

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
- $GMm_S/x^2 = m_S v^2/x$ (allow x or r ; allow m or m_S) M1
- $E_K = \frac{1}{2}m_S v^2$ 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
 $c_{\text{r.m.s.}} = 1480 \text{ m s}^{-1}$ A1 [3]
- 3 (a) heat/thermal energy gained by system or energy transferred to system by heating plus work done on the system or minus work done by the system B1
B1 [2]
- (b) (i) either volume decreases so work done on the system or small volume change so work done on system negligible (thermal) energy absorbed to break lattice structure internal energy increases M1
M1
A1 [3]
- (ii) gas expands so work done by gas (against atmosphere) no time for thermal energy to enter or leave the gas internal energy decreases M1
M1
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>) $= 0.62 \text{ ms}^{-1}$	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 <i>or</i> $x = r$	B1	[1]
	3. $F \propto 1/x^2$ <i>or</i> $F = q_1 q_2 / (4\pi \epsilon_0 x^2)$ ratio = 16	C1 A1	[2]
	(b) $E = q / (4\pi \epsilon_0 x^2)$ <i>or</i> $E \propto q$ maximum charge = $(2.0 / 1.5) \times 6.0 \times 10^{-7}$ $= 8.0 \times 10^{-7} \text{ C}$ additional charge = $2.0 \times 10^{-7} \text{ C}$	C1 C1 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>) forces are equal (and opposite) so $Bv = E$ <i>or</i> $Eq = Bqv$ so $E = Bv$	B1 B1 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
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)** $I_T / I = e^{-3.0 \times 1.4}$ C1
= 0.015 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]