**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* $pV / T$ = 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 | |
| | | | $c_{r.m.s.} = 1480\ \mathrm{m\,s^{-1}}$ | 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 | | |
| | | | *or* small volume change so work done on system negligible | M1 | |
| | | | (thermal) energy absorbed to break lattice structure | M1 | |
| | | | internal energy increases | A1 | [3] |
| | | **(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] |

| | | | | | |
|---|---|---|---|---|---|
| | **(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 | |
| | | | $= 0.62\,\text{m s}^{-1}$ | 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* $F = q_1q_2/(4\pi\varepsilon_0x^2)$ | C1 | |
| | | | ratio = 16 | A1 | [2] |
| | **(b)** | | $E = q/(4\pi\varepsilon_0x^2)$ *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*) | | |

**(b)** $E_{MAX}$ corresponds to electron emitted from surface B1
electron (below surface) requires energy to bring it to surface, so less than $E_{MAX}$ B1 [2]

**(c)** **(i)** $1/\lambda_0 = 1.85 \times 10^6$ *(allow 1.82 to 1.88)* C1

$f_0 = c/\lambda_0$
$= 3.00 \times 10^8 \times 1.85 \times 10^6$
$= 5.55 \times 10^{14}$ Hz A1 [2]

**(ii)** $\Phi = hf_0$
$= 6.63 \times 10^{-34} \times 5.55 \times 10^{14}$ *(allow ECF from **(c)(i)**)* C1
$= 3.68 \times 10^{-19}$ J A1 [2]

**(d)** sketch: straight line with same gradient M1
intercept between 1.0 and 1.5 A1 [2]

**8** **(a)** nucleus: <u>small</u> 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 $\text{m}^3$ 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]

## Section B

| | | | | | |
|---|---|---|---|---|---|
| **9** | **(a)** | **(i)** | (+) 3.0 V | B1 | [1] |
| | | **(ii)** | potential = 6.0 × {2.0 / (2.0 + 2.8)} | C1 | |
| | | | = 2.5 V | A1 | [2] |
| | | **(iii)** | potential = 6.0 × {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, $\mu x$ or $e^{\mu x}$ or $e^{-\mu x}$ must be very different | B1 | |
| | | | $\mu x$ 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)** | 5.0 V | A1 | [1] |
| | | **(ii)** | 720 kHz | A1 | [1] |
| | | **(iii)** | 780 kHz | A1 | [1] |
| | | **(iv)** | 7500 | A1 | [1] |

| | | | |
|---|---|---|---|
| **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] |