Cambridge International AS & A Level

PHYSICS **9702/42**

Paper 4 A Level Structured Questions **May/June 2024**

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.

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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 independent 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 method 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 compensatory 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 answer 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 the centre of a circle) when arc (length) = radius	**B1**
1(b)(i)	arrow, labelled V, pointing in NE direction	**B1**
1(b)(ii)	arrow, labelled A, pointing in NW direction	**B1**
1(c)(i)	$v = r\omega$	**C1**
	$\omega = 0.68 / (0.093 - 0.012)$ $= 8.4\ \text{rad s}^{-1}$	**A1**
1(c)(ii)	$a = v^2 / r$ **or** $a = r\omega^2$	**C1**
	$a = 0.68^2 / (0.093 - 0.012)$ **or** $(0.093 - 0.012) \times 8.4^2$ $= 5.7\ \text{m s}^{-2}$	**A1**
1(d)	angular speed: same for both pieces	**B1**
	linear speed: less for second piece than first piece	**B1**
	acceleration: less for second piece than first piece	**B1**

Question	Answer	Marks
2(a)	(if in thermal contact) no <u>net transfer</u> of (thermal) energy (between them)	**B1**
2(b)(i)	$pV = nRT$	**C1**
	T = $(1.20 \times 10^5 \times 0.0260) / (0.740 \times 8.31)$ (= 507 K)	**M1**
	temperature = 507 – 273 = 234 °C	**A1**
2(b)(ii)	thermal equilibrium <u>so</u> temperatures (of X and Y) are equal	**B1**
	$pV = NkT$	**C1**
	N = $(2.90 \times 10^5 \times 0.0430) / (1.38 \times 10^{-23} \times 507)$ = 1.78×10^{24}	**A1**
2(b)(iii)	• (molecular) kinetic energy is proportional to temperature **or** kinetic energy (of molecules) is same in both cylinders • kinetic energy proportional to mass × mean-square speed **or** temperature proportional to mass × mean-square speed **or** r.m.s. speed proportional to √(temperature / mass) • mean-square speed inversely proportional to mass **or** r.m.s. speed inversely proportional to √(mass) *Any two bulleted points, 1 mark each*	**B2**
	r.m.s. speed (of molecules) in X is half r.m.s. speed (of molecules) in Y	**B1**

Question	Answer	Marks
3(a)	sum of potential energy and kinetic energy	**B1**
	(total) energy of random motion of particles	**B1**
3(b)(i)	no change in separation so no change in (molecular) potential energy	**B1**
	temperature increases so kinetic energy (of molecules) increases	**B1**
	kinetic energy increases and potential energy unchanged, so internal energy increases	**B1**
3(b)(ii)	temperature constant so no change in (molecular) kinetic energy	**B1**
	separation increases so potential energy (of molecules) increases	**B1**
	potential energy increases and kinetic energy unchanged, so internal energy increases	**B1**

Question	Answer	Marks
4(a)	straight line through the origin shows that *a* is proportional to *x*	**B1**
	negative gradient shows that *a* and *x* are (always) in opposite <u>directions</u>	**B1**
4(b)(i)	$a = -\omega^2 x$ $\omega = \sqrt{(2A / 3Y)}$	**A1**
4(b)(ii)	$v_0 = \omega x_0$	**C1**
	$= 3Y \times \sqrt{(2A / 3Y)}$ $= \sqrt{(6AY)}$	**A1**
4(b)(iii)	$E = ½\, m\omega^2 x_0^2$	**C1**
	$= ½\, m \times (2A / 3Y) \times (3Y)^2$ $= 3mAY$	**A1**
4(c)	$\omega = 2\pi / T$ $(= 2\pi / 0.75)$	**C1**
	$x = 1.8 \sin (8.4\, t)$	**A1**

Question	Answer	Marks
5(a)	work done per unit charge	**B1**
	work (done) moving positive charge from infinity (to the point)	**B1**
5(b)	*Any three points from*: *Up to 2 points from*: • radius of sphere X is 0.30 m • radius of sphere Y is 0.10 m • radius of X is treble the radius of Y *Up to 2 points from*: • charge on X is positive • charge on Y is positive • spheres X and Y carry charges of the same sign *Up to 1 point from*: • (magnitudes of) charges on the spheres are equal • charges on the spheres have the same magnitude	**B3**
5(c)	proton remains at rest (in the position of release)	**M1**
	potential <u>energy</u> of proton is (already) at its minimum **or** (electric) forces (from spheres) on proton are equal and opposite **or** no resultant (electric) force on proton **or** resultant electric field strength (at proton) is zero	**A1**

Question	Answer	Marks
6(a)	equal charge on both capacitors	**B1**
	$V_X + V_Y = V$	**M1**
	$(Q / C_X) + (Q / C_Y) = (Q / C_T)$ <u>leading to</u> $(1 / C_X) + (1 / C_Y) = (1 / C_T)$ **or** $(V_X / Q) + (V_Y / Q) = (V / Q)$ <u>leading to</u> $(1 / C_X) + (1 / C_Y) = (1 / C_T)$	**A1**
6(b)(i)	$E = ½CV^2$	**C1**
	$V = \sqrt{[(2 \times 2.5 \times 10^{-3}) / (200 \times 10^{-6})]} = 5.0$ V	**A1**
6(b)(ii)	total capacitance = 600 μF	**C1**
	$E = ½ \times 600 \times 10^{-6} \times 5.0^2$ (= 7.5×10^{-3} J)	**C1**
	= 7.5 mJ	**A1**
6(b)(iii)	line with positive gradient starting at (0, 2.5)	**B1**
	straight line passing through (400, 7.5)	**B1**

