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

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UNIVERSITY of CAMBRIDGE
International Examinations

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	GCE AS/A LEVEL – October/November 2011	9702	43

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
$v = 5.03 \times 10^3$ 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)
$v = 5.02 \times 10^3$ 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
= 2.1×10^{-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 charge conservation, 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
= $\frac{1}{2} \times 12 \times 10^{-6} \times 9.0^2$
= 4.9×10^{-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 N m ^{1} A1 [3]

(b) **(i)** force on particle always normal to direction of motion M1
(and speed of particle is constant)
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) minimum 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
per unit time A1 [2]

(ii) $\lambda t_{½} = \ln 2$
$\lambda = \ln 2/(3.82 \times 24 \times 3600)$ M1
$= 2.1 \times 10^{-6}$ 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) $V^+ = (500/2200) \times 4.5$
$\approx 1\,V$ — 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. carrier 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]