

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.

Cambridge will not enter into discussions about these mark schemes.

Cambridge is publishing the mark schemes for the May/June 2014 series for most IGCSE, GCE Advanced Level and Advanced Subsidiary Level components and some Ordinary Level components.

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 $= 3.2/40$
 $= 0.080 \text{ mol}$ 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 °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
 $\langle c^2 \rangle = 1.93 \times 10^5$
 $c_{\text{RMS}} = 440 \text{ m s}^{-1}$ 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 °C not 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)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 $(2r, \frac{1}{4}E_0)$ 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 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 $1.6 \times 10^{-19} \text{ C/elementary charge/e}$
integral multiples of $1.6 \times 10^{-19} \text{ C/elementary charge/e}$
- (b) weight = qV/d
 $4.8 \times 10^{-14} = (q \times 680)/(7.0 \times 10^{-3})$ C1
 $q = 4.9 \times 10^{-19} \text{ C}$ A1 [2]
- (c) elementary charge = $1.6 \times 10^{-19} \text{ C}$ (allow $1.6 \times 10^{-19} \text{ C}$ to $1.7 \times 10^{-19} \text{ C}$) 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]

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

(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

$hf = \Phi + E_{\text{MAX}}$ (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 Ω A1
 $R_B = 10$ k Ω A1
 $V_{\text{IN}} = 1000$ 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 = 2.4×30
= 72 dB A1 [1]
- (ii)** gain/attenuation/dB = $10 \lg(P_2/P_1)$ C1
 $72 = 10 \lg(P_{\text{IN}}/P_{\text{OUT}})$ or $-72 = 10 \lg(P_{\text{OUT}}/P_{\text{IN}})$ 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]

CAMBRIDGE INTERNATIONAL EXAMINATIONS

GCE Advanced Level

MARK SCHEME for the May/June 2014 series

9702 PHYSICS

9702/42

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.

Cambridge will not enter into discussions about these mark schemes.

Cambridge is publishing the mark schemes for the May/June 2014 series for most IGCSE, GCE Advanced Level and Advanced Subsidiary Level components and some Ordinary Level components.

Page 2	Mark Scheme	Syllabus	Paper
	GCE A LEVEL – May/June 2014	9702	42

Section A

- 1 (a) gravitational force provides/is the centripetal force
 $GMm/r^2 = mv^2/r$
 $v = \sqrt{GM/r}$
 allow gravitational field strength provides/is the centripetal acceleration
 $GM/r^2 = v^2/r$
 (B1)
 (M1)
 A0 [2]
- (b) (i) kinetic energy increase/change = loss/change in (gravitational) potential energy
 $\frac{1}{2}mV_0^2 = GMm/x$
 $V_0^2 = 2GM/x$
 $V_0 = \sqrt{2GM/x}$
 (max. 2 for use of r not x)
 (ii) V_0 is (always) greater than v (for $x = r$)
 so stone could not enter into orbit
 (expressions in (a) and (b)(i) must be dimensionally correct)
 B1
 C1
 A1 [3]
- 2 (a) use of kelvin temperatures
 both values of (V/T) correct (11.87), V/T is constant so pressure is constant
 (allow use of $n = 1$. Do not allow other values of n .)
 B1
 M1 [2]
- (b) (i) work done = $p\Delta V$
 $= 4.2 \times 10^5 \times (3.87 - 3.49) \times 10^3 \times 10^{-6}$
 $= 160 \text{ J}$
 (do not allow use of V instead of ΔV)
 C1
 A1 [2]
- (ii) increase/change in internal energy = heating of system
 + work done on system
 $= 565 - 160$
 $= 405 \text{ J}$
 C1
 A1 [2]
- (c) internal energy = sum of kinetic energy and potential energy / $E_k + E_p$
 no intermolecular forces
 no potential energy (so $\Delta U = \Delta E_k$)
 B1
 M1
 A1 [3]
- 3 (a) resonance
 B1 [1]
- (b) $Pt = mc \Delta \theta$
 $750 \times 2 \times 60 = 0.28 \times c \times (98 - 25)$
 $c = 4400 \text{ J kg}^{-1} \text{ K}^{-1}$
 (use of $\Delta \theta = 73 + 273$ max. 1/3)
 (use of $t = 2 \text{ s}$ not 120 s max. 2/3)
 C1
 C1
 A1 [3]

