Quadrant II – Transcript and Related Materials

Programme: Bachelor of Science (First Year)

Subject: Chemistry

Paper Code: CHC-101

Paper Title: Inorganic Chemistry and Organic Chemistry (Section A)

Unit: 1 (Atomic Structure)

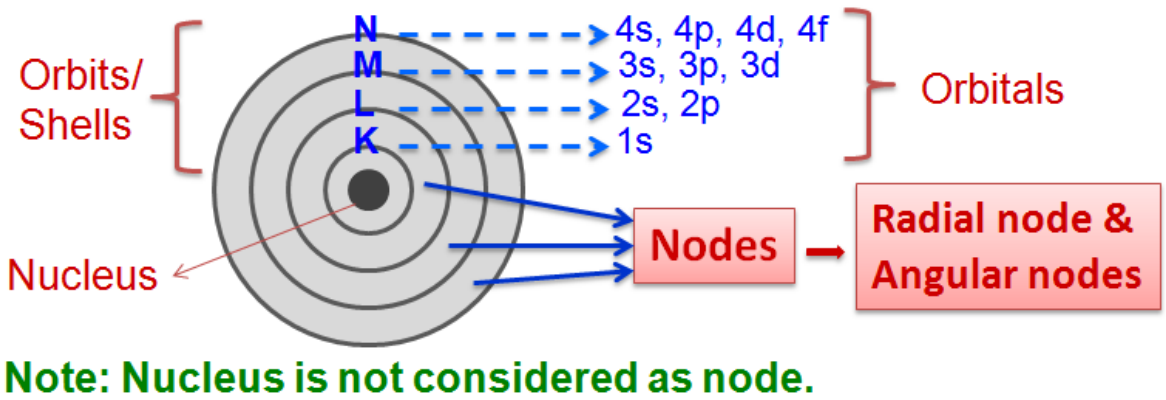
Module Name: Radial and Angular Nodes

Module No: 09

Name of the Presenter: Dr. Rita N. Jyai

Notes

Nodes in an atom: The region at which the probability of finding an electron is **zero** is called as a **node**.



Note: Nucleus is not considered as node.

Orbital representation using wave function

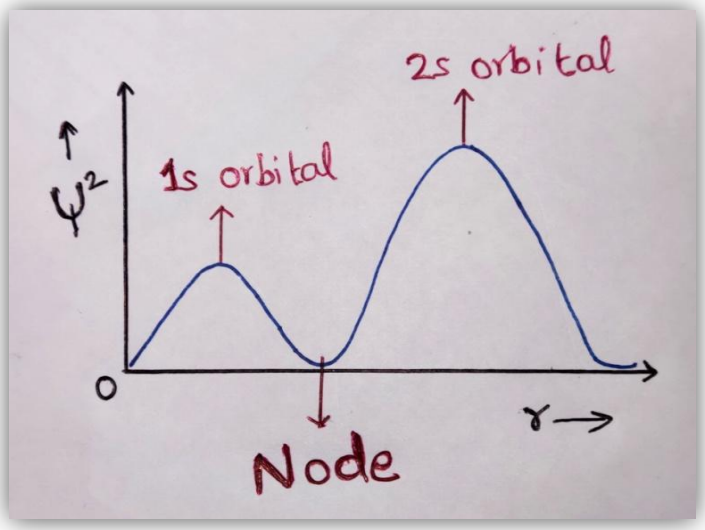
$\Psi = R_{n\ell}(r) \times Y_{\ell m}(\theta, \phi)$

Radial wave function — Angular wave function

Size — **Shape**

Where, r, θ, ϕ = Polar coordinates.

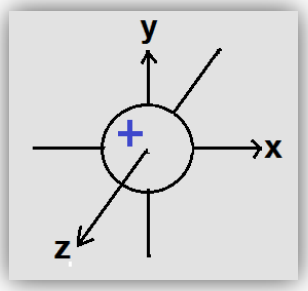
- The value of Ψ^2 gives electron density distribution.
- When **$\Psi^2 = 0$**, we get the node i.e., **R(r) and/or Y = 0**

