CAMBRIDGE
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Cambridge International AS & A Level

PHYSICS **9702/42**

Paper 4 A Level Structured Questions **February/March 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.

Cambridge International will not enter into discussions about these mark schemes.

Cambridge International is publishing the mark schemes for the February/March 2024 series for most Cambridge IGCSE, Cambridge International A and AS Level components, and some Cambridge O Level components.

Generic Marking Principles

These general marking principles must be applied by all examiners when marking candidate answers. They should be applied alongside the specific content of the mark scheme or generic level descriptions for a question. Each question paper and mark scheme will also comply with these marking principles.

GENERIC MARKING PRINCIPLE 1:

Marks must be awarded in line with:

- the specific content of the mark scheme or the generic level descriptors for the question
- the specific skills defined in the mark scheme or in the generic level descriptors for the question
- the standard of response required by a candidate as exemplified by the standardisation scripts.

GENERIC MARKING PRINCIPLE 2:

Marks awarded are always **whole marks** (not half marks, or other fractions).

GENERIC MARKING PRINCIPLE 3:

Marks must be awarded **positively**:

- marks are awarded for correct/valid answers, as defined in the mark scheme. However, credit is given for valid answers which go beyond the scope of the syllabus and mark scheme, referring to your Team Leader as appropriate
- marks are awarded when candidates clearly demonstrate what they know and can do
- marks are not deducted for errors
- marks are not deducted for omissions
- answers should only be judged on the quality of spelling, punctuation and grammar when these features are specifically assessed by the question as indicated by the mark scheme. The meaning, however, should be unambiguous.

GENERIC MARKING PRINCIPLE 4:

Rules must be applied consistently, e.g. in situations where candidates have not followed instructions or in the application of generic level descriptors.

GENERIC MARKING PRINCIPLE 5: Marks should be awarded using the full range of marks defined in the mark scheme for the question (however; the use of the full mark range may be limited according to the quality of the candidate responses seen).
GENERIC MARKING PRINCIPLE 6: Marks awarded are based solely on the requirements as defined in the mark scheme. Marks should not be awarded with grade thresholds or grade descriptors in mind.

Science-Specific Marking Principles

1	Examiners should consider the context and scientific use of any keywords when awarding marks. Although keywords may be present, marks should not be awarded if the keywords are used incorrectly.
2	The examiner should not choose between contradictory statements given in the same question part, and credit should not be awarded for any correct statement that is contradicted within the same question part. Wrong science that is irrelevant to the question should be ignored.
3	Although spellings do not have to be correct, spellings of syllabus terms must allow for clear and unambiguous separation from other syllabus terms with which they may be confused (e.g. ethane / ethene, glucagon / glycogen, refraction / reflection).
4	The error carried forward (ecf) principle should be applied, where appropriate. If an incorrect answer is subsequently used in a scientifically correct way, the candidate should be awarded these subsequent marking points. Further guidance will be included in the mark scheme where necessary and any exceptions to this general principle will be noted.
5	<u>'List rule' guidance</u> For questions that require ***n*** responses (e.g. State **two** reasons …): • The response should be read as continuous prose, even when numbered answer spaces are provided. • Any response marked *ignore* in the mark scheme should not count towards ***n***. • Incorrect responses should not be awarded credit but will still count towards ***n***. • Read the entire response to check for any responses that contradict those that would otherwise be credited. Credit should **not** be awarded for any responses that are contradicted within the rest of the response. Where two responses contradict one another, this should be treated as a single incorrect response. • Non-contradictory responses after the first ***n*** responses may be ignored even if they include incorrect science.

6	Calculation specific guidance Correct answers to calculations should be given full credit even if there is no working or incorrect working, **unless** the question states 'show your working'. For questions in which the number of significant figures required is not stated, credit should be awarded for correct answers when rounded by the examiner to the number of significant figures given in the mark scheme. This may not apply to measured values. For answers given in standard form (e.g. $a \times 10^n$) in which the convention of restricting the value of the coefficient (a) to a value between 1 and 10 is not followed, credit may still be awarded if the answer can be converted to the answer given in the mark scheme. Unless a separate mark is given for a unit, a missing or incorrect unit will normally mean that the final calculation mark is not awarded. Exceptions to this general principle will be noted in the mark scheme.
7	Guidance for chemical equations Multiples / fractions of coefficients used in chemical equations are acceptable unless stated otherwise in the mark scheme. State symbols given in an equation should be ignored unless asked for in the question or stated otherwise in the mark scheme.

