Exemplar Problems

Q. 54 Calculate the energy and frequency of the radiation emitted when an electron jumps from $n = 3$ to $n = 2$ in a hydrogen atom.

Ans. In hydrogen spectrum, the spectral lines are expressed in term of wave number $\bar{\nu}$ obey the following formula

Wave number, $\bar{\nu} = R_H\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$ (where, R_H = Rydberg constant 109677 cm^{-1})

$$\bar{\nu} = 109677\ cm^{-1}\left(\frac{1}{2^2} - \frac{1}{3^2}\right)$$

$$\bar{\nu} = 109677 \times \frac{5}{36} = 15232.9\ cm^{-1}$$

$$\bar{\nu} = \frac{1}{\lambda}$$

or, $$\lambda = \frac{1}{\nu} = \frac{1}{15232.9} = 6.564 \times 10^{-5} cm$$

Wavelength, $\lambda = 6.564 \times 10^{-7}\ m$

Energy, $$E = \frac{hc}{\lambda}$$

$$= \frac{6.626 \times 10^{-34}\ Js \times 3.0 \times 10^{8}\ ms^{-1}}{6.564 \times 10^{-7}\ m}$$

$$= 3.028 \times 10^{-19}\ J$$

Frequency, $$\nu = \frac{c}{\lambda} = \frac{3.0 \times 10^{8}\ ms^{-1}}{6.564 \times 10^{-7}\ m}$$

$$= 0.457 \times 10^{15}\ s^{-1} = 4.57 \times 10^{14} s^{-1}$$

Note *When an electron returns from n_2 to n_1 state, the number of lines in the spectrum will be equal to* $\frac{(n_2 - n_1)(n_2 - n_1 + 1)}{2}$.