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MARK SCHEME for the October/November 2015 series

9702 PHYSICS

9702/43 Paper 4 (A2 Structured Questions), maximum raw mark 100

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1 (a) (gravitational) force proportional to product of masses
and inversely proportional to square of separation M1
either point masses *or* particles *or* 'size' ≪ separation A1 [2]

(b) gravitational force provides the centripetal force B1

either $GMm/x^2 = mx\omega^2$ *or* mv^2/x M1
either $\omega = 2\pi/T$ *or* $v = 2\pi x/T$ and working to $GM = 4\pi^2x^3/T^2$ A1 [3]

(c) *either* use of gradient of graph *or* line through origin so can use single point
or line shown extrapolated to origin B1

gradient = $(4.5 \times 10^{14})/0.35$
$6.67 \times 10^{-11} \times M = 4\pi^2 \times (4.5 \times 10^{14} \times 10^9)/(0.35 \times \{24 \times 3600\}^2)$

correct conversion for km^3 and power of 10 C1
correct conversion for day^2 C1
$M = 1.02 \times 10^{26}$ kg A1 [4]

2 (a) total volume of molecules negligible compared to that of containing vessel
no intermolecular forces
molecules in random motion
time of collision small compared with the time between collisions
large number of molecules
any two B2 [2]

(b) in a real gas there is a range of velocities *or* must take the average of v^2 B1 [1]

(c) (i) *either* $p = \frac{1}{3}\rho\langle c^2\rangle$

or $1.0 \times 10^5 = \frac{1}{3} \times 1.2 \times \langle c^2\rangle$ C1

$\langle c^2\rangle = 2.5 \times 10^5$ C1
$c_{r.m.s.} = 500\,m\,s^{-1}$ A1 [3]

(ii) $T \propto \langle c^2\rangle$ C1
$\langle c^2\rangle = 2.5 \times 10^5 \times 480/300$
$= 4.0 \times 10^5\,m^2\,s^{-2}$ (*allow ECF from* ***(c)(i)***) A1 [2]

3 (a) same temperature B1
no (net) transfer of thermal energy (between the bodies) B1 [2]

(b) (i) 41.3 K B1 [1]

(ii) 330.4 K B1 [1]

(c) $\Delta E_K = \frac{3}{2} \times 1.9 \times 60$

$= 171$ J C1

work done $= p\Delta V$

$= 1.2 \times 10^5 \times 950 \times 10^{-6}$ C1

$= 114$ J C1

thermal energy $= 114 + 171$

$= 285\ (290)$ J A1 [4]

4 **(a)** acceleration/force proportional to distance from a fixed point or displacement M1

either acceleration/force and displacement in opposite directions

or acceleration/force (always) directed towards a fixed point/mean position/equilibrium position A1 [2]

(b) $h\rho g = Mg/A$ B1

$h \times 790 \times 4.9 \times 10^{-4} = 70 \times 10^{-3}$ leading to $h = 0.18$ m or 18 cm A1 [2]

(c) **(i)** **1.** $\omega^2 = (790 \times 4.9 \times 10^{-4} \times 9.81)/(70 \times 10^{-3})$ C1

$= 54.25$

$\omega = 7.37$ (rad s^{-1})

period $(= 2\pi/\omega) = 0.85$ s C1

$t_1 = 0.43$ s A1 [3]

2. $t_3 = 1.28$ s (*allow 2 s.f.*) A1 [1]

(ii) energy of peak $= \frac{1}{2}M\omega^2 x_0^2$ B1

change $= \frac{1}{2} \times 70 \times 10^{-3} \times 54.25\ \{(2.2 \times 10^{-2})^2 - (1.0 \times 10^{-2})^2\}$ C1

$= 7.3 \times 10^{-4}$ J A1 [3]

5 **(a)** charges in metal do not move — B1
no (resultant) force on charges so no (electric) field — B1 [2]
(*allow 1/2 for "no field inside sphere"*)

(b) *either* average field strength = ½ (28 + 54) $N C^{-1}$ — C1

average force = $8.5 \times 10^{-9} \times$ ½ (28 + 54) — C1
= 3.49×10^{-7} N

change in potential energy = $3.49 \times 10^{-7} \times 2.0 \times 10^{-2}$
= 7.0×10^{-9} J (*allow 1 s.f.*) — A1
(*allow range 54 ± 1*)

or (for a point charge) $V = Ex$ — (C1)

$\Delta V = (54 \times 5.0 \times 10^{-2}) - (28 \times 7.0 \times 10^{-2})$ — (C1)

change in potential energy = $8.5 \times 10^{-9} \times (2.70 - 1.96)$
= 6.3×10^{-9} J (*allow 1 s.f.*) — (A1)
(*allow range 54 ± 1*)

or ΔV is area under curve — (C1)
ΔV = 0.74 V — (C1)

change in potential energy = $8.5 \times 10^{-9} \times 0.74$
= 6.3×10^{-9} J (*allow 1 s.f.*) — (A1) [3]
(*allow range 0.70 to 0.84*)

