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.

Mark schemes must be read in conjunction with the question papers and the report on the examination.

- Cambridge will not enter into discussions or correspondence in connection with these mark schemes.

Cambridge is publishing the mark schemes for the October/November 2011 question papers for most IGCSE, GCE Advanced Level and Advanced Subsidiary Level syllabuses and some Ordinary Level syllabuses.

## 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 | |
| | = $-1.77 \times 10^7$ 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) | |
| | $v^2 = (2 \times 6.67 \text{ x } 10^{-11} \times 6.42 \times 10^{23})/(6.79 \times 10^6/2)$ | (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 | |
| | | $= 2.1 \times 10^{-5}$ 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<br>separating charge<br>blocking d.c.<br>producing electrical oscillations<br>tuning circuits<br>smoothing<br>preventing sparks<br>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 | |
| | | $= \frac{1}{2} \times 12 \times 10^{-6} \times 9.0^2$ | | |
| | | $= 4.9 \times 10^{-4}$ 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<br>greater <u>average/mean</u> power<br>*(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<br>*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 $\text{N m}^{-1}$ | A1 | [3] |
| | **(b) (i)** | force on particle always normal to direction of motion<br>(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 $\rightarrow 6.9 \times 10^{-34}$ 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 $\rightarrow 6.9 \times 10^{-34}$ 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
$= 2.1 \times 10^{-6}$ 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) × 4.5 | | |
| | | ≈ 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: difference in degree of blackening between structures | B1 | [2] |
| | **(b) (i)** | $I = I_0 e^{-\mu x}$ | C1 | |
| | | $I/I_0$ = exp(–0.20 × 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 × 4) × exp(–12 × 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] |