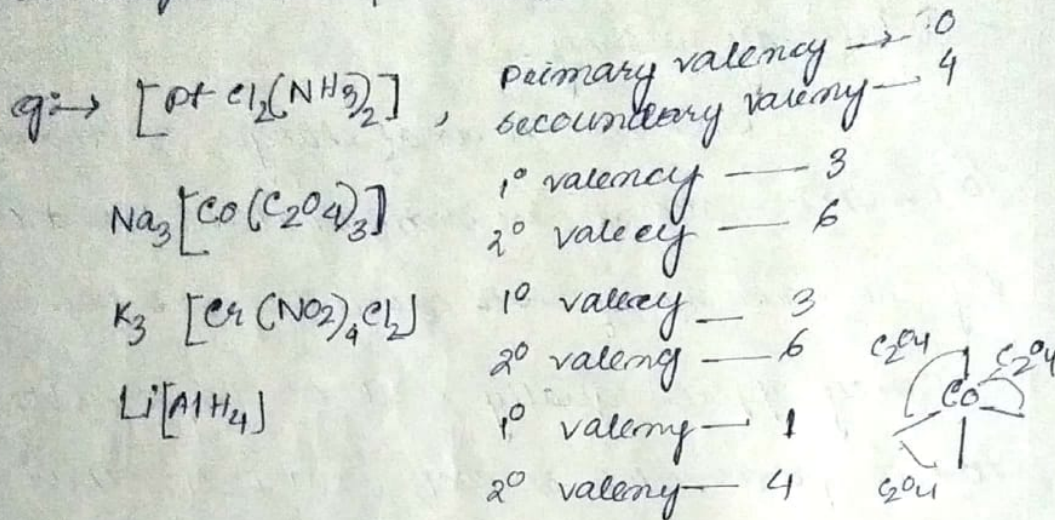


groups are held by secondary valency.

③ secondary valencies are directional and so a complex ion has a particular shape for eg- the complex ion $[\text{Co}(\text{NH}_3)_6]^{3+}$ is octahedral.



Nomenclature of Co-ordination compounds

- ① For compounds that consist of one or more ions, the cation is named first, followed by the anion, regardless of which is complex.
- ② Complex ions are named with their ligands in alphabetic order.
- ③ The ligand names are followed by the name of the metal atom, with either its oxidation no. in parentheses, or with the overall charge.
- ④ For anion the complex specified in parentheses.

For eg: \rightarrow

- ④ The suffix "ate" is added to the name of the metal if the complex is an anion.

For eg: \rightarrow

| | |
|----------------|----------------|
| Ni → Nickelate | Fe → Ferrate |
| Cu → Cuprate | Zn → Zincate |
| Al → Aluminate | Pt → Platinate |
| Mn → Manganate | Ag → Argentate |
| Cr → Chromate | Au → Aurate |
| Co → Cobaltate | |

⑦ The no. of a particular type of ligand in a complex is indicated by the prefixes mono, di, tri and tetra. The same prefixes are present to state the no. of metal atoms if more than one is present in a complex. For eg: → $[Re_2Cl_8]^{2-}$ is named as octachloro dichlorate.

⑧ If di, tri etc prefixes are already present in the name of the ligand itself, then use the prefix tris, bis etc.

⑨ Ligands that bridge two metal centres are denoted by a prefix μ added to the name of the relevant ligand.

⑩ During naming of ligands, specially on negatively charged ligands the name 'end' in 'o'. For eg: →

| | |
|----------------------------|---|
| * Cl ⁻ → Chloro | NO ₂ ⁻ → Nitro |
| Br ⁻ → Bromo | ONO ⁻ → Nitrito |
| H ⁻ → Hydride | SCN ⁻ → thiocyanate |
| CN ⁻ → Cyano | NCS ⁻ → isothiocyanate |
| F ⁻ → Fluoro | SO ₄ ²⁻ → sulphate |
| I ⁻ → Iodide | CO ₃ ²⁻ → carbonate |
| NH ⁻ → Amido | C ₂ O ₄ ²⁻ → oxalate |

any name of \rightarrow ve ligands remain as they are
 have donot have any specific ending.

CO \rightarrow carbonyl.

H₂O \rightarrow Aqua.

H₂N-CH₂-CH₂-NH₂ Ethylene diamine.

NH₃

Ammonia.

