

GCE

Physics A

Unit **H556/02**: Exploring physics

Advanced GCE

Mark Scheme for June 2017

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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 RM Assessor

| Annotation | Meaning |
|---|--|
|  | Benefit of doubt given |
|  | Contradiction |
|  | Incorrect response |
|  | Error carried forward |
|  | Level 1 |
|  | Level 2 |
|  | Level 3 |
|  | Transcription error |
|  | Benefit of doubt not given |
|  | Power of 10 error |
|  | Omission mark |
|  | Error in number of significant figures |
|  | Correct response |
|  | 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 |
| 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 |

MARKING INSTRUCTIONS

Generic version as supplied by OCR Sciences

CATEGORISATION OF MARKS

The marking schemes categorise marks on the MACB 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 answers.

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 answers. 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 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 to 2 or more significant figures.
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 Additional Guidance.

SECTION A

| Question | Answer | Marks | Guidance |
|----------|--------------|-----------|----------|
| 1 | B | 1 | |
| 2 | C | 1 | |
| 3 | D | 1 | |
| 4 | B | 1 | |
| 5 | A | 1 | |
| 6 | C | 1 | |
| 7 | A | 1 | |
| 8 | D | 1 | |
| 9 | D | 1 | |
| 10 | C | 1 | |
| 11 | D | 1 | |
| 12 | A | 1 | |
| 13 | D | 1 | |
| 14 | B | 1 | |
| 15 | B | 1 | |
| | Total | 15 | |

SECTION B

| Question | | Answer | Marks | Guidance |
|----------|-----|--|----------|--|
| 16 | (a) | (When two or more waves meet at a point in space) the resultant (displacement) is equal to the (vector) sum of the individual <u>displacements</u> of waves (meeting at a point) | B1 | Allow total / Σ / net for resultant Not amplitude for displacement |
| | (b) | (i) | | |
| | | Clear evidence of at least two fringe separations used to determine x and x in the range 7.0 to 9.0 mm | B1 | Expect 8 (mm) |
| | | $\lambda = \frac{0.25 \times 10^{-3} \times 8 \times 10^{-3}}{4.25} \quad (\text{Allow any subject})$ | C1 | Allow ecf for incorrect value of x |
| | | $\lambda = 4.7 \times 10^{-7} \text{ (m)}$ | A1 | |
| | | (ii) | | |
| | | Red light has longer wavelength / λ and separation between fringes increases (AW) | M1 | |
| | | Separation between fringes justified in terms of $x \propto \lambda$ or $x = \lambda D/a$, D <u>and</u> a are constants | A1 | Allow other acceptable labels for D and a |
| | | Total | 6 | |

| Question | | Answer | Marks | Guidance |
|--------------|---------|---|--|--|
| 17 | (a) | Any <u>one</u> from: current, temperature, light intensity and amount of substance / matter | B1 | Not: ampere, kelvin, candela and mole Not correct quantity with its unit, e.g. current in <u>A</u> or current (A) |
| | (b) (i) | $R = \frac{\rho L}{A} \quad \text{and} \quad A = \pi \left(\frac{d}{2}\right)^2$ $R_x = \frac{4\rho L}{\pi d^2} \quad \text{and} \quad R_y = \frac{8\rho L}{\pi d^2}$ Clear steps leading to $R = \frac{12\rho L}{\pi d^2}$ | M1 A1 | |
| | (ii)1 | Ruler / tape measure (for L) and micrometer (for d) | B1 | Allow (vernier / digital) calipers or travelling microscope for micrometer |
| | (ii)2 | $R = 2.3(4) (\Omega)$ $\frac{0.1}{9.5} \quad \text{or} \quad 2 \times \frac{0.003}{0.270}$ $\frac{0.1}{9.5} + 2 \times \frac{0.003}{0.270} \quad \text{or} \quad 0.0327 \quad \text{or} \quad 3.27\%$ absolute uncertainty in $R = 0.0327 \times 2.34 = 0.077$ $R = 2.3 \pm 0.1 (\Omega)$ | C1 C1 C1 A1 | Allow other correct methods for getting $2.3 \pm 0.1 (\Omega)$ Allow 2 or more sf for this C1 mark Note 0.0105 or 1.05% or 0.0222 or 2.22% scores this mark, allow 2sf or more Allow: $2.34 \pm 0.08 (\Omega)$ Note use of R_x or R_y instead of R can score the second and third C1 marks only |
| | (ii)3 | (The actual) R is large(r) because (the actual) d is small(er) or (the actual) A is small(er) or $R \propto 1/d^2$ | B1 | Allow: The <u>calculated</u> R is small(er) because (the measured) A is large(r) or $R \propto 1/d^2$ |
| Total | | | 9 | |

