Cambridge Assessment International Education

Cambridge International AS & A Level

PHYSICS **9702/42**

Paper 4 A Level Structured Questions **March 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.

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This document consists of **19** printed pages.

Examples of how to apply the list rule

State **three** reasons…. [3]

A

1. Correct	✓	**2**
2. Correct	✓	
3. Wrong	✗	

B (4 responses)

1. Correct, Correct	✓, ✓	**3**
2. Correct	✓	
3. Wrong	ignore	

C (4 responses)

1. Correct	✓	**2**
2. Correct, Wrong	✓, ✗	
3. Correct	ignore	

D (4 responses)

1. Correct	✓	**2**
2. Correct, CON (of 2.)	✗, (discount 2)	
3. Correct	✓	

E (4 responses)

1. Correct	✓	**3**
2. Correct	✓	
3. Correct, Wrong	✓	

F (4 responses)

1. Correct	✓	**2**
2. Correct	✓	
3. Correct CON (of 3.)	✗ (discount 3)	

G (5 responses)

1. Correct	✓	**3**
2. Correct	✓	
3. Correct Correct CON (of 4.)	✓ ignore ignore	

H (4 responses)

1. Correct	✓	**2**
2. Correct	✗	
3. CON (of 2.) Correct	(discount 2) ✓	

I (4 responses)

1. Correct	✓	**2**
2. Correct	✗	
3. Correct CON (of 2.)	✓ (discount 2)	

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)	(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)	correct read offs from the graph with correct power of ten for R^3	C1
	$M = \dfrac{4 \times \pi^2 \times 1.2 \times 10^{34}}{6.67 \times 10^{-11} \times 2.4 \times (365 \times 24 \times 3600)^2}$	C1
	$= 3.0 \times 10^{30}$ kg	A1
1(c)(i)	potential energy is zero at infinity	B1
	(gravitational) forces are attractive	B1
	work must be done on the rock to move it to infinity	B1
1(c)(ii)	$\dfrac{GMm}{r^2} = \dfrac{mv^2}{r}$ *OR* $v^2 = \dfrac{GM}{r}$ *OR* $v = \sqrt{\dfrac{GM}{r}}$	M1
	use of ½ mv^2 (e.g. multiplication by ½ m) leading to $\dfrac{GMm}{2r}$	A1
1(c)(iii)	Ep = ϕ m <u>and</u> $\phi = \dfrac{-GM}{r}$ or $E_p = \dfrac{-GMm}{r}$ Total energy = $E_k + E_p$	C1
	Total energy $= \dfrac{GMm}{2r} + \dfrac{-GMm}{r} = \dfrac{-GMm}{2r}$	A1

Question	Answer	Marks
2(a)(i)	$pV = NkT$ or $pV = nRT$ <u>and</u> $N = nN_A$ $N = \dfrac{2.3\times10^{5}\times3.5\times10^{-3}}{1.38\times10^{-23}\times294}$	C1
	= **2.0 × 10^{23}**	A1
2(a)(ii)	$pV = \dfrac{1}{3}Nmc^{2}$ $c^{2} = \dfrac{3\times2.3\times10^{5}\times3.5\times10^{-3}}{2.0\times10^{23}\times40\times1.66\times10^{-27}}$ = 182 000 r.m.s. speed = **430** m s^{-1}	C1
	or $\frac{1}{2}mc^{2} = \frac{3}{2}kT$	A1
	$c^{2} = \dfrac{3\times1.38\times10^{-23}\times294}{40\times1.66\times10^{-27}}$ = 183 000	(C1)
	r.m.s.speed = 430 m s^{-1}	(A1)

Question	Answer	Marks
2(b)	$c^2 = \dfrac{3\times2.0\times10^{23}\times1.38\times10^{-23}\times(294+84)}{2.0\times10^{23}\times40\times1.66\times10^{-27}}$ $c^2 = 236\,000$ $c = 485$	**C1**
	$ratio\left(=\dfrac{485}{430}\right)=1.1$	**A1**
	OR $v\propto\sqrt{T}$ or $v^2\propto T$	**(C1)**
	$ratio=\sqrt{\dfrac{273+21+84}{273+21}}$ or $\sqrt{\dfrac{378}{294}}$ ratio = **1.1**	**(A1)**

