**GCE**

**Physics A**

**H556/03: Unified physics**

Advanced GCE

**Mark Scheme for Autumn 2021**

Oxford Cambridge and RSA Examinations

Annotations available in RM Assessor

| | Annotation | Meaning |
|---|---|---|
| ✔ | Correct response | Used to indicate the point at which a mark has been awarded (**one tick per mark awarded**). |
| ✘ | Incorrect response | Used to indicate an incorrect answer or a point where a mark is lost. |
| AE | Arithmetic error | Do not allow the mark where the error occurs. Then follow through the working/calculation giving full subsequent ECF if there are no further errors. |
| BOD | Benefit of doubt given | Used to indicate a mark awarded where the candidate provides an answer that is not totally satisfactory, but the examiner feels that sufficient work has been done. |
| BP | Blank page | Use BP on additional page(s) to show that there is no additional work provided by the candidates. |
| CON | Contradiction | No mark can be awarded if the candidate contradicts himself or herself in the same response. |
| ECF | Error carried forward | Used in <u>numerical answers only</u>, unless specified otherwise in the mark scheme. Answers to later sections of numerical questions may be awarded up to full credit provided they are consistent with earlier incorrect answers. Within a question, ECF can be given for AE, TE and POT errors but not for XP. |
| L1 | Level 1 | L1 is used to show 2 marks awarded and L1^ is used to show 1 mark awarded. |
| L2 | Level 2 | L2 is used to show 4 marks awarded and L2^ is used to show 3 marks awarded. |
| L3 | Level 3 | L3 is used to show 6 marks awarded and L3^ is used to show 5 marks awarded. |
| POT | Power of 10 error | This is usually linked to conversion of SI prefixes. Do not allow the mark where the error occurs. Then follow through the working/calculation giving ECF for subsequent marks if there are no further errors. |
| SEEN | Seen | To indicate working/text has been seen by the examiner. |
| SF | Error in number of significant figures | Where more SFs are given than is justified by the question, do not penalise. Fewer significant figures than necessary will be considered within the mark scheme. **Penalised only once in the paper.** |
| TE | Transcription error | This error is when there is incorrect transcription of the correct data from the question, graphical read-off, formulae booklet or a previous answer. Do not allow the relevant mark and then follow through the working giving ECF for subsequent marks. |
| XP | Wrong physics or equation | Used in <u>numerical answers only</u>, unless otherwise specified in the mark scheme. Use of an incorrect equation is wrong physics even if it happens to lead to the correct answer. |

| ^ | Omission | Used to indicate where more is needed for a mark to be awarded (what is written is not wrong but not enough). |
|---|---|---|

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 |

.

**General rule**: For substitution into an equation, allow any subject – unless stated otherwise in the guidance

| Question | | | Answer | Marks | Guidance |
|---|---|---|---|---|---|
| 1 | (a) | (i) | $(F = ma =) \ 190 \times 10^3 = 2.1 \times 10^5 \ a$ | M1 | |
| | | | $a = 0.90 \ (\text{m s}^{-2})$ | A0 | $a = 0.905$ to 3 SF |
| | | (ii) | $(v^2 = u^2 + 2as \text{ gives}) \ 36 = 2 \times 0.90 \times s$ | C1 | **Allow** any valid *suvat* approach; **allow ECF** from (a)(i) |
| | | | $s = 20 \ (\text{m})$ | A1 | **Note** using $a = 1$ gives $s = 18(\text{m})$ |
| | | (iii)1 | $P = Fv$ | B1 | Equation must be seen (not inferred from working) |
| | | | One correct calculation <br> e.g. $F = 100 \times 10^3$ and $v = 42$ gives $P = 4.2 \times 10^6 \ (\text{W})$ | B1 | **Allow** any corresponding values of $F$ and $v$; working must be shown. No credit for finding area below curve |
| | | | $Fv$ = constant | B1 | **Allow** $F$ is proportional to $1/v$ **or** graph is hyperbolic **or** correct calculation of $Fv$ at <u>two</u> points (or more) |
| | | (iii)2 | $(P = VI = 4.2\text{MW so}) \ 4.2 \times 10^6 = 25 \times 10^3 \times I$ | C1 | **Allow** $P$ = 4MW or **ECF from (iii)1** |
| | | | $I = 170 \ (\text{A})$ | A1 | Expect answers between 160 - 170 (A) |
| | (b) | (i) | $R \ (= \rho L/A) = 1.8 \times 10^{-8} \times 1500/1.1 \times 10^{-4}$ | C1 | |
| | | | $R = 0.25 \ (\Omega)$ | A1 | |
| | | (ii) | $E = \sigma/\varepsilon = T/A\varepsilon \ (\text{so } T = EA\varepsilon)$ | C1 | **or** calculation of $\sigma = 1.56 \times 10^8 \ (\text{Nm}^{-2})$ |
| | | | $T = 1.2 \times 10^{10} \times 1.1 \times 10^{-4} \times 0.013$ | C1 | **or** $T = 1.56 \times 10^8 \times 1.1 \times 10^{-4}$ |
| | | | $T = 1.7 \times 10^4 \ (\text{N})$ or 17 (kN) | A1 | |
| | | | **Total** | 13 | |

