

Physics A

Advanced Subsidiary GCE

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

Mark Scheme for June 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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1. Annotations

| 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 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 (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 |
| <u> </u> | 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 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.

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 ($R = V/I =$) $10/ 0.04$ $= 250 (\Omega)$ | C1 M1 A0 | allow 9.8 or 9.9 ecf reading from graph |
| | (b) | | $R = \rho l/A$ or $\rho = RA/l$ $\rho = 250 \times 1.2 \times 10^{-3}$ $\rho = 0.30 (\Omega \text{ m})$ | 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) current 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) | $(Q = It =) 200 \times 4 \times 60 \times 60$ $= 2.9 \times 10^6 \text{ (C)}$ | M1 A1 | accept 200 x 14400 accept 2.88×10^6 |
| | (iii) | $E = QV = 2.88 \times 10^6 \times 24$ $= 6.9 \times 10^7 \text{ (J)}$ | 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) | $V = 30 - 24 = 6 \text{ V}$ $R = V/I = 6/120$ $= 0.05 \text{ (}\Omega\text{)}$ | M1 M1 A0 | evidence of the V subtraction needed do not allow use of $E = V + Ir$; it must be IR |
| | (iii) | $P = VI = 6 \times 120$ $= 720 \text{ (J s}^{-1}\text{)}$ | C1 A1 | or $I^2R = 120^2 \times 0.05$ or $V^2/R = 6^2 / 0.05$ |
| | (iv) | $(3600 - 720)/3600 = 2880/3600$ $= 0.8$ $= 80 \text{ (}\%\text{)}$ | C1 C1 A1 | ecf b(iii) ; using 2880 instead of 3600 gives 75%; scores zero allow $(30 - 6)/30I = 24/30 = 0.8 = 80 \text{ (}\%\text{)}$ |
| | (c) (i) | $t = Q/I = 2.88 \times 10^6/120$ or $E/VI = 69 \times 10^6/(24 \times 120)$ $t = 2.4 \times 10^4/3600 = 6.7 \text{ h}$ | M1 A1 | ecf (a)(iii) ; accept 3×10^6 giving $2.5 \times 10^4 \text{ s}$ and 6.9 h allow ora using 7.0 h giving $E = 72.5 \text{ MJ}$ |
| | (ii) | power supplied = $30 \times 120/1000 = 3.6 \text{ kW}$ cost = $3.6 \times 7 \times 26 = 655 \text{ (p)}$ | 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 $750 \Omega = 0.020 \text{ A}$ | A1 | allow 20 mA or 0.02 A | |
| | | (ii) | V across $750 \Omega = 0.02 \times 750 = 15 \text{ V}$ | A1 | ecf b(i) | |
| | | (iii) | $R_1 = (45 - 15)/0.03 = 1000 \Omega$ $R_2 = 15/0.01 = 1500 \Omega$ | A1 A1 | ecf b(ii) | |
| | (c) | (i) | correct symbol connected in circuit | B1 | 2 arrows pointing towards the resistor at about 45° 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</u> R_1 increases so V across R_1 increases <u>and</u> V across 750Ω 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 750Ω 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) | <i>a progressive wave transfers energy</i> <i>a progressive wave transfers shape/information</i> either every point on a <i>progressive wave</i> has the same amplitude or every point on a <i>progressive wave</i> oscillates all points on a <i>progressive wave</i> have different phase (in one λ) | B1 B1 B1 B1 | or a <i>stationary wave</i> traps energy in pockets/AW or a <i>stationary wave</i> does not transfer shape/information or a <i>stationary wave</i> has nodes and antinodes or in a <i>stationary wave</i> some points do not move (nodes) or all points in a <i>stationary wave</i> 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 $\lambda = 0.60 \times 2 = 1.2$ (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 $1.9 \text{ (m s}^{-1}\text{)}$ | M1 A1 | N.B. zero marks for using $v = f \lambda$ as this is the wave velocity not the particle velocity allow $v = 2\pi fA$ or v proportional to f(mark BOD) accept $1.88 \text{ (m s}^{-1}\text{)}$ |
| | | 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 <i>meet</i> 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 $\lambda/4 = 0.75 \text{ cm}$ | 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/ $\frac{1}{2}\lambda$ or phase difference of $\pi/2$ is caused by 0.75 cm shift maximum of 3/4 if nodes and antinodes interchanged QWC mark in bold |
| | | (ii) | emitted waves are polarised (in vertical plane) detected signal from T_2 falls to zero (when T_2 is rotated by 90°) 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 <u>metal</u> (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) | (i)1 | the <u>minimum</u> energy required to release an electron from the <u>surface</u> of the metal | B1 | |
| | | (i)2 | $\phi = 8.0 \times 10^{-19} - 1.1 \times 10^{-19}$ $= 6.9 \times 10^{-19}$ J | B1 | no mark if unit incorrect unless unit in a(iii) incorrect |
| | | (ii)1 | $\frac{1}{2}mv^2 = 1.1 \times 10^{-19}$ $v^2 = 2.2 \times 10^{-19} / 9.11 \times 10^{-31}$ ($= 2.4 \times 10^{11}$) $v = 4.9 \times 10^5$ (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 <u>regular/ordered</u> 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 | 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 |
| | | | 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° or π rad at B: 0 or 360° 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) | 2λ 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 | |

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