

WJEC (Eduqas) Chemistry AS-level

C2 - Energy, Rate and Chemistry of Carbon Compounds

Definitions and Concepts

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Definitions and Concepts for WJEC (Eduqas) Chemistry AS-level C2 - Energy, Rate and Chemistry of Carbon Compounds

C2.1 - Thermochemistry

Bond enthalpy: The amount of energy required to break one mole of the stated bond in the gas phase.

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

Enthalpy change of reaction: The enthalpy change when quantities of substances in standard states react completely.

Enthalpy of combustion: The enthalpy change when one mole of a substance is burned in excess oxygen.

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

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

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

C2.2 - Rates of Reaction

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

Catalysts: Provide a lower activation energy for a reaction to occur by providing an alternative reaction route. A catalyst does not affect the equilibrium constant since it increases the rate of the forward and backward reaction equally.

Collision theory: Reactions can only occur when collisions take place between particles that have sufficient energy.





Colorimetry: This method is used to calculate the concentration of a specific coloured compound in a solution by measuring the extent to which it absorbs certain wavelengths of light. This is measured with a colorimeter.

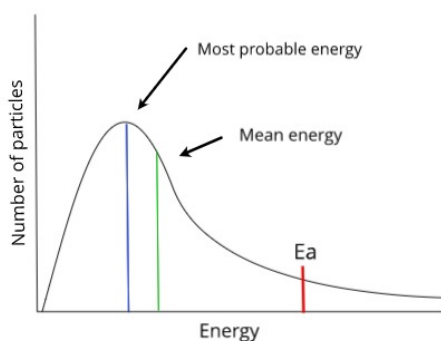
Effect of concentration on reaction rate: As the concentration of reactants increases, the reacting particles get closer together meaning they will collide more often. As a result, there will be a higher rate of successful collisions and a faster rate of reaction.

Effect of pressure on reaction rate: As the pressure of gaseous reactants increases, the reacting particles get closer together meaning they will collide more often. As a result, there will be a higher rate of successful collisions and a faster rate of reaction.

Effect of temperature on reaction rate: Increasing the temperature means the particles will have more kinetic energy and so will move faster. If the molecules are moving faster they will collide more often and, since they've gained kinetic energy, a larger proportion of the particles will have at least the activation energy. For both these reasons the rate of reaction increases.

Energy profile: A graph used to show the relative energy levels of reaction species (including reactants and products) as a reaction proceeds.

Maxwell-Boltzmann distribution: Shows the distribution of the molecular energies in a gas at a constant temperature. The area under the curve indicates the total number of particles present.



C2.3 - The Wider Impact of Chemistry

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

Green chemistry: Chemistry that aims to be sustainable in terms of energy and resources and restricts pollution.





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

Sustainability: The process of using resources at a rate that allows their supply to be maintained.

C2.4 - Organic Compounds

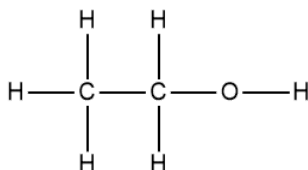
Alcohol: An organic compound containing the functional group -OH.

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} .

Carboxylic acid: An organic compound containing the -COOH functional group.

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



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.

Free radicals: A species with an unpaired electron. These are represented in mechanisms by a single dot.

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

Halogenoalkane: A saturated molecule where one or more of the hydrogen atoms in an alkane have been substituted for a halogen.

Heterolytic (bond breaking): The type of bond breaking in which both the electrons from the bond move together to one of the bonding atoms.





Homolytic (bond breaking): The type of bond breaking in which the electrons from the bond move separately, one goes to each of the atoms of the bonding pair.

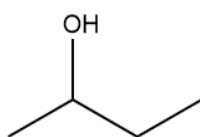
Nomenclature: The naming system for compounds.

Nucleophile: An atom or molecule that donates an electron pair to form a covalent bond.

Attracted to electron-deficient areas.

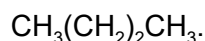
Organic compound: A carbon-containing compound.

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:



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

Structural formula: Shows the arrangement of atoms in a molecule. E.g. butane:



Structural isomer: Structural isomers are compounds that have the same molecular formula but a different structural formula. Structural isomers include chain isomers, functional group isomers and position isomers.

C2.5 - Hydrocarbons

Addition: Joining two or more molecules together to form a larger molecule. *Hydration* is the addition of a H_2O molecule. *Halogenation* involves the addition of a halogen. *Hydrogenation* is the addition of H. *Electrophilic addition* describes all the above examples.

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

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

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





Catalyst: A substance which speeds up the rate of a reaction without being used up. Enzymes are biological catalysts.

Combustion: A reaction in which the carbon and hydrogen within fuels are oxidised to release energy and to produce carbon dioxide and water.

Double bond: A double bond is a covalent bond between two atoms involving four bonding electrons as opposed to two in a single bond.

E/Z 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.

Electrophilic addition: A reaction where a π bond is broken and 2 new σ bonds form due to the addition of an electrophile.

Free radical substitution: A photochemical reaction between halogens and alkanes to form halogenoalkanes. The reaction requires UV light and involves three stages: initiation, propagation and termination. Initiation creates a radical species. Propagation involves a series of chain reactions where free radicals bond to molecules to form new free radicals. Termination involves the reaction of free radicals with other free radicals to form new molecules.

Free radicals: A species with an unpaired electron. These are represented in mechanisms by a single dot.

Hydrocarbon: A compound consisting of hydrogen and carbon atoms only.