| Question | | | Answer | Marks | Guidance |
|---|---|---|---|---|---|
| 2 | (a) | (i) | $R = 3000 + 1500$ | C1 | $R = 4500$ $(\Omega)$ |
| | | | $V = 12 \times 1500/4500 = 4(.0)$ (V) | A1 | *or* $I = V/R = 12 /4500 = 2.67$ mA <br> $V_{1500} = 2.67$ mA x 1.5 k$\Omega$ = 4.0 (V) |
| | | (ii) | $V (= 12 \times 1500/1600) = 11.25$ (V) | C1 | |
| | | | $\Delta V = 11.25 - 4.0 = 7.25$ (V) | A0 | |
| | (b) | | **see next page** | | |

| Question | | | Answer | Marks | Guidance |
|---|---|---|---|---|---|
| | (b) | * | **Level 3 (5–6 marks)** Clear description of a valid experiment which would lead to accurate results, sensible suggestions for table, graph and accuracy<br><br>*There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.*<br><br>**Level 2 (3–4 marks)** Reasonable description of experiment and sensible suggestion for table **or** graph **or** accuracy, or attempt at all three<br><br>*There is a line of reasoning presented with some structure. The information presented is in the most-part relevant and supported by some evidence.*<br><br>**Level 1 (1–2 marks)** Attempt at experiment and attempt at table **or** graph **or** accuracy<br><br>*There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.*<br><br>**0 marks** No response or no response worthy of credit. | B1 x 6 | **Indicative scientific points may include:**<br><br>**Experiment**<br>• Diagram(s) to show electrical circuit and/or set-up of apparatus<br>• Use ammeter in series to measure current $I$ through LED<br>• Use micrometer to measure thickness of (one sheet of) tracing paper<br>• or use calliper with $m$ sheets of thickness $t$; measure $t$ and use $x = mt$<br>• Measure $I$ for various $x$<br>• Calculate $\ln I$<br><br>**Results table**<br>• Need columns for total thickness $x$ (or number of sheets $m$ and $x = mt$), current $I$, $\ln (I)$<br>• Units if included should be appropriate and presented in an appropriate format e.g. $\ln(I/\text{mA})$<br><br>**Graph**<br>• plot $\ln I$ against $x$<br>• expect straight line graph with negative gradient and non-zero intercept<br>• gradient = $-n$ and y–intercept c = $\ln k$<br>• $k = e^c$ (alternatively, $k$ is the current when no sheets of paper are used)<br><br>**Accuracy**<br>• work in darkened room/constant low light conditions<br>• keep distance between light-source and LDR constant<br>• use same power light source and same LDR throughout<br>• position yourself so as not to cast shadow on LDR<br>• clamp equipment to bench to ensure distances do not change |
| | | | **Total** | 9 | |

