Chemistry Study Materials for Class 11 (NCERT Based Notes of Chapter- 02)

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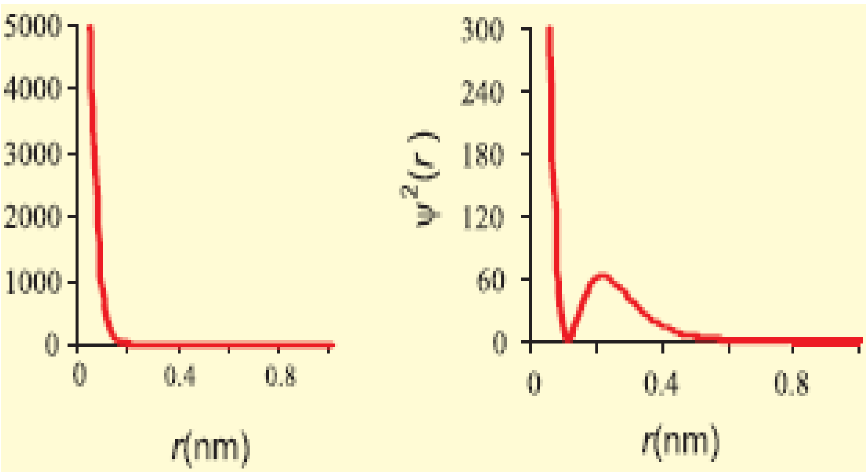
Structure of Atom

Shapes of orbitals

1. s-orbitals

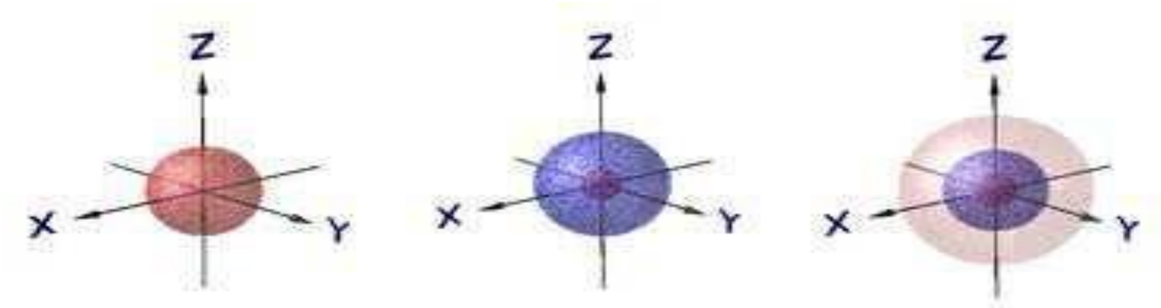
For s-orbitals, $l = 0$ and hence $m_l = 0$. So there is only one possible orientation for s orbitals. They are spherically symmetrical. The plots of probability density (ψ^2) against distance from the nucleus (r) for 1s and 2s atomic orbitals are as follows:



For 1s orbital the probability density is maximum at the nucleus and it decreases with increase in r. But for 2s orbital the probability density first decreases sharply to zero and again starts increasing. After reaching a small maximum it decreases again and approaches zero as the value of r increases. The region where the probability density (ψ^2) reduces to zero is called **nodal surface** or **node**.

For 1s orbital, there is no node, for 2s orbital there is only one node, for 3s orbital there are 2 nodes and so on. In general, for an ns-orbital there are (n – 1) nodes.

All the s-orbitals are spherically symmetrical and their size increases with increase in n. The boundary surface diagrams for 1s, 2sand 3s orbitals are as follows:



2. p- Orbitals

For p-orbitals, l = 1 and m_l = -1, 0, +1. i.e., there are three possible orientations for p orbitals. So there are 3 types of p-orbitals – p_x, p_y and p_z. Each p orbital consists of two lobes. The probability density function is zero on the plane where the two lobes touch each other.

The size, shape and energy of the three orbitals are identical. They differ only in the orientation of the lobes. For p_x orbital, the lobes are along the x-axis, for p_y, they are along the y-axis and for p_z, they are along the z-axis. All the p-orbitals have dumb-bell shape.

