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Coordination Chemistry

KCl (single salt)

$MgCl_2$ (" ")

$KCl + MgCl_2 \xrightarrow{+6H_2O} KCl \cdot MgCl_2 \cdot 6H_2O$

(Double salt)

Simple salt:

When an acid reacts with an alkali, neutralisation takes place & simple salt is produced.

Ex. $NaOH + HCl \rightarrow NaCl + H_2O$

When dissolved in water, these salts ionise & produce ions in sol".

Mixed salt:

They contain more than one acidic or basic radicals.

Ex. $NaKSO_4$.

Molecular or addition compounds:

When sol" containing two or more salts in a stoichiometric proportions, is allowed to evaporate we get crystals of compounds known as molecular or addition compounds. They are of two types depending on their

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behaviours in aq. sol^n:

1. Double salt (lattice compound) :-
These are additional compounds which are stable in solid state but give their constituent ions when dissolved in water or in any other ionic solvent. In these compounds, the individual properties of constituent ions are not lost.
For ex. $KCl.MgCl_2.6H_2O$ gives K^+, Mg^{+2} & Cl^- ions.
Mohr's Salt ($FeSO_4.(NH_4)_2SO_4.6H_2O$)
and potash alum ($K_2SO_4.Al_2(SO_4)_3.24H_2O$).

2. Coordination or complex compounds :
It has been observed that when sol^n of $Fe(CN)_2$ + KCN are mixed together & evaporated, potassium ferrocyanide is obtained which in aq. sol^n does not give test of Fe^{+2} ions & CN^- ions, but gives test of K^+ ion and $[Fe(CN)_6]^{4-}$ ions.

$$Fe(CN)_2 + 4KCN \rightarrow K_4[Fe(CN)_6] \overset{H_2O}{\rightleftharpoons} 4K^+ + [Fe(CN)_6]^{4-}$$

$K_4[Fe(CN)_6]$

$[Pt Cl_6][CoF_6]$

$[Fe(\cancel{CN})(H_2O)_6]SO_4$

$[Fe(NH_2-CH_2-CH_2-NH_2)_3]SO_4$

[ ] : ionisation or coordination sphere

+ve, -ve or neutral

∴ Coordination sphere may be anion or cation or bo

Acc. to VBT, bond b/w central atom & ligand is coord^{n} bond (b/w filled & empty orbital)
C.N = 1 σ bond

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Central atom :

D-block element present in a coordination sphere which may bond with ligands is central atom.

Ligands :

It is an ion or molecule which makes bonds with central atom ion in a coordination sphere.

or

It is an ion or molecule capable of donating a lone pair of $\bar{e}$ to the central atom.

According to VBT

Valency → Primary : ~~Oxidation no.~~ oxidation of C.A ~~charge on coord^{n} sphere~~

Valency → Secondary : Coordination no.

Coordination no. :

C.N = Σ No. of ligands × no. of dented nature

Metal ion	Min. O.N → C.N	Max. O.N → C.N
✓ Fe	Fe^{+2} → 6	Fe^{+3} → 6
Au	Au^{+} → 2, 4	Au^{3+} → 4
✓ Ag	Ag^{0}	Ag^{+1} → 2
Hg	Hg_2^{+2}	Hg^{+2} → 4
✓ Cu	Cu^{+} → 2, 4	Cu^{+2} → 4, 6
✓ Zn	Zn^{+2}	Zn^{+2} → 4
Cd	Cd^{+2} → 4	Cd^{+2} → 4
✓ Co	Co^{+2} → 4, 6, 5	Co^{+3} → 6
✓ Ni	Ni^{+2} → 4, 6	
✓ Pt	Pt^{+2} → 4	Pt^{+4} → 6

3, 4

- Mo^{4+} → 7, W^{4+} → 8
- Cu^{2+}, Pt^{2+}, Ni^{2+}, Mn^{2+}, Pd^{2+}, Zn^{2+}, Ni have C.N. = 4
- Fe^{0} → 5 ; Fe^{+2}, Fe^{3+}, Co^{3+}, Pt^{4+}, Cr^{3+}, Cr, Ni^{2+}, Ir^{3+} have CN = 6

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Types of ligands :

a) On the basis of dented nature or classification based on the no. of donor atoms present

b) On the basis of charge

c) On the basis of interaction b/w ligands & central atom

*ba) On the basis of charge

- Anionic ligands / -ve ligands
  Ex. OH^-, CN^-, Br^-, F^-, CO_3^-, etc.
- Positive ligands
  Ex. NO^+, $NH_2-NH_3^+$, etc.
- Neutral ligands
  Ex. NH_3, H_2O, NC, CO, C_6H_6, etc.

