Cambridge International AS & A Level

PHYSICS **9702/42**

Paper 4 A Level Structured Questions **October/November 2023**

MARK SCHEME

Maximum Mark: 100

Published

This mark scheme is published as an aid to teachers and candidates, to indicate the requirements of the examination. It shows the basis on which Examiners were instructed to award marks. It does not indicate the details of the discussions that took place at an Examiners' meeting before marking began, which would have considered the acceptability of alternative answers.

Mark schemes should be read in conjunction with the question paper and the Principal Examiner Report for Teachers.

Cambridge International will not enter into discussions about these mark schemes.

Cambridge International is publishing the mark schemes for the October/November 2023 series for most Cambridge IGCSE, Cambridge International A and AS Level components, and some Cambridge O Level components.

Generic Marking Principles

These general marking principles must be applied by all examiners when marking candidate answers. They should be applied alongside the specific content of the mark scheme or generic level descriptors for a question. Each question paper and mark scheme will also comply with these marking principles.

GENERIC MARKING PRINCIPLE 1: Marks must be awarded in line with: • the specific content of the mark scheme or the generic level descriptors for the question • the specific skills defined in the mark scheme or in the generic level descriptors for the question • the standard of response required by a candidate as exemplified by the standardisation scripts.
GENERIC MARKING PRINCIPLE 2: Marks awarded are always **whole marks** (not half marks, or other fractions).
GENERIC MARKING PRINCIPLE 3: Marks must be awarded **positively**: • marks are awarded for correct/valid answers, as defined in the mark scheme. However, credit is given for valid answers which go beyond the scope of the syllabus and mark scheme, referring to your Team Leader as appropriate • marks are awarded when candidates clearly demonstrate what they know and can do • marks are not deducted for errors • marks are not deducted for omissions • answers should only be judged on the quality of spelling, punctuation and grammar when these features are specifically assessed by the question as indicated by the mark scheme. The meaning, however, should be unambiguous.
GENERIC MARKING PRINCIPLE 4: Rules must be applied consistently, e.g. in situations where candidates have not followed instructions or in the application of generic level descriptors.

GENERIC MARKING PRINCIPLE 5: Marks should be awarded using the full range of marks defined in the mark scheme for the question (however; the use of the full mark range may be limited according to the quality of the candidate responses seen).
GENERIC MARKING PRINCIPLE 6: Marks awarded are based solely on the requirements as defined in the mark scheme. Marks should not be awarded with grade thresholds or grade descriptors in mind.

Science-Specific Marking Principles

1	Examiners should consider the context and scientific use of any keywords when awarding marks. Although keywords may be present, marks should not be awarded if the keywords are used incorrectly.
2	The examiner should not choose between contradictory statements given in the same question part, and credit should not be awarded for any correct statement that is contradicted within the same question part. Wrong science that is irrelevant to the question should be ignored.
3	Although spellings do not have to be correct, spellings of syllabus terms must allow for clear and unambiguous separation from other syllabus terms with which they may be confused (e.g. ethane / ethene, glucagon / glycogen, refraction / reflection).
4	The error carried forward (ecf) principle should be applied, where appropriate. If an incorrect answer is subsequently used in a scientifically correct way, the candidate should be awarded these subsequent marking points. Further guidance will be included in the mark scheme where necessary and any exceptions to this general principle will be noted.
5	<u>'List rule' guidance</u> For questions that require ***n*** responses (e.g. State **two** reasons …): • The response should be read as continuous prose, even when numbered answer spaces are provided. • Any response marked *ignore* in the mark scheme should not count towards ***n***. • Incorrect responses should not be awarded credit but will still count towards ***n***. • Read the entire response to check for any responses that contradict those that would otherwise be credited. Credit should **not** be awarded for any responses that are contradicted within the rest of the response. Where two responses contradict one another, this should be treated as a single incorrect response. • Non-contradictory responses after the first ***n*** responses may be ignored even if they include incorrect science.

