CAMBRIDGE INTERNATIONAL EXAMINATIONS

GCE Advanced Level

MARK SCHEME for the May/June 2014 series

9702 PHYSICS

9702/42 Paper 4 (A2 Structured Questions), maximum raw mark 100

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CAMBRIDGE
International Examinations

Section A

1	(a)	gravitational force provides/is the centripetal force	B1	
		$GMm / r^2 = mv^2 / r$	M1	
		$v = \sqrt{(GM / r)}$	A0	[2]
		allow gravitational field strength provides/is the centripetal acceleration	(B1)	
		$GM / r^2 = v^2 / r$	(M1)	
	(b) (i)	kinetic energy increase/change = loss / change in (gravitational) potential energy	B1	
		$½mV_0^2 = GMm / x$	C1	
		$V_0^2 = 2GM / x$		
		$V_0 = \sqrt{(2GM / x)}$	A1	[3]
		(max. 2 for use of r not x)		
	(ii)	V_0 is (always) greater than v (for $x = r$)	M1	
		so stone could not enter into orbit	A1	[2]
		(*expressions in* ***(a)*** *and* ***(b)(i)*** *must be dimensionally correct)*		
2	(a)	use of kelvin temperatures	B1	
		both values of (V / T) correct (11.87), V / T is constant so pressure is constant	M1	[2]
		(*allow use of n =1. Do not allow other values of n.)*		
	(b) (i)	work done $= p\Delta V$		
		$= 4.2 \times 10^5 \times (3.87 – 3.49) \times 10^3 \times 10^{-6}$	C1	
		$= 160$ J	A1	[2]
		(do not allow use of V instead of ∆V)		
	(ii)	increase / change in internal energy = heating of system + work done on system	C1	
		= 565 – 160		
		= 405 J	A1	[2]
	(c)	internal energy = sum of kinetic energy and potential energy / $E_K + E_P$	B1	
		no intermolecular forces	M1	
		no potential energy (so $\Delta U = \Delta E_K$)	A1	[3]
3	(a)	resonance	B1	[1]
	(b)	$Pt = mc\,\Delta\theta$	C1	
		$750 \times 2 \times 60 = 0.28 \times c \times (98 – 25)$	C1	
		$c = 4400\,\text{J kg}^{-1}\,\text{K}^{-1}$	A1	[3]
		(*use of ∆θ = 73 + 273 max. 1/3*)		
		(*use of t = 2 s not 120 s max. 2/3*)		

(c) e.g. some microwave leakage from the cooker
e.g. container for the water is also heated
(*any sensible suggestion*) B1 [1]

4 (a) (i) $F_E = Q_1Q_2/4\pi\varepsilon_0r^2$ C1
$= 8.99 \times 10^9 \times (1.6 \times 10^{-19})^2/(2.0 \times 10^{-15})^2$
$= 58$ N A1 [2]

(ii) $F_G = Gm_1m_2/r^2$ C1
$= 6.67 \times 10^{-11} \times (1.67 \times 10^{-27})^2/(2.0 \times 10^{-15})^2$
$= 4.7 \times 10^{-35}$ N A1 [2]

(b) (i) force of repulsion (much) greater than force of attraction B1
must be some other force of attraction M1
to hold nucleus together A1 [3]

(*Do not allow if $F_G > F_E$ in **(a)** or one of the forces not calculated in **(a)***)

(ii) outside nucleus there is repulsion between protons B1
either attractive force must act only in nucleus
or if not short range, all nuclei would stick together B1 [2]

5 (a) only curve with decreasing gradient M1
acceptable value near $x = 0$ and does not reach zero A1 [2]

(*if graph line less than 4.0 cm do not allow A1 mark*)
(*no credit if graph line has positive and negative values of V_H*)

(b) graph: from 0 to $2T$, two cycles of a sinusoidal wave M1
all peaks above 3.5 mV C1
peaks at 4.95 / 5.0 mV (*allow 4.8 mV to 5.2 mV*) A1 [3]

(c) e.m.f. induced in coil when magnetic field / flux is changing / cutting B1

either at each position, magnetic field does not vary
so no e.m.f. is induced in the coil / no reading on the millivoltmeter
or at each position, switch off current and take millivoltmeter reading
or at each position, rapidly remove coil from field and take meter reading B1 [2]

6 (a) electric and magnetic fields normal to each other B1

either charged particle enters region normal to both fields
or correct B direction w.r.t. E for zero deflection B1
for no deflection, $v = E/B$ B1 [3]

(*no credit if magnetic field region clearly not overlapping with electric field region*)

