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MARK SCHEME for the October/November 2014 series

9702 PHYSICS

9702/41 Paper 4 (A2 Structured Questions), maximum raw mark 100

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Section A

1 (a) $g = GM/R^2$ C1
$= (6.67 \times 10^{-11} \times 6.4 \times 10^{23})/(3.4 \times 10^6)^2 = 3.7\,\text{N kg}^{-1}$ A1 [2]

(b) $\Delta E_P = mg\Delta h$
because $\Delta h \ll R$ (or $1800\,\text{m} \ll 3.4 \times 10^6\,\text{m}$) g is constant B1
$\Delta E_P = 2.4 \times 3.7 \times 1800$ C1
$= 1.6 \times 10^4\,\text{J}$ A1 [3]
(*use of $g = 9.8\,\text{m s}^{-2}$ max. 1 for explanation*)

(c) gravitational potential energy = $(-)GMm/x$ C1
$v^2 = 2GM/x$ C1
$x = 4D = 4 \times 6.8 \times 10^6$ C1

$v^2 = (2 \times 6.67 \times 10^{-11} \times 6.4 \times 10^{23})/(4 \times 6.8 \times 10^6)$
$= 3.14 \times 10^6$
$v = 1.8 \times 10^3\,\text{m s}^{-1}$ A1 [4]
(*use of $3.5D$ giving $1.9 \times 10^3\,\text{m s}^{-1}$, allow max. 3*)

2 (a) (i) $F = R\cos\theta$ M1
$W = R\sin\theta$ M1
dividing, $W = F\tan\theta$ A0 [2]
(max. 1 if derivation to final line not shown)

(ii) provides the centripetal force B1 [1]

(b) *either* $F = mv^2/r$ and $W = mg$
or $v^2 = rg/\tan\theta$ C1
$v^2 = (14 \times 10^{-2} \times 9.8)/\tan 28°$ C1
$= 2.58$
$v = 1.6\,\text{m s}^{-1}$ A1 [3]

3 (a) obeys the equation pV/T = constant B1 [1]
(accept $pV = nRT$)

(b) (i) $pV = nRT$ C1
$5.0 \times 10^7 \times 3.0 \times 10^{-4} = n \times 8.31 \times 296$ giving $n = 6.1\,\text{mol}$ A1 [2]

(ii) pressure $\propto$ amount of substance
loss = $0.40/100 \times 6.1\,\text{mol} = 0.0244\,\text{mol}$ C1
$= 0.0244 \times 6.02 \times 10^{23}$ (atoms) C1
$= 1.47 \times 10^{22}$ atoms C1

rate = $(1.47 \times 10^{22})/(35 \times 24 \times 60 \times 60)$
$= 4.9 \times 10^{15}\,\text{s}^{-1}$ A1 [4]

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4 (a) acceleration / force proportional to displacement (from a fixed point) M1
either acceleration and displacement in opposite directions
or acceleration always directed towards a fixed point A1 [2]

(b) (i) *g* and *r* are constant so *a* is proportional to *x* B1
negative sign shows *a* and *x* are in opposite directions B1 [2]

(ii) $\omega^2 = g / r$ and $\omega = 2\pi / T$ C1
$\omega^2 = 9.8 / 0.28$
$= 35$ C1
$T = 2\pi / \sqrt{35} = 1.06\,\text{s}$
time interval $\tau = 0.53\,\text{s}$ A1 [3]

(c) sketch: time period constant (or increases very slightly) M1
drawn line always 'inside' given loops A1
successive decrease in peak height A1 [3]

5 (a) work done in moving unit positive charge M1
from infinity (to the point) A1 [2]

(b) (i) inside the sphere, the potential would be constant B1 [1]

(ii) for point charge, *Vx* is constant B1
co-ordinates clear and determines two values of *Vx* at least 4 cm apart M1
conclusion made clear A1 [3]

(c) $q = 4\pi\varepsilon_0 Vx$
$q = 4\pi \times 8.85 \times 10^{-12} \times 180 \times 1.0 \times 10^{-2}$ M1
$= 2.0 \times 10^{-10}\,\text{C}$ A1 [2]

6 (a) $F = BIL\sin\theta$ C1
$= 2.6 \times 10^{-3} \times 5.4 \times 4.7 \times 10^{-2} \times \sin 34°$
$= 3.69 \times 10^{-4}\,\text{N}$ A1 [2]
(*allow 1 mark for use of cos 34°*)

