Cambridge Assessment International Education

Cambridge International AS & A Level

PHYSICS **9702/42**

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.

© UCLES 2023

PUBLISHED

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.

© UCLES 2023

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.

© UCLES 2023

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.

© UCLES 2023

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 independent 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 method 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 compensatory 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 answer marks. They may depend on an **M** mark or allow a **C** mark to be awarded by implication.

© UCLES 2023

Question	Answer	Marks
1(a)	(gravitational) force is (directly) proportional to product of masses	**B1**
	force (between point masses) is inversely proportional to the square of their separation	**B1**
1(b)	$GMm / R^2 = mR\omega^2$	**M1**
	$\omega = 2\pi / T$ and algebra leading to $4\pi^2R^3 = GMT^2$	**A1**
	or	
	$GMm / R^2 = mv^2 / R$	**(M1)**
	$v = 2\pi R / T$ and algebra leading to $4\pi^2R^3 = GMT^2$	**(A1)**
1(c)	$4\pi^2 \times R^3 = 6.67 \times 10^{-11} \times 5.98 \times 10^{24} \times (24 \times 60 \times 60)^2$ ($R = 4.22 \times 10^7$ m)	**C1**
	$h = R - (6.37 \times 10^6)$	**C1**
	$h = (4.22 \times 10^7) - (6.37 \times 10^6)$ $= 3.6 \times 10^7$ m	**A1**
1(d)(i)	$\omega = 2\pi / T$	**C1**
	$= 2\pi / (24 \times 60 \times 60)$ $= 7.3 \times 10^{-5}$ rad s^{-1}	**A1**
1(d)(ii)	orbit is from east to west	**B1**
	orbit is not equatorial / orbit is polar	**B1**

© UCLES 2023

Question	Answer	Marks
2(a)(i)	(gas that obeys) $pV \propto T$ (for all values of p,V and T)	**M1**
	where T is thermodynamic temperature	**A1**
2(a)(ii)	temperature = –273.15 °C	**A1**
2(b)(i)	$pV = NkT$	**C1**
	$N = (1.37 \times 10^5 \times 0.640) / (1.38 \times 10^{-23} \times (227 + 273))$	**C1**
	$= 1.27 \times 10^{25}$	**A1**
2(b)(ii)	mass $= 0.0424 / (1.27 \times 10^{25})$ $= 3.34 \times 10^{-27}$ kg	**A1**
2(b)(iii)	$½m\langle c^2\rangle = (3/2)kT$	**C1**
	$3.34 \times 10^{-27} \times v^2 = 3 \times 1.38 \times 10^{-23} \times 500$	**C1**
	$v = 2490$ m s^{-1}	**A1**
	or	
	$pV = ⅓(Nm)\langle c^2\rangle$ and Nm = mass of gas	**(C1)**
	$0.0424 \times v^2 = 3 \times 1.37 \times 10^5 \times 0.640$	**(C1)**
	$v = 2490$ m s^{-1}	**(A1)**
2(c)	sketch: line from (0, 0) to (500, v)	**B1**
	line with decreasing positive gradient throughout	**B1**

© UCLES 2023

Question	Answer	Marks
3(a)	change in internal energy = work done + energy transfer by heating	**C1**
	increase in internal energy = work done on system + energy transferred to the system by heating	**A1**
3(b)(i)	AB change in internal energy: decrease	**B1**
	AB work done on gas: positive	**B1**
	BC change in internal energy: increase	**B1**
	BC work done on gas: zero	**B1**
3(b)(ii)	more work done by gas in CD than is done on gas in AB **or** (no work done on gas in BC and DA so) (overall) gas does work	**B1**
	(overall) change in internal energy is zero	**B1**
	(must be an overall) input of thermal energy	**B1**

© UCLES 2023

Question	Answer	Marks
4(a)(i)	$\omega = 2\pi f$	**C1**
	$f = 9.7 / 2\pi$ $= 1.5$ Hz	**A1**
4(a)(ii)	amplitude = $\sqrt{(11.6)} = 3.4$ cm	**A1**
4(a)(iii)	$a_0 = \omega^2 x_0$	**C1**
	$= 9.7^2 \times 3.4 \times 10^{-2}$ $= 3.2$ m s^{-2}	**A1**
4(b)	sketch: straight line through the origin with negative gradient	**B1**
	line with negative gradient passing through (+3.4, $-a_0$) and (–3.4, $+a_0$)	**B1**
	line with ends at $x = \pm 3.4$ cm and $a = \pm a_0$	**B1**
4(c)	sum of potential energy and kinetic energy is constant	**B1**
	at maximum displacement, kinetic energy is zero **or** at maximum displacement, potential energy is maximum	**B1**
	at zero displacement, kinetic energy is maximum **or** at zero displacement, potential energy is minimum	**B1**

© UCLES 2023

Question	Answer	Marks
5(a)(i)	$Q_A = CV$	**A1**
5(a)(ii)	$E_A = ½CV^2$	**A1**
5(b)(i)	some of the charge transfers to (the plates of) capacitor B	**B1**
	transfer is because the p.d.s across the capacitors are not equal **or** transfer stops when the p.d.s across the capacitors become equal	**B1**
5(b)(ii)	$V_A = V_B$	**M1**
	charge on A + charge on B = CV	**M1**
	$CV_B + 3CV_B = CV$ leading to $V_B = V / 4$	**A1**
	or	
	$C_T = 4C$	**(M1)**
	$Q_T = CV$	**(M1)**
	$V_B = CV / 4C = V / 4$	**(A1)**
5(b)(iii)	$\Delta E = ½CV^2 - nCV^2$, where n is a multiple that is less than ½ **or** total final energy $= ½ \times 4C \times (V / 4)^2$ $= ⅛CV^2$	**C1**
	$\Delta E = ½CV^2 - ⅛CV^2$ $= ⅜CV^2$	**A1**

