

Quantum Numbers: The Atomic Blueprint



Locating electrons using the
 $n \rightarrow l \rightarrow m_l \rightarrow m_s$ hierarchy.



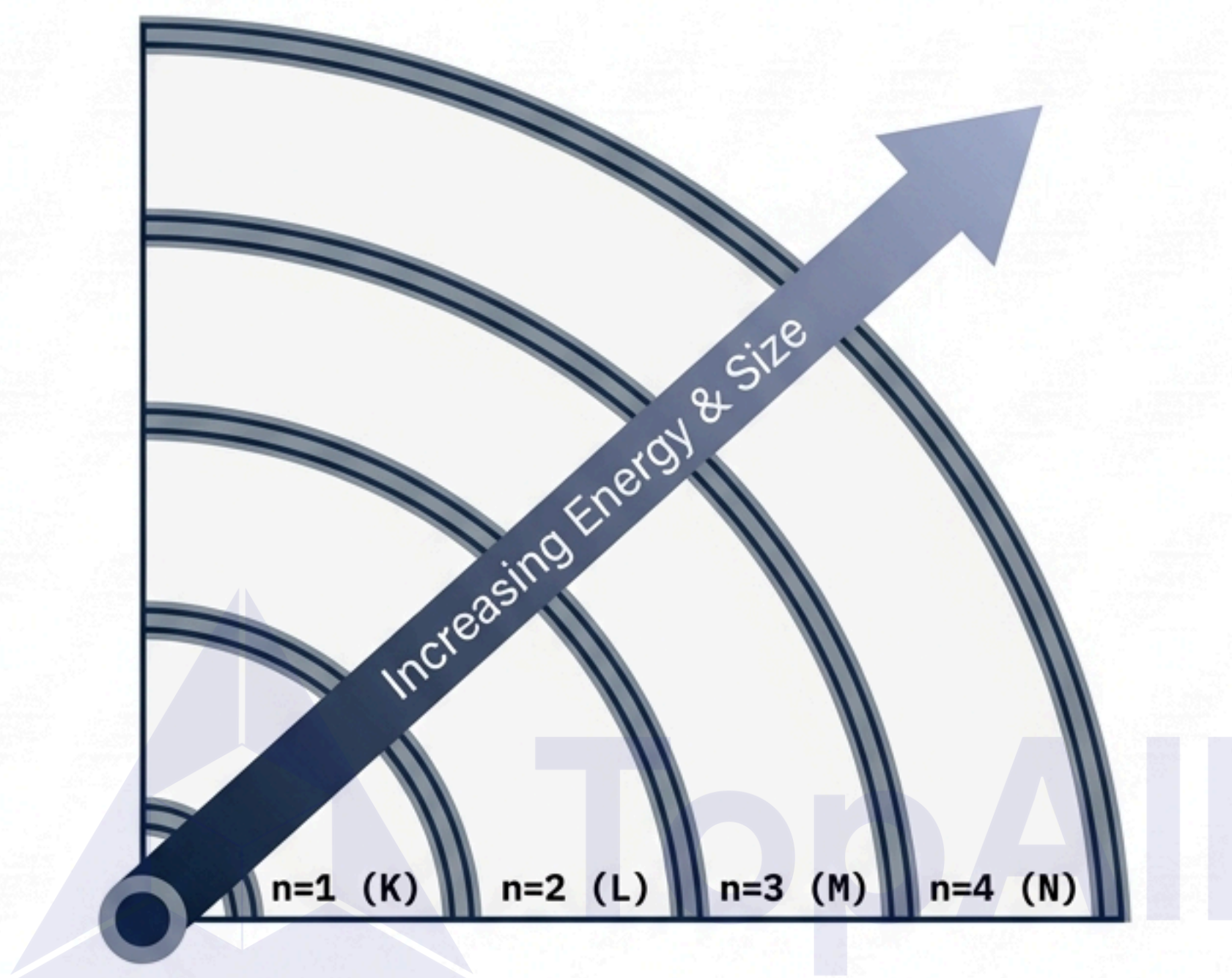
Orbit
(Classical Path)



Orbital
(Quantum Probability)

Atomic Orbital: A mathematical wave function (ψ) defining the 3D region where the probability of finding an electron is maximum ($\geq 90\%$). Defined entirely by quantum numbers.

