UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS

GCE Advanced Subsidiary Level and GCE Advanced Level

MARK SCHEME for the October/November 2009 question paper for the guidance of teachers

9702 PHYSICS

9702/41 Paper 41 (A2 Structured Questions), maximum raw mark 100

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UNIVERSITY of CAMBRIDGE
International Examinations

Section A

1 (a) $F \propto Mm / R^2$ ……(*words or explained symbols*) M1
either M and m are point masses
or $R >>$ diameter of masses …(*do not allow 'size'*) ..... A1 [2]

(b) (i) equatorial orbit B1
period 24 hours / same angular speed B1
from west to east / same direction of rotation ..... B1 [3]
(*allow one of the last two marks for 'always overhead' if 2nd or 3rd marks not scored*)

(ii) gravitational force provides centripetal force
/ gives rise to centripetal acceleration ….(*in 'words'*) B1
$GM / x^2 = x\omega^2$ M1
$g = GM / R^2$ M1
to give $gR^2 = x^3\omega^2$ ..... A0 [3]

(iii) $\omega = 2\pi / (24 \times 3600) = 7.27 \times 10^{-5}$ rad s^{-1} C1
$9.81 \times (6.4 \times 10^6)^2 = x^3 \times (7.27 \times 10^{-5})^2$ C1
$x^3 = 7.6 \times 10^{22}$
$x = 4.2 \times 10^7$ m ..... A1 [3]
(*use of g = 10 m s^{-2}, loses 1 mark but once only in the Paper*)

[Total: 11]

2 (a) *either* $pV = NkT$ *or* $pV = nRT$ *and* $n = N / N_A$ C1
clear correct substitution e.g.
$2.5 \times 10^5 \times 4.5 \times 10^3 \times 10^{-6} = N \times 1.38 \times 10^{-23} \times 290$ M1
$N = 2.8 \times 10^{23}$ ..... A0 [2]
(*allow 1 mark for calculation of n = 0.467 mol*)

(b) (i) volume $= (1.2 \times 10^{-10})^3 \times 2.8 \times 10^{23}$ *or* $\frac{4}{3}\pi r^3 \times 2.8 \times 10^{23}$ C1
$= 4.8 \times 10^{-7}$ m^3 2.53×10^{-7} m^3 ..... A1 [2]

(ii) *either* 4.5×10^3 cm^3 >> 0.48 cm^3 *or* ratio of volumes is about 10^{-4} B1
justified because volume of molecules is negligible ..... B1 [2]

[Total: 6]

3 **(a)** e.g. two objects of different masses at same temperature (M1)
same material would have different amount of heat (A1)
e.g. temperature shows direction of heat transfer (M1)
from high to low regardless of objects (A1)
e.g. when substance melts/boils (M1)
heat input but no temperature change (A1)
any two, M1 + A1 each, max 4 [4]

(b) **(i)** energy losses (to the surroundings) M1
either increase as the temperature rises
or rise is zero when heat loss = heat input A1 [2]

(ii) idea of input power = maximum rate of heat loss C1
power = $m \times c \times \Delta\theta / \Delta t$
$54 = 0.96 \times c \times 3.7 / 60$ C1
$c = 910$ J kg^{-1} K^{-1} A1 [3]

[Total: 9]

4 **(a)** **(i)** amplitude = 0.2 mm A1 [1]

(ii) period = 1.2 ms C1
frequency = 830 Hz A1 [2]

(b) **(i)** any two of zero, 0.6 ms and 1.2 ms A1 [1]

(ii) any two of 0.3 ms, 0.9 ms, 1.5 ms A1 [1]

(c) *either* $v = \omega x_0 = 2\pi f x_0$
$= 2\pi \times 830 \times 0.2 \times 10^{-3} = 1.05$ m s^{-1}
or slope of graph = 1.0 m s^{-1} ……(allow ± 0.1 m s^{-1}) C1
$E_K = \frac{1}{2}mv^2$
$= \frac{1}{2} \times 2.5 \times 10^{-3} \times 1.05^2$ C1
$= 1.4 \times 10^{-3}$ J A1 [3]

(d) **(i)** large / maximum amplitude of vibration B1
when impressed frequency equals natural frequency of vibration B1 [2]

(ii) e.g. metal panels on machinery vibrate / oscillate (M1)
motor in machine impresses frequency on panel (A1)
e.g. car suspension system vibrates / oscillates (M1)
going over bumps would give large amplitude vibrations (A1)
any feasible example, M1 + A1 [2]

[Total: 12]

5 **(a)** work done per / on unit positive charge M1
moving charge from infinity to the point ..... A1 [2]

(b) **(i)** α-particle and gold nucleus repel each other B1
all kinetic energy of α-particle converted into electric potential energy ..... B1 [2]

