
PHYSICS

9702/21

Paper 2 AS Level Structured Questions

October/November 2016

MARK SCHEME

Maximum Mark: 60

Published

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 October/November 2016 series for most Cambridge IGCSE[®], Cambridge International A and AS Level components and some Cambridge O Level components.

Page 2	Mark Scheme	Syllabus	Paper
	Cambridge International AS/A Level – October/November 2016	9702	21

- 1 (a) (density =) mass / volume B1 [1]
- (b) (i) $d = [(6 \times 7.5) / (\pi \times 8100)]^{1/3}$
 $= 0.12(1) \text{ m}$ A1 [1]
- (ii) percentage uncertainty = $(4 + 5) / 3$ (= 3%)
or
fractional uncertainty = $(0.04 + 0.05) / 3$ (= 0.03) C1
absolute uncertainty = $(0.03 \times 0.121) = 0.0036$ C1
 $d = 0.121 \pm 0.004 \text{ m}$ A1 [3]
- 2 (a) force per unit positive charge B1 [1]
- (b) (i) time = $5.9 \times 10^{-2} / 3.7 \times 10^7$
 $= 1.6 \times 10^{-9} \text{ s}$ ($1.59 \times 10^{-9} \text{ s}$) A1 [1]
- (ii) $E = V / d$ C1
 $= 2500 / 4.0 \times 10^{-2}$
 $= 6.3 \times 10^4 \text{ NC}^{-1}$ (6.25×10^4 or 62500 NC^{-1}) A1 [2]
- (iii) $a = Eq / m$ or $F = ma$ and $F = Eq$ C1
 $= (6.3 \times 10^4 \times 1.60 \times 10^{-19}) / 9.11 \times 10^{-31} = 1.1 \times 10^{16} \text{ ms}^{-2}$ A1 [2]
- (iv) $s = ut + \frac{1}{2}at^2$
 $= \frac{1}{2} \times 1.1 \times 10^{16} \times (1.6 \times 10^{-9})^2$ C1
 $= 1.4 \times 10^{-2} \text{ (m)}$ C1
distance from plate = $2.0 - 1.4$
 $= 0.6 \text{ cm}$ (allow 1 or more s.f.) A1 [3]
- (v) electric force $\gg$ gravitational force (on electron)/weight
or
acceleration due to electric field $\gg$ acceleration due to gravitational field B1 [1]
- (vi) v_x - t graph: horizontal line at a non-zero value of v_x B1
 v_y - t graph: straight line through the origin with positive gradient B1 [2]

Page 3	Mark Scheme	Syllabus	Paper
	Cambridge International AS/A Level – October/November 2016	9702	21

- 3 (a) force/load is proportional to extension/compression (provided proportionality limit is not exceeded) B1 [1]
- (b) (i) $k = F/x$ or $k = \text{gradient}$ C1
 $k = 600 \text{ N m}^{-1}$ A1 [2]
- (ii) $(W =) \frac{1}{2}kx^2$ or $(W =) \frac{1}{2}Fx$ or $(W =) \text{area under graph}$ C1
 $(W =) 0.5 \times 600 \times (0.040)^2 = 0.48 \text{ J}$ or $(W =) 0.5 \times 24 \times 0.040 = 0.48 \text{ J}$ A1 [2]
- (iii) 1. $(E_K =) \frac{1}{2}mv^2$ C1
 $= \frac{1}{2} \times 0.025 \times 6.0^2$
 $= 0.45 \text{ J}$ A1 [2]
2. (work done against resistive force $=$) $0.48 - 0.45 [= 0.03(0) \text{ J}]$ C1
average resistive force $= 0.030/0.040$ C1
 $= 0.75 \text{ N}$ A1 [3]
- (iv) efficiency $= [\text{useful energy out}/\text{total energy in}] (\times 100)$ C1
 $= [0.45/0.48] (\times 100)$
 $= 0.94$ or 94% A1 [2]
- 4 (a) the number of oscillations per unit time of the source/of a point on the wave/of a particle (in the medium) M1
or A1 [2]
the number of wavelengths/wavefronts per unit time (M1)
passing a (fixed) point (A1)
- (b) T or period $= 2.5 \times 250 (\mu\text{s}) (= 625 \mu\text{s})$ M1
frequency $= 1/(6.25 \times 10^{-4})$ or $1/(2.5 \times 250 \times 10^{-6}) = 1600 \text{ Hz}$ A1 [2]
- (c) (i) for maximum frequency: $f_o = f_s v / (v - v_s)$
 $1640 = (1600 \times 330) / (330 - v_s)$ C1
 $v_s = 8(.0) \text{ m s}^{-1} (8.049 \text{ m s}^{-1})$ A1 [2]
- (ii) loudspeaker moving towards observer causes rise in/higher frequency B1
loudspeaker moving away from observer causes fall in/lower frequency B1 [2]
or
repeated rise and fall/higher and then lower frequency (M1)
caused by loudspeaker moving towards and away from observer (A1)