| Question | | | Answer | Marks | Guidance |
|----------|-----|------|--|---|--|
| 18 | (a) | (i) | Resistance of parallel combination = 40 (Ω) $I = \frac{4.2 - 1.5}{40 + 33}$ $I = 0.037 \text{ (A)}$ | C1 C1 A1 | Allow $(1/60 + 1/120)^{-1}$ Allow 2 marks for $I = \frac{4.2 + 1.5}{40 + 33} = 0.078 \text{ (A)}$ |
| | | (ii) | Any <u>two</u> from: The current decreases up to 1.5 V The current is zero at 1.5 V The current changes direction / is negative when < 1.5 V The current increases below 1.5 V | B1 ×2 | Allow 'current is zero when the e.m.f.s are the same' |

| Question | Answer | Marks | Guidance |
|----------|---|-----------|---|
| (b)* | <p>Level 3 (5–6 marks) Clear description including a reasonable estimate of r and clear limitations <i>There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.</i></p> <p>Level 2 (3–4 marks) Some description with an attempt to estimate r and some limitations <i>There is a line of reasoning presented with some structure. The information presented is in the most part relevant and supported by some evidence.</i></p> <p>Level 1 (1–2 marks) Limited description <i>There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.</i></p> <p>0 marks <i>No response or no response worthy of credit.</i></p> | B1×6 | <p>Use level of response annotations in RM Assessor, e.g. L2 for 4 marks, L2^ for 3 marks, etc.</p> <p>Indicative scientific points may include:</p> <p>Description and estimation</p> <ul style="list-style-type: none"> • Correct circuit with (variable) resistor, ammeter and voltmeter • Correct symbols used for all the components • R changed to get different values for P • $R = V/I$ (using ammeter and voltmeter readings) or R measured directly using an ohmmeter with the variable resistor isolated from the circuit or R read directly from a resistance box • Power calculated using $P = V^2/R$ or $P = VI$ or $P = I^2R$ • The value of r is between 1.0 to 3.0 Ω • A smooth curve drawn on Fig. 18.2 (to determine r) • A better approximation from sketched graph or r is between 1.5 and 2.7 Ω • Any <u>attempt</u> at using $E = V + Ir$, with or without the power equation(s) to determine r - even if the value is incorrect <p>Limitations</p> <ul style="list-style-type: none"> • 'More data' required • Data point necessary at $R = 2.0 \Omega$ / More data (points) needed between 1 to 3 Ω • No evidence of averaging / Error bars necessary (for both P and R values) |
| | Total | 11 | |