Question	Answer	Marks
6(a)(i)	product of (magnetic) flux density and area	**M1**
	area perpendicular to the (magnetic) field	**A1**
6(a)(ii)	flux $= B \times \pi r^2$ $= 0.17 \times \pi \times 0.36^2$	**C1**
	$= 6.9 \times 10^{-2}$ Wb	**A1**
6(b)	time for one revolution = 1 / 25 s	**C1**
	e.m.f. = rate of cutting flux **or** $\Delta\Phi / \Delta t$	**C1**
	$= 0.069 \times 25$ $= 1.7$ V	**A1**
6(c)	current (in disc) is perpendicular to magnetic field **or** current causes force to act on disc	**B1**
	force opposes rotation of disc	**B1**
	left-hand rule indicates current is from rim to axle	**B1**

© UCLES 2023

Question	Answer	Marks
7(a)(i)	full-wave (rectification)	**B1**
7(a)(ii)	lower left diode shown pointing left	**B1**
	lower right and upper left diodes shown pointing left	**B1**
7(a)(iii)	arrow indicating current direction in resistor to the right	**B1**
7(b)(i)	sketch: periodic line showing minimum $V_{OUT} = 0$ and maximum $V_{OUT} = +V_0$	**B1**
	line showing peak V_{OUT} at $t = 0$, $0.5T$, $1.0T$, $1.5T$ and $2.0T$, with V_{OUT} going to zero half-way in between each peak	**B1**
	line showing correct modulated sine shape	**B1**
7(b)(ii)	sketch: sinusoidal curve with troughs sitting on the time axis	**B1**
	peak power at $t = 0$, $0.5T$, $1.0T$, $1.5T$ and $2.0T$ and zero power half-way in between each peak	**B1**
7(b)(iii)	same power-time graph with or without rectification, so same V_{rms} **or** V^2-time graph is same for both V_{OUT} and V_{IN}, so same V_{rms} **or** power does not depend on sign of V, so same V_{rms}	**B1**

© UCLES 2023

Question	Answer	Marks
8(a)	transition (emits) (one) photon with energy equal to the difference in energy between the two levels	**B1**
	frequency of radiation corresponds to energy of photon	**B1**
8(b)(i)	line to the left of the pair in Fig. 8.2, labelled A	**B1**
	larger gap between line A and the nearest of the pair in Fig. 8.2 than between the lines in the pair	**B1**
8(b)(ii)	line to the left of both the pair in Fig. 8.2 and line A, labelled B	**B1**
	larger gap between line B and line A than between line A and the nearest one of the pair in Fig. 8.2	**B1**
8(c)	$E = hf$	**C1**
	$E_3 = E_1 + h(f_A + f_B)$	**A1**

© UCLES 2023

Question	Answer	Marks
9(a)	difference between mass of nucleus and (total) mass of nucleons	**M1**
	when infinitely separated	**A1**
9(b)(i)	neutron	**B1**
9(b)(ii)	$E = \Delta m\, c^2$	**C1**
	Δm = (0.030377 – 0.002388 – 0.009105)u (= 0.018884u)	**C1**
	energy release = $(0.030377 - 0.002388 - 0.009105) \times 1.66 \times 10^{-27} \times (3.00 \times 10^8)^2 = 2.8 \times 10^{-12}$ J	**A1**
9(c)(i)	number of atoms per unit time = $(1.4 \times 10^{28}) / (2.8 \times 10^{-12})$ (= 5.0×10^{39} s^{-1})	**C1**
	mass of one atom = $4 \times 1.66 \times 10^{-27}$ or $(4 \times 10^{-3}) / (6.02 \times 10^{23})$ (= 6.64×10^{-27} kg)	**C1**
	mass per unit time = $6.64 \times 10^{-27} \times 5.0 \times 10^{39}$ = 3.3×10^{13} kg s^{-1}	**A1**
9(c)(ii)	$L = 4\pi\sigma r^2 T^4$ $1.4 \times 10^{28} = 4\pi \times 5.67 \times 10^{-8} \times (2.3 \times 10^9)^2 \times T^4$	**C1**
	T = 7800 K	**A1**

© UCLES 2023

Question	Answer	Marks
10(a)(i)	electrons	**B1**
10(a)(ii)	electrons are decelerated / stopped on impact with the target	**B1**
	(kinetic) energy lost by electrons emitted as (X-ray) photons	**B1**
10(a)(iii)	$eV = hc / \lambda$	**C1**
	$\lambda = (6.63 \times 10^{-34} \times 3.00 \times 10^{8}) / (1.60 \times 10^{-19} \times 5800)$	**C1**
	$= 2.14 \times 10^{-10}$ m	**A1**
10(b)	$I = I_0 \exp(-\mu x)$	**C1**
	$I_T / I_0 = \exp(-(1.4 \times 2.8))$ $= 0.020$	**C1**
	% absorbed $= (1.000 - 0.0198) \times 100$ $= 98\%$	**A1**

© UCLES 2023