

Complex ions

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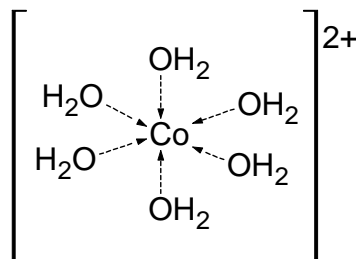
Complex ion formation

A complex ion is formed when a metal ion is surrounded by ligands which are bonded by co-ordinate bonding into the metal ion

A ligand is a molecule or negative ion which can donate a lone pair of electrons. eg H_2O , NH_3 , amines, Cl^- , CN^-

The number of ligands bonded to the metal ion is called the co-ordination number.

The co-ordination number exceeds its oxidation state.

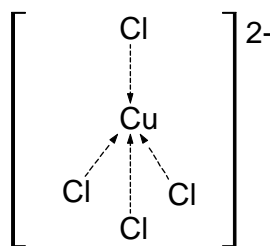


COMPLEX FORMATION

Lewis base electron pair donor (ligands are Lewis bases)

Lewis acid electron pair acceptor

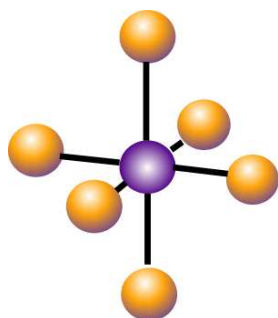
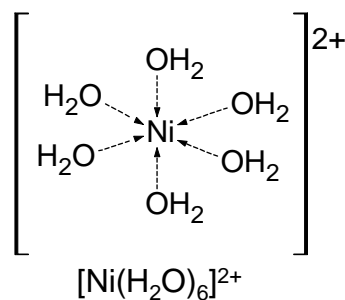
In the formation of complex ions the ligand is the Lewis base as it donates a pair of electrons in the dative covalent bond and the metal ion is the Lewis acid



Ligands form co-ordinate bonds via lone pairs

Shapes of Complex ions: Octahedral

Most common complex ions have a **coordination number 6** (i.e six ligands). The shape is called **octahedral**.

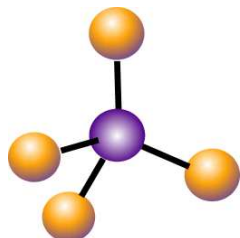


All the bond angles are 90°

The octahedral complexes are usually with small ligands such as H_2O and NH_3

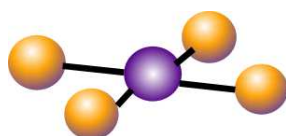
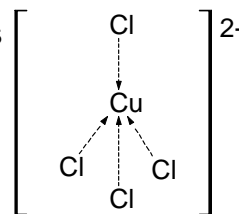
Shapes of Complex ions: Coordination number 4

