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Haggerston School

SIXTH FORM KNOWLEDGE ORGANISER

Chemistry

2023/2024

Aspiration Creativity Character

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Module 2: Foundations in Chemistry

Definitions and Concepts

2.1.1 - Atomic Structure and Isotopes

Atomic Number	the number of protons in the nucleus of an atom.
Bohr Model	describes an atom as a small dense nucleus with electrons orbiting around the nucleus. This model explains different periodic properties of atoms.
Electron	a negatively charged subatomic particle which orbits the nucleus at various energy levels. The relative mass of an electron is 1/1836.
Ion	a charged atom or molecule.
Isotopes	atoms of the same element with the same number of protons and electrons but different numbers of neutrons. Isotopes of an element have different masses.
Mass Number	the total number of protons and neutrons in the nucleus of an atom.
Mass Spectrometry	an instrument which gives accurate information about relative isotopic mass and the relative abundance of isotopes.
Neutron	a neutral subatomic particle found in the nucleus of an atom. The relative mass of a neutron is 1.
Proton	a positively charged subatomic particle found in the nucleus of an atom. The relative mass of a proton is 1.
Relative Abundance	the amount of one substance compared with another.
Relative Atomic Mass	the weighted mean mass of an atom compared with 1/12th mass of an atom of carbon-12.
Relative Isotopic Mass	the mass of an atom of an isotope compared with 1/12th mass of an atom of carbon-12.
Relative Formula Mass	the mass of the formula unit of a compound with a giant structure. For example, NaCl has a relative formula mass of 58.44 g mol ⁻¹ .
Relative Molecular Mass (Mr)	the mass of a simple molecule.

2.1.2 - Compounds, Formulae and Equations

Ammonium ion	an ion with the formula NH ₄ ⁺ .
Carbonate	an ion with the formula CO ₃ ²⁻ .
Hydroxide	an ion with the formula OH ⁻ .
Ionic Compound	a compound which is made up of oppositely charged ions that are held together by electrostatic forces.
Nitrate	an ion with the formula NO ₃ ⁻ .
Silver ion	has the formula Ag ⁺ .
State symbols	symbols within a chemical equation which indicate the state of each compound under the reaction conditions. (g) gaseous, (l) liquid, (s) solid and (aq) aqueous.
Sulfate	an ion with the formula SO ₄ ²⁻ .
Zinc ion	has the formula Zn ²⁺ .

2.1.3 - Amount of Substance

Amount of substance	the quantity that has moles as its units, used as a way of counting atoms. The amount of substance can be calculated using mass ($n = m/M$), gas volumes ($n = pV/(RT)$) or solution volume and concentration ($n = CV$).
Anhydrous	a crystalline compound containing no water.
Atom Economy	a measure of the amount of starting materials that end up as useful products. A high atom economy means a process is more sustainable as there is less waste produced. $\text{Percentage atom economy} = \frac{\text{Molecular mass of desired product}}{\text{Sum of molecular masses of all reactants}} \times 100$
Avogadro Constant (N_A)	the number of particles per mole of substance ($6.02 \times 10^{23} \text{ mol}^{-1}$).
Composition by mass	the relative mass of each element in a compound.

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Module 2: Foundations in Chemistry

Definitions and Concepts

2.1.3 - Amount of Substance continued

Empirical Formula	the simplest whole number ratio of atoms of each element present in a compound.
Hydrated	a crystalline compound that contains water.
Ideal Gas	a gas which has molecules that occupy negligible space with no interactions between them. The ideal gas equation is: $pV = nRT$.
Molar Gas Volume	the volume of 1 mole of gas (units: $\text{dm}^3 \text{mol}^{-1}$).
Molar Mass	mass per mole of a substance (units: g mol^{-1}).
Mole (mol)	the amount of any substance containing as many particles as there are carbon atoms in exactly 12g of carbon-12 isotope.
Molecular Formula	the number and type of atoms of each element in a molecule.
Percentage Yield	the percentage ratio of the actual yield of product from a reaction compared with the theoretical yield. $\text{Percentage yield} = \frac{\text{Actual yield}}{\text{Theoretical yield}} \times 100$
Relative Molecular Mass	the average mass of one molecule of an element or compound compared to 1/12th the mass of an atom of carbon-12.
Stoichiometry	the relative quantities of substances in a reaction.
Water of Crystallisation	water molecules that form part of the crystalline structure of a compound.

2.1.4 - Acids

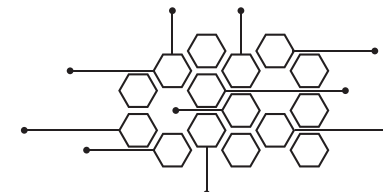
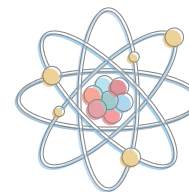
Acid	compounds that release H^+ ions in aqueous solution. Common acids include: HCl , H_2SO_4 , HNO_3 and CH_3COOH .
Alkali	water soluble bases. Alkalis release OH^- ions into aqueous solution. Common alkalis include: NaOH , KOH and NH_3 .
Base	a substance that can accept H^+ ions from another substance.
Neutralisation	a reaction between H^+ and OH^- , forming water. This may be a reaction between an acid and a base to form a salt (types of bases include carbonates, metal oxides and alkalis).
Strong Acid	an acid that completely dissociates in solution.
Titration	a technique used to determine the amount of one solution of a known concentration required to completely react with a known volume of another solution of unknown concentration.
Weak Acid	an acid that only partially dissociates in solution.

2.1.5 - Redox

Oxidation	loss of electrons/ increase in oxidation number.
Oxidation Number	a number that represents the number of electrons lost or gained by an atom of an element. A positive oxidation number indicates the loss of electrons. Roman numerals are typically used to indicate the oxidation number of elements that may have different oxidation states (e.g. iron(II) and iron(III)).
Redox Reaction	a reaction in which one element is oxidised and another is reduced.
Reduction	gain of electrons / decrease in oxidation number.

2.2.1 - Electron Structure

Atomic Orbital	a region of space around the nucleus that can hold up to 2 electrons with opposite spins. There is 1 orbital in the s subshell, 3 orbitals in the p subshell and 5 orbitals in the d subshell. Orbitals are filled in order of increasing energy, with orbitals of the same energy occupied singly before pairing.
Electronic Configuration	the arrangement of electrons into orbitals and energy levels around the nucleus of an atom / ion.
Energy Level	the shell that an electron is in.
Shell	the orbit that an orbital is in around the nucleus of an atom. The shell closest to the nucleus is the first shell. The outermost shell that is occupied by electrons is the valence shell.
Sub-shell	a subdivision of the electronic shells into different orbitals. The types of subshell are s, p, d and f.



