Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

PHYSICS **9702/41**

Paper 4 A Level Structured Questions **May/June 2016**

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 will not enter into discussions about these mark schemes.

Cambridge is publishing the mark schemes for the May/June 2016 series for most Cambridge IGCSE®, Cambridge International A and AS Level components and some Cambridge O Level components.

1 **(a)** (gravitational) potential at infinity defined as/is zero — B1

(gravitational) force <u>attractive</u> so work got out/done as object moves from infinity (so potential is negative) — B1 [2]

(b) **(i)** $\Delta E = m\Delta\phi$
$= 180 \times (14 - 10) \times 10^8$ — C1

$= 7.2 \times 10^{10}$ J — A1

increase — B1 [3]

(ii) energy required = $180 \times (10 - 4.4) \times 10^8$
or
energy per unit mass = $(10 - 4.4) \times 10^8$ — C1

$\frac{1}{2} \times 180 \times v^2 = 180 \times (10 - 4.4) \times 10^8$
or
$\frac{1}{2} \times v^2 = (10 - 4.4) \times 10^8$ — C1

$v = 3.3 \times 10^4\ \mathrm{m\,s^{-1}}$ — A1 [3]

2 **(a)** e.g. time of collisions negligible compared to time between collisions

no intermolecular forces (except during collisions)

random motion (of molecules)

large numbers of molecules

(total) volume of molecules negligible compared to volume of containing vessel
or
average/mean separation large compared with size of molecules

any two — B2 [2]

2 **(b)** **(i)** mass = $4.0 / (6.02 \times 10^{23}) = 6.6 \times 10^{-24}$ g
or
mass = $4.0 \times 1.66 \times 10^{-27} \times 10^3 = 6.6 \times 10^{-24}$ g — B1 [1]

(ii) $\frac{3}{2}kT = \frac{1}{2}m\langle c^2\rangle$ — C1

$\frac{3}{2} \times 1.38 \times 10^{-23} \times 300 = \frac{1}{2} \times 6.6 \times 10^{-27} \times \langle c^2\rangle$

$\langle c^2\rangle = 1.88 \times 10^6\ (\mathrm{m^2\,s^{-2}})$ — C1

r.m.s. speed = $1.4 \times 10^3\ \mathrm{m\,s^{-1}}$ — A1 [3]

3	(a)	acceleration/force proportional to displacement (from fixed point)	M1	
		acceleration/force and displacement in opposite directions	A1	[2]
	(b)	<u>maximum</u> displacements/accelerations are different	B1	
		graph is curved/not a straight line	B1	[2]
	(c) (i)	$\omega = 2\pi / T$ and $T = 0.8\,\text{s}$	C1	
		$\omega = 7.9\ \text{rad s}^{-1}$	A1	[2]
	(ii)	$a = (-)\omega^2 x$ $= 7.85^2 \times 1.5 \times 10^{-2}$	C1	
		$= 0.93\ \text{m s}^{-2}$ or $0.94\ \text{m s}^{-2}$	A1	[2]
	(iii)	$\Delta E = ½\, m\omega^2 (x_0^{\,2} - x^2)$	C1	
		$= ½ \times 120 \times 10^{-3} \times 7.85^2 \times \{(1.5 \times 10^{-2})^2 - (0.9 \times 10^{-2})^2\}$	C1	
		$= 5.3 \times 10^{-4}\ \text{J}$	A1	[3]
4	(a) (i)	product of speed and density	M1	
		reference to speed in medium (and density of medium)	A1	[2]
	(ii)	α: ratio of reflected <u>intensity</u> and/to incident <u>intensity</u>	B1	
		Z_1 and Z_2: (specific) acoustic impedances of media (on each side of boundary)	B1	[2]
	(b)	in muscle: $I_M = I_0\, e^{-\mu x}$ $= I_0 \exp(-23 \times 3.4 \times 10^{-2})$	C1	
		$I_M / I_0 = 0.457$	C1	
		at boundary: $\alpha = (6.3 - 1.7)^2 / (6.3 + 1.7)^2$ $= 0.33$	C1	
		$I_T / I_M = [(1 - \alpha) =]\ 0.67$	C1	
		$I_T / I_0 = 0.457 \times 0.67$ $= 0.31$	A1	[5]

5 **(a)** **(i)** 1011 A1 [1]

(ii)

0	0.25	0.50	0.75	1.00	1.25	1.50
1011	0110	1000	1110	0101	0011	0001

All 6 correct, 2 marks. 5 correct, 1 mark. A2 [2]

(b) sketch: 6 horizontal steps of width 0.25 ms shown M1

steps at correct heights and all steps shown A1

steps shown in correct time intervals A1 [3]

(c) increase sampling frequency/rate M1

so that step width/depth is reduced A1

increase number of bits (in each number) M1

so that step height is reduced A1 [4]

