Q.2. Hydrogen atom in its ground state is excited by means of monochromatic radiation of wavelength 975Å. How many different lines are possible in the resulting spectrum ?

Calculate the longest wavelength amongst them. You may assume the ionization energy for hydrogen atom as 13.6 eV. (1982 - 5 Marks)

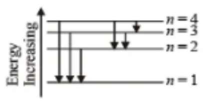
Solution.

$$E = \frac{12400}{\lambda(\text{in Å})}\ \text{eV} = \frac{12400}{975} = 12.75\ \text{eV} \qquad \text{...(i)}$$

Also

$$13.6\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right] = 12.75 \Rightarrow \left[\frac{1}{1} - \frac{1}{n_2^2}\right] = \frac{12.75}{13.6} \Rightarrow n_2 = 4$$

For every possible transition one downward arrow is shown therefore the possibilities are 6.



Note : For longest wavelength, the frequency should be smallest.

This corresponds to the transition from n = 4 to n = 3, the energy will be $E_4 = -\frac{13.6}{4^2}; E_3 = -\frac{13.6}{3^2}$

$$\therefore E_4 - E_3 = \frac{-13.6}{4^2} - \left(\frac{-13.6}{3^2}\right) = 13.6\left[\frac{1}{9} - \frac{1}{16}\right]$$

$$= 0.66\ \text{eV} = 0.66 \times 1.6 \times 10^{-19}\ \text{J} = 1.056 \times 10^{-19}\ \text{J}$$

$$\text{Now, } E = \frac{12400}{\lambda(\text{in Å})}\ \text{eV} \quad \therefore \quad \lambda = 18787\ \text{Å}$$