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

Monomer: A small molecule that can react to form polymers.

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

Polymer: A large molecule made from many small 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.





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.

σ -bond: A covalent bond formed of overlapping s orbitals.

Solubility: The ability of a given substance to dissolve in a solvent. Solubility of the Group 2 hydroxides increases down the group and solubility of the Group 2 sulfates decreases down the group.

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.

Unsaturated bond: A type of bond made up of both a σ -bond and a π -bond.

C2.6 - Halogenoalkanes

Bond enthalpy: The amount of energy required to break one mole of the stated bond in the gas phase.

Elimination: A reaction in which a molecule loses atoms or groups of atoms to form a C=C bond.

Halogenoalkane: A saturated molecule where one or more of the hydrogen atoms in an alkane have been substituted for a halogen.

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 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: Ozone is formed naturally in the upper atmosphere. It is beneficial because it absorbs ultraviolet radiation and this prevents harmful radiation reaching the earth.



Polar bond: A covalent bond in which there is an unequal distribution of the electrons between the two atoms due to the differing electronegativities of the bonding atoms. One atom will have a partial positive charge while the other will have a partial negative charge.

Primary halogenoalkane: A halogenoalkane in which the carbon bonded to the halogen is itself only bonded to one other carbon atom.

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.

Secondary halogenoalkane: A halogenoalkane in which the carbon bonded to the halogen is itself bonded to two other carbon atoms.

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

Tertiary halogenoalkane: A halogenoalkane in which the carbon bonded to the halogen is itself bonded to three other carbon atoms.

Toxicity: A measure of how poisonous a chemical substance is.

C2.7 - Alcohols and Carboxylic Acids

Alcohol: A compound containing the -OH functional group.

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 $\text{Cr}_2\text{O}_7^{2-}/\text{H}^+$.

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

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

Carbon neutrality (fuels): A fuel is described as carbon-neutral if the production and use of the fuel has no net increase on the amount of carbon dioxide in the atmosphere.

Carboxylic acid: An organic compound containing the -COOH functional group.

Dehydration: A reaction in a water molecule is lost from a molecule/compound.





Distillation: A technique used to purify a liquid by heating and cooling. When the liquid evaporates it moves into a condenser where it is cooled, recondenses and collected.

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

Esterification: The process of making esters. Esters can be made by the reaction between carboxylic acids and alcohols in the presence of an acid catalyst, or by the reaction between acid anhydrides and alcohols.

Fermentation: The process by which ethanol is produced from organic sugars, such as glucose. This process requires yeast and anaerobic conditions.

Ketone: A compound containing the C=O functional group within an alkyl chain. Ketones cannot be oxidised further.

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

Oxidising agent: A species which brings about oxidation by gaining electrons. The oxidising agent is itself reduced.

Primary alcohol: An alcohol in which the -OH is attached to a primary carbon atom (i.e. RCH₂OH). Primary alcohols can be oxidised with Cr₂O₇²⁻/H⁺ 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. R₂CHOH). Secondary alcohols can be oxidised under reflux with Cr₂O₇²⁻/H⁺ to form a ketone.

Tertiary alcohol: An alcohol in which the -OH is attached to a tertiary carbon atom (i.e. R₃COH). Tertiary alcohols cannot be oxidised.

C2.8 Instrumental Analysis

Carbon-13 NMR spectroscopy: A type of NMR spectroscopy which analyses ¹³C nuclei. The number of peaks in the spectrum shows the number of different environments and the chemical shifts represent the environments present.

Chemical shift: The shift of a carbon or proton environment relative to standard tetramethylsilane (TMS). This chemical shift value (δ) depends on the molecular environment of the proton/carbon atom.



Coupling: The interaction between adjacent non-equivalent protons during NMR spectroscopy.

Doublet: A signal on a ^1H NMR spectra made up of two peaks, indicating that there is one adjacent non-equivalent proton.

Fingerprint region: The region on an IR spectrum below 1500 cm^{-1} which is unique to each molecule.

Infrared spectroscopy: An analytical technique used to identify particular bonds and functional groups within a molecule. Infrared spectroscopy can also be used to identify impurities.

M/Z ratio: The mass to charge ratio on a mass spectrum. For $1+$ ions, this is equivalent to the mass of the ion.

Mass spectrometry: A technique that measures the mass to charge ratio of gaseous ions.

Molecular ion peak: The peak on a mass spectrum with the highest m/z value, this is used to determine the molecular mass of a compound.

Nuclear magnetic resonance (NMR): A technique that uses the absorption of electromagnetic radiation by an atomic nucleus in an external magnetic field to analyse the structure of a compound. Typically, either ^{13}C or ^1H nuclei are analysed. ^{13}C NMR spectra are generally simpler than ^1H NMR spectra.

Proton NMR spectroscopy: A type of NMR spectroscopy which analyses ^1H nuclei. The number of peaks on the spectrum shows the number of proton environments and the chemical shifts represent the environments. The area under each peak shows the relative number of protons in each environment. The splitting pattern can be used to work out the number of adjacent protons.

Quartet: A signal on a ^1H NMR spectra made up of four peaks, indicating that there are three adjacent non-equivalent protons.

Tetramethylsilane (TMS): The standard for chemical shift measurement in NMR spectroscopy.

Triplet: A signal on a ^1H NMR spectra made up of three peaks, indicating that there are two adjacent non-equivalent protons.

Wavenumber: Represents the energy and frequency of infrared radiation absorbed by a bond in a molecule. This is the x-axis on IR spectra.

