Ligands — Coordination Compounds

NEET Chemistry Notes

1. Definition of a ligand

A ligand is an ion or molecule that donates one or more lone pairs of electrons to a central metal atom or ion to form coordinate bonds.

Examples: NH_3, H_2O, Cl^-, CN^-, OH^-

The ligand acts as a Lewis base (electron-pair donor), while the central metal ion acts as a Lewis acid (electron-pair acceptor).

Example:

$$Ag^+ + 2NH_3 \rightarrow [Ag(NH_3)_2]^+$$

Here, NH_3 donates its nitrogen lone pair to Ag^+.

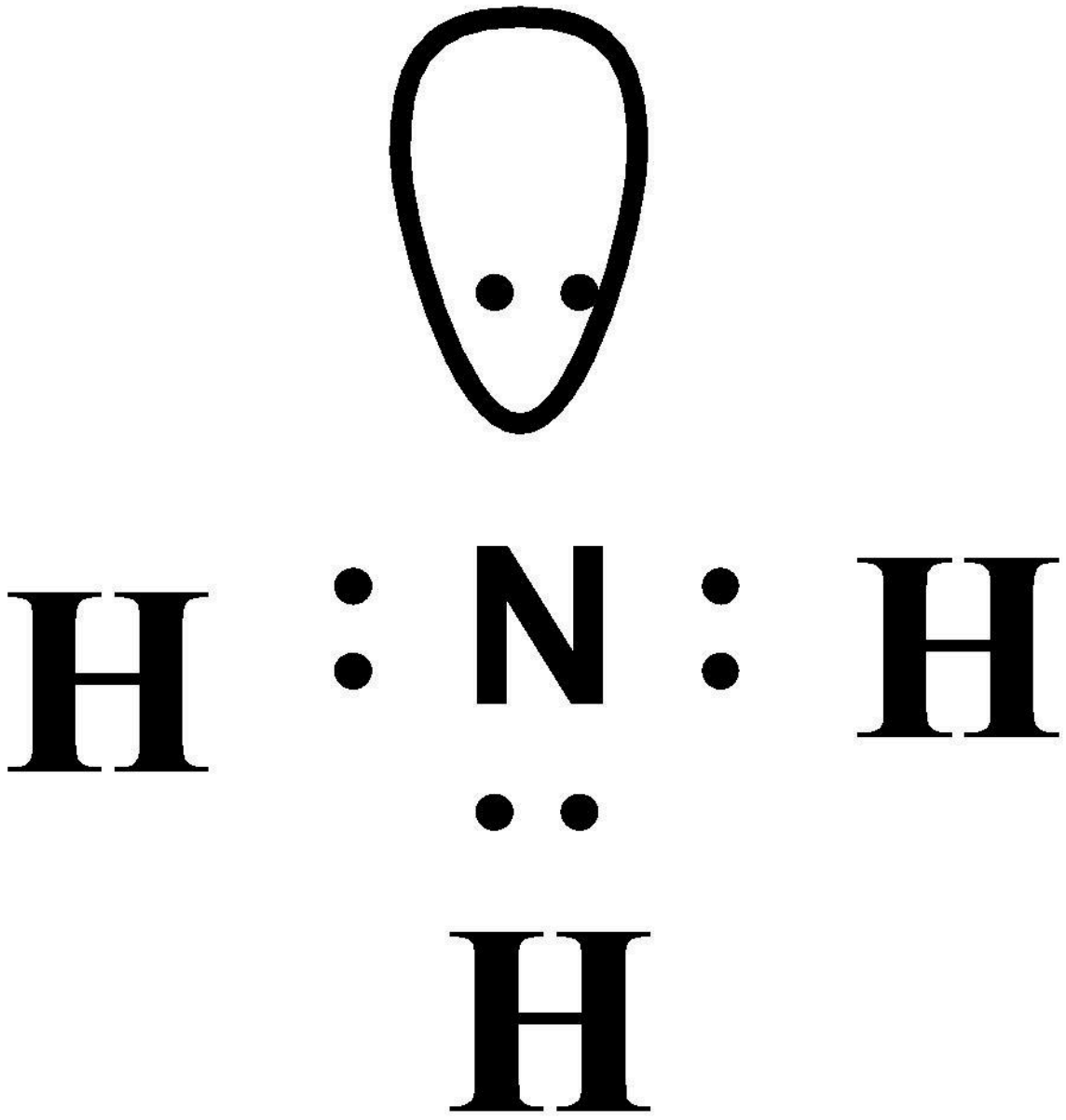
2. Classification of ligands according to charge

