OCR (B) Chemistry A-level

Storyline 2: Developing Fuels

Definitions and Concepts

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

Developing Fuels

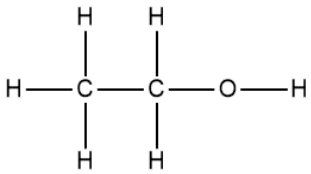
Formulae, Equations and Amount of Substance

Enthalpy change (ΔH): The heat energy change measured under a constant pressure.

Ideal gas: A model of gases that assumes that gas molecules are perfect spheres that move in straight lines at a constant speed.

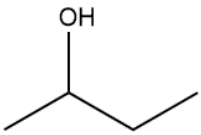
Bonding and Structure

Displayed formula: A formula showing the relative positions of atoms and all the bonds between them. E.g. Ethanol:



Empirical formula: The simplest whole number ratio of atoms of each element present in a compound.

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: Shows the arrangement of atoms in a molecule. E.g. Butane: $CH_3(CH_2)_2CH_3$.

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 cannot rotate. As π-bonds have low bond enthalpy, alkenes are more reactive than alkanes.

Energetics

Average bond enthalpy: The enthalpy change when one mole of a specified covalent bond is broken, averaged out across the range of compounds.

Endothermic: A reaction that takes in energy from the surroundings (ΔH is positive). The energy of the products is higher than the reactants.

Enthalpy (H): A value that represents the heat content of a system.

Enthalpy change (ΔH): The heat energy change measured under a constant pressure.

Enthalpy change of neutralisation ($\Delta_{neut}H$): The enthalpy change that takes place when one mole of water is formed from a neutralisation reaction.

Enthalpy change of reaction (Δ_rH): The enthalpy change that is associated with a particular chemical reaction.

Exothermic: A reaction that releases energy into the surroundings (ΔH is negative). The energy of the reactants is higher than the products.

Hess's law: The enthalpy change of a reaction is independent of the route taken.

Standard conditions: Solution concentrations of 1.00 mol dm^{-3}, pressure 100 kPa and a stated temperature (generally 298K).

Standard state: The physical state (s, l, g, aq) of a substance under standard conditions.

Standard enthalpy of combustion ($\Delta_cH^{\ominus}$): The enthalpy change when one mole of a substance is burned completely in excess oxygen under standard conditions.

Standard enthalpy of formation ($\Delta_fH^{\ominus}$): The enthalpy change when one mole of a substance in its standard state under standard conditions is formed from its elements under standard conditions.

Kinetics

Activation energy: The minimum amount of energy for particles to collide with for a successful reaction to take place.

Catalysis: The increase in the rate of a reaction by the use of a catalyst.

Catalyst: A substance that speeds up the rate of a reaction without being used up. A catalyst allows the reaction to proceed via a different route with a lower activation energy. Catalysts are important in terms of economics and sustainability as they enable processes to take place at lower temperatures meaning less energy is required (this decreases the combustion of fossil fuels so CO_2 emissions are reduced).

Catalyst poisoning: The decrease in the activity of a heterogeneous catalyst due to another compound. As catalysts are regenerated in theory they can be used indefinitely, however, in reality, the surface of the catalyst sometimes gets 'poisoned' by impurities and is, therefore, less exposed for reacting particles so the catalyst may need to be replaced.

Cracking: The process of breaking long chain alkanes into smaller, more useful hydrocarbons. Helps to convert low demand hydrocarbons into more highly demanded ones.

Heterogeneous catalyst: A catalyst that is in a different state as the reactants.

Hydrocarbon: A compound that contains hydrogen and carbon atoms only.

Organic Chemistry and the Periodic Table

Aliphatic compound: An organic compound that is made up of straight or branched chains.

Alkane: A homologous series of saturated hydrocarbons with the general formula C_nH_{2n+2}.

Alkene: An hydrocarbon containing at least one C=C double bond with the general formula C_nH_{2n}.

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

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

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

Global warming: The increase in the global temperature due to an increase in greenhouse gasses and other pollutants being released into the atmosphere.

Homologous series: A series of compounds with the same functional group and similar chemical properties. For example, all alkanes belong to the same homologous series. They all share the same general formula.

Nomenclature: The naming of a molecule/compound in chemistry.

Organic compound: A carbon-containing compound.

Pollutant: A substance that has an undesired effect on the air, water or environment.

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

Structural isomers: Compounds with the same molecular formula but different structural formulae.

Unsaturated: An organic compound that contains at least one C=C double bond, a C≡C triple bond or an aromatic ring.

Polymers

Addition polymer: A polymer formed by addition polymerisation. Formed from monomers with C=C bonds.

Addition polymerisation: The process by which addition polymers are formed. Lots of short chain monomers (alkenes) join together to form a long chain polymer by the 'opening up' of double carbon bonds.

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

Polymer: A large molecule made from many small units (monomers) that have been bonded together.

Polymerisation: The process of making a polymer from its monomers. There are two types: addition polymerisation and condensation polymerisation.

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

Organic Mechanisms

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

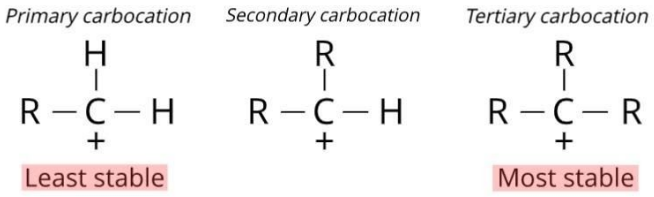
Carbocation: A compound containing a carbon atom bearing a positive charge.

Curly arrow: Used in mechanisms to show the movement of a pair of electrons.

Electrophile: An electron pair acceptor.

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

Major/minor products: Formed in electrophilic addition reactions due to the differing relative stabilities of the primary/secondary/tertiary carbocation intermediates. The major product is formed from the most stable intermediate and the minor product is formed from the least stable intermediate.



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.

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.

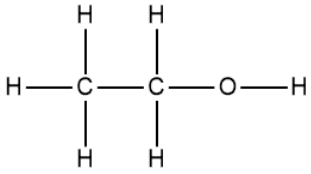
Tertiary carbocation: A molecule in which the carbon with the positive charge is attached to three alkyl groups. This is the most stable type of carbocation.

Isomerism

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.

Cis-trans isomerism: A type of stereoisomerism in which the two substituent groups attached to the cabon 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).

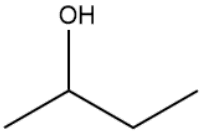
Displayed formula: A formula showing the relative positions of atoms and all the bonds between them. E.g. Ethanol:



Empirical formula: The simplest whole number ratio of atoms of each element present in a compound.

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).

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:



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

Structural formula: Shows the arrangement of atoms in a molecule. E.g. Butane: $CH_3(CH_2)_2CH_3$.

Structural isomers: Compounds with the same molecular formula but different structural formulae.

Sustainability

Biofuels: Fuels made from once-living organic matter. These fuels are renewable and sustainable and are an alternative to fossil fuels.

Complete combustion: When a compound is burnt in an excess of oxygen. When alkanes are completely combusted, the only products are water and carbon dioxide.

Hydrogen fuel cell: An electrochemical cell that converts the chemical energy of hydrogen and oxygen, which is an oxidising agent, into electricity through redox reactions. They do not need to be recharged but require a constant supply of fuel to maintain the potential difference.

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