6	Calculation specific guidance Correct answers to calculations should be given full credit even if there is no working or incorrect working, **unless** the question states ‘show your working’. For questions in which the number of significant figures required is not stated, credit should be awarded for correct answers when rounded by the examiner to the number of significant figures given in the mark scheme. This may not apply to measured values. For answers given in standard form (e.g. $a \times 10^n$) in which the convention of restricting the value of the coefficient (a) to a value between 1 and 10 is not followed, credit may still be awarded if the answer can be converted to the answer given in the mark scheme. Unless a separate mark is given for a unit, a missing or incorrect unit will normally mean that the final calculation mark is not awarded. Exceptions to this general principle will be noted in the mark scheme.
7	Guidance for chemical equations Multiples / fractions of coefficients used in chemical equations are acceptable unless stated otherwise in the mark scheme. State symbols given in an equation should be ignored unless asked for in the question or stated otherwise in the mark scheme.

Abbreviations

/	Alternative and acceptable answers for the same marking point.
( )	Bracketed content indicates words which do not need to be explicitly seen to gain credit but which indicate the **context** for an answer. The context does not need to be seen but if a context is given that is incorrect then the mark should not be awarded.
___	Underlined content must be present in answer to award the mark. This means either the exact word or another word that has the same technical meaning.

Mark categories

B marks	These are <u>independent</u> marks, which do not depend on other marks. For a **B** mark to be awarded, the point to which it refers must be seen specifically in the candidate's answer.
M marks	These are <u>method</u> marks upon which **A** marks later depend. For an **M** mark to be awarded, the point to which it refers must be seen specifically in the candidate's answer. If a candidate is not awarded an **M** mark, then the later **A** mark cannot be awarded either.
C marks	These are <u>compensatory</u> marks which can be awarded 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 them. 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 awarded. If a correct answer is given to a numerical question, all of the preceding **C** marks are awarded automatically. It is only necessary to consider each of the **C** marks in turn when the numerical answer is not correct.
A marks	These are <u>answer</u> marks. They may depend on an **M** mark or allow a **C** mark to be awarded by implication.

Question	Answer	Marks
1(a)	angle (subtended at centre of circle) when arc length = radius	**B1**
1(b)	$\omega = 2\pi / T$	**C1**
	$= 2\pi / (1.0 \times 60 \times 60)$ $= 1.7 \times 10^{-3}$ rad s^{-1}	**A1**
1(c)(i)	angle $= 1.7 \times 10^{-3} \times 1400$ $= 2.4$ rad	**A1**
1(c)(ii)	L = arc length / angle $= 0.44 / 2.4$ **or** $L = 0.44 \times (3600 / 1400) / 2\pi$	**C1**
	$L = 0.18$ m	**A1**
1(c)(iii)	$a = r\omega^2$	**C1**
	$= 0.18 \times (1.745 \times 10^{-3})^2$ $= 5.5 \times 10^{-7}$ m s^{-2}	**A1**
1(d)	centripetal acceleration is negligible compared with acceleration of free fall **or** numerical comparison establishing answer to **(c)(iii)** $\ll 9.81$	**B1**
	resultant force is negligible compared with weight (of modelling clay) (so variation is negligible) **or** force exerted by minute hand (approximately) equal (and opposite) to weight of modelling clay	**B1**

Question	Answer	Marks
2(a)(i)	work done per unit mass	**B1**
	work (done) moving mass from infinity (to the point)	**B1**
2(a)(ii)	$\phi = -GM / r$ $= -(6.67 \times 10^{-11} \times 7.3 \times 10^{22}) / (1.7 \times 10^{6})$	**C1**
	$= -2.9 \times 10^{6}$ J kg^{-1}	**A1**
2(b)(i)	$E_P = m\phi$	**B1**
2(b)(ii)	$½mv^2 + m\phi = 0$	**M1**
	correct algebra leading to $v = \sqrt{(-2\phi)}$	**A1**
2(c)	speed $= \sqrt{(2 \times 2.9 \times 10^{6})}$ $= 2400$ m s^{-1}	**A1**
2(d)	$½m\langle c^2\rangle = (3/2)kT$	**C1**
	$3.34 \times 10^{-27} \times \langle c^2\rangle = 3 \times 1.38 \times 10^{-23} \times 400$	**C1**
	$c_{r.m.s.} = 2200$ m s^{-1}	**A1**
2(e)	r.m.s. speed is an average so many molecules have speeds greater than the escape speed **or** there is a distribution of molecular speeds (around the r.m.s. value) so many molecules have speeds greater than the escape speed	**B1**