Question	Answer	Marks
3(a)	Any 2 from: • particles / atoms / molecules / ions (very) close together / touching • regular, repeating pattern • vibrate about a fixed point	**B2**
3(b)	(much) greater <u>increase</u> in spacing of molecules (for vaporisation compared with fusion)	**B1**
3(c)(i)	–100 °C	**B1**

Question	Answer	Marks
3(c)(ii)	time = 8.5 – 3.0 = 5.5 min	**C1**
	$Pt = mL$ energy = power × time = 150 × 5.5 × 60 = 49 500 J $L = \frac{E}{m}$ $= \frac{49500}{0.045}$	**C1**
	$= 1100\,kJ\,kg^{-1}$	**A1**
3(c)(iii)	gas has a higher specific heat capacity (than liquid)	**B1**

Question	Answer	Marks
4(a)	acceleration and displacement are in opposite directions	**B1**
4(b)(i)	$F = kx$ $= 8.0 \times (0.060 - 0.048)$ *or* $8.0 \times (0.060 + 0.048)$ or 8.0×0.012 *or* 8.0×0.108	**M1**
	$\Sigma F = (8.0 \times 0.012) - (8.0 \times 0.108) = 0.77\,N$ or $\Sigma F = 0.864 - 0.096 = 0.77\,N$	**A1**

Question	Answer	Marks
4(b)(ii)	$a = \frac{F}{m}$ $= \frac{0.77}{0.25}$ $= 3.1 m s^{-2}$	**A1**
4(b)(iii)	$a = - \omega^2 x$ $\omega = \sqrt{\frac{3.1}{0.048}}$ $\omega = 8.04$	**C1**
	$T = 2 \pi / \omega$	**C1**
	$T = 2\pi / 8.04$ $= 0.78$ s	**A1**
4(b)(iv)	(resultant) force halved and distance halved	**B1**
	same T	**B1**

Question	Answer	Marks
5(a)(i)	amplitude of the carrier wave varies	**M1**
	in synchrony with the displacement of the (information) signal	**A1**
5(a)(ii)	Any 2 from: • fewer transmitters needed / each transmitter can cover a greater distance • more stations can share waveband • transmitters and receivers are cheaper	**B2**

Question	Answer	Marks
5(b)(i)	$\lambda = \dfrac{v}{f}$ $= \dfrac{3.0 \times 10^8}{1.5 \times 10^6} = 200\,m$	**A1**
5(b)(ii)	**10** kHz	**B1**
5(c)	**1520** kHz	**B1**

Question	Answer	Marks
6(a)	(both have) radial field lines	**B1**
6(b)(i)	**2.1** cm	**B1**
6(b)(ii)	$E = \dfrac{Q}{4\pi\varepsilon_o r^2}$ e.g. r = 2.1 cm, E = 1.30 × 10^5 V m^{-1} $Q = 4\pi\varepsilon_o r^2 E$ $= 4 \times \pi \times 8.85 \times 10^{-12} \times 0.021^2 \times 1.30 \times 10^5$	**C1**
	$= 6.4 \times 10^{-9} C$	**A1**

Question	Answer	Marks
6(c)	$C = \dfrac{Q}{V}$ *either* $V = \dfrac{Q}{4\pi\varepsilon_o r}$ leading to $C = 4\pi\varepsilon_o r$	C1
	$C = 4 \times \pi \times 8.85 \times 10^{-12} \times 0.021$	C1
	$(C =) 2.3 \times 10^{-12}$ F	A1
	or $V = \dfrac{Q}{4\pi\varepsilon_o r}$ $= \dfrac{6.4 \times 10^{-9}}{4 \times \pi \times 8.85 \times 10^{-12} \times 0.021}$ $= 2740 V$ $C = \dfrac{6.4 \times 10^{-9}}{2740}$	(C1)
	$= 2.3 \times 10^{-12}$F	(A1)

Question	Answer	Marks
7(a)(i)	non-inverting (amplifier)	**B1**
7(a)(ii)	$\text{gain} = \dfrac{R_f}{R} + 1$ $\text{gain} = \dfrac{3.6}{0.72} + 1 = 6.0$	**B1**
7(a)(iii)	straight line from (0,0) to (*T* / 2, 3)	**B1**
	line from origin to 3.0 V then horizontal line at 3.0 V to *T*	**B1**
7(a)(iv)	ldr / light dependent resistor replaces one of the two resistors	**B1**
7(b)(i)	relay coil	**B1**
7(b)(ii)	relay coil between op-amp and earth	**B1**
	diode with correct polarity (pointing away from output) connected between output and device and no other connections or diode with correct polarity (pointing towards earth) between device and earth and no other connections	**B1**
	switch connected to high voltage circuit	**B1**

