Cambridge Assessment International Education

Cambridge International AS & A Level

PHYSICS **9702/42**

Paper 4 A Level Structured Questions **May/June 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.

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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)	(gravitational) force is (directly) proportional to product of masses	**B1**
	force (between point masses) is inversely proportional to the square of their separation	**B1**
1(b)	$GMm / R^2 = mR\omega^2$	**M1**
	$\omega = 2\pi / T$ <u>and</u> algebra leading to $4\pi^2R^3 = GMT^2$	**A1**
	or	
	$GMm / R^2 = mv^2 / R$	**(M1)**
	$v = 2\pi R / T$ <u>and</u> algebra leading to $4\pi^2R^3 = GMT^2$	**(A1)**
1(c)	$4\pi^2 \times R^3 = 6.67 \times 10^{-11} \times 5.98 \times 10^{24} \times (24 \times 60 \times 60)^2$ ($R = 4.22 \times 10^7$ m)	**C1**
	$h = R - (6.37 \times 10^6)$	**C1**
	$h = (4.22 \times 10^7) - (6.37 \times 10^6)$ $= 3.6 \times 10^7$ m	**A1**
1(d)(i)	$\omega = 2\pi / T$	**C1**
	$= 2\pi / (24 \times 60 \times 60)$ $= 7.3 \times 10^{-5}$ rad s^{-1}	**A1**
1(d)(ii)	orbit is from east to west	**B1**
	orbit is not equatorial / orbit is polar	**B1**

Question	Answer	Marks
2(a)(i)	(gas that obeys) $pV \propto T$ (for all values of p, V and T)	M1
	where T is thermodynamic temperature	A1
2(a)(ii)	temperature = –273.15 °C	A1
2(b)(i)	$pV = NkT$	C1
	$N = (1.37 \times 10^5 \times 0.640) / (1.38 \times 10^{-23} \times (227 + 273))$	C1
	$= 1.27 \times 10^{25}$	A1
2(b)(ii)	mass $= 0.0424 / (1.27 \times 10^{25})$ $= 3.34 \times 10^{-27}$ kg	A1
2(b)(iii)	$\frac{1}{2}m\langle c^2\rangle = (3/2)kT$	C1
	$3.34 \times 10^{-27} \times v^2 = 3 \times 1.38 \times 10^{-23} \times 500$	C1
	$v = 2490\ \text{m s}^{-1}$	A1
	or	
	$pV = \frac{1}{3}(Nm)\langle c^2\rangle$ <u>and</u> Nm = mass of gas	(C1)
	$0.0424 \times v^2 = 3 \times 1.37 \times 10^5 \times 0.640$	(C1)
	$v = 2490\ \text{m s}^{-1}$	(A1)
2(c)	sketch: line from (0, 0) to (500, v)	B1
	line with decreasing positive gradient throughout	B1

Question	Answer	Marks
3(a)	change in internal energy = work done + energy transfer by heating	C1
	increase in internal energy = work done on system + energy transferred to the system by heating	A1
3(b)(i)	AB change in internal energy: decrease	B1
	AB work done on gas: positive	B1
	BC change in internal energy: increase	B1
	BC work done on gas: zero	B1
3(b)(ii)	more work done by gas in CD than is done on gas in AB **or** (no work done on gas in BC and DA so) (overall) gas does work	B1
	(overall) change in internal energy is zero	B1
	(must be an overall) input of thermal energy	B1

Question	Answer	Marks
4(a)(i)	$\omega = 2\pi f$	**C1**
	$f = 9.7 / 2\pi$ $= 1.5$ Hz	**A1**
4(a)(ii)	amplitude = $\sqrt{(11.6)}$ = 3.4 cm	**A1**
4(a)(iii)	$a_0 = \omega^2 x_0$	**C1**
	$= 9.7^2 \times 3.4 \times 10^{-2}$ $= 3.2$ m s^{-2}	**A1**
4(b)	sketch: straight line through the origin with negative gradient	**B1**
	line with negative gradient passing through (+3.4, $-a_0$) and (–3.4, $+a_0$)	**B1**
	line with ends at $x = \pm$ 3.4 cm and $a = \pm a_0$	**B1**
4(c)	sum of potential energy and kinetic energy is constant	**B1**
	at maximum displacement, kinetic energy is zero **or** at maximum displacement, potential energy is maximum	**B1**
	at zero displacement, kinetic energy is maximum **or** at zero displacement, potential energy is minimum	**B1**

Question	Answer	Marks
5(a)(i)	$Q_A = CV$	**A1**
5(a)(ii)	$E_A = \frac{1}{2}CV^2$	**A1**
5(b)(i)	some of the charge transfers to (the plates of) capacitor B	**B1**
	transfer is because the p.d.s across the capacitors are not equal **or** transfer stops when the p.d.s across the capacitors become equal	**B1**
5(b)(ii)	$V_A = V_B$	**M1**
	charge on A + charge on B = CV	**M1**
	$CV_B + 3CV_B = CV$ leading to $V_B = V / 4$	**A1**
	or	
	$C_T = 4C$	**(M1)**
	$Q_T = CV$	**(M1)**
	$V_B = CV / 4C = V / 4$	**(A1)**
5(b)(iii)	$\Delta E = \frac{1}{2}CV^2 - nCV^2$, where n is a multiple that is less than ½ **or** total final energy $= \frac{1}{2} \times 4C \times (V / 4)^2$ $= \frac{1}{8}CV^2$	**C1**
	$\Delta E = \frac{1}{2}CV^2 - \frac{1}{8}CV^2$ $= \frac{3}{8}CV^2$	**A1**

