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PHYSICS **9702/43**

Paper 4 A Level Structured Questions **October/November 2016**

MARK SCHEME

Maximum Mark: 100

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1	(a)		gravitational force provides/is the centripetal force	B1	
			$GMm/r^2 = mv^2/r$ *or* $GMm/r^2 = mr\omega^2$ **and** $v = 2\pi r/T$ *or* $\omega = 2\pi/T$	M1	
			with algebra to $T^2 = 4\pi^2 r^3/GM$	A1	[3]
			or		
			acceleration due to gravity is the centripetal acceleration	(B1)	
			$GM/r^2 = v^2/r$ *or* $GM/r^2 = r\omega^2$ **and** $v = 2\pi r/T$ *or* $\omega = 2\pi/T$	(M1)	
			with algebra to $T^2 = 4\pi^2 r^3/GM$	(A1)	
	(b)	(i)	equatorial orbit/orbits (directly) above the equator	B1	
			from west to east	B1	[2]
		(ii)	$(24 \times 3600)^2 = 4\pi^2 r^3/(6.67 \times 10^{-11} \times 6.0 \times 10^{24})$	C1	
			$r^3 = 7.57 \times 10^{22}$		
			$r = 4.2 \times 10^7$ m	A1	[2]
	(c)		$(T/24)^2 = \{(2.64 \times 10^7)/(4.23 \times 10^7)\}^3$ $= 0.243$	B1	
			T = 12 hours	A1	[2]
			or		
			$k\ (= T^2/r^3) = 24^2/(4.23 \times 10^7)^3$ $= 7.61 \times 10^{-21}$	(B1)	
			$T^2\ (= kr^3) = 7.61 \times 10^{-21} \times (2.64 \times 10^7)^3$ $= 140$		
			T = 12 hours	(A1)	
2	(a)	(i)	$p \propto T$ *or* pV/T = constant *or* $pV = nRT$	C1	
			T (= 5 × 300 =) 1500 K	A1	[2]
		(ii)	$pV = nRT$		
			$1.0 \times 10^5 \times 4.0 \times 10^{-4} = n \times 8.31 \times 300$ *or* $5.0 \times 10^5 \times 4.0 \times 10^{-4} = n \times 8.31 \times 1500$	C1	
			n = 0.016 mol	A1	[2]

(b)	**(i)**	**1.**	heating/thermal energy supplied	B1	
		2.	work done on/to system	B1	[2]
	(ii)	**1.**	240 J	A1	
		2.	same value as given in **1.** (= 240 J) **and** zero given for **3.**	A1	
		3.	zero	A1	[3]

3	**(a)**	$2k/m = \omega^2$	M1	
		$\omega = 2\pi f$	M1	
		$(2 \times 64 / 0.810) = (2\pi \times f)^2$ leading to $f = 2.0$ Hz	A1	[3]
	(b)	$v_0 = \omega x_0$ *or* $v_0 = 2\pi f x_0$ *or* $v = \omega(x_0^2 - x^2)^{1/2}$ <u>and</u> $x = 0$	C1	
		$v_0 = 2\pi \times 2.0 \times 1.6 \times 10^{-2}$		
		$= 0.20\,\mathrm{m\,s^{-1}}$	A1	[2]
	(c)	frequency: reduced/decreased maximum speed: reduced/decreased	B1 B1	 [2]

4	**(a)**	**(i)**	noise/distortion is removed (from the signal) the (original) signal is reformed/reproduced/recovered/restored	B1 B1	 [2]
			or		
			signal detected above/below a threshold creates new signal of 1s and 0s	(B1) (B1)	
		(ii)	noise is superposed on the (displacement of the) signal/cannot be distinguished *or* analogue/signal is continuous (so cannot be regenerated) *or* analogue/signal is not discrete (so cannot be regenerated)	B1	
			noise is amplified with the signal	B1	[2]

