

MARK SCHEME for the October/November 2013 series

9702 PHYSICS

9702/41

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

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Section A

- 1 (a) work done in moving unit mass from infinity (to the point) M1 A1 [2]
- (b) (i) gravitational potential energy = GMm/x
energy = $(6.67 \times 10^{-11} \times 7.35 \times 10^{22} \times 4.5) / (1.74 \times 10^6)$ M1
energy = 1.27×10^7 J A0 [1]
- (ii) change in grav. potential energy = change in kinetic energy B1
 $\frac{1}{2} \times 4.5 \times v^2 = 1.27 \times 10^7$
 $v = 2.4 \times 10^3 \text{ m s}^{-1}$ A1 [2]
- (c) Earth would attract the rock / potential at Earth('s surface) not zero / <0
/ at Earth, potential due to Moon not zero M1
escape speed would be lower A1 [2]
- 2 (a) (i) N : (total) number of molecules B1 [1]
- (ii) $\langle c^2 \rangle$: mean square speed/velocity B1 [1]
- (b) $pV = \frac{1}{3}Nm\langle c^2 \rangle = NkT$
(mean) kinetic energy = $\frac{1}{2} m\langle c^2 \rangle$ C1
algebra clear leading to $\frac{1}{2} m\langle c^2 \rangle = (3/2)kT$ A1 [2]
- (c) (i) *either* energy required = $(3/2) \times 1.38 \times 10^{-23} \times 1.0 \times 6.02 \times 10^{23}$ C1
= 12.5 J (12J if 2 s.f.) A1 [2]
or energy = $(3/2) \times 8.31 \times 1.0$ (C1)
= 12.5 J (A1)
- (ii) energy is needed to push back atmosphere/do work against atmosphere M1
so total energy required is greater A1 [2]
- 3 (a) (i) any two from 0.3(0) s, 0.9(0) s, 1.50 s (allow 2.1 s etc.) B1 [1]
- (ii) *either* $v = \omega x$ and $\omega = 2\pi/T$ C1
 $v = (2\pi/1.2) \times 1.5 \times 10^{-2}$ M1
= 0.079 m s^{-1} A0 [2]
or gradient drawn clearly at a correct position (C1)
working clear (M1)
to give $(0.08 \pm 0.01) \text{ m s}^{-1}$ (A0)

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	(b) (i) sketch: <u>curve</u> from ($\pm 1.5, 0$) passing through (0, 25) reasonable shape (<i>curved with both intersections between $y = 12.0 \rightarrow 13.0$</i>)	M1	
		A1	[2]
	(ii) at max. amplitude potential energy is total energy total energy = 4.0 mJ	B1	
		B1	[2]
4	(a) (i) force proportional to product of (two) charges and inversely proportional to square of separation reference to point charges	M1	
		A1	[2]
	(ii) $F = 2 \times (1.6 \times 10^{-19})^2 / \{4\pi \times 8.85 \times 10^{-12} \times (20 \times 10^{-6})^2\}$ $= 1.15 \times 10^{-18} \text{ N}$	C1	
		A1	[2]
	(b) (i) force per unit charge on <i>either</i> a stationary charge or a positive charge	M1	
		A1	[2]
	(ii) 1. electric field is a vector quantity electric fields are in opposite directions charges repel <i>Any two of the above, 1 each</i>	B2	[2]
	2. graph: line always between given lines crosses x-axis between 11.0 μm and 12.3 μm reasonable shape for curve	M1	
		A1	[3]
5	(a) (i) field shown as right to left	B1	[1]
	(ii) lines are more spaced out at ends	B1	[1]
	(b) Hall voltage depends on angle <i>either</i> between field and plane of probe or maximum when field normal to plane of probe or zero when field parallel to plane of probe	M1	
		A1	[2]
	(c) (i) (induced) e.m.f. proportional to rate of change of (magnetic) flux (linkage) (<i>allow rate of cutting of flux</i>)	M1	
		A1	[2]
	(ii) e.g. move coil towards/away from solenoid rotate coil vary current in solenoid insert iron core into solenoid (<i>any three sensible suggestions, 1 each</i>)		
		B3	[3]

