Cambridge Assessment International Education

Cambridge International AS & A Level

PHYSICS **9702/21**

Paper 2 AS Level Structured Questions **October/November 2021**

MARK SCHEME

Maximum Mark: 60

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.

Cambridge International is publishing the mark schemes for the October/November 2021 series for most Cambridge IGCSE™, Cambridge International A and AS Level components and some Cambridge O Level components.

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)	mass / volume	**B1**
1(b)(i)	(vernier/digital) calipers	**B1**
1(b)(ii)	percentage uncertainty = $(0.0004 / 0.0420) \times 100$ = 1%	**A1**
1(c)(i)	kg m^{-3} = kg $\times$ m^n / m **or** kg m^{-3} = kg $\times$ $m^n \times m^{-1}$	**M1**
	$-3 = n - 1$ and (so) $n = -2$	**A1**
1(c)(ii)	$(\Delta\rho / \rho) = (\Delta M / M) + 2(\Delta r / r) + (\Delta L / L)$	**C1**
	percentage uncertainty = $[(0.001 / 1.072) + 2 \times (0.0004 / 0.0420) + (0.0001 / 0.1242)]$ $(\times 100)$	**C1**
	= 0.09% + 2 $\times$ 0.95% + 0.08% = 2%	**A1**
1(c)(iii)	ρ = $(1.072 \times 0.0420^{-2}) / (2.094 \times 0.1242)$ = 2337 (kg m^{-3})	**C1**
	$\Delta\rho$ = 0.021×2337 = 49 (kg m^{-3})	**C1**
	ρ = (2340 ± 50) kg m^{-3}	**A1**

Question	Answer	Marks
2(a)	mass × velocity	**B1**
2(b)(i)	kinetic energy = $\frac{1}{2}mv^2$	**C1**
	= $\frac{1}{2} \times 0.24 \times 2.3^2$	**C1**
	= 0.63 J	**A1**
2(b)(ii)	change in momentum = $\frac{1}{2} \times 240 \times 5.0 \times 10^{-3}$	**C1**
	= 0.60 N s	**A1**
2(b)(iii)	(change in velocity of Y) = 0.60 / 0.12 (= 5.0 m s^{-1})	**C1**
	final velocity of Y = 5.0 – 2.3 = 2.7 m s^{-1}	**A1**
	or	
	(final momentum of Y) = 0.60 – 0.12 × 2.3 (= 0.324 N s)	**(C1)**
	final velocity of Y = 0.324 / 0.12 = 2.7 m s^{-1}	**(A1)**
2(c)	sloping straight line from (0, 0) to t = 3.0 ms **and** another straight line continuous with the first from t = 3.0 ms to (5.0, 0)	**B1**
	lines showing maximum force of magnitude 240 N	**B1**
	lines wholly in the negative F region of the graph	**B1**

Question	Answer	Marks
3(a)(i)	$\sigma = F / xy$	**B1**
3(a)(ii)	$\varepsilon = (z - w) / w$	**B1**
3(a)(iii)	$E = \sigma / \varepsilon$	**C1**
	$= Fw / xy(z - w)$	**A1**
3(b)(i)	extension = 2.2 mm (*allow* 2.0–2.4 mm)	**A1**
3(b)(ii)	strain energy = area under graph/line **or** $\frac{1}{2}Fx$ **or** $\frac{1}{2}kx^2$	**C1**
	$= \frac{1}{2} \times 120 \times 1.4 \times 10^{-3}$ **or** $\frac{1}{2} \times 8.6 \times 10^4 \times (1.4 \times 10^{-3})^2$	**C1**
	= 0.084 J	**A1**
3(b)(iii)	(some of the) deformation of the wire is plastic/permanent/not elastic **or** wire goes past the elastic limit/enters plastic region	**B1**
	energy (that cannot be recovered) is dissipated as thermal energy/becomes internal energy	**B1**

Question	Answer	Marks
4(a)	oscillations (of particles) are parallel to (the direction of) energy transfer	**B1**
4(b)(i)	(frequency varies as) vehicle moves relative to (stationary) observer	**C1**
	(vehicle) moving towards (observer) gives higher (observed) frequency (than 1.2 kHz) and (vehicle) moving away (from observer) gives lower (observed) frequency (than 1.2 kHz)	**A1**
4(b)(ii)	Doppler effect	**B1**
4(b)(iii)	position of vehicle labelled 'X' at top (12 o'clock) position on track	**B1**
4(b)(iv)	position of vehicle labelled 'Y' at right-hand edge (3 o'clock) position on track	**B1**
4(c)	maximum frequency = 1.40 (kHz) **or** 1.40×10^3 (Hz)	**C1**
	$1.40 = (1.2 \times 320) / (320 - v)$	**C1**
	$v = 46\ \text{m s}^{-1}$	**A1**
	or	
	minimum frequency = 1.05 (kHz) **or** 1.05×10^3 (Hz)	**(C1)**
	$1.05 = (1.2 \times 320) / (320 + v)$	**(C1)**
	$v = 46\ \text{m s}^{-1}$	**(A1)**

Question	Answer	Marks
5(a)	sum of current(s) in = sum of current(s) out **or** (algebraic) sum of current(s) is zero	**M1**
	at a junction (in a circuit)	**A1**
5(b)(i)	(current in R_4 or R_1 =) 0.30 + 0.30 (= 0.60 A)	**B1**
	(R =) 2.4 / 0.60 = 4.0 (Ω)	**A1**
	or	
	(p.d. across R_3 or R_2 =) 2.4 / 2 (= 1.2 V)	**(B1)**
	(R =) 1.2 / 0.30 = 4.0 (Ω)	**(A1)**
5(b)(ii)	E = 2.4 + 2.4 + 1.2	**C1**
	= 6.0 V	**A1**
	or	
	total resistance = 10 (Ω)	**(C1)**
	E = 10 × 0.60 = 6.0 V	**(A1)**
5(c)	total resistance increases	**B1**
	current decreases (in battery) so total power decreases	**B1**

Question	Answer	Marks
5(d)	resistivity = RA / L	**C1**
	$= 4.0 \times \pi \times (240 \times 10^{-6})^2 / 0.67$	**C1**
	$= 1.1 \times 10^{-6}\ \Omega$ m	**A1**

Question	Answer	Marks
6(a)	α-particle mass given as 4u	**B1**
	α-particle charge given as (+)2*e*	**B1**
	both β-particles mass given as 0.0005 u	**B1**
	β^+ charge given as (+)*e* and β^- charge given as –*e* (Completed table: mass / u: α 4; β^+ 0.0005; β^- 0.0005 charge / *e*: α (+)2; β^+ (+)1; β^- –1)	**B1**
6(b)(i)	neutron decays into proton and an electron / β^- particle	**B1**
6(b)(ii)	down to up	**B1**
6(b)(iii)	(electron) antineutrino(s) emitted	**B1**
	energy (released in decay)/momentum shared between antineutrino and β^- particle	**B1**