

UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
GCE Advanced Subsidiary Level and GCE Advanced Level

MARK SCHEME for the October/November 2007 question paper

9702 PHYSICS

9702/04

Paper 4 (A2 Structured Questions), maximum raw mark 100

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Section A

- 1 (a) (i) angle subtended at centre of circle B1
arc equal in length to the radius B1 [2]
- (ii) arc = $r\theta$ and for one revolution, arc = $2\pi r$ M1
so, $\theta = 2\pi r/r = 2\pi$ A0 [1]
- (b) (i) *either* weight provides/equals the centripetal force B1
or acceleration of free fall is centripetal acceleration B1
 $9.8 = 0.13 \times \omega^2$ M1
 $\omega = 8.7 \text{ rad s}^{-1}$ A0 [2]
- (ii) force in cord = weight + centripetal force (*can be an equation*) C1
force in cord = $(L - 13) \times 5/1.8$ *or* force constant = $5.0/1.8$ C1
 $(L - 13) \times 5/1.8 = 5.0 + 5/9.8 \times L \times 10^{-2} \times 8.7^2$ C1
 $L = 17.2 \text{ cm}$ A1 [4]
(*constant centripetal force of 5.0 N gives L = 16.6 cm allow 2/4*)
- 2 (a) (i) $pV = nRT$ C1
 $V = (8.31 \times 300)/(1.02 \times 10^5)$ C1
 $= 0.0244 \text{ m}^3$ (if uses Celsius, then 0/2) A1 [2]
- (ii) volume occupied by one atom = $0.0244 / (6.02 \times 10^{23}) = 4.06 \times 10^{-26} \text{ m}^3$ M1
separation $\approx \sqrt[3]{(4.06 \times 10^{-26})}$ A1
 $= 3.44 \times 10^{-9} \text{ m}$ A0 [2]
- (b) (i) $F = GMm / r^2$ C1
 $= (6.67 \times 10^{-11} \times \{4 \times 1.66 \times 10^{-27}\}^2) / (3.44 \times 10^{-9})^2$ C1
 $= 2.49 \times 10^{-46} \text{ N}$ A1 [3]
- (ii) ratio = $(4 \times 1.66 \times 10^{-27} \times 9.8) / 2.49 \times 10^{-46}$ C1
 $= 2.6 \times 10^{20}$ A1 [2]
- (c) assumption that forces between atoms are negligible B1
comment e.g. ratio shows gravitational force to be very small
e.g. force is very much less than weight
e.g. if there are forces, they are not gravitational B1 [2]

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- 3 (a) (i) 0.8 cm B1 [1]
- (ii) (max.) kinetic energy = 2.56 mJ C1
 $v_{(MAX)} = \omega a$ C1
(max.) kinetic energy = $\frac{1}{2}m\omega^2 a^2$ or $\frac{1}{2}m\omega^2 (a^2 - x^2)$ C1
 $2.56 \times 10^{-3} = \frac{1}{2} \times 0.130 \times \omega^2 \times (0.8 \times 10^{-2})^2$ M1
 $\omega = 24.8 \text{ rad s}^{-1}$ C1
 $f = \omega/2\pi$ M1
= 4.0 Hz (3.95 Hz) A0 [6]
- (b) (i) line parallel to x-axis at 2.56 mJ B1 [1]
- (ii) 1 4.0 Hz B1
2 0.50 cm (allow $\pm 0.03 \text{ cm}$) B1 [2]
- 4 (a) (i) *either* lines directed away from sphere
or lines go from positive to negative
or line shows direction of force on positive charge M1
so positively charged A1 [2]
- (ii) *either* all lines (appear to) radiate from centre
or all lines are normal to surface of sphere B1 [1]
- (b) tangent to curve B1
in correct position and direction B1 [2]
- (c) (i) $V = (0.76 \times 10^{-9}) / (4\pi \times 8.85 \times 10^{-12} \times 0.024)$ C1
= 285 V A1 [2]
- (ii) negative charge is induced on (inside of) box M1
formula applies to isolated (point) charge
OR less work done moving test charge from infinity A1
so potential is lower A1 [3]
- (d) *either* gravitational field is always attractive
or field lines must be directed towards both box and sphere B1 [1]

