Cambridge International AS & A Level

PHYSICS **9702/41**

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 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.

Question	Answer	Marks
1(a)	work done per unit mass	**B1**
	work done moving mass from infinity (to the point)	**B1**
1(b)(i)	potential is zero at infinity	**B1**
	work is done **by** (two) masses in moving them **closer** together **or** work is done **on** (two) masses in moving them **apart**	**B1**
1(b)(ii)	magnitude of potential shown as 4Φ	**B1**
	potential negative **and** shown as a multiple of $-\Phi$ [potential = -4Φ if fully correct]	**B1**
1(b)(iii)	field strength at X: $\Phi / 4R$	**A1**
	field strength at Y: $4\Phi / R$	**A1**
	potential energy at X: $-M\Phi$	**A1**
	potential energy at Y: $-8M\Phi$	**A1**

Question	Answer	Marks
2(a)(i)	0 K	**B1**
2(a)(ii)	(measurement) depends on properties of the liquid	**B1**
2(b)(i)	• resistivity varies with temperature • variation with temperature is linear • unique value of resistivity for each (different value of) temperature *Any two points, 1 mark each*	**B2**
2(b)(ii)	thermometer has high heat capacity/specific heat capacity **or** energy transfer needed for thermometer to reach correct temperature **or** thermometer takes time to reach the correct temperature	**B1**
2(b)(iii)	thermocouple	**B1**
2(c)	(variation is) inverse **or** (variation is) non-linear	**B1**

Question	Answer	Marks
3(a)(i)	gas for which $pV \propto T$	**M1**
	where T is thermodynamic temperature	**A1**
3(a)(ii)	no intermolecular forces	**B1**
	(so) potential energy is zero	**B1**
3(b)(i)	$pV = NkT$	**C1**
	$N = (2.0 \times 10^5 \times 0.26) / (1.38 \times 10^{-23} \times 290)$ $= 1.3 \times 10^{25}$	**A1**
3(b)(ii)	$E_K = (3/2)\ kT$	**C1**
	$E_K = (3/2) \times 1.38 \times 10^{-23} \times 290$ $= 6.0 \times 10^{-21}$ J	**A1**
3(b)(iii)	internal energy = total KE + PE of molecules **or** PE = 0 so internal energy = total KE of molecules	**B1**
	internal energy $= 1.3 \times 10^{25} \times 6.0 \times 10^{-21}$ $= 7.8 \times 10^4$ J	**A1**
3(c)	straight line with positive gradient	**B1**
	line passing through the origin	**B1**

Question	Answer	Marks
4(a)	oscillation (of object) at maximum amplitude	**B1**
	when driving frequency = natural frequency (of system)	**B1**
4(b)(i)	light damping	**B1**
4(b)(ii)	oscillations (of ball) lose energy	**B1**
	(due to) resistive forces (acting on ball)	**B1**
4(b)(iii)	frequency = 1 / 0.25 = 4.0 Hz	**A1**
4(c)	curve showing a maximum amplitude at a single non-zero frequency	**B1**
	single maximum amplitude shown at 4.0 Hz	**B1**

Question	Answer	Marks
5(a)	force per unit charge	B1
	force on positive charge	B1
5(b)(i)	four straight vertical parallel lines, approximately evenly spaced	B1
	arrows downwards	B1
5(b)(ii)	$E = V / d$	C1
	$E = 430 / 0.067$ $= 6.4 \times 10^3$ N C^{-1}	A1
5(b)(iii)	smooth curve within plates and straight lines outside plates	B1
	direction of deflection shown as upwards	B1
5(c)(i)	into the page	B1
5(c)(ii)	forces are in opposite directions	B1
	(undeviated) when (magnitudes of) forces are equal	B1
5(c)(iii)	$Eq = Bqv$	C1
	$B = E / v = (6.4 \times 10^3) / (2.6 \times 10^7)$ $= 2.5 \times 10^{-4}$ T	A1

