Stereoisomerism or space isomerism :→

In this type of isomerism, isomers have same empirical formula but the arrangement of ligands in space around the metal atom is different.

Stereoisomerism can be divided into two types.

① Geometrical isomerism or cis-trans isomerism

② Optical or mirror image isomerism.

① Geometrical or cis-trans isomerism :→

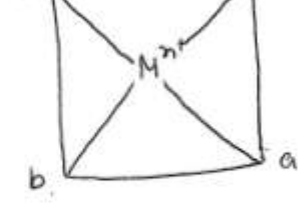
Here, the isomers have same empirical formula but have different physical and chemical properties because of the difference in arrangement of ligands in space.

cis-isomer :→ Two identical ligands are occupied at adjacent positions.

Example.

$[Ma_2b_2]$

$[Pt^{2+}(NH_3)_2Cl_2]^0$



cis - isomer.

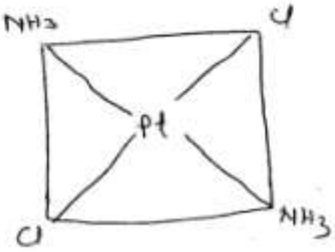
* a & b are monodentate ligand, a ≠ b.
* It is a square planar complex & the two a's are occupied adjacent to each other. Ily the two b's are occupied at adjacent positions.

Trans isomer :→ Two identical ligands are occupied diagonally.

Example.

$[M^{n+}a_2b_2]$

$[Pt(NH_3)_2Cl_2]$



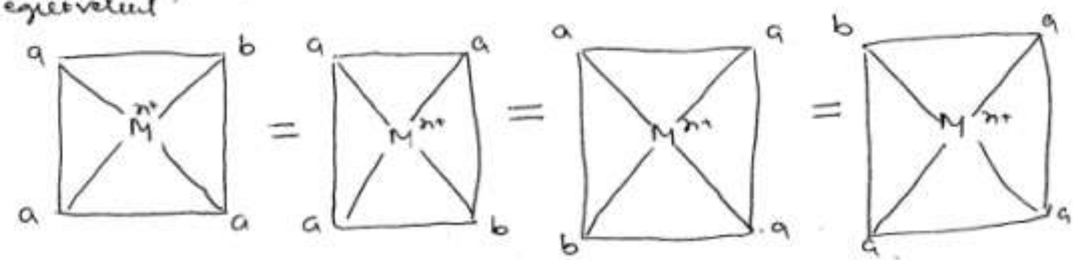
trans - isomer.

Here, the two Cl ions are occupied at the positions diagonally to each other. Ily the two NH_3 molecules are occupied diagonally.

<u>Note</u> cis-trans isomerism is exhibited by square planar & octahedral complexes. But it does not show in tetrahedral geometry, because in tetrahedral geometry all the ligands are occupied in cis positions as all the bond angles between the ligands are same, which is equal to 109°28' (approximately) in regular tetrahedral geometry.

(*) Let us take some examples.

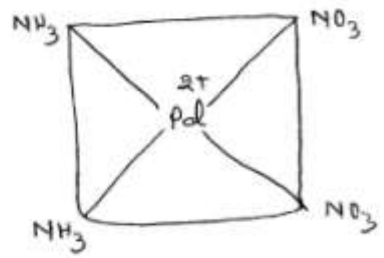
(1) $[Ma_3b]$, $[Mb_3a]$, $[Ma_4]$ → These type of square planar complexes don't show geometrical isomerism, because every conceivable spatial arrangement of ligand around the metal ion is exactly equivalent.



All these arrangements are equivalent. So this complex doesn't show geometrical isomerism

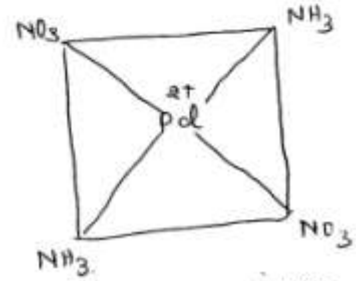
However geometrical isomerism show in the following square planar complexes.

