Cambridge Assessment International Education

Cambridge International AS & A Level

PHYSICS **9702/42**

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

MARK SCHEME

Maximum Mark: 40

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 <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.

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)	(gravitational) force per unit mass	B1
1(b)(i)	$g = GM / r^2$	C1
	$= (6.67 \times 10^{-11} \times 6.42 \times 10^{23}) / (3.39 \times 10^6)^2$ $= 3.73\ \text{N kg}^{-1}$	A1
1(b)(ii)	$a = r\omega^2$ **and** $\omega = 2\pi / T$ **or** $a = v^2 / r$ **and** $v = 2\pi r / T$	C1
	$a = 3.39 \times 10^6 \times (2\pi / (24.6 \times 3600))^2$ $= 0.0171\ \text{m s}^{-2}$	A1
1(b)(iii)	force per unit mass $= 3.73 - 0.0171$ $= 3.71\ \text{N kg}^{-1}$	A1

Question	Answer	Marks
2(a)	$pV = nRT$	**C1**
	$pV = nRT$ **and** $N = nN_A$ **or** $pV = NkT$	**C1**
	$3.1 \times 10^{-3} \times 8.5 \times 10^{5} = (N \times 290 \times 8.31) / (6.02 \times 10^{23})$ so $N = 6.6 \times 10^{23}$ **or** $3.1 \times 10^{-3} \times 8.5 \times 10^{5} = N \times 1.38 \times 10^{-23} \times 290$ so $N = 6.6 \times 10^{23}$	**A1**
2(b)(i)	$(3.1 \times 10^{-3} \times 8.5 \times 10^{5}) / 290 = (6.3 \times 10^{-3} \times 2.7 \times 10^{5}) / T$ so $T = 190$ K **or** $6.3 \times 10^{-3} \times 2.7 \times 10^{5} = 6.6 \times 10^{23} \times 1.38 \times 10^{-23} \times T$ so $T = 190$ K	**A1**
2(b)(ii)	$\Delta U = 3/2 \times k \times \Delta T \times N$	**C1**
	$= 3/2 \times 1.38 \times 10^{-23} \times (190 - 290) \times 6.6 \times 10^{23}$	**C1**
	$= -1400$ J	**A1**
2(c)	$\Delta U = q + w$	**M1**
	$q = 0$ so $\Delta U = w$	**A1**

Question	Answer	Marks
3(a)	acceleration in opposite direction to displacement shown by – sign	**B1**
	g / L is constant	**M1**
	(so) acceleration is (directly) proportional to displacement	**A1**
3(b)	$\omega^2 = g / L$	**C1**
	$\omega = 2\pi / T$ **or** $\omega = 2\pi f$ **and** $f = 1 / T$	**C1**
	$(2\pi / T)^2 = 9.81 / 0.18$ $T = 0.85$ s	**A1**
3(c)	energy $\propto x_0^2$	**C1**
	(after 3 cycles,) amplitude $= (0.94)^3 x_0$ $= 0.83 x_0$	**C1**
	ratio final energy / initial energy $= 0.83^2$ $= 0.69$	**A1**

Question	Answer	Marks
4(a)(i)	frequency (modulation)	B1
4(a)(ii)	**1.** zero	B1
	2. frequency (of 1.2 MHz) varies by ±50 kHz	B1
	frequency varies (by ±50 kHz) at a rate of 8000 times per second	B1
4(b)(i)	wavelength = $(3.00 \times 10^8) / (240 \times 10^3)$	C1
	(= 1250 m) = 1.25 km	A1
4(b)(ii)	bandwidth = 30 kHz	A1
4(b)(iii)	frequency = 15 kHz	A1

Question	Answer	Marks
5(a)	from $x = 0$ to $x = r$: horizontal line at $V = 1.0V_0$	**B1**
	from $x = r$ to $x = 3r$: curve with negative gradient of decreasing magnitude starting at $(r, 1.0V_0)$	**B1**
	line passing through $(2r, \frac{1}{2}V_0)$ and $(3r, \frac{1}{3}V_0)$	**B1**
5(b)	line with negative gradient from $\lambda = \frac{1}{3}\lambda_0$ to $\lambda = \lambda_0$	**B1**
	line passing through $(\lambda_0, 0)$	**B1**
	curve with negative gradient of decreasing magnitude passing through $(\frac{1}{2}\lambda_0, E_{MAX})$ and $(\frac{1}{3}\lambda_0, 2E_{MAX})$	**B1**
5(c)	$1.0T_{½}$ shown at $\frac{1}{2}N_0$ **and** $2.0T_{½}$ shown at $\frac{1}{4}N_0$	**B1**
	line starting at (0, 0) and reaching $(T, N_0–N)$	**B1**
	line starting at (0, 0) and reaching original curve at $(1.0T_{½}, \frac{1}{2}N_0)$	**B1**

Question	Answer	Marks
6(a)	potential difference applied between the plates	**M1**
	causes charge separation (between the plates) **or** causes energy to be stored (between the plates)	**A1**
6(b)(i)	$I = Q / t$	**M1**
	clear substitution of $Q = CV$ and $f = 1 / t$, leading to $I = fCV$	**A1**
6(b)(ii)	$2.5 \times 10^{-6} = 50 \times C \times 180$	**C1**
	C = 280 pF	**A1**
6(c)	(total) capacitance increases	**B1**
	greater charge (for each cycle/discharge) so greater (average) current **or** V and f are constant so (average) current increases **or** I is (directly) proportional to C so (average) current increases	**B1**

