Classification of ligands

Depending on the number of sites at which one molecule of a ligand is coordinated to the central metallic atom, the ligands have been classified as mono dentate (or uni dentate) and poly dentate (or multi dentate) ligands.

1- Mono dentate ligands

The ligands which have only one donor atom or are co-ordinated through one electron pair are called mono dentate ligands. Such ligands are coordinated to the central metal ion at one site or by one metal-ligand bond only.

These ligands may be neutral molecules or in anionic form.

(*a*) **Neutral ligands which are named as such.**

$(C_2H_5)_3N$	...	Triethyl amine	$(C_6H_5)_3P$	...	Triphenyl phosphine
CH_3NH_2	...	Methyl amine	CH_3CN	...	Acetonitrile
NH_2OH	...	Hydroxylamine	PF_3	...	Phosphorus trifluoride
$(CH_3)_2NH$	...	Dimethylamine	$(C_2H_5)_3P$	...	Triethyl phosphine
C_5H_5N or py	...	Pyridine			

(*b*) **Neutral ligands which are given special names,** *e.g.*

CO	...	Carbonyl	NO	...	Nitrosyl
CS	...	Thiocarbonyl	NS	...	Thionitrosyl
H_2O	...	Aquo or aqua	NH_3	...	Ammine

According to latest system of nomenclature, the word ''aqua'' is used for H_2O molecule.

Anionic (negative) ligands. The names of negative ligands end in *o*

F^-	……	Fluoro	Cl^-	……	Chloro
Br^-	……	Bromo	I^-	……	Iodo
H^-	……	Hydro or Hydrido	CH_3COO^-	……	Acetato
NH_2^-	……	Amido	OH^-	……	Hydroxo or hydroxyl
N^{3-}	……	Nitrido	N_3^-	……	Azido
O^{2-}	……	Oxo	HS^-	……	Mercapto
S^{2-}	……	Sulphido or thio	CN^-	……	Cyano(coordination through C-atom)
NC^-	……	Iso-cyano(coordination through N-atom)	CH_3O^-	……	Methoxo
$C_2H_5O^-$	……	Ethoxo	NO_2^-	……	Nitro (coordination through N-atom)
ONO^-	……	Nitrito (coordination Through O-atom)	SCN^-	……	Thiocyanato
NCS^-	……	Iso-thiocyanato			

2- Poly-dentate ligands

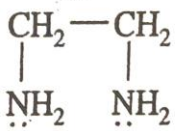
These may be bi-dentate, tri-dentate, tetra-dentate, penta-dentate and hexa-dentate, if the number of donor atoms present in one molecule of the ligand attached with the central metallic atom is 2, 3, 4, 5 and 6 respectively.

(one molecule of these ligands makes 2, 3, 4, 5 and 6 metal-ligand coordinated bonds respectively.

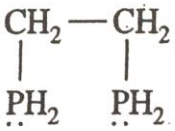
Bi-dentate ligands may be neutral molecules or anions.

Examples of bi-dentate ligands

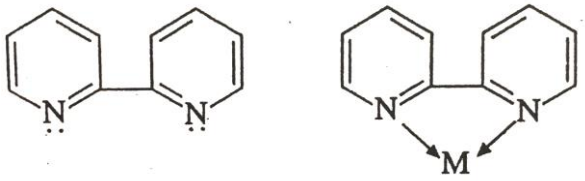
Ethylene diamine (*en*)



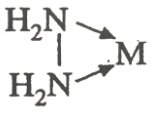
Ethylene diphosphine (*diphos*)



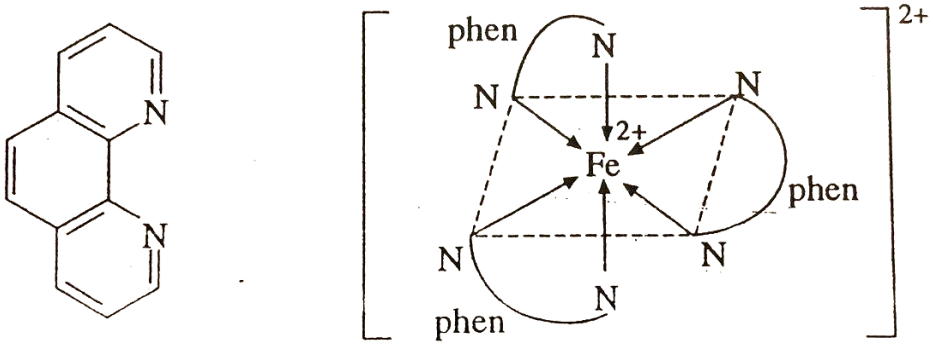
*2,2-bipyridine (bipy)



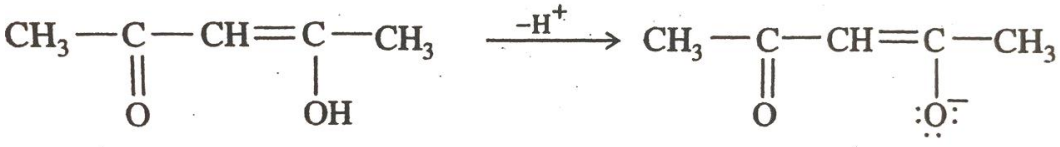
*Hydrazine



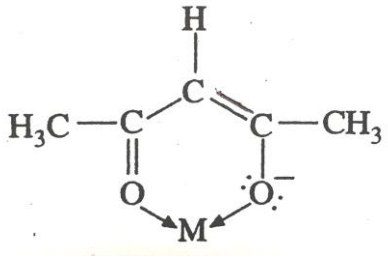
*o-phenanthroline or 1,10-phenanthroline (0-phen or phen or phenan)



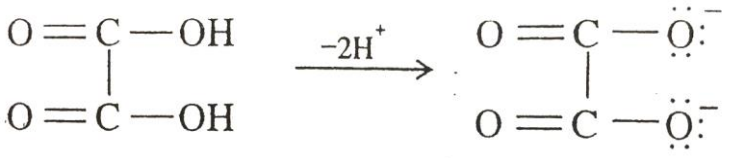
*Acetylacetonato ion (acac)



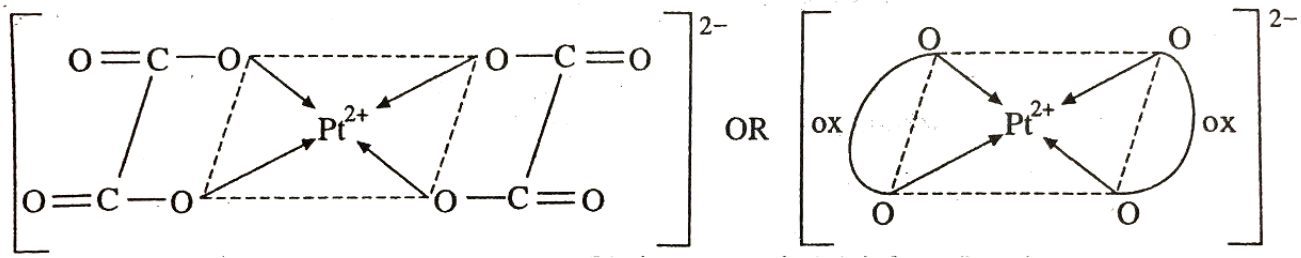
Mode of attachment of acetylacetanato ion to the metal atom, M.



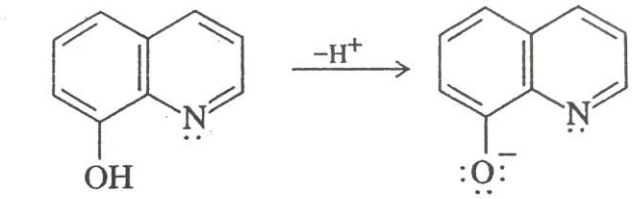
*Oxalato ion $C_2O_4^{2-}$ (ox^{2-})



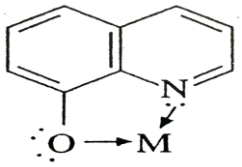
$[Pt^{2+}(ox)_2]^{2-}$



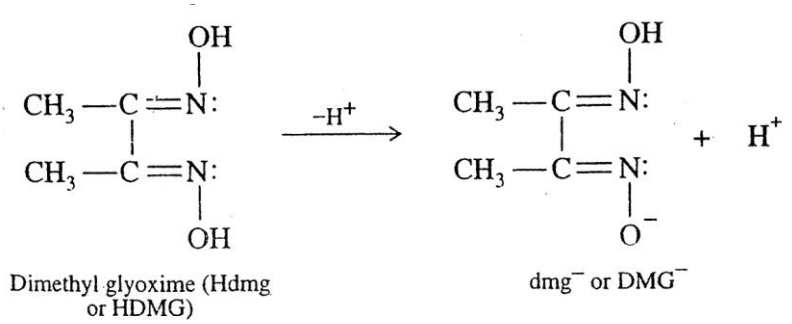
* 8- hydroxyl quinolinato ion ($oxine^-$)

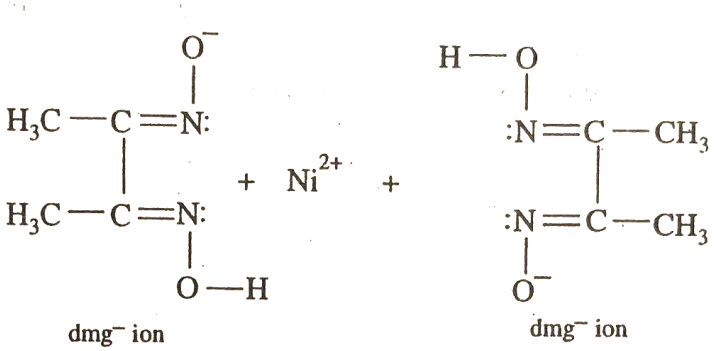


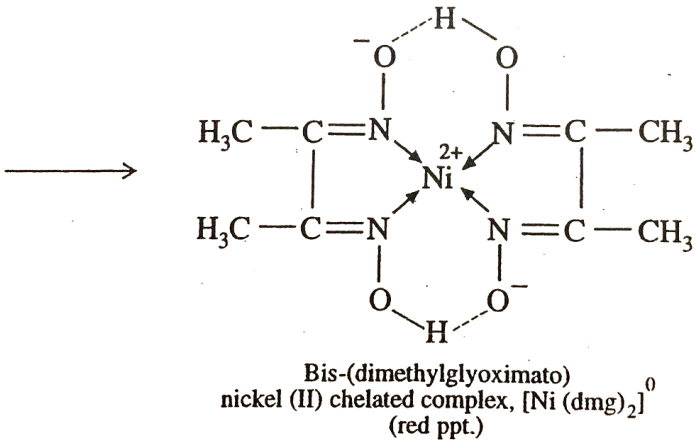
Attachment of oxine ion to a metal atom (M) in complex compounds



*Dimethyl glyoximato ion (dmg^- or DMG^-)

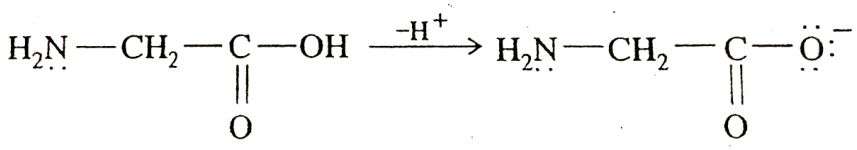




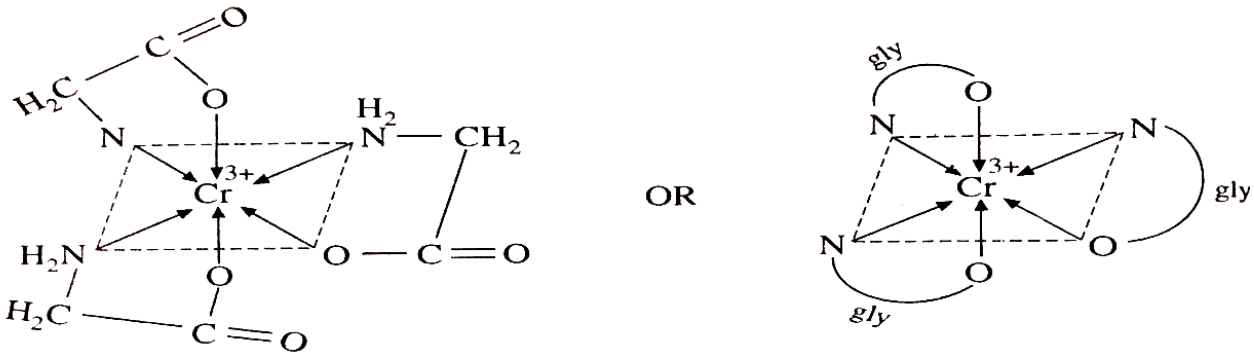


Bis-(dimethylglyoximato) nickel (II) chelated complex, $[Ni(dmg)_2]^0$ (red ppt.)

