Marks
4

- The "Paschen" series of emission lines corresponds to emission from higher lying energy states to the $n = 3$ state in hydrogen-like atoms. Calculate the wavelength (in nm) of the lowest energy "Paschen" emission line in Li^{2+}.

The energy of an orbital in an 1-electron atom or ion is given by

$$E_n = -Z^2 E_R (1/n^2)$$

The energy difference between two levels is therefore:

$$\Delta E = E_{n1} - E_{n2} = [-Z^2 E_R (1/n_1^2)] - [-Z^2 E_R (1/n_2^2)] = Z^2 E_R (1/n_2^2 - 1/n_1^2)$$

The lowest energy line in the Paschen series corresponds to moving from $n = 4$ to $n = 3$. As Li^{2+} has $Z = 3$, the energy of this transition is therefore:

$$\Delta E = (3)^2 E_R (1/3^2 - 1/4^2) = 9.54 \times 10^{-19} \text{ J}$$

Using $E = hc / \lambda$, this corresponds to a wavelength of:

$$\lambda = hc / E = (6.626 \times 10^{-34} \text{ J s})(2.998 \times 10^8 \text{ m s}^{-1}) / (9.54 \times 10^{-19} \text{ J}) = 2.08 \times 10^{-7} \text{ m} = 208 \text{ nm}$$

Answer: **208 nm**

What are the possible l states for the $n = 4$ level of Li^{2+}? **$l = 0, 1, 2$ and 3**

Sketch the atomic orbital with $n = 3$ and the lowest value of l.

The orbital is 3*s*: