**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 | [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)* | | |
| | | *$3.6 \pm 0.3$ cm $s^{-1}$ (A2)* | | |
| | | *but allow 1 mark for > $\pm 0.3$ 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 $2.4 \times 10^{-9}$ C scores one mark)* | | |
| | (c) | field strength = (–) gradient of graph | B1 | |
| | | force = charge × gradient / field strength *or force $\propto$ 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 cos$\theta$ 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 $1.6 \times 10^{-19}$ C between droplets / integral multiples | M1 | |
| so charge on electron is $1.6 \times 10^{-19}$ 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] |