(i) [M a_2 b_2] type. eg. $[Pt^{2+}(NH_3)_2 Cl_2]^0$, $[Pd^{2+}(NO_3)_2(NH_3)_2]^0$



cis – isomer

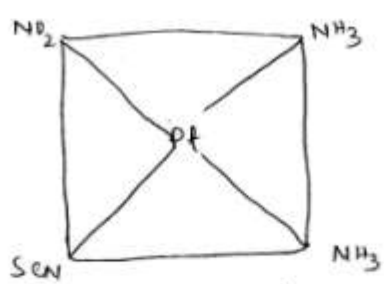
(identical ligands are in adjacent position)



trans - isomer.

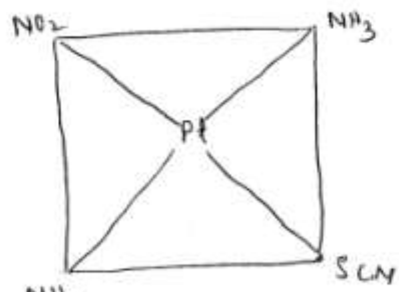
(identical ligands are occupied digonally)

(ii) [M a_2 bc] type :- $[Pt^{2+}(NH_3)_2 NO_2, SCN]^0$



cis – Position

(Here the two NH_3 molecules are occupied at adjacent) Position.

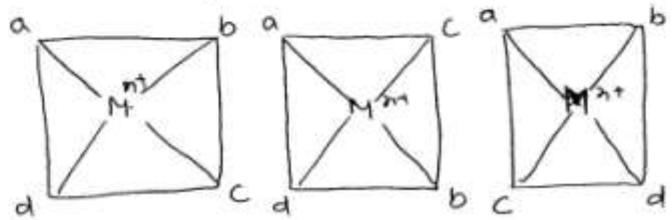


trans isomer

(Here the two NH_3 molecules are occupied diagonally).

(iii) [M a b c d] type complex :> $[Pt^{2+}(NO_2)(Py)(NH_3)(NH_2OH)]^{+}$

Three ~~types~~ geometrical isomers are Possible.



(a is diagonally occupied with d)

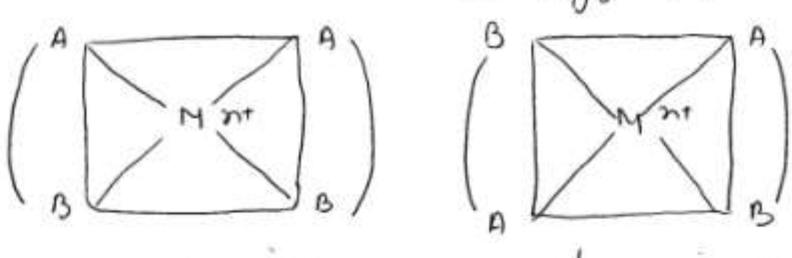
(a is diagonally occupied with c) (a is diagonally occupied with b)

(iv) Square planar complex having unsymmetrical bidentate chelating ligands

$[M(AB)_2]^{n+}$ Here AB is the bidentate ligand & A & B represent the donor atoms of bidentate ligand.

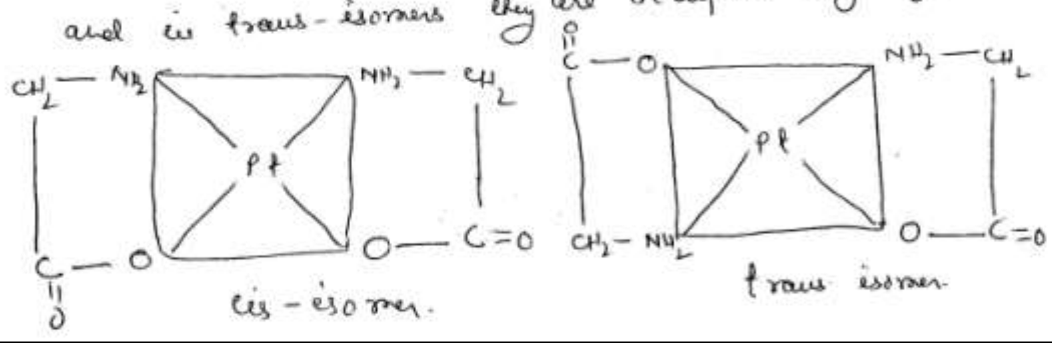
Example $[Pt(gly)_2]^{0}$ $gly = NH_2 - CH_2COO^-$

One donor atom is N & other donor atom is Oxygen (O)



cis - isomer. trans - isomer.

