

CAMBRIDGE INTERNATIONAL EXAMINATIONS

Cambridge International Advanced Subsidiary and Advanced Level

MARK SCHEME for the March 2016 series

9702 PHYSICS

9702/42

Paper 4 (A Level Structured Questions),
maximum raw mark 100

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- 1 (a) force proportional to product of the (two) masses and inversely proportional to the square of their separation
either reference to point masses *or* separation $\ll$ 'size' of masses
M1
A1 [2]
- (b) gravitational force provides/is the centripetal force
 $GMm/r^2 = mv^2/r$ *or* $GMm/r^2 = m\omega^2 r$ and $v = r\omega$
and algebra leading to $v = (GM/r)^{1/2}$
B1
B1 [2]
- (c) (i) 1. $v_A/v_B = (r_B/r_A)^{1/2}$
 $= (2.2 \times 10^{10}/1.3 \times 10^8)^{1/2}$
 $= 13$ (13.0)
C1
A1 [2]
2. $v = 2\pi r/T$ *or* $v \propto r/T$ *or* $vT/r = \text{constant}$
 $T_A/T_B = (r_A/r_B) \times (v_B/v_A)$
 $= (1.3 \times 10^8/2.2 \times 10^{10}) \times (1/13)$
 $= 4.5$ (4.54) $\times 10^{-4}$
C1
C1
A1
- or*
- $T^2 = 4\pi^2 r^3/GM$ *or* $T^2 \propto r^3$ *or* $T^2/r^3 = \text{constant}$
 $T_A/T_B = (r_A^3/r_B^3)^{1/2}$
 $= [(1.3 \times 10^8)^3/(2.2 \times 10^{10})^3]^{1/2}$
 $= 4.5$ (4.54) $\times 10^{-4}$
(C1)
(C1)
(A1) [3]
- (ii) $T = 2\pi/1.7 \times 10^{-4}$
 $= 3.70 \times 10^4 \text{ s}$
 $T_B = 3.70 \times 10^4/4.54 \times 10^{-4}$
 $= 8.1 \times 10^7 \text{ s}$
A1 [2]
If identifies T_A as T_B then 0/2
- 2 (a) (i) sum of kinetic and potential energy of atoms/molecules
reference to random (distribution)
M1
A1 [2]
- (ii) no forces (of attraction or repulsion) between molecules
B1 [1]
- (b) $pV = NkT$ *or* $pV = nRT$ and $R = kN_A$, $n = N/N_A$
 $\frac{1}{3}Nm\langle c^2 \rangle = NkT$ *or* $\frac{1}{3}m\langle c^2 \rangle = kT$
 $\langle E_K \rangle = \frac{1}{2}m\langle c^2 \rangle$ so $\langle E_K \rangle = \frac{3}{2}kT$
B1
B1
B1 [3]
- (c) (i) $\langle E_K \rangle = \frac{3}{2} \times 1.38 \times 10^{-23} \times (273 + 12)$
 $= 5.9$ (5.90) $\times 10^{-21} \text{ J}$
C1
A1 [2]
- (use of $T = 12 \text{ K}$ *not* $T = 285 \text{ K}$ scores 0/2)
- (ii) number $= (17/32) \times 6.02 \times 10^{23}$
 $= 3.2$ (3.20) $\times 10^{23}$
C1
A1 [2]

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(iii) internal energy = $5.9 \times 10^{-21} \times 3.2 \times 10^{23}$
= 1900 (1890) J

A1 [1]

- 3 (a) the (thermal) energy per unit mass to raise the temperature of a substance by one degree

M1
A1 [2]

(If ratio not clear for M1 mark, allow 1/2 marks for an otherwise correct answer)

- (b) (i) to allow for / determine / cancel heat transfer to / from tube / surroundings

B1 [1]

(do not allow 'to stop / prevent' heat loss)

- (ii) either $P = mc\Delta\theta \pm h$

or $44.9 = 1.58 \times 10^{-3} \times c \times (25.5 - 19.5) \pm h$

or $33.3 = 1.11 \times 10^{-3} \times c \times (25.5 - 19.5) \pm h$

$(44.9 - 33.3) = (1.58 - 1.11) \times 10^{-3} \times c \times (25.5 - 19.5)$

$c = 4100 \text{ (4110) J kg}^{-1} \text{ K}^{-1}$

B1
C1
A1 [3]