Page 4	Mark Scheme	Syllabus	Paper
	Cambridge International AS/A Level – October/November 2016	9702	21

- 5 (a) wave incident on/passes by or through an aperture/edge
wave spreads (into geometrical shadow) B1 B1 [2]
- (b) $n\lambda = d \sin \theta$ C1
substitution of $\theta = 90^\circ$ or $\sin \theta = 1$ C1
 $4 \times 500 \times 10^{-9} = d \times \sin 90^\circ$
line spacing = $2.0 \times 10^{-6} \text{ m}$ A1 [3]
- (c) wavelength of red light is longer (than 500 nm) M1
(each order/fourth order is now at a greater angle so) the fifth-order maximum cannot be formed/not formed A1 [2]
- 6 (a) $\frac{\text{work done or energy (transformed) (from electrical to other forms)}}{\text{charge}}$ B1 [1]
- (b) (i) 1. $V = IR$ or $E = IR$ C1
 $I = 14/6.0$
 $= 2.3 \text{ (2.33) A}$ A1 [2]
2. total resistance of parallel resistors = 8.0Ω C1
current = $14/(6.0 + 8.0)$
 $= 1.0 \text{ A}$ A1 [2]
- (ii) $P = EI$ (allow $P = VI$) or $P = V^2/R$ or $P = I^2R$ C1
change in power = $(14 \times 2.33) - (14 \times 1.0)$
or $(14^2/6.0) - (14^2/14)$
or $(2.33^2 \times 6.0) - (1.0^2 \times 14)$
 $= 19 \text{ W (18 W if 2.3 A used)}$ A1 [2]
- (c) $I = Anvq$
ratio = $(0.50n/n) \times (1.8 \text{ A/A})$ or ratio = 0.50×1.8 C1
 $= 0.90$ A1 [2]

Page 5	Mark Scheme	Syllabus	Paper
	Cambridge International AS/A Level – October/November 2016	9702	21

- 7 (a) hadron not a fundamental particle/lepton is fundamental particle
or
 hadron made of quarks/lepton not made of quarks
or
 strong force/interaction acts on hadrons/does not act on leptons B1 [1]
- (b) (i) proton: up, up, down / uud B1
 neutron: up, down, down / udd B1 [2]
- (ii) composition: $2(\text{uud}) + 2(\text{udd})$
 $= 6 \text{ up, } 6 \text{ down} / 6\text{u, } 6\text{d}$ B1 [1]
- (c) (i) most of the atom is empty space
or
 the nucleus (volume) is (very) small compared to the atom B1 [1]
- (ii) nucleus is (positively) charged B1
- the mass is concentrated in (very small) nucleus/small region/small volume/small core
or
 the majority of mass in (very small) nucleus/small region/small volume/small core B1 [2]

PHYSICS

9702/22

Paper 2 AS Structured Questions

October/November 2016

MARK SCHEME

Maximum Mark: 60

Published

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 October/November 2016 series for most Cambridge IGCSE[®], Cambridge International A and AS Level components and some Cambridge O Level components.

Page 2	Mark Scheme	Syllabus	Paper
	Cambridge International AS/A Level – October/November 2016	9702	22

