

CRYSTAL FIELD THEORY

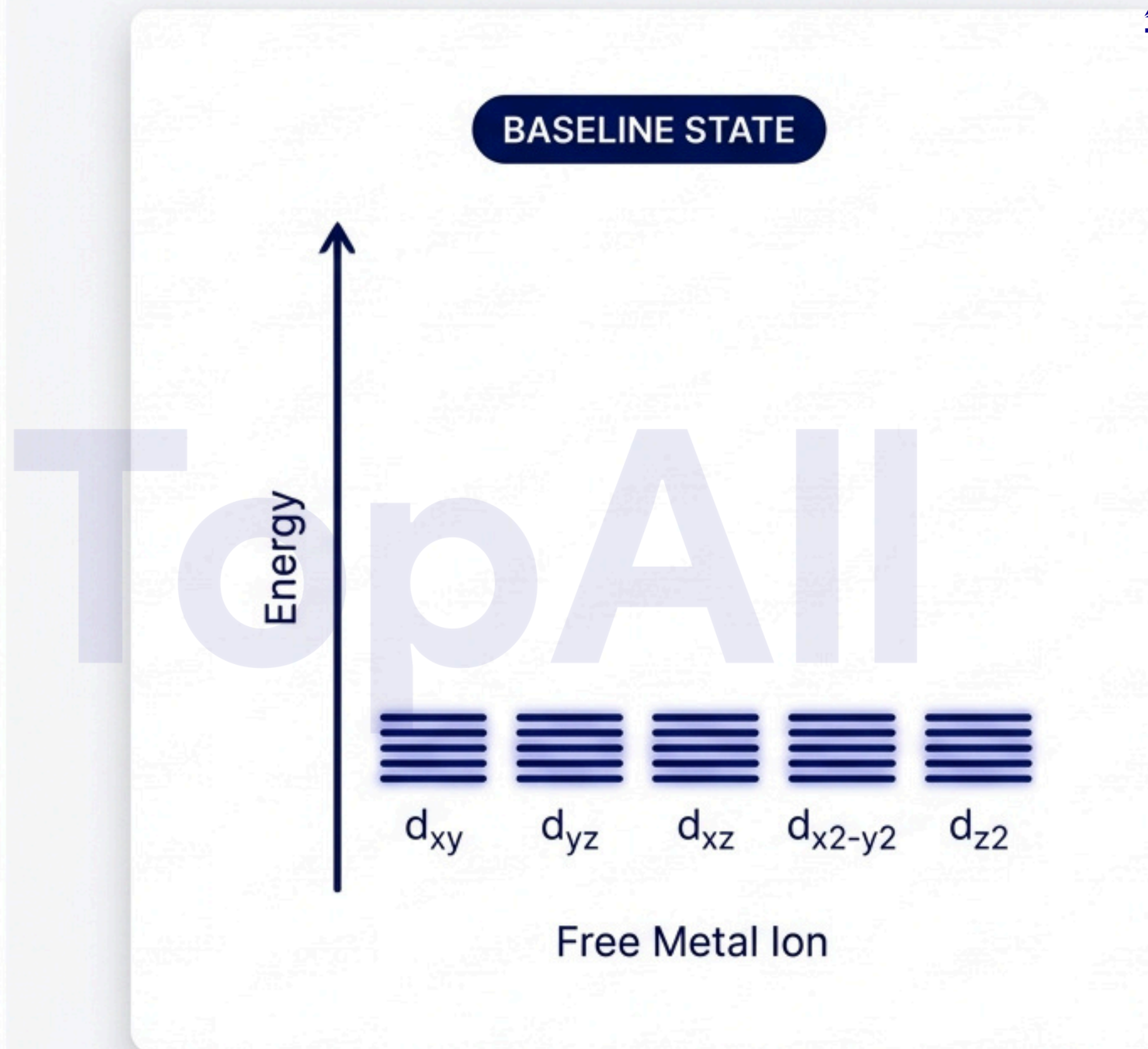
The Concept of Degeneracy

In an isolated, gaseous transition metal atom or ion, all five d orbitals share the exact same energy level. They exist in a state of perfect energetic balance.