(ii) **1** potential energy = $(79 \times 2 \times \{1.6 \times 10^{-19}\}^2) / (4\pi \times 8.85 \times 10^{-12} \times d)$ C1
kinetic energy = $4.8 \times 1.6 \times 10^{-13} = 7.68 \times 10^{-13}$ J C1
equating to give $d = 4.7 \times 10^{-14}$ m ..... A1 [3]

(ii) **2** $F = Qq / 4\pi\varepsilon_0 d \times 1 / d = 7.68 \times 10^{-13} \times 1 / (4.7 \times 10^{-14})$ C1
$= 16$ N ..... A1 [2]

[Total: 9]

6 **(a)** concentric circles …(*at least three lines*) M1
with increasing separation A1
correct direction clear ..... B1 [3]

(b) **(i)** correct position to left of wire ..... B1 [1]

(ii) $B = (4\pi \times 10^{-7} \times 1.7) / (2\pi \times 1.9 \times 10^{-2})$ C1
$= 1.8 \times 10^{-5}$ T ..... A1 [2]

(c) distance $\propto$ current C1
current $= (2.8 / 1.9) \times 1.7$
$= 2.5$ A ..... A1 [2]

[Total: 8]

7 **(a)** e.g. more (output) power available
e.g. less ripple for same smoothing capacitor
any sensible suggestion ..... B1 [1]

(b) **(i)** curve showing half-wave rectification ..... B1 [1]

(ii) similar to **(i)** but phase shift of 180° ..... B1 [1]

(c) **(i)** correct symbol, connected in parallel with R ..... B1 [1]

(ii) **1** larger capacitor / second capacitor in parallel with R ..... B1 [1]
(not increase *R*)
2 same peak values B1
correct shape giving less ripple ..... B1 [2]

[Total: 7]

8 **(a)** neutron is a single nucleon / particle ..... B1 [1]

(b) binding energy = $4 \times 7.07 \times 1.6 \times 10^{-13}$ C1
= 4.52×10^{-12} J
binding energy = $c^2 \Delta m$ C1
$4.52 \times 10^{-12} = (3.0 \times 10^8)^2 \times \Delta m$
$\Delta m = 5.03 \times 10^{-29}$ kg ..... A1 [3]

(c) **(i)** fusion ……(*do not allow fussion*) ..... B1 [1]

(ii) $(2 \times 1.12) + 3x = 28.28$ C1
…... –17.7 ..... C1
x = 2.78 MeV per nucleon ..... A1 [3]
(*use of +17.7 gives x = 14.6 MeV, allow 1 mark only*)

[Total: 8]

Section B

9 **(a)** resistance of wire = $\rho L / A$ B1
as crack widens, L increases M1
and A decreases M1
so resistance increases ..... A0 [3]

(b) $\Delta L / L = \Delta R / R$ B1
$= (146.2 - 143.0) / 143.0 \times 100$ C1
$\Delta L / L = 2.24\%$ ..... A1 [3]

[Total: 6]

10 at 16 °C, $V^+ = 1.00$ V and $V^- = 0.98$ V *or* $V^+ > V^-$ B1
at 16 °C, output is positive M1
diode R is 'on' and diode G is 'off' A1
as temperature rises, diode R goes 'off' and diode G goes 'on' ..... B1 [4]
(*allow e.c.f. from 2nd to 3rd marks and also 3rd to 4th marks*)

[Total: 4]

11 large / 1 T magnetic field applied along body (*allow 'across'*) (1)
r.f. pulse applied ..... (1)
causes hydrogen nuclei / protons ..... (1)
to resonate ..... (1)
(nuclei) return to equilibrium state / after relaxation time ..... (1)
r.f. (pulse) emitted ..... (1)
pulses detected, processed and displayed ..... (1)
resonant frequency depends on magnetic field strength ..... (1)
calibrated non-uniform field enables nuclei to be located ..... (1)

any six points, one mark each ..... B6 [6]

[Total: 6]

12 (a) e.g. signal can be regenerated M1
so that there is minimal noise A1
e.g. extra data can be added M1
so that signal can be checked for errors ..... A1 [4]
(*any two, sensible suggestions, M1 + A1, max 4*)

(b) (i) 1101 ..... B1 [1]

(ii) 5 ..... B1 [1]

(c) (i) block X: serial-to parallel B1
block Y: DAC / digital-to-analogue (converter) ..... B1 [2]

(ii) takes the simultaneous / all bits of a number M1
and transmits them one after another / down a single line ..... A1 [2]

(d) increase number of bits in digital number at each sampling M1
so that step height is reduced A1
increase sampling <u>frequency</u> / reduce time between samples M1
so that depth / width of step is reduced ..... A1 [4]
(*do not allow 'smoother output'*)

[Total: 14]