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	
$\omega = 2\pi / 0.30$		
$= 20.9\,\text{rad s}^{-1}$ (*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)	$A = A_0 e^{-\lambda t}$ and $\lambda t_{½} = \ln 2$	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)	
	$t = 17.4 \times 92$ = 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]