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

This mark scheme is published as an aid to teachers and candidates, to indicate the requirements of the examination. It shows the basis on which Examiners were instructed to award marks. It does not indicate the details of the discussions that took place at an Examiners' meeting before marking began.

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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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

(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

(ii) period = 0.8 s — A1

(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 $\leqslant \pm0.6$ 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)

(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

Question	Answer		Mark	Total
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 $\rightarrow$ lower limit $\rightarrow$ 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]