

CAMBRIDGE INTERNATIONAL EXAMINATIONS

Cambridge International Advanced Subsidiary and Advanced Level

MARK SCHEME for the October/November 2015 series

9702 PHYSICS

9702/41

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
- $$GMm_S/x^2 = m_S v^2/x \text{ (allow } x \text{ or } r; \text{ allow } m \text{ or } m_S)$$
- M1
- $$E_K = \frac{1}{2}m_S v^2 \text{ and clear algebra leading to } E_K = GMm_S/2x$$
- 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 maximum amplitude at natural frequency frequency = 2.1 Hz (<i>allow 2.08 to 2.12 Hz</i>)	B1 B1 B1	[3]
	(ii) peak not very sharp/amplitude not infinite so frictional forces are present	B1	[1]
	(c) $v = \omega x_0$ $= 2\pi \times 2.1 \times 4.7 \times 10^{-2}$ (<i>allow ECF from (b)(i)</i>) $= 0.62 \text{ m s}^{-1}$	C1 A1	[2]
5	(a) (i) force proportional to the product of the two/point charges and inversely proportional to the square of their separation	B1 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 = $(2.0/1.5) \times 6.0 \times 10^{-7}$ $= 8.0 \times 10^{-7} \text{ C}$	C1	
	additional charge = $2.0 \times 10^{-7} \text{ C}$	A1	[3]
6	(a) (i) force = mg along the direction of the field/of the motion	M1 A1	[2]
	(ii) no force	B1	[1]
	(b) (i) force due to E -field downwards so force due to B -field upwards into the plane of the paper	B1 B1	[2]
	(ii) force due to magnetic field = Bqv force due to electric field = Eq (<i>use of F_B and F_E not explained, allow 1/2</i>)	B1 B1	
	forces are equal (and opposite) so $Bv = E$ or $Eq = Bqv$ so $E = Bv$	B1	[3]
	(c) sketch: smooth curved path in 'upward' direction	M1 A1	[2]
7	(a) minimum frequency of e.m. radiation/a photon (not "light") for emission of electrons from a surface (<i>reference to light/UV rather than e.m. radiation, allow 1/2</i>)	M1 A1	[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 [2]
B1
- (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
intercept between 1.0 and 1.5 M1
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
- 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)** (+) 3.0 V B1 [1]
- (ii)** potential = $6.0 \times \{2.0 / (2.0 + 2.8)\}$
= 2.5 V C1
A1 [2]
- (iii)** potential = $6.0 \times \{2.0 / (2.0 + 1.8)\}$
= 3.2 V A1 [1]
- (b)** at 10 °C, $V_A > V_B$ M1
 V_{OUT} is –9.0 V (allow “negative saturation”) A1
- at 20 °C, V_{OUT} is +9.0 V B1
(if 20 °C considered initially, mark as M1,A1,B1)
- sudden switch (from –9 V to +9 V) 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 80 kV
or electrons have (kinetic) energy of 80 keV B1 [2]
- (ii)** $I_T / I = e^{-3.0 \times 1.4}$ C1
= 0.015 A1 [2]
- (c)** for good contrast, μ_X or e^{μ_X} or $e^{-\mu_X}$ must be very different B1
 μ_X or e^{μ_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)** 5.0 V A1 [1]
- (ii)** 720 kHz A1 [1]
- (iii)** 780 kHz 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]