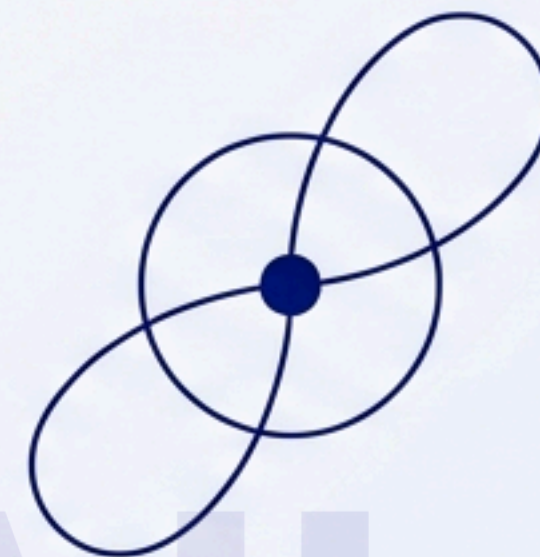


Energies of Orbitals

The Quantum Blueprint
of Atomic Structure

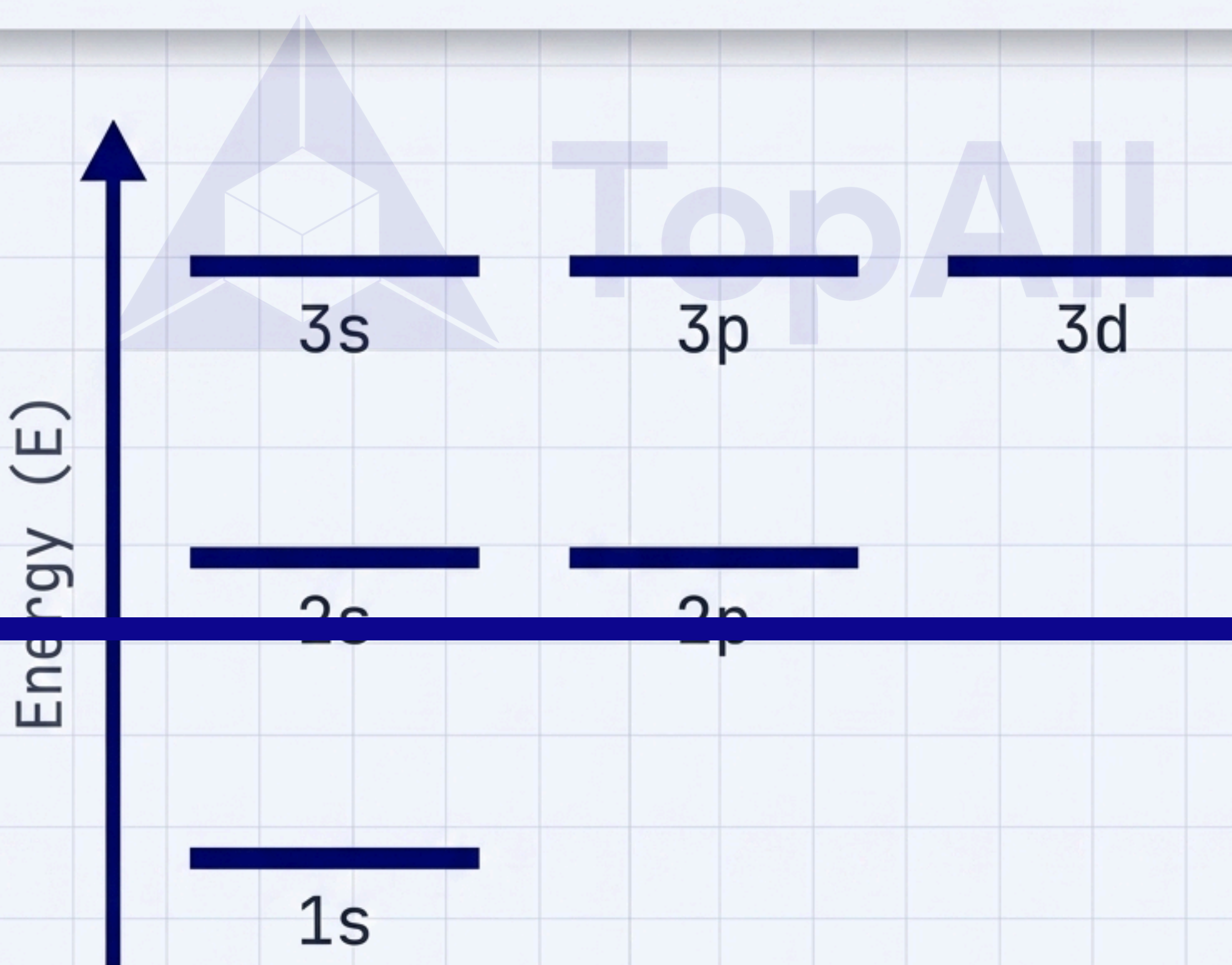


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The Hydrogen Baseline

(1-Electron System)