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Module 2: Foundations in Chemistry

Definitions and Concepts

2.2.2 - Bonding and Structure

Average bond enthalpy	the average energy required to break a bond, used as a measurement of the strength of a covalent bond. The average bond enthalpy is measured using a variety of molecules that contain a specific bond.
Bonding pair	a pair of outer-shell electrons involved in bonding.
Covalent bond	a strong bond formed between 2 atoms due to the electrostatic attraction between a shared pair of electrons and the atomic nuclei.
Dative Covalent (Coordinate) bond	a type of covalent bond in which both of the electrons in the shared pair come from one atom.
Electronegativity	the ability of an atom to attract bonding electrons in a covalent bond. This is often quantified using Pauling's electronegativity values. Electronegativity increases towards F in the periodic table.
Electron Pair Repulsion Theory	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. Lone pairs offer more repulsion than bonding pairs as they are closer to the nucleus of the central atom.
Hydrogen Bonding	a type of intermolecular bonding that occurs between molecules containing N, O or F and a H atom of -NH, -OH or HF. A lone pair on the electronegative atom (N, O or F) allows the formation of a hydrogen bond.
Intermolecular Forces	interactions between different molecules. Types of intermolecular forces including permanent dipole-dipole interactions and induced dipole-dipole interactions (both of these are also known as van der Waals' forces) as well as hydrogen bonding.
Ionic Bond	electrostatic attraction between positive and negative ions.
Ionic Compounds	compounds made up of oppositely charged ions. These compounds generally have high melting and boiling points. Typically, ionic compounds are soluble and can conduct electricity when liquid or aqueous (but not when solid).
Ionic Lattice	a giant structure in which oppositely charged ions are strongly attracted in all directions.
Linear	the shape of a molecule in which the central atom has 2 bonding pairs.

London (Dispersion) 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.
Lone Pair	a pair of outer-shell electrons not involved in bonding.
Macroscopic Properties	properties of a bulk material rather than the individual atoms/molecules that make up the material.
Non-linear	the shape of a molecule in which the central atom has 2 bonding pairs and 2 lone pairs.
Octahedral	the shape of a molecule in which the central atom has 6 bonding pairs.
Permanent Dipole	a permanent uneven distribution of charge.
Polar Bond	a covalent bond that has a permanent dipole due to the different electronegativities of the atoms that make up the bond.
Polar Molecule	a molecule that contains polar bonds with dipoles that don't cancel out due to their direction (must be unsymmetrical).
Pyramidal	the shape of a molecule in which the central atom has 3 bonding pairs and 1 lone pair.
Simple Molecular Lattice	a solid structure made up of covalently bonded molecules attracted by intermolecular force (e.g. I_2 and ice). These compounds generally have relatively low melting and boiling points and are typically insoluble in water but soluble in organic solvents. Molecular substances don't conduct electricity.
Tetrahedral	the shape of a molecule in which the central atom has 4 bonding pairs.
Trigonal bipyramidal	the shape of a molecule in which the central atom has 5 bonding pairs.
Trigonal Planar	the shape of a molecule in which the central atom has 3 bonding pairs.

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Module 3: Periodic Table and Energy

Definitions and Concepts

3.1.1 - Periodicity

Atomic (Proton) Number	the number of protons in the nucleus of an atom.
Bohr Model	describes an atom as a small dense nucleus with electrons orbiting around the nucleus. This model explains different periodic properties of atoms.
Cations	positively charged ions.
d-block	the part of the periodic table in which the elements have their highest energy electron in a d-orbital.
Electron Configuration	the arrangement of electrons into orbitals and energy levels around the nucleus of an atom / ion.
First Ionisation Energy	the removal of one mole of electrons from one mole of gaseous atoms. Factors which affect the first ionisation energy are: the strength of attraction between the electron and the nucleus, the nuclear charge and the atomic radius. There is a small decrease in first ionisation energy due to s- and p-subshell energies (between Be and B) and p-orbital repulsion (between N and O).
Giant Covalent Lattice	a network of atoms bonded by strong covalent bonds (e.g. carbon (diamond, graphite and graphene) and silicon). Giant covalent lattices typically insoluble with a high melting and boiling point due to the presence of strong covalent bonds. They are also poor electrical conductors as they don't contain mobile charged particles.
Giant Metallic Lattice Structure	the structure of all metals, made up of cations and delocalised electrons. Giant metallic structures are typically insoluble with a high melting and boiling points due to strong electrostatic forces of attraction between cations and electrons. Metals are good electrical conductors due to the presence of delocalised electrons (mobile charges).
Group	a column in the periodic table.
Melting Point	the temperature at which a solid melts and becomes a liquid. This increases from giant metallic to giant covalent structures then decreases to simple molecular structures.
Metallic Bonding	strong electrostatic attraction between cations and delocalised electrons.

p-block	the part of the periodic table in which the elements have their highest energy electron in a p-orbital.
Period	a row in the periodic table.
Periodicity	a repeating trend in physical and chemical properties across the periods of the periodic table.
s-block	the part of the periodic table in which the elements have their highest energy electron in an s-orbital.
Successive Ionisation Energies	the energy required to remove each electron one-by-one from one mole of gaseous atoms / ions.

3.1.2 - Group 2

Base	a substance that can accept H^+ ions from another substance. Group 2 compounds can be used as bases: $Ca(OH)_2$ is used to neutralise acidic soils in agriculture and $Mg(OH)_2$ and $CaCO_3$ are used as antacids to treat indigestion.
Electron Configuration	the arrangement of electrons into orbitals and energy levels around the nucleus of an atom/ ion. Group 2 elements have an s^2 outer shell electron configuration.
First Ionisation Energy	the removal of one mole of electrons from one mole of gaseous atoms. Factors which affect the first ionisation energy are: the strength of attraction between the electron and the nucleus, the nuclear charge and the atomic radius.
Group 2 Oxide	a compound with the general formula MO , where M is a group 2 element. When group 2 oxides react with water, they form an alkaline solution, with alkalinity increasing down the group.
Oxidation	the loss of electrons / increase in oxidation number.
Redox	a reaction in which oxidation of one element and reduction of another occurs. During a redox reaction involving group 2 elements, 2 electrons are lost to form $2+$ ions. Group 2 elements undergo redox reactions with water, oxygen and dilute acids.
Reduction	the gain of electrons/ decrease in oxidation number.
Second Ionisation Energy	the removal of one mole of electrons from one mole of gaseous $1+$ ions to form one mole of $2+$ ions.

Module 3: Periodic Table and Energy

Definitions and Concepts

3.1.3 - The Halogens

Boiling Point	the temperature at which a liquid boils and becomes a gas. Boiling point increases down group 7 due to the increasing strength of London Forces between the halogen molecules.
Diatomic Molecules	molecules that are made up of 2 atoms. Halogens are diatomic.
Displacement Reaction	a reaction in which one atom is replaced by another. Halogens can undergo displacement reactions as their reactivity decreases down the group. The more reactive halogen will displace the less reactive halogen from a solution of its salt.
Disproportionation	the oxidation and reduction of the same element. Examples include the water treatment (reacting chlorine with water) and bleach formation (reacting chlorine with cold, dilute aqueous sodium hydroxide).
Electron Configuration	the arrangement of electrons into orbitals and energy levels around the nucleus of an atom / ion. The halogens have a s^2p^5 outer shell electron configuration.
Induced Dipole-Dipole Interactions	forces of attraction between molecules caused when the random movement of electrons creates a temporary dipole in one molecule which then induces a dipole in a neighbouring molecule.
London Forces	another name for induced dipole-dipole interactions.
Oxidation	the loss of electrons / increase in oxidation number.
Precipitation Reaction	a reaction in which two aqueous solutions are combined to form an insoluble salt (a precipitate). Halide anions undergo precipitation reactions with aqueous silver ions.
Redox reaction	a reaction in which oxidation of one element and reduction of another occurs. During a redox reaction involving group 7 elements, 1 electron is gained to form 1- ions.
Reduction	the gain of electrons/ decrease in oxidation number.
Water Treatment	the addition of chlorine to water to kill bacteria. The risks associated with the use of chlorine to treat water are the hazards of toxic chlorine gas and the possible risks from the formation of chlorinated hydrocarbons.

