UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS

GCE Advanced Subsidiary Level and GCE Advanced Level

MARK SCHEME for the May/June 2008 question paper

9702 PHYSICS

9702/04 Paper 4 (A2 Structured Questions), maximum raw mark 100

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All Examiners are instructed that alternative correct answers and unexpected approaches in candidates' scripts must be given marks that fairly reflect the relevant knowledge and skills demonstrated.

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UNIVERSITY of CAMBRIDGE
International Examinations

Section A

1	(a)	(i)	angle (subtended) at centre of circle	B1	
			by an arc equal in length to the radius (of the circle)	B1	[2]
		(ii)	angle swept out per unit time / rate of change of angle	M1	
			by the string	A1	[2]
	(b)		friction provides / equals the centripetal force	B1	
			$0.72\ W = md\omega^2$	C1	
			$0.72\ mg = m \times 0.35\omega^2$		
			$\omega = 4.49$ (rad s^{-1})	C1	
			$n = (\omega/2\pi) \times 60$	B1	
			$= 43\ min^{-1}$ (allow 42)	A1	[5]
	(c)		*either* centripetal force increases as *r* increases		
			or centripetal force larger at edge	M1	
			so flies off at edge first	A1	[2]
			($F = mr\omega^2$ so edge first – treat as special case and allow one mark)		
2	(a)		molecule(s) rebound from wall of vessel / hits walls	B1	
			change in momentum gives rise to impulse / force	B1	
			either (many impulses) averaged to give constant force / pressure		
			or the molecules are in random motion	B1	[3]
	(b)	(i)	$p = \frac{1}{3}\rho\langle c^2\rangle$	C1	
			$1.02 \times 10^5 = \frac{1}{3} \times 0.900 \times \langle c^2\rangle$		
			$\langle c^2\rangle = 3.4 \times 10^5$	C1	
			$c_{RMS} = 580\ m\ s^{-1}$	A1	[3]
		(ii)	*either* $\langle c^2\rangle \propto T$ *or* $\langle c^2\rangle = 2 \times 3.4 \times 10^5$	C1	
			$c_{RMS} = 830\ m\ s^{-1}$ (allow 820)	A1	[2]
	(c)		c_{RMS} depends on temperature (alone)	B1	
			so no effect	B1	[2]

3 **(a)** **(i)**	amplitude = 0.5 cm	A1	[1]
(ii)	period = 0.8 s	A1	[1]
(b) **(i)**	$\omega = 2\pi / T$	C1	
	$= 7.85$ rad s^{-1}		
	correct use of $v = \omega \sqrt{(x_0^2 - x^2)}$	B1	
	$= 7.85 \times \sqrt{(\{0.5 \times 10^{-2}\}^2 - \{0.2 \times 10^{-2}\}^2)}$		
	$= 3.6$ cm s^{-1}	A1	[3]
	(if tangent drawn or clearly implied (B1)		
	3.6 ± 0.3 cm s^{-1} (A2)		
	but allow 1 mark for > ±0.3 but ⩽ ±0.6 cm s^{-1})		
(ii)	d = 15.8 cm	A1	[1]
(c) **(i)**	(continuous) loss of energy / reduction in amplitude (from the oscillating system)	B1	
	caused by force acting in opposite direction to the motion / friction / viscous forces	B1	[2]
(ii)	same period / small increase in period	B1	
	line displacement always less than that on Fig.3.2 *(ignore first T/4)*	M1	
	peak progressively smaller	A1	[3]
4 **(a)**	work done moving unit positive charge	M1	
	from infinity to the point	A1	[2]
(b) **(i)**	x = 18 cm	A1	[1]
(ii)	$V_A + V_B = 0$	C1	
	$(3.6 \times 10^{-9}) / (4\pi\varepsilon_0 \times 18 \times 10^{-2}) + q / (4\pi\varepsilon_0 \times 12 \times 10^{-2}) = 0$	C1	
	$q = -2.4 \times 10^{-9}$ C	A1	[3]
	(use of $V_A = V_B$ giving 2.4×10^{-9} C scores one mark)		
(c)	field strength = (–) gradient of graph	B1	
	force = charge × gradient / field strength *or force ∝ gradient*	B1	
	force largest at x = 27 cm	B1	[3]
5 **(a)**	at t = 1.0 s, V = 2.5 V	C1	
	energy = $\frac{1}{2}CV^2$	C1	
	$0.13 = \frac{1}{2} \times C \times (8.0^2 - 2.5^2)$	M1	
	C = 4500 μF	A0	[3]
(b)	use of two capacitors in series in all branches of combination	M1	
	connected into correct parallel arrangement	A1	[2]

