Answers to Exercise 12.3
Isomers

The easiest way to approach this question is to look for relationships (e.g. bond angles) between the ligands. That helps prevent you from drawing the same isomer in different orientations.

e.g. *In (b), it is possible for Br to be opposite I or for Br to be opposite Cl.*

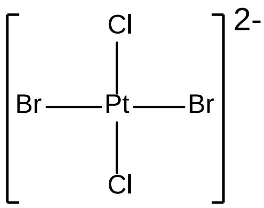
If Br is opposite I then the two Cl are also opposite, and the Br-Pt-Cl and I-Pt-Cl bond angles are both ~90˚.

If Br is opposite Cl then I is opposite the other Cl, and the Cl-Pt-Cl and Br-Pt-I bond angles are both ~90˚.

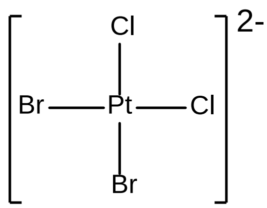
There is no way to draw square planar $[PtBrCl_2I]^{2-}$ *that does not meet one of those two descriptions. If you build a model of square planar* $[PtBrCl_2I]^{2-}$*, it will be possible to flip and/or rotate it (without breaking any bonds) so that it perfectly matches one of the two answers shown. (Toothpicks and jujubes make good "model kits" for this exercise.)*

Answers to questions 1 and 2 are presented together.

(a)

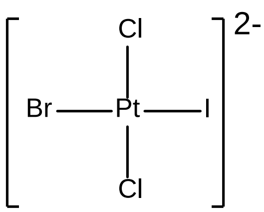


trans

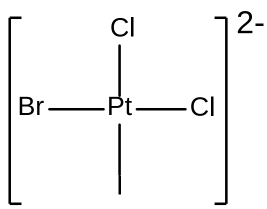


cis

(b)



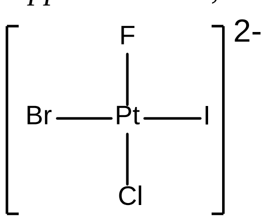
trans

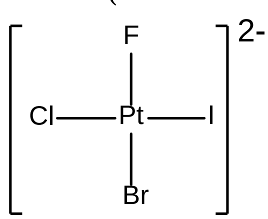


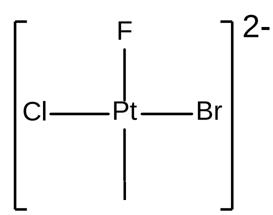
cis

For cis/trans, look at the relationship between the two ligands that are the same as each other (in this case, the two Cl). If they are on the "same side", the complex is cis (Cl-Pt-Cl is ~90˚). If they are on "opposite sides", the complex is trans (Cl-Pt-Cl is ~180˚).

(c)

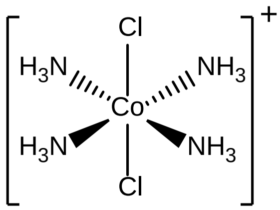


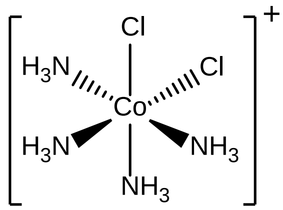




Because no two ligands are the same, the terms cis and trans do not apply (nor do fac and mer).

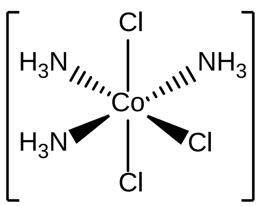
Key relationships to look for: What is opposite F? What is opposite Cl? What is opposite Br? What is opposite I?

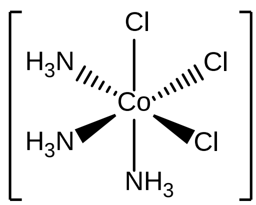
(d) 



trans *cis*

For cis/trans, look at the relationship between the two ligands that are the same as each other (in this case, the two Cl). If they are on the "same side", the complex is cis (Cl-Co-Cl is ~90˚). If they are on "opposite sides", the complex is trans (Cl-Co-Cl is ~180˚).

(e) 



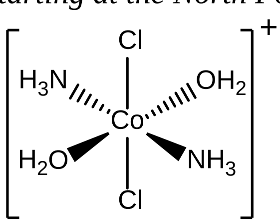
mer *fac*

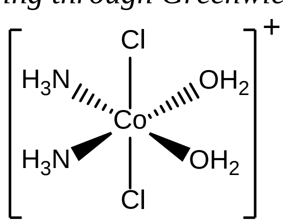
For fac/mer, look at the relationship between the three ligands that are the same as each other. In this case, you can either look at the three Cl or the three NH_3.

Recall that the term "octahedral" refers to the fact that the six ligands can each be imagined to be the corners of an octahedron ("8 sided dice") with the transition metal in the middle.

In the fac complex, the three Cl are all on the same "face" of the octahedron. Thus, all Cl-Co-Cl angles are ~90˚.

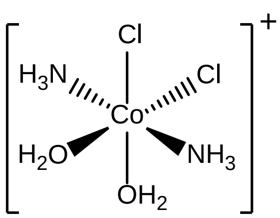
In the mer complex, the three Cl all fall along a "meridian" around the octahedron. Thus, one of the Cl-Co-Cl angles is 180˚. Recall geography class: the Prime Meridian is a line around the Earth starting at the North Pole, going through Greenwich and ending at the South Pole.

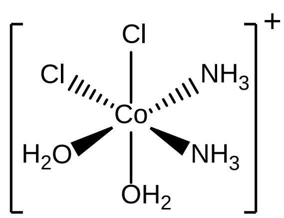
(f) 



Cl opposite Cl

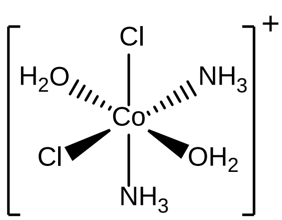
- *N-Co-N angles ~180˚, or*
- *N-Co-N angles ~90˚*

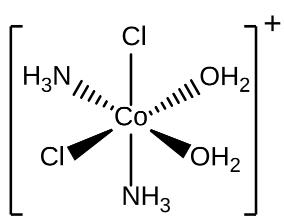




Cl opposite OH_2

- *N-Co-N angles ~180˚, or*
- *N-Co-N angles ~90˚*





Cl opposite NH_3

- *O-Co-O angles ~180˚, or*
- *O-Co-O angles ~90˚*

Some of the complexes in (f) also have mirror images which cannot be superimposed upon them regardless of how much you rotate/flip the model. That's a different kind of isomerism (chirality; enantiomers) that will be discussed in CHEM 2000. "Geometric isomers" have different angles.