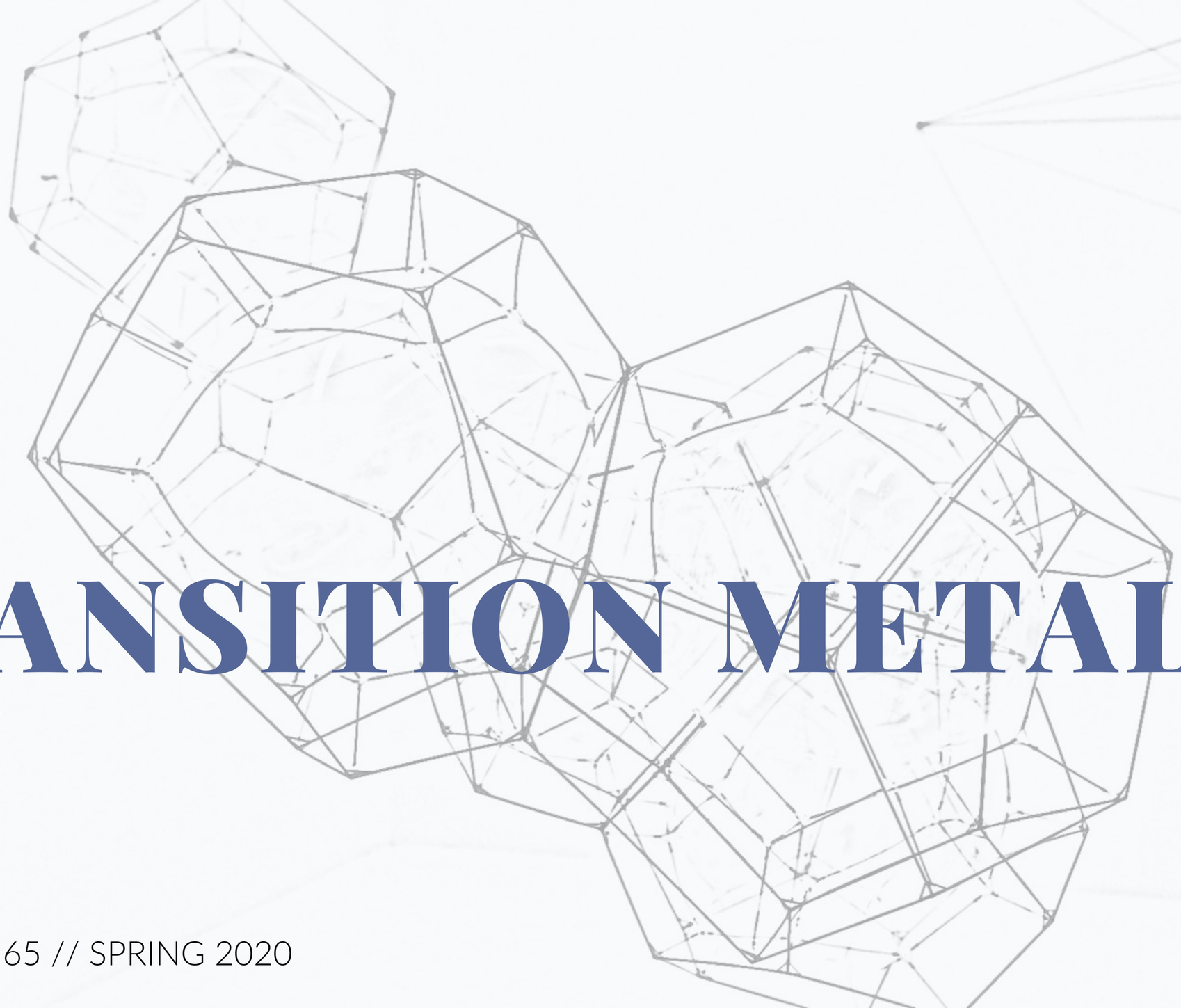


TRANSITION METALS

ISOMERS

CHEMISTRY 165 // SPRING 2020

DR. MIOY T. HUYNH | 2020

PRACTICE PROBLEM 1

Tetraamminedichlorocobalt(III) exists as a *cis* and a *trans* isomer. Draw and label both isomers.

