

**UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS**

**GCE Advanced Subsidiary Level and GCE Advanced Level**

**MARK SCHEME for the May/June 2010 question paper  
for the guidance of teachers**

**9702 PHYSICS**

**9702/43**

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

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Section A

- 1 (a) work done moving unit mass from infinity to the point M1 A1 [2]
- (b) (i) at  $R$ ,  $\phi = 6.3 \times 10^7 \text{ J kg}^{-1}$  (allow  $\pm 0.1 \times 10^7$ ) B1  
 $\phi = GM / R$   
 $6.3 \times 10^7 = (6.67 \times 10^{-11} \times M) / (6.4 \times 10^6)$  C1  
 $M = 6.0 \times 10^{24} \text{ kg}$  (allow 5.95  $\rightarrow$  6.14) A1 [3]  
Maximum of 2/3 for any value chosen for  $\phi$  not at  $R$
- (ii) change in potential =  $2.1 \times 10^7 \text{ J kg}^{-1}$  (allow  $\pm 0.1 \times 10^7$ ) C1  
loss in potential energy = gain in kinetic energy B1  
 $\frac{1}{2} mv^2 = \phi m$  or  $\frac{1}{2} mv^2 = GM / 3R$  C1  
 $\frac{1}{2} v^2 = 2.1 \times 10^7$   
 $v = 6.5 \times 10^3 \text{ m s}^{-1}$  .....(allow 6.3  $\rightarrow$  6.6) A1 [4]  
(answer  $7.9 \times 10^3 \text{ m s}^{-1}$ , based on  $x = 2R$ , allow max 3 marks)
- (iii) e.g. speed / velocity / acceleration would be greater B1  
deviates / bends from straight path B1 [2]  
(any sensible ideas, 1 each, max 2)
- 2 (a) (i) reduction in energy (of the oscillations) (B1)  
reduction in amplitude / energy of oscillations (B1)  
due to force (always) opposing motion / resistive forces (B1) [2]  
any two of the above, max 2
- (ii) amplitude is decreasing (very) gradually / oscillations would M1  
continue (for a long time) / many oscillations A1 [2]  
light damping
- (b) (i) frequency =  $1 / 0.3$   
= 3.3 Hz A1 [1]  
allow points taken from time axis giving  $f = 3.45 \text{ Hz}$
- (ii) energy =  $\frac{1}{2} mv^2$  and  $v = \omega a$  C1  
=  $\frac{1}{2} \times 0.065 \times (2\pi/0.3)^2 \times (1.5 \times 10^{-2})^2$  M1  
= 3.2 mJ A0 [2]
- (c) amplitude reduces exponentially / does not decrease linearly M1  
so will be not be 0.7 cm A1 [2]

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- 3 (a) (i) 1 deg C corresponds to  $(3840 - 190) / 100 \Omega$   
for resistance 2300  $\Omega$ , temperature is  $100 \times (2300 - 3840) / (190 - 3840)$   
temperature is 42 °C  
C1  
A1 [2]
- (ii) *either* 286 K  $\equiv$  13 °C *or* 42 °C  $\equiv$  315 K  
thermodynamic scale does not depend on the property of a substance  
so change in resistance (of thermistor) with temperature is non-linear  
B1  
M1  
A1 [3]
- (b) heat gained by ice in melting =  $0.012 \times 3.3 \times 10^5 \text{ J}$   
= 3960 J  
C1  
heat lost by water =  $0.095 \times 4.2 \times 10^3 \times (28 - \theta)$   
C1  
 $3960 + (0.012 \times 4.2 \times 10^3 \times \theta) = 0.095 \times 4.2 \times 10^3 \times (28 - \theta)$   
C1  
 $\theta = 16^\circ\text{C}$   
A1 [4]  
(answer 18 °C – melted ice omitted – allow max 2 marks)  
(use of  $(\theta - T)$  then allow max 1 mark)
- 4 (a) force =  $q_1q_2 / 4\pi\epsilon_0x^2$   
=  $(6.4 \times 10^{-19})^2 / (4\pi \times 8.85 \times 10^{-12} \times \{12 \times 10^{-6}\}^2)$   
=  $2.56 \times 10^{-17} \text{ N}$   
C1  
C1  
A1 [3]
- (b) potential at P is same as potential at Q  
B1  
work done =  $q\Delta V$   
M1  
 $\Delta V = 0$  so zero work done  
A0 [2]
- (c) at midpoint, potential is  $2 \times (6.4 \times 10^{-19}) / (4\pi\epsilon_0 \times 6 \times 10^{-6})$   
C1  
at P, potential is  $(6.4 \times 10^{-19}) / (4\pi\epsilon_0 \times 3 \times 10^{-6}) + (6.4 \times 10^{-19}) / (4\pi\epsilon_0 \times 9 \times 10^{-6})$   
C1  
change in potential =  $(6.4 \times 10^{-19}) / (4\pi\epsilon_0 \times 9 \times 10^{-6})$   
energy =  $1.6 \times 10^{-19} \times (6.4 \times 10^{-19}) / (4\pi\epsilon_0 \times 9 \times 10^{-6})$   
C1  
=  $1.0 \times 10^{-22} \text{ J}$   
A1 [4]
- 5 (a) e.g. 'storage of charge' / storage of energy  
blocking of direct current  
producing of electrical oscillations  
smoothing  
(any two, 1 mark each)  
B2 [2]
- (b) (i) capacitance of parallel combination = 60  $\mu\text{F}$   
C1  
total capacitance = 20  $\mu\text{F}$   
A1 [2]
- (ii) p.d. across parallel combination =  $\frac{1}{2} \times$  p.d. across single capacitor  
C1  
maximum is 9V  
A1 [2]
- (c) *either* energy =  $\frac{1}{2}CV^2$  *or* energy =  $\frac{1}{2}QV$  and  $Q = CV$   
C1  
energy =  $\frac{1}{2} \times 4700 \times 10^{-6} \times (18^2 - 12^2)$   
C1  
= 0.42 J  
A1 [3]

