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Cambridge International Advanced Subsidiary and Advanced Level

MARK SCHEME for the October/November 2014 series

9702 PHYSICS

9702/43 Paper 4 (A2 Structured Questions), maximum raw mark 100

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1	(a)	(i)	*either* $\omega = 2\pi / T$ *or* $\omega = 2\pi f$ and $f = 1/T$	C1	
			$\omega = 2\pi / 0.30$		
			$= 20.9\,\text{rad s}^{-1}$ (*accept 2 s.f.*)	A1	[2]
		(ii)	kinetic energy $= \frac{1}{2}m\omega^2 x_0^2$ *or* $v = \omega x_0$ and $\frac{1}{2}mv^2$	C1	
			$= \frac{1}{2} \times 0.130 \times 20.9^2 \times (1.5 \times 10^{-2})^2 = 6.4 \times 10^{-3}\,\text{J}$	A1	[2]
	(b)	(i)	as magnet moves, flux is cut by <u>cup / aluminium</u> giving rise to induced e.m.f. (in cup)	B1	
			induced e.m.f. gives rise to currents and heating of the cup	B1	
			thermal energy derived from oscillations of magnet so amplitude decreases	B1	
			or		
			induced e.m.f. gives rise to currents which generate a magnetic field	(B1)	
			the magnetic field opposes the motion of the magnet so amplitude decreases	(B1)	[3]
		(ii)	*either* use of $\frac{1}{2}m\omega^2 x_0^2$ and $x_0 = 0.75\,\text{cm}$ *or* x_0 is halved so ¼ energy to give new energy = 1.6 mJ	C1	
			either loss in energy = 6.4 – 1.6 *or* loss = ¾ × 6.4 giving loss = 4.8 mJ	A1	[2]
	(c)		$q = mc\Delta\theta$		
			$4.8 \times 10^{-3} = 6.2 \times 10^{-3} \times 910 \times \Delta\theta$	C1	
			$\Delta\theta = 8.5 \times 10^{-4}\,\text{K}$	A1	[2]
2	(a)		smooth curve with decreasing gradient, not starting at $x = 0$	M1	
			end of line not at $g = 0$ or horizontal	A1	[2]
	(b)		straight line with positive gradient	M1	
			line starts at origin	A1	[2]
	(c)		sinusoidal shape	B1	
			only positive values and peak / trough height constant	B1	
			4 'loops'	B1	[3]
3	(a)		initially, $pV/T = (2.40 \times 10^5 \times 5.00 \times 10^{-4}) / 288 = 0.417$	M1	
			finally, $pV/T = (2.40 \times 10^5 \times 14.5 \times 10^{-4}) / 835 = 0.417$	M1	
			ideal gas because pV/T is constant	A1	[3]
			(*allow 2 marks for two determinations of V / T and then 1 mark for V / T <u>and</u> p constant, so ideal*)		

(b) **(i)** work done $= p\Delta V$
$= 2.40 \times 10^5 \times (14.5 - 5.00) \times 10^{-4}$ C1
$= 228$ J (*ignore sign, not 2 s.f.*) A1 [2]

(ii) $\Delta U = q + w$ $= 569 - 228$
$= 341$ J M1
increase A1 [2]

4 **(a)** acceleration / force proportional to displacement (from a fixed point) M1
either acceleration and displacement in opposite directions
or acceleration always directed towards a fixed point A1 [2]

(b) **(i)** zero <u>&</u> 0.625 s *or* 0.625 s <u>&</u> 1.25 s *or* 1.25 s <u>&</u> 1.875 s *or* 1.875 s <u>&</u> 2.5 s A1 [1]

(ii) **1.** $\omega = 2\pi / T$ <u>and</u> $v_0 = \omega x_0$ C1
$\omega = 2\pi / 1.25$
$= 5.03$ rad s^{-1} C1

$v_0 = 5.03 \times 3.2$
$= 16.1$ cm s^{-1} (*allow 2 s.f.*) A1 [3]

2. $v = \omega\sqrt{(x_0^2 - x^2)}$
either $\tfrac{1}{2}\omega a = \omega\sqrt{(x_0^2 - x^2)}$ *or* $\tfrac{1}{2} \times 16.1 = 5.03\sqrt{(3.2^2 - x^2)}$ C1
$x_0^2/4 = x_0^2 - x^2$ $2.58 = 3.2^2 - x^2$
$x = 2.8$ cm $x = 2.8$ cm A1 [2]

(c) sketch: loop with origin at its centre M1
correct intercepts & shape based on **(b)(ii)** A1 [2]

5 **(a)** work done / energy in moving unit positive charge M1
from infinity (to the point) A1 [2]

(b) **(i)** $V = q / 4\pi\varepsilon_0 r$
at 16 kV, $q = 3.0 \times 10^{-8}$ C

$r = (3.0 \times 10^{-8}) / (4\pi \times 8.85 \times 10^{-12} \times 16 \times 10^3)$ C1
$= 1.69 \times 10^{-2}$ m (*allow 2 s.f.*) A1 [2]
(*allow any answer which rounds to* 1.7×10^{-2})

(ii) energy is / represented by area 'below' line C1
energy $= \tfrac{1}{2}qV$
$= \tfrac{1}{2} \times 24 \times 10^3 \times 4.5 \times 10^{-8}$ C1
$= 5.4 \times 10^{-4}$ J A1 [3]