NO

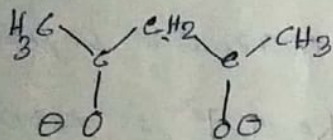
Nitrosyl.


NH₂CH₂COO⁻

glycinate

etc.

* Acetylacetonate (acac)



cyclopentadienyl C₅H₅⁻ ()

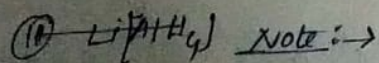
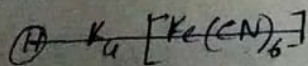
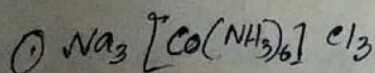
oxo \rightarrow O²⁻

sulfido \rightarrow S²⁻

triphenyl phosphine \rightarrow Ph₃P

trimethyl phosphine \rightarrow P(CH₃)₃

Ex: atomic complexes \rightarrow



neutral ligands \rightarrow

(CH₃)₂SO \rightarrow dimethylsulphoxide (DMSO)

(NH₂)₂CO \rightarrow Urea.

C₅H₅N \rightarrow pyridine

④ ~~terpy~~ \rightarrow terpyridine

bpy \rightarrow 2,2'-bipyridine.

SO₂ \rightarrow sulphur dioxide.

OP(CH₃)₃ \rightarrow Trimethylphosphine oxide

⑤ CS \rightarrow thiocarbonyl.

N³⁻ \rightarrow Nitrido

N₃⁻ \rightarrow Azido

NH₂⁻ \rightarrow Amido

S₂O₃²⁻ \rightarrow thiosulphate.

O₂ \rightarrow Dioxygen.

N₂ \rightarrow Dinitrogen

PCl₃ \rightarrow trichlorophosphine

PPh₃ \rightarrow Triphenylphosphine

P(OCH₃)₃ \rightarrow Trimethylphosphite

Ex: - atomic complexes: ->

- (I) $[Co(NH_3)_6]Cl_3$ → Hexaammine cobalt(II) chloride.
- (II) $[Cr(CO)_5](NO_2)_3$ → Pentacarbonylchromium(II) nitrate.
- (III) $[Fe(en)_3]^{3+}$ → Trisethylenediammine ferrate(III).
- (IV) $[Cu(H_2O)_6]SO_4$ → Hexaqua copper(II) sulphate.
- (V) $[MnCl_2(en)_2]NO_2$ → Dichlorobisethylenediammine manganese(II) nitrate.
- (VI) $[CoCl(NH_3)_5]CO_3$ → Pentaamminechlorocobalt(II) carbonate.
- (VII) $[Cr(NO_2)_2(NH_3)_4]NO_3$ → Tetraammine dinitrochromium(II) nitrate.
- (VIII) $[Al(SCN)_2(H_2O)_4]HCO_3$ → Tetraqua dithiocyanatoaluminum(III) bicarbonate.
- (IX) $[Pt(Py)_4]SO_4$ → Tetrapyridine platinum(II) sulphate.
- (X) $[Cr(PPh_3)_3(H_2O)_3]^{3+}$ → Tris(triphenylphosphine)chromium(III).
- (XI) $[NiCl_2(O_2)_2]$ → Dioxo dichlorobisdioxygen nickel(II).

Anionic complex: ->

- (I) $Li[AlH_4]$ → Lithium tetrahydroaluminate(III).
- (II) $K_4[Fe(CN)_6]$ → Potassium hexacyanoferrate(II).
- (III) $K_3[Fe(ONO)_2(CN)_4]$ → Potassium tetracyano dinitrito ferrate(III).
- (IV) $Na_2[O_6Cl_5N]$ → Sodium pentachloronitride osmium(VI).
- (V) $Na_3[Ag(S_2O_3)_2]$ → Sodium dithiosulphato silver argentate(I).

Types of ligands

The majority of ligands are anions or ~~neutral~~ ^{neutral} molecules that can be caught up on e^- pair donor.

Ligands are defined as atoms or molecules having lone pair of e^- and capable of forming co-ordinate bonds with central metal atom. ~~low~~

Common ligands are F^- , Cl^- , Br^- , CN^- , NH_3 , H_2O , OH^- group etc.

Classification of ligands: →

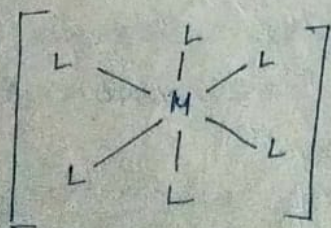
Ligands are mainly classified according to their no. of bonding sites with the central metal atom. and are also classified w.r.t. the charge associated with the ligands.

