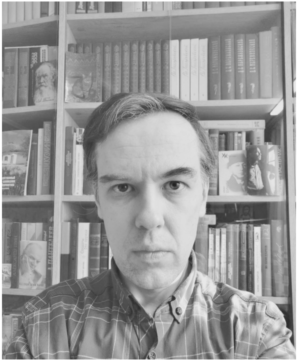
General and Inorganic Chemistry Department,
National Technical University “Kharkiv Polytechnic Institute”

INTRODUCTION TO COORDINATION COMPOUNDS



Responsible Lecturer:
Andrey V. Kramarenko

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`avkramar@gmail.com`

Kharkiv 2026

BASIC DEFINITIONS

- The COORDINATION COMPOUNDS contain complex particles
- The complex particle general formula is as follows:

$$\left[\mathrm{Me}_x^{n+}\mathrm{L}_y^{m-}\right]^{nx-my}, \text{where}$$

  - Me^{n+} is the CENTRAL ION of metal having **unoccupied orbitals**;
    L^{m-} is the , the molecule or ion having **lone electron pair**.
- Hence, the coordination bond is a **dative** bond

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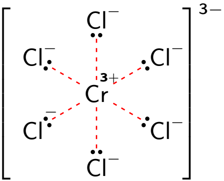
- The complex particle general formula is as follows:

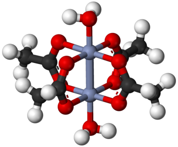
$$\left[\mathrm{Me}_x^{n+}\mathrm{L}_y^{m-}\right]^{nx-my}\text{, where}$$

  - Me^{n+} is the central ion of metal having **unoccupied orbitals**;
  - L^{m-} is the ligand, the molecule or ion having **lone electron pair**.
- Hence, the coordination bond is a **dative** bond



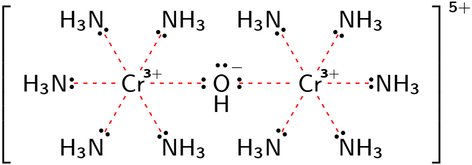
mononuclear

hexachloridochromate (III)



dinuclear cluster

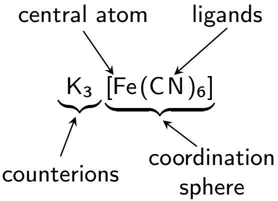
chromium (II) acetate



dinuclear bridged

μ-hydroxo-bis(pentaammine)chromium (III)

Coordination compounds main components



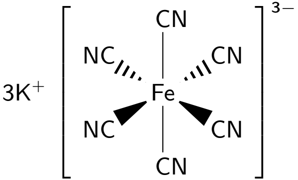
$$\underbrace{K_3}\underbrace{[Fe(CN)_6]}$$

central atom

ligands

counterions

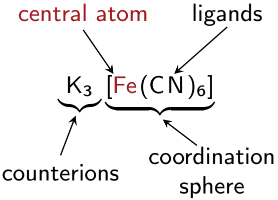
coordination sphere



Potassium hexacyanoferrate (III)

COORDINATION COMPOUNDS MAIN COMPONENTS

The central atom is a coordination center



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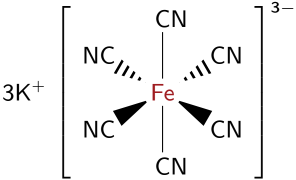

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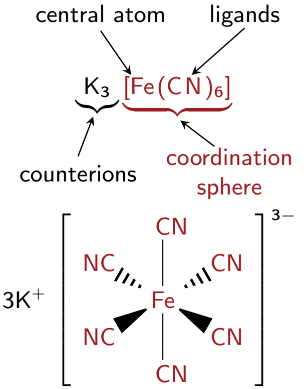

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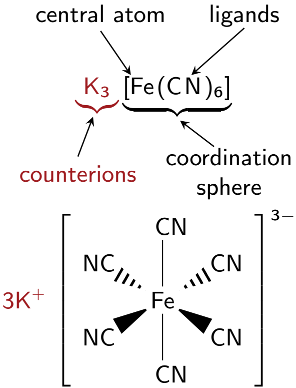

