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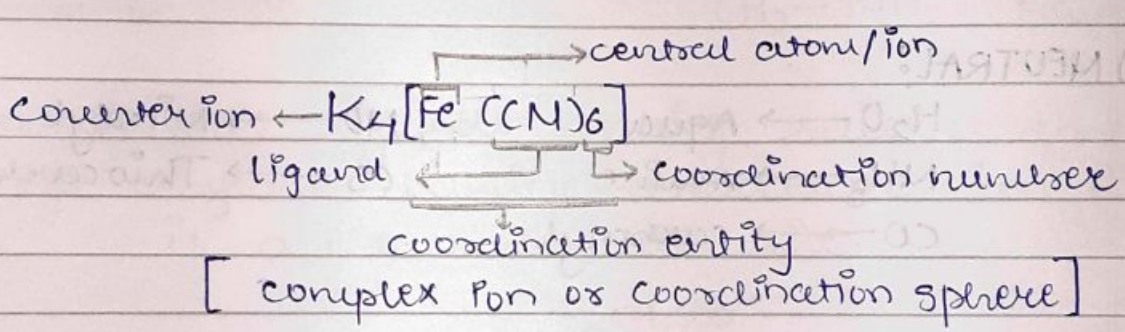
CO-ORDINATION COMPOUND

co-ordination compound

* Double Salts:

- addition molecular compounds which are stable in solid state but dissociate into constituent ions in their sol.

eg: Mohr's salt $[FeSO_4 . (NH_4)_2SO_4 . 6H_2O]$ dissociates into Fe^{+2}, NH_4^+ and SO_4^{2-} ions; Potash alum $[K_2SO_4 . Al_2(SO_4)_3 . 24H_2O]$



* Coordination Compounds:

- compounds having complex ions like $[Co(NH_3)_6]$; $[Fe(CN)_6]^{-4}$; etc
- these compounds contain central metal atom or cation which is attached with fixed number of anions or molecules (ligands) through coordinate bond.

* Coordination entity:

- constitutes of central metal atom or ion bonded to a fixed number of ions or molecules.

eg: $K_4[Fe(CN)_6]$; $[Fe(CN)_6]^{-4}$ represent complex ion.

* Central atom or ion:

- atom or ion to which fixed number of ions or molecule are bound in definite geometrical arrangement. It is also referred as ~~defin~~ Lewis Acid.

eg: $K_4[Fe(CN)_6]$; Fe is a central atom.
(They're generally transition / inner-transition elements)

* **Ligands:**
- molecule, ion or groups, bonded to metal atom or ion in complex or coordination compound by coordinate or dative bond.

→ * **Classification:**
(A) Basis of charge

I.) **NEUTRAL:**

H_2O ⟶ Aqua
NH_3 ⟶ Amine
CO ⟶ carbonyl
NO ⟶ Nitrosyl
CS ⟶ Thiocarbonyl

II.) **CATIONIC:**

NO_2^+ ⟶ Nitronium
$H_2NNH_3^+$ ⟶ Hydrazinium
NO^+ ⟶ Nitrosonium

III.) **ANIONIC:**

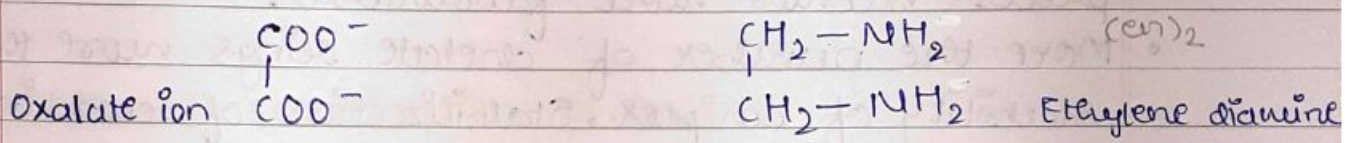
F^- ⟶ Fluorido (fluoro)
I^- ⟶ Iodido (iodo)
Cl^- ⟶ Chloride (chloro)
OH^- ⟶ Hydroxo
O_2^{2-} ⟶ Peroxo
O_2^- ⟶ Superoxo
CH_3COO^- ⟶ Acetato
CO_3^{2-} ⟶ Carbonato
SO_4^{2-} ⟶ Sulphato
SO_3^{2-} ⟶ Sulphito
NH_2^- ⟶ Amido
SCN ⟶ Thiocyano-S
NCS ⟶ Isothiocyano-N

donor sidenai.

