Cambridge Assessment International Education

Cambridge International AS & A Level

PHYSICS **9702/43**

Paper 4 A Level Structured Questions **May/June 2021**

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.

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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 method 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.

Annotations

✓	Indicates the point at which a mark has been awarded.
X	Indicates an incorrect answer or a point at which a decision is made not to award a mark.
XP	Indicates a physically incorrect equation ('incorrect physics'). No credit is given for substitution, or subsequent arithmetic, in a physically incorrect equation.
ECF	Indicates 'error carried forward'. Answers to later numerical questions can always be awarded up to full credit provided they are consistent with earlier incorrect answers. Within a section of a numerical question, ECF can be given after AE, TE and POT errors, but **not** after XP.
AE	Indicates an arithmetic error. Do not allow the mark where the error occurs. Then follow through the working/calculation giving full subsequent ECF if there are no further errors.
POT	Indicates a power of ten error. Do not allow the mark where the error occurs. Then follow through the working/calculation giving full subsequent ECF if there are no further errors.
TE	Indicates incorrect transcription of the correct data from the question, a graph, data sheet or a previous answer. For example, the value of 1.6×10^{-19} has been written down as 6.1×10^{-19} or 1.6×10^{19}. Do not allow the mark where the error occurs. Then follow through the working/calculation giving full subsequent ECF if there are no further errors.
SF	Indicates that the correct answer is seen in the working but the final answer is incorrect as it is expressed to too few significant figures.
BOD	Indicates that a mark is awarded where the candidate provides an answer that is not totally satisfactory, but the examiner feels that sufficient work has been done ('benefit of doubt').
CON	Indicates that a response is contradictory.
I	Indicates parts of a response that have been seen but disregarded as irrelevant.
M0	Indicates where an A category mark has not been awarded due to the M category mark upon which it depends not having previously been awarded.

^	Indicates where more is needed for a mark to be awarded (what is written is not wrong, but not enough). May also be used to annotate a response space that has been left completely blank.
SEEN	Indicates that a page has been seen.

Question	Answer	Marks
1(a)	force per unit mass	**B1**
1(b)	$GMm / r^2 = mr\omega^2$ **and** $\omega = 2\pi/T$ **or** $GMm / r^2 = mv^2 / r$ **and** $v = 2\pi r / T$	**C1**
	$6.67 \times 10^{-11} \times 6.0 \times 10^{24} = r^3 \times [2\pi / (94 \times 60)]^2$	**C1**
	$r = 6.9 \times 10^6$ m	**A1**
1(c)(i)	$r^3\omega^2$ = constant **or** r^3 / T^2 = constant	**C1**
	$r^3 / (6.9 \times 10^6)^3 = (150 / 94)^2$ so $r = 9.4 \times 10^6$ m	**A1**
	or	
	$GMT^2/4\pi^2 = r^3$ **and** clear that M is 6.0×10^{24}	**(C1)**
	$6.67 \times 10^{-11} \times 6.0 \times 10^{24} = r^3 \times [2\pi / (150 \times 60)]^2$ so $r = 9.4 \times 10^6$ m	**(A1)**
1(c)(ii)	separation increases so (potential energy) increases **or** movement is against gravitational force so (potential energy) increases	**B1**
1(c)(iii)	potential energy = (–)GMm / r	**C1**
	$\Delta E_P = 6.67 \times 10^{-11} \times 6.0 \times 10^{24} \times 1200 \times [(6.9 \times 10^6)^{-1} - (9.4 \times 10^6)^{-1}]$	**C1**
	$= 1.9 \times 10^{10}$ J	**A1**