Question	Answer	Marks
6(a)(i)	product of (magnetic) flux density and area	**M1**
	area perpendicular to the (magnetic) field	**A1**
6(a)(ii)	flux $= B \times \pi r^2$ $= 0.17 \times \pi \times 0.36^2$	**C1**
	$= 6.9 \times 10^{-2}$ Wb	**A1**
6(b)	time for one revolution = 1 / 25 s	**C1**
	e.m.f. = rate of cutting flux **or** $\Delta\Phi / \Delta t$	**C1**
	= 0.069 × 25 = 1.7 V	**A1**
6(c)	current (in disc) is perpendicular to magnetic field **or** current causes force to act on disc	**B1**
	force opposes rotation of disc	**B1**
	left-hand rule indicates current is from rim to axle	**B1**

Question	Answer	Marks
7(a)(i)	full-wave (rectification)	**B1**
7(a)(ii)	lower left diode shown pointing left	**B1**
	lower right and upper left diodes shown pointing left	**B1**
7(a)(iii)	arrow indicating current direction in resistor to the right	**B1**
7(b)(i)	sketch: periodic line showing minimum V_{OUT} = 0 and maximum V_{OUT} = $+V_0$	**B1**
	line showing peak V_{OUT} at t = 0, 0.5T, 1.0T, 1.5T and 2.0T, with V_{OUT} going to zero half-way in between each peak	**B1**
	line showing correct modulated sine shape	**B1**
7(b)(ii)	sketch: sinusoidal curve with troughs sitting on the time axis	**B1**
	<u>peak</u> power at t = 0, 0.5T, 1.0T, 1.5T and 2.0T and zero power half-way in between each peak	**B1**
7(b)(iii)	same power-time graph with or without rectification, so same V_{rms} **or** V^2-time graph is same for both V_{OUT} and V_{IN}, so same V_{rms} **or** power does not depend on sign of V, so same V_{rms}	**B1**

Question	Answer	Marks
8(a)	transition (emits) (one) photon with energy equal to the difference in energy between the two levels	**B1**
	frequency of radiation corresponds to energy of photon	**B1**
8(b)(i)	line to the left of the pair in Fig. 8.2, labelled A	**B1**
	larger gap between line A and the nearest of the pair in Fig. 8.2 than between the lines in the pair	**B1**
8(b)(ii)	line to the left of both the pair in Fig. 8.2 and line A, labelled B	**B1**
	larger gap between line B and line A than between line A and the nearest one of the pair in Fig. 8.2	**B1**
8(c)	$E = hf$	**C1**
	$E_3 = E_1 + h(f_A + f_B)$	**A1**

Question	Answer	Marks
9(a)	difference between mass of nucleus and (total) mass of nucleons	**M1**
	when infinitely separated	**A1**
9(b)(i)	neutron	**B1**
9(b)(ii)	$E = \Delta m\, c^2$	**C1**
	Δm = (0.030377 – 0.002388 – 0.009105)u (= 0.018884u)	**C1**
	energy release = (0.030377 – 0.002388 – 0.009105) × 1.66 × 10^{-27} × (3.00 × 10^{8})^2 = 2.8 × 10^{-12} J	**A1**
9(c)(i)	number of atoms per unit time = (1.4 × 10^{28}) / (2.8 × 10^{-12}) (= 5.0 × 10^{39} s^{-1})	**C1**
	mass of one atom = 4 × 1.66 × 10^{-27} or (4 × 10^{-3}) / (6.02 × 10^{23}) (= 6.64 × 10^{-27} kg)	**C1**
	mass per unit time = 6.64 × 10^{-27} × 5.0 × 10^{39} = 3.3 × 10^{13} kg s^{-1}	**A1**
9(c)(ii)	$L = 4\pi\sigma r^2 T^4$ 1.4 × 10^{28} = 4π × 5.67 × 10^{-8} × (2.3 × 10^{9})^2 × T^4	**C1**
	T = 7800 K	**A1**

Question	Answer	Marks
10(a)(i)	electrons	**B1**
10(a)(ii)	electrons are decelerated / stopped on impact with the target	**B1**
	(kinetic) energy lost by electrons emitted as (X-ray) photons	**B1**
10(a)(iii)	$eV = hc / \lambda$	**C1**
	$\lambda = (6.63 \times 10^{-34} \times 3.00 \times 10^{8}) / (1.60 \times 10^{-19} \times 5800)$	**C1**
	$= 2.14 \times 10^{-10}$ m	**A1**
10(b)	$I = I_0 \exp(-\mu x)$	**C1**
	$I_T / I_0 = \exp(-(1.4 \times 2.8))$ $= 0.020$	**C1**
	% absorbed $= (1.000 - 0.0198) \times 100$ $= 98\%$	**A1**