

Cambridge International AS & A Level

PHYSICS**9702/41**

Paper 4 A Level Structured Questions

May/June 2024

MARK SCHEME

Maximum Mark: 100

Published

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Mark schemes should be read in conjunction with the question paper and the Principal Examiner Report for Teachers.

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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.

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>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)	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

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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 <i>Any two points, 1 mark each</i>	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
	$N = (2.0 \times 10^5 \times 0.26) / (1.38 \times 10^{-23} \times 290)$	A1
	$= 1.3 \times 10^{25}$	
3(b)(ii)	$E_K = (3/2) kT$	C1
	$E_K = (3/2) \times 1.38 \times 10^{-23} \times 290$	A1
	$= 6.0 \times 10^{-21} \text{ J}$	
3(b)(iii)	internal energy = total KE + PE of molecules or PE = 0 so internal energy = total KE of molecules	B1
	internal energy = $1.3 \times 10^{25} \times 6.0 \times 10^{-21}$	A1
	$= 7.8 \times 10^4 \text{ J}$	
3(c)	straight line with positive gradient	B1
	line passing through the origin	B1

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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)	<u>oscillations</u> (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
	$E = 430 / 0.067$ $= 6.4 \times 10^3 \text{ N C}^{-1}$	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
	$B = E / v = (6.4 \times 10^3) / (2.6 \times 10^7)$ $= 2.5 \times 10^{-4} \text{ T}$	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 <i>Any two points, 1 mark each</i>	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 $I = 0.048 \text{ mA}$ or substitution of a correct pair of values of I and t into $I = 0.13 \exp(-t / \tau)$	C1
	$\tau = 4.3 \text{ s}$	A1
6(c)	$\tau = RC$	C1
	$C = \tau / R = 4.3 / (9.2 \times 10^4)$ $= 4.7 \times 10^{-5} \text{ F}$	A1

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Question	Answer	Marks
7(a)	rectification (of the input voltage)	M1
	full-wave	A1
7(b)(i)	$P = V^2 / R$ or maximum $V = 9.0 \text{ V}$	C1
	$P_{\text{MAX}} = 9.0^2 / 370 = 0.22 \text{ W}$	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 = $(0.032 \times 1.60 \times 10^{-13}) / (3.00 \times 10^8)$ $= 1.7 \times 10^{-23} \text{ N s}$	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
	$\lambda = 3.9 \times 10^{-11} \text{ m}$	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

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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 $2.0 \times 10^{21} \text{ Bq}$ <i>Any three points, 1 mark each</i>	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
	$= (7.3 \times 10^{-4}) / (4.0 \times 10^{22} \times 1.66 \times 10^{-27})$ $= 11 \text{ and given as an integer}$	A1

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Question	Answer	Marks
10(a)(i)	<u>total</u> 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
	$= 3.85 \times 10^{26} \text{ W}$	A1
10(b)(ii)	$\lambda_{\text{MAX}} T = \text{constant}$	C1
	temperature $= (5780 \times 501) / 624$ $= 4640 \text{ K}$	A1

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Mark categories

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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.

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Question	Answer	Marks
1(a)	angle (subtended at the centre of a circle) when arc (length) = radius	B1
1(b)(i)	arrow, labelled V, pointing in NE direction	B1
1(b)(ii)	arrow, labelled A, pointing in NW direction	B1
1(c)(i)	$v = r\omega$	C1
	$\omega = 0.68 / (0.093 - 0.012)$ $= 8.4 \text{ rad s}^{-1}$	A1
1(c)(ii)	$a = v^2 / r$ or $a = r\omega^2$	C1
	$a = 0.68^2 / (0.093 - 0.012)$ or $(0.093 - 0.012) \times 8.4^2$ $= 5.7 \text{ m s}^{-2}$	A1
1(d)	angular speed: same for both pieces	B1
	linear speed: less for second piece than first piece	B1
	acceleration: less for second piece than first piece	B1