Type	Description	Examples
Neutral ligands	No net charge	NH_3, H_2O, CO, NO (in common coordination notation)
Anionic ligands	Negatively charged	Cl^-, CN^-, OH^-, $C_2O_4^{2-}$
Cationic ligands	Positively charged	NO^+ in suitable complexes

NEET tip: The ligand's charge is important for calculating the oxidation state of the central metal.

3. Classification according to denticity

Denticity is the number of donor atoms of a ligand that bind to a single metal centre.



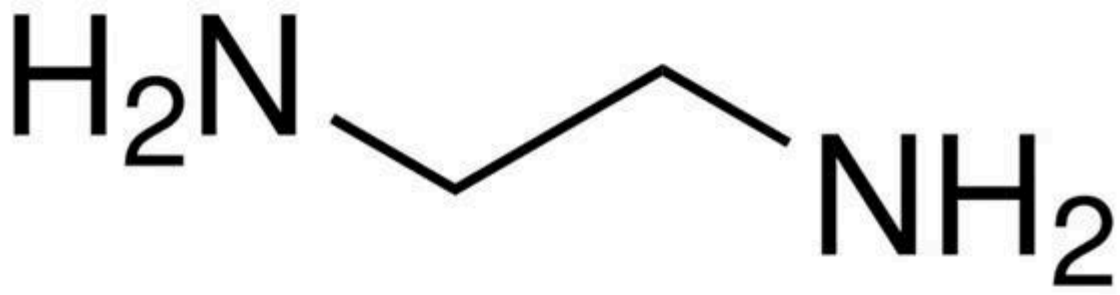
A. Monodentate ligand

Binds through one donor atom.

Examples:

- NH_3 — ammine

- H_2O — aqua
- Cl^- — chlorido
- CN^- — cyanido
- OH^- — hydroxido

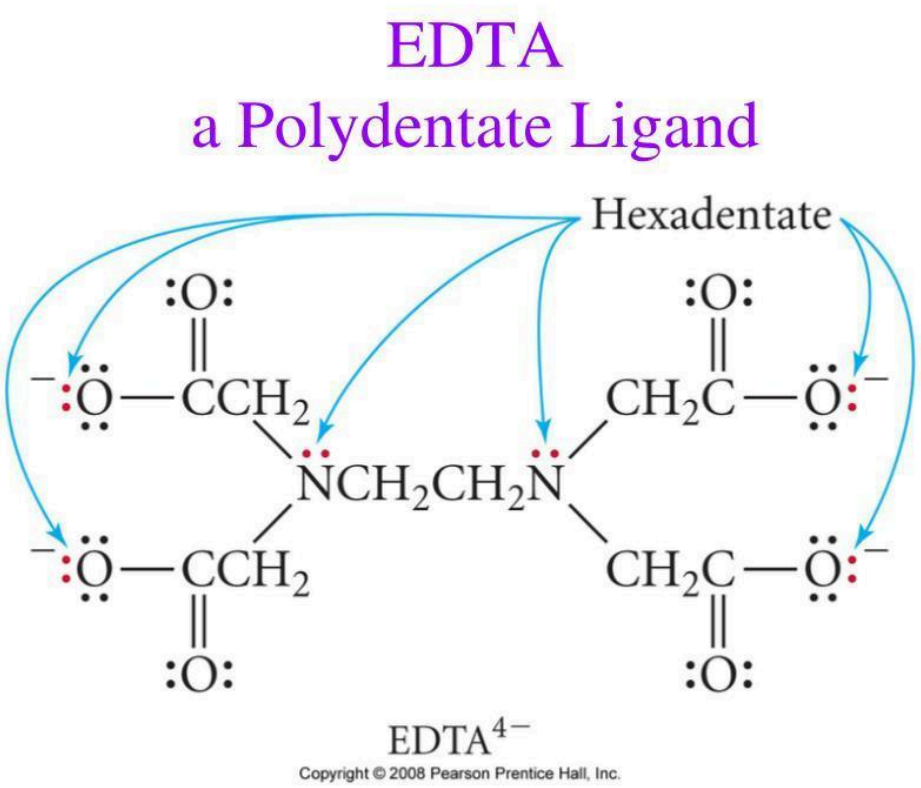


B. Bidentate ligand

Binds through two donor atoms.

