

Cambridge International AS & A Level

PHYSICS**9702/41**

Paper 4 A Level Structured Questions

October/November 2024

MARK SCHEME

Maximum Mark: 100

Published

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GENERIC MARKING PRINCIPLE 1:

Marks must be awarded in line with:

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- 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.

PUBLISHED**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 'List rule' guidance

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 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.

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.

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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)(i)	(gravitational) force acts perpendicular to direction of motion	B1
	gravitational force provides centripetal acceleration	B1
1(b)(ii)	$(F =) GMm / x^2 = m\omega^2$ and $\omega = 2\pi / T$ or $GMm / x^2 = 4\pi^2 mx / T^2$	M1
	completion of algebra leading to $x^3 = GMT^2 / 4\pi^2$	A1
	clear indication that B = radius of planet and that A = mass (of planet)	B1
1(b)(iii)	gradient = $\sqrt[3]{(4\pi^2 / GA)}$	C1
	e.g. $(1280 - 360) / (12 \times 10^6) = \sqrt[3]{(4\pi^2 / [6.67 \times 10^{-11} \times A])}$	C1
	$A = 1.3 \times 10^{24} \text{ kg}$	A1
	intercept = gradient $\times B$	C1
	e.g. $360 = ((1280 - 360) \times B) / (12 \times 10^6)$ $B = 4.7 \times 10^6 \text{ m}$	A1

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Question	Answer	Marks
2(a)	(thermal) energy per unit mass (to change temperature)	B1
	(thermal) energy per unit change in temperature	B1
2(b)(i)	<i>Any three bulleted points from:</i> - the blocks end up in thermal equilibrium - heat capacity of Y is larger than heat capacity of X - no heat loss to the surroundings <i>Up to 2 points from these six:</i> - initial temperature of X = 85 °C - initial temperature of Y = 25 °C - the temperature change of X = 45 °C - the temperature change of Y = 15 °C - the temperature change in X is three times that in Y - final temperature of both = 40 °C	B3
2(b)(ii)	$\Delta\theta = 45\text{ °C}$ for X and 15 °C for Y	C1
	$mc \times 45 = 1.3 \times m \times 901 \times 15$	C1
	$c = 390\text{ J kg K}^{-1}$	A1

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Question	Answer	Marks
3(a)(i)	number of particles per unit amount of substance	B1
3(a)(ii)	$N_A = R / k$	B1
3(b)(i)	X pressure and Y pressure <u>both</u> = NkT / V	B1
	X amount = N / N_A and Y amount = $2N / N_A$	B1
	X mean-square speed = $3kT / m$ and Y mean-square speed = $3kT / 2m$	B1
	X internal energy = $3NkT / 2$ and Y internal energy = $3NkT$	B1
3(b)(ii)	line passing through the origin and not returning to either axis	B1
	curve with positive decreasing gradient	B1

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Question	Answer	Marks
4(a)	(motion in which) acceleration is (directly) proportional to displacement	B1
	(motion in which): acceleration is (always) in the opposite <u>direction</u> to displacement or acceleration is (always) <u>directed</u> towards a fixed point	B1
4(b)(i)	amplitude = $(9.5 - 3.5) / 2$ = 3.0 cm	A1
4(b)(ii)	$\omega = v_0 / x_0$	C1
	= $9.5 / 3.0 = 3.2 \text{ rad s}^{-1}$	A1
4(b)(iii)	$T = 2\pi / \omega$	C1
	= $2\pi / 3.2$ = 2.0 s	A1
4(b)(iv)	attempted sinusoidal curve starting with a minimum at $t = 0$	B1
	sinusoidal curve of period 2.0 s from $t = 0$ to $t = 6.0$ s	B1
	all peaks shown at $h = 9.5$ cm	B1
	all troughs shown at $h = 3.5$ cm	B1

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Question	Answer	Marks
5(a)	(electric) field equals (electric) potential gradient	M1
	reference to minus sign	A1
5(b)	- for potential to be zero, one potential must be positive and the other potential must be negative - for potential to be zero, the charges must have opposite sign - for field to be zero, the fields (due to X and Y) must be in opposite directions - for field to be zero, the charges must have the same sign - the signs of the charges cannot (simultaneously) be both the same and opposite (so not possible) <i>Any three points, 1 mark each</i>	B3
5(c)(i)	$V_X = (-) Q / 4\pi\epsilon_0 x$ and $V_Y = (-) 2Q / 4\pi\epsilon_0 y$	C1
	$(V_X + V_Y = 0 \text{ so } Q / 4\pi\epsilon_0 x = 2Q / 4\pi\epsilon_0 y \text{ leading to } y = 2x)$	A1
5(c)(ii)	$E_X = Q / 4\pi\epsilon_0 x^2$	A1
5(c)(iii)	$E_Y = 2Q / 4\pi\epsilon_0 (2x)^2$ $(= Q / 8\pi\epsilon_0 x^2)$	C1
	(opposite charges so fields in same direction so magnitudes add): $E = (Q / 4\pi\epsilon_0 x^2) + (Q / 8\pi\epsilon_0 x^2)$ $= 3Q / 8\pi\epsilon_0 x^2$	A1

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Question	Answer	Marks
6(a)(i)	conversion (from a.c.) to d.c.	B1
6(a)(ii)	half-wave: voltage in one direction is removed	B1
	full-wave: voltage in one direction is reversed	B1
6(b)(i)	one gap connected by a single diode and other gap connected directly	B1
	diode drawn (in a circuit) with correct circuit symbol	B1
6(b)(ii)	smoothing	B1
6(c)(i)	$E = \frac{1}{2}CV^2$	C1
	$C = 2 \times 0.041 / 12^2 = 5.7 \times 10^{-4} \text{ F} = 570 \mu\text{F}$	A1
6(c)(ii)	$8.0 = 12.0 \exp(-0.010 / RC)$	C1
	$\ln(8.0 / 12.0) = -0.010 / (R \times 5.7 \times 10^{-4})$	C1
	$R = 43 \Omega$	A1

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Question	Answer	Marks
7(a)	• force per unit length • force per unit current • length / current perpendicular to field <i>1 mark for any two points, 2 marks for all three points</i>	B2
7(b)	concentric circles around the wire (at least two circles needed)	B1
	spacing between circles increases with distance from wire (at least four circles needed)	B1
	arrows showing direction of field is clockwise	B1
7(c)(i)	(each) wire sits in the (magnetic) field created by the other	B1
	current (in one wire) is perpendicular to (magnetic) field (due to other wire) so (magnetic) force acts (on wire)	B1
7(c)(ii)	arrow drawn, starting from X and pointing towards Y, labelled F	B1
7(c)(iii)	(forces have) equal magnitudes	B1
	(forces are in) opposite directions	B1
7(c)(iv)	no change (in the direction of the force) since both the current in X and the field due to Y have reversed	B1

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Question	Answer	Marks
8(a)	photoelectric effect	B1
8(b)(i)	$E = hf$	C1
	work function = $6.63 \times 10^{-34} \times 8.8 \times 10^{14}$ $= 5.8 \times 10^{-19} \text{ J}$	A1
8(b)(ii)	$hf = \phi + \frac{1}{2}mv_{\text{MAX}}^2$	C1
	$6.63 \times 10^{-34} \times 11 \times 10^{14} = (5.8 \times 10^{-19}) + (\frac{1}{2} \times 9.11 \times 10^{-31} \times v_{\text{MAX}}^2)$	C1
	$v_{\text{MAX}} = 5.7 \times 10^5 \text{ m s}^{-1}$	A1
8(c)	E_{MAX} shown as zero from $f = 8.0$ to 8.8 and non-zero from $f = 8.8$ to 11	B1
	all non-zero E_{MAX} shown as a single straight line with a positive gradient	B1
	line passing through (11, 1.45)	B1

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Question	Answer	Marks
9(a)(i)	positron	B1
9(a)(ii)	$\lambda = \ln 2 / (110 \times 60) = 1.05 \times 10^{-4} \text{ s}^{-1}$	A1
9(a)(iii)	$N = M / (18 \text{ u})$ or $(M \text{ in grams} \times N_A / 18)$ $N = (2.1 \times 10^{-12}) / (18 \times 1.66 \times 10^{-27})$ or $(2.1 \times 10^{-9} \times 6.02 \times 10^{23}) / 18$ $(= 7.0 \times 10^{13})$	C1
	$A = \lambda N$	C1
	$= 1.05 \times 10^{-4} \times 7.0 \times 10^{13}$ $= 7.4 \times 10^9 \text{ Bq}$	A1
9(b)(i)	(pair) annihilation occurs - the <u>mass</u> of the two particles is converted into energy - two <u>gamma</u> photons are formed and travel in opposite directions or two <u>gamma</u> photons are formed and leave the body - difference in arrival times of photons (at detector) is processed <i>Any three points, 1 mark each</i>	B3
9(b)(ii)	with a shorter half-life: sample would (almost) fully decay before the test is complete	B1
	a longer half-life: exposes patient to harmful/ionising radiation unnecessarily or with a longer half-life: a larger dose (of tracer) needed to produce detectable activity	B1

