

MARK SCHEME for the May/June 2012 question paper
for the guidance of teachers

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 must be read in conjunction with the question papers and the report on the examination.

- Cambridge will not enter into discussions or correspondence in connection with these mark schemes.

Cambridge is publishing the mark schemes for the May/June 2012 question papers for most IGCSE, GCE Advanced Level and Advanced Subsidiary Level syllabuses and some Ordinary Level syllabuses.



Page 2	Mark Scheme: Teachers' version	Syllabus	Paper
	GCE AS/A LEVEL – May/June 2012	9702	41

Section A

- 1 (a) work done in bringing unit mass from infinity (to the point) B1 [1]
- (b) gravitational force is (always) attractive B1
either as r decreases, object/mass/body does work
or work is done by masses as they come together B1 [2]
- (c) *either* force on mass = mg (where g is the acceleration of free fall /gravitational field strength) B1
 $g = GM/r^2$ B1
if $r \approx h$, g is constant B1
 $\Delta E_P = \text{force} \times \text{distance moved}$ M1
 $= mgh$ A0
or $\Delta E_P = m\Delta\phi$ (C1)
 $= GMm(1/r_1 - 1/r_2) = GMm(r_2 - r_1)/r_1r_2$ (B1)
if $r_2 \approx r_1$, then $(r_2 - r_1) = h$ and $r_1r_2 = r^2$ (B1)
 $g = GM/r^2$ (B1)
 $\Delta E_P = mgh$ (A0) [4]
- (d) $\frac{1}{2}mv^2 = m\Delta\phi$
 $v^2 = 2 \times GM/r$ C1
 $= (2 \times 4.3 \times 10^{13}) / (3.4 \times 10^6)$ C1
 $v = 5.0 \times 10^3 \text{ m s}^{-1}$ A1 [3]
(Use of diameter instead of radius to give $v = 3.6 \times 10^3 \text{ m s}^{-1}$ scores 2 marks)
- 2 (a) (i) *either* random motion
or constant velocity until hits wall/other molecule B1 [1]
- (ii) (total) volume of molecules is negligible M1
compared to volume of containing vessel A1
or
radius/diameter of a molecule is negligible (M1)
compared to the average intermolecular distance (A1) [2]
- (b) *either* molecule has component of velocity in three directions
or $c^2 = c_x^2 + c_y^2 + c_z^2$ M1
random motion and averaging, so $\langle c_x^2 \rangle = \langle c_y^2 \rangle = \langle c_z^2 \rangle$ M1
 $\langle c^2 \rangle = 3\langle c_x^2 \rangle$ A1
so, $pV = \frac{1}{3}Nm\langle c^2 \rangle$ A0 [3]
- (c) $\langle c^2 \rangle \propto T$ or $c_{\text{rms}} \propto \sqrt{T}$ C1
temperatures are 300 K and 373 K C1
 $c_{\text{rms}} = 580 \text{ m s}^{-1}$ A1 [3]
(Do not allow any marks for use of temperature in units of °C instead of K)

Page 3	Mark Scheme: Teachers' version	Syllabus	Paper
	GCE AS/A LEVEL – May/June 2012	9702	41

- 3 (a) (numerically equal to) quantity of (thermal) energy required to change the state of unit mass of a substance without any change of temperature
(Allow 1 mark for definition of specific latent heat of fusion/vaporisation)
- M1
A1 [2]
- (b) either energy supplied = $2400 \times 2 \times 60 = 288000 \text{ J}$
energy required for evaporation = $106 \times 2260 = 240000 \text{ J}$
difference = 48000 J
rate of loss = $48000 / 120 = 400 \text{ W}$
or energy required for evaporation = $106 \times 2260 = 240000 \text{ J}$
power required for evaporation = $240000 / (2 \times 60) = 2000 \text{ W}$
rate of loss = $2400 - 2000 = 400 \text{ W}$
- C1
C1
A1
(C1)
(C1)
(A1) [3]
- 4 (a) $a = (-)\omega^2 x$ and $\omega = 2\pi/T$
 $T = 0.60 \text{ s}$
 $a = (4\pi^2 \times 2.0 \times 10^{-2}) / (0.6)^2$
 $= 2.2 \text{ ms}^{-2}$
- C1
C1
A1 [3]
- (b) sinusoidal wave with all values positive
all values positive, all peaks at E_K and energy = 0 at $t = 0$
period = 0.30 s
- B1
B1
B1 [3]
- 5 (a) force per unit positive charge acting on a stationary charge
- B1 [1]
- (b) (i) $E = Q / 4\pi\epsilon_0 r^2$
 $Q = 1.8 \times 10^4 \times 10^2 \times 4\pi \times 8.85 \times 10^{-12} \times (25 \times 10^{-2})^2$
 $Q = 1.25 \times 10^{-5} \text{ C} = 12.5 \mu\text{C}$
- C1
M1
A0 [2]
- (ii) $V = Q / 4\pi\epsilon_0 r$
 $= (1.25 \times 10^{-5}) / (4\pi \times 8.85 \times 10^{-12} \times 25 \times 10^{-2})$
 $= 4.5 \times 10^5 \text{ V}$
(Do not allow use of $V = Er$ unless explained)
- C1
A1 [2]