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- 6 (a) force due to magnetic field is constant B1
force is (always) normal to direction of motion
this force provides the centripetal force A1 [3]
- (b) $mv^2 / r = Bqv$ M1
hence $q / m = v / Br$ A0 [1]
- (c) (i) $q / m = (2.0 \times 10^7) / (2.5 \times 10^{-3} \times 4.5 \times 10^{-2})$ C1
 $= 1.8 \times 10^{11} \text{ C kg}^{-1}$ A1 [2]
- (ii) sketch: curved path, constant radius, in direction towards bottom of page M1
tangent to curved path on entering and on leaving the field A1 [2]
- 7 (a) *either* if light passes through suitable film / cork dust etc. M1
diffraction occurs and similar pattern observed A1
or concentric circles are evidence of diffraction (M1)
diffraction is a wave property (A1) [2]
- (b) (speed increases so) momentum increases M1
 $\lambda = h/p$ so λ decreases M1
hence radii decrease A1 [3]
(special case: wavelength decreases so radii decreases – scores 1/3)
or
(speed increases so) energy increases (B1)
 $\lambda = h / \sqrt{2Em}$ so λ decreases (M1)
hence radii decrease (A1)
- (c) electron and proton have same (kinetic) energy C1
either $E = p^2 / 2m$ *or* $p = \sqrt{2Em}$ C1
ratio = $p_e / p_p = \sqrt{(m_e / m_p)}$ C1
 $= \sqrt{(9.1 \times 10^{-31}) / (1.67 \times 10^{-27})}$
 $= 2.3 \times 10^{-2}$ A1 [4]
- 8 (a) energy to separate nucleons (in a nucleus) M1
separate to infinity A1 [2]
- (b) (i) fission B1 [1]
- (ii) 1. U: near right-hand end of line B1 [1]
2. Mo: to right of peak, less than 1/3 distance from peak to U B1 [1]
3. La: 0.4 $\rightarrow$ 0.6 of distance from peak to U B1 [1]

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- (iii) 1. right-hand side, mass = 235.922 u
mass change = 0.210 u C1 A1 [2]
2. energy = mc^2
 $= 0.210 \times 1.66 \times 10^{-27} \times (3.0 \times 10^8)^2$
 $= 3.1374 \times 10^{-11} \text{ J}$
 $= 196 \text{ MeV}$ (need 3 s.f.) C1 A1 [3]
(use of 1 u = 934 MeV, allow 3/3; use of 1 u = 930 MeV or 932 MeV, allow 2/3)
(use of 1.67×10^{-27} not 1.66×10^{-27} scores max. 2/3)

Section B

- 9 (a) operates on / takes signal from sensing device B1
(so that) it gives an voltage output B1 [2]
- (b) thermistor and resistor in series between +4 V line and earth M1
 V_{OUT} shown clearly across *either* thermistor or resistor A1
 V_{OUT} shown clearly across thermistor A1 [3]
- (c) e.g. remote switching
switching large current by means of a small current
isolating circuit from high voltage
switching high voltage by means of a small voltage/current
(any two sensible suggestions, 1 each to max. 2) B2 [2]
- 10 (a) pulse (of ultrasound) B1
produced by quartz / piezo-electric crystal (1)
reflected from boundaries (between media) B1
reflected pulse detected B1
by the ultrasound transmitter (1)
signal processed and displayed B1
intensity of reflected pulse gives information about the boundary (1)
time delay gives information about depth (1)
(four B marks plus any two from the four, max. 6) B2 [6]
- (b) shorter wavelength B1
smaller structures resolved / detected (*not more sharpness*) B1 [2]
- (c) (i) $I = I_0 e^{-\mu x}$ C1
ratio = $\exp(-23 \times 6.4 \times 10^{-2})$ C1
 $= 0.23$ A1 [3]
- (ii) later signal has passed through greater thickness of medium M1
so has greater attenuation / greater absorption / smaller intensity A1 [2]

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- 11 (a) left-hand bit underlined B1 [1]
- (b) 1010, 1110, 1111, 1010, 1001
(5 correct scores 2, 4 correct scores 1) A2 [2]
- (c) significant changes in detail of V between samplings
so frequency too low M1
A1 [2]
- 12 (a) e.g. logarithm provides a smaller number
gain of amplifiers is series found by addition, (not multiplication)
(any sensible suggestion) B1 [1]
- (b) (i) optic fibre B1 [1]
- (ii) attenuation/dB = $10 \lg(P_2/P_1)$ C1
 $= 10 \lg(\{6.5 \times 10^{-3}\}/\{1.5 \times 10^{-15}\})$ C1
 $= 126$
length = $126 / 1.8$
 $= 70 \text{ km}$ A1 [3]