

Cambridge International AS & A Level

PHYSICS**9702/42**

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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This document consists of **18** printed pages.











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
	arithmetic error
	benefit of the doubt given
	contradiction in response, mark not awarded
	correct point or mark awarded
	error carried forward applied
	error in number of significant figures
	incorrect or insufficient point ignored while marking the rest of the response
	incorrect physics
	incorrect point or mark not awarded
	information missing or insufficient for credit

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Annotation	Meaning
MO	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 <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>mandatory</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)	angle (subtended at centre of a circle) when arc (length) = radius	B1
1(b)(i)	$v = r\omega$	C1
	$\omega = 17 / 0.46$ $= 37 \text{ rad s}^{-1}$	A1
1(b)(ii)	$T = 2\pi r / v$ or $T = 2\pi / \omega$	C1
	$= 2\pi \times 0.46 / 17$ or $2\pi / 37$ $= 0.17 \text{ s}$	A1
1(b)(iii)	distance = $2\pi \times 0.038 = 0.24 \text{ m}$	A1
1(b)(iv)	angle = arc length / radius	C1
	$= 0.24 / 0.15$ $= 1.6 \text{ rad}$	A1
1(c)	point X moves through a smaller distance in the same time or (linear) speed of movement of point X / chain decreases or (linear) speed of (circumference of) both cogs decreases	B1
	angular speed (of pedals) decreases	B1

Question	Answer	Marks
2(a)(i)	direction of force	B1
	force acting on a (test) mass	B1
2(a)(ii)	at least four radial lines from the Earth's surface, equally spaced around the surface	B1
	arrows indicating direction towards Earth	B1
2(b)(i)	top pole labelled S and bottom pole labelled N	B1
2(b)(ii)	<p>solenoid field pattern at the poles:</p> <p>at least two field lines either side of both poles, close to the poles, clustered closely together, leaving the surface approximately perpendicularly to the surface and curving away from the axis of the poles as their distance from the surface increases</p>	B1
	<p>solenoid field pattern above the equator:</p> <p>at least one field line either side of the Earth connecting two points on the surface that are on the same side of the poles, one north of the equator and one south of it, passing above the surface near the magnetic equator approximately parallel to the surface</p>	B1
2(c)(i)	(around the surface) lines are evenly spaced	B1
	<p>all lines perpendicular to surface</p> <p>or</p> <p>pointing down towards surface (at all points around the surface)</p>	B1

Question	Answer	Marks
2(c)(ii)	<p><i>Any three bulleted points from:</i></p> <ul style="list-style-type: none"> • strongest at the poles • weakest near the Equator <p><i>Up to two points from:</i></p> <ul style="list-style-type: none"> • perpendicular to surface at the poles • parallel to the surface near the Equator • angle to surface increases from Equator to poles 	B3

Question	Answer	Marks
3(a)	(thermal) energy per unit mass (to cause temperature change)	B1
	(thermal) energy per unit change in temperature	B1
3(b)(i)	density = mass / volume	C1
	$\text{mass} = 2.700 \times 10^3 \times 3.612 \times 10^{-3}$ $= 9.752 \text{ kg}$	A1
3(b)(ii)	$\text{volume} = 3.612 \times 10^{-3} \times (2.700 / 2.620) = 3.722 \times 10^{-3} \text{ m}^3$ or $\text{volume} = 9.752 / (2.620 \times 10^3) = 3.722 \times 10^{-3} \text{ m}^3$	A1

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Question	Answer	Marks
3(b)(iii)	$W = p\Delta V$	C1
	$= 1.01 \times 10^5 \times (3.722 - 3.612) \times 10^{-3}$	A1
	$= 11.1 \text{ J}$	
3(b)(iv)	volume (of block) increases	B1
	work is done against the atmosphere so work done (on block) is negative	B1
3(b)(v)	thermal energy $= (4.38 \times 10^6) + 11.1$	B1
	specific heat capacity $= (4.38 \times 10^6) / (9.75 \times 500)$	C1
	$= 898 \text{ J kg}^{-1} \text{ }^\circ\text{C}^{-1}$	A1
3(c)	work done is negligible compared with (change in) internal energy so (answer in (b)(v) would be) unchanged	B1