3.1.4 - Qualitative Analysis

Anion	a negatively charged ion.
Ammonium Ion	an ion with the formula NH_4^+ . The test for ammonium ions is a reaction with warm NaOH, which forms NH_3 .
Cation	a positively charged ion.
Carbonate	a salt containing the CO_3^{2-} anion. A reaction between a carbonate and H^+ will form $\text{CO}_2(\text{g})$.
Halide	a salt containing a group 7 anion. Cl^- , Br^- and I^- can be tested for using a solution of silver ions as this reaction forms a coloured precipitate. The solubility of the precipitate is then tested using dilute and concentrated ammonia.
Qualitative Analysis	identifies the elements present in a substance, typically using test-tube reactions.
Sulfate	a salt containing the anion SO_4^{2-} . A reaction between SO_4^{2-} and $\text{Ba}^{2+}(\text{aq})$ will form a precipitate.

3.2.1 - Enthalpy Changes

Activation Energy	the minimum energy required for a reaction to take place.
Average 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.
Endothermic	a reaction which takes in energy (ΔH is positive). More energy is required to break bonds than is released by making bonds.
Enthalpy (H)	a value that represents the heat content of a system.
Enthalpy Change (ΔH)	the change in the heat content of a system during a reaction. This can be determined from experimental results using $q = mc\Delta T$ (where q is the heat change of the surroundings, m is the mass of the surroundings, c is the specific heat capacity and ΔT is the change in temperature).
Enthalpy Change of Combustion ($\Delta_c H$)	the enthalpy change that takes place when one mole of a substance is completely combusted.

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Module 3: Periodic Table and Energy

Definitions and Concepts

3.2.1 - Enthalpy Changes continued

Enthalpy Change of Formation ($\Delta_f H$)	the enthalpy change that takes place when one mole of a compound is formed from its elements.
Enthalpy Change of Neutralisation ($\Delta_{\text{neut}} H$)	the enthalpy change that takes place when one mole of water is formed from a neutralisation reaction.
Enthalpy Change of Reaction ($\Delta_r H$)	the enthalpy change that is associated with a particular chemical equation.
Enthalpy Profile Diagram	shows the difference in the enthalpy of reactants and products as well as the activation energy of a reaction.
Exothermic	a reaction which gives out energy (ΔH is negative). More energy is released by bond making than is used in bond breaking.
Hess' Law	the enthalpy change of a reaction is independent of the route it takes.
Standard Conditions	a pressure of 100 kPa and a temperature of 298K.
Standard State	the physical state (s, l, g, aq) of a substance under standard conditions.

3.2.2 - Reaction Rates

Boltzmann Distribution	a graph showing the distribution of the energies of molecules in relation to the activation energy. Increasing temperature will increase the proportion of molecules with energy above the activation energy. A catalyst lowers the activation energy meaning more molecules will have sufficient energy to react.
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).
Collision Theory	the theory which states that molecules must collide with sufficient energy at the correct orientation for a reaction to occur.

Concentration	the amount of a substance that is dissolved per unit volume of solution. Increasing the concentration increases the rate of reaction as there are more molecules in the same volume meaning more frequent successful collisions.
Enthalpy Profile Diagram	shows the difference in the enthalpy of reactants and products as well as the activation energy of a reaction.
Heterogeneous Catalyst	a catalyst that is in a different state to the reactants (e.g. a solid catalyst with gaseous reactants).
Homogeneous catalyst	a catalyst which is in the same state as the reactants.
Pressure	the force that a gas exerts on the walls of a container. Increasing the pressure increases the rate of reaction as there are more molecules in the same volume (or the same number of molecules in a smaller volume) meaning more frequent successful collisions.
Rate of Reaction	a measure of how quickly a reactant is used up/ a product is formed. Rate can be determined by measuring concentration, the volume of gas produced or the mass lost over time.

3.2.3 - Chemical Equilibrium

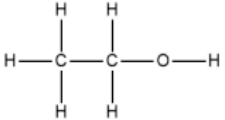
Catalyst	a substance that increases the rate of a reaction without being used up. In an equilibrium, the rates of both the forwards and reverse reactions are increased meaning the position of equilibrium is unchanged. A catalyst will increase the rate at which the equilibrium is established.
Compromise	balancing several different factors in order to get the best possible outcome. In industry, the position of the equilibrium and rate of reaction must be considered when deciding the conditions for the reaction. These factors must also be balanced with safety and economics.
Dynamic Equilibrium	a closed system in which the rates of the forward and reverse reactions are equivalent. The concentrations of reactants and products don't change.
Homogeneous Equilibrium	an equilibrium in which all reactants are in the same state.
Le Chatelier's Principle	when a system in dynamic equilibrium is subject to change, the position of equilibrium will shift to minimise the change. This principle is used to determine the effect of changing pressure, temperature or concentration on the position of equilibrium.
K_c	the equilibrium constant that is equal to the concentration of products raised to their stoichiometric coefficients divided by the concentration of reactants to the power of their stoichiometric coefficients. When K _c is greater than 1, the equilibrium favours the products. When K _c is less than 1, the equilibrium favours the reactants.

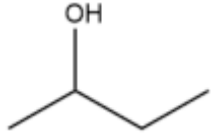
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Module 4: Core Organic Chemistry

Definitions and Concepts

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 $-CH_2$.
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. $Cl\bullet$.
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: $CH_3(CH_2)_2CH_3$.
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 $C\equiv C$ 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 C_nH_{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.

Module 4: Core Organic Chemistry

Definitions and Concepts

4.1.2 - Alkanes continued

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. Cl•.
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.

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Module 4: Core Organic Chemistry

Definitions and Concepts

4.1.3 - Alkenes continued

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 \equiv 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 ₂ O 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.