Classification of ligands acc to their binding sites: →

① When ligands donate one e^- pair to the central metal atom they are called monodentate ligands.

② This type of ligands have only one point of attachment to the metal atom.

For eg: → H_2O , CN^- , OH^- , NH_3 , NO_2^- , CO etc are monodentate ligands.



monodentate ligands
complex $[ML_6]$

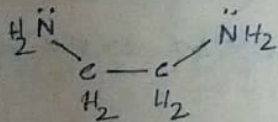
2) polydentate ligands :->

Ligands that have more than one point of attachment are classified as polydentate ligands. This type includes bidentate, tridentate, tetradentate and hexadentate etc.

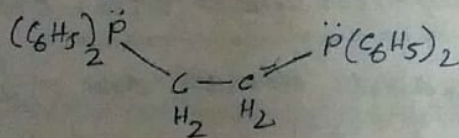
(a) Bidentate ligands :-> the most common polydentate ligands are bidentate i.e. having two possible points of attachment to a metal atom.

For eg :-> Neutral bidentate ligands include the following :-

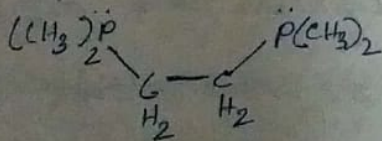
(a) Ethylenediamine (en)



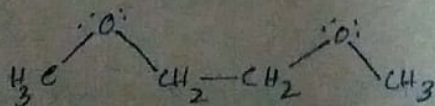
(b) Bis(diphenylphosphino) ethane (diphos or dppe)



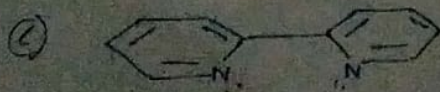
(c) Bis(dimethylphosphino) ethane (dmpe)



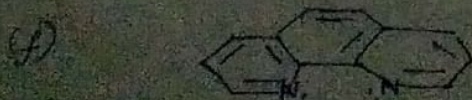
(d) Glycine



above ligands form 5 membered rings with a metal atom.

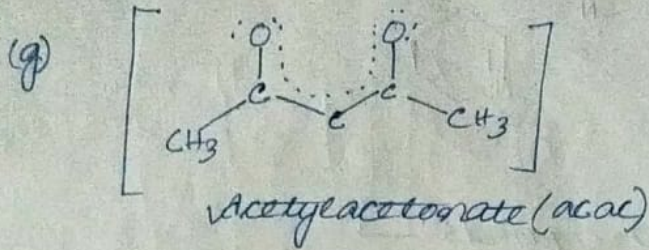


2,2'-Bipyridine (bpy)



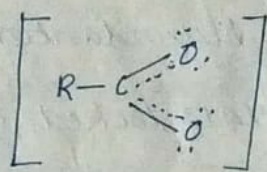
1,10-Phenanthroline (phen)

these two aromatic amines also form 5 membered rings with the metal.

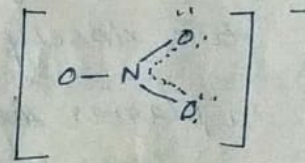


The anion acac forms a six membered rings when coordinated to a metal.

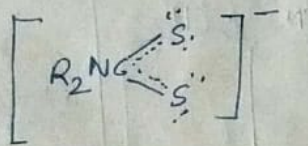
However the no of common anions acting as bidentate ligands form four membered rings with metal atom.



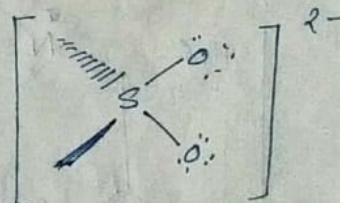
Carbonylate



Nitrate



Dithiocarbonates

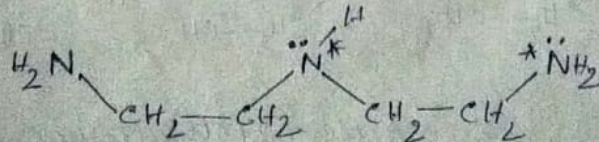


Sulphates

③ Tridented ligand :-

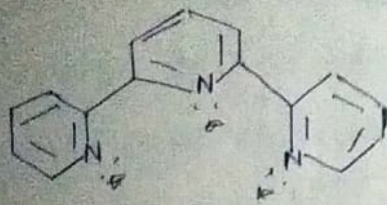
Tridented ligands have three binding sites by which they can co-ordinate with central metal atom. Two important examples of tridented ligands are →

