CAMBRIDGE
International Education

Cambridge International AS & A Level

PHYSICS **9702/42**

Paper 4 A Level Structured Questions **October/November 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 October/November 2024 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.

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)(i)	$v = r\omega$	C1
	$= 0.85 \times 140$ $= 120\ \text{m s}^{-1}$	A1
1(a)(ii)	$a = r\omega^2$ **or** $a = v^2 / r$	C1
	$a = 0.85 \times 140^2$ **or** $120^2 / 0.85$ $= 1.7 \times 10^4\ \text{m s}^{-2}$	A1
1(b)(i)	direction of (induced) e.m.f.	M1
	is such as to (produce effects that) oppose the change that caused it	A1
1(b)(ii)	$T = 2\pi / \omega$ $= 2\pi / 140 = 0.045\ \text{s} = 45\ \text{ms}$	A1
1(b)(iii)	$\Phi = BA$	C1
	$= 0.18 \times \pi \times 0.85^2$	C1
	$= 0.41\ \text{Wb}$	A1
1(b)(iv)	$E = \Phi / t$	C1
	$= 0.41 / 0.045$ $= 9.1\ \text{V}$	A1
1(b)(v)	force (on spoke) must be anticlockwise, so current is from A to X (by Fleming's left hand rule), so X is at the higher potential	B1

Question	Answer	Marks
2(a)	force per unit mass	**B1**
2(b)(i)	$g = GM / x^2$	**C1**
	$= (6.67 \times 10^{-11} \times 1.99 \times 10^{30}) / (1.47 \times 10^{11})^2$ $= 6.14 \times 10^{-3}$ N kg^{-1}	**A1**
2(b)(ii)	$E_P = -GMm / x$ $= -(6.67 \times 10^{-11} \times 1.99 \times 10^{30} \times 2.63) / (1.47 \times 10^{11})$	**C1**
	$= -2.37 \times 10^9$ J	**A1**
2(c)(i)	$F = L / 4\pi x^2$	**C1**
	($g = GM / x^2$ and so) $x^2 = GM / g$ **and** $x^2 = L / 4\pi F$	**M1**
	elimination of x and subsequent algebra shown leading to $g = 4\pi GMF / L$	**A1**
2(c)(ii)	correct read-off of pair of values of g and F and full substitution of values of g, G, M and F into equation e.g. $L = (4\pi \times 6.67 \times 10^{-11} \times 1.99 \times 10^{30} \times 1.83 \times 10^3) / (8.0 \times 10^{-3})$	**C1**
	$L = 3.8 \times 10^{26}$ W	**A1**
2(c)(iii)	$L = 4\pi\sigma r^2 T^4$ $3.8 \times 10^{26} = (4\pi \times 5.67 \times 10^{-8} \times 5780^4) \times r^2$	**C1**
	$r = 6.9 \times 10^8$ m	**A1**

Question	Answer	Marks
3(a)	(thermal) energy per unit mass (to cause change of state)	**B1**
	(thermal) energy to change state at constant temperature	**B1**
3(b)(i)	$W = p\Delta V$	**C1**
	$= 1.0 \times 10^5 \times 0.017 = 1700$ J = 1.7 kJ	**A1**
3(b)(ii)	$\Delta U = Q + W$	**C1**
	$Q = 17.6 + 1.7$ = 19.3 kJ	**A1**
3(b)(iii)	mass $= 710 \times 7.2 \times 10^{-5}$ (= 0.051 kg)	**C1**
	$L = 19.3 / 0.051$ = 380 kJ kg^{-1}	**A1**
3(c)	fusion involves (much) smaller volume change (than vaporisation)	**B1**
	smaller change in intermolecular spacing so smaller change in internal energy	**B1**
	negligible work done (by substance during fusion) so L_F is less (than L_V)	**B1**

Question	Answer	Marks
4(a)	• molecules are in (constant) random motion • (all) collisions between molecules are (perfectly) elastic • no forces between molecules (except during collisions) • volume of molecules is negligible (compared with volume of gas) • collisions involving molecules are instantaneous *Any three points, 1 mark each*	**B3**
4(b)	• molecules collide with (walls of) container • momentum of molecule changes during collision (with walls) • change in momentum is caused by force on molecule by wall • molecule experiences force from wall so molecule exerts force on wall • many molecules exerting force across the area of the wall leads to pressure (on the wall) *Any three points, 1 mark each*	**B3**
4(c)	*Any three bulleted points from:* • both gases are ideal *Up to 2 points from:* • mass of one molecule of gas X is 3.3×10^{-27} kg • mass of one molecule of gas Y is 6.6×10^{-27} kg • mass of one molecule of gas Y is double mass of one molecule of gas X *Up to 2 points from:* • sample of X contains 0.27 mol / 1.6×10^{23} molecules • sample of Y contains 0.81 mol / 4.9×10^{23} molecules • sample of Y contains treble the amount of gas / number of molecules as sample of X *Up to 2 points from:* • mass of gas X is 5.4×10^{-4} kg • mass of gas Y is 3.2×10^{-3} kg • mass of gas Y is six times mass of gas X	**B3**

