

E-Content Study Material

B. Sc. Chemistry (H)

2nd Year

Paper II B

Inorganic Chemistry

Chapter IV: Coordination Compounds

Topic: Isomerism in Coordination Compounds

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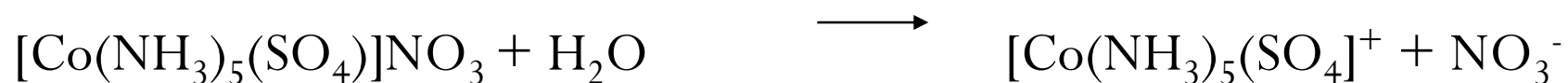
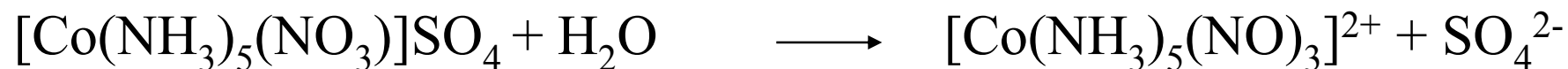
Isomerism in Coordination Compounds

Compounds having the same molecular formula but different structural or spacial arrangements are called isomers and the phenomenon is called isomerism (Greek, iso=equal, meros=parts). It is very common in organic compounds. In inorganic compounds, coordination compounds often show various types of isomerism. Coordination compounds show two main types of isomerism.

1. Structural isomerism.
2. Stereo isomerism or Space isomerism.

1. Structural isomerism- This type of isomerism arises due to the difference in structures of coordination compounds. It is further subdivided into different types as follows.

(i) Ionization isomerism: Compounds which have same composition but give different ions in solution are called ionization isomers. e.g.



(ii) Solvate or Hydrate isomerism: Compounds which have the same composition but differ in the number of solvent molecules present as ligands (i.e. in the coordination sphere) and as free solvent molecules (present outside the coordination sphere) in the crystal lattice are called solvate isomers. If water is the solvent, these are called hydrate isomers. e.g.

There are three different hexahydrates of chromic chloride with an empirical formula of $\text{CrCl}_3 \cdot 6\text{H}_2\text{O}$.

One of these hydrates is violet and the other two are green in colours. All the three differ in the number of molecules of water in the coordination sphere.



Violet

(Three Ionic chlorines)



Blue Green

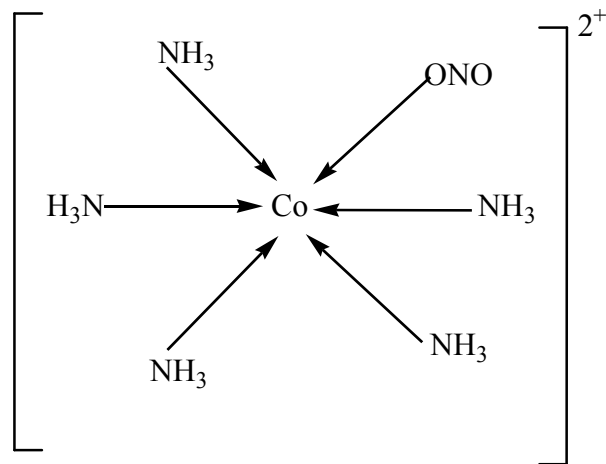
(Two ionic chlorines)



Dark Green

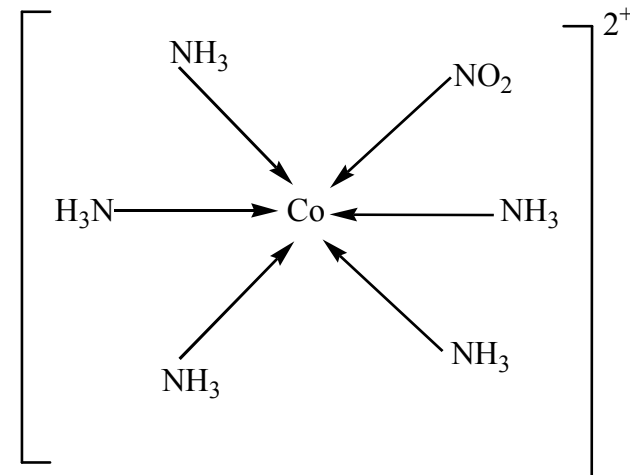
(One ionic chlorine)

(iii) Linkage isomerism: This type of isomerism occurs in compounds containing ambidentate ligands. e.g. In case of NO_2^- ion either nitrogen or an oxygen atom may act as a donor giving two different isomers.



pentaamminenitritocobalt(III) ion

(Red)