| Question | | Answer | Marks | Guidance |
|--------------|-----|--|---|---|
| 19 | (a) | <p>Photon(s) mentioned</p> <p>One-to-one interaction between photons and electrons</p> <p>Energy of photon is independent of intensity / intensity is to do with <u>rate</u> (of photons / photoelectric emission) / photon energy depends on frequency / energy of photon depends on wavelength / photon energy \propto frequency / photon energy $\propto 1/\lambda$</p> <p>energy of uv photon(s) > work function (of zinc) / frequency of uv > threshold frequency</p> | <p>B1</p> <p>B1</p> <p>B1</p> <p>B1</p> | <p>Allow 'photon absorbed by an electron'</p> <p>Allow: collide etc. for interaction</p> <p>Allow $E = hf$ or $E = hc/\lambda$</p> <p>Allow energy of light photon(s) < work function (of zinc) / frequency of light < threshold frequency</p> <p>Allow \geq instead of > here</p> <p>Not $f > f_0$</p> |
| | (b) | <p>$\phi = \frac{6.63 \times 10^{-34} \times 3.0 \times 10^8}{2.9 \times 10^{-7}}$ or 6.86×10^{-19} (J)</p> <p>$E = 5.1 \times 1.60 \times 10^{-19}$ or 8.16×10^{-19} (J)</p> <p>max kinetic energy = $(8.16 - 6.86) \times 10^{-19}$</p> <p>max kinetic energy = 1.3×10^{-19} (J)</p> | <p>C1</p> <p>C1</p> <p>A1</p> | <p>Note: Using 5.1 and not 8.16×10^{-19} cannot score this mark or the next mark</p> <p>Allow 2 marks for 0.81 eV</p> |
| | (c) | <p>Any <u>three</u> from:</p> <p>The electrons are repelled by C / electrons travel against the electric field (AW)</p> <p>The electrons are emitted with a 'range' of speed / velocity / kinetic energy (AW)</p> <p>As V increases the slow(er) electrons do not reach C and hence I decreases</p> <p>maximum KE in the range 2.1 eV to 2.2 eV or 3.36×10^{-19} J to 3.52×10^{-19} J</p> | <p>B1×3</p> | <p>Note 'range' can be implied by 'highest' or 'lowest'</p> <p>Allow 'find p.d. when current is (just) zero, and then KE = $e \times V$'</p> |
| Total | | | 10 | |

| Question | | Answer | Marks | Guidance |
|--------------|-------|---|--------------|--|
| 20 | (a) | Correct pattern | B1 | Note: At least five field lines must be drawn and of these, two must be perpendicular (by eye) to the surface of the sphere and plate |
| | | Correct direction of the field | B1 | Note: This may be shown on just one line |
| | (b) | (Electric potential) is the <u>work</u> done per (unit) charge in bringing a <u>positive</u> charge from infinity (to the point). | B1 | Allow: <u>work</u> done / <u>energy</u> required to bring a unit <u>positive</u> charge from infinity (to the point) |
| | (c) | (i) $V = Q/4\pi\epsilon_0 r$ (Allow any subject) | C1 | Note using $E = V/d$ with $E = Q/4\pi\epsilon_0 r^2$ is wrong physics and hence scores zero |
| | | $Q = 4\pi \times 8.85 \times 10^{-12} \times 0.015 \times 5000$ | C1 | Note if the value of ϵ_0 is not given here, it could be implied in the correct 3sf answer Allow any subject here if the answer is given to more than 2sf Allow the use of $1/4\pi\epsilon_0 = 9 \times 10^9$ |
| | | $Q = 8.3(4) \times 10^{-9}$ (C) | A0 | |
| | (ii)1 | (electric force =) $1.7 \times 10^{-2} \times \tan 4.0$ (Allow any subject) (electric force = 1.19×10^{-3} N) | M1 (A0) | Not $1.7 \times 10^{-2} \sin 4$ or $1.7 \times 10^{-2} \cos 86$ Allow $1.7 \times 10^{-2} \times \sin 4 / \cos 4$ |
| | (ii)2 | $E = 1.2 \times 10^{-3} / 8.3(4) \times 10^{-9}$ $E = 1.4 \times 10^5$ (N C ⁻¹) | C1 A1 | Allow 2 marks for 1.45×10^5 (N C ⁻¹), 8.3×10^{-9} used Allow 2 marks for 1.43×10^5 (N C ⁻¹), 1.19×10^{-3} (N) used |
| Total | | | 8 | |

