CAMBRIDGE INTERNATIONAL EXAMINATIONS

Cambridge International Advanced Subsidiary and Advanced Level

MARK SCHEME for the October/November 2015 series

9702 PHYSICS

9702/41 Paper 4 (A2 Structured Questions), maximum raw mark 100

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Section A

1	**(a)**	**(i)**	gravitational force provides/is the centripetal force	B1	
			$GMm_S / x^2 = m_S v^2 / x$ (allow x or r; allow m or m_S)	M1	
			$E_K = ½m_S v^2$ and clear algebra leading to $E_K = GMm_S / 2x$	A1	[3]
		(ii)	$E_P = – GMm_S / x$ (*sign essential*)	B1	[1]
		(iii)	$E_T = E_K + E_P$		
			$= GMm_S / 2x – GMm_S / x$	C1	
			$= – GMm_S / 2x$ (*allow ECF from* ***(a)(ii)***)	A1	[2]
	(b)	**(i)**	decreases	B1	[1]
		(ii)	decreases	B1	[1]
		(iii)	decreases	B1	[1]
		(iv)	increases	B1	[1]
			(*for answers in* ***(b)*** *allow ECF from* ***(a)(iii)***)		
2	**(a)**		obeys the equation $pV = nRT$ *or* pV / T = constant	M1	
			all symbols explained; T in kelvin/thermodynamic temperature	A1	[2]
	(b)	**(i)**	temperature rise = 48 K	A1	[1]
		(ii)	$<c^2> \propto T$ or equivalent	C1	
			$<c^2> = (353 / 305) \times 1.9 \times 10^6$	C1	
			$c_{r.m.s.} = 1480\,m\,s^{-1}$	A1	[3]
3	**(a)**		heat/thermal energy gained by system *or* energy transferred to system by heating	B1	
			plus work done on the system *or* minus work done by the system	B1	[2]
	(b)	**(i)**	*either* volume decreases so work done on the system		
			or small volume change so work done on system negligible	M1	
			(thermal) energy absorbed to break lattice structure	M1	
			internal energy increases	A1	[3]
		(ii)	gas expands so work done by gas (against atmosphere)	M1	
			no time for thermal energy to enter or leave the gas	M1	
			internal energy decreases	A1	[3]
4	**(a)**		free: (body oscillates) without any loss of energy/no resistive forces/no external forces applied	B1	
			forced: continuous energy input (required)/body is made to vibrate by an (external) periodic force/driving oscillator	B1	[2]

	(b)	**(i)**	idea of resonance	B1	
			maximum amplitude at natural frequency	B1	
			frequency = 2.1 Hz (*allow 2.08 to 2.12 Hz*)	B1	[3]
		(ii)	peak not very sharp/amplitude not infinite so frictional forces are present	B1	[1]
	(c)		$v = \omega x_0$		
			$= 2\pi \times 2.1 \times 4.7 \times 10^{-2}$ *(allow ECF from **(b)(i)**)*	C1	
			$= 0.62\,\text{m}\,\text{s}^{-1}$	A1	[2]
5	**(a)**	**(i)**	force proportional to the product of the two/point charges	B1	
			and inversely proportional to the square of their separation	B1	[2]
		(ii)	**1.** force radially away from sphere/to right/to east	B1	[1]
			2. (maximum) at/on surface of sphere *or* $x = r$	B1	[1]
			3. $F \propto 1/x^2$ *or* $F = q_1q_2/(4\pi\varepsilon_0 x^2)$	C1	
			ratio = 16	A1	[2]
	(b)		$E = q/(4\pi\varepsilon_0 x^2)$ *or* $E \propto q$	C1	
			maximum charge $= (2.0/1.5) \times 6.0 \times 10^{-7}$	C1	
			$= 8.0 \times 10^{-7}\,\text{C}$		
			additional charge $= 2.0 \times 10^{-7}\,\text{C}$	A1	[3]
6	**(a)**	**(i)**	force = *mg*	M1	
			along the direction of the field/of the motion	A1	[2]
		(ii)	no force	B1	[1]
	(b)	**(i)**	force due to *E*-field downwards so force due to *B*-field upwards	B1	
			into the plane of the paper	B1	[2]
		(ii)	force due to magnetic field = *Bqv*	B1	
			force due to electric field = *Eq*	B1	
			(*use of F_B and F_E not explained, allow 1/2*)		
			forces are equal (and opposite) so *Bv* = *E* *or* *Eq* = *Bqv* so *E* = *Bv*	B1	[3]
	(c)		sketch: smooth curved path	M1	
			in 'upward' direction	A1	[2]
7	**(a)**		minimum frequency of e.m. radiation/a photon (not "light")	M1	
			for emission of electrons from a surface	A1	[2]
			(*reference to light/UV rather than e.m. radiation, allow 1/2*)		