There are two shapes with a coordination number of 4



Tetrahedral complexes are more common with larger ligands e.g. Cl^-

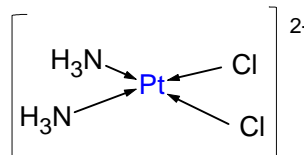
Bond angle $109\frac{1}{2}^\circ$



Square planar

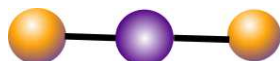
Bond angle 90°

Occur in Pt^{2+} complexes



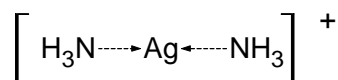
Shapes of Complex ions: linear

Linear



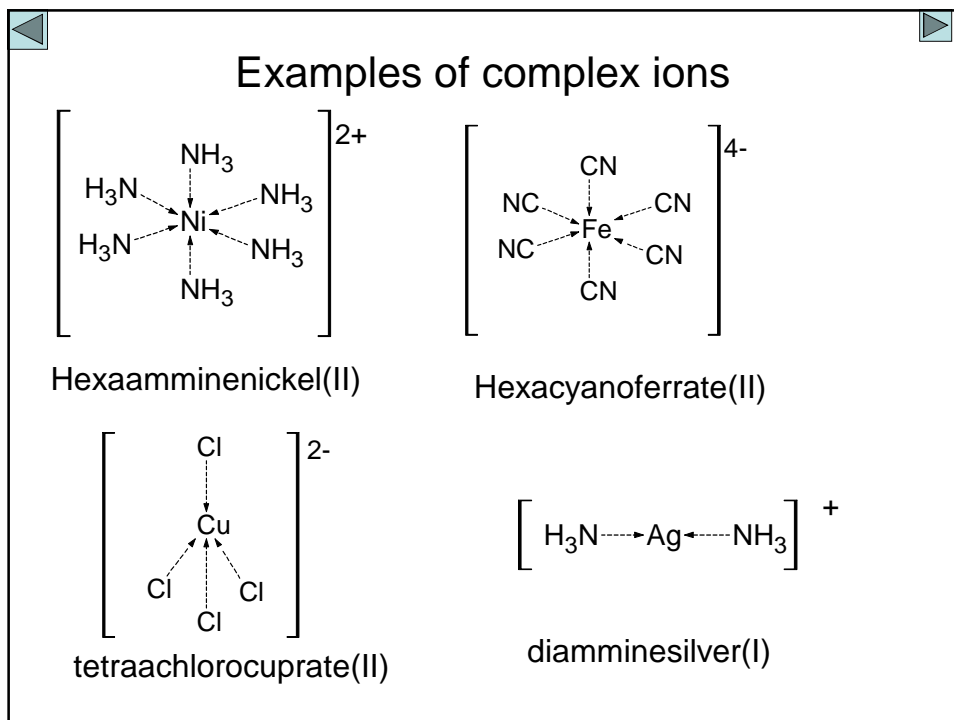
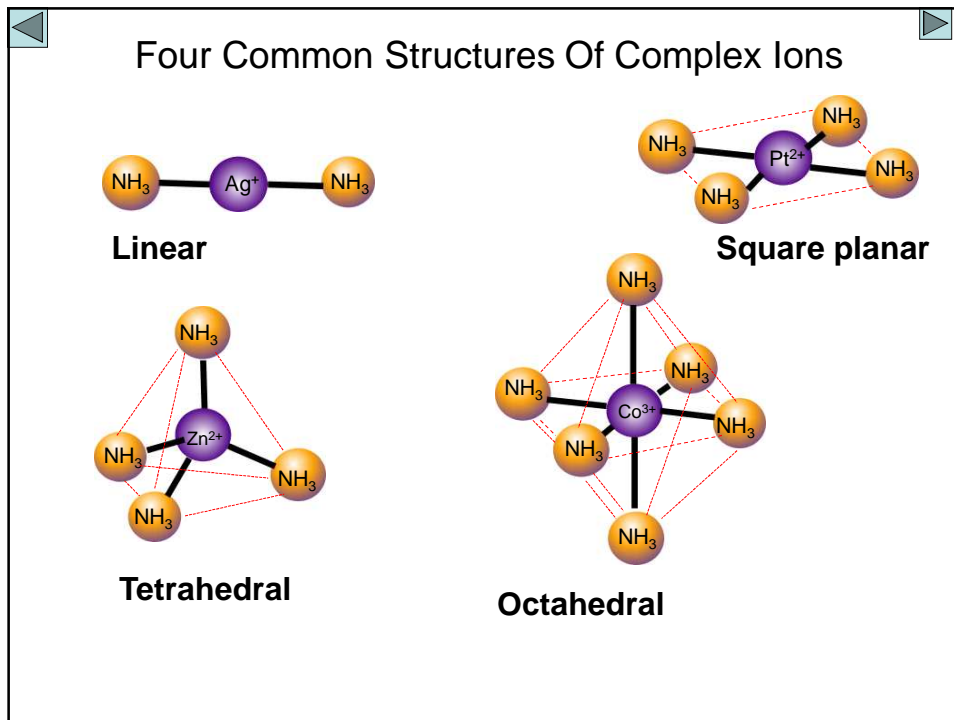
Silver commonly forms linear complexes e.g. $[\text{Ag}(\text{NH}_3)_2]^+$, $[\text{Ag}(\text{S}_2\text{O}_3)_2]^{3-}$ and $[\text{Ag}(\text{CN})_2]^+$.

coordination number 2



diamminesilver(I)

Bond angle 180°

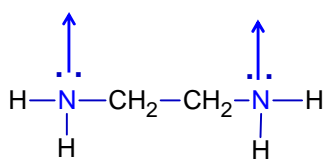


Ligands

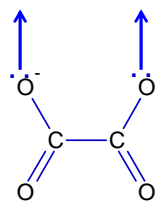
Unidentate ligands

These are ligands that can form one dative covalent bond with the metal ion. They will generally have one lone pair. eg H_2O , NH_3 , OH^- , Cl^- , CN^-

Bidentate ligands contain two donor atoms. They bond to the metal ion through two atoms.

