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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UNIVERSITY of CAMBRIDGE
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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
or acceleration of free fall is centripetal acceleration B1
$9.8 = 0.13 \times \omega^2$ M1
$\omega = 8.7$ 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
$L = 17.2$ cm .... A1 [4]
(*constant centripetal force of 5.0 N gives L = 16.6 cm allow 2/4*)

2 (a) (i) $pV = nRT$
$V = (8.31 \times 300)/(1.02 \times 10^5)$ C1
$= 0.0244$ m^3 (if uses Celsius, then 0/2) .... A1 [2]

(ii) volume occupied by one atom = $0.0244 / (6.02 \times 10^{23}) = 4.06 \times 10^{-26}$ m^3 .... M1
separation $\approx \sqrt[3]{(4.06 \times 10^{-26})}$ A1
$= 3.44 \times 10^{-9}$ 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
$= 2.49 \times 10^{-46}$ 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]

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* ±*0.03 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 <u>always</u> attractive
or field lines must be directed towards both box and sphere .... B1 [1]

5 **(a)** e.g. separate charges, store energy, smoothing circuit. etc. .... B1 [1]
(*allow 'stores charge'*)

(b) **(i)** charge = current × time .... B1 [1]

(ii) area is 21.2 cm^2 (*allow* $\pm$*0.5* cm^2) C2
(*allow 1 mark if outside* $\pm$*0.5* cm^2 *but within* $\pm$*1.0* cm^2)
1.0 cm^2 represents ($0.125 \times 10^{-3} \times 1.25$ =) 156 μC C1
charge = 3300 μC .... A1 [4]

(iii) capacitance = Q/V C1
= $(3300 \times 10^{-6}) / 15$
= 220 μF .... 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 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) $B = 2 \times 10^{-7} I / 0.75 \times 10^{-2}$ (= $2.67 \times 10^{-5} I$) C1
force = $0.26 \times 10^{-3} \times 9.81$ (= 2.55×10^{-3} 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 A .... A1 [4]

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)

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 μs) A1
correct period for carrier waveform (20 μs) .... A1 [3]

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
<u>computer</u> selects base station with strongest signal B1
and allocates a (carrier) frequency .... B1 [4]