(b)	E_{MAX} corresponds to electron emitted from surface	B1	
	electron (below surface) requires energy to bring it to surface, so less than E_{MAX}	B1	[2]
(c) (i)	$1/\lambda_0 = 1.85 \times 10^6$ *(allow 1.82 to 1.88)*	C1	
	$f_0 = c/\lambda_0$		
	$= 3.00 \times 10^8 \times 1.85 \times 10^6$		
	$= 5.55 \times 10^{14}$ Hz	A1	[2]
(ii)	$\Phi = hf_0$		
	$= 6.63 \times 10^{-34} \times 5.55 \times 10^{14}$ *(allow ECF from **(c)(i)**)*	C1	
	$= 3.68 \times 10^{-19}$ J	A1	[2]
(d)	sketch: straight line with same gradient	M1	
	intercept between 1.0 and 1.5	A1	[2]
8 (a)	nucleus: small central part/core of an atom	B1	
	nucleon: proton or a neutron	B1	
	particle contained within a nucleus	B1	[3]
(b) (i) 1.	decay constant $= \ln 2/(3.8 \times 24 \times 3600)$	C1	
	$= 2.1 \times 10^{-6}$ s^{-1}	A1	[2]
2.	$A = \lambda N$		
	$97 = 2.1 \times 10^{-6} \times N$	C1	
	$N = 4.6 \times 10^7$	A1	[2]
(ii)	1.0 m^3 contains $(6.02 \times 10^{23})/(2.5 \times 10^{-2})$ air molecules	C1	
	ratio $= (4.6 \times 10^7 \times 2.5 \times 10^{-2})/(6.02 \times 10^{23})$		
	$= 1.9 \times 10^{-18}$	A1	[2]

Section B

9	**(a)**	**(i)**	(+) 3.0 V	B1	[1]
		(ii)	potential $= 6.0 \times \{2.0 / (2.0 + 2.8)\}$	C1	
			$= 2.5\text{ V}$	A1	[2]
		(iii)	potential $= 6.0 \times \{2.0 / (2.0 + 1.8)\}$		
			$= 3.2\text{ V}$	A1	[1]
	(b)		at 10 °C, $V_A > V_B$	M1	
			V_{OUT} is –9.0 V (*allow "negative saturation"*)	A1	
			at 20 °C, V_{OUT} is +9.0 V	B1	
			(*if 20 °C considered initially, mark as M1,A1,B1*)		
			sudden switch (from –9 V to +9 V) when $V_A = V_B$	B1	[4]
10	**(a)**		sharpness: clarity of edges/resolution (of image)	B1	
			contrast: difference in degree of blackening (of structures)	B1	[2]
	(b)	**(i)**	X-rays produced when (high speed) electrons hit target/anode	B1	
			either electrons have been accelerated through 80 kV		
			or electrons have (kinetic) energy of 80 keV	B1	[2]
		(ii)	$I_T / I = e^{-3.0 \times 1.4}$	C1	
			$= 0.015$	A1	[2]
	(c)		for good contrast, μx or $e^{\mu x}$ or $e^{-\mu x}$ must be very different	B1	
			μx or $e^{\mu x}$ or $e^{-\mu x}$ for bone and muscle will be different than that for muscle	M1	
			so good contrast	A1	[3]
11	**(a)**		frequency of carrier wave varies	M1	
			in synchrony with the displacement of the signal/information wave	A1	[2]
	(b)	**(i)**	5.0 V	A1	[1]
		(ii)	720 kHz	A1	[1]
		(iii)	780 kHz	A1	[1]
		(iv)	7500	A1	[1]

12	**(a)**	**(i)**	(gradual) loss of power/intensity/amplitude (not "signal")	B1	[1]
		(ii)	e.g. noise can be eliminated (not "there is no noise")	M1	
			because pulses can be regenerated	A1	
			e.g. much greater data handling/carrying capacity	M1	
			because many messages can be carried at the same time/greater bandwidth	A1	
			e.g. more secure	(M1)	
			because it can be encrypted	(A1)	
			e.g. error checking	(M1)	
			because extra information/parity bit can be added	(A1)	[4]
			(*allow any two sensible suggestions with 'state' M1 and 'explain' A1*)		
	(b)		attenuation = 10 lg(145/29) (= 7.0)	C1	
			attenuation per unit length = 7.0/36		
			= 0.19 dB km^{-1}	A1	[2]