

**MARK SCHEME for the May/June 2011 question paper**  
**for the guidance of teachers**

**9702 PHYSICS**

**9702/42**

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

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## Section A

- 1 (a) region (of space) where a particle / body experiences a force B1 [1]
- (b) similarity: e.g. force  $\propto 1/r^2$   
potential  $\propto 1/r$  B1 [1]
- difference: e.g. gravitation force (always) attractive B1  
electric force attractive or repulsive B1 [2]
- (c) *either* ratio is  $Q_1 Q_2 / 4\pi\epsilon_0 m_1 m_2 G$  C1  
 $= (1.6 \times 10^{-19})^2 / 4\pi \times 8.85 \times 10^{-12} \times (1.67 \times 10^{-27})^2 \times 6.67 \times 10^{-11}$  C1  
 $= 1.2 \times 10^{36}$  A1 [3]
- or*  $F_E = 2.30 \times 10^{-28} \times R^{-2}$  (C1)  
 $F_G = 1.86 \times 10^{-64} \times R^{-2}$  (C1)  
 $F_E / F_G = 1.2 \times 10^{36}$  (A1)
- 2 (a) amount of substance M1  
containing same number of particles as in 0.012 kg of carbon-12 A1 [2]
- (b)  $pV = nRT$  C1  
amount =  $(2.3 \times 10^5 \times 3.1 \times 10^{-3}) / (8.31 \times 290)$   
 $+ (2.3 \times 10^5 \times 4.6 \times 10^{-3}) / (8.31 \times 303)$  C1  
 $= 0.296 + 0.420$  C1  
 $= 0.716 \text{ mol}$  A1 [4]  
*(give full credit for starting equation  $pV = NkT$  and  $N = nN_A$ )*
- 3 (a) charges on plates are equal and opposite M1  
so no resultant charge A1  
energy stored because there is charge separation B1 [3]
- (b) (i) capacitance =  $Q / V$  C1  
 $= (18 \times 10^{-3}) / 10$   
 $= 1800 \mu\text{F}$  A1 [2]
- (ii) use of area under graph *or* energy =  $\frac{1}{2}CV^2$  C1  
energy =  $2.5 \times 15.7 \times 10^{-3}$  *or* energy =  $\frac{1}{2} \times 1800 \times 10^{-6} \times (10^2 - 7.5^2)$   
 $= 39 \text{ mJ}$  A1 [2]
- (c) combined capacitance of Y & Z =  $20 \mu\text{F}$  *or* total capacitance =  $6.67 \mu\text{F}$  C1  
p.d. across capacitor X =  $8 \text{ V}$  *or* p.d. across combination =  $12 \text{ V}$  C1  
charge =  $10 \times 10^{-6} \times 8$  *or*  $6.67 \times 10^{-6} \times 12$   
 $= 80 \mu\text{C}$  A1 [3]

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- 4 (a)  $+\Delta U$ : increase in internal energy B1  
 $+q$ : thermal energy / heat supplied to the system B1  
 $+w$ : work done on the system B1 [3]
- (b) (i) (thermal) energy required to change the state of a substance per unit mass M1  
without any change of temperature A1  
A1 [3]
- (ii) when evaporating M1  
greater change in separation of atoms/molecules M1  
greater change in volume A1  
identifies each difference correctly with  $\Delta U$  and  $w$  [3]
- 5 (a) (i) (induced) e.m.f. proportional to M1  
rate of change of (magnetic) flux (linkage) / rate of flux cutting A1 [2]
- (ii) 1. moving magnet causes change of flux linkage B1 [1]  
2. speed of magnet varies so varying rate of change of flux B1 [1]  
3. magnet changes direction of motion (so current changes direction) B1 [1]
- (b) period = 0.75 s C1  
frequency = 1.33 Hz A1 [2]
- (c) graph: smooth correctly shaped curve with peak at  $f_0$  M1  
A never zero A1 [2]
- (d) (i) resonance B1 [1]  
(ii) e.g. quartz crystal for timing / production of ultrasound A1 [1]
- 6 (a) (i)  $2\pi f = 380$  C1  
frequency = 60 Hz A1 [2]
- (ii)  $I_{\text{RMS}} \times \sqrt{2} = I_0$  C1  
 $I_{\text{RMS}} = 9.9 / \sqrt{2}$   
= 7.0 A A1 [2]
- (b) power =  $I^2 R$  C1  
 $R = 400 / 7.0^2$   
= 8.2  $\Omega$  A1 [2]

