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Cambridge International AS & A Level

PHYSICS **9702/41**

Paper 4 A Level Structured Questions **October/November 2025**

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 2025 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 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.

Annotations guidance for centres

Examiners use a system of annotations as a shorthand for communicating their marking decisions to one another. Examiners are trained during the standardisation process on how and when to use annotations. The purpose of annotations is to inform the standardisation and monitoring processes and guide the supervising examiners when they are checking the work of examiners within their team. The meaning of annotations and how they are used is specific to each component and is understood by all examiners who mark the component.

We publish annotations in our mark schemes to help centres understand the annotations they may see on copies of scripts. Note that there may not be a direct correlation between the number of annotations on a script and the mark awarded. Similarly, the use of an annotation may not be an indication of the quality of the response.

The annotations listed below were available to examiners marking this component in this series.

Annotations

Annotation	Meaning
AE	arithmetic error
BOD	benefit of the doubt given
CON	contradiction in response, mark not awarded
✓	correct point or mark awarded
ECF	error carried forward applied
SF	error in number of significant figures
I	incorrect or insufficient point ignored while marking the rest of the response
XP	incorrect physics
✗	incorrect point or mark not awarded
^	information missing or insufficient for credit

Annotation	Meaning
MO	mandatory mark not awarded
SEEN	point has been noted, but no credit has been given or blank page seen
POT	power of ten error
TE	transcription error

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>mandatory</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)	velocity and acceleration both have constant magnitude	B1
	velocity is (always) perpendicular to acceleration	B1
1(b)(i)	$v = R\omega$	A1
1(b)(ii)	$a = R\omega^2$ **or** $a = v^2 / R$	C1
	$a = v\omega$	A1
1(c)(i)	$x = R \sin \theta$	A1
1(c)(ii)	$\theta = \omega t$	A1
1(c)(iii)	clear substitution of $\theta = \omega t$ into $x = R \sin \theta$ leading to $x = R \sin \omega t$	A1
1(c)(iv)	equation is of the form $x = x_0 \sin \omega t$ (so simple harmonic motion)	B1
1(d)(i)	amplitude = 0.46 / 2 = 0.23 m	A1
1(d)(ii)	$\omega = 2\pi / T$	C1
	period = 2π / 1.9 = 3.3 s	A1

Question	Answer	Marks
1(d)(iii)	$a_0 = \omega^2 x_0$	C1
	$= 1.9^2 \times 0.23$ $= 0.83\ \text{m s}^{-2}$	A1
1(e)	shadow on screen, labelled A, above left-hand edge of the circular path	B1

Question	Answer	Marks
2(a)	work done on / by system	B1
	thermal energy supplied to / removed from system	B1
2(b)(i)	no thermal energy transferred to / from system (due to lack of time)	B1
	work is done on the gas to compress it / to decrease its volume	B1
	internal energy increases so temperature increases	B1
2(b)(ii)	(during vaporisation) molecular separation increases	B1
	(heating causes) potential energy of molecules to increase	B1
	kinetic energy of molecules unchanged so temperature unchanged	B1

Question	Answer	Marks
3(a)	force per unit mass	**B1**
3(b)(i)	$F = GMm / x^2$	**C1**
	$g = F / m$ $g = [GMm / x^2] / m = GM / x^2$ **and** G = gravitational constant	**A1**
3(b)(ii)	arrow drawn at P pointing directly towards the point mass	**B1**
3(b)(iii)	fields are in opposite directions	**B1**
	field strength at Q is four times the field strength at P	**B1**
3(c)	line starting at (R, $-g_0$) and ending at ($L - R$, $+g_0$)	**B1**
	line passing through (L / 2, 0)	**B1**
	curve becoming shallower from R to (L / 2) and then steeper from (L / 2) to ($L - R$)	**B1**

Question	Answer	Marks
4(a)(i)	temperature = –273.15 °C	**A1**
4(a)(ii)	temperature = 0 K	**A1**
4(b)(i)	gas is ideal	**B1**
4(b)(ii)	$pV = NkT$	**C1**
	$N = 270 / (8.0 \times 10^{-21})$ $= 3.4 \times 10^{22}$	**A1**
4(b)(iii)	$n = (3.4 \times 10^{22}) / (6.02 \times 10^{23})$ $= 0.056$ mol	**A1**
4(c)	$½\, m\langle c^2\rangle = (3 / 2)\, kT$	**C1**
	$½ \times m \times 1900^2 = 1.5 \times 8.0 \times 10^{-21}$ ($m = 6.65 \times 10^{-27}$ kg)	**C1**
	$m = (6.65 \times 10^{-27}) / (1.66 \times 10^{-27})$	**C1**
	= 4.0 u	**A1**