— answer —

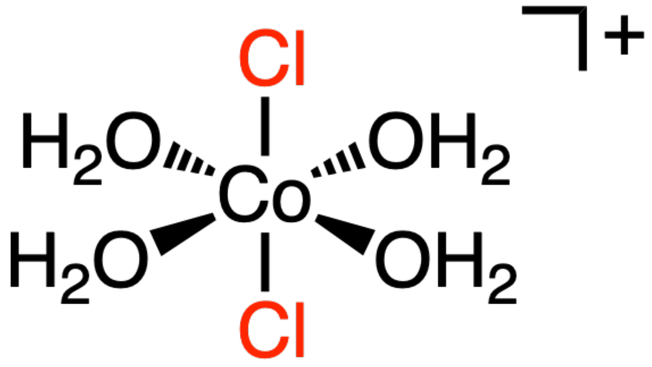
PRACTICE PROBLEM 1

Tetraamminedichlorocobalt(III) exists as a *cis* and a *trans* isomer. Draw and label both isomers.

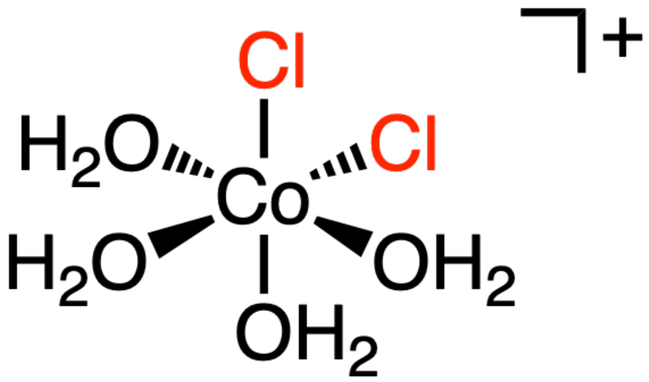
— answer —

First, write out the chemical formula based on the name: $[Co(NH_3)_4Cl_2]^+$

Since there are 6 ligands around the Co(III), the shape will be octahedral and we can draw the two isomers.



trans-tetraaquadichlorocobalt(III)



cis-tetraaquadichlorocobalt(III)

The left isomer is the trans isomer because the Cl atoms are directly across from each other.

The right isomer is the cis isomer because the Cl atoms are adjacent each other.

(We need not designate the configuration of the 4 H_2O ligands because there is only one way to arrange them once we designate the 2 Cl ligands as cis or trans.)

* These are the only two isomers that can exist for a complex ion with the general formula MA_4B_2.

PRACTICE PROBLEM 2

Triamminetriaquairon(II) exists as a *fac* and a *mer* isomer. Draw and label both isomers.

