

## **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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Mark schemes should be read in conjunction with the question paper and the Principal Examiner Report for Teachers.

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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 =  $(6.67 \times 10^{-11} \times 7.35 \times 10^{22} \times 4.5) / (1.74 \times 10^6)$   
energy =  $1.27 \times 10^7$  J M1 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  $\text{m s}^{-1}$  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)<br>reasonable shape ( <i>curved with both intersections between <math>y = 12.0 \rightarrow 13.0</math></i> ) | M1<br>A1       | [2] |
|   | (ii) at max. amplitude potential energy is total energy<br>total energy = 4.0 mJ  | B1<br>B1       | [2] |
| 4 | (a) (i) force proportional to product of (two) charges and inversely<br>proportional to square of separation<br>reference to point charges  | M1<br>A1       | [2] |
|   | (ii) $F = 2 \times (1.6 \times 10^{-19})^2 / \{4\pi \times 8.85 \times 10^{-12} \times (20 \times 10^{-6})^2\}$<br>$= 1.15 \times 10^{-18} \text{ N}$                                   | C1<br>A1       | [2] |
|   | (b) (i) force per unit charge<br>on <i>either</i> a stationary charge<br>or a positive charge   | M1<br>A1       | [2] |
|   | (ii) 1. electric field is a vector quantity<br>electric fields are in opposite directions<br>charges repel<br><i>Any two of the above, 1 each</i>                                       | B2             | [2] |
|   | 2. graph: line always between given lines<br>crosses x-axis between 11.0 $\mu\text{m}$ and 12.3 $\mu\text{m}$<br>reasonable shape for curve   | M1<br>A1<br>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<br><i>either</i> between field and plane of probe<br>or maximum when field normal to plane of probe<br>or zero when field parallel to plane of probe  | M1<br>A1       | [2] |
|   | (c) (i) (induced) e.m.f. proportional to rate<br>of change of (magnetic) flux (linkage)<br>( <i>allow rate of cutting of flux</i> )   | M1<br>A1       | [2] |
|   | (ii) e.g. move coil towards/away from solenoid<br>rotate coil<br>vary current in solenoid<br>insert iron core into solenoid<br>( <i>any three sensible suggestions, 1 each</i> )        | B3             | [3] |

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- 6 (a) force due to magnetic field is constant  
force is (always) normal to direction of motion  
this force provides the centripetal force  
B1  
A1 [3]
- (b)  $mv^2 / r = Bqv$   
hence  $q / m = v / Br$   
M1  
A0 [1]
- (c) (i)  $q / m = (2.0 \times 10^7) / (2.5 \times 10^{-3} \times 4.5 \times 10^{-2})$   
 $= 1.8 \times 10^{11} \text{ C kg}^{-1}$   
C1  
A1 [2]
- (ii) sketch: curved path, constant radius, in direction towards bottom of page  
tangent to curved path on entering and on leaving the field  
M1  
A1 [2]
- 7 (a) *either* if light passes through suitable film / cork dust etc.  
diffraction occurs and similar pattern observed  
*or* concentric circles are evidence of diffraction  
diffraction is a wave property  
M1  
A1  
(M1)  
(A1) [2]
- (b) (speed increases so) momentum increases  
 $\lambda = h/p$  so  $\lambda$  decreases  
hence radii decrease  
(*special case: wavelength decreases so radii decreases – scores 1/3*)  
*or*  
(speed increases so) energy increases  
 $\lambda = h / \sqrt{2Em}$  so  $\lambda$  decreases  
hence radii decrease  
M1  
M1  
A1 [3]  
(B1)  
(M1)  
(A1)
- (c) electron and proton have same (kinetic) energy  
*either*  $E = p^2 / 2m$  *or*  $p = \sqrt{2Em}$   
ratio =  $p_e / p_p = \sqrt{(m_e / m_p)}$   
 $= \sqrt{\{(9.1 \times 10^{-31}) / (1.67 \times 10^{-27})\}}$   
 $= 2.3 \times 10^{-2}$   
C1  
C1  
C1  
A1 [4]
- 8 (a) energy to separate nucleons (in a nucleus)  
separate to infinity  
M1  
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
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.)  
*(use of 1 u = 934 MeV, allow 3/3; use of 1 u = 930 MeV or 932 MeV, allow 2/3)*  
*(use of  $1.67 \times 10^{-27}$  not  $1.66 \times 10^{-27}$  scores max. 2/3)*

### Section B

- 9 (a) operates on / takes signal from sensing device  
(so that) it gives an voltage output
- (b) thermistor and resistor in series between +4 V line and earth  
 $V_{\text{OUT}}$  shown clearly across *either* thermistor or resistor  
 $V_{\text{OUT}}$  shown clearly across thermistor
- (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)*
- 10 (a) pulse (of ultrasound)  
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)*
- (b) shorter wavelength  
smaller structures resolved / detected (*not more sharpness*)
- (c) (i)  $I = I_0 e^{-\mu x}$   
ratio =  $\exp(-23 \times 6.4 \times 10^{-2})$   
= 0.23
- (ii) later signal has passed through greater thickness of medium  
so has greater attenuation / greater absorption / smaller intensity

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