CAMBRIDGE INTERNATIONAL EXAMINATIONS

Cambridge International Advanced Subsidiary and Advanced Level

MARK SCHEME for the October/November 2015 series

9702 PHYSICS

9702/42 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* $F = q_1q_2/(4\pi\varepsilon_0x^2)$	C1	
			ratio = 16	A1	[2]
	(b)		$E = q/(4\pi\varepsilon_0x^2)$ *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 × {2.0 / (2.0 + 2.8)} = 2.5 V	C1 A1	[2]
		(iii)	potential = 6.0 × {2.0 / (2.0 + 1.8)} = 3.2 V	A1	[1]
	(b)		at 10 °C, $V_A > V_B$ V_{OUT} is –9.0 V (*allow "negative saturation"*)	M1 A1	
			at 20 °C, V_{OUT} is +9.0 V (*if 20 °C considered initially, mark as M1,A1,B1*)	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) contrast: difference in degree of blackening (of structures)	B1 B1	[2]
	(b)	**(i)**	X-rays produced when (high speed) electrons hit target/anode *either* electrons have been accelerated through 80 kV *or* electrons have (kinetic) energy of 80 keV	B1 B1	[2]
		(ii)	$I_T / I = e^{-3.0 \times 1.4}$ = 0.015	C1 A1	[2]
	(c)		for good contrast, μx or $e^{\mu x}$ or $e^{-\mu x}$ must be very different μx or $e^{\mu x}$ or $e^{-\mu x}$ for bone and muscle will be different than that for muscle so good contrast	B1 M1 A1	[3]
11	**(a)**		frequency of carrier wave varies in synchrony with the displacement of the signal/information wave	M1 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]