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PHYSICS **9702/41**

Paper 4 A Level Structured Questions **May/June 2017**

MARK SCHEME

Maximum Mark: 100

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Question	Answer	Marks
1(a)	gravitational force (of attraction between satellite and planet)	**B1**
	provides / is centripetal force (on satellite about the planet)	**B1**
1(b)	$M = (4/3) \times \pi R^3 \rho$	**B1**
	$\omega = 2\pi / T$ **or** $v = 2\pi nR / T$	**B1**
	$GM / (nR)^2 = nR\omega^2$ **or** v^2 / nR	**M1**
	substitution clear to give $\rho = 3\pi n^3 / GT^2$	**A1**
1(c)	$n = (3.84 \times 10^5) / (6.38 \times 10^3) = 60.19$ or 60.2	**C1**
	$\rho = 3\pi \times 60.19^3 / [(6.67 \times 10^{-11}) \times (27.3 \times 24 \times 3600)^2]$	**C1**
	$\rho = 5.54 \times 10^3\ \text{kg m}^{-3}$	**A1**

Question	Answer	Marks
2(a)	e.g. period = 3 / 2.5	**C1**
	frequency = 0.83 Hz	**A1**
2(b)	light (damping)	**B1**
2(c)	at 2.7 s, A_0 = 1.5 (cm)	**B1**
	energy = $\frac{1}{2} m \times 4\pi^2 f^2 A_0^2$	**B1**
	= $\frac{1}{2} \times 0.18 \times 4\pi^2 \times 0.83^2 \times (1.5 \times 10^{-2})^2$ = 5.51×10^{-4} (J)	**C1**
	at 7.5 s, A_0 = 0.75 (cm)	**B1**
	energy = $\frac{1}{4} \times 5.51 \times 10^{-4}$ **or** energy = $\frac{1}{2} \times 0.18 \times 4\pi^2 \times 0.83^2 \times (0.75 \times 10^{-2})^2$	**C1**
	energy = 1.38×10^{-4} (J) change = $(5.51 \times 10^{-4} - 1.38 \times 10^{-4})$ = 4.13 J	**A1**

Question	Answer	Marks
3(a)(i)	signal consists of (a series of) 1s and 0s **or** offs and ons **or** highs and lows	**B1**
3(a)(ii)	component X: parallel-to-serial converter	**B1**
	component Y: DAC/digital-to-analogue converter	**B1**
3(a)(iii)	sample the (analogue) signal	**M1**
	at regular intervals and converts the analogue number to a digital number	**A1**
3(b)(i)	attenuation in fibre = 84×0.19 (= 16 dB)	**C1**
	ratio = 16 + 28 = 44 dB	**A1**
3(b)(ii)	ratio / dB = $10 \lg (P_2 / P_1)$	**C1**
	$44 = 10 \lg (\{9.7 \times 10^{-3}\} / P)$ **or** $-44 = 10 \lg (P / \{9.7 \times 10^{-3}\})$	**C1**
	power = 3.9×10^{-7} W	**A1**

Question	Answer	Marks
4(a)	random/haphazard	**B1**
	constant velocity **or** speed in a straight line between collisions **or** distribution of speeds/different directions	**B1**
4(b)	(small) specks of light/bright specks/pollen grains/dust particles/smoke particles	**M1**
	moving haphazardly/randomly/jerky/in a zigzag fashion	**A1**
4(c)(i)	$pV = ⅓\, Nm\langle c^2\rangle$ $1.05 \times 10^5 \times 0.0240 = ⅓ \times 4.00 \times 10^{-3} \times \langle c^2\rangle$	**C1**
	$\langle c^2\rangle = 1.89 \times 10^6$	**C1**
	or	
	$½\, m\langle c^2\rangle = (3/2)\, kT$ $0.5 \times (4.00 \times 10^{-3} / 6.02 \times 10^{23}) \times \langle c^2\rangle = 1.5 \times 1.38 \times 10^{-23} \times 300$	**(C1)**
	$\langle c^2\rangle = 1.87 \times 10^6$	**(C1)**
	or	
	$nRT = ⅓\, Nm\langle c^2\rangle$ $1.00 \times 8.31 \times 300 = ⅓ \times 4.00 \times 10^{-3} \times \langle c^2\rangle$	**(C1)**
	$\langle c^2\rangle = 1.87 \times 10^6$	**(C1)**
	$c_{r.m.s.} = 1.37 \times 10^3\ \text{m s}^{-1}$	**A1**

Question	Answer	Marks
4(c)(ii)	$\langle c^2 \rangle \propto T$	**C1**
	$\langle c^2 \rangle$ at 177 °C = 1.89 × 10^6 × (450 / 300)	**C1**
	$c_{r.m.s.}$ at 177 °C = 1.68 × 10^3 m s^{-1}	**A1**

Question	Answer	Marks
5(a)	(loss in) kinetic energy of α-particle = $Qq / 4\pi\varepsilon_0 r$ **or** 7.7 × 10^{-13} = $Qq / 4\pi\varepsilon_0 r$	**C1**
	7.7 × 10^{-13} = 8.99 × 10^9 × 79 × 2 × (1.60 × 10^{-19})^2 / r	**M1**
	r = 4.7 × 10^{-14} m r is closest distance of approach so radius less than this	**A1**
5(b)	force = $Qq / 4\pi\varepsilon_0 r^2$ = 4u × a	**C1**
	8.99 × 10^9 × 79 × 2 × (1.60 × 10^{-19})^2 / (4.7 × 10^{-14})^2 = 4 × 1.66 × 10^{-27} × a	**C1**
	a = 2.5 × 10^{27} m s^{-2}	**A1**
5(c)	so that single interactions between nucleus and α-particle can be studied **or** so that multiple deflections with nucleus do not occur	**B1**

