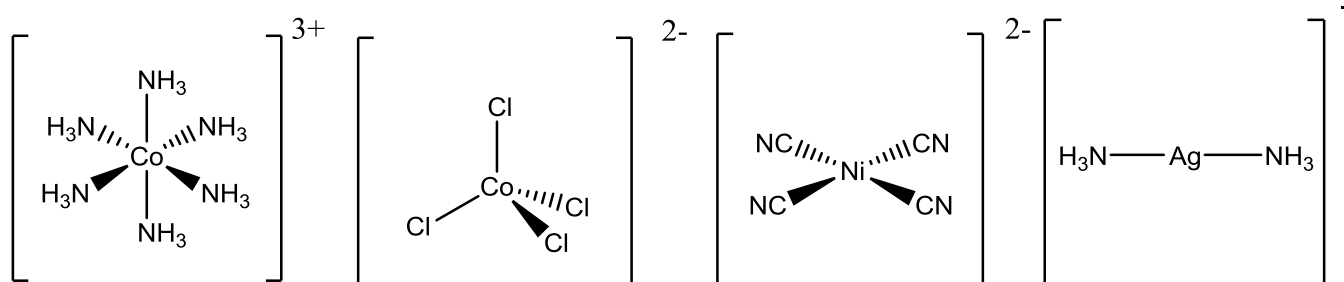
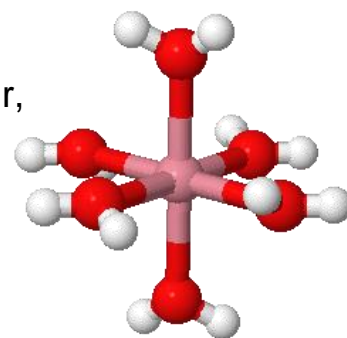


G16- Transition Metals and Ligands

The bonding in transition metal complex is called coordinate bonding/dative covalent bonding. This is similar to normal covalent bonding except both electrons are donated from one species. A ligand can be defined as a molecule with a lone pair or multiple lone pairs of electrons, which it is able to donate into empty orbitals of a transition metals. This forms a transition metal complex or complex ion. The most common examples of ligands are H_2O , NH_3 , CN^- , CO and OH^- . The bonding between ligands and metals can occur in both ions and neutral atoms, as long as empty orbitals on the metal can be filled. A ligand complex can usually be identified by square brackets, so the molecule in the box below would be written as $[\text{Co}(\text{H}_2\text{O})_6]$.

For an example of a complex, search for DIJSIZ and observe its structure. For some entries in WebCSD, the bonds are rather different to the standard double and single bond on the basis that they are weaker, and indeed, if you measure the bond lengths of any single C-C bonds and Co-O, the latter bonds are much longer, which usually indicates less strength. It is often the case that ligands form weak bonds and are labile (easily changed). However, some ligands and metals will form shorter bonds and be much stronger. The strength/length of the bond is dependent on many factors due to the type of metal and ligand.

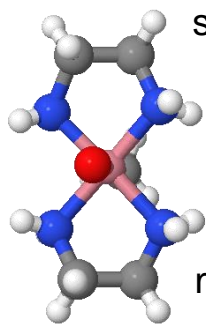


Transition metal complexes form a variety of shapes, the most common of these being octa

hedral, square planar, tetrahedral and linear complexes (see above). However, there are many other types of shapes that transition metal complexes can form (See the VSEPR exercises for shape examples).

G6- Transition Metals and Ligands

The previous ligands shown can only bind once with one metal orbital, but there are some ligands which can bind twice or multiple times with the same transition metal. These can be split into categories – the monodentate/unidentate (molecule binds once), bidentate (the same molecule binds twice) and multidentate (the same molecule binds multiple times). Take for example the compound on the left which has two 1,2-diaminoethane ($\text{NH}_2\text{-CH}_2\text{-CH}_2\text{-NH}_2$) ligands with two bonds each to the transition metal centre. The ligand is bonded twice to the metal by lone pairs on the two nitrogen atoms, which are joined in the same molecule. This means that it is a bidentate ligand. This pattern can be continued from monodentate all the way up to hexadentate and beyond.



Activity

1. Identify the complex ions in the following structures as either Octahedral, Tetrahedral, Square Planar or Linear: AJETIS, CEIMPT, YAXXAW.
2. What example of ligand bonding (Unidentane, bidentane etc) do the following structures have: ACABRH02, ABIFUM, ABUZAY.

Answers

1a) Tetrahedral. 1b) Square planar. 1c) Octahedral.

2a) Unidentate and Didentate. 2b) Tridentate and Monodentate. 2c) Quadridentate and Monodentate.