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- 5 (a) e.g. separate charges, store energy, smoothing circuit. etc. B1 [1]
(allow 'stores charge')
- (b) (i) charge = current \times time B1 [1]
- (ii) area is 21.2 cm^2 (allow $\pm 0.5 \text{ cm}^2$) C2
(allow 1 mark if outside $\pm 0.5 \text{ cm}^2$ but within $\pm 1.0 \text{ cm}^2$)
 1.0 cm^2 represents $(0.125 \times 10^{-3} \times 1.25 =)$ $156 \mu\text{C}$ C1
charge = $3300 \mu\text{C}$ A1 [4]
- (iii) capacitance = Q/V C1
 $= (3300 \times 10^{-6}) / 15$
 $= 220 \mu\text{F}$ A1 [2]
- (c) either energy = $\frac{1}{2}CV^2$ or energy = $\frac{1}{2}QV$ and $C = Q/V$ C1
 $\frac{1}{2} \times C \times 15^2 = 2 \times \frac{1}{2} \times C \times V^2$ C1
 $V = 10.6 \text{ V}$ A1 [3]
- 6 (a) (i) $BI \sin \theta$ B1 [1]
- (ii) (downwards) into (the plane of) the paper B1 [1]
- (b) (i) magnetic field (due to current) in one loop OR each loop acts as a coil B1
cuts/is normal to current in second loop OR produces magnetic field B1
causing force on second loop OR fields in same direction M1
either Newton's 3rd discussed
or vice versa clear gives rise to attraction OR so attracts A1 [4]
- (ii) $B = 2 \times 10^{-7} I / 0.75 \times 10^{-2} (= 2.67 \times 10^{-5} \text{ T})$ C1
force = $0.26 \times 10^{-3} \times 9.81 (= 2.55 \times 10^{-3} \text{ N})$ C1
 $F = BIL$
 $2.55 \times 10^{-3} = 2.67 \times 10^{-5} \times I^2 \times 2\pi \times 4.7 \times 10^{-2}$ C1
 $I = 18 \text{ A}$ A1 [4]

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- 7 (a) energy required to (completely) separate the nucleons (in a nucleus) B1 [1]
- (b) (i) U labelled near right-hand end of line B1
Ba and Kr in approximately correct positions B1 [2]
- (ii) binding energy is $A \times E_B$ B1
either binding energy of U < binding energy of (Ba + Kr)
or E_B of U < E_B of (Ba + Kr) B1 [2]
- (c) Krypton-92 reduced to 1/8 in 9 s M1
in 9 s, very little decay of Barium-141 M1
so, approximately 9 s A1 [3]
- OR
- $\lambda_{Kr} = 0.231$ or $\lambda_{Ba} = 6.42 \times 10^{-4}$ (M1)
 $8 = e^{-\lambda_B \times t} / e^{-\lambda_K \times t}$ (C1)
 $t = 9.0$ s (A1)

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Section B

- 8 (a) (i) - 9 V
- (ii) + 9 V (*both (i) and (ii) correct for the mark*) B1 [1]
- (b) × × B1
 ✓ × B1
 ✓ ✓ B1 [3]
(no e.c.f. from (a))
- (c) (i) cct: thermistor and resistor in series M1
 output connections across thermistor A1 [2]
- (ii) as temperature decreases, thermistor resistance increases B1
 p.d. across thermistor = $R_T / (R + R_T) \times V$ M1
 as R_T increases, output increases A1 [3]
- 9 (a) product of density (of medium) and speed of sound (in medium) B1 [1]
- (b) difference in acoustic impedance M1
 determines fraction of incident intensity
 that is reflected/amount of reflection A1 [2]
- (c) pulse of ultrasound (directed into body) B1
 reflected at boundary (between tissues) B1
 (reflected pulse is) detected and processed B1
 time for return of echo gives (information on) depth B1
 amount of reflection gives information on tissue structures B1 [5]
- 10 (a) (i) amplitude (modulated) (*allow 'AM'*) B1 [1]
- (ii) carrier (frequency / wave) B1 [1]
- (iii) sideband (frequency) B1 [1]
- (b) 10 kHz B1 [1]
- (c) sketch: general shape i.e. any wave that is amplitude modulated M1
 correct period for modulating waveform (200 μ s) A1
 correct period for carrier waveform (20 μ s) A1 [3]

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- 11 (a)** carrier frequencies can be re-used (simultaneously without interference) B1
so that number of handsets possible is increased B1
OR anything sensible e.g. UHF used (B1)
so 'line of sight' (B1) [2]
- (b)** handset sends out an (identifying) signal M1
communicated by base stations to (computer at) exchange A1
computer selects base station with strongest signal B1
and allocates a (carrier) frequency B1 [4]