Cambridge Assessment International Education

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.

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 transferred	**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 = $(1200 \times 3.2 \times 10^{-19}) / (9.81 \times 0.052)$ = 7.5×10^{-16} kg	**A1**

Question	Answer	Marks
6(a)(i)	energy stored = area under graph	C1
	$= ½ \times 450 \times 10^{-6} \times 8.0 = 1.8 \times 10^{-3}$ J **or** 1.8 mJ	A1
6(a)(ii)	$C = Q / V$ **or** $E = ½CV^2$	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 2.0×10^{-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