

OCR (A) Chemistry A-Level

Module 4 - Core Organic Chemistry Definitions and Concepts



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

Module 4 - Core Organic Chemistry

4.1.1 - Basic Concepts of Organic Chemistry

Alicyclic: an aliphatic compound that is arranged in non-aromatic rings (with or without side chains).

Aliphatic: a compound containing carbon and hydrogen atoms joined in straight or branched chains or in non-aromatic rings.

Alkane: a homologous series with the general formula C_nH_{2n+2} .

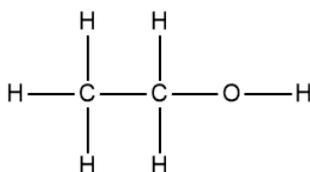
Alkyl: a group with the general formula C_nH_{2n+1} .

Aromatic: an organic compound containing a benzene ring.

Curly Arrow: shows the movement of a pair of electrons. Curly arrows must start from a bond, a lone pair of electrons or a negative charge.

Dipole: a partial charge on an atom which is caused by the differing electronegativities of atoms in a covalent bond.

Displayed Formula: the relative positions of atoms and the bonds between them. E.g. Ethanol:



Empirical Formula: the simplest whole number ratio of atoms of each element present in a compound.

Functional Group: a group of atoms responsible for the characteristic reactions of a compound.

General Formula: the simplest algebraic formula of a member of a homologous series. E.g. Alkane: C_nH_{2n+2} .

Heterolytic Fission: when a covalent bond breaks, one bonding atom receives both electrons from the bonded pair.



Homologous Series: a series of organic compounds containing the same functional group with successive members differing by $-\text{CH}_2$.

Homolytic Fission: when a covalent bond breaks, each bonding atom receives one electron from the bonding pair, forming 2 radicals.

IUPAC: International Union of Pure and Applied Chemistry.

Molecular Formula: the number and type of atoms of each element in a molecule.

Nomenclature: the naming system for compounds.

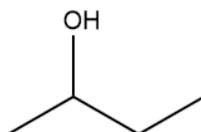
Organic Compound: a carbon-containing compound.

Radical: a species with an unpaired electron. E.g. $\text{Cl}\cdot$.

Reaction Mechanism: a series of steps that represent the overall reaction by showing the breaking and forming of bonds using curly arrows.

Saturated: an organic compound which only contains C-C single bonds.

Skeletal Formula: the simplified organic formula, shown by removing hydrogen atoms from alkyl chains, leaving the carbon skeleton and the functional groups. E.g. butan-2-ol



Structural Formula: the minimal detail that shows the arrangement of atoms in a molecule. E.g. butane: $\text{CH}_3(\text{CH}_2)_2\text{CH}_3$.

Structural Isomers: compounds with the same molecular formula but different structural formulae.

Unsaturated: an organic compound which contains at least one C=C double bond, a $\text{C}\equiv\text{C}$ triple bond or an aromatic ring.

4.1.2 - Alkanes

σ -bond: a type of covalent bond which forms when atomic orbitals overlap head-on. Sigma (σ) bonds can rotate freely.

Alkane: a homologous series with the general formula $\text{C}_n\text{H}_{2n+2}$.



Boiling point: the temperature at which a liquid boils and becomes a gas. Shorter, more branched alkanes have higher boiling points as there are weaker London forces between the molecules which require less energy to overcome.

Bond Enthalpy: the energy required to break one mole of gaseous bonds. Actual bond enthalpies may differ from the average as the average bond enthalpy considers a particular bond in a range of molecules.

Complete Combustion: when a compound is burnt in a plentiful supply of oxygen. When alkanes are completely combusted, the only products are water and carbon dioxide.

Covalent Bond: a strong bond formed between 2 atoms due to the electrostatic attraction between a shared pair of electrons and the atomic nuclei.

Electron Pair Repulsion: pairs of electrons around a nucleus repel each other so the shape that a molecule adopts has these pairs of electrons positioned as far apart as possible. As a result, carbon atoms in alkanes have a tetrahedral shape and a bond angle of 109.5° .

Homolytic Fission: when a covalent bond breaks, each bonding atom receives one electron from the bonding pair, forming 2 radicals.

Hydrocarbon: a compound which contains hydrogen and carbon atoms only.

Incomplete Combustion: when a compound is burnt in a limited supply of oxygen. When alkanes are incompletely combusted, water, carbon monoxide, particulates and some carbon dioxide may be produced.

Initiation: the first step in a radical substitution mechanism, involving the formation of the radicals.

London Forces: induced dipole-dipole interactions caused when the random movement of electrons creates a temporary dipole in one molecule which then induces a dipole in a neighbouring molecule.

Polar Bond: a covalent bond that has a permanent dipole due to the different electronegativities of the atoms that make up the bond.

Propagation: the intermediate steps in a radical substitution mechanism where a radical reacts with another species.

Radical: a species with an unpaired electron, E.g. $\text{Cl}\cdot$.

