Nomenclature of Coordination Complexes

(Self quiz after overview) *Overview:* Ligands = attached atoms or molecules

Anion Name	*Ligand Name*
Bromide, Br^-	Bromo
Carbonate, CO_3^{2-}	Carbonato
Chloride, Cl^-	Chloro
Cyanide, CN^-	Cyano
Fluoride, F^-	Fluoro
Hydroxide, OH^-	Hydroxo
Oxalate, $C_2O_4^{2-}$	Oxalato
EDTA	Ethylenediamine tetracetato

Neutral Ligand	*Ligand Name*
Ammonia, NH3	Ammine
Water, H2O	Aqua
Carbon Monoxide, CO	Carbonyl
Ethylenediamine, en	Ethylenediamine

Metal	*Anion Name*
Aluminum	Aluminate
Chromium	Chromate
Cobalt	Cobaltate
Copper	Cuprate
Gold	Aurate
Iron	Ferrate
Manganese	Manganate
Nickel	Nickelate
Platinum	Platinate
Zinc	Zincate

If more than one ligand is attached then,

2 = di
3 = tri
4 = tetra
5 = penta
6 = hexa

If the ligand has di, tri, tetra, in its name or is a dentate molecule, and you want to indicate you have more than one of them then use,

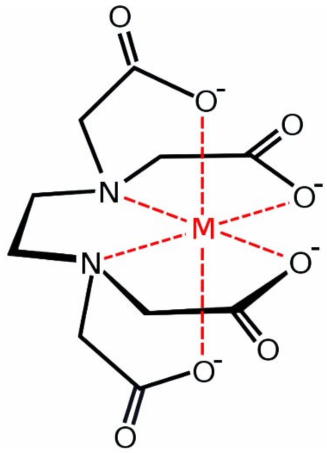
2 = bis
3= tris
4 = tetrakis

The Dentates

Bidentates – two bites
- Oxalate (ox)
- Ethylenediamine (en)
- Malate (mal)

Tridentate – three bites
- Citrate (cit)

Hexadentate – six bites
- EDTA



EDTA wrapped around a metal ion.

How to name complex ions that are positively charged.

The name of the transition metal comes at the end of the name along with a Roman numeral indicating its charge,

Ex:
- $Co(NH_3)_6^{3+}$ = hexamminecobalt(III)
- $Fe(H_2O)_6^{2+}$ = hexaquairon(II)
- $Ni(en)_2^{2+}$ = bis(ethylenediamine)nickel(II)
- $Cu(CO)_4^{2+}$ = tetracarbonylcopper(II)

Now, every compound has both a positive part and a negative part, like NaCl is really Na^+ and Cl^-. The same is true for complex ions only the positive and negative parts can be really large and complex (which is why they are called complex ions).

In the above examples I gave several positive ions and their name, but each of them also has a negative part that goes with them. Consider the following compounds,

Ex:
- $Co(NH_3)_6Cl_3$ = hexamminecobalt(III) chloride
- $Fe(H_2O)_6(OH)_2$ = hexaquairon(II) hydroxide
- $Ni(en)_2SO_4$ = bis(ethylenediamine)nickel(II) sulfate
- $Cu(CO)_4CO_3$ = tetracarbonylcopper(II) carbonate

In each case an anion has been added to the complex ion. This completes the structure and produces an overall neutral compound that could be stored in a bottle in our storeroom. You will notice that the nomenclature has not changed much from what we learned about transition metal nomenclature, you name the metal ion, indicate its charge with a Roman Numeral, and then add the anion onto the end. Only in this case the positive ion is large and complex but the nomenclature is the same.

How to name complex ions that are negatively charged

A large number of complex ions are negatively charged. This is caused by having several negatively charged ligands attached to the metal. Consider the following compounds,

Ex: $CoCl_6^{3-}$ = Co^{3+} with 6 Cl^-
$Fe(CN)_6^{3-}$ = Fe^{3+} with 6 CN^-
$Cr(OH)_4^-$ = Cr^{3+} with 4 OH^-
$RhBr_4^{2-}$ = Rh^{2+} with 4 Br^-

When a complex is negative the name of the metal changes. Generally we use its actual name (iron becomes ferrium) and we add an –ate at the end of its name. So $Fe(CN)_6^{3-}$ becomes hexacyanoferrate(III). Therefore, from the example given above we get the following names;

Ex: $CoCl_6^{3-}$ = hexachlorocobaltate(III)
$Fe(CN)_6^{3-}$ = hexacyanoferrate(III)
$Cr(OH)_4^-$ = tetrahydroxochromate(III)
$RhBr_4^{2-}$ = tetrabromorhodate(II)