1. Principal Quantum Number (n)



$n = 1, 2, 3, \dots$ (Positive Integers)

Defines:

The Principal Shell.

Physical Meaning:

Determines the size of the orbital and the primary energy level of the electron.

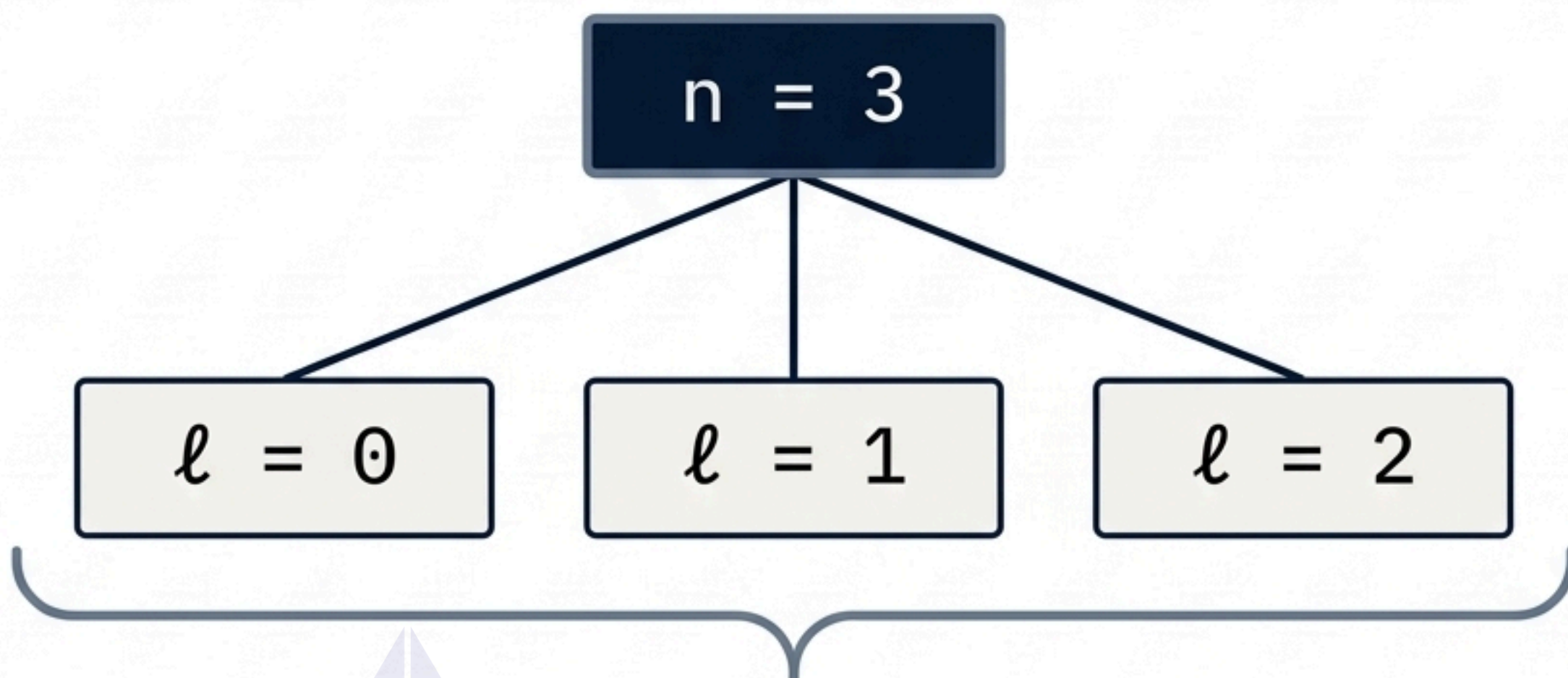
Max Electrons per Shell:

$$2n^2$$

Max Orbitals per Shell:

$$n^2$$

2. Azimuthal Quantum Number (ℓ)



$$\ell = 0, 1, 2, \dots, (n - 1)$$

Also Known As:

Orbital Angular Momentum.

Defines:

The Subshell.

Physical Meaning:

Determines the 3D shape of the orbital and the number of angular nodes.