Radical Substitution: a type of substitution reaction in which a radical replaces another atom/ group of atoms in a compound. Alkanes can undergo radical substitution reactions with chlorine or bromine in the presence of UV light, forming a mixture of organic products (further substitution or reactions at different positions may occur).



Saturated: an organic compound which only contains single C-C bonds.

Termination: the final steps in a radical substitution mechanism in which 2 radicals react together to form a species which only contains paired electrons.

Tetrahedral: the shape of a molecule in which the central atom has 4 bonding pairs of electrons.

4.1.3 - Alkenes

σ -bond: a type of covalent bond which forms when atomic orbitals overlap head-on. Sigma (σ) bonds can rotate freely.

π -bond: a type of covalent bond formed when adjacent p orbitals overlap sideways above and below the bonding C atoms. Pi (π) bonds can't be rotated. As π -bonds have low bond enthalpy, alkenes are more reactive than alkanes.

Addition Polymerisation: the formation of a long chain molecule when many monomers join together (the polymer is the only product).

Addition Reaction: a reaction in which molecules combine to form a single product.

Alkene: an organic compound containing at least one C=C double bond.

Biodegradable: a substance that can be decomposed by bacteria or other living organisms.

Bond Enthalpy: the energy required to break one mole of gaseous bonds. Actual bond enthalpies may differ from the average as the average bond enthalpy considers a particular bond in a range of molecules.

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 increases the rate of a reaction without being used up.



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).

Covalent Bond: a strong bond formed between 2 atoms due to the electrostatic attraction between a shared pair of electrons and the atomic nuclei.

Electron Pair Repulsion: pairs of electrons around a nucleus repel each other so the shape that a molecule adopts has these pairs of electrons positioned as far apart as possible. As a result, carbon atoms in alkenes have a trigonal planar shape and a bond angle of 120° .

Electrophile: an electron pair acceptor.

Electrophilic addition: a reaction in which a π bond is broken and 2 new σ bonds form as a result of the addition of an electron pair acceptor (electrophile).

E/Z Isomerism: a type of stereoisomerism caused by the restricted rotation of π bonds. Two different groups must be attached to each carbon atom of the C=C group. According to the CIP priority rules, Z isomers have the highest priority substituents on the same side of the double bond (both above or below) while E isomers have them on the opposite sides (one above and one below).

Heterolytic Fission: when a covalent bond breaks, one bonding atom receives both electrons from the bonding pair, resulting in the formation of oppositely charged ions.

Hydrocarbon: a compound which contains carbon and hydrogen atoms only.

Markownikoff's Rule: used to predict what the major product of an addition reaction will be when H-X is added to an unsymmetrical alkene. H attaches to the less substituted carbon to generate the more stable carbocation intermediate.

Monomer: a small molecule that is used to form polymers.

Photodegradable: a substance that can be broken down by light.

Polymer: a large molecule made from many small units that have been bonded together.

Primary Carbocation: a molecule in which the carbon with the positive charge is only attached to one alkyl group. This is the least stable carbocation.

Repeat Unit: a structure within a polymer that appears over and over again. Joining many repeat units together would form the polymer.

Secondary Carbocation: a molecule in which the carbon with the positive charge is attached to two alkyl groups. This is more stable than a primary carbocation but less stable than a tertiary carbocation.



Stereoisomers: compounds with the same structural formula but a different arrangement of atoms in space.

Structural Formula: the minimal detail that shows the arrangement of atoms in a molecule. E.g. butane: $\text{CH}_3(\text{CH}_2)_2\text{CH}_3$.

Tertiary Carbocation: a molecule in which the carbon with the positive charge is attached to three alkyl groups. This is the most stable type of carbocation.

Trigonal Planar: the shape of a molecule in which the central atom has 3 bonding pairs of electrons.

Unsaturated: an organic compound containing at least one C=C double bond, a C≡C triple bond or an aromatic ring. The presence of a C=C double bond means that bromine water will be decolourised.

4.2.1 - Alcohols

Alcohol: an organic compound containing the OH functional group. The polarity of the OH functional group means that alcohols can form hydrogen bonds and are soluble in water (when the alkyl chain is short). In addition to this, alcohols have a relatively low volatility compared with alkanes.

Aldehyde: an organic compound containing the -CHO functional group. Aldehydes can be formed from the oxidation of primary alcohols using $\text{Cr}_2\text{O}_7^{2-}/\text{H}^+$ and distillation.

Alkene: an organic compound containing a C=C double bond. Alkenes can be formed from alcohols via the elimination of H_2O using an acid catalyst and heat.

Carboxylic Acid: an organic compound containing the -COOH functional group. Carboxylic acids can be formed from the oxidation of primary alcohols using $\text{Cr}_2\text{O}_7^{2-}/\text{H}^+$ and reflux.

Combustion: a rapid exothermic reaction of a substance with oxygen.

Elimination: a type of reaction in which 2 atoms/ groups of atoms are removed from a molecule.

Haloalkanes: an organic compound containing a halogen atom (F/ Cl/ Br/ I) bound to an alkyl chain. Haloalkanes can be formed from alcohols via a substitution reaction with halide ions in the presence of acid.