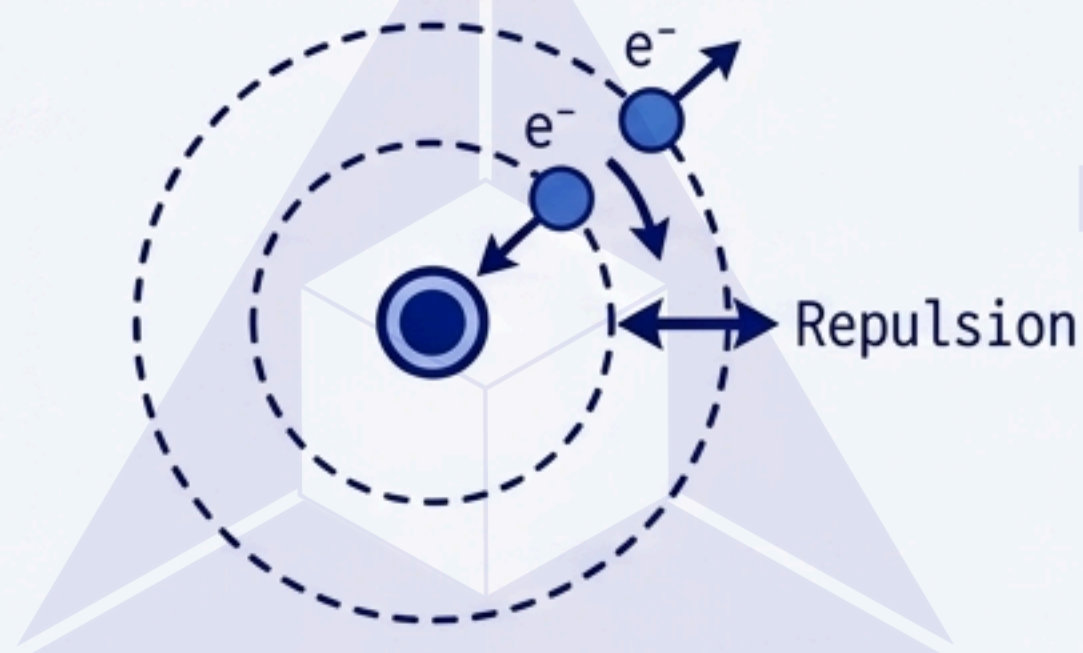
In a single-electron atom, energy depends **solely on** the principal quantum number (n).



Degenerate Orbitals: Orbitals with the exact same energy (e.g., $2s = 2p$).

The Multi-Electron Reality

The Cause: Electron-Electron Repulsion & Screening



Mutual repulsion and partial screening from the nucleus (Z_{eff}) mean energy now depends on BOTH n (shell) and l (subshell).

The Effect: Orbital Energy Splitting



Within the same shell (same n), orbital energy **increases** in the order: $s < p < d < f$.



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Diagnostic Comparison: Energy Dependence



Single Electron (H, He⁺, Li²⁺)

Energy = $f(n)$ only.

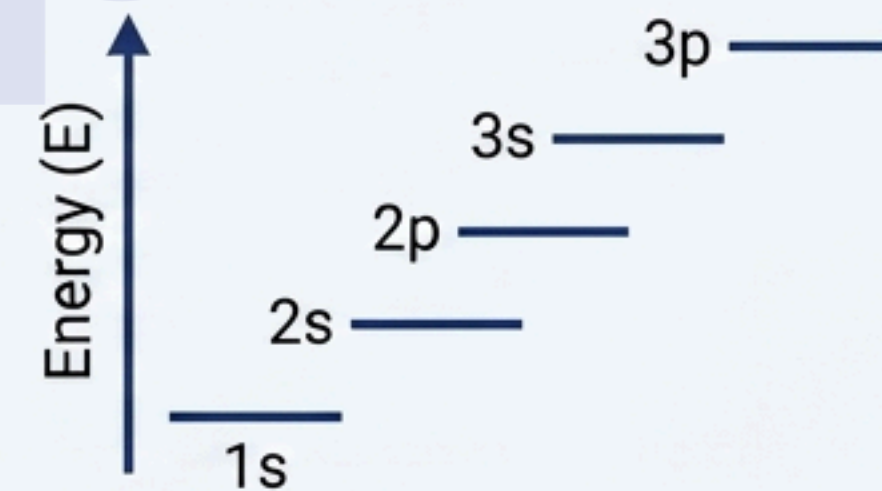
$$1s < 2s=2p < 3s=3p=3d$$



2+ Electrons (All other atoms)

Energy = $f(n, l)$.

$$1s < 2s < 2p < 3s < 3p$$



! JEE TRAP: Never apply splitting rules or the (n+l) rule to a Hydrogen atom in its excited state!

The Core Formula: The $(n+l)$ Rule

The lower the value of $(n+l)$ for an orbital, the lower its energy.

4s Orbital



$n=4$, $l=0$



Sum = 4

3d Orbital



$n=3$, $l=2$



Sum = 5

Because $4 < 5$, the 4s orbital fills before 3d.

The Tie-Breaker Rule

If two orbitals have the same $(n+l)$ value, the orbital **with the lower value of n** has the lower energy.



Since $2 < 3$, the 2p orbital has lower energy and **fills first**.
 $2p < 3s$.

The Master Sequence (Aufbau Principle)

	s	p	d	f
1	1s			
2	2s	2p		
3	3s	3p	3d	
4	4s	4p	4d	4f
5	5s	5p	5d	5f
6	6s	6p	6d	
7	7s	7p		



Notice how the arrows force 4s to be filled before 3d. This is a frequently tested sequence shift.

1s < 2s < 2p < 3s < 3p < 4s < 3d < 4p < 5s < 4d ...

JEE Key Takeaways

- ✓ For Multi-electron atoms, **always** use the $(n+1)$ rule to determine orbital energy order.
- ✓ In the event of an $(n+1)$ tie, the lower n value dictates lower energy.
- ✓ Remember the subshell energy order within a shell: $s < p < d < f$.

- ✗ **TRAP:** Assuming 3d fills before 4s. (Reality: $4s(4) < 3d(5)$)).
- ✗ **TRAP:** Applying splitting rules to Hydrogen. (Reality: In H, 2s and 2p are exactly equal in energy).

Trust the math of $(n+l)$, not just the numerical order of shells.



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