Cambridge International Education

Cambridge International AS & A Level

PHYSICS **9702/44**

Paper 4 A Level Structured Questions **May/June 2025**

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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Annotations guidance for centres

Examiners use a system of annotations as a shorthand for communicating their marking decisions to one another. Examiners are trained during the standardisation process on how and when to use annotations. The purpose of annotations is to inform the standardisation and monitoring processes and guide the supervising examiners when they are checking the work of examiners within their team. The meaning of annotations and how they are used is specific to each component and is understood by all examiners who mark the component.

We publish annotations in our mark schemes to help centres understand the annotations they may see on copies of scripts. Note that there may not be a direct correlation between the number of annotations on a script and the mark awarded. Similarly, the use of an annotation may not be an indication of the quality of the response.

The annotations listed below were available to examiners marking this component in this series.

Annotations

Annotation	Meaning
AE	arithmetic error
BOD	benefit of the doubt given
CON	contradiction in response, mark not awarded
✓	correct point or mark awarded
ECF	error carried forward applied
SF	error in number of significant figures
I	incorrect or insufficient point ignored while marking the rest of the response
XP	incorrect physics
✗	incorrect point or mark not awarded
^	information missing or insufficient for credit

Annotation	Meaning
M0	mandatory mark not awarded
SEEN	point has been noted, but no credit has been given or blank page seen
POT	power of ten error
TE	transcription error

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 mandatory 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)	force per unit mass	**B1**
1(b)(i)	radial	**B1**
	towards (centre of) planet	**B1**
1(b)(ii)	(changes in) height (very) much smaller than radius	**B1**
	$(\text{radius} + \text{height})^2 \approx \text{radius}^2$ **or** field lines are approximately parallel	**B1**
1(c)(i)	$9.81 \times R^2 = 3.99 \times 10^{14}$	**C1**
	$R = 6.38 \times 10^6$ m	**A1**
1(c)(ii)	gravitational potential $= -(GM / R)$ $= -(3.99 \times 10^{14}) / (6.38 \times 10^6)$	**C1**
	$= -6.25 \times 10^7 \text{ J kg}^{-1}$	**A1**
1(d)	potential (energy) zero at infinite separation	**B1**
	(gravitational) force is attractive	**B1**

Question	Answer	Marks
2(a)	same temperature (as each other)	B1
	no net transfer of thermal energy (between them)	B1
2(b)(i)	$E_1 = XL$	B1
2(b)(ii)	$E_2 = Mc(t - \theta)$	A1
2(b)(iii)	$E_3 = Xc\theta$	B1
2(c)	$E_2 = E_1 + E_3$	C1
	$Mc(t - \theta) = XL + Xc\theta$ **and** completion of algebra to reach $\theta = (Mct - XL) / c(M + X)$	A1

Question	Answer	Marks
3(a)	(gas that obeys) $pV \propto T$ (at all values of p, V and T)	**M1**
	where T is thermodynamic temperature	**A1**
3(b)(i)	$pV = ⅓\ Nm\langle c^2\rangle$ **and** $Nm / V = \rho$ ($p = ⅓\ \rho\ \langle c^2\rangle$)	**C1**
	r.m.s. speed = $\sqrt{\langle c^2\rangle}$	**C1**
	$1.6 \times 10^5 = ⅓ \times 1.9 \times \langle c^2\rangle$ leading to r.m.s. speed = 500 m s^{-1} **or** r.m.s. speed = $\sqrt{(3 \times 1.6 \times 10^5 / 1.9)}$ = 500 m s^{-1}	**A1**
3(b)(ii)	(pV =) $⅓\ Nm\langle c^2\rangle = NkT$ (so) $½\ m\langle c^2\rangle = (3 / 2)\ kT$	**C1**
	$½ \times 4.7 \times 10^{-26} \times 503^2 = (3 / 2) \times 1.38 \times 10^{-23} \times T$ T = 290 K	**A1**
	or	
	$pV = NkT$ **and** $Nm / V = \rho$ (so) $T = pm / \rho k$	**(C1)**
	$T = 1.6 \times 10^5 \times 4.7 \times 10^{-26} / (1.9 \times 1.38 \times 10^{-23})$ = 290 K	**(A1)**

