C1 A1	**or** $I^2R = 120^2$ x 0.05 **or** $V^2/R = 6^2$ /0.05
		(iv)	(3600 – 720)/3600 = 2880/3600 = 0.8 = 80 (%)	C1 C1 A1	**ecf b(iii)**; using 2880 instead of 3600 gives 75%; scores zero **allow** (30 – 6)I/30I = 24/30 = 0.8 = 80 (%)
	(c)	**(i)**	t = Q/I = 2.88 x 10^6/120 **or** E/VI = 69 x 10^6/(24 x 120) t = 2.4 x 10^4/3600 = 6.7 h	M1 A1	**ecf (a)(iii); accept** 3 x 10^6 giving 2.5 x 10^4 s and 6.9 h **allow ora** using 7.0 h giving E = 72.5 MJ
		(ii)	power supplied = 30 x 120/1000 = 3.6 kW cost = 3.6 x 7 x 26 = 655 (p)	 A1	**ecf c(i) accept** any consistent answer **do not allow** 2.88 kW giving 524 p **unless** repeated error from **b(iv)**
			Total	**17**	

Question			Answer		Marks	Guidance
3	(a)	(i)	<u>sum of/total</u> current into a junction equals the <u>sum of/total</u> current out conservation of charge		B1 B1	total vector sum of currents is zero **allow** '<u>point in a circuit</u>' for 'junction'
		(ii)	(sum of) e.m.f.s = <u>sum /total</u> of p.d.s/sum of voltages in/around a (closed) loop (in a circuit) energy is conserved		B1 B1	**allow** 'in a (closed) circuit' in place of 'loop'
	(b)	(i)	current in 750 Ω = 0.020 A		A1	**allow** 20 mA **or** 0.02 A
		(ii)	V across 750 Ω = 0.02 x 750 = 15 V		A1	**ecf b(i)**
		(iii)	R_1 = (45 – 15)/0.03 = 1000 Ω R_2 = 15/0.01 = 1500 Ω		A1 A1	**ecf b(ii)**
	(c)	(i)	correct symbol connected in circuit		B1	2 arrows pointing towards the resistor at about 45^0 with or without a circle; arrows outside circle if drawn
A A A		(ii)	<u>total</u> R falls so I <u>in circuit/in R_1</u> increases so V across R_1 increases <u>and</u> V across 750 Ω falls		B1 M1 A1	**accept** sum of R's in parallel falls R_1 is fixed so V across R_1 increases so V across R's in parallel falls (so V across 750 Ω falls) **or** correct potential divider argument
		(iii)	in series with LDR ammeter (A) 50 mA	in parallel with LDR voltmeter (V) 20 V	M1 A1 B1	**allow** voltmeter in parallel with R_1 (30 – 50 V) **allow** multimeter connected as A (series) or V (parallel) and a correct unit for range given **allow** 20 to 100 mA; or 15 to 50 V
				Total	**15**	

Question			Answer	Marks	Guidance
4	(a)	(i)	is a transfer of energy as a result of oscillations (of the source/medium/particles through which energy is travelling)	M1 A1	**accept** carries/AW **accept** without the transfer of the medium/particles/matter
		(ii)	a *progressive* wave transfers energy a *progressive* wave transfers shape/information **either** every point on a *progressive* wave has the same amplitude **or** every point on a *progressive* wave oscillates all points on *a progressive* wave have different phase (in one λ)	B1 B1 B1 B1	**or** a *stationary* wave traps energy in pockets/AW **or** a *stationary* wave does not transfer shape/information **or** a *stationary* wave has nodes and antinodes **or** in a *stationary* wave some points do not move (nodes) **or** all points in a *stationary* wave between nodes are in phase **or** in adjacent loops are in antiphase **max** 2 marks
A **A** **A**	(b)	(i)	shape: sinusoidal and only 2 cycles amplitude constant at 0.03 m (y-axis labelled) period 0.2 s (x-axis labelled to 0.4 s) phase: cosine curve	B1 B1 B1 B1	one correct label of 0.03 m on y-axis is enough to score mark
		(ii) 1 2 3	X W W and X	B1 B1 B1	
		(iii)	Y vertically up Z vertically down	B1 B1	**award** 1 mark if directions of both reversed
	(c)		v has increased by 2 so (λ has increased by same factor) new λ = 0.60 x 2 = 1.2 (m)	M1 A1	correct reasoning correct answer
A **A** **A**	(d)		f has increased by 2 so point W has to move same distance in half the time/double the distance in the same time therefore speed is doubled to 1.9 (m s^{-1})	M1 A1	**N.B.** zero marks for using v = f λ as this is the wave velocity not the particle velocity **allow** v = 2πfA **or** v proportional to f(mark BOD) **accept** 1.88 (m s^{-1})
			Total	**17**	