Page 4	Mark Scheme: Teachers' version	Syllabus	Paper
	GCE AS/A LEVEL – May/June 2012	9702	41

- 6 (a) (i) peak voltage = 4.0 V A1 [1]
- (ii) r.m.s. voltage ($= 4.0/\sqrt{2} = 2.8$ V) A1 [1]
- (iii) period $T = 20$ ms M1
frequency = $1 / (20 \times 10^{-3})$ M1
frequency = 50 Hz A0 [2]
- (b) (i) change = $4.0 - 2.4 = 1.6$ V A1 [1]
- (ii) $\Delta Q = C\Delta V$ or $Q = CV$ C1
 $= 5.0 \times 10^{-6} \times 1.6 = 8.0 \times 10^{-6}$ C A1 [2]
- (iii) discharge time = 7 ms C1
current = $(8.0 \times 10^{-6}) / (7.0 \times 10^{-3})$ M1
 $= 1.1(4) \times 10^{-3}$ A A0 [2]
- (c) average p.d. = 3.2 V C1
resistance = $3.2 / (1.1 \times 10^{-3})$
 $= 2900 \Omega$ (allow 2800 Ω) A1 [2]
- 7 (a) sketch: concentric circles (*minimum of 3 circles*) M1
separation increasing with distance from wire A1
correct direction B1 [3]
- (b) (i) arrow direction from wire B towards wire A B1 [1]
- (ii) *either* reference to Newton's third law M1
or force on each wire proportional to product of the two currents A1
so forces are equal [2]
- (c) force always towards wire A/always in same direction B1
varies from zero (to a maximum value) (1)
variation is sinusoidal / $\sin^2$ (1)
(at) twice frequency of current (1)
(*any two, one each*) B2 [3]
- 8 (a) packet/quantum/discrete amount of energy M1
of electromagnetic radiation A1
(allow 1 mark for 'packet of electromagnetic radiation')
energy = Planck constant $\times$ frequency (*seen here or in b*) B1 [3]
- (b) each (coloured) line corresponds to one wavelength/frequency B1
energy = Planck constant $\times$ frequency
implies specific energy change between energy levels B1
so discrete levels A0 [2]

Page 5	Mark Scheme: Teachers' version	Syllabus	Paper
	GCE AS/A LEVEL – May/June 2012	9702	41

- 9 (a) (i) *either* probability of decay (of a nucleus) per unit time M1
or $\lambda = (-)(dN/dt) / N$ A1 [2]
 $(-)(dN/dt)$ and N explained (M1)
(A1)
- (ii) in time $t_{1/2}$, number of nuclei changes from N_0 to $\frac{1}{2}N_0$ B1
 $\frac{1}{2} = \exp(-\lambda t_{1/2})$ *or* $2 = \exp(\lambda t_{1/2})$ B1
 $\ln(\frac{1}{2}) = -\lambda t_{1/2}$ and $\ln(\frac{1}{2}) = -0.693$ *or* $\ln 2 = \lambda t_{1/2}$ and $\ln 2 = 0.693$ B1
 $0.693 = \lambda t_{1/2}$ A0 [3]
- (b) $228 = 538 \exp(-8\lambda)$ C1
 $\lambda = 0.107 \text{ (hours}^{-1}\text{)}$ C1
 $t_{1/2} = 6.5 \text{ hours (do not allow 3 or more SF)}$ A1 [3]
- (c) e.g. random nature of decay
background radiation
daughter product is radioactive
(any two sensible suggestions, 1 each) B2 [2]

