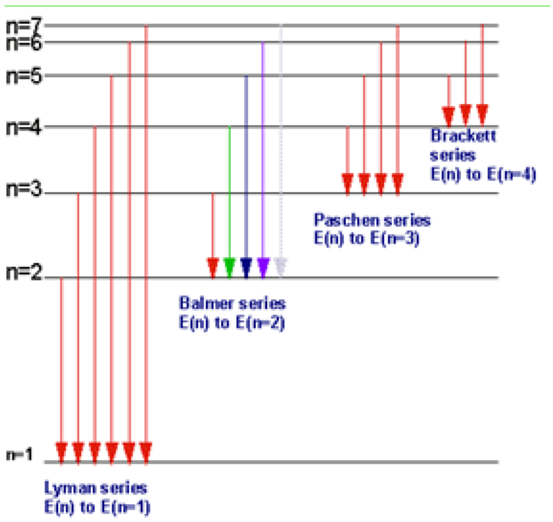
Answer on Question #77313, Chemistry / General Chemistry

Calculate wave number of first and second spectral line in the lyman series of H- atom

Solution

The **Lyman series** is a hydrogen spectral series of transitions and resulting ultraviolet emission lines of the hydrogen atom as an electron goes from $n \geq 2$ to $n = 1$ (where n is the principal quantum number), the lowest energy level of the electron. The transitions are named sequentially by Greek letters: from $n = 2$ to $n = 1$ is called Lyman-alpha, 3 to 1 is Lyman-beta, 4 to 1 is Lyman-gamma, and so on. The series is named after its discoverer, Theodore Lyman.



To find wavenumber $\tilde{\nu} = \frac{1}{\lambda}$ we should use the Rydberg equation for Lyman series, i.e. n_1=1 :

$$\frac{1}{\lambda} = R_H \left(\frac{1}{n_1^2} - \frac{1}{n_2^2} \right)$$

$$\frac{1}{\lambda} = R_H \left(\frac{1}{1^2} - \frac{1}{n_2^2} \right)$$

where $R_H = 1.0968 \times 10^7\ m^{-1} = 1.0968 \times 10^5\ cm^{-1}$

Then

$$\tilde{\nu} = \frac{1}{\lambda} = R_H \left(\frac{1}{1^2} - \frac{1}{n_2^2} \right)$$

For Lyman-alpha line Ly α (from $n = 2$ to $n = 1$):

$$\tilde{\nu}(Ly\ \alpha) = \frac{1}{\lambda} = 1.0968 \times 10^5\ cm^{-1} \left(\frac{1}{1^2} - \frac{1}{2_2^2} \right) = 8.226 \times 10^4 cm^{-1}$$

For Lyman-beta line Ly β (from $n = 3$ to $n = 1$):

$$\tilde{\nu}(Ly\ \beta) = \frac{1}{\lambda} = 1.0968 \times 10^5\ cm^{-1} \left(\frac{1}{1^2} - \frac{1}{3_2^2} \right) = 9.7493 \times 10^4 cm^{-1}$$

Answer: 1) $\tilde{v}(Ly\ \alpha) = 8.226 \times 10^4 cm^{-1}$

2) $\tilde{v}(Ly\ \beta) = 9.7493 \times 10^4 cm^{-1}$

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