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Question	Answer	Marks
10(a)	<u>redshift</u> is the increase in observed wavelength / decrease in observed frequency (caused by Doppler effect) - radiation from distant galaxies is observed to be redshifted - redshift provides evidence that galaxies are moving apart <u>galaxies</u> moving apart means Universe must be expanding <i>Any three points, 1 mark each</i>	B3
10(b)(i)	$F = L / 4\pi d^2$	C1
	$d = \sqrt{(1.90 \times 10^{36} / [4\pi \times 8.42 \times 10^{-16}])}$ $= 1.34 \times 10^{25} \text{ m}$	A1
10(b)(ii)	$\Delta\lambda / \lambda = v / c$ $(726 - 658) / 658 = v / (3.00 \times 10^8)$	C1
	$v = 3.1 \times 10^7 \text{ m s}^{-1}$	A1
10(c)(i)	line with positive gradient passing through the origin	B1
	straight line with positive gradient	B1
10(c)(ii)	Hubble constant	B1

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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
	$= 0.85 \times 140$	A1
	$= 120 \text{ m s}^{-1}$	
1(a)(ii)	$a = r\omega^2$ or $a = v^2 / r$	C1
	$a = 0.85 \times 140^2$ or $120^2 / 0.85$	A1
	$= 1.7 \times 10^4 \text{ m s}^{-2}$	
1(b)(i)	direction of (induced) e.m.f.	M1
	is such as to (produce effects that) oppose the <u>change</u> that caused it	A1
1(b)(ii)	$T = 2\pi / \omega$	A1
	$= 2\pi / 140 = 0.045 \text{ s} = 45 \text{ ms}$	
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
	$= 0.41 / 0.045$	A1
	$= 9.1 \text{ V}$	
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
	$= (6.67 \times 10^{-11} \times 1.99 \times 10^{30}) / (1.47 \times 10^{11})^2$	A1
	$= 6.14 \times 10^{-3} \text{ N kg}^{-1}$	
2(b)(ii)	$E_p = -GMm/x$	C1
	$= - (6.67 \times 10^{-11} \times 1.99 \times 10^{30} \times 2.63) / (1.47 \times 10^{11})$	
	$= - 2.37 \times 10^9 \text{ J}$	A1
2(c)(i)	$F = L / 4\pi x^2$	C1
	$(g = GM/x^2 \text{ and so } x^2 = GM/g)$	M1
	and	
	$x^2 = L / 4\pi F$	
	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
	$L = 3.8 \times 10^{26} \text{ W}$	A1
2(c)(iii)	$L = 4\pi\sigma r^2 T^4$	C1
	$3.8 \times 10^{26} = (4\pi \times 5.67 \times 10^{-8} \times 5780^4) \times r^2$	
	$r = 6.9 \times 10^8 \text{ m}$	A1

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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
	$= 1.0 \times 10^5 \times 0.017 = 1700 \text{ J} = 1.7 \text{ kJ}$	A1
3(b)(ii)	$\Delta U = Q + W$	C1
	$Q = 17.6 + 1.7$ $= 19.3 \text{ kJ}$	A1
3(b)(iii)	mass $= 710 \times 7.2 \times 10^{-5}$ $(= 0.051 \text{ kg})$	C1
	$L = 19.3 / 0.051$ $= 380 \text{ kJ kg}^{-1}$	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 <i>Any three points, 1 mark each</i>	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) <i>Any three points, 1 mark each</i>	B3
4(c)	<i>Any three bulleted points from:</i> - both gases are ideal <i>Up to 2 points from:</i> - 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 <i>Up to 2 points from:</i> - 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 <i>Up to 2 points from:</i> - 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