What is Degeneracy?

When orbitals possess identical energy, they are called degenerate.

If the metal ion is surrounded by a perfectly spherical field of negative charge, this degeneracy is maintained, although the average energy of the system rises slightly.



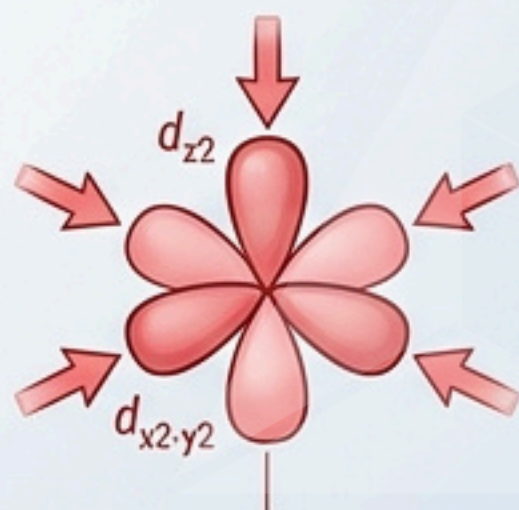
THE OCTAHEDRAL FIELD

Why the Orbitals Split

Crystal Field Theory treats metal-ligand bonds as purely ionic—an electrostatic interaction. When six ligands surround a metal ion in an octahedral geometry, their negative charges approach along the x, y, and z axes. This asymmetric disruption breaks the degeneracy of the d orbitals.

Panel 1: The e_g Set (Direct Hit)

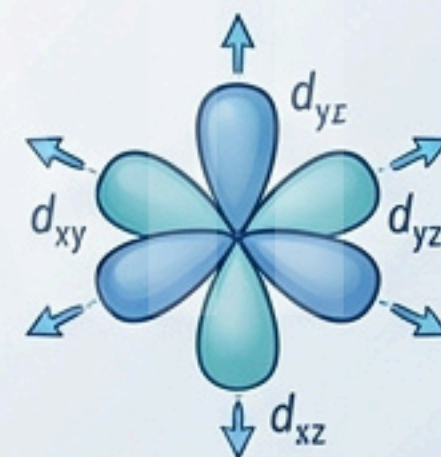
The $d_{x^2-y^2}$ and d_{z^2} orbitals point directly along the axes toward the approaching ligands.