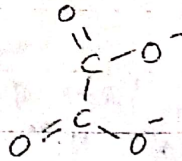
a) On the basis of no. of potential donor atoms (denticity)

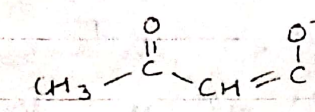
- Mono-dented -
  Ligands with only one donor atom. Ex. NH_3, CN^-, F^-, H_2O, CO.

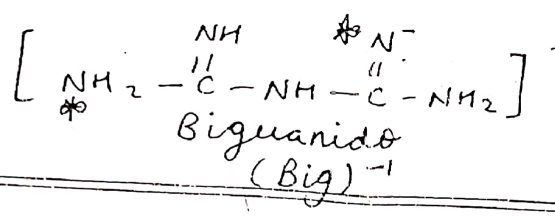
- Bi-dented - (poly-dented starts from bi-dented)
  Ligands with two donor atoms.

Ex. $CH_2(NH_2)-CH_2(NH_2)$
Ethylenediamine
or
Ethane-1,2-diamine
(en)

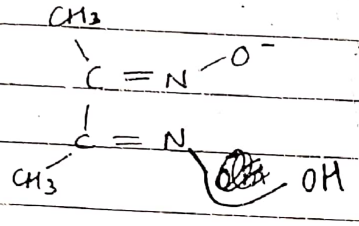
$CH_2(NH_2)-CH_2-CH_2(NH_2)$
Trimethylenediamine
(tn)


oxalate (ox^{-2})

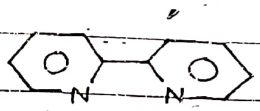

acetylacetonate ion
($acac^-$)



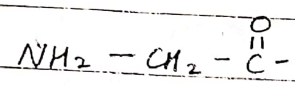
Biguanido
(Big)$^{-1}$



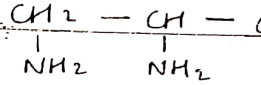
Dimethylglyoximate
(dmg)



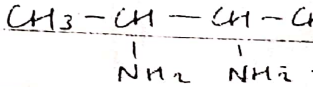
~~dipy~~ dipyridyl
(dipy)



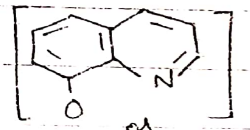
glycinato
(gly)



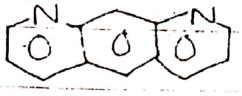
1, 2 diamino propane
or
Propylene diamine
(Pn)



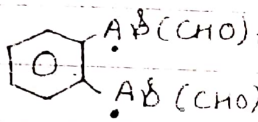
~~Byt~~ Butylene diamine
(bn)



$(oxin)^-$ or $(oxinate)^-$
8-Hydroxyquinolinate



1, 10 phenanthraline
(Phen)

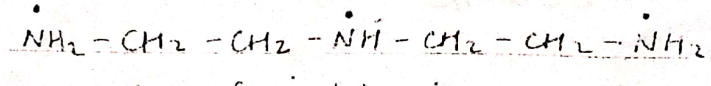


O-phenylene bis dimethyl arsine
diarsine
or
(D)

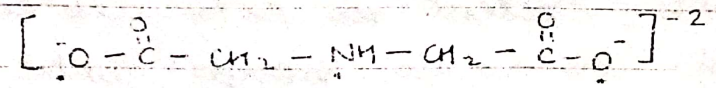
- Tri-dented –

Ligands which have 3 donor atoms.

Ex.

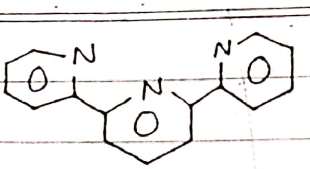


Diethylene triamine
or dien

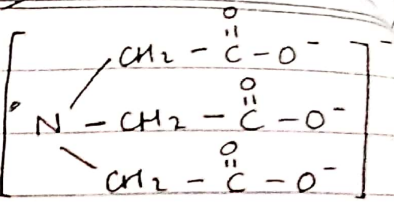


Imino-di-acetato
or
$(IDA)^{-2}$

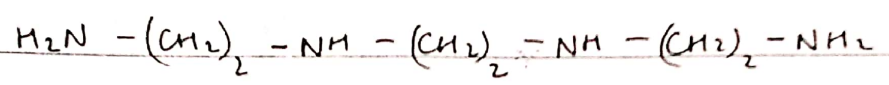
Tetradented



2, 2', 2'' terpyridine
or
(terpy)

