Cambridge International AS & A Level

Cambridge Assessment International Education
Cambridge International Advanced Subsidiary and Advanced Level

PHYSICS	**9702/42**
Paper 4 A Level Structured Questions	**May/June 2019**
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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Cambridge Assessment International Education

Generic Marking Principles

These general marking principles must be applied by all examiners when marking candidate answers. They should be applied alongside the specific content of the mark scheme or generic level descriptors for a question. Each question paper and mark scheme will also comply with these marking principles.

GENERIC MARKING PRINCIPLE 1:

Marks must be awarded in line with:

- the specific content of the mark scheme or the generic level descriptors for the question
- the specific skills defined in the mark scheme or in the generic level descriptors for the question
- the standard of response required by a candidate as exemplified by the standardisation scripts.

GENERIC MARKING PRINCIPLE 2:

Marks awarded are always **whole marks** (not half marks, or other fractions).

GENERIC MARKING PRINCIPLE 3:

Marks must be awarded **positively**:

- marks are awarded for correct/valid answers, as defined in the mark scheme. However, credit is given for valid answers which go beyond the scope of the syllabus and mark scheme, referring to your Team Leader as appropriate
- marks are awarded when candidates clearly demonstrate what they know and can do
- marks are not deducted for errors
- marks are not deducted for omissions
- answers should only be judged on the quality of spelling, punctuation and grammar when these features are specifically assessed by the question as indicated by the mark scheme. The meaning, however, should be unambiguous.

GENERIC MARKING PRINCIPLE 4:

Rules must be applied consistently e.g. in situations where candidates have not followed instructions or in the application of generic level descriptors.

GENERIC MARKING PRINCIPLE 5: Marks should be awarded using the full range of marks defined in the mark scheme for the question (however; the use of the full mark range may be limited according to the quality of the candidate responses seen).
GENERIC MARKING PRINCIPLE 6: Marks awarded are based solely on the requirements as defined in the mark scheme. Marks should not be awarded with grade thresholds or grade descriptors in mind.

Question	Answer	Marks
1(a)	(F =) GMm / x^2, where G is the (universal) gravitational constant	**B1**
1(b)(i)	angle = $(1.2 \times 10^{-3}) / (8.0 \times 10^{-2}) = 1.5 \times 10^{-2}$ (rad)	**B1**
1(b)(ii)	torque $= 1.5 \times 10^{-2} \times 9.3 \times 10^{-10}$ $= 1.4 \times 10^{-11}$ N m	**A1**
1(c)(i)	force $\times 8.0 \times 10^{-2} = 1.4 \times 10^{-11}$	**C1**
	$(G \times 1.3 \times 7.5 \times 10^{-3} \times 8.0 \times 10^{-2}) / (6.0 \times 10^{-2})^2 = 1.4 \times 10^{-11}$	**C1**
	$G = 6.4 \times 10^{-11}$ N m^2 kg^{-2}	**A1**
1(c)(ii)	Any one from: • law applies only to point masses/spheres are not point masses • radii of spheres not small compared with separation • spheres may not be uniform • the masses are not isolated • force between L and rod • spheres may be charged/may be electrostatic force (between spheres)	**B1**

<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td rowspan="2">2(a)(i)</td><td>1. energy transfer <u>to</u> the system by heating</td><td>B1</td></tr>
<tr><td>2. (external) work done <u>on</u> the system</td><td>B1</td></tr>
<tr><td>2(a)(ii)</td><td><u>decrease</u> in internal energy</td><td>B1</td></tr>
<tr><td rowspan="2">2(b)(i)</td><td>no change (in internal energy)</td><td>B1</td></tr>
<tr><td>(because) no change in temperature</td><td>B1</td></tr>
<tr><td rowspan="2">2(b)(ii)</td><td>work done $= p\Delta V$
$= (–)1.6 \times 10^{5} \times (2.4 – 0.87) \times 10^{–3}$</td><td>C1</td></tr>
<tr><td>= (–)240 J</td><td>A1</td></tr>
<tr><td rowspan="4">2(b)(iii)</td><td>first row all correct (0, 480, 480)</td><td>A1</td></tr>
<tr><td>second row all correct (–1100, 0, –1100)</td><td>A1</td></tr>
<tr><td>final column of third row calculated correctly from the two values above it, so that the final column adds up to 0</td><td>A1</td></tr>
<tr><td>second column in final row correct, with correct negative sign
and
first column in final row calculated correctly so that it adds to the second column to give the third column

