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MARK SCHEME

Maximum Mark: 60

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1 **(a)** (density =) mass / volume B1 [1]

(b) **(i)** $d = [(6 \times 7.5) / (\pi \times 8100)]^{1/3}$

$= 0.12(1)$ 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 × 0.121) = 0.0036 C1

$d = 0.121 \pm 0.004$ m A1 [3]

2 **(a)** force per unit positive charge B1 [1]

(b) **(i)** time $= 5.9 \times 10^{-2} / 3.7 \times 10^{7}$
$= 1.6 \times 10^{-9}$ s (1.59×10^{-9} s) A1 [1]

(ii) $E = V / d$ C1

$= 2500 / 4.0 \times 10^{-2}$

$= 6.3 \times 10^{4}$ N C^{-1} (6.25×10^{4} or 62500 N C^{-1}) A1 [2]

(iii) $a = Eq / m$ *or* $F = ma$ *and* $F = Eq$ C1

$= (6.3 \times 10^{4} \times 1.60 \times 10^{-19}) / 9.11 \times 10^{-31} = 1.1 \times 10^{16}$ m s^{-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

$= 1.4 \times 10^{-2}$ (m) C1

distance from plate = 2.0 – 1.4
= 0.6 cm (*allow 1 or more s.f.*) A1 [3]

(v) electric force ≫ gravitational force (on electron)/weight
or
acceleration due to electric field ≫ 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]

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3 **(a)** force/load is proportional to extension/compression (provided proportionality limit is not exceeded) B1 [1]

(b) **(i)** $k = F/x$ *or* k = gradient C1

$k = 600\,\text{N m}^{-1}$ A1 [2]

(ii) (W =) ½kx^2 *or* (W =) ½Fx *or* (W =) 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 =) ½mv^2 C1

$= ½ \times 0.025 \times 6.0^2$

$= 0.45\,\text{J}$ A1 [2]

2. (work done against resistive force =) $0.48 - 0.45$ [= 0.03(0) J] C1

average resistive force = 0.030 / 0.040 C1

= 0.75 N A1 [3]

(iv) efficiency = [useful energy out / total energy in] (×100) C1

= [0.45 / 0.48] (×100)

= 0.94 *or* 94% A1 [2]

4 **(a)** the number of oscillations per unit time M1
of the source/of a point on the wave/of a particle (in the medium) A1 [2]
or
the number of wavelengths/wavefronts per unit time (M1)
passing a (fixed) point (A1)

(b) T or period = 2.5×250 (μs) (= 625 μs) M1

frequency = $1/(6.25 \times 10^{-4})$ or $1/(2.5 \times 250 \times 10^{-6})$ = 1600 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 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)

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5 **(a)** wave incident on/passes by or through an aperture/edge B1
wave spreads (into geometrical shadow) B1 [2]

(b) $n\lambda = d \sin\theta$ C1

substitution of $\theta = 90°$ *or* $\sin\theta = 1$ C1

$4 \times 500 \times 10^{-9} = d \times \sin 90°$

line spacing = 2.0×10^{-6} 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)** $\dfrac{\text{work done or energy (transformed) (from electrical to other forms)}}{\text{charge}}$ B1 [1]

(b) **(i)** **1.** $V = IR$ *or* $E = IR$ C1

$I = 14 / 6.0$
$= 2.3\ (2.33)$ A A1 [2]

2. total resistance of parallel resistors = 8.0 Ω C1

current $= 14 / (6.0 + 8.0)$
$= 1.0$ 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 W (18 W if 2.3 A used) A1 [2]

(c) $I = Anvq$

ratio $= (0.50n / n) \times (1.8A / A)$ or ratio $= 0.50 \times 1.8$ C1

= 0.90 A1 [2]

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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(uud) + 2(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]

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