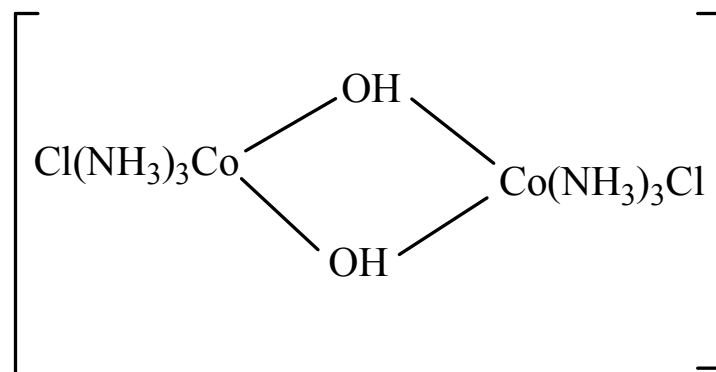
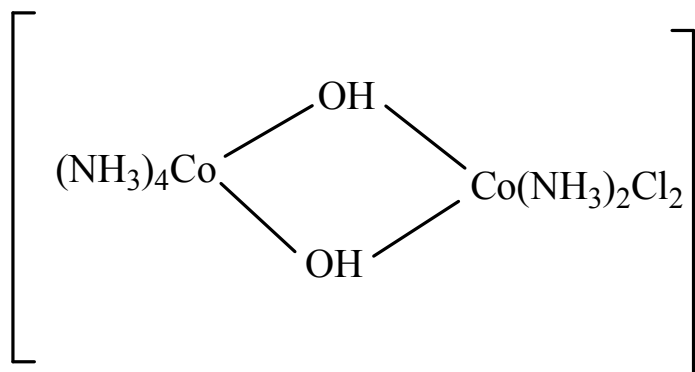
pentaamminenitrocobalt(III) ion

(Yellow)

(iv) **Coordination isomerism:** This type of isomerism is possible when both negative ions of a salt are complex ions and the two isomers differ in the distribution of ligands in the cation(positive ion) and the anion(negative ion). e.g.

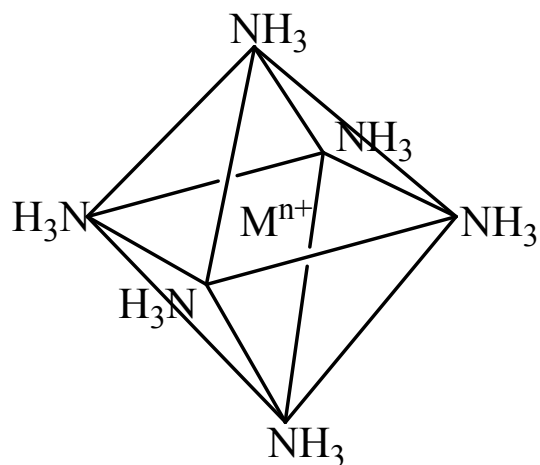


(v) **Coordination position isomerism:** This type of isomerism is exhibited by bridged complexes and results from different placement of ligands. e.g.

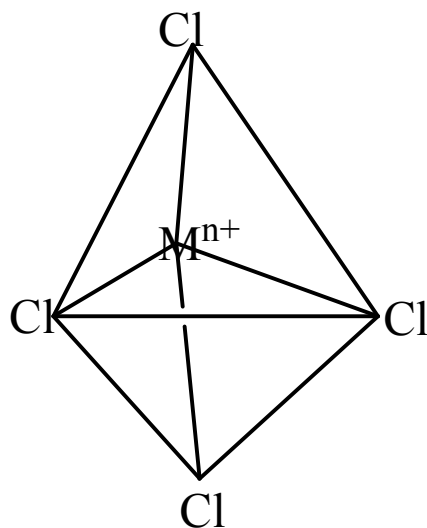


(2) Stereo isomerism or Space isomerism.

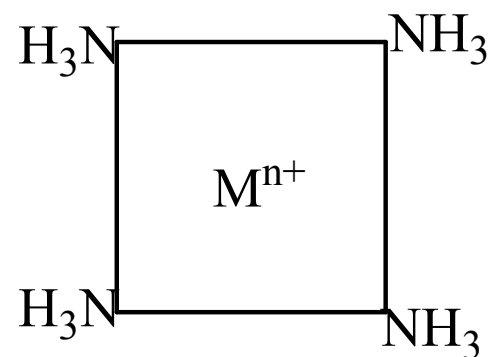
In coordination compounds, the ligands are arranged in space in specific orientation around a given metal atom or ion. e.g.