Page 6	Mark Scheme: Teachers' version	Syllabus	Paper
	GCE AS/A LEVEL – May/June 2012	9702	41

Section B

- 10 (a)** light-dependent resistor (allow LDR) B1 [1]
- (b) (i)** two resistors in series between +5 V line and earth
midpoint connected to inverting input of op-amp M1 A1 [2]
- (ii)** relay coil between diode and earth
switch between lamp and earth M1 A1 [2]
- (c) (i)** switch on/off mains supply using a low voltage/current output
(allow 'isolates circuit from mains supply') B1 [1]
- (ii)** relay will switch on for one polarity of output (voltage)
switches on when output (voltage) is negative C1 A1 [2]
- 11 (a) (i)** e.m. radiation produced whenever charged particle is accelerated
electrons hitting target have distribution of accelerations M1 A1 [2]
- (ii)** *either* wavelength shorter/shortest for greater/greatest acceleration
or $\lambda_{\min} = hc/E_{\max}$
or minimum wavelength for maximum energy B1
all electron energy given up in one collision/converted to single photon B1 [2]
- (b) (i)** hardness measures the penetration of the beam
greater hardness, greater penetration C1 A1 [2]
- (ii)** controlled by changing the anode voltage
higher anode voltage, greater penetration/hardness C1 A1 [2]
- (c) (i)** long-wavelength radiation more likely to be absorbed in the body/less
likely to penetrate through body B1 [1]
- (ii)** (aluminium) filter/metal foil placed in the X-ray beam B1 [1]
- 12 (a)** strong uniform (magnetic) field M1
either aligns nuclei
or gives rise to Larmor/resonant frequency in r.f. region A1
non-uniform (magnetic) field M1
either enables nuclei to be located
or changes the Larmor/resonant frequency A1 [4]
- (b) (i)** difference in flux density = $2.0 \times 10^{-2} \times 3.0 \times 10^{-3} = 6.0 \times 10^{-5} \text{ T}$ A1 [1]
- (ii)** $\Delta f = 2 \times c \times \Delta B$ C1
 $= 2 \times 1.34 \times 10^8 \times 6.0 \times 10^{-5}$
 $= 1.6 \times 10^4 \text{ Hz}$ A1 [2]

Page 7	Mark Scheme: Teachers' version	Syllabus	Paper
	GCE AS/A LEVEL – May/June 2012	9702	41

- 13 (a) (i)** no interference (between signals) near boundaries (of cells) B1 [1]
- (ii)** for large area, signal strength would have to be greater and this could be hazardous to health B1 [1]
- (b)** mobile phone is sending out an (identifying) signal M1
computer/cellular exchange continuously selects cell/base station
with strongest signal A1
computer/cellular exchange allocates (carrier) frequency (and slot) A1 [3]

MARK SCHEME for the May/June 2012 question paper
for the guidance of teachers

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 must be read in conjunction with the question papers and the report on the examination.

- Cambridge will not enter into discussions or correspondence in connection with these mark schemes.

Cambridge is publishing the mark schemes for the May/June 2012 question papers for most IGCSE, GCE Advanced Level and Advanced Subsidiary Level syllabuses and some Ordinary Level syllabuses.



Page 2	Mark Scheme: Teachers' version	Syllabus	Paper
	GCE AS/A LEVEL – May/June 2012	9702	42