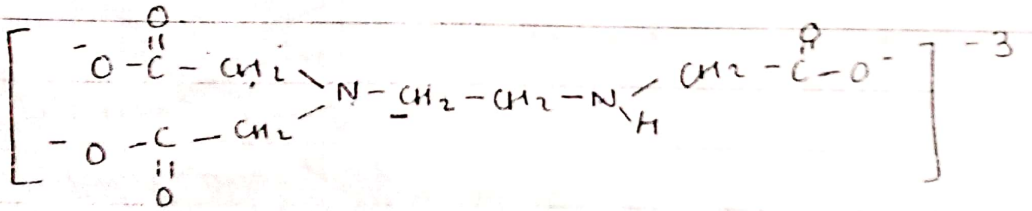


Nitrilotriacetato
or
$(NTA)^{-3}$



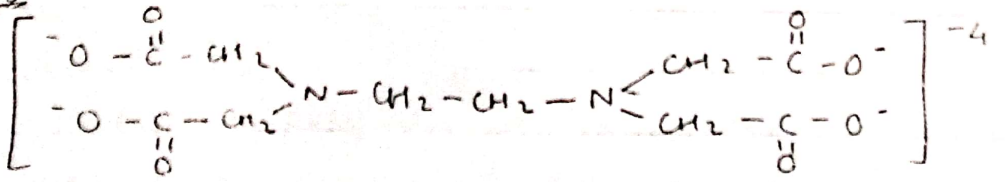
Tri-ethylene tetra amine
or
(trien)

Penta



Ethylene diamine triacetato
$[EDTA]^{-3}$

Hexa



Ethylene diamine tetra acetato
$[EDTA]^{-4}$

Poly-dented ligands have flexibility in dented character. It is not necessary that all the donor atoms present in poly-dented ligands should form coordinate bonds with central metal atom. For ex. Ethylene diamine tetra acetic acid $[EDTA]^{-4}$

Flexidentate → denticity depends on comp. formed

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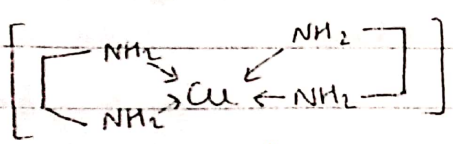
which is hexa-dented can function as penta-dented, tetra-dented ligands with certain metals. Similarly, sulphate ion can also act as mono-dented ligands.

denticity depends on comp. formed

Chellating ligand:

A bi-dented or poly-dented ligand is known as chellating ligand if it produces one or more ring with central atom during bond formation. Chellating ligands form more stable complex.

Ex.  or $[Cu(en)_2]^{2+}$

Chellating complex.

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Ambi-dented ligands:

These are ligands which have two or more donor atoms, but in forming complex only one donor atom is attached to metal ion at a given time. Such ligands are ambidentate ligands.

Ex. NO_2^- ⟶ $M-NO_2$ Nitro
$M-O-N=O$ Nitrito

CN^- ion ⟶ $M-CN$ cyano
$M-NC$ isocyano

NCS^- ion ⟶ $M-SCN$ Thio cyanate
$M-NCS$ iso thio cyanate

NCO^- ⟶ $M-OCN$
$M-NCO$

$SeCN^-$ ⟶ $M-SeCN$
$M-NCSe$

R_2SO ⟶ S-bonded
O-bonded

$S_2O_3^{2-}$ ⟶ $MSSO_3$ → thio sulphato-S
$MOSO_2S$ → thio sulphato-O

c) On the basis of interaction b/w ligands & central atoms:

1. Classical or simple donor ligands -
Ligands only donate lone pair of $\bar{e}$ to central atom
Ex. NH_3, NH_2^-, H_2O, etc.

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2. Non-classical ligands or π-acid or π-acceptor ligands- These ligands not only donate their lone pair to central atom but also gain $\bar{e}$-cloud from the central atom in their low-lying vacant (Low e) orbitals. This kind of back donation is called ~~synergist~~ synergic effect.

Ex. CO, C_2H_4, C_2H_2, etc., CN^-, PR_3 R = H/Ph/Et
(d, Antibonding MO empty) CO_2, NO^+, PF_3.

Effective atomic number (EAN):

EAN = At. no. of metal - no. of $\bar{e}$ lost in ion formation + no. of $\bar{e}$ gained from the donor atom of ligands

It is defined as resultant no. of $\bar{e}$ with metal atom or ion after gaining $\bar{e}$ from the donor atoms of the ligand-

$K_4[Fe(CN)_6]$ EAN = 26 - 2 + (2×6) = 36 ← At no of Kr

$[Cu(NH_3)_4]SO_4$ EAN = 29 - 2 + (2×4) = 35

$Ni(CO)_4$ EAN = 28 - 0 + (4×2) = 36

$[Co(NH_3)_6]Cl_3$ EAN = 27 - 3 + (2×6) = 36

EAN concept has been particularly successful for complexes of low valent metals (i.e. C O N ≤ 2)

Sidgwick suggested that complex in which EAN of central atom is equal to at. no. of next noble gas are extra stable but this is found to be incorrect in many complexes. EAN rule is valid in case of

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N_3^- SCN^-

metal carbonates and metal carbonyls.