Question			Answer	Marks	Guidance
5	(a)	(i)	when 2 or more waves <u>meet</u> (at a point) the (resultant) <u>displacement</u> is equal to the (vector) <u>sum</u> of the <u>displacements</u> of each wave	B1 B1	**accept** alternative words which mean *meet* **not** *collide, interfere* or *superpose* **not** amplitude
		(ii)	travel through a vacuum/ at c (in a vacuum)	B1	**allow** caused by oscillating charges; consist of electric and magnetic fields/oscillations
		(iii)	only transverse waves can be polarised	B1	**accept** sound waves are longitudinal/not transverse
A A A	(b)	(i)	the waves interfere/superpose producing a stationary wave (with nodes and antinodes) **the resultant signal is zero at a node** distance from max (antinode) to zero (node) is <u>$\lambda/4 = 0.75$ cm</u>	B1 B1 B1 B1	 constructive interference produces maximum (at R) **or** signals in phase/zero path diff. of waves (at R) **destructive interference produces minimum/zero signal or out of phase/ ½λ** **or** phase difference of <u>$\pi/2$</u> is caused by 0.75 cm shift maximum of 3/4 if nodes and antinodes interchanged QWC mark in bold
A A A		(ii)	emitted waves are polarised (in vertical plane) detected signal from T_2 falls to zero (when T_2 is rotated by 90^o) aerial only receives signal from one transmitter (T_1 , signal is halved) (no change in detected signal as) no interference/signals at right angles to each other/AW	B1 B1 B1 B1	 plane of oscillation of waves from T_2 changes/AW **max** 3 marks from 4 marking points
			Total	**11**	

Question			Answer	Marks	Guidance
6	(a)	(i)	emission of electron(s) from a metal (surface) when photon(s)/ light/uv/em radiation are incident (on surface)	B1	**allow** singular electron and absorption of photon
		(ii)	energy to accelerate/move an electron through a p.d. of 1 V/AW	B1	**not** 1.6×10^{-19} J
		(iii)	$5.0 \times 1.6 \times 10^{-19} = 8.0 \times 10^{-19}$ J	B1	**allow** 8 for 8.0; no mark if unit incorrect
	(b)	(i)1	the minimum energy required to release an electron from the surface of the metal	B1	
		(i)2	$\varphi = 8.0 \times 10^{-19} – 1.1 \times 10^{-19}$ $= 6.9 \times 10^{-19}$ J	B1	no mark if unit incorrect unless unit in **a(iii)** incorrect
		(ii)1	$½mv^2 = 1.1 \times 10^{-19}$ $v^2 = 2.2 \times 10^{-19}/9.11 \times 10^{-31}$ $(= 2.4 \times 10^{11})$ $v = 4.9 \times 10^5$ (m s^{-1})	C1 M1 A0	**accept ora** substitute 5×10^5 to find $E = 1.1 \times 10^{-19}$
		(ii)2	$\lambda = h/mv$ $= 6.63 \times 10^{-34} / 9.11 \times 10^{-31} \times 4.9 \times 10^5$ $= 1.5 \times 10^{-9}$ (m)	C1 C1 A1	**accept** 1.46×10^{-9} if using $v = 5 \times 10^5$
A A A	(c)	(i)	Electrons behave as waves/diffract (observable because) gaps/atoms are of similar wavelength to electrons regular/ordered pattern of atoms/atoms act as a grating/AW allowing interference to produce pattern on screen/AW rings occur because atomic 'crystals' at all possible orientations to beam/AW	B1 B1 B1 B1 B1	**allow** graphite for atoms **max** 3 from 5 marking points
		(ii)	wavelength is too large to produce a diffraction pattern/electrons not travelling fast enough/AW	B1	**ecf (b)(ii)2**; e.g. for AW: wavelength is about 10 times atomic spacing **or** wavelength is different to spacing
			Total	**14**	

Question			Answer	Marks	Guidance
7	(a)		light from the two sources must be/slits is coherent only possible to produce constant phase difference using a single source	B1 B1	**allow** ‘has a constant phase difference’ for ‘is coherent’ **allow** separate light sources are not coherent/do not have a constant phase difference
	(b)		at D: 180^o **or** π rad at B: 0 or 360^o **or** 2π rad	B1 B1	**max** 1 out of 2 if unit omitted except on zero **allow** ^{c} as symbol for rad
	(c)	(i)	2.0×10^{-3} (m)	B1	**allow** 1 SF and 2 mm; **allow** 1.8 or 1.9 mm, **only** 2 SF
		(ii)	$\lambda = ax/D$ $= 0.4 \times 10^{-3} \times 2.0 \times 10^{-3} /1.5$ $= 5.3(3) \times 10^{-7}$ (m)	C1 C1 A1	select formula **ecf c(i)**; substitute answer
	(d)		2 λ 1060 (nm)	C1 A1	**ecf c(ii); allow** 1000 for 5×10^{-7} **allow** 1066, 1067, 1070,1100
A A A	(e)	(i)	$E = (8.7 \times 10^{-19} - 5.0 \times 10^{-19}) = 3.7 \times 10^{-19}$ (J) select $E = hc/\lambda$ $E = 6.63 \times 10^{-34} \times 3.0 \times 10^{8}/5.3 \times 10^{-7}$ $= 3.73 \times 10^{-19}$ (J) [or 3.98×10^{-19} if using 5.0×10^{-7}]	B1 C1 M1 A1	readings from diagram must see substitution **ora** substitute for E and find λ calculation **ora** 5.4×10^{-7} (m) **N.B**. the B mark can be awarded inside the calculation **only** for the **ora** method
		(ii)	**X** in infra-red/ir **Z** in ultra-violet/uv	B1 B1	**allow** 1 mark for answers reversed
			Total	**16**	

OCR (Oxford Cambridge and RSA Examinations)
1 Hills Road
Cambridge
CB1 2EU

OCR Customer Contact Centre

Education and Learning
Telephone: 01223 553998
Facsimile: 01223 552627
Email: general.qualifications@ocr.org.uk

www.ocr.org.uk

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Head office
Telephone: 01223 552552
Facsimile: 01223 552553

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