Question	Answer	Marks
3(a)	sum of potential energy and kinetic energy (of particles)	**B1**
	(total) energy of random motion of particles	**B1**
3(b)(i)	no thermal energy <u>transferred</u>	**B1**
	work is done on the spring (increasing the potential energy of particles)	**M1**
	so internal energy increases	**A1**
3(b)(ii)	thermal energy transferred to water	**B1**
	work is done by water (expanding against atmosphere as it vaporises)	**B1**
	more thermal energy transferred than work done so internal energy increases	**B1**

Question	Answer	Marks
4(a)(i)	amplitude $= \frac{1}{2} \times 7.2 \times 10^{-15}$ $= 3.6 \times 10^{-15}$ m	A1
4(a)(ii)	$\omega = 2\pi / (0.20 \times 10^{-6})$ $= 3.1 \times 10^{7}$ rad s^{-1}	A1
4(a)(iii)	$v_0 = \omega x_0$	C1
	$v_0 = 3.1 \times 10^{7} \times 3.6 \times 10^{-15} = 1.1 \times 10^{-7}$ m s^{-1}	A1
4(b)(i)	$I_0 = nAv_0e$ $= 8.5 \times 10^{28} \times 4.3 \times 10^{-4} \times 1.1 \times 10^{-7} \times 1.60 \times 10^{-19}$	C1
	$= 0.64$ A	A1
4(b)(ii)	sketch: two cycles of sinusoidal curve of amplitude I_0 and period 0.20 μs	B1
	correct phase, with $I = +I_0$ at $t = 0$	B1
4(b)(iii)	equation of form $I = I_0 \cos \omega t$	M1
	value of I_0 used matches answer to **(b)(i)** and value of ω used matches answer to **(a)(ii)** [if **(a)(ii)** and **(b)(i)** correct then $I = 0.64 \cos (3.1 \times 10^{7}\, t)$]	A1
4(b)(iv)	$I_{r.m.s.} = I_0 / \sqrt{2}$ $= 0.64 / \sqrt{2}$ $= 0.45$ A	A1

Question	Answer	Marks
5(a)	(electric) force is (directly) proportional to product of charges	**B1**
	(electric) force (between point charges) is inversely proportional to the square of their separation	**B1**
5(b)	$F = Q^2 / 4\pi\varepsilon_0 x^2$ $6.3 \times 10^{-17} = Q^2 / [4\pi \times 8.85 \times 10^{-12} \times (3.8 \times 10^{-6})^2]$	**C1**
	charge = 3.2×10^{-19} C	**A1**
5(c)(i)	negative	**B1**
5(c)(ii)	four straight lines perpendicular to the plates, starting on one plate and finishing on the other	**B1**
	lines equally spaced	**B1**
	arrows indicating direction downwards	**B1**
5(c)(iii)	$E = V / d$	**C1**
	$mg = EQ$	**C1**
	mass $= (1200 \times 3.2 \times 10^{-19}) / (9.81 \times 0.052)$ $= 7.5 \times 10^{-16}$ kg	**A1**

Question	Answer	Marks
6(a)(i)	energy stored = area under graph	**C1**
	$= \frac{1}{2} \times 450 \times 10^{-6} \times 8.0 = 1.8 \times 10^{-3}$ J **or** 1.8 mJ	**A1**
6(a)(ii)	$C = Q/V$ **or** $E = \frac{1}{2}CV^2$	**C1**
	$C = (450 \times 10^{-6}) / 8.0$ **or** $(2 \times 1.8 \times 10^{-3}) / 8.0^2$ $= 5.6 \times 10^{-5}$ F	**A1**
6(b)(i)	$V = V_0 \exp(-t/RC)$ **and** $\tau = RC$	**C1**
	$V = V_0 \exp(-t/\tau)$ $V_0 = 8.0$ V, and at one time constant, $t = \tau$ $V/8.0 = \exp(-\tau/\tau)$, so $\ln(V/8.0) = -1.0$ **or** $-\ln(V/8.0) = 1.0$	**A1**
6(b)(ii)	[t read from graph at $-\ln(V/8.0) = 1.0$]: $\tau = 3.2$ s	**A1**
6(b)(iii)	$\tau = RC$	**C1**
	$R = 3.2 / (5.6 \times 10^{-5})$ $= 5.7 \times 10^{4}\,\Omega$	**A1**

