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.

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Section A

1 (a) work done bringing unit mass from infinity (to the point) — M1 A1 [2]

(b) $E_P = -m\phi$ — B1 [1]

(c) $\phi \propto 1/x$ — C1

either at $6R$ from centre, potential is $(6.3 \times 10^7)/6$ $(= 1.05 \times 10^7$ J kg$^{-1})$
and at $5R$ from centre, potential is $(6.3 \times 10^7)/5$ $(= 1.26 \times 10^7$ 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 in 12 g of carbon-12 — M1 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* $pV = 1/3 \times Nm \langle c^2 \rangle$
$N = 0.080 \times 6.02 \times 10^{23}$ $(= 4.82 \times 10^{22})$
and $m = 40 \times 1.66 \times 10^{-27}$ $(= 6.64 \times 10^{-26})$ — 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
$\langle c^2 \rangle = 1.93 \times 10^5$
$c_{RMS} = 440$ 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)
$\langle c^2 \rangle = 1.93 \times 10^5$
$c_{RMS} = 440$ 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)
$\langle c^2 \rangle = 1.93 \times 10^5$
$c_{RMS} = 440$ 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 = $(1.69 - 1.00 \times 10^{-3})$
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
or max 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 $(2r, ¼E_0)$ A1 [3]
(*for 3rd mark line must be drawn to x = 4r and must not touch x-axis*)

6 **(a)** **(i)** energy $= EQ$ C1
$= 9.0 \times 22 \times 10^{-3}$
$= 0.20$ J A1 [2]

(ii) **1.** $C = Q/V$
$V = (22 \times 10^{-3})/(4700 \times 10^{-6})$ C1
$= 4.7$ V A1 [2]

2. *either* $E = ½CV^2$ C1
$= ½ \times 4700 \times 10^{-6} \times 4.7^2$
$= 5.1 \times 10^{-2}$ J A1 [2]

or $E = ½QV$ (C1)
$= ½ \times 22 \times 10^{-3} \times 4.7$
$= 5.1 \times 10^{-2}$ J (A1)

or $E = ½Q^2/C$ (C1)
$= ½ \times (22 \times 10^{-3})^2/4700 \times 10^{-6}$
$= 5.1 \times 10^{-2}$ J (A1)

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(b) energy lost (as thermal energy) in resistance/wires/battery/resistor B1 [1]
*(award only if answer in **(a)(i)** > answer in **(a)(ii)2**)*

7 **(a)** graph: V_H increases from zero when current switched on B1
V_H then non-zero constant B1
V_H returns to zero when current switched off B1 [3]

(b) **(i)** (induced) e.m.f. proportional to rate M1
of change of (magnetic) flux (linkage) A1 [2]

(ii) pulse as current is being switched on B1
zero e.m.f. when current in coil B1
pulse in opposite direction when switching off B1 [3]

8 **(a)** discrete and equal amounts (of charge) B1 [1]
allow: discrete amounts of 1.6 × 10^{-19}C/elementary charge/e
integral multiples of 1.6 × 10^{-19}C/elementary charge/e

(b) weight = qV/d
$4.8 \times 10^{-14} = (q \times 680)/(7.0 \times 10^{-3})$ C1
$q = 4.9 \times 10^{-19}$ C A1 [2]

(c) elementary charge = 1.6×10^{-19} C (*allow* 1.6×10^{-19} C to 1.7×10^{-19} C) M0
either the values are (approximately) multiples of this
or it is a common factor C1
it is the highest common factor A1 [2]

9 **(a)** e.g. no time delay between illumination and emission
max. (kinetic) energy of electron dependent on frequency
max. (kinetic) energy of electron independent of intensity
rate of emission of electrons dependent on/proportional to intensity
(*any three separate statements, one mark each, maximum 3*) B3 [3]

(b) **(i)** (photon) interaction with electron may be below surface B1
energy required to bring electron to surface B1 [2]

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(ii) **1.** threshold frequency = 5.8×10^{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]

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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 rate 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 = 2.4×30
= 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 = 1.6×10^7 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]

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