CLASS 12 CHEMISTRY — FORMULA SHEET

Chapter 5 : Coordination Compounds (NCERT)

5.1 Basic Terms

Term	Definition
Coordination compound	Contains a central metal atom/ion bonded to ligands by coordinate bonds
Central atom/ion	Metal that accepts electron pairs (Lewis acid)
Ligand	Ion/molecule that donates an electron pair (Lewis base)
Coordination number	Number of ligand donor atoms bonded to the central metal
Coordination sphere	Central metal + ligands, written inside square brackets
Counter ion	Ion outside the coordination sphere
Oxidation number of metal	Charge on metal after removing ligands with their charges

5.2 Types of Ligands

Type	Detail / Example
Monodentate	One donor atom (e.g. Cl^-, H_2O, NH_3, CN^-)
Bidentate	Two donor atoms (e.g. ethylenediamine 'en', oxalate)
Polydentate	Many donor atoms (e.g. EDTA — hexadentate)
Chelate ligand	Bidentate/polydentate forming a ring → extra stability
Ambidentate ligand	Can attach via two different atoms (e.g. NO_2^- / ONO^-, SCN^- / NCS^-)
Chelate effect	Ring-forming ligands give more stable complexes

5.3 IUPAC Nomenclature Rules

Rule	Detail
Order in formula	Cation first, then anion ; metal before ligands inside brackets
Order in naming	Ligands (alphabetical) named first, then the metal
Anionic ligands end in	'-o' (chloro, cyano, hydroxo, sulphato)
Neutral ligands	aqua (H_2O), ammine (NH_3), carbonyl (CO), nitrosyl (NO)
Number of ligands	di, tri, tetra (or bis, tris for complex names)
Metal in anionic complex	ends in '-ate' (e.g. ferrate, cuprate, argentate)
Oxidation state	Roman numeral in brackets after the metal

5.4 Isomerism in Coordination Compounds

Isomerism	Detail
Structural — Ionisation	Different ions in solution (e.g. SO_4 vs Br exchange)
Structural — Linkage	Ambidentate ligand binds via different atoms (NO_2 / ONO)

Isomerism	Detail
Structural — Coordination	Ligand swap between cation & anion complex
Structural — Hydrate	Water inside vs outside coordination sphere
Stereo — Geometrical	cis / trans (and fac / mer) arrangements
Stereo — Optical	Non-superimposable mirror images (chiral, d & l forms)

5.5 Werner's Theory & Valence Bond Theory

Concept	Detail
Primary valency	Ionisable ; satisfied by negative ions (= oxidation state)
Secondary valency	Non-ionisable ; satisfied by ligands (= coordination number)
VBT idea	Metal uses hybrid orbitals to accept ligand electron pairs
CN 6 (inner orbital)	d^2sp^3 hybridisation → octahedral, low spin
CN 6 (outer orbital)	sp^3d^2 hybridisation → octahedral, high spin
CN 4 (tetrahedral)	sp^3 hybridisation
CN 4 (square planar)	dsp^2 hybridisation (e.g. $[Ni(CN)_4]^{2-}$)

5.6 Crystal Field Theory (CFT)

Concept	Detail / Formula
CFT idea	Ligands split d-orbitals into two energy levels
Octahedral splitting	t_{2g} (lower) and e_g (higher) ; gap = Δ_o
Tetrahedral splitting	e (lower) and t_2 (higher) ; $\Delta_t = (4/9)\Delta_o$
Spectrochemical series	$I^- < Br^- < Cl^- < F^- < H_2O < NH_3 <$ en $< CN^- < CO$
Strong field ligand	Large Δ → low spin (electrons pair up)
Weak field ligand	Small Δ → high spin (electrons stay unpaired)
CFSE	Crystal field stabilisation energy (extra stability)
Cause of colour	d–d transition across the Δ gap

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Coordination number	Count ligand DONOR atoms, not ligands (bidentate counts as 2).
Naming order	Name ligands alphabetically first, then metal. Anion complex → '-ate'.
Ambidentate	Binds via different atoms: NO_2^-/ONO^-, SCN^-/NCS^- → linkage isomerism.
Chelate effect	Ring-forming (poly)dentate ligands give EXTRA stability.
Werner valencies	Primary = oxidation state (ionisable) ; Secondary = coordination number.
VBT hybridisation	Octahedral: d^2sp^3 (inner) or sp^3d^2 (outer). Square planar: dsp^2.
Spectrochemical series	CO, CN^- strong (low spin) ; I^-, Br^- weak (high spin).

Colour & CFT	d–d transition across Δ. Strong field → larger Δ → different colour.