Edexcel IAL Chemistry A-level

Unit 1: Structure, Bonding and Introduction to Organic Chemistry

Definitions

Definitions and Concepts for Edexcel IAL Chemistry A-level

Structure, Bonding and Introduction to Organic Chemistry

Topic 1: Formulae, Equations and Amount of Substance

Atom: The smallest part of an element that can exist. All substances are made up of atoms.

Atom economy: Measure of the proportion of reacting atoms that become part of the desired product in the balanced chemical equation.

$$\text{Percentage atom economy} = \frac{\textit{Molecular mass of desired product}}{\textit{Sum of molecular masses of all products}} \times 100$$

Avogadro constant (*L*): The number of atoms, molecules or ions in one mole of a given substance. It is the number of atoms in exactly 12 g of carbon-12 (6.02×10^{23}mol).

Compound: A substance that combines two or more different elements through the formation of chemical bonds.

Element: A substance that contains one type of atom only. Atoms of the same element all have the same number of protons.

Empirical formula: Smallest whole number ratio of atoms of each element in a compound. For example, the empirical formula of benzene (C_6H_6), cyclobutadiene (C_4H_4) and acetylene (C_2H_2) are all simply “CH”.

Ion: Formed when an atom loses or gains electrons. This gives it an overall charge - a positive charge if it has lost at least one electron and a negative charge if it has gained at least one electron.

Ionic equation: A chemical equation that involves dissociated ions.

Molar mass: Mass of one mole of a substance expressed in g/mol.

Mole: The unit for the amount of substance. This is the amount of chemical species found in 12 g of ^{12}C. One mole is 6.02×10^{23}.

Molecular formula: The actual number of atoms of each element in a molecule.

Molecule: Formed from two or more atoms held together by covalent bonds.

Percentage yield: The percentage ratio of the actual yield of product from a reaction compared with the theoretical yield.

$$\text{Percentage yield} = \frac{\textit{Actual yield}}{\textit{Theoretical Yield}} \times 100$$

Relative atomic mass: Average mass of an atom of an element, relative to 1/12 of the mass of an atom of carbon-12.

Relative formula mass: Average mass of a compound relative to 1/12 of the mass of an atom of carbon-12. Relative formula mass refers to compounds that have a giant structure.

Relative molecular mass: Average mass of a molecule relative to 1/12 of the mass of an atom of carbon-12.

State symbol: State symbols show the physical state of the substance during the reaction, they are usually in brackets: gas (g), liquid(l), solid(s) and aqueous(aq). Aqueous means the substance is dissolved in water.

Topic 2: Atomic Structure and the Periodic Table

Atomic/Proton number: The number of protons found in the nucleus of an atom of a particular element.

Boiling temperature: The temperature at which a substance changes from a liquid state to a gaseous state.

Diatomic molecule: A molecule containing two atoms that are chemically bonded to each other, e.g. Cl_2.

Electron: Negatively charged subatomic particle which orbit the nucleus at various energy levels. Relative mass of 1/2000.

Electron subshell: Divisions of electron shells which are each at slightly different energy levels. The subshells have different numbers of orbitals which can each hold up to two electrons. The first four types of sub-shell are: s, p, d and f.

Electronic configuration: The distribution of electrons of an atom in its orbitals.
E.g. Ca: $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2$.

Endothermic reaction: A reaction which takes in energy from the surroundings so that the temperature of the surroundings decreases. The energy needed to break bonds in the reactants is greater than the energy released from forming new bonds in the products.

First ionisation energy: The energy required to remove 1 mole of electrons from 1 mole of gaseous atoms to form 1 mole of gaseous 1+ ions. For example, $Mg_{(g)} \rightarrow Mg^{+}_{(g)} + e^{-}$.

Isotope: Atoms of the same element with the same number of protons but a different number of neutrons in the nucleus, e.g. ^{35}Cl and ^{37}Cl.

Mass number: Sum of number of protons and neutrons in the nucleus of an atom.

Mass spectrometry: A technique that measures the mass to charge ratio of gaseous ions. Mass spectrometry may be used after a mixture has been separated by GC to identify the compounds present.

Melting temperature: The temperature at which a substance changes from solid state to liquid state.

Neutron: Neutral subatomic particle present in the nucleus of the atom. Relative mass of 1.

Nuclear charge: Total charge of all the protons in the nucleus. It has the same value as the atomic number. Increases as you go across the periodic table.

Orbital: A cloud of negative charge that can hold up to two electrons. Different orbitals have different shapes.

p orbital: A dumbbell shaped region in which up to two electrons can be found. There are three p orbitals at right angles to each other, so in total the p subshell can hold up to 6 electrons.

Periodicity: Trends in properties of elements with increasing atomic number. The trends are caused by the changes in element atomic structure.

