



Cambridge International AS & A Level

PHYSICS

9702/43

Paper 4 A Level Structured Questions

October/November 2022

MARK SCHEME

Maximum Mark: 100

Published

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

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This document consists of **15** printed pages.

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	<p>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.</p> <p>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.</p>
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)	$F = (Gm_1m_2) / r^2$	M1
	where G is the gravitational constant	A1
1(b)	gravitational force provides the centripetal force	B1
	$mR\omega^2 = GMm / R^2$ and $\omega = 2\pi / T$	M1
	or	
	$mv^2 / R = GMm / R^2$ and $v = 2\pi R / T$	
1(c)(i)	or	
	$4\pi^2 mR / T^2 = GMm / R^2$	
1(c)(i)	correct completion of algebra to get $T^2 = (4\pi^2 / GM) R^3$, with identification of $(4\pi^2 / GM)$ as k	A1
	$(24 \times 3600)^2 = (4\pi^2 \times R^3) / (6.67 \times 10^{-11} \times 6.0 \times 10^{24})$	C1
1(c)(ii)	$R = 4.2 \times 10^7$ m	A1
	(orbit) must be above the Equator	B1
	(direction) must be from west to east	B1

Question	Answer	Marks
2(a)	<ul style="list-style-type: none"> • resistance of a metal • volume of a gas at constant pressure • e.m.f. of a thermocouple <p><i>Any two points, 1 mark each</i></p>	B2
2(b)(i)	$Q = mc\Delta T$	C1
	evidence of realisation that Q lost by water = Q gained by mercury	C1
	$18.7 \times 4.18 \times (37.4 - T) = 6.94 \times 0.140 \times (T - 23.0)$	C1
	$T = 37.2 \text{ }^{\circ}\text{C}$	A1
2(b)(ii)	use a liquid with a lower (specific) heat capacity (than mercury) or use a smaller mass of mercury	B1
2(c)(i)	depends on properties of a real substance	B1
	$0 \text{ }^{\circ}\text{C}$ is not absolute zero	B1
2(c)(ii)	ideal gas	B1

Question	Answer	Marks
3(a)	$a = -\omega^2 x$	M1
	a = acceleration, x = displacement from equilibrium position and ω = angular frequency	A1
3(b)(i)	$x_0 = 0.12 \text{ m}$	A1
3(b)(ii)	$v = \omega\sqrt{(x_0^2 - x^2)}$ two (x, v) pairs correctly read from Fig. 3.2 (one may be $(x_0, 0)$ or value of x_0 from (i)) e.g. $0.20 = \omega\sqrt{(0.12^2 - 0)}$ leading to $\omega = 1.7 \text{ rad s}^{-1}$	C1 A1
3(b)(iii)	$E = \frac{1}{2}M\omega^2 x_0^2$ $0.050 = \frac{1}{2} \times M \times 1.67^2 \times 0.12^2$ $M = 2.5 \text{ kg}$ or $(E_K)_{\text{max}} = \frac{1}{2}Mv_0^2$ $0.050 = \frac{1}{2} M \times 0.20^2$ $M = 2.5 \text{ kg}$	C1 A1 (C1) (A1)
3(c)(i)	loss of (total) energy (of system) due to resistive forces	B1 B1
3(c)(ii)	closed loop surrounding the origin with maximum x at $\pm 0.060 \text{ m}$ passing through $v = 0$ maximum velocity shown as $\pm 0.10 \text{ m s}^{-1}$ passing through $x = 0$	B1 B1

Question	Answer	Marks
4(a)	(field line indicates) direction of force	B1
	force on a positive charge	B1
4(b)(i)	one straight line perpendicular to plates, starting on one plate and finishing on the other	B1
	five straight lines perpendicular to plates between the plates, uniformly spaced	B1
	downwards arrows on lines	B1
4(b)(ii)	$E = V/d$	C1
	$= 2400 / 0.046$	A1
	$= 5.2 \times 10^4 \text{ N C}^{-1}$	
4(c)(i)	smooth curve in region of field and straight line outside field	B1
	direction of deflection shown as downwards in region of field	B1
4(c)(ii)	helium nucleus has double the charge but four times the mass	B1
	velocity parallel to plates same and acceleration perpendicular to plates smaller (for helium)	B1
	final speed is lower (for helium)	B1

Question	Answer	Marks
5(a)(i)	$Q = CV$	C1
	$Q_0 = 24 \times 470 \times 10^{-6}$ $= 0.011 \text{ C}$	A1
5(a)(ii)	$I_0 = 24 / 5600$ $= 4.3 \times 10^{-3} \text{ A}$	A1
5(a)(iii)	$\tau = RC$	C1
	$= 5600 \times 470 \times 10^{-6}$ $= 2.6 \text{ s}$	A1
5(a)(iv)	line with negative gradient throughout passing through $(0, I_0)$	B1
	exponential decay curve asymptotic to t -axis	B1
5(b)(i)	current in wire P gives rise to a magnetic field	B1
	as current (in P) changes, wire Q cuts (magnetic) flux (of wire P)	B1
	cutting magnetic flux causes induced e.m.f. (across Q)	B1
5(b)(ii)	sketch shows line with a negative gradient throughout	B1