6 **(a)** sketch: from $x = 0$ to $x = R$, potential is constant at V_S B1

smooth curve through (R, V_S) and ($2R$, $0.5V_S$) B1

smooth curve continues to ($3R$, $0.33V_S$) B1 [3]

(b) sketch: from $x = 0$ to $x = R$, field strength is zero B1

smooth curve through (R, E) and ($2R$, $0.25E$) B1

smooth curve continues to ($3R$, $0.11E$) B1 [3]

7 **(a)** line has non-zero intercept/line does not pass through origin B1

charge is/should be proportional to potential (difference)
or
charge is/should be zero when p.d. is zero
(therefore there is a systematic error) B1 [2]

	(b)	reasonable attempt at line of best fit	B1	
		use of gradient of line of best fit clear	M1	
		C = 2800 μF (allow ± 200 μF)	A1	[3]
	(c)	energy = ½ CV^2 or energy = ½ QV <u>and</u> $C = Q / V$	C1	
		Δ energy = $\frac{1}{2} \times 2800 \times 10^{-6} \times (9.0^2 - 6.0^2)$	C1	
		= 6.3×10^{-2} J	A1	[3]
8	**(a)**	op-amp has infinite/(very) large gain	B1	
		op-amp saturates if $V^+ \neq V^-$	M1	
		V^+ is at earth potential so P (or V^-) must be at earth	A1	[3]
	(b)	input resistance to op-amp is very large *or* current in R_2 = current in R_1	B1	
		V_{IN} (– 0) = IR_2 <u>and</u> (0) – V_{OUT} = IR_1	M1	
		$V_{OUT} / V_{IN} = -R_1 / R_2$	A1	[3]
	(c)	relay coil connected between V_{OUT} and earth	M1	
		correct diode symbol connected between V_{OUT} and coil or between coil and earth	M1	
		correct polarity for diode ('clockwise')	A1	[3]
9	**(a)**	0.10 mm	B1	[1]
	(b)	$V_H = (0.13 \times 3.8) / (6.0 \times 10^{28} \times 0.10 \times 10^{-3} \times 1.60 \times 10^{-19})$	C1	
		$= 5.1 \times 10^{-7}$ V	A1	[2]
10	**(a)**	(non-uniform) magnetic flux <u>in core</u> is changing	M1	
		induces (different) e.m.f. in (different parts of) the core	A1	
		(eddy) currents form in the core	M1	
		which give rise to heating	A1	[4]

	(b)	as magnet falls, tube cuts magnetic flux	M1	
		e.m.f./(eddy) currents induced in metal/aluminium (tube)	A1	
		(eddy) current heating of tube	M1	
		with energy taken from falling magnet	A1	
		or		
		(eddy) currents produce magnetic field	(M1)	
		that opposes motion of magnet	(A1)	
		so magnet B has acceleration < *g* *or* magnet B has smaller acceleration/reaches terminal speed	A1	[5]
11	**(a)**	period = 15 ms	C1	
		frequency (= 1 / *T*) = 67 Hz	A1	[2]
	(b)	zero	A1	[1]
	(c)	$I_{\text{r.m.s.}} = I_0 / \sqrt{2}$	C1	
		= 0.53 A	A1	[2]
	(d)	energy = $I_{\text{r.m.s.}}^2 \times R \times t$ or $\frac{1}{2} I_0^2 \times R \times t$ *or* power = $I_{\text{r.m.s.}}^2 \times R$ and energy = power × *t*	C1	
		energy = $0.53^2 \times 450 \times 30 \times 10^{-3}$		
		= 3.8 J	A1	[2]
12	**(a)**	(in a solid electrons in) neighbouring atoms are close together (and influence/interact with each other)	M1	
		this changes their electron energy levels	M1	
		(many atoms in lattice) cause a spread of energy levels into a band	A1	[3]

(b) photons of light give energy to electrons in valence band B1

electrons move into the conduction band M1

leaving holes in the valence band A1

these electrons and holes are charge carriers B1

increased number/increased current, hence reduced resistance B1 [5]

13 (a) e.g. background count (rate)/radiation

multiple possible counts from each decay

radiation emitted in all directions

dead-time of counter

(daughter) product unstable/also emits radiation

self-absorption of radiation in sample or absorption in air/detector window

three sensible suggestions, 1 each B3 [3]

(b) $A = A_0 \exp(-\ln 2 \times t / T_{½})$

$1.21 \times 10^2 = 3.62 \times 10^4 \exp(-\ln 2 \times 42.0 / T_{½})$
or
$1.21 \times 10^2 = 3.62 \times 10^4 \exp(-\lambda \times 42.0)$ C1

$T_{½}$ = 5.1 minutes (306 s) A1 [2]

(c) discrete energy levels (in nuclei) B1 [1]