# Definitions and Concepts for Edexcel Chemistry A-level

## Topic 15: Transition Metals

**Transition metals:** *d*-block elements that form one or more stable ions with incompletely filled *d* orbitals.

**Colours in transition metal complexes:** Have their origin in electronic transitions. A complex containing a transition metal ion with incompletely filled *d* orbitals will have the set of *d* orbitals split into two sets of orbitals of different energies. An electron can be excited from a lower energy level to a higher energy level by absorbing some energy. The amount of energy needed depends on the energy difference between the two energy levels. This energy difference is proportional to the frequency of the absorbed light (and hence inversely proportional to the wavelength of the absorbed light). This tells us what is the colour of the radiation absorbed. By looking at the electromagnetic spectrum and complimentary colours, we can deduce the colour that is transmitted (e.g. yellow absorbed, violet transmitted).

**Complex ion:** A central metal cation surrounded by ligands, e.g. $Cu(H_2O)_6^{2+}$.

**Ligand**: Atom, ion or molecule that donates a pair of electrons to a central metal ion, e.g. $H_2NCH_2CH_2NH_2$ (called *en* - *ethylenediamine*)

**Square planar shape:** Sometimes molecules display square planar geometry around the central atom. This could be due to the presence of the lone pairs ($XeF_4$), or *d* orbitals ($Pt(NH_3)_2Cl_2$ - also displays cis/trans isomerism).

**Cisplatin**: $Pt(NH_3)_2Cl_2$ with *cis* geometry. An anticancer compound that binds to the two strands of DNA during cell division process. This prevents them from separating and hence stops the cell division. On the other hand, the *trans* isomer is not useful.

**Denticity:** Describes how many dative bonds a ligand can form. *Monodentate* ligand (e.g. $NH_3$) forms one. *Bidentate* (e.g. $C_2O_4^{2-}$) forms two, etc. In general, *multidentate* ligands have more than one electron pair to donate to the metal centre.

***Charge of the complex ion = Oxidation number of the metal + Total charge from ligands***

*e.g. in $K_4[Fe(CN)_6]$, the charge of the complex ion is 4–, as the whole molecule is electrically neutral and 4 potassium cations contribute a total charge of 4+. The 6 cyanide ligands contribute a total charge of –6. To find the oxidation number of the metal, we can write:*

***$-4 = x + (-6)$, i.e. $x = 2$, so the oxidation number of iron in this complex is +II***

**Coordination number:** Number of dative covalent bonds that ligands form with the central metal ion. Common coordination numbers are 2 (linear, e.g. $Ag(NH_3)_2^+$), 4 (tetrahedral, e.g. $CuCl_4^{2-}$ and square planar, e.g. *cisplatin*), and 6 (octahedral, e.g. $Cr(H_2O)_6^{3+}$).

**Ligand exchange:** A reaction in which a ligand is substituted by another ligand.

$$\text{e.g. } Cr(H_2O)_6^{3+} + 3\,en \rightarrow Cr(en)_3^{3+} + 6H_2O$$

*This bit contains important considerations on entropy change for a ligand exchange reaction. Comparing the number of molecules on both sides (4 left hand side vs 7 right hand side, greater* *disorder on the product side) allows us to predict a positive value of* $\Delta S_{system}$ *of this reaction. The equilibrium lies heavily to the right in this case.*

**Adsorption:** The process of forming weak bonds by reactants to a surface of a solid catalyst. In hydrogenation (heterogeneous catalysis), gases (alkene and hydrogen) adsorb on the surface of solid nickel, where the reaction takes place.

**Desorption:** The reverse process to adsorption. Adsorbed molecules leave the surface.

**Autocatalysis:** When a product catalyses the reaction, e.g. $Mn^{2+}$ in oxidation of oxalate with permanganate under acidic conditions.

**Haemoglobin:** A protein responsible for oxygen transport in human blood. Contains an $Fe^{2+}$ site. Four haem groups (made of N,C, and H atoms) bind to iron (II) in a square planar fashion *via* a coordinate bond from nitrogens' lone pairs. Fifth bond is made from protein part (globin) to the iron (II) centre. Sixth site (this now adds up to the octahedral geometry) can be occupied by an oxygen molecule - one of the O's acts as a ligand. The process of $O_2$ binding is reversible. On the other hand, the process of binding CO is irreversible - that's why the carbon monoxide is dangerous. CO can easily replace $O_2$ at the iron (II) site *via* a ligand exchange reaction.