St Thomas More Catholic Academy
FAITH | EXCELLENCE | RESPECT

Chemistry Curriculum Sequence – Key Stage 5

	KS4 prior learning	**By the end of the term, students can:**	Year 12 Term 1 - Atomic Structure	Year 12 - Term 2 - Periodicity	Year 12 Term 3 - Equilibria	Year 13 Term 1 - Thermodynamics	Year 13 Term 2 - Electrode potentials and electrochemical cells	Year 13 - Term 3 - Period 3 elements and their Oxides
What we want our students to know and remember	A-level Chemistry attempts to answer the big question 'what is the world made of' and it's the search for this answer that makes this subject so fascinating. From investigating how one substance can be changed drastically into another, to researching a new wonder drug to save millions of lives, the opportunities that chemistry provides are endless	Define the key tier 3 **vocabulary**:	Acceleration: Second stage of TOF spectrometry. The positively charged ions are accelerated by an electric field so that they have the same kinetic energy. Atom: The smallest part of an element that can exist. All substances are made up of atoms. Atomic nucleus: Positively charged object composed of protons and neutrons at the centre of every atom with one or more electrons orbiting it. Atomic number: The number of protons in the nucleus. Electron: Negatively charged subatomic particle which orbit the nucleus at various energy levels. Relative mass of 1/2000. Electron configuration: The distribution of electrons of an atom in orbitals. E.g. Ca: 1s 2 2s 2 2p 6 3s 2 3p 6 4s 2 . Electron impact ionisation: Method of ionisation in TOF spectrometry. The sample is dissolved and pushed through a fine nozzle at a high pressure. A high voltage is applied to it causing each particle to gain an H + ion. The sample is then turned into a gas. Electrospray ionisation: Method of ionisation in TOF spectrometry. The	Atomic radius trend: Atomic radius decreases across a period. This is because positive charge increases across a period due to the increasing proton number and this means the electrons are attracted closer to the nucleus, making the atomic radius smaller. Element classification: An element is classified as s, p, d or f block according to its position in the Periodic Table. Periodicity: Trends in element properties with increasing atomic number. The trends are caused by the changes in element atomic structure. Proton number: The number of protons found in the nucleus of every atom of that element. Elements are arranged in the periodic table in order of increasing proton number.	Catalyst: A substance that increases the rate of a reaction without being changed in chemical composition or amount. They work by providing an alternative reaction pathway with a lower activation energy. Closed system: A system where there is only heat exchange occurring between the system and its surroundings. No matter can enter or exit the system. Dynamic equilibrium: Dynamic equilibrium is reached when the rate of the forward reaction of a reversible reaction equals the rate of the backward reaction. The concentrations of the reactants and products remain constant. Equilibrium constant (Kc): A value that expresses the relationship between the concentration of products and reactants present at equilibrium in a reversible reaction. Heterogeneous system: A system where not all the chemicals are in the same phase. Homogeneous system: A system where all the chemicals are in the same phase. Le Chatelier's principle: If a reaction at equilibrium is subjected to a change in concentration, temperature or pressure, the position of	Bond enthalpy: The amount of energy required to break one mole of the stated bond in the gas phase. Born-Haber cycle: Calculates the lattice enthalpy by applying Hess's law and comparing the standard enthalpy change of formation of the ionic compound to values such as ionisation energy and electron affinity. Covalent character: The partial sharing of electrons between atoms that have an ionic bond. Enthalpy of atomisation: Enthalpy change when one mole of gaseous atoms is formed from the elements in its standard states. It is always endothermic. Enthalpy of formation: Enthalpy change when one mole of a compound is formed from its elements in their standard states under standard conditions. Enthalpy of hydration: Enthalpy change when one mole of a gaseous ion is completely dissolved in water under standard conditions. Enthalpy of lattice dissociation: Enthalpy change when one mole of a solid ionic compound is converted into its gaseous ions. Enthalpy of lattice formation: E enthalpy change when one mole	Anode: Positive electrode where oxidation takes place. Cathode: Negative electrode where reduction takes place. Electrochemical cell: Combination of two half cells, consists of two electron conductors (electrodes) separated by an ionic conductor (electrolyte). Cells are used to measure electrode potentials by reference to the standard hydrogen electrode. Electrochemical series: A series of elements arranged in order of their standard electrode potentials. Electrode: A conductor through which electricity enters or leaves a substance or region. Electrode potential: The potential difference of a cell consisting of a specific electrode as the cathode and the standard hydrogen electrode as the anode. Reduction always takes place at the cathode, and oxidation at the anode. EMF: The difference between the potential differences of the cathode and anode in an electrochemical cell. Fuel cell: An electrochemical cell that converts the chemical energy of a fuel (often hydrogen) and an oxidising agent (often oxygen) into electricity	Amphoteric: A substance is called amphoteric if it is able to react as a base and as an acid. Aluminium oxide will react with acids and bases to form salts so it is classed as amphoteric. Aluminium oxide is amphoteric due to the fact that it is partially ionic and partially covalent bonded. Oxides: A compound containing oxygen bonded with one other element. Dissociate: Split up into ions.