- 1 (a) (i) force / area (normal to the force) B1 [1]
- (ii) ($p = F/A$ so) units: $\text{kg m s}^{-2} / \text{m}^2 = \text{kg m}^{-1} \text{s}^{-2}$ A1 [1]
- allow use of other correct equations:
e.g. ($\Delta p = \rho g \Delta h$ so) $\text{kg m}^{-3} \text{m s}^{-2} \text{m} = \text{kg m}^{-1} \text{s}^{-2}$
e.g. ($p = W/\Delta V$ so) $\text{kg m s}^{-2} \text{m} / \text{m}^3 = \text{kg m}^{-1} \text{s}^{-2}$
- (b) units for m : kg, t : s and ρ : kg m^{-3} C1
- units of C : kg/s ($\text{kg m}^{-3} \text{kg m}^{-1} \text{s}^{-2}$)^{1/2}
or
units of C^2 : $\text{kg}^2 / \text{s}^2 \text{kg m}^{-3} \text{kg m}^{-1} \text{s}^{-2}$ C1
- units of C : m^2 A1 [3]
- 2 (a) $\Delta E = mg\Delta h$ C1
- $= 0.030 \times 9.81 \times (-)0.31$
- $= (-)0.091 \text{ J}$ A1 [2]
- (b) $E = \frac{1}{2}mv^2$ C1
- (initial) $E = \frac{1}{2} \times 0.030 \times 1.3^2 (= 0.0254)$ C1
- $0.5 \times 0.030 \times v^2 = (0.5 \times 0.030 \times 1.3^2) + (0.030 \times 9.81 \times 0.31)$ so $v = 2.8 \text{ ms}^{-1}$
or
 $0.5 \times 0.030 \times v^2 = (0.0254) + (0.091)$ so $v = 2.8 \text{ ms}^{-1}$ A1 [3]
- (c) (i) $0.096 = 0.030(v + 2.8)$ C1
- $v = 0.40 \text{ ms}^{-1}$ A1 [2]
- (ii) $F = \Delta p / (\Delta)t$ or $F = ma$
 $= 0.096 / 20 \times 10^{-3}$ or $0.030 (0.40 + 2.8) / 20 \times 10^{-3}$ C1
- $= 4.8 \text{ N}$ A1 [2]
- (d) kinetic energy (of ball and wall) decreases/changes/not conserved, so inelastic
or
(relative) speed of approach (of ball and wall) not equal to/greater than (relative) speed of separation, so inelastic. B1 [1]
- (e) force = work done / distance moved
 $= (0.091 - 0.076) / 0.60$ C1
- $= 0.025 \text{ N}$ A1 [2]

Page 3	Mark Scheme	Syllabus	Paper
	Cambridge International AS/A Level – October/November 2016	9702	22

- 3 (a) resultant force (in any direction) is zero B1
resultant moment/torque (about any point) is zero B1 [2]
- (b) (i) force = $33 \sin 52^\circ$ or $33 \cos 38^\circ$
= 26 N A1 [1]
- (ii) 26×0.30 or $W \times 0.20$ or 12×0.40 C1
 $26 \times 0.30 = (W \times 0.20) + (12 \times 0.40)$ C1
 $W = 15 \text{ N}$ A1 [3]
- (c) (i) $E = \Delta\sigma / \Delta\varepsilon$ or $E = \sigma / \varepsilon$ C1
 $\Delta\sigma = 2.0 \times 10^{11} \times 7.5 \times 10^{-4}$
= $1.5 \times 10^8 \text{ Pa}$ A1 [2]
- (ii) $\Delta\sigma = \Delta F / A$ or $\sigma = F / A$ C1
 $A = 78 / 1.5 \times 10^8 (= 5.2 \times 10^{-7} \text{ m}^2)$ C1
 $5.2 \times 10^{-7} = \pi d^2 / 4$
 $d = 8.1 \times 10^{-4} \text{ m}$ A1 [3]
- 4 (a) wave incident on/passes by or through an aperture/edge B1
wave spreads (into geometrical shadow) B1 [2]
- (b) (i) waves (from slits) overlap (at point X) B1
path difference (from slits to X) is zero/
phase difference (between the two waves) is zero
(so constructive interference gives bright fringe) B1 [2]
- (ii) difference in distances = $\lambda / 2 = 580 / 2$
= 290 nm A1 [1]
- (iii) $\lambda = ax / D$ C1
 $D = [0.41 \times 10^{-3} \times (2 \times 2.0 \times 10^{-3})] / 580 \times 10^{-9}$ C1
= 2.8 m A1 [3]
- (iv) same separation/fringe width/number of fringes
bright fringe(s)/central bright fringe/(fringe at) X less bright
dark fringe(s)/(fringe at) Y/(fringe at) Z brighter
contrast between fringes decreases
Any two of the above four points, 1 mark each B2 [2]

Page 5	Mark Scheme	Syllabus	Paper
	Cambridge International AS/A Level – October/November 2016	9702	22

