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MARK SCHEME

Maximum Mark: 60

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This document consists of **5** printed pages.

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 $= [\text{useful energy out/total energy in}] (\times 100)$ 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: $2(\text{uud}) + 2(\text{udd})$
 $= 6 \text{ up, } 6 \text{ down} / 6\text{u, } 6\text{d}$ 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]