Question	Answer	Marks
2(a)	(if in thermal contact) no <u>net transfer</u> of (thermal) energy (between them)	B1
2(b)(i)	$pV = nRT$	C1
	$T = (1.20 \times 10^5 \times 0.0260) / (0.740 \times 8.31)$ (= 507 K)	M1
	temperature = 507 – 273 = 234 °C	A1
2(b)(ii)	thermal equilibrium <u>so</u> temperatures (of X and Y) are equal	B1
	$pV = NkT$	C1
	$N = (2.90 \times 10^5 \times 0.0430) / (1.38 \times 10^{-23} \times 507)$ = 1.78×10^{24}	A1
2(b)(iii)	(molecular) kinetic energy is proportional to temperature or kinetic energy (of molecules) is same in both cylinders - kinetic energy proportional to mass $\times$ mean-square speed or temperature proportional to mass $\times$ mean-square speed or r.m.s. speed proportional to $\sqrt{(\text{temperature} / \text{mass})}$ - mean-square speed inversely proportional to mass or r.m.s. speed inversely proportional to $\sqrt{(\text{mass})}$ <i>Any two bulleted points, 1 mark each</i>	B2
	r.m.s. speed (of molecules) in X is half r.m.s. speed (of molecules) in Y	B1

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Question	Answer	Marks
3(a)	sum of potential energy and kinetic energy	B1
	(total) energy of random motion of particles	B1
3(b)(i)	no change in separation so no change in (molecular) potential energy	B1
	temperature increases so kinetic energy (of molecules) increases	B1
	kinetic energy increases and potential energy unchanged, so internal energy increases	B1
3(b)(ii)	temperature constant so no change in (molecular) kinetic energy	B1
	separation increases so potential energy (of molecules) increases	B1
	potential energy increases and kinetic energy unchanged, so internal energy increases	B1

Question	Answer	Marks
4(a)	straight line through the origin shows that a is proportional to x	B1
	negative gradient shows that a and x are (always) in opposite <u>directions</u>	B1
4(b)(i)	$a = -\omega^2 x$ $\omega = \sqrt{(2A / 3Y)}$	A1
4(b)(ii)	$v_0 = \omega x_0$	C1
	$= 3Y \times \sqrt{(2A / 3Y)}$ $= \sqrt{(6AY)}$	A1
4(b)(iii)	$E = \frac{1}{2} m \omega^2 x_0^2$	C1
	$= \frac{1}{2} m \times (2A / 3Y) \times (3Y)^2$ $= 3mAY$	A1
4(c)	$\omega = 2\pi / T$ $(= 2\pi / 0.75)$	C1
	$x = 1.8 \sin (8.4 t)$	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>Any three points from:</i> <i>Up to 2 points from:</i> • radius of sphere X is 0.30 m • radius of sphere Y is 0.10 m • radius of X is treble the radius of Y <i>Up to 2 points from:</i> • charge on X is positive • charge on Y is positive • spheres X and Y carry charges of the same sign <i>Up to 1 point from:</i> • (magnitudes of) charges on the spheres are equal • charges on the spheres have the same magnitude	B3
5(c)	proton remains at rest (in the position of release)	M1
	potential <u>energy</u> of proton is (already) at its minimum or (electric) forces (from spheres) on proton are equal and opposite or no resultant (electric) force on proton or resultant electric field strength (at proton) is zero	A1

Question	Answer	Marks
6(a)	equal charge on both capacitors	B1
	$V_X + V_Y = V$	M1
	$(Q / C_X) + (Q / C_Y) = (Q / C_T)$ <u>leading to</u> $(1 / C_X) + (1 / C_Y) = (1 / C_T)$ or $(V_X / Q) + (V_Y / Q) = (V / Q)$ <u>leading to</u> $(1 / C_X) + (1 / C_Y) = (1 / C_T)$	A1
6(b)(i)	$E = \frac{1}{2}CV^2$	C1
	$V = \sqrt{[(2 \times 2.5 \times 10^{-3}) / (200 \times 10^{-6})]} = 5.0 \text{ V}$	A1
6(b)(ii)	total capacitance = 600 μF	C1
	$E = \frac{1}{2} \times 600 \times 10^{-6} \times 5.0^2$ $(= 7.5 \times 10^{-3} \text{ J})$	C1
	$= 7.5 \text{ mJ}$	A1
6(b)(iii)	line with positive gradient starting at (0, 2.5)	B1
	straight line passing through (400, 7.5)	B1

