

UNIT 5 • COORDINATION COMPOUNDS

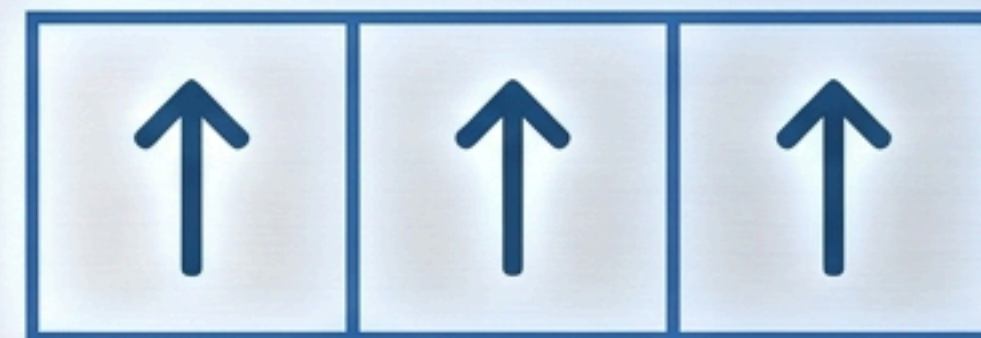
Magnetic Properties of Coordination Compounds

3d



Hund's Rule

Electrons fill degenerate orbitals singly before pairing up.



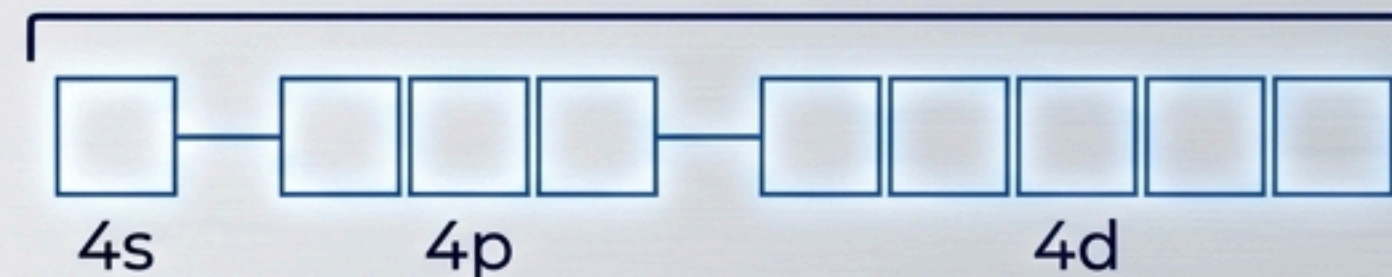
Inner vs. Outer Orbital Complexes

The metal's choice of hybridization. Inner uses 3d orbitals (requiring pairing). Outer uses 4d orbitals (leaving 3d electrons unpaired).

Inner



Outer



The Pairing Logic Flow

Raw Metal Ions (d^4 to d^6)



+ Strong Ligand

+ Weak Ligand



Inner Orbital (d^2sp^3) • Low Spin



Outer Orbital (sp^3d^2) • High Spin



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$$E=mc^2$$



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Diagnostic Comparison: Manganese(III)



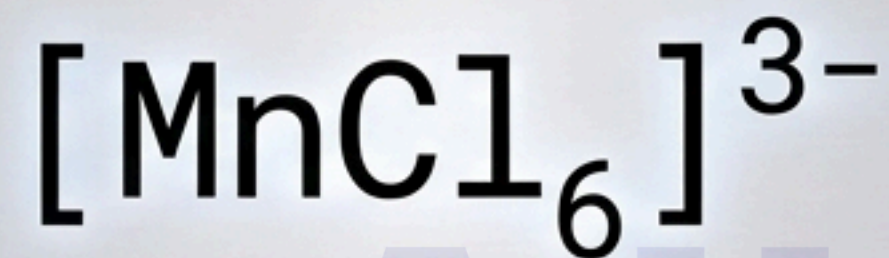
Ligand: CN^- (Strong)