Question	Answer	Marks
6(a)(i)	PQRS and WXYZ	B1
6(a)(ii)	force on charge carriers is perpendicular to both (magnetic) field and current	B1
	as charge carriers are deflected to one side, an electric field is set up	B1
	(steady V_H when) electric and magnetic forces on charge carriers are equal (and opposite)	B1
6(b)(i)	n : number density of charge carriers	B1
	t : distance PW (or SZ or QX or RY)	B1
	q : charge on each charge carrier	B1
6(b)(ii)	V_H inversely proportional to t	B1
	(so t needs to be small for) V_H to be large enough to measure	B1

Question	Answer	Marks
7(a)(i)	peak voltage = $4.2 \times \sqrt{2}$ $(= 5.9 \text{ V})$	B1
	power = V^2 / R $= 5.9^2 / 760 = 0.046 \text{ W}$ or 46 mW	A1
7(a)(ii)	sketch shows peak(s) in power at 46 mW	B1
	correct shape (sinusoidal wave sitting on t -axis)	B1
	four cycles of repeating pattern shown, with $P = 0$ at $0, 10, 20, 30, 40 \mu\text{s}$	B1
7(a)(iii)	line is symmetrical about 23 mW	B1
7(b)(i)	(alternating p.d. makes) the crystal vibrate	B1
	vibrations (of crystal) causes air to vibrate	B1
	frequency is in ultrasound range	B1
7(b)(ii)	(air makes) crystal vibrate, which causes an e.m.f. to be generated across the (second) crystal	B1

Question	Answer	Marks
8(a)	photon energy (to remove electron) minimum energy to remove electron or energy to remove electron from surface or energy to remove electron with zero kinetic energy	B1
8(b)(i)	photon energy = hf number per unit time = $8.36 \times 10^{-3} / (1.36 \times 10^{15} \times 6.63 \times 10^{-34})$ $= 9.27 \times 10^{15} \text{ s}^{-1}$	C1 A1
8(b)(ii)	$hf = \Phi + E_{\text{MAX}}$ $\Phi = (1.36 \times 10^{15} \times 6.63 \times 10^{-34}) - (3.09 \times 10^{-19})$ $= 5.93 \times 10^{-19} \text{ J}$	C1 A1
8(c)(i)	greater photon energy (and same work function) so maximum kinetic energy is increased	M1 A1
8(c)(ii)	(greater photon energy and same power so) lower number of photons (per unit time) (each electron absorbs one photon) so lower rate of emission	M1 A1

Question	Answer	Marks
9(a)	total power of radiation emitted (by the star)	B1
9(b)(i)	$F = L / (4\pi d^2)$ $= 9.86 \times 10^{27} / [4\pi \times (8.14 \times 10^{16})^2]$ $= 1.18 \times 10^{-7} \text{ W m}^{-2}$	C1 A1
9(b)(ii)	$L = 4\pi\sigma r^2 T^4$ $9.86 \times 10^{27} = 4 \times \pi \times 5.67 \times 10^{-8} \times r^2 \times 9830^4$	C1
	radius = $1.22 \times 10^9 \text{ m}$	A1
9(c)	wavelength of peak intensity determined (from spectrum of star)	B1
	wavelength of peak intensity from object of known temperature determined	B1
	Wien's displacement law used or wavelength of peak intensity inversely proportional to temperature	B1

Question	Answer	Marks
10(a)(i)	cannot predict when a (particular) nucleus will decay or cannot predict which nucleus will decay next	B1
10(a)(ii)	not affected by external / environmental factors	B1
10(b)(i)	line fluctuates or trend is a straight line	B1
10(b)(ii)	straight line of best fit drawn on Fig. 10.1	B1
10(b)(iii)	$M = M_0 \exp(-\lambda t)$ so $\ln M = \ln M_0 - \lambda t$ so gradient = $-\lambda$ (and magnitude of gradient = λ)	B1
10(b)(iv)	gradient = $(-)(8.0 - 4.8) / (11.6 - 0)$ (allow any correct pair of values from Fig. 10.1)	C1
	$\lambda = 0.28 \text{ s}^{-1}$	A1
10(b)(v)	half-life = $0.693 / \lambda$ $= 0.693 / 0.28$ $= 2.5 \text{ s}$	A1
10(c)	(for reaction to occur,) energy is released	B1
	energy release comes from fall in mass so total mass of products must be less (than mass of carbon-15)	B1