Question	Answer	Marks
4(a)(i)	thermodynamic temperature	B1
4(a)(ii)	molar gas constant	B1
4(b)(i)	m : mass of one molecule (of the gas)	B1
	$\langle c^2 \rangle$: mean-square speed (of molecules)	B1
4(b)(ii)	$NBT / A = \frac{1}{3} Nm \langle c^2 \rangle$	M1
	clear use of $E_K = \frac{1}{2} m \langle c^2 \rangle$ leading to $E_K = 3BT / 2A$	A1
4(c)	line with positive gradient passing through the origin	B1
	smooth curve with decreasing positive gradient	B1

Question	Answer	Marks
5(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
5(b)(i)	period = $2\pi / 16$ = 0.39 s	A1
5(b)(ii)	$v_0 = \omega x_0$ or $v_0 = \omega \sqrt{(x_0^2 - 0^2)}$	C1
	$x_0 = 0.56 / 16$ = 0.035 m	A1
5(b)(iii)	$v = \pm 16 \sqrt{(0.0352 - x^2)}$	A1
5(b)(iv)	closed loop surrounding the origin	B1
	loop crosses $v = 0$ at maximum values of x at $x = \pm 3.5$ cm	B1
	loop crosses $x = 0$ at maximum values of v at $v = \pm 0.56$ m s ⁻¹	B1

Question	Answer	Marks
6(a)	plate X marked as negative and plate Y marked as positive	B1
6(b)(i)	$E = V / x$	C1
	$= (58 \times 10^3) / 0.041$	A1
	$= 1.4 \times 10^6 \text{ N C}^{-1}$	
6(b)(ii)	$ma = eE$	C1
	$a = (1.60 \times 10^{-19} \times 1.41 \times 10^6) / (9.11 \times 10^{-31})$	A1
	$= 2.5 \times 10^{17} \text{ m s}^{-2}$	
6(c)(i)	$eV = hc / \lambda$ or $eV = hf$ and $f = c / \lambda$	C1
	$(1.60 \times 10^{-19} \times 58 \times 10^3) = (6.63 \times 10^{-34} \times 3.00 \times 10^8) / \lambda$	M1
	clear conversion from m to pm leading to $\lambda = 21 \text{ pm}$	A1
6(c)(ii)	X-rays	B1
6(c)(iii)	Any two points from: <ul style="list-style-type: none"> waves are passed into structure and transmitted waves detected different parts of the structure absorb different fractions of energy difference in detected / transmitted <u>intensities</u> used (to form image) 	B2

Question	Answer	Marks
7(a)	$V_C = V_R$	B1
7(b)(i)	$C = Q / V$	C1
	$= (7.2 \times 10^{-3}) / 12 \quad (= 6.0 \times 10^{-4} \text{ F})$	A1
	$= 600 \mu\text{F}$	
7(b)(ii)	$R = V / I$	C1
	$= 12 / (1.5 \times 10^{-3}) \quad (= 8000 \Omega)$	A1
	$= 8.0 \text{ k}\Omega$	
7(b)(iii)	$\tau = RC$	C1
	$= 8000 \times 6.0 \times 10^{-4}$	A1
	$= 4.8 \text{ s}$	
7(c)	<i>Any two points from:</i> <ul style="list-style-type: none"> charge and current are both (directly) proportional to voltage charge is (directly) proportional to current current is the rate of change of charge 	B2
	Q is proportional to the rate of change of Q (so exponential variation)	B1

