Cambridge International AS & A Level

PHYSICS **9702/41**

Paper 4 A Level Structured Questions **May/June 2023**

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 2023 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 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 <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)(i)	force per unit mass	**B1**
1(a)(ii)	force per unit positive charge	**B1**
1(a)(iii)	similarity: • inversely proportional to distance (from point) • points of equal potential lie on concentric spheres • zero at infinite distance *Any point, 1 mark*	**B1**
	difference: • gravitational potential is (always) negative • electric potential can be positive or negative *Any point, 1 mark*	**B1**
1(b)(i)	$g = GM / r^2$	**M1**
	$E = Q / 4\pi\varepsilon_0 r^2$	**M1**
	algebra showing the elimination of r leading to $M / Q = (1 / 4\pi G\varepsilon_0)(g / E)$	**A1**
1(b)(ii)	$\alpha = 1 / (4\pi \times 6.67 \times 10^{-11} \times 8.85 \times 10^{-12}) = 1.35 \times 10^{20}$ (kg^2 C^{-2}) **or** $\alpha = (8.99 \times 10^9) / (6.67 \times 10^{-11}) = 1.35 \times 10^{20}$ (kg^2 C^{-2})	**A1**
1(c)(i)	$E = \alpha gQ / M$ $= (1.35 \times 10^{20} \times 9.81 \times 4.80 \times 10^5) / (5.98 \times 10^{24})$	**C1**
	$= 106$ N C^{-1} **or** 106 V m^{-1}	**A1**
1(c)(ii)	same (direction)	**B1**

Question	Answer	Marks
2(a)	horizontal force on sphere causes centripetal acceleration	**B1**
	weight of sphere is (now) equal to vertical component of tension **or** horizontal and vertical components (of force) (now) combine to give greater tension (in spring)	**B1**
	greater tension in spring so greater extension of spring	**B1**
2(b)(i)	$r = 10.8 \times \sin 27° = 4.9\,\text{cm}$	**A1**
2(b)(ii)	$T\cos\theta = mg$ **or** $T\cos\theta = W$ **and** $W = mg$	**C1**
	$T\cos 27° = 0.29 \times 9.81$ leading to $T = 3.2\,\text{N}$	**A1**
2(b)(iii)	$\Delta T = 3.2 - (0.29 \times 9.81)$	**C1**
	$k = \Delta T / \Delta x$ $= [3.2 - (0.29 \times 9.81)] / [10.8 - 8.5]$ $= 0.15\,\text{N cm}^{-1}$	**A1**
2(c)(i)	centripetal acceleration $= (T\sin\theta)/m$ $= (3.2 \times \sin 27°)/0.29$	**C1**
	$= 5.0\,\text{m s}^{-2}$	**A1**

Question	Answer	Marks
2(c)(ii)	$a = r\omega^2$ **and** $\omega = 2\pi / T$ **or** $a = v^2 / r$ **and** $v = 2\pi r / T$	**C1**
	$T = 2\pi \times \sqrt{(0.049 / 5.0)}$ $= 0.62$ s	**A1**

Question	Answer	Marks
3(a)	no <u>net</u> thermal energy is transferred (between them)	**B1**
3(b)(i)	variation (of density with temperature) is linear **or** each temperature has a unique value of density	**B1**
3(b)(ii)	• variation (of density with temperature) is not linear • region where the density does not vary with temperature • different temperatures have the same density *Any two points, 1 mark each*	**B2**
3(c)(i)	boiling point = 80 °C	**A1**
3(c)(ii)	$Q = Pt$ **and** $t = 21$ s (thermal energy supplied = 810 × 21 = 17000 J)	**C1**
	$c = Q / m\Delta\theta$	**C1**
	thermal energy absorbed by beaker = 42 × 0.84 × (80 – 25) (= 1940 J)	**C1**
	s.h.c. of liquid = [(810 × 21) – (42 × 0.84 × (80 – 25))] / [120 × (80 – 25)] = 2.3 J g^{-1} K^{-1}	**A1**
3(d)	sketch: straight diagonal line from 25 °C to 100 °C **and** then horizontal at 100 °C	**B1**
	straight diagonal line starting at 25 °C with gradient approximately half that of the original line	**B1**

Question	Answer	Marks
4(a)	• particles are in (continuous) random motion • particles have negligible volume (compared with the gas) • negligible forces between particles (except during collisions) • (all) collisions (perfectly) elastic • time of collision negligible (in comparison with time between collisions) *Any two points, 1 mark each*	B2
4(b)(i)	(general starting equation) $pV = nRT$	C1
	$T = (2pV / nR)$ where R is the (molar) gas constant	A1
4(b)(ii)	sketch: straight vertical line XY from (V, 2p) to (V, p)	B1
	straight horizontal line YZ from (V, p) to (2V, p)	B1
	curve with gradient increasing from Z to X from (2V, p) to (V, 2p)	B1
4(b)(iii)	XY work done on gas correct (= 0)	B1
	ZX increase in internal energy correct (= 0)	B1
	YZ work done on gas correct (= $-pV$)	B1
	XY increase in internal energy such that the increase in internal energy column adds up to zero	B1
	all three thermal energies transferred such that $\Delta U = q + w$ in each row (completely correct answer: change | ΔU | Q | w X to Y | $-U$ | $-U$ | 0 Y to Z | [$+U$] | $U + pV$ | $-pV$ Z to X | 0 | $-W$ | [$+W$])	B1