Rules for nomenclature :

1. Naming of ligands : (according to alphabetical order)

Naming of -ve ligands

A, E, I, O, U replaced by O

H^- : Hydrido
O^{-2} : oxo
O_2^{-2} : Peroxo
O_2H^- : perhydroxo : (H_2O_2)
F^- : Fluorido
Cl^- : Chlorido
Br^- : Bromido
I^- : Iodido
CO_3^{--} : Carbonato
$C_2O_4^{-2}$: Oxalato
CH_3COO^- : acetato
$EDTA^{-4}$: Ethylene diamine tetra acetato
SO_4^{2-} : Sulphato
SO_3^{2-} : Sulphito
S^{-2} : Sulphido
HSO_3^- : Hydrogen sulphito
$S_2O_3^{-2}$: thio sulphato
HS^- : Mercapto
NH_2^- : Amido or Azanido
NH^{--} : Imido or Azanediido
NO_3^- : Nitrato
ONO^- : Nitrito-O / O-nitro
NO_2^- : Nitro / Nitrito-N / N-Nitro
N^{-3} : Nitrido
CN^- : cyano / cyanido

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N_3^- : Azido
SCN^- : thiocyanato -S
NCS^- : isothiocyanato - N
HCO_3^- : Hydrogen carbonato
$S_4O_6^-$: tetra thionoso

If the ligand is an organic anion then the name of ligand does not end with 'O'.

Ph^- Phenyl
$CH_2=CH^-$ Vinyl
CH_3^- Methyl

For the π donor ligands prefix η^x is used, where η indicates π-electron donation and x is known as the capacity of the ligand (no. of atoms involved in the π-donation)

Ex. $\pi - C_5H_5^-$ η^5 (cyclopentadienyl)
$\pi - C_6H_6$ η^6 (Benzene)

2 pi bonds + 1 lone pair

3 pi bonds

→ Homoleptic complexes : In which metal atom/ion is linked to only 1 type of ligand.
eg : $[Cr(H_2O)_6]^{3+}$

→ Heteroleptic complexes : In which metal atom/ion is linked to more than 1 type of ligands. eg : $[Cr(H_2O)_2(NH_3)_2Br_2]^+$

→ Labile complex : complex in which ligands can be easily replaced by other ligands

→ Homonuclear complex : in which only 1 metal atom is present. eg: $[Cr(H_2O)_6]^{3+}$

→ Polynuclear complexes : more than 1 metal atom/ion present
eg: any bridge complex

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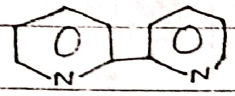
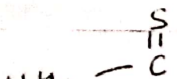
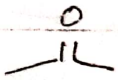
Neutral ligands:

- H_2O : Aquo / Aqua
- CO : Carbonyl
- NH_3 : Ammine
- NO : Nitrosyl
- CS : thio carbonyl
- NS : thio nitrosyl
- C_5H_5N : Pyridine
- NH_2-NH_2 : Hydrazine
- PH_3 : Phosphine
- O_2 : dioxygen
- Ph_3P : triphenyl phosphine

 : Dipyridyl

- N_2 : dinitrogen
- $CH_2(NH_2)-CH_2(NH_2)$ (en) : Ethylene diamine or ethane-1,2-diamine

 : thio urea

 : acetone

+ve ligands.

Neutral ligand + ium

- NO^+ : Nitrosylium / Nitrosonium
- $NH_2-NH_3^+$: Hydraziniium
- H_3O^+ : Hydronium

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Indication of no. of ligands:

No. of simple ligands such as Cl^-, Acetate ion is indicated by using before them Greek prefix: di, tri, tetra, etc.

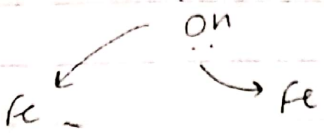
In case of chelating ligands like (en) & trialkyl phosphine which contain prefix di, tri, etc. in their ligand's name, we have bis for 2, tris for 3, tetrakis for 4, pentakis for 5.

Ligands to which these prefixes refer are often placed in parentheses.

Bridge ligands:

Monodentate ligands may have more than 1 free $\bar{e}$ pair and, thus, may simultaneously coordinate with two or more atoms. Ligands form 2 sigma bonds with two metal atoms & thus, act as a bridge b/w metal atoms. Such ligands are called bridging ligands & resulting complex is bridge complex.

Ex. OH^-, F^-, Cl^-, NH_2^-, etc.



Naming of bridge ligands of bridged poly nuclear complexes:

Complexes having two or more metal atoms are called poly-nuclear complexes. In these complexes bridging grp is indicated in the formula of complex by separating it from the rest of complex by hyphen & by adding the prefix μ before its name. Two or more bridging grps of same kind are indicated by di-μ, tri-μ.

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Naming of central atom: -

If coordination sphere has +ve or 0 charge, then central metals follow English name.

If coordination sphere has -ve charge then central metals follow Latin name.

