MARK SCHEME for the May/June 2014 series

9702 PHYSICS

9702/43   Paper 4 (A2 Structured Questions), maximum raw mark 100

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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 $(6.3 \times 10^7)/6$ $(= 1.05 \times 10^7$ J kg$^{-1})$
<u>and</u> 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   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
$\langle c^2 \rangle = 1.93 \times 10^5$
$c_{RMS} = 440$ 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))

3 **(a)** *either* change in volume = $(1.69 - 1.00 \times 10^{-3})$
    or   liquid volume $\ll$ 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   **B1**
    or   <u>max</u> E proportional to $(\text{amplitude})^2$/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)**

(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]

(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]

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 × 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]