Question	Answer	Marks
7(a)(i)	$V_H = BI / ntq$ $= (4.0 \times 10^{-6} \times 5.4) / (1.5 \times 10^{16} \times 1.8 \times 10^{-3} \times 1.60 \times 10^{-19}) = 5.0\,V$	**A1**
7(a)(ii)	sketch: straight diagonal line from (0, 0) to $t = 0.020$ s **and** straight diagonal line between two non-zero V_H values of same sign from $t = 0.040$ to 0.050 s	**B1**
	horizontal straight line at $V_H = 5.0\,V$ from $t = 0.020$ to 0.040 s	**B1**
	horizontal straight line at $V_H = 2.5\,V$ from $t = 0.050$ to 0.080 s	**B1**
7(b)(i)	e.m.f. = rate of change of (magnetic) flux (linkage)	**C1**
	$E = NA\,\Delta B / \Delta t$ **or** $E = NA \times$ gradient (at $t = 0.010$ s)	**C1**
	$E = 3000 \times 3.4 \times 10^{-4} \times (4.0 \times 10^{-6}) / (0.020) = 2.0 \times 10^{-4}\,V$	**A1**
7(b)(ii)	sketch: line showing non-zero E from $t = 0$ to $t = 0.020$ s and from $t = 0.040$ s to $t = 0.050$ s, and $E = 0$ at all other times	**B1**
	'top hats' showing constant non-zero E from $t = 0$ to $t = 0.020$ s and from $t = 0.040$ s to $t = 0.050$ s	**B1**
	magnitude of E shown as $2.0 \times 10^{-4}\,V$ in both non-zero sections	**B1**
	sign of E in the $t = 0$ to $t = 0.020$ s region opposite to the sign of E in the $t = 0.040$ s to $t = 0.050$ s region	**B1**

Question	Answer	Marks
8(a)	packet / quantum of <u>energy</u>	**M1**
	of electromagnetic radiation	**A1**
8(b)(i)	photoelectric effect	**B1**
8(b)(ii)	• electron needs a minimum energy to escape **or** electron emitted if energy in packet is enough • energy must be absorbed in packets that are related to frequency • intensity relates to number of packets (not to energy in packet) • electron absorbs only a single whole packet *Any three points, 1 mark each*	**B3**
8(c)(i)	Planck constant	**B1**
8(c)(ii)	– work function (energy)	**B1**

Question	Answer	Marks
9(a)(i)	material introduced into the body **and** (position in body) can be detected **or** absorbed by the tissue (being studied)	**B1**
9(a)(ii)	X = β^+ **or** e^+ **and** $P = 1$	**B1**
	$Q = 0$ **and** $R = 18$	**B1**
9(b)(i)	positrons (emitted in the decay) and electrons annihilate	**B1**
	mass of particles becomes energy of gamma photons	**B1**
9(b)(ii)	arrival times of photons are processed	**B1**
	image built up of tracer concentration in the tissue	**B1**
9(c)(i)	$A = \lambda N$ **and** $\lambda = \ln 2 / T$	**C1**
	$N = n \times N_A$	**C1**
	2 photons produced from each decay, so $R_0 = 2 \times \lambda \times n \times N_A$ $R_0 = (2 \ln 2)\, nN_A / T$ (*allow 0.693 for ln 2*)	**A1**
9(c)(ii)	sketch: exponential decay curve from $t = 0$ to $t = 2T$, starting at $(0, R_0)$ and with a negative gradient of continuously decreasing magnitude	**B1**
	line with negative gradient passing through $(T, R_0 / 2)$ and $(2T, R_0 / 4)$	**B1**

Question	Answer	Marks
10(a)	temperature inversely proportional to wavelength	M1
	temperature is thermodynamic temperature of surface, and wavelength is the wavelength at which maximum emission rate occurs	A1
10(b)(i)	(astronomical) object of known luminosity	B1
10(b)(ii)	star / galaxy is moving away from the student	B1
10(b)(iii)	one tick placed in correct column in each row: wavelength: too high	B1
	surface temperature: too low	B1
	distance: unchanged	B1
	radius: too high	B1