Latin names:

Iron - Ferrate	Silver - Argentate
Copper - Cuprate	Gold - Aurate
Lead - Plumbate	Tin - Stannate
Chromium - chromate	Platinum - Platinate
Mercury - Mercurate /	Cobalt - Cobaltate
Nickel - Nickelate	Aluminium - Aluminate

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Q. Name the following compounds:

1. $[Pt(NH_3)_6]Cl_4$ – Hexa ammine platinum (IV) choride

2. $[Co(NH_3)_4H_2OCl]Cl_2$ – Tetra ammine aqua chlorido cobalt (II) chloride

3. $[Cu(en)_2]SO_4$ – Bis (ethylene diamine) copper (II) sulphate

4. $[Cr(H_2O)_4Cl_2]^+$ – Tetra aqua di chlorido chromium (III) ion

5. $[Fe(H_2O)_4(C_2O_4)]_2SO_4$ – Tetra aqua oxalato iron (III) sulphate

6. $[Cr(NH_3)_4(ONO)Cl]NO_3$ – Tetra ammine chlorido o-nitro chromium(III) nitrate

7. $[Ag(NH_3)_2]Cl$ – Di ammine silver (I) chloride

8. $[Co(NH_3)_5(NCS)]Cl_2$ – Penta ammine isothiocyanato-N cobalt (III) chloride

9. $[\{(C_6H_5)_3P\}_3Rh]Cl$ – Tris triphenyl phosphine rhodium (I) chloride

10. $K_4[Fe(CN)_6]$ – Potassium hexa cyanido ferrate (II)

11. $K_3[Fe(CN)_6]$ – Potassium hexa cyanido ferrate (III)

12. $K_3[Cr(C_2O_4)_3]$ – Potassium tri oxalato chromate (III)

13. $K_3[Co(C_2O_4)_2Cl_2]$ – Potassium dichlorido di oxalato cobaltate (III)

14. $K_2[HgI_4]$ – Potassium tetra iodido mercurate (II)

15. $K_2[PtCl_6]$ – Potassium hexa chlorido platinate (IV)

16. $Na[Ag(CN)_2]$ – Sodium di cyanido argentate (I)

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1c

17. $[Ni(CN)_4]^-$ - Tetra cyanido nickelate(IV) ion

18. $Na_3[Co(NO_2)_6]$ - Sodium hexa nitro cobaltate (III)

19. $K_3[Fe(CN)_5NO]$ - Potassium penta cyanido nitrosyl ferrate(II)

20. $[Cr(NH_3)_6][Co(CN)_6]$ - Hexa ammine chromium (III)
hexa cyanido cobaltate (III)

21. $[Pt(NH_3)_4][CuCl_4]$ - Tetra ammine platinum (II)
tetra chloride cuprate (II)

22. $[Cr(NH_3)_6][Co(C_2O_4)_3]$ - Hexa ammine chromium (III)
Tri oxalato cobaltate (III)

23. $[Pt(Py)_4][PtCl_4]$ - Tetra pyridine platinum (II)
tetra chlorido platinate (II)

24. $Fe(CO)_5$ - Penta carbonyl iron (0)

25. $[Co(NO_2)_3(NH_3)_3]$ - Tri ammine trinitro cobalt (III)

→ 26. $Cu(gly)_2$ - Di glycinato copper (II)

→ 27. $Ni(DMG)_2$ - Bis dimethyl glyoximato nickel (II)

✳ 28. $[Cr(H_2O)_4Cl_2]Cl.2H_2O$ - Tetra aqua di chlorido chromium (III) chloride di hydrate

29. $[(NH_3)_5Cr-OH-Cr(NH_3)_5]Cl_5$ - μ-hydroxido bis (penta ammine chromium (III) chloride
Penta ammine chromium (III)-μ-hydroxido or Penta ammine chromium (III) chloride

30. $[(H_2O)_4Co(OH)(NH_2)Cr(NH_3)_4]SO_4$

31. $[(en)_2Co(NH_2)(OH)Co(en)_2](SO_4)_2$

32. $[(H_2O)_4Fe(OH)(OH)Fe(H_2O)_4](SO_4)_2$

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33. $[Fe(C_5H_5)_2]$ - Bis (cyclopentadienyl) Iron (II)

34. ~~NO_2~~ $[Na_2[Fe(CN)_5NO]$ - Sodium penta cyanido nitro-sikium ferrate (II)

35. $K_4[FeO_4]$ - Potassium tetra oxido ferrate (IV)

36. $K_2[Co(N_3)_4]$ - Potassium tetra azido cobaltate (II)

37. $[Co(SO_4)(NH_3)_4]NO_3$ - Tetra ammine sulphato cobalt (III) nitrate

38. $Li[AlH_4]$ - Lithium tetra hydrido aluminate (III)

