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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.

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

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 independent 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 mandatory 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 compensatory 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 answer marks. They may depend on an **M** mark or allow a **C** mark to be awarded by implication.

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 =) $GMm / x^2 = mx\omega^2$ **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**
	$A = 1.3 \times 10^{24}$ kg	**A1**
	intercept = gradient × B	**C1**
	e.g. $360 = ((1280 - 360) \times B) / (12 \times 10^6)$ $B = 4.7 \times 10^6$ m	**A1**

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)	*Any three bulleted points from:* • the blocks end up in thermal equilibrium • heat capacity of Y is larger than heat capacity of X • no heat loss to the surroundings *Up to 2 points from these six:* • 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 °C for X **and** 15 °C for Y	**C1**
	$mc \times 45 = 1.3 \times m \times 901 \times 15$	**C1**
	c = 390 J kg K^{-1}	**A1**

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 both = 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**

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**
	$= 9.5 / 3.0 = 3.2$ 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**

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) *Any three points, 1 mark each*	**B3**
5(c)(i)	$V_X = (–)\ Q / 4\pi\varepsilon_0 x$ **and** $V_Y = (–)\ 2Q / 4\pi\varepsilon_0 y$	**C1**
	($V_X + V_Y = 0$ so) $Q / 4\pi\varepsilon_0 x = 2Q / 4\pi\varepsilon_0 y$ leading to $y = 2x$	**A1**
5(c)(ii)	$E_X = Q / 4\pi\varepsilon_0 x^2$	**A1**
5(c)(iii)	$E_Y = 2Q / 4\pi\varepsilon_0 (2x)^2$ $(= Q / 8\pi\varepsilon_0 x^2)$	**C1**
	(opposite charges so fields in same direction so magnitudes add): $E = (Q / 4\pi\varepsilon_0 x^2) + (Q / 8\pi\varepsilon_0 x^2)$ $= 3Q / 8\pi\varepsilon_0 x^2$	**A1**

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**
	$C = 2 \times 0.041 / 12^2 = 5.7 \times 10^{-4}$ F = 570 μF	**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**

Question	Answer	Marks
7(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**
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**

Question	Answer	Marks
8(a)	photoelectric effect	B1
8(b)(i)	$E = hf$	C1
	work function $= 6.63 \times 10^{-34} \times 8.8 \times 10^{14}$ $= 5.8 \times 10^{-19}$ J	A1
8(b)(ii)	$hf = \Phi + ½\, mv_{MAX}^2$	C1
	$6.63 \times 10^{-34} \times 11 \times 10^{14} = (5.8 \times 10^{-19}) + (½ \times 9.11 \times 10^{-31} \times v_{MAX}^2)$	C1
	$v_{MAX} = 5.7 \times 10^5$ 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

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 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**
	$= 1.05 \times 10^{-4} \times 7.0 \times 10^{13}$ $= 7.4 \times 10^{9}$ 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 *Any three points, 1 mark each*	**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**

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 *Any three points, 1 mark each*	**B3**
10(b)(i)	$F = L / 4\pi d^2$	**C1**
	$d = \sqrt{(1.90 \times 10^{36} / [4\pi \times 8.42 \times 10^{-16}])}$ $= 1.34 \times 10^{25}$ m	**A1**
10(b)(ii)	$\Delta\lambda / \lambda = v / c$ $(726 - 658) / 658 = v / (3.00 \times 10^8)$	**C1**
	$v = 3.1 \times 10^7$ 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**