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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 = $\frac{1}{2}m\omega^2x_0^2$	C1
	$= \frac{1}{2} \times 0.15 \times 15.7^2 \times 0.016^2$ $= 4.7 \times 10^{-3} \text{ J}$	A1
5(c)	dome-shaped curve starting and ending on the x-axis, with peak at $x = 0$	B1
	maximum E_K shown as $4.7 \times 10^{-3} \text{ J}$	B1
	minimum x shown as -0.016 m and maximum x shown as $+0.016 \text{ m}$ at the ends of the line	B1

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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)	$E = Q / (4\pi\epsilon_0 X^2)$	C1
	$Q = \text{e.g. } 2.2 \times 10^5 \times 4\pi \times 8.85 \times 10^{-12} \times 0.032^2$	C1
	$= 2.5 \times 10^{-8} \text{ C}$	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 <i>Any point, 1 mark</i>	B1

PUBLISHED

Question	Answer	Marks							
7(a)	charge / potential (difference)	M1							
	charge is charge on one plate, <u>and</u> potential is p.d. between the plates	A1							
7(b)(i)	straight line starting at the origin	B1							
	line with positive gradient ending at (V, Q)	B1							
7(b)(ii)	work done is the area under the graph	B1							
	$W = \frac{1}{2}QV$	A1							
7(c)(i)	final p.d. shown as $V/4$ for both capacitors	B1							
	final charges add together to give Q	B1							
	charge on Y = $3 \times$ charge on X (and both charges shown as a multiple of Q)	B1							
	Fully correct answer: <table border="1"> <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>			X	Y	final p.d.	$V/4$	$V/4$	final charge
	X	Y							
final p.d.	$V/4$	$V/4$							
final charge	$Q/4$	$3Q/4$							
7(c)(ii)	less than	B1							

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Question	Answer	Marks
8(a)	number of cycles per unit time	B1
8(b)(i)	period = $2\pi / 40\pi = 0.050 \text{ s} = 50 \text{ ms}$	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 $t = 100 \text{ ms}$	B1
	all peaks shown at $I = +3.5 \text{ A}$ and all troughs shown at $I = -3.5 \text{ A}$	B1
8(b)(iii)	$I_{\text{r.m.s}} = 3.5 / \sqrt{2}$ $= 2.5 \text{ A}$	A1
8(c)	$P = I^2 R$	C1
	peak power = $3.5^2 \times 680 (= 8330 \text{ W})$ or mean power = $2.47^2 \times 680 (= 4170 \text{ W})$	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

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Question	Answer	Marks
9(a)	diffraction is characteristic of wave behaviour so shows that electrons can behave like waves	B1
9(b)	$qV = \frac{1}{2}mv^2$	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

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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 <i>Any three points, 1 mark each</i>	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

Cambridge International AS & A Level

PHYSICS**9702/43**

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.

This document consists of **15** printed pages.

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 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.

PUBLISHED**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 'List rule' guidance

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 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.

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.

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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)(i)	(gravitational) force acts perpendicular to direction of motion	B1
	gravitational force provides centripetal acceleration	B1
1(b)(ii)	$(F =) GMm / x^2 = m\omega^2$ and $\omega = 2\pi / T$ or $GMm / x^2 = 4\pi^2 mx / T^2$	M1
	completion of algebra leading to $x^3 = GMT^2 / 4\pi^2$	A1
	clear indication that B = radius of planet and that A = mass (of planet)	B1
1(b)(iii)	gradient = $\sqrt[3]{(4\pi^2 / GA)}$	C1
	e.g. $(1280 - 360) / (12 \times 10^6) = \sqrt[3]{(4\pi^2 / [6.67 \times 10^{-11} \times A])}$	C1
	$A = 1.3 \times 10^{24} \text{ kg}$	A1
	intercept = gradient $\times B$	C1
	e.g. $360 = ((1280 - 360) \times B) / (12 \times 10^6)$ $B = 4.7 \times 10^6 \text{ m}$	A1

