Quadrant II – Transcript and Related Materials

Programme: Bachelor of Science (Second year)

Subject: Chemistry

Paper Code: CHC 104

Paper Title: Physical Chemistry and Inorganic Chemistry (Section B)

Unit: Coordination Chemistry

Module Name: Stereo-isomerism: Geometric isomerism

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Notes

STEREOISOMERISM

Stereoisomerism is a phenomenon shown by stereoisomers which are compounds which have the same position of atoms or groups i.e. same connectivity but differ in 3 dimensional arrangements around the central atom.

There are two types of stereoisomerism as follows:

1. Geometrical isomerism.
2. Optical isomerism.

Geometrical isomerism:

- Geometrical isomerism is observed because of ligands occupying different positions around the central metal ion.

- Complexes in which same two ligands occupy positions adjacent to each other (90° apart) are termed as *cis*-isomer.

- Complexes in which same two ligands occupy positions opposite to each other (180° apart) are termed as *trans*-isomer.

- This type of isomerism is not shown by complexes having coordination number 2, 3 and tetrahedral complexes because in these arrangements all the positions are adjacent to each other.

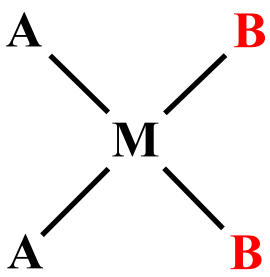
- This type of isomerism commonly occurs in four coordinated square planar complexes and six coordinated octahedral complexes.

Geometrical isomerism in square planar complexes:

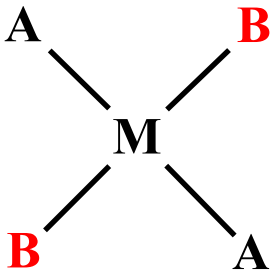
- **MA_4, MA_3B** and **MAB_3** doesn't show geometrical isomerism as all possible arrangement for any these complexes are equivalent.

(i) MA_2B_2 Type:

MA_2B_2 type of complexes can show 2 geometrical isomers i.e. *cis* isomer and *trans* isomer where A and B are unidentate ligands and M is metal atom.



Cis-isomer



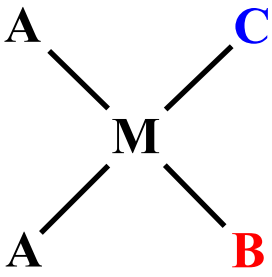
Trans- isomer

Examples are $[PtCl_2(NH_3)_2]$, $[Pd(NO_2)_2(NH_3)_2]$ etc.

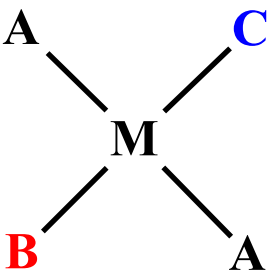
(ii) MA_2BC Type:

Here A, B and C are unidentate ligands and M is metal atom.

This type of complexes also shows *cis* and *trans* isomers depending upon whether the two A ligands are adjacent or opposite to each other.



Cis-isomer



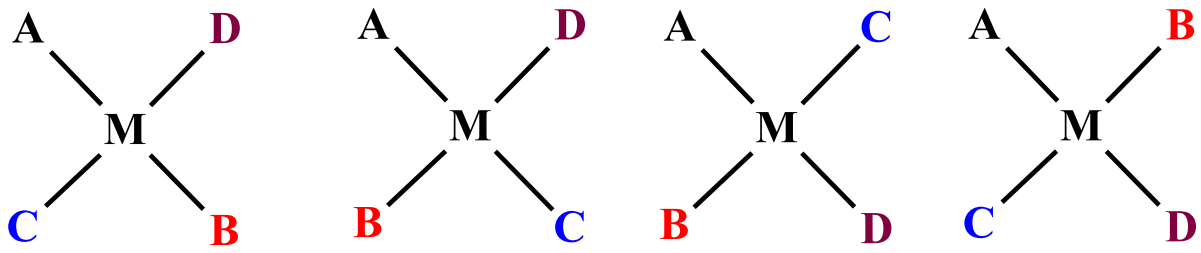
Trans- isomer

A common example is $[Pt(py)_2NH_3Cl]$, where py = Pyridine.

(iii) MABCD Type:

Here A, B, C and D are unidentate ligands and M is metal atom.