Of course, once again, negative ions are never found without a corresponding positive ion. So the compounds above would actually look something like this,

Ex: Na_3CoCl_6 = Sodium Hexachlorocobaltate(III)
$K_3Fe(CN)_6$ = Potassium Hexacyanoferrate(III)
$LiCr(OH)_4$ = Lithium Tetrahydroxochromate(III)
$CaRhBr_4$ = Calcium Tetrabromorhodate(II)

Problems

1) Name the following compounds,

$Cu(OH)_4^{2-}$

Na_3AuCl_4

$Mo(CN)_6^{4-}$

$Fe(CO)_6ScCl_6$

$[Cr(NH_3)_3(H_2O)_3]Cl_3$

$[Pt(NH_3)_5Cl]Br_3$

$[Pt(en)_2Cl_2]Cl_2$

$[Co(en)_3]_2(SO_4)_3$

$K_4[Fe(CN)_6]$

$Na_2[NiCl_4]$

$Pt(NH_3)_2Cl_4$

$(NH_4)_2[Ni(C_2O_4)_2(H_2O)_2]$

$[Ag(NH_3)_2][Ag(CN)_2]$

$[CoBr(NH_3)_5]SO_4$

$[Fe(NH_3)_6][Cr(CN)_6]$

$[Co(SO_4)(NH_3)_5]^+$

$[Fe(OH)(H_2O)_5]^{2+}$

2) Write the formula of the following coordination compounds.

hexaammineiron(III) nitrate

ammonium tetrachlorocuprate(II)

sodium monochloropentacyanoferrate(III)

potassium hexafluorocobaltate(III)

3) Give the number of d electrons for each of the complexes listed below. Are the complexes paramagnetic or diamagnetic?

	# d electrons	Paramagnetic or Diamagnetic
$Pd(NH_3)_2Cl$		
$Ru(CO)_6^{3+}$		
$Ni(H_2O)_6^{2+}$		
$HgCl_4^{2-}$		

Answer Key

1) Name the following compounds,

$Cu(OH)_4^{2-}$	tetrahydoxocuprate(II)
Na_3AuCl_4	Sodium tetrachloroaurate(I)
$Mo(CN)_6^{4-}$	hexacyanomolybdenate(II)
$Fe(CO)_6ScCl_6$	hexacarbonyliron(III) hexachloroscanadate(III)
$[Cr(NH_3)_3(H_2O)_3]Cl_3$	triamminotriaquachromium(III) chloride
$[Pt(NH_3)_5Cl]Br_3$	pentaamminochloroplatinum(IV) bromide
$[Pt(en)_2Cl_2]Cl_2$	dichlorobis(ethylenediamine)platinum(II) chloride
$[Co(en)_3]_2(SO_4)_3$	tris(ethylenediamine)cobalt(III) sulfate
$K_4[Fe(CN)_6]$	Potassium hexacyanoferrate(II)
$Na_2[NiCl_4]$	Sodium tetrachloronickelate(II)
$Pt(NH_3)_2Cl_4$	diamminoplatinum(IV) chloride
$(NH_4)_2[Ni(C_2O_4)_2(H_2O)_2]$	Ammonium diaquabis(oxalate)nickelate(II)
$[Ag(NH_3)_2][Ag(CN)_2]$	diamminosilver(I) dicyanoargentate(I)
$[CoBr(NH_3)_5]SO_4$	pentamminobromocobalt(III) sulfate
$[Fe(NH_3)_6][Cr(CN)_6]$	hexamminoiron(III) hexacyanochromate(III)
$[Co(SO_4)(NH_3)_5]^+$	pentamminosulfatocobalt(III)
$[Fe(OH)(H_2O)_5]^{2+}$	pentaaquahydroxoiron(III)

2) Write the formula of the following coordination compounds.

hexaammineiron(III) nitrate	$Fe(NH_3)_6(NO_3)_3$
ammonium tetrachlorocuprate(II)	$(NH_4)_2CuCl_4$
sodium monochloropentacyanoferrate(III)	$Na_3Fe(CN)_5Cl$
potassium hexafluorocobaltate(III)	K_3CoF_6

3) Give the number of d electrons for each of the complexes listed below. Are the complexes paramagnetic or diamagnetic?

	# d electrons	Paramagnetic or Diamagnetic
$Pd(NH_3)_2Cl$	d8	Diamagnetic
$Ru(CO)_6^{3+}$	d5	Paramagnetic
$Ni(H_2O)_6^{2+}$	d8	Paramagnetic
$HgCl_4^{2-}$	d10	Diamagnetic