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Module 4: Core Organic Chemistry

Definitions and Concepts

4.2.1 - Alcohols continued

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. $\text{}^1\text{RCH OH}$). 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. $\bullet\text{Cl}$).
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

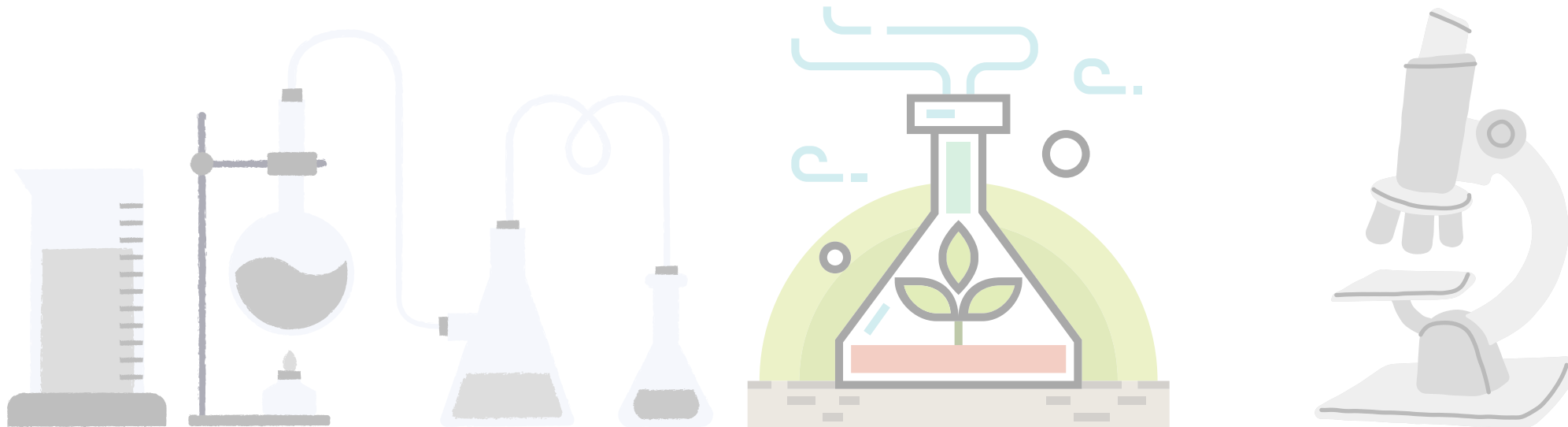
Anhydrous Salt	a salt such as MgSO_4 or CaCl_2 which is used to remove traces of water from an organic solution.
Distillation	a technique in which a liquid is heated then the vapour is cooled and collected in a separate flask to the reaction mixture. During distillation, the condenser must be positioned 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.

Module 4: Core Organic Chemistry

Definitions and Concepts

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 CO ₂ , H ₂ O and CH ₄) 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.



Module 5 - Physical Chemistry & Transition Elements

Definitions and Concepts

5.1.1 - How Fast?

Arrhenius Equation	$k = Ae^{E_a/RT}$ where k is the rate constant, A is the pre-exponential factor, E_a is the activation energy, R is the gas constant and T is the temperature.
Clock Reaction	a reaction in which the time taken for an abrupt visible change to occur is measured. The abrupt change typically indicates the formation of the product.
Colorimetry	a technique used to measure the amount of light absorbed by a solution, used to determine the rate of a reaction. Typically, a calibration curve is plotted and used to relate the absorbance recorded by the colorimeter to the concentration of the solution.
Concentration-time Graph	a graph in which concentration is plotted on the y axis and time on the x axis. The gradient of the line is equal to the rate of reaction.
Continuous Monitoring	during a rate experiment, continuous measurements are taken as the reaction progresses. The results can then be plotted on a concentration-time graph.
First Order Reactant	doubling the concentration of a first order reactant will double the rate (if all other conditions remain the same).
Gradient	change in y \div change in x.
Half-life ($t_{1/2}$)	the time taken for the concentration of a reactant to half.
Initial Rate	the rate of a reaction at $t=0$.
Order	a number that relates the rate of a reaction to the concentrations of each reactant.
Overall Order	the sum of the orders with respect to each reactant.
Rate Constant (k)	a constant value that relates the rate of a reaction at a given temperature to the concentrations of the reactants. For a first order reaction, this can be determined using the relationship $k = \ln 2/t_{1/2}$.
Rate-concentration Graph	a graph that has concentration plotted on the x axis and rate on the y axis.

Rate-determining Step	the slowest step of a reaction.
Rate equation	relates rate to the concentrations of the reactants multiplied by the rate constant. Each concentration is raised to the power of the order with respect to that reactant.
Rate of Reaction	a measure of how quickly a reactant is used up / a product is formed.
Reaction Mechanism	a step-by-step sequence of the individual reactions that make up the overall reaction.
Second Order Reactant	doubling the concentration of a first order reactant will quadruple the rate (if all other conditions remain the same).
Zero Order Reactant	doubling the concentration of a first order reactant will have no impact on the rate (if all other conditions remain the same).

5.1.2 - How Far?

Catalyst	a substance which speeds up the rate of a reaction without being used up.
Concentration	the amount of a substance that is dissolved per unit volume of solution.
Endothermic	a reaction that takes in energy from the surroundings. The energy of the products is higher than the reactants.
Equilibrium	the forward and reverse reactions of a process occur at exactly the same rate meaning there is no overall change.
Equilibrium Constant (K)	a value that relates the amount of products and reactants at equilibrium in a reversible reaction at a specific temperature. K is unaffected by pressure and presence of a catalyst but is affected by temperature.
Exothermic	a reaction that gives out energy into the surroundings. The energy of the reactants is higher than the products.
Heterogeneous Equilibrium	an equilibrium reaction that involves substances in different states (solid, liquid gaseous or aqueous).

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Module 5 - Physical Chemistry & Transition Elements

Definitions and Concepts

5.1.1 - How Far? continued

Homogeneous Equilibrium	an equilibrium reaction that involves substances all in the same state (solid, liquid gaseous or aqueous).
K_c	the equilibrium constant that is equal to the concentration of products raised to their stoichiometric coefficients divided by the concentration of reactants to the power of their stoichiometric coefficients. Liquids and solids are not included in heterogeneous K_c expressions as their concentrations effectively remain constant.
K_p	the equilibrium constant that is equal to the partial pressures of the products raised to the power of their stoichiometric coefficients divided by the partial pressures of the reactants raised to the power of their stoichiometric coefficients.
Mole Fraction	$X_A = n_A/n$ where X_A is the mole fraction of A, n_A is the number of moles of A and n is the total number of moles.
Partial Pressure	the pressure that would be exerted by one gas in a mixture if it occupied the container alone. $P_A = PX_A$ where P_A is the partial pressure of A, P is the total pressure and X_A is the mole fraction of A.

5.1.3 - Acids, Bases and Buffers

Acid Dissociation Constant (K_a)	the extent of acid dissociation. $pK_a = -\log(K_a)$ and $K_a = 10^{-pK_a}$
Bronsted-Lowry Acid	a proton donor.
Bronsted-Lowry Base	a proton acceptor.
Buffer Solution	a system that minimises pH change on addition of small amounts of an acid or base. A buffer solution can be formed from a weak acid and a salt of the weak acid or from excess weak acid and a strong alkali.
Carbonic Acid-Hydrogencarbonate Buffer	the buffer system present in blood plasma, used to maintain blood pH between 7.35 and 7.45.
Conjugate Acid-Base Pair	a pair of compounds that transform into each other by the transfer of a proton. Conjugate acid-base pairs are important in the formation of buffers to control pH.

