**CAMBRIDGE INTERNATIONAL EXAMINATIONS**

**GCE Advanced Subsidiary Level and GCE Advanced Level**

# MARK SCHEME for the May/June 2014 series

## 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.

Mark schemes should be read in conjunction with the question paper and the Principal Examiner Report for Teachers.

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## Section A

| | | | | |
|---|---|---|---|---|
| **1** | **(a)** | work done bringing unit mass | M1 | |
| | | from infinity (to the point) | A1 | [2] |
| | **(b)** | $E_P = -m\phi$ | B1 | [1] |
| | **(c)** | $\phi \propto 1/x$ | C1 | |
| | | *either* at $6R$ from centre, potential is $(6.3 \times 10^7)/6$ $(= 1.05 \times 10^7 \text{ J kg}^{-1})$ | | |
| | | <u>and</u> at $5R$ from centre, potential is $(6.3 \times 10^7)/5$ $(= 1.26 \times 10^7 \text{ J kg}^{-1})$ | C1 | |
| | | change in energy $= (1.26 - 1.05) \times 10^7 \times 1.3$ | C1 | |
| | | $= 2.7 \times 10^6$ J | A1 | |
| | | *or* change in potential $= (1/5 - 1/6) \times (6.3 \times 10^7)$ | (C1) | |
| | | change in energy $= (1/5 - 1/6) \times (6.3 \times 10^7) \times 1.3$ | (C1) | |
| | | $= 2.7 \times 10^6$ J | (A1) | [4] |
| **2** | **(a)** | the number of atoms | M1 | |
| | | in 12 g of carbon-12 | A1 | [2] |
| | **(b)** | **(i)** amount = 3.2/40 | | |
| | | = 0.080 mol | A1 | [1] |
| | | **(ii)** $pV = nRT$ | | |
| | | $p \times 210 \times 10^{-6} = 0.080 \times 8.31 \times 310$ | C1 | |
| | | $p = 9.8 \times 10^5$ Pa | A1 | [2] |
| | | *(do not credit if T in °C not K)* | | |
| | | **(iii)** *either* $pV = 1/3 \times Nm \langle c^2 \rangle$ | | |
| | | $N = 0.080 \times 6.02 \times 10^{23}$ $(= 4.82 \times 10^{22})$ | | |
| | | <u>and</u> $m = 40 \times 1.66 \times 10^{-27}$ $(= 6.64 \times 10^{-26})$ | C1 | |
| | | $9.8 \times 10^5 \times 210 \times 10^{-6} = 1/3 \times 4.82 \times 10^{22} \times 6.64 \times 10^{-26} \times \langle c^2 \rangle$ | C1 | |
| | | $\langle c^2 \rangle = 1.93 \times 10^5$ | | |
| | | $c_{RMS} = 440 \text{ m s}^{-1}$ | A1 | [3] |
| | | *or* $Nm = 3.2 \times 10^{-3}$ | (C1) | |
| | | $9.8 \times 10^5 \times 210 \times 10^{-6} = 1/3 \times 3.2 \times 10^{-3} \times \langle c^2 \rangle$ | (C1) | |
| | | $\langle c^2 \rangle = 1.93 \times 10^5$ | | |
| | | $c_{RMS} = 440 \text{ m s}^{-1}$ | (A1) | |
| | | *or* $1/2\, m\langle c^2 \rangle = 3/2\, kT$ | (C1) | |
| | | $1/2 \times 40 \times 1.66 \times 10^{-27} \langle c^2 \rangle = 3/2 \times 1.38 \times 10^{-23} \times 310$ | (C1) | |
| | | $\langle c^2 \rangle = 1.93 \times 10^5$ | | |
| | | $c_{RMS} = 440 \text{ m s}^{-1}$ | (A1) | |
| | | (*if T in °C not K award max 1/3, unless already penalised in* ***(b)(ii)***) | | |

