

GCE

Physics A

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

Advanced Subsidiary GCE

Mark Scheme for June 2014

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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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These are the annotations, (including abbreviations), including those used in scoris, which are used when marking

Annotation	Meaning
	Blank Page – this annotation must be used on all blank pages within an answer booklet (structured or unstructured) and on each page of an additional object where there is no candidate response.
	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 repeated error
	Error in number of significant figures
	Correct response
	Arithmetic error
	Wrong physics or equation

Abbreviations, annotations and conventions used in the detailed Mark Scheme

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

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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.

IMPORTANT UPDATE:

ADDITIONAL OBJECTS: You **must** annotate the additional objects for each script you mark. If no credit is to be awarded for the additional object, please use annotation as agreed at the SSU, likely to be 'seen', a cross or the highlighting tool.

CROSSED OUT, RUBRIC ERROR (OPTIONAL QUESTIONS) AND MULTIPLE RESPONSES

Crossed-out Responses: Where a candidate has crossed out a response and provided a clear alternative then the crossed out response is not marked. Where no alternative response has been provided, examiners may give candidates the benefit of the doubt and mark the crossed out response where legible.

Rubric Error Responses – Optional Questions: Where candidates have a choice of question across a whole paper or a whole section and have provided more answers than required, then all responses are marked and the highest mark allowable within the rubric is given. *(The underlying assumption is that the candidate has penalised themselves by attempting more questions than necessary in the time allowed.)*

Multiple Choice Question Responses: When a multiple choice question has only a single, correct response and a candidate provides two responses (even if one of these responses is correct), then no mark should be awarded (as it is not possible to determine which was the first response selected by the candidate).

When a question requires candidates to select more than one option/multiple options, then local marking arrangements need to ensure consistency of approach.

Contradictory Responses: When a candidate provides contradictory responses, then no mark should be awarded, even if one of the answers is correct.

Short Answer Questions (requiring only a list by way of a response, usually worth only **one mark per response**): Where candidates are required to provide a set number of short answer responses then only the set number of responses should be marked. The response space should be marked from left to right on each line and then line by line until the required number of responses have been considered. The remaining responses should not then be marked. Examiners will have to apply judgement as to whether a 'second response' on a line is a development of the 'first response', rather than a separate, discrete response. *(The underlying assumption is that the candidate is attempting to hedge their bets and therefore getting undue benefit rather than engaging with the question and giving the most relevant/correct responses.)*

Short Answer Questions (requiring a more developed response, worth **two or more marks**): If the candidates are required to provide a description of, say, three items or factors and four items or factors are provided, then mark on a similar basis – that is downwards (as it is unlikely in this situation that a candidate will provide more than one response in each section of the response space.)

Longer Answer Questions (requiring a developed response): Where candidates have provided two (or more) responses to a medium or high tariff question which only required a single (developed) response and not crossed out the first response, then only the first response should be marked.

Examiners will need to apply professional judgement as to whether the second (or a subsequent) response is a 'new start' or simply a poorly expressed continuation of the first response.

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.

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

Please put a tick for every mark awarded in the body of the text at the point where the mark is given.

Question			Answer	Marks	Guidance
1	a	i	V is not proportional to I	B1	accept not a straight line; R is not constant
		ii	R (approximately) constant up to $V = 0.5$ V and $I = 50$ mA so $R = 0.5/0.05 = 10$ (Ω)	B1 B1	allow graph is (almost) linear/straight (to $V = 0.5$ V) or constant gradient allow any correct calculation, e.g. $0.2/0.02$
		iii	the resistivity/resistance of the (metal) filament increases with temperature the larger the current in the filament the hotter it becomes/AW	B1 B1	<u>larger current</u> heats filament <u>so</u> resistance increases or electron-ion collisions increase/AW; allow atom for ion
	b		Any potential divider argument or calculation <i>In the light</i> parallel combination less than or about 1Ω /AW so V across lamp less than 0.5 V (so lamp out)/ small compared to V across 25Ω	B1 B1 B1	QWC the arguments must be clear for full marks allow $R_{\text{lamp}} = 10$ to 25Ω for any calculation or comparison of voltage across 25Ω to 1Ω N.B. answers given in terms of current are likely to score zero
			<i>In the dark</i> parallel combination about 25Ω /AW so V across lamp approximately 6.0 V so lamp on	B1 B1	
			Total	10	

Question		Answer	Marks	Guidance
2	a	emf – $J C^{-1}$, resistance – $V A^{-1}$, energy – $V C$, charge – $A s$	B1 B1	4 correct 2 marks; 2 correct 1 mark
	b	i	B1 B1	NOT coulomb allow any other form e.g. heat, light, etc
		ii	B1	allow any description which uses $E = V + Ir$ but not just the formula alone, e.g. 'lost volts' per unit current is just acceptable
		iii	B1 B1 A0	allow R in X branch is half that in YZ branch/AW
		iv	C1 A1	
		v	B1 B1 A0	p.d./voltage across 3Ω and 6Ω are equal with justification
		vi	C1 C1 C1 A1	or $V = 0.24 \times 4$ or 0.08×12 or 0.16×6 or (iv) $\times 2$ alt: R in parallel gives 4.0Ω ; total R = $1.2/0.24 = 5.0 \Omega$ $r = 5.0 - 4.0 = 1.0 (\Omega)$ allow 1SF
			Total	15

