GCE

Physics A

H556/03: Unified physics

Advanced GCE

Mark Scheme for Autumn 2021

OCR (Oxford Cambridge and RSA) is a leading UK awarding body, providing a wide range of qualifications to meet the needs of candidates of all ages and abilities. OCR qualifications include AS/A Levels, Diplomas, GCSEs, Cambridge Nationals, Cambridge Technicals, Functional Skills, Key Skills, Entry Level qualifications, NVQs and vocational qualifications in areas such as IT, business, languages, teaching/training, administration and secretarial skills.

It is also responsible for developing new specifications to meet national requirements and the needs of students and teachers. OCR is a not-for-profit organisation; any surplus made is invested back into the establishment to help towards the development of qualifications and support, which keep pace with the changing needs of today's society.

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.

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 numerical answers only, 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 numerical answers only, 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

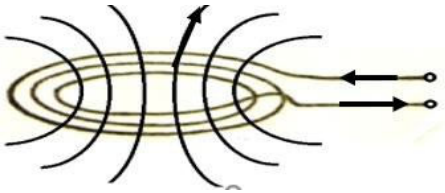
Question			Answer	Marks	Guidance
1	(a)	(i)	$(F = ma =)\ 190 \times 10^3 = 2.1 \times 10^5\ a$	M1	
			$a = 0.90$ (m s^{-2})	A0	$a = 0.905$ to 3 SF
		(ii)	$(v^2 = u^2 + 2as$ gives) $36 = 2 \times 0.90 \times s$	C1	**Allow** any valid *suvat* approach; **allow ECF** from (a)(i)
			$s = 20$ (m)	A1	**Note** using $a = 1$ gives $s = 18$(m)
		(iii)1	$P = Fv$	B1	Equation must be seen (not inferred from working)
			One correct calculation e.g. $F = 100 \times 10^3$ and $v = 42$ gives $P = 4.2 \times 10^6$ (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	$(P = VI = 4.2$MW so) $4.2 \times 10^6 = 25 \times 10^3 \times I$	C1	**Allow** $P = 4$MW or **ECF from (iii)1**
			$I = 170$ (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)	$E = \sigma/\varepsilon = T/A\varepsilon$ (so $T = EA\varepsilon$)	C1	**or** calculation of $\sigma = 1.56 \times 10^8$ (Nm^{-2})
			$T = 1.2 \times 10^{10} \times 1.1 \times 10^{-4} \times 0.013$	C1	**or** $T = 1.56 \times 10^8 \times 1.1 \times 10^{-4}$
			$T = 1.7 \times 10^4$ (N) or 17 (kN)	A1	
			Total	13	

