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 ΔV)

(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* $\Delta\theta = 73 + 273$ *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 <u>repulsion</u> (much) greater than force of <u>attraction</u>	B1	
		must be some other force of <u>attraction</u>	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)**	<u>only</u> curve with decreasing gradient	M1	
		acceptable value near $x = 0$ <u>and</u> 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 2*T*, 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 × 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]