

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
either point masses *or* separation \gg size of masses
- M1
A1 [2]
- (b) (i) gravitational force provides the centripetal force
 $mv^2/r = GMm/r^2$ and $E_K = \frac{1}{2}mv^2$
hence $E_K = GMm/2r$
- B1
M1
A0 [2]
- (ii) 1. $\Delta E_K = \frac{1}{2} \times 4.00 \times 10^{14} \times 620 \times (\{7.30 \times 10^6\}^{-1} - \{7.34 \times 10^6\}^{-1})$
 $= 9.26 \times 10^7 \text{ J}$ (*ignore any sign in answer*)
(*allow* $1.0 \times 10^8 \text{ J}$ *if evidence that* E_K *evaluated separately for each* r)
- C1
A1 [2]
2. $\Delta E_P = 4.00 \times 10^{14} \times 620 \times (\{7.30 \times 10^6\}^{-1} - \{7.34 \times 10^6\}^{-1})$
 $= 1.85 \times 10^8 \text{ J}$ (*ignore any sign in answer*)
(*allow* 1.8 *or* $1.9 \times 10^8 \text{ J}$)
- C1
A1 [2]
- (iii) *either* $(7.30 \times 10^6)^{-1} - (7.34 \times 10^6)^{-1}$ *or* ΔE_K *is positive* / E_K *increased*
speed has increased
- M1
A1 [2]
- 2 (a) (i) sum of potential energy and kinetic energy of atoms / molecules / particles
reference to random
- M1
A1 [2]
- (ii) no intermolecular forces
no potential energy
internal energy is kinetic energy (of random motion) of molecules
(*reference to random motion here then allow back credit to (i) if M1 scored*)
- B1
B1
B1 [3]
- (b) kinetic energy \propto thermodynamic temperature
either temperature in Celsius, not kelvin so incorrect
or temperature in kelvin is not doubled
- B1
B1 [2]
- 3 (a) temperature of the spheres is the same
no (net) transfer of energy between the spheres
- B1
B1 [2]
- (b) (i) power = $m \times c \times \Delta\theta$ where m is mass per second
 $3800 = m \times 4.2 \times (42 - 18)$
 $m = 38 \text{ g s}^{-1}$
- C1
C1
A1 [3]
- (ii) some thermal energy is lost to the surroundings
so rate is an overestimate
- M1
A1 [2]
- 4 (a) straight line through origin
shows acceleration proportional to displacement
negative gradient
shows acceleration and displacement in opposite directions
- M1
A1
M1
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 = $(22/2\pi) = 3.5 \text{ Hz}$ 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 $24 \mu\text{F}$ 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
 $Q = (CV) = 8.0 \times 10^{-6} \times 9.0$ 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 = $36 \mu\text{C}$ A1 [2]
 Must have correct voltage in (iii)1 if just quote of $36 \mu\text{C}$ 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 \times 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
 $\lambda = 450 \text{ nm}$ to give work function of 3.5 eV
energy = 4.4×10^{-19} or 2.8 eV to give $\lambda = 355 \text{ nm}$ M1
 $2.8 \text{ eV} < 3.5 \text{ eV}$ so no emission $355 \text{ nm} < 450 \text{ nm}$ so no A1 [3]
- or* work function = 3.5 eV
threshold frequency = $8.45 \times 10^{14} \text{ Hz}$ C1
 $450 \text{ nm} = 6.67 \times 10^{14} \text{ Hz}$ M1
 $6.67 \times 10^{14} \text{ Hz} < 8.45 \times 10^{14} \text{ Hz}$ 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 5V 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
= $7.06 \times 10^5 \text{ s}^{-1}$
number = $7.06 \times 10^6 \times 340$
= 2.4×10^8 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 = $10^{2.5} \times 3.8 \times 10^{-8}$
- = $1.2 \times 10^{-5} \text{ W}$ 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)*