Question			Answer	Marks	Guidance
2	(a)	(i)	R = 3000 + 1500 V = 12 × 1500/4500 = 4(.0) (V)	C1 A1	R = 4500 (Ω) ***or*** $I = V/R$ = 12 /4500 = 2.67 mA V_{1500} = 2.67 mA x 1.5 kΩ = 4.0 (V)
		(ii)	V (= 12 × 1500/1600) = 11.25 (V) ΔV = 11.25 – 4.0 = 7.25 (V)	C1 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 *There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.* **Level 2 (3–4 marks)** Reasonable description of experiment and sensible suggestion for table **or** graph **or** accuracy, or attempt at all three *There is a line of reasoning presented with some structure. The information presented is in the most-part relevant and supported by some evidence.* **Level 1 (1–2 marks)** Attempt at experiment and attempt at table **or** graph **or** accuracy *There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.* **0 marks** No response or no response worthy of credit.	**B1 x 6**	**Indicative scientific points may include:** **Experiment** • Diagram(s) to show electrical circuit and/or set-up of apparatus • Use ammeter in series to measure current I through LED • Use micrometer to measure thickness of (one sheet of) tracing paper • or use calliper with m sheets of thickness t; measure t and use $x = mt$ • Measure I for various x • Calculate ln I **Results table** • Need columns for total thickness x (or number of sheets m *and* $x = mt$), current I, ln (I) • Units if included should be appropriate and presented in an appropriate format e.g. ln(I/mA) **Graph** • plot ln I against x • expect straight line graph with negative gradient and non-zero intercept • gradient = - n *and* y–intercept c = ln k • $k = e^c$ (alternatively, k is the current when no sheets of paper are used) **Accuracy** • work in darkened room/constant low light conditions • keep distance between light-source and LDR constant • use same power light source and same LDR throughout • position yourself so as not to cast shadow on LDR • 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 6.67×10^{-11} for G
			GPE = (-) 7.2×10^{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 = 3.6×10^{11} (J)	A1	Therefore KE/GPE = $\frac{1}{2}mv^2/(GMm/r) = \frac{1}{2}$
		(iii)	total energy = (-) (7.2×10^{11} - 3.6×10^{11})	M1	working must be shown; **ECF (i) and (ii)**
			total energy = (-) 3.6×10^{11} (J)	A0	
	(c)	(i)	$\underline{\boldsymbol{A =}}$ $470/8.8 \times 10^{-13} = 5.3 \times 10^{14}$ (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 x 10^{-10} s^{-1})	C1	Mark is for correct working to give λ in s^{-1}
			($A = \lambda N$); N (= 5.3 x10^{14} / 2.5 x 10^{-10}) = 2.1 x 10^{24}	A1	
		(ii)	$P = P_o \exp(-\lambda t)$	C1	**Allow** formula in terms of N or A
			P = 470 exp (- ln 2 x 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)** Clear explanation using kinetic theory ideas **and either** a clear proof using formulae **or** a correct calculation *There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.* **Level 2 (3 – 4 marks)** A partial explanation using kinetic theory ideas **and either** a partial proof using formulae **or** a partial calculation *There is a line of reasoning presented with some structure. The information presented is in the most part relevant and supported by some evidence.* **Level 1 (1 – 2 marks)** An attempt at either explanation **or** proof **or** calculation *There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.* **0 marks** *No response or no response worthy of credit.*	B1 x 6	**Indicative scientific points may include:** **Explanation using kinetic theory** • pressure = force/area • force is caused by air molecules colliding with oven walls • Newton's 2nd Law states force = rate of momentum change • increased temperature means each molecule has greater KE • hence greater velocity and hence greater momentum • and more collisions with walls per second • hence greater rate of momentum change on hitting walls. • This would lead to greater pressure if N remained constant • so number of molecules in oven must decrease (air escapes) • so fewer but 'harder' collisions at higher temperatures giving constant pressure. • 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 **Proof using formulae** • equate $pV = NkT$ and $E = \frac{3}{2}NkT$ to show $E = \frac{3}{2}pV$ • in an ideal gas, all internal energy E is kinetic energy • so E is independent of temperature **Calculation** • Internal energy = $\frac{3}{2}pV$ = 1.5 x 0.065 x 1.0 x 10^5 = 9.8 kJ • At T = 293K, $N = pV/kT$ = 1.6 x 10^{24} and n = 2.7 moles • At T = 473K, N = 1.0 x 10^{24} and n = 1.7 moles • so we can show that NT (and/or nT) remain constant

Question			Answer	Marks	Guidance
4	(b)	(i)		B1 B1	One correct line (or dot and cross) drawn Line must go through centre of coil **Allow** an incomplete line or a complete circle round the coil **Ignore** direction of arrow More than one line drawn All lines drawn must go through centre of coil and follow correct shape and direction of field **Ignore** spacing of lines **Ignore** any lines to the right of the coil
		(ii)	• (the magnetic) flux (of the coil) links the base / saucepan • (the size/direction of) the flux linkage (constantly) changes/alternates (causing an alternating induced e.m.f.) • (induced) current is large because metal/base/ saucepan has low resistance	B1 x 2	2 out of 3 possible marking points **Allow** (the magnetic) field lines cut the (base of the) saucepan **Allow** the (magnetic) field constantly changes/alternates **Allow** a bald statement of Faraday's Law
		(iii)	The resistance of glass-ceramic/the (cook's) hand is (very) large So (induced) current (or heating effect of current) is zero/negligible	M1 A1	**Allow** glass-ceramic/hand is an insulator/not a (good) conductor **Do not allow** the induced e.m.f. 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 **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 x 10^{-3}s and 2.84 x 10^{-3}s **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	
			$+ \frac{100\,(\Delta l + \Delta k)}{(l + k)}$	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 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	B1 x 2	any 2 from 3 marking points **Allow** F provides the horizontal (component of the) centripetal force
		(ii)	Sine wave with period 30 min and amplitude 0.050 (N) Correct phase, i.e. <u>negative</u> sine wave	B1 B1	Must start at the origin
		(iii)	$F = 0.050 \cos 40^{o}$ $F = 0.038$ (N)	C1 A1	**Allow** alternative methods e.g. triangle of forces **Allow ECF** from graph if used
	(c)		$m = 650/g$ **or** $m = 650/9.81$ (= 66.3 kg) ($F = mr\omega^2$ gives) $d = 0.050 / m\omega^2 = 0.050 / 66.3 \times (3.5 \times 10^{-3})^2$ $d = 62$ (m)	C1 C1 A1	**Not** $m = 650$ kg or $m = 65$ kg **or** ($F = mv^2/r$ and $v = 2\pi r/T$ gives) $d = 0.050 \times (30 \times 60)^2 / (4\pi^2 \times 66.3)$
			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