(fully correct table is:
<table><tr><td>0</td><td>480</td><td>480</td></tr><tr><td>–1100</td><td>0</td><td>–1100</td></tr><tr><td>860</td><td>–240</td><td>620</td></tr></table>)</td><td>A1</td></tr>
</table>

Question	Answer	Marks
3(a)(i)	0.10 s **or** 0.30 s **or** 0.50 s **or** 0.70 s **or** 0.90 s	**A1**
3(a)(ii)	0 **or** 0.40 s **or** 0.80 s	**A1**
3(b)(i)	$\omega = 2\pi / T$	**C1**
	$= 2\pi / 0.40$ $= 16\ \text{rad s}^{-1}$	**A1**
3(b)(ii)	$v_0 = \omega x_0$	**C1**
	$= 15.7 \times 2.5 \times 10^{-2}$ $= 0.39\ \text{m s}^{-1}$	**A1**
	or	
	tangent drawn at steepest part and working to show attempted calculation of gradient	**(C1)**
	leading to $v_0 = 0.39\ \text{m s}^{-1}$ (*allow* ± *0.15 m s*$^{-1}$)	**(A1)**
3(b)(iii)	$a_0 = \omega^2 x_0$	**C1**
	$a_0 = (15.7^2 \times 2.5 \times 10^{-2})$ $= 6.2\ \text{m s}^{-2}$	**A1**
	or	
	$a_0 = \omega v_0$	**(C1)**
	$a_0 = 15.7 \times 0.39$ $= 6.2\ \text{m s}^{-2}$	**(A1)**

Question	Answer	Marks
3(c)	period is shorter/lower	**B1**
	Any one from: • greater spring constant/stiffness • (restoring) force is greater (for any given extension) • acceleration is greater (for any given extension) • greater energy/maximum speed (for a given amplitude)	**B1**

Question	Answer	Marks
4(a)	product of density and speed	**M1**
	speed of sound in medium	**A1**
4(b)	Any two from: • if $Z_A \gg Z_B$ then ratio is (nearly) zero **or** if $Z_B \gg Z_A$ then ratio is (nearly) zero **or** if Z_B and Z_A are very different then ratio is (nearly) zero **or** the greater the difference the lower the ratio • if $Z_A \approx Z_B$ then ratio is (nearly) 1 **or** if $Z_A = Z_B$ then ratio is 1 **or** the smaller the difference the closer the ratio to 1 (**not** 'large') • $I_T / I_0 = 1 - [(Z_A - Z_B)^2 / (Z_A + Z_B)^2]$	**B2**
4(c)	$I = I_0 e^{-\mu x}$	**C1**
	$0.34 = \exp(-23 \times x)$	**C1**
	$x = 0.047$ m	**A1**

Question	Answer	Marks
5(a)(i)	loss of (signal) power/amplitude/intensity	**B1**
5(a)(ii)	unwanted/random signal	**B1**
	superposed on (transmitted) signal	**B1**
5(b)(i)	attenuation = 10 lg(P_2 / P_1)	**C1**
	attenuation per unit length = (1 / L) × 10 lg(P_2 / P_1) = (1 / 52) × 10 lg [(2.5 × 10^{-3}) / (7.8 × 10^{-16})]	**C1**
	= 2.4 dB km^{-1}	**A1**
5(b)(ii)	gain / dB = 10 lg(P_2 / P_1) 115 = 10 lg [P / (7.8 × 10^{-16})]	**C1**
	P = 2.5 × 10^{-4} W	**A1**

Question	Answer	Marks
6(a)	work done per unit charge	**B1**
	(work done) moving positive charge from infinity	**B1**
6(b)	straight line with non-zero gradient from $x = 0$ to $x = d$	**B1**
	line with gradient of constant sign and end-points between which $\Delta V = V_0$ and $\Delta x = d$	**B1**
	line passes through (d, 0) and (0, $+V_0$) with negative gradient throughout	**B1**
6(c)	V constant (and non-zero) from $0 \rightarrow R$ and from $(D - R) \rightarrow D$	**B1**
	equal (non-zero) values of (magnitude of) V at R and $(D - R)$.	**B1**
	curve (with a minimum) from R to $(D - R)$ with V always positive	**B1**
	minimum at mid-point of curve	**B1**

