



# OCR (B) Chemistry A-level

## Storyline 10: Colour by Design

### Definitions and Concepts

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## Definitions and Concepts for OCR (B) Chemistry A-level

### Colour by Design

#### Bonding and Structure

**Chromophore:** An atom or group of atoms whose presence causes a compound to be a given colour.

**Covalent bond:** The strong electrostatic attraction between two nuclei and the shared pair of electrons between them. Polar covalent bonds occur when there is an asymmetric electron distribution within the covalent bond due to differences in electronegativities.

**Dye:** An often synthetic substance that is used to change the colour of something.

**Functional group:** An atom/group of atoms responsible for the characteristic reactions of a compound.

**Hydrogen bonding:** An interaction between a hydrogen atom and an electronegative atom, commonly nitrogen, fluorine or oxygen. The slightly positive hydrogen is attracted to the lone pair on the electronegative atom. Hydrogen bonds are stronger than van der Waals and dipole-dipole forces but weaker than ionic and covalent bonds.

**Intermolecular forces:** The forces which exist between molecules. The strength of the intermolecular forces impacts physical properties like boiling/melting point.

**Ionic bond:** Strong electrostatic attraction between two oppositely charged ions. The strength of attraction depends on the relative sizes and charges of ions.

**Permanent dipole-dipole forces:** When molecules with polar covalent bonds interact with dipoles in other molecules, dipole-dipole intermolecular forces are produced between the molecules. These intermolecular forces are generally stronger than van der Waals forces but weaker than hydrogen bonding.

**Solubility:** The ability of a given substance to dissolve in a solvent.

**Van der Waals:** Also known as induced dipole–dipole, dispersion and London forces, van der Waals forces exist between all molecules. They arise due to fluctuations of electron density within a nonpolar molecule. These fluctuations may temporarily cause an uneven electron distribution, producing an instantaneous dipole. This dipole can induce a dipole in another molecule, and so on.





## Organic Functional Groups

**Aromatic compound/Arene:** A compound containing at least one benzene ring.

**Benzene:** A 6 membered carbon ring ( $C_6H_6$ ) containing a delocalised  $\pi$  system. Benzene has a planar structure and an intermediate bond length between a single and double bond. Delocalisation of the p electrons into the  $\pi$  system makes benzene more stable than expected.

**Delocalised electrons:** Electrons that are not fixed within a single atom or a covalent bond.

**Enthalpy of hydrogenation:** The enthalpy change that takes place when one mole of an unsaturated compound reacts completely with hydrogen to form a saturated compound. Comparing the enthalpy of hydrogenation of benzene with that of the theoretical molecule cyclohexa-1,3,5-triene shows that benzene is more thermodynamically stable as more energy is needed to hydrogenate benzene.

**Ester:** A compound containing the  $R-COO-R'$  functional group (where R and R' are alkyl groups).

**Hydrogenation:** A reaction between  $H_2$  and another substance, this often reduces or saturates a compound. These reactions usually require a catalyst like nickel.

**Unsaturated:** Hydrocarbons that contain at least one carbon-carbon double bond which consists of a  $\sigma$  bond and a  $\pi$  bond.

## Organic Reactions

**Aldehyde:** A compound containing the  $-CHO$  functional group at the end of an alkyl chain. Aldehydes can be oxidised to carboxylic acids by heating them under reflux with  $Cr_2O_7^{2-}/H^+$ .

**Azo dyes:** Used as dyes for textiles, they contain the functional group  $R-N=N-R'$ , where R and R' are usually aromatic.

**Carbonyl:** The  $C=O$  functional group. Aldehydes and ketones are carbonyl compounds.

**Diazonium compounds:** Compounds with the functional group  $R-N_2^+ X^-$ .

**Electrophile:** A species that can accept electrons in a reaction, to form a chemical bond. Electrophiles are attracted to areas with a lot of electrons/high negative charge.



**Electrophilic substitution:** A reaction in which an electrophile replaces an atom/group of atoms in a compound.

**Fehling's reagent:** A solution used to distinguish between aldehydes and ketones. When heated in Fehling's solution an aldehyde is oxidised and forms a brick red solution whereas a ketone is not oxidised and the solution remains blue.

**Friedel-Crafts acylation:** An important synthetic reaction involving an electrophilic aromatic substitution reaction between benzene and acyl chlorides or anhydrides used to form monoacylated benzene rings.  $\text{AlCl}_3$  is used as a catalyst.