Question	Answer	Marks
3(c)	potential energy (of molecules) is zero	**B1**
	$U = N \times ½\, m\langle c^2\rangle = 6.0 \times 6.02 \times 10^{23} \times ½ \times 4.7 \times 10^{-26} \times 503^2$ **or** $U = N \times (3/2)\, kT = 6.0 \times 6.02 \times 10^{23} \times (3/2) \times 1.38 \times 10^{-23} \times 287$ **or** $U = n \times (3/2)\, RT = 6.0 \times (3/2) \times 8.31 \times 287$	**C1**
	U = 21000 J	**A1**

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Question	Answer	Marks
4(a)	(motion in which) acceleration is (directly) proportional to displacement	**B1**
	(motion in which) acceleration is (always) in the opposite <u>direction</u> to displacement **or** acceleration is (always) directed towards a fixed point	**B1**
4(b)(i)	t_1 **and** t_5 **or** t_3 **and** t_7	**B1**
4(b)(ii)	$f = 1 / T$	**C1**
	period = 2.2 / 1.25 f = 1.25 / 2.2 = 0.57 Hz	**A1**
4(c)	$v_0 = \omega x_0$ **and** $\omega = 2\pi f$	**C1**
	$0.080 = 2\pi \times 0.57 \times x_0$	**C1**
	$x_0 = 0.022$ m	**A1**

Question	Answer	Marks
5(a)	work done per unit charge	**B1**
	work done (on charge) in moving positive charge from infinity (to the point)	**B1**
5(b)(i)	electric field strength inversely proportional to distance^2	**C1**
	$E = 3^2 \times 2.0 \times 10^5$ $= 1.8 \times 10^6\ \mathrm{N\,C^{-1}}$	**A1**
5(b)(ii)	$V = Q / 4\pi\varepsilon_0 r$ **and** $E = Q / 4\pi\varepsilon_0 r^2$ (so $E = V / r$)	**B1**
	$r = (9.0 \times 10^4) / (1.8 \times 10^6) = 0.050\ \mathrm{m} = 5.0\ \mathrm{cm}$	**A1**
5(b)(iii)	$Q = 4\pi\varepsilon_0 Vr$ $= 4\pi \times 8.85 \times 10^{-12} \times 9.0 \times 10^4 \times 0.050$	**C1**
	$= 5.0 \times 10^{-7}\ \mathrm{C}$	**A1**
5(b)(iv)	$C = Q / V$	**C1**
	$= (5.0 \times 10^{-7}) / (9.0 \times 10^4)$ $= 5.6 \times 10^{-12}\ \mathrm{F}$	**A1**

Question	Answer	Marks
6(a)(i)	$F = BIL$	**C1**
	force on QR = $5.2 \times 10^{-3} \times 1.2 \times 0.054 \times 190$	**C1**
	= 0.064 N	**A1**
6(a)(ii)	torque = force × perpendicular distance between forces	**C1**
	= $0.064 \times 0.025 \cos\theta = (1.6 \times 10^{-3}) \cos\theta$ N m	**A1**
6(a)(iii)	one complete cycle of a sinusoidal curve between 0 and 360°	**B1**
	τ axis labelled to show maximum and minimum torques at $\pm 1.6 \times 10^{-3}$ N m	**B1**
	maximum at 0 and 360° and minimum at 180° (or vice versa), with torque shown as zero at 90° and 270°	**B1**
6(b)	(ferrous core) increases magnetic flux density	**B1**
	amplitude of torque increases	**B1**

