Cambridge Assessment International Education
Cambridge International Advanced Subsidiary and Advanced Level

PHYSICS **9702/41**

Paper 4 A Level Structured Questions **October/November 2018**

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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This document consists of **12** printed pages.

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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)(i)	work done per unit mass	**B1**
	work done moving mass from infinity (to the point)	**B1**
1(a)(ii)	(near Earth's surface change in) height $\ll$ radius **or** height <u>much</u> less than radius	**B1**
	potential inversely proportional to radius **and** radius approximately constant (so potential approximately constant)	**B1**
1(b)	initial kinetic energy = (–) potential energy (at surface) **or** $\frac{1}{2}mv^2 = GMm/r$	**B1**
	$v^2 = (2 \times 6.67 \times 10^{-11} \times 7.4 \times 10^{22}) / (0.5 \times 3.5 \times 10^6)$	**C1**
	$v = 2.4 \times 10^3\,\text{m}\,\text{s}^{-1}$	**A1**

Question	Answer	Marks
2(a)	sum of potential and kinetic energies (of molecules/atoms/particles)	**B1**
	(energy of) molecules/atoms/particles in random motion	**B1**
2(b)(i)	final temperature = initial temperature	**B1**
	no change in internal energy	**B1**
2(b)(ii)	**1.** work done on gas (P$\rightarrow$Q): 0	**A1**
	increase in internal energy (P$\rightarrow$Q): (+)97.0 J	**A1**
	2. increase in internal energy (Q$\rightarrow$R): –42.5 J	**A1**
	3. increase in internal energy (R$\rightarrow$P): –54.5 J	**A1**
	thermal energy supplied (R$\rightarrow$P): –91.5 J	**A1**

Question	Answer	Marks
3(a)	$\omega^2 = 2g / L$	C1
	$T = 2\pi / \omega$	C1
	$\omega^2 = (2 \times 9.81) / 0.19$ $\omega = 10.2$ (rad s^{-1}) $T = 2\pi / 10.2$ $= 0.62$ s	A1
3(b)(i)	e.g. viscosity of liquid/friction within the liquid/viscous drag/friction between walls of tube and liquid	B1
3(b)(ii)	(maximum) KE = $\frac{1}{2}mv_0^2$ **and** $v_0 = \omega x_0$ **or** energy = $\frac{1}{2}m\omega^2 x_0^2$	C1
	change = $\frac{1}{2} \times 18 \times 10^{-3} \times 103 \times [(2.0 \times 10^{-2})^2 - (0.95 \times 10^{-2})^2]$	C1
	$= 2.9 \times 10^{-4}$ J	A1

Question	Answer	Marks
4(a)	pulses (of ultrasound from generator)	**B1**
	reflected at boundaries (between media)	**B1**
	time delay (between transmission and receipt) gives information about depth	**B1**
	intensity of reflected pulse gives information about nature (of tissues)/type (of tissues)/boundary	**B1**
	Any two from: • (reflected pulses) detected by the (ultrasound) generator • gel used to minimise reflection at skin/maximise transmission into skin • degree of reflection depends upon impedances of two media (at boundary)	**B2**
4(b)(i)	product of density and speed	**M1**
	speed of ultrasound in medium	**A1**
4(b)(ii)	Z_1 about equal to Z_2 results in negligible/no reflection	**B1**
	$Z_1 \gg Z_2$ (or $Z_1 \ll Z_2$) results in mostly reflection	**B1**

Question	Answer	Marks
5(a)	Any two reasonable suggestions e.g.: • noise can be eliminated/(signal/data) can be regenerated • bits can be added to correct for errors • data compression/multiplexing (is possible) • signal can be encrypted/better security	**B2**
5(b)	sketch: series of seven steps	**B1**
	each step width 2 ms	**B1**
	correct levels in correct order (2, 5, 14, 4, 9, 11, 7) (*1 mark for 6 levels correct, 2 marks for 7 levels correct*)	**A2**
5(c)(i)	step width reduced **or** higher frequencies can be reproduced	**B1**
5(c)(ii)	step height reduced **or** smaller changes in signal (intensity) can be reproduced	**B1**

Question	Answer	Marks
6(a)(i)	work done per unit charge	**B1**
	work done moving positive charge from infinity (to the point)	**B1**
6(a)(ii)	field strength = potential gradient	**M1**
	'–' sign included **or** directions discussed	**A1**
6(b)(i)	gain in kinetic energy (= loss in potential energy) = charge × p.d. **or** $qV = ½mv^2$	**M1**
	so v is independent of separation (because separation not in expressions)	**A1**