Allowed Values:

Always strictly less than n .

The Subshell Map



Quantum Value (ℓ)	Subshell Notation	3D Shape	Number of Orbitals ($2\ell + 1$)
$\ell = 0$	s	Spherical	1 Orbital
$\ell = 1$	p	Dumbbell	3 Orbitals
$\ell = 2$	d	Double-Dumbbell	5 Orbitals
$\ell = 3$	f	Complex	7 Orbitals

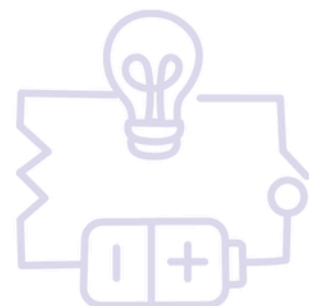


PRO TIP: In multi-electron atoms, energy within the same shell increases as $s < p < d < f$ due to shielding.



You've Learned the Theory. Let's Test Them Now.

$$E=mc^2$$



Turn theory into marks with **unlimited MCQs, smart analysis, and focused revision.**

Practice Now



At prep.topall.app

Key Highlights

- » Free Study Material, Videos & Infographics
- » Push Your Limits with Level-Based Challenges
- » Climb the Leaderboard Among Fellow Aspirants
- » Practice Unlimited MCQs for NEET & JEE
- » Get Clear Explanations, Not Just Marks
- » Track Your Performance Smarter



The Trap: l Cannot Equal n

The value of l is capped at $n - 1$. A subshell's quantum number can never equal or exceed its principal shell.

Valid States:

1s ✓ 2p ✓ 3d ✓

Invalid States:

1p ✗ 2d ✗ 3f ✗

Exam Application Breakdown

1p orbital? $\rightarrow n = 1$.
Allowed $l = 0$.
p requires $l = 1$.

INVALID.

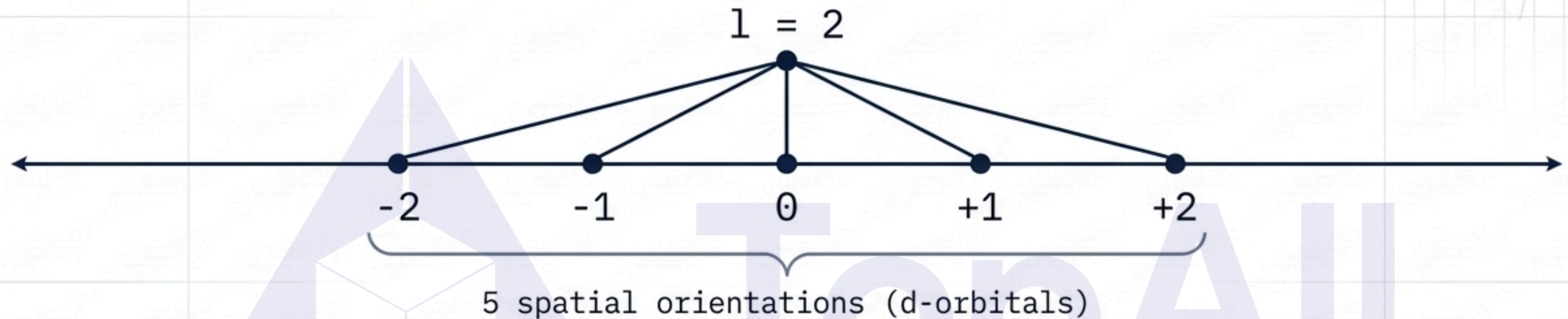
2d orbital? $\rightarrow n = 2$.
Allowed $l = 0, 1$.
d requires $l = 2$.

INVALID.

3f orbital? $\rightarrow n = 3$.
Allowed $l = 0, 1, 2$.
f requires $l = 3$.

INVALID.

3. Magnetic Quantum Number (m_l)



$$m_l = -l, \dots, 0, \dots, +l$$

Defines:

The exact Orbital within a subshell.