— answer —

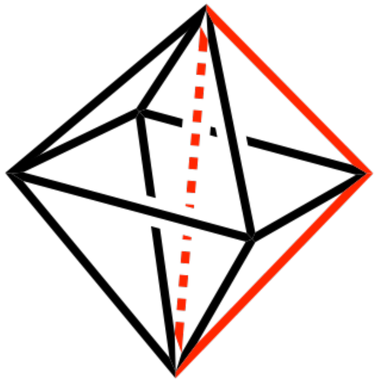
PRACTICE PROBLEM 2

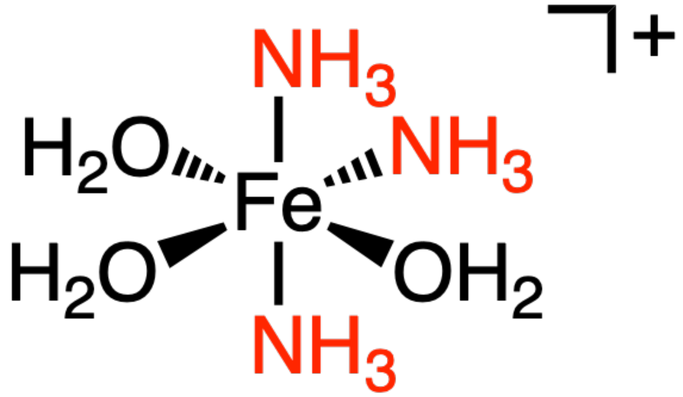
Triamminetriaquairon(II) exists as a *fac* and a *mer* isomer. Draw and label both isomers.

– answer –

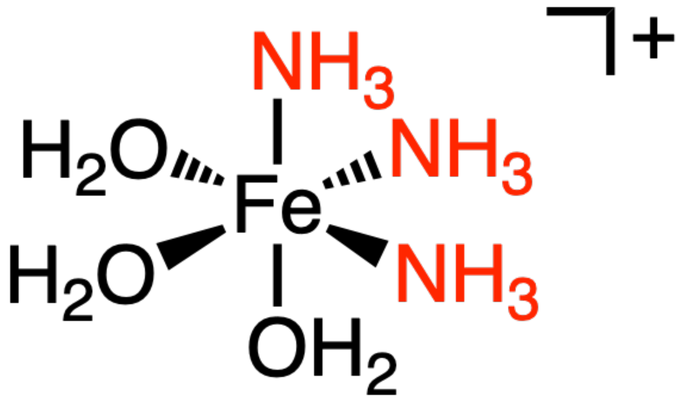
First, write out the chemical formula based on the name: $[Fe(NH_3)_3(H_2O)_3]^{2+}$

Since there are 6 ligands around the Fe(II), the shape will be octahedral and we can draw the two isomers.

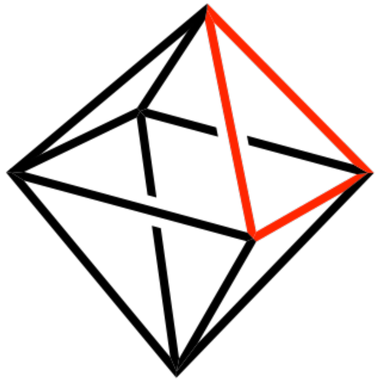




mer-triamminetriaquairon(II)



fac-triamminetriaquairon(II)



The left isomer is the mer isomer because the NH_3 ligands lie in a plane that cuts through the middle/meridian of the octahedron.

The right isomer is the fac isomer because the NH_3 ligands lie in a plane on the face of the octahedron.

(We need not designate the configuration of the 3 H_2O ligands because there is only one way to arrange them once we designate the 3 NH_3 ligands as fac or mer.)

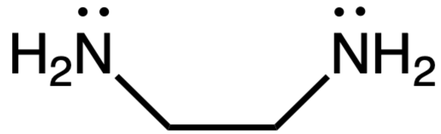
* These are the only two isomers that can exist for a complex ion with the general formula MA_3B_3.

PRACTICE PROBLEM 3

When the ligands in a complex ion are polydentate, the complex ion can exhibit stereoisomerism. $[Co(en)_2Cl_2]^+$ exists as a *cis* and a *trans* isomer, but the *cis* isomer exhibits stereoisomerism. Draw the enantiomer of the *cis* isomer.

