# The Coordination Bond

**Definition:**

***The donation of an electron pair from a ligand to a metal***


**- a Lewis acid/base reaction where a Lewis base (electron donor, ligand) "donates" a pair of electrons to a Lewis acid (electron acceptor, metal)**

# Ligands

**A LIGAND is a neutral molecule or an ion having a lone pair of electrons that can be used to form a bond with a metal ion.**

***Unidentate (Monodentate) ligand*** **– forms ONE bond**

***Bidentate ligand*** **– can form TWO bonds**

***Polydentate ligand*** **– can form MORE THAN TWO bonds**

- **tridentate**
- **tetradentate**
- **pentadentate**
- **hexadentate**
- **...**

} ***CHELATE LIGANDS***

# The Chelate Effect

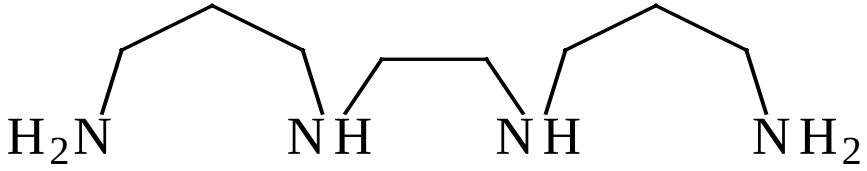
**Complexes of bidentate and polydentate ligands are more stable than those with unidentate ligands of similar strength**

$$Ni^{2+} + 6NH_3 \rightleftharpoons [Ni(NH_3)_6]^{2+} \qquad \log \beta = 8.61$$

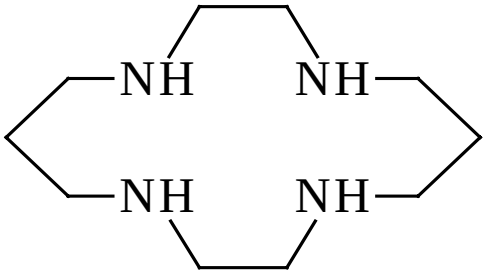
$$Ni^{2+} + 3en \rightleftharpoons [Ni(en)_3]^{2+} \qquad \log \beta = 18.28$$

# The Macrocycle Effect

**Complexes of macrocyclic ligands are more stable than those with polydentate ligands of similar strength**




1,4,8,11-tetradecanetetraamine (tdta)




1,4,8,11-cyclotetraazatetradecane (cyclam)

$[Zn(H_2O)_6]^{2+}$ + tdta $\rightleftharpoons$ $[Zn(tdta)]^{2+} + 6H_2O$ $\log \beta = 11.2$

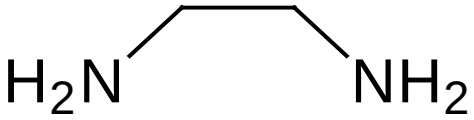
$[Zn(H_2O)_6]^{2+}$ + cyclam $\rightleftharpoons$ $[Ni(cyclam)]^{2+} + 6H_2O$ $\log \beta = 15.3$

# Some Common Ligands

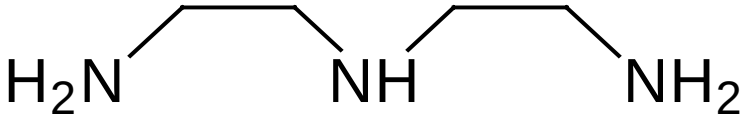
***Amines***

$NH_3$

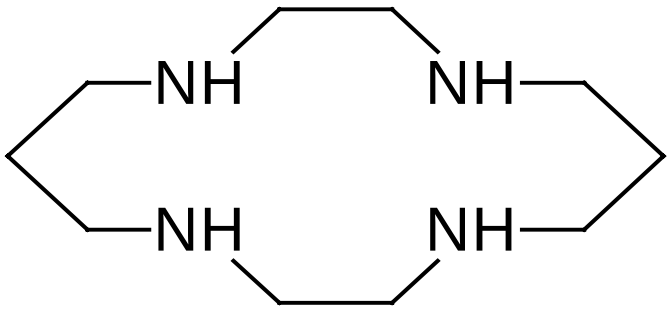
ammonia




ethane-1,2-diamine (en)
(or ethylendiamine)



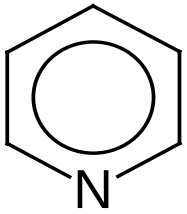

diethylenetriamine (dien)



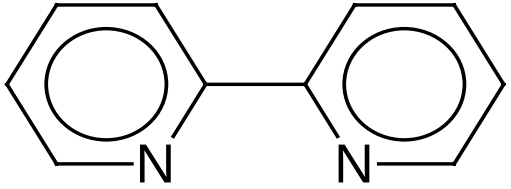

1,4,8,11-cyclotetraazatetradecane (cyclam)

