Cambridge Assessment International Education

Cambridge International AS & A Level

PHYSICS **9702/42**

Paper 4 A Level Structured Questions **October/November 2022**

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 October/November 2022 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 descriptors 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)	force per unit mass	**B1**
1(b)(i)	lines drawn are radial from the surface	**B1**
	arrows show pointing towards planet	**B1**
1(b)(ii)	field lines show force (on satellite) is towards centre of planet **or** velocity of satellite is perpendicular to field lines	**B1**
	(gravitational) force perpendicular to velocity causes centripetal <u>acceleration</u>	**B1**
1(c)(i)	T = 24 hours	**C1**
	$a = r\omega^2$ **and** $\omega = 2\pi / T$ **or** $a = v^2 / r$ **and** $v = 2\pi r / T$ **or** $a = 4\pi^2 r / T^2$	**C1**
	$a = (4\pi^2 \times 6.4 \times 10^6) / (24 \times 60 \times 60)^2$ $= 0.034\ \mathrm{m\,s^{-2}}$	**A1**
1(c)(ii)	identification of the two forces acting on the object as gravitational force and (normal) contact force	**M1**
	gravitational force and normal contact force are in opposite directions, and their resultant causes the (centripetal) acceleration	**A1**

Question	Answer	Marks
2(a)	(thermal) energy per unit mass (to cause temperature change)	**B1**
	(thermal) energy per unit change in temperature	**B1**
2(b)(i)	work done correct (0)	**B1**
	increase in internal energy correct ($+E$)	**B1**
2(b)(ii)	work done correct ($-W$) **and** increase in internal energy same as **(b)(i)**	**B1**
	thermal energy correct so that it adds to work done to give increase in internal energy	**B1**
2(c)	more thermal energy needed so specific heat capacity is greater	**B1**

Question	Answer	Marks
3(a)	p = pressure (of gas), V = volume (of gas) **and** k = Boltzmann constant	**B1**
	N = number of molecules	**B1**
	T = thermodynamic temperature	**B1**
3(b)	($pV = NkT$ and $pV = \frac{1}{3}Nm\langle c^2\rangle$ leading to) $NkT = \frac{1}{3}Nm\langle c^2\rangle$	**M1**
	algebra leading to $(3/2)kT = \frac{1}{2}m\langle c^2\rangle$ **and** use of $\frac{1}{2}m\langle c^2\rangle = E_K$ leading to $(3/2)kT = E_K$	**A1**
3(c)(i)	T = 296 K	**C1**
	$\frac{1}{2}m\langle c^2\rangle = (3/2)kT$ $\frac{1}{2} \times 5.31 \times 10^{-26} \times u^2 = (3/2) \times 1.38 \times 10^{-23} \times 296$	**C1**
	u = 480 m s^{-1}	**A1**
3(c)(ii)	line passing through (P, u)	**B1**
	horizontal straight line	**B1**

Question	Answer	Marks
4(a)(i)	$x_0 = 8.0$ cm	A1
4(a)(ii)	$\omega = 2\pi / T$	C1
	$= 2\pi / 4.0 = 1.6$ rad s^{-1}	A1
4(a)(iii)	$E = \frac{1}{2}m\omega^2 x_0^2$	C1
	$= \frac{1}{2} \times 36 \times 1.6^2 \times 0.080^2$	C1
	$= 0.29$ J	A1
4(b)	dome-shaped curve, starting and ending at $E_K = 0$	B1
	maximum E_K shown as 0.29 J	B1
	position of peak shown at $h = 10.0$ cm	B1
	line intercepts h-axis at $h = 2.0$ cm and at $h = 18.0$ cm	B1

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)	radius = 0.060 m	**A1**
5(b)(ii)	$V = Q / 4\pi\varepsilon_0 x$ $Q = (–)\ 850 \times 4\pi \times 8.85 \times 10^{–12} \times 0.060$ **or** $Q = (–)\ 850 \times 0.060 / 8.99 \times 10^{9}$ (*any correct pair of V and x values from curve*)	**C1**
	$Q = – 5.7 \times 10^{–9}$ C	**A1**
5(c)(i)	$E_P = Q^2 / 4\pi\varepsilon_0 x$ $= (5.67 \times 10^{–9})^2 / (4\pi \times 8.85 \times 10^{–12} \times 0.46)$	**C1**
	$= 6.3 \times 10^{–7}$ J	**A1**
5(c)(ii)	• force is repulsive so spheres move apart • force in direction of motion so speed increases • potential energy converted to kinetic energy so speed increases • force decreases with distance so acceleration decreases • momentum is conserved (at zero) (and masses are equal) so velocities are always equal and opposite *Any three points, 1 mark each*	**B3**

Question	Answer	Marks
6(a)	• p.d. across resistor = p.d. across capacitor • current (in resistor) proportional to p.d. across it • current causes capacitor to lose charge • charge (on capacitor) proportional to p.d. so p.d. decreases *Any two points, 1 mark each*	**B2**
	rate of change of p.d. decreases as p.d. decreases	**B1**
6(b)	Q_0 = 0.90 mC **and** at t = one time constant, $Q = Q_0 \exp(-1)$	**B1**
	at t = one time constant, Q = 0.90 exp (–1) = 0.33 mC	**M1**
	evidence of graph reading: when Q = 0.33 mC, t = 5.5 s	**A1**
	or	
	evidence of two correct sets of readings for Q and t from the graph	**(B1)**
	correct substitution of Q and t values into $Q_2 = Q_1 \exp[(t_1 - t_2) / \tau]$	**(M1)**
	calculation to give τ = 5.5 s	**(A1)**
	or	
	read-off of half-life as 3.75 s	**(B1)**
	use of $Q = Q_0 \exp(-t/\tau)$ to show that τ = half-life / ln 2	**(M1)**
	τ = 3.75 / ln 2 = 5.4 s	**(A1)**