Dibasic Acid	an acid that can donate 2 hydrogen atoms per molecule of the acid.
End Point	the point during a titration when the indicator changes colour. A suitable indicator should change colour near the equivalence point (it should have a pH range within the vertical section of the titration curve).
Equivalence Point	the point during a titration when the amount of acid is exactly equal to the amount of base (full neutralisation occurs). When titrating an acid with a base, $[H^+]$ is equal to $[OH^-]$ at this point.
Indicator	a weak acid that changes colour with changing pH due to an equilibrium shift between HA and A ⁻ . For an indicator to be suitable, its pH range must be within the vertical section of the titration curve (there is no suitable indicator for weak acid-weak base titration as the titration curve does not have a vertical section).
Ionic Equation	a chemical equation that involves dissociated ions.
Ionic Product of Water (K_w)	the temperature dependent constant that represents the dissociation of water into H ⁺ and OH ⁻ .
Monobasic Acid	an acid that can donate 1 hydrogen atom per molecule of acid.
pH	a way of communicating the concentration of hydrogen ions. $pH = -\log[H^+]$ and $[H^+] = 10^{-pH}$.
pH Meter	an instrument used to measure the pH of a solution.
Strength of Acids and Bases	a measure of the relative degree of dissociation of an acid or base (where strong means complete dissociation and weak means partial dissociation).
Titration	a technique used to determine the amount of one solution of a known concentration required to completely react with a known volume of another solution of unknown concentration.
Titration Curves	a graph which shows the change in pH over the course of a titration.
Tribasic Acid	an acid that can donate 3 hydrogen atoms per molecule of acid.
Vertical Section	the vertical part of a titration curve which contains the equivalence point for the titration. During this section, there is a very large change in pH but a small change in the volume of acid or alkali added.

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Module 5 - Physical Chemistry & Transition Elements

Definitions and Concepts

5.2.1 - Lattice Enthalpy

Born-Haber Cycle	a cycle which can be used to calculate the lattice enthalpy of an ionic compound using other enthalpy changes.
Conservation of Energy	the total energy of an isolated system remains constant (energy cannot be lost or created).
Enthalpy (H)	a value that represents the heat content of a system.
Enthalpy Change (ΔH)	the change in the heat content of a system during a reaction.
Enthalpy Change of Atomisation (ΔH)	the enthalpy change that takes place when one mole of gaseous atoms is formed from an element in its standard state.
Enthalpy Change of Formation ($\Delta_f H$)	the enthalpy change that takes place when one mole of a compound is formed from its elements.
Enthalpy Change of Hydration ($_{hyd}H$)	the enthalpy change that takes place when one mole of gaseous ions are dissolved in water (exothermic). Increasing ionic charges and decreasing ionic radii make this value more negative as there would be greater attraction between the water molecules and the ions.
Enthalpy Change of Solution ($_{sol}H$)	the enthalpy change that takes place when one mole of solute is dissolved.
First Electron Affinity	the amount of energy released when one mole of electrons is added to one mole of gaseous atoms, forming one mole of 1- ions.
First Ionisation Energy	the removal of one mole of electrons from one mole of gaseous atoms to form one mole of 1+ ions.
Ionic Bond	electrostatic attraction between positive and negative ions.
Giant Ionic Lattice	a regular repeating structure made up of oppositely charged ions.
Lattice Enthalpy ($\Delta_{LE}H$)	the formation of one mole of an ionic lattice from gaseous ions. Lattice enthalpy is used as a measure of the strength of ionic bonds in a giant lattice, with a more negative value meaning stronger bonds. Increasing ionic charges and decreasing ionic radii make this value more negative as there would be greater attraction between the ions.

5.2.2 - Enthalpy and Entropy

Enthalpy (H)	a value that represents the heat content of a system.
Entropy (S)	a measure of the dispersal of energy in a system. The greater the entropy, the more disordered the system. The order of entropy for different states is solids < liquids < gases. Increasing the number of gaseous molecules in a reaction results in an increase in entropy.
Free Energy Change (ΔG)	the feasibility of a process depends on entropy change, temperature and enthalpy change. The equation for Gibbs free energy is: $\Delta G = \Delta H - T\Delta S$. A process is spontaneous/ feasible when ΔG is negative. Gibbs free energy doesn't consider kinetics.
Kinetics	the part of chemistry relating to rates of reaction.

5.2.3 - Redox and Electrode Potentials

Cell Potential	a measure of the potential difference between two half cells, calculated by combining 2 standard electrode potentials. The calculated cell potential can be used to predict feasibility of a reaction, although this doesn't consider concentration or kinetics.
Electrochemical Cell	contains electrodes in an electrolyte and is used to generate current. A cell could be made up of either a metal or non-metal in contact with a solution of its ions or a solution of ions of the same element in different oxidation states with a Pt electrode. If the cell is a standard cell, ions of the same element should have concentrations of 1 mol dm ³ or they should be equimolar.
E.M.F.	electromotive force, measured in volts.
Equimolar Solution	a solution of ions in which there is an equal number of moles of each ion.
Fuel Cell	a type of cell that requires a constant supply of fuel and oxygen in order to generate a potential difference.
Half Equation	an equation which shows the number of electrons that are transferred during a reaction.
Oxidation	the loss of electrons/ increase in oxidation number.
Oxidation Number	a number that represents the number of electrons lost or gained by an atom of an element. A positive oxidation number indicates the loss of electrons.

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Module 5 - Physical Chemistry & Transition Elements

Definitions and Concepts

5.2.3 - Redox and Electrode Potentials continued

Oxidising Agent	a substance that can oxidise another substance.
Redox	a reaction in which oxidation of one element and reduction of another occurs.
Redox Titration	a type of titration which involves the reduction of one substance and the oxidation of another. The exact volume of titrant required to react with the analyte is determined using an indicator which shows the end point of the reaction.
Reducing Agent	a substance that can reduce another substance.
Reduction	the gain of electrons/ decrease in oxidation number.
Standard Electrode (Redox) Potential (E^\ominus)	the e.m.f. of a half cell compared with a standard hydrogen half cell. This is measured under standard conditions (1 mol dm ³ solution concentrations, 298K and 1 atm).
Storage Cell	a type of cell that can store energy. Storage cells convert chemical energy into electrical energy by a reaction and they may be recharged by reversing the chemical reaction.

5.3.1 - Transition Elements and 5.3.2 - Qualitative Analysis


Anion	a negatively charged ion.
Bidentate Ligand	a substance that can form 2 dative covalent (coordinate) bonds with a metal ion/ metal. E.g. NH ₂ CH ₂ CH ₂ NH ₂ ('en').
Catalyst	a substance which increases the rate of a reaction without being used up.
Cation	a positively charged ion.
Cis-platin	the cis-isomer of Pt(NH ₃) ₂ Cl ₂ , used as an anticancer drug. Cis-platin binds to DNA, preventing cell replication.
Cis-trans Isomerism	a type of stereoisomerism that can occur within transition metal complexes. Substituents are either on the same side/ next to each other (cis) or on opposite sides (trans). Cis-trans isomerism occurs in Pt(NH ₃) ₂ Cl ₂
Complex Ion	an ion which has a central metal atom (typically a transition element) surrounded by ligands. The ligands are bound to the transition metal centre by dative coordinate bonds.

