Cambridge Assessment International Education

Cambridge International AS & A Level

PHYSICS **9702/41**

Paper 4 A Level Structured Questions **October/November 2023**

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 2023 series for most Cambridge IGCSE, Cambridge International A and AS Level components, and some Cambridge O Level components.

This document consists of **16** printed pages.

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)(i)	direction of the force acting on a (test) mass placed at the point	**B1**
1(a)(ii)	change in height negligible compared with radius (of Earth)	**B1**
	(so) field lines are (effectively) parallel	**B1**
1(b)(i)	$Y = GM / R^2$	**M1**
	G is the gravitational constant	**A1**
1(b)(ii)	gravitational force is (always) attractive **or** gravitational force (always) acts towards the centre of the sphere	**B1**
	force is in opposite direction to displacement **or** at a point to the right of the centre, force acts to the left **or** at a point to the left of the centre, force acts to the right	**B1**
1(b)(iii)	sketch: smooth curve with decreasing positive gradient, starting at (R, –Y) and reaching 3R with g still negative **or** smooth curve with increasing positive gradient, ending at (–R, Y) and reaching –3R with g still positive	**B1**
	both of the above curves, in correct quadrants	**B1**
	curve passing through (±2R, ±0.25Y) and (±3R, ±0.11Y)	**B1**

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)	work done $= p\Delta V$ $= (2.0 \times 10^5) \times (0.063 - 0.038) = 5000$ J	**A1**
2(b)(ii)	gas is expanding (against external pressure)	**B1**
	gas does work / work is done by gas, so (work done on gas is) negative	**B1**
2(b)(iii)	$\Delta U = q + W$	**C1**
	$7600 = q + (-5000)$ $q = 12\,600$ J	**A1**
2(b)(iv)	specific heat capacity $= q / m\Delta T$ $= 12600 / (0.35 \times 56)$	**C1**
	$= 640$ J kg^{-1} K^{-1}	**A1**
2(c)	same gain in internal energy so same temperature rise	**B1**
	no change in volume so no work done **or** no work done so less thermal energy needed (for same change in internal energy)	**B1**
	less thermal energy needed (for same temperature change) so lower specific heat capacity	**B1**

Question	Answer	Marks
3(a)(i)	*N*: number of molecules (of the gas)	**B1**
	m: mass of one molecule (of the gas)	**B1**
	$<c^2>$: mean square speed (of molecules)	**B1**
3(a)(ii)	$pV = NkT$	**M1**
	$NkT = ⅓Nm<c^2>$ **and** $E_K = ½m<c^2>$ leading to $E_K = (3/2)\,kT$	**A1**
3(b)	$½ \times 3.34 \times 10^{-27} \times 9300^2 = (3/2) \times 1.38 \times 10^{-23} \times T$	**C1**
	$T = 6980\,K$	**A1**
3(c)(i)	$L = F \times 4\pi d^2$	**C1**
	$L = 2.52 \times 10^{-8} \times 4\pi \times (4.16 \times 10^{16})^2$ $= 5.48 \times 10^{26}\,W$	**A1**
3(c)(ii)	$L = 4\pi\sigma r^2 T^4$ $5.48 \times 10^{26} = 4\pi \times 5.67 \times 10^{-8} \times r^2 \times 6980^4$	**C1**
	$r = 5.69 \times 10^8\,m$	**A1**
3(d)	(very high pressure so) molecules are (very) close together (*not just 'nearer'*)	**B1**
	forces between molecules are not negligible **or** volume of molecules not negligible compared with gas volume	**B1**

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) directed towards a fixed point	**B1**
4(b)(i)	$\omega = 2\pi / T$	**C1**
	$\omega = 2\pi / 3.0$ $= 2.1\ \text{rad s}^{-1}$	**A1**
4(b)(ii)	$E = ½ m\omega^2 x_0^2$	**C1**
	$= ½ \times 0.81 \times 2.1^2 \times 0.036^2$ $= 2.3 \times 10^{-3}$ J	**A1**
4(c)	sketch: line starting at (0, 0.036) and not reaching $x = \pm 0.036$ m at any other time	**B1**
	smooth curve, with no sudden changes in gradient, showing continuously decreasing magnitude of x from maximum displacement at $t = 0$ to final displacement of zero where the gradient is also zero	**B1**
	displacement reaches final value of zero between $t = 0.75$ s and $t = 3.0$ s at the latest	**B1**

Question	Answer	Marks
5(a)	work done per unit charge	**B1**
	work (done on charge) moving positive charge from infinity (to the point)	**B1**
5(b)	*Any three points from*: *Up to 2 points from*: • radius of sphere X is 2.0 m • radius of sphere Y is 4.0 m • radius of Y is double the radius of X *Up to 2 points from*: • charge on X is negative • charge on Y is positive • spheres carry opposite charges *Up to 1 point from*: • magnitudes of charges on the spheres are equal	**B3**
5(c)	particle is attracted to X or repelled from Y **or** resultant force on particle is towards X / away from Y / to the left	**B1**
	particle accelerates towards X / away from Y / to the left	**B1**
	(magnitude of) acceleration of particle increases	**B1**

