

**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

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Page 2	Mark Scheme	Syllabus	Paper
	GCE AS/A LEVEL – May/June 2014	9702	41

### 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  $(6.3 \times 10^7)/6$  ( $= 1.05 \times 10^7 \text{ J kg}^{-1}$ )  
and 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  
=  $2.7 \times 10^6 \text{ J}$  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)  
=  $2.7 \times 10^6 \text{ J}$  (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  
 $p = 9.8 \times 10^5 \text{ Pa}$  A1 [2]  
(do not credit if  $T$  in  $^{\circ}\text{C}$  not  $\text{K}$ )
- (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  
 $\langle c^2 \rangle = 1.93 \times 10^5$   
 $c_{\text{RMS}} = 440 \text{ m s}^{-1}$  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)  
 $\langle c^2 \rangle = 1.93 \times 10^5$   
 $c_{\text{RMS}} = 440 \text{ m s}^{-1}$  (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)  
 $\langle c^2 \rangle = 1.93 \times 10^5$   
 $c_{\text{RMS}} = 440 \text{ m s}^{-1}$  (A1)
- (if  $T$  in  $^{\circ}\text{C}$  not  $\text{K}$  award max 1/3, unless already penalised in (b)(ii))

Page 3	Mark Scheme	Syllabus	Paper
	GCE AS/A LEVEL – May/June 2014	9702	41

- 3 (a) *either* change in volume =  $(1.69 - 1.00 \times 10^{-3})$   
*or* liquid volume  $\ll$  volume of vapour  
work done =  $1.01 \times 10^5 \times 1.69 = 1.71 \times 10^5$  (J) M1  
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)<sup>2</sup>/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  $(2r, \frac{1}{4}E_0)$  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*  $E = \frac{1}{2}CV^2$  C1  
=  $\frac{1}{2} \times 4700 \times 10^{-6} \times 4.7^2$   
=  $5.1 \times 10^{-2}$  J A1 [2]
- or*  $E = \frac{1}{2}QV$  (C1)  
=  $\frac{1}{2} \times 22 \times 10^{-3} \times 4.7$   
=  $5.1 \times 10^{-2}$  J (A1)
- or*  $E = \frac{1}{2}Q^2/C$  (C1)  
=  $\frac{1}{2} \times (22 \times 10^{-3})^2/4700 \times 10^{-6}$   
=  $5.1 \times 10^{-2}$  J (A1)

Page 4	Mark Scheme	Syllabus	Paper
	GCE AS/A LEVEL – May/June 2014	9702	41

- (b) energy lost (as thermal energy) in resistance/wires/battery/resistor  
(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  
 $V_H$  then non-zero constant  
 $V_H$  returns to zero when current switched off B1  
B1  
B1 [3]
- (b) (i) (induced) e.m.f. proportional to rate  
of change of (magnetic) flux (linkage) M1  
A1 [2]
- (ii) pulse as current is being switched on  
zero e.m.f. when current in coil  
pulse in opposite direction when switching off B1  
B1  
B1 [3]
- 8 (a) discrete and equal amounts (of charge)  
allow: discrete amounts of  $1.6 \times 10^{-19} \text{C}$ /elementary charge/e  
integral multiples of  $1.6 \times 10^{-19} \text{C}$ /elementary charge/e B1 [1]
- (b) weight =  $qV/d$   
 $4.8 \times 10^{-14} = (q \times 680)/(7.0 \times 10^{-3})$   
 $q = 4.9 \times 10^{-19} \text{C}$  C1  
A1 [2]
- (c) elementary charge =  $1.6 \times 10^{-19} \text{C}$  (allow  $1.6 \times 10^{-19} \text{C}$  to  $1.7 \times 10^{-19} \text{C}$ )  
either the values are (approximately) multiples of this  
or it is a common factor  
it is the highest common factor M0  
C1  
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  
energy required to bring electron to surface B1  
B1 [2]

Page 5	Mark Scheme	Syllabus	Paper
	GCE AS/A LEVEL – May/June 2014	9702	41

- (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) total 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 very large/infinite B1  
 $V^+$  is earthed/zero B1  
for amplifier not to saturate, P must be (almost) earth/zero B1 [3]
- (b) (i)  $R_A = 100$  k $\Omega$  A1  
 $R_B = 10$  k $\Omega$  A1  
 $V_{IN} = 1000$  mV A1 [3]
- (ii) variable range meter B1 [1]

Page 6	Mark Scheme	Syllabus	Paper
	GCE AS/A LEVEL – May/June 2014	9702	41

- 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
- $P = 5 \quad Q = 9 \quad R = 7 \quad S = 13$
- (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 =  $2.4 \times 30$   
 = 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]