Coordination Number	the number of dative covalent bonds formed between ligands and a metal ion centre.
Dative Covalent (Coordinate) Bond	a type of covalent bond in which one bonding atom provides both electrons in the bonding pair.
d-Block	the part of the periodic table containing elements in which the highest energy electron is in a d orbital.
Disproportionation	a reaction in which the same element is both oxidised and reduced.
Electron Configuration	the arrangement of electrons into orbitals and energy levels around the nucleus of an atom/ ion.
Haemoglobin	a protein which is important for oxygen transport in blood. The iron ion in haemoglobin undergoes a ligand substitution reaction involving CO ₂ and O ₂ .
Ligand Substitution	a reaction in which one ligand in a transition metal complex is replaced by another. Typically, these reactions are associated with a colour change.
Monodentate Ligand	a substance that can form 1 dative covalent (coordinate) bond with a metal ion/ metal. E.g. H ₂ O, Cl ⁻ and NH ₃ .
Octahedral	the shape of a transition metal complex with a coordination number 6. E.g. [Cu(H ₂ O) ₆] ²⁺ .
Optical Isomer	compounds that have the same structural formulae but are mirror images of one another. Optical isomerism occurs in [Ni(en) ₃] ²⁺ .
Oxidation State	a number that represents the number of electrons lost or gained by an atom of an element. A positive oxidation number indicates the loss of electrons.
Precipitation Reaction	a reaction in which 2 aqueous solutions are combined to form a solid (a precipitate).
Qualitative analysis	techniques that are used to identify whether or not an element, functional group or ion is present in a sample.
Redox	a reaction in which oxidation of one species and reduction of another occurs.
Square Planar	one of the possible shapes of a transition metal complex with a coordination number of 4. E.g. Pt(NH ₃) ₂ Cl ₂ .
Stereoisomerism	a type of isomerism in which compounds have the same structural formula but a different arrangement of atoms in space.
Tetrahedral	one of the possible shapes of a transition metal complex with a coordination number of 4. E.g. CuCl ₄ ²⁻
Transition Elements	d-block elements that can form an ion with an incomplete d-subshell. Transition elements have more than one oxidation state, form coloured ions and can act as catalysts.

Module 6 - Organic Chemistry & Analysis

Definitions and Concepts

6.1.1 - Aromatic Compounds

Acyl Chloride	a molecule containing the functional group below. 
Aromatic Compound	a compound containing at least one benzene ring.
Delocalised Model of Benzene	the p-orbitals of the 6 carbon atoms overlap to form a delocalised π system. This model is supported by experimental evidence: all the C-C bond lengths in benzene are the same, the enthalpy change of hydrogenation is less exothermic than would be expected for cyclohex-1,3,5-triene and the benzene does not undergo addition reactions.
Electron Density	a representation of the probability of finding an electron at a specific point around an atom/ molecule. Benzene has a lower electron density than an alkene. In benzene, the electron density is delocalised into the π system across 6 carbon atoms while in an alkene, the pair of electrons is localised between 2 carbon atoms in a π bond.
Electron Donating Groups	groups which donate electrons into the aromatic ring when they are attached to a carbon in the ring. OH, an electron donating group, is 2- and 4-directing, meaning that substituents will be substituted at positions 2 and 4 during an electrophilic substitution reaction.
Electron Withdrawing Groups	groups which pull electron density away from the delocalised π system of benzene. NO_2 , an electron withdrawing group, is 3-directing meaning that substituents will be substituted at carbon 3 during an electrophilic substitution reaction.
Electrophilic Substitution	a reaction in which an electrophile (an electron pair acceptor) reacts with another compound to replace an atom / group of atoms.
Haloalkane	an organic compound containing a halogen atom (F/Cl/Br/I) bound to an alkyl chain.
Halogen Carrier	a Lewis acid that can bind to a halogen molecule, weakening the halogen bond and allowing the halogen to function as an electrophile and attack electrons in an aromatic ring. Examples of halogen carriers include iron, iron halides and aluminium halides.

Kekulé's Structure of Benzene

a model of benzene which contains alternating C=C double and C-C single bonds in a hexagonal ring, with each carbon atom bound to one hydrogen atom.

Phenol

a weak acid that reacts with NaOH but not carbonates. Phenol has an aromatic ring with an OH group attached. Phenol can undergo electrophilic substitution reactions more easily than benzene as the lone pair in the p-orbital of oxygen is donated into the π system of phenol, increasing its electron density. As a result of this electron donation, phenol is more susceptible to electrophilic attack than benzene.

6.1.2 - Carbonyl Compounds

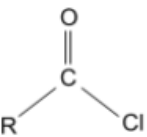
2,4-dinitrophenylhydrazine	also known as Brady's reagent, this compound forms an orange precipitate in the presence of aldehydes and ketones. The melting point of the 2,4-DNP derivative of a carbonyl can be used to identify the carbonyl compound.
Aldehyde	a compound containing the -CHO functional group at the end of an alkyl chain. Aldehydes can be oxidised to carboxylic acids using $\text{Cr}_2\text{O}_7^{2-} / \text{H}^+$.
Carbonyl	the C=O group. Aldehydes and ketones are carbonyl compounds.
Nucleophile	an electron pair donor.
Nucleophilic Addition	a reaction in which an electrophilic π bond reacts with a nucleophile, breaking the π bond and forming 2 new σ bonds. Examples include carbonyl compounds reacting with NaBH_4 to form alcohols or with HCN to form hydroxynitriles.
Oxidation	the loss of electrons/ increase in oxidation number.
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.

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Module 6 - Organic Chemistry & Analysis

Definitions and Concepts

6.1.3 - Carboxylic Acids and Esters

Acyl Chloride	a compound containing the functional group shown below. Acyl chlorides can be made from carboxylic acids and SOCl_2 and they are used to form esters, carboxylic acids and primary and secondary amides.	
Bronsted-Lowry Acid	a proton donor.	
Bronsted-Lowry Base	a proton acceptor.	
Carboxylic Acid	an organic compound containing the $-\text{COOH}$ functional group. Carboxylic acids react with metals as well as bases such as carbonates, metal oxides and alkalis.	
Ester	a compound containing the $\text{R-COO-R}'$ functional group (where R and R' are alkyl groups).	
Esterification	the process of making esters. Esters can be made by a reaction between carboxylic acids and alcohols in the presence of an acid catalyst or by a reaction between acid anhydrides and alcohols.	
Hydrolysis	a reaction in which water is used to break down a compound. Esters can either be hydrolysed with hot aqueous acid (forming carboxylic acids and alcohols) or with hot aqueous alkali (forming carboxylate salts and alcohols).	
Water Soluble	a compound that can dissolve in water. Carboxylic acids are water soluble as they can form hydrogen bonds with the H_2O molecules.	

6.2.1 - Amines

Aliphatic Amine	an amine which only contains straight or branched alkyl chains. Aliphatic amines can be formed via a substitution reaction of haloalkanes with either ammonia or amines in ethanol solvent.
Amines	compounds that contain the NR_3 functional group (where R could be hydrogen atoms or alkyl chains). Amines are basic as the nitrogen lone pair allows the acceptance of a proton. In a reaction between amines and dilute acids, salts are formed.
Aromatic Amine	an amine which contains a benzene ring directly attached to the nitrogen atom. Aromatic amines can be formed by reducing nitroarenes with tin and concentrated HCl.