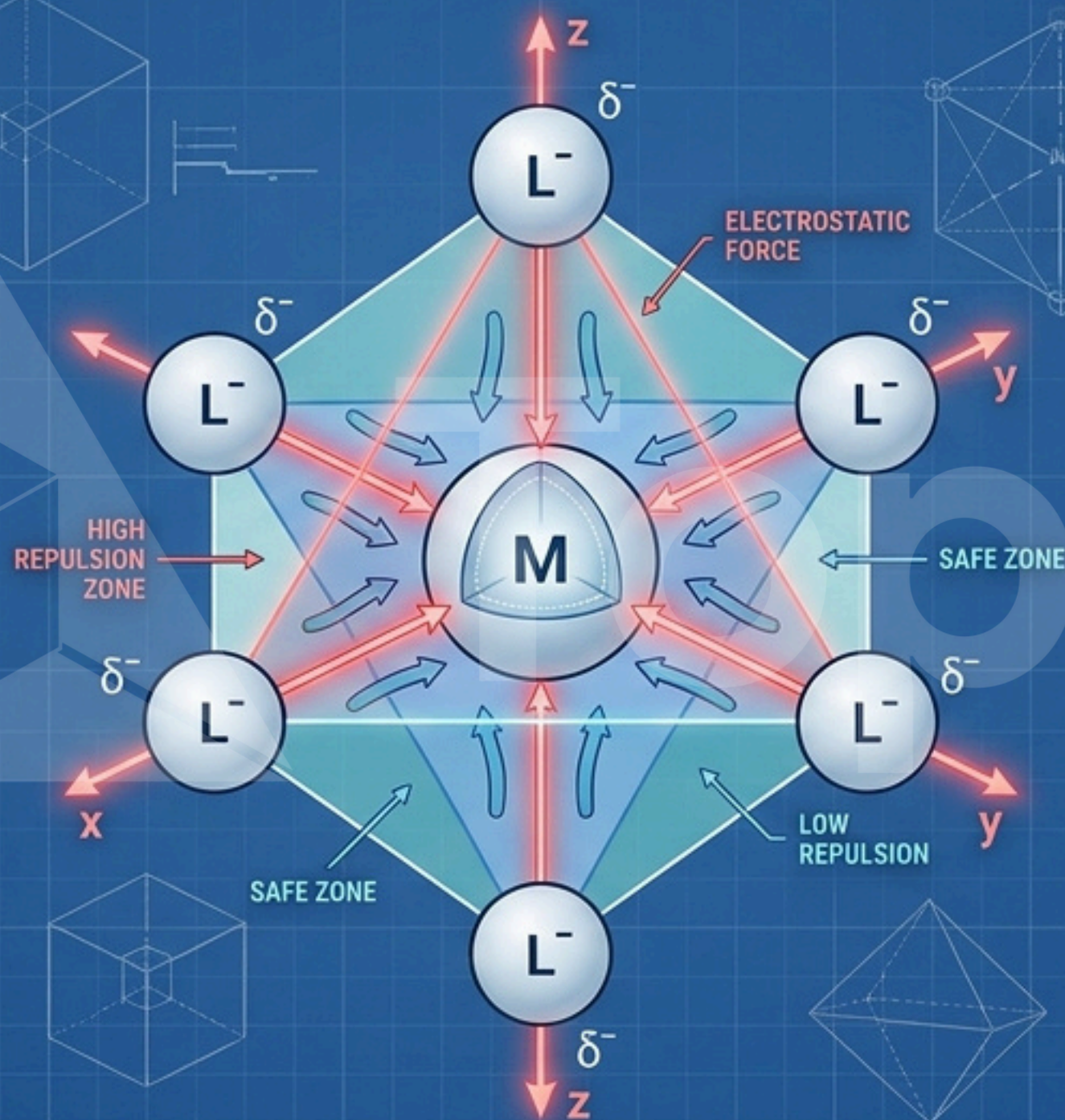
Result: Maximum electrostatic repulsion. Energy rises.

Panel 2: The t_{2g} Set (Safe Zones)