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)	$\Phi = BA$	C1
	$= 7.2 \times 10^{-3} \times 3.2 \times 10^{-4}$	A1
	$= 2.3 \times 10^{-6} \text{ Wb}$	
7(b)(ii)	tangent drawn at steepest point on Fig. 7.2	C1
	evidence of multiplication by 340	C1
	maximum rate of change of flux = 0.82 Wb s^{-1}	A1
7(b)(iii)	$V_0 = 0.82 \text{ V}$ or V_0 given as identical numerical answer to the answer in (b)(ii)	A1
7(b)(iv)	sinusoidal curve of period 2.0 ms from $t = 0$ to $t = 6.0 \text{ ms}$	B1
	all peaks at $+V_0$ and all troughs at $-V_0$	B1
	line showing $V = 0$ at (and only at) $t = 0, 1.0, 2.0, 3.0, 4.0, 5.0$ and 6.0 ms	B1
7(b)(v)	$A = 0.82 \text{ V}$ or A has same numerical value as answer in (b)(iii) , with unit V	A1
	$B = 2\pi / (2.0 \times 10^{-3})$	C1
	$= 3100 \text{ rad s}^{-1}$	A1

Question	Answer	Marks
8(a)(i)	movement of star causes change in (observed) frequency or movement of star causes redshift	B1
	observed frequency is lower (than emitted frequency)	B1
8(a)(ii)	all three lines shown to left of corresponding printed lines	B1
	distance between drawn line and corresponding printed line approximately the same for all three lines	B1
8(b)(i)	$E = hf$ and $\lambda = c / f$	C1
	$E = (6.63 \times 10^{-34} \times 3.00 \times 10^8) / (488 \times 10^{-9})$ $= 4.08 \times 10^{-19} \text{ J}$	A1
8(b)(ii)	photon energy = $(4.08 \times 10^{-19}) / (1.60 \times 10^{-19})$ $= 2.55 \text{ eV}$	C1
	energy level = $-3.40 + 2.55$ $= -0.85 \text{ eV}$	A1
8(b)(iii)	$\Delta\lambda = \lambda \times (v / c)$ $= (488 \times 6.2 \times 10^6) / (3.00 \times 10^8)$ (= 10 nm)	C1
	observed wavelength = $488 + \Delta\lambda = 488 + 10$ $= 498 \text{ nm}$	A1

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Question	Answer	Marks
8(c)	$v = H_0 d$	C1
	$d = (6.2 \times 10^6) / (2.3 \times 10^{-18})$ $= 2.7 \times 10^{24} \text{ m}$	A1

Question	Answer	Marks
9(a)	energy required to separate (all) the nucleons (in the nucleus)	M1
	to infinity	A1
9(b)(i)	$\Delta m = \{[(84 \times 1.007276) + (128 \times 1.008665)] - 211.942749\} \text{ (u)}$ $(= 1.778 \text{ u})$	C1
	$= 1.778 \times 1.66 \times 10^{-27} \text{ (kg)}$	C1
	$= 2.95 \times 10^{-27} \text{ kg}$	A1
9(b)(ii)	$E = (\Delta)mc^2$	C1
	binding energy $= 2.95 \times 10^{-27} \times (3.00 \times 10^8)^2$ $= 2.66 \times 10^{-10} \text{ J}$	A1
9(b)(iii)	binding energy per nucleon $= (2.66 \times 10^{-10}) / 212$ $= 1.25 \times 10^{-12} \text{ J}$	A1
9(c)(i)	line rising to a single peak that is to the left of the '9' in the Fig. 9.1 label and then continually decreasing	B1
	steep positive gradient on the left of the peak and shallow negative gradient on the right	B1
9(c)(ii)	X shown on the line at a value of A that is to the right of the left-hand edge of the 'A' in the axis label, and to the left of '2' in the 250 label	B1
9(c)(iii)	nucleus formed (as a result of the decay) has a lower nucleon number	B1
	(nucleus formed has a) greater binding energy per nucleon	B1