Question	Answer	Marks
6(a)(i)	lamp needs 'high' power/'large' current/'large' voltage	**B1**
	op-amp can deliver only a small current/small voltage	**B1**
6(a)(ii)	correct symbol for relay coil connected between output and earth	**B1**
	switch between mains supply and lamp	**B1**
6(b)(i)	vary light intensity at which lamp is switched on/off	**B1**
6(b)(ii)	so that relay operates for only one current/voltage direction **or** so that relay/lamp operates for either dark or light conditions	**B1**
6(c)	when light level increases, LDR resistance decreases	**B1**
	(R_{LDR} low,) so $V^- > V^+$, so V_{OUT} negative/–5 V (must be consistent with B1 mark)	**M1**
	or	
	when light level decreases, LDR resistance increases	**(B1)**
	(R_{LDR} high,) so $V^- < V^+$, so V_{OUT} is positive/+5 V (must be consistent with B1 mark)	**(M1)**
	lamp comes on as light level decreases **or** lamp goes off as light level increases	**A1**

Question	Answer	Marks
7(a)	(magnetic) force (always) normal to velocity/direction of motion	**M1**
	(magnitude of magnetic) force constant **or** speed is constant/kinetic energy is constant	**M1**
	so provides the centripetal force	**A1**
7(b)	increase in KE = loss in PE **or** $\frac{1}{2} mv^2 = qV$	**M1**
	$p = mv$ with algebra leading to $p = \sqrt{(2mqV)}$	**A1**
7(c)	$Bqv = mv^2 / r$ $mv = Bqr$ **or** $p = Bqr$	**C1**
	$(2 \times 9.11 \times 10^{-31} \times 1.60 \times 10^{-19} \times 120)^{1/2} = B \times 1.60 \times 10^{-19} \times 0.074$	**C1**
	$B = 5.0 \times 10^{-4}$ T	**A1**
7(d)	greater momentum	**M1**
	($p = Bqr$ and) so r increased	**A1**

Question	Answer	Marks
8	strong (uniform) magnetic field	**B1**
	* nuclei precess/rotate about field (direction)	
	radio frequency pulse/RF pulse (applied)	**B1**
	* RF or pulse is at Larmor frequency / frequency of precession	
	causes resonance / excitation (of nuclei)/nuclei to absorb energy	**B1**
	on relaxation/de-excitation, nuclei emit RF/pulse	**B1**
	* (emitted) RF/pulse detected and processed	
	non-uniform field (superposed on uniform field)	**B1**
	allows positions of (resonating) nuclei to be determined	**B1**
	* allows for position of detection to be changed/different slices to be studied	
	*max. 2 of additional detail points marked **	**B2**

Question	Answer	Marks
9(a)(i)	core reduces loss of (magnetic) flux linkage/improves flux linkage	**B1**
9(a)(ii)	reduces (size of eddy) currents in core	**B1**
	(so that) heating of core is reduced	**B1**
9(b)	alternating voltage gives rise to changing magnetic flux in core	**M1**
	(changing) flux links the secondary coil	**A1**
	induced e.m.f. (in secondary) only when flux is changing/cut	**B1**

Question	Answer	Marks
10(a)(i)	penetration of beam	**M1**
	greater hardness means greater penetration/shorter wavelength/higher frequency/higher photon energy	**A1**
10(a)(ii)	greater accelerating potential difference **or** greater p.d. between anode and cathode	**B1**
10(b)	$I = I_0 \exp(-\mu x)$ ratio = (exp {–1.5 × 2.9}) / (exp {–4.0 × 0.95}) (= exp {–0.55})	**C1**
	= 0.58	**A1**

Question	Answer	Marks
11(a)	electrons (in gas atoms/molecules) interact with photons	**B1**
	photon energy causes electron to move to higher energy level/to be excited	**B1**
	photon energy = difference in energy of (electron) energy levels	**B1**
	when electrons de-excite, photons emitted in all directions (so dark line)	**B1**
11(b)(i)	photon energy $\propto 1 / \lambda$	**C1**
	energy = 1.68 eV	**A1**
	or	
	$E = hc / \lambda$ $E = 6.63 \times 10^{-34} \times 3.0 \times 10^{8} / (740 \times 10^{-9})$ $= 2.688 \times 10^{-19}$ J	**(C1)**
	energy = 1.68 eV	**(A1)**
11(b)(ii)	3.4 eV → 1.5 eV 3.4 eV → 0.85 eV 3.4 eV → 0.54 eV *all correct and none incorrect 2/2* *2 correct and 1 incorrect or only 2 correctly drawn 1/2*	**B2**

Question	Answer	Marks
12(a)	$x = 7$	A1
12(b)(i)	$E = mc^2$	C1
	$= 1.66 \times 10^{-27} \times (3.0 \times 10^8)^2$ $= 1.494 \times 10^{-10}$ J	C1
	division by 1.6×10^{-13} clear to give 934 MeV	A1
12(b)(ii)	$\Delta m = (235.123 + 1.00863) - (94.945 + 138.955 + 2 \times 1.00863 + 7 \times 5.49 \times 10^{-4})$ **or** $\Delta m = 235.123 - (94.945 + 138.955 + 1 \times 1.00863 + 7 \times 5.49 \times 10^{-4})$	C1
	$= 0.21053$ u	C1
	energy $= 0.21053 \times 934$ $= 197$ MeV	A1
12(c)	kinetic energy of nuclei/particles/products/fragments	B1
	γ–ray photon energy	B1