39. $K_2[Cr(CN)_2O_2(O_2)NH_3]$ - Potassium ammine di cyanido di oxo per oxo chromate (VI)

* $[Fe(H_2O)_5NO]SO_4$

O.N = +1 +1 -2

30. → Bis (ethane-1,2-diamine) cobalt (III) μ-amido-μ-hydroxo bis (ethane-1,2-diamine) cobalt (III) sulphate

or

Tetra kis (ethane 1,2 diamine) -μ-amido-μ-hydroxo di cobalt (III) sulphate

32. Tetra aquo iron (III) ~~di-μ-hydroxo~~ - tetra aquo Iron (III) sulphate

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Isomerism :

- Structural isomerism
  - → Ionisation "
  - → Hydrate "
  - → Ligand "
  - → Linkage "
  - → Co-ordination "
  - → Co-ordination position iso.
  - → Polymerisation iso.
- Stereo isomerism or space "
  - Geometrical or Cis-Trans iso. or Position iso
  - Optical or Mirror image iso.

Structural isomerism :

This isomerism arises due to differene in structure of coordination compounds.

1. **Ionisation iso. :** -

Compienes which have same empirical formula but give different ions in sol"s on ionisation are called ionisation isomers.

Ex. $[Co(NO_3)(NH_3)_5]SO_4$ & $[Co(SO_4)(NH_3)_5]NO_3$

$[Pt\,Cl_2(NH_3)_4]Br_2$ & $[PtBr_2(NH_3)_4]Cl_2$

$[Co(NH_3)_5Br]SO_4$ & $[Co(NH_3)_5SO_4]Br$

2. **Hydrated iso.:**

This type of isomerism arises due to different pos" of water molecule inside & outside of the coordination sphere.

Ex. $CrCl_3 \cdot 6H_2O$, $[Cr(H_2O)_6]Cl_3$ (Violet) $[CrCl(H_2O)_5]Cl_2 \cdot H_2O$ (Pale green)

and $[CrCl_2(H_2O)_4]Cl \cdot 2H_2O$ → Dark green

Violet → Does not lose water over H_2SO_4 & also all Cl ions are immediately ppt.d by Ag^+

Pale green → Lose water over H_2SO_4, 2 Cl ions are ppt. by Ag^+

Dark green → Lose water, 1 Cl ion ppt.d

$[Cr(H_2O)_3Cl_3].3H_2O$ → Dark green

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$[Co(H_2O)_6]Cl_3$, $[Co(H_2O)_5Cl]Cl_2.H_2O$ → Hydrated iso.

$[Co(NH_3)_4(H_2O)Cl]Br_2$ & $[Co(NH_3)_4Br_2]Cl.H_2O$

Ionisation & Hydrated iso.

3. Ligand isomers:

Some ligands themselves are capable of existing as isomers. Ex.

$CH_2(NH_2)-CH(NH_2)-CH_3$ (Pn) $CH_2(NH_2)-CH_2-CH_2(NH_2)$ (tn)

$[Co(Pn)_2Cl_2]^+$ & $[Co(tn)_2Cl_2]^+$.

4. Linkage isomers:

This type of isomerism is found in those complexes in which ligands can coordinate with central metal ion through either of two atoms. Ambi-dentate ligands are involved in linkage isom.

Ex. $[Co(NO_2)(NH_3)_5]^{+2}$

→ $[Co(ONO)(NH_3)_5]^{2+}$ Red.

→ $[Co(NO_2)(NH_3)_5]^{+2}$ Yellow

5. Coordination isomers:

Coordination compounds made up of cationic & anionic coordination spheres show this isomerism due to interchange of cationic & anionic ligands or due to interchange of central atoms.

Ex. $[Co(NH_3)_6][Cr(CN)_6]$
$[Cr(NH_3)_6][Co(CN)_6]$
$[Co(CN)_6][Cr(NH_3)_6]$
} Coordination isomers

$[Cu(NH_3)_4][PtCl_4]$
$[Pt(NH_3)_4][CuCl_4]$

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Some ~~e~~ Such isomers are expected to have significant differences in their physical & chemical properties.

$[Co(NH_3)_6]^{+3}[Cr(NO_2)_6]^{-3}$: 6 possibilities

$[Pt(NH_3)_4]^{+2}[PtCl_4]^{-2}$: 2 possibilities

$[Ni(en)_3]^{+3}[Fe(C_2O_4)_3]^{-3}$: 4 possibilities

→ 6. Polymerisation isomers:

~~They denote~~ This is not true isomerism because it occurs b/w compounds having same empirical formula but different molecular weight. Molecular compositions are simple multiples of simplest stoichiometric ~~coe~~ arrangement.

Ex. $[Pt(NH_3)_2Cl_2]$

↓↑ Dimerises

$[Pt(NH_3)_4][PtCl_4]$

or $[Pt(NH_3)_4][Pt(NH_3)_2Cl_2]_2$

→ 7. Coordination position isomers

This isomerism arises in polynuclear complexes. ~~on interchange of ligands b/w different metal nuclei in polynuclear complex~~

To interchange the ligands b/w metal nuclei which are present as part of complex, is possible.

Ex. $[(NH_3)_4Co\underset{O_2}{\overset{NH_2}{<}}Co(NH_3)_2Cl_2]^{+2}$

&

$[Cl(NH_3)_3Co\underset{O_2}{\overset{NH_2}{<}}Co(NH_3)_3Cl]^{+2}$

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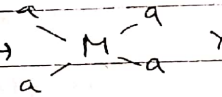
Stereo isomers → G.I
→ O.I

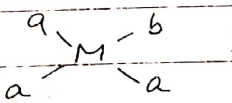
G.I :

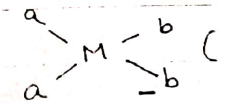
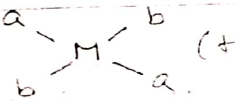
CN = 4 → sp^3 ⇒ tetrahedral ×(no Geometrical iso.)
→ dsp^2 ⇒ square planar ✓ (Geometrical iso.)

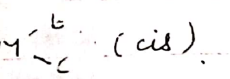
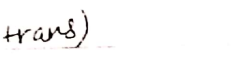
CN = 6 → sp^3d^2 ✓ Octahedral
→ d^2sp^3 ✓

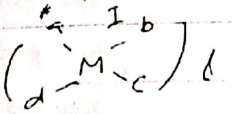
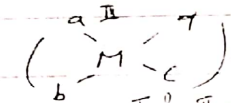
Ex. CN = 4

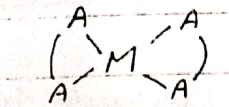
Ma_4 × →  ×

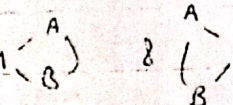
Ma_3b →  ×

Ma_2b_2 →  (cis) &  (trans)

Ma_2bc →  (cis) &  (trans)

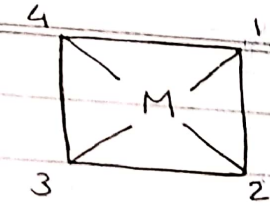
* $Mabcd$ →  & 
I & III are same.

$M(AA)_2$ → ×  but if in (AA) there is a chiral centre, then $M(AA)_2$ shows G.I & optical isom.

$M(AB)_2$ →  (cis) &  (trans)

dsp^2 : $[Ma_4]^{n\pm}$, $[Ma_3b]^{n\pm}$, $[Mab_2]^{n\pm}$ } × , $[M(AA)_2]^{n\pm}$

G.I ✓ : $[Ma_2b_2]^{n\pm}$, $[M(AB)_2]^{n\pm}$, $[Ma_2bc]^{n\pm}$, $[Mabcd]^{n\pm}$,
$[M_2a_2b_4]$ → Bridged binuclear planar complex of square planar complex



(4,3), (1,2) ⇒ Cis

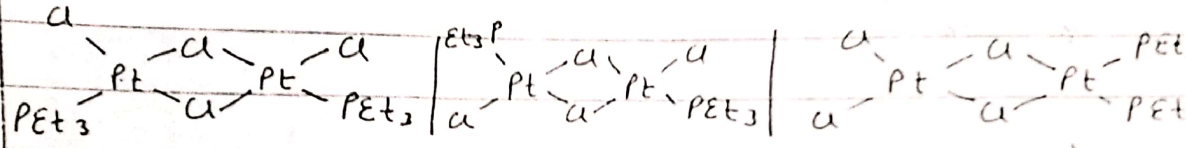
(1,3), (4,2) ⇒ Trans

$[Pt(PEt_3)a_2]^{1}_{2}$ → Total no. of isomers

= 3

Symm. — Unsymm.

Cis + Trans

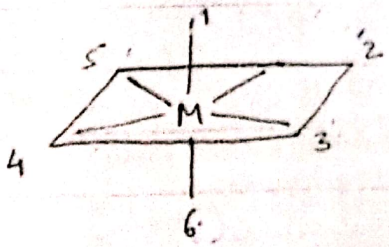


C.N = 6 d^2sp^3 ✓

sp^3d^2 ✓

$[Ma_5b]^{n_1}_{n_2}$ ⊗ no GI

$[Ma_6]^{n_1}_{n_2}$



(1,2)
(1,3)
(1,4)
(1,5)
(6,3)
(6,2)
(6,4)
(6,5)
(2,3)
(3,4)
(5,1)
(5,2)
} 12 positions (cis)

(1,6)
(2,4)
(5,3)
} Trans (3)