*Glycinato ion (gly^-)

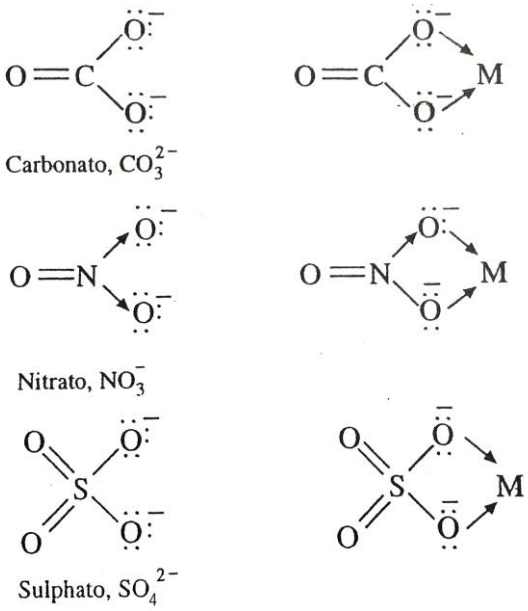


Glycine molecule (Hgly) Glycinato ion (gly^-)



*Carbonato CO_3^{2-}, nitrato NO_3^- and sulphato SO_4^{2-}

The structure of these ions and the way in which they are coordinated to the metal atom are shown blow:

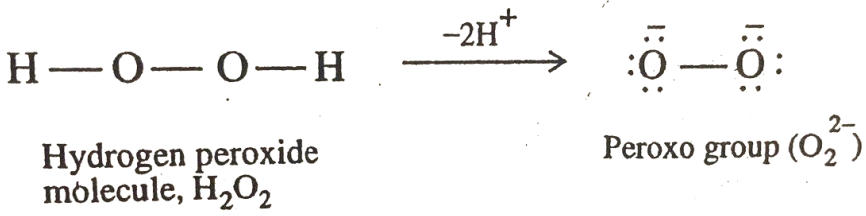


Carbonato, CO_3^{2-}

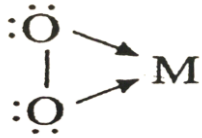
Nitrato, NO_3^-

Sulphato, SO_4^{2-}

* Peroxo, O_2^{2-}

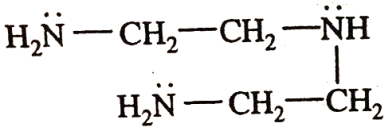


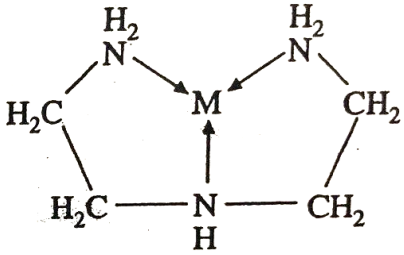
O_2^{2-} group gets coordinated to the central metal ion as:



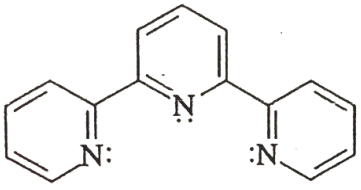
Examples of tridentate ligands

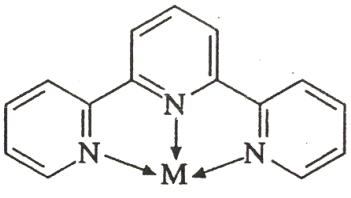
a- Diethylene triamine (dien)





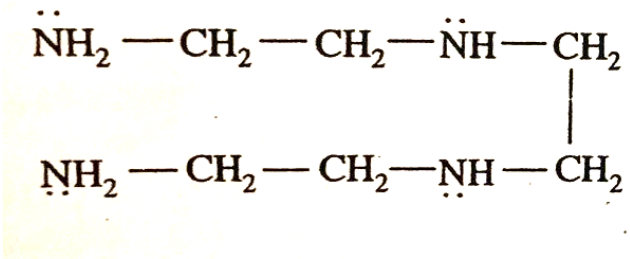
b- 2,2^{-},2^{--}-terpyridine or terpyridyl (terpy)

