

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

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, which would have considered the acceptability of alternative answers.

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Page 2	Mark Scheme: Teachers' version	Syllabus	Paper
	GCE A/AS LEVEL – October/November 2009	9702	41

Section A

- 1 (a) $F \propto Mm / R^2$ (words or explained symbols)M1
 either M and m are point masses
 or $R \gg$ 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) $\omega = 2\pi / (24 \times 3600) = 7.27 \times 10^{-5} \text{ rad s}^{-1}$ C1
 $9.81 \times (6.4 \times 10^6)^2 = x^3 \times (7.27 \times 10^{-5})^2$ C1
 $x^3 = 7.6 \times 10^{22}$
 $x = 4.2 \times 10^7 \text{ m}$ A1 [3]
 (use of $g = 10 \text{ m s}^{-2}$, 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 $n = 0.467 \text{ mol}$)
- (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
 $= 4.8 \times 10^{-7} \text{ m}^3$ A1 [2]
 $2.53 \times 10^{-7} \text{ m}^3$ A1
- (ii) either $4.5 \times 10^3 \text{ cm}^3 \gg 0.48 \text{ cm}^3$ or ratio of volumes is about 10^{-4} B1
 justified because volume of molecules is negligible B1 [2]

[Total: 6]

Page 3	Mark Scheme: Teachers' version	Syllabus	Paper
	GCE A/AS LEVEL – October/November 2009	9702	41

- 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
 $c = 910 \text{ J kg}^{-1} \text{ K}^{-1}$ 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 $v = \omega x_0 = 2\pi f x_0$
 $= 2\pi \times 830 \times 0.2 \times 10^{-3} = 1.05 \text{ m s}^{-1}$
 or slope of graph = 1.0 m s^{-1} (allow $\pm 0.1 \text{ m s}^{-1}$) C1
 $E_K = \frac{1}{2}mv^2$
 $= \frac{1}{2} \times 2.5 \times 10^{-3} \times 1.05^2$ C1
 $= 1.4 \times 10^{-3} \text{ J}$ 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]

Page 4	Mark Scheme: Teachers' version	Syllabus	Paper
	GCE A/AS LEVEL – October/November 2009	9702	41

- 5 (a) work done per / on unit positive chargeM1
 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 $F = Qq / 4\pi\epsilon_0 d \times 1 / d = 7.68 \times 10^{-13} \times 1 / (4.7 \times 10^{-14})$ 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
 = 1.8×10^{-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]**

Page 5	Mark Scheme: Teachers' version	Syllabus	Paper
	GCE A/AS LEVEL – October/November 2009	9702	41

- 8 (a) neutron is a single nucleon / particle B1 [1]
- (b) binding energy = $4 \times 7.07 \times 1.6 \times 10^{-13}$ C1
 $= 4.52 \times 10^{-12}$ 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
 $\dots -17.7$ C1
 $x = 2.78$ MeV per nucleon A1 [3]
 (use of +17.7 gives $x = 14.6$ MeV, allow 1 mark only)

[Total: 8]

Page 6	Mark Scheme: Teachers' version	Syllabus	Paper
	GCE A/AS LEVEL – October/November 2009	9702	41

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, $V^+ = 1.00 \text{ V}$ and $V^- = 0.98 \text{ V}$ 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]

Page 7	Mark Scheme: Teachers' version	Syllabus	Paper
	GCE A/AS LEVEL – October/November 2009	9702	41

- 12 (a)** e.g. signal can be regeneratedM1
 so that there is minimal noise A1
 e.g. extra data can be addedM1
 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 numberM1
 and transmits them one after another / down a single line A1 [2]
- (d)** increase number of bits in digital number at each samplingM1
 so that step height is reduced A1
 increase sampling frequency / reduce time between samplesM1
 so that depth / width of step is reduced A1 [4]
(do not allow 'smoother output')

[Total: 14]