16.4 Free Energy

Template:VCE

A **coordination compound** or **complex ion** is a molecule that contains a central metal ion to which are attached one or more **ligands**. In many complexes there is more than one way in which the ligands may be attached to or arranged around the metal center. **Isomers** are compounds that have the same molecular formula but possess different arrangements of atoms. Two isomers are **non-superimposable**, which means that one cannot mentally have the two compounds occur the same space with each atom in one isomer perfectly coinciding with the same atom in the other isomer.

The scheme and definitions provided below are commonly used to classify coordination chemistry isomers. A compound can exhibit multiple types of isomerism.

Isomerization in Coordination Compounds

Structural Isomers

The atoms are connected in different ways in structural isomers. Thus there is a difference in chemical bonding. Structural isomers possess different physical properties and chemical reactivities.

- **Coordination Isomers or Ionization Isomerism**
  - *Coordination isomers* yield different ions in solutions, because some ions are bound to the metal as ligands and some ions serve as counter-ions and are free to move about the solution.
- **Linkage Isomers**
  - When a ligand has multiple Lewis base sites, different sites (atoms) on the ligand can bond to the metal and linkage isomers exist. For example: oxalate and nitrate ligands.

Stereoisomers

Stereoisomers have the same connectivity of atoms (bonding), but the spatial arrangement of atoms differs.

- **Diastereomers or Geometric Isomers**
  - *Diastereomers* are non-mirror-image molecules that have the same chemical bonding but different spatial arrangements of atoms.
  - *cis/trans isomers*: The Latin words cis and trans mean "next to" and "across", respectively. This type of geometric isomerism involves a distintive pair of ligands that can either be next to each other (cis isomer) or on opposite sides of the molecule (trans isomer).
  - *fac/mer isomers*: In complexes with coordination numbers of five or greater containing three distinctive ligands, all three distintive ligands may lie on the same triangular face of the octahedral (fac or facial isomer) or on a plane bisecting the complex (mer or meridional isomer).
- **Enantiomers or Optical Isomers**
  - *Mirror-image molecules* that cannot be superimposed on each other are called enantiomers. That is, the mirror image of an isomer is not identical to itself. Such molecules are called **chiral** and are identified by their handedness: **?** (the right-handed isomer) and **?** (the left-handed isomer). Enantiomers possess identical physical properties. Their chemical properties are also identical, except in a chiral reaction environment.
  - *A chiral molecule* will rotate the plane of polarized light passing through the solution. The enantiomer that rotates the polarized light clockwise is denoted with + while the enantiomer that rotates the polarized light counterclockwise is denoted with -. Whether the ? or ? rotates the polarized light clockwise often depends upon the wavelength of light. A 50/50 mixture of ? and ? isomers is called a **racemic mixture** and does not rotate the plane of polarized light passing through the solution.

Compounds

- (•) $[Cu(gly)_2]$
- ( ) $[Co(en)_2Cl_2]^+$
- ( ) $[CoCl_2Br_2]^{2-}$
- ( ) [Cr(py)(OH)(CN)Cl]
- ( ) $[Co(NH_3)_4Cl_2]^+$
- ( ) $[Cr(H_2O)_4Cl_2]Cl.2H_2O$
- ( ) $[Ru(pa)_3]^{2+}$
- ( ) $[Pt(bpy)(SCN)_2]$
- ( ) $[Ru(tpm)Cl_3]$

Ball and Stick | Show Answer

Exercise

Choose one of the coordination compounds from the list below. Carefully examine the chemical structure and answer the following questions.

- Does the complex have isomeric forms?
- If multiple isomers exist, draw their structures and identify the type(s) of isomerization.
- Write the chemical name of the complex.
- When isomers exist, do the isomers have identical physical properties and chemical reactivities?

Template:Blauch