UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS

GCE Advanced Subsidiary Level and GCE Advanced Level

MARK SCHEME for the October/November 2011 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)	weight = GMm/r^2	C1	
			= $(6.67 \times 10^{-11} \times 6.42 \times 10^{23} \times 1.40)/(½ \times 6.79 \times 10^6)^2$	C1	
			= 5.20 N	A1	[3]
		(ii)	potential energy = $-GMm/r$	C1	
			= $-(6.67 \times 10^{-11} \times 6.42 \times 10^{23} \times 1.40)/(½ \times 6.79 \times 10^6)$	M1	
			= -1.77×10^7 J	A0	[2]
	(b)	*either*	$½mv^2 = 1.77 \times 10^7$	C1	
			$v^2 = (1.77 \times 10^7 \times 2)/1.40$	C1	
			$v = 5.03 \times 10^3\ \mathrm{m\,s^{-1}}$	A1	
		or	$½mv^2 = GMm/r$	(C1)	
			$v^2 = (2 \times 6.67 \times 10^{-11} \times 6.42 \times 10^{23})/(6.79 \times 10^6/2)$	(C1)	
			$v = 5.02 \times 10^3\ \mathrm{m\,s^{-1}}$	(A1)	[3]
	(c)	(i)	$½ \times 2 \times 1.66 \times 10^{-27} \times (5.03 \times 10^3)^2 = \frac{3}{2} \times 1.38 \times 10^{-23} \times T$	C1	
			T = 2030 K	A1	[2]
		(ii)	*either* because there is a range of speeds	M1	
			some molecules have a higher speed	A1	
			or some escape from point above planet surface	(M1)	
			so initial potential energy is higher	(A1)	[2]
2	(a)		temperature scale calibrated assuming linear change of property with temperature	B1	
			neither property varies linearly with temperature	B1	[2]
	(b)	(i)	does not depend on the property of a substance	B1	[1]
		(ii)	temperature at which atoms have minimum/zero energy	B1	[1]
	(c)	(i)	323.15 K	A1	[1]
		(ii)	30.00 K	A1	[1]

3	**(a)** acceleration proportional to displacement/distance from fixed point	M1	
	and in opposite directions/directed towards fixed point	A1	[2]
	(b) energy $= \frac{1}{2}m\omega^2 x_0^2$ and $\omega = 2\pi f$	C1	
	$= \frac{1}{2} \times 5.8 \times 10^{-3} \times (2\pi \times 4.5)^2 \times (3.0 \times 10^{-3})^2$	C1	
	$= 2.1 \times 10^{-5}$ J	A1	[3]
	(c) **(i)** at maximum displacement	M1	
	above rest position	A1	[2]
	(ii) acceleration $= (-)\omega^2 x_0$ and acceleration $= 9.81$ or g	C1	
	$9.81 = (2\pi \times 4.5)^2 \times x_0$		
	$x_0 = 1.2 \times 10^{-2}$ m	A1	[2]
4	**(a)** e.g. storing energy		
	separating charge		
	blocking d.c.		
	producing electrical oscillations		
	tuning circuits		
	smoothing		
	preventing sparks		
	timing circuits		
	(any two sensible suggestions, 1 each, max 2)	B2	[2]
	(b) **(i)** $-Q$ (induced) on opposite plate of C_1	B1	
	by <u>charge conservation</u>, charges are $-Q$, $+Q$, $-Q$, $+Q$, $-Q$	B1	[2]
	(ii) total p.d. $V = V_1 + V_2 + V_3$	B1	
	$Q/C = Q/C_1 + Q/C_2 + Q/C_3$	B1	
	$1/C = 1/C_1 + 1/C_2 + 1/C_3$	A0	[2]
	(c) **(i)** energy $= \frac{1}{2}CV^2$ or energy $= \frac{1}{2}QV$ and $C = Q/V$	C1	
	$= \frac{1}{2} \times 12 \times 10^{-6} \times 9.0^2$		
	$= 4.9 \times 10^{-4}$ J	A1	[2]
	(ii) energy dissipated in (resistance of) wire/as a spark	B1	[1]

5	**(a)**	supply connected correctly (to left & right)		B1	
		load connected correctly (to top & bottom)		B1	[2]
	(b)	e.g. power supplied on every half-cycle greater <u>average/mean</u> power *(any sensible suggestion, 1 mark)*		B1	[1]
	(c)	**(i)**	reduction in the variation of the output voltage/current	B1	[1]
		(ii)	larger capacitance produces more smoothing	M1	
			either product *RC* larger *or* for the same load	A1	[2]
6	**(a)**	unit of magnetic flux density		B1	
		field normal to (straight) conductor carrying current of 1 A		M1	
		force per unit length is 1 $\mathrm{N\,m^{-1}}$		A1	[3]
	(b)	**(i)**	force on particle always normal to direction of motion (and speed of particle is constant)	M1	
			magnetic force provides the centripetal force	A1	[2]
		(ii)	$mv^2/r = Bqv$	M1	
			$r = mv/Bq$	A0	[1]
	(c)	**(i)**	the momentum/speed is becoming less	M1	
			so the radius is becoming smaller	A1	[2]
		(ii)	**1.** spirals are in opposite directions	M1	
			so oppositely charged	A1	[2]
			2. equal <u>initial</u> radii	M1	
			so equal (initial) speeds	A1	[2]

