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

This mark scheme is published as an aid to teachers and candidates, to indicate the requirements of the examination. It shows the basis on which Examiners were instructed to award marks. It does not indicate the details of the discussions that took place at an Examiners' meeting before marking began, which would have considered the acceptability of alternative answers.

Mark schemes must be read in conjunction with the question papers and the report on the examination.

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Section A

1	**(a)** work done in bringing unit mass from infinity (to the point)	B1	
	(b) gravitational <u>force</u> 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 @ h, g is constant	B1	
	ΔE_P = force × 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) $½mv^2 = m\Delta\phi$		
	$v^2 = 2 \times GM/r$	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	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		
	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, $pV = ⅓Nm\langle c^2\rangle$	A0	[3]
	(c) $\langle c^2\rangle \propto T$ or $c_{rms} \propto \sqrt{T}$	C1	
	temperatures are 300 K and 373 K	C1	
	$c_{rms} = 580\,\text{m s}^{-1}$	A1	[3]
	(Do not allow any marks for use of temperature in units of °C instead of K)		

3	**(a)**	(numerically equal to) quantity of (thermal) energy required to change the state of unit mass of a substance	M1	
		without any change of temperature	A1	
		(Allow 1 mark for definition of specific latent heat of fusion/vaporisation)		
	(b)	*either* energy supplied = 2400 × 2 × 60 = 288000 J	C1	
		energy required for evaporation = 106 × 2260 = 240000 J	C1	
		difference = 48000 J		
		rate of loss = 48000 / 120 = 400 W	A1	
		or energy required for evaporation = 106 × 2260 = 240000 J	(C1)	
		power required for evaporation = 240000 / (2 × 60) = 2000 W	(C1)	
		rate of loss = 2400 – 2000 = 400 W	(A1)	[3]
4	**(a)**	$a = (-)\omega^2 x$ and $\omega = 2\pi/T$	C1	
		$T = 0.60\,\text{s}$	C1	
		$a = (4\pi^2 \times 2.0 \times 10^{-2}) / (0.6)^2$		
		$= 2.2\,\text{m}\,\text{s}^{-2}$	A1	[3]
	(b)	sinusoidal wave with all values positive	B1	
		all values positive, all peaks at E_K and energy = 0 at $t = 0$	B1	
		period = 0.30 s	B1	[3]
5	**(a)**	force per unit positive charge acting on a stationary charge	B1	[1]
	(b) (i)	$E = Q / 4\pi\varepsilon_0 r^2$	C1	
		$Q = 1.8 \times 10^4 \times 10^2 \times 4\pi \times 8.85 \times 10^{-12} \times (25 \times 10^{-2})^2$	M1	
		$Q = 1.25 \times 10^{-5}\,\text{C} = 12.5\,\mu\text{C}$	A0	[2]
	(ii)	$V = Q / 4\pi\varepsilon_0 r$		
		$= (1.25 \times 10^{-5}) / (4\pi \times 8.85 \times 10^{-12} \times 25 \times 10^{-2})$	C1	
		$= 4.5 \times 10^5\,\text{V}$	A1	[2]
		(Do not allow use of V = Er unless explained)		

6	(a)	(i)	peak voltage = 4.0 V	A1	
		(ii)	r.m.s. voltage (= 4.0/√2) = 2.8 V	A1	
		(iii)	period T = 20 ms	M1	
			frequency = 1 / (20 × 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 × 10^{-6} × 1.6 = 8.0 × 10^{-6} C	A1	[2]
		(iii)	discharge time = 7 ms	C1	
			current = (8.0 × 10^{-6}) / (7.0 × 10^{-3})	M1	
			= 1.1(4) × 10^{-3} A	A0	[2]
	(c)		average p.d. = 3.2 V	C1	
			resistance = 3.2 / (1.1 × 10^{-3})		
			= 2900 Ω *(allow 2800 Ω)*	A1	[2]
7	(a)		sketch: concentric circles *(minimum of 3 circles)*	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)	*either* reference to Newton's third law		
			or 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 × frequency *(seen here or in **b**)*	B1	[3]
	(b)		each (coloured) line corresponds to one wavelength/frequency	B1	
			energy = Planck constant × frequency		
			implies specific energy change between energy levels	B1	
			so discrete levels	A0	[2]

9 (a) (i)	*either* probability of decay (of a nucleus)	M1	
	per unit time	A1	
	or $\lambda = (-)(\mathrm{d}N/\mathrm{d}t) / N$	(M1)	
	$(-)\mathrm{d}N/\mathrm{d}t$ and N explained	(A1)	
(ii)	in time $t_{½}$, number of nuclei changes from N_0 to $½N_0$	B1	
	$½ = \exp(-\lambda\, t_{½})$ *or* $2 = \exp(\lambda\, t_{½})$	B1	
	$\ln(½) = -\lambda\, t_{½}$ and $\ln(½) = -0.693$ *or* $\ln 2 = \lambda\, t_{½}$ and $\ln 2 = 0.693$	B1	
	$0.693 = \lambda\, t_{½}$	A0	[3]
(b)	$228 = 538 \exp(-8\lambda)$	C1	
	$\lambda = 0.107$ (hours^{-1})	C1	
	$t_{½} = 6.5$ hours *(do not allow 3 or more SF)*	A1	[3]
(c)	e.g. random nature of decay background radiation daughter product is radioactive *(any two sensible suggestions, 1 each)*	B2	[2]

Section B

10 (a) light-dependent resistor (allow LDR) B1

(b) (i) two resistors in series between +5 V line and earth M1
midpoint connected to inverting input of op-amp 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 B1 [1]
(allow 'isolates circuit from mains supply')

(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 <u>in r.f. region</u> 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 = $2.0 \times 10^{-2} \times 3.0 \times 10^{-3} = 6.0 \times 10^{-5}$ T A1 [1]

(ii) $\Delta f = 2 \times c \times \Delta B$ C1
$= 2 \times 1.34 \times 10^{8} \times 6.0 \times 10^{-5}$
$= 1.6 \times 10^{4}$ Hz A1 [2]

13 (a) (i) no interference (between signals) near boundaries (of cells)	B1	
(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]