Title:H-Spectra (Hydrogen Spectra)

Course:B.Sc part 1 Chemistry (Hons.)

By,Mr.Sanjeev Kumar Gautam
Department of chemistry

In hydrogen atom there is one electron which is present in first orbit in ground state. When energy is supplied, such as by passing electric discharge, this electron may be excited to some higher energy level. Since in a sample of hydrogen there are large number of atoms, the electrons in different atoms absorb different amounts of energies and are excited to different higher energy levels. For example, the electron in some atoms may jump to third energy level while in others it may be raised to fourth energy level and so on. Now, from excited states the electron may return to ground state in one or more jumps.

For example, let us consider the electron present in the fourth energy level ($n = 4$) of different hydrogen atoms. In some atoms it may come to ground state ($n = 1$) by direct jump while in some others it may first jump to second energy level ($n = 2$) and then to first energy level ($n = 1$), while in still others it may come to ground state via third ($n = 3$) and second energy levels ($n = 2$) as illustrated in Fig. 2.26.

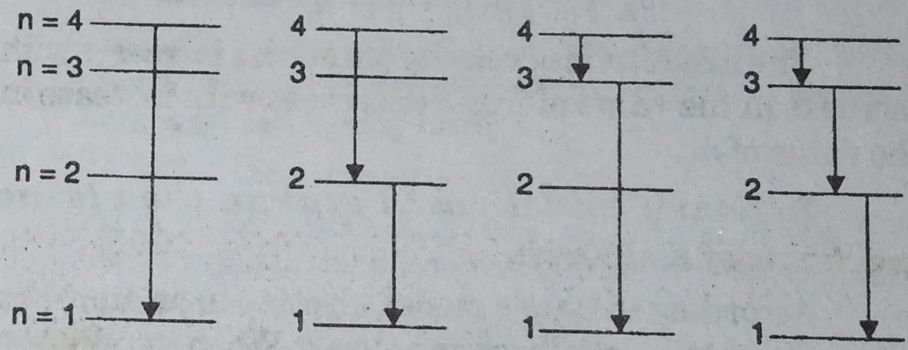

Fig. 2.26. Different routes to the ground state from fourth energy level.

These different downwards jumps are associated with different amounts of energies and hence result in the emission of radiations of different wavelengths which appear as different lines in the hydrogen spectrum. ***Since large number of different type of downward transitions take place simultaneously in a sample of hydrogen, therefore, large number of lines are obtained in emission spectrum of hydrogen.***

The lines which arise due to the transitions from higher energy levels to first energy level are grouped as **Lyman Series.** Similarly, the lines obtained as a result of transitions of electrons from higher energy levels to *second, third, fourth* and *fifth* energy levels give rise to **Balmer, Paschen, Brackett** and **Pfund** series respectively as illustrated in Fig. 2.27.

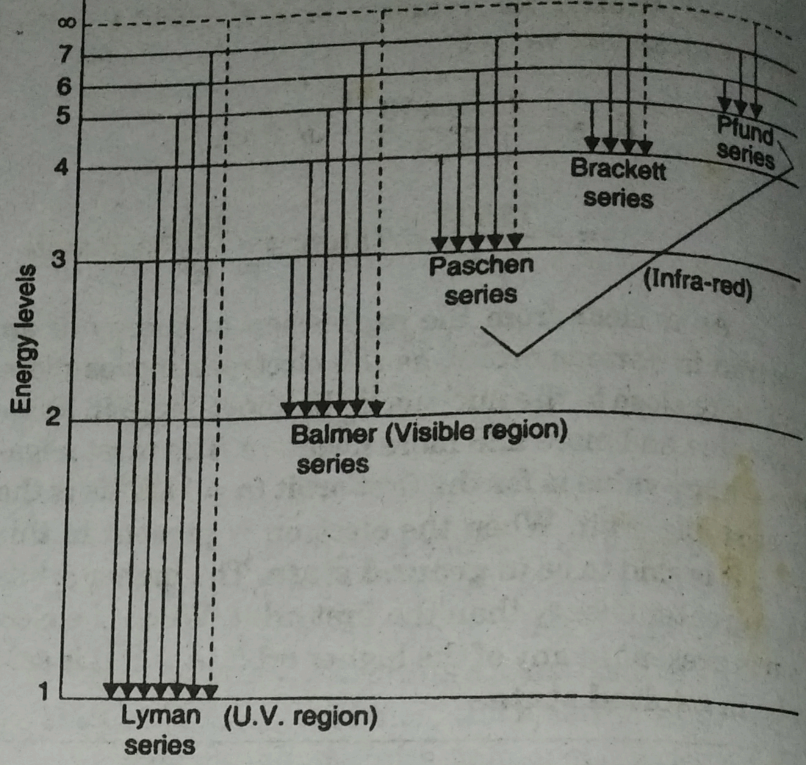

Fig. 2.27. Generation of various spectral series in hydrogen spectrum.

Lyman series	From $n = 2, 3, 4, 5$ ...... to $n = 1$
Balmer series	From $n = 3, 4, 5, 6$ ...... to $n = 2$
Paschen series	From $n = 4, 5, 6, 7$ ...... to $n = 3$
Brackett series	From $n = 5, 6, 7, 8$ ...... to $n = 4$
Pfund series	From $n = 6, 7, 8, 9$ ...... to $n = 5$.

Bohr was able to calculate frequencies and wavelengths of various lines in the atomic spectrum of hydrogen.

Suppose an electron from an higher orbit having $n = n_i$ jumps to a lower level having $n = n_f$ in hydrogen atom. As a result of this transition, the electron emits energy equal to ΔE in the form of a photon of radiation.

$$\Delta E = E_i - E_f$$

$$= \left(\frac{-2.18 \times 10^{-18}\ J}{n_i^2}\right) - \left(\frac{-2.18 \times 10^{-18}\ J}{n_f^2}\right)$$

$$= 2.18 \times 10^{-18}\left[\frac{1}{n_f^2} - \frac{1}{n_i^2}\right] \text{J/atom}$$

The frequency of the emitted photon is related to ΔE as :

$$\Delta E = h\nu$$

or

$$\nu = \frac{\Delta E}{h} = \frac{2.18 \times 10^{-18}}{h}\left[\frac{1}{n_f^2} - \frac{1}{n_i^2}\right] s^{-1}$$

$$\nu = \frac{2.18 \times 10^{-18}\ .\text{J}}{6.626 \times 10^{-34}\ \text{J.s}}\left[\frac{1}{n_f^2} - \frac{1}{n_i^2}\right]$$

$$\boxed{\nu = 3.29 \times 10^{15}\left[\frac{1}{n_f^2} - \frac{1}{n_i^2}\right]\ \text{s}^{-1}}$$

The wave number, $\bar{\nu}$ of the radiation may be calculated as under :

$$\bar{\nu} = \frac{\nu}{c} = \frac{3.29 \times 10^{15}\ \text{s}^{-1}}{3 \times 10^{10}\ \text{cm s}^{-1}}\left[\frac{1}{n_f^2} - \frac{1}{n_i^2}\right]$$

$$\boxed{\bar{\nu} = 109677\left[\frac{1}{n_f^2} - \frac{1}{n_i^2}\right]\ \text{cm}^{-1}}$$

or

$$\boxed{\bar{\nu} = 1.09677 \times 10^{7}\left[\frac{1}{n_f^2} - \frac{1}{n_i^2}\right]\ \text{m}^{-1}}$$

This expression is same as deduced by Rydberg from experimental data.