Cambridge Assessment International Education

Cambridge International AS & A Level

PHYSICS **9702/42**

Paper 4 A Level Structured Questions **October/November 2020**

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)	work done per unit mass	**B1**
	(work done) moving mass from infinity (to the point)	**B1**
1(b)(i)	gravitational potential energy = (–)*GMm* / *r*	**C1**
	$\Delta E_P = 6.67 \times 10^{-11} \times 6.0 \times 10^{24} \times 2.4 \times 10^3 \times [(6.4 \times 10^6)^{-1} - (1.2 \times 10^7)^{-1}]$	**C1**
	or	
	$\Delta\phi = 6.67 \times 10^{-11} \times 6.0 \times 10^{24} \times [(6.4 \times 10^6)^{-1} - (1.2 \times 10^7)^{-1}]$	**(C1)**
	$\Delta E_P = m\Delta\phi$	**(C1)**
	$\Delta E_P = 7.0 \times 10^{10}$ J	**A1**
1(b)(ii)	$GMm / r^2 = mv^2 / r$	**C1**
	$v^2 = GM / r$ $= (6.67 \times 10^{-11} \times 6.0 \times 10^{24}) / (1.2 \times 10^7)$	**C1**
	$v = 5800$ m s^{-1}	**A1**
1(c)	any one point from: • smaller gain in energy required if orbit is west to east • smaller change in velocity if orbit is west to east • smaller gain in energy if orbit is in same direction as Earth's rotation • smaller change in velocity if orbit is in same direction as Earth's rotation • satellite already moving west to east at launch • Earth's rotation is from west to east	**B1**

Question	Answer	Marks
2(a)	sum of potential energy and kinetic energy (of particles)	**B1**
	(total) energy of random motion of particles	**B1**
2(b)(i)	$pV = nRT$	**C1**
	$2.60 \times 10^5 \times 2.30 \times 10^{-3} = n \times 8.31 \times 180$ $n = 0.400$ mol	**A1**
2(b)(ii)	$(2.30 \times 10^{-3}) / 180 = (3.80 \times 10^{-3}) / T$ **or** $2.60 \times 10^5 \times 3.80 \times 10^{-3} = 0.400 \times 8.31 \times T$	**C1**
	$T = 297$ K	**A1**
2(c)(i)	$\Delta W = p\Delta V$ $= 2.60 \times 10^5 \times (2.30 - 3.80) \times 10^{-3}$	**C1**
	= (–)390 J	**A1**
	negative because work is done by gas **or** negative because work is done against atmospheric pressure **or** negative because volume of gas increases	**B1**
2(c)(ii)	$\Delta U = (980 - 390)$ = 590 J	**A1**

Question	Answer	Marks
3(a)	acceleration (directly) proportional to displacement	**B1**
	acceleration is in opposite <u>direction</u> to displacement **or** acceleration is (directed) towards a fixed point	**B1**
3(b)(i)	zero	**B1**
3(b)(ii)	E_T is maximum potential energy = mgh E_T = $94 \times 10^{-3} \times 9.81 \times 0.90 \times 10^{-2}$	**C1**
	= 8.3×10^{-3} J	**A1**
3(b)(iii)	$E_{MAX} = ½\, mv_0^2$ **and** $v_0 = \omega x_0$ **or** $E_{MAX} = ½m(\omega x_0)^2$	**C1**
	$8.3 \times 10^{-3} = ½ \times 94 \times 10^{-3} \times \omega^2 \times (12.7 \times 10^{-2})^2$ …leading to ω = 3.3 rad s^{-1}	**A1**
3(c)	$T = 2\pi / \omega$	**C1**
	$2\pi / 3.3 = 2\pi \times (L / 9.81)^{½}$	**C1**
	L = 0.90 m	**A1**

Question	Answer	Marks
4(a)	any two points from: • signal can be regenerated/noise can be removed • signal can be encrypted • signal can be checked for errors • multiplexing is possible • circuits are more reliable/cheaper • data can be transmitted at a greater rate	**B2**
4(b)(i)	right-hand zero underlined (0110)	**B1**
4(b)(ii)	analogue signals given as: 3.0, 4.8, 1.0	**B1**
	0011 at 0.30 ms **and** 0001 at 0.50 ms	**B1**
	0100 at 0.40 ms	**B1**
4(c)	series of steps, all of width 0.1 ms	**B1**
	steps levels, in order, at output voltage 0, 5, 6, 3 and 4 mV 2 marks: all levels correct 1 mark: one level incorrect and all others correct **or** one level omitted and last step shown at 1 mV	**B2**