6.2.2 - Amino Acids, Amides and Chirality

α-Amino Acid	a compound with the general formula $\text{RCH}(\text{NH}_2)\text{COOH}$, where an amino group and a carboxylic acid group are bonded to the same carbon atom. The carboxylic acid group of an amino acid reacts with alkalis or can be used to form esters. The amine group of an amino acid reacts with acids.
Amine Group	the $-\text{NH}_2$ group in an organic compound.
Carboxylic Acid Group	the $-\text{COOH}$ group in an organic compound.
Chiral Centre	a carbon atom which is bonded to 4 different groups.
Ester	a compound containing the $\text{R-COO-R}'$ functional group (where R and R' are alkyl groups).
Optical Isomerism	a type of stereoisomerism in which compounds are non-superimposable mirror images of one another (caused by the presence of a chiral centre).
Primary Amide	an organic compound which contains the functional group RNH_2 (where R is an alkyl chain).
Secondary Amide	an organic compound which contains the functional group R_2NH (where R is an alkyl chain).
Stereoisomers	compounds with the same structural formula but a different arrangement of atoms in space.

6.2.3 - Polyesters and Polyamides

Addition Polymerisation	the formation of a long chain molecule when many monomers join together (the polymer is the only product).
Amide Hydrolysis	amides can either be hydrolysed under acidic conditions (forming carboxylic acids and ammonium salts) or under alkaline conditions (forming carboxylate salts and either ammonia or an amine). Polyamides can be hydrolysed in a similar way.
Condensation Polymerisation	a long chain molecule formed when monomers react together with the release of small molecules such as water. Types of condensation polymers are polyamides (formed from carboxylic acids / acyl chlorides and amines) and polyesters (formed from carboxylic acids / acyl chlorides and alcohols).

Module 6 - Organic Chemistry & Analysis

Definitions and Concepts

6.2.3 - Polyesters and Polyamides calendar

Ester Hydrolysis	esters can either be hydrolysed with hot aqueous acid (forming carboxylic acids and alcohols) or with hot aqueous alkali (forming carboxylate salts and alcohols). Polyesters can be hydrolysed in a similar way.
Monomer	a small molecule that is used to form polymers.
Polymer	a large molecule made from many small units 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.

6.2.4 - Carbon-Carbon Bond Formation

Acylation	a reaction that is used to form substituted aromatic compounds, using an acyl chloride to form a C-C bond in the presence of a halogen carrier.
Acid Hydrolysis	the breakdown of a compound using aqueous acid. Nitriles can be hydrolysed to form carboxylic acids.
Alkylation	a reaction which is used to form substituted aromatic compounds, using a haloalkane to form a C-C bond in the presence of a halogen carrier.
Carbonyl	a compound which contains the C=O functional group.
Friedel-Crafts Reactions	reactions which were developed to attach substituents to an aromatic ring. Acylation and alkylation are the 2 main types of Friedel-Craft reactions.
Halogen Carrier	a Lewis acid that can bind to a halogen molecule, weakening the halogen bond and allowing the halogen to function as an electrophile and attack electrons in an aromatic ring. Examples of halogen carriers include iron, iron halides and aluminium halides.
Nitrile	an organic compound which contains a $\text{-C}\equiv\text{N}$ group bound to an alkyl chain.
Nucleophile	an electron pair donor.
Nucleophilic Addition	a reaction in which an electrophilic π bond reacts with a nucleophile, breaking the π bond and forming 2 new σ bonds. One example is the reaction of carbonyl compounds with HCN to form hydroxynitriles.

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. One example is the reaction of haloalkanes with CN^- and ethanol to form nitriles.
Reduction	gain of electrons/ decrease in oxidation number. Nitriles can be reduced to amines with H_2/Ni .

6.2.5 - Organic Synthesis

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.
Filtration Under Reduced Pressure	a technique used to separate and dry an organic solid. A Büchner funnel is inserted into the top of a side-arm flask and a vacuum is applied. The solution is poured onto filter paper in the Büchner funnel so that the solid product can be separated.
Functional Group	a group of atoms responsible for the characteristic reactions of a compound.
Melting Point Apparatus	a piece of apparatus used to determine the melting point of a sample. The recorded melting point range is compared with known values to determine whether the sample is pure.
Quickfit Apparatus	glassware that easily fits together in a variety of arrangements.
Recrystallisation	a technique used to purify an organic solid. The sample is dissolved in the minimum volume of hot solvent and filtered. The filtrate is then cooled before being filtered under reduced pressure. The purified solid will collect on the filter paper in the Büchner funnel.
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.
Synthetic Route	a series of steps that are followed to make a specific compound.

SIXTH FORM KNOWLEDGE ORGANISER

Module 6 - Organic Chemistry & Analysis

Definitions and Concepts

6.3.1 - Chromatography and Qualitative Analysis

Aldehyde	an organic compound containing the C=O functional group at the end of an alkyl chain. Aldehydes form a silver mirror when reacted with Tollens' reagent. Aldehydes can be oxidised to carboxylic acids with acidified potassium dichromate, causing a colour change from orange to green.
Alkene	an organic compound containing the C=C functional group. Alkenes decolourise bromine water.
Carbonyl	an organic compound containing the C=O functional group. Carbonyl compounds react with 2,4-DNP to form an orange precipitate.
Carboxylic Acid	an organic compound containing the -COOH functional group. Carboxylic acids react with CO_3^{2-} , causing effervescence.
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 solubility in the mobile phase and retention by the stationary phase.
Gas Chromatography	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 be used to analyse components separated by GC.
Haloalkane	an organic compound containing a halogen atom attached to an alkyl chain. The test for haloalkanes is a reaction with aqueous silver nitrate in ethanol. Chloroalkanes form a white precipitate, bromoalkanes form a cream precipitate and iodoalkanes form a yellow precipitate.
Mobile Phase	a substance that moves through the chromatography system to separate the mixture. This may be a gas (GC) or a liquid (TLC).
Phenol	an organic compound containing an aromatic ring with an -OH group attached. Phenols are weak acids but do not react with CO_3^{2-} .
Primary Alcohol	an organic compound with the general formula RCH_2OH . Primary alcohols can be oxidised with acidified dichromate, causing a colour change from orange to green.

Qualitative Analysis

techniques that are used to identify whether or not an element, functional group or ion is present in a sample.

Retention Time

the time taken for a sample to travel from the inlet to the detector in GC. The recorded retention time can be compared with standards to identify the substances in the mixture.

R_f value

in TLC, the R_f values can be calculated as shown below then compared with standards to identify what substances present in a mixture.

$$R_f = \text{distance moved by substance} \div \text{distance moved by solvent}$$

Secondary Alcohol

an organic compound with the general formula R_2CHOH . Secondary alcohols can be oxidised with acidified dichromate, causing a colour change from orange to green.

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 GC.

Thin Layer Chromatography (TLC)

a type of chromatography in which a plate is coated with a solid and a solvent moves up the plate.

6.3.2 - Spectroscopy

Carbon-13 NMR Spectroscopy

a type of NMR spectroscopy which analyses ^{13}C nuclei. The number of peaks in the spectrum shows the number of different environments and the chemical shifts show what environments are present.

