

Coordination Compounds: one-page cheat sheet

NEET Chemistry · Unit 12 · Inorganic Chemistry

1 · Werner's theory

Primary ionisable; equals the **oxidation state**

Secondary non-ionisable; equals the **coordination number**

Complex	AgCl	Ions
$[\text{Co}(\text{NH}_3)_6]\text{Cl}_3$	3	4
$[\text{Co}(\text{NH}_3)_5\text{Cl}]\text{Cl}_2$	2	3
$[\text{Co}(\text{NH}_3)_4\text{Cl}_2]\text{Cl}$	1	2
$[\text{Co}(\text{NH}_3)_3\text{Cl}_3]$	0	0

Only Cl^- **outside** the bracket precipitates. A double salt (Mohr's salt) gives all its ions in water; a complex keeps its coordination entity.

2 · Ligands

Unidentate Cl^- , H_2O , NH_3 , CN^-

Didentate en, oxalate (ox), glycinate (gly)

Polydentate dien (3); EDTA^{4-} (6: 2 N + 4 O)

Ambidentate NO_2^- (N or O); SCN^- (S or N)

Homoleptic one kind of ligand: $[\text{Co}(\text{NH}_3)_6]^{3+}$

Heteroleptic more than one kind: $[\text{Co}(\text{NH}_3)_4\text{Cl}_2]^+$

Chelate rings of 5 or 6 members make a complex more stable (chelate effect).

3 · IUPAC naming

Order cation first, then anion; ligands **alphabetical**, then metal

Anionic ligand ends in *-ido*: chlorido, cyanido; neutral: ammine, aqua, carbonyl

Multipliers di, tri; bis, tris for complex ligands

Anionic complex metal ends in *-ate*: ferrate, cuprate, argentate, aurate

Oxidation no. Roman numeral in brackets

$[\text{Ag}(\text{H}_2\text{O})_2][\text{Ag}(\text{CN})_2]$ is **diaquasilver(I) dicyanidoargentate(I)**.

4 · Isomerism

Type	Example
Ionisation	$[\text{Co}(\text{NH}_3)_5\text{Br}]\text{SO}_4$ / $[\text{Co}(\text{NH}_3)_5\text{SO}_4]\text{Br}$
Hydrate	$[\text{Cr}(\text{H}_2\text{O})_6]\text{Cl}_3$ / $[\text{CrCl}(\text{H}_2\text{O})_5]\text{Cl}_2 \cdot \text{H}_2\text{O}$
Coordination	$[\text{Co}(\text{NH}_3)_6][\text{Cr}(\text{CN})_6]$ / $[\text{Cr}(\text{NH}_3)_6][\text{Co}(\text{CN})_6]$
Linkage	$[\text{Co}(\text{NH}_3)_5\text{NO}_2]\text{Cl}_2$ / $[\text{Co}(\text{NH}_3)_5\text{ONO}]\text{Cl}_2$
Geometrical	cis/trans (MA_2B_2 square planar); fac/mer (MA_3B_3)
Optical	$[\text{Co}(\text{en})_3]^{3+}$, cis- $[\text{CoCl}_2(\text{en})_2]^+$

trans- $[\text{CoCl}_2(\text{en})_2]^+$ has a mirror plane: optically inactive. Tetrahedral complexes show no geometrical isomerism.

5 · Oxidation state & coordination number

Complex	O.S.	C.N.
$\text{K}_4[\text{Fe}(\text{CN})_6]$	+2	6
$[\text{Co}(\text{en})_3]\text{Cl}_3$	+3	6
$[\text{Pt}(\text{NH}_3)_2\text{Cl}_2]$	+2	4
$[\text{Cu}(\text{NH}_3)_4]\text{SO}_4$	+2	4

C.N. counts donor **atoms**, so each en adds 2.

Six traps to remember

- Only chloride outside the coordination sphere is precipitated by AgNO_3 .
- An anionic complex takes *-ate* (often a Latin stem: ferrate, cuprate, argentate).
- $[\text{NiCl}_4]^{2-}$ is tetrahedral and paramagnetic; $[\text{Ni}(\text{CN})_4]^{2-}$ is square planar and diamagnetic.
- $\Delta_t = \frac{4}{9}\Delta_o$, so tetrahedral complexes are almost always high spin.
- cis- $[\text{CoCl}_2(\text{en})_2]^+$ is optically active; the trans isomer is not.
- In metal carbonyls, back-donation weakens C–O and strengthens M–C.

6 · Valence bond theory

Complex	Hybrid.	Shape	Unp. e^-
$[\text{Co}(\text{NH}_3)_6]^{3+}$	$d^2 sp^3$	octahedral	0
$[\text{CoF}_6]^{3-}$	$sp^3 d^2$	octahedral	4
$[\text{Ni}(\text{CN})_4]^{2-}$	dsp^2	sq. planar	0
$[\text{NiCl}_4]^{2-}$	sp^3	tetrahedral	2
$[\text{Ni}(\text{CO})_4]$	sp^3	tetrahedral	0
$[\text{Fe}(\text{CO})_5]$	dsp^3	trig. bipyramidal	0

7 · Crystal field theory

Octahedral t_{2g} at $-0.4\Delta_o$; e_g at $+0.6\Delta_o$

$$\Delta_t = \frac{4}{9}\Delta_o, \quad \text{CFSE} = [-0.4n(t_{2g}) + 0.6n(e_g)]\Delta_o + mP$$

$\Delta_o > P$ low spin (strong field), electrons pair in t_{2g}

$\Delta_o < P$ high spin (weak field)

Δ_t is always small, so tetrahedral complexes are nearly always high spin.



8 · Colour

Origin $d-d$ transition; the colour seen is **complementary** to the light absorbed

Ti^{3+} aqua $[\text{Ti}(\text{H}_2\text{O})_6]^{3+}$ absorbs blue-green, appears violet

Cu^{2+} aqua $[\text{Cu}(\text{H}_2\text{O})_4]^{2+}$ absorbs red, appears blue

Colourless d^0 and d^{10} ions (Sc^{3+} , Zn^{2+})

9 · Carbonyls & biology

σ bond CO lone pair $\rightarrow$ empty metal orbital

π back-bond filled metal $d \rightarrow$ CO π^*

M–C bond order rises; C–O bond order falls.

Complex	Metal / use
Chlorophyll	Mg^{2+}
Haemoglobin	Fe^{2+}
Vitamin B_{12}	Co^{3+}
cis-Platin	Pt; anticancer
Wilkinson's catalyst	Rh; hydrogenation
EDTA	removes Pb poisoning

Seen in NEET 2025

Which of the four Co(III) ammine chlorides conducts least in water?

$[\text{Co}(\text{NH}_3)_3\text{Cl}_3]$ is neutral and gives **no ions**.

Seen in NEET 2020

Increasing field strength:

