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.

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UNIVERSITY of CAMBRIDGE
International Examinations

Section A

1	**(a)**	work done in bringing unit mass from infinity (to the point)	B1	[1]
	(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 [2]
(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
$a = (4\pi^2 \times 2.0 \times 10^{-2}) / (0.6)^2$
$= 2.2\,\text{m s}^{-2}$ — 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	[1]
		(ii)	r.m.s. voltage (= 4.0/√2) = 2.8 V	A1	[1]
		(iii)	period T = 20 ms frequency = 1 / (20 × 10^{-3}) frequency = 50 Hz	M1 M1 A0	 [2]
	(b)	**(i)**	change = 4.0 – 2.4 = 1.6 V	A1	[1]
		(ii)	$\Delta Q = C\Delta V$ or $Q = CV$ = 5.0 × 10^{-6} × 1.6 = 8.0 × 10^{-6} C	C1 A1	 [2]
		(iii)	discharge time = 7 ms current = (8.0 × 10^{-6}) / (7.0 × 10^{-3}) = 1.1(4) × 10^{-3} A	C1 M1 A0	 [2]
	(c)		average p.d. = 3.2 V resistance = 3.2 / (1.1 × 10^{-3}) = 2900 Ω *(allow 2800 Ω)*	C1 A1	 [2]
7	**(a)**		sketch: concentric circles *(minimum of 3 circles)* separation increasing with distance from wire correct direction	M1 A1 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 so forces are equal	 M1 A1	 [2]
	(c)		force <u>always</u> towards wire A/<u>always</u> in same direction varies from zero (to a maximum value) (1) variation is sinusoidal / $\sin^2$ (1) (at) twice frequency of current (1) *(any two, one each)*	B1 B2	 [3]
8	**(a)**		packet/quantum/discrete amount of energy of electromagnetic radiation *(allow 1 mark for 'packet of electromagnetic radiation')* energy = Planck constant × frequency *(seen here or in **b**)*	M1 A1 B1	 [3]
	(b)		each (coloured) line corresponds to one wavelength/frequency energy = Planck constant × frequency implies specific energy change between energy levels so discrete levels	B1 B1 A0	 [2]

9 **(a)** **(i)**	*either*	probability of decay (of a nucleus)	M1	
		per unit time	A1	[2]
	or	$\lambda = (-)(dN/dt) / N$	(M1)	
		$(-)dN/dt$ 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	[1]
	(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 (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 <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	[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]