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**PHYSICS** **9702/22**

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MARK SCHEME

Maximum Mark: 60

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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) m $s^{-2}$ | A1 | [2] |
| | **(ii)** $s = ½(u + v)t$ or $s = v^2 / 2a$ or $s = ½at^2$ | | |
| | $= ½ \times 36 \times 19$ $= 36^2 / (2 \times 1.89)$ $= ½ \times 1.89 \times 19^2$ | | |
| | = 340 m (342 m / 343 m / 341 m) | M1 | [1] |
| | **(iii) 1.** (ΔKE =) $½ \times 95 \times (36)^2$ | C1 | |
| | = 62 000 (61 560) J | A1 | [2] |
| | **2.** (ΔPE =) 95 × 9.81 × 340 sin 40° or 95 × 9.81 × 218.5 | C1 | |
| | = 200 000 J | A1 | [2] |
| | **(iv)** work done (by frictional force) = ΔPE – ΔKE *or* work done = 200 000 – 62 000 (values from **1b(iii) 1.** and **2.**) | C1 | |
| | (frictional force = 138 000 / 340 =) 410 (406) N [420 N if full figures used] | A1 | [2] |
| | **(v)** $-ma = mg \sin 20° - f$ or $ma = -mg \sin 20° + f$ | C1 | |
| | –95 × 3.0 = 95 × 3.36 – $f$ | | |
| | $f$ = 600 (604) 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) <u>pressure</u> from the air/atmosphere | B1 | [1] |
| | **(ii)** gradient = $\rho g$ 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) 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 | |
| | | $e \propto 1/E$<br>*or*<br>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: $kg\,m\,s^{-2} \times m \times s^{-1} \times m^{-2}$ or $kg\,m^2 s^{-3} \times m^{-2}$ | B1 | |
| | | RHS: units: $m\,s^{-1} \times kg\,m^{-3} \times s^{-2} \times m^2$ | M1 | |
| | | LHS and RHS both $kg\,s^{-3}$ | A1 | [3] |
| | **(c) (i)** | change/difference in the <u>observed</u>/<u>apparent</u> frequency when the source is moving (relative to the observer) | B1 | [1] |
| | **(ii)** | wavelength increases/frequency decreases/red shift | B1 | [1] |
| | **(d)** | observed frequency = $vf_S/(v - v_S)$ | C1 | |
| | | $550 = (340 \times 510)/(340 - v_S)$ | C1 | |
| | | $v_S = 25\ (24.7)\ m\,s^{-1}$ | A1 | [3] |
| **5** | **(a)** | diffraction: <u>spreading</u>/<u>diverging</u> of <u>waves</u>/<u>light</u> (takes place) at (each) slit/ element/gap/aperture | B1 | |
| | | interference: overlapping of waves (from coherent sources at each element) | B1 | |
| | | path difference $\lambda$/phase difference of 360(°)/2$\pi$ (produces the first order) | B1 | [3] |
| | **(b)** | $d \sin\theta = n\lambda$ or $\sin\theta = Nn\lambda$ | C1 | |
| | | $d = (2 \times 486 \times 10^{-9})/\sin 29.7° \ (= 1.962 \times 10^{-6})$ | 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 2*e* | C1 | |
| | | gain in KE = $15 \times 1.6 \times 10^{-19} \times 10^{3} = 2 \times 1.6 \times 10^{-19} \times V$ (p.d.across plates)<br>*or*<br>$F$ $(= W/d) = 15 \times 1.6 \times 10^{-19} \times 10^{3}/16 \times 10^{-3}$ | C1 | |
| | | (hence $V = 7500$ V  or  $F = 1.5 \times 10^{-13}$ N) | | |
| | | $E = V/d$  or  $E = F/Q$ | C1 | |
| | | $E = (7500/16 \times 10^{-3})$  or  $E = (1.5 \times 10^{-13}/3.2 \times 10^{-19})$ | | |
| | | $E = 4.7 \times 10^{5}$ (468 750) V m$^{-1}$ | A1 | [4] |
| | | **or** | | |
| | | KE $(= ½mv^{2}) = 15 \times 10^{3} \times 1.6 \times 10^{-19}$ | | |
| | | $v = [(2 \times 15 \times 10^{3} \times 1.6 \times 10^{-19})/(6.68 \times 10^{-27})]^{1/2} = 8.5 \times 10^{5}$ m s$^{-1}$ | (C1) | |
| | | $a$ $(= v^{2}/2s) = (8.5 \times 10^{5})^{2}/2 \times 16 \times 10^{-3} = 2.25 \times 10^{13}$ m s$^{-2}$ | | |
| | | $F$ $(= 6.68 \times 10^{-27} \times 2.25 \times 10^{-13}) = 1.5 \times 10^{-13}$ N | | |
| | | $E = F/Q$ | (C1) | |
| | | $Q = 2e$ | (C1) | |
| | | $E = 4.7 \times 10^{5}$ V m$^{-1}$ | (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 Ω) | M1 | |
| | | | $I$ = 9.0 / (2.7 + 0.30 + 0.25) or 9.0 / 3.25 = 2.8 A | A1 | [3] |
| | | (ii) | $V = IR_{ext}$<br>= 2.77 × 3.0 or 2.8 × 3.0 | C1 | |
| | | | **or** | | |
| | | | $V = E - Ir$<br>= 9.0 – 2.77 × 0.25 or 9.0 – 2.8 × 0.25 | (C1) | |
| | | | $V$ = 8.3 (8.31) 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 <u>of Z</u> goes up by 4× | M1 | |
| | | | current goes down but by <u>less than</u> 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 → up down down or udd | B1 | [1] |
| | | (iii) | weak (nuclear) | B1 | [1] |