6	**(a)**	parallel (to the field)	B1	[1]
	(b) (i)	torque = $F \times d$		
		$2.1 \times 10^{-3} = F \times 2.8 \times 10^{-2}$	C1	
		$F = 0.075$ N	A1	[2]
		(use of 4.5 cm scores no marks)		
	(ii)	zero	A1	[1]
	(c)	$F = BILN(\sin\theta)$	C1	
		$0.075 = B \times 0.170 \times 4.5 \times 10^{-2} \times 140$	M1	
		$B = 7.0 \times 10^{-2}$ T = 70 mT	A0	[2]
	(d) (i)	(induced) <u>e.m.f.</u> is proportional to / equal to <u>rate of change</u> of	M1	
		(magnetic) flux (linkage)	A1	[2]
	(ii)	change in flux linkage = BAN		
		$= 0.070 \times 4.5 \times 10^{-2} \times 2.8 \times 10^{-2} \times 140$	C1	
		= 0.0123 Wb turns		
		induced e.m.f = 0.0123 / 0.14	C1	
		= 88 mV	A1	[3]
		(Note: This is a simplified treatment. A full treatment would involve the averaging of B cosθ leading to a $\sqrt{2}$ factor)		
7	**(a)**	charge is quantised / discrete quantities	B1	[1]
	(b) (i)	parallel so that the electric field is uniform / constant	B1	
		horizontal so that *either* oil drop will not drift sideways		
		or field is vertical		
		or electric force is equal to weight	B1	[2]
	(ii)	$qE = mg$	C1	
		$q \times 850 / (5.4 \times 10^{-3}) = 7.7 \times 10^{-15} \times 9.8$	C1	
		$q = 4.8 \times 10^{-19}$ C <u>and is negative</u>	A1	[3]
	(c)	charge changes by 1.6×10^{-19} C between droplets / integral multiples	M1	
		so charge on electron is 1.6×10^{-19} C	A0	[1]
8	**(a)**	since momentum before combining is zero	B1	
		momenta must be equal and opposite after	B1	
		<u>equal momenta so</u> photon energies equal	B1	[3]
	(b)	$E = mc^2$	C1	
		$= 9.1 \times 10^{-31} \times (3.0 \times 10^8)^2$		
		$= 8.19 \times 10^{-14}$ (J)	C1	
		$= (8.19 \times 10^{-14}) / (1.6 \times 10^{-13})$		
		= 0.51 MeV	A1	[3]

Section B

9 **(a)** blocks labelled sensing device / sensor / transducer			B1	
processor / processing unit / signal conditioning			B1	[2]
(b) **(i)** two LEDs with opposite polarities *(ignore any series resistors)*			M1	
correctly identified as red and green			A1	[2]
(ii) correct polarity for diode to conduct identified			M1	
hence red LED conducts when input (+)ve or *vice versa*			A0	[1]
10 large / strong (constant) magnetic field			B1	
nuclei rotate about direction of field / precess	(1)			
radio frequency / r.f. pulse			B1	
causes resonance in nuclei , nuclei absorb energy	(1)			
(pulse) is at the Larmor frequency	(1)			
on relaxation / nuclei de-excite emit (pulse of) r.f.			B1	
detected <u>and</u> processed			B1	
non-uniform field (superimposed)			B1	
allows for position of nuclei to be determined			B1	
and for location of detection to be changed	(1)			
(B6 plus any two extra details, 1 each, max 2)			B2	[8]
11 **(a)** **(i)** frequency of carrier wave varies			M1	
in synchrony with <u>displacement</u> of information signal			A1	[2]
(ii) **1.** zero (accept constant)			B1	[1]
2. upper limit 530 kHz			B1	
lower limit 470 kHz			B1	
changes upper limit → lower limit → upper limit at 8000 s^{-1}			B1	[3]
(b) e.g. more radio stations required / shorter range				
more complex electronics				
larger bandwidth required				
(any two sensible suggestions, 1 each)			B2	[2]
12 **(a)** **(i)** picking up of signal in one cable			M1	
from a second (nearby) cable			A1	[2]
(ii) <u>random</u> (unwanted) signal / power			B1	
that masks / added to / interferes with / distorts transmitted signal			B1	[2]
*(allow this mark in **(i)** or **(ii)**)*				
(b) if P is power at receiver,				
$30 = 10\lg(P / (6.5 \times 10^{-6})$			C1	
$P = 6.5 \times 10^{-3}$ W			C1	
loss along cable $= 10\lg(\{26 \times 10^{-3}\} / \{6.5 \times 10^{-3}\})$			C1	
$= 6.0$ dB			C1	
length = 6.0 / 0.2 = 30 km			A1	[5]