Question	Answer	Marks
5(a)(i)	correct circuit symbol for a diode shown correctly connected in series with the wires leading into and out of the dotted box	**B1**
5(a)(ii)	smoothing / V_{OUT} is smoothed	**B1**
5(b)(i)	frequency = 1 / 0.04 = 25 Hz	**A1**
5(b)(ii)	$V = V_0 \exp(-t/RC)$ **and** $\tau = RC$ **or** $V = V_0 \exp(-t/\tau)$	**C1**
	$3.25 = 5.50 \exp(-0.020/\tau)$ leading to $\tau = 0.038$ s	**A1**
5(b)(iii)	$\tau = RC$	**C1**
	capacitance = 0.038 / 14000 $= 2.7 \times 10^{-6}$ F	**A1**
5(c)	V_{IN} has constant magnitude in both positive and negative directions	**B1**
	(so) V_{OUT} is (now) constant / V_{OUT} does not vary with time	**B1**

Question	Answer	Marks
6(a)	a region where a force acts on	**M1**
	a current-carrying conductor **or** a moving charge **or** a magnetic material / magnetic pole	**A1**
6(b)	concentric circles around the wire	**B1**
	spacing between circles increases with distance from wire	**B1**
	arrows showing direction of field is clockwise	**B1**
6(c)(i)	$F = BIL$	**C1**
	force per unit length $= BI$ $= 2.6 \times 10^{-3} \times 5.0$ $= 0.013\ \text{N m}^{-1}$	**A1**
6(c)(ii)	to the right	**B1**
6(c)(iii)	force (per unit length) has the same magnitude due to Newton's 3rd law	**B1**
	$0.013 = 1.5 \times 10^{-3} \times I$ current = 8.7 A	**A1**

Question	Answer	Marks
7(a)	wavelength associated with a <u>moving</u> particle	**B1**
7(b)(i)	(electron) diffraction	**B1**
7(b)(ii)	beam spreads out indicating diffraction **or** light and dark regions indicate an interference pattern	**B1**
	electron beam is behaving as a wave	**B1**
7(c)(i)	central blob and concentric rings	**B1**
	rings closer together (than previously)	**B1**
7(c)(ii)	(greater p.d. so) electrons to have greater momentum	**B1**
	greater momentum so decrease in (de Broglie) wavelength	**B1**
	lower (de Broglie) wavelength (for same grating spacing in crystal) causes: smaller diffraction angle **or** smaller angle of intensity maxima (for each order) **or** decrease in fringe spacing in diffraction pattern	**B1**

Question	Answer	Marks
8(a)(i)	specific acoustic impedance = 1200 × 1400 = 1.68×10^6 kg m^{-2} s^{-1}	A1
8(a)(ii)	density of air shown in table as 1.29	A1
	speed of sound in tissue shown in table as 1540	A1
8(b)(i)	intensity reflection coefficient = $(Z_1 - Z_2)^2 / (Z_1 + Z_2)^2$ = $(1680000 - 440)^2 / (1680000 + 440)^2$	C1
	= 0.999	A1
8(b)(ii)	intensity reflection coefficient = $(Z_1 - Z_2)^2 / (Z_1 + Z_2)^2$ = $(1680000 - 1680000)^2 / (1680000 + 1680000)^2$ = 0	A1
8(c)	without gel, (almost) all of the (incident) ultrasound is reflected (from skin)	B1
	with gel, (almost) all of the (incident) ultrasound is transmitted (into the body)	B1

Question	Answer	Marks
9(a)	time for activity (of sample) to halve	**B1**
9(b)	sketch: line with positive gradient starting at (0,0) and extending to t = 80 min	**B1**
	exponential curve, extending from t = 0 to t = 80 min, with gradient of steadily decreasing magnitude	**B1**
	line passing through (0,0), (20, 0.5N_0) and (40, 0.75 N_0)	**B1**
9(c)(i)	every (undecayed) nucleus has the same probability of decay	**M1**
	fewer (undecayed) nuclei remaining (with time), so fewer will decay (in a given time interval)	**A1**
9(c)(ii)	• sample emits in all directions but detector only captures emissions in one direction • some emissions are absorbed before reaching detector • some emissions are scattered within the sample • simultaneous arrival of multiple particles only registers once • some particles may reach detector but not cause ionisation *Any two points, 1 mark each*	**B2**
	measured count rate is less than the activity	**B1**

Question	Answer	Marks
10(a)	speed is (directly) proportional to distance	**M1**
	speed is speed of recession of galaxy from an observer, and distance is the distance of the galaxy from the observer	**A1**
10(b)	$F = L / (4\pi d^2)$	**C1**
	$= (3.8 \times 10^{31}) / [4\pi \times (1.8 \times 10^{24})^2]$ $= 9.3 \times 10^{-19}$ W m^{-2}	**A1**
10(c)(i)	galaxy is moving away (from the Earth)	**B1**
	wavelength (of light from the galaxy) increased by the Doppler effect / due to redshift	**B1**
10(c)(ii)	$\Delta\lambda / \lambda = v / c$ $v = [(492 - 486) \times 3.00 \times 10^8] / 486$ ($v = 3.7 \times 10^6$ m s^{-1})	**C1**
	$H_0 = v / d$	**C1**
	$= (3.7 \times 10^6) / (1.8 \times 10^{24})$ $= 2.1 \times 10^{-18}$ s^{-1}	**A1**