UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS

GCE Advanced Subsidiary Level and GCE Advanced Level

MARK SCHEME for the October/November 2010 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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Section A

1	**(a)**	**(i)**	rate of change of angle / angular displacement	M1	
			swept out by radius	A1	[2]
		(ii)	$\omega \times T = 2\pi$	B1	[1]
	(b)		centripetal force is provided by the gravitational force	B1	
			either $mr(2\pi/T)^2 = GMm/r^2$ *or* $mr\omega^2 = GMm/r^2$	M1	
			$r^3 \times 4\pi^2 = GM \times T^2$	A1	
			$GM/4\pi^2$ is a constant (c)	A1	
			$T^2 = cr^3$	A0	[4]
	(c)	**(i)**	*either* $T^2 = (45/1.08)^3 \times 0.615^2$ *or* $T^2 = 0.30 \times 45^3$	C1	
			T = 165 years	A1	[2]
		(ii)	speed = $(2\pi \times 1.08 \times 10^8) / (0.615 \times 365 \times 24 \times 3600)$	C1	
			= 35 km s^{-1}	A1	[2]
2	**(a)**		atoms / molecules / particles behave as elastic (identical) spheres	(1)	
			volume of atoms / molecules negligible compared to volume of containing vessel	(1)	
			time of collision negligible to time between collisions	(1)	
			no forces of attraction or repulsion between atoms / molecules	(1)	
			atoms / molecules / particles are in (continuous) random motion	(1)	
			(*any four, 1 each*)	B4	[4]
	(b)		$pV = \frac{1}{3}Nm\langle c^2\rangle$ and $pV = nRT$ *or* $pV = NkT$	B1	
			$\frac{1}{3}Nm\langle c^2\rangle = nRT$ or $= NkT$ and $\langle E_K\rangle = \frac{1}{2}m\langle c^2\rangle$	B1	
			$n = N/N_A$ *or* $k = R/N_A$	B1	
			$\langle E_K\rangle = \dfrac{3}{2} \times R/N_A \times T$	A0	[3]
	(c)	**(i)**	reaction represents *either* build-up of nucleus from light nuclei		
			or build-up of heavy nucleus from nuclei	M1	
			so fusion reaction	A1	[2]
		(ii)	proton and deuterium nucleus will have equal kinetic energies	B1	
			$1.2 \times 10^{-14} = \frac{3}{2} \times 8.31 / (6.02 \times 10^{23}) \times T$	C1	
			$T = 5.8 \times 10^8$ K	A1	[3]
			(*use of $E = 2.4 \times 10^{-14}$ giving 1.16×10^9 K scores 1 mark*)		
		(iii)	*either* inter-molecular / atomic / nuclear forces exist		
			or proton and deuterium nucleus are positively charged / repel	B1	[1]

3 (a) (i) 8.0 cm — A1 [1]

(ii) $2\pi f = 220$ — C1
$f = 35$ (*condone unit*) — A1 [2]

(iii) line drawn mid-way between AB and CD (*allow ±2 mm*) — B1 [1]

(iv) $v = \omega a$ — C1
$= 220 \times 4.0$
$= 880$ cm s^{-1} — A1 [2]

(b) (i) **1.** line drawn 3 cm above AB (*allow ±2 mm*) — B1 [1]
2. arrow pointing upwards — B1 [1]

(ii) **1.** line drawn 3 cm above AB (*allow ±2 mm*) — B1 [1]
2. arrow pointing downwards — B1 [1]

(iii) $v = \omega\sqrt{(a^2 - x^2)}$
$= 220 \times \sqrt{(4.0^2 - 2.0^2)}$ — C1
$= 760$ cm s^{-1} — A1 [2]
(*incorrect value for x, 0/2 marks*)

4 (a) (i) work done moving unit positive charge — M1
from infinity to the point — A1 [2]

(ii) charge / potential (difference) (*ratio must be clear*) — B1 [1]

(b) (i) capacitance = $(2.7 \times 10^{-6}) / (150 \times 10^{3})$ — C1
(*allow any appropriate values*)
capacitance = 1.8×10^{-11} (*allow 1.8 ±0.05)* — A1 [2]

(ii) *either* energy = $\frac{1}{2}CV^2$ *or* energy = $\frac{1}{2}QV$ and $Q = CV$ — C1
energy $= \frac{1}{2} \times 1.8 \times 10^{-11} \times (150 \times 10^{3})^2$ *or* $\frac{1}{2} \times 2.7 \times 10^{-6} \times 150 \times 10^{3}$
$= 0.20$ J — A1 [2]

(c) *either* since energy $\propto V^2$, capacitor has $(\frac{1}{2})^2$ of its energy left
or full formula treatment — C1
energy lost = 0.15 J — A1 [2]

