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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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]

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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 $\leqslant \pm 0.6$ 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 = ½CV^2 — C1
$0.13 = ½ \times C \times (8.0^2 - 2.5^2)$ — 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]

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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) e.m.f. is proportional to / equal to rate of change 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 and is negative 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
equal momenta so 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]

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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 and 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 displacement 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) random (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]

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