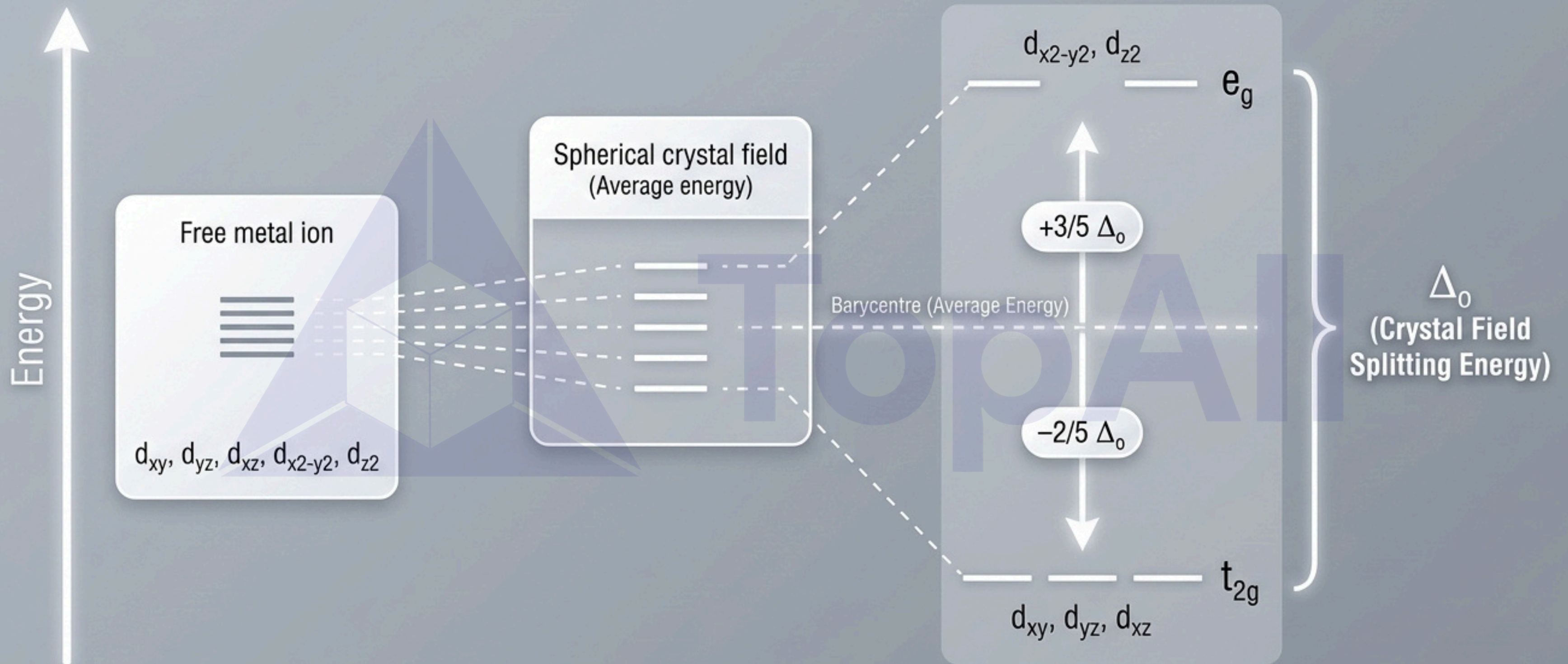
The d_{xy} , d_{yz} , and d_{xz} orbitals point between the axes, away from the direct path of the ligands.



Result: Less repulsion. Energy falls relative to the average.



Crystal Field Splitting in Octahedral Complexes





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

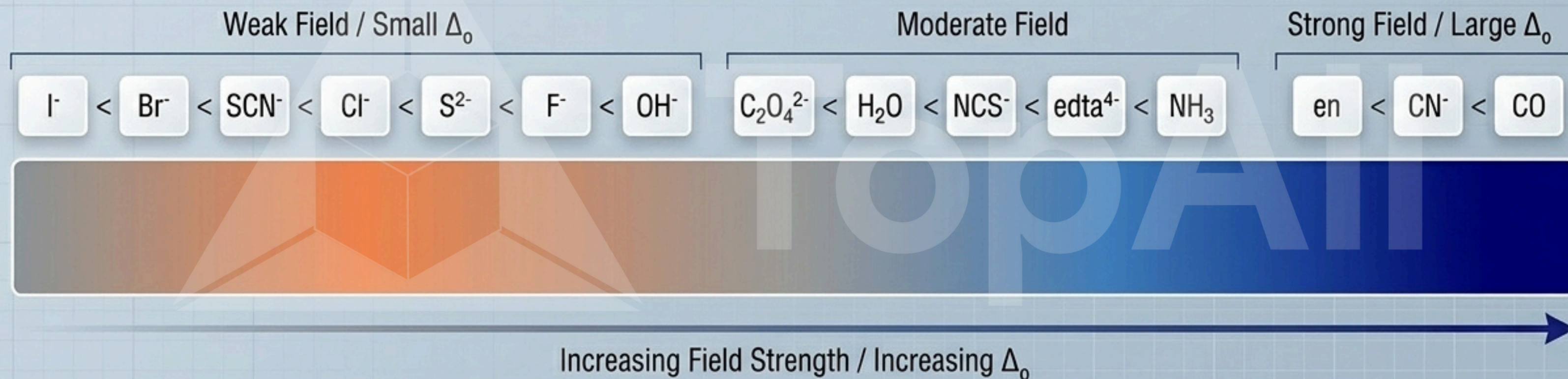
- » Free Study Material, Videos & Infographics
- » Push Your Limits with Level-Based Challenges
- » Climb the Leaderboard Among Fellow Aspirants
- » Practice Unlimited MCQs for NEET & JEE
- » Get Clear Explanations, Not Just Marks
- » Track Your Performance Smarter



