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

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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 $E_K = \frac{1}{2}mv^2$ M1
hence $E_K = GMm/2r$ A0 [2]

(ii) 1. $\Delta E_K = \frac{1}{2} \times 4.00 \times 10^{14} \times 620 \times (\{7.30 \times 10^6\}^{-1} - \{7.34 \times 10^6\}^{-1})$ 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]

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(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 = $13.5 / (2.8 \times 10^{-2}) = 482$
$\omega = 22\ \text{rad s}^{-1}$ C1
frequency = $(22/2\pi =)$ 3.5 Hz A1 [3]

(c) e.g. lower spring may not be extended
e.g. upper 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
total 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
$Q = (CV =) \underline{8.0 \times 10^{-6}} \times 9.0$ M1
= 72 μC A0 [2]

(iii) 1. $V = (72 \times 10^{-6}) / (12 \times 10^{-6})$
= 6.0 V (*allow* 1 s.f.) (allow 72/12) A1 [1]

2. *either* $Q = 12 \times 10^{-6} \times 3.0$ *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 36* μ*C 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 electric field M1
either $F_E = qE$ (*no need to explain symbols*)
or electric field gives rise to force (on an electron) A1 [2]

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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 and demagnetised — B1 [1]

2. to reduce energy / heat losses (*do not allow 'to prevent energy losses'*) caused by eddy currents — M1 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 secondary coil — 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 energy = 4.4×10^{-19} or 2.8 eV; work function of *3.5 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

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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)** A1 [3]
(*R points 'down' if **(i)** correct*)

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
$= 7.06 \times 10^5\ s^{-1}$
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]

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(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)*

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