| Question | | Answer | Marks | Guidance | |
|----------|-----|--|---|--|---|
| 21 | (a) | $\epsilon = 7.2 \times 10^{-12} \times 1.2 \times 10^{-3} / 4.0 \times 10^{-4}$ permittivity = 2.2×10^{-11} (F m ⁻¹) | C1 A1 | Allow any subject Allow ϵ_0 instead of ϵ Note answer to 3 sf is 2.16×10^{-11} (F m ⁻¹) Allow 1 mark for bald 2.4; relative permittivity calculated | |
| | (b) | (i) | capacitance of two capacitors in series = 500 (μ F) $C = 1000 + 500$ $C = 1500$ (μ F) | C1 A1 | |
| | | (ii) | $V = 1.5 \times e^{-12/15}$ $V = 0.67$ (V) | C1 A1 | Possible ecf from (i) Allow 1 mark for 0.83 V, $V = 1.5[1 - e^{-12/15}]$ used |
| | | | Total | 6 | |

| Question | | Answer | Marks | Guidance |
|----------|------|---|-------|--|
| 22 | (a)* | <p>Level 3 (5–6 marks) Clear evaluation of Fig. 22.1 and clear analysis <i>There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.</i></p> <p>Level 2 (3–4 marks) Some evaluation of Fig. 22.1 and some analysis <i>There is a line of reasoning presented with some structure. The information presented is in the most part relevant and supported by some evidence.</i></p> <p>Level 1 (1–2 marks) Limited evaluation of Fig. 22.1 or limited analysis <i>There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.</i></p> <p>0 marks <i>No response or no response worthy of credit.</i></p> | B1×6 | <p>Use level of response annotations in RM Assessor, e.g. L2 for 4 marks, L2^ for 3 marks, etc.</p> <p>Ignore incorrect references to the terms precision and accuracy</p> <p>Indicative scientific points may include:</p> <p>Evaluation of Fig. 22.1</p> <ul style="list-style-type: none"> • Comment on the line • The straight line misses one error bar / anomalous point ringed or indicated • Too few data points plotted • The triangle used to calculate the gradient is (too) small • Some plots should have been repeated / checked • No error bars for current • ‘Not regular intervals’ (for current) • No origin shown (AW) <p>Evaluation of analysis</p> <ul style="list-style-type: none"> • The value of B is close to the accepted value • The difference of only 7% • No absolute or percentage uncertainty in B shown (AW) • Worst-fit line or maximum / minimum gradient line could have been used to determine the (absolute or percentage) uncertainty in B • F against I graph should be a straight line or • $BL = \text{gradient}$ (any subject) |

| Question | | Answer | Marks | Guidance |
|--------------|---------|--|---|---|
| | (b) (i) | <p>There is a changing / fluctuating (magnetic) field / flux (linkage)</p> <p>(magnetic) field / flux (linkage) in <u>core</u> and <u>secondary</u> (coil)</p> <p>Statement of Faraday's law: e.m.f. (induced) \propto <u>rate</u> of change of (magnetic) flux <u>linkage</u></p> | <p>M1</p> <p>A1</p> <p>B1</p> | <p>Note: This changing flux can be anywhere Allow 'the direction of the field oscillates'</p> <p>Allow 'the core helps to link the flux to the secondary coil'</p> <p>Allow 'equal to / =' Ignore 'cutting of flux' Not just $E = (-)\Delta(N\phi)/\Delta t$</p> |
| | (ii)1 | <p>($I_S =$) 24/12 or 2.0 (A)</p> <p>($I_P =$) $\frac{20}{400} \times 2.0$</p> <p>(current in primary =) 0.10 (A)</p> <p>or</p> <p>($V_P =$) 12 \times 20 or 240 (V)</p> <p>($I_P =$) $\frac{24}{240}$</p> <p>(current in primary =) 0.10 (A)</p> | <p>C1</p> <p>A1</p> <p>C1</p> <p>A1</p> | <p>Allow 1 sf answer</p> <p>Allow 1 sf answer</p> |
| | (ii)2 | <p>Idea of changing / increasing (magnetic) field / flux / current (in primary) at the start</p> <p>Eventually <u>current</u> and <u>flux</u> (linkage) are constant, therefore no <u>e.m.f.</u></p> | <p>B1</p> <p>B1</p> | <p>Note: Any labels used must be clearly defined</p> |
| Total | | | 13 | |