- 6 (a) hadron not a fundamental particle/lepton is fundamental particle
or
hadron made of quarks/lepton not made of quarks
or
strong force/interaction acts on hadrons/does not act on leptons B1 [1]
- (b) (i) ${}^0_1\text{e}^{(+)}$ or ${}^0_1\beta^{(+)}$ B1
- ${}^0_0\nu_{(\text{e})}$ B1 [2]
- (ii) weak (nuclear force / interaction) B1 [1]
- (iii) • mass-energy
• momentum
• proton number
• nucleon number
• charge
- Any three of the above quantities, 1 mark each* B3 [3]
- (c) (quark structure of proton is) up, up, down or uud B1
- up/u (quark charge) is $(+)\frac{2}{3}(\text{e})$, down/d (quark charge) is $-\frac{1}{3}(\text{e})$ C1
- $\frac{2}{3}\text{e} + \frac{2}{3}\text{e} - \frac{1}{3}\text{e} = (+)\text{e}$ A1 [3]

PHYSICS

9702/23

Paper 2 AS Level Structured Questions

October/November 2016

MARK SCHEME

Maximum Mark: 60

Published

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 October/November 2016 series for most Cambridge IGCSE[®], Cambridge International A and AS Level components and some Cambridge O Level components.

Page 2	Mark Scheme	Syllabus	Paper
	Cambridge International AS/A Level – October/November 2016	9702	23

- 1 (a) (density =) mass / volume B1 [1]
- (b) (i) $d = [(6 \times 7.5) / (\pi \times 8100)]^{1/3}$
 $= 0.12(1) \text{ m}$ A1 [1]
- (ii) percentage uncertainty = $(4 + 5) / 3$ (= 3%)
or
fractional uncertainty = $(0.04 + 0.05) / 3$ (= 0.03) C1
absolute uncertainty = $(0.03 \times 0.121) = 0.0036$ C1
 $d = 0.121 \pm 0.004 \text{ m}$ A1 [3]
- 2 (a) force per unit positive charge B1 [1]
- (b) (i) time = $5.9 \times 10^{-2} / 3.7 \times 10^7$
 $= 1.6 \times 10^{-9} \text{ s}$ ($1.59 \times 10^{-9} \text{ s}$) A1 [1]
- (ii) $E = V / d$ C1
 $= 2500 / 4.0 \times 10^{-2}$
 $= 6.3 \times 10^4 \text{ NC}^{-1}$ (6.25×10^4 or 62500 NC^{-1}) A1 [2]
- (iii) $a = Eq / m$ or $F = ma$ and $F = Eq$ C1
 $= (6.3 \times 10^4 \times 1.60 \times 10^{-19}) / 9.11 \times 10^{-31} = 1.1 \times 10^{16} \text{ ms}^{-2}$ A1 [2]
- (iv) $s = ut + \frac{1}{2}at^2$
 $= \frac{1}{2} \times 1.1 \times 10^{16} \times (1.6 \times 10^{-9})^2$ C1
 $= 1.4 \times 10^{-2} \text{ (m)}$ C1
distance from plate = $2.0 - 1.4$
 $= 0.6 \text{ cm}$ (allow 1 or more s.f.) A1 [3]
- (v) electric force $\gg$ gravitational force (on electron)/weight
or
acceleration due to electric field $\gg$ acceleration due to gravitational field B1 [1]
- (vi) v_x - t graph: horizontal line at a non-zero value of v_x B1
 v_y - t graph: straight line through the origin with positive gradient B1 [2]

Page 3	Mark Scheme	Syllabus	Paper
	Cambridge International AS/A Level – October/November 2016	9702	23

