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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

$GMm_S / x^2 = m_S v^2 / x$ (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
$c_{r.m.s.} = 1480\ \text{m s}^{-1}$ — 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
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]

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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
$= 0.62\,\text{m s}^{-1}$ 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*)

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(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: 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
$= 2.1 \times 10^{-6}\,s^{-1}$ 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 × {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, 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) 5.0 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]

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