OCR
RECOGNISING ACHIEVEMENT

GCE

# Physics A

Advanced Subsidiary GCE

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

# Mark Scheme for January 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.

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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 |

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 |
| __ | 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.

**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)**

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

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

| Question | | | Answer | Marks | Guidance |
|---|---|---|---|---|---|
| 3 | (a) | (i) | energy transferred from source/changed from some form to electrical energy;<br>per unit charge (to drive charge round a complete circuit) | M1<br>A1 | **allow** chemical |
| | | (ii) | (some) energy is transferred into thermal energy /lost as heat in (driving charge through) the battery. It behaves as if it has an (internal) resistance/AW<br>**or** there is a voltage drop across/decrease in voltage from the battery when a current is drawn from it/AW | 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) | correct substitution into resistors in parallel formula<br>R = 90 Ω | C1<br>A1 | 1/R = 1/90 or 0.011<br>correct answer |
| | | (ii) | using $V_{out} = R_2/(R_1 + R_2)\ V_{in}$ : **alt:** 16 = I x 120<br>$V_{out}$ = 90/(30 + 90) 16 so I = 0.133 A<br>$V_{out}$ = 12 V $V_{out}$ = 0.13 x 90 = 12 V | C1<br>C1<br>A1 | **ecf (b)(i)**<br>**accept** $V_{out}$ = (90/120) x 16 = 12 V for full marks<br>**N.B.** beware of false ratios, e.g. 360/(120 + 360) giving correct answer; give first marking point only |
| **A**<br>**A**<br>**A** | | (iii) | resistance (of thermistor) decreases (with temperature increase)<br>current <u>in circuit</u> increases **or** as <u>total</u> resistance is less<br>so current in thermistor increases<br>voltage ratio between 30 Ω and combination changes<br>so voltage across thermistor falls | B1<br>M1<br>A1<br>M1<br>A1 | **max** 4 marks<br>QWC mark is either of the M marks |
| | (c) | (i) | Q = It = 1.2 x 8 x 60 x 60<br>Q = 34560 (C)<br>correct unit, | C1<br>A1<br>B1 | **accept** 3.5 or 3.46 x $10^4$<br>**allow** 1 mark for answer of 9.6 or 576<br>**allow** C, kC, A s; **N.B.** 9.6 A h or 576 A min score 3/3 |
| | | (ii) | energy = 34560 x 16 = 552960 J **or** I = 1.4/16 = 00875 A<br>time = 552960/1.4 = 394970 s **then** t = 34560/I<br>time = 394970/3600 = (109.7 h) = 110 h | C1<br>C1<br>A1 | **ecf (c)(i)**<br>**allow** full marks for 1.2 x 8 x 16/1.4 = 110 h<br>**allow** 111 h when using 3.5 x $10^4$ C |
| | | | **Total** | **18** | |

| Question | | | Answer | Marks | Guidance |
|---|---|---|---|---|---|
| 4 | (a) | (i) | f = 1000/2<br>f = 500 (Hz) | C1<br>A1 | **give** 1 mark for ½ (POT error) |
| | | (ii) | v = fλ giving 340 = 500 x λ<br>λ = 0.68 (m) | C1<br>A1 | **ecf(a)(i)** |
| | (b) | | sinusoidal curve of same frequency and amplitude<br>± cosine curve | B1<br>B1 | **must** be drawn for 2 full cycles to score this mark<br>**allow** drawn as sine curve from t = 0.5 ms |
| A<br>A<br>A | (c) | | relates to the oscillation of two points on the (same) wave<br>how far 'out of step' one oscillation is from the other/AW<br>λ/4 means a phase difference of 90° or π/2 (rad) | B1<br>B1<br>B1 | **accept** vibration<br>**N.B.** statements about oscillations of two waves can only score the third marking point |
| | (d) | | sine wave of same frequency with increased amplitude<br>realisation that intensity is proportional to (amplitude)$^2$<br>giving amplitude increase by √2, i.e.2.8 mm | B1<br>B1<br>B1 | |
| A<br>A<br>A | (e) | (i) | the wave reflected at the end of the pipe<br>interferes/superposes with the incident wave<br>to produce a resultant wave with nodes and antinodes<br>both ends must be antinodes<br>the pipe must be nλ/2 in length for this to happen | <br>B1<br>B1<br>B1<br>B1 | **max** 3 marks |
| | | (ii) 1 | air molecules oscillate<br>along the axis of the tube<br>with maximum amplitude | B1<br>B1<br>B1 | **max** 2 marks; **allow** vibrate;<br>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** | | |

