CAMBRIDGE
International Education

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.

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

Cambridge International is publishing the mark schemes for the May/June 2024 series for most Cambridge IGCSE, Cambridge International A and AS Level and Cambridge Pre-U 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	<u>Calculation specific guidance</u> 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	<u>Guidance for chemical equations</u> 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)	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**
	$\omega = 0.68 / (0.093 - 0.012)$ $= 8.4$ 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** $(0.093 - 0.012) \times 8.4^2$ $= 5.7$ 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**
	$N = (2.90 \times 10^5 \times 0.0430) / (1.38 \times 10^{-23} \times 507)$ $= 1.78 \times 10^{24}$	**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**
	$E = ½ \times 600 \times 10^{-6} \times 5.0^2$ $(= 7.5 \times 10^{-3}$ 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**