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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## 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* $pV = nRT$ <u>*and*</u> $n = N / N_A$ .....................................................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$^3$ $2.53 \times 10^{-7}$ m$^3$ ..................................... A1 [2]

**(ii)** *either* $4.5 \times 10^3$ 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 <u>power</u> = maximum <u>rate</u> 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 <u>two</u> of zero, 0.6 ms and 1.2 ms ................................................... A1 [1]

**(ii)** any <u>two</u> 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 = $1.0\ \text{m s}^{-1}$ ……(allow $\pm 0.1\ \text{m s}^{-1}$) ...................................... C1
$E_K = ½mv^2$
$= ½ \times 2.5 \times 10^{-3} \times 1.05^2$ ........................................................................ 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) $\alpha$-particle and gold nucleus repel each other ... B1
<u>all</u> kinetic energy of $\alpha$-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
= $4.52 \times 10^{-12}$ 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
….. –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' <u>and</u> diode G is 'off' .................................................... A1
as temperature rises, diode R goes 'off' <u>and</u> 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)
<u>r.f. pulse</u> 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]**