CAIE Chemistry A-level

28: Chemistry of Transition Metals

(A-level only)

Definitions

Definitions and Concepts for CAIE Chemistry A-level

Chemistry of Transition Elements

Bidentate ligand: Ligands that can form two dative covalent (coordinate) bonds with a metal ion/metal.

Cahn-Ingold-Prelog (CIP) priority rules: A set of rules used to identify whether a stereoisomer is E or Z. Atoms with a higher atomic number have a higher priority. If the highest priority substituents on the same side of the double bond (both above or below), it's the Z isomer whereas if the highest priority groups are on the opposite sides (one above and one below), it's the E isomer.

Catalyst: A substance which speeds up the rate of a reaction without being used up. They increase the rate of reaction by providing an alternative reaction pathway with a lower activation energy.

Catalytic activity of transition metals: Transition metals have variable oxidation states, allowing them to catalyse other reactions by acting as an oxidising/reducing agent.

Cis-trans isomerism: A type of E/Z isomerism in which the two substituent groups attached to the carbon atoms are the same. According to the CIP priority rules, cis isomers have the highest priority substituents on the same side of the double bond (both above or below) while trans isomers have them on the opposite sides (one above and one below).

Colours in transition metal complexes: Colour arises when some of the wavelengths of visible light are absorbed and the remaining wavelengths of light are transmitted or reflected. The d-orbital electrons move from the ground state to an excited state when light is absorbed.

Complex ion: An ion which has a central metal atom (typically a transition element) surrounded by ligands. The ligands are bound to the transition metal centre by dative coordinate bonds.

Coordination number: The number of dative covalent bonds formed with the central metal ion.

d-block: The section of the periodic table in which the elements have their highest energy electron in a d-orbital.

Dative covalent (coordinate) bond: A type of covalent bond in which one bonding atom provides both electrons in the bonding pair.

Degenerate orbitals: Orbitals of the same energy.

Feasible reaction: For a reaction to be feasible at a given temperature it must occur spontaneously. This means no extra energy is required for the reaction to occur.

Geometric isomerism: A type of stereoisomerism that occurs due to the restricted rotation around the carbon double bond. This results in two different groups on either end of the double bond. If the highest priority groups for each carbon are found on the same side of the molecule, then it is the Z-isomer. If the highest priority groups for each carbon are found on opposite sides of the molecule, then it is the E-isomer.

Ligand: An atom, ion or molecule that forms a coordinate bond with a central transition metal ion by donating a pair of electrons.

Ligand exchange: A reaction in which one ligand in a transition metal complex is replaced by another. Typically, these reactions are associated with a colour change.

Linear: The shape of a molecule when the central atom has two bonding pairs and no lone pairs of electrons.

Monodentate ligand: Ligands that can form one dative covalent (coordinate) bond with a metal ion/metal. E.g. H_2O, Cl^- and NH_3.

Octahedral: The shape of a transition metal complex with a coordination number of 6 and a bond angle of 90^o. E.g. $[Cu(H_2O)_6]^{2+}$.

Optical isomerism: A type of stereoisomerism present in compounds that are non-superimposable mirror images of one another caused by the presence of a chiral centre. They have the same molecular formula with different arrangements of atoms in space.

Oxidation state: The charge of an ion or a theoretical charge of an atom in a covalently bonded compound assuming the bond becomes ionic.

Polydentate ligand: Ligands that can form two or more dative covalent (coordinate) bonds with a metal ion/metal.

Redox reaction: A reaction in which reduction and oxidation occur simultaneously.

Splitting of d-orbitals: When a ligand bonds to a central metal ion it affects the d-orbitals differently depending on how they are arranged in space. Consequently the d-orbitals split into two sets of degenerate (same energy) orbitals; in octahedral complexes, there are two orbitals that are higher in energy and three that are lower, in tetrahedral complexes, there are three orbitals higher and two lower.

Stability constant: An equilibrium constant that indicates the strength of interactions during the formation of a complex in solution.

Stereoisomers: Two or more molecules with the same molecular and structural formula that only differ in their spatial arrangement of atoms.

Square planar: One of the possible shapes of a transition metal complex with a coordination number of 4 and a bond angle of 90°. Platinum and nickel complexes form square planar complexes. E.g, $Pt(NH_3)_2Cl_2$.

Tetrahedral: One of the possible shapes of a transition metal complex with a coordination number of 4 and a bond angle of 109.5°. E.g. $CuCl_4^{2-}$.

Transition metal elements: d-block elements that can form one or more stable ions with an incomplete d-subshell. Transition elements have more than one oxidation state, form coloured ions and can often act as catalysts.

Variable oxidation states: Transition metals have incomplete d-subshells meaning they can have variable oxidation states. This is due to the 4s and 3d subshells being similar in energies.