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PHYSICS **9702/42**

Paper 4 A Level Structured Questions **May/June 2016**

MARK SCHEME

Maximum Mark: 100

Published

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1	**(a)**	**(i)**	gravitational force provides/is the centripetal force	B1	
			same gravitational force (by Newton III)	B1	[2]
		(ii)	$\omega = 2\pi / T$ $= 2\pi / (4.0 \times 365 \times 24 \times 3600)$	C1	
			$= 5.0\ (4.98) \times 10^{-8}\ \text{rad s}^{-1}$	A1	[2]
	(b)	**(i)**	(centripetal force =) $M_A d\omega^2 = M_B(2.8 \times 10^8 - d)\omega^2$ *or* $M_A d_A = M_B d_B$	C1	
			$M_A / M_B = 3.0 = (2.8 \times 10^8 - d) / d$	C1	
			$d = 7.0 \times 10^7$ km	A1	[3]
		(ii)	$GM_A M_B / (2.8 \times 10^{11})^2 = M_A d\omega^2$	B1	
			$M_B = (2.8 \times 10^{11})^2 \times d\omega^2 / G$ $= (2.8 \times 10^{11})^2 \times (7.0 \times 10^{10}) \times (4.98 \times 10^{-8})^2 / (6.67 \times 10^{-11})$	C1	
			$= 2.0 \times 10^{29}$ kg	A1	[3]
2	**(a)**	**(i)**	number of <u>atoms/nuclei</u> in 12 g of carbon-12	B1	[1]
		(ii)	amount of substance	M1	
			containing N_A (or 6.02×10^{23}) particles/molecules/atoms *or* which contains the same number of particles/atoms/molecules as there are atoms in 12 g of carbon-12	A1	[2]
	(b)		$pV = nRT$		
			$2.0 \times 10^7 \times 1.8 \times 10^4 \times 10^{-6} = n \times 8.31 \times 290$, so $n = 149$ mol or 150 mol	A1	[1]
	(c)	**(i)**	V and T constant and so pressure reduced by 5.0% pressure $= 0.95 \times 2.0 \times 10^7$	C1	
			or		
			calculation of new n (= 142.5 mol) and correct substitution into $pV = nRT$	(C1)	
			pressure $= 1.9 \times 10^7$ Pa	A1	[2]

		(ii)	loss is $5/100 \times 150$ mol = 7.5 mol *or* $\Delta N = 4.52 \times 10^{24}$	C1	
			$t = (7.5 \times 6.02 \times 10^{23})/1.5 \times 10^{19}$ *or* $t = 4.52 \times 10^{24}/1.5 \times 10^{19}$	C1	
			$= 3.0 \times 10^{5}$ s	A1	[3]
3	**(a)**		no <u>net</u> energy transfer between the bodies *or* bodies are at the same temperature	B1	[1]
	(b)	**(i)**	thermocouple, platinum/metal resistance thermometer, pyrometer	B1	[1]
		(ii)	thermistor, thermocouple	B1	[1]
	(c)	**(i)**	change = 11.5 K	B1	[1]
		(ii)	final temperature = 311.2 K	B1	[1]
4	**(a)**	**(i)**	$T = 0.60$ s <u>and</u> $\omega = 2\pi/T$	C1	
			$\omega = 10\,(10.47)$ rad s^{-1}	A1	[2]
		(ii)	energy $= \frac{1}{2}m\omega^2 x_0^2$ or $\frac{1}{2}mv^2$ <u>and</u> $v = \omega x_0$	C1	
			$= \frac{1}{2} \times 120 \times 10^{-3} \times (10.5)^2 \times (2.0 \times 10^{-2})^2$		
			$= 2.6 \times 10^{-3}$ J	A1	[2]
	(b)		sketch: smooth curve in correct directions	B1	
			peak at f	M1	
			amplitude never zero and line extends from $0.7f$ to $1.3f$	A1	[3]
	(c)		sketch: peaked line always below a peaked line A	M1	
			peak not as sharp <u>and</u> at (or slightly less than) frequency of peak in line A	A1	[2]

5	**(a)**	amplitude of the carrier wave varies		M1	
		in synchrony with displacement of the information/audio signal		A1	[2]
	(b)	**(i)**	10 kHz	A1	[1]
		(ii)	5 kHz	A1	[1]
	(c)	**(i)**	$24 = 10 \lg (P_{MIN} / \{5.0 \times 10^{-13}\})$	C1	
			$P_{MIN} = 1.3\ (1.26) \times 10^{-10}$ W	A1	[2]
		(ii)	$45 \times 2 = 10 \lg (\{500 \times 10^{-3}\} / P)$		
			$P = 5.0 \times 10^{-10}$ (W)	M1	
			$P > P_{MIN}$ so yes	A1	
			or		
			maximum attenuation calculated to be 96 (dB) 96 dB > 2 × 45 dB so yes	(M1) (A1)	
			or		
			maximum length of wire calculated to be 48 (km) actual length 45 km < 48 km so yes	(M1) (A1)	
			or		
			maximum attenuation per unit length calculated to be 2.2 dB km^{-1} 2.2 dB km^{-1} > 2.0 dB km^{-1} so yes	(M1) (A1)	[2]
6	**(a)**	lines perpendicular to surface *or* lines are radial		M1	
		lines <u>appear</u> to come from centre		A1	[2]
	(b)	**(i)**	$F_E = (1.6 \times 10^{-19})^2 / 4\pi\varepsilon_0 x^2$	C1	
			$F_G = G \times (1.67 \times 10^{-27})^2 / x^2$	C1	
			$F_E / F_G = (1.6 \times 10^{-19})^2 \times (8.99 \times 10^9) / [(1.67\times10^{-27})^2 \times (6.67\times10^{-11})]$ $= 1.2\ (1.24) \times 10^{36}$	A1	[3]
		(ii)	$F_E \gg F_G$	B1	[1]