**Friedel-Crafts alkylation:** An important synthetic reaction involving an electrophilic aromatic substitution reaction between benzene, a haloalkane and aluminium chloride.

**Halogenation:** A reaction which involves the addition of a halogen.

**Ketone:** A compound containing the  $\text{C}=\text{O}$  functional group within an alkyl chain. Ketones cannot be oxidised further.

**Nitration:** A reaction which involves the addition of a nitro group.

**Oxidation:** Process involving the loss of electrons. Results in an increase in oxidation number.

**Reflux:** The continual boiling and condensing of a reaction mixture. This technique is often used to make sure a volatile liquid reaches a high enough temperature to ensure that the reaction goes to completion.

**Substitution reaction:** A reaction in which one atom/group of atoms is replaced by another atom/group of atoms.

**Sulfonation:** A reaction which involves the addition of a sulfonic acid functional group ( $\text{S}(\text{O})_2\text{OH}$ ).

**Synthesis:** The process of combining different elements and compounds to produce new molecules.

**Tollens' reagent:** Also known as ammoniacal silver nitrate, this reagent forms a silver mirror in the presence of an aldehyde and can be used to distinguish between aldehydes and ketones. An aldehyde is oxidised to a carboxylic acid while silver ions in Tollens' are reduced to silver, forming a silver mirror on the wall of the test tube.



## Reaction Mechanism

**Addition:** Joining two or more molecules together to form a larger molecule. *Hydration* is the addition of a  $\text{H}_2\text{O}$  molecule. *Halogenation* involves the addition of a halogen. *Hydrogenation* is the addition of H. *Electrophilic addition* describes all the above examples.

**Condensation:** A type of reaction where two molecules join to form a larger molecule whilst producing a small molecule as a by-product.

**Curly arrows:** In reaction mechanisms, the movement of a pair of electrons is represented by a double-headed arrow.

**Elimination:** A reaction in which a molecule loses atoms or groups of atoms to form a  $\text{C}=\text{C}$  bond.

**Hydrolysis:** A reaction in which water is used to break down a compound.

**Nucleophile:** An atom or molecule that donates an electron pair to form a covalent bond. Attracted to electron-deficient areas.

**Nucleophilic addition:** A reaction in which an electrophilic  $\pi$  bond reacts with a nucleophile, breaking the  $\pi$  bond and forming 2 new  $\sigma$  bonds. Examples include carbonyl compounds reacting with  $\text{NaBH}_4$  to form alcohols or with  $\text{HCN}$  to form hydroxynitriles.

**Oxidation:** The loss of electrons/increase in oxidation number.

**Partial charge:** An atom may have a partial charge if it is part of a polar bond; if it is more electronegative than the atom it is bonded to it will be slightly negative and if it is less electronegative it will be slightly positive.

**Reduction:** The gain of electrons/decrease in oxidation number.

**Substitution:** A reaction in which one functional group is replaced with a different functional

## Energy and Matter

**Ultra-violet:** An area of the electromagnetic spectrum that has wavelengths between 10 nm and 400 nm.





**UV absorption spectra:** Shows the transitions between electronic energy levels in the molecule being measured. The spectra also shows the relationship between the extent of delocalisation in the chromophore and the energy absorbed by the molecule.

## **Modern Analytical Techniques**

**Chromatography:** A technique used to separate and identify components in a mixture. There are several different types of chromatography, including thin layer chromatography and gas chromatography. Separation during chromatography depends on the balance between each individual compound's solubility in the mobile phase and retention by the stationary phase.

**Gas chromatography (GC):** A type of chromatography in which a column is packed with a solid (or a solid coated in a liquid) and a gas is passed through the column under pressure at high temperature. Mass spectrometry may then be used to analyse the components separated by GC.

**Mobile phase:** A substance that moves through a chromatography system to separate a mixture. This may be a gas (GC) or a liquid (TLC). The different components of the mixture have differing affinities to the mobile phase, causing them to be separated.

**Retention time:** The time taken for a sample to travel through the GC column. The recorded retention time can be compared with standards to identify the substances in the mixture.

**Stationary phase:** A substance through which the mobile phase moves in chromatography. This is typically a solid, although a solid coated in a liquid may be used in gas chromatography (GC).

