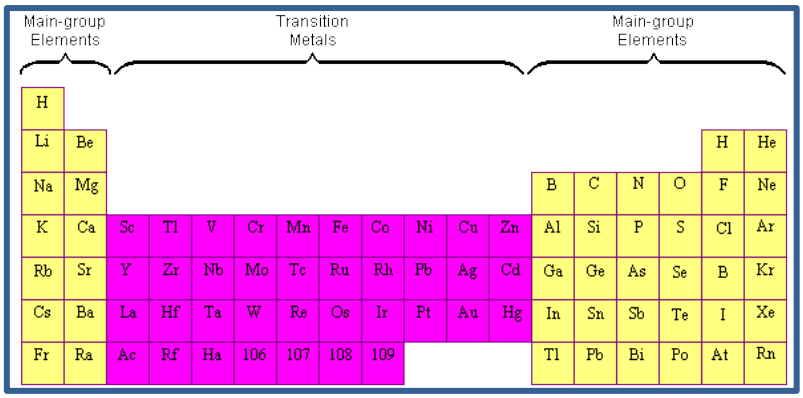
G1-Transition Metals: An Introduction

A transition metal is defined as having **incomplete d-orbitals**. They also form one or more **stable** ions. All transition metals are found in the centre of the periodic table. They encompass groups 3 to 12, as shown.

In general, transition metals:

- Form coloured compounds
- Have varying oxidation states (numbers)
- Form complexes with ligands
- Have catalytic functions



http://chemed.chem.purdue.edu/genchem/topicreview/bp/ch12/graphics/12_1.gif (04/08/14)

At A Level, you only need to know about: Titanium (**Ti**), Vanadium (**V**), Chromium (**Cr**), Manganese (**Mn**), Iron (**Fe**), Cobalt (**Co**), Nickel (**Ni**) and Copper (**Cu**)

Transition Metal Complexes

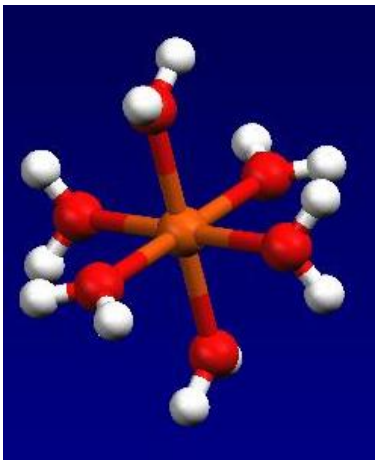
A special property of transition metals, making them very useful in Biology and Chemistry, is the formation of complexes. A **complex** contains a metal ion in the centre, with other molecules surrounding it. The attached substances are known as **ligands**. They attach via dative covalent bonding, with the ligand providing **both** electrons for the bond. Ligands must therefore be either **negatively charged** or contain an electron **lone pair**.

Some common ligands are: OH^- NH_3 CO

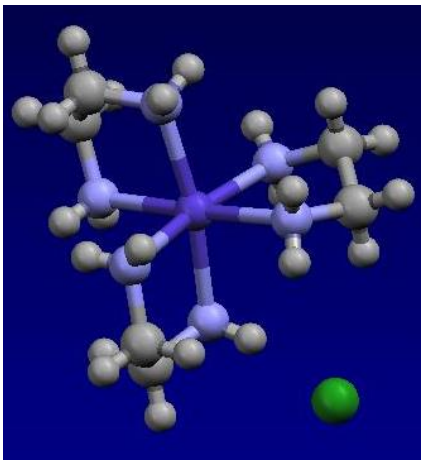
Depending on the ligand, they can attach to the central metal in one of several ways, as follows:

- **Unidentate/Monodentate** (by one atom), e.g. Cl^-
- **Bidentate** (by two atoms), e.g. $NH_2CH_2CH_2NH_2$ by both nitrogen atoms
- **Multidentate/Polydentate** (by many atoms), e.g. $EDTA^{4-}$