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) potential is zero at infinity (gravitational force between two masses is attractive so)	B1
	either work is done on a mass to move it away from another mass **or** work is done on a mass to move it to infinity	B1
1(b)(i)	M = (–) gradient / G	C1
	e.g. $M = (1.76 \times 10^{8}) / (3.0 \times 10^{-8} \times 6.67 \times 10^{-11}) = 8.8 \times 10^{25}$ kg	A1
1(b)(ii)	**either** $GMm / r^2 = mr\omega^2$ **and** $\omega = 2\pi / T$ **or** $GMm / r^2 = mv^2 / r$ **and** $v = 2\pi r / T$ **or** $GMm / r^2 = 4\pi^2 mr / T^2$	C1
	$R^3 = 6.67 \times 10^{-11} \times 8.8 \times 10^{25} \times (0.72 \times 24 \times 60 \times 60)^2 / 4\pi^2$	C1
	$R = 8.3 \times 10^{7}$ m	A1
1(b)(iii)	$\Delta E = (GMm / r) - ½mv^2$ kinetic energy = $(½ \times 1200 \times 8400^2)$	C1
	potential energy = $(–)[(6.67 \times 10^{-11} \times 8.8 \times 10^{25} \times 1200) / (8.3 \times 10^{7})]$	C1
	$\Delta E = [(6.67 \times 10^{-11} \times 8.8 \times 10^{25} \times 1200) / (8.3 \times 10^{7})] - (½ \times 1200 \times 8400^2)$ $= 4.3 \times 10^{10}$ J	A1

Question	Answer	Marks
2(a)	total kinetic energy associated with random motion of molecules	M1
	plus total potential energy (of molecules) but potential energy is zero	A1
2(b)(i)	$W = p\Delta V$	C1
	$= 1.01 \times 10^{5} \times 5.20 \times 10^{-5}$ $= (+)5.25$ J	A1
2(b)(ii)	$V \propto T$ or V / T = constant	C1
	$1.24 / (273 + 20) = (1.24 + 0.520) / T$ $T = 416$ K	A1
2(b)(iii)	$c = Q / m\Delta T$	C1
	$= 960 / (0.016 \times (416 - 293))$ $= 490$ J kg^{-1} K^{-1}	A1
2(c)	no change in volume so no work is done (by the gas)	B1
	(same temperature change so) same change in internal energy	B1
	less thermal energy needs to be supplied so *c* is less	B1

Question	Answer	Marks
3(a)	$E = ½ m\omega^{2}x_{0}^{2}$	C1
	$2.2 \times 10^{-4} = ½ \times 24 \times 10^{-3} \times (14 \times 10^{-3} / 4)^{2} \times \omega^{2}$	C1
	$\omega = 39$ rad s^{-1}	A1

Question	Answer	Marks
3(b)(i)	use of acceleration = 9.81 m s^{-2} x_0 = 9.81 / 39^2	C1
	= 6.4 × 10^{-3} m	A1
3(b)(ii)	at top of oscillation	B1
	any one point from: where the downward acceleration first exceeds free-fall acceleration where the greatest downwards acceleration occurs where the resultant force is the maximum downwards where the contact force is a minimum	B1

Question	Answer	Marks
4(a)	combined capacitance of parallel capacitors = 30 (μF)	C1
	total capacitance = $(1 / 45 + 1 / 30)^{-1}$ = 18 μF	A1
4(b)	$E = ½CV^2$	C1
	ΔE = ½ × 45 × 10^{-6} (9.6^2 – 8.0^2) = 6.3 × 10^{-4} J	A1
4(c)(i)	gaps in circuit closed and correct symbol for capacitor shown in parallel with load resistor	B1
4(c)(ii)	two correct pairs of values of *t* and *V* read off from within same discharge cycle, e.g. (5.0, 4.0) and (13.0, 3.2)	C1
	correct substitution of values of V, V_0 and Δt into $V = V_0 \exp(-\Delta t / \tau)$ e.g. 3.2 = 4.0 exp (–8.0 / τ)	C1
	τ = 36 ms	A1

Question	Answer	Marks
4(d)(i)	8.0 W	**A1**
4(d)(ii)	4.0 W	**A1**

Question	Answer	Marks
5(a)	*any 2 points from*: • (angular) displacement • velocity • momentum • (centripetal) acceleration • (resultant) force	**B2**
5(b)(i)	$Bqv = mv^2 / r$	**M1**
	$v = 2\pi r / T$	**M1**
	completion of algebra leading to $B = 2\pi m / qT$	**A1**
5(b)(ii)	$B = (2\pi \times 4 \times 1.66 \times 10^{-27}) / (2 \times 1.60 \times 10^{-19} \times 2.5 \times 10^{-6})$	**C1**
	= 0.052 T	**A1**
5(b)(iii)	**either** the same because T is independent of r **or** the same because B, q and m are unchanged **or** the same because both radius and speed have doubled	**B1**
5(b)(iv)	$qE = Bqv$	**C1**
	$E = Bv = 0.052 \times 1.1 \times 10^6$ $= 5.7 \times 10^4$ N C^{-1}	**A1**