Question	Answer	Marks
5(a)	work done per unit charge	B1
	work (done) moving positive charge from infinity (to the point)	B1
5(b)(i)	potential (due to proton) = $(1.60 \times 10^{-19}) / (4\pi \times 8.85 \times 10^{-12} \times 10 \times 10^{-12})$ **or** potential (due to electron) = $(-1.60 \times 10^{-19}) / (4\pi \times 8.85 \times 10^{-12} \times 110 \times 10^{-12})$	C1
	$V = [(1.60 \times 10^{-19}) / (4\pi \times 8.85 \times 10^{-12})] \times [(10^{-1} - 110^{-1}) \times 10^{12}] = 130\ \text{V}$	A1
5(b)(ii)	$V = [(1.60 \times 10^{-19}) / (4\pi \times 8.85 \times 10^{-12})] \times [(30^{-1} - 90^{-1}) \times 10^{12}]$	C1
	= (+) 32 V	A1
5(b)(iii)	cross drawn midway between the electron and the proton	B1
5(b)(iv)	line from (10, +130) to (110, –130)	B1
	curve getting shallower until x = 60 pm, crossing V = 0 at (60, 0) and then getting steeper after x = 60 pm	B1
	curve passing through (30, ±32) and (90, ±32)	B1

Question	Answer	Marks
6(a)	series charges: $Q_S = Q_1 = Q_2$	B1
	series p.d.s: $V_S = V_1 + V_2$	B1
	parallel charges: $Q_S = Q_1 + Q_2$	B1
	parallel p.d.s: $V_S = V_1 = V_2$	B1
6(b)(i)	$E = ½ CV^2$	C1
	p.d. = $[(2 \times 19 \times 10^{-3}) / (470 \times 10^{-6})]^{½}$ = 9.0 V	A1
6(b)(ii)	$E = Q^2 / 2C$ **or** $C = Q / V$	C1
	$Q = (19 \times 10^{-3} \times 2 \times 470 \times 10^{-6})^{½}$ **or** $Q = 470 \times 10^{-6} \times 9.0$ $Q = 4.2 \times 10^{-3}$ C	A1
6(b)(iii)	total charge unchanged	C1
	total capacitance = $(470 + 180) \times 10^{-6}$ (F)	C1
	$E = Q^2 / 2C = (4.23 \times 10^{-3})^2 / (2 \times 650 \times 10^{-6})$ (= 0.014 J) E = 14 mJ	A1

Question	Answer	Marks
7(a)	(induced) e.m.f. is (directly) proportional to rate	**M1**
	of change of (magnetic) flux (linkage)	**A1**
7(b)(i)	flux = e.m.f. × time	**C1**
	flux = 0.54 × 15 = 8.1 Wb	**A1**
7(b)(ii)	$\Phi = BA$	**C1**
	area = 8.1 / (38 × 10^{-6}) = 2.1 × 10^{5} m^2	**A1**
7(b)(iii)	area = speed × time × width	**C1**
	v = (2.1 × 10^5) / (15 × 68) = 210 m s^{-1}	**A1**
7(b)(iv)	opposing force (due to current in wings) must be backwards	**B1**
	from Fleming's left-hand rule, current (in wings) must be from Q to P	**B1**
	current is from – to + inside an e.m.f. source so P is at higher potential	**B1**

Question	Answer	Marks
8(a)	packet / quantum of <u>energy</u>	**M1**
	of electromagnetic radiation	**A1**
8(b)(i)	$E = c^2 \Delta m$	**C1**
	$\Delta m = (4.274 \times 10^6 \times 1.60 \times 10^{-19}) / (1.66 \times 10^{-27} \times (3.00 \times 10^8)^2)$ (= 0.00458 u)	**C1**
	m = 233.915174 + 4.000407 + 0.00458 = 237.92016 u	**A1**
8(b)(ii)	$E = hc / \lambda$ **or** $E = hf$ **and** $c = f\lambda$	**C1**
	$(4.274 - 4.200) \times 1.60 \times 10^{-13} = (6.63 \times 10^{-34} \times 3.00 \times 10^8) / \lambda$	**C1**
	$\lambda = 1.7 \times 10^{-11}$ m	**A1**
8(b)(iii)	(true) energy of gamma photon is smaller so (true) wavelength is larger	**B1**
8(c)	(anti)neutrinos are emitted during beta decay	**B1**
	particles emitted during beta decay carry varying amounts of energy, so energy of gamma photon is also variable (between decays)	**B1**

Question	Answer	Marks
9(a)	temperature inversely proportional to wavelength	**M1**
	temperature is thermodynamic temperature of surface of star **and** wavelength is the wavelength at which maximum emission rate from star occurs	**A1**
9(b)	*Any three points from:* • (surface) temperature of star X = 7000 K **or** star X has a higher temperature than the Sun • star X has a higher luminosity than the Sun • luminosity of star X = 2.7×10^{27} W • radius of star X = 1.3×10^{9} m	**B3**
9(c)	light (from star X) is redshifted	**B1**
	wavelength of peak emission rate would be greater (using observed data)	**B1**

Question	Answer	Marks
10(a)	product of density and speed	**M1**
	speed of sound in medium (and density of the medium)	**A1**
10(b)	ultrasound waves cause crystal to vibrate	**B1**
	vibrations (of crystal) cause induced e.m.f. (across crystal)	**B1**
10(c)(i)	intensity reflection coefficient= $(40.4 – 1.48)^2 / (40.4 + 1.48)^2$	**C1**
	= 0.86	**A1**
10(c)(ii)	*Z* values are very similar	**B1**
	(almost) all the ultrasound will be transmitted **or** (almost) none of the ultrasound will be reflected	**B1**