THE LIGAND EFFECT

The Spectrochemical Series

The magnitude of the energy gap (Δ_o) is not fixed. It is dictated by the field strength of the specific ligands surrounding the metal. The spectrochemical series arranges these ligands by their ability to split the d orbitals.



Note: This sequence is an experimentally determined series based entirely on the absorption of light by complexes.

ELECTRON CONFIGURATION

Pairing Energy (P) vs. Splitting Energy (Δ_o)

For d^1 , d^2 , and d^3 complexes, electrons easily fill the lower t_{2g} orbitals individually. But for the 4th electron (a d^4 configuration), the complex faces an energetic dilemma. It must choose the path of lowest overall energy.

Path 1: The Splitting Cost (Δ_o)

The energy required to jump across the central gap into the higher-tier e_g orbital.

Path 2: The Pairing Cost (P)

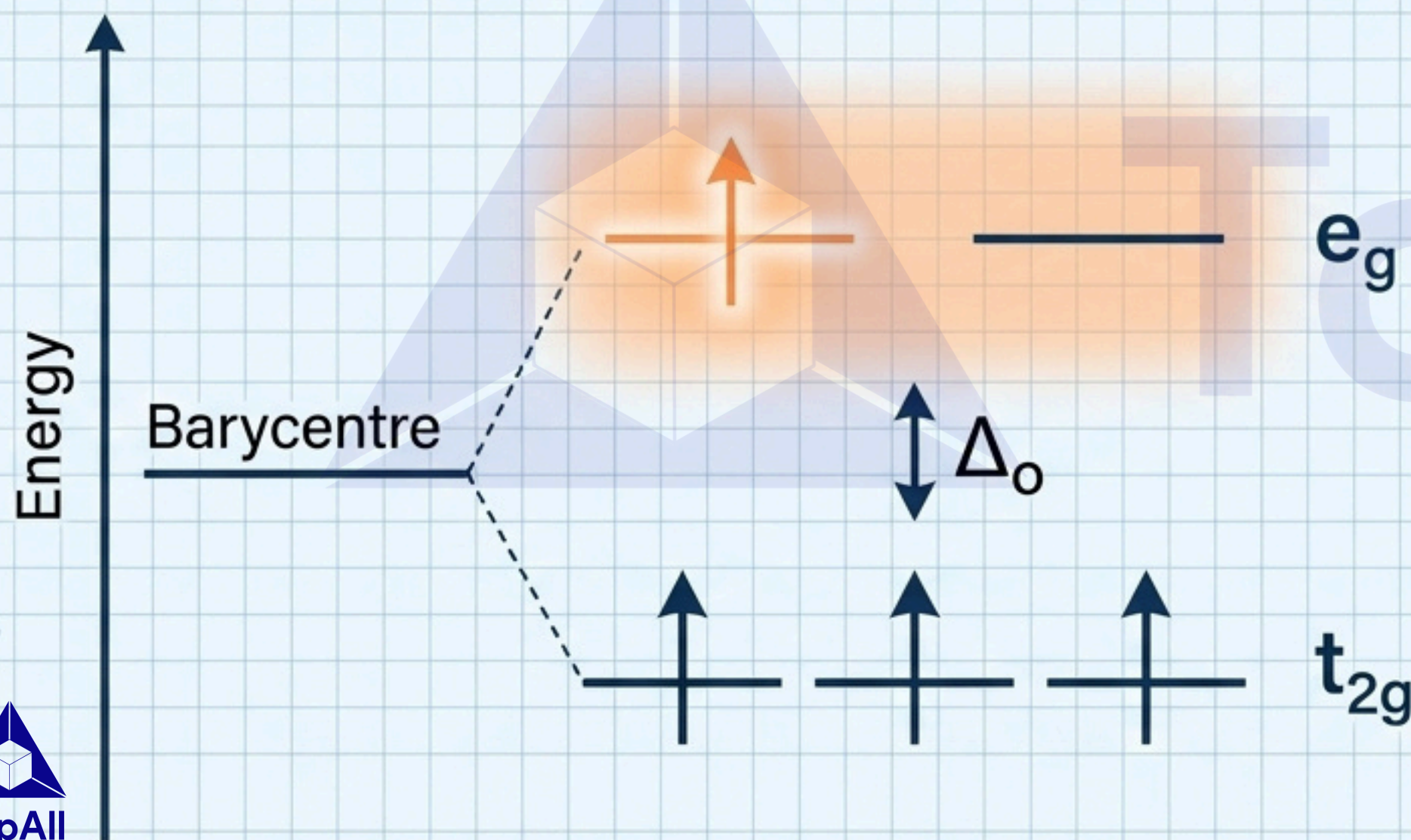
The energy penalty required to force two negatively charged, repelling electrons to share a single t_{2g} orbital.

