Cambridge Assessment International Education

Cambridge International AS & A Level

PHYSICS **9702/43**

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	<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)	$F = (Gm_1m_2) / r^2$	**M1**
	where G is the gravitational constant	**A1**
1(b)	gravitational force provides the centripetal force	**B1**
	$mR\omega^2 = GMm / R^2$ **and** $\omega = 2\pi / T$ **or** $mv^2 / R = GMm / R^2$ **and** $v = 2\pi R / T$ **or** $4\pi^2 mR / T^2 = GMm / R^2$	**M1**
	correct completion of algebra to get $T^2 = (4\pi^2 / GM) R^3$, with identification of $(4\pi^2 / GM)$ as k	**A1**
1(c)(i)	$(24 \times 3600)^2 = (4\pi^2 \times R^3) / (6.67 \times 10^{-11} \times 6.0 \times 10^{24})$	**C1**
	$R = 4.2 \times 10^7$ m	**A1**
1(c)(ii)	(orbit) must be above the Equator	**B1**
	(direction) must be from west to east	**B1**

Question	Answer	Marks
2(a)	• resistance of a metal • volume of a gas at constant pressure • e.m.f. of a thermocouple *Any two points, 1 mark each*	**B2**
2(b)(i)	$Q = mc\Delta T$	**C1**
	evidence of realisation that *Q* lost by water = *Q* gained by mercury	**C1**
	$18.7 \times 4.18 \times (37.4 - T) = 6.94 \times 0.140 \times (T - 23.0)$	**C1**
	$T = 37.2\,°C$	**A1**
2(b)(ii)	use a liquid with a lower (specific) heat capacity (than mercury) **or** use a smaller mass of mercury	**B1**
2(c)(i)	depends on properties of a real substance	**B1**
	0 °C is not absolute zero	**B1**
2(c)(ii)	ideal gas	**B1**

Question	Answer	Marks
3(a)	$a = -\omega^2 x$	M1
	a = acceleration, x = displacement from equilibrium position and ω = angular frequency	A1
3(b)(i)	$x_0 = 0.12$ m	A1
3(b)(ii)	$v = \omega\sqrt{(x_0^2 - x^2)}$ two (x, v) pairs correctly read from Fig. 3.2 (one may be (x_0, 0) or value of x_0 from **(i)**)	C1
	e.g. $0.20 = \omega\sqrt{(0.12^2 - 0)}$ leading to $\omega = 1.7$ rad s^{-1}	A1
3(b)(iii)	$E = ½M\omega^2 x_0^2$	C1
	$0.050 = ½ \times M \times 1.67^2 \times 0.12^2$ $M = 2.5$ kg	A1
	or	
	$(E_K)_{max} = ½Mv_0^2$	(C1)
	$0.050 = ½ M \times 0.20^2$ $M = 2.5$ kg	(A1)
3(c)(i)	loss of (total) energy (of system)	B1
	due to resistive forces	B1
3(c)(ii)	closed loop surrounding the origin with maximum x at ± 0.060 m passing through $v = 0$	B1
	maximum velocity shown as ± 0.10 m s^{-1} passing through $x = 0$	B1

Question	Answer	Marks
4(a)	(field line indicates) direction of force	B1
	force on a positive charge	B1
4(b)(i)	one straight line perpendicular to plates, starting on one plate and finishing on the other	B1
	five straight lines perpendicular to plates between the plates, uniformly spaced	B1
	downwards arrows on lines	B1
4(b)(ii)	$E = V / d$	C1
	$= 2400 / 0.046$ $= 5.2 \times 10^4$ N C^{-1}	A1
4(c)(i)	smooth curve in region of field and straight line outside field	B1
	direction of deflection shown as downwards in region of field	B1
4(c)(ii)	helium nucleus has double the charge but four times the mass	B1
	velocity parallel to plates same and acceleration perpendicular to plates smaller (for helium)	B1
	final speed is lower (for helium)	B1

Question	Answer	Marks
5(a)(i)	$Q = CV$	**C1**
	$Q_0 = 24 \times 470 \times 10^{-6}$ $= 0.011$ C	**A1**
5(a)(ii)	$I_0 = 24 / 5600$ $= 4.3 \times 10^{-3}$ A	**A1**
5(a)(iii)	$\tau = RC$	**C1**
	$= 5600 \times 470 \times 10^{-6}$ $= 2.6$ s	**A1**
5(a)(iv)	line with negative gradient throughout passing through (0, I_0)	**B1**
	exponential decay curve asymptotic to t-axis	**B1**
5(b)(i)	current in wire P gives rise to a magnetic field	**B1**
	as current (in P) changes, wire Q cuts (magnetic) flux (of wire P)	**B1**
	cutting magnetic flux causes induced e.m.f. (across Q)	**B1**
5(b)(ii)	sketch shows line with a negative gradient throughout	**B1**

