## Paper 1 Mark scheme

| Question Number | Acceptable Answer | Additional Guidance | Mark |
|---|---|---|---|
| **1** | D | | **1** |
| **2** | B | | **1** |
| **3** | D | | **1** |
| **4** | D | | **1** |
| **5** | C | | **1** |
| **6** | C | | **1** |
| **7** | C | | **1** |
| **8** | A | | **1** |

**(Total for Multiple Choice Questions = 8 marks)**

| Question Number | Acceptable Answer | Additional Guidance | Mark |
|---|---|---|---|
| **9** | • use of $\Delta E_{grav} = mg\Delta h$ and use of $P = VI$ **(1)**<br>• correct use of time **(1)**<br>• efficiency = 0.816 or 81.6 % **(1)** | Example of calculation:<br><br>$\Delta E_{grav}$ = 800 kg × 9.81 m $s^{-2}$ × 14 m/s = 109900 J<br>$P$ = 230 V × 13.0 A = 2990 W<br>E = Pt = 2990 W x 45 s = 134600 J<br>efficiency = 109900 J/134600 J = 0.816<br><br>Alternative calculation:<br><br>$\text{Efficiency} = \frac{(800\,\text{kg} \times 9.81\,\text{N kg}^{-1} \times 14\,\text{m})/45.0\,\text{s}}{230\,\text{V} \times 13.0\,\text{A}} = 0.816$<br><br>Accept rounding variations if alternative calculation method used. | **3** |

**(Total for Question 9 = 3 marks)**

| Question Number | Acceptable Answer | Additional Guidance | Mark |
|---|---|---|---|
| **10 (a)(i)** | • Two straight lines drawn between points (0, 31) to (0.6, 31) and (0.6, 31) to (10.6, 0) **(1)** | | **1** |
| **10 (a)(ii)** | • Use of area under graph or equations of motion to determine distance **(1)**<br>• Distance travelled = 170 m which is less than 180 m so concludes car stops without colliding **(1)** | Example of calculation<br>distance = (0.6 s x 31 m $s^{-1}$) + (10 s × 31 m $s^{-1}$) /2<br>= 174 m | **2** |
| **10 (b)** | Must give at least on benefit to obtain full marks<br><br>**Risks**<br><br>• Increased speed produces increased kinetic energy so more energy to dissipate in a collision **(1) OR** collisions more likely to result in injury **(1) OR** collisions more likely to cause damage to vehicle/property **(1)**<br>• Human reaction time unchanged so thinking distance is larger at higher speed **(1)**<br>• Greater likelihood of colliding with stationary traffic **(1) OR** Greater hazard to stationary vehicles **(1) OR** maintenance crews on the hard shoulder **(1)**<br>• Road surfaces need to be better maintained **(1)**<br><br>**Benefits**<br><br>• Shorter journey times **(1)**<br>• Cars on road for shorter time leading to less congestion **(1)** | Allow credit for correct equivalent points provided they have a physics basis. | **4** |

**(Total for Question 10 = 7 marks)**

| Question Number | Acceptable Answer | Additional Guidance | Mark |
|---|---|---|---|
| **11 (a)** | • Uses scale 1:10 **(1) OR** determines the ratio of lengths from the diagram **(1)**<br>• Use of moment equation for tooth force = force × (perp) distance **(1)**<br>• Use of moment equation for muscle force = force × sin (angle with jaw) × (perp) distance **(1)**<br>• Moment of tooth force = moment of muscle force **(1)**<br>• Muscle force = 24 000 N **(1)** | | **5** |
| **11 (b)** | • Accuracy relates to how close the measurement is to the true value **(1) OR** accuracy depends on the way in which the measurement is made **(1)**<br>• Callipers reduce random/measurement errors in determining the value, giving a lower uncertainty in the measurement than that for a metre rule **(1)**<br>• so scientist B has not made a more accurate measurement he has made a measurement with lower uncertainty **(1)** | This refers to digital, dial or vernier callipers but if reference to a compass style callipers MP2 would become:<br>The callipers would reduce parallax errors due to movement and MP 3 becomes a more accurate measurement because it is closer to a true value | **3** |