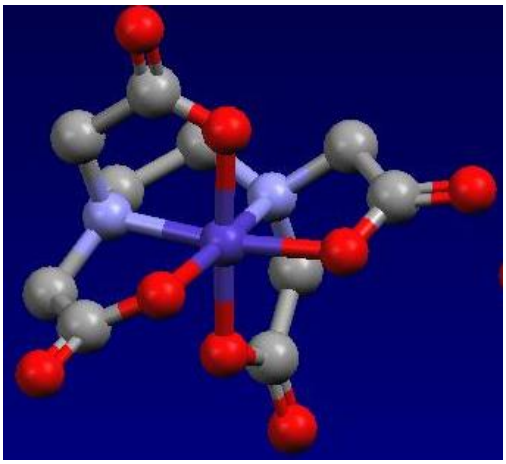
Some examples of ligands seen at A Level are shown below:



An iron complex containing 6 **unidentate** water ligands, $[Fe(H_2O)_6]^{2+}$
All ligands are bound by an O atom
CSD Refcode: AMITAR



A nickel complex containing 3 **bidentate** ligands, $[Ni(H_2NCH_2CH_2NH_2)_3]^{2+}$
All ligands are bound by a N atom
CSD Refcode: IDULOK



A cobalt complex containing 1 **multidentate** ligand, [Co(EDTA)]
Ligands are bound by either N or O atoms
CSD Refcode: AETACO

Produced by Aaron Bourne as part of a summer outreach project

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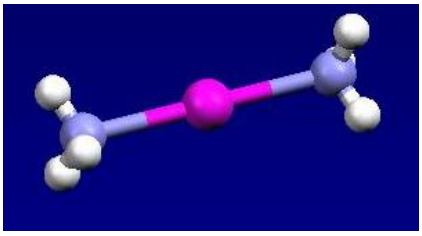
Complex Shapes (Geometries)

Metal complexes can be many different shapes when looked at in 3-D. This is known as their geometry. The geometry of a transition metal complex depends on the number of **bonds** (not ligands) to the central metal. The shapes that you will encounter during your A Level studies are:

- **Octahedral** when 6 ligands are attached to the central metal
- **Tetrahedral** when 4 large ligands are attached to the central metal
- **Square planar** when 4 ligands are attached to the central metal (sometimes occurs)
- **Linear** when 2 ligands are attached to the central metal

Examples of these are shown below:



Linear

When only two ligands are attached to the central metal, they align at 180° from each other, as shown in this silver and ammonia complex.

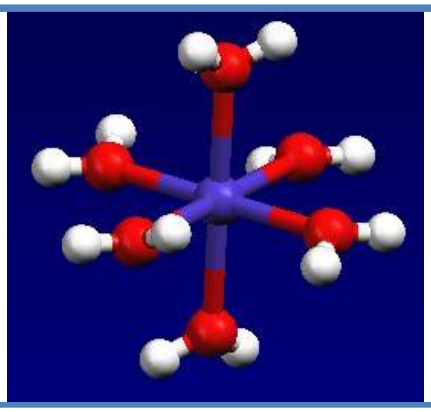
CSD Refcode: AWEGOZ

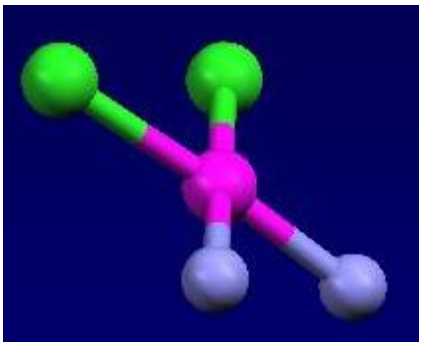
Octahedral

By far the most common geometry of complexes is octahedral (meaning '8 faces'). In this case, there are 6 atoms around the central metal. These are arranged in two planes, as shown in this copper and water complex. All bond angles here are 90°.

Octahedral complexes can also form isomers. This, however, only occurs wheneithyer bidentate or multidentate ligands. (See extension theory sheet)

CSD Refcode: DIJSIZ





Square planar

Square planar complexes have 4 ligands attached to a central metal, all in one plane. These ligands are all at 90° to each other. The compound shown is *cis*-platin – a platinum centre containing two NH_3 groups and two Cl atoms. *Cis*-platin is an important drug used in anti-cancer therapy.

CSD Refcode: CUKRAB01

Tetrahedral

Like with elemental carbon atoms, the ligands are attached at 109.5° to each other. Generally, larger ligands attach in this way as they can attach far apart from each other. This complex has a copper centre with four external chlorine atoms.

CSD Refcode: MADPAK01