(c) $V = q / 4\pi\varepsilon_0 r$ and $E = q / 4\pi\varepsilon_0 r^2$ giving $Er = V$ B1
$2.0 \times 10^6 \times 1.7 \times 10^{-2} = V$ C1
$V = 3.4 \times 10^4$ V A1 [3]

6	**(a)**	for the two capacitors in parallel, capacitance = 96 μF	C1	
		for complete arrangement, $1/C_T = 1/96 + 1/48$		
		C_T = 32 μF	A1	[2]
	(b)	p.d. across parallel combination is one half p.d. across single capacitor	C1	
		total p.d. = 9 V	A1	[2]
7	**(a)**	*either* charge exists in discrete and <u>equal</u> quantities		
		or multiples of elementary charge / *e* / 1.6×10^{-19} C	B1	[1]
	(b) (i)	force due to magnetic field must be upwards	B1	
		B-field into the plane of the paper	B1	[2]
	(ii)	sketch showing: deflection consistent with force in **(b)(i)**	B1	
		reasonable curve	B1	[2]
8	**(a)**	discrete amount / packet / quantum of <u>energy</u>	M1	
		of electromagnetic radiation / EM radiation	A1	[2]
	(b) (i)	$E = hc/\lambda$		
		$= (6.63 \times 10^{-34} \times 3.0 \times 10^{8}) / (570 \times 10^{-9}) = 3.49 \times 10^{-19}$ J	A1	[1]
	(ii) 1.	number $= (2.7 \times 10^{-3}) / (3.5 \times 10^{-19})$	C1	
		$= 7.7 \times 10^{15}$	A1	[2]
	2.	momentum of photon $= h/\lambda$	C1	
		$= (6.63 \times 10^{-34}) / (570 \times 10^{-9})$		
		$= 1.16 \times 10^{-27}$ kg m s^{-1}	C1	
		change in momentum $= 1.16 \times 10^{-27} \times 7.7 \times 10^{15}$		
		$= 8.96 \times 10^{-12}$ kg m s^{-1}	A1	[3]
		(*allow E = pc route to* 9×10^{-12})		
	(c)	pressure = (change in momentum per second) / area	C1	
		$= (8.96 \times 10^{-12}) / (1.3 \times 10^{-5})$		
		$= 6.9 \times 10^{-7}$ Pa	A1	[2]
9	**(a)**	activity $= (1.7 \times 10^{14}) / (2.5 \times 10^{6})$		
		$= 6.8 \times 10^{7}$ Bq kg^{-1}	A1	[1]
	(b) (i)	energy released per second in 1.0 kg of steel		
		$= 6.8 \times 10^{7} \times 0.067 \times 1.6 \times 10^{-13}$		
		$= 7.3 \times 10^{-7}$ J	B1	[1]

		(ii)	this is a very small quantity of energy so steel will not be warm	B1	[1]
		(iii)	$A = A_0 e^{-\lambda t}$ <u>and</u> $\lambda t_{½} = \ln 2$	C1	
			$400 = (6.8 \times 10^7) \exp(-[\ln 2 \times t]/92)$	C1	
			t = 1600 years	A1	
			or		
			$A = A_0 / 2^n$	(C1)	
			n = 17.4	(C1)	
			t = 17.4 × 92 = 1600 years	(A1)	[3]

Section B

10	**(a)**	**(i)**	thermistor / thermocouple	B1	[1]
		(ii)	quartz crystal / piezoelectric crystal *or* transducer / microphone	B1	[1]
	(b)	**(i)**	$V_{OUT} = -5\,V$	A1	
			inverting input is positive *or* V_- is positive *or* $V_- > V_+$ so V_{OUT} is negative	B1	
			op-amp has very large / infinite gain and so saturates	B1	[3]
		(ii)	sketch: V_{OUT} switches from (+) to (–) when V_{IN} is zero	B1	
			V_{OUT} is +5 V or –5 V	M1	
			V_{OUT} is negative when V_{IN} is positive (*or v.v.*)	A1	[3]
11	**(a)**		product of density and speed	M1	
			density of medium, speed of wave in medium	A1	[2]
			(*not "speed of light", 0/2*)		
	(b)	**(i)**	$\alpha = (6.4 - 1.7)^2 / (6.4 + 1.7)^2$	C1	
			$= 0.34$	A1	[2]
		(ii)	$I / I_0 = e^{-\mu x}$	C1	
			$= \exp(-23 \times 3.4 \times 10^{-2})$	C1	
			$= 0.46$	A1	[3]
		(iii)	$I_R / I = (0.46)^2 \times 0.34$	C1	
			$= 0.072$	A1	[2]
12	**(a)**		analogue: continuously variable	B1	
			digital: two / distinct levels only *or* 1 s and 0 s *or* highs and lows	B1	[2]
	(b)	**(i)**	5	A1	[1]
		(ii)	1 1 0 1	A1	[1]

	(c)	greater number of voltage / signal levels	B1	
		smaller step heights in reproduced signal	B1	
		smaller voltage / signal changes can be seen	B1	[3]
13	**(a)**	same carrier frequencies can be re-used	M1	
		but not in neighbouring cells / possible to use more handsets	A1	[2]
	(b)	e.g. wavelength is short	(M1)	
		so aerial on mobile phone conveniently short	(A1)	
		e.g. limited range	(M1)	
		so low power / less interference between cells	(A1)	
		e.g. large number of channels / greater bandwidth	(M1)	
		so more simultaneous callers	(A1)	[4]