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* <u>centripetal</u> force increases as *r* increases		
	or <u>centripetal</u> 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	
			$= 7.85 \text{ rad s}^{-1}$		
			correct use of $v = \omega \sqrt{(x_0^2 - x^2)}$	B1	
			$= 7.85 \times \sqrt{(\{0.5 \times 10^{-2}\}^2 - \{0.2 \times 10^{-2}\}^2)}$		
			$= 3.6 \text{ cm s}^{-1}$	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 $\leqslant \pm 0.6$ 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 <u>progressively</u> 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	
			$C = 4500\ \mu$F	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]