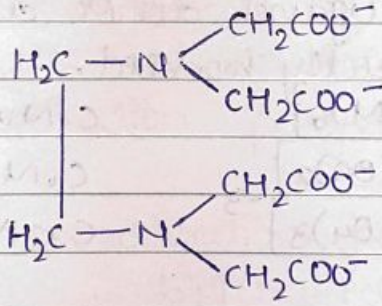
(B) Basis of No. of Donor site.

i.) **UNIDENTATE:** ligands having one donor site so, that bound to metal ion through single donor site.
eg: H_2O ; NH_3; etc.

ii.) **BIDENTATE:** ligands having two donor sites.
eg: oxalate ion ; ethylene diamine (en); etc.

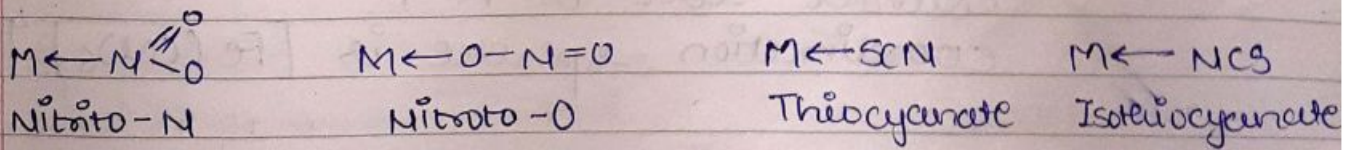


iii.) **POLYDENTATE:** ligands having several donor sites
eg: ethylene diamine tetraacetate ion $[EDTA]^{-4}$ is a hexadentate site.



(C) Basis of Bonding.

i.) **AMBIDENTATE:** ligands which have two donor sites but only one can form coordinate bond with the central atom/ion at a time.
eg: NO_2^- ; SCN^-; etc.



strongest ligand

II) CHELATING: when bidentate or polydentate ligand uses its two or more donor atoms to bind a single metal ion, then a ring like structure is obtained. It is called chelate and ligand is known as chelating ligands.

- Chelating ligands form more stable complexes than the unidentate ligands this is because when chelation occurs entropy increases and the process becomes more favourable.
- More the number of chelate rings more the stability of complex. Stabilization of coordination compound due to chelation is known as chelating effect.

* Coordination Number:

- number of ligand donor atoms to which the metal is directly bonded.

eg: $K_4[Fe(CN)_6]$ — C.Number = 06.

$K_2[Co(en)_2]$ — C.Number = 04.

en = ethylene diamine, i.e., 2 carbons

$[Fe(C_2O_4)_3]^{-3}$ — C.Number = 06.

* Coordination Sphere & Counter Ion:

- central atom / ion and the ligands attached to it are enclosed in square bracket and is collectively termed as coordination sphere.
- the ionisable groups are written outside the bracket are counter ion (or spectator ion).

eg: in $K_4[Fe(CN_6]$:

counter ion is K^+;

coordination sphere is $[Fe(CN)_6]^{-4}$.

⟶* Types of coordination Sphere: 03 types.

I.) Anionic coordination Sphere:

eg: $K_4[Fe(CN)_6]$ - where : $4K^+ + [Fe(CN)_6]^{-4}$

II.) Cationic coordination Sphere:

eg: $[Co(NH_3)_4]Cl_2$ where : $[Co(NH_3)_4]^{+2} + 2Cl^-$

III.) Neutral coordination sphere:

eg: $[M(\ddot{C}\ddot{O})_4]$ Metal carbonyl [have lone pair but no chg]

* Coordination Polyhedron:

- The Spatial arrangement of ligand atoms which are directly attached to the central atom/ion defines a coordination polyhedron about the central atom.
- Most common coordination polyhedrons are:
  - ↳ a) octahedral b) Tetrahedral c) Square planer

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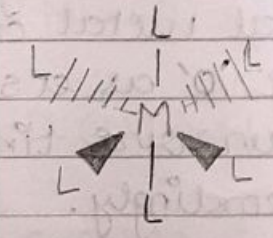
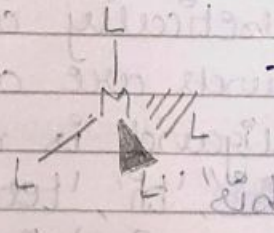
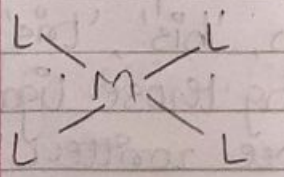


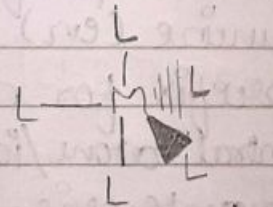
octahedral



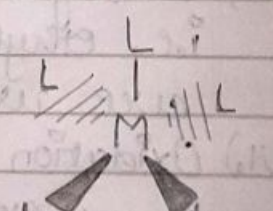
Tetrahedral



Sq. planer



Trigonal pyramidal



Square pyramidal.