Question	Answer	Marks
7(a)(i)	loss of energy (of oscillations)	**B1**
	due to resistive forces	**B1**
7(a)(ii)	amplitude (of oscillations) decreases gradually **or** oscillations continue (for several periods)	**B1**
7(a)(iii)	cutting of (magnetic) flux causes induced e.m.f. (in coil) **or** induced e.m.f. causes current (in resistor / circuit)	**B1**
	current causes dissipation of thermal energy in resistor **or** current in resistor causes dissipation of thermal energy	**B1**
	thermal energy comes from energy of oscillations	**B1**
7(b)	(for any given e.m.f.) current is lower so thermal energy dissipated at a lower rate **or** (for any given e.m.f.) current is lower so the resistive force is lower	**B1**
	oscillations are less damped **or** *s*maller decrease in amplitude of oscillations (in each period) **or** oscillations continue for longer	**B1**

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Question	Answer	Marks
8(a)	four diodes shown (one in each gap) with correct circuit symbols	**B1**
	all four diodes connected in correct direction (pointing left to right)	**B1**
8(b)(i)	three lines showing exponential decay from the peaks at 0.5T, 1.0T and 1.5T, ending at the point where the decay meets the next rising peak	**B1**
	three curved lines rising along the upwards dotted lines from the minima to the peaks at 1.0T, 1.5T and 2.0T	**B1**
	minimum V at (2 / 3) V_0	**B1**
8(b)(ii)	from graph: discharge time (from V_0 to (2 / 3)V_0) = (11 / 30) T	**C1**
	(2 / 3) V_0 = V_0 exp (– (11 / 30)T / τ)	**C1**
	ln (2 / 3) = – 11T / 30τ τ = 0.90 T	**A1**
8(b)(iii)	time constant is increased	**B1**
	line shows a larger minimum voltage **or** smaller difference between maximum and minimum voltages	**B1**

Question	Answer	Marks
9(a)(i)	electromagnetic wave can behave like a particle	**B1**
	moving particle can behave like a wave	**B1**
9(a)(ii)	$\lambda = h / p$	**M1**
	h is the Planck constant	**A1**
9(b)(i)	*Any two points from:* • pattern similar to diffraction of light • diffraction (pattern) is characteristic of wave behaviour • rings show constructive and destructive interference	**B2**
9(b)(ii)	(de Broglie) wavelength decreases	**B1**
	rings become closer together	**B1**

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Question	Answer	Marks
10(a)	alternating p.d. (applied to crystal) makes crystal vibrate	**B1**
	when frequency of applied p.d. equals natural frequency of crystal, crystal resonates	**B1**
	natural frequency of crystal is in ultrasound range	**B1**
10(b)(i)	product of density and speed	**M1**
	speed is speed of ultrasound in medium (and density of medium)	**A1**
10(b)(ii)	(α is close to) 0 when Z_1 and Z_2 are equal	**B1**
	(α is close to) 1 when Z_1 and Z_2 are very different	**B1**
10(c)	$I = I_0 \exp(-\mu x)$	**C1**
	$\ln(I / I_0) = -\mu x$ $\ln 0.62 = -\mu \times 2.1$ $\mu = 0.23\,\text{cm}^{-1}$	**A1**

Question	Answer	Marks
11(a)(i)	(nuclear) fusion	B1
11(a)(ii)	Δm = [0.030377 – (3 × 0.002388)] u (= 0.023213 u)	B1
	$E = \Delta m\, c^2$	C1
	= 0.023213 × 1.66 × 10^{-27} × (3.00 × 10^8)^2 = 3.47 × 10^{-12} J	A1
11(b)(i)	mass of 1 mol of helium-4 = 4 g **or** mass of 1 helium atom = 4 u	C1
	N rate = (6.02 × 10^{23} × 7.34 × 10^{11}) / (4 × 10^{-3}) **or** N rate = (7.34 × 10^{11}) / (4 × 1.66 × 10^{-27})	C1
	luminosity = 1.10 × 10^{38} × 3.47 × 10^{-12} = 3.83 × 10^{26} W	A1
11(b)(ii)	$L = 4\pi\sigma r^2 T^4$ 3.83 × 10^{26} = 4π × 5.67 × 10^{-8} × (6.96 × 10^8)^2 × T^4	C1
	T = 5770 K	A1

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