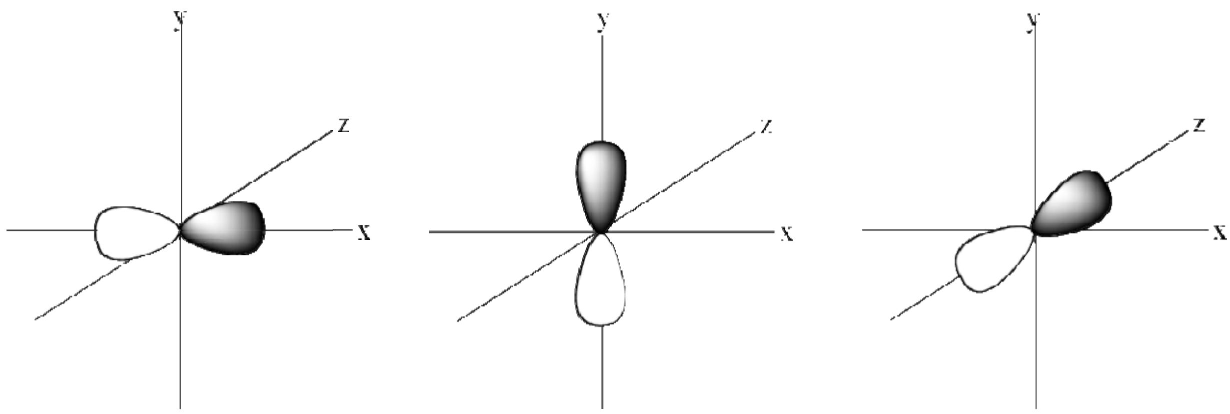
The number of radial nodes for p-orbitals are given by (n –2), that is number of radial node is 1 for 3p orbital, two for 4p orbital and so on. Besides the radial nodes, the probability density functions for the np orbitals are zero at the plane, passing through the nucleus (origin). For example, in the case of p_z orbital, xy-plane is a nodal plane. These are called angular nodes and number of angular nodes is given by 'l'.

Number of radial nodes = n - l – 1

Number of angular nodes = l

Total number of nodes = n-1

The boundary surface diagrams for three 2p orbitals are as follows:



3. d- Orbitals

For d-orbitals, $l = 2$ and $m_l = -2, -1, 0, +1$ and $+2$.

i.e., there are five possible orientations for d orbitals.

So there are 5 types of d-orbitals.

They are d_{xy}, d_{xz}, d_{yz}, $dx^2 - y^2$ and dz^2

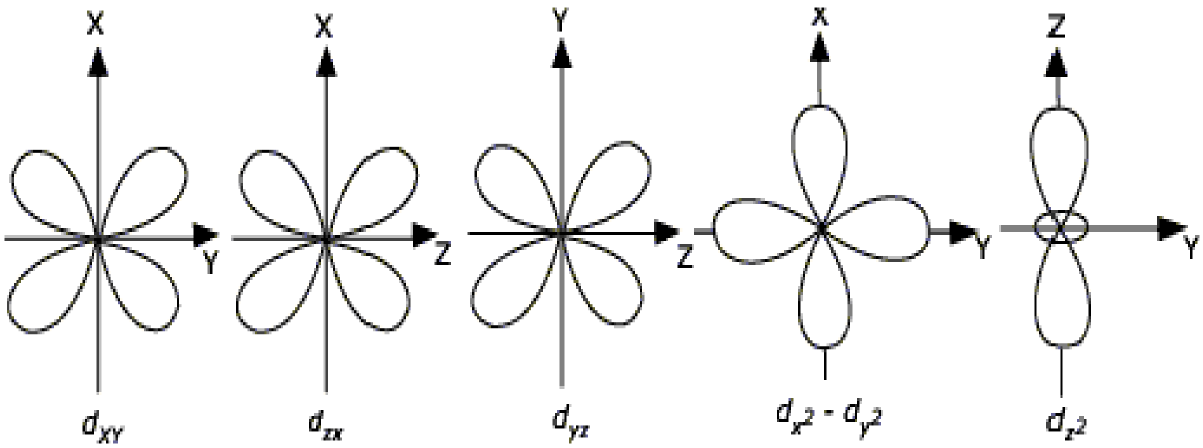
The shapes of the first four d-orbitals are double dumb-bell and that of the fifth one, dz^2, is dumb-bell having a circular collar in the xy-plane.

The five d- orbitals have equivalent energies.

For d-orbitals the number of radial nodes is 2

and the total number of nodes is n-2.

Boundary surface diagrams for d-orbitals are as follows:



4. f- Orbitals

For f-orbitals, $l = 3$ and $m_l = -3, -2, -1, 0, +1, +2$ and $+3$.

i.e., there are seven possible orientations for f orbitals.

So there are 7 types of f-orbitals.

They are fx^3, fy^3, fz^3, $fx(y^2-z^2)$, $fy(z^2-x^2)$, $fz(x^2-y^2)$ and fxyz.

They have diffused shapes.

(Details of f- Orbitals are not mention in the syllabus of class 11th)

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