

CAMBRIDGE INTERNATIONAL EXAMINATIONS

Cambridge International Advanced Subsidiary and Advanced Level

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
either point masses *or* particles *or* 'size' \ll separation
- M1
A1 [2]
- (b) gravitational force provides the centripetal force
- B1
- either* $GMm/x^2 = mx\omega^2$ *or* mv^2/x
either $\omega = 2\pi/T$ *or* $v = 2\pi x/T$ and working to $GM = 4\pi^2 x^3/T^2$
- M1
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
correct conversion for day^2
 $M = 1.02 \times 10^{26}$ kg
- C1
C1
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
- $\langle c^2 \rangle = 2.5 \times 10^5$
 $c_{\text{r.m.s.}} = 500 \text{ m s}^{-1}$
- C1
A1 [3]
- (ii) $T \propto \langle c^2 \rangle$
 $\langle c^2 \rangle = 2.5 \times 10^5 \times 480/300$
 $= 4.0 \times 10^5 \text{ m}^2 \text{ s}^{-2}$ (*allow ECF from (c)(i)*)
- C1
A1 [2]
- 3 (a) same temperature
no (net) transfer of thermal energy (between the bodies)
- B1
B1 [2]
- (b) (i) 41.3 K
- B1 [1]
- (ii) 330.4 K
- B1 [1]

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$$\begin{aligned} \text{(c) } \Delta E_k &= \frac{3}{2} \times 1.9 \times 60 \\ &= 171 \text{ J} \end{aligned}$$

C1

$$\begin{aligned} \text{work done} &= p\Delta V \\ &= 1.2 \times 10^5 \times 950 \times 10^{-6} \\ &= 114 \text{ J} \end{aligned}$$

C1

C1

$$\begin{aligned} \text{thermal energy} &= 114 + 171 \\ &= 285 \text{ (290) J} \end{aligned}$$

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]

$$\text{(b) } h\rho g = Mg/A$$

B1

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

A1 [2]

$$\begin{aligned} \text{(c) (i) 1. } \omega^2 &= (790 \times 4.9 \times 10^{-4} \times 9.81) / (70 \times 10^{-3}) \\ &= 54.25 \end{aligned}$$

C1

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

$$\text{period } (= 2\pi / \omega) = 0.85 \text{ s}$$

C1

$$t_1 = 0.43 \text{ s}$$

A1 [3]

$$\text{2. } t_3 = 1.28 \text{ s (allow 2 s.f.)}$$

A1 [1]

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

B1

$$\begin{aligned} \text{change} &= \frac{1}{2} \times 70 \times 10^{-3} \times 54.25 \{ (2.2 \times 10^{-2})^2 - (1.0 \times 10^{-2})^2 \} \\ &= 7.3 \times 10^{-4} \text{ J} \end{aligned}$$

C1

A1 [3]

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5	(a) charges in metal do not move		B1	[2]	
	no (resultant) force on charges so no (electric) field (allow 1/2 for “no field inside sphere”)		B1		
	(b) either average field strength	$= \frac{1}{2} (28 + 54) \text{ NC}^{-1}$		C1	
	average force	$= 8.5 \times 10^{-9} \times \frac{1}{2} (28 + 54)$ $= 3.49 \times 10^{-7} \text{ N}$		C1	
	change in potential energy	$= 3.49 \times 10^{-7} \times 2.0 \times 10^{-2}$ $= 7.0 \times 10^{-9} \text{ J (allow 1 s.f.)}$		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	$= 8.5 \times 10^{-9} \times (2.70 - 1.96)$ $= 6.3 \times 10^{-9} \text{ J (allow 1 s.f.)}$		(A1)	
	(allow range 54 ± 1)				
or ΔV is area under curve			(C1)		
$\Delta V = 0.74 \text{ V}$			(C1)		
change in potential energy	$= 8.5 \times 10^{-9} \times 0.74$ $= 6.3 \times 10^{-9} \text{ J (allow 1 s.f.)}$		(A1)	[3]	
(allow range 0.70 to 0.84)					
6	(a) magnetic fields are equal in magnitude/strength/flux density		M1	[3]	
	magnetic fields are opposite in direction		M1		
	fields superpose/add/cancel to give zero/negligible resultant field		A1		
(b) core causes increase in magnetic flux in the solenoid/induced poles in core			B1	[4]	
or field induced in core			M1		
changing flux threads/cuts the turns on the solenoid (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		
7	(a) (i) $V_0 (= 14\sqrt{2}) = 19.8 (20) \text{ V}$		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			M1		
or capacitor would charge and discharge 750/1500 times per second			M1		
$I = Q/t$, so large current			A1	[3]	

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- 8 (a) $hc/\lambda = \Phi + E_{\text{MAX}}$
 $h = \text{Planck constant, } c = \text{speed of light/e.m. radiation}$ M1
 A1 [2]
- (b) (i) gradient of line is hc
 h and c are both constants M1
 A1 [2]
- (ii) $\Phi = 2.28 \times 1.6 \times 10^{-19}$
 $= 3.65 \times 10^{-19} \text{ (J)}$ C1
- $hc/\lambda_0 = 3.65 \times 10^{-19}$
- $\lambda_0 = (6.63 \times 10^{-34} \times 3.0 \times 10^8)/(3.65 \times 10^{-19})$ C1
 $= 5.45 \times 10^{-7} \text{ m}$ 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
 protons with different numbers of neutrons M1
 A1 [2]
- (ii) 1784 MeV (accept min. 3 s.f.) A1
 7.57 MeV A1 [2]
- (c) (i) $\lambda = \ln 2 / (7.1 \times 10^8 \times 365 \times 24 \times 3600) = 3.1 \times 10^{-17} \text{ s}^{-1}$ 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
 $= 0.063 \text{ g (accept min. 2 s.f.)}$ A1 [3]

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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
 = 1.96×90
 = 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]

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- 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]