Question	Answer	Marks
7(a)(i)	no current enters/leaves the input	**B1**
7(a)(ii)	gain is the same for all frequencies	**B1**
7(b)(i)	$V_{IN} = 1.5 \times 400 / (400 + 1100) = 0.40\,V$ **or** $V_{IN} = 1.5 – (1.5 \times 1100 / 1500) = 0.40\,V$ **or** $(1.5 – V_{IN}) / 1100 = V_{IN} / 400$ so $V_{IN} = 0.40\,V$	**A1**
7(b)(ii)	gain = (–) R_f / R_i	**C1**
	$V_{OUT} / 0.40 = (360 + 100) / 96$	**C1**
	$V_{OUT} = 1.9\,V$	**A1**
7(b)(iii)	resistance <u>of thermistor</u> decreases	**B1**
	(magnitude of) gain decreases so reading decreases	**B1**
7(b)(iv)	(at gain 12.5) V_{OUT} is 5.0 V, so (above gain 12.5) output becomes saturated	**B1**

Question	Answer	Marks
8(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**
8(b)	change in potential energy = change in kinetic energy **or** $qV = ½mv^2$	**B1**
	$v = \sqrt{(2qV / m)}$	**A1**
8(c)(i)	magnetic force = centripetal force **or** $Bqv = mv^2 / r$	**M1**
	clear substitution of expression for *v* and correct algebra leading to $q / m = 2V / B^2r^2$	**A1**
8(c)(ii)	$q / m = (2 \times 230) / [(0.38 \times 10^{-3})^2 \times 0.14^2]$	**C1**
	$= 1.6 \times 10^{11}$ C kg^{-1}	**A1**
8(c)(iii)	(for α-particle,) *q* / *m* is (much) smaller	**B1**
	r would be <u>much</u> larger	**B1**

Question	Answer	Marks
9(a)	(particle is) stationary/not moving	**B1**
	(particle is) moving parallel to the (magnetic) field	**B1**
9(b)	magnetic field around each coil is circular **or** each coil is normal to magnetic field due to adjacent coils	**B1**
	current in coil interacts with (magnetic) field to exert force (on coil)	**B1**
	force is normal to both coil and magnetic field **or** force parallel to axis (of coil)	**B1**
	forces between coils are attractive so spring contracts	**B1**
9(c)	(oscillating) coils cut magnetic flux **or** as separation of coils changes, magnetic flux changes	**B1**
	cutting flux causes induced e.m.f. in coils	**B1**
	<u>changing</u> (induced) e.m.f. causes changing current (in coil)	**B1**

Question	Answer	Marks
10(a)	the steady current **or** the direct current	**M1**
	that produces the same heating effect (as the alternating current)	**A1**
10(b)(i)	peak current = 2.6 A **and** r.m.s. current = 1.8 A	**A1**
10(b)(ii)	peak current = 2.0 A **and** r.m.s. current = 2.0 A	**A1**
10(c)(i)	$k = 2\pi f$	**C1**
	$= 2\pi \times 50$ $= 310\ \text{rad s}^{-1}$	**A1**
10(c)(ii)	power = V_{RMS}^2 / R **or** power = $V_0^2 / 2R$	**C1**
	$R = (240 / \sqrt{2})^2 / 3200$ **or** $R = 240^2 / (2 \times 3200)$ $R = 9.0\ \Omega$	**A1**

Question	Answer	Marks
11(a)	to produce a 3-dimensional image of structure/body	**B1**
11(b)	X-rays (are used)	**B1**
	scanning in sections	**B1**
	scanning from many angles	**B1**
	image of each section is 2-dimensional	**B1**
	scanning repeated for many sections **or** images of many sections combined together	**B1**

Question	Answer	Marks
12(a)	quantum of energy	**M1**
	of electromagnetic radiation	**A1**
12(b)(i)	energy = hc/λ **or** energy = hf **and** $f = c/\lambda$	**C1**
	$0.57 \times 10^{6} \times 1.60 \times 10^{-19} = (6.63 \times 10^{-34} \times 3.00 \times 10^{8})/\lambda$ $\lambda = 2.2 \times 10^{-12}$ m	**A1**

Question	Answer	Marks
12(b)(ii)	$p = h / \lambda$	**C1**
	$= (6.63 \times 10^{-34}) / (2.2 \times 10^{-12})$ $= 3.0 \times 10^{-22}$ N s	**A1**
	or	
	$p = E / c$	**(C1)**
	$= (0.57 \times 10^{6} \times 1.60 \times 10^{-19}) / (3.00 \times 10^{8})$ $= 3.0 \times 10^{-22}$ N s	**(A1)**
12(c)(i)	mass (of Sm-157 nucleus) = $157 \times 1.66 \times 10^{-27}$ **or** mass (of Sm-157 nucleus) = $0.157 / (6.02 \times 10^{23})$	**C1**
	recoil speed = $(3.00 \times 10^{-22}) / (157 \times 1.66 \times 10^{-27})$ $= 1.2 \times 10^{3}$ m s^{-1}	**A1**
12(c)(ii)	$(1.2 \times)\ 10^{3}$ m s^{-1} is <u>much</u> less than $(3.0 \times)\ 10^{8}$ m s^{-1}	**B1**