* Types of Coordination Compounds: or complexes

a) Homoleptic
b) Heteroleptic

1.) Homoleptic complex:
- complexes in which central atoms or ions is linked to only one kind of donor atoms.

eg: $K_4[Fe(CN)_6]$; $[Co(NH_3)_4]Cl_2$

2.) Heteroleptic complex:
- complexes in which central atom or ion is linked to more than one kind of donor atoms.

eg: $[Co(NH_3)_4Cl_2]Cl_2$

* Nomenclature:

⟹ 1.) Naming of MONONUCLEAR coordination compounds:

- **Rules:**

I.) Write down the name of cation and then anion.
II.) While naming complex part, first name ligands alphabetically and then central metal atom/ion.
III.) If ligands are anionic then use 'o' as a suffix.
IV.) If a ligand is used more than one time then use 'bi', 'tri', 'tetra' as prefix accordingly.
V.) In ligand, if 'di or tri' prefixes are present already i.e. ethylene diamine (en) then, 'bis', 'tris', 'tetraki' are used as prefix for naming those ligands.
VI.) Oxidation No. of central atom/ion are written in ROMAN numbers. in parenthesis.
VII.) If coordination sphere is negative then use 'ate' suffix after the [Greek] name of central atom/ion.

cyano = cyanato.

$C_2O_4^{2-}$ classmate

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eg: Ni = Nickelate — Cu = Cuprate
Fe = Ferrate — Ag = Argentate
Co = cobaltate — Pb = Plumbate
Au = Aurate — Hg = Mercurate

eg:

Ref: 1) $K_4[Fe(CN)_6]$: Potassium hexacyanoferrate (II)

2) $K_2[Zn(OH)_2]$: Potassium dihydroxozincate

3) $[Co\,Cl_2(en)_2]^+$: Dichloro bis(ethylene diamine) cobalt (III) ion.

4) $[Co(NH_3)_6]Cl_3$: Hexaammine cobalt (III) chloride

5) $[Cr(NH_3)_4Cl_2]Cl$: Tetraammine dichloro chromium (III) chloride

6) $[Fe(H_2O)_5NO]SO_4$: Pentaaquanitrosonium iron (I) sulphate

7) $Hg[Co(SCN)_4]$: Mercury tetrathiocyano-S cobaltate (III)

8) $K_3[Al(C_2O_4)_3]$: Potassium trioxalatoaluminate (III)

9) $[Ni(CO)_4]$: Tetracarbonylnickle.

10) $[Pt(NH_3)_2Cl(NO_2)]$: Diammine chloronitro-N platinum (II)

11) $[Co(NH_3)_5(CO_3)]Cl$: Pentaammine carbonatocobalt (III) chloride

12) $[Co(NH_3)_4(H_2O)Cl]Cl_2$: Tetraammine aquachloro cobalt (III) chloride

13) $K_3[Cr(C_2O_4)_3]$: Potassium trioxalatochromate (III)

14)

* NOTE:
- $H[AuCl_4]$: Tetrachloroauric (III) acid.
  if H or H_2 as cation then acid.
- $H_2[PtCl_6]$: Hexachloroplatinic (IV) acid.

⟹ 2.) Naming of DOUBLE complex sphere compounds:

imp ∘ Most common oxidation state of some metals:

Cobalt (Co): +2, +3	Platinum (Pt): +2, +4
Copper (Cu): +1, +2	Nickel (Ni): +2, +4
Silver (Ag): +1, +2	Palladium (Pd): +2, +4
Chromium (Cr): +3	Tin (Sn): +2, +4
Gold (Au): +1, +3	Iron (Fe): +2, +3

Eg: • $[Ag(NH_3)_2][Ag(CN)_2]$: $x+y=2$
↳ diammine silver (I) dicyanoargenate (I)

Ref: 1.) $[Pt(NH_3)_4Cl_2][PtCl_4]$: $x+y=6$
↳ tetraammine dichloro platinum (IV) tetrachloroplatinate (II)
as $+4-2=+2$ (true bana) as $+2-4=-2$ (true ba

2.) $[Ag(NH_3)_4][AuCl_4]$: $x+y=4$
↳ tetraammine silver (I) tetrachloroaurate (III)

3.) $[Ag(NH_3)_2][Ag(CN)_2]$: $x+y$
↳

4.)
↳