Coordination Compounds

1. What is a coordination compound composed of?

    a. Metal Ion

    b. Ligand

    c. Counter Ion

2. What is a complex ion?

    The metal ion and ligand combination.

3. What is a counter ion?

    An ion that neutralizes the charge on the complex ion. Counter ion can be positive or negative.

4. What is a ligand?

    A Lewis Base connected to a metal ion.

    a. What is a Lewis Base?

        An electron donor. So the ligand must have a "free" lone pair.

5. Two characteristics of many coordination compounds.

    a. Paramagnetic.

    a. Colorful (absorb light in the visible range).

6. What is a primary valence? What does it correspond to?

    Primary Valence = Oxidation Number

It corresponds to the charge on the metal ion.

7. What is a secondary valence? What does it correspond to?

Secondary Valence = Coordination Number

It corresponds to the number of bonds on the metal. Please keep in mind this is not always equal to the number of ligands attached, as some ligands are able to bind to the metal more than once.

8. Define

   a. Monodentate

      A ligand that attaches once (NH_3, H_2O, etc.)

   b. Bidentate

      A ligand that attaches twice ($H_2NCH_2CH_2NH_2$)

   c. Polydentate

      A ligand with multiple attachments.

   d. Chelate

      A ligand with more than one atom that can bind to an ion. Capable of forming rings.

9. A coordination compound of cobalt(III) contains four ammonia molecules, one sulfate ion, and one chloride ion. Addition of aqueous $BaCl_2$ solution to an aqueous solution of the compound gives no precipitate. Addition of aqueous $AgNO_3$ to an aqueous solution of the compound produces white precipitate. Propose a structure for this coordination compound.

Let's first figure out all of the species in solution.

Co^{3+}, $4NH_3$, SO_4^{2-} , Cl^-

We can figure out what is directly attached to the metal and what the counter ion is based on the precipitate that forms. Remember that if a ligand is directly attached to the metal it will not react to form a precipitate.

Now, let's look at the reactions described:

$BaCl_2 \rightarrow Ba^{2+} + 2Cl^-$

This was put in because if SO_4^{2-} was the counter ion the addition of barium would produce the following reaction:

$Ba^{2+} + SO^{2-} \rightarrow BaSO_{4\,(s)}$

This problem indicates this reaction did NOT occur, therefore the SO_4^{2-} must be a ligand.

Let's look at the next reaction:

$AgNO_3 \rightarrow Ag^+ + NO_3^-$

This would undergo the following reaction if Cl^- was the counter ion:

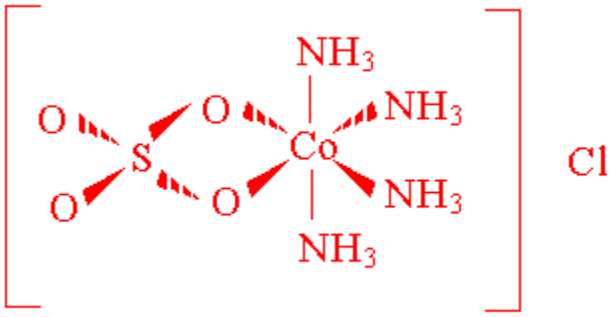
$Ag^+ + Cl^- \rightarrow AgCl_{(s)}$

According to the question this reaction DID occur. This means that Cl^- is the counter ion.

This means that the sulfate and ammonia groups are attached to the metal. We will need to figure out the charge to determine the number of Cl^- ions required to neutralize the charge.

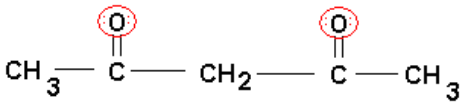
$$(+3) + (-2) + 4(0) = +1$$
$$Co^{3+} \quad SO_4^{2-} \quad NH_3$$

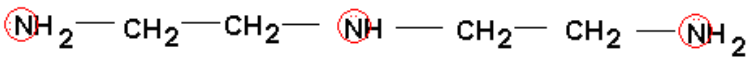
Meaning we need one chlorine. Before proposing a structure it is important to note that SO_4^{2-} is bidentate. Knowing this we can propose the following structure:

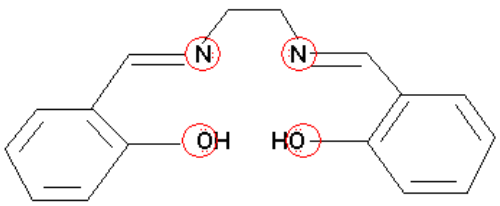


10. How many bonds could each of the following chelates form with a metal ion?

Remember that is based on the number of distinct atoms with available lone pairs for bonding.





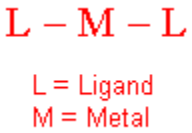


11. Predicting the shape of a complex ion depends on the coordination number.

12. When the coordination number is

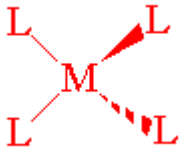
a. 2

i. Linear



b. 4

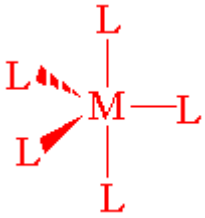
i. Tetrahedral



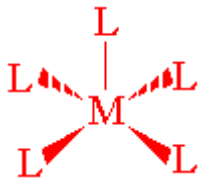
ii. Square Planar

c. 5

i. Trigonal bipyramidal



ii. Square Pyramid



d. 6

i. Octahedral