CAMBRIDGE INTERNATIONAL EXAMINATIONS

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
$\omega = 2\pi / 0.30$
$= 20.9$ 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
$= \frac{1}{2} \times 0.130 \times 20.9^2 \times (1.5 \times 10^{-2})^2 = 6.4 \times 10^{-3}$ 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 $x_0 = 0.75$ 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
$\Delta\theta = 8.5 \times 10^{-4}$ 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 $\frac{1}{2}\omega a = \omega\sqrt{(x_0^2 - x^2)}$ *or* $\frac{1}{2} \times 16.1 = 5.03\sqrt{(3.2^2 - x^2)}$ — 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 $= \frac{1}{2}qV$
$= \frac{1}{2} \times 24 \times 10^3 \times 4.5 \times 10^{-8}$ — 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, $1/C_T = 1/96 + 1/48$		
		$C_T = 32\,\mu F$	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]