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.

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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 ∝ 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
$m = 38\,\text{g}\,\text{s}^{-1}$ — 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	M1	
		to oppose the change causing it	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'*)	M1	
		caused by eddy currents	A1	[2]
		(*allow 1 mark for 'reduce eddy currents'*)		
	(ii)	alternating current / voltage	B1	
		gives rise to (changing) flux in core	B1	
		flux links the <u>secondary coil</u>	M1	
		(by Faraday's law) changing flux induces e.m.f. (in secondary coil)	A1	[4]
8	(a)	discrete quantity / packet / quantum of energy of electromagnetic radiation	B1	
		energy of photon = Planck constant × frequency	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* $hc/\lambda = eV$	C1	
		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	M1	
		2.8 eV < 3.5 eV so no emission — 355 nm < 450 nm so no	A1	[3]
		or work function = 3.5 eV		
		threshold frequency = 8.45×10^{14} Hz	C1	
		450 nm = 6.67×10^{14} Hz	M1	
		6.67 × 10^{14} Hz < 8.45 × 10^{14} Hz	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 correct cross-over points where $V_2 = V_1$ amplitude 5 V correct polarity (*positive at t = 0*)		M1 A1 A1 A1	[4]
	(ii)	correct symbol for LED diodes connected correctly between V_{OUT} and earth correct polarity consistent with graph in **(i)** (*R points 'down' if **(i)** correct*)		M1 A1 A1	[3]
10		X-ray images taken from different angles / X-rays directed from different angles of one section / slice all images in the same plane images combined to give image of section / slice images of successive sections / slices combined image formed using a computer image formed is 3D image that can be rotated / viewed from different angles (*four B-marks plus any two additional marks*)	 (1) (1) (1) (1)	B1 B1 B1 B1 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 $= 44.1 \times 10^3 \times 16$ $= 7.06 \times 10^5\ s^{-1}$ number $= 7.06 \times 10^6 \times 340$ $= 2.4 \times 10^8$		C1 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 outer shields the core from noise / external signals		B1 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)*		