Configuration: $3d^4$



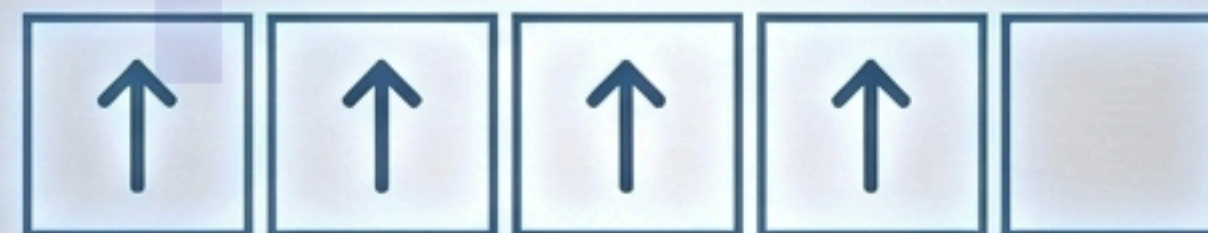
2 Unpaired Electrons

Paramagnetic (Low Spin)



Ligand: Cl^- (Weak)

Configuration: $3d^4$



4 Unpaired Electrons

Highly Paramagnetic (High Spin)

Diagnostic Comparison: Iron(III)



Ligand: CN^- (Strong)

Configuration: $3d^5$



1 Unpaired Electron

Weakly Paramagnetic



Ligand: F^- (Weak)

Configuration: $3d^5$



5 Unpaired Electrons

Strongly Paramagnetic

Worked Example: Reverse Engineering Geometry

Given $[\text{MnBr}_4]^{2-}$ has a magnetic moment $\mu = 5.9 \text{ BM}$, deduce its geometry.

$$\mu = 5.9 \text{ BM} \rightarrow n = 5 \text{ (5 unpaired electrons)}$$

Mn^{2+} is naturally a $3d^5$ system. If all 5 electrons are unpaired, zero 3d orbitals are empty and available for bonding.

Because no 3d orbitals are available, the complex must use the outer 4s and 4p orbitals to accommodate its 4 bonds. Hybridization = sp^3 .

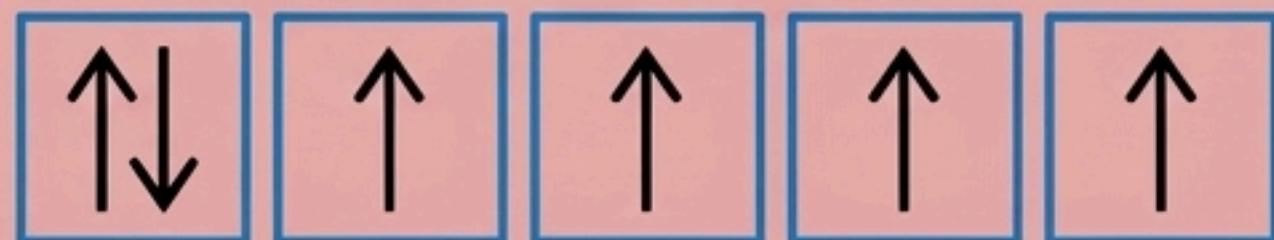
Geometry = Tetrahedral (Not square planar dsp^2)

⚠ WATCH FOR THIS

Assuming the metal ion alone determines magnetic behavior.
Ligand strength makes the final call.

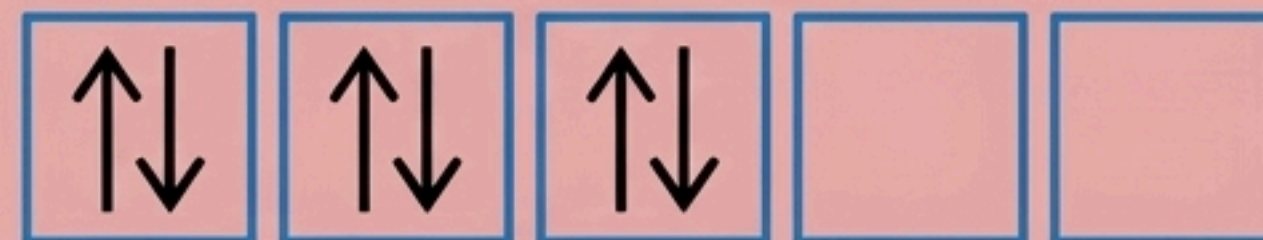
Co(III) with F⁻ (Weak)

[CoF₆]³⁻ is Paramagnetic
 (4 unpaired)



Co(III) with C₂O₄²⁻ (Strong)

[Co(C₂O₄)₃]³⁻ is Diamagnetic
 (0 unpaired)



Key Takeaways

- Ligands run the architecture. For d^4 - d^6 complexes, strong ligands force pairing (inner orbital/low spin), while weak ligands leave electrons unpaired (outer orbital/high spin).
- Magnetism reveals geometry. The magnetic moment (μ) isn't just a number; it is a diagnostic tool to count unpaired electrons and reverse-engineer molecular shapes (e.g., sp^3 vs dsp^2).



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