Physical Meaning:

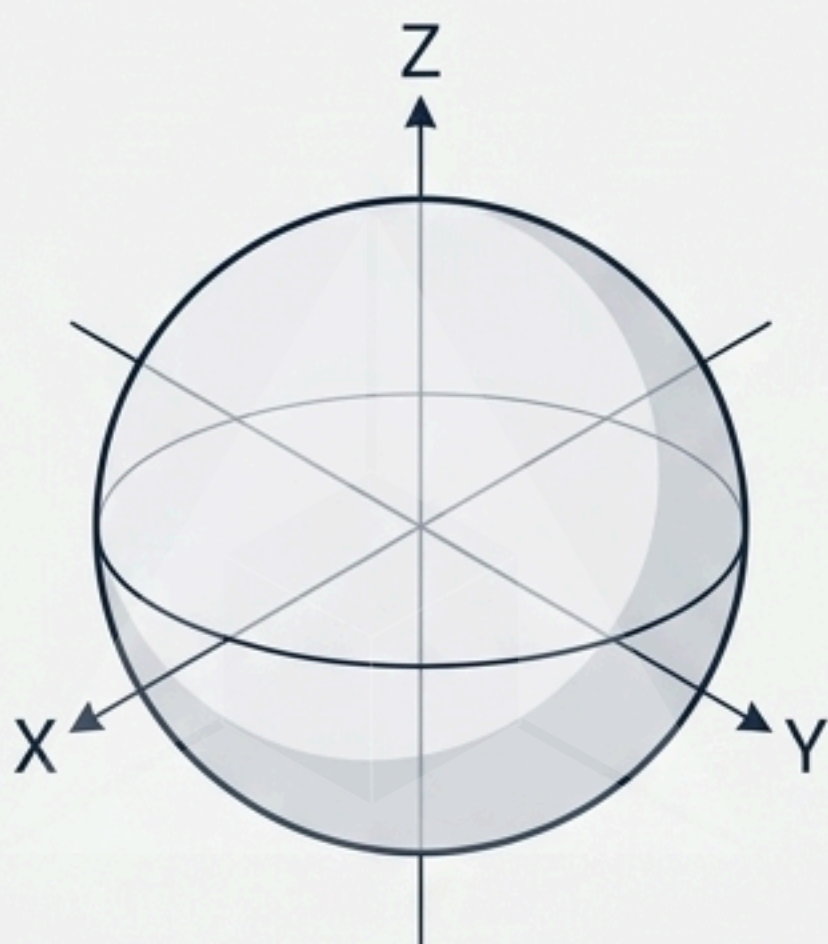
The spatial orientation of the orbital with respect to a standard coordinate axis.

Total Orbitals:

For any given l , there are exactly $(2l + 1)$ possible values for m_l .

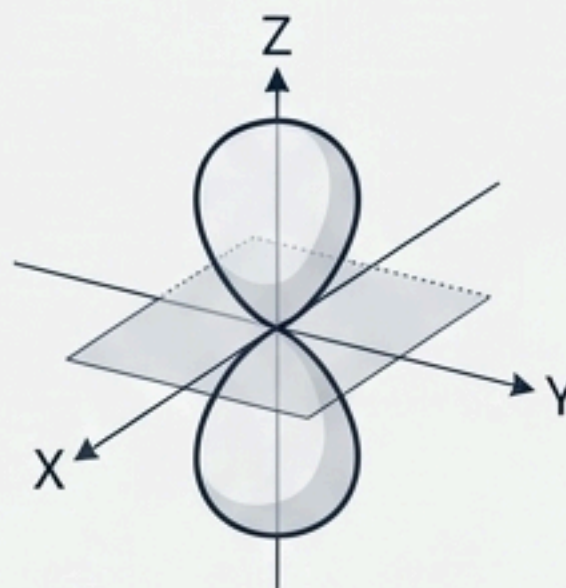
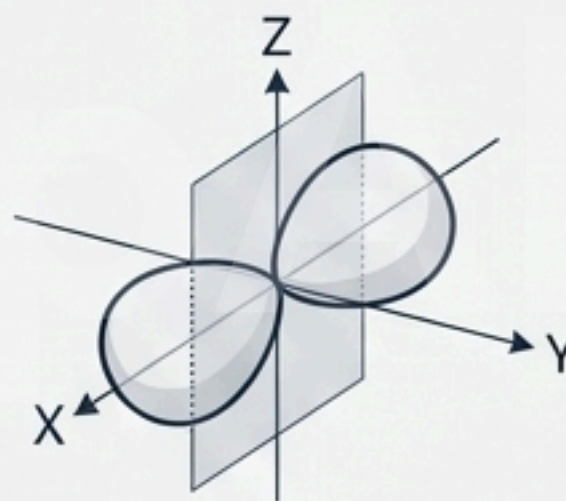
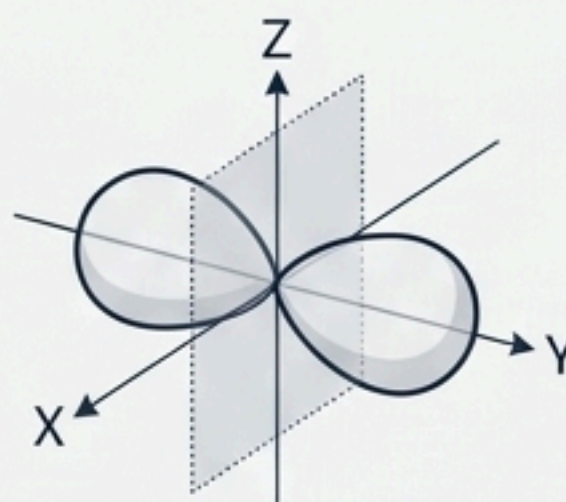
Visualizing Shape & Orientation

