

Unit 17 Transition Metals Part One (Paper 1 & 3)

17.1 General properties of transition metals

Transition metal characteristics of elements Ti–Cu arise from an incomplete d sub-level in atoms or ions.

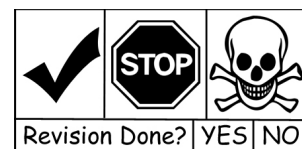
The characteristic properties include:

- complex formation
- formation of coloured ions
- variable oxidation state
- catalytic activity.

A ligand is a molecule or ion that forms a co-ordinate bond with a transition metal by donating a pair of electrons.

A complex is a central metal atom or ion surrounded by ligands.

Co-ordination number is number of co-ordinate bonds to the central metal atom or ion.



17.2 Ligand Substitution reactions

H₂O, NH₃ and Cl⁻ can act as monodentate ligands.

The ligands NH₃ and H₂O are similar in size and are uncharged.

Exchange of the ligands NH₃ and H₂O occurs without change of co-ordination number (eg Co²⁺ and Cu²⁺).

Substitution may be incomplete (eg the formation of [Cu(NH₃)₄(H₂O)₂]²⁺).

The Cl⁻ ligand is larger than the uncharged ligands NH₃ and H₂O

Exchange of the ligand H₂O by Cl⁻ can involve a change of co-ordination number (eg Co²⁺, Cu²⁺ and Fe³⁺).

Ligands can be bidentate (eg H₂NCH₂CH₂NH₂ and C₂O₄²⁻).

Ligands can be multidentate (eg EDTA⁴⁻).

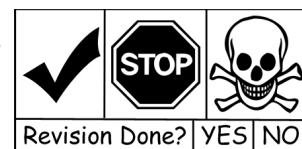
Haem is an iron(II) complex with a multidentate ligand.

Oxygen forms a co-ordinate bond to Fe(II) in haemoglobin, enabling oxygen to be transported in the blood.

Carbon monoxide is toxic because it replaces oxygen co-ordinately bonded to Fe(II) in haemoglobin.

Bidentate and multidentate ligands replace monodentate ligands from complexes. This is called the chelate effect.

You should be able to: explain the chelate effect, in terms of the balance between the entropy and enthalpy change in these reactions.



17.3 Shapes of complex ions

Transition metal ions commonly form octahedral complexes with small ligands (eg H₂O and NH₃).

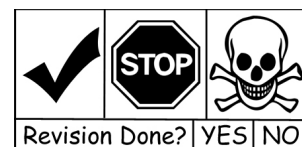
Octahedral complexes can display cis–trans isomerism (a special case of E–Z isomerism) with monodentate ligands and optical isomerism with bidentate ligands.

Transition metal ions commonly form tetrahedral complexes with larger ligands (eg Cl⁻).

Square planar complexes are also formed and can display cis–trans isomerism.

Cisplatin is the cis isomer.

Ag⁺ forms the linear complex [Ag(NH₃)₂]⁺ as used in Tollens' reagent.



17.4 Variable oxidation states

Transition elements show variable oxidation states.

Vanadium species in oxidation states IV, III and II are formed by the reduction of vanadate(V) ions by zinc in acidic solution.

The redox potential for a transition metal ion changing from a higher to a lower oxidation state is influenced by pH and by the ligand.

The reduction of [Ag(NH₃)₂]⁺ (Tollens' reagent) to metallic silver is used to distinguish between aldehydes and ketones.

The redox titrations of Fe²⁺ and C₂O₄²⁻ with MnO₄⁴⁻

You should be able to: perform calculations for these titrations and similar redox reactions.