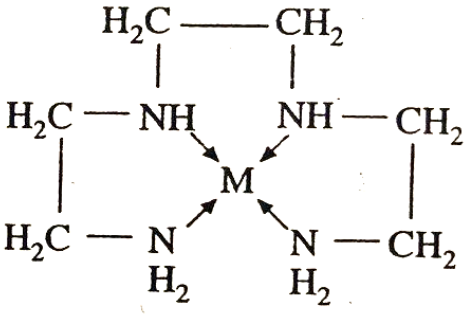




Example of tetra-dentate ligand

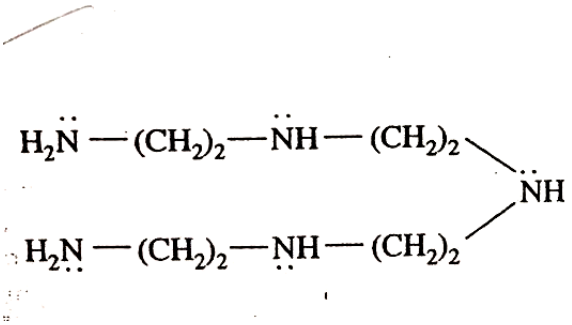
Triethylene tetraamine (trien)

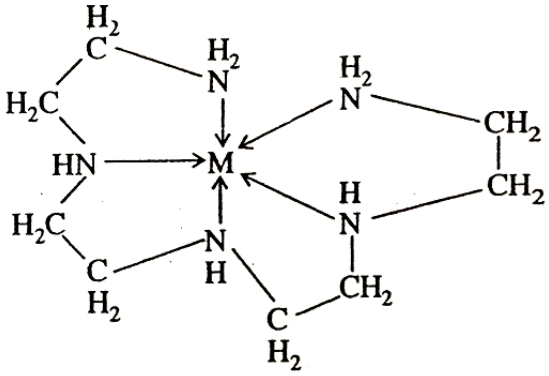




Example of penta-dentate ligand

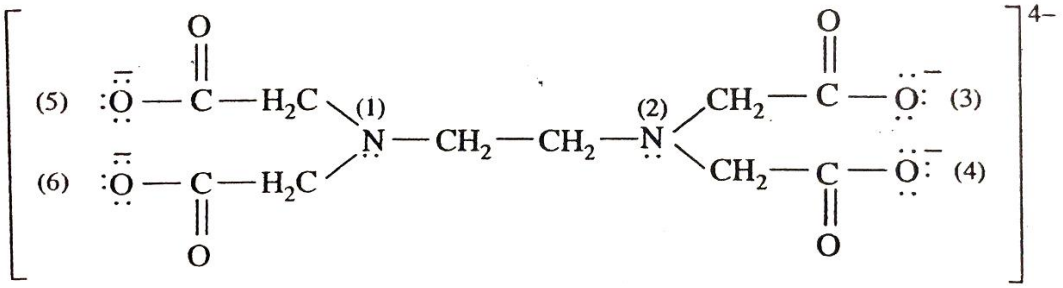
Tetraethylene pentaamine (tetraen)





Example of hexa-dentate ligand

Ethylene diamine tetraacetate ion ($edta^{4-}$ or $EDTA^{4-}$ or Y^{4-})



Bridging Ligand and Bridged Complexes

Although the ligands like OH^- (hydroxo), NH_2^- (amido or amino), NH^{2-} (imido), Cl^-, F^-, SO_4^{2-}, NO_2^-, CO etc. are mono-dentate ligands, they also act as bi-dentate ligands when they attached with two separate metals atoms, making a bridge between them. Such ligands are called bridging ligands and the complexes thus formed are called bridged (or polynuclear ligands or multinuclear) complexes. Each ligand makes two σ-bonds with two metal atoms. A bridging ligand must have at least two lone pairs of electrons which the ligand uses to get coordinated to two metal atoms. The polynuclear complex may be dinuclear, trinuclear, teranuclear etc.