Cambridge International AS & A Level

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PHYSICS **9702/41**

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

MARK SCHEME

Maximum Mark: 100

Published

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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

$v = 3.3 \times 10^4$ 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

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

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

r.m.s. speed = 1.4×10^3 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)		maximum 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	
			$\omega = 7.9\,\text{rad}\,\text{s}^{-1}$	A1	[2]
		(ii)	$a = (-)\omega^2 x$ $= 7.85^2 \times 1.5 \times 10^{-2}$	C1	
			$= 0.93\,\text{m}\,\text{s}^{-2}$ or $0.94\,\text{m}\,\text{s}^{-2}$	A1	[2]
		(iii)	$\Delta E = \tfrac{1}{2} m\omega^2 (x_0^2 - x^2)$	C1	
			$= \tfrac{1}{2} \times 120 \times 10^{-3} \times 7.85^2 \times \{(1.5 \times 10^{-2})^2 - (0.9 \times 10^{-2})^2\}$	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 intensity and/to incident intensity	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 = ½ × 2800 × 10^{-6} × ($9.0^2 - 6.0^2$)	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 × 3.8) / (6.0 × 10^{28} × 0.10 × 10^{-3} × 1.60 × 10^{-19})	C1	
		= 5.1 × 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)	$I_{r.m.s.} = I_0 / \sqrt{2}$	C1	
		$= 0.53$ A	A1	[2]
	(d)	energy = $I_{r.m.s.}^2 \times R \times t$ or $\frac{1}{2} I_0^2 \times R \times t$ *or* power = $I_{r.m.s.}^2 \times R$ 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]