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GCE Advanced Subsidiary Level and GCE Advanced Level

MARK SCHEME for the May/June 2013 series

9702 PHYSICS

9702/43 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 (-1.7×10^{-2}, 5.2) to (1.7×10^{-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 = $\frac{1}{2}m\omega^2x^2$ <u>and</u> potential energy = kinetic energy	B1	
$\frac{1}{2}m\omega^2(x_0 - x^2) = \frac{1}{2} \times \frac{1}{2}m\omega^2x_0^2$ or $\frac{1}{2}m\omega^2x^2 = \frac{1}{2} \times \frac{1}{2}m\omega^2x_0^2$	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	
$\frac{1}{2}mv^2 = qV$ 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)	

5	**(a)**		(uniform magnetic) flux normal to long (straight) wire carrying a current of 1 A (creates) force per unit length of 1 N m^{-1}	M1 A1	 [2]
	(b)	**(i)**	flux density = $4\pi \times 10^{-7} \times 1.5 \times 10^{3} \times 3.5$ = 6.6×10^{-3} T	C1 A1	 [2]
		(ii)	flux linkage = $6.6 \times 10^{-3} \times 28 \times 10^{-4} \times 160$ = 3.0×10^{-3} Wb	C1 A1	 [2]
	(c)	**(i)**	(induced) e.m.f. proportional to rate of change of (magnetic) flux (linkage)	M1 A1	 [2]
		(ii)	e.m.f. = $(2 \times 3.0 \times 10^{-3}) / 0.80$ = 7.4×10^{-3} V	C1 A1	 [2]
6	**(a)**	**(i)**	to reduce power loss in the core due to eddy currents/induced currents	B1 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 × (8100 / 300) peak voltage across load = $\sqrt{2} \times 243$ = 340 V *or* peak voltage across primary coil = $9.0 \times \sqrt{2}$ peak voltage across load = 12.7 × (8100/300) = 340 V	C1 A1 (C1) (A1)	 [2]
7	**(a)**	**(i)**	lowest frequency of e.m. radiation giving rise to emission of electrons (from the surface)	M1 A1	 [2]
		(ii)	$E = hf$ threshold frequency = $(9.0 \times 10^{-19}) / (6.63 \times 10^{-34})$ = 1.4×10^{15} Hz	C1 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 λ_0 = 340 nm, platinum λ_0 = 220 nm (and sodium λ_0 = 520 nm) emission from sodium <u>and</u> zinc	 M1 A1	 [2]
	(c)		each photon has larger energy fewer photons per unit time fewer electrons emitted per unit time	M1 M1 A1	 [3]

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 <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 × 3.5) / exp(–0.95 × 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 $= (3.0 \times 10^{8}) / (909 \times 10^{3})$ $= 330\,\text{m}$	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	
		$P = 2.3 \times 10^{-4}\,\text{W}$	A1	[2]
	(b)	loss in fibre $= 10\,\lg(\{9.8 \times 10^{-3}\} / \{2.27 \times 10^{-4}\})$	C1	
		$= 16\,\text{dB}$	A1	[2]
	(c)	attenuation per unit length $= 16 / 85$ $= 0.19\,\text{dB km}^{-1}$	A1	[1]

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