Question	Answer	Marks
6(b)(ii)	(at x = 0.40 cm), potential = (–) 75 × 0.40 / 1.2 (= (–) 25 V)	**C1**
	$\frac{1}{2}mv^2 = qV$ $\frac{1}{2} \times 4 \times 1.66 \times 10^{-27} \times v^2 = 2 \times 1.60 \times 10^{-19} \times 25$	**C1**
	or	
	$a = Vq/dm$ **and** $v^2 = 2as$	**(C1)**
	$v^2 = (2 \times 75 \times 2 \times 1.60 \times 10^{-19} \times 0.40 \times 10^{-2}) / (1.2 \times 10^{-2} \times 4 \times 1.66 \times 10^{-27})$	**(C1)**
	$v = 4.9 \times 10^4\,\text{m s}^{-1}$	**A1**

Question	Answer	Marks
7(a)(i)	gain is constant	**M1**
	for all frequencies	**A1**
7(a)(ii)	no time delay between input (voltage) and output (voltage)	**B1**
	clear reference to <u>change</u>(s) in input and/or output (voltages)	**B1**
7(b)	diagram: V_{IN} connected to V^+ only	**B1**
	midpoint between resistors R_1 and R_2 connected to V^- only	**B1**
7(c)(i)	–3.6 V	**A1**
7(c)(ii)	(+)5.0 V	**A1**

Question	Answer	Marks
8(a)	region where there is a force	**M1**
	experienced by a current-carrying conductor/moving charge/(permanent) magnet	**A1**
8(b)(i)	single path, deflection in 'upward' direction	**B1**
	acceptable circular arc in whole field	**B1**
	no 'kinks' at start or end of curvature, and straight outside region of field	**B1**
8(b)(ii)	force (on particle) is normal to velocity/direction of motion/direction of speed	**B1**
8(c)	magnetic force provides/is the centripetal force	**B1**
	$Bqv = mv^2 / r$ **or** $r = mv / Bq$	**C1**
	(if q is doubled), new speed = $2v$	**A1**

Question	Answer	Marks
9(a)	(induced) e.m.f. proportional/equal to <u>rate</u>	**M1**
	of change of (magnetic) flux (linkage)	**A1**
9(b)(i)	induced e.m.f. $= (\Delta B)AN / \Delta t$ $= (2 \times 0.19 \times 1.5 \times 10^{-4} \times 120) / 0.13$	**C1**
	$= 0.053\,\text{V}$	**A1**
9(b)(ii)	reading on voltmeter connected to coil C / V: 0 0.053 0 (*all three values required*)	**A1**
	reading on voltmeter connected to Hall probe / V: zero in middle column	**B1**
	final column correct sign (negative)	**B1**
	final column correct magnitude (0.20)	**B1**

Question	Answer	Marks
10	Any five points from: • as temperature rises electrons gain energy • electrons enter conduction band • (positively charged) holes left in valence band • more charge carriers (so resistance decreases) • (as temperature rises,) lattice vibrations increase • effect of increase in number of electrons or holes or charge carriers outweighs effect of increased lattice vibrations (so resistance decreases)	**B5**

Question	Answer	Marks
11(a)	discrete amount/quantum/packet of energy	M1
	of electromagnetic radiation	A1
11(b)(i)	energy = hc/λ	C1
	$\lambda = (6.63 \times 10^{-34} \times 3.00 \times 10^{8})/(0.51 \times 10^{6} \times 1.60 \times 10^{-19})$ $= 2.4 \times 10^{-12}$ m	A1
11(b)(ii)	$p = h/\lambda$ $= (6.63 \times 10^{-34})/(2.44 \times 10^{-12})$ **or** $p = E/c$ $= (0.51 \times 1.60 \times 10^{-13})/(3.00 \times 10^{8})$	C1
	$p = 2.7 \times 10^{-22}$ N s	A1
11(c)(i)	$E = c^2 \Delta m$	C1
	$\Delta m = (0.51 \times 1.60 \times 10^{-13})/(3.00 \times 10^{8})^2$ $= 9.1 \times 10^{-31}$ kg	A1
11(c)(ii)	(momentum is conserved so) nucleus must have momentum in opposite direction to photon	B1

Question	Answer	Marks
12(a)	unstable nucleus	**B1**
	emission of particles/photons	**B1**
	emission is spontaneous **or** (particles/radiation) are ionising	**B1**
12(b)(i)	tangent drawn and gradient calculation attempted	**B1**
	activity = 1.3×10^6 Bq (*1 mark for answer within* $\pm 0.2 \times 10^6$ Bq, *2 marks for answer within* $\pm 0.1 \times 10^6$ Bq)	**A2**
12(b)(ii)	$A = \lambda N$	**C1**
	$\lambda = (1.3 \times 10^6) / (3.05 \times 10^{10}) = 4.3 \times 10^{-5}\, s^{-1}$ ($\approx 4 \times 10^{-5}\, s^{-1}$)	**A1**
12(c)	$A = A_0 e^{-\lambda t}$ $1.0 \times 10^3 = 4.6 \times 10^3 \exp(-5.5 \times 10^{-7} \times t)$	**C1**
	$\ln (4.6) = 5.5 \times 10^{-7} \times t$	**C1**
	$t = 2.78 \times 10^6$ s = 32 days	**A1**