| Question | | Answer | Marks | Guidance |
|----------|-----|---|----------------------------|---|
| 23 | (a) | Any <u>two</u> from: It acts between quarks / nucleons / hadrons 'Short-range' force Repulsive below (about) 0.5 fm Attractive up to (about) 3 fm | B1 ×2 | Allow any correctly named particle Allow any value between 0.5 fm and 5 fm |
| | (b) | (i) proton = u u d or neutron = u d d | B1 | |
| | | (ii) $d \rightarrow u + {}^0_{-1}e$ $+ \bar{\nu}_{(e)}$ | M1 A1 | Allow the equation expressed in words Allow $udd \rightarrow uud + {}^0_{-1}e$ Allow ${}^0_{-1}\beta$ Not e^- for electron Allow this mark if electron written as e^- or β^- |
| | (c) | mass (of nucleus) $\propto A$ volume (of nucleus) $\propto \text{radius}^3 \propto A$ and clears steps using $\rho = m/V$ to show density is (about) the same | B1 B1 | Allow mass = Am , mass = Au , etc. Allow r or R for radius Allow any sensible constant in front of the r^3 |
| | | Total | 7 | |

| Question | | Answer | Marks | Guidance |
|--------------|-----|--|------------------------|--|
| 24 | (a) | ${}^2_1\text{H}$ has two nucleons binding energy per nucleon = 1.1 <u>MeV</u> (per nucleon) | B1 B1 | Allow 1.76×10^{-13} <u>J</u> (per nucleon) |
| | (b) | The <u>protons</u> / <u>nuclei</u> repel each other (At high temperature) particles have more <u>KE</u> and hence can get <u>close</u> (enough to fuse) | B1 B1 | Not atoms / particles Allow 'enough <u>KE</u> to get close' Not atoms or ions |
| | (c) | $E = hc/\lambda$ and $E = mc^2$ or $E = 2 \times mc^2$ $\lambda = \frac{6.63 \times 10^{-34}}{2 \times 9.11 \times 10^{-31} \times 3.0 \times 10^8}$ maximum wavelength = 1.2×10^{-12} (m) | C1 C1 A1 | Allow $hc/\lambda = 2mc^2$ with or without the factor of 2 Note: The mass must be $2m_e$ to score this and the next mark Not de Broglie equation $\lambda = h/mv$ with speed of c ; which gives 2.4×10^{-12} (m) Allow 2 marks for 6.6×10^{-16} (m); mass of neutron or proton used instead Allow the following marks for 1.02 MeV recalled: $E = 1.63 \times 10^{-13}$ (J) C1 $\lambda = \frac{6.63 \times 10^{-34} \times 3.0 \times 10^8}{1.63 \times 10^{-13}}$ C1 maximum wavelength = 1.2×10^{-12} (m) A1 |
| Total | | | 7 | |

| Question | | Answer | Marks | Guidance |
|--------------|-----|---|----------|--|
| 25 | (a) | The patient is surrounded by (gamma) detectors or Increased activity is where F-18 accumulates (AW) | B1 | Allow 'diametrically opposite detectors' |
| | | The positrons (from the F-18) <u>annihilate</u> electrons (inside the patient) | B1 | |
| | | Each annihilation produces two gamma photons travelling in <u>opposite</u> directions | B1 | Not gamma rays / radiation |
| | | The arrival times are used to locate position (of increased activity) | B1 | Allow 'delay time' |
| | (b) | $\lambda = \ln 2 / 110$ or $6.3 \times 10^{-3} \text{ (min}^{-1}\text{)}$ $0.30 = e^{-6.3 \times 10^{-3} t}$ $t = \frac{\ln(0.30)}{-6.3 \times 10^{-3}}$ $t = 190 \text{ (minutes)}$ | C1 | Allow $1.05 \times 10^{-4} \text{ (s}^{-1}\text{)}$ This is the same as $0.30 = e^{-1.05 \times 10^{-4} t}$ |
| | (c) | Any sensible suggestion, e.g. 'post-code' lottery, some patients may not get the treatment because of where they live, longer waiting lists, etc. | B1 | |
| Total | | | 8 | |

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