			sample is vaporised and an electron gun fires high energy electrons at it, causing an electron to be knocked off each particle to produce 1+ ions. First ionisation energy: : The energy required to remove 1 mole of electrons from 1 moles of gaseous atoms to form 1 mole of gaseous 1+ ions. E.g. $O(g) \rightarrow O^+(g) + e^-$. Ion detection: Fourth stage of TOF spectrometry. The negatively charged plate detects charged particles and a mass spectrum is produced. Ion drift: Third stage of TOF spectrometry. The ions enter a region with no electric field, so they drift through it. The lighter the ion, the faster they will drift. Ionisation: First stage of TOF spectrometry. The sample can be ionised by electrospray ionisation or electron impact ionisation. Isotope: Atoms of the same element with the same number of protons but a different number of neutrons. E.g. ^{35}Cl and ^{37}Cl. Mass number: The total number of protons and neutrons in the nucleus. Mass spectrometer: A mass spectrometer gives accurate information about relative isotopic mass and also about the relative abundance of isotopes. Mass spectrometry: Mass spectrometry can be used to identify elements and determine relative molecular mass. Neutron: Neutral subatomic particle present in the nucleus of the atom. Relative mass		equilibrium will move to counteract the change. Reversible reaction: Reactions in which the products from the reaction can react together to form the original reactants. The direction of reversible reactions can be changed by changing the conditions.	of a solid ionic compound is formed from its gaseous ions. Enthalpy of solution: Enthalpy change when one mole of ionic solid completely dissolves in water under standard conditions to form an infinitely dilute solution. Entropy: A measure of the disorder of a system. The units of entropy are $JK^{-1} mol^{-1}$. On a molecular level, gases are more disordered than liquids, which are more disordered than solids. A reaction that produces a greater number of molecules than the number of reactants molecules will have a positive entropy change, as there will exist more random arrangements of these molecules, i.e. the system will become more disordered. Feasible reaction: For a reaction to be feasible at a given temperature it must occur spontaneously. This means no extra energy is required for the reaction to occur. First electron affinity: Enthalpy change when one electron is added to each atom in one mole of gaseous atoms to form one mole of gaseous 1- ions. First ionisation energy: Enthalpy change when one mole of gaseous atoms gains one mole of electrons to form one mole of gaseous ions. Gibbs free-energy change: A measure of the feasibility of a chemical reaction. $\Delta G = \Delta H - T\Delta S_{system}$ Ionic character: The amount the electrons are shared between two atoms. Limited electron	through redox reactions. They do not need to be recharged. Non-rechargeable cell: A cell that is designed to be used only once since the reactions involved are irreversible. Rechargeable cell: cells in which reversible reactions occur, allowing them to be recharged to regain their cell potential Redox reaction: A reaction in which reduction and oxidation occur simultaneously. Salt bridge: A porous substance soaked with a solution of an inert, strong electrolyte, e.g. a filter paper soaked in KNO_3 (aq). The salt ions flow through the bridge to complete the cell and balance charges in solutions.	

			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. Proton: Positively charged subatomic particle present in the nucleus of the atom. Relative mass of 1. Second ionisation energy: The energy required to remove 1 mole of electrons from 1 moles of gaseous 1+ ions to form 1 moles of gaseous 2+ ions. E.g. O - (g) → O 2+ (g) + e - . Sub-shells (orbitals): Electron shells are divided up into sub-shells which have slightly different energy levels. The sub-shells have different numbers of orbitals which can each hold up to two electrons. Types of sub-shell: s, p, d and f. Time of Flight (TOF) spectrometer: A method of mass spectrometry where an ions mass-to-charge ratio is determined by a time of flight measurement. Consists of four stages: ionisation, acceleration, ion drift and detection.			sharing corresponds with a higher percentage of ionic character.		
			Year 12 Term 1 - Amount of Substance	Year 12 - Term 2 - Group 2 - Alkaline Earth Metals	Year 12 Term 3 - Kinetics	Year 13 Term 1 - Rate Equations	Year 13 Term 2 - Acids and Bases	Year 13 - Term 3 - Transition Metals - General Properties and Substitution Reactions