# Common Ligands cont'd

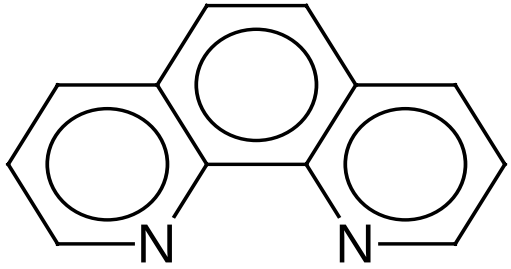
***Aromatic Amines***



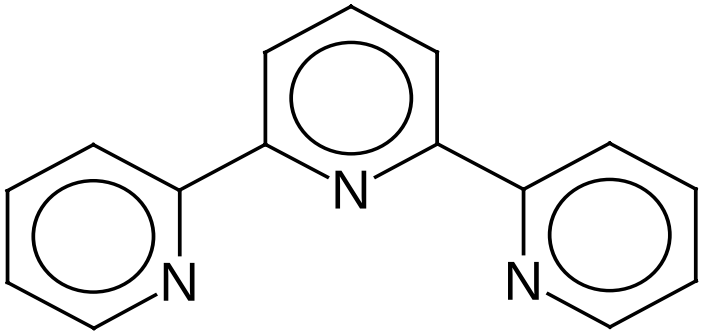

pyridine




2,2'-bipyridine (bipy)

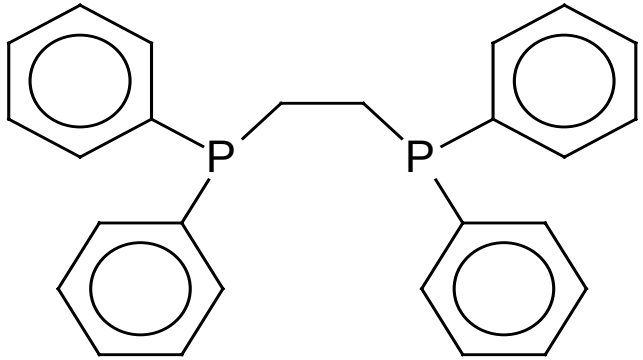



1,10-phenanthroline (phen)

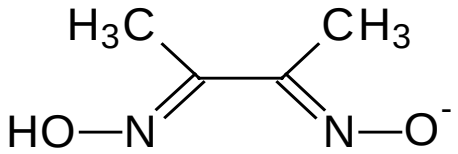



terpyridine (terpy)

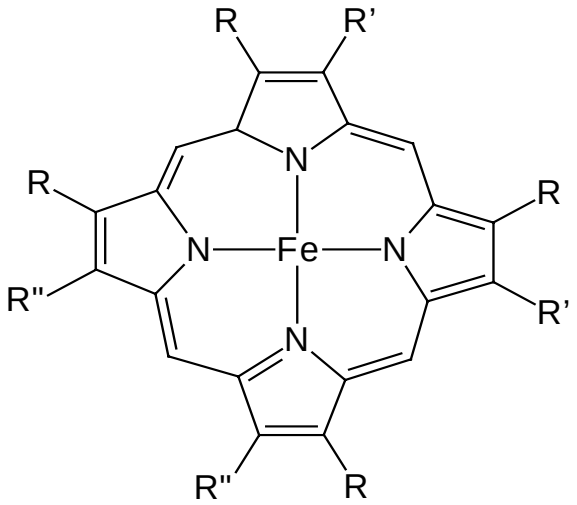
# Common Ligands cont’d




1,2-bis(diphenylphosphino)ethane (dppe)

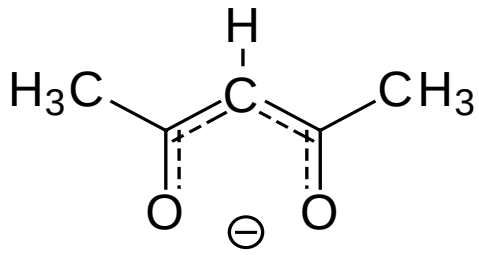



2,3-butanedioximato(1-) (dmgH)

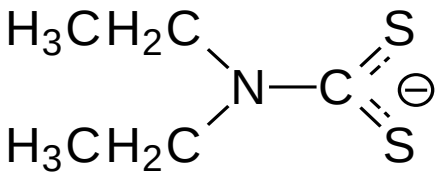



heme

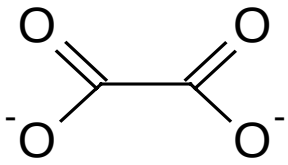
# Common Ligands cont'd



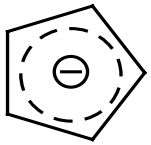

2,4-pentanedionato(1-) (acac)
(or acetylacetonato)