— answer —

The ligand en is an abbreviation for ethylenediamine, which is a bidentate ligand with this structure:



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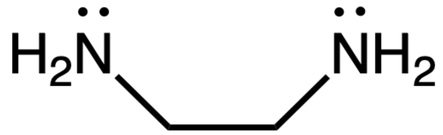
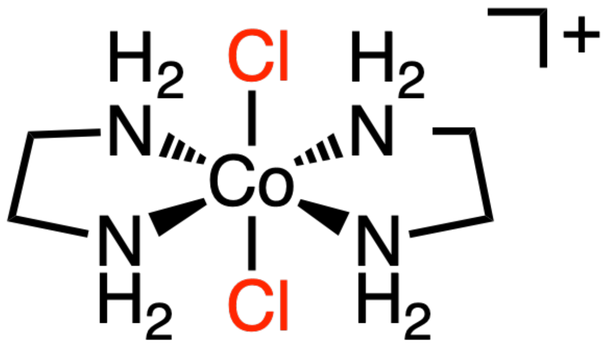


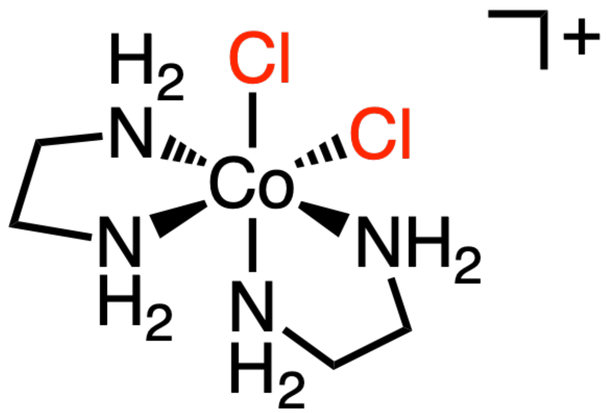
Because the en ligand "bites" in two places on the Co, the shape of the complex is octahedral.

First, draw the *trans* (left) and *cis* (right) isomers.

Then, draw the mirror image of the *cis* isomer.

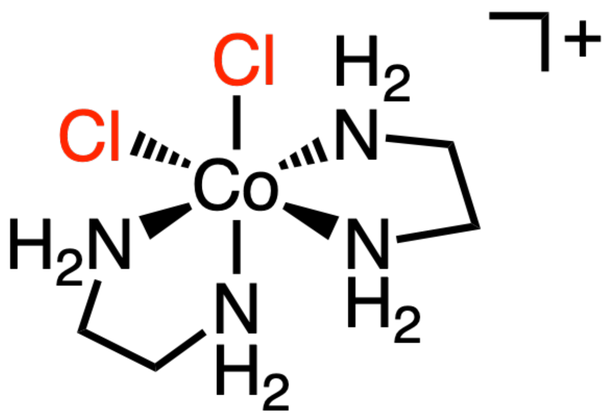


trans isomer



cis isomer

mirror plane



enantiomer of cis isomer

The enantiomer of the *cis* isomer is a mirror image of the *cis* isomer that is non-superimposable onto the *cis* isomer.

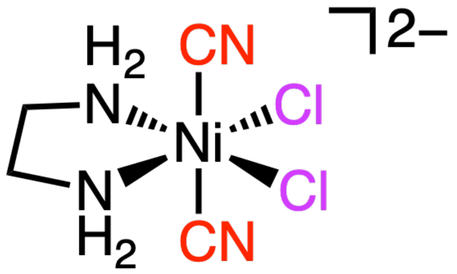
(If you drew the mirror image of the trans isomer, it would be superimposable onto the trans isomer; hence, no enantiomer exists.)

PRACTICE PROBLEM 4

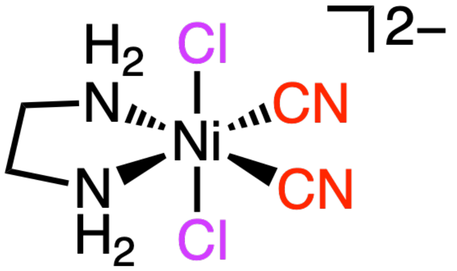
Dichlorodicyanoethylenediaminenickelate(II) can exist as the three geometric isomers shown below.

Do any of these structures have enantiomers (i.e., are any chiral)?