Section A

- 1 (a) force proportional to product of masses and inversely proportional to
square of separation (*do not allow square of distance/radius*) M1
either point masses *or* separation @ size of masses A1 [2]
- (b) (i) $\omega = 2\pi / (27.3 \times 24 \times 3600)$ *or* $2\pi / (2.36 \times 10^6)$ M1
 $= 2.66 \times 10^{-6} \text{ rad s}^{-1}$ A0 [1]
- (ii) $GM = r^3 \omega^2$ *or* $GM = v^2 r$ C1
 $M = (3.84 \times 10^5 \times 10^3)^3 \times (2.66 \times 10^{-6})^2 / (6.67 \times 10^{-11})$ M1
 $= 6.0 \times 10^{24} \text{ kg}$ A0 [2]
(special case: uses $g = GM/r^2$ with $g = 9.81$, $r = 6.4 \times 10^6$ scores max 1 mark)
- (c) (i) grav. force $= (6.0 \times 10^{24}) \times (7.4 \times 10^{22}) \times (6.67 \times 10^{-11}) / (3.84 \times 10^8)^2$ C1
 $= 2.0 \times 10^{20} \text{ N}$ (*allow 1 SF*) A1 [2]
- (ii) *either* $\Delta E_p = Fx$ because F constant as $x \ll$ radius of orbit B1
 $\Delta E_p = 2.0 \times 10^{20} \times 4.0 \times 10^{-2}$ C1
 $= 8.0 \times 10^{18} \text{ J}$ (*allow 1 SF*) A1 [3]
- or* $\Delta E_p = GMm/r_1 - GMm/r_2$ C1
Correct substitution B1
 $8.0 \times 10^{18} \text{ J}$ A1
($\Delta E_p = GMm/r_1 + GMm/r_2$ is incorrect physics so 0/3)
- 2 (a) energy $= \frac{1}{2} m \omega^2 a^2$ and $\omega = 2\pi f$ C1
 $= \frac{1}{2} \times 37 \times 10^{-3} \times (2\pi \times 3.5)^2 \times (2.8 \times 10^{-2})^2$ M1
 $= 7.0 \times 10^{-3} \text{ J}$ A0 [2]
(allow $2\pi \times 3.5$ shown as 7π)
- Energy $= \frac{1}{2} m v^2$ and $v = r\omega$ (C1)
Correct substitution (M1)
Energy $= 7.0 \times 10^{-3} \text{ J}$ (A0)
- (b) $E_K = E_p$ C1
 $\frac{1}{2} m \omega^2 (a^2 - x^2) = \frac{1}{2} m \omega^2 x^2$ *or* E_K *or* $E_p = 3.5 \text{ mJ}$ C1
 $x = a/\sqrt{2} = 2.8/\sqrt{2}$ *or* $E_K = \frac{1}{2} m \omega^2 (a^2 - x^2)$ *or* $E_p = \frac{1}{2} m \omega^2 x^2$ C1
 $= 2.0 \text{ cm}$ A1 [3]
(E_K *or* $E_p = 7.0 \text{ mJ}$ scores 0/3)
- Allow: $k = 17.9$ (C1)
 $E = \frac{1}{2} k x^2$ (C1)
 $x = 2.0 \text{ cm}$ (A1)

Page 3	Mark Scheme: Teachers' version	Syllabus	Paper
	GCE AS/A LEVEL – May/June 2012	9702	42

	(c) (i) graph: horizontal line, y-intercept = 7.0 mJ with end-points of line at +2.8 cm and –2.8 cm	B1	[1]
	(ii) graph: reasonable curve with maximum at (0,7.0) end-points of line at (–2.8, 0) and (+2.8, 0)	B1 B1	[2]
	(iii) graph: inverted version of (ii) with intersections at (–2.0, 3.5) and (+2.0, 3.5) (Allow marks in (iii), but not in (ii), if graphs K & P are not labelled)	M1 A1	[2]
	(d) <u>gravitational potential</u> energy	B1	[1]
	3 (a) sum of potential energy and kinetic energy of atoms/molecules/particles reference to random (distribution)	M1 A1	[2]
	(b) (i) as lattice structure is 'broken'/bonds broken/forces between molecules reduced (not molecules separate) no change in kinetic energy, potential energy increases internal energy increases	B1 M1 A1	[3]
4	(ii) <i>either</i> molecules/atoms/particles move faster/ $\langle c^2 \rangle$ is increasing <i>or</i> kinetic energy increases with temperature (increases) no change in potential energy, kinetic energy increases internal energy increases	B1 M1 A1	[3]
	(a) (i) as r decreases, energy decreases/work got out (due to) <u>attraction</u> so point mass is negatively charged	M1 A1	[2]
	(ii) electric potential energy = charge $\times$ electric potential electric field strength is potential gradient field strength = gradient of potential energy graph/charge	B1 B1 A0	[2]
	(b) tangent drawn at (4.0, 14.5) gradient = 3.6×10^{-24} (for $< \pm 0.3$ allow 2 marks, for $< \pm 0.6$ allow 1 mark) field strength = $(3.6 \times 10^{-24}) / (1.6 \times 10^{-19})$ = $2.3 \times 10^{-5} \text{ V m}^{-1}$ (allow ecf from gradient value) (one point solution for gradient leading to $2.3 \times 10^{-5} \text{ V m}^{-1}$ scores 1 mark only)	B1 A2 A1	[4]