Question	Answer	Marks
7(a)	Any five from: • (as temperature rises) energy of electrons increases • electrons (have enough energy to) cross forbidden band • electrons enter conduction band • leaving holes in valence band • both holes and electrons act as charge carriers • more charge carriers results in lower resistance • increased lattice vibrations outweighed by increase in (number of) charge carriers	**B5**
7(b)	(at 10 °C resistance is) 2.55 kΩ	**C1**
	new potential difference = 9.00 × 2.55 / (2.55 + 12.0) = 1.58 V	**C1**
	change in p.d. = 0.58 V	**A1**
7(c)	change of resistance with temperature is not linear	**B1**
	change in potential with resistance is not linear **or** potential divider equation is non-linear	**B1**

Question	Answer	Marks
8(a)(i)	v_N = 3.4 × 10^7 × sin 30° = 1.7 × 10^7 m s^{-1}	**A1**
8(a)(ii)	$mv^2 / r = Bqv$ **or** $r = mv / Bq$	**C1**
	r = (9.11 × 10^{-31} × 1.7 × 10^7) / (3.2 × 10^{-3} × 1.60 × 10^{-19})	**C1**
	= 0.030 m	**A1**
8(b)	zero	**B1**
8(c)	helix/coil	**B1**

Question	Answer	Marks
9(a)(i)	relay coil shown connected between diode and earth	**B1**
	switch shown connected across lamp	**B1**
9(a)(ii)	Any one from: • (for diode to conduct) current flow is into output of op-amp • when earth is at higher potential diode is forward biased • diode blocks current when output positive • diode must conduct	**M1**
	so V_{OUT} is negative	**A1**
9(b)(i)	strain gauge	**B1**
9(b)(ii)	light-dependent resistor	**B1**

Question	Answer	Marks
10(a)	(induced) e.m.f. proportional to rate	**M1**
	of change of (magnetic) flux (linkage)	**A1**
10(b)	current in primary coil gives rise to magnetic flux	**B1**
	changing (magnetic) flux in core links with secondary coil	**B1**
	induced e.m.f. (in secondary coil) causes current in load/resistor	**B1**
10(c)	correct application of turns ratio: to peak voltage ratio, giving (V_0 / 220) = (450 / 2700) **or** to r.m.s. voltage ratio, giving ($V_{r.m.s.}$ / 156) = (450 / 2700)	**C1**
	correct application of √2 factor: to peak applied e.m.f., giving 220 / √2 **or** to peak output em.f., giving 37 / √2	**C1**
	$V_{r.m.s.}$ = 26 V	**A1**

Question	Answer	Marks
11(a)	packet/quantum of energy	M1
	of electromagnetic radiation	A1
11(b)(i)	$E = hc / \lambda$	C1
	$1.18 \times 1.60 \times 10^{-13} = (6.63 \times 10^{-34} \times 3.00 \times 10^{8}) / \lambda$ $\lambda = 1.05 \times 10^{-12}$ m	A1
11(b)(ii)	$\lambda = h / p$ **or** $E = pc$	C1
	$p = (6.63 \times 10^{-34}) / (1.05 \times 10^{-12})$ **or** $p = (1.18 \times 1.60 \times 10^{-13}) / (3.00 \times 10^{8})$ leading to $p = 6.3 \times 10^{-22}$ N s	B1
11(c)	$6.3 \times 10^{-22} = 60 \times 1.66 \times 10^{-27} \times v$	C1
	$v = 6.3 \times 10^{3}$ m s^{-1}	A1

Question	Answer	Marks
12(a)	energy required to separate the nucleons (in a nucleus)	**M1**
	to infinity	**A1**
	or	
	energy released when nucleons come together (to form nucleus)	**(M1)**
	from infinity	**(A1)**
12(b)	mass defect = 140.911 – (57 × 1.007) – (84 × 1.009)	**C1**
	= 140.911 – 142.155 = (–)1.244 (u)	**C1**
	energy = $c^2(\Delta)m$	**C1**
	= $(3.00 \times 10^8)^2 \times 1.244 \times 1.66 \times 10^{-27}$ = 1.9×10^{-10} J	**A1**
12(c)(i)	$A = A_0 e^{-\lambda t}$ **and** $\ln 2 = \lambda t_{½}$	**C1**
	$0.40 = \exp(-\ln 2 \times t / 3.9)$	**C1**
	or	
	$(0.5)^n = 0.40$	**(C1)**
	$n = 1.32$ **and** $t = 1.32 \times 3.9$	**(C1)**
	$t = 5.2$ hours	**A1**
12(c)(ii)	daughter product may be radioactive **or** random nature of decay	**B1**