(allow 1/3 for use of only 33.3 W, 1.11 g s^{-1} leading to $5000 \text{ J kg}^{-1} \text{ K}^{-1}$)

(allow 1/3 for use of only 44.9 W, 1.58 g s^{-1} leading to $4740 \text{ J kg}^{-1} \text{ K}^{-1}$)

- (c) $V_0 = 27$ or $V_{\text{rms}} = 19.1$
 $33.3 = 27^2 / 2R$ or $33.3 = 19.1^2 / R$
 $R = 11 \Omega$

C1
C1
A1 [3]

- 4 (a) amplitude = 1.8 cm and period = 0.30 s

A1 [1]

- (b) $E_K = \frac{1}{2}m\omega^2(x_0^2 - x^2)$ or $E_K = \frac{1}{2}mv^2$ and $v = \pm \omega \sqrt{(x_0^2 - x^2)}$
 $= \frac{1}{2} \times 0.080 \times (2\pi / 0.30)^2 \times [(1.8 \times 10^{-2})^2 - (1.2 \times 10^{-2})^2]$
 $= 3.2 \times 10^{-3} \text{ J}$

C1
C1
A1 [3]

- 5 (a) (i) (series of) 'highs' and 'lows' / 'on' and 'off' / 1's and 0's / two values with no intermediate values / the values are discrete

M1
A1 [2]

- (ii) either use higher sampling frequency / rate
or use more bits in each sample / each digital number
or use more levels in each sample

B1 [1]

- (b) voltage = 30 mV

A1 [1]

- 6 (a) speed = Z / ρ
 $= 1.4 \times 10^6 / 940 (=1490)$
time = $(1.1 \times 10^{-2} \times 2) / 1490$
 $= 1.5 \times 10^{-5} \text{ s}$

C1
C1
A1 [3]

(time of $7.4 \times 10^{-6} \text{ s}$ is one way only and scores 2/3 marks)

(use of speed of light is wrong physics and scores 0/3 marks)

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- (b) $I = I_0 \exp(-\mu x)$ or $I_2 = I_1 \exp(-\mu x)$ C1
ratio = $\exp(-48 \times 1.1 \times 10^{-2})$
= 0.59 A1 [2]
- (c) $0.33/100 = 0.59 \times (I_3/I_2) \times 0.59$ C1
ratio = 9.5×10^{-3} A1
or
 $0.33/100 = \exp(-48 \times 2.2 \times 10^{-2}) \times (I_3/I_2)$ (C1)
ratio = 9.5×10^{-3} (A1) [2]
- (d) ratio I_3/I_2 increases B1 [1]
(accept: "there is an increase in the proportion of the intensity that is reflected")
- 7 (a) (capacitance =) charge/potential (difference) B1 [1]
- (b) $V = V_1 + V_2 + V_3$ B1
either $Q/C = Q/C_1 + Q/C_2 + Q/C_3$ or $V/Q = V_1/Q + V_2/Q + V_3/Q$
and so $1/C = 1/C_1 + 1/C_2 + 1/C_3$ B1 [2]
- (c) (i) 1. $1/C_T = (1/200) + (1/600)$
 $C_T = 150 \mu\text{F}$ A1 [1]
2. $Q = CV$
= $150 \times 10^{-6} \times 12$ or $600 \times 10^{-6} \times 3.0$ or $200 \times 10^{-6} \times 9.0$
= $1.8 \times 10^{-3} \text{ C}$ A1 [1]
3. $V = Q/C = 1.8 \times 10^{-3} / 600 \times 10^{-6}$ or $V = [200 / (200 + 600)] \times 12$
= 3(.0) V A1 [1]
- (ii) energy = $\frac{1}{2}CV^2$ or energy = $\frac{1}{2}QV$ and $C = Q/V$ C1
 $\frac{1}{2} \times C \times 3^2 = 2 \times \frac{1}{2} \times C \times V^2$ C1
 $V = 2.1 \text{ V}$ A1 [3]
- 8 (a) decreases gain B1
increases bandwidth/decreases distortion/increases (operating) stability B1 [2]
- (b) (i) additional resistor connected between 7.2 k Ω resistor and earth B1
 V^- joined to lower end of 7.2 k Ω resistor and V^+ joined to V_{IN} B1 [2]
- (ii) either $5 = 1 + (7.2/R)$ or $5 = 1 + (7200/R)$ C1
 $R = 1.8 \text{ k}\Omega$ A1 [2]
- (iii) horizontal line from (0, 8.0) to (1.8, 8.0) B1
straight line from (1.8, 8.0) to (5.0, 0) B1 [2]
- (allow a tolerance of $\pm \frac{1}{2}$ small square when marking the graph)