(b) **(i)**	gain/dB = $10\lg(P_2/P_1)$		
	$32 = 10\lg[P_{MIN}/(0.38 \times 10^{-6})]$ *or* $-32 = 10\lg(0.38 \times 10^{-6}/P_{MIN})$	C1	
	$P_{MIN} = 6.0 \times 10^{-4}$ W	A1	[2]
(ii)	attenuation $= 10\lg[(9.5 \times 10^{-3})/(6.02 \times 10^{-4})]$	C1	
	$= 12$ dB		
	attenuation per unit length (= 12/58) = 0.21 dB km^{-1}	A1	[2]
5 **(a)**	in an electric field, charges (in a conductor) would move	B1	
	no movement of charge so zero field strength *or* charge moves until $F = 0$ / $E = 0$	B1	[2]
	or		
	charges in metal do not move no (resultant) force on charges so no (electric) field	(B1) (B1)	
(b)	at P, $E_A = (3.0 \times 10^{-12})/[4\pi\varepsilon_0(5.0 \times 10^{-2})^2]$ (= 10.79 N C^{-1})	M1	
	at P, $E_B = (12 \times 10^{-12})/[4\pi\varepsilon_0(10 \times 10^{-2})^2]$ (= 10.79 N C^{-1})	M1	
	or		
	$(3.0 \times 10^{-12})/[4\pi\varepsilon_0(5.0 \times 10^{-2})^2] - (12 \times 10^{-12})/[4\pi\varepsilon_0(10 \times 10^{-2})^2] = 0$ *or* $(3.0 \times 10^{-12})/[4\pi\varepsilon_0(5.0 \times 10^{-2})^2] = (12 \times 10^{-12})/[4\pi\varepsilon_0(10 \times 10^{-2})^2]$	(M2)	
	fields due to charged spheres are (equal and) <u>opposite in direction</u>, so $E = 0$	A1	[3]
(c)	potential $= 8.99 \times 10^9 \{(3.0 \times 10^{-12})/(5.0 \times 10^{-2}) + (12 \times 10^{-12})/(10 \times 10^{-2})\}$	C1	
	$= 1.62$ V	A1	[2]
(d)	$\frac{1}{2}mv^2 = qV$		
	$E_K = \frac{1}{2} \times 107 \times 1.66 \times 10^{-27} \times v^2$	C1	
	$qV = 47 \times 1.60 \times 10^{-19} \times 1.62$	C1	
	$v^2 = 1.37 \times 10^8$		
	$v = 1.2 \times 10^4$ m s^{-1}	A1	[3]

6	**(a)**	reference to input (voltage) and output (voltage)		B1	
		there is no time delay between change in input and change in output		B1	[2]
		or			
		reference to rate at which output voltage changes		(B1)	
		infinite rate of change (of output voltage)		(B1)	
	(b)	**(i)**	$2.00 / 3.00 = 1.50 / R$	C1	
			or		
			$V_+ = (3.00 \times 4.5) / (2.00 + 3.00) = 2.7$ $2.7 = 4.5 \times R / (R + 1.50)$	(C1)	
			resistance = 2.25 kΩ	A1	[2]
		(ii)	**1.** correct symbol for LED	M1	
			two LEDs connected with opposite polarities between V_{OUT} and earth	A1	[2]
			2. below 24 °C, $R_T > 1.5$ kΩ or resistance of thermistor increases/high	B1	
			$V_- < V_+$ or V_- decreases/low (must not contradict initial statement)	M1	
			V_{OUT} is positive/+5 (V) <u>and</u> LED labelled as 'pointing' from V_{OUT} to earth	A1	[3]
7	**(a)**	region (of space) where a force is experienced by a particle		B1	[1]
	(b)	**(i)**	gravitational	B1	
		(ii)	gravitational and electric	B1	
		(iii)	gravitational, electric and magnetic	B1	[3]
	(c)	**(i)**	force (always) normal to direction of motion	M1	
			(magnitude of) force constant *or* speed is constant/kinetic energy is constant	M1	
			magnetic force provides/is the centripetal force	A1	[3]
		(ii)	$mv^2 / r = Bqv$	B1	
			momentum or p or $mv = Bqr$	B1	[2]