7 (a) (i) packet/quantum of energy — M1
of electromagnetic radiation — A1 [2]

(ii) <u>minimum</u> energy to cause emission of an electron (from surface) — B1 [1]

(b) (i) $hc/\lambda = \Phi + E_{max}$ — M1
c and h explained — A1 [2]

(ii) 1. *either* when $1/\lambda = 0$, $\Phi = -E_{max}$
or evidence of use of x-axis intercept from graph
or chooses point close to the line and substitutes values of $1/\lambda$ and E_{max} into $hc/\lambda = \Phi + E_{max}$ — C1
$\Phi = 4.0 \times 10^{-19}$ J (allow $\pm 0.2 \times 10^{-19}$ J) — A1 [2]

2. *either* gradient of graph is $1/hc$ — C1
gradient $= 4.80 \times 10^{24} \rightarrow 5.06 \times 10^{24}$ — M1
$h = 1/(\text{gradient} \times 3.0 \times 10^{8})$
$= 6.6 \times 10^{-34}$ J s $\rightarrow$ 6.9×10^{-34} J s — A1
or chooses point close to the line and substitutes values of $1/\lambda$ and E_{max} into $hc/\lambda = \Phi + E_{max}$ — (C1)
values of $1/\lambda$ and E_{max} are correct within half a square — (M1)
$h = 6.6 \times 10^{-34}$ J s $\rightarrow$ 6.9×10^{-34} J s — (A1) [3]
(Allow full credit for the correct use of any appropriate method)
*(Do not allow 'circular' calculations in **part 2** that lead to the same value of Planck constant that was substituted in **part 1**)*

8 (a) (i) probability of decay (of a nucleus) — M1
<u>per</u> unit time — A1 [2]

(ii) $\lambda t_{½} = \ln 2$
$\lambda = \ln 2/(3.82 \times 24 \times 3600)$ — M1
$= 2.1 \times 10^{-6}\ \text{s}^{-1}$ — A0 [1]

(b) $A = \lambda N$ — C1
$200 = 2.1 \times 10^{-6} \times N$ — C1
$N = 9.5 \times 10^{7}$
ratio $= (2.5 \times 10^{25})/(9.5 \times 10^{7})$
$= 2.6 \times 10^{17}$ — A1 [3]

Section B

9	**(a)** any value greater than, or equal to, 5 kΩ	B1	[1]
	(b) **(i)** 'positive' shown in correct position	B1	[1]
	(ii) $V^+ = (500/2200) \times 4.5$		
	$\approx 1\,\text{V}$	B1	
	$V^- > V^+$ so output is negative	M1	
	green LED on, (red LED off)	A1	[3]
	(allow full ecf of incorrect value of V^+)		
	(iii) *either* V^+ increases *or* $V^+ > V^-$	M1	
	green LED off, red LED on	A1	[2]
10	quartz/piezo-electric crystal	B1	
	p.d. across crystal causes *either* centres of (+) and (–) charge to move		
	or crystal to change shape	B1	
	alternating p.d. (in ultrasound frequency range) causes crystal to vibrate	B1	
	crystal cut to produce resonance	B1	
	when crystal made to vibrate by ultrasound wave	M1	
	alternating p.d. produced across the crystal	A1	[6]
11	**(a)** sharpness: ease with which edges of structures can be seen	B1	
	contrast: <u>difference</u> in degree of blackening between structures	B1	[2]
	(b) **(i)** $I = I_0 e^{-\mu x}$	C1	
	$I/I_0 = \exp(-0.20 \times 8)$		
	$= 0.20$	A1	[2]
	(ii) $I/I_0 = \exp(-\mu_1 \times x_1) \times \exp(-\mu_2 \times x_2)$ *(could be three terms)*	C1	
	$I/I_0 = \exp(-0.20 \times 4) \times \exp(-12 \times 4)$	C1	
	$I/I_0 = 6.4 \times 10^{-22}$ or $I/I_0 \approx 0$	A1	[3]
	(c) **(i)** sharpness unknown/no	B1	[1]
	(ii) contrast good/yes *(ecf from **(b)**)*	B1	[1]

12	**(a)**	e.g. <u>carrier</u> frequencies can be re-used (without interference)	(M1)	
		so increased number of handsets can be used	(A1)	
		e.g. lower power transmitters	(M1)	
		so less interference	(A1)	
		e.g. UHF used	(M1)	
		so must be line-of-sight/short handset aerial	(A1)	
		(any two sensible suggestions with explanation, max 4)	B4	[4]
	(b)	computer at cellular exchange	B1	
		monitors the signal power	B1	
		relayed from several base stations	B1	
		switches call to base station with strongest signal	B1	[4]