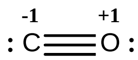
Answers to Exercise 12.1
Ligands

1.

(a)

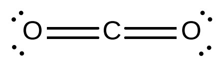


C can co-ordinate to a transition metal via its lone pair *(C^- is a better Lewis base than O^+)*

CO is a monodentate ligand

six CO are required to make an octahedral complex

(b)

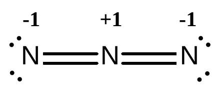


one of the O can co-ordinate to a transition metal via one of its lone pairs
(since CO_2 is linear, both O cannot reach the same cation at the same time)

$\mathrm{CO_2}$ is a monodentate ligand

six $\mathrm{CO_2}$ are required to make an octahedral complex

(c)

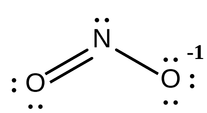


one of the terminal N can co-ordinate to a transition metal via one of its lone pairs
(since N_3^- is linear, both N cannot reach the same cation at the same time)

$\mathrm{N_3^-}$ is a monodentate ligand

six $\mathrm{N_3^-}$ are required to make an octahedral complex

(d)



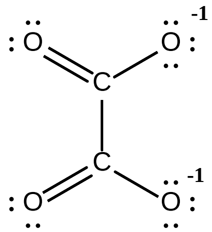
three different ways to co-ordinate to a single transition metal:

- one of the terminal O can co-ordinate to a transition metal via one of its lone pairs
- *both* terminal O can co-ordinate to a transition metal via one lone pair each
  (since NO_2^- is bent, both O can reach the same cation at the same time)
- the N can co-ordinate to a transition metal via its lone pair

$\mathrm{NO_2^-}$ can act as either a monodentate (first and third options in list above) *or* bidentate ligand (second option in list above)

six $\mathrm{NO_2^-}$ are required to make an octahedral complex when it acts as a monodentate ligand; three $\mathrm{NO_2^-}$ are required to make an octahedral complex when it acts as a bidentate ligand.

(e)



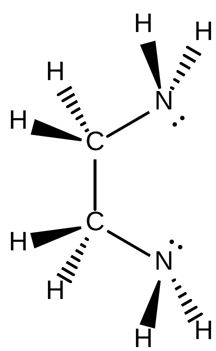
two O (one attached to each C) can co-ordinate to a transition metal via one lone pair each
(the geometry of $C_2O_4^{2-}$ allows two O to reach the same cation at the same time)

$C_2O_4^{2-}$ usually acts as a bidentate ligand (as described above)

(given the geometry of this ligand, if one O is close enough to a transition metal cation to co-ordinate to it, one of the O attached to the other C will also be very close to the transition metal cation)

three $C_2O_4^{2-}$ are required to make an octahedral complex

(f)



*It's not the end of the world if your diagram doesn't look *exactly* like this.*

What must be the same:

- *connectivity (which atoms are attached to which),*
- *lone pairs on N,*
- *both C are tetrahedral (wedge and dashed wedge must be next to each other; if there is a line between them, that signifies square planar geometry)*
- *both N are trigonal pyramidal*
- ***NO*** *90˚ angles!!!*

both N can co-ordinate to a transition metal via one lone pair each
(the geometry of $NH_2CH_2CH_2NH_2$ allows both N to reach the same cation at the same time)

$NH_2CH_2CH_2NH_2$ usually acts as a bidentate ligand (as described above)

(given the geometry of this ligand, if one N is close enough to a transition metal cation to co-ordinate to it, the other N can also rotate to be very close to the transition metal cation)

three $NH_2CH_2CH_2NH_2$ are required to make an octahedral complex