The relationship between Δ_o and P determines the final structure.

SCENARIO A: $\Delta_o < P$

H1: Weak Field = High Spin

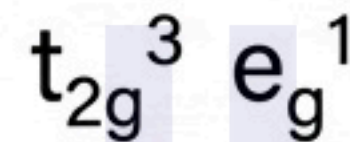
When the ligand produces a weak field, the gap (Δ_o) is small. The energy required to cross the gap is less than the energy required to pair up.



■ The Choice

The 4th electron avoids the pairing penalty (P) and jumps the small gap to the e_g level.

■ Configuration



■ Result

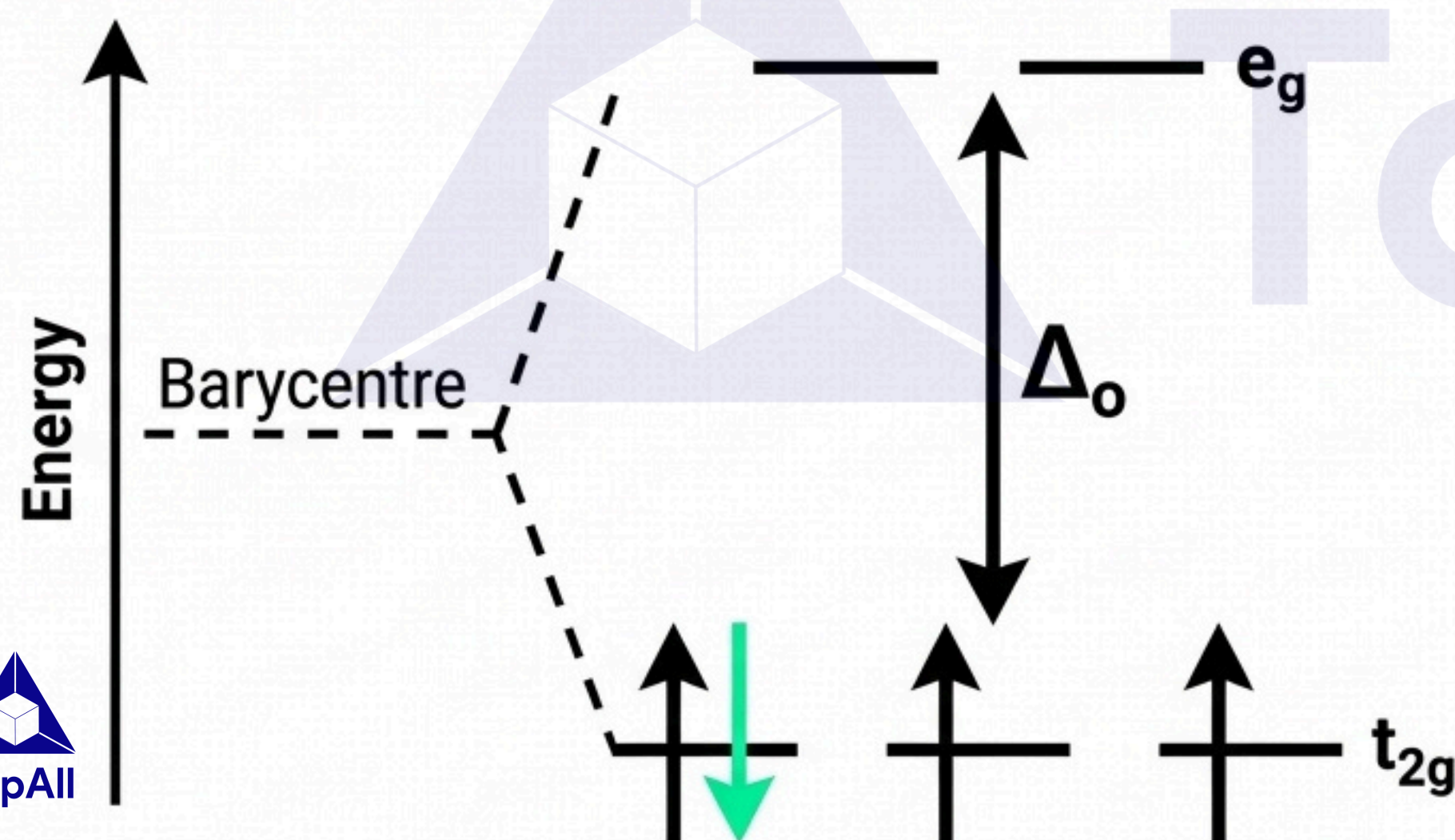
Because the electrons remain unpaired across both levels, this maximizes total spin, creating a High Spin complex.

Halogens (F^- , Cl^- , etc.) often create High Spin complexes.

SCENARIO B: $\Delta_o > P$

H1: Strong Field = Low Spin

When the ligand produces a strong field, the gap (Δ_o) is massive. It becomes too energetically expensive for the electron to jump to the e_g level.



The Choice

- The 4th electron pays the **pairing penalty** (P) to stay in the lower-energy t_{2g} orbital rather than crossing the huge gap.

Configuration

- $t_{2g}^4 e_g^0$

Result

- With electrons forced to pair up, their spins cancel out, reducing the overall spin and creating a **Low Spin** complex.

Cyanide (CN⁻) and Carbon Monoxide (CO) typically create **Low Spin** complexes.

H1: High-Spin vs. Low-Spin Complexes

Dimension	Weak-Field Ligands	Strong-Field Ligands
Splitting Energy (Δ_o)	Small	Large
Energy Relationship	$\Delta_o < P$	$\Delta_o > P$
d4 Electron Choice	Jumps to e_g	Pairs in t_{2g}
d4 Configuration	$t_{2g}^3 e_g^1$	$t_{2g}^4 e_g^0$
Complex Type	High Spin	Low Spin

The Golden Rule of Crystal Field Theory

The architecture of coordination entities is a delicate negotiation between spatial repulsion and energy efficiency. The strength of the ligand alone dictates whether an electron pays the price to pair up, or pays the price to jump the gap.



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