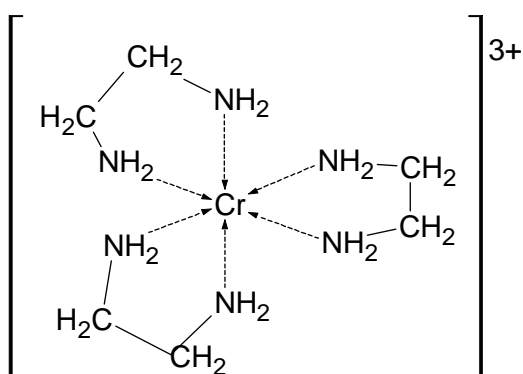


1,2-diaminoethane
 $\text{NH}_2\text{CH}_2\text{CH}_2\text{NH}_2$

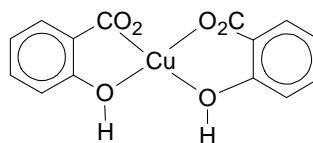


Ethanedioate(oxalate) ion $^-$
 $^- \text{OOC-COO}^-$

Complexes containing bidentate ligands



$[\text{Cr}(\text{NH}_2\text{CH}_2\text{CH}_2\text{NH}_2)_3]^{3+}$

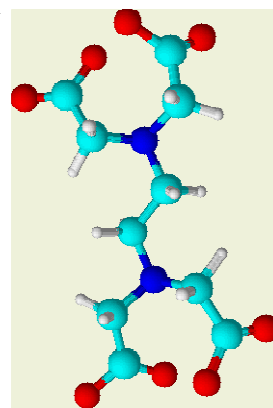
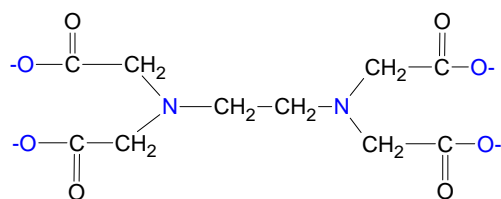


Multidentate Ligands

Hexadentate ligand

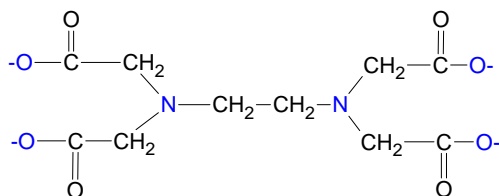
EDTA is a hexadentate ligand which has six atoms that can form a dative covalent bond.

It has a 4⁻ charge (edta)⁴⁻



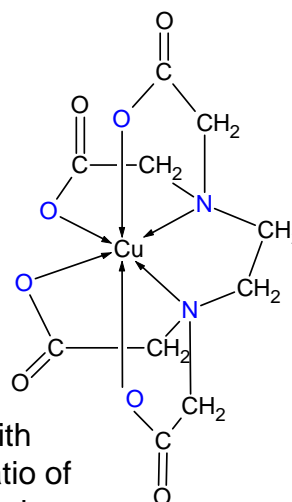
EDTA

The EDTA⁴⁻ anion has the formula



with six donor sites (4O and 2N) and forms a 1:1 complex with metal(II) ions

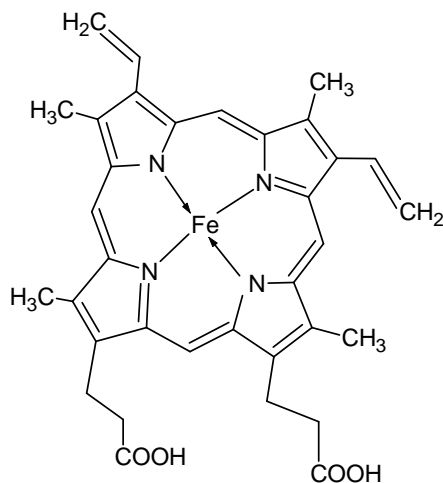
As it can form six dative covalent bonds with the metal ion, edta will only ever have a ratio of one molecule of edta to one ion of the metal eg [Ni(edta)]²⁻



