

# Isomerism in Coordination Compounds

Understanding how identical chemical formulas yield distinct structural and spatial arrangements.

 Study Guide



# Same Formula, Distinct Identities

Isomers are two or more compounds that possess the exact **same chemical formula** but feature a fundamentally different arrangement of atoms. This **subtle** shift alters their physical and chemical properties.

## Stereoisomerism

Same chemical bonds, different spatial arrangement.

Geometrical

Optical

## Structural Isomerism

Different chemical bonds entirely.

Linkage

Coordination

Ionisation

Solvate

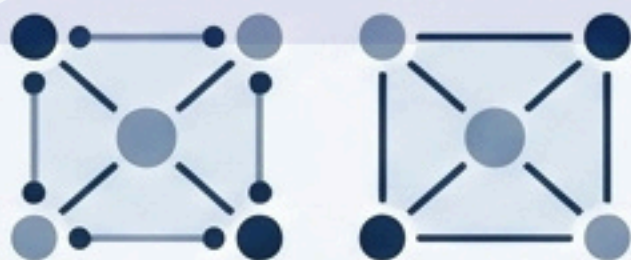
# Stereoisomerism: Spatial Variations

Stereoisomers retain the exact same chemical bonds but orient their atoms differently in 3D space.

## 1. Geometrical Isomerism

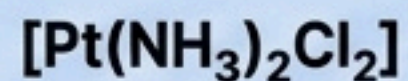
Arises in heteroleptic complexes due to different possible geometric arrangements of ligands.

Cis (adjacent ligands) vs. Trans (opposite ligands).  
Facial (fac) vs. Meridional (mer) in octahedral complexes.



Cis

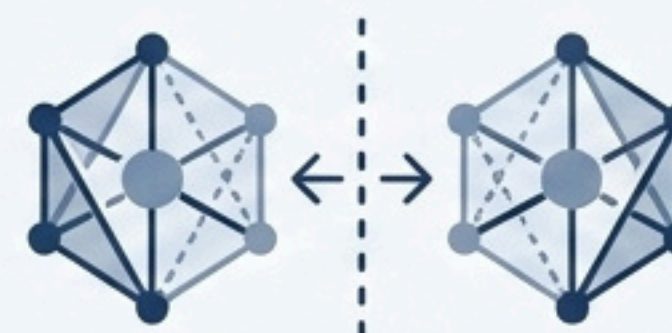
Trans



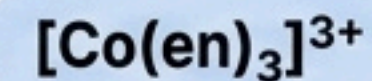
## 2. Optical Isomerism

Mirror images that cannot be superimposed on one another (Chiral enantiomers).

Dextro (d) (rotates polarized light right) vs. Laevo (l) (rotates left).



Chiral Enantiomers





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$$E=mc^2$$



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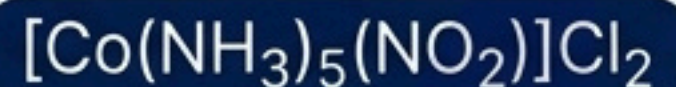
# Structural Isomerism: Bonding Variations

Structural isomers have fundamentally different connectivity and chemical bonds between the metal and ligands.

## 1. Linkage Isomerism

**Trigger:** Ambidentate ligands.

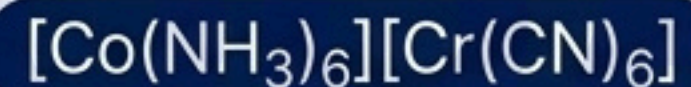
**Action:** Ligand binds through a different atom (e.g., nitrite via N or O).



## 2. Coordination Isomerism

**Trigger:** Both cation and anion are complex entities.

**Action:** Ligands interchange between the metal ions.



## 3. Ionisation Isomerism

**Trigger:** Counter ion is a potential ligand.

**Action:** Counter ion displaces a ligand, swapping places.



## 4. Solvate (Hydrate) Isomerism

**Trigger:** Solvent molecules (like  $\text{H}_2\text{O}$ ).

**Action:** Solvent acts as a direct ligand vs. free crystal lattice solvent.



# Isomerism Identification Matrix

| Category   | Subtype      | Core Identifier                                                        | Classic Example                                      |
|------------|--------------|------------------------------------------------------------------------|------------------------------------------------------|
| Stereo     | Geometrical  | Cis/Trans or Fac/Mer spatial positioning                               | $[\text{Co}(\text{NH}_3)_4\text{Cl}_2]^+$            |
| Stereo     | Optical      | Non-superimposable mirror images (Chirality)                           | $[\text{PtCl}_2(\text{en})_2]^{2+}$                  |
| Structural | Linkage      | Ambidentate ligand binding points ( $\text{SCN}^-$ vs $\text{NCS}^-$ ) | $[\text{Co}(\text{NH}_3)_5(\text{NO}_2)]\text{Cl}_2$ |
| Structural | Coordination | Ligand swap between complex cation & anion                             | $[\text{Co}(\text{NH}_3)_6][\text{Cr}(\text{CN})_6]$ |
| Structural | Ionisation   | Counter ion and internal ligand swap                                   | $[\text{Co}(\text{NH}_3)_5(\text{SO}_4)]\text{Br}$   |
| Structural | Solvate      | Water inside coordination sphere vs. outside                           | $[\text{Cr}(\text{H}_2\text{O})_6]\text{Cl}_3$       |

# Key Takeaways

- ✓ You have successfully mapped the foundational rules of isomerism in coordination compounds. Keep these primary rules in mind:
  - ✓ The Golden Rule: Isomers always share an identical empirical formula but exhibit distinct physical or chemical properties.
  - ✓ Spatial vs. Structural: Always ask first: 'Are the bonds identical?' If yes, it's Stereoisomerism (Geometrical or Optical). If no, it's Structural.
  - ✓ Ligand Clues: Specific ligands act as clues. Ambidentate ligands point to Linkage isomerism. Complex counter-ions point to Ionisation isomerism.



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