Question	Answer	Marks
6(a)(i)	PQRS and WXYZ	**B1**
6(a)(ii)	force on charge carriers is perpendicular to both (magnetic) field and current	**B1**
	as charge carriers are deflected to one side, an electric field is set up	**B1**
	(steady V_H when) electric and magnetic forces on charge carriers are equal (and opposite)	**B1**
6(b)(i)	*n*: number density of charge carriers	**B1**
	t: distance PW (or SZ or QX or RY)	**B1**
	q: charge on each charge carrier	**B1**
6(b)(ii)	V_H inversely proportional to *t*	**B1**
	(so *t* needs to be small for) V_H to be large enough to measure	**B1**

Question	Answer	Marks
7(a)(i)	peak voltage = $4.2 \times \sqrt{2}$ (= 5.9 V)	**B1**
	power = V^2 / R $= 5.9^2 / 760 = 0.046$ W or 46 mW	**A1**
7(a)(ii)	sketch shows peak(s) in power at 46 mW	**B1**
	correct shape (sinusoidal wave sitting on *t*-axis)	**B1**
	four cycles of repeating pattern shown, with $P = 0$ at 0, 10, 20, 30, 40 μs	**B1**
7(a)(iii)	line is symmetrical about 23 mW	**B1**
7(b)(i)	(alternating p.d. makes) the crystal vibrate	**B1**
	vibrations (of crystal) causes air to vibrate	**B1**
	frequency is in ultrasound range	**B1**
7(b)(ii)	(air makes) crystal vibrate, which causes an e.m.f. to be generated across the (second) crystal	**B1**

Question	Answer	Marks
8(a)	photon energy (to remove electron)	**B1**
	minimum energy to remove electron **or** energy to remove electron from surface **or** energy to remove electron with zero kinetic energy	**B1**
8(b)(i)	photon energy = hf	**C1**
	number per unit time = $8.36 \times 10^{-3} / (1.36 \times 10^{15} \times 6.63 \times 10^{-34})$ $= 9.27 \times 10^{15}\ s^{-1}$	**A1**
8(b)(ii)	$hf = \Phi + E_{MAX}$	**C1**
	$\Phi = (1.36 \times 10^{15} \times 6.63 \times 10^{-34}) - (3.09 \times 10^{-19})$ $= 5.93 \times 10^{-19}\ J$	**A1**
8(c)(i)	greater photon energy (and same work function)	**M1**
	so maximum kinetic energy is increased	**A1**
8(c)(ii)	(greater photon energy and same power so) lower number of photons (per unit time)	**M1**
	(each electron absorbs one photon) so lower rate of emission	**A1**

Question	Answer	Marks
9(a)	total power of radiation emitted (by the star)	**B1**
9(b)(i)	$F = L / (4\pi d^2)$	**C1**
	$= 9.86 \times 10^{27} / [4\pi \times (8.14 \times 10^{16})^2]$ $= 1.18 \times 10^{-7}$ W m^{-2}	**A1**
9(b)(ii)	$L = 4\pi\sigma r^2 T^4$ $9.86 \times 10^{27} = 4 \times \pi \times 5.67 \times 10^{-8} \times r^2 \times 9830^4$	**C1**
	radius = 1.22×10^9 m	**A1**
9(c)	wavelength of peak intensity determined (from spectrum of star)	**B1**
	wavelength of peak intensity from object of known temperature determined	**B1**
	Wien's displacement law used **or** wavelength of peak intensity inversely proportional to temperature	**B1**

Question	Answer	Marks
10(a)(i)	cannot predict when a (particular) nucleus will decay **or** cannot predict which nucleus will decay next	**B1**
10(a)(ii)	not affected by external / environmental factors	**B1**
10(b)(i)	line fluctuates **or** trend is a straight line	**B1**
10(b)(ii)	straight line of best fit drawn on Fig. 10.1	**B1**
10(b)(iii)	$M = M_0 \exp(-\lambda t)$ so $\ln M = \ln M_0 - \lambda t$ so gradient = $-\lambda$ (and magnitude of gradient = λ)	**B1**
10(b)(iv)	gradient = (–) (8.0 – 4.8) / (11.6 – 0) (*allow any correct pair of values from Fig. 10.1*)	**C1**
	$\lambda = 0.28\ s^{-1}$	**A1**
10(b)(v)	half-life = 0.693 / λ = 0.693 / 0.28 = 2.5 s	**A1**
10(c)	(for reaction to occur,) energy is released	**B1**
	energy release comes from fall in mass so total mass of products must be less (than mass of carbon-15)	**B1**