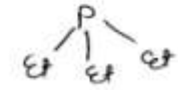
(*) In cis - isomer, identical donor atoms are in adjacent Positions and in trans - isomers they are occupied diagonally.



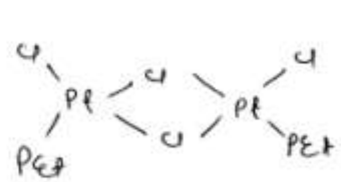
cis - isomer. trans isomer.

(v) Bridged bi-nuclear complexes of $M_2a_2b_4$ type.

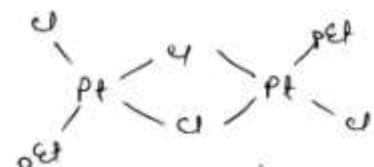
$[Pt(PEt_3)Cl_2]_2$. $PEt_3 \rightarrow$ Tri ethyl phosphine



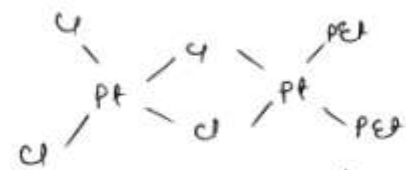
Here three isomers are possible :-



cis – isomer



trans - isomer



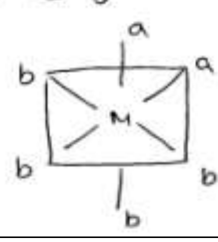
Unsymmetrical isomer.

Geometrical isomerism in octahedral complex (Oh)

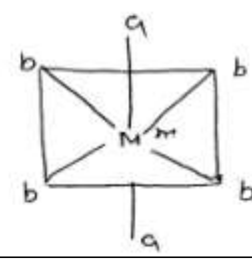
(1) $[Ma_6]^{2+}$, $[Ma_5b]^{2+}$ $[Mb_5a]^{2+}$ $\rightarrow$ They don't exhibit geometrical isomerism.

Geometrical isomerism can be shown in the following types of Oh complexes :-

(1) $[Ma_2b_4]^{2+}$ type or $[Ma_4b_2]^{2+} \rightarrow [Co(NH_3)_4Br_2]^+$

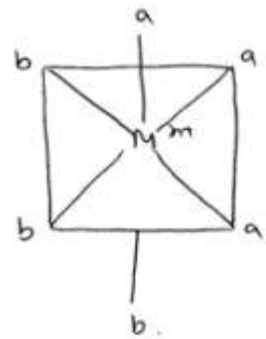


(cis-isomer because identical 'a' ligands are in adjacent positions)

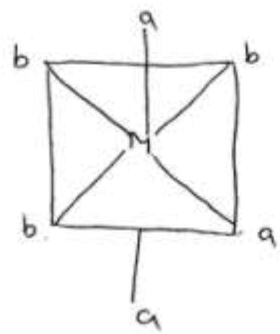


trans - isomer because the two 'a' ligands are occupied diagonally.

(ii) $[Ma_3b_3]^{n+}$ type. → $[Cr(NH_3)_3Cl_3]$.



cis-isomer.
(Here all identical ligands are occupied in adjacent position).



trans-isomer
(Here two 'a' ligands & two 'b' ligands are occupied diagonally.

(iii) $[Mabcdef]$ → Here all the monodentate ligands are different. One example of this type of complex is
$[Pt^{IV}(Py)(NH_3)(NO_2)(Cl)(Br)(I)]$

There are total 15 geometrical isomers possible for this complex.

