Transition Metal Compounds

Lets look at the electron configurations for the first ten transition metals.

Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn
4s 3d	4s 3d	4s 3d	4s 3d	4s 3d	4s 3d	4s 3d	4s 3d	4s 3d	4s 3d

Note they do not follow the pattern you may predict!
These are all very similar in size and give interesting reactions!

Complex Ion

Ligand

$[CoCl_4^{2-}]$

How these compounds were arranged was a very big question

Alfred Werner

Formula Color of Compound

$CoCl_3 \cdot 6NH_3$

$CoCl_3 \cdot 5NH_3$

$CoCl_3 \cdot 4NH_3$

We have experimental evidence that needs to be addressed:

$CoCl_3 \cdot 6NH_3$ + excess$AgNO_3$ ➔

$CoCl_3 \cdot 5NH_3$ + excess$AgNO_3$ ➔

$CoCl_3 \cdot 4NH_3$ + excess$AgNO_3$ ➔

The first proposed structures from Joergensen:

These are wrong. Why?

Werner's Structures:

Coordination Compound:

Counter Ion:

Coordinate Covalent Bond:

Ligands:

unidentate:

bidentate:

polydentate:

Nomenclature
Rules for naming coordination compounds

1.

2.

3.

4.

5.

6.

7.

Ligand Names

Prefixes

Name the following compounds:

1. $[Ag(NH_3)_2]Cl$
2. $[Co(NH_3)_3Cl_3]$
3. $[Co(NH_3)_3Cl_2]Cl$
4. $[Co(NH_3)_6]Cl_2$
5. $K_4[Fe(CN)_6]$
6. $[Ni(NH_3)_4]^{2+}$
7. $[PtCl_4]^{2-}$
8. $[Pt(NO_2)_4]^{2-}$
9. $K[Pt(NH_3)Cl_5]$
10. $[Co(NO_2)(NH_3)_4]\ Br_2$
11. $[Cu(NH_3)_4]^{2+}$
12. $[CrCl(NH_3)I_4]Cl$
13. $K_2[Pt(SO_4)_2(NH_3)_4]$
14. $[Fe(OH)_6]^{4-}$
15. $[Cu(NH_3)_4]SO_4$

Isomerism

Isomers

This gives different chemical and physical properties.

Coordination Isomer

Linkage Isomer

Geometric Isomers

Stereo Isomer

Crystal Field Theory

Diamagnetic

Paramagnetic

Our focus will be on the d orbitals:

What happens to the energy of these d orbitals is what governs inorganic chemistry!

The orbitals experience a splitting due to repulsion when a ligand approaches it.

Octahedral

e_g

t_{2g}

What is 10Dq?

Strong Field versus Weak Field
Strong Field Case

Weak Field Case

Spectrochemical Series

$$CN^- > NO_2^- > en > NH_3 > H_2O > OH^- > F^- > Cl^- > Br^- > I^-$$

How does charge affect splitting?

Low Spin

High Spin

Other Geometries

Tetrahedral

Square Planar

How do we count the number of electrons in a transition metal ion?

Mn^{2+}

Co^{3+}

Fe^{2+}

Au^{3+}

Ni^{2+}

Cu^{2+}

1. Draw the d-orbital splitting diagram for the octahedral complex ions for V^{2+}.

2. The complex ion $Mn(OH)_6^{3-}$ is paramagnetic and octahedral. Draw the d-orbital splitting diagram and show why it is paramagnetic. OH^- is a very STRONG ligand.

3. Draw the d-orbital splitting diagram for the octahedral complex ions for Ni^{2+}.

4. Draw the d orbital splitting diagram for Co^{2+} in an octahedral field. Do this for both spin cases. Is it paramagnetic or diamagnetic.

5. The complex ion $Fe(CN)_6^{3-}$ is paramagnetic and octahedral. Draw the d-orbital splitting diagram and show why it is paramagnetic. CN^- is a very STRONG ligand.