

## **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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### Section A

- 1 (a) (i) angle (subtended) at centre of circle  
by an arc equal in length to the radius (of the circle) B1  
B1 [2]
- (ii) angle swept out per unit time / rate of change of angle  
by the string M1  
A1 [2]
- (b) friction provides / equals the centripetal force B1  
 $0.72 W = md\omega^2$  C1  
 $0.72 mg = m \times 0.35\omega^2$   
 $\omega = 4.49 \text{ (rad s}^{-1}\text{)}$  C1  
 $n = (\omega/2\pi) \times 60$  B1  
 $= 43 \text{ min}^{-1} \text{ (allow 42)}$  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  
 $c_{\text{RMS}} = 580 \text{ m s}^{-1}$  A1 [3]
- (ii) *either*  $\langle c^2 \rangle \propto T$  *or*  $\langle c^2 \rangle = 2 \times 3.4 \times 10^5$  C1  
 $c_{\text{RMS}} = 830 \text{ m s}^{-1} \text{ (allow 820)}$  A1 [2]
- (c)  $c_{\text{RMS}}$  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)  $\omega = 2\pi / T$   
 $= 7.85 \text{ rad s}^{-1}$   
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)*  
 $3.6 \pm 0.3 \text{ cm s}^{-1}$  (A2)  
*but allow 1 mark for  $> \pm 0.3$  but  $\leq \pm 0.6 \text{ cm s}^{-1}$ )*
- (ii)  $d = 15.8 \text{ cm}$  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 from infinity to the point M1  
A1 [2]
- (b) (i)  $x = 18 \text{ cm}$  A1 [1]
- (ii)  $V_A + V_B = 0$  C1  
 $(3.6 \times 10^{-9}) / (4\pi\epsilon_0 \times 18 \times 10^{-2}) + q / (4\pi\epsilon_0 \times 12 \times 10^{-2}) = 0$  C1  
 $q = -2.4 \times 10^{-9} \text{ C}$  A1 [3]  
*(use of  $V_A = V_B$  giving  $2.4 \times 10^{-9} \text{ C}$  scores one mark)*
- (c) field strength = (–) gradient of graph B1  
force = charge  $\times$  gradient / field strength *or force  $\propto$  gradient* B1  
force largest at  $x = 27 \text{ cm}$  B1 [3]
- 5 (a) at  $t = 1.0 \text{ s}$ ,  $V = 2.5 \text{ V}$  C1  
energy =  $\frac{1}{2}CV^2$  C1  
 $0.13 = \frac{1}{2} \times C \times (8.0^2 - 2.5^2)$  M1  
 $C = 4500 \mu\text{F}$  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 =  $F \times d$   
 $2.1 \times 10^{-3} = F \times 2.8 \times 10^{-2}$   
 $F = 0.075 \text{ N}$   
*(use of 4.5 cm scores no marks)* C1  
A1 [2]
- (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  
 $B = 7.0 \times 10^{-2} \text{ T} = 70 \text{ mT}$  A0 [2]
- (d) (i) (induced) e.m.f. is proportional to / equal to rate of change of (magnetic) flux (linkage) M1  
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  
 $= 0.0123 \text{ Wb turns}$   
induced e.m.f =  $0.0123 / 0.14$  C1  
 $= 88 \text{ mV}$  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  
 $q = 4.8 \times 10^{-19} \text{ C}$  and is negative A1 [3]
- (c) charge changes by  $1.6 \times 10^{-19} \text{ C}$  between droplets / integral multiples M1  
so charge on electron is  $1.6 \times 10^{-19} \text{ C}$  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  
 $= 9.1 \times 10^{-31} \times (3.0 \times 10^8)^2$   
 $= 8.19 \times 10^{-14} \text{ (J)}$  C1  
 $= (8.19 \times 10^{-14}) / (1.6 \times 10^{-13})$   
 $= 0.51 \text{ MeV}$  A1 [3]

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### Section B

- 9 (a) blocks labelled sensing device / sensor / transducer  
processor / processing unit / signal conditioning B1 B1 [2]
- (b) (i) two LEDs with opposite polarities (*ignore any series resistors*)  
correctly identified as red and green M1 A1 [2]
- (ii) correct polarity for diode to conduct identified  
hence red LED conducts when input (+)ve or *vice versa* M1 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<sup>-1</sup> 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  
 $P = 6.5 \times 10^{-3} \text{ W}$  C1  
loss along cable =  $10\lg(\{26 \times 10^{-3}\} / \{6.5 \times 10^{-3}\})$  C1  
= 6.0 dB C1  
length =  $6.0 / 0.2 = 30 \text{ km}$  A1 [5]