While ℓ dictates the geometric shape (spherical vs. lobed), m_ℓ dictates how those lobes align along the X, Y, and Z axes in space.



$$\ell=0, m_\ell=0$$

1s Orbital (Sphere)



$$\ell=1, m_\ell = -1, 0, +1 \rightarrow p_x, p_y, p_z$$

2p Orbitals (Dumbbells)

4. Electron Spin Quantum Number (m_s)

$+1/2$



(Spin Up, $\uparrow$)

$-1/2$



(Spin Down, $\downarrow$)



Pauli Exclusion Limit

$$m_s = +1/2, -1/2$$

Defines: The individual Electron.

Physical Meaning: The intrinsic angular momentum (spin state) of the electron.

The Pauli Limit:

An orbital can hold a maximum of 2 electrons, and they must have opposite spins.

The Quantum Hierarchy

$$n \rightarrow l \rightarrow m_l \rightarrow m_s$$

Layer 1: $n = 3$ (3rd Shell)

Layer 2: $l = 1$ (p-subshell)

Layer 3: $m_l = 0$ (pz orbital)

Layer 4: $m_s = +1/2$
(Specific Spin-up Electron)

RESTRICTED
POSSIBILITIES

RESTRICTED
POSSIBILITIES

No two electrons in an atom can have the same set of four quantum numbers. Together, they form a unique mathematical address.

Key Takeaways: The Master Cheat Sheet

Symbol	Name	Formula Constraint	Physical Meaning
n	Principal	$1, 2, 3 \dots$	Shell / Size / Energy
l	Azimuthal	$0 \text{ to } (n-1)$	Subshell / 3D Shape
m_l	Magnetic	$-1 \text{ to } +1$	Orbital / Orientation
m_s	Spin	$+1/2, -1/2$	Electron / Spin State

Total Orbitals in Shell = n^2 | Total Electrons in Shell = $2n^2$



You've Learned the Theory.

Now Let's Test It.

Reading notes gets you knowledge.

Practicing MCQs gets you marks.

That's exactly what TopAll Pro is built for.

Try TopAll Pro Now

What TopAll Pro Does Differently

-  **Stuck? Snap it. Solve it. — Doubts AI**
Photo → step-by-step solution in seconds, 24/7
-  **Your AI Coach finds your blind spots**
Concept-level weakness detection — not just chapter-level
-  **4.5 Lakh+ questions. Never run out.**
13× more content than any other prep app in India
-  **Build your own test in 60 seconds**
Pick a chapter, set difficulty — AI does the rest instantly.
-  **AI Recommendation that helps you improve**
AI Recommendation Analysis your Tests and tell you where you need to improve.



Practice the moment you finish studying
Jump in while the concept is still fresh in your head

4.5L+
MCQs

1.5L+
Students

AI Powered
In-Depth Analysis