| 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<br><br>B1 | **do not allow** for two waves travelling in opposite directions<br>**allow** as a special case: the <u>resultant wave</u> is….. |
| | (b) | (i) | <u>constant</u> phase difference/relationship (between the waves) | B1 | **allow** fixed |
| | | (ii) | 6 x (2n + 1)/2 x$10^{-7}$ (m) where n = 0, 1,2, etc. | B1 | **expect** 3 x $10^{-7}$; next values: 9 x $10^{-7}$, 15 x $10^{-7}$<br>allow 300 nm, etc |
| | | (iii) | select λ = ax/D<br>6.00 x $10^{-7}$ = 1.20 x $10^{-3}$ x/2.50<br>x = 1.25 x $10^{-3}$ (m) | C1<br>C1<br>A1 | |
| | | (iv) 1 | fringes move closer together<br>a smaller distance is required between the rays from the slits to produce λ/2 /π phase change | B1<br><br>B1 | **allow** (use of formula) x α λ as (a and D fixed) and λ decreases |
| | | (iv) 2 | fringes same distance apart<br>paths of rays unchanged/slit centres same distance apart | B1<br>B1 | **allow** (use of formula) x unchanged as a (λ and D) fixed |
| | | (iv) 3 | fringes move closer together<br>the angle at which the dark fringes appear from the slits is the same, but the distance to the screen is much less | B1<br><br>B1 | **allow** (use of formula) x α D (as λ and a fixed) |
| | | | **Total** | **13** | |

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

| Question | | | Answer | Marks | Guidance |
|---|---|---|---|---|---|
| 7 | (a) | | the energy of an electron✓ equals the energy of the (emitted) photon✓ | B1<br>B1 | **alt:** the electron energy✓ is converted into the energy of the emitted photon✓<br>**or** the minimum energy✓ of an electron required to produce a photon✓/AW |
| A<br>A<br>A | (b) | | Adjust the potential divider to low/zero voltage<br>connect flying lead to one LED<br>increase voltage until LED just lights/strikes<br>repeat several times and average to find $V_{min}$<br>repeat for each LED<br>shield LED inside opaque tube to judge strike more accurately | B1<br>B1<br>B1<br>B1<br>B1<br>B1 | **max** 3 marks |
| A<br>A<br>A | (c) | (i) | values of 1/λ calculated correctly: 2.14 and 2.43<br>2 points plotted correctly<br>line of best fit drawn through origin<br>gradient = $1.24 \times 10^{-6}$ (V m) | B1<br>B1<br>B1<br>B1 | **not** 2.13 unless this is second rounding error in paper<br>**ecf** calculated values in table<br><br>working **must be shown** to score the mark **allow ecf** for correct gradient from line drawn |
| | | (ii) | gradient of line = V λ<br>from eV = hc/ λ Vλ = hc/e | B1<br>B1 | **must have** clear indication that V λ is gradient of graph |
| | | (iii) | $1.24 \times 10^{-6}$ = hc/e<br>h = $1.24 \times 10^{-6} \times 1.6 \times 10^{-19} / 3.0 \times 10^{8}$<br>h = 6.6(1) $\times 10^{-34}$ (J s) | <br>M1<br>A1 | **ecf (c)(i)**<br>correct substitution into equation mark<br>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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