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- 9 (a) direction of force due to electric field opposite to force due to magnetic field
electric field is up the page
B1
B1 [2]
- (b) force due to electric field = force due to magnetic field or $Eq = Bqv$
 $E = Bv$
 $= 9.7 \times 10^{-2} \times 1.6 \times 10^5$
 $= 1.6 (1.55) \times 10^4 \text{ V m}^{-1}$
B1
C1
A1 [3]
- (c) $q/m = v/Br$
 $= 1.6 \times 10^5 / (9.7 \times 10^{-2} \times 4.0 \times 10^{-2})$
 $= 4.1 (4.12) \times 10^7 \text{ C kg}^{-1}$
C1
C1
A1 [3]
- (d) (i) $m = (3 \times 1.60 \times 10^{-19}) / (4.12 \times 10^7)$
 $m = 1.16 \times 10^{-26} / 1.66 \times 10^{-27}$
 $= 7(.0) \text{ u (allow 7.1 u)}$
C1
A1 [2]
- (ii) 3 protons, 4 neutrons
A1 [1]
- 10 (a) (i) change in flux linkage $= 40 \times (5.0 - 3.0) \times 10^{-6}$
 $= 8(.0) \times 10^{-5} \text{ Wb}$
A1 [1]
- (ii) time taken $= 8.0 \times 10^{-5} / 5.0 \times 10^{-4}$
 $= 0.16 \text{ (s)}$
C1
speed $= 3.0 \times 10^{-2} / 0.16$
 $= 0.19 (0.188) \text{ m s}^{-1}$
A1
- or
- $E = (\Delta\Phi / \Delta x) \times \text{speed}$
speed $= 5.0 \times 10^{-4} / (8.0 \times 10^{-5} / 3.0 \times 10^{-2})$
 $= 0.19 (0.188) \text{ m s}^{-1}$
(C1)
(A1) [2]
- (b) a constant non-zero value of E from 0 to 3 cm and
a different constant non-zero value of E from 3 to 6 cm
 E from 3–6 cm has the opposite sign to and larger value than E from 0–3 cm
M1
A1 [2]
- 11 (a) minimum frequency for electron(s) to be emitted (from surface)
reference to frequency of electromagnetic radiation / photon
M1
A1
- or
- frequency causing emission of electron(s)
from surface with zero kinetic energy
reference to frequency of electromagnetic radiation / photon
(M1)
(A1) [2]

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- (b) (i) positive intercept on $(1/\lambda)$ -axis (when extrapolated)
straight line with positive gradient B1 [2]
B1
- (ii) gradient = hc where c is the speed of light B1 [1]
- (iii) maximum kinetic energy when electron emitted from surface
energy is required to bring an electron to the surface B1 [2]
B1
- (iv) each photon has more energy M1
fewer photons per unit time M1
fewer electrons per unit time / less current A1 [3]
- 12 (a) (i) the penetration of the beam B1 [1]
- (ii) *either* decrease the accelerating voltage
or decrease voltage between cathode and anode B1 [1]
- (b) advantage: image gives depth / image is 3D / final image can be
viewed from any angle B1
disadvantage: greater exposure / more risk to health / more expensive /
person must remain stationary B1 [2]
- 13 (a) $\lambda = \ln 2 / T_{1/2}$
 $= \ln 2 / (53.3 \times 24 \times 60 \times 60) = 1.5 \times 10^{-7} \text{ s}^{-1}$ A1 [1]
- (b) $A = \lambda N$ C1
 $N = 39 \times 10^{-3} / 1.5 \times 10^{-7} = 2.6 \times 10^5$
 $m = (2.6 \times 10^5 / 6.0 \times 10^{23}) \times 7 \times 10^{-3}$ *or* $2.6 \times 10^5 \times 1.66 \times 10^{-27} \times 7$ C1
 $= 3.0 \times 10^{-21} \text{ kg}$ A1 [3]
- (c) $2/39 = \exp(-1.5 \times 10^{-7} \times t)$ *or* $2/39 = (1/2)^{[t/(53.3 \times 24 \times 3600)]}$ C1
 $t = 2.0 \times 10^7 \text{ s}$ A1 [2]