

CAMBRIDGE INTERNATIONAL EXAMINATIONS

Cambridge International Advanced Subsidiary and Advanced Level

MARK SCHEME for the October/November 2015 series

9702 PHYSICS

9702/42

Paper 4 (A2 Structured Questions), maximum raw mark 100

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Section A

- 1 (a) (i) gravitational force provides/is the centripetal force B1
- $$GMm_S/x^2 = m_S v^2/x \text{ (allow } x \text{ or } r, \text{ allow } m \text{ or } m_S) \text{ M1}$$
- $$E_K = \frac{1}{2}m_S v^2 \text{ and clear algebra leading to } E_K = GMm_S/2x \text{ A1 [3]}$$
- (ii) $E_P = -GMm_S/x$ (sign essential) B1 [1]
- (iii) $E_T = E_K + E_P$
 $= GMm_S/2x - GMm_S/x$ C1
 $= -GMm_S/2x$ (allow ECF from (a)(ii)) A1 [2]
- (b) (i) decreases B1 [1]
- (ii) decreases B1 [1]
- (iii) decreases B1 [1]
- (iv) increases B1 [1]
- (for answers in (b) allow ECF from (a)(iii))
- 2 (a) obeys the equation $pV = nRT$ or $pV/T = \text{constant}$ M1
all symbols explained; T in kelvin/thermodynamic temperature A1 [2]
- (b) (i) temperature rise = 48 K A1 [1]
- (ii) $\langle c^2 \rangle \propto T$ or equivalent C1
 $\langle c^2 \rangle = (353/305) \times 1.9 \times 10^6$ C1
 $c_{r.m.s.} = 1480 \text{ m s}^{-1}$ A1 [3]
- 3 (a) heat/thermal energy gained by system or energy transferred to system by heating B1
plus work done on the system or minus work done by the system B1 [2]
- (b) (i) either volume decreases so work done on the system M1
or small volume change so work done on system negligible M1
(thermal) energy absorbed to break lattice structure A1 [3]
internal energy increases
- (ii) gas expands so work done by gas (against atmosphere) M1
no time for thermal energy to enter or leave the gas M1
internal energy decreases A1 [3]
- 4 (a) free: (body oscillates) without any loss of energy/no resistive forces/no external forces applied B1
forced: continuous energy input (required)/body is made to vibrate by an (external) periodic force/driving oscillator B1 [2]

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- (b) (i) idea of resonance B1
maximum amplitude at natural frequency B1
frequency = 2.1 Hz (*allow 2.08 to 2.12 Hz*) B1 [3]
- (ii) peak not very sharp/amplitude not infinite so frictional forces are present B1 [1]
- (c) $v = \omega x_0$
 $= 2\pi \times 2.1 \times 4.7 \times 10^{-2}$ (*allow ECF from (b)(i)*) C1
 $= 0.62 \text{ ms}^{-1}$ A1 [2]
- 5 (a) (i) force proportional to the product of the two/point charges B1
and inversely proportional to the square of their separation B1 [2]
- (ii) 1. force radially away from sphere/to right/to east B1 [1]
2. (maximum) at/on surface of sphere *or* $x = r$ B1 [1]
3. $F \propto 1/x^2$ *or* $F = q_1 q_2 / (4\pi \epsilon_0 x^2)$ C1
ratio = 16 A1 [2]
- (b) $E = q / (4\pi \epsilon_0 x^2)$ *or* $E \propto q$ C1
maximum charge = $(2.0 / 1.5) \times 6.0 \times 10^{-7}$ C1
 $= 8.0 \times 10^{-7} \text{ C}$
additional charge = $2.0 \times 10^{-7} \text{ C}$ A1 [3]
- 6 (a) (i) force = mg M1
along the direction of the field/of the motion A1 [2]
- (ii) no force B1 [1]
- (b) (i) force due to E -field downwards so force due to B -field upwards B1
into the plane of the paper B1 [2]
- (ii) force due to magnetic field = Bqv B1
force due to electric field = Eq B1
(*use of F_B and F_E not explained, allow 1/2*)
forces are equal (and opposite) so $Bv = E$ *or* $Eq = Bqv$ so $E = Bv$ B1 [3]
- (c) sketch: smooth curved path M1
in 'upward' direction A1 [2]
- 7 (a) minimum frequency of e.m. radiation/a photon (not "light") M1
for emission of electrons from a surface A1 [2]
(*reference to light/UV rather than e.m. radiation, allow 1/2*)

