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MARK SCHEME

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- 1 (a) acceleration = change in velocity / time (taken) or rate of change of velocity B1 [1]
- (b) (i) $v = 0 + at$ or $v = at$ C1
 $(a = 36/19 =) 1.9 (1.8947) \text{ m s}^{-2}$ A1 [2]
- (ii) $s = \frac{1}{2}(u + v)t$ or $s = v^2/2a$ or $s = \frac{1}{2}at^2$
 $= \frac{1}{2} \times 36 \times 19 = 36^2/(2 \times 1.89) = \frac{1}{2} \times 1.89 \times 19^2$
 $= 340 \text{ m} (342 \text{ m}/343 \text{ m}/341 \text{ m})$ M1 [1]
- (iii) 1. $(\Delta KE =) \frac{1}{2} \times 95 \times (36)^2$ C1
 $= 62\,000 (61\,560) \text{ J}$ A1 [2]
2. $(\Delta PE =) 95 \times 9.81 \times 340 \sin 40^\circ$ or $95 \times 9.81 \times 218.5$ C1
 $= 200\,000 \text{ J}$ A1 [2]
- (iv) work done (by frictional force) = $\Delta PE - \Delta KE$
or
work done = $200\,000 - 62\,000$ (values from 1b(iii) 1. and 2.) C1
(frictional force = $138\,000/340 =$) $410 (406) \text{ N}$ [420 N if full figures used] A1 [2]
- (v) $-ma = mg \sin 20^\circ - f$ or $ma = -mg \sin 20^\circ + f$ C1
 $-95 \times 3.0 = 95 \times 3.36 - f$
 $f = 600 (604) \text{ N}$ A1 [2]
- 2 (a) $p = F/A$ M1
use of $m = \rho V$ and use of $V = Ah$ and use of $F = mg$ M1
correct substitution to obtain $p = \rho gh$ A1 [3]
- (b) (i) (when h is zero the pressure is not zero due to) pressure from the air/atmosphere B1 [1]
- (ii) gradient = ρg or $P - 1.0 \times 10^5 = \rho gh$ C1
e.g. $\rho g = 1.0 \times 10^5/0.75 (= 133333)$
 $\rho = 133\,333/9.81$
 $= 14\,000 (13\,592) \text{ kg m}^{-3}$ A1 [2]

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- 3 (a)** Young modulus = stress / strain B1 [1]
- (b) (i)** $E = (F \times l) / (A \times e)$ or $e = (F \times l) / (A \times E)$ B1
- $e \propto 1/E$
or
ratio $e_C / e_S = E_S / E_C$ or $(1.9 \times 10^{11}) / (1.2 \times 10^{11})$ or 19/12 C1
- (ratio =) 1.6 (1.58) A1 [3]
- (ii)** two straight lines from (0,0) with **S** having the steepest gradient B1 [1]
- 4 (a)** longitudinal: vibrations/oscillations (of the particles/wave) are parallel to the direction **or** in the same direction (of the propagation of energy) B1
- transverse: vibrations/oscillations (of the particles/wave) are perpendicular to the direction (of the propagation of energy) B1 [2]
- (b)** LHS: intensity = power / area units: $\text{kg m s}^{-2} \times \text{m} \times \text{s}^{-1} \times \text{m}^{-2}$ or $\text{kg m}^2 \text{s}^{-3} \times \text{m}^{-2}$ B1
- RHS: units: $\text{m s}^{-1} \times \text{kg m}^{-3} \times \text{s}^{-2} \times \text{m}^2$ M1
- LHS and RHS both kg s^{-3} A1 [3]
- (c) (i)** change/difference in the observed/apparent frequency when the source is moving (relative to the observer) B1 [1]
- (ii)** wavelength increases/frequency decreases/red shift B1 [1]
- (d)** observed frequency = $v f_S / (v - v_S)$ C1
- $550 = (340 \times 510) / (340 - v_S)$ C1
- $v_S = 25$ (24.7) m s^{-1} A1 [3]
- 5 (a)** diffraction: spreading/diverging of waves/light (takes place) at (each) slit/element/gap/aperture B1
- interference: overlapping of waves (from coherent sources at each element) B1
- path difference λ /phase difference of $360(^{\circ})/2\pi$ (produces the first order) B1 [3]
- (b)** $d \sin \theta = n \lambda$ or $\sin \theta = N n \lambda$ C1
- $d = (2 \times 486 \times 10^{-9}) / \sin 29.7^{\circ}$ ($= 1.962 \times 10^{-6}$) C1
- number of lines = 510 (509.7) mm^{-1} A1 [3]