Question	Answer	Marks
8(a)(i)	at least one anticlockwise arrow and no clockwise arrows	**B1**
8(a)(ii)	(force is to the) left	**B1**
8(a)(iii)	force is the same	**B1**
	Newton's third law (of motion) *or* force depends on the product of the two currents	**B1**

Question	Answer	Marks
8(b)(i)	frequency of radio waves is equal to natural frequency of protons	**B1**
	resonance of protons occurs / protons absorb energy	**B1**
8(b)(ii)	in between pulses / when pulse stops	**B1**
	Any 1 from: • protons de-excite • protons emit r.f. pulses • emitted (r.f.) pulse (from proton) detected	**B1**

Question	Answer	Marks
9(a)	(magnetic) flux density × area × number of turns	**M1**
	area is perpendicular to (magnetic) field	**A1**
9(b)	use of t = 1.2 s	**C1**
	$\varepsilon = \dfrac{\Delta BAN}{\Delta t}$ $= \dfrac{0.250 \times \pi \times 0.030^2 \times 540}{1.2}$	**C1**
	$= 0.32V$	**A1**
9(c)(i)	light damping	**B1**

Question	Answer	Marks
9(c)(ii)	sheet cuts (magnetic) flux and causes induced emf	**B1**
	(induced) emf causes (eddy) currents (in sheet)	**B1**
	either currents (in sheet) cause resistive force or currents (in sheet) dissipate energy	**B1**
	smaller currents in Y or larger currents in X, so dashed line is X	**B1**

Question	Answer	Marks
10(a)	**230** V	**A1**
10(b)	$\omega = 100\pi$ $T = \frac{2\pi}{\omega} = \frac{2\pi}{100\pi}$	**C1**
	$= 0.020\,s$	**A1**
10(c)(i)	half-wave (rectification)	**B1**
10(c)(ii)	sinusoidal half waves in positive V only or negative V only, peak at 320 V	**B1**
	line at zero for second half of cycle	**B1**
	two time periods shown, each of 0.020 s	**B1**
10(c)(iii)	capacitor added in parallel with resistor	**B1**

Question	Answer	Marks
11(a)(i)	electrons decelerate (on hitting target) so X-ray photons produced	B1
	range of decelerations	B1
	photon energy depends on (magnitude of) deceleration	B1
11(a)(ii)	$eV = \dfrac{hc}{\lambda}$	C1
	$\lambda = \dfrac{6.63\times10^{-34}\times3.0\times10^{8}}{1.6\times10^{-19}\times15000}$	C1
	$= 8.3\times10^{-11} m$	A1
	or *E* = *hf* <u>and</u> *c* = *f*λ <u>and</u> electron energy = eV *or* *E* = *hc* / λ <u>and</u> electron energy = eV electron energy = $1.6 \times 10^{-19} \times 15000$ = 2.4×10^{-15}	(C1)
	$\lambda = \dfrac{6.63\times10^{-34}\times3.0\times10^{8}}{2.4\times10^{-15}}$	(C1)
	$\lambda = 8.3\times10^{-11} m$	(A1)
11(b)(i)	μ = – gradient *or* ln (I / I_o) = $-\mu x$	C1
	(e.g. 2.08 / 10.0) = **0.21** cm^{-1}	A1

Question	Answer	Marks
11(b)(ii)	$\ln(0.05) = -\mu x$	**C1**
	$x = \dfrac{\ln 0.05}{-\mu}$ $e.g.\ x = 14\,cm$	**A1**

Question	Answer	Marks
12(a)	1 not affected by external factors	**B1**
	2 cannot predict when a (particular) nucleus will decay *or* cannot predict which nucleus will decay (next)	**B1**
12(b)(i)	Number of atoms = $\dfrac{1.0\times10^{-9}}{90\times1.66\times10^{-27}}$ *or* $\dfrac{1.0\times10^{-9}\times6.02\times10^{23}}{90\times10^{-3}}$ $= 6.693\times10^{15}$	**C1**
	$A = \lambda N$ $\lambda = \dfrac{5.2\times10^{6}}{6.693\times10^{15}}$	**C1**
	$\lambda = 7.8\times10^{-10}$ s^{-1}	**A1**
12(b)(ii)	daughter nucleus is unstable	**B1**