Page 4	Mark Scheme: Teachers' version	Syllabus	Paper
	GCE AS/A LEVEL – May/June 2012	9702	42

- 5 (a) (long) straight conductor carrying current of 1 A
current/wire normal to magnetic field
(for flux density 1 T,) force per unit length is 1 N m^{-1} M1
M1
A1 [3]
- (b) (i) (originally) downward force on magnet (due to current) B1
by Newton's third law (allow "N3") M1
upward force on wire A1 [3]
- (ii) $F = BIL$
 $2.4 \times 10^{-3} \times 9.8 = B \times 5.6 \times 6.4 \times 10^{-2}$ C1
 $B = 0.066 \text{ T}$ (need 2 SF) A1 [2]
(g missing scores 0/2, but g = 10 leading to 0.067 T scores 1/2)
- (c) new reading is $2.4\sqrt{2} \text{ g}$ C1
either changes between +3.4 g and –3.4 g
or total change is 6.8 g A1 [2]
- 6 (a) oil drop charged by friction/beta source B1
between parallel metal plates B1
plates are horizontal (1)
adjustable potential difference/field between plates B1
until oil drop is stationary B1
 $mg = q \times V/d$ B1
symbols explained (1)
oil drop viewed through microscope (1)
 m determined from terminal speed of drop (when p.d. is zero) (1)
(any two extras, 1 each) B2 [7]
- (b) $3.2 \times 10^{-19} \text{ C}$ A1 [1]
- 7 (a) minimum energy to remove an electron from the metal/surface B1 [1]
- (b) gradient = 4.17×10^{-15} (allow 4.1 → 4.3) C1
 $h = 4.15 \times 10^{-15} \times 1.6 \times 10^{-19}$ or $h = 4.1 \text{ to } 4.3 \times 10^{-15} \text{ eVs}$ A1
 $= 6.6 \times 10^{-34} \text{ Js}$ A0 [2]
- (c) graph: straight line parallel to given line B1
with intercept at any higher frequency B1
intercept at between $6.9 \times 10^{14} \text{ Hz}$ and $7.1 \times 10^{14} \text{ Hz}$ [3]

Page 5	Mark Scheme: Teachers' version	Syllabus	Paper
	GCE AS/A LEVEL – May/June 2012	9702	42

- 8 (a) nuclei having same number of protons/proton (atomic) number
different numbers of neutrons/neutron number
(allow second mark for nucleons/nucleon number/mass number/atomic
mass if made clear that same number of protons/proton number)
- B1
B1 [2]
- (b) probability of decay per unit time is the decay constant
 $\lambda = \ln 2 / t_{1/2}$
 $= 0.693 / (52 \times 24 \times 3600)$
 $= 1.54 \times 10^{-7} \text{ s}^{-1}$
- C1
C1
A1 [3]
- (c) (i) $A = A_0 \exp(-\lambda t)$
 $7.4 \times 10^6 = A_0 \exp(-1.54 \times 10^{-7} \times 21 \times 24 \times 3600)$
 $A_0 = 9.8 \times 10^6 \text{ Bq}$
(alternative method uses 21 days as 0.404 half-lives)
- C1
A1 [2]
- (ii) $A = \lambda N$ and $\text{mass} = N \times 89 / N_A$
 $\text{mass} = (9.8 \times 10^6 \times 89) / (1.54 \times 10^{-7} \times 6.02 \times 10^{23})$
 $= 9.4 \times 10^{-9} \text{ g}$
- C1
A1 [2]

Page 6	Mark Scheme: Teachers' version	Syllabus	Paper
	GCE AS/A LEVEL – May/June 2012	9702	42