① Diethylenetriamine



Diethylenetriamine (dien)

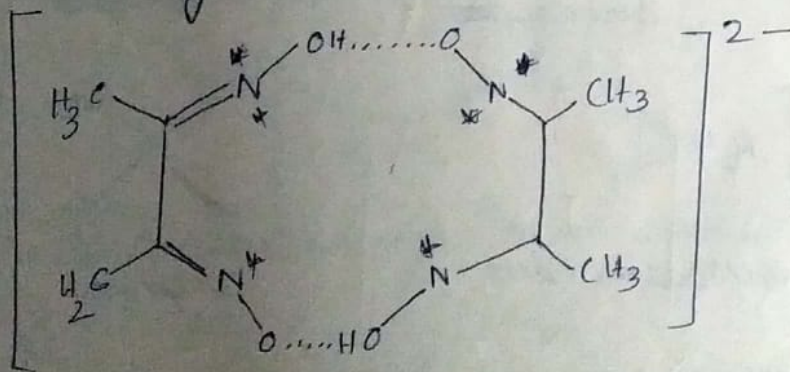
(2) Terpyridine (terpy)



(c) Tetradentate ligands:

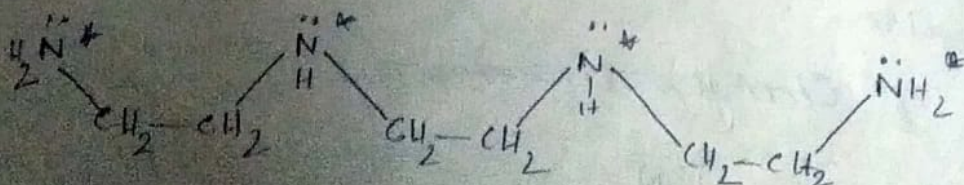
There are many important tetradentate ligands. This type of ligands have four possible points of attachment to a metal atom. There are many important tetradentate ligands. For eg: →

(i) Bis(dimethylglyoximate) system. It consists of two closely coupled bidentate units that form a planar chelate locked onto planarity by two strong H-bonds.



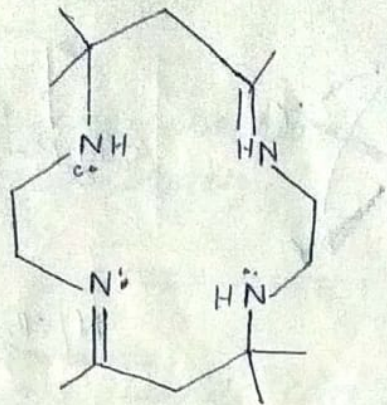
Bis(dimethylglyoximate) (dmgh)

(ii) An important open chain tetradentate ligand is triethylenetetramine.



triethylenetetramine.

(ii) Another important biologically useful tetradentate ligand is porphyrin. used in haemoglobin and myoglobin.

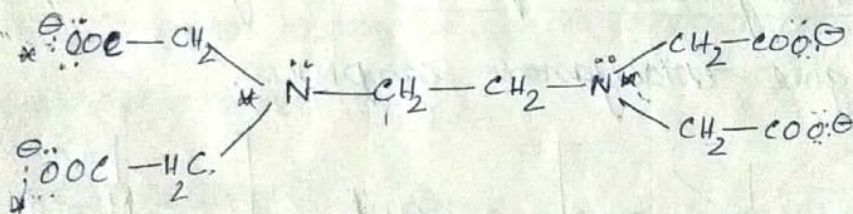


(a) Hexadentate ligands: →

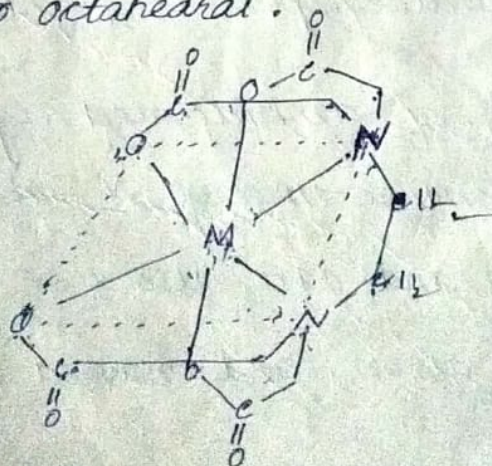
Hexadentate ligands has six binding sites for having six possible sites of attachment to a metal atom.

