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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UNIVERSITY of CAMBRIDGE
International Examinations

Section A

1	(a)		angle (subtended) <u>at centre</u> of circle (by) arc equal in length to radius	B1 B1	[2]
	(b)	(i)	point S shown below C	B1	[1]
		(ii)	(max) force / tension = weight + centripetal force centripetal force = $mr\omega^2$ $15 = 3.0/9.8 \times 0.85 \times \omega^2$ $\omega = 7.6$ rad s^{-1}	C1 C1 C1 A1	[4]
2	(a)	(i)	27.2 + 273.15 or 27.2 + 273.2 300.4 K	C1 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 <u>N explained</u> so, $pV = 1/3\ Nm<c^2>$ and $pV = NkT$ with <u>k explained</u> <u>so mean kinetic energy / $<E_K> = ½m<c^2> = 3/2\ kT$</u>	B1 B1 B1 B1	[4]
	(c)	(i)	$pV = nRT$ $2.1 \times 10^7 \times 7.8 \times 10^{-3} = n \times 8.3 \times 290$ $n = 68$ mol	 C1 A1	[2]
		(ii)	mean kinetic energy $= 3/2\ kT$ $= 3/2 \times 1.38 \times 10^{-23} \times 290$ $= 6.0 \times 10^{-21}$ J	 C1 A1	[2]
		(iii)	realisation that total internal energy is the total kinetic energy energy $= 6.0 \times 10^{-21} \times 68 \times 6.02 \times 10^{23}$ $= 2.46 \times 10^5$ J	C1 C1 A1	[3]
3	(a)	(i)	to-and-fro / backward and forward motion (between two limits)	B1	[1]
		(ii)	no energy loss or gain / no <u>external</u> force acting / constant energy / constant amplitude	B1	[1]
		(iii)	acceleration directed towards a fixed point acceleration proportional to <u>distance from the fixed point</u> / displacement	B1 B1	[2]
	(b)		acceleration is constant (magnitude) so cannot be s.h.m.	M1 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	$\Delta E_{gpe} = GMm / r$	C1	
				$= (6.67 \times 10^{-11} \times \{2 \times 1.66 \times 10^{-27}\}^2) / (3.8 \times 10^{-15})$	C1	
				$= 1.93 \times 10^{-49}$ J	A1	[3]
			2	$\Delta E_{epe} = Qq / 4\pi\varepsilon_0 r$	C1	
				$= (1.6 \times 10^{-19})^2 / (4\pi \times 8.85 \times 10^{-12} \times 3.8 \times 10^{-15})$	C1	
				$= 6.06 \times 10^{-14}$ 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	
			$= 1.3 \times 10^7 \text{ m s}^{-1}$	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	
			$= 1.8 \times 10^{11} \text{ C kg}^{-1}$	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	
			$= 1.2 \times 10^{-28} \times (3.0 \times 10^8)^2$		
			$= 1.08 \times 10^{-11} \text{ J}$	A1	[2]
		(ii)	$E = hc / \lambda$		
			$\lambda = (6.63 \times 10^{-34} \times 3.0 \times 10^8) / (1.08 \times 10^{-11})$	C1	
			$= 1.84 \times 10^{-14} \text{ m}$	A1	[2]
		(iii)	$\lambda = h / p$		
			$p = (6.63 \times 10^{-34}) / (1.84 \times 10^{-14})$	C1	
			$= 3.6 \times 10^{-20} \text{ N s}$	A1	[2]

Section B

9	**(a)**	**(i)**	point X shown correctly	B1	[1]
		(ii)	op-amp has <u>very large</u> / 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 carrier wave varies (in synchrony) with signal M1
(in synchrony) with displacement of signal A1 [2]

(b) advantages e.g. less noise / less interference
greater 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 × 10^3 / P_2)
or –190 = 10 lg P_2 / 18 × 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]