Section B

- 9 (a)** e.g. infinite input impedance/resistance
zero output impedance/resistance
infinite (open loop) gain
infinite bandwidth
infinite slew rate
(any four, one mark each) B4 [4]
- (b)** graph: square wave M1
180° phase change A1
amplitude 5.0 V A1 [3]
- (c)** correct symbol for LED M1
diodes connected correctly between V_{OUT} and earth A1
diodes identified correctly A1 [3]
(special case: if diode symbol, not LED symbol, allow 2nd and 3rd marks to be scored)
- 10 (a)** e.g. beam is divergent/obeys inverse square law
absorption (in block)
scattering (of beam in block)
reflection (at boundaries)
(any two sensible suggestions, 1 each) B2 [2]
- (b) (i)** $I = I_0 \exp(-\mu x)$ C1
 $I_0/I = \exp(0.27 \times 2.4)$
 $= 1.9$ A1 [2]
- (ii)** $I_0/I = \exp(0.27 \times 1.3) \times \exp(3.0 \times 1.1)$ C1
 $= 1.42 \times 27.1$
 $= 38.5$ A1 [2]
- (c)** either much greater absorption in bone than in soft tissue
or I_0/I much greater for bone than soft tissue B1 [1]
- 11 (a) (i)** loss of (signal) power B1 [1]
- (ii)** unwanted power (on signal)
that is random M1
A1 [2]
- (b)** for digital, only the 'high' and the 'low' / 1 and 0 are necessary M1
variation between 'highs' and 'lows' caused by noise not required A1 [2]
- (c)** attenuation = $10 \lg(P_2 / P_1)$ C1
either $195 = 10 \lg(\{2.4 \times 10^3\} / P)$
or $-195 = 10 \lg(P / 2.4 \times 10^3)$ C1
 $P = 7.6 \times 10^{-17} \text{ W}$ A1 [3]

Page 7	Mark Scheme: Teachers' version	Syllabus	Paper
	GCE AS/A LEVEL – May/June 2012	9702	42

- 12 (a) (i)** modulator B1 [1]
- (ii) serial-to-parallel converter (*accept series-to-parallel converter*) B1 [1]
- (b) (i)** enables one aerial to be used for transmission and receipt of signals A1 [1]
- (ii) all bits for one number arrive at one time B1
bits are sent out one after another B1 [2]

MARK SCHEME for the May/June 2012 question paper
for the guidance of teachers

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 must be read in conjunction with the question papers and the report on the examination.

- Cambridge will not enter into discussions or correspondence in connection with these mark schemes.

Cambridge is publishing the mark schemes for the May/June 2012 question papers for most IGCSE, GCE Advanced Level and Advanced Subsidiary Level syllabuses and some Ordinary Level syllabuses.

Page 2	Mark Scheme: Teachers' version	Syllabus	Paper
	GCE AS/A LEVEL – May/June 2012	9702	43

Section A

- 1 (a) work done in bringing unit mass from infinity (to the point) B1 [1]
- (b) gravitational force is (always) attractive B1
either as r decreases, object/mass/body does work
or work is done by masses as they come together B1 [2]
- (c) either force on mass = mg (where g is the acceleration of free fall /gravitational field strength) B1
 $g = GM/r^2$ B1
if $r \approx h$, g is constant B1
 $\Delta E_P = \text{force} \times \text{distance moved}$ M1
= mgh A0
or $\Delta E_P = m\Delta\phi$ (C1)
= $GMm(1/r_1 - 1/r_2) = GMm(r_2 - r_1)/r_1r_2$ (B1)
if $r_2 \approx r_1$, then $(r_2 - r_1) = h$ and $r_1r_2 = r^2$ (B1)
 $g = GM/r^2$ (B1)
 $\Delta E_P = mgh$ (A0) [4]
- (d) $\frac{1}{2}mv^2 = m\Delta\phi$
 $v^2 = 2 \times GM/r$ C1
= $(2 \times 4.3 \times 10^{13}) / (3.4 \times 10^6)$ C1
 $v = 5.0 \times 10^3 \text{ m s}^{-1}$ A1 [3]
(Use of diameter instead of radius to give $v = 3.6 \times 10^3 \text{ m s}^{-1}$ scores 2 marks)
- 2 (a) (i) either random motion
or constant velocity until hits wall/other molecule B1 [1]
- (ii) (total) volume of molecules is negligible M1
compared to volume of containing vessel A1
or
radius/diameter of a molecule is negligible (M1)
compared to the average intermolecular distance (A1) [2]
- (b) either molecule has component of velocity in three directions
or $c^2 = c_x^2 + c_y^2 + c_z^2$ M1
random motion and averaging, so $\langle c_x^2 \rangle = \langle c_y^2 \rangle = \langle c_z^2 \rangle$ M1
 $\langle c^2 \rangle = 3\langle c_x^2 \rangle$ A1
so, $pV = \frac{1}{3}Nm\langle c^2 \rangle$ A0 [3]
- (c) $\langle c^2 \rangle \propto T$ or $c_{\text{rms}} \propto \sqrt{T}$ C1
temperatures are 300 K and 373 K C1
 $c_{\text{rms}} = 580 \text{ m s}^{-1}$ A1 [3]
(Do not allow any marks for use of temperature in units of °C instead of K)

Page 3	Mark Scheme: Teachers' version	Syllabus	Paper
	GCE AS/A LEVEL – May/June 2012	9702	43

- 3 (a) (numerically equal to) quantity of (thermal) energy required to change the state of unit mass of a substance without any change of temperature
(Allow 1 mark for definition of specific latent heat of fusion/vaporisation)
- M1
A1 [2]
- (b) either energy supplied = $2400 \times 2 \times 60 = 288000 \text{ J}$
energy required for evaporation = $106 \times 2260 = 240000 \text{ J}$
difference = 48000 J
rate of loss = $48000 / 120 = 400 \text{ W}$
or energy required for evaporation = $106 \times 2260 = 240000 \text{ J}$
power required for evaporation = $240000 / (2 \times 60) = 2000 \text{ W}$
rate of loss = $2400 - 2000 = 400 \text{ W}$
- C1
C1
A1
(C1)
(C1)
(A1) [3]
- 4 (a) $a = (-)\omega^2 x$ and $\omega = 2\pi/T$
 $T = 0.60 \text{ s}$
 $a = (4\pi^2 \times 2.0 \times 10^{-2}) / (0.6)^2$
 $= 2.2 \text{ ms}^{-2}$
- C1
C1
A1 [3]
- (b) sinusoidal wave with all values positive
all values positive, all peaks at E_K and energy = 0 at $t = 0$
period = 0.30 s
- B1
B1
B1 [3]
- 5 (a) force per unit positive charge acting on a stationary charge
- B1 [1]
- (b) (i) $E = Q / 4\pi\epsilon_0 r^2$
 $Q = 1.8 \times 10^4 \times 10^2 \times 4\pi \times 8.85 \times 10^{-12} \times (25 \times 10^{-2})^2$
 $Q = 1.25 \times 10^{-5} \text{ C} = 12.5 \mu\text{C}$
- C1
M1
A0 [2]
- (ii) $V = Q / 4\pi\epsilon_0 r$
 $= (1.25 \times 10^{-5}) / (4\pi \times 8.85 \times 10^{-12} \times 25 \times 10^{-2})$
 $= 4.5 \times 10^5 \text{ V}$
(Do not allow use of $V = Er$ unless explained)
- C1
A1 [2]

Page 4	Mark Scheme: Teachers' version	Syllabus	Paper
	GCE AS/A LEVEL – May/June 2012	9702	43

- 6 (a) (i) peak voltage = 4.0 V A1 [1]
- (ii) r.m.s. voltage ($= 4.0/\sqrt{2}$) = 2.8 V A1 [1]
- (iii) period $T = 20$ ms M1
frequency = $1 / (20 \times 10^{-3})$ M1
frequency = 50 Hz A0 [2]
- (b) (i) change = $4.0 - 2.4 = 1.6$ V A1 [1]
- (ii) $\Delta Q = C\Delta V$ or $Q = CV$ C1
 $= 5.0 \times 10^{-6} \times 1.6 = 8.0 \times 10^{-6}$ C A1 [2]
- (iii) discharge time = 7 ms C1
current = $(8.0 \times 10^{-6}) / (7.0 \times 10^{-3})$ M1
 $= 1.1(4) \times 10^{-3}$ A A0 [2]
- (c) average p.d. = 3.2 V C1
resistance = $3.2 / (1.1 \times 10^{-3})$
 $= 2900 \Omega$ (allow 2800 Ω) A1 [2]
- 7 (a) sketch: concentric circles (*minimum of 3 circles*) M1
separation increasing with distance from wire A1
correct direction B1 [3]
- (b) (i) arrow direction from wire B towards wire A B1 [1]
- (ii) *either* reference to Newton's third law M1
or force on each wire proportional to product of the two currents A1
so forces are equal [2]
- (c) force always towards wire A/always in same direction B1
varies from zero (to a maximum value) (1)
variation is sinusoidal / $\sin^2$ (1)
(at) twice frequency of current (1)
(*any two, one each*) B2 [3]
- 8 (a) packet/quantum/discrete amount of energy M1
of electromagnetic radiation A1
(allow 1 mark for 'packet of electromagnetic radiation')
energy = Planck constant $\times$ frequency (*seen here or in b*) B1 [3]
- (b) each (coloured) line corresponds to one wavelength/frequency B1
energy = Planck constant $\times$ frequency
implies specific energy change between energy levels B1
so discrete levels A0 [2]