Octahedral



Tetrahedral



Square Planar

(M^{n+} is at centre of polygon)

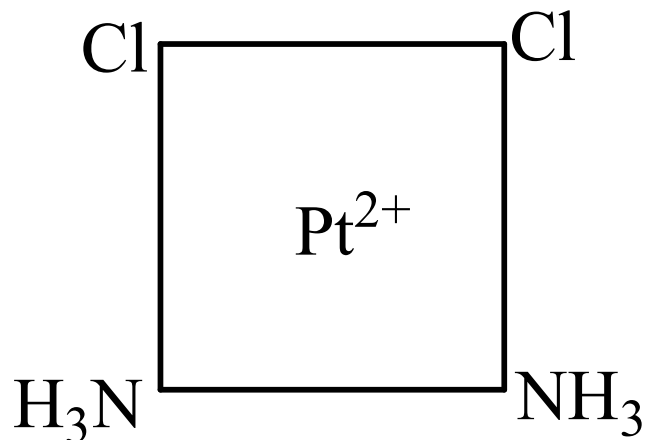
Space isomerism arises on account of the different positions and arrangements of ligands (atoms or groups) in space around the metal atom/ion. It is of two types.

(i) Geometrical isomerism

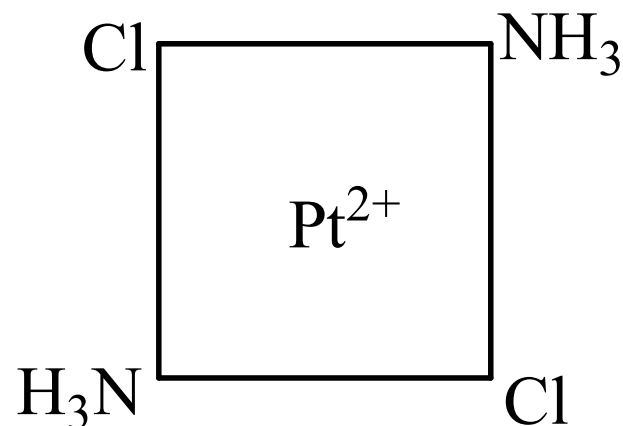
(ii) Optical isomerism

(i). Geometrical isomerism or cis-trans isomerism: This type of isomerism occurs in heteroleptic complexes due to different possible geometric arrangements of the ligands. When two identical groups (ligands) occupy adjacent positions, the isomer is called cis and when arranged opposite to one another the isomer is called trans. This isomerism is not possible for complexes with coordination number 2,3 and tetrahedral complexes with coordination number 4. Because in this case all the four positions are equivalent. Cis-trans isomerism is quite common in square planar and octahedral complexes. e.g.

In square planar complexes.



cis- $[\text{Pt}(\text{NH}_3)_2\text{Cl}_2]$

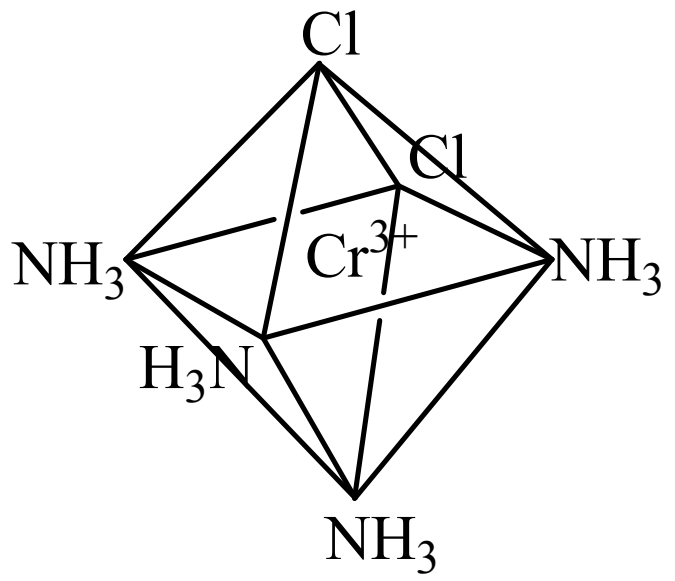


trans- $[\text{Pt}(\text{NH}_3)_2\text{Cl}_2]$

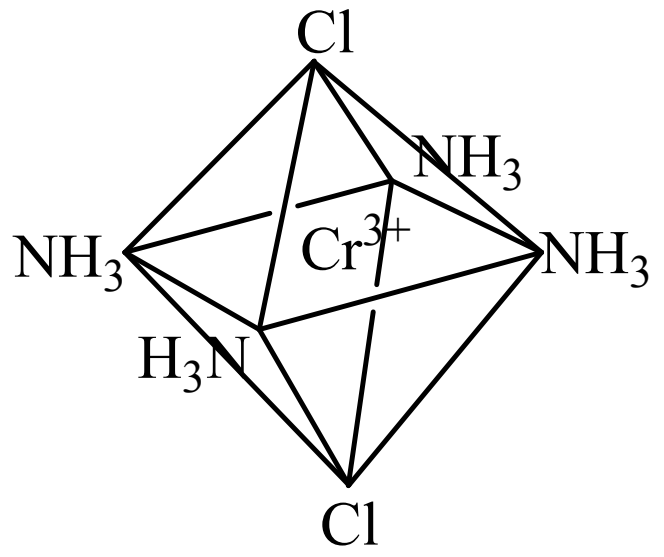
Usually X-ray diffraction methods are used to distinguish between cis and trans isomers.

