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

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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CAMBRIDGE
International Examinations

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 × 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]

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
$= 5.2\,\mathrm{m\,s^{-2}}$ 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 = $\tfrac{1}{2}m\omega^2(x_0^{\,2} - x^2)$
or potential energy = $\tfrac{1}{2}m\omega^2x^2$ <u>and</u> potential energy = kinetic energy B1
$\tfrac{1}{2}m\omega^2(x_0 - x^2) = \tfrac{1}{2} \times \tfrac{1}{2}m\omega^2x_0^{\,2}$ or $\tfrac{1}{2}m\omega^2x^2 = \tfrac{1}{2} \times \tfrac{1}{2}m\omega^2x_0^{\,2}$ 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
$\tfrac{1}{2}mv^2 = qV$ leading to $v = (2Vq/m)^{1/2}$ B1 [2]

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

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

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

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 ≡ 10×10^{15} Hz (and 600 nm ≡ 5.0×10^{14} Hz)
or 300 nm ≡ 6.6×10^{-19} J (and 600 nm ≡ 3.3×10^{-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]

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

(b) **(i)** $\Delta m = (2.01410\,\text{u} + 1.00728\,\text{u}) - 3.01605\,\text{u}$
$= 5.33 \times 10^{-3}\,\text{u}$ C1
energy $= c^2 \times \Delta m$ C1
$= 5.33 \times 10^{-3} \times 1.66 \times 10^{-27} \times (3.00 \times 10^8)^2$
$= 8.0 \times 10^{-13}\,\text{J}$ 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 <u>and</u> $V_{OUT} = IR$ 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)**)

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 $= 16 / 85$
$= 0.19\,\text{dB km}^{-1}$ A1 [1]