

**UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS****GCE Advanced Subsidiary Level and GCE Advanced Level****MARK SCHEME for the May/June 2012 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 in bringing unit mass from infinity (to the point) B1 [1]
- (b) gravitational force is (always) attractive B1  
 either as  $r$  decreases, object/mass/body does work  
 or work is done by masses as they come together B1 [2]
- (c) either force on mass =  $mg$  (where  $g$  is the acceleration of free fall /gravitational field strength) B1  
 $g = GM/r^2$  B1  
 if  $r \ll h$ ,  $g$  is constant B1  
 $\Delta E_P = \text{force} \times \text{distance moved}$  M1  
 $= mgh$  A0  
 or  $\Delta E_P = m\Delta\phi$  (C1)  
 $= GMm(1/r_1 - 1/r_2) = GMm(r_2 - r_1)/r_1r_2$  (B1)  
 if  $r_2 \approx r_1$ , then  $(r_2 - r_1) = h$  and  $r_1r_2 = r^2$  (B1)  
 $g = GM/r^2$  (B1)  
 $\Delta E_P = mgh$  (A0) [4]
- (d)  $\frac{1}{2}mv^2 = m\Delta\phi$   
 $v^2 = 2 \times GM/r$  C1  
 $= (2 \times 4.3 \times 10^{13}) / (3.4 \times 10^6)$  C1  
 $v = 5.0 \times 10^3 \text{ m s}^{-1}$  A1 [3]  
 (Use of diameter instead of radius to give  $v = 3.6 \times 10^3 \text{ m s}^{-1}$  scores 2 marks)
- 2 (a) (i) either random motion B1 [1]  
 or constant velocity until hits wall/other molecule
- (ii) (total) volume of molecules is negligible M1  
 compared to volume of containing vessel A1  
 or  
 radius/diameter of a molecule is negligible (M1)  
 compared to the average intermolecular distance (A1) [2]
- (b) either molecule has component of velocity in three directions M1  
 or  $c^2 = c_x^2 + c_y^2 + c_z^2$  M1  
 random motion and averaging, so  $\langle c_x^2 \rangle = \langle c_y^2 \rangle = \langle c_z^2 \rangle$  M1  
 $\langle c^2 \rangle = 3\langle c_x^2 \rangle$  A1  
 so,  $pV = \frac{1}{3}Nm\langle c^2 \rangle$  A0 [3]
- (c)  $\langle c^2 \rangle \propto T$  or  $c_{\text{rms}} \propto \sqrt{T}$  C1  
 temperatures are 300 K and 373 K C1  
 $c_{\text{rms}} = 580 \text{ m s}^{-1}$  A1 [3]  
 (Do not allow any marks for use of temperature in units of °C instead of K)

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- 3 (a) (numerically equal to) quantity of (thermal) energy required to change the state of unit mass of a substance without any change of temperature  
(Allow 1 mark for definition of specific latent heat of fusion/vaporisation)
- M1  
A1 [2]
- (b) *either* energy supplied =  $2400 \times 2 \times 60 = 288000 \text{ J}$   
energy required for evaporation =  $106 \times 2260 = 240000 \text{ J}$   
difference =  $48000 \text{ J}$   
rate of loss =  $48000 / 120 = 400 \text{ W}$   
*or* energy required for evaporation =  $106 \times 2260 = 240000 \text{ J}$   
power required for evaporation =  $240000 / (2 \times 60) = 2000 \text{ W}$   
rate of loss =  $2400 - 2000 = 400 \text{ W}$
- C1  
C1  
A1  
(C1)  
(C1)  
(A1) [3]
- 4 (a)  $a = (-)\omega^2 x$  and  $\omega = 2\pi/T$   
 $T = 0.60 \text{ s}$   
 $a = (4\pi^2 \times 2.0 \times 10^{-2}) / (0.6)^2$   
 $= 2.2 \text{ ms}^{-2}$
- C1  
C1  
A1 [3]
- (b) sinusoidal wave with all values positive  
all values positive, all peaks at  $E_K$  and energy = 0 at  $t = 0$   
period = 0.30 s
- B1  
B1  
B1 [3]
- 5 (a) force per unit positive charge acting on a stationary charge
- B1 [1]
- (b) (i)  $E = Q / 4\pi\epsilon_0 r^2$   
 $Q = 1.8 \times 10^4 \times 10^2 \times 4\pi \times 8.85 \times 10^{-12} \times (25 \times 10^{-2})^2$   
 $Q = 1.25 \times 10^{-5} \text{ C} = 12.5 \mu\text{C}$
- C1  
M1  
A0 [2]
- (ii)  $V = Q / 4\pi\epsilon_0 r$   
 $= (1.25 \times 10^{-5}) / (4\pi \times 8.85 \times 10^{-12} \times 25 \times 10^{-2})$   
 $= 4.5 \times 10^5 \text{ V}$   
(Do not allow use of  $V = Er$  unless explained)
- C1  
A1 [2]