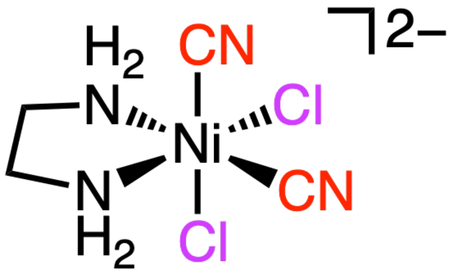
— answer —



cis-dichloro-*trans*-dicyano



trans-dichloro-*cis*-dicyano



cis-dichloro-*cis*-dicyano

PRACTICE PROBLEM 4

Dichlorodicyanoethylenediaminenickelate(II) can exist as the three geometric isomers shown below.

Do any of these structures have enantiomers (i.e., are any chiral)?

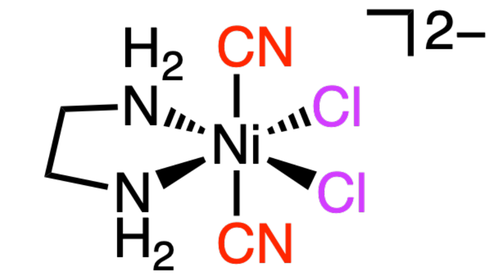
– answer –

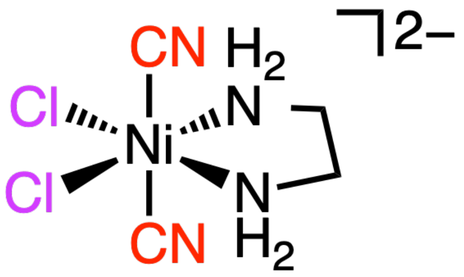
Begin by drawing the mirror image of each of the isomers shown.

Now, convince yourself that the mirror image of each of the first two sets of isomers drawn is superimposable onto the corresponding isomer itself.

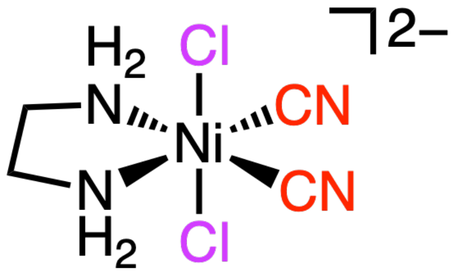
Only the last isomer is chiral and has an enantiomer (non-superimposable mirror image).

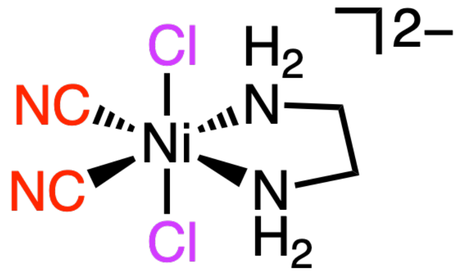
mirror plane



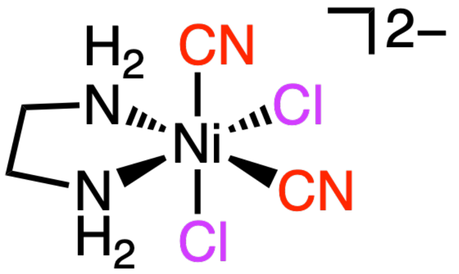


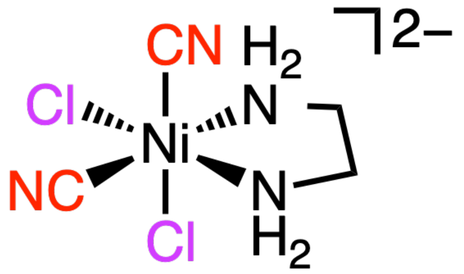
cis-dichloro-*trans*-dicyano





trans-dichloro-*cis*-dicyano





cis-dichloro-*cis*-dicyano