- 3 (a) force/load is proportional to extension/compression (provided proportionality limit is not exceeded) B1 [1]
- (b) (i) $k = F/x$ or $k = \text{gradient}$ C1
 $k = 600 \text{ N m}^{-1}$ A1 [2]
- (ii) $(W =) \frac{1}{2}kx^2$ or $(W =) \frac{1}{2}Fx$ or $(W =) \text{area under graph}$ C1
 $(W =) 0.5 \times 600 \times (0.040)^2 = 0.48 \text{ J}$ or $(W =) 0.5 \times 24 \times 0.040 = 0.48 \text{ J}$ A1 [2]
- (iii) 1. $(E_K =) \frac{1}{2}mv^2$ C1
 $= \frac{1}{2} \times 0.025 \times 6.0^2$
 $= 0.45 \text{ J}$ A1 [2]
2. (work done against resistive force $=$) $0.48 - 0.45 [= 0.03(0) \text{ J}]$ C1
average resistive force $= 0.030/0.040$ C1
 $= 0.75 \text{ N}$ A1 [3]
- (iv) efficiency $= [\text{useful energy out}/\text{total energy in}] (\times 100)$ C1
 $= [0.45/0.48] (\times 100)$
 $= 0.94$ or 94% A1 [2]
- 4 (a) the number of oscillations per unit time of the source/of a point on the wave/of a particle (in the medium) M1
or A1 [2]
the number of wavelengths/wavefronts per unit time (M1)
passing a (fixed) point (A1)
- (b) T or period $= 2.5 \times 250 (\mu\text{s}) (= 625 \mu\text{s})$ M1
frequency $= 1/(6.25 \times 10^{-4})$ or $1/(2.5 \times 250 \times 10^{-6}) = 1600 \text{ Hz}$ A1 [2]
- (c) (i) for maximum frequency: $f_o = f_s v / (v - v_s)$
 $1640 = (1600 \times 330) / (330 - v_s)$ C1
 $v_s = 8(.0) \text{ m s}^{-1} (8.049 \text{ m s}^{-1})$ A1 [2]
- (ii) loudspeaker moving towards observer causes rise in/higher frequency B1
loudspeaker moving away from observer causes fall in/lower frequency B1 [2]
or
repeated rise and fall/higher and then lower frequency (M1)
caused by loudspeaker moving towards and away from observer (A1)

Page 4	Mark Scheme	Syllabus	Paper
	Cambridge International AS/A Level – October/November 2016	9702	23

- 5 (a) wave incident on/passes by or through an aperture/edge
wave spreads (into geometrical shadow) B1 [2]
B1
- (b) $n\lambda = d \sin \theta$ C1
substitution of $\theta = 90^\circ$ or $\sin \theta = 1$ C1
 $4 \times 500 \times 10^{-9} = d \times \sin 90^\circ$
line spacing = $2.0 \times 10^{-6} \text{ m}$ A1 [3]
- (c) wavelength of red light is longer (than 500 nm) M1
(each order/fourth order is now at a greater angle so) the fifth-order maximum cannot be formed/not formed A1 [2]
- 6 (a) $\frac{\text{work done or energy (transformed) (from electrical to other forms)}}{\text{charge}}$ B1 [1]
- (b) (i) 1. $V = IR$ or $E = IR$ C1
 $I = 14/6.0$
 $= 2.3 \text{ (2.33) A}$ A1 [2]
2. total resistance of parallel resistors = 8.0Ω C1
current = $14/(6.0 + 8.0)$
 $= 1.0 \text{ A}$ A1 [2]
- (ii) $P = EI$ (allow $P = VI$) or $P = V^2/R$ or $P = I^2R$ C1
change in power = $(14 \times 2.33) - (14 \times 1.0)$
or $(14^2/6.0) - (14^2/14)$
or $(2.33^2 \times 6.0) - (1.0^2 \times 14)$
 $= 19 \text{ W (18 W if 2.3 A used)}$ A1 [2]
- (c) $I = Anvq$
ratio = $(0.50n/n) \times (1.8 \text{ A/A})$ or ratio = 0.50×1.8 C1
 $= 0.90$ A1 [2]

Page 5	Mark Scheme	Syllabus	Paper
	Cambridge International AS/A Level – October/November 2016	9702	23

- 7 (a) hadron not a fundamental particle/lepton is fundamental particle
or
hadron made of quarks/lepton not made of quarks
or
strong force/interaction acts on hadrons/does not act on leptons B1 [1]
- (b) (i) proton: up, up, down / uud B1
neutron: up, down, down / udd B1 [2]
- (ii) composition: $2(\text{uud}) + 2(\text{udd})$
= 6 up, 6 down / 6u, 6d B1 [1]
- (c) (i) most of the atom is empty space
or
the nucleus (volume) is (very) small compared to the atom B1 [1]
- (ii) nucleus is (positively) charged B1
- the mass is concentrated in (very small) nucleus/small region/small volume/small core
or
the majority of mass in (very small) nucleus/small region/small volume/small core B1 [2]