Proton: Positively charged subatomic particle present in the nucleus of the atom. Relative mass of 1.

Quantum shell: Electrons orbit the nucleus in different energy levels known as shells. Each energy level is assigned a principal quantum number, n. The shell which is found closest to the nucleus has a value of n=1, the quantum number increases by one for each successive shell.

Relative abundance (of isotopes): The percentage of atoms found within a naturally occurring sample of an element that has a specific atomic mass.

Relative peak height: Found in mass spectra, indicating the relative abundance of the substance that made the peak.

s orbital: Spherical and symmetrical regions found around the nucleus, which can each hold up to two electrons.

Second ionisation energy: The energy required to remove 1 mole of electrons from each ion in 1 mole of gaseous 1+ ions to form 1 mole of gaseous 2+ ions (could be asked for any successive ionisation energy).

Shielding: A decrease in the nuclear attraction experienced by an outer shell electron caused by electron-electron repulsion between the outer shell electron and electrons from adjacent quantum shells.

Subatomic particles: Particles that are smaller than an atom. Protons, neutrons and electrons are the three most common subatomic particles.

Third ionisation energy: The energy required to remove 1 mole of electrons from each ion in 1 mole of gaseous 2+ ions to form 1 mole of gaseous 3+ ions (could be asked for any successive ionisation energy).

Topic 3: Bonding and Structure

Anion: A negatively charged ion, formed when an atom gains at least one electron, e.g. S^{2-}.

Atomic nucleus: A collection of subatomic particles in the centre of an atom. It is positively charged and composed of protons and neutrons with one or more electrons orbiting it.

Bond angle: The angle that is found between two bonds bonded from the same atom in a covalently bonded compound.

Bond length: Internuclear distance between two covalently bonded atoms.

Cation: A positively charged ion, formed when an atom loses at least one electron, e.g.Na^{+}.

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 difference in electronegativities.

Covalent substance: A substance that is made up of atoms that are covalently bonded to each other.

Dative covalent bonding: Occurs when one atom donates both electrons in a covalent bond. For example, in $^{+}NH_4$ the nitrogen atom supplies both of the electrons for one of the N-H bonds.

Delocalised electrons: The electrons that are not contained within a single atom or a covalent bond.

Dot-and-cross diagram: Diagrams used to model the bonding that occurs in a simple molecule. The shells of an atom are drawn as circles, with crosses or dots marked on the circles to represent the electrons. The circles overlap when there is a covalent bond. The electrons from one atom are drawn as dots, and the electrons from a different atom as crosses.

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

Electrical conductivity: A measure of the amount of electrical current a material can carry or its ability to carry the current.

Electron density map: Maps which show the region around a nucleus in which electrons are distributed. A high density corresponds to a high probability of an electron being there. They are used to infer the type of bonding present in a species.

Electron pair repulsion: Repulsion between electron pairs which means that the shape a molecule adopts has the electron pairs positioned as far apart as possible. As a result, carbon atoms in alkanes have a tetrahedral shape and a bond angle of 109.5°.

Electronegativity: The ability of an atom to attract the bonding electrons in a covalent bond. The most electronegative elements (N,O,F) are small and have a relatively high nuclear charge.

Electrostatic attraction: The attraction between two species with opposite charges.

Giant atomic structure: Large structures containing lots of atoms that are covalently bonded to each other. They are usually arranged in a regular lattice. E.g. Diamond.

Giant ionic lattice: A regular repeating structure made up of oppositely charged ions.

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

Ionic charge: The electrical charge of an ion caused by the gain (negative charge) or loss (positive charge) of electrons. The magnitude of the charge is related to how many electrons have been lost or gained as electrons have a relative charge of -1.

Ionic compound: A compound made up of anions and cations, held together by ionic bonds, which arise due to the electrostatic attraction between oppositely charged ions. These structures are neutral overall.

Ionic radius: The radius of an ion. It is the distance between the nucleus and the outermost electron of the ion.

Isoelectronic ions: Refers to two atoms or ions that have the same electron configuration and the same number of valence electrons. These species often have similar chemical properties. For example, Ca^{2+} and Mg^{+}.

Metallic bonding: Strong electrostatic attraction between positive metal ions and the sea of delocalised electrons that surround them.

Polar bond: A covalent bond between two atoms in which the electrons in the bond are unevenly distributed. This causes a slight charge difference, inducing a dipole in the molecule.

Polar molecule: A molecule in which the electrons are not evenly distributed between the bonding atoms. The molecule is said to have a dipole.

Polarisability: The ability of a molecule to induce a dipole in another molecule.

Single bond: A covalent bond in which a single pair of electrons is shared between two atoms.

Triple bond: A covalent bond between two atoms which involves six bonding electrons instead of the usual two in a single bond.

Topic 4: Introductory Organic Chemistry and Alkanes

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.