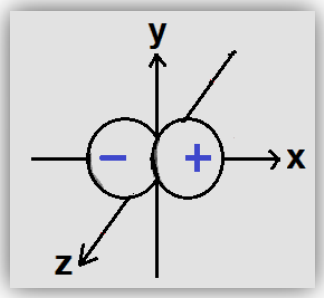


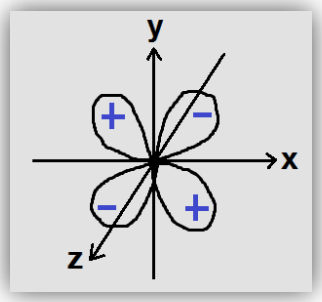
Node for 2*s* orbital

Dependence of orbitals on r, θ, ϕ

- The **radial part (R)** of the wave function ψ is always positive as **r** (radius) has to be positive.
- The **angular part (Y)** of the wavefunction ψ may be positive or negative depending on **θ** and **ϕ** (angles).







s-orbital *p*-orbital *d*-orbital

Radial Nodes

- It occur where the radial component **R(r)** of the wave function passes through zero i.e., probability of finding an electron here is zero. **R(r) = 0**
- These regions are described as **radial nodes** or **spherical radial nodes** since it has fixed radius and depicts their size.
- The number of radial node is determined by principal quantum number **(n)**.

Angular Nodes

- It occur where the angular component **Y** of the wave function passes through zero. **Y = 0**
- These regions are described as angular nodes or nodal planes (if planar) and can be conical as well. They have fixed angles.
- The number of angular nodes is determined by the azimuthal quantum number (ℓ).

Significance of Radial and Angular nodes

- Radial wavefunction gives the size.
- The number of radial node increases with principal quantum number (n).
- Angular part determines its shape.

- Angular node is equal to azimuthal quantum number (ℓ).
- From n and ℓ, the number of nodes is derived and the type of node (radial and/or angular) is determined.

The number and type of nodes for an orbital

- Total number of nodes = n - 1
- The number of angular nodes = ℓ
- The number of radial nodes

= (number of nodes) – (angular nodes)

= n -1 - ℓ

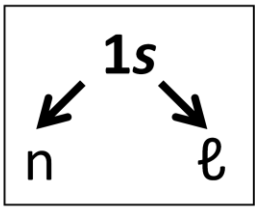
Or

= n-1 (for n*s* orbital); n-2 (for n*p* orbital);

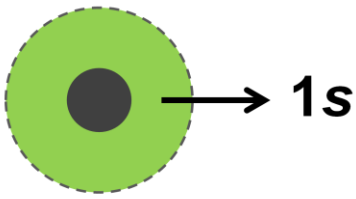
n-3 (for n*d* orbital); n-4 (for n*f* orbital)

Calculating number of nodes, type of nodes and diagrammatical representation of nodes for first, second and third orbital

Orbital 1st shell	No. of nodes (n-1)	Angular nodes (ℓ)	Radial Nodes Method I (n-1-ℓ)	 Method II (n-1/2/3..)	Type of node
1*s* n=1, ℓ=0	1-1= 0	0	1-1-0= 0	(n*s*) 1-1= 0	Zero nodes

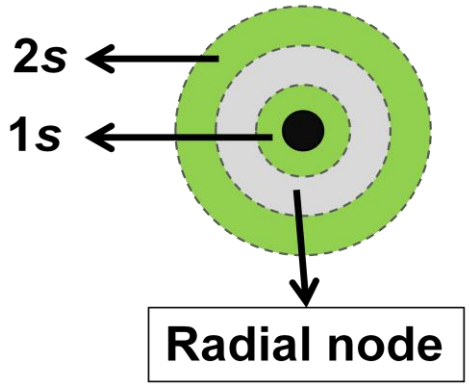


ℓ = 0 (*s*);
1 (*p*);
2 (*d*);
3 (*f*)

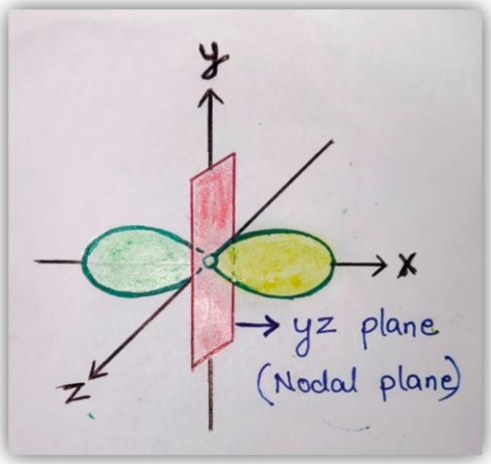


Orbita 2nd shell	No. of nodes (n-1)	Angular nodes (ℓ)	Radial Nodes Method I (n-1-ℓ)	 Method II (n-1/2/3..)	Type of node
2*s* n=2, ℓ=0	2-1= 1	0	2-1-0= 1	(n*s*) 2-1= 1	1 Radial node
2*p* n=2, ℓ=1	2-1= 1	1	2-1-1= 0	(n*p*) 2-2= 0	1 Angular no