In octahedral complexes.

e.g. $[\text{Cr}(\text{NH}_3)_4\text{Cl}_2]^+$

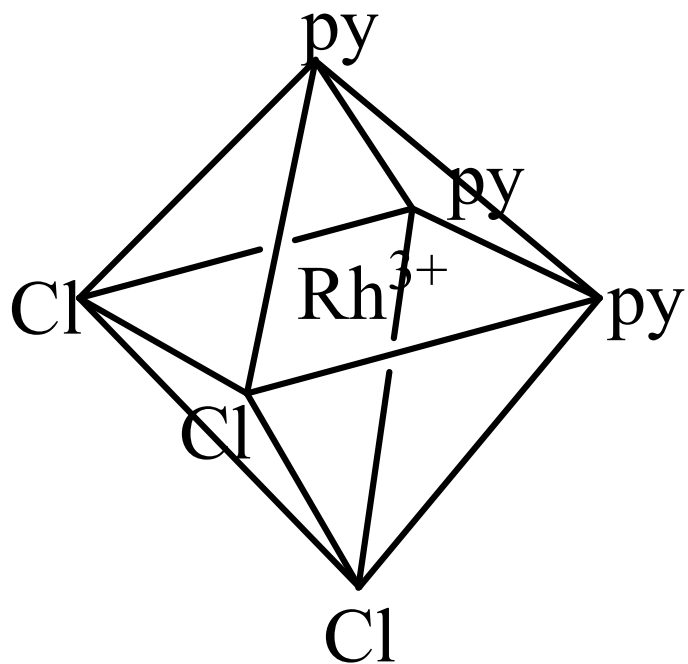


$\text{cis}-[\text{Cr}(\text{NH}_3)_4\text{Cl}_2]^+$



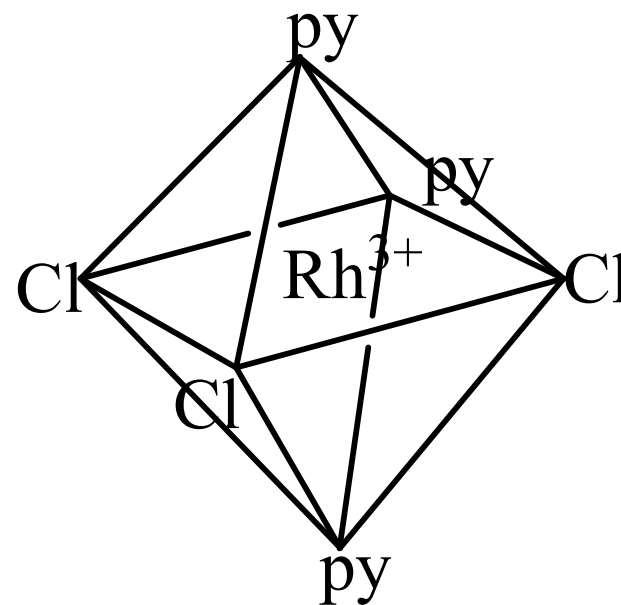
$\text{trans}-[\text{Cr}(\text{NH}_3)_4\text{Cl}_2]^+$

e.g. $[\text{RhCl}_3(\text{py})_3]$



cis- or fac- $[\text{RhCl}_3(\text{py})_3]$

(fac-facial)



trans- or mer- $[\text{RhCl}_3(\text{py})_3]$

(mer-meridional)

(2) Optical isomerism.

Optical isomers rotate the plane of polarised light in opposite direction. The two isomers are structurally non-superimposable mirror image of each other. i.e. they do not possess the plane of symmetry. The molecular ion which are non-superimposable mirror image of each other are called chiral and this property is called chirality. The optical isomers are called dextro or laevo (d or l) depending upon the direction of in which plane of polarised light is rotated. i.e. (towards right and left). The d and l isomers are called enantiomers or enantiomorphs. Optical isomerism is common in octahedral complexes with coordination number 6 involving 1,2 or 3 symmetrical didentate ligands. e.g.

