CAMBRIDGE INTERNATIONAL EXAMINATIONS

GCE Advanced Subsidiary Level and GCE Advanced Level

MARK SCHEME for the October/November 2012 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.

Mark schemes should be read in conjunction with the question paper and the Principal Examiner Report for Teachers.

Cambridge will not enter into discussions about these mark schemes.

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Section A

1	**(a)**	force is proportional to the product of the masses and			
		inversely proportional to the square of the separation		M1	
		either point masses *or* separation >> size of masses		A1	[2]
	(b) (i)	gravitational force provides the centripetal force		B1	
		$mv^2/r = GMm/r^2$ and $E_K = ½mv^2$		M1	
		hence $E_K = GMm/2r$		A0	[2]
	(ii)	**1.**	$\Delta E_K = ½ \times 4.00 \times 10^{14} \times 620 \times (\{7.30 \times 10^6\}^{-1} - \{7.34 \times 10^6\}^{-1})$	C1	
			$= 9.26 \times 10^7$ J (*ignore any sign in answer*)	A1	[2]
			(*allow* 1.0×10^8 J *if evidence that* E_K *evaluated separately for each* r)		
		2.	$\Delta E_P = 4.00 \times 10^{14} \times 620 \times (\{7.30 \times 10^6\}^{-1} - \{7.34 \times 10^6\}^{-1})$	C1	
			$= 1.85 \times 10^8$ J (*ignore any sign in answer*)	A1	[2]
			(*allow* 1.8 or 1.9×10^8 J)		
	(iii)	*either* $(7.30 \times 10^6)^{-1} - (7.34 \times 10^6)^{-1}$ *or* ΔE_K is positive / E_K increased		M1	
		speed has increased		A1	[2]
2	**(a) (i)**	sum of potential energy and kinetic energy of atoms / molecules / particles		M1	
		reference to random		A1	[2]
	(ii)	no intermolecular forces		B1	
		no potential energy		B1	
		internal energy is kinetic energy (of random motion) of molecules		B1	[3]
		(*reference to random motion here then allow back credit to* ***(i)*** *if M1 scored*)			
	(b)	kinetic energy $\propto$ thermodynamic temperature		B1	
		either temperature in Celsius, not kelvin so incorrect			
		or temperature in kelvin is not doubled		B1	[2]
3	**(a)**	temperature of the spheres is the same		B1	
		no (net) transfer of energy between the spheres		B1	[2]
	(b) (i)	power $= m \times c \times \Delta\theta$ where m is mass per second		C1	
		$3800 = m \times 4.2 \times (42 - 18)$		C1	
		$m = 38\,\text{g s}^{-1}$		A1	[3]
	(ii)	some thermal energy is lost <u>to the surroundings</u>		M1	
		so rate is an overestimate		A1	[2]
4	**(a)**	straight line through origin		M1	
		shows acceleration proportional to displacement		A1	
		negative gradient		M1	
		shows acceleration and displacement in opposite directions		A1	[4]

(b)	**(i)**	2.8 cm	A1	[1]
	(ii)	*either* gradient = ω^2 and $\omega = 2\pi f$ *or* $a = -\omega^2 x$ and $\omega = 2\pi f$	C1	
		gradient = 13.5 / (2.8 × 10^{-2}) = 482		
		ω = 22 rad s^{-1}	C1	
		frequency = (22/2π =) 3.5 Hz	A1	[3]
(c)		e.g. <u>lower</u> spring may not be extended		
		e.g. <u>upper</u> spring may exceed limit of proportionality / elastic limit		
		(*any sensible suggestion*)	B1	[1]
5 (a)	**(i)**	ratio of charge and potential (difference) / voltage		
		(*ratio must be clear*)	B1	[1]
	(ii)	capacitor has equal magnitudes of (+)ve and (-)ve charge	B1	
		<u>total</u> charge on capacitor is zero (so does not store charge)	B1	
		(+)ve and (-)ve charges to be separated	M1	
		work done to achieve this so stores energy	A1	[4]
(b)	**(i)**	capacitance of Y and Z together is 24 μF	C1	
		1 / C = 1 / 24 + 1 / 12		
		C = 8.0 μF (*allow* 1 s.f.)	A1	[2]
	(ii)	some discussion as to why all charge of one sign on one plate of X	B1	
		Q = (CV =) <u>8.0 × 10^{-6}</u> × 9.0	M1	
		= 72 μC	A0	[2]
	(iii)	**1.** V = (72 × 10^{-6}) / (12 × 10^{-6})		
		= 6.0 V (*allow* 1 s.f.) (allow 72/12)	A1	[1]
		2. *either* Q = 12 × 10^{-6} × 3.0 *or* charge is shared between Y and Z	C1	
		charge = 36 μC	A1	[2]
		Must have correct voltage in ***(iii)****1 if just quote of 36μC in* ***(iii)****2.*		
6 (a)	**(i)**	particle must be moving	M1	
		with component of velocity normal to magnetic field	A1	[2]
	(ii)	$F = Bqv \sin\theta$	M1	
		q, v and θ explained	A1	[2]
(b)	**(i)**	face BCGF shaded	A1	[1]
	(ii)	between face BCGF and face ADHE	A1	[1]
(c)		potential difference gives rise to an <u>electric</u> field	M1	
		either $F_E = qE$ (*no need to explain symbols*)		
		or electric field gives rise to force (on an electron)	A1	[2]

