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$$E_{n_1} = -\frac{2\pi^2 m e^4}{n_1^2 h^2}$$

$$E_{n_2} = -\frac{2\pi^2 m e^4}{n_2^2 h^2}$$

The difference of energy between the levels n_1 and n_2 is

$$\Delta E = E_{n_2} - E_{n_1} = \frac{2\pi^2 m e^4}{h^2}\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right) \text{---} (i)$$

According to Planck's constant

$$\Delta E = h\nu = \frac{hc}{\lambda} \text{ ---} (ii)$$

Where λ is wavelength of photon and c is velocity of light. From equation (i) and (ii) we can write

$$\frac{hc}{\lambda} = \frac{2\pi^2 m e^4}{h^2}\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$$

or $$\frac{1}{\lambda} = \frac{2\pi^2 m e^4}{ch^3}\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$$

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

Where R is Rydberg constant.

The value of R can be calculated (5)
as the value of e, m, h, and c
are known. It comes out to
be 109,679 cm^{-1} and agrees
closely with the value of
Rydberg constant in the original
empirical Balmer's equation
109,677 cm^{-1}.

Calculation of wave lengths of the spectral lines of Hydrogen in the visible region. These lines constitute the Balmer series when $n_1 = 2$, now the equation

$$\frac{1}{\lambda} = R\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$$ can be written as

$$\frac{1}{\lambda} = 109679\left(\frac{1}{2^2} - \frac{1}{n_2^2}\right)$$

Thus the wave lengths of the photons emitted as the electron returns from energy levels 7, 6, 5, 4 and 3 were calculated by Bohr. The calculated values corresponding exactly to the values of wave lengths of the spectral lines already known. This was in fact, a great success of the Bohr atom.

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(6)

Example - Find the wave length in Å of the line in Balmer series that is associated with drop of the electron from the 4th orbit. The value of Rydberg constant is 109676 cm^{-1}.

Solution:- The wave lengths of lines in Balmer series are given by

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

where $R = 109676\ cm^{-1}$ $n_2 = 4$

$$\therefore \frac{1}{\lambda} = 109676\left(\frac{1}{2^2} - \frac{1}{4^2}\right)$$

$$= 109676\left(\frac{16-4}{64}\right)$$

$$= 109676 \times \frac{12}{64} = 109676 \times \frac{3}{16}$$

$$\therefore \lambda = \frac{16}{109676 \times 3}$$

$$= 4.862 \times 10^{-8}\ cm$$

$$= 4862 \times 10^{-8} \times 10^{8}\ Å$$

$$= 4862\ Å$$

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