**(Total for Question 11 = 8 marks)**

| Question Number | Acceptable Answer | Additional Guidance | Mark |
|---|---|---|---|
| **12 (a)** | An explanation that makes reference to:<br><br>• amplitude of lattice vibration increases **(1)**<br>• resulting in more frequent collisions of electrons with lattice ions **(1)**<br>• so this results in a smaller (mean) drift velocity $I=nAve$ and consequently the current decreases **(1)** | Must be the idea of a greater frequency of collisions, not just a greater number of collisions.<br>Do not accept collisions between electrons.<br><br>MP3 dependent on MP1 and MP2 | **3** |
| **12 (b)(i)** | • Reads current values at 3V for both components **(1)**<br>• Current through fixed resistor R = 0.94 A **(1)** | Current values are 0.33 (A) and 0.61 (A)<br>Allow tolerance of ± 0.01 A<br>Allow tolerance of ± 0.02 A | **2** |
| **12 (b)(ii)** | An explanation that makes reference to:<br><br>• resistance of Y will be greater than resistance of parallel combination **(1)**<br>• Y will have a greater share of the p.d **(1) OR** R will have a lower share of the p.d. **(1)**<br>• so the reading on the voltmeter will increase. **(1)**<br><br>**OR**<br><br>• the current through R decreases **(1)**<br>• as V = IR, the p.d. across R decreases**(1)**<br>• so the p.d. across Y and the voltmeter reading will increase **(1)** | To score the final marking point candidates must score both MP1 and MP2 | **3** |

**(Total for Question 12 = 8 marks)**

| Question Number | Acceptable Answer | Additional Guidance | Mark |
|---|---|---|---|
| **13 (a)** | • Use of R = V/I **(1)**<br>• Use of R = ρl/A **(1)**<br>• ρ = 1.34 × $10^{-8}$ Ωm **(1)** | Example of calculation:<br><br>$R$ = 1.50 V/4.11 A = 0.365 Ω<br>$\rho = RA/l$ = 0.365 Ω × π × (1.82 × $10^{-3}$/2)$^2$ $m^2$ /0.707 m<br>$\rho$ = 1.34 ×$10^{-8}$ Ωm | **3** |
| **13 (b)** | An explanation that makes reference to:<br><br>• Calculates percentage uncertainty in *l* as 0.3% and in *d* as 1% **(1)**<br>• Calculates percentage uncertainty in resistivity by doubling that for *d* and adding that for *l* **(1)**<br>• Calculates range of values for $\rho$ **(1)**<br>• Using these values the technician could not conclude whether the wire was Kanthal or Nichrome **(1)** | Example of calculation:<br><br>(0.2/70.7) x 100 % = 0.3 %<br>(0.02/1.82) x 100 % = 1 %<br>%U in $\rho$ = 2 x 1% + 0.3 % = 2.3 %<br>1.34 ×$10^{-8}$ x 0.0023 = 0.003<br>1.37×$10^{-8}$ > $\rho$ > 1.31×$10^{-8}$<br><br>If answer to calculation is wrong, then credit can still be given for MP4 for comments consistent with the calculated value.<br><br>If no calculation is completed then MP4 cannot be awarded. | **4** |

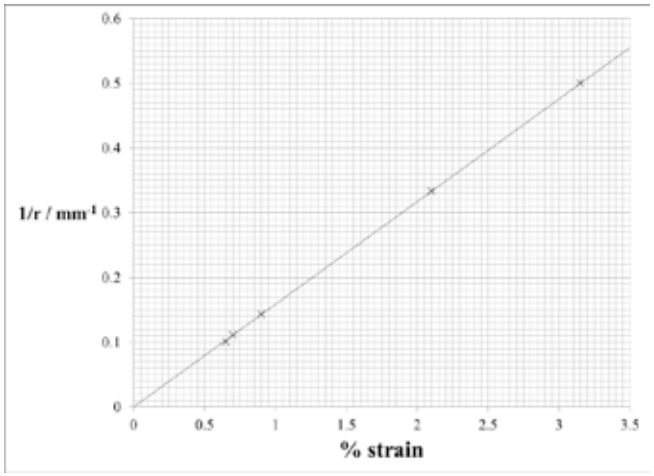
**(Total for Question 13 = 7 marks)**

| Question Number | Acceptable Answer | Additional Guidance | Mark |
|---|---|---|---|
| **14 (a)** | • Means of varying the current **(1)**<br>• Ammeter, voltmeter and variable resistor correctly connected **(1)** | Accept a circuit that will allow correct measurements to be taken. | **2** |
| **14 (b)** | An explanation that makes reference to:<br><br>• Vary the current using the variable resistor **(1)**<br>• Record corresponding values for *I* and *V* **(1)**<br>• Graph of V against I is a straight line with negative gradient **(1)**<br>• The e.m.f. is given by the intercept on the V axis **(1)**<br>• The internal resistance is given by the gradient **(1)** | | **5** |