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6 (a) at least six horizontal lines equally spaced and arrow to the right B1 [1]

(b) charge used $2e$ C1

$$\text{gain in KE} = 15 \times 1.6 \times 10^{-19} \times 10^3 = 2 \times 1.6 \times 10^{-19} \times V \text{ (p.d. across plates)}$$

or

$$F (= W/d) = 15 \times 1.6 \times 10^{-19} \times 10^3 / 16 \times 10^{-3} \quad \text{C1}$$

$$\text{(hence } V = 7500 \text{ V or } F = 1.5 \times 10^{-13} \text{ N)}$$

$$E = V/d \quad \text{or} \quad E = F/Q \quad \text{C1}$$

$$E = (7500 / 16 \times 10^{-3}) \quad \text{or} \quad E = (1.5 \times 10^{-13} / 3.2 \times 10^{-19})$$

$$E = 4.7 \times 10^5 \text{ (468 750) } \text{V m}^{-1} \quad \text{A1 [4]}$$

or

$$\text{KE } (= \frac{1}{2}mv^2) = 15 \times 10^3 \times 1.6 \times 10^{-19}$$

$$v = [(2 \times 15 \times 10^3 \times 1.6 \times 10^{-19}) / (6.68 \times 10^{-27})]^{1/2} = 8.5 \times 10^5 \text{ m s}^{-1} \quad \text{(C1)}$$

$$a (= v^2/2s) = (8.5 \times 10^5)^2 / 2 \times 16 \times 10^{-3} = 2.25 \times 10^{13} \text{ m s}^{-2}$$

$$F (= 6.68 \times 10^{-27} \times 2.25 \times 10^{13}) = 1.5 \times 10^{-13} \text{ N}$$

$$E = F/Q \quad \text{(C1)}$$

$$Q = 2e \quad \text{(C1)}$$

$$E = 4.7 \times 10^5 \text{ V m}^{-1} \quad \text{(A1)}$$

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- 7 (a) charge exists only in discrete amounts B1 [1]
- (b) (i) $E = I(R + r)$ or $V = IR$ C1
- (total resistance =) $2.7 + 0.30 + 0.25 (= 3.25 \Omega)$ M1
- $I = 9.0 / (2.7 + 0.30 + 0.25)$ or $9.0 / 3.25 = 2.8 \text{ A}$ A1 [3]
- (ii) $V = IR_{\text{ext}}$ C1
- $= 2.77 \times 3.0$ or 2.8×3.0
- or
- $V = E - Ir$ (C1)
- $= 9.0 - 2.77 \times 0.25$ or $9.0 - 2.8 \times 0.25$
- $V = 8.3 (8.31) \text{ V}$ or 8.4 V A1 [2]
- (c) (i) $I = nevA$
- $v = 2.77 / (8.5 \times 10^{29} \times 1.6 \times 10^{-19} \times 2.5 \times 10^{-6})$ M1
- $= 8.1 (8.147) \times 10^{-6} \text{ m s}^{-1}$ or $8.2 \times 10^{-6} \text{ m s}^{-1}$ A1 [2]
- (ii) A reduces by a factor 4 (1/4 less) or resistance of Z goes up by 4× M1
- current goes down but by less than a factor of 4 (as total resistance does not go up by a factor of 4) so drift speed goes up A1 [2]
- 8 (a) both electron and neutrino: lepton(s) B1
- both neutron and proton: hadron(s)/baryon(s) B1 [2]
- (b) (i) ${}^1_1\text{p} \rightarrow {}^1_0\text{n} + {}^0_{-1}\beta + {}^0_0\nu$
- correct symbols for particles M1
- correct numerical values (allow no values on neutrino) A1 [2]
- (ii) up up down or uud $\rightarrow$ up down down or udd B1 [1]
- (iii) weak (nuclear) B1 [1]