

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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Section A

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

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- (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) $F_E = Q_1 Q_2 / 4\pi\epsilon_0 r^2$
 $= 8.99 \times 10^9 \times (1.6 \times 10^{-19})^2 / (2.0 \times 10^{-15})^2$
 $= 58 \text{ N}$ C1
A1 [2]
- (ii) $F_G = Gm_1 m_2 / r^2$
 $= 6.67 \times 10^{-11} \times (1.67 \times 10^{-27})^2 / (2.0 \times 10^{-15})^2$
 $= 4.7 \times 10^{-35} \text{ N}$ C1
A1 [2]
- (b) (i) force of repulsion (much) greater than force of attraction
must be some other force of attraction
to hold nucleus together B1
M1
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)

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- (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
 $= 6.61 \times 10^{-26} \text{ kg}$ C1
 $= (6.61 \times 10^{-26}) / (1.66 \times 10^{-27}) \text{ u}$
 $= 40 \text{ u}$ 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 \times angle C1
diameter $= 3.8 \times 10^5 \times 9.7 \times 10^{-6}$
 $= 3.7 \text{ km}$ 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
 $= 3.37 \times 10^{-19} \text{ J}$ 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
 $= (6.63 \times 10^{-34}) / (590 \times 10^{-9})$
 $= 1.12 \times 10^{-27} \text{ kg ms}^{-1}$ C1
- total momentum $= 9.5 \times 10^{15} \times 1.12 \times 10^{-27}$
 $= 1.06 \times 10^{-11} \text{ kg ms}^{-1}$ A1 [3]
- (ii) force $= 1.06 \times 10^{-11} \text{ N}$ 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]

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- (c) $A = A_0 e^{-\lambda t}$ and $\lambda t_{1/2} = \ln 2$ C1
 $170 = 460 \exp(-\{\ln 2\}/8.1)$ 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]

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- (ii) *either* uplink signal is highly attenuated B1
or signal is highly amplified (before transmission) as downlink signal B1 [2]
prevents downlink signal swamping the uplink signal
- (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]