UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS

GCE Advanced Subsidiary Level and GCE Advanced Level

MARK SCHEME for the May/June 2010 question paper

for the guidance of teachers

9702 PHYSICS

9702/41 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)		angle (subtended) at centre of circle	B1	
			(by) arc equal in length to radius	B1	[2]
	(b)	(i)	point S shown below C	B1	[1]
		(ii)	(max) force / tension = weight + centripetal force	C1	
			centripetal force = $mr\omega^2$	C1	
			$15 = 3.0/9.8 \times 0.85 \times \omega^2$	C1	
			$\omega = 7.6$ rad s^{-1}	A1	[4]
2	(a)	(i)	27.2 + 273.15 or 27.2 + 273.2	C1	
			300.4 K	A1	[2]
		(ii)	11.6 K	A1	[1]
	(b)	(i)	($<c^2>$ is the) mean / average square speed	B1	[1]
		(ii)	$\rho = Nm/V$ with N explained	B1	
			so, $pV = 1/3\ Nm<c^2>$	B1	
			and $pV = NkT$ with k explained	B1	
			so mean kinetic energy / $<E_K> = ½m<c^2> = 3/2\ kT$	B1	[4]
	(c)	(i)	$pV = nRT$		
			$2.1 \times 10^7 \times 7.8 \times 10^{-3} = n \times 8.3 \times 290$	C1	
			$n = 68$ mol	A1	[2]
		(ii)	mean kinetic energy $= 3/2\ kT$		
			$= 3/2 \times 1.38 \times 10^{-23} \times 290$	C1	
			$= 6.0 \times 10^{-21}$ J	A1	[2]
		(iii)	realisation that total internal energy is the total kinetic energy	C1	
			energy $= 6.0 \times 10^{-21} \times 68 \times 6.02 \times 10^{23}$	C1	
			$= 2.46 \times 10^5$ J	A1	[3]
3	(a)	(i)	to-and-fro / backward and forward motion (between two limits)	B1	[1]
		(ii)	no energy loss or gain / no external force acting / constant energy / constant amplitude	B1	[1]
		(iii)	acceleration directed towards a fixed point	B1	
			acceleration proportional to distance from the fixed point / displacement	B1	[2]
	(b)		acceleration is constant (magnitude)	M1	
			so cannot be s.h.m.	A1	[2]

4 **(a)**	ability to do work	B1	
	as a result of the position/shape, etc. of an object	B1	[2]
(b) **(i)** **1**	ΔE_{gpe} = *GMm / r*	C1	
	= $(6.67 \times 10^{-11} \times \{2 \times 1.66 \times 10^{-27}\}^2) / (3.8 \times 10^{-15})$	C1	
	= 1.93×10^{-49} J	A1	[3]
2	ΔE_{epe} = $Qq / 4\pi\varepsilon_0 r$	C1	
	= $(1.6 \times 10^{-19})^2 / (4\pi \times 8.85 \times 10^{-12} \times 3.8 \times 10^{-15})$	C1	
	= 6.06×10^{-14} J	A1	[3]
(ii)	idea that $2E_K = \Delta E_{epe} - \Delta E_{gpe}$	B1	
	$E_K = 3.03 \times 10^{-14}$ J		
	= $(3.03 \times 10^{-14}) / 1.6 \times 10^{-13}$	M1	
	= 0.19 MeV	A0	[2]
(iii)	fusion may occur / may break into sub-nuclear particles	B1	[1]
5 **(a)** **(i)**	V_H depends on angle between (plane of) probe and *B*-field	B1	
	either V_H max when plane and *B*-field are normal to each other		
	or V_H zero when plane and *B*-field are parallel		
	or V_H depends on sine of angle between plane and *B*-field	B1	[2]
(ii) **1**	calculates $V_H r$ at least three times	M1	
	to 1 s.f. constant so valid or approx constant so valid		
	or to 2 s.f., not constant so invalid	A1	[2]
2	straight line passes through origin	B1	[1]
(b) **(i)**	e.m.f. induced is proportional / equal to	M1	
	rate of change of (magnetic) flux (linkage)	A1	
	constant field in <u>coil</u> / flux (linkage) of <u>coil</u> does not change	B1	[3]
(ii)	e.g. vary current (in wire) / switch current on or off / use a.c. current		
	rotate coil		
	move coil <u>towards</u> / <u>away</u> from wire (1 mark each, max 3)	B3	[3]
6 **(a)**	all four diodes correct to give output, regardless of polarity	M1	
	connected for correct polarity	A1	[2]
(b)	$N_S / N_P = V_S / V_P$	C1	
	$V_0 = \sqrt{2} \times V_{rms}$	C1	
	ratio = $9.0 / (\sqrt{2} \times 240)$		
	= 1/38 or 1/37 or 0.027	A1	[3]