Question	Answer	Marks
7(a)	(induced) e.m.f. is (directly) proportional to rate	**M1**
	of change of (magnetic) flux (linkage)	**A1**
7(b)(i)	$\Phi = BA$	**C1**
	$= 7.2 \times 10^{-3} \times 3.2 \times 10^{-4}$ $= 2.3 \times 10^{-6}$ Wb	**A1**
7(b)(ii)	tangent drawn at steepest point on Fig. 7.2	**C1**
	evidence of multiplication by 340	**C1**
	maximum rate of change of flux = 0.82 Wb s^{-1}	**A1**
7(b)(iii)	V_0 = 0.82 V **or** V_0 given as identical numerical answer to the answer in **(b)(ii)**	**A1**
7(b)(iv)	sinusoidal curve of period 2.0 ms from t = 0 to t = 6.0 ms	**B1**
	all peaks at $+V_0$ and all troughs at $-V_0$	**B1**
	line showing V = 0 at (and only at) t = 0, 1.0, 2.0, 3.0, 4.0, 5.0 and 6.0 ms	**B1**
7(b)(v)	A = 0.82 V **or** A has same numerical value as answer in **(b)(iii)**, with unit V	**A1**
	$B = 2\pi / (2.0 \times 10^{-3})$	**C1**
	$= 3100$ rad s^{-1}	**A1**

Question	Answer	Marks
8(a)(i)	movement of star causes change in (observed) frequency **or** movement of star causes redshift	**B1**
	observed frequency is lower (than emitted frequency)	**B1**
8(a)(ii)	all three lines shown to left of corresponding printed lines	**B1**
	distance between drawn line and corresponding printed line approximately the same for all three lines	**B1**
8(b)(i)	$E = hf$ **and** $\lambda = c / f$	**C1**
	$E = (6.63 \times 10^{-34} \times 3.00 \times 10^{8}) / (488 \times 10^{-9})$ $= 4.08 \times 10^{-19}$ J	**A1**
8(b)(ii)	photon energy $= (4.08 \times 10^{-19}) / (1.60 \times 10^{-19})$ $= 2.55$ eV	**C1**
	energy level $= -3.40 + 2.55$ $= -0.85$ eV	**A1**
8(b)(iii)	$\Delta\lambda = \lambda \times (v / c)$ $= (488 \times 6.2 \times 10^{6}) / (3.00 \times 10^{8})$ (= 10 nm)	**C1**
	observed wavelength $= 488 + \Delta\lambda = 488 + 10$ $= 498$ nm	**A1**

Question	Answer	Marks
8(c)	$v = H_0 d$	C1
	$d = (6.2 \times 10^6) / (2.3 \times 10^{-18})$ $= 2.7 \times 10^{24}$ m	A1

Question	Answer	Marks
9(a)	energy required to separate (all) the nucleons (in the nucleus)	**M1**
	to infinity	**A1**
9(b)(i)	Δm = {[(84 × 1.007276) + (128 × 1.008665)] – 211.942749} (u) (= 1.778 u)	**C1**
	= 1.778 × 1.66 × 10^{-27} (kg)	**C1**
	= 2.95 × 10^{-27} kg	**A1**
9(b)(ii)	$E = (\Delta)mc^2$	**C1**
	binding energy = 2.95 × 10^{-27} × (3.00 × 10^8)^2 = 2.66 × 10^{-10} J	**A1**
9(b)(iii)	binding energy per nucleon = (2.66 × 10^{-10}) / 212 = 1.25 × 10^{-12} J	**A1**
9(c)(i)	line rising to a single peak that is to the left of the '9' in the Fig. 9.1 label and then continually decreasing	**B1**
	steep positive gradient on the left of the peak and shallow negative gradient on the right	**B1**
9(c)(ii)	X shown on the line at a value of *A* that is to the right of the left-hand edge of the '*A*' in the axis label, and to the left of '2' in the 250 label	**B1**
9(c)(iii)	nucleus formed (as a result of the decay) has a lower nucleon number	**B1**
	(nucleus formed has a) greater binding energy per nucleon	**B1**

Question	Answer	Marks
10(a)	time gives information about depth (of boundary)	**B1**
	intensity gives information about <u>nature</u> of <u>boundary</u>	**B1**
10(b)(i)	product of density and speed	**M1**
	speed of ultrasound in medium (and density of medium)	**A1**
10(b)(ii)	$Z_{water} = 1000 \times 1420$ (= 1.42×10^6 kg m^{-2} s^{-1}) **and** $Z_{glass} = 2500 \times 4560$ (= 11.4×10^6 kg m^{-2} s^{-1})	**C1**
	intensity reflection coefficient = $(11.4 - 1.42)^2 / (11.4 + 1.42)^2$	**C1**
	= 0.61	**A1**

