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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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**Published**

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

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

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

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

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

Question	Answer	Marks
5(a)	(loss in) kinetic energy of $\alpha$ -particle = $Qq / 4\pi\epsilon_0 r$ <b>or</b> $7.7 \times 10^{-13} = Qq / 4\pi\epsilon_0 r$	<b>C1</b>
	$7.7 \times 10^{-13} = 8.99 \times 10^9 \times 79 \times 2 \times (1.60 \times 10^{-19})^2 / r$	<b>M1</b>
	$r = 4.7 \times 10^{-14} \text{ m}$ $r$ is closest distance of approach so radius less than this	<b>A1</b>
5(b)	force = $Qq / 4\pi\epsilon_0 r^2 = 4u \times a$	<b>C1</b>
	$8.99 \times 10^9 \times 79 \times 2 \times (1.60 \times 10^{-19})^2 / (4.7 \times 10^{-14})^2 = 4 \times 1.66 \times 10^{-27} \times a$	<b>C1</b>
	$a = 2.5 \times 10^{27} \text{ m s}^{-2}$	<b>A1</b>
5(c)	so that single interactions between nucleus and $\alpha$ -particle can be studied <b>or</b> so that multiple deflections with nucleus do not occur	<b>B1</b>

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

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



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

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

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

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

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