Chemical Shift

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

Coupling

interaction between adjacent non-equivalent protons during NMR spectroscopy.

D₂O Exchange

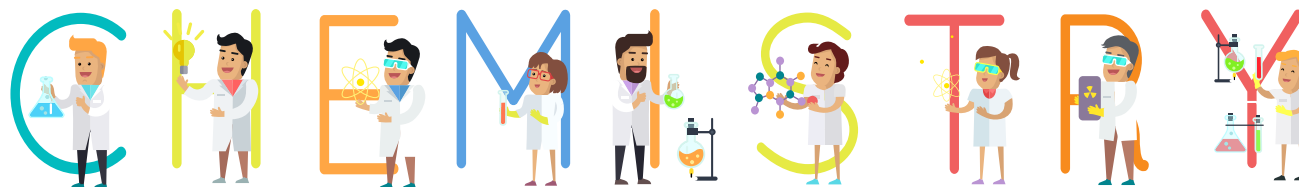
as O-H and N-H peaks can appear across a wide range of chemical shift values on a proton NMR spectrum, D_2O exchange can be used to identify which peaks are caused by O-H and N-H protons. Firstly, a proton NMR is run on a sample. The sample is then shaken with D_2O and a second proton NMR is run. Any peaks that are due to O-H or N-H protons will disappear on the second spectrum as these protons will be exchanged for deuterium.

Module 6 - Organic Chemistry & Analysis

Definitions and Concepts

6.3.2 - Spectroscopy continued

Deuterated Solvent	a solvent, such as CDCl_3 , in which all of the hydrogen atoms have been replaced by deuterium (^2H). Deuterated solvents are used in order to prevent the appearance of a solvent peak on the ^1H NMR spectrum.
Doublet	a signal on a ^1H NMR spectra made up of 2 peaks, indicating that there is 1 adjacent non-equivalent proton.
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.
Environment	in NMR spectroscopy, a proton or carbon environment considers the atoms/ groups that are adjacent to that hydrogen/ carbon atom. If 2 protons / carbons are surrounded by different groups of atoms, they are in different environments.
Equivalent protons	protons that are in the same environment.
IR Spectroscopy	a technique used to identify particular bonds and functional groups within a molecule. Infrared radiation is absorbed by covalent bonds in molecules, causing them to vibrate at a specific frequency.
Mass Spectroscopy	a technique used to identify compounds and determine relative molecular mass by measuring their mass to charge ratio.
n+1 Rule	used to determine spin-spin splitting patterns of adjacent non-equivalent protons. A proton with n adjacent non-equivalent protons will have a signal made up of n+1 peaks on a ^1H NMR spectrum.
Nuclear Magnetic Resonance (NMR)	a technique that uses the absorption of electromagnetic radiation by a 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 show the type of environments. The integration trace (equivalent to 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 4 peaks, indicating that there are 3 adjacent non-equivalent protons.
Spin-Spin Splitting	an interaction between adjacent non-equivalent protons. When protons couple (interact with one another), the signal on the ^1H NMR spectrum is split into a multiplet according to the n+1 rule.
Tetramethylsilane (TMS)	the standard for chemical shift measurement in NMR spectroscopy.
Triplet	a signal on a ^1H NMR spectra made up of 3 peaks, indicating that there are 2 adjacent non-equivalent protons.



SPaG

Grammar: Write in Sentences

A sentence is a group of words that make sense. Sentences start with a capital letter and end with a full stop, question mark or exclamation mark. All sentences contain clauses. You should try to use a range of sentences when writing. There are three main types of sentences.

Simple sentence: A sentence containing one main clause with a **subject** and a **verb**.

He reads.

Literacy is important.

Compound sentence: Two simple sentences joined with a conjunction. Both of these simple sentences would make sense on their own. Varying conjunctions makes your writing more interesting.

He read his book because it was written by his favourite author.

Literacy is important so students had an assembly about reading.

Complex sentence: A longer sentence containing a main clause and one or more subordinate clause(s), used to add more detail. The main clause makes sense on its own. However, a subordinate clause would not make sense on its own, it needs the main clause to make sense. The subordinate clause is separated by a comma (s) and/or conjunction. The clause can go at the beginning, middle or end of the sentence.

He read his book even though it was late.

Even though it was late, he read his book.

He read his book, even though it was late, because it was written by his favourite author.

How can you develop your sentences?

1. Start sentences in different ways. For example, you can start sentences with adjectives, adverbs or verbs.

Adjective: **Funny** books are my favourite!

Adverb: **Regularly** reading helps me develop a reading habit.

Verb: **Looking** at the front cover is a good way to choose a reading book.

2. Use a range of **punctuation**.

3. **Nominalisation**

Nominalisation is the noun form of verbs; verbs become concepts rather than actions. Nominalisation is often used in academic writing. For example:

It is important to read because it helps you in lots of ways.

Becomes: Reading is beneficial in many ways.

Germany invaded Poland in 1939. This was the immediate cause of the Second World War breaking out. Becomes:

Germany's invasion of Poland in 1939 was the immediate cause of the outbreak of the Second World War.

Connectives and Conjunctions

Cause
And
Effect

Because
So
Consequently
Therefore
Thus

Addition

And
Also
In addition
Further (more)

Comparing

Whereas
However
Similarly
Yet
As with/
equally/Likewise

Sequencing

Firstly
Initially
Then
Subsequently
Finally
After

Emphasis

Importantly
Significantly
In particular
Indeed

Subordinate

Who, despite, until, if,
while, as, although,
even though, that,
which

SPaG: Spelling and Punctuation**Punctuation**

Use a range of punctuation accurately when you are writing.

. Full stop Marks the end of a sentence.

, Comma Separates the items on a list or the clauses in a sentence.

' Apostrophe Shows possession (belonging) or omission (letters taken away).

" " Quotation marks Indicate a quotation or speech.

' ' Inverted commas Indicate a title.

? Question mark Used at the end of a sentence that asks a question.

! Exclamation mark Used at the end of a sentence to show surprise or shock.

: Colon Used to introduce a list or an explanation/ elaboration/ answer to what preceded. A capital letter is only needed after a colon if you are writing a proper noun (name of person or place) or two or more sentences.

; Semi-colon Joins two closely related clauses that could stand alone as sentences. Also used to separate items on a complicated list. A capital letter is not needed after a semi-colon unless you are writing a proper noun (name of person or place).

Brackets Used to add extra information which is not essential in the sentence.

Spelling

Use the following strategies to help you spell tricky words.

1. Break it into sounds (d-i-a-r-y)

2. Break it into syllables (re-mem-ber)

3. Break it into affixes (dis + satisfy)

4. Use a mnemonic (necessary - one collar, two sleeves)

5. Refer to word in the same family (muscle - muscular)

6. Say it as it sounds - spell speak (Wed-nes day)

7. Words within words (Parliament - I AM parliament)

8. Refer to etymology (bi + cycle = two + wheels)

9. Use analogy (bright, light, night, etc)

10. Use a key word to remember a spelling rule (horrible/drinkable for -ible & -able / advice/advise for -ice & -ise)

11. Apply spelling rules (writing, written)

12. Learn by sight (look-cover-say-write check)