- Determine the value of n that corresponds to the lowest excited state of He^{+} from which radiation with a wavelength of 600 nm is able to ionise the electron (*i.e.* excite it to a state of $n = \infty$). Show all working.

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For a 1-electron atom or ion, the energy levels are given exactly by the equation,

$$E = -Z^2 E_R\left(\frac{1}{n^2}\right)$$

Ionization corresponds to excitation from level n_1 to level $n_2 = \infty$:

$$\Delta E = -Z^2 E_R\left(\frac{1}{\infty^2} - \frac{1}{{n_1}^2}\right) = Z^2 E_R\left(\frac{1}{{n_1}^2}\right)$$

Radiation with wavelength 600 nm has energy:

$$E = \frac{hc}{\lambda} = \frac{(6.626 \times 10^{-34}\ \text{J s})(2.998 \times 10^{8}\ \text{m s}^{-1})}{600 \times 10^{-9}\ \text{m}} = 3.31 \times 10^{-19}\ \text{J}$$

If this is able to provide the energy required to ionize He^{+} ($Z = 2$) from level n_1:

$$Z^2 E_R\left(\frac{1}{{n_1}^2}\right) = 2^2 \times (2.18 \times 10^{-18}\ \text{J}) \times \left(\frac{1}{{n_1}^2}\right) = 3.31 \times 10^{-19}\ \text{J}$$

This gives $n_1 = 5.13$. As n must be an integer, the radiation can ionize from $n = 6$ or above.

Answer: $\boldsymbol{n = 6}$