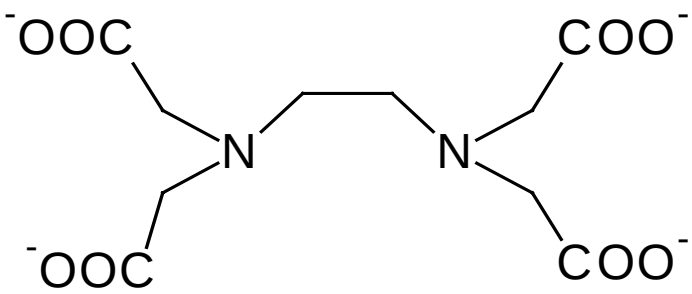

diethyldithiocarbamate(1-) (Et $_2$dtc)




oxalato(2-) (ox)



cyclopentadienyl (cp)




ethylenediaminetetraacetato(4-) (edta)

# Naming Transition Metal Complexes

**(See also Section 3 of the Chemistry 1 Problem Book)**

## *Naming Ligands:*

**The normal chemical name is used unless the ligand is negatively charged in which cases "o" is used as the suffix.**

| Name | Formula | |
|---|---|---|
| **A. Neutral** | | |
| Aqua | $H_2O$ | } Special Cases |
| Ammine | $NH_3$ | |
| Carbonyl | CO | |
| Nitrosyl | NO | |
| **B. Anionic** | | |
| Fluoro | $F^-$ | |
| Chloro | $Cl^-$ | |
| Bromo | $Br^-$ | |
| Iodo | $I^-$ | |
| Hydroxo | $OH^-$ | |
| Cyano | $CN^-$ | |

# Naming Transition Metal Complexes cont'd

## *Naming Metal Ions:*

**(a) If the complex is neutral or positively charged the normal metal name is used.**

**(b) If the complex is negatively charged, 'ate' is added to the metal name.**

e.g. Co cobaltate, Zn zincate, etc.

**Special cases:**

| Metal | Name in Anion |
|---|---|
| Iron | Ferrate |
| Copper | Cuprate |
| Lead | Plumbate |
| Silver | Argentate |
| Gold | Aurate |
| Tin | Stannate |

**Special special cases:**

| | |
|---|---|
| **Hg** | **Mercurate (not hydragyrate)** |
| **Sb** | **Antimonate (not stibnate)** |

# Naming Transition Metal Complexes cont'd

## *Specifying the number of ligands:*

**The number of ligands of any one type is indicated with the appropriate Greek prefix;**

di, tri, tetra, penta, hexa, etc.

**If the ligand is bidentate or polydentate the prefix becomes**

bis, tris, tetrakis, etc. *(i.e. bis(ethylenediamine)* not *di(ethylenediamine)*

## *Ordering the names:*

**Ligands are named first and are listed in alphabetical order *(Note: prefixes do not affect the order).***

## *Specifying the oxidation state:*

**The oxidation state of the metal is indicated by roman numerals.**

e.g. $Fe^{3+}$ is given as iron(III) or ferrate(III)

# Naming Transition Metal Complexes cont'd

## *Naming complex salts:*

**If cations or anions are present they are named as separate words and are *not* numbered. (There are no differences to the rules for naming simple salts.)**

e.g. $K_3[Fe(CN)_6]$

potassium hexacyanoferrate(III)

$[Fe(en)_2(NO_2)_2]_2SO_4$

bis(ethylenediamine)dinitroiron(III) sulfate

## *Indicating the presence of solvent molecules:*

**Water of crystallisation (hydration) is indicated separately at the end of the name.**

e.g. $[Co(NH_3)_4Cl_2]Cl \cdot 2H_2O$

tetraamminedichlorocobalt(III) chloride-2-water

# Naming Transition Metal Complexes cont'd

***Naming complexes with bridging ligands:***

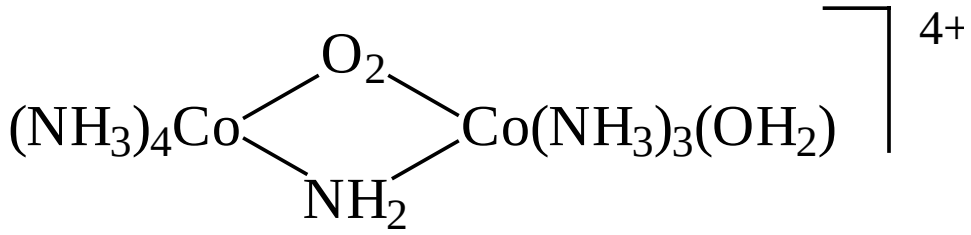
**Bridging ligands are indicated by use of the symbol "μ" in the name. If the complex is symmetric the bridging ligand is named first:**

e.g. $[(NH_3)_5CoO_2Co(NH_3)_5]^{4+}$

μ -peroxobis[pentaamminecobalt(III)] ion

**If the complex is unsymmetric then the bridging ligand(s) name appears in the middle of the complex name.**

e.g.




tetraamminecobalt(III)-μ-amido-μ-superoxotriammineaquacobalt(III) ion