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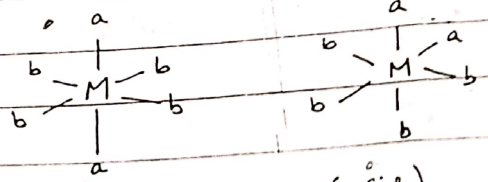
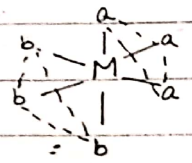
Ma_2b_4 :

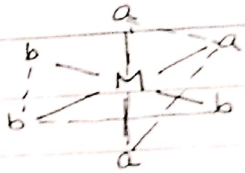


(Trans) (Cis)

★ $[Ma_2b_2]^{n\pm}$ → Cis
→ Trans (optically inactive)

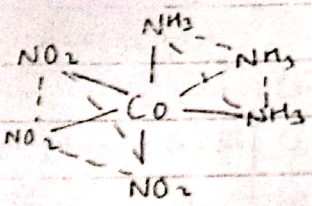


Cis (Facial isomers)
or fac isomers

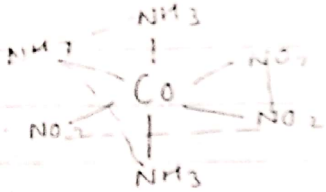


Trans (Meridional isomers
or mer
or peripheral "

Ex. $[Co(NO_2)_3(NH_3)_3]$



(fac)



(mer)

Optical isomers:

Conditions for molecules to show O.I :

1. No plane of symmetry (no symmetry).
2. Molecules should be non-superimposable with its mirror image.

C.N = 4 : sp^3 ✓ ——→ $Mabcd$ ✓ $a \neq b \neq c \neq d$

dsp^2 ✗

$[Ma_4bc]$ ✗

$[Ma_2bc]$ ✗

$[Ma_3c]$ ✗

C.N = 6 : d^2sp^3 ✓

sp^3d^2 ✓

Stereoisomerism in Octahedratral Complexes

Types of complex	Geometrical Isomers (Cis + Trans)	Optical Isomers (O.A. + O.Inactive)	Total S.I.
$[Ma_4b_2]^{n\pm}$	2(1Cis + 1Trans)	No Optical Isomers	2
$[Ma_4bc]^{n\pm}$	2(1Cis + 1Trans)	No Optical Isomers	2
$[Ma_3b_3]^{n\pm}$	2(1Cis + 1Trans)	No Optical Isomers	2
$[Ma_3b_2c]^{n\pm}$	3(1Cis + 2Trans)	No Optical Isomers	3
$[Ma_3bcd]^{n\pm}$	4(1Cis + 3Trans)	5(2 + 3)	5
$[Ma_2b_2c_2]^{n\pm}$	5(1Cis + 4Trans)	6(2 + 4)	6
$[Ma_2b_2cd]^{n\pm}$	6(2Cis + 4Trans)	8(4 + 4)	8
$[Ma_2bcde]^{n\pm}$	9(6Cis + 3Trans)	15(12 + 3)	15
$[Mabcdef]^{n\pm}$	15(Cis & trans not defined)	30(30 + 0)	30

Types of complex	Geometrical Isomers (Cis + Trans)	Optical Isomers (O.A. + O.Inactive)	Total S.I.
$[M(AA)_3]^{n\pm}$	No Geometrical Isomers	2(2 + 0)	2
$[M(AA)_2b_2]^{n\pm}$	2(1Cis + 1Trans)	3(2 + 1)	3
$[M(AA)_2bc]^{n\pm}$	2(1Cis + 1Trans)	3(2 + 1)	3
$[M(AA)b_2c_2]^{n\pm}$	3(1Cis + 2Trans)	4(2 + 2)	4
$[M(AA)b_3c]^{n\pm}$	2(1Cis + 1trans)	No Optical Isomers	2
$[M(AA)b_2cd]^{n\pm}$	4(2Cis + 2Trans)	6(4 + 2)	6
$[M(AA)bcde]^{n\pm}$	6(Cis & trans not defined)	12(12 + 0)	12

Types of complex	Geometrical Isomers (Cis + Trans)	Optical Isomers (O.A. + O.Inactive)	Total S.I.
$[M(AB)_3]^{n\pm}$	2(1Cis + 1Trans)	4(4 + 0)	4
$[M(AB)_2c_2]^{n\pm}$	5(1Cis + 4Trans)	8(6 + 2)	8
$[M(AB)_2cd]^{n\pm}$	6(2Cis + 4Trans)	11(10 + 1)	11
$[M(AB)c_2d_2]^{n\pm}$	4(2Cis + 2Trans)	6(4 + 2)	6
$[M(AB)c_2d]^{n\pm}$	3(1Cis + 2Trans)	4(2 + 2)	4
$[M(AB)c_2de]^{n\pm}$	7(4Cis + 3Trans)	12(10 + 2)	12
$[M(AB)cdef]^{n\pm}$	12(Cis & trans not defined)	24(24 + 0)	24