Question	Answer	Marks
5(a)	arrow from sphere, perpendicular to string, pointing left and down	**B1**
5(b)(i)	amplitude = 0.016 m	**A1**
5(b)(ii)	angular frequency = $2\pi / T$	**C1**
	$= 2\pi / 0.40$ $= 16 \text{ rad s}^{-1}$	**A1**
5(b)(iii)	total energy $= ½m\omega^2 x_0^2$	**C1**
	$= ½ \times 0.15 \times 15.7^2 \times 0.016^2$ $= 4.7 \times 10^{-3}$ J	**A1**
5(c)	dome-shaped curve starting and ending on the x-axis, with peak at $x = 0$	**B1**
	maximum E_K shown as 4.7×10^{-3} J	**B1**
	minimum x shown as –0.016 m and maximum x shown as +0.016 m at the ends of the line	**B1**

Question	Answer	Marks
6(a)	(electric) force is (directly) proportional to product of charges	**B1**
	force (between point charges) is inversely proportional to the square of their separation	**B1**
6(b)	at least four straight, radial lines to/from surface of sphere	**B1**
	at least four straight radial lines drawn, approximately equally spaced	**B1**
	arrows pointing away from the surface of the sphere	**B1**
6(c)(i)	radius = 3.2 cm	**A1**
6(c)(ii)	$E = Q / (4\pi\varepsilon_0 x^2)$	**C1**
	Q = e.g. $2.2 \times 10^5 \times 4\pi \times 8.85 \times 10^{-12} \times 0.032^2$	**C1**
	$= 2.5 \times 10^{-8}$ C	**A1**
6(c)(iii)	• the (positive) charge is all the way around the surface • a charge placed inside the sphere is pulled equally in all directions • if the field was not zero, the charges would move (until field is zero) • electric field lines go from positive charge to negative charge, and there are no negative charges inside the sphere *Any point, 1 mark*	**B1**

<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td rowspan="2">7(a)</td><td>charge / potential (difference)</td><td>M1</td></tr>
<tr><td>charge is charge on one plate, <u>and</u> potential is p.d. between the plates</td><td>A1</td></tr>
<tr><td rowspan="2">7(b)(i)</td><td>straight line starting at the origin</td><td>B1</td></tr>
<tr><td>line with positive gradient ending at (V, Q)</td><td>B1</td></tr>
<tr><td rowspan="2">7(b)(ii)</td><td>work done is the area under the graph</td><td>B1</td></tr>
<tr><td>$W = ½QV$</td><td>A1</td></tr>
<tr><td rowspan="3">7(c)(i)</td><td>final p.d. shown as $V / 4$ for both capacitors</td><td>B1</td></tr>
<tr><td>final charges add together to give Q</td><td>B1</td></tr>
<tr><td>charge on Y = 3 × charge on X (and both charges shown as a multiple of Q)

Fully correct answer:<table><tr><td></td><td>X</td><td>Y</td></tr><tr><td>final p.d.</td><td>$V / 4$</td><td>$V / 4$</td></tr><tr><td>final charge</td><td>$Q / 4$</td><td>$3Q / 4$</td></tr></table></td><td>B1</td></tr>
<tr><td>7(c)(ii)</td><td>less than</td><td>B1</td></tr>
</table>

Question	Answer	Marks
8(a)	number of cycles per unit time	**B1**
8(b)(i)	period = $2\pi / 40\pi$ = 0.050 s = 50 ms	**A1**
8(b)(ii)	sinusoidal curve, starting at (0, 0) and initially increasing from there	**B1**
	periodic line showing 2 cycles with period 50 ms from t = 0 to t = 100 ms	**B1**
	all peaks shown at I = +3.5 A and all troughs shown at I = –3.5 A	**B1**
8(b)(iii)	$I_{r.m.s}$ = $3.5 / \sqrt{2}$ = 2.5 A	**A1**
8(c)	$P = I^2R$	**C1**
	peak power = $3.5^2 \times 680$ (= 8330 W) **or** mean power = $2.47^2 \times 680$ (= 4170 W)	**M1**
	peak and mean powers both calculated correctly, with supporting working, and compared leading to conclusion that mean power is half the peak power	**A1**

Question	Answer	Marks
9(a)	diffraction is characteristic of wave behaviour so shows that electrons can behave like waves	**B1**
9(b)	$qV = ½mv^2$	**C1**
	$p = mv$	**C1**
	$p = m \times \sqrt{(2qV / m)}$ $= \sqrt{(2qVm)}$	**A1**
9(c)	(electrons have) greater momentum <u>so</u> smaller (de Broglie) wavelength	**B1**
	fringes become closer together	**B1**
9(d)(i)	straight line with positive gradient	**B1**
	line with positive gradient passing through the origin	**B1**
9(d)(ii)	Planck constant	**B1**

Question	Answer	Marks
10(a)(i)	cannot predict when a particular <u>nucleus</u> will decay **or** cannot predict which <u>nucleus</u> will decay next	**B1**
10(a)(ii)	(decay is) not affected by external (environmental) factors	**B1**
10(a)(iii)	fluctuations in (measured) count rate	**B1**
10(b)(i)	• large nuclei undergo fission whereas small nuclei undergo fusion • fission involves one nucleus splitting into two (or more) (smaller) nuclei • fusion involves two nuclei joining together to form one (larger) nucleus • fission is (usually) initiated by neutron bombardment • fusion is (usually) initiated by (very) high temperatures *Any three points, 1 mark each*	**B3**
10(b)(ii)	binding energy <u>per nucleon</u> is greatest for intermediate nucleon numbers (may be shown on sketch graph with axes labelled 'binding energy <u>per nucleon</u>' and 'nucleon number')	**B1**
	both fusion and fission involve an increase in binding energy (per nucleon)	**B1**