Q. Draw all the 15 geometrical isomers of this complex.

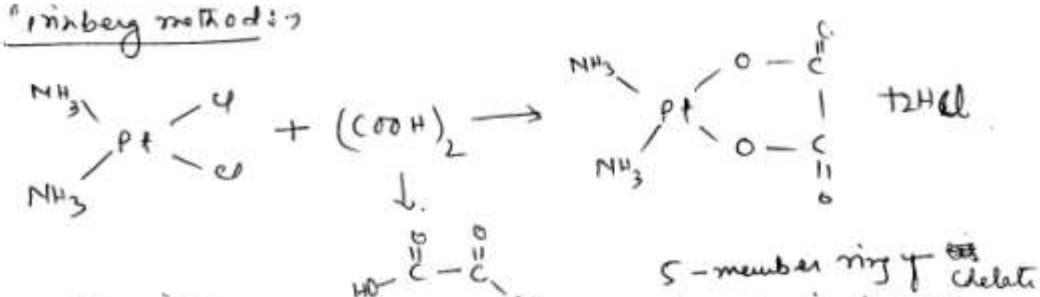
→ Hints: Keep one of the ligand fix at one of the 6 positions of Oh. complex & then keep the other five ligands opposite to this fix ligand. Then again keep another ligand at the fix position & keep other ligands opposite to it. Ly do for 3rd, 4th, 5th ligands also

Distinguish between cis and trans isomers :-

(i) Dipole moment measurement :-

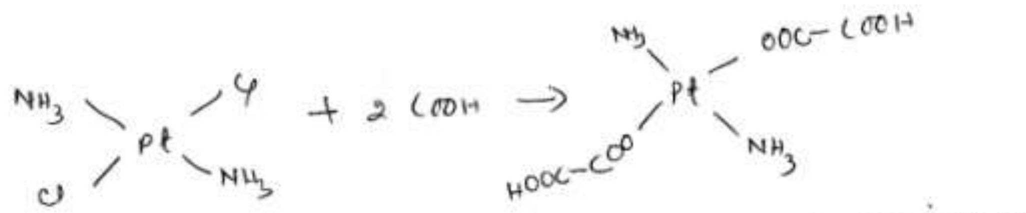
For the complex of the type $[Ma_2b_2]^{n+}$, the trans isomer has Zero (0) dipole moment since the two ~~~~ identical ligands ~~~~ their ~~~~ individual moments are opposite to each others. Because ~~consequently~~ are cancelled one another, therefore the dipole moment is zero in trans isomer. However there are some dipole moment value i.e. not zero in ~~~~ cis isomer.

(ii) Grinberg method :-



cis - isomer.

5 - member ring of chelate complex is formed.



trans - isomer

No - chelate complex is formed.

Ans 1. Indicate the type of isomerism exhibited by the following pairs of isomers & suggest one method in each set to distinguish them.

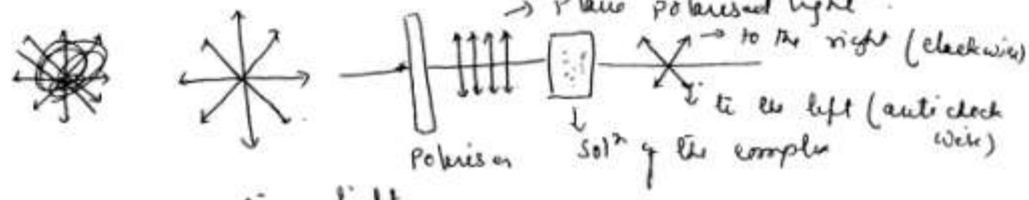
(a) cis - $[Pt(NH_3)_2Cl_2]$ and trans - $[Pt(NH_3)_2Cl_2]$

(b) $[Co(NH_3)_5SO_4]Cl$ and $[Co(NH_3)_5Cl]SO_4$

Optical or Mirror image isomerism :-

Note

* In ordinary light, the waves of the light is vibrated in all the directions or planes. However in a plane polarised light, the wave of the light is vibrated only in one possible plane.