Question	Answer	Marks
2(a)	$pV = NkT$	**C1**
	$N = (1.8 \times 10^{-3} \times 3.3 \times 10^{5}) / (1.38 \times 10^{-23} \times 310) = 1.4 \times 10^{23}$	**A1**
	or	
	$pV = nRT$ **and** $nN_A = N$	**(C1)**
	$N = (1.8 \times 10^{-3} \times 3.3 \times 10^{5} \times 6.02 \times 10^{23}) / (8.31 \times 310) = 1.4 \times 10^{23}$	**(A1)**
2(b)	speed of molecule decreases on impact with moving piston	**B1**
	mean square speed (directly) proportional to (thermodynamic) temperature **or** mean square speed (directly) proportional to kinetic energy (of molecules) **or** kinetic energy (of molecules) (directly) proportional to (thermodynamic) temperature	**B1**
	kinetic energy (of molecules) decreases (so temperature decreases)	**B1**
2(c)(i)	$\Delta U = 3/2 \times k \times \Delta T \times N$	**C1**
	$= 3/2 \times 1.38 \times 10^{-23} \times (288 - 310) \times 1.4 \times 10^{23}$	**C1**
	= – 64 J	**A1**
2(c)(ii)	decrease in internal energy is less than work done by gas	**M1**
	(thermal energy is) transferred <u>to</u> the gas (during the expansion)	**A1**

Question	Answer	Marks
3(a)	acceleration (directly) proportional to displacement	**B1**
	acceleration is in opposite <u>direction</u> to displacement	**B1**
3(b)	$\omega^2 = 2k / m$ **and** $\omega = 2\pi f$	**C1**
	$(2\pi f)^2 = (2 \times 130) / 0.84$	**C1**
	$f = 2.8$ Hz	**A1**
3(c)(i)	resonance	**B1**
3(c)(ii)	oscillator supplies energy (continuously)	**B1**
	energy of trolley constant so energy must be dissipated **or** without loss of energy the amplitude would continuously increase	**B1**

Question	Answer	Marks
4	(ultrasound) pulse	**B1**
	reflected at boundaries	**B1**
	gel is used to minimise reflection at skin **or** generated <u>and</u> detected by quartz crystal	**B1**
	time delay between generation and detection gives information about depth	**B1**
	intensity (of reflected wave) gives information about nature of boundary	**B1**

Question	Answer	Marks
5(a)	amplitude of the carrier wave varies	**M1**
	in synchrony with the displacement of the (information) signal	**A1**
5(b)(i)	wavelength $= (3.0 \times 10^8) / (300 \times 10^3)$ $= 1000$ m	**A1**
5(b)(ii)	bandwidth = 16 kHz	**A1**
5(b)(iii)	frequency = 8 kHz	**A1**
5(c)	attenuation = 10 lg (P_1 / P_2)	**C1**
	73 = 10 lg (P_T / P_R) 73 = 10 lg ($P_T\, x^2 / 0.082\, P_T$) **or** $x^2 / 0.082 = 10^{7.3}$	**C1**
	x = 1300 m	**A1**

Question	Answer	Marks
6(a)	from $x = 0$ to $x = r$: $E = 0$	**B1**
	from $x = r$ to $x = 3r$: curve with negative gradient of decreasing magnitude passing through (r, E_0)	**B1**
	line passing through $(2r, E_0 / 4)$ and $(3r, E_0 / 9)$	**B1**
6(b)	from $p = p_0 / 2$ to $p = p_0$: curve with negative gradient of decreasing magnitude passing through (p_0, λ_0)	**B1**
	line passing through $(½p_0, 2\lambda_0)$	**B1**
6(c)	from $t = 0$ to $t = 45$ s: curve with positive gradient of decreasing magnitude starting at (0, 0)	**B1**
	line passing through $(15, ½N_0)$	**B1**
	line passing through $(30, 0.75N_0)$ <u>and</u> $(45, 0.88N_0)$	**B1**

Question	Answer	Marks
7(a)	charge / potential	**M1**
	charge is on one plate, potential is p.d. between the plates	**A1**
7(b)(i)	$I = Q / t$	**M1**
	charge = CV <u>and</u> time = $1 / f$ leading to $I = fCV$	**A1**
7(b)(ii)	$4.8 \times 10^{-6} = 150 \times 60 \times C$	**C1**
	$C = 530$ pF	**A1**
7(c)	(total) capacitance is halved	**B1**
	charge (for each cycle/discharge) is halved **or** since f and V are constant, current is proportional to capacitance	**B1**
	current = 2.4 μA	**B1**