Examples:

- Ethane-1,2-diamine (en)
- Oxalate, $C_2O_4^{2-}$



C. Polydentate ligand

Binds through several donor atoms.

Examples:

- EDTA — usually hexadentate
- DTPA — commonly octadentate

Important distinction

- Denticity = number of donor atoms contributed by one ligand.
- Coordination number = total number of donor atoms directly attached to the central metal.

Example: $[Co(en)_3]^{3+}$

- Number of ligands = 3
- Denticity of each en ligand = 2
- Coordination number = $3 \times 2 = 6$

4. Classification according to the number of metal centres

A. Ambidentate ligands

These ligands can coordinate through either of two different donor atoms, but generally bind through one donor atom at a time to a given metal centre.

Ligand	Donor atoms	Example
NO_2^-	N or O	Nitro / nitrito complexes
SCN^-	S or N	Thiocyanato / isothiocyanato complexes
CN^-	C or N in different bonding modes	Cyanido / isocyanido forms

NEET favourite: NO_2^- and SCN^- are classic ambidentate ligands.

B. Bridging ligands

A bridging ligand connects two or more metal centres.

Examples include Cl^-, OH^- and CN^- in suitable polynuclear complexes.

Do not confuse a bridging ligand with a chelating ligand: a chelating ligand binds to one metal centre through multiple donor atoms, forming one or more rings.

5. Chelating ligands and the chelate effect

A chelating ligand binds to the same metal ion through two or more donor atoms, forming a ring.

Examples:

- Ethane-1,2-diamine (en)
- Oxalate ion
- EDTA

Chelate complexes are often more stable than comparable complexes with monodentate ligands. This is known as the chelate effect, which is frequently related to favourable entropy and bonding factors.

6. Common ligands and their names

Formula	Ligand name	Charge	Denticity
NH_3	Ammine	0	Monodentate
H_2O	Aqua	0	Monodentate
CO	Carbonyl	0	Monodentate
Cl^-	Chlorido	−1	Monodentate
OH^-	Hydroxido	−1	Monodentate
CN^-	Cyanido	−1	Monodentate
NO_2^-	Nitrito / nitro, depending on donor atom and naming convention	−1	Ambidentate
$C_2O_4^{2-}$	Oxalato	−2	Bidentate
en	Ethane-1,2-diamine	0	Bidentate

EDTA\(^{4-}\)	Ethylenediaminetetraacetato	−4	Usually hexadentate

7. How ligands affect coordination number

Complex	Ligand arrangement	Coordination number
$[Ag(NH_3)_2]^+$	Two monodentate ligands	2
$[Cu(NH_3)_4]^{2+}$	Four monodentate ligands	4
$[Co(NH_3)_6]^{3+}$	Six monodentate ligands	6
$[Co(en)_3]^{3+}$	Three bidentate ligands	6
$[Fe(C_2O_4)_3]^{3-}$	Three bidentate ligands	6

8. NEET practice MCQs

1. A ligand acts as a:

Lewis acid
Lewis base
Proton only
Neutron donor

2. Which of the following is a bidentate ligand?

NH_3
Cl^-
H_2O
Oxalate ion

3. Which pair contains classic ambidentate ligands?

NH_3 and H_2O
en and EDTA
NO_2^- and SCN^-
CO and NH_3

4. The coordination number of cobalt in $[Co(en)_3]^{3+}$ is:

3
4
6
9

5. EDTA generally acts as a:

Monodentate ligand
Bidentate ligand
Tetradentate ligand
Hexadentate ligand

6. A ligand that joins two metal centres is called:

Chelating ligand only
Bridging ligand
Neutral ligand only
Monodentate ligand only
Reset answers

Quick memory aid: Monodentate = one donor atom; bidentate = two; polydentate = several; ambidentate = alternative donor atoms; bridging = connects metal centres.