CAMBRIDGE INTERNATIONAL EXAMINATIONS

GCE Advanced Subsidiary Level and GCE Advanced Level

MARK SCHEME for the May/June 2013 series

9702 PHYSICS

9702/41 Paper 4 (A2 Structured Questions), maximum raw mark 100

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Section A

1 (a) region of space area / volume — B1
where a mass experiences a force — B1 [2]

(b) (i) force proportional to product of two masses — M1
force inversely proportional to the square of their separation — M1
either reference to point masses *or* separation >> 'size' of masses — A1 [3]

(ii) field strength = GM / x^2 **or** field strength $\propto 1 / x^2$ — C1
ratio = $(7.78 \times 10^8)^2 / (1.5 \times 10^8)^2$ — C1
= 27 — A1 [3]

(c) (i) *either* centripetal force = $mR\omega^2$ and $\omega = 2\pi / T$
or centripetal force = mv^2 / R and $v = 2\pi R / T$ — B1
gravitational force provides the centripetal force — B1
either $GMm / R^2 = mR\omega^2$ *or* $GMm / R^2 = mv^2 / R$ — M1
$M = 4\pi^2 R^3 / GT^2$ — A0 [3]
(allow working to be given in terms of acceleration)

(ii) $M = \{4\pi^2 \times (1.5 \times 10^{11})^3\} / \{6.67 \times 10^{-11} \times (3.16 \times 10^7)^2\}$ — C1
$= 2.0 \times 10^{30}$ kg — A1 [2]

2 (a) obeys the equation pV = constant $\times T$ or $pV = nRT$ — M1
p, V and T explained — A1
at all values of p, V and T/fixed mass/n is constant — A1 [3]

(b) (i) $3.4 \times 10^5 \times 2.5 \times 10^3 \times 10^{-6} = n \times 8.31 \times 300$ — M1
$n = 0.34$ mol — A0 [1]

(ii) for total mass/amount of gas
$3.9 \times 10^5 \times (2.5 + 1.6) \times 10^3 \times 10^{-6} = (0.34 + 0.20) \times 8.31 \times T$ — C1
$T = 360$ K — A1 [2]

(c) when tap opened
gas passed (from cylinder B) to cylinder A — B1
work done <u>on</u> gas in cylinder A (and no heating) — M1
so internal energy and hence temperature increase — A1 [3]

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3 (a) (i) 1. amplitude = 1.7 cm — A1 [1]

2. period = 0.36 cm — C1
frequency = 1/0.36
= 2.8 Hz — A1 [2]

(ii) $a = (-)\omega^2 x$ and $\omega = 2\pi/T$ — C1
acceleration = $(2\pi/0.36)^2 \times 1.7 \times 10^{-2}$ — M1
= 5.2 m s^{-2} — A0 [2]

(b) graph: straight line, through origin, with negative gradient — M1
from $(-1.7 \times 10^{-2}, 5.2)$ to $(1.7 \times 10^{-2}, -5.2)$ — A1 [2]
(if scale not reasonable, do not allow second mark)

(c) *either* kinetic energy = $\frac{1}{2}m\omega^2(x_0^2 - x^2)$
or potential energy = $\frac{1}{2}m\omega^2 x^2$ and potential energy = kinetic energy — B1
$\frac{1}{2}m\omega^2(x_0 - x^2) = \frac{1}{2} \times \frac{1}{2}m\omega^2 x_0^2$ or $\frac{1}{2}m\omega^2 x^2 = \frac{1}{2} \times \frac{1}{2}m\omega^2 x_0^2$ — C1
$x_0^2 = 2x^2$
$x = x_0 / \sqrt{2} = 1.7 / \sqrt{2}$
= 1.2 cm — A1 [3]

4 (a) work done moving unit positive charge — M1
from infinity (to the point) — A1 [2]

(b) (gain in) kinetic energy = change in potential energy — B1
$\frac{1}{2}mv^2 = qV$ leading to $v = (2Vq/m)^{\frac{1}{2}}$ — B1 [2]

(c) *either* $(2.5 \times 10^5)^2 = 2 \times V \times 9.58 \times 10^7$ — C1
$V =$ 330 V — M1
this is less than 470 V and so 'no' — A1 [3]

or $v = (2 \times 470 \times 9.58 \times 10^7)$ — (C1)
$v = 3.0 \times 10^5$ m s^{-1} — (M1)
this is greater than 2.5×10^5 m s^{-1} and so 'no' — (A1)

or $(2.5 \times 10^5)^2 = 2 \times 470 \times (q/m)$ — (C1)
$(q/m) = 6.6 \times 10^7$ C kg^{-1} — (M1)
this is less than 9.58×10^7 C kg^{-1} and so 'no' — (A1)

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5 **(a)** (uniform magnetic) flux normal to long (straight) wire carrying a current of 1 A — M1
(creates) force per unit length of $1\,N\,m^{-1}$ — A1 [2]

(b) **(i)** flux density $= 4\pi \times 10^{-7} \times 1.5 \times 10^{3} \times 3.5$ — C1
$= 6.6 \times 10^{-3}\,T$ — A1 [2]