7	**(a)**		arrow pointing up the page	B1	[1]
	(b)	**(i)**	$Eq = Bqv$	C1	
			$v = (12 \times 10^3) / (930 \times 10^{-6})$	C1	
			$= 1.3 \times 10^7$ m s^{-1}	A1	[3]
		(ii)	$Bqv = mv^2 / r$	C1	
			$q/m = (1.3 \times 10^7) / (7.9 \times 10^{-2} \times 930 \times 10^{-6})$	C1	
			$= 1.8 \times 10^{11}$ C kg^{-1}	A1	[3]
8	**(a)**		momentum conservation hence momenta of photons are equal (but opposite)	M1	
			same momentum so same energy	A1	[2]
	(b)	**(i)**	$(\Delta)E = (\Delta)mc^2$	C1	
			$= 1.2 \times 10^{-28} \times (3.0 \times 10^8)^2$		
			$= 1.08 \times 10^{-11}$ J	A1	[2]
		(ii)	$E = hc / \lambda$		
			$\lambda = (6.63 \times 10^{-34} \times 3.0 \times 10^8) / (1.08 \times 10^{-11})$	C1	
			$= 1.84 \times 10^{-14}$ m	A1	[2]
		(iii)	$\lambda = h / p$		
			$p = (6.63 \times 10^{-34}) / (1.84 \times 10^{-14})$	C1	
			$= 3.6 \times 10^{-20}$ N s	A1	[2]

Section B

9	**(a)**	**(i)**	point X shown correctly	B1	[1]
		(ii)	op-amp has very large / infinite gain	M1	
			non-inverting input is at earth (potential) / earthed / at 0 V	M1	
			if amplifier is not to saturate, inverting input must be (almost) at earth potential / 0 (V) same potential as inverting input	A1	[3]
	(b)	**(i)**	total input resistance = 1.2 kΩ	C1	
			(amplifier) gain (= –4.2 / 1.2) = –3.5	C1	
			(voltmeter) reading = –3.5 × –1.5		
			= 5.25 V	A1	[3]
			(total disregard of signs or incorrect sign in answer, max 2 marks)		
		(ii)	(less bright so) resistance of LDR increases	M1	
			(amplifier) gain decreases	M1	
			(voltmeter) reading decreases	A1	[3]

10	**(a)**	X-ray taken of slice / plane / section	B1	
		repeated at different angles	B1	
		images / data is processed	B1	
		combined / added to give (2-D) image of slice	B1	
		repeated for successive slices	B1	
		to build up a 3-D image	B1	
		image can be viewed from different angles / rotated	B1	
			max 6	[6]

(b) **(i)** 16 — A1 [1]

(ii) evidence of deducting 16 then dividing by 3 — C1
to give — A1 [2]

3	2
6	5

11 **(a)** frequency of <u>carrier</u> wave <u>varies</u> (in synchrony) with signal — M1
(in synchrony) with <u>displacement</u> of signal — A1 [2]

(b) advantages e.g. <u>less</u> noise / <u>less</u> interference
<u>greater</u> bandwidth / better quality
(1 each, max 2)
disadvantages e.g. short range / more transmitters / line of sight
more complex circuitry
greater expense
(1 each, max 2) — B4 [4]

12 **(a)** gain / loss/dB = $10 \lg(P_1/P_2)$ — C1
$190 = 10 \lg(18 \times 10^3 / P_2)$
or $-190 = 10 \lg P_2 / 18 \times 10^3)$ — C1
power = 1.8×10^{-15} W — A1 [3]

(b) **(i)** 11 GHz / 12 GHz — B1 [1]

(ii) e.g. so that input signal to satellite will not be 'swamped'
to avoid interference of uplink with / by downlink — B1 [1]