7	**(a)**	induced e.m.f./current produces effects / acts in such a direction / tends to oppose the change causing it	M1 A1	[2]
	(b) (i)	**1.** to reduce flux losses / increase flux linkage / easily magnetised <u>and</u> demagnetised	B1	[1]
		2. to <u>reduce</u> energy / heat losses (*do not allow 'to prevent energy losses'*) caused by eddy currents (*allow 1 mark for 'reduce eddy currents'*)	M1 A1	[2]
	(ii)	alternating current / voltage gives rise to (changing) flux in core flux links the <u>secondary coil</u> (by Faraday's law) changing flux induces e.m.f. (in secondary coil)	B1 B1 M1 A1	[4]
8	**(a)**	discrete quantity / packet / quantum of energy of electromagnetic radiation energy of photon = Planck constant × frequency	B1 B1	[2]
	(b)	threshold frequency (1) rate of emission is proportional to intensity (1) max. kinetic energy of electron dependent on frequency (1) max. kinetic energy independent of intensity (1) (*any three, 1 each, max 3*)	B3	[3]
	(c)	*either* $E = hc/\lambda$ — *or* $hc/\lambda = eV$ λ = 450 nm to give — work function of *3.5 eV* energy = 4.4 × 10^{-19} or 2.8 eV — to give λ = 355 nm 2.8 eV < 3.5 eV so no emission — 355 nm < 450 nm so no	C1 M1 A1	[3]
		or work function = 3.5 eV threshold frequency = 8.45×10^{14} Hz 450 nm = 6.67×10^{14} Hz 6.67 × 10^{14} Hz < 8.45 × 10^{14} Hz	 C1 M1 A1	

Section B

9	**(a)**	e.g. zero output impedance / resistance infinite input impedance / resistance infinite (open loop) gain infinite bandwidth infinite slew rate *1 each, max. 3*	B3	[3]
	(b) (i)	graph: square wave	M1	
		correct cross-over points where $V_2 = V_1$	A1	
		amplitude 5 V	A1	
		correct polarity (*positive at t = 0*)	A1	[4]
	(ii)	correct symbol for LED	M1	
		diodes connected correctly between V_{OUT} and earth	A1	
		correct polarity consistent with graph in **(i)** (*R points 'down' if* ***(i)*** *correct*)	A1	[3]
10		X-ray images taken from different angles / X-rays directed from different angles	B1	
		of one section / slice (1)		
		all images in the same plane (1)		
		images combined to give image of section / slice	B1	
		images of successive sections / slices combined	B1	
		image formed using a computer	B1	
		image formed is 3D image (1)		
		that can be rotated / viewed from different angles (1)		
		(*four B-marks plus any two additional marks*)	B2	[6]
11	**(a)**	e.g. noise can be eliminated / filtered / signal can be regenerated extra bits can be added to check for errors multiplexing possible digital circuits are more reliable / cheaper data can be encrypted for security *any sensible advantages, 1 each, max. 3*	B3	[3]
	(b) (i)	**1.** higher frequencies can be reproduced	B1	[1]
		2. smaller changes in loudness / amplitude can be detected	B1	[1]
	(ii)	bit rate $= 44.1 \times 10^3 \times 16$	C1	
		$= 7.06 \times 10^5\ \text{s}^{-1}$		
		number $= 7.06 \times 10^6 \times 340$		
		$= 2.4 \times 10^8$	A1	[2]
12	**(a) (i)**	signal in one wire (pair) is picked up by a neighbouring wire (pair)	B1	[1]
	(ii)	outer of coaxial cable is earthed	B1	
		outer shields the core from noise / external signals	B1	[2]

(b)	attenuation per unit length = $1/L \times 10\,\lg(P_2/P_1)$	C1	
	signal power at receiver = $10^{2.5} \times 3.8 \times 10^{-8}$		
	= 1.2×10^{-5} W	C1	
	attenuation in wire pair = $10\,\lg(\{3.0 \times 10^{-3}\}/\{1.2 \times 10^{-5}\})$		
	= 24 dB	C1	
	attenuation per unit length = 24 / 1.4		
	= 17 dB km^{-1}	A1	[4]
	(*other correct methods of calculation are possible)*		