(b)	**(i)**	$m = Bqr / v$	C1	
		$= (640 \times 10^{-3} \times 1.6 \times 10^{-19} \times 6.2 \times 10^{-2}) / (9.6 \times 10^{4})$	C1	
		$= 6.61 \times 10^{-26}$ kg	C1	
		$= (6.61 \times 10^{-26}) / (1.66 \times 10^{-27})$ u		
		$= 40$ u	A1	[4]
	(ii)	$q / m \propto 1 / r$ *or* m constant <u>and</u> $q \propto 1 / r$	B1	
		q / m for A is twice that for B	B1	
		ions in path A have (same mass but) twice the charge (of ions in path B)	B1	[3]
7 (a)		angle subtended at the centre of a circle	B1	
		by an arc equal in length to the radius	B1	[2]
(b)	**(i)**	arc = distance × angle	C1	
		diameter $= 3.8 \times 10^{5} \times 9.7 \times 10^{-6}$		
		$= 3.7$ km	A1	[2]
	(ii)	Mars is (much) further from Earth / away (*answer must be comparative)*	B1	
		angle (at telescope is much) smaller	B1	[2]
8 (a)		photon energy $= hc / \lambda$		
		$= (6.63 \times 10^{-34} \times 3.0 \times 10^{8}) / (590 \times 10^{-9})$	C1	
		$= 3.37 \times 10^{-19}$ J	C1	
		number $= (3.2 \times 10^{-3}) / (3.37 \times 10^{-19})$		
		$= 9.5 \times 10^{15}$ (allow 9.4×10^{15})	A1	[3]
(b)	**(i)**	$p = h / \lambda$	C1	
		$= (6.63 \times 10^{-34}) / (590 \times 10^{-9})$		
		$= 1.12 \times 10^{-27}$ kg m s^{-1}	C1	
		total momentum $= 9.5 \times 10^{15} \times 1.12 \times 10^{-27}$		
		$= 1.06 \times 10^{-11}$ kg m s^{-1}	A1	[3]
	(ii)	force $= 1.06 \times 10^{-11}$ N	A1	[1]
9 (a)		time for number of atoms / nuclei / activity (of the isotope)	M1	
		to be reduced to one half (of its initial value)	A1	[2]
(b)	**(i)**	$A = \lambda N$	C1	
		$460 = N \times \ln 2 / (8.1 \times 24 \times 60 \times 60)$	C1	
		$N = 4.6 \times 10^{8}$	A1	[3]
	(ii)	number of water molecules in 1.0 kg $= (6.02 \times 10^{23}) / (18 \times 10^{-3})$	C1	
		$= 3.3 \times 10^{25}$		
		ratio $= (3.3 \times 10^{25}) / (4.6 \times 10^{8})$		
		$= 7.2\ (7.3) \times 10^{16}$	A1	[2]

(c)	$A = A_0 e^{-\lambda t}$ <u>and</u> $\lambda t_{½} = \ln 2$	C1	
	$170 = 460 \exp(-\{\ln 2\ t\}/8.1)$	C1	
	t = 11.6 days (*allow 2 s.f.*)	A1	[3]

Section B

10	**(a)**		compares the potentials/voltages at the (inverting and non-inverting) <u>inputs</u>		B1	
			either output (potential) dependent on which input is the larger			
			or $V^+ > V^-$, then V_{OUT} is positive		B1	
			states the other condition		B1	[3]
	(b)	**(i)**	ring drawn around both the LEDs (and series resistors)		B1	[1]
		(ii)	$V^- = (1.5 \times 2.4)/(1.2 + 2.4) = 1.0\,V$		B1	[1]
			(*allow* $1.5 \times 2.4/3.6 = 1.0\,V$)			
		(iii)	**1.**	V_{OUT} switches at +1.0 V	B1	
				maximum V_{OUT} is 5.0 V	B1	
				when curve is above +1.0 V, V_{OUT} is negative (*or v.v.*)	B1	[3]
			2.	at time t_1, diode R is emitting light, diode G is not emitting	B1	
				at time t_2, diode R is not emitting, diode G is emitting	B1	[2]
				(*must be consistent with graph line. If no graph line then 0/2*)		

11	**(a)**		X-ray: flat/shadow/2D image	B1	
			regardless of depth of object/depth not indicated	B1	
			CT scan: built up from (many) images at different angles	B1	
			image is three-dimensional	B1	
			image can be rotated/viewed at different angles	B1	[5]
	(b)	**(i)**	$I = I_0 e^{-\mu x}$	C1	
			$0.25 = e^{-0.69x}$		
			x = 2.0 mm (*allow 1 s.f.*)	A1	[2]
		(ii)	for aluminium, $I/I_0 = e^{-0.46 \times 2.4}$		
			$= 0.33$	C1	
			fraction $= 0.33 \times 0.25$		
			$= 0.083$	A1	[2]
		(iii)	gain/dB $= 10\lg(I/I_0)$	C1	
			$= 10\lg(0.083)$		
			= (–) 10.8 dB (*allow 2 s.f.*)	A1	
			with negative sign	B1	[3]

12	**(a)**	**(i)**	satellite is in equatorial orbit	B1	
			travelling from west to east	B1	
			period of 24 hours/1 day	B1	[3]

(ii)	*either* uplink signal is highly attenuated		
	or signal is highly amplified (before transmission) as downlink signal	B1	
	prevents downlink signal swamping the uplink signal	B1	[2]
(b)	speed of signal is same order of magnitude in both systems	B1	
	optic fibre link (much) shorter than via satellite	M1	
	time delay using optic fibre is less	A1	[3]