Question		Answer	Marks	Guidance
3	a	p.d./voltage (across component) divided by current (in it)	B1	accept V/I with V and I defined; per (unit) current, etc
	b	i	C1 C1 A1	allow $A = 4\pi r^2 = 4.5 \times 10^{-19}$ giving 285 Ω accept 220 to 230 Ω
		ii	A1	accept alternatives, e.g. 80/volume
		iii	C1 A1	1 mark for substitution into formula, ecf n, A values accept 3.16 and 3.5 (using $n = 2 \times 10^{28}$) accept 2.48 and 2.76 (for 285 Ω)
		iv	C1 C1 A1	ecf b(i) & (iii) accept 1 SF as estimate; can obtain 1.2 to 2.8 using all values possible in (iii)
	c	electron moves at drift velocity signal travels at/close to the speed of light	B1 B1	accept answers explaining idea of drift velocity
Total			12	

Question			Answer	Marks	Guidance
4	a	i	ammeter in series voltmeter in parallel with LED	B1	both correct to score 1 mark
		ii	(at 20 mA) $V_{\text{led}} = 4.0 \text{ V}$ $V_R = 0.020 \times 100 = 2.0 \text{ V}$ so p.d. = 6.0 V	B1 C1 A1	allow $R_{\text{led}} = (4.0/0.02) = 200 \Omega$ p.d. = 0.020 (200 + 100) allow answer to 1 SF
	b	i	energy in eV = $4.1 \times 10^{-19}/1.6 \times 10^{-19} = 2.6 \text{ (eV)}$	B1	expect 2.56 eV
		ii	LED strikes at 2.6 V/ only conducts above 2.6 V an electron must pass through a p.d. of 2.6 V to lose energy as a photon of blue light/AW.	M1 A1	
	c	i	$n = I/e = 0.02/1.6 \times 10^{-19}$ $= 1.3 \times 10^{17}$	C1 A1	expect 1.25×10^{17}
		ii	energy/s = $1.25 \times 10^{17} \times 4.1 \times 10^{-19}$ or $2.6 \text{ V} \times 0.020 \text{ A}$ $= 0.051 \text{ to } 0.053 \text{ (J s}^{-1}\text{)}$	C1 A1	ecf (c)(i); NOT 4.0×0.020 answer is 0.053 using 1.3×10^{17}
		iii	efficiency = $0.052/(4.0 \times 20 \times 10^{-3})$ $= 0.64$	C1 A1	ecf (c)(ii) accept $V_{\text{strike}}/V_{\text{operate}} = 2.6/4.0$ or any other correct (P or W out)/ (P or W in) calculation accept 64 %
	d		shape similar to the curve drawn leaving x-axis at close to 2.0 V and passing through (3.4, 20)	B1 B1	Within half a square
Total				15	

Question		Answer	Marks	Guidance	
5	a	<u>constant</u> phase difference/relationship (between the waves) <u>or always</u> at π radians/ 180° <u>or</u> because they are generated by the same source/AW	B1	allow fixed NOT same	
	b	(for a minimum) the two oscillations/amplitudes add in antiphase/ are π (rad) out of phase/ <u>completely</u> out of phase there is a resultant <u>amplitude</u> (of $2.0 \mu\text{m}$) so a sound will still be heard	B1 B1	for zero intensity the two oscillations must have equal amplitudes/AW and be in antiphase allow the word waves for oscillations	
	c	B $\pi/2$ radians/ 90° C $3\pi/4$ radians/ 135°	B1 B1	max 1 out of 2 marks if unit omitted	
	d	i	$f = 10^3/0.8 = 1.25 \text{ kHz}$ or $T = 0.8 \times 10^{-3} \text{ s}$ $\lambda = v/f$ or $vT = 340 \times 0.8 \times 10^{-3}$ $\lambda = 0.27 \text{ m}$	C1 C1 A1	if T value from graph incorrect ecf with max 2/3
		ii	select $\lambda = ax/D$ $D = 0.4 \times 4.8 / 0.27$ $D = 7.1 \text{ (m)}$	C1 C1 A1	ecf (d)(i) expect 7.06 m if using $\lambda = 0.272 \text{ m}$ 3.5 m or 3.6 m scores 2 marks
	e	i	energy per unit time/power per unit area (perpendicular to the direction of energy transfer)	B1	accept per second as a special case
		ii	ratio of amplitudes = 3 intensity is proportional to (amplitude) ² ratio of intensities = 9 so intensity at O = $4.0 \times 10^{-6} \times 9$ $I = 3.6 \times 10^{-5} \text{ (W m}^{-2}\text{)}$	C1 C1 A1	or A at P = $2.0 \mu\text{m}$ and A at O = $6.0 \mu\text{m}$ clearly stated allow $I \propto A^2$ i.e. symbols only
			Total	15	