Page 3	Mark Scheme	Syllabus	Paper
	GCE A LEVEL – May/June 2014	9702	42

- (c) e.g. some microwave leakage from the cooker
e.g. container for the water is also heated
(any sensible suggestion) B1 [1]
- 4 (a) (i) $F_E = Q_1 Q_2 / 4\pi\epsilon_0 r^2$
 $= 8.99 \times 10^9 \times (1.6 \times 10^{-19})^2 / (2.0 \times 10^{-15})^2$
 $= 58 \text{ N}$ C1
A1 [2]
- (ii) $F_G = Gm_1 m_2 / r^2$
 $= 6.67 \times 10^{-11} \times (1.67 \times 10^{-27})^2 / (2.0 \times 10^{-15})^2$
 $= 4.7 \times 10^{-35} \text{ N}$ C1
A1 [2]
- (b) (i) force of repulsion (much) greater than force of attraction
must be some other force of attraction
to hold nucleus together B1
M1
A1 [3]
- (Do not allow if $F_G > F_E$ in (a) or one of the forces not calculated in (a))
- (ii) outside nucleus there is repulsion between protons B1
either attractive force must act only in nucleus
or if not short range, all nuclei would stick together B1 [2]
- 5 (a) only curve with decreasing gradient M1
acceptable value near $x = 0$ and does not reach zero A1 [2]
- (if graph line less than 4.0 cm do not allow A1 mark)
(no credit if graph line has positive and negative values of V_H)
- (b) graph: from 0 to $2T$, two cycles of a sinusoidal wave M1
all peaks above 3.5 mV C1
peaks at 4.95/5.0 mV (allow 4.8 mV to 5.2 mV) A1 [3]
- (c) e.m.f. induced in coil when magnetic field / flux is changing / cutting B1
- either at each position, magnetic field does not vary
so no e.m.f. is induced in the coil / no reading on the millivoltmeter
or at each position, switch off current and take millivoltmeter reading
or at each position, rapidly remove coil from field and take meter reading B1 [2]
- 6 (a) electric and magnetic fields normal to each other B1
- either charged particle enters region normal to both fields
or correct B direction w.r.t. E for zero deflection B1
for no deflection, $v = E/B$ B1 [3]
- (no credit if magnetic field region clearly not overlapping with electric field region)

Page 4	Mark Scheme	Syllabus	Paper
	GCE A LEVEL – May/June 2014	9702	42

- (b) (i) $m = Bqr/v$ C1
 $= (640 \times 10^{-3} \times 1.6 \times 10^{-19} \times 6.2 \times 10^{-2}) / (9.6 \times 10^4)$ C1
 $= 6.61 \times 10^{-26} \text{ kg}$ C1
 $= (6.61 \times 10^{-26}) / (1.66 \times 10^{-27}) \text{ u}$
 $= 40 \text{ u}$ A1 [4]
- (ii) $q/m \propto 1/r$ or m constant and $q \propto 1/r$ B1
 q/m for A is twice that for B B1
ions in path A have (same mass but) twice the charge (of ions in path B) B1 [3]
- 7 (a) angle subtended at the centre of a circle B1
by an arc equal in length to the radius B1 [2]
- (b) (i) arc = distance $\times$ angle C1
diameter $= 3.8 \times 10^5 \times 9.7 \times 10^{-6}$
 $= 3.7 \text{ km}$ A1 [2]
- (ii) Mars is (much) further from Earth/away (*answer must be comparative*) B1
angle (at telescope is much) smaller B1 [2]
- 8 (a) photon energy $= hc/\lambda$
 $= (6.63 \times 10^{-34} \times 3.0 \times 10^8) / (590 \times 10^{-9})$ C1
 $= 3.37 \times 10^{-19} \text{ J}$ C1
- number $= (3.2 \times 10^{-3}) / (3.37 \times 10^{-19})$
 $= 9.5 \times 10^{15}$ (allow 9.4×10^{15}) A1 [3]
- (b) (i) $p = h/\lambda$ C1
 $= (6.63 \times 10^{-34}) / (590 \times 10^{-9})$
 $= 1.12 \times 10^{-27} \text{ kg ms}^{-1}$ C1
- total momentum $= 9.5 \times 10^{15} \times 1.12 \times 10^{-27}$
 $= 1.06 \times 10^{-11} \text{ kg ms}^{-1}$ A1 [3]
- (ii) force $= 1.06 \times 10^{-11} \text{ N}$ A1 [1]
- 9 (a) time for number of atoms/nuclei/activity (of the isotope) M1
to be reduced to one half (of its initial value) A1 [2]
- (b) (i) $A = \lambda N$ C1
 $460 = N \times \ln 2 / (8.1 \times 24 \times 60 \times 60)$ C1
 $N = 4.6 \times 10^8$ A1 [3]
- (ii) number of water molecules in 1.0 kg $= (6.02 \times 10^{23}) / (18 \times 10^{-3})$ C1
 $= 3.3 \times 10^{25}$
- ratio $= (3.3 \times 10^{25}) / (4.6 \times 10^8)$
 $= 7.2$ (7.3) $\times 10^{16}$ A1 [2]