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Question	Answer	Marks
2(a)	(thermal) energy per unit mass (to change temperature)	B1
	(thermal) energy per unit change in temperature	B1
2(b)(i)	<i>Any three bulleted points from:</i> - the blocks end up in thermal equilibrium - heat capacity of Y is larger than heat capacity of X - no heat loss to the surroundings <i>Up to 2 points from these six:</i> - initial temperature of X = 85 °C - initial temperature of Y = 25 °C - the temperature change of X = 45 °C - the temperature change of Y = 15 °C - the temperature change in X is three times that in Y - final temperature of both = 40 °C	B3
2(b)(ii)	$\Delta\theta = 45\text{ °C}$ for X and 15 °C for Y	C1
	$mc \times 45 = 1.3 \times m \times 901 \times 15$	C1
	$c = 390\text{ J kg K}^{-1}$	A1

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Question	Answer	Marks
3(a)(i)	number of particles per unit amount of substance	B1
3(a)(ii)	$N_A = R / k$	B1
3(b)(i)	X pressure and Y pressure <u>both</u> = NkT / V	B1
	X amount = N / N_A and Y amount = $2N / N_A$	B1
	X mean-square speed = $3kT / m$ and Y mean-square speed = $3kT / 2m$	B1
	X internal energy = $3NkT / 2$ and Y internal energy = $3NkT$	B1
3(b)(ii)	line passing through the origin and not returning to either axis	B1
	curve with positive decreasing gradient	B1

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Question	Answer	Marks
4(a)	(motion in which) acceleration is (directly) proportional to displacement	B1
	(motion in which): acceleration is (always) in the opposite <u>direction</u> to displacement or acceleration is (always) <u>directed</u> towards a fixed point	B1
4(b)(i)	amplitude = $(9.5 - 3.5) / 2$ = 3.0 cm	A1
4(b)(ii)	$\omega = v_0 / x_0$	C1
	= $9.5 / 3.0 = 3.2 \text{ rad s}^{-1}$	A1
4(b)(iii)	$T = 2\pi / \omega$	C1
	= $2\pi / 3.2$	A1
	= 2.0 s	
4(b)(iv)	attempted sinusoidal curve starting with a minimum at $t = 0$	B1
	sinusoidal curve of period 2.0 s from $t = 0$ to $t = 6.0$ s	B1
	all peaks shown at $h = 9.5$ cm	B1
	all troughs shown at $h = 3.5$ cm	B1

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Question	Answer	Marks
5(a)	(electric) field equals (electric) potential gradient	M1
	reference to minus sign	A1
5(b)	- for potential to be zero, one potential must be positive and the other potential must be negative - for potential to be zero, the charges must have opposite sign - for field to be zero, the fields (due to X and Y) must be in opposite directions - for field to be zero, the charges must have the same sign - the signs of the charges cannot (simultaneously) be both the same and opposite (so not possible) <i>Any three points, 1 mark each</i>	B3
5(c)(i)	$V_X = (-) Q / 4\pi\epsilon_0 X$ and $V_Y = (-) 2Q / 4\pi\epsilon_0 Y$	C1
	$(V_X + V_Y = 0 \text{ so } Q / 4\pi\epsilon_0 X = 2Q / 4\pi\epsilon_0 Y \text{ leading to } y = 2x)$	A1
5(c)(ii)	$E_X = Q / 4\pi\epsilon_0 X^2$	A1
5(c)(iii)	$E_Y = 2Q / 4\pi\epsilon_0 (2x)^2$ $(= Q / 8\pi\epsilon_0 X^2)$	C1
	(opposite charges so fields in same direction so magnitudes add): $E = (Q / 4\pi\epsilon_0 X^2) + (Q / 8\pi\epsilon_0 X^2)$ $= 3Q / 8\pi\epsilon_0 X^2$	A1

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Question	Answer	Marks
6(a)(i)	conversion (from a.c.) to d.c.	B1
6(a)(ii)	half-wave: voltage in one direction is removed	B1
	full-wave: voltage in one direction is reversed	B1
6(b)(i)	one gap connected by a single diode and other gap connected directly	B1
	diode drawn (in a circuit) with correct circuit symbol	B1
6(b)(ii)	smoothing	B1
6(c)(i)	$E = \frac{1}{2}CV^2$	C1
	$C = 2 \times 0.041 / 12^2 = 5.7 \times 10^{-4} \text{ F} = 570 \mu\text{F}$	A1
6(c)(ii)	$8.0 = 12.0 \exp(-0.010 / RC)$	C1
	$\ln(8.0 / 12.0) = -0.010 / (R \times 5.7 \times 10^{-4})$	C1
	$R = 43 \Omega$	A1