Question		Answer	Marks	Guidance
6	a	all travel at speed of light through a vacuum are oscillating E and B fields or are caused by accelerating charges/AW	B1 B1	max 2 marks from 3 marking points if 3 properties are given withhold one mark for each incorrect property so 2 correct and 1 incorrect would score 1 mark ;1 correct and 2 incorrect would score zero, etc
	b	i	B1 B1	
		ii	B1 B1	allow any words indicating <u>vertical</u> , e.g. up and down; for <u>horizontal</u> , e.g. at 90° to vertical or crossed polarisers accept using Malus' law $I_{\text{trans}} = I_{\text{incident}} \cos^2 \theta$ with $\theta = 90^\circ$ gives $I_{\text{trans}} = 0$
		iii	B1 B1 B1	QWC statement to the effect that component of light along polarising axis of filter is transmitted accept using Malus' law $I_{\text{trans}} = I_{\text{incident}} \cos^2 \theta$ with $\theta = 45^\circ$ gives $I_{\text{trans}} = I_{\text{incident}}/2$ same process gives $I_{\text{trans}} = I_{\text{incident}}/2$ again so 1/4 of light after polariser 1 reaches eye (assuming no absorption) accept answers in terms of amplitudes rather than intensities, i.e. $A = A_0 \cos \theta$, etc.
			Total	9

Question		Answer	Marks	Guidance
7	a	(micro)waves are <u>reflected</u> (at the metal walls) reflected waves interfere/superpose with the incident waves to produce nodes and antinodes (– a stationary wave pattern)	B1 B1 B1	allow points of constructive and destructive interference
	b	X are the points of <u>maximum</u> energy/intensity/amplitude so are antinodes	M1 A1	allow displacement in this case
	c	measurement = 3 cm or $\lambda/2 = 6$ cm so $\lambda = 0.12$ m $c = f\lambda = 2.5 \times 10^9 \times 0.12$ $= 3.0 \times 10^8$ (m s ⁻¹)	B1 C1 M1 A1	measurement to within ± 1 mm ecf measurement, i.e. $\lambda = 4 \times$ measurement there must be a valid calculation shown scores 1 out of final 3 for answer of 1.5×10^8 allow 1 SF, i.e. 3×10^8
Total			9	

Question			Answer	Marks	Guidance
8	a	i	energy ϕ required for an electron to escape from <u>metal surface</u> the minimum energy.....	M1 A1	inclusion of the word minimum in the sentence scores the second mark
		ii	a <u>photon</u> with less than the threshold frequency f_0 cannot cause electron emission/AW so work function = h (threshold frequency)	B1 B1	allow $\phi = hf_0$ when the symbols ϕ and f_0 have been defined somewhere in the question
		iii	$\phi = hc/\lambda$ $= 6.63 \times 10^{-34} \times 3.0 \times 10^8 / 550 \times 10^{-9}$ $= 3.6 \times 10^{-19}$ (J)	C1 A1	
	b	i	$KE_{\max} = hf - \phi$ or $hf = \phi + KE_{\max}$ $hf = 6.63 \times 10^{-34} \times 3.0 \times 10^8 / 440 \times 10^{-9} = 4.5 \times 10^{-19}$ J $\frac{1}{2}mv^2 = 9 \times 10^{-20}$ giving $v^2 = 1.8 \times 10^{-19} / 9.1 \times 10^{-31}$ $v = 4.45 \times 10^5$ (m s ⁻¹)	C1 B1 B1 A0	ecf (a)(iii) allow 4.5 or 4.4×10^5
		ii	$\lambda = h/mv = 6.63 \times 10^{-34} / 9.1 \times 10^{-31} \times 4.5 \times 10^5$ $\lambda = 1.6 \times 10^{-9}$ (m)	C1 A1	allow 1.7×10^{-9} for $v = 4.4 \times 10^5$
	c	i	$n = 3$ <u>to</u> $n = 2$	B1	allow between or and when there is a downward arrow on Fig. 8.1
		ii	$E_{32} + E_{21} = E_{31}$ $hc/\lambda_{32} + hc/\lambda_{21} = hc/\lambda_{31}$ $1/590 + 1/440 = 1/252$ so $\lambda_{31} = 250 \times 10^{-9}$ (m)	C1 C1 A1	accept equation using $1/\lambda$ or $1/590 + 1/440 = 1/\lambda_{31}$ allow 2 or 3 sf allow 2/3 for using 550 for 590 nm giving 244 nm
Total				15	

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