Question	Answer	Marks
6(a)(i)	non-zero horizontal straight line from X to Y	**B1**
6(a)(ii)	constant flux density (inside coil)	**B1**
	either (magnetic) flux linkage proportional to flux density **or** $\Phi = BAN$ and B, A and N are all constant	**B1**
6(a)(iii)	$\Phi = BAN$	**C1**
	$= 0.080 \times 0.71 \times 10^{-4} \times 64$ $= 3.6 \times 10^{-4}$ Wb	**A1**
6(a)(iv)	*sketch showing*: *E* is zero from time 0 to time *t* and non-zero after time *t*	**B1**
	E has constant non-zero magnitude between time *t* and time 4*t*	**B1**
	E has non-zero value of one sign between time *t* and time 2*t*, and non-zero value of the opposite sign between time 2*t* and time 4*t*	**B1**
6(b)	current in spring creates a magnetic field around the spring	**B1**
	either (magnetic) fields around adjacent turns interact to cause a force to be exerted (between the turns) **or** current in one turn interacts with (magnetic) field due to adjacent turns to cause force to be exerted (between the turns)	**B1**
	(magnetic force) is attractive so distance (between turns) decreases	**B1**

Question	Answer	Marks
7(a)	$p = E / c$	C1
	$= (3.11 \times 10^{-19}) / (3.00 \times 10^{8})$ $= 1.04 \times 10^{-27}$ N s	A1
7(b)(i)	$E = hf$ and $c = f\lambda$ so energy of one photon = hc / λ $350 \times 10^{-3} = N \times (6.63 \times 10^{-34} \times 3.00 \times 10^{8}) / (640 \times 10^{-9})$	C1
	$N = 1.1 \times 10^{18}$	A1
7(b)(ii)	F = (change in) momentum / time	M1
	Clear use of $p = E / c$ and $t = E / P$ to complete the algebra and arrive at the final equation: e.g. $F = [E / c] / [E / P] = P / c$	A1
7(c)(i)	maximum wavelength (of electromagnetic radiation) that causes electrons to be emitted (from surface of metal)	B1
7(c)(ii)	work function = $2.26 \times 1.60 \times 10^{-19}$ (J) $E = hc / \lambda$ so $(2.26 \times 1.60 \times 10^{-19}) = (6.63 \times 10^{-34} \times 3.00 \times 10^{8}) / \lambda_0$	C1
	$\lambda_0 = 5.50 \times 10^{-7}$ m	A1

Question	Answer	Marks
8(a)	(minimum) energy required to separate the nucleons (of a nucleus)	M1
	to infinity	A1
8(b)(i)	4	A1

Question	Answer	Marks
8(b)(ii)	energy= (142 × 8.37) + (90 × 8.72) – (235 × 7.59)	C1
	= 190 MeV	A1
8(b)(iii)	**either** it has too many neutrons (for the number of protons) **or** its neutron to proton ratio is too high	B1
8(b)(iv)	(when t = 6.0 s), N / N_0 = 1 / 32	C1
	either (1 / 32) = exp (– ln2 × 6.0 / $t_{½}$)	C1
	$t_{½}$ = 1.2 s	A1
	or 32 / 2^n = 1 so n = 5 (half-lives)	(C1)
	$t_{1/2}$ = 6.0 / 5 = 1.2 s	(A1)

Question	Answer	Marks
9(a)(i)	$eV = hc / \lambda$	C1
	λ = (6.63 × $10^{–34}$ × 3.00 × 10^8) / (84 × 10^3 × 1.60 × $10^{–19}$) = 1.5 × $10^{–11}$ m	A1
9(a)(ii)	**either** (some) kinetic energy (of electrons) is converted to thermal energy at target **or** some X-rays are absorbed by the target so its temperature increases	B1
	(tungsten) has higher melting point so does not melt quickly / easily	B1

Question	Answer	Marks
9(b)	$I = I_0 \exp(-\mu t)$	C1
	$0.13 = [\exp(-3.0x)] \times [\exp(-0.22x)]$ $= \exp(-3.22x)$	C1
	$x = 0.63$ cm	A1
9(c)(i)	product of density and speed	M1
	speed of ultrasound in medium	A1
9(c)(ii)	$I_R / I_0 = (7.8 - 1.7)^2 / (7.8 + 1.7)^2$ $= 0.41$ fraction transmitted = 1.00 – 0.41 = 0.59	C1
	percentage transmitted = **59%**	A1
9(c)(iii)	more than one <u>boundary</u> so more reflections	B1
	some ultrasound is attenuated in matter	B1

Question	Answer	Marks
10(a)(i)	$L = 4\pi\sigma r^2 T^4$ $3.85 \times 10^{26} = 4\pi \times 5.67 \times 10^{-8} \times r^2 \times 5780^4$	C1
	$r = 6.96 \times 10^8$ m	A1

Question	Answer	Marks
10(a)(ii)	$F = L / 4\pi d^2$ $= (3.85 \times 10^{26}) / (4\pi \times (1.50 \times 10^{11})^2)$	C1
	$= 1.36 \times 10^3\ \text{W m}^{-2}$	A1
10(a)(iii)	line of same shape showing peak intensity at greater wavelength	B1
	line of same shape showing lower peak intensity	B1
10(b)(i)	5 lines in same pattern shifted to longer wavelengths	B1
10(b)(ii)	$\Delta\lambda / \lambda = v / c$ $\Delta\lambda = (21400 / 300000) \times 656$ $= 46.8$ nm	C1
	wavelength $= 656 + 46.8$ $= 703$ nm	A1
10(b)(iii)	(peak) wavelength too high so temperature too low	B1