Question	Answer	Marks
6(a)	• force per unit length • force per unit current • length / current perpendicular to field *1 mark for any two points, 2 marks for all three points*	**B2**
6(b)(i)	into the page	**B1**
6(b)(ii)	$F = Bqv$	**C1**
	$= 4.8 \times 10^{-3} \times 1.6 \times 10^{-19} \times 1.7 \times 10^{7} = 1.3 \times 10^{-14}$ N	**A1**
6(b)(iii)	arrow at point X pointing down the page	**B1**
6(b)(iv)	$F = mv^2 / r$	**C1**
	$1.3 \times 10^{-14} = (9.11 \times 10^{-31}) \times (1.7 \times 10^{7})^2 / r$	**C1**
	(r = 0.020 m) $d = 2r$ d = 0.040 m	**A1**
6(c)	path shows upwards deflection such that the curvature is always anticlockwise within the field	**B1**
	circular path with larger radius	**B1**
	line enters field at X and leaves field at distance 2*d* vertically from X	**B1**

Question	Answer	Marks
7(a)(i)	$P = I_0^2R$	A1
7(a)(ii)	$P = 4I_0^2R$	A1
7(b)	sketch: square wave of period *T*, with *P* always non-zero	B1
	horizontal lines, from 0 to 0.5*T* and from 1.0*T* to 1.5*T*, all at the same level that the scale indicates to be I_0^2R	B1
	horizontal lines, from 0.5*T* to 1.0*T* and from 1.5*T* to 2.0*T*, at a level that is four times higher than the lower lines	B1
7(c)(i)	$\langle P \rangle = (5/2)I_0^2R$	A1
7(c)(ii)	$\langle P \rangle = I_{r.m.s.}^2R$	C1
	$I_{r.m.s.}^2R = (5/2)I_0^2R$ $I_{r.m.s.} = \sqrt{(5/2)}\ I_0$	A1

Question	Answer	Marks
8(a)(i)	$p = E / c$	**M1**
	$E = hc / \lambda$ and completion of algebra leading to $p = h / \lambda$	**A1**
8(a)(ii)	wavelength = $(6.63 \times 10^{-34}) / (9.5 \times 10^{-28}) = 700 \times 10^{-9}$ m so red	**B1**
8(b)(i)	power = intensity × area	**C1**
	number per unit time = $(160 \times 2.5 \times 10^{-6}) / (9.5 \times 10^{-28} \times 3.00 \times 10^{8}) = 1.4 \times 10^{15}$ s^{-1}	**A1**
8(b)(ii)	pressure = force / area	**C1**
	force = rate of change of momentum $= 2 \times 9.5 \times 10^{-28} \times 1.4 \times 10^{15}$	**C1**
	pressure = $(2 \times 9.5 \times 10^{-28} \times 1.4 \times 10^{15}) / (2.5 \times 10^{-6})$ $= 1.1 \times 10^{-6}$ Pa	**A1**
8(c)	photons have greater momentum **or** fewer photons per unit time	**B1**
	greater photon momentum but smaller number of photons (per unit time) so pressure is the same	**B1**

Question	Answer	Marks
9(a)	(two small) nuclei join together	**M1**
	to form one larger nucleus	**A1**
9(b)	line with a peak at $A \approx 56$	**B1**
	line with steep initial positive gradient on the left of peak and shallower negative gradient at all points to the right of peak and line does not return to 0 binding energy	**B1**
9(c)(i)	X shown at value of *A* to the right of the peak	**B1**
9(c)(ii)	Y shown at value of *A* close to 1	**B1**
9(d)	energy from 1 nucleus = $(1.77 \times 10^{13}) / (6.02 \times 10^{23})$ $(= 2.94 \times 10^{-11}$ J)	**C1**
	binding energy of Z = $[(1.25 + 1.81) \times 10^{-10}] - 2.94 \times 10^{-11}$ $(= 2.77 \times 10^{-10}$ J)	**C1**
	nucleon number of Z = 93 + 139 + 2 – 1 (= 233)	**C1**
	binding energy per nucleon $= (2.77 \times 10^{-10}) / (233 \times 1.60 \times 10^{-13})$ = 7.43 MeV	**A1**

Question	Answer	Marks
10(a)	ultrasound production: vibrating quartz crystal	**B1**
	X-ray production: electrons hitting metal target	**B1**
	ultrasound detected wave: reflected	**B1**
	X-ray detected wave: transmitted	**B1**
10(b)(i)	$I = I_0 \exp(-\mu x)$	**C1**
	$\ln(0.72) = -6.2\mu$ $\mu = 0.053\,\text{cm}^{-1}$	**A1**
10(b)(ii)	$I / I_0 = \exp(-9.3 \times 0.053)$ $(= 0.61)$	**C1**
	percentage attenuated $= 100 \times (1.00 - 0.61)$ $= 39\%$	**A1**