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

Alkane fuel: Alkanes are good fuels as they are considered to burn cleanly, they undergo combustion in excess oxygen to produce only carbon dioxide and water.

Bond breaking: When a bond breaks, energy is absorbed making it an endothermic process.

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.

Catalyst: A substance which speeds up the rate of a reaction by providing an alternative reaction pathway with a lower activation energy. They are not used up. Enzymes are biological catalysts.

Chain isomers: Structural isomers that have carbon backbones of differing lengths. These occur due to the branching in the carbon chain.

Combustion of alkanes: The burning of alkanes to release energy. During combustion, the carbon and hydrogen in the fuels are oxidised. Alkanes can undergo complete or incomplete combustion. Water and carbon dioxide are the only products of complete combustion, whereas carbon monoxide and carbon particulates can be produced in incomplete combustion.

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

Crude oil: A finite resource found in rocks. It is the remains of an ancient biomass consisting mainly of plankton that was buried in mud. Most of the compounds in crude oil are hydrocarbons.

Cycloalkane: Saturated hydrocarbons that contain a cyclic ring. They only contain single bonds and have a general formula of C_nH_{2n}, which is different to alkanes.

Electrophile: Electron pair acceptor in an organic mechanism. Attracted to areas with a lot of electrons/high negative charge.

Fractional distillation: A distillation process that utilises a fractionating column (packed with glass beads that provide a surface for the vapour to condense and evaporate again). The mixture of liquids is vaporised and then the gases enter the fractionating column, where they condense at different fractions due to their different boiling points.

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.

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

Functional group isomers: Structural isomers that contain different functional groups. This means they belong to different homologous series.

Halogen: Any element found in Group 7 of the periodic table. E.g. Fluorine.

Hazard: A property of a chemical that could cause damage to the user.

Heterolytic (bond breaking): The type of bond breaking in which both the electrons from the bond move together to one of the bonding atoms. This leads to the formation of a cation and an anion.

Homologous series: Series of organic compounds with the same functional group and general formula. Consecutive members of a series differ by $-CH_2$.

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. This leads to the formation of radicals.

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

Initiation step: The first step in a radical substitution mechanism, involving the formation of the radicals by homolytic bond breaking.

Mechanism: A step by step sequence of reactions that occur during a chemical change when reactants are converted to products. They show the movement of electrons during the reaction, represented by curly arrows.

Organic molecules: Molecules which contain carbon and hydrogen atoms and often also include additional elements like oxygen and nitrogen.

Oxidation: Loss of electron(s), increase in oxidation number.

Pollutant: A chemical substance that can damage parts of the environment, like the air, land, or water.

Polymerisation: Joining together lots of short chain molecules (monomers) to form a giant long chain molecule (a polymer).

Position isomer: Structural isomers that differ in their position of one or more functional groups. The carbon backbone of the molecules are the same.

Propagation step: Part of the free radical substitution reaction process which involves a series of chain reactions where free radicals react with molecules to form new free radicals.

Radical: A species with an unpaired electron. Represented in mechanisms by a single dot, e.g. Cl•.

Reduction: Gain in electron(s), decrease in oxidation number.

Risk: A possible effect a hazard may have on a user. Control measures are used to restrict the risk.

Risk assessment: A process of evaluating all the risks that might be involved when undertaking a specific task or activity.

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

Structural isomers: Compounds which have the same molecular formula but a different structural formula. Structural isomers include chain isomers, functional group isomers and position isomers.

Synthesis: Combining different elements and compounds to build new molecules.

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

Thermal decomposition: A reaction in which a chemical substance is broken down by heating.

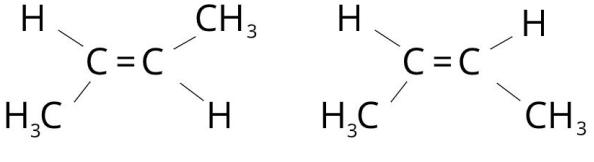
Toxicity: A measure of how poisonous a chemical substance is.

Topic 5: Alkenes

Biodegradable polymer: A polymer that can be decomposed by bacteria or other living organisms.

Cycloalkenes: Unsaturated hydrocarbons that contain a cyclic ring. They contain both single and double bonds.

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 (both above or below), then it is the Z-isomer. If the highest priority groups for each carbon are found on opposite sides of the molecule (one above and one below), then it is the E-isomer.



E-isomer:
E-but-2-ene

Z-isomer:
Z-but-2-ene

Polymer: A long-chain molecule formed by joining together many small molecules known as monomers.

Polymer disposal: Most polymers are unreactive which means they are not biodegradable. This means they are often disposed of in landfills, incinerated (releases greenhouse gases), or recycled (often expensive and takes time).

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.

Unsaturated: Hydrocarbons that contain at least one carbon-carbon double bond which consists of a σ bond and a π bond.