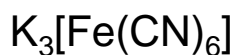
Multidentate Ligands

Multidentate ligands – form several co-ordinate bonds

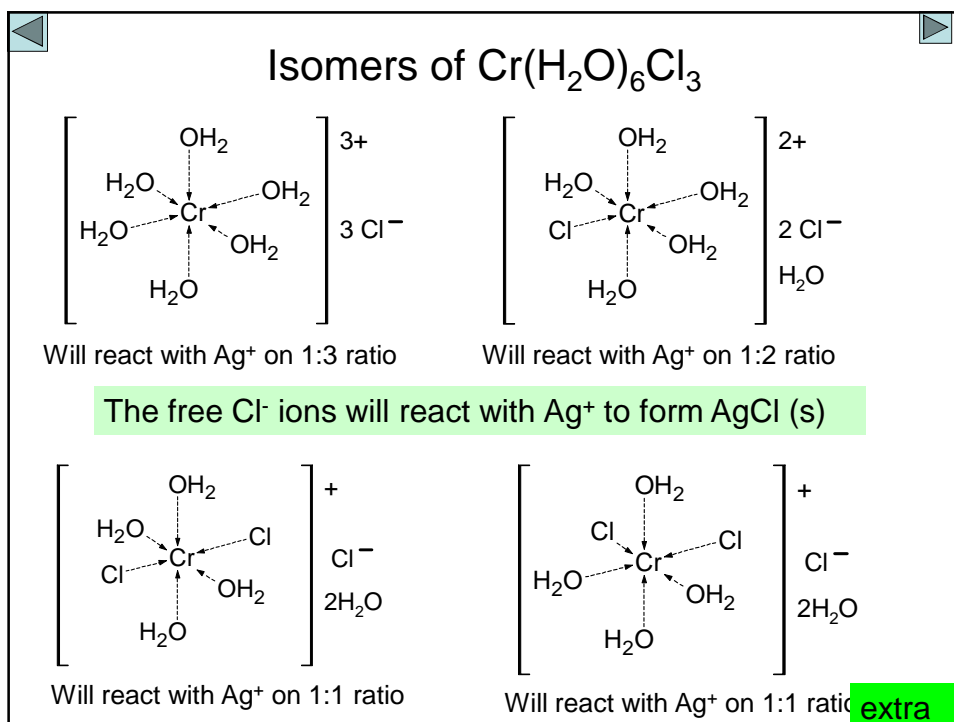
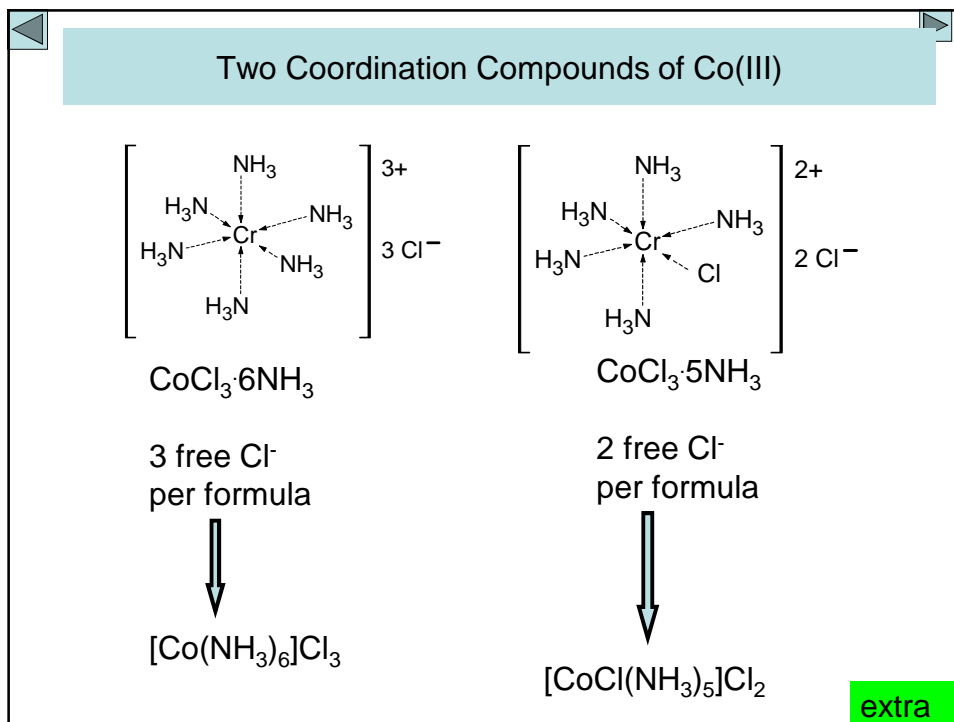
haem