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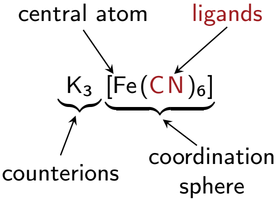

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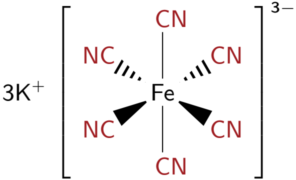

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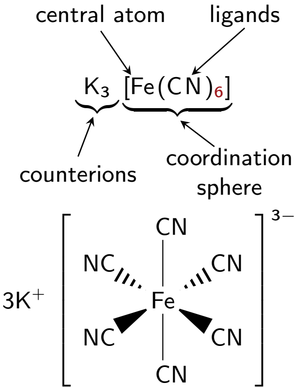

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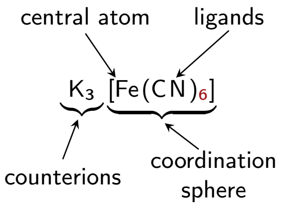

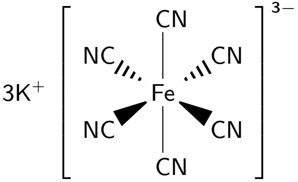

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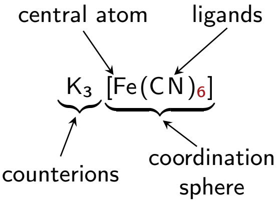

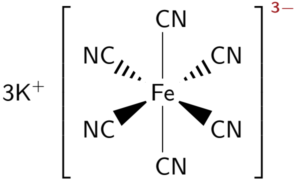

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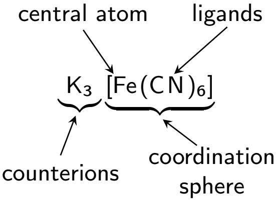

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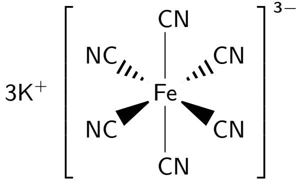

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monodentate ligands:
$:\!\ddot{\underset{\cdot\cdot}{Cl}}\!:^-$, $\ddot{N}H_3$, $H_2\ddot{\underset{\cdot\cdot}{O}}$, $O\ddot{N}O^-$, $\ddot{C}\equiv N^-$, $\ddot{S}CN^-$, etc
only one atom can coordinate the central ion;

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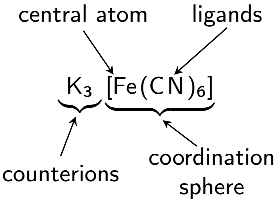

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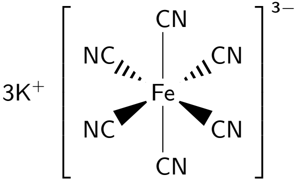

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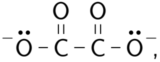

${}^{-}\ddot{O}-\overset{\overset{O}{\|}}{C}-\overset{\overset{O}{\|}}{C}-\ddot{O}{}^{-}$, $H_2\ddot{N}-CH_2-CH_2-\ddot{N}H_2$ etc
more than one atom coordinates the central ion

Coordination compounds nomenclature

- A cation must be called first then anion
  - $[Ni(NH_3)_6]Cl_2$ – hexaamminenickel (II) chloride
  - $K_2[Ni(CN)_4]$ – potassium tetracyanonickelate (II)
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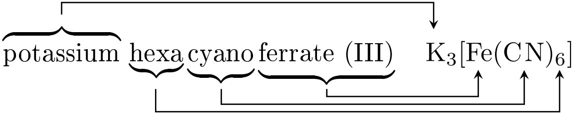

