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 $E_K = \frac{1}{2}mv^2$ 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
$m = 38\,\text{g}\,\text{s}^{-1}$ 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 = $13.5 / (2.8 \times 10^{-2}) = 482$
$\omega = 22\ \text{rad s}^{-1}$ 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
$1/C = 1/24 + 1/12$
$C = 8.0\ \mu\text{F}$ (*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
$= 72\ \mu\text{C}$ A0 [2]

(iii) 1. $V = (72 \times 10^{-6}) / (12 \times 10^{-6})$
$= 6.0\ \text{V}$ (*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]

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

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]

(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)*