Question	Answer	Marks
6(a)	• p.d. across capacitor proportional to charge on capacitor • p.d. across capacitor = p.d. across resistor • current in resistor proportional to p.d. across resistor • current in resistor = rate of decrease of charge on capacitor *Any two points, 1 mark each*	**B2**
	charge proportional to current so rate of decrease of current decreases as current decreases (therefore exponential shape)	**B1**
6(b)(i)	$R = V / I$ $= 12 / (0.13 \times 10^{-3})$	**C1**
	$= 9.2 \times 10^{4}\ \Omega$	**A1**
6(b)(ii)	correct read-off of at least one pair of values for I and t	**C1**
	attempted read-off of t when $I = 0.048$ mA **or** substitution of a correct pair of values of I and t into $I = 0.13 \exp(-t / \tau)$	**C1**
	$\tau = 4.3$ s	**A1**
6(c)	$\tau = RC$	**C1**
	$C = \tau / R = 4.3 / (9.2 \times 10^{4})$ $= 4.7 \times 10^{-5}$ F	**A1**

Question	Answer	Marks
7(a)	rectification (of the input voltage)	**M1**
	full-wave	**A1**
7(b)(i)	$P = V^2 / R$ **or** maximum V = 9.0 V	**C1**
	$P_{MAX} = 9.0^2 / 370 = 0.22$ W	**A1**
7(b)(ii)	sinusoidal shape with minima sitting on the time axis	**B1**
	correct frequency and phase, with minima at 0, 0.02, 0.04, 0.06 and 0.08 s and maxima at 0.01, 0.03, 0.05 and 0.07 s	**B1**
	all maxima shown at 0.22 W	**B1**
7(b)(iii)	mean power = peak power / 2 = 0.22 / 2 = 0.11 W	**A1**
7(c)	power–time graph is identical	**B1**
	(so) mean powers are equal	**B1**

Question	Answer	Marks
8(a)	packet / quantum of <u>energy</u>	**M1**
	of electromagnetic radiation	**A1**
8(b)(i)	electron(s)	**B1**
8(b)(ii)	X labelled – **and** Y labelled +	**B1**
8(c)(i)	0.032 MeV	**A1**
8(c)(ii)	momentum = E / c	**C1**
	momentum = $(0.032 \times 1.60 \times 10^{-13}) / (3.00 \times 10^{8})$ = 1.7×10^{-23} N s	**A1**
8(c)(iii)	$E = hf$ **and** $\lambda = c / f$	**C1**
	$\lambda = hc / E$ = $(6.63 \times 10^{-34} \times 3.00 \times 10^{8}) / (0.032 \times 1.60 \times 10^{-13})$	**C1**
	$\lambda = 3.9 \times 10^{-11}$ m	**A1**
8(d)	discussion of bone and soft tissue	**B1**
	discussion of different attenuation (coefficients) **or** discussion differences in penetration / transmission / absorption	**B1**
	<u>transmitted intensities</u> (by bone and tissue) are very different (leading to good contrast images)	**B1**

Question	Answer	Marks
9(a)	time for activity (of sample) to halve	**B1**
9(b)(i)	activity (of X at time *t*)	**B1**
9(b)(ii)	• Y is a stable isotope • total number of nuclei is constant • half-life (of X) is 13.6 s • decay constant (of X) is 0.051 s^{-1} • amount (of X) at $t = 0$ is 0.066 mol • activity (of X) at $t = 0$ is 2.0×10^{21} Bq *Any three points, 1 mark each*	**B3**
9(c)	mass of 1 nucleus = $(7.3 \times 10^{-4}) / (4.0 \times 10^{22})$	**C1**
	nucleon number = mass of nucleus / (1.66×10^{-27})	**C1**
	= $(7.3 \times 10^{-4}) / (4.0 \times 10^{22} \times 1.66 \times 10^{-27})$ = 11 **and** given as an integer	**A1**

Question	Answer	Marks
10(a)(i)	total power	**B1**
	power radiated (by the star)	**B1**
10(a)(ii)	standard candle has known luminosity	**B1**
	radiant flux intensity measured by observer	**B1**
	(distance calculated using) $F = L / 4\pi d^2$	**B1**
10(b)(i)	luminosity $= 4\pi\sigma r^2 T^4$ $= 4\pi \times 5.67 \times 10^{-8} \times (6.96 \times 10^8)^2 \times 5780^4$	**C1**
	$= 3.85 \times 10^{26}$ W	**A1**
10(b)(ii)	$\lambda_{MAX} T$ = constant	**C1**
	temperature $= (5780 \times 501) / 624$ $= 4640$ K	**A1**