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
$\frac{1}{2}mV_0^2 = GMm/x$ — 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)** $F_E = Q_1Q_2/4\pi\varepsilon_0 r^2$ 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 and $q \propto 1/r$ 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) $A = A_0 e^{-\lambda t}$ and $\lambda t_{½} = \ln 2$ 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) inputs 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]