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

	(b)	**(i)**	idea of resonance maximum amplitude at natural frequency frequency = 2.1 Hz (*allow 2.08 to 2.12 Hz*)	B1 B1 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)**)* $= 0.62\,\text{m s}^{-1}$	 C1 A1	 [2]
5	**(a)**	**(i)**	force proportional to the product of the two/point charges and inversely proportional to the square of their separation	B1 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 $= (2.0/1.5) \times 6.0 \times 10^{-7}$ $= 8.0 \times 10^{-7}\,\text{C}$	C1	
			additional charge = $2.0 \times 10^{-7}\,\text{C}$	A1	[3]
6	**(a)**	**(i)**	force = *mg* along the direction of the field/of the motion	M1 A1	 [2]
		(ii)	no force	B1	[1]
	(b)	**(i)**	force due to *E*-field downwards so force due to *B*-field upwards into the plane of the paper	B1 B1	 [2]
		(ii)	force due to magnetic field = *Bqv* force due to electric field = *Eq* (*use of F_B and F_E not explained, allow 1/2*)	B1 B1	
			forces are equal (and opposite) so *Bv* = *E* *or* *Eq* = *Bqv* so *E* = *Bv*	B1	[3]
	(c)		sketch: smooth curved path in ‘upward’ direction	M1 A1	 [2]
7	**(a)**		minimum frequency of e.m. radiation/a photon (not “light”) for emission of electrons from a surface (*reference to light/UV rather than e.m. radiation, allow 1/2*)	M1 A1	 [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: <u>small</u> 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 × {2.0 / (2.0 + 2.8)}	C1	
			= 2.5 V	A1	[2]
		(iii)	potential = 6.0 × {2.0 / (2.0 + 1.8)}		
			= 3.2 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]