

UNIT 5 • COORDINATION COMPOUNDS

Limitations of Valence Bond Theory

VBT successfully explains bonding and shape for many complexes, but it hits a theoretical ceiling. Here are the 6 critical limitations you need to know.

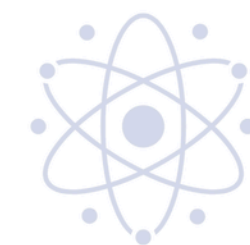
The 6 Limitations of VBT (NCERT §5.5.3)

- 1 Involves numerous assumptions:** Relies heavily on hypothetical orbital hybridization.
- 2 No quantitative magnetic data:** Cannot mathematically interpret magnetic measurements.
- 3 Fails to explain colour:** Cannot account for the optical properties or spectra of complexes.
- 4 No quantitative stability data:** Cannot interpret the thermodynamic or kinetic stability of complexes.
- 5 Ambiguous 4-coordinate geometry:** Cannot exactly predict if a 4-coordinate complex is tetrahedral or square planar.
- 6 Ignores ligand strength:** Fails to distinguish between weak and strong field ligands.



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Spotlight: The Most Tested Limitation

Limitation (iii): It does not explain the colour exhibited by coordination compounds.



Why this matters for exams:

Valence Bond Theory assumes full or empty hybridized orbitals for bonding, completely ignoring the splitting of d orbitals.

Because VBT does not account for d–d transitions, it is entirely silent on why complexes like $[\text{Ti}(\text{H}_2\text{O})_6]^{3+}$ exhibit vivid violet colours. *If an exam question asks about the origin of a complex's colour, VBT is never the correct theoretical framework to apply.*

Spotlight: The 4-Coordinate Ambiguity

Limitation (v): No exact predictions regarding tetrahedral and square planar structures.

For a metal ion with coordination number 4, VBT cannot independently determine if the geometry is tetrahedral (sp^3) or square planar (dsp^2).

The VBT Dependency

To know the geometry of $[MnBr_4]^{2-}$, VBT **requires** **experimental magnetic data first**. Only after knowing the magnetic moment is 5.9 BM (indicating 5 unpaired electrons) can VBT retroactively assign the sp^3 (tetrahedral) hybridization. It cannot predict this from the formula alone.



Common Conceptual Trap

 **Watch for this:** VBT rationalizes, but it does not independently predict.

The Trap: Exam options often incorrectly state that VBT can *predict* the magnetic behavior or structural geometry of an unknown complex just by looking at its formula.

The Reality: VBT is a post-facto (after-the-fact) theory. It uses experimental data (like magnetic susceptibility) to reverse-engineer and explain the hybridization. *Never choose an option that gives VBT the power of independent, quantitative prediction.*

Summary

Key Takeaways

- **VBT is limited by its assumptions and lack of quantitative power.** It cannot mathematically interpret magnetic data, thermodynamic/kinetic stability, or the difference between strong and weak ligands.
- **CFT steps in where VBT fails.** Crystal Field Theory (CFT) is required to explain the colour of coordination compounds (via d-d transitions) and to independently predict geometries without relying purely on post-facto magnetic data.



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