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Question	Answer	Marks
7(a)	• force per unit length • force per unit current • length / current perpendicular to field <i>1 mark for any two points, 2 marks for all three points</i>	B2
7(b)	concentric circles around the wire (at least two circles needed)	B1
	spacing between circles increases with distance from wire (at least four circles needed)	B1
	arrows showing direction of field is clockwise	B1
7(c)(i)	(each) wire sits in the (magnetic) field created by the other	B1
	current (in one wire) is perpendicular to (magnetic) field (due to other wire) so (magnetic) force acts (on wire)	B1
7(c)(ii)	arrow drawn, starting from X and pointing towards Y, labelled F	B1
7(c)(iii)	(forces have) equal magnitudes	B1
	(forces are in) opposite directions	B1
7(c)(iv)	no change (in the direction of the force) since both the current in X and the field due to Y have reversed	B1

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Question	Answer	Marks
8(a)	photoelectric effect	B1
8(b)(i)	$E = hf$	C1
	work function = $6.63 \times 10^{-34} \times 8.8 \times 10^{14}$ $= 5.8 \times 10^{-19} \text{ J}$	A1
8(b)(ii)	$hf = \phi + \frac{1}{2}mv_{\text{MAX}}^2$	C1
	$6.63 \times 10^{-34} \times 11 \times 10^{14} = (5.8 \times 10^{-19}) + (\frac{1}{2} \times 9.11 \times 10^{-31} \times v_{\text{MAX}}^2)$	C1
	$v_{\text{MAX}} = 5.7 \times 10^5 \text{ m s}^{-1}$	A1
8(c)	E_{MAX} shown as zero from $f = 8.0$ to 8.8 and non-zero from $f = 8.8$ to 11	B1
	all non-zero E_{MAX} shown as a single straight line with a positive gradient	B1
	line passing through (11, 1.45)	B1

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Question	Answer	Marks
9(a)(i)	positron	B1
9(a)(ii)	$\lambda = \ln 2 / (110 \times 60) = 1.05 \times 10^{-4} \text{ s}^{-1}$	A1
9(a)(iii)	$N = M / (18 \text{ u})$ or $(M \text{ in grams} \times N_A / 18)$ $N = (2.1 \times 10^{-12}) / (18 \times 1.66 \times 10^{-27})$ or $(2.1 \times 10^{-9} \times 6.02 \times 10^{23}) / 18$ $(= 7.0 \times 10^{13})$	C1
	$A = \lambda N$	C1
	$= 1.05 \times 10^{-4} \times 7.0 \times 10^{13}$ $= 7.4 \times 10^9 \text{ Bq}$	A1
9(b)(i)	(pair) annihilation occurs - the <u>mass</u> of the two particles is converted into energy - two <u>gamma</u> photons are formed and travel in opposite directions or - two <u>gamma</u> photons are formed and leave the body - difference in arrival times of photons (at detector) is processed <i>Any three points, 1 mark each</i>	B3
9(b)(ii)	with a shorter half-life: sample would (almost) fully decay before the test is complete	B1
	a longer half-life: exposes patient to harmful/ionising radiation unnecessarily or with a longer half-life: a larger dose (of tracer) needed to produce detectable activity	B1

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Question	Answer	Marks
10(a)	<u>redshift</u> is the increase in observed wavelength / decrease in observed frequency (caused by Doppler effect) - radiation from distant galaxies is observed to be redshifted - redshift provides evidence that galaxies are moving apart <u>galaxies</u> moving apart means Universe must be expanding <i>Any three points, 1 mark each</i>	B3
10(b)(i)	$F = L / 4\pi d^2$	C1
	$d = \sqrt{(1.90 \times 10^{36} / [4\pi \times 8.42 \times 10^{-16}])}$ $= 1.34 \times 10^{25} \text{ m}$	A1
10(b)(ii)	$\Delta\lambda / \lambda = v / c$ $(726 - 658) / 658 = v / (3.00 \times 10^8)$	C1
	$v = 3.1 \times 10^7 \text{ m s}^{-1}$	A1
10(c)(i)	line with positive gradient passing through the origin	B1
	straight line with positive gradient	B1
10(c)(ii)	Hubble constant	B1