| | | | | |
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| **3** | **(a)** | *either* change in volume = $(1.69 - 1.00 \times 10^{-3})$<br>*or* liquid volume $<<$ volume of vapour | M1 | |
| | | work done = $1.01 \times 10^5 \times 1.69 = 1.71 \times 10^5$ (J) | A1 | [2] |
| | **(b) (i)** | **1.** heating of system/thermal energy supplied to the system | B1 | [1] |
| | | **2.** work done on the system | B1 | [1] |
| | **(ii)** | $\Delta U = (2.26 \times 10^6) - (1.71 \times 10^5)$ | C1 | |
| | | $= 2.09 \times 10^6$ J (*3 s.f. needed*) | A1 | [2] |
| **4** | **(a)** | kinetic (energy)/KE/$E_K$ | B1 | [1] |
| | **(b)** | *either* change in energy = 0.60 mJ<br>*or* <u>max</u> $E$ proportional to (amplitude)$^2$/equivalent numerical working | B1 | |
| | | new amplitude is 1.3 cm | B1 | |
| | | change in amplitude = 0.2 cm | B1 | [3] |
| **5** | **(a)** | graph: straight line at constant potential = $V_0$ from $x = 0$ to $x = r$ | B1 | |
| | | curve with decreasing gradient | M1 | |
| | | passing through $(2r, 0.50V_0)$ and $(4r, 0.25V_0)$ | A1 | [3] |
| | **(b)** | graph: straight line at $E = 0$ from $x = 0$ to $x = r$ | B1 | |
| | | curve with decreasing gradient from $(r, E_0)$ | M1 | |
| | | passing through $(2r, ¼E_0)$<br>(*for 3rd mark line must be drawn to x = 4r and must not touch x-axis*) | A1 | [3] |
| **6** | **(a) (i)** | energy $= EQ$ | C1 | |
| | | $= 9.0 \times 22 \times 10^{-3}$<br>$= 0.20$ J | A1 | [2] |
| | **(ii)** | **1.** $C = Q / V$<br>$V = (22 \times 10^{-3})/(4700 \times 10^{-6})$ | C1 | |
| | | $= 4.7$ V | A1 | [2] |
| | | **2.** *either* $E = ½CV^2$ | C1 | |
| | | $= ½ \times 4700 \times 10^{-6} \times 4.7^2$<br>$= 5.1 \times 10^{-2}$ J | A1 | [2] |
| | | *or* $E = ½QV$ | (C1) | |
| | | $= ½ \times 22 \times 10^{-3} \times 4.7$<br>$= 5.1 \times 10^{-2}$ J | (A1) | |
| | | *or* $E = ½Q^2/C$ | (C1) | |
| | | $= ½ \times (22 \times 10^{-3})^2/4700 \times 10^{-6}$<br>$= 5.1 \times 10^{-2}$ J | (A1) | |

| | | | | |
|---|---|---|---|---|
| | **(b)** | energy lost (as thermal energy) in resistance/wires/battery/resistor<br>*(award only if answer in* ***(a)(i)*** *> answer in* ***(a)(ii)2****)* | B1 | [1] |
| **7** | **(a)** | graph: $V_H$ increases from zero when current switched on<br>$V_H$ then non-zero constant<br>$V_H$ returns to zero when current switched off | B1<br>B1<br>B1 | <br><br>[3] |
| | **(b) (i)** | (induced) e.m.f. proportional to rate<br>of change of (magnetic) flux (linkage) | M1<br>A1 | <br>[2] |
| | **(ii)** | pulse as current is being switched on<br>zero e.m.f. when current in coil<br>pulse in opposite direction when switching off | B1<br>B1<br>B1 | <br><br>[3] |
| **8** | **(a)** | discrete and equal amounts (of charge)<br>*allow: discrete amounts of 1.6 × $10^{-19}$C/elementary charge/e*<br>*integral multiples of 1.6 × $10^{-19}$C/elementary charge/e* | B1 | [1] |
| | **(b)** | weight = $qV/d$<br>$4.8 \times 10^{-14} = (q \times 680)/(7.0 \times 10^{-3})$<br>$q = 4.9 \times 10^{-19}$ C | <br>C1<br>A1 | <br><br>[2] |
| | **(c)** | elementary charge = $1.6 \times 10^{-19}$ C (*allow* $1.6 \times 10^{-19}$ C to $1.7 \times 10^{-19}$ C )<br>*either* the values are (approximately) multiples of this<br>*or* it is a common factor<br>it is the highest common factor | M0<br><br>C1<br>A1 | <br><br><br>[2] |
| **9** | **(a)** | e.g. no time delay between illumination and emission<br>max. (kinetic) energy of electron dependent on frequency<br>max. (kinetic) energy of electron independent of intensity<br>rate of emission of electrons dependent on/proportional to intensity<br>(*any three separate statements, one mark each, maximum 3*) | <br><br><br><br>B3 | <br><br><br><br>[3] |
| | **(b) (i)** | (photon) interaction with electron may be below surface<br>energy required to bring electron to surface | B1<br>B1 | <br>[2] |