(b) peak current $= 1.7 \times \sqrt{2}$ C1
$= 2.4\,\text{A}$

max. force $= 2.6 \times 10^{-3} \times 2.4 \times 4.7 \times 10^{-2} \times \sin 34°$
$= 1.64 \times 10^{-4}\,\text{N}$ C1

variation $= 2 \times 1.64 \times 10^{-4}$
$= 3.3 \times 10^{-4}\,\text{N}$ A1 [3]

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7 (a) (i) *either* heating effect in a resistor $\propto$ (current)^2 B1
square of value of an alternating current is always positive B1
so heating effect A0
or current moves in opposite directions in resistor during half-cycles (B1)
heating effect is independent of direction (B1) [2]

(ii) that value of the direct current M1
producing the same heating effect (as the alternating current) in a resistor A1 [2]

(b) (i) induced e.m.f. proportional to the rate M1
of change of (magnetic) flux (linkage) A1 [2]

(ii) flux in core is in phase with current in the primary coil B1
(induced) e.m.f. in secondary because coil cuts the flux B1
flux and rate of change of flux are not in phase B1 [3]

8 (a) photon 'absorbed' by electron B1
photon has energy equal to difference in energy of two energy levels B1
electron de-excites emitting photon (of same energy) in any direction B1 [3]

(b) (i) $E = hc/\lambda$ C1
$= (6.63 \times 10^{-34} \times 3 \times 10^{8})/(435 \times 10^{-9})$ C1
$= 4.57 \times 10^{-19}$ J (*allow 2 s.f.*) C1
$= (4.57 \times 10^{-19})/(1.6 \times 10^{-19})$ (eV)
$= 2.86$ eV (*allow 2 s.f.*) A1 [4]

(ii) arrow pointing in either direction between –3.41 eV and –0.55 eV B1 [1]

9 (a) 'light' nuclei combine to form 'heavier' nuclei B1 [1]

(b) (i) *either* energy = $c^2\Delta m$
or energy = $(3.00 \times 10^{8})^2 \times 1.66 \times 10^{-27}$ C1
energy $= 1.494 \times 10^{-10}$ J C1
$= (1.494 \times 10^{-10})/(1.60 \times 10^{-13})$
$= 934$ MeV (*3 s.f.*) A1 [3]

(ii) $\Delta m = (2.01356 + 3.01551) - (4.00151 + 1.00867)$
$= 5.02907 - 5.01018$
$= 0.01889$ u C1

energy $= 0.01889 \times 934$
$= 17.6$ MeV (*allow 2 s.f.*) A1 [2]

(iii) high temperature means high speeds / kinetic energy of nuclei B1
D and T nuclei collide despite repelling one another B1 [2]

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Section B

10 (a) e.g. zero output resistance / impedance
infinite bandwidth
infinite slew rate
1 mark each, max. 3 — B3 [3]

(b) (i) at 1.0 °C, thermistor resistance is 3.7 kΩ — B1
amplifier gain = $-R/740 = -3700/740$ *(negative sign essential)* — C1
$= -5.0$ — C1

potential = $1.0/-5.0 = -0.20$ V — A1 [4]

(ii) at 15 °C, $R = 2.15$ kΩ (*allow ±0.05 kΩ*) — C1
reading = $(2150/740) \times 0.2$
= 0.58 V (0.59 V → 0.57 V) — A1 [2]

(c) (i) 0.68 V — A1 [1]

(ii) resistance (of thermistor) does not change linearly with temperature — B1 [1]

11 (a) X-ray beam contains many wavelengths — B1
aluminium filter absorbs long wavelength X-ray radiation — M1
that would be absorbed by the body (and not contribute to the image) — A1 [3]

(b) CT scan consists of (many) X-ray <u>images</u> of a slice — M1
and there are many slices — A1
X-ray image is a single exposure — B1
(so much) greater exposure with CT scan — B1 [4]

12 (a) (i) e.g. satellite <u>communication</u>, mobile phones, line of sight communication, wifi — B1 [1]

(ii) e.g. connection of TV to aerial, loudspeaker, microphone (if clearly identified) — B1 [1]

(iii) e.g. a.f. amplifier to loudspeaker, landline for phone — B1 [1]

(b) (i) attenuation / dB = $10 \lg (P_2/P_1)$ — C1
$-190 = 10 \lg (P_2/3.1)$
$P_2 = 3.1 \times 10^{-19}$ kW — A1 [2]

(ii) signal is amplified — M1
frequency is changed — M1
to prevent swamping of up-link signal by down-link (signal) — A1 [3]

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13 (a) *either* for transmission and reception of signal
or switching between transmitted and received signals M1
either so that one aerial may be used
or so that transmission and reception can occur in quick succession A1 [2]

(b) gives large signal for one (input) frequency M1
(and) rejects / very small signal for all other frequencies A1 [2]

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