What types of bonding are present in the following compound containing a complex ion?



- Ionic bonding between the potassium and the complex ion $[\text{Fe}(\text{CN})_6]^{3-}$
- Dative covalent bonding between the CN^- ligand and the Fe^{3+} ion
- Covalent bonding in the CN^- ion



Isomerism In Complex Ions

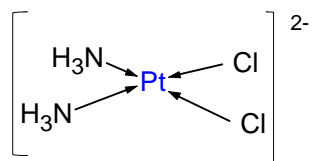
Structural isomers differ in the ligands that are attached to the central atom or in the donor atoms through which the ligands are bonded.

Geometric isomers differ in the arrangement of the attached ligands, forming either *cis*- (same side) or *trans*- (opposite sides) compounds.

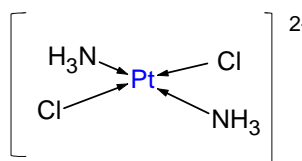
Optical isomers are isomers that differ in their ability to rotate the plane of polarized light. Each of the two molecules or ions of an optical isomer is called an enantiomer and each enantiomer rotates the plane-polarized light in opposite directions.

key

Geometric Isomerism In A Square Planar Complex



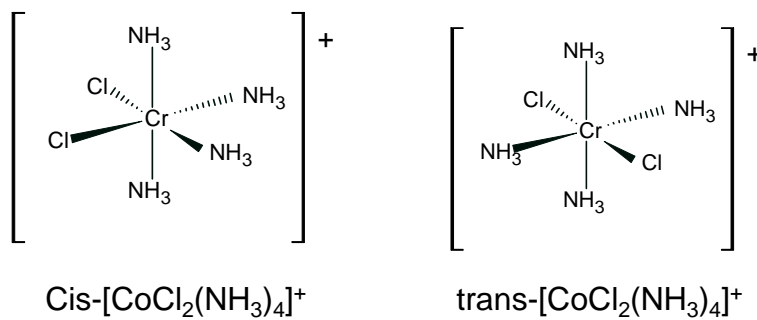
Cis-Diamminedichloroplatinum(II)
Cisplatin



trans-Diamminedichloroplatinum(II)
transplatin

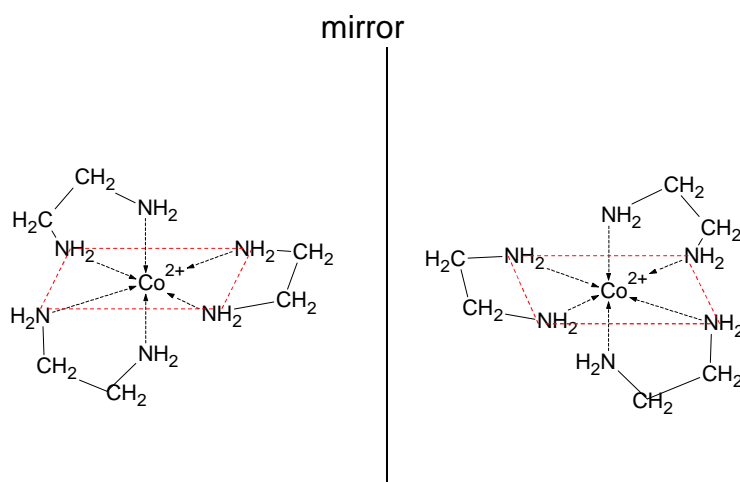
key

Geometric Isomerism In An Octahedral Complex



extra

Optical Isomers



extra