| Question | | | Answer | Marks | Guidance |
|---|---|---|---|---|---|
| 3 | (a) | | GPE is the work done in bringing an object from infinity (to that point) | B1 | **Ignore** any equations |
| | (b) | (i) | GPE = (-) $GMm/r$ | C1 | |
| | | | GPE = (-) $6.67 \times 10^{-11} \times 2 \times 10^{30} \times 810/1.5 \times 10^{11}$ | C1 | Mark is for full substitution, including $6.67 \times 10^{-11}$ for $G$ |
| | | | GPE = (-) $7.2 \times 10^{11}$ (J) | A0 | |
| | | (ii) | $v = 2\pi r/T = 2\pi \times 1.5 \times 10^{11} / 3.16 \times 10^{7}$ (= 29.8 km s$^{-1}$) | C1 | **Allow** proof by algebraic method for full marks e.g. $mv^2/r = GMm/r^2$ |
| | | | KE = $\frac{1}{2}mv^2 = 0.5 \times 810 \times (29.8 \times 10^{3})^2$ | M1 | so $mv^2 = GMm/r$ |
| | | | KE = $3.6 \times 10^{11}$ (J) | A1 | Therefore KE/GPE = $\frac{1}{2}mv^2/(GMm/r)$ = $\frac{1}{2}$ |
| | | (iii) | total energy = (-) $(7.2 \times 10^{11} - 3.6 \times 10^{11})$ | M1 | working must be shown; **ECF (i) and (ii)** |
| | | | total energy = (-) $3.6 \times 10^{11}$ (J) | A0 | |
| | (c) | (i) | $\underline{A} = 470/8.8 \times 10^{-13} = 5.3 \times 10^{14}$ (Bq) | C1 | Mark is for correct calculation of A (in Bq **or** decays per s) |
| | | | $\lambda = \ln 2/(88 \times 3.16 \times 10^{7})$ (= $2.5 \times 10^{-10}$ s$^{-1}$) | C1 | Mark is for correct working to give $\lambda$ in s$^{-1}$ |
| | | | $(A = \lambda N)$; $N$ (= $5.3 \times 10^{14} / 2.5 \times 10^{-10}$) = $2.1 \times 10^{24}$ | A1 | |
| | | (ii) | $P = P_0 \exp (-\lambda t)$ | C1 | **Allow** formula in terms of $N$ or $A$ |
| | | | $P = 470 \exp (-\ln 2 \times 100 / 88)$ | C1 | **Allow** calculation in terms of $N$ or $A$; **allow ECF** for $N$ or $A$ |
| | | | $P = 210$ (W) | A1 | |
| | | | Total | 13 | |

| Question | | | Answer | Marks | Guidance |
|---|---|---|---|---|---|
| 4 | (a) | * | **Level 3 (5 - 6 marks)**<br>Clear explanation using kinetic theory ideas **and either** a clear proof using formulae **or** a correct calculation<br><br>*There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.*<br><br>**Level 2 (3 – 4 marks)**<br>A partial explanation using kinetic theory ideas **and either** a partial proof using formulae **or** a partial calculation<br><br>*There is a line of reasoning presented with some structure. The information presented is in the most part relevant and supported by some evidence.*<br><br>**Level 1 (1 – 2 marks)**<br>An attempt at either explanation **or** proof **or** calculation<br><br>*There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.*<br><br>**0 marks**<br>*No response or no response worthy of credit.* | B1 x 6 | **Indicative scientific points may include:**<br><br>**Explanation using kinetic theory**<br>• pressure = force/area<br>• force is caused by air molecules colliding with oven walls<br>• Newton's 2nd Law states force = rate of momentum change<br>• increased temperature means each molecule has greater KE<br>• hence greater velocity and hence greater momentum<br>• and more collisions with walls per second<br>• hence greater rate of momentum change on hitting walls.<br>• This would lead to greater pressure if $N$ remained constant<br>• so number of molecules in oven must decrease (air escapes)<br>• so fewer but 'harder' collisions at higher temperatures giving constant pressure.<br>• Rms velocity $c$ increases with temperature but number $N$ decreases and so effects balance out to keep total KE ($\frac{1}{2}Nmc^2$) constant<br><br>**Proof using formulae**<br>• equate $pV = NkT$ and $E = \frac{3}{2}NkT$ to show $E = \frac{3}{2}pV$<br><br>• in an ideal gas, all internal energy $E$ is kinetic energy<br>• so $E$ is independent of temperature<br><br>**Calculation**<br>• Internal energy $= \frac{3}{2}pV = 1.5 \times 0.065 \times 1.0 \times 10^5 = 9.8$ kJ<br><br>• At $T = 293$K, $N = pV/kT = 1.6 \times 10^{24}$ and $n = 2.7$ moles<br>• At $T = 473$K, $N = 1.0 \times 10^{24}$ and $n = 1.7$ moles<br>• so we can show that $NT$ (and/or $nT$) remain constant |

| Question | | | Answer | Marks | Guidance |
|---|---|---|---|---|---|
| 4 | (b) | (i) |  | B1 | One correct line (or dot and cross) drawn<br>Line must go through centre of coil<br>**Allow** an incomplete line or a complete circle round the coil<br>**Ignore** direction of arrow |
| | | | | B1 | More than one line drawn<br>All lines drawn must go through centre of coil and follow correct shape and <u>direction</u> of field<br>**Ignore** spacing of lines<br>**Ignore** any lines to the right of the coil |
| | | (ii) | <br>• (the magnetic) flux (of the coil) links the <u>base</u> / <u>saucepan</u><br><br>• (the size/direction of) the flux linkage (constantly) <u>changes/alternates</u> (causing an alternating induced e.m.f.)<br><br>• (induced) <u>current</u> is large because metal/base/ saucepan has low resistance | B1 x 2 | 2 out of 3 possible marking points<br><br>**Allow** (the magnetic) field lines cut the (base of the) <u>saucepan</u><br><br>**Allow** the (magnetic) field constantly changes/alternates<br>**Allow** a bald statement of Faraday's Law |
| | | (iii) | The resistance of glass-ceramic/the (cook's) hand is (very) large<br><br>So (induced) <u>current</u> (or heating effect of <u>current</u>) is zero/negligible | M1<br><br><br><br>A1 | **Allow** glass-ceramic/hand is an insulator/not a (good) conductor<br><br><br>**Do not allow** the induced <u>e.m.f.</u> is (very) small |
| | | | Total | 12 | |

