

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

9702/41

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 $r \approx h$, 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
or constant velocity until hits wall/other molecule B1 [1]
- (ii) (total) volume of molecules is negligible compared to volume of containing vessel M1
or radius/diameter of a molecule is negligible compared to the average intermolecular distance (M1) (A1) [2]
- (b) *either* molecule has component of velocity in three directions
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 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	(a) (i) peak voltage = 4.0V	A1	[1]
	(ii) r.m.s. voltage (= $4.0/\sqrt{2}$) = 2.8V	A1	[1]
	(iii) period $T = 20$ ms	M1	
	frequency = $1 / (20 \times 10^{-3})$	M1	
	frequency = 50 Hz	A0	[2]
	(b) (i) change = $4.0 - 2.4 = 1.6$ V	A1	[1]
	(ii) $\Delta Q = C\Delta V$ or $Q = CV$	C1	
	= $5.0 \times 10^{-6} \times 1.6 = 8.0 \times 10^{-6}$ C	A1	[2]
	(iii) discharge time = 7 ms	C1	
	current = $(8.0 \times 10^{-6}) / (7.0 \times 10^{-3})$	M1	
	= $1.1(4) \times 10^{-3}$ A	A0	[2]
	(c) average p.d. = 3.2V	C1	
	resistance = $3.2 / (1.1 \times 10^{-3})$		
	= 2900Ω (allow 2800Ω)	A1	[2]
7	(a) sketch: concentric circles (<i>minimum of 3 circles</i>)	M1	
	separation increasing with distance from wire	A1	
	correct direction	B1	[3]
	(b) (i) arrow direction from wire B towards wire A	B1	[1]
	(ii) <i>either</i> reference to Newton's third law		
	<i>or</i> force on each wire proportional to product of the two currents	M1	
	so forces are equal	A1	[2]
	(c) force <u>always</u> towards wire A/ <u>always</u> in same direction	B1	
	varies from zero (to a maximum value) (1)		
	variation is sinusoidal / \sin^2 (1)		
	(at) twice frequency of current (1)		
	(any two, one each)	B2	[3]
8	(a) packet/quantum/discrete amount of energy	M1	
	of electromagnetic radiation	A1	
	(allow 1 mark for 'packet of electromagnetic radiation')		
	energy = Planck constant \times frequency (<i>seen here or in b</i>)	B1	[3]
	(b) each (coloured) line corresponds to one wavelength/frequency	B1	
	energy = Planck constant \times frequency		
	implies specific energy change between energy levels	B1	
	so discrete levels	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 $^{-1}$)
 $t_{1/2} = 6.5$ 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 M1
switch between lamp and earth 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) C1
switches on when output (voltage) is negative A1 [2]
- 11 (a) (i) e.m. radiation produced whenever charged particle is accelerated M1
electrons hitting target have distribution of accelerations A1 [2]
- (ii) *either* wavelength shorter/shortest for greater/greatest acceleration
or $\lambda_{\min} = hc/E_{\max}$
or minimum wavelength for maximum energy B1
all electron energy given up in one collision/converted to single photon B1 [2]
- (b) (i) hardness measures the penetration of the beam C1
greater hardness, greater penetration A1 [2]
- (ii) controlled by changing the anode voltage C1
higher anode voltage, greater penetration/hardness 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 M1
either aligns nuclei
or gives rise to Larmor/resonant frequency in r.f. region A1
non-uniform (magnetic) field M1
either enables nuclei to be located
or changes the Larmor/resonant frequency 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) $\Delta f = 2 \times c \times \Delta B$ C1
 $= 2 \times 1.34 \times 10^8 \times 6.0 \times 10^{-5}$
 $= 1.6 \times 10^4 \text{ Hz}$ 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]