Ketone: an organic compound containing the C=O functional group in the middle of an alkyl chain. Ketones can be formed by the oxidation of a secondary alcohol.



Oxidation: the loss of electrons/ increase in oxidation number. Alcohols can be oxidised using $\text{Cr}_2\text{O}_7^{2-}/\text{H}^+$.

Oxidising Agent: a substance that can oxidise another species while being reduced.

Polar Bond: a covalent bond in which there is an unequal share of the electrons between the 2 atoms due to the differing electronegativities of the atoms involved. One atom will have a partial positive charge while the other will have a partial negative charge.

Primary Alcohol: an alcohol in which the OH is attached to a primary carbon atom (i.e. RCH_2OH). Primary alcohols can be oxidised to form either an aldehyde or a carboxylic acid, depending on the conditions.

Secondary Alcohol: an alcohol in which the OH is attached to a secondary carbon atom (i.e. R_2CHOH). Secondary alcohols can be oxidised under reflux with $\text{Cr}_2\text{O}_7^{2-}/\text{H}^+$ to form a ketone.

Tertiary Alcohol: an alcohol in which the OH is attached to a tertiary carbon atom (i.e. R_3COH). Tertiary alcohols cannot be oxidised.

4.2.2 - Haloalkanes

Bond Enthalpy: the energy required to break one mole of gaseous bonds. The bond enthalpy of the carbon halogen bond in haloalkanes decreases from C-F to C-I.

CFC: a class of compound made up of carbon, fluorine and chlorine, used as refrigerants and aerosol propellants. CFCs can be broken down by UV light in the upper atmosphere to form chlorine radicals which catalyse the breakdown of ozone.

Haloalkane: an organic compound containing a halogen atom (F/ Cl/ Br/ I) bound to an alkyl chain.

Hydrolysis: the breakdown of a compound as a result of a reaction with water. The rate of haloalkane hydrolysis for different carbon-halogen bonds can be determined via a reaction with water in the presence of AgNO_3 and ethanol.

Nucleophile: an electron pair donor.

Nucleophilic Substitution: a reaction in which an electron pair donor attacks an electrophilic atom (an atom with a partial or full positive charge) to replace an atom / group of atoms.

Ozone: a molecule with the formula O_3 , which absorbs UV light in the atmosphere. The breakdown of ozone can be catalysed by chlorine radicals as well as other radicals such as $\bullet\text{NO}$.



Radical: a species with an unpaired electron (e.g. $\cdot\text{Cl}$).

Substitution: a reaction in which one atom/ group of atoms replaces another. Haloalkanes can undergo substitution reactions with aqueous alkali or with water. The rate of reaction increases from C-F to C-I due to the decreasing bond enthalpy of the carbon-halogen bond.

4.2.3 - Organic Synthesis

Anhydrous Salt: a salt such as MgSO_4 or CaCl_2 which is used to remove traces of water from an organic solution.

Distillation: a technique in which a liquid is heated then the vapour is cooled and collected in a separate flask to the reaction mixture. During distillation, the condenser must be positioned horizontally.

Functional Group: a group of atoms responsible for the characteristic reactions of a compound.

Quickfit Apparatus: glassware that easily fits together in a variety of arrangements.

Redistillation: a technique used to purify an organic liquid using multiple distillations.

Reflux: the continual boiling and condensing of a reaction mixture. This is to ensure that the reaction goes to completion. During reflux, the condenser must be positioned vertically.

Separating Funnel: a piece of apparatus that is used to purify an organic liquid by removing the organic layer from an aqueous layer.

Synthetic Route: a series of steps that are followed to make a specific compound.

4.2.4 - Analytical Techniques

Elemental Analysis: a sample is analysed to determine the proportion of elements that make up the compound present. This is done by converting a known amount of an unknown sample into simple known compounds.

Fragmentation: during mass spectrometry, unstable molecular ions break down into smaller fragments.

Fragment Ions: smaller ions formed when an unstable molecular ion breaks down during mass spectrometry.



Infrared Radiation: a type of electromagnetic radiation that is absorbed by covalent bonds, causing them to vibrate at a specific frequency.

Infrared Spectroscopy: a technique used to identify particular bonds and functional groups within a molecule. This technique has been used to link global warming with increased energy usage as atmospheric gases containing C=O, O-H and C-H bonds (such as CO₂, H₂O and CH₄) show distinct peaks on IR spectra. IR spectroscopy is used to monitor gases causing air pollution (CO and NO from car emissions) and to measure alcohol in the breath in modern breathalysers.

M+1 Peak: a small peak on a mass spectrum caused by the presence of a small proportion of carbon-13.

M/Z Ratio: the mass to charge ratio on a mass spectrum. This is equivalent to the mass of an ion.

Mass spectrometry: a technique used to identify compounds and determine relative molecular mass.

Molecular Ion Peak: the peak on a mass spectrum with the highest m/z value, used to determine molecular mass of a compound.

Molecular Mass: the total number of atoms of each element in the compound.