Page 5	Mark Scheme: Teachers' version	Syllabus	Paper
	GCE AS/A LEVEL – May/June 2012	9702	43

- 9 (a) (i) *either* probability of decay (of a nucleus) per unit time
or $\lambda = (-)(dN/dt) / N$
 $(-)(dN/dt)$ and N explained
- M1
A1
(M1)
(A1) [2]
- (ii) in time $t_{1/2}$, number of nuclei changes from N_0 to $\frac{1}{2}N_0$
 $\frac{1}{2} = \exp(-\lambda t_{1/2})$ *or* $2 = \exp(\lambda t_{1/2})$
 $\ln(\frac{1}{2}) = -\lambda t_{1/2}$ and $\ln(\frac{1}{2}) = -0.693$ *or* $\ln 2 = \lambda t_{1/2}$ and $\ln 2 = 0.693$
 $0.693 = \lambda t_{1/2}$
- B1
B1
B1
A0 [3]
- (b) $228 = 538 \exp(-8\lambda)$
 $\lambda = 0.107 \text{ (hours}^{-1}\text{)}$
 $t_{1/2} = 6.5 \text{ hours (do not allow 3 or more SF)}$
- C1
C1
A1 [3]
- (c) e.g. random nature of decay
background radiation
daughter product is radioactive
(any two sensible suggestions, 1 each)
- B2 [2]

Page 6	Mark Scheme: Teachers' version	Syllabus	Paper
	GCE AS/A LEVEL – May/June 2012	9702	43

Section B

10 (a)	light-dependent resistor (allow LDR)	B1	[1]
(b) (i)	two resistors in series between +5 V line and earth midpoint connected to inverting input of op-amp	M1 A1	[2]
(ii)	relay coil between diode and earth switch between lamp and earth	M1 A1	[2]
(c) (i)	switch on/off mains supply using a low voltage/current output (allow 'isolates circuit from mains supply')	B1	[1]
(ii)	relay will switch on for one polarity of output (voltage) switches on when output (voltage) is negative	C1 A1	[2]
11 (a) (i)	e.m. radiation produced whenever charged particle is accelerated electrons hitting target have distribution of accelerations	M1 A1	[2]
(ii)	<i>either</i> wavelength shorter/shortest for greater/greatest acceleration <i>or</i> $\lambda_{\min} = hc/E_{\max}$ <i>or</i> minimum wavelength for maximum energy all electron energy given up in one collision/converted to single photon	B1 B1	[2]
(b) (i)	hardness measures the penetration of the beam greater hardness, greater penetration	C1 A1	[2]
(ii)	controlled by changing the anode voltage higher anode voltage, greater penetration/hardness	C1 A1	[2]
(c) (i)	long-wavelength radiation more likely to be absorbed in the body/less likely to penetrate through body	B1	[1]
(ii)	(aluminium) filter/metal foil placed in the X-ray beam	B1	[1]
12 (a)	strong uniform (magnetic) field <i>either</i> aligns nuclei <i>or</i> gives rise to Larmor/resonant frequency <u>in r.f. region</u> non-uniform (magnetic) field <i>either</i> enables nuclei to be located <i>or</i> changes the Larmor/resonant frequency	M1 A1 M1 A1	[4]
(b) (i)	difference in flux density = $2.0 \times 10^{-2} \times 3.0 \times 10^{-3} = 6.0 \times 10^{-5} \text{ T}$	A1	[1]
(ii)	$\Delta f = 2 \times c \times \Delta B$ $= 2 \times 1.34 \times 10^8 \times 6.0 \times 10^{-5}$ $= 1.6 \times 10^4 \text{ Hz}$	C1 A1	[2]

Page 7	Mark Scheme: Teachers' version	Syllabus	Paper
	GCE AS/A LEVEL – May/June 2012	9702	43

- 13 (a) (i)** no interference (between signals) near boundaries (of cells) B1 [1]
- (ii)** for large area, signal strength would have to be greater and this could be hazardous to health B1 [1]
- (b)** mobile phone is sending out an (identifying) signal M1
- computer/cellular exchange continuously selects cell/base station with strongest signal A1
- computer/cellular exchange allocates (carrier) frequency (and slot) A1 [3]