SUBJECT - CHEMISTRY
CLASS - B.Sc(Hons) PART- III
PAPER - V
TOPIC - quantum degeneracy

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Q Explain the meaning of quantum degeneracy.

Ans Quantum degeneracy:- The Same energy States with different eigen functions are called degenerate states. This phenomenon is called quantum degeneracy. The Complete wave function ψ for a particle (electron) in a cubical box of length l is given by

$$\psi_{n_x n_y n_z} = \sqrt{\frac{8}{L^3}} \cdot \sin\left(\frac{n_x \pi}{L}\right) \cdot x \cdot \sin\left(\frac{n_y \pi}{L}\right) \cdot y \sin\left(\frac{n_z \pi}{L}\right) \cdot z \quad \text{--- (1)}$$

And its total energy (E) is given by -

$$E_{n_x n_y n_z} = \frac{h^2}{8mL^2}\left(n_x^2 + n_y^2 + n_z^2\right) \quad \text{--- (2)}$$

where n_x, n_y and n_z are quantum numbers along x, y and z axes and are integers except zero.

For states having quantum numbers (2,1,1), (1,2,1) and (1,1,2) eigen functions and their energies are given below -

States ($n_x n_y n_z$)	$\psi_{n_x n_y n_z}$	$E_{n_x n_y n_z}$
2,1,1	$\psi_{211} = \sqrt{\frac{8}{L^3}} \sin\left(\frac{2\pi}{L}\right) \cdot x \sin\left(\frac{\pi}{L}\right) \cdot y \sin\left(\frac{\pi}{L}\right) \cdot z$	$E_{211} = \frac{6h^2}{8mL^2}$
1,2,1	$\psi_{121} = \sqrt{\frac{8}{L^3}} \sin\left(\frac{\pi}{L}\right) x \sin\left(\frac{2\pi}{L}\right) \cdot y \sin\left(\frac{\pi}{L}\right) \cdot z$	$E_{121} = \frac{6h^2}{8mL^2}$
1,1,2	$\psi_{112} = \sqrt{\frac{8}{L^3}} \sin\left(\frac{\pi}{L}\right) \cdot x \sin\left(\frac{\pi}{L}\right) y \sin\left(\frac{2\pi}{L}\right) z$	$E_{112} = \frac{6h^2}{8mL^2}$

where $2^2+1^2+1^2 = 1^2+2^2+1^2 = 1^2+1^2+2^2 = 6$

we see that These three States have the Same energy. So the energy level Corresponding to energy $6h^2/8mL^2$ is Three fold or triply degenerate These np_x np_y and np_z orbital for which $m = +1, 0, -1$ Constitute three independent states as Their eigen functions are different but they give the Same energy. Hence p-orbital are triply degenerate Similarly d and f-orbital have five and Seven fold degeneracy. respectively in absence of any applied field.