When the solution of certain complex is placed in the path of this Plane polarised light, the plane of this light may be rotated by the sol^n through a certain angle. The rotation takes place either to the left or to the right. This Property of complex for rotating the plane polarised light is called its optical activity and the complex which can rotate the plane polarised light is called optically active. If the complex rotate the plane polarised light towards right (the clockwise), then it is called d-form or if it rotates towards left (anticlockwise), then the complex is called l-form. So d & l form are called optical isomers

If the complex sol^n doesn't rotate the plane polarised light, then the complex is called Optically inactive. It is called racemic mixture which consist of 50% d-form & 50% l-form.

d & l forms are mirror image to each other just as left hand is the mirror image of right hand. They are non-superimposable. & They are called enantiomers.

So the complexes which show optical isomerism should be mirror image to each other.

There are some conditions for a molecule or complex to show optical isomerism.

(I) The complex should not have plane of symmetry.

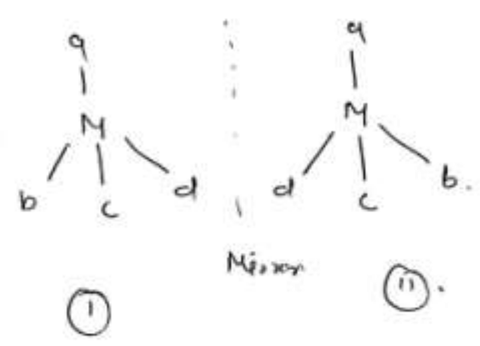
(II) The complex should not be superimposable with mirror image.

Examples:

Note: Optical isomerism rarely occurs in square planar complex since they have all the four ligands and the metal atom in the same plane, therefore exhibit plane of symmetry.

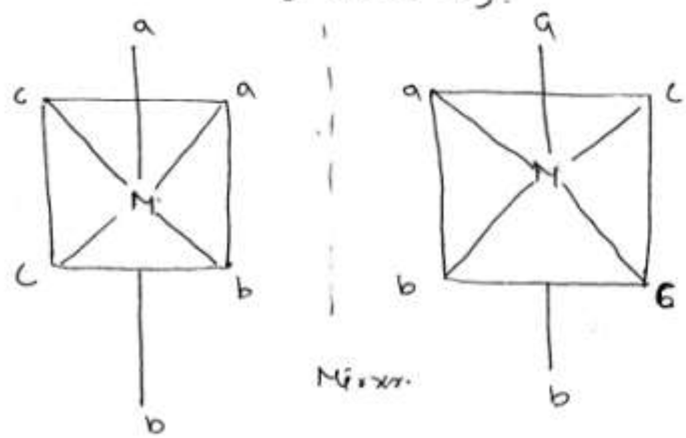
But it can show in Td (tetrahedral) & Oh (octahedral) complexes

Td complex: [Mabcd].



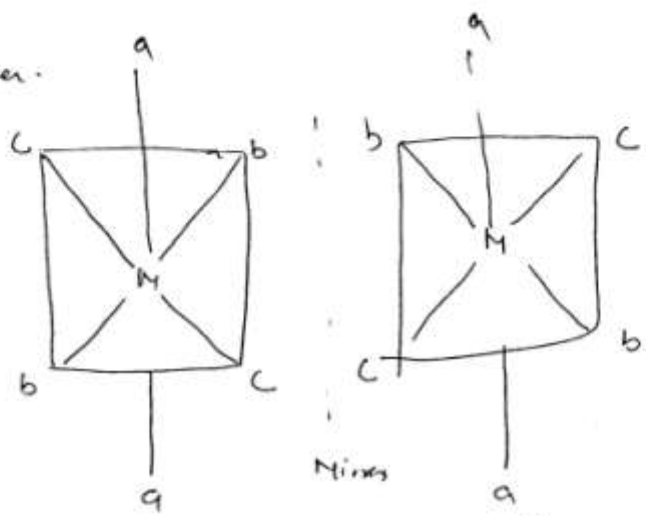
They are optical isomers.

Octahedral complex: $[M a_2 b_2 c_2]$.



cis-isomer. cis-isomer.

However.



trans. trans.

→ Not optical isomers. because. they have plane of symmetry. although mirror image is not superimposed.

Que 2. Draw the geometrical isomers of [M a b c d e f] & also their optical isomers.

Que 3. Draw the possible geometrical & optical isomers of $[Co(en)_2(C_2O_4)]^+$