2*s*

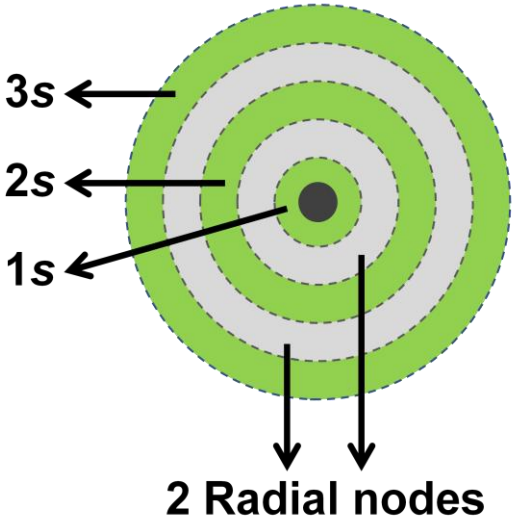


$2P_x$

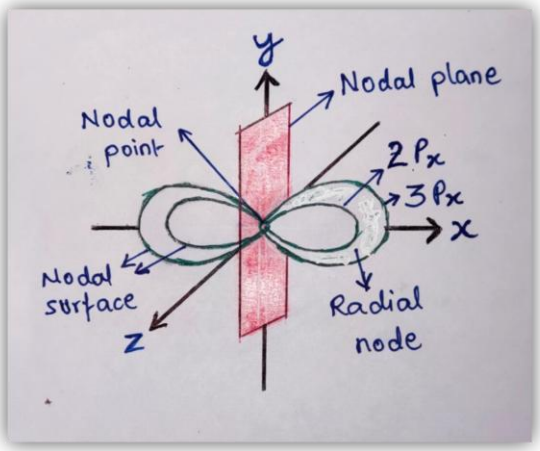


Orbital 3rd shell	No. of nodes (n-1)	Angular nodes (ℓ)	Radial Nodes Method I (n-1-ℓ)	 Method II (n-1/2/3..)	Type of node
3*s* n=3, ℓ=0	3-1= 2	0	3-1-0= 2	(n*s*) 3-1= 2	2 Radial node
3*p* n=3, ℓ=1	3-1= 2	1	3-1-1= 1	(n*p*) 3-2= 1	1 Radial + 1 Angular node
3*d* n=3, ℓ=2	3-1= 2	2	3-1-2= 0	(n*d*) 3-3= 0	2 Angular node

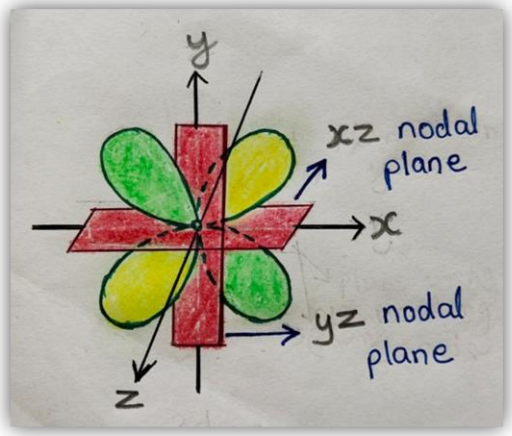
3s



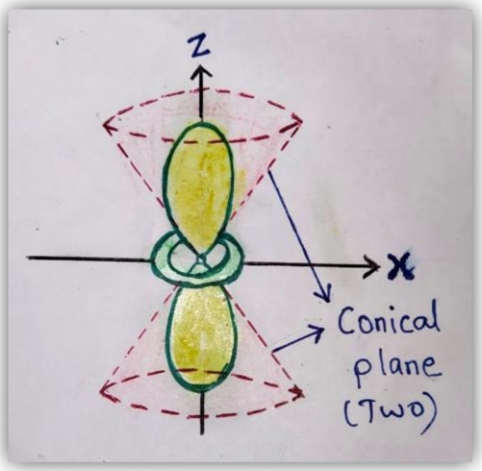
$3P_x$



$3d_{xy}$



$3d_z^2$



SUMMARY

- Nodes are points/planes of zero electron density.
- Radial nodes determines the size of the orbital.
- Radial nodes are spherical in shape.
- Angular nodes determines the shape of the orbital.
- Angular nodes are planar/conical.