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Question	Answer	Marks
10(a)	time gives information about depth (of boundary)	B1
	intensity gives information about <u>nature</u> of <u>boundary</u>	B1
10(b)(i)	product of density and speed	M1
	speed of ultrasound in medium (and density of medium)	A1
10(b)(ii)	$Z_{\text{water}} = 1000 \times 1420 (= 1.42 \times 10^6 \text{ kg m}^{-2} \text{ s}^{-1})$ and $Z_{\text{glass}} = 2500 \times 4560 (= 11.4 \times 10^6 \text{ kg m}^{-2} \text{ s}^{-1})$	C1
	intensity reflection coefficient = $(11.4 - 1.42)^2 / (11.4 + 1.42)^2$	C1
	= 0.61	A1

Cambridge International AS & A Level

PHYSICS**9702/43**

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.

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.

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>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.

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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

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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 <i>Any two points, 1 mark each</i>	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
	$N = (2.0 \times 10^5 \times 0.26) / (1.38 \times 10^{-23} \times 290)$	A1
	$= 1.3 \times 10^{25}$	
3(b)(ii)	$E_K = (3/2) kT$	C1
	$E_K = (3/2) \times 1.38 \times 10^{-23} \times 290$	A1
	$= 6.0 \times 10^{-21} \text{ J}$	
3(b)(iii)	internal energy = total KE + PE of molecules or PE = 0 so internal energy = total KE of molecules	B1
	internal energy = $1.3 \times 10^{25} \times 6.0 \times 10^{-21}$	A1
	$= 7.8 \times 10^4 \text{ J}$	
3(c)	straight line with positive gradient	B1
	line passing through the origin	B1

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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)	<u>oscillations</u> (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

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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
	$E = 430 / 0.067$ $= 6.4 \times 10^3 \text{ N C}^{-1}$	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
	$B = E / v = (6.4 \times 10^3) / (2.6 \times 10^7)$ $= 2.5 \times 10^{-4} \text{ T}$	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 <i>Any two points, 1 mark each</i>	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 $I = 0.048 \text{ mA}$ or substitution of a correct pair of values of I and t into $I = 0.13 \exp(-t / \tau)$	C1
	$\tau = 4.3 \text{ s}$	A1
6(c)	$\tau = RC$	C1
	$C = \tau / R = 4.3 / (9.2 \times 10^4)$ $= 4.7 \times 10^{-5} \text{ F}$	A1

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Question	Answer	Marks
7(a)	rectification (of the input voltage)	M1
	full-wave	A1
7(b)(i)	$P = V^2 / R$ or maximum $V = 9.0 \text{ V}$	C1
	$P_{\text{MAX}} = 9.0^2 / 370 = 0.22 \text{ W}$	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 = $(0.032 \times 1.60 \times 10^{-13}) / (3.00 \times 10^8)$ $= 1.7 \times 10^{-23} \text{ N s}$	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
	$\lambda = 3.9 \times 10^{-11} \text{ m}$	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

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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 $2.0 \times 10^{21} \text{ Bq}$ <i>Any three points, 1 mark each</i>	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
	$= (7.3 \times 10^{-4}) / (4.0 \times 10^{22} \times 1.66 \times 10^{-27})$ $= 11 \text{ and given as an integer}$	A1

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Question	Answer	Marks
10(a)(i)	<u>total</u> 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
	$= 3.85 \times 10^{26} \text{ W}$	A1
10(b)(ii)	$\lambda_{\text{MAX}} T = \text{constant}$	C1
	temperature $= (5780 \times 501) / 624$ $= 4640 \text{ K}$	A1