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- (b) E_{MAX} corresponds to electron emitted from surface
electron (below surface) requires energy to bring it to surface, so less than E_{MAX} B1
B1 [2]
- (c) (i) $1/\lambda_0 = 1.85 \times 10^6$ (allow 1.82 to 1.88) C1
- $$f_0 = c/\lambda_0$$
- $$= 3.00 \times 10^8 \times 1.85 \times 10^6$$
- $$= 5.55 \times 10^{14} \text{ Hz}$$
- A1 [2]
- (ii) $\Phi = hf_0$
 $= 6.63 \times 10^{-34} \times 5.55 \times 10^{14}$ (allow ECF from (c)(i)) C1
 $= 3.68 \times 10^{-19} \text{ J}$ A1 [2]
- (d) sketch: straight line with same gradient M1
intercept between 1.0 and 1.5 A1 [2]
- 8 (a) nucleus: small central part/core of an atom B1
nucleon: proton or a neutron B1
particle contained within a nucleus B1 [3]
- (b) (i) 1. decay constant $= \ln 2 / (3.8 \times 24 \times 3600)$ C1
 $= 2.1 \times 10^{-6} \text{ s}^{-1}$ A1 [2]
2. $A = \lambda N$
 $97 = 2.1 \times 10^{-6} \times N$ C1
 $N = 4.6 \times 10^7$ A1 [2]
- (ii) 1.0 m^3 contains $(6.02 \times 10^{23}) / (2.5 \times 10^{-2})$ air molecules C1
- $$\text{ratio} = (4.6 \times 10^7 \times 2.5 \times 10^{-2}) / (6.02 \times 10^{23})$$
- $$= 1.9 \times 10^{-18}$$
- A1 [2]

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Section B

- 9 (a) (i) (+) 3.0V B1 [1]
- (ii) potential = $6.0 \times \{2.0 / (2.0 + 2.8)\}$
= 2.5V C1
A1 [2]
- (iii) potential = $6.0 \times \{2.0 / (2.0 + 1.8)\}$
= 3.2V A1 [1]
- (b) at 10°C, $V_A > V_B$ M1
 V_{OUT} is -9.0V (allow "negative saturation") A1
- at 20°C, V_{OUT} is +9.0V B1
(if 20°C considered initially, mark as M1,A1,B1)
- sudden switch (from -9V to +9V) when $V_A = V_B$ B1 [4]
- 10 (a) sharpness: clarity of edges/resolution (of image) B1
contrast: difference in degree of blackening (of structures) B1 [2]
- (b) (i) X-rays produced when (high speed) electrons hit target/anode B1
either electrons have been accelerated through 80kV
or electrons have (kinetic) energy of 80keV B1 [2]
- (ii) $I_T / I = e^{-3.0 \times 1.4}$
= 0.015 C1
A1 [2]
- (c) for good contrast, μX or $e^{\mu X}$ or $e^{-\mu X}$ must be very different B1
 μX or $e^{\mu X}$ or $e^{-\mu X}$ for bone and muscle will be different than that for muscle M1
so good contrast A1 [3]
- 11 (a) frequency of carrier wave varies M1
in synchrony with the displacement of the signal/information wave A1 [2]
- (b) (i) 5.0V A1 [1]
- (ii) 720kHz A1 [1]
- (iii) 780kHz A1 [1]
- (iv) 7500 A1 [1]

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- 12 (a) (i)** (gradual) loss of power/intensity/amplitude (not “signal”) B1 [1]
- (ii)** e.g. noise can be eliminated (not “there is no noise”) M1
because pulses can be regenerated A1
- e.g. much greater data handling/carrying capacity M1
because many messages can be carried at the same time/greater bandwidth A1
- e.g. more secure (M1)
because it can be encrypted (A1)
- e.g. error checking (M1)
because extra information/parity bit can be added (A1) [4]
- (allow any two sensible suggestions with ‘state’ M1 and ‘explain’ A1)*
- (b)** attenuation = $10 \lg(145/29)$ (= 7.0) C1
- attenuation per unit length = $7.0/36$
= 0.19 dB km^{-1} A1 [2]