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

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
$v = 5.03 \times 10^3\ \text{m s}^{-1}$ 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)
$v = 5.02 \times 10^3\ \text{m s}^{-1}$ (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 $\mathrm{N\,m^{-1}}$ 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]