<table>
<tr><th>Question Number</th><th>Answer</th><th>Mark</th></tr>
<tr><td>4(a)</td><td>
• Re-arranges equation $V_a = \frac{hc}{e}\frac{1}{\lambda} + \frac{W}{e}$ and compares to $y = mx + c$ (1)
• Identifies $gradient = \frac{hc}{e}$ (1)
• States that h, c and e are all constants (1)
</td><td>3</td></tr>
<tr><td>4(b)(i)</td><td>
• Correct values calculated (1)
• Values correctly rounded to 3 sig. fig. (1)

Example
<table>
<tr><th>λ / × 10^{-7} m</th><th>$1/\lambda$ / × 10^{6} m^{-1}</th></tr>
<tr><td>6.60</td><td>1.52</td></tr>
<tr><td>6.12</td><td>1.63</td></tr>
<tr><td>5.92</td><td>1.69</td></tr>
<tr><td>5.85</td><td>1.71</td></tr>
<tr><td>5.30</td><td>1.89</td></tr>
<tr><td>4.70</td><td>2.13</td></tr>
</table>
</td><td>2</td></tr>
<tr><td>4(b)(ii)</td><td>
• Labels axes with quantities and units (1)
• Sensible scales (1)
• Plotting – 2 points furthest from their line (1)
• Plotting – 2 points at the ends (1)
• Line of best fit (1)

Refer to Mark Scheme Notes – Section 5 for guidance on axis labels, suitable scales & checking accuracy of plots. An example of the graph can be seen on page 11.
<table>
<tr><th>V_a / V</th><th>$1/\lambda$ / × 10^{6} m^{-1}</th></tr>
<tr><td>1.82</td><td>1.52</td></tr>
<tr><td>1.97</td><td>1.63</td></tr>
<tr><td>2.02</td><td>1.69</td></tr>
<tr><td>2.07</td><td>1.71</td></tr>
<tr><td>2.31</td><td>1.89</td></tr>
<tr><td>2.58</td><td>2.13</td></tr>
</table>
</td><td>5</td></tr>
<tr><td>4(b)(iii)</td><td>
• Calculates gradient using large triangle - at least half their line of best fit (1)
• Use of gradient = hc/e (1)
• $h = 6.65\times10^{-34}$ to 6.85×10^{-34} J s (1)

<u>Example calculation</u>
Gradient = (2.55 – 1.80) V / (2.10 – 1.60)×10^{6} m^{-1} = 1.25×10^{-6} V m
$h = 1.25\times10^{-6}$ V m × 1.60×10^{-19} C / 3.00×10^{8} m s^{-1} = 6.67×10^{-34} J s
</td><td>3</td></tr>
<tr><td>4(b)(iv)</td><td>
• Mathematical comparison between their value from (b)(iii) and 6.63×10^{-34} J s (1)
• Comparative statement consistent with MP1 (1)

MP2 is for a statement that is justified by their value for h.
E.g.
Difference between the values is 0.04 (×10^{-34}) is very small compared to 6.63 (×10^{-34}), so method is accurate.
Or
Percentage difference is 0.6%, which is small, so method is accurate.
</td><td>2</td></tr>
</table>

4(c)	• Manufacturer's wavelength would be shorter (than the wavelength of photons with least energy) **Or** Manufacturer's wavelength would be shorter (than the wavelength of photons emitted at V_a) (1) • A lower λ would give a higher 1/λ **Or** the line would shift to the right, (1) **EITHER** • Difference in wavelength would be small, so negligible shift in points (Accept shift would be the same for all points, so same gradient) (1) • No change in the value of *h* obtained. (1) **OR** • Points for longer λ would shift 1/λ values less, decreasing the gradient (1) • Decreasing the value of *h* obtained. (1)	**4**
	Total for question 5	**19**