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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.

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**

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

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

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 V	**C1**
	$P_{MAX} = 9.0^2 / 370 = 0.22$ 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 = $(0.032 \times 1.60 \times 10^{-13}) / (3.00 \times 10^{8})$ = 1.7×10^{-23} 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**
	$\lambda = 3.9 \times 10^{-11}$ 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**

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 2.0×10^{21} Bq *Any three points, 1 mark each*	**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 **and** given as an integer	**A1**

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