An important example of hexadentate ligand is,

(i) ethylenediaminetetraacetic acid (EDTA).



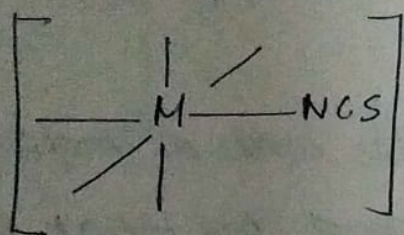
EDTA — co-ordinates with a metal atom using six co-ordination sites and by that way give rise to octahedral.



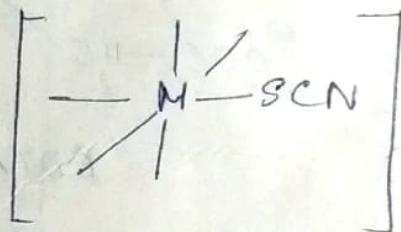
Ambident ligands:-

Ligands which have more than one ^{different} potential donor atom but using only one at a time are called ambident ligands.

For eg:- \rightarrow ① thiocyanate ion ~~SCN⁻~~ can attach to a metal atom either by the N-atom to give isothiocyanato complexes or by the sulphur atom to give thiocyanato complexes.



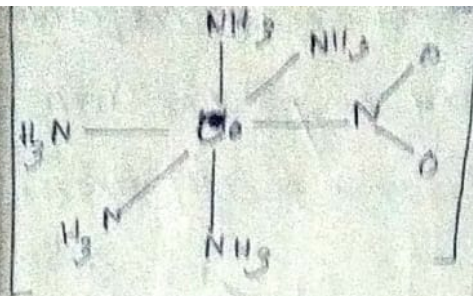
and



Isothiocyanato complex.

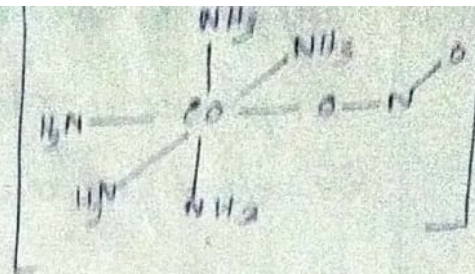
thiocyanato complex.

② Another eg. of ambident ligand is nitro ion which can combine through N-atom to give nitro complex and can also use oxygen atom for oxygen atom. and named as nitrido complex.



Pentammine nitrocobalt(III) ion
(yellow isomer)

and



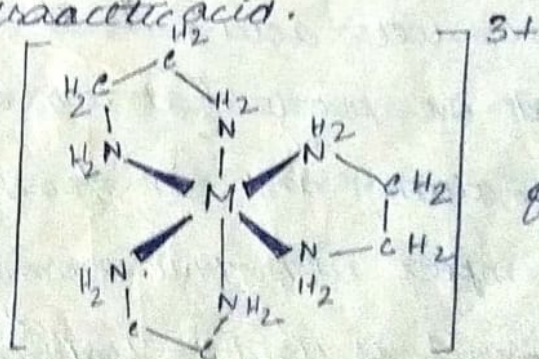
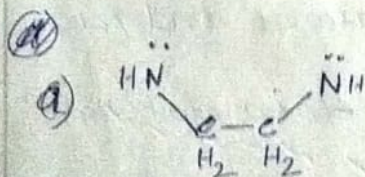
Pentammine nitrocobalt(III) ion
(red isomer)

chelate ligand: →

Polydentate ligands can produce a ring structure enclosing the central metal atom. Such type of cyclic compounds are called chelate compounds. (chelate means cage or closed compounds). Thermodynamically these complexes are very stable because formation of such five or six membered ring structure give rise to high positive enthalpy change.

Common examples of chelating ligands are

- (a) ethylenediamine
- (b) acetylacetonate
- (c) ethylenediaminetetraacetic acid.



five member ring

chelate complex of
 $[M(en)_2]^{3+}$

It is important to note that normal chelating ligands will only attached to the metal at two