**(Total for Question 14 = 7 marks)**

| Question Number | Acceptable Answer | Additional Guidance | Mark |
|---|---|---|---|
| **15 (a)** | • use of $v^2 = u^2 + 2as$ **(1) OR** use of ½ m$v^2$ =mgh **(1)**<br>• initial speed = 7.0 m $s^{-1}$ **(1)** | Example of calculation:<br>$v = 0$ $a = -9.81$ m $s^{-1}$ $s = 2.5$ m<br>$u^2 = -2as$<br>$u^2 = -(2 \times -9.81 \text{ m s}^{-1} \times 2.5 \text{ m}) = 49 \text{ m}^2 \text{ s}^{-2}$<br>$u = 7.0$ m $s^{-1}$<br><br>Alternative calculation:<br>½ $v^2$ = gh<br>v = √(2gh) = √(2 x 9.81 x 2.5) = = 7.0 m $s^{-1}$ | **2** |
| **15 (b)** | • use of trig function to find *v* vertical **(1)**<br>• use of trig function to find *v* horizontal **(1)**<br>• use of equation of motion to find time of flight **(1)**<br>• use of equation of motion to find distance **(1)**<br>• horizontal distance = 2.7 m **(1)** | Example of calculation<br>vertical velocity = 6.5 m $s^{-1}$ sin 20 = 2.22 m $s^{-1}$<br>time of flight using $v = u + at$<br>-2.22 m $s^{-1}$ = 2.22 m $s^{-1}$ + (-9.81 m $s^{-1}$× $t$)<br>$t = 0.45$ s<br>horizontal velocity = 6.5 m $s^{-1}$ cos 20 = 6.11 m $s^{-1}$<br>horizontal distance using $s = ut$<br>$s = 6.11 \text{ m s}^{-1} \times 0.45$ s<br>$s = 2.7$ m | **5** |
| **15 (c)(i)** | • use of $p=mv$ **(1)**<br>• correctly applies conservation of momentum **(1)**<br>• $v$ = 14.8 m $s^{-1}$ **(1)** | Example of calculation:<br>momentum of lid = − momentum of canister<br>1.6 g × $v$ = 4.3 g × 5.5 m $s^{-1}$<br>$v$ = 14.8 m $s^{-1}$ | **3** |
| **15 (c)(ii)** | An explanation that makes reference to:<br>• no unbalanced force on dry ice **(1)**<br>• so no acceleration according to Newton's First Law **(1)** | MP2 is dependent on MP1<br>Allow suitable reference to Newton's Second Law for MP2 | **2** |

**(Total for Question 15 = 12 marks)**

<table>
<tr><th>Question Number</th><th>Acceptable Answer</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr><td>16 (a)(i)</td><td>• Student analyses inverse relationship by determining 1/r or 1/strain values (1)<br>• Axes labelled and sensible scales chosen (1)<br>• All points plotted correctly (1)<br>• Student concludes from straight line drawn through origin that strain in the fibre is inversely proportional to its bending radius (1)<br> 
</td><td>Example of calculation:<br><table><tr><td>Radius, r/mm</td><td>% strain</td><td>1/r/mm$^{-1}$</td></tr><tr><td>2</td><td>3.15</td><td>0.50</td></tr><tr><td>3</td><td>2.10</td><td>0.33</td></tr><tr><td>7</td><td>0.90</td><td>0.14</td></tr><tr><td>9</td><td>0.70</td><td>0.11</td></tr><tr><td>10</td><td>0.65</td><td>0.10</td></tr></table><br>Must cover at least half of grid in both directions for MP2 to be awarded.<br>One mis-plot loses MP3<br><br>Alternative calculation:<br><table><tr><td>Radius/mm</td><td>% strain</td><td>1/strain</td></tr><tr><td>2</td><td>3.15</td><td>0.32</td></tr><tr><td>3</td><td>2.10</td><td>0.48</td></tr><tr><td>7</td><td>0.90</td><td>1.11</td></tr><tr><td>9</td><td>0.70</td><td>1.43</td></tr><tr><td>10</td><td>0.65</td><td>1.54</td></tr></table></td><td>4</td></tr>
<tr><td>16 (a)(ii)</td><td>• Lines drawn on graph and 1/r = 0.38 mm$^{-1}$ (1)<br>• r = 2.6 (3) mm (1)</td><td>Example of calculation<br>R= 1/ y value = 1/0.38 min$^{-1}$ = 2.6 mm<br>Ecf for their graph</td><td>2</td></tr>
<tr><td>16 (b)</td><td>An explanation that makes reference to:<br>• Stress caused by component of F (1)<br>• Parallel to surface (1)<br>• = F sin α (1)<br>• As α increases, sin α increases (1)</td><td></td><td>4</td></tr>
</table>