6 **(a)** magnetic fields are equal in magnitude/strength/flux density — M1
magnetic fields are opposite in direction — M1
fields superpose/add/cancel to give zero/negligible resultant field — A1 [3]

(b) core causes increase in magnetic flux in the solenoid/induced poles in core
or field induced in core — B1
changing flux threads/cuts the turns on the solenoid — M1
(by Faraday's law) an e.m.f. is induced in the solenoid — A1
by Lenz's law, this e.m.f. opposes the battery e.m.f. — A1 [4]

7 **(a)** **(i)** $V_0 (= 14\sqrt{2}) = 19.8\ (20)$ V — A1 [1]

(ii) $\omega (= 2\pi \times 750) = 4700\ \text{rad s}^{-1}$ — A1 [1]

(b) large amount of charge required to charge capacitor — M1
capacitor would charge and discharge rapidly/in a very short time
or capacitor would charge and discharge 750/1500 times per second — M1

$I = Q/t$, so large current — A1 [3]

8 **(a)** $hc/\lambda = \Phi + E_{MAX}$ M1
h = Planck constant, c = speed of light / e.m. radiation A1 [2]

(b) **(i)** gradient of line is hc M1
h and c are both constants A1 [2]

(ii) $\Phi = 2.28 \times 1.6 \times 10^{-19}$ C1
$= 3.65 \times 10^{-19}$ (J)

$hc/\lambda_0 = 3.65 \times 10^{-19}$

$\lambda_0 = (6.63 \times 10^{-34} \times 3.0 \times 10^{8})/(3.65 \times 10^{-19})$ C1
$= 5.45 \times 10^{-7}$ m A1 [3]

9 **(a)** energy required to separate the nucleons (in a nucleus)
or energy required to separate the protons and neutrons in a nucleus M1
(*or energy released when nucleons combine (to form a nucleus)/energy released when protons and neutrons combine to form a nucleus*)

either completely *or* to infinity A1 [2]
(*either free protons and neutrons or from infinity*)

(b) **(i)** *either* different forms of same element *or* nuclei having same number of M1
protons with different numbers of neutrons A1 [2]

(ii) 1784 MeV (*accept min. 3 s.f.*) A1
7.57 MeV A1 [2]

(c) **(i)** $\lambda = \ln 2/(7.1 \times 10^{8} \times 365 \times 24 \times 3600) = 3.1 \times 10^{-17}\,s^{-1}$ B1 [1]

(ii) $A = \lambda N$
$5000 = 3.1 \times 10^{-17} \times N$ C1
$N = 1.61 \times 10^{20}$

mass $= 235 \times (1.61 \times 10^{20})/(6.02 \times 10^{23})$ C1
$= 0.063$ g (*accept min. 2 s.f.*) A1 [3]

Section B

10 (a) correct LED symbol — B1
separately connected between V_{OUT} and earth with opposite polarities — M1
diode B 'pointing' from V_{OUT} to earth — A1 [3]
(*ignore protective resistors*)

(b) diode in V_{OUT} line — M1
diode 'pointing' towards V_{OUT} from earth — A1
relay coil connected between V_{OUT} and earth — M1
switch connected across lamp — A1 [4]
(*if a diode is placed across the relay it must point down otherwise max. 2/4; one diode but wrong direction max. 3/4*)

11 (a) e.g. scattering (in metal)
non-parallel beam (not just "A closer than B")
reflection (from metal)
diffraction in the metal/lattice
any two — B2 [2]

(b) (i) 1. ratio $= e^{\mu x}$
$= \exp(0.27 \times 4.0)$ — C1
$= 2.94$ (2.9) — A1 [2]

2. ratio $= \exp(0.27 \times 2.5) \times \exp(3.0 \times 1.5)$ — C1
$= 1.96 \times 90$
$= 177$ (180) — A1 [2]

(*do not penalise unit error more than once*)

(ii) each ratio gives measure of transmission — B1
ratios (in **(i)**) very different so good contrast — B1 [2]

12 (a) (i) serial-to-parallel converter — B1 [1]

(ii) digital-to-analogue converter *or* DAC — B1 [1]

(iii) (audio) amplifier *or* AF amplifier — B1 [1]

(b) (i) 4 — A1 [1]

(ii) 1011 — A1 [1]

(c) correct levels at 0.25 ms intervals
0, 8, 11, 10, 15 — A1
and 7, 4 — A1
series of steps, each of depth 0.25 ms — M1
voltage levels shown in correct intervals — A1 [4]

13 (a) advantage: e.g. shorter time delay
greater coverage over a long time B1

disadvantage: e.g. satellite needs to be tracked
more satellites for (continuous) coverage/communication
(*any sensible suggestions*) B1 [2]

(b) (i) frequencies linking Earth with satellite B1

6 GHz is uplink frequency }
4 GHz is downlink frequency } (*allow vice versa*) B1 [2]

(ii) *either* signal from Earth to satellite is attenuated greatly
or downlink must be amplified greatly before transmission B1

downlink would swamp uplink unless frequencies are different B1 [2]