(ii) flux linkage $= 6.6 \times 10^{-3} \times 28 \times 10^{-4} \times 160$ — C1
$= 3.0 \times 10^{-3}\,Wb$ — A1 [2]

(c) **(i)** (induced) e.m.f. proportional to rate of — M1
change of (magnetic) flux (linkage) — A1 [2]

(ii) e.m.f. $= (2 \times 3.0 \times 10^{-3}) / 0.80$ — C1
$= 7.4 \times 10^{-3}\,V$ — A1 [2]

6 **(a)** **(i)** to reduce power loss in the core — B1
due to eddy currents/induced currents — B1 [2]

(ii) *either* no power loss in transformer
or input power = output power — B1 [1]

(b) *either* r.m.s. voltage across load $= 9.0 \times (8100 / 300)$ — C1
peak voltage across load $= \sqrt{2} \times 243$
$= 340\,V$ — A1 [2]
or peak voltage across primary coil $= 9.0 \times \sqrt{2}$ — (C1)
peak voltage across load $= 12.7 \times (8100/300)$
$= 340\,V$ — (A1)

7 **(a)** **(i)** lowest frequency of e.m. radiation — M1
giving rise to emission of electrons (from the surface) — A1 [2]

(ii) $E = hf$ — C1
threshold frequency $= (9.0 \times 10^{-19}) / (6.63 \times 10^{-34})$
$= 1.4 \times 10^{15}\,Hz$ — A1 [2]

(b) *either* $300\,nm \equiv 10 \times 10^{15}\,Hz$ (and $600\,nm \equiv 5.0 \times 10^{14}\,Hz$)
or $300\,nm \equiv 6.6 \times 10^{-19}\,J$ (and $600\,nm \equiv 3.3 \times 10^{-19}\,J$)
or zinc $\lambda_0 = 340\,nm$, platinum $\lambda_0 = 220\,nm$ (and sodium $\lambda_0 = 520\,nm$) — M1
emission from sodium and zinc — A1 [2]

(c) each photon has larger energy — M1
fewer photons per unit time — M1
fewer electrons emitted per unit time — A1 [3]

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8 **(a)** two (light) nuclei combine M1
to form a more massive nucleus A1 [2]

(b) **(i)** Δm = (2.01410 u + 1.00728 u) – 3.01605 u
= 5.33×10^{-3} u C1
energy = $c^2 \times \Delta m$ C1
= $5.33 \times 10^{-3} \times 1.66 \times 10^{-27} \times (3.00 \times 10^8)^2$
= 8.0×10^{-13} J A1 [3]

(ii) speed/kinetic energy of proton and deuterium must be very large B1
so that the nuclei can overcome electrostatic repulsion B1 [2]

Section B

9 **(a)** **(i)** light-dependent resistor/LDR B1 [1]

(ii) strain gauge B1 [1]

(iii) quartz/piezo-electric crystal B1 [1]

(b) **(i)** resistance of thermistor decreases as temperature increses M1
etiher $V_{OUT} = V \times R / (R + R_T)$
or current increases and $V_{OUT} = I R$ A1
V_{OUT} increases A1 [3]

(ii) *either* change in R_T with temperature is non-linear
or V_{OUT} is not proportional to R_T/ change in V_{OUT} with R_T is non-linear M1
so change is non-linear A1 [2]

10 **(a)** sharpness: how well the edges (of structures) are defined B1
contrast: difference in (degree of) blackening between structures B1 [2]

(b) e.g. scattering of photos in tissue/no use of a collimator/no use of lead grid
large penumbra on shadow/large area anode/wide beam
large pixel size
(any two sensible suggestions, 1 each) B2 [2]

(c) **(i)** $I = I_0 e^{-\mu x}$ C1
ratio = $\exp(-2.85 \times 3.5) / \exp(-0.95 \times 8.0)$ C1
= $(4.65 \times 10^{-5}) / (5.00 \times 10^{-4})$
= 0.093 A1 [3]

(ii) *either* large difference (in intensities)
or ratio much less than 1.0 M1
so good contrast A1 [2]

(*answer given in* **(c)(ii)** *must be consistent with ratio given in* **(c)(i)**)

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11 (a) (i) amplitude of the carrier wave varies M1
(in synchrony) with the displacement of the information signal A1 [2]

(ii) e.g. more than one radio station can operate in same region/less interference
enables shorter aerial
increased range/less power required/less attenuation
less distortion
(any two sensible answers, 1 each) B2 [2]

(b) (i) frequency = 909 kHz C1
wavelength = $(3.0 \times 10^8) / (909 \times 10^3)$
= 330 m A1 [2]

(ii) bandwidth = 18 kHz A1 [1]

(iii) frequency = 9000 Hz A1 [1]

12 (a) for received signal, $28 = 10 \lg(P / \{0.36 \times 10^{-6}\})$ C1
$P = 2.3 \times 10^{-4}$ W A1 [2]

(b) loss in fibre $= 10 \lg(\{9.8 \times 10^{-3}\} / \{2.27 \times 10^{-4}\})$ C1
= 16 dB A1 [2]

(c) attenuation per unit length = 16 / 85
= 0.19 dB km^{-1} A1 [1]

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