**(Total for Question 16 = 10 marks)**

<table>
<tr><th>Question Number</th><th>Acceptable Answer</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr><td>17 (a)</td><td>• Use of I = P/V (1)<br>• Use of Q=It (1)<br>• Use of number of electrons = Q/e (1)<br>• N= 7.7 x $10^{20}$ (1)</td><td>Example of calculation:<br>I = P/V = 8 W/230 V= 0.034 A<br>Q = It = 0.34 A x 3600 = 122.4 C<br>N=Q/e = 122.4 C /1.6 x $10^{-19}$ C = 7.65 x $10^{20}$ $s^{-1}$</td><td>4</td></tr>
<tr><td>17 (b)*</td><td>This question assesses a student’s ability to show a coherent and logically structured answer with linkages and fully-sustained reasoning.<br><br>Marks are awarded for indicative content and for how the answer is structured and shows lines of reasoning.<br><br>The following table shows how the marks should be awarded for indicative content.<br><br>
<table>
<tr><th>Number of indicative marking points seen in answer</th><th>Number of marks awarded for indicative marking points</th></tr>
<tr><td>6</td><td>4</td></tr>
<tr><td>5 - 4</td><td>3</td></tr>
<tr><td>3 - 2</td><td>2</td></tr>
<tr><td>1</td><td>1</td></tr>
<tr><td>0</td><td>0</td></tr>
</table>
</td><td>Guidance on how the mark scheme should be applied:<br><br>The mark for indicative content should be added to the mark for lines of reasoning. For example, an answer with five indicative marking points which is partially structured with some linkages and lines of reasoning scores 4 marks (3 marks for indicative content and 1 mark for partial structure and some linkages and lines of reasoning).<br><br>If there are no linkages between points, the same five indicative marking points would yield an overall score of 3 marks (3 marks for indicative content and no marks for linkages).</td><td></td></tr>
</table>

<table>
<tr><th>Question Number</th><th>Acceptable Answer</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr><td>17 (b)* (continued)</td><td>The following table shows how the marks should be awarded for structure and lines of reasoning.<br><br>
<table>
<tr><td></td><td>Number of marks awarded for structure of answer and sustained line of reasoning</td></tr>
<tr><td>Answer shows a coherent and logical structure with linkages and fully sustained lines of reasoning demonstrated throughout</td><td>2</td></tr>
<tr><td>Answer is partially structured with some linkages and lines of reasoning</td><td>1</td></tr>
<tr><td>Answer has no linkages between points and is unstructured</td><td>0</td></tr>
</table>
</td><td></td><td></td></tr>
</table>

| Question Number | Acceptable Answer | Additional Guidance | Mark |
|---|---|---|---|
| **17 (b)* (continued)** | **Indicative content**<br><br>• Analyses and interprets the text to conclude that diffraction occurs when light is reflected from the CD surface<br>• Each ring on the CD acts as a diffraction centre scattering light in all directions<br>• Interference occurs (superposition of light from the multiple light sources)<br>• In directions in which there is a phase difference equal to an even multiple of π rad constructive interference (reinforcement) occurs **OR** in directions in which there is a path difference equal to a whole number of wavelengths constructive interference (reinforcement) occurs<br>• White light is a range (mixture) of wavelengths<br>• Hence each wavelength of light reinforces in a different direction which explains why a spectrum is seen | | **6** |

**(Total for Question 17 = 10 marks)**