			Atom economy: The measure of the amount of starting materials that end up as useful products. Avogadro's constant: The number of atoms, molecules or ions in one mole of a given substance. Concentration: The amount of substance per unit volume. Empirical formula: The smallest whole number ratio of atoms of each element in a compound. Limiting reactant: The reactant that is completely used up since it limits the amount of products formed. Mole: The mass of a substance containing the same number of units as there are atoms in exactly 12 g of carbon-12. Molecular formula: The actual ratio of atoms of each element present in a compound. Percentage by mass: A value representing the concentration of an element in a compound or a component in a mixture. Percentage yield: The percentage ratio of the actual yield of product from a reaction compared with the theoretical yield. Relative atomic mass: The average mass of an atom of an element compared to 1/12th the mass of an atom of carbon-12. 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.	Barium meals: Barium sulfate is used in barium meals. Barium sulfate is opaque to x-rays (they won't pass through it) so barium meals can help to solve problems in the stomach or intestine. Flue gases: The gases emitted from chimneys and industrial exhausts. Solubility: The ability for a given substance to dissolve in a solvent. Solubility of the Group 2 hydroxides increases down the group and solubility of the Group 2 sulfates decreases down the group. Sparingly soluble: Compounds which have very low solubilities are described as sparingly soluble. Magnesium hydroxide is sparingly soluble. Wet scrubbing: A process used to remove acidic sulfur dioxide from flue gases by reacting the gases with an alkali.	Activation energy: The minimum amount of energy for particles to collide with for a successful reaction to take place. Catalyst: A substance that increases the rate of a reaction without being changed in chemical composition or amount. They work by providing an alternative reaction pathway with a lower activation energy. Collision theory: Reactions can only occur when collisions take place between particles having sufficient energy. Maxwell-Boltzmann distribution: Shows the distribution of the molecular energies in a gas at a constant temperature. The area under the curve indicates the total number of particles present. Rate of reaction: The measure of the amount of product formed or reactant used over time. The units of rate of reaction may be given as g/s, cm^3/s or mol/s.	Concentration-time graph: A graph which can be used to deduce the rate of reaction by drawing tangents to the curve. Order of reaction: Tells you how the reactant's concentration will affect the rate of reaction. In the rate equation, it is the appropriate power to which the concentration of the reagent is raised. Overall order of a reaction: Sum of all the individual orders of all the reactants in a chemical reaction. Rate-concentration data: Rate-concentration data or graphs can be used to deduce the order (0, 1 or 2) with respect to a particular reactant. Rate constant: Relates the rate of a chemical reaction at a given temperature to the product of the concentrations of reactants. Rate determining step: The slowest step in a multi-step reaction. The overall rate is decided by this step since species occurring in the RDS will also occur in the rate equation. Rate equation: Describes the relationship between the rate of chemical reaction and the concentrations/pressures of reagents. Rate = $k[A]^m[B]^n$, where k is the rate constant and where m and n are the orders of reaction with respect to reactants A and B.	Brønsted-Lowry acid: Proton donors. They release hydrogen ions when mixed with water. The hydrogen ions mix with water molecules to form hydroxonium ions: $HA + H_2O \rightarrow H_3O^+ + A^-$ Brønsted-Lowry base: Proton acceptors. When in solution they bond to hydrogen ions from water molecules. For a base B: $B + H_2O \rightarrow BH^+ + OH^-$. Diprotic acid: An acid which can release two H^+ ions upon dissociation, e.g. H_2SO_4. End point: The point during the titration when the indicator changes colour. A suitable indicator should change colour near the equivalence point (so should have a pH range within the pH change during the equivalence point). Equivalence point: The point when full neutralisation occurs. When titrating an acid with a base, it is the point when all acid has been neutralised, and so $[H^+]=[OH^-]$. Indicators: Indicators are chemical solutions which will change colour when there is a change of pH. Methyl orange and phenolphthalein are indicators commonly used in titrations. Methyl orange is red in an acid and changes to yellow in an alkali. Phenolphthalein is colourless in an acid and changes to pink in an alkali. K_a : Acid dissociation constant, a quantitative measure of the strength of an acid in solution.	Bidentate ligand: Ligands that can only form two coordinate bonds Complex: A central metal atom or ion surrounded by coordinately bonded ligands. Coordinate bond: A co-ordinate, or dative, bond is a covalent bond in which both electrons in the shared pair come from the same atom. Coordination number: The number of coordinate bonds that are formed with the central metal ion. d-block: The block of elements in the middle of the periodic table. Most d-block elements are transition metals. Elements in the d block have their outer electron in the d orbital. Ligand: An atom, ion or molecule that forms a co-ordinate bond with a central transition metal ion by donating a pair of electrons. Ligand substitution: A reaction in which a ligand is substituted by another ligand. Monodentate ligand: Ligands that