Question	Answer	Marks
8(a)	$V^+ = 3.0 \times 3.0 / (2.5 + 3.0)$	**C1**
	$= 1.6$ V	**A1**
8(b)	V^- is +2.0 V **or** $V^- > V^+$	**B1**
	output is negative so (LED) does not emit light	**B1**
8(c)	at 0 °C, $V^- = 1.7$ V **or** for all temperatures above 0 °C, resistance of thermistor < 4.2 kΩ	**B1**
	V^- always greater than V^+ (so no switching)	**B1**
8(d)	(at 20 °C,) $R_T = 1.8$ kΩ	**C1**
	$2.5 / 3.0 = 1.8 / R$ **or** $[R / (R + 1.8)] \times 3.0 = 1.6$	**C1**
	$R = 2.2$ kΩ	**A1**

Question	Answer	Marks
9(a)	region where there is a force exerted on	**M1**
	a current-carrying conductor **or** a <u>moving</u> charge **or** a magnetic material/magnetic pole	**A1**
9(b)(i)	face PSWV shaded	**B1**
9(b)(ii)	accumulating electrons cause an electric field (between the faces)	**B1**
	force due to electric field opposes force due to magnetic field	**B1**
	accumulation stops when magnetic force equals electric force	**B1**
9(c)(i)	number density of charge carriers	**B1**
9(c)(ii)	PV **or** QT **or** SW	**B1**
9(d)	(for semiconductor,) n is (much) smaller so V_H (much) larger	**B1**

Question	Answer	Marks
10(a)	direction of (induced) e.m.f.	**M1**
	is such as to oppose the <u>change</u> causing it	**A1**
10(b)	ring cuts (magnetic) flux and causes induced e.m.f. in ring	**B1**
	(induced) e.m.f. causes (eddy/induced) currents (in ring)	**B1**
	currents (in ring) cause magnetic field (around ring)	**M1**
	two fields interact to cause resistive/opposing force	**A1**
	or	
	current (in ring) is in a magnetic field	**(M1)**
	which causes resistive force	**(A1)**
	or	
	currents (in ring) dissipate thermal energy	**(M1)**
	(thermal) energy comes from energy of oscillations	**(A1)**
10(c)	current cannot pass all the way around the ring	**B1**
	(induced) currents smaller	**B1**
	smaller resistive force (so more oscillations) **or** smaller <u>rate</u> of dissipation of energy (so more oscillations)	**B1**

Question	Answer	Marks
11(a)	intensity: vary filament current/p.d. across filament	**B1**
	hardness: vary accelerating potential difference	**B1**
11(b)(i)	$I = I_0 e^{-\mu x}$	**C1**
	$I_S = I_0 \exp(-0.92 \times 9.0)$ $= 2.5 \times 10^{-4} I_0$	**A1**
11(b)(ii)	$I_C = [\exp(-0.92 \times 6.0) \times \exp(-2.9 \times 3.0)] I_0$	**C1**
	$= 6.7 \times 10^{-7} I_0$	**A1**
11(c)	conclusion consistent with values in **(b)(i)** and **(b)(ii)** e.g. $I_S \gg I_C$ so good contrast	**B1**

Question	Answer	Marks
12(a)	• frequency determines energy of photon • intensity determines number of photons (per unit time) • intensity does not determine energy of a photon *Any two points, 1 mark each*	**B2**
	kinetic energy (of the electron) depends on the energy of one photon	**B1**
12(b)(i)	$E = hc / \lambda$ **or** $E = hf$ **and** $c = f\lambda$	**C1**
	$E = (6.63 \times 10^{-34} \times 3.00 \times 10^{8}) / (250 \times 10^{-9})$	**C1**
	$(= 7.96 \times 10^{-19}$ J) = 5.0 eV	**A1**
12(b)(ii)	E_{MAX} = photon energy – work function	**C1**
	work function = 5.0 – 1.4 = 3.6 eV	**A1**