This type of complexes shows 3 isomers. These isomers can be obtained by fixing the position of one ligand (consider A) and then placing the remaining with respect to that as shown below:



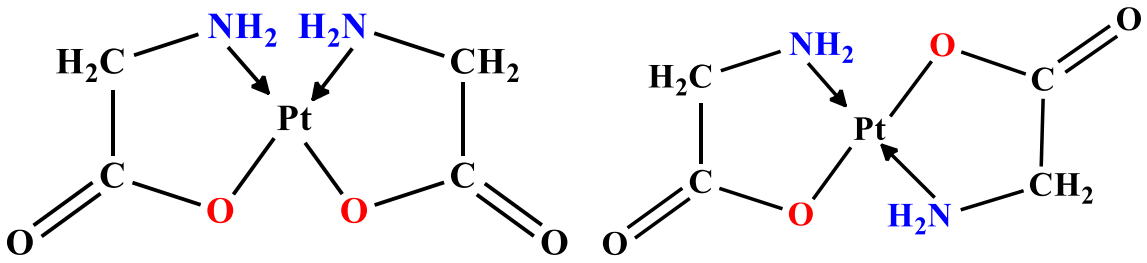
Here in 3rd and 4th structures are identical because in both ligand A is *trans* to ligand D.

Example is $[Pt(NO_2(C_5H_5N)NH_3)(NH_2OH)]^+$.

(iv) $M(ab)_2$ type:

Here **ab** stands for unsymmetrical bidentate ligand and M is metal atom.

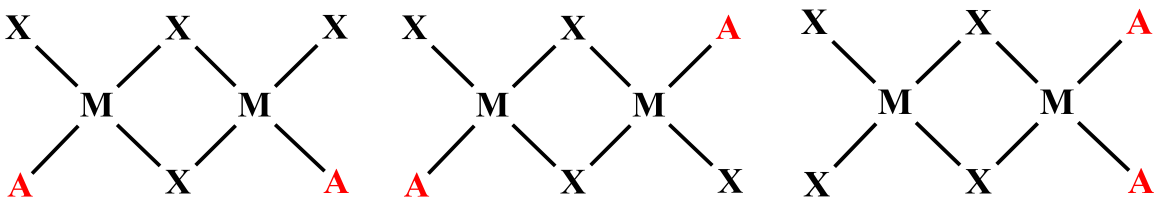
For example $[Pt(gly)_2]$ where gly stands for $NH_2CH_2COO^-$ exists in *cis* and *trans* forms as shown below:



Cis-isomer *Trans*- isomer

(v) Square planar complexes having bridged ligands ($M_2A_2X_4$)

This type of complexes exists in three isomeric forms i.e. *cis* isomer, *trans* isomer and unsymmetrical isomer as shown below:



Cis-isomer *Trans*- isomer Unsymmetric isomer

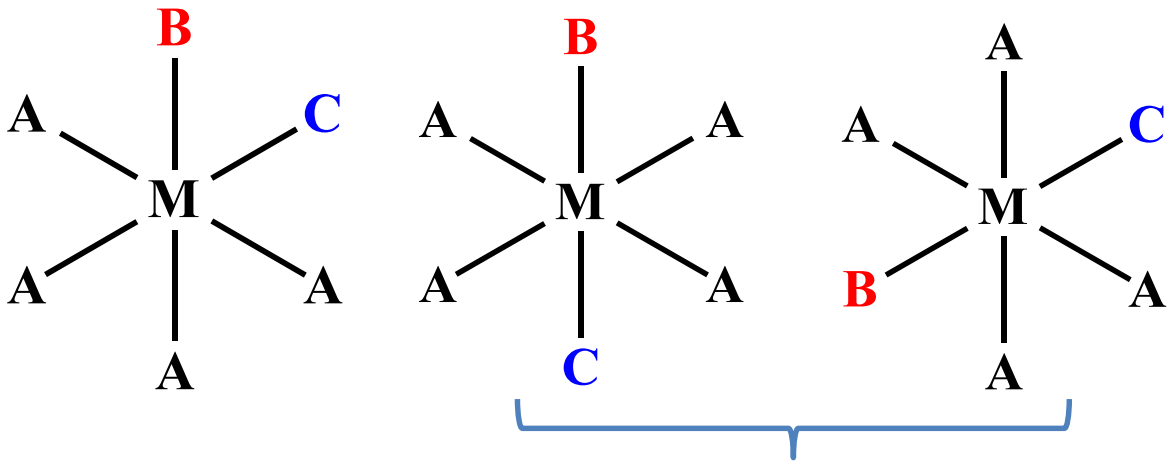
Example: $[Pd(PPh_3)Cl_2]_2$, $[PtCl_2(PEt_3)]_2$ where PPh_3 is triphenylphosphine and PEt_3 is triethylenephosphine.

Geometrical isomerism in octahedral complexes:

- **MA_6, MA_5B** and **MAB_5** doesn't show geometrical isomerism as all possible arrangement for any these complexes are equivalent.