| Question | | | Answer | Marks | Guidance |
|---|---|---|---|---|---|
| 5 | (a) | | the (sound) wave reflects at the water (surface) | B1 | |
| | | | reflected wave interferes/superposes with the incident wave | B1 | **Allow** the (two) waves interfere/superpose<br>**Do not allow** interact/combine |
| | | | to produce a (resultant) wave with a node at the water surface <u>and</u> an antinode at the top of the tube | B1 | |
| | | | $l = \lambda/4$ | B1 | |
| | (b) | (i) | $l = (v/4)(1/f) - k$ | M1 | Correct manipulation of equation **must** be shown |
| | | | Correct comparison with $y = mx + c$ | A1 | |
| | | (ii) | large triangle used to determine gradient | B1 | $\Delta x > 0.6 \times 10^{-3}$s |
| | | | gradient calculated correctly | B1 | Expect between 80 and 82 (m s$^{-1}$) |
| | | | $v = 320$ (m s$^{-1}$) | B1 | **Allow** 320 ± 20; **allow ECF** from an incorrect gradient |
| | (c) | (i) | Value of $1/F$ determined correctly from graph | C1 | **Allow values between** $2.83 \times 10^{-3}$s and $2.84 \times 10^{-3}$s<br>**Allow** only alternative methods which use values from line of best fit |
| | | | $F = 350$ (Hz) | A1 | |
| | | (ii) | $(100 (\Delta F/F) =) 100 \Delta v/v$ | B1 | |
| | | | $+ \dfrac{100 (\Delta l + \Delta k)}{(l + k)}$ | B1 | |
| | | | **Total** | 13 | |

| Question | | | Answer | Marks | Guidance |
|---|---|---|---|---|---|
| 6 | (a) | | At $t = 0$ (and $t = 15, 30$) the (magnitude of the) centripetal force equals $R - W$ (as only vertical forces act on the tourist) | B1 | **Allow** at $t = 0$ (**or** the bottom of the circle) the centripetal force is provided by the resultant/ upwards/vertical force |
| | (b) | (i) | (For circular motion) there must (always) be a resultant force towards the centre | B1 x 2 | any 2 from 3 marking points |
| | | | The resultant force is not always vertical/sometimes has a horizontal component | | |
| | | | This can only be provided by friction/cannot be provided by $R$ and W / $R$ and W are always vertical/only $F$ is horizontal | | **Allow** $F$ provides the horizontal (component of the) centripetal force |
| | | (ii) | Sine wave with period 30 min and amplitude 0.050 (N) | B1 | Must start at the origin |
| | | | Correct phase, i.e. <u>negative</u> sine wave | B1 | |
| | | (iii) | $F = 0.050 \cos 40°$ | C1 | **Allow** alternative methods e.g. triangle of forces |
| | | | $F = 0.038$ (N) | A1 | **Allow ECF** from graph if used |
| | (c) | | $m = 650/g$ **or** $m = 650/9.81$ (= 66.3 kg) | C1 | **Not** $m = 650$ kg or $m = 65$ kg |
| | | | $(F = mr\omega^2$ gives) $d = 0.050 / m\omega^2 = 0.050 / 66.3 \times (3.5 \times 10^{-3})^2$ | C1 | **or** ( $F = mv^2/r$ and $v = 2\pi r/T$ gives) $d = 0.050 \times (30 \times 60)^2 / (4\pi^2 \times 66.3)$ |
| | | | $d = 62$ (m) | A1 | |
| | | | **Total** | 10 | |

**OCR (Oxford Cambridge and RSA Examinations)**
**The Triangle Building**
**Shaftesbury Road**
**Cambridge**
**CB2 8EA**

**OCR Customer Contact Centre**

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

**www.ocr.org.uk**

For staff training purposes and as part of our quality assurance programme your call may be recorded or monitored