Question	Answer	Marks
6(b)	**or**	
	tangent drawn on Q–t graph and value of Q at exact same time as tangent read from graph	**(M1)**
	gradient of tangent correctly calculated	**(A1)**
	$\tau = Q$ / gradient used to correctly calculate a value for τ as 5.5 s	**(A1)**
6(c)(i)	$C = Q / V$	**C1**
	$= [(0.90 \times 10^{-3}) / 7.5] = 1.2 \times 10^{-4}$ C $= 120\ \mu$F	**A1**
6(c)(ii)	$R = \tau / C$	**C1**
	$= 5.5 / (1.2 \times 10^{-4})$ (= 45 800 Ω) $= 46$ kΩ	**A1**

Question	Answer	Marks
7(a)	force per unit current	**M1**
	force per unit length	**M1**
	current / wire is perpendicular to (magnetic) field (lines)	**A1**
7(b)(i)	current (in coil) is perpendicular to magnetic field (so force on wire)	**B1**
	force (on wire) is perpendicular to current and field (so is vertical) **or** current and field are both horizontal (so force is vertical)	**B1**
7(b)(ii)	$NBIL = mg$	**C1**
	$B = (2.16 \times 10^{-3} \times 9.81) / (40 \times 3.94 \times 0.0300)$	**C1**
	$= 4.48 \times 10^{-3}$ T	**A1**
7(b)(iii)	(magnetic) forces (on balance and newton meter) are (equal and) opposite	**B1**
	reading $= 0.563 - (2.16 \times 10^{-3} \times 9.81)$ $= 0.542$ N	**A1**

Question	Answer	Marks
8(a)	direction of induced e.m.f.	**M1**
	such as to (produce effects that) oppose the change that caused it	**A1**
8(b)(i)	X = 0.85 A	**A1**
	Y = $2\pi / 0.040$	**C1**
	= 160 rad s^{-1}	**A1**
8(b)(ii)	two cycles of a sinusoidal curve with a period of 0.040 s	**B1**
	correct phase (i.e. V_2 max / min at t = 0, 0.02, 0.04, 0.06 and 0.08 s, and V_2 zero at t = 0.01, 0.03, 0.05, 0.07 s)	**B1**
	maximum / minimum V_2 shown (consistently) at ± 6.5 V	**B1**
8(b)(iii)	(magnitude of) V_2 is proportional to rate of change of (magnetic) flux	**B1**
	• V_2 is proportional to <u>gradient</u> of I_1–t curve • V_2 has maximum magnitude when I_1–t curve is steepest • V_2 is zero when I_1–t curve is horizontal / a maximum or minimum • V_2 changes sign when sign of gradient of I_1–t curve changes *Any two points, 1 mark each*	**B2**

Question	Answer	Marks
9(a)(i)	• energy of photon has a corresponding frequency • change in electron energy level emits a single photon • photon energy = difference in energy levels • discrete frequencies must have come from discrete energy gaps • discrete energy changes imply discrete energy levels *Any three points, 1 mark each*	**B3**
9(a)(ii)	transition (to – 3.400 eV) from X corresponds to 658 nm line	**C1**
	$E_1 - E_2 = hc / \lambda$	**C1**
	$E_1 - (-3.400) = (6.63 \times 10^{-34} \times 3.00 \times 10^{8}) / (658 \times 10^{-9} \times 1.60 \times 10^{-19})$ and so $E_1 = -1.51$ eV (*full substitution and answer needed*)	**A1**
9(b)(i)	redshift	**B1**
9(b)(ii)	moving away (from observer)	**B1**
9(b)(iii)	$\Delta\lambda / \lambda = v / c$ e.g. for 658 nm line: $\Delta\lambda = 686 - 658$ (= 28 nm) (*other lines may be used*)	**C1**
	$28 / 658 = v / (3.00 \times 10^{8})$ (*other lines may be used*)	**C1**
	$v = 1.3 \times 10^{7}$ m s^{-1}	**A1**
9(c)	$v = H_0 d$	**C1**
	$H_0 = (1.3 \times 10^{7}) / (5.7 \times 10^{24})$ $= 2.3 \times 10^{-18}$ s^{-1}	**A1**

Question	Answer	Marks
10(a)(i)	introduction of tracer (into the body)	**M1**
	containing a β^+ emitter	**A1**
10(a)(ii)	positron interacts with electron	**B1**
	(pair) annihilation occurs	**B1**
	mass of particles converted into gamma photons	**B1**
10(b)	(annihilation of electron and positron) produces two photons	**B1**
	$E = (\Delta)mc^2$	**B1**
	$E = hf$ **and** $f = c / \lambda$ **or** $E = hc / \lambda$	**B1**
	$\lambda = \{[2\times]\ 6.63 \times 10^{-34} \times 3.00 \times 10^8\} / \{[2\times]\ 9.11 \times 10^{-31} \times (3.00 \times 10^8)^2\}$ $= 2.4(3) \times 10^{-12}$ m or 2.4(3) pm (*full substitution and answer with unit needed*)	**B1**