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6	<p><b>(a) (i)</b> peak voltage = 4.0V</p> <p><b>(ii)</b> r.m.s. voltage (= <math>4.0/\sqrt{2}</math>) = 2.8V</p> <p><b>(iii)</b> period <math>T = 20</math> ms frequency = <math>1 / (20 \times 10^{-3})</math> frequency = 50 Hz</p>	A1 A1 M1 M1 A0	[1] [1] [2]
6	<p><b>(b) (i)</b> change = <math>4.0 - 2.4 = 1.6</math> V</p> <p><b>(ii)</b> <math>\Delta Q = C\Delta V</math> or <math>Q = CV</math> <math>= 5.0 \times 10^{-6} \times 1.6 = 8.0 \times 10^{-6}</math> C</p> <p><b>(iii)</b> discharge time = 7 ms current = <math>(8.0 \times 10^{-6}) / (7.0 \times 10^{-3})</math> <math>= 1.1(4) \times 10^{-3}</math> A</p>	A1 C1 A1 C1 M1 A0	[1] [2] [2]
6	<p><b>(c)</b> average p.d. = 3.2V resistance = <math>3.2 / (1.1 \times 10^{-3})</math> <math>= 2900 \Omega</math> (allow <math>2800 \Omega</math>)</p>	C1 A1	[2]
7	<p><b>(a)</b> sketch: concentric circles (<i>minimum of 3 circles</i>) separation increasing with distance from wire correct direction</p>	M1 A1 B1	[3]
7	<p><b>(b) (i)</b> arrow direction from wire B towards wire A</p> <p><b>(ii)</b> <i>either</i> reference to Newton's third law <i>or</i> force on each wire proportional to product of the two currents so forces are equal</p>	B1 M1 A1	[1] [2]
7	<p><b>(c)</b> force <u>always</u> towards wire A/<u>always</u> in same direction varies from zero (to a maximum value) (1) variation is sinusoidal / <math>\sin^2</math> (1) (at) twice frequency of current (1) (any two, one each)</p>	B1 B2	[3]
8	<p><b>(a)</b> packet/quantum/discrete amount of energy of electromagnetic radiation (allow 1 mark for 'packet of electromagnetic radiation') energy = Planck constant <math>\times</math> frequency (<i>seen here or in b</i>)</p>	M1 A1 B1	[3]
8	<p><b>(b)</b> each (coloured) line corresponds to one wavelength/frequency energy = Planck constant <math>\times</math> frequency implies specific energy change between energy levels so discrete levels</p>	B1 B1 A0	[2]

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- 9 (a) (i) *either* probability of decay (of a nucleus)  
per unit time  
*or*  $\lambda = (-)(dN/dt) / N$   
( $-)dN/dt$  and  $N$  explained
- (ii) in time  $t_{1/2}$ , number of nuclei changes from  $N_0$  to  $\frac{1}{2}N_0$   
 $\frac{1}{2} = \exp(-\lambda t_{1/2})$  *or*  $2 = \exp(\lambda t_{1/2})$   
 $\ln(\frac{1}{2}) = -\lambda t_{1/2}$  and  $\ln(\frac{1}{2}) = -0.693$  *or*  $\ln 2 = \lambda t_{1/2}$  and  $\ln 2 = 0.693$   
 $0.693 = \lambda t_{1/2}$
- (b)  $228 = 538 \exp(-8\lambda)$   
 $\lambda = 0.107$  (hours<sup>-1</sup>)  
 $t_{1/2} = 6.5$  hours (*do not allow 3 or more SF*)
- (c) e.g. random nature of decay  
background radiation  
daughter product is radioactive  
(*any two sensible suggestions, 1 each*)

M1  
A1 [2]  
(M1)  
(A1)

B1  
B1  
B1  
A0 [3]

C1  
C1  
A1 [3]

B2 [2]

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## Section B

10 (a)	light-dependent resistor (allow LDR)	B1	[1]
(b) (i)	two resistors in series between +5V line and earth midpoint connected to inverting input of op-amp	M1 A1	[2]
(ii)	relay coil between diode and earth switch between lamp and earth	M1 A1	[2]
(c) (i)	switch on/off mains supply using a low voltage/current output (allow 'isolates circuit from mains supply')	B1	[1]
(ii)	relay will switch on for one polarity of output (voltage) switches on when output (voltage) is negative	C1 A1	[2]
11 (a) (i)	e.m. radiation produced whenever charged particle is accelerated electrons hitting target have distribution of accelerations	M1 A1	[2]
(ii)	<i>either</i> wavelength shorter/shortest for greater/greatest acceleration <i>or</i> $\lambda_{\min} = hc/E_{\max}$ <i>or</i> minimum wavelength for maximum energy all electron energy given up in one collision/converted to single photon	B1 B1	[2]
(b) (i)	hardness measures the penetration of the beam greater hardness, greater penetration	C1 A1	[2]
(ii)	controlled by changing the anode voltage higher anode voltage, greater penetration/hardness	C1 A1	[2]
(c) (i)	long-wavelength radiation more likely to be absorbed in the body/less likely to penetrate through body	B1	[1]
(ii)	(aluminium) filter/metal foil placed in the X-ray beam	B1	[1]
12 (a)	strong uniform (magnetic) field <i>either</i> aligns nuclei <i>or</i> gives rise to Larmor/resonant frequency <u>in r.f. region</u> non-uniform (magnetic) field <i>either</i> enables nuclei to be located <i>or</i> changes the Larmor/resonant frequency	M1 A1 M1 A1	[4]
(b) (i)	difference in flux density = $2.0 \times 10^{-2} \times 3.0 \times 10^{-3} = 6.0 \times 10^{-5} \text{ T}$	A1	[1]
(ii)	$\Delta f = 2 \times c \times \Delta B$ $= 2 \times 1.34 \times 10^8 \times 6.0 \times 10^{-5}$ $= 1.6 \times 10^4 \text{ Hz}$	C1 A1	[2]

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- 13 (a) (i) no interference (between signals) near boundaries (of cells) B1 [1]
- (ii) for large area, signal strength would have to be greater and this could be hazardous to health B1 [1]
- (b) mobile phone is sending out an (identifying) signal M1  
computer/cellular exchange continuously selects cell/base station with strongest signal A1  
computer/cellular exchange allocates (carrier) frequency (and slot) A1 [3]