Question	Answer	Marks
5(a)(i)	region (of space)	**B1**
	where a particle experiences a force	**B1**
5(a)(ii)	similarity – any one point from: • both have an inverse square variation • both decrease with distance • both are radial	**B1**
	difference – any one point from: • gravitational field always towards (the mass) • electric field can be towards or away from (the charge)	**B1**
5(b)(i)	$E = Q / 4\pi\varepsilon_0 x^2$	**C1**
	$Q = 4\pi \times 8.85 \times 10^{-12} \times 84 \times 0.15^2$ $= 2.1 \times 10^{-10}$ C	**A1**
5(b)(ii)	$E = 84 \times (0.15 / 0.45)^2$ **or** $E = (2.1 \times 10^{-10}) / (4\pi \times 8.85 \times 10^{-12} \times 0.45^2)$	**C1**
	$E = 9.3$ V m^{-1}	**A1**
5(c)	line at $E = 0$ from $x = 0$ to $x = 0.15$ m	**B1**
	smooth curve with decreasing negative gradient throughout, from $x = 0.15$ m to $x = 0.45$ m, passing through (0.15, 84)	**B1**
	line passing through (0.45, 9.3)	**B1**

Question	Answer	Marks
6(a)(i)	charge per unit potential (difference)	**M1**
	charge on one plate and potential difference between the plates	**A1**
6(a)(ii)	any three points from: • smoothing • timing/(time) delaying • tuning • oscillator • blocking d.c. • surge protection • temporary power supply	**B3**
6(b)(i)	parallel combination of two in series and a single capacitor	**B1**
6(b)(ii)	one capacitor in series with two in parallel	**B1**

Question	Answer	Marks
7(a)	X-ray photon produced when electron is decelerated	**B1**
	larger acceleration results in larger photon energy	**B1**
	continuous range of accelerations so continuous spectrum of wavelengths/frequencies	**B1**
7(b)	electron in (inner shell of) target atom is excited (on collision)	**B1**
	electron de-excites causing emission of a photon	**B1**
	discrete energy levels so discrete photon wavelengths	**B1**

Question	Answer	Marks
8(a)(i)	gain is the same for all frequencies	**B1**
8(a)(ii)	no (time) delay in change in output when input is changed	**B1**
8(b)(i)	(at saturation,) V_{OUT} = 5.0 V	**C1**
	gain = 5.0 / 0.40 = 12.5 or 13	**A1**
8(b)(ii)	12.5 = 1 + (R / 800)	**C1**
	R = 9200 Ω	**A1**

Question	Answer	Marks
9(a)(i)	(induced) e.m.f. (directly) proportional to rate	**M1**
	of change of magnetic flux (linkage)	**A1**
9(a)(ii)	e.m.f. = 0 apart from thin pulses at t_1 and t_2	**B1**
	rectangular pulses centred on t_1 and t_2, of widths 2 small squares and 1 small square respectively	**B1**
	e.m.fs. at t_1 and t_2 have opposite polarities	**B1**
	magnitude of e.m.f. at t_2 double the magnitude of e.m.f. at t_1	**B1**
9(b)	V_H shown as zero before (t_1 – 2 squares) and after (t_2 + 2 squares) and rises to a constant non-zero value between t_1 and t_2	**M1**
	change at t_1 shown as 2 small squares wide and change at t_2 shown as 1 small square wide	**A1**

Question	Answer	Marks
10(a)	concentric circles centred on the wire	**B1**
	separation of lines increasing with distance from wire	**B1**
	arrows show anti-clockwise direction	**B1**
10(b)(i)	current in (each) wire creates a magnetic field (at the other wire)	**B1**
	current (in wire) at 90° to field causes force	**B1**
10(b)(ii)	force on each wire towards other wire/attractive	**B1**
10(c)	Newton's third law pair of forces so yes (forces are equal) **or** force proportional to product of both currents so yes (forces are equal)	**B1**

Question	Answer	Marks
11(a)	any two points from: • (maximum) kinetic energy of electrons is independent of intensity • maximum kinetic energy of electrons depends on frequency • no time delay (between illumination and emission)	**B2**
11(b)(i)	(for $E_{MAX} = 0$,) $1 / \lambda_0 = 1.93 \times 10^6$ (m^{-1})	**C1**
	$f_0 = 3.00 \times 10^8 \times 1.93 \times 10^6$ $= 5.8 \times 10^{14}$ Hz	**A1**
11(b)(ii)	$hc / \lambda = \Phi + E_{MAX}$	**C1**
	hc = gradient	**C1**
	gradient = e.g. $[(0.40 - 0.20) \times 1.60 \times 10^{-19}] / [(2.25 - 2.09) \times 10^6]$ (*working needed*) $(= 2.0 \times 10^{-25})$	**M1**
	$h = (2.0 \times 10^{-25}) / (3.00 \times 10^8) = 6.7 \times 10^{-34}$ J s (*both working and answer needed*)	**A1**
11(c)	straight line with same gradient as the original	**B1**
	straight line with x-axis intercept greater than 1.93×10^6 m^{-1}	**B1**

Question	Answer	Marks
12(a)(i)	energy required to separate nucleons (of nucleus)	**M1**
	to infinity	**A1**
12(a)(ii)	a (single) large nucleus divides to form (smaller) nuclei	**B1**
	any one point from: • initiated by neutron bombardment • resulting nuclei are of similar size • binding energy per nucleon increases • total binding energy increases • neutrons released • combined mass of smaller nuclei is less than mass of large nucleus	**B1**
12(b)	binding energy per nucleon is a maximum at around $A = 56$	**B1**
	products of splitting a ^{56}Fe nucleus must have a lower total binding energy	**B1**
	(reaction would require) a net input of energy	**B1**