Cambridge Assessment International Education

Cambridge International AS & A Level

PHYSICS	**9702/42**
Paper 4 A Level Structured Questions	**May/June 2020**
MARK SCHEME	
Maximum Mark: 100	

Published

Students did not sit exam papers in the June 2020 series due to the Covid-19 global pandemic.

This mark scheme is published to support teachers and students and should be read together with the question paper. It shows the requirements of the exam. The answer column of the mark scheme shows the proposed basis on which Examiners would award marks for this exam. Where appropriate, this column also provides the most likely acceptable alternative responses expected from students. Examiners usually review the mark scheme after they have seen student responses and update the mark scheme if appropriate. In the June series, Examiners were unable to consider the acceptability of alternative responses, as there were no student responses to consider.

Mark schemes should usually be read together with the Principal Examiner Report for Teachers. However, because students did not sit exam papers, there is no Principal Examiner Report for Teachers for the June 2020 series.

Cambridge International will not enter into discussions about these mark schemes.

Cambridge International is publishing the mark schemes for the June 2020 series for most Cambridge IGCSE™ and Cambridge International A & AS Level components, and some Cambridge O Level components.

This document consists of **17** printed pages.

6	<u>Calculation specific guidance</u> Correct answers to calculations should be given full credit even if there is no working or incorrect working, **unless** the question states 'show your working'. For questions in which the number of significant figures required is not stated, credit should be awarded for correct answers when rounded by the examiner to the number of significant figures given in the mark scheme. This may not apply to measured values. For answers given in standard form, (e.g. $a \times 10^n$) in which the convention of restricting the value of the coefficient (a) to a value between 1 and 10 is not followed, credit may still be awarded if the answer can be converted to the answer given in the mark scheme. Unless a separate mark is given for a unit, a missing or incorrect unit will normally mean that the final calculation mark is not awarded. Exceptions to this general principle will be noted in the mark scheme.
7	<u>Guidance for chemical equations</u> Multiples / fractions of coefficients used in chemical equations are acceptable unless stated otherwise in the mark scheme. State symbols given in an equation should be ignored unless asked for in the question or stated otherwise in the mark scheme.

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)	work done per unit mass	**B1**
	(work done to) move mass from infinity (to the point)	**B1**
1(b)	curve from r to $4r$, with gradient of decreasing magnitude and starting at (r, $\pm\phi$)	**B1**
	line passing through ($2r$, $\pm 0.5\phi$) and ($4r$, $\pm 0.25\phi$)	**B1**
	line showing potential is negative throughout	**B1**
1(c)(i)	gravitational potential energy = (–) GMm / R	**C1**
	change $= (6.67 \times 10^{-11} \times 6.0 \times 10^{24} \times 3.4 \times 10^{3}) / (6.4 \times 10^{6}) \times [1/3 - 1/4]$	**C1**
	$= 1.8 \times 10^{10}$ J	**A1**
1(c)(ii)	rock loses potential energy	**B1**
	(so) kinetic energy increases so speed increases	**B1**
	or	
	force is attractive	**(B1)**
	moves towards planet so speeds up	**(B1)**

Question	Answer	Marks
2(a)	ρ: Nm / V	B1
	⅓: molecules move in three dimensions (not one) so ⅓ in any (one) direction	B1
	$<c^2>$: molecules have different speeds so take average	M1
	of (speed)^2	A1
2(b)	$pV = NkT$	C1
	$N = (3.0 \times 10^5 \times 6.0 \times 10^{-3}) / (1.38 \times 10^{-23} \times 290)$	C1
	$= 4.5 \times 10^{23}$	C1
	mass $= 20.7 / (4.5 \times 10^{23})$ $= 4.6 \times 10^{-23}$ g	A1

Question	Answer	Marks
3(a)	(little/no volume change so) little/no external work done	B1
	thermal energy supplied to provide latent heat	M1
	internal energy increases	A1
3(b)	(rapid) increase in volume	B1
	gas does work against the atmosphere	M1
	internal energy decreases	A1

Question	Answer	Marks
4(a)	($\omega = 2\pi / T$ and $T = 2.2$ s so) $\omega = 2\pi / 2.2 = 2.9$ rad s^{-1}	A1
4(b)(i)	$\omega^2 = g / R$	C1
	$R = 9.81 / 2.86^2$ $= 1.2$ m	A1
4(b)(ii)	$v_0 = \omega x_0$	C1
	$= 2.9 \times 3.0 \times 10^{-2}$ $= 0.087$ m s^{-1}	A1
4(c)	smooth wave starting at 3.0 cm when $t = 0$	B1
	positions of peaks and troughs show same period (or slightly longer)	B1
	each peak and trough at lower amplitude than the previous one	B1

Question	Answer	Marks
5(a)	pulses of ultrasound	**B1**
	ultrasound incident on quartz crystal	**B1**
	waves make crystal oscillate	**B1**
	oscillations (of crystal) generates an e.m.f. (across the crystal)	**B1**
5(b)	specific acoustic impedances of air and skin are very different	**B1**
	intensity reflection coefficient depends on difference between acoustic impedance	**B1**
	most ultrasound reflected so little transmission	**B1**

Question	Answer	Marks
6(a)	• greater bandwidth • less noise • less attenuation **or** fewer repeaters • less crosslinking **or** greater security *Any three points, 1 mark each*	**B3**
6(b)(i)	ratio / dB = 10 lg(P_1 / P_2)	**C1**
	21 = 10 lg [(6.3×10^{-17}) / P] $P = 5.0 \times 10^{-19}$ W	**A1**
6(b)(ii)	attenuation per unit length = (1 / 4.5×10^{3}) × 10 lg [(9.8×10^{-3}) / (6.3×10^{-17})]	**C1**
	= 0.032 dB km^{-1}	**A1**