8	strong <u>uniform</u> magnetic field		B1	
	nuclei precess/rotate about field (direction)		(1)	
	radio-frequency pulse (applied)		B1	
	R.F. or pulse is at Larmor frequency/frequency of precession		(1)	
	causes resonance/excitation (of nuclei)/nuclei absorb energy		B1	
	on relaxation/de-excitation, nuclei emit r.f./pulse		B1	
	(emitted) r.f./pulse detected and processed		(1)	
	non-uniform magnetic field		B1	
	allows position of nuclei to be located		B1	
	allows for location of detection to be changed/different slices to be studied		(1)	
	any two of the points marked (1)		B2	[8]
9	**(a)**	(induced) e.m.f. proportional to rate of change of (magnetic) flux (linkage)	M1 A1	[2]
	(b)	flux linkage $= BAN$		
		$= \pi \times 10^{-3} \times 2.8 \times \pi \times (1.6 \times 10^{-2})^2 \times 85 = 6.0 \times 10^{-4}$ Wb	B1	[1]
	(c)	e.m.f. $= \Delta N\Phi / \Delta t$		
		$= (6.0 \times 10^{-4} \times 2) / 0.30$	C1	
		$= 4.0$ mV	A1	[2]
	(d)	sketch: $E = 0$ for $t = 0 \rightarrow 0.3$ s, 0.6 s $\rightarrow 1.0$ s, 1.6 s $\rightarrow 2.0$ s	B1	
		$E = 4$ mV for $t = 0.3$ s $\rightarrow 0.6$ s (either polarity)	B1	
		$E = 2$ mV for $t = 1.0$ s $\rightarrow 1.6$ s	B1	
		with opposite polarity	B1	[4]

10 **(a)**	electromagnetic radiation/photons incident on a surface	B1	
	causes emission of electrons (from the surface)	B1	[2]
(b)	$E = hc / \lambda$		
	$= (6.63 \times 10^{-34} \times 3.00 \times 10^{8}) / (436 \times 10^{-9})$	C1	
	$= 4.56 \times 10^{-19}$ J (4.6×10^{-19} J)	A1	[2]
(c) **(i)**	$\Phi = hc / \lambda_0$		
	$\lambda_0 = (6.63 \times 10^{-34} \times 3.00 \times 10^{8}) / (1.4 \times 1.60 \times 10^{-19})$	C1	
	= 890 nm	A1	[2]
(ii)	$\lambda_0 = (6.63 \times 10^{-34} \times 3.00 \times 10^{8}) / (4.5 \times 1.60 \times 10^{-19})$		
	= 280 nm	A1	[1]
(d)	caesium: wavelength of photon less than threshold wavelength (or v.v.) *or* λ_0 = 890 nm > 436 nm so yes	A1	
	tungsten: wavelength of photon greater than threshold wavelength (or v.v.) *or* λ_0 = 280 nm < 436 nm so no	A1	[2]
11	in metal, conduction band overlaps valence band/no forbidden band/no band gap	B1	
	as temperature rises, no increase in number of free electrons/charge carriers	B1	
	as temperature rises, lattice vibrations increase	M1	
	(lattice) vibrations restrict movement of electrons/charge carriers	M1	
	(current decreases) so resistance increases	A1	[5]

12	**(a)**	**(i)**	time for number of atoms/nuclei or activity to be reduced to one half	M1	
			reference to (number of…) original nuclide/single isotope *or* reference to half of original value/initial activity	A1	[2]
		(ii)	$A = A_0 \exp(-\lambda t)$ <u>and</u> either $t = t_{½}$, $A = ½A_0$ or $½A_0 = A_0 \exp(-\lambda t_{½})$	M1	
			so $\ln 2 = \lambda t_{½}$ (and $\ln 2 = 0.693$), hence $0.693 = \lambda t_{½}$	A1	[2]
	(b)		$A = \lambda N$		
			$N = 200 / (2.1 \times 10^{-6})$	C1	
			$= 9.52 \times 10^{7}$	C1	
			mass $= (9.52 \times 10^{7} \times 222 \times 10^{-3}) / (6.02 \times 10^{23})$ *or* mass $= 9.52 \times 10^{7} \times 222 \times 1.66 \times 10^{-27}$	C1	
			$= 3.5 \times 10^{-17}$ kg	A1	[4]