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- 7 (a) wavelength of wave associated with a particle that is moving M1 A1 [2]
- (b) (i) energy of electron =  $850 \times 1.6 \times 10^{-19}$  M1  
 $= 1.36 \times 10^{-16} \text{ J}$   
energy =  $p^2 / 2m$  or  $p = mv$  and  $E_K = \frac{1}{2}mv^2$   
momentum =  $\sqrt{(1.36 \times 10^{-16} \times 2 \times 9.11 \times 10^{-31})}$  M1  
 $= 1.6 \times 10^{-23} \text{ N s}$  A0 [2]
- (ii)  $\lambda = h / p$  C1  
wavelength =  $(6.63 \times 10^{-34}) / (1.6 \times 10^{-23})$   
 $= 4.1 \times 10^{-11} \text{ m}$  A1 [2]
- (c) diagram or description showing:  
electron beam in a vacuum B1  
incident on thin metal target / carbon film B1  
fluorescent screen B1  
pattern of concentric rings observed M1  
pattern similar to diffraction pattern observed with visible light A1 [5]
- 8 (a) energy required to separate nucleons in a nucleus to infinity M1 A1 [2]
- (b)  $1\text{u} = 1.66 \times 10^{-27} \text{ kg}$   
 $E = mc^2$  C1  
 $= 1.66 \times 10^{-27} \times (3.0 \times 10^8)^2$  M1  
 $= 1.49 \times 10^{-10} \text{ J}$   
 $= (1.49 \times 10^{-10}) / (1.6 \times 10^{-13})$  M1  
 $= 930 \text{ MeV}$  A0 [3]
- (c) (i)  $\Delta m = 2.0141\text{u} - (1.0073 + 1.0087)\text{u}$   
 $= -1.9 \times 10^{-3} \text{ u}$  C1  
binding energy =  $1.9 \times 10^{-3} \times 930$   
 $= 1.8 \text{ MeV}$  A1 [2]
- (ii)  $\Delta m = (57 \times 1.0087\text{u}) + (40 \times 1.0073\text{u}) - 97.0980\text{u}$  C1  
 $= (-)0.69 \text{ u}$   
binding energy per nucleon =  $(0.69 \times 930) / 97$  C1  
 $= 6.61 \text{ MeV}$  A1 [3]

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## Section B

- 9 (a) thin / fine metal wire B1  
lay-out shown as a grid B1  
encased in plastic B1 [3]
- (b) (i) gain (of amplifier) B1 [1]
- (ii) for  $V_{OUT} = 0$ , then  $V^+ = V^-$  or  $V_1 = V_2$  C1  
 $V_1 = (1000/1125) \times 4.5$  C1  
 $V_1 = 4.0V$  A1 [3]
- (iii)  $V_2 = (1000 / 1128) \times 4.5$  C1  
 $= 3.99V$   
 $V_{OUT} = 12 \times (3.99 - 4.00)$   
 $= (-) 0.12V$  A1 [2]
- 10 strong / large (uniform) magnetic field B1  
nuclei precess / rotate about field direction (1)  
radio frequency pulse B1  
at Larmor frequency (1)  
causes resonance / nuclei absorb energy B1  
on relaxation / de-excitation, nuclei emit r.f. pulse B1  
pulse detected and processed (1)  
non-uniform field superposed on uniform field B1  
allows position of resonating nuclei to be determined B1  
allows for location of detection to be changed (1)  
(six points, 1 each plus any two extra – max 8) [8]
- 11 (a) e.g. unreliable communication (M1)  
because ion layers vary in height / density (A1)  
e.g. cannot carry all information required (M1)  
bandwidth too narrow (A1)  
e.g. coverage limited (M1)  
reception poor in hilly areas (A1)  
(any two sensible suggestions, M1 & A1 for each, max 4) [4]
- (b) signal must be amplified (greatly) before transmission back to Earth B1  
uplink signal would be swamped by downlink signal B1 [2]

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- 12 (a) (i)** ratio / dB =  $10 \lg(P_1 / P_2)$  C1  
 $24 = 10 \lg(P_1 / \{5.6 \times 10^{-19}\})$  C1  
 $P_1 = 1.4 \times 10^{-16} \text{ W}$  A1 [3]
- (ii)** attenuation per unit length =  $1 / L \times 10 \lg(P_1 / P_2)$  C1  
 $1.9 = 1 / L \times 10 \lg(\{3.5 \times 10^{-3}\} / \{1.4 \times 10^{-16}\})$  C1  
 $L = 1 \text{ km}$  A1 [3]  
*or*  
attenuation =  $10 \lg(\{3.5 \times 10^{-3}\} / \{5.6 \times 10^{-19}\})$  (C1)  
= 158 dB  
attenuation along fibre = (158 – 24) (C1)  
 $L = (158 - 24) / 1.9 = 71 \text{ km}$  (A1)
- (b)** less attenuation (per unit length) / longer uninterrupted length of fibre B1 [1]