Question	Answer	Marks
7(a)	force per unit charge	**M1**
	(force on) positive charge	**A1**
7(b)(i)	no electric field inside a conductor	**B1**
	$R = 4.5\,\text{cm}$	**A1**
7(b)(ii)	$E = Q / (4\pi\varepsilon_0 x^2)$	**C1**
	clear correct read-off of a pair of values of *E* and *x*	**C1**
	e.g. $Q = 18 \times 10^5 \times 4\pi \times 8.85 \times 10^{-12} \times (4.5 \times 10^{-2})^2$ $= 4.0 \times 10^{-7}\,\text{C}$ **or** $4.1 \times 10^{-7}\,\text{C}$	**A1**
7(c)	At 8.0 cm, $E = 5.75 \times 10^5\,\text{V m}^{-1}$	**C1**
	$F = Eq$ **and** $a = F / m$	**C1**
	$F = (5.75 \times 10^5 \times 2 \times 1.6 \times 10^{-19}) / (4 \times 1.66 \times 10^{-27})$ $= 2.8 \times 10^{13}\,\text{m s}^{-2}$	**A1**

Question	Answer	Marks
8(a)(i)	constant gain for all frequencies	**B1**
8(a)(ii)	unchanged	**B1**
8(b)(i)	(open loop) gain of op-amp is infinite	**B1**
	feedback loop ensures $V^+ \approx V^-$ **or** any difference between V^+ and V^- results in saturated output	**B1**
	non-inverting input is 0 V so inverting input also at 0 V	**B1**
8(b)(ii)	input = (40 × 1.5) / (40 + 110)	**C1**
	= 0.40 V	**A1**
8(b)(iii)	gain = (–) (100 + 230) / 150 **or** feedback current = 0.40 / (150 × 10^3) (A)	**C1**
	p.d. = [(100 + 230) / 150] × 0.40 = 0.88 V	**A1**
8(c)	(magnitude of) gain decreases	**M1**
	voltmeter reading decreases	**A1**

Question	Answer	Marks
9(a)(i)	force is downwards/down the page **or** current is (right) to left	**B1**
	by left-hand rule, field is into plane of paper	**B1**
9(a)(ii)	magnetic force provides the centripetal force	**C1**
	$Bqv = mv^2 / r$	**C1**
	$v = Bqr / m$ $= (8.0 \times 10^{-4} \times 1.60 \times 10^{-19} \times 6.4 \times 10^{-2}) / (9.11 \times 10^{-31})$ $= 9.0 \times 10^{6}$ m s^{-1}	**A1**
9(b)(i)	arrow showing field direction down the page	**B1**
9(b)(ii)	$Bqv = Eq$ **or** $v = E / B$	**C1**
	$E = 9.0 \times 10^{6} \times 8.0 \times 10^{-4}$ $= 7.2 \times 10^{3}$ N C^{-1}	**A1**
9(c)	straight line/undeviated	**B1**
	condition for no deflection depends only on *v* **or** condition for no deflection does not depend on *m* or *q*	**B1**

Question	Answer	Marks
10(a)	(induced) electromotive force is proportional to rate	**M1**
	of change of (magnetic) flux (linkage)	**A1**
10(b)(i)	to change magnitude of potential difference	**B1**
10(b)(ii)	magnitude of e.m.f. varies as rate of change of flux changes	**B1**
	direction of e.m.f. changes when direction of change of flux reverses/when flux changes from increasing to decreasing	**B1**
	flux is continuously increasing and decreasing, so polarity of e.m.f. is continuously switching	**B1**
10(b)(iii)	to reduce energy/power losses **or** to reduce eddy currents	**B1**

Question	Answer	Marks
11(a)	conduction band and valence band overlap	**B1**
	number (density) of charge carriers does not vary	**B1**
	increase in temperature gives rise to <u>increased</u> lattice vibrations	**B1**
	(lattice) vibrations hinder movement of charge carriers so resistance increases	**B1**
11(b)	$mv = h / \lambda$	**C1**
	$v = (6.63 \times 10^{-34}) / [(2.6 \times 10^{-11}) \times (9.11 \times 10^{-31})]$ $(= 2.80 \times 10^{7}\ \text{m s}^{-1})$	**C1**
	$qV = ½mv^2$	**C1**
	$V = [9.11 \times 10^{-31} \times (2.80 \times 10^{7})^2] / [2 \times 1.60 \times 10^{-19}]$ $= 2.2 \times 10^{3}\ \text{V}$	**A1**

Question	Answer	Marks
12(a)	difference between mass of nucleus and mass of (constituent) nucleons	**M1**
	where nucleons are separated to infinity	**A1**
12(b)(i)	$E = mc^2$	**C1**
	$= 1.66 \times 10^{-27} \times (3.00 \times 10^8)^2 / (1.60 \times 10^{-13}) = 934$ MeV	**A1**
12(b)(ii)	mass defect = $2 \times (1.007276 + 1.008665) - 4.001506$ (= 0.030376)	**B1**
	binding energy per nucleon = $(0.030376 \times 934) / 4 = 7.09$ MeV	**A1**
12(c)	binding energy per nucleon is much greater	**M1**
	so would require a large amount of energy to separate the nucleons in helium	**A1**
	or	
	amount of energy released in forming hydrogen isotopes	**(M1)**
	is less than energy required to break apart helium nucleus	**(A1)**