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- 6 (a) (i) straight line with positive gradient through origin M1  
A1 [2]
- (ii) maximum force shown at  $\theta = 90^\circ$  M1  
zero force shown at  $\theta = 0^\circ$  M1  
reasonable curve with  $F$  about  $\frac{1}{2}$  max at  $30^\circ$  A1 [3]
- (b) (i) force on electron due to magnetic field B1  
force on electron normal to magnetic field and direction of electron B1 [2]
- (ii) quote / mention of (Fleming's) left hand rule M1  
electron moves towards QR A1 [2]
- 7 (a) *either* the value of steady / constant voltage M1  
that produces same power (in a resistor) as the alternating voltage A1 [2]  
*or* if alternating voltage is squared and averaged (M1)  
the r.m.s. value is the square root of this averaged value (A1)
- (b) (i) 220 V A1 [1]
- (ii) 156 V A1 [1]
- (iii) 60 Hz A1 [1]
- (c) power =  $V_{\text{rms}}^2 / R$  C1  
 $R = 156^2 / 1500$   
 $= 16 \Omega$  A1 [2]
- 8 (a) (i) number =  $(5.1 \times 10^6 \times 6.02 \times 10^{23}) / 241$  C1  
 $= 1.27 \times 10^{16}$  A1 [2]
- (ii)  $A = \lambda N$  C1  
 $5.9 \times 10^5 = \lambda \times 1.27 \times 10^{16}$   
 $\lambda = 4.65 \times 10^{11} \text{ s}^{-1}$  A1 [2]
- (iii)  $4.65 \times 10^{11} \times t_{1/2} = \ln 2$  C1  
 $t_{1/2} = 1.49 \times 10^{10} \text{ s}$   
 $= 470 \text{ years}$  A1 [2]
- (b) sample / activity would decay appreciably whilst measurements are being made B1 [1]

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### Section B

- 9 (a) (i) fraction of the output (signal) is added to the input (signal)  
out of phase by  $180^\circ / \pi$  rad / to inverting input M1  
A1 [2]
- (ii) e.g. reduces gain  
increases bandwidth  
greater stability  
reduces distortion  
(any two, 1 mark each) B2 [2]
- (b) (i) gain =  $4.4 / 0.062$   
= 71 A1 [1]
- (ii)  $71 = 1 + 120/R$  C1  
 $R = 1.7 \times 10^3 \Omega$  A1 [2]
- (c) for the amplifier not to saturate B1  
maximum output is ( $71 \times 95 \times 10^{-3} =$ ) approximately 6.7 V M1  
supply should be  $\pm 9$  V A1 [3]
- 10 (a) (i) strain gauge B1 [1]
- (ii) piezo-electric / quartz crystal / transducer B1 [1]
- (b) circuit: coil of relay connected between sensing circuit output and earth B1  
switch across terminals of external circuit B1  
diode in series with coil with correct polarity for diode B1  
second diode with correct polarity B1 [4]
- 11 *either* quartz *or* piezo-electric crystal B1  
opposite faces /two sides coated (with silver) to act as electrodes B1  
*either* molecular structure indicated  
*or* centres of (+) and (–) charge not coincident B1  
potential difference across crystal causes crystal to change shape B1  
alternating voltage (in US frequency range) applied across crystal B1  
causes crystal to oscillate / vibrate B1  
(crystal cut) so that it vibrates at resonant frequency B1 [6]  
(max 6)

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- 12 (a) signal becomes distorted / noisy B1  
 signal loses power / energy / intensity / is attenuated B1 [2]
- (b) (i) *either* numbers involved are smaller / more manageable / cover wider range  
*or* calculations involve addition & subtraction rather than multiplication and division B1 [1]
- (ii)  $25 = 10 \lg(P_{\min} / (6.1 \times 10^{-19}))$  C1  
 minimum signal power =  $1.93 \times 10^{-16}$  W C1  
 signal loss =  $10 \lg(6.5 \times 10^3 / (1.93 \times 10^{-16}))$   
 = 135 dB C1  
 maximum cable length =  $135 / 1.6$  C1  
 = 85 km so no repeaters necessary A1 [5]