$\overbrace{\text{potassium}}\ \underbrace{\text{hexa}}\,\underbrace{\text{cyano}}\,\underbrace{\text{ferrate (III)}}$ $K_3[Fe(CN)_6]$

CLASSIFICATION OF COORDINATION COMPOUNDS

- By class: acid, base or salt
  $H[AuCl_4]$, $[Ag(NH_3)_2]OH$, $[Cr(H_2O)_6]Cl_3$
- By the nature of ligand:
  - aquacomplexes ($[Cu(H_2O)_4]^{2+}$)
  - ammincomplexes ($[Ag(NH_3)_2]^{+}$)
  - hydroxocomplexes ($[Al(OH)_6]^{3-}$)
- By charge: cation, anion, neutral
  $[Co(NH_3)_6]Cl_3$, $Li[AlH_4]$, $[Co(NH_3)_3Cl_3]$
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  $[Co(NH_3)_6]Cl_3$, $Li[AlH_4]$, $[Co(NH_3)_3Cl_3]$
- By central atoms number: mononuclear, polynuclear (bridged or cluster complexes)

Classification of coordination compounds

- By class: acid, base or salt
  $H[AuCl_4]$, $[Ag(NH_3)_2]OH$, $[Cr(H_2O)_6]Cl_3$
- By the nature of ligand:
  - aquacomplexes ($[Cu(H_2O)_4]^{2+}$)
  - ammincomplexes ($[Ag(NH_3)_2]^{+}$)
  - hydroxocomplexes ($[Al(OH)_6]^{3-}$)
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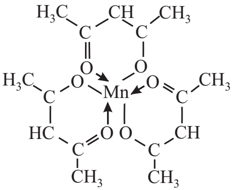

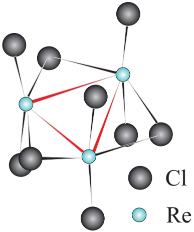

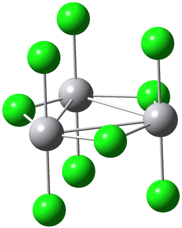

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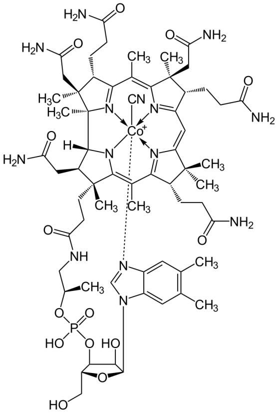
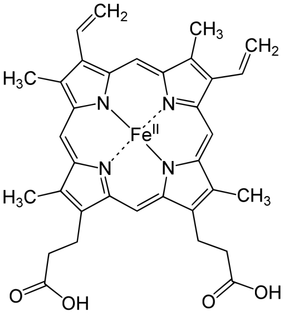
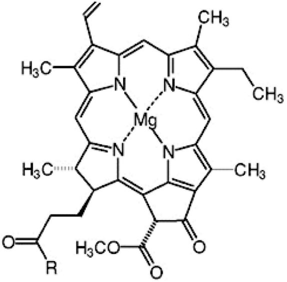
FAMOUS COMPLEXES



Cyanocobalamin (B12)



Hemoglobine heme



Chlorophyll

TASK EXAMPLE

- *Does the* CdS *precipitate will form, if some volume of 0.1 solution of* Na_2S *will be added to the equal volume of 0.1* $K_2[Cd(CN)_4]$ *solution?*
- Condition of sedimentation: $c(Cd^{2+})c(S^{2-}) > K_S(CdS) = 8{\cdot}10^{-27}$
- It's easy to determine $c(S^{2-})$ from $Na_2S \rightarrow 2Na^+ + S^{2-}$
  $c(S^{2-}) = 1/2\ c_{st}(Na_2S) = 0.05$ (because of mixing dilution)
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	$[Cd(CN)_4]^{2-}$	Cd^{2+}	CN^-
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c_{rctd}	x	–	–
c_{frmd}	–	x	$4x$
c_{eq}	$0.05 - x$	x	$4x$

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