Page 5	Mark Scheme	Syllabus	Paper
	GCE A LEVEL – May/June 2014	9702	42

- (c) $A = A_0 e^{-\lambda t}$ and $\lambda t_{1/2} = \ln 2$ C1
 $170 = 460 \exp(-\{\ln 2\}/8.1)$ C1
 $t = 11.6$ days (allow 2 s.f.) A1 [3]

Section B

- 10 (a) compares the potentials/voltages at the (inverting and non-inverting) inputs B1
either output (potential) dependent on which input is the larger
or $V^+ > V^-$, then V_{OUT} is positive B1
states the other condition B1 [3]
- (b) (i) ring drawn around both the LEDs (and series resistors) B1 [1]
- (ii) $V^- = (1.5 \times 2.4)/(1.2 + 2.4) = 1.0 \text{ V}$ B1 [1]
(allow $1.5 \times 2.4/3.6 = 1.0 \text{ V}$)
- (iii) 1. V_{OUT} switches at $+1.0 \text{ V}$ B1
maximum V_{OUT} is 5.0 V B1
when curve is above $+1.0 \text{ V}$, V_{OUT} is negative (or v.v.) B1 [3]
2. at time t_1 , diode R is emitting light, diode G is not emitting B1
at time t_2 , diode R is not emitting, diode G is emitting B1 [2]
(must be consistent with graph line. If no graph line then 0/2)
- 11 (a) X-ray: flat/shadow/2D image B1
regardless of depth of object/depth not indicated B1
- CT scan: built up from (many) images at different angles B1
image is three-dimensional B1
image can be rotated/viewed at different angles B1 [5]
- (b) (i) $I = I_0 e^{-\mu x}$ C1
 $0.25 = e^{-0.69x}$
 $x = 2.0 \text{ mm}$ (allow 1 s.f.) A1 [2]
- (ii) for aluminium, $I/I_0 = e^{-0.46 \times 2.4}$
 $= 0.33$ C1
fraction $= 0.33 \times 0.25$
 $= 0.083$ A1 [2]
- (iii) gain/dB $= 10 \lg(I/I_0)$ C1
 $= 10 \lg(0.083)$
 $= (-) 10.8 \text{ dB}$ (allow 2 s.f.) A1
with negative sign B1 [3]
- 12 (a) (i) satellite is in equatorial orbit B1
travelling from west to east B1
period of 24 hours/1 day B1 [3]

Page 6	Mark Scheme	Syllabus	Paper
	GCE A LEVEL – May/June 2014	9702	42

- (ii) *either* uplink signal is highly attenuated B1
or signal is highly amplified (before transmission) as downlink signal B1 [2]
prevents downlink signal swamping the uplink signal
- (b) speed of signal is same order of magnitude in both systems B1
optic fibre link (much) shorter than via satellite M1
time delay using optic fibre is less A1 [3]

MARK SCHEME for the May/June 2014 series

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

Cambridge will not enter into discussions about these mark schemes.

Cambridge is publishing the mark schemes for the May/June 2014 series for most IGCSE, GCE Advanced Level and Advanced Subsidiary Level components and some Ordinary Level components.

Page 2	Mark Scheme	Syllabus	Paper
	GCE AS/A LEVEL – May/June 2014	9702	43

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 $= 3.2/40$
 $= 0.080 \text{ mol}$ 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 °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
 $\langle c^2 \rangle = 1.93 \times 10^5$
 $c_{\text{RMS}} = 440 \text{ m s}^{-1}$ 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 °C not 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	43

- 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)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 $(2r, \frac{1}{4}E_0)$ 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	43

- (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 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 $1.6 \times 10^{-19} \text{ C/elementary charge/e}$
integral multiples of $1.6 \times 10^{-19} \text{ C/elementary charge/e}$
- (b) weight = qV/d
 $4.8 \times 10^{-14} = (q \times 680)/(7.0 \times 10^{-3})$ C1
 $q = 4.9 \times 10^{-19} \text{ C}$ A1 [2]
- (c) elementary charge = $1.6 \times 10^{-19} \text{ C}$ (allow $1.6 \times 10^{-19} \text{ C}$ to $1.7 \times 10^{-19} \text{ C}$) 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]

Page 5	Mark Scheme	Syllabus	Paper
	GCE AS/A LEVEL – May/June 2014	9702	43

(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

$hf = \Phi + E_{\text{MAX}}$ (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 Ω A1
 $R_B = 10$ k Ω A1
 $V_{\text{IN}} = 1000$ mV A1 [3]

(ii) variable range meter B1 [1]

Page 6	Mark Scheme	Syllabus	Paper
	GCE AS/A LEVEL – May/June 2014	9702	43

- 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 = 2.4×30
 = 72 dB A1 [1]
- (ii)** gain/attenuation/dB = $10 \lg(P_2/P_1)$ C1
 $72 = 10 \lg(P_{\text{IN}}/P_{\text{OUT}})$ or $-72 = 10 \lg(P_{\text{OUT}}/P_{\text{IN}})$ 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]