5	**(a)**	magnetic flux $= BA$		
		$= 89 \times 10^{-3} \times 5.0 \times 10^{-2} \times 2.4 \times 10^{-2}$	C1	
		$= 1.07 \times 10^{-4}$ Wb	A1	[2]
	(b) (i)	e.m.f. $= \Delta\phi / \Delta t$	C1	
		(for $\Delta\phi = 1.07 \times 10^{-4}$ Wb), $\Delta t = 2.4 \times 10^{-2} / 1.8 = 1.33 \times 10^{-2}$ s	C1	
		e.m.f. $= (1.07 \times 10^{-4}) / (1.33 \times 10^{-2})$		
		$= 8.0 \times 10^{-3}$ V	A1	[3]
	(ii)	current $= 8.0 \times 10^{-3} / 0.12$	M1	
		≈ 70 mA	A0	[1]
	(c)	force on wire $= BIL$		
		$= 89 \times 10^{-3} \times 70 \times 10^{-3} \times 5.0 \times 10^{-2}$	C1	
		$\approx 3 \times 10^{-4}$ (N)	M1	
		suitable comment e.g. this force is too / very small (to be felt)	A1	[3]
6	**(a)**	power / heating depends on I^2	M1	
		so independent of current direction	A1	[2]
	(b)	*either* maximum power $= I_0^2R$ *or* average power $= I_{RMS}^2R$	M1	
		$I_0 = \sqrt{2} \times I_{RMS}$	M1	
		maximum power = 2 × average power		
		ratio = 0.5	A1	[3]
7	**(a)**	force due to *E*-field is equal and opposite to force due to *B*-field	B1	
		$Eq = Bqv$	B1	
		$v = E/B$	B1	[3]
	(b)	*either* charge and mass are not involved in the equation in **(a)**		
		or F_E and F_B are both doubled		
		or *E, B* and *v* do not change	M1	
		so no deviation	A1	[2]
8	**(a)**	minimum frequency for electron to be emitted (from surface)	M1	
		of electromagnetic radiation / light / photons	A1	[2]
	(b)	$E = hc / \lambda$ *or* $E = hf$ and $c = f\lambda$	C1	
		either threshold wavelength $= (6.63 \times 10^{-34} \times 3.0 \times 10^{8}) / (5.8 \times 10^{-19})$ $= 340$ nm		
		or energy of 340 nm photon $= 4.4 \times 10^{-19}$ J		
		or threshold frequency $= 8.7 \times 10^{14}$ Hz		
		or 450 nm $\rightarrow 6.7 \times 10^{14}$ Hz	A1	
		appropriate comment comparing wavelengths / energies / frequencies	B1	
		so no effect on photo-electric current	B1	[4]

Section B

9 **(a)** **(i)** edges can be (clearly) distinguished B1 [1]

(ii) e.g. size of X-ray source / anode / target / aperture
scattering of X-ray beam
pixel size
(*any two, 1 each*) B2
further detail e.g. use of lead grid B1 [3]

(b) X-ray image involves a single exposure B1
CT scan: exposure of a slice from many different angles M1
repeated for different slices A1
CT scan involves a (much) greater exposure B1 [4]

10 **(a)** e.g. infinite input impedance / resistance
zero output impedance / resistance
infinite gain
infinite bandwidth
infinite slew rate
(*any three, 1 each*) B3 [3]

(b) **(i)** with switch open, V^- is less (positive) than V^+ M1
output is positive A1
with switch closed, V^- is more (positive) than V^+ so output is negative A1 [3]
(*allow similar scheme if V^- more positive than V^+ treated first*)

(ii) **1.** diodes connected correctly between output and earth M1
2. green identified correctly A1 [2]
(*do not allow this mark if not argued in **(i)***)

11 **(a)** **(i)** $I / I_0 = \exp(-1.5 \times 2.9)$ C1
$= 0.013$ A1 [2]

(ii) $I / I_0 = \exp(-4.6 \times 0.95)$
$= 0.013$ A1 [1]

(b) attenuation (coefficients) in muscle and in fat are similar B1
attenuation (coefficients) in bone and muscle / fat are different B1
contrast depends on difference in attenuation B1 [3]

12	**(a)**	**(i)**	**1.** signal has same variation (with time) as the data	B1	
			2. consists of (a series of) 'highs' and 'lows'	B1	
			either analogue is continuously variable (between limits)		
			or digital has no intermediate values	B1	[3]
		(ii)	e.g. can be regenerated / noise can be eliminated		
			extra data can be added to check / correct transmitted signal		
			(*any two reasonable suggestions, 1 each*)	B2	[2]
	(b)	**(i)**	analogue signal is sampled at (regular time) intervals	B1	
			sampled signal is converted into a binary number	B1	[2]
		(ii)	one channel is required for each bit (of the digital number)	B1	[1]