Question	Answer	Marks
8(a)(i)	half-wave (rectification)	B1
8(a)(ii)	$V_0 = 6.0 \times \sqrt{2}$ $= 8.5 \text{ V}$	A1
8(b)(i)	$P = V^2 / R$	C1
	$P_0 = 8.5^2 / 45$ $= 1.6 \text{ W}$	A1
8(b)(ii)	two humps of width $0.5T$ and two sections of zero power of width $0.5T$	B1
	all humps drawn have width $0.5T$, minima at $P = 0$ and peaks at $P = P_0$	B1
	correct sinusoidal shape, with smooth troughs sitting on t -axis at $P = 0$	B1
8(b)(iii)	mean power within each hump is $\frac{1}{2}P_0$ from the symmetry of the curve	B1
	additional half factor from removal of half of the power in each cycle	B1
8(b)(iv)	$\langle P \rangle = V_{\text{r.m.s.}}^2 / R$ $V_{\text{r.m.s.}} = \sqrt{[(1.6 / 4) \times 45]}$ $= 4.2 \text{ V}$	A1

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Question	Answer	Marks
9(a)	emission of electrons (from a metal surface)	B1
	when electromagnetic radiation is incident (on surface / electrons)	B1
9(b)(i)	current falls to zero when applied voltage equals energy per unit charge of emitted electrons	B1
	energy of photon depends on frequency	B1
	maximum energy of electron depends on energy of photon	B1
9(b)(ii)	<p><i>Any three points from:</i></p> <ul style="list-style-type: none"> • threshold frequency = 1.5×10^{15} Hz • threshold wavelength = 2.0×10^{-7} m • work function = 6.2 eV (or 9.9×10^{-19} J) • Planck constant = 6.6×10^{-34} J s (not 6.63×10^{-34} J s) • number per unit time (of photons / electrons) = $1.7 \times 10^{16} \text{ s}^{-1}$ (in stage 1) • power of incident radiation = 0.028 W (in stage 1) 	B3

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Question	Answer	Marks															
10(a)	(decay is) not affected by external / environmental factors	B1															
10(b)(i)	half-life of X = $2T$ and half-life of Y = $3T$	B1															
	both samples show decay constant, in terms of $1 / T$, equal to $\ln 2 / \text{half-life}$ (decay constant of X = $\ln 2 / 2T$ and decay constant of Y = $\ln 2 / 3T$ if both half-lives correct)	B1															
	both samples show N_0 , in terms of AT , equal to initial activity / decay constant (N_0 for X = $8AT / \ln 2$ and N_0 for Y = $3AT / \ln 2$ if both decay constants correct) (Fully correct table: <table><tr><td></td><td>half-life</td><td>decay constant</td><td>A_0</td><td>N_0</td></tr><tr><td>X</td><td>$2T$</td><td>$\ln 2 / 2T$</td><td>$4A$</td><td>$8AT / \ln 2$</td></tr><tr><td>Y</td><td>$3T$</td><td>$\ln 2 / 3T$</td><td>A</td><td>$3AT / \ln 2$</td></tr></table>)		half-life	decay constant	A_0	N_0	X	$2T$	$\ln 2 / 2T$	$4A$	$8AT / \ln 2$	Y	$3T$	$\ln 2 / 3T$	A	$3AT / \ln 2$	B1
		half-life	decay constant	A_0	N_0												
X	$2T$	$\ln 2 / 2T$	$4A$	$8AT / \ln 2$													
Y	$3T$	$\ln 2 / 3T$	A	$3AT / \ln 2$													
10(b)(ii)	correct substitution of A_0 and λ into $A_0 \exp (-\lambda t)$ for sample X or sample Y	C1															
	$4A \exp (-t \ln 2 / 2T) = A \exp (-t \ln 2 / 3T)$	C1															
	$t = 12T$	A1															
10(c)	<i>Any two points from:</i> <ul style="list-style-type: none">(radiation) emitted in all directions, not just in direction of detectorsome radiation absorbed by air / sample / window of detectorsome radiation may not register even though it reaches detector	B2															