| | | | |
|---|---|---|---|
| **(ii)** **1.** threshold frequency = $5.8 \times 10^{14}$ Hz | A1 | [1] |
| **2.** $\Phi = hf_0$ | C1 | |
| $= 6.63 \times 10^{-34} \times 5.8 \times 10^{14}$ | | |
| $= 3.84 \times 10^{-19}$ (J) | C1 | |
| $= (3.84 \times 10^{-19})/(1.6 \times 10^{-19})$ | | |
| $= 2.4$ eV | A1 | [3] |
| *or* | | |
| $hf = \Phi + E_{MAX}$ | (C1) | |
| chooses point on line and substitutes values $E_{MAX}$, $f$ and $h$ into equation with the units of the $hf$ term converted from J to eV | (C1) | |
| $\Phi = 2.4$ eV | (A1) | |

| | | |
|---|---|---|
| **10** **(a)** energy required to separate the nucleons (in a nucleus) | M1 | |
| to infinity | A1 | [2] |
| (*allow reverse statement*) | | |
| **(b)** **(i)** $\Delta m = (2 \times 1.00867) + 1.00728 - 3.01551$ | C1 | |
| $= 9.11 \times 10^{-3}$ u | C1 | |
| binding energy $= 9.11 \times 10^{-3} \times 930$ | | |
| $= 8.47$ MeV | A1 | [3] |
| (*allow 930 to 934 MeV so answer could be in range 8.47 to 8.51 MeV)* | | |
| (*allow 2 s.f.*) | | |
| **(ii)** $\Delta m = 211.70394 - 209.93722$ | | |
| $= 1.76672$ u | C1 | |
| binding energy per nucleon $= (1.76672 \times 930)/210$ | C1 | |
| $= 7.82$ MeV | A1 | [3] |
| (*allow 930 to 934 MeV so answer could be in range 7.82 to 7.86 MeV*) | | |
| (*allow 2 s.f.*) | | |
| **(c)** <u>total</u> binding energy of barium and krypton | M1 | |
| is greater than binding energy of uranium | A1 | [2] |

## Section B

| | | |
|---|---|---|
| **11** **(a)** **(i)** inverting amplifier | B1 | [1] |
| **(ii)** gain is <u>very</u> large/infinite | B1 | |
| $V^+$ is earthed/zero | B1 | |
| for amplifier not to saturate, P must be (almost) earth/zero | B1 | [3] |
| **(b)** **(i)** $R_A = 100$ kΩ | A1 | |
| $R_B = 10$ kΩ | A1 | |
| $V_{IN} = 1000$ mV | A1 | [3] |
| **(ii)** variable range meter | B1 | [1] |

| | | | | |
|---|---|---|---|---|
| **12** | **(a)** | series of X-ray images (for one section/slice) | M1 | |
| | | taken from different angles | M1 | |
| | | to give image of the section/slice | A1 | |
| | | repeated for many slices | M1 | |
| | | to build up three-dimensional image (of whole object) | A1 | [5] |
| | **(b)** | deduction of background from readings | C1 | |
| | | division by three | C1 | |
| | | $P = 5$ $Q = 9$ $R = 7$ $S = 13$ | | |
| | | (four correct 2/2, three correct 1/2) | A2 | [4] |
| **13** | **(a)** | e.g. noise can be eliminated/waveform can be regenerated | | |
| | | extra bits of data can be added to check for errors | | |
| | | cheaper/more reliable | | |
| | | greater <u>rate</u> of transfer of data | | |
| | | (*1 each, max 2*) | B2 | [2] |
| | **(b)** | receives bits all at one time | B1 | |
| | | transmits the bits one after another | B1 | [2] |
| | **(c)** | sampling frequency must be higher than/(at least) twice frequency to be sampled | M1 | |
| | | *either* higher (range of) frequencies reproduced on the disc | | |
| | | *or* lower (range of) frequencies on phone | A1 | |
| | | *either* higher quality (of sound) on disc | | |
| | | *or* high quality (of sound) not required for phone | B1 | [3] |
| **14** | **(a)** | reduction in power (*allow intensity/amplitude*) | B1 | [1] |
| | **(b)** | **(i)** attenuation $= 2.4 \times 30$ | | |
| | | $= 72$ dB | A1 | [1] |
| | | **(ii)** gain/attenuation/dB $= 10 \lg(P_2/P_1)$ | C1 | |
| | | $72 = 10 \lg(P_{IN}/P_{OUT})$ *or* $-72 = 10 \lg(P_{OUT}/P_{IN})$ | C1 | |
| | | ratio $= 1.6 \times 10^7$ | A1 | [3] |
| | **(c)** | e.g. enables smaller/more manageable numbers to be used | | |
| | | e.g. gains in dB for series amplifiers are added, not multiplied | B1 | [1] |