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Cambridge International Advanced Subsidiary and Advanced Level

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 m $\ll 3.4 \times 10^6$ 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 m s*$^{-2}$ *max. 1 for explanation*)

(c) gravitational potential <u>energy</u> = (–)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* $\times 10^3$ *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) <u>provides</u> 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 $n = 6.1$ mol A1 [2]

(ii) pressure $\propto$ amount of substance
loss = $0.40/100 \times 6.1$ mol = 0.0244 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]

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) $\omega^2 = g / r$ <u>and</u> $\omega = 2\pi / T$	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]

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 / <u>kinetic</u> energy of nuclei	B1	
			D and T nuclei collide despite repelling one another	B1	[2]

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 amplifier gain = $-R/740 = -3700/740$ *(negative sign essential)* = –5.0	B1 C1 C1	
			potential = 1.0 / –5.0 = –0.20 V	A1	[4]
		(ii)	at 15 °C, R = 2.15 kΩ (*allow ±0.05 kΩ*) reading = (2150 / 740) × 0.2 = 0.58 V (0.59 V → 0.57 V)	C1 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 aluminium filter absorbs long wavelength X-ray radiation that would be absorbed by the body (and not contribute to the image)	B1 M1 A1	 [3]
	(b)		CT scan consists of (many) X-ray <u>images</u> of a slice and there are many slices X-ray image is a single exposure (so much) greater exposure with CT scan	M1 A1 B1 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) $-190 = 10\lg(P_2/3.1)$ $P_2 = 3.1 \times 10^{-19}$ kW	C1 A1	 [2]
		(ii)	signal is amplified frequency is changed to prevent swamping of up-link signal by down-link (signal)	M1 M1 A1	 [3]

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]