7	**(a)** e.g. storing energy blocking d.c. in oscillator circuits in tuning circuits in timing circuits		
	any two	B2	[2]
	(b) **(i)** $1/6 + 1/C + 1/C = 1/4$	C1	
	$C = 24\,\mu\text{F}$	A1	[2]
	(ii) $Q = CV$ $= 4.0 \times 10^{-6} \times 12$	C1	
	$= 48\,\mu\text{C}$	A1	[2]
	(iii) **1.** $48\,\mu\text{C}$	A1	
	2. $24\,\mu\text{C}$	A1	[2]
8	**(a)** **(i)** gain = <u>voltage</u> output / <u>voltage</u> input	B1	[1]
	(ii) changes in V_{OUT} occur immediately when V_{IN} changes	M1 A1	
	or		
	changes in V_{IN} result in immediate changes to V_{OUT}	(M1) (A1)	[2]
	(b) $12 = 1 + R/(1.5 \times 10^3)$	C1	
	$R = 16.5\text{ k}\Omega$	A1	[2]
	(c) straight line from (0,0) to ($0.75t_1$, 9.0 V)	B1	
	horizontal line from endpoint of straight line to t_1	B1	
	+9 V to –9 V (or *v.v.*) at t_1	B1	
	correct line to t_2	B1	[4]

9	**(a)**	**(i)**	number density of charge carriers/free electrons *or* number per unit volume of charge carriers/free electrons	B1	[1]
		(ii)	PX or QY or RZ	B1	[1]
	(b)	**(i)**	V_H is inversely proportional to n	B1	
			for semiconductors, n is (much) smaller than for metals	B1	[2]
		(ii)	magnetic field would deflect holes and electrons in same direction	B1	
			(because) electrons are (–)ve, holes are (+)ve	M1	
			so V_H has opposite polarity/opposite sign	A1	[3]
10	**(a)**		iron rod changes flux (density)/field	B1	
			change of flux in coil Q causes induced e.m.f.	B1	[2]
	(b)		constant reading (either polarity) from time zero to near t_1	B1	
			spike in one direction near t_1 clearly showing a larger voltage	M1	
			of opposite polarity	A1	
			zero reading from near t_1 to t_2	B1	[4]
11	**(a)**		point P shown at 'lower end' of load	B1	[1]
	(b)		$V_{r.m.s.} = 6.0/\sqrt{2} = 4.24\,V$	C1	
			$I_{r.m.s.} = 4.24/(2.4 \times 10^3)$ $= 1.8 \times 10^{-3}\,A$	A1	[2]
	(c)	**(i)**	capacitor in parallel with load	B1	[1]
		(ii)	line from peak to curve at 3.0 V for either half- or full-wave rectified	M1	
			correct curvature on line (gradient becoming more shallow)	A1	
			line drawn as for full-wave rectified	A1	[3]

12	**(a)**	**(i)**	(X–ray) <u>photon</u> produced when electron/charged particle is stopped/accelerated (suddenly)	B1	
			range of accelerations (in target)	M1	
			hence distribution of wavelengths	A1	[3]
		(ii)	electron gives all its energy to one photon	B1	
			electron stopped in single collision	B1	[2]
		(iii)	de-excitation of (orbital) electrons in target/anode/metal	B1	[1]
	(b)	**(i)**	aluminium sheet/filter/foil (placed in beam from tube)	B1	[1]
		(ii)	(long wavelength X-rays) do not pass through the body	B1	[1]
13	**(a)**		(photons of) electromagnetic radiation	M1	
			emitted from nuclei	A1	[2]
	(b)		line of best fit drawn	B1	
			recognises μ as given by the gradient of best-fit line *or* $\ln C = \ln C_0 - \mu x$	B1	
			$\mu = 0.061\,\text{mm}^{-1}$ (within $\pm 0.004\,\text{mm}^{-1}$, 1 mark; within $\pm 0.002\,\text{mm}^{-1}$, 2 marks)	A2	[4]
	(c)		aluminium is less absorbing (than lead) *or* gradient of graph would be less	M1	
			so μ is smaller	A1	[2]