(i) MA_4B_2 MA_2B_4 and MA_4BC type

MA_4B_2 MA_2B_4 and MA_4BC type of complexes show *cis* and *trans* isomers as shown below:

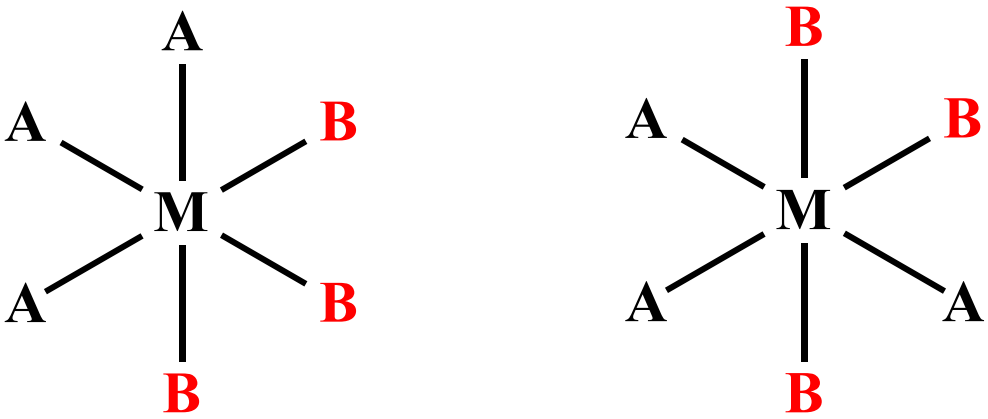


Cis-isomer *Trans*- isomer

Examples are $[Cr(NH_3)_4Cl_2]^+$, $[Co(NH_3)_4(H_2O)Cl]^{2+}$ etc.

(ii) MA_3B_3 type

MA_3B_3 type shows two isomers i.e. *cis* isomer and *trans* isomers as shown below:



Cis-isomer / *Fac* isomer *Trans*- isomer / *Mer* isomer

It is observed that in the *cis* form, like ligands occupy the corners of one of the triangular faces of the octahedron hence it is also termed as facial or *fac* isomer whereas in *trans* form like ligands are at the corners of the square plane hence it is termed as meridional or *mer* isomer.

Examples are $[Co(NH_3)_3Cl_3]$, $[Co(NO_2)_3Cl_3]$, $[Rh(py)_3Cl_3]$ etc.

(iii) [MABCDEF] type

[MABCDEF] type of complexes have a tendency to show 15 geometrical isomers.

However only one complex of this type has been reported till now, $[PtBrClI(NO_2)(C_5H_5N)(NH_3)]$ of which only 3 different isomers can be isolated practically.

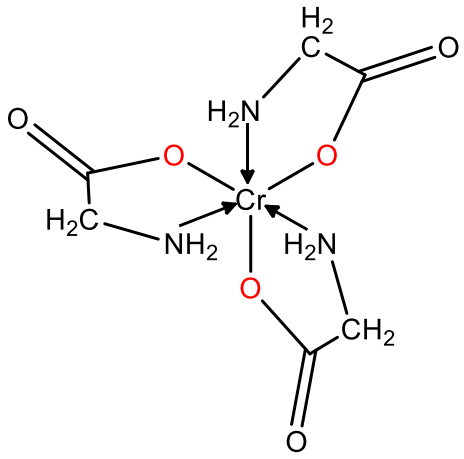
(iv) $[M(ab)_2CD]$, $[M(ab)_2C_2]$, $[M(ab)_3]$ type

Here **ab** stands for unsymmetrical bidentate ligand, C,D stands for unidentate ligands and M is metal atom.

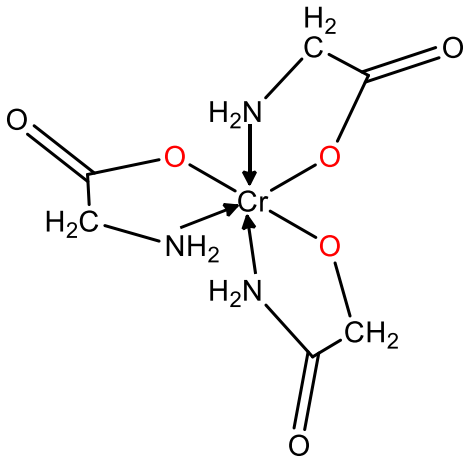
$[M(ab)_2CD]$, $[M(ab)_2C_2]$, $[M(ab)_3]$ type of complexes show two isomers i.e. cis isomer and trans isomer.

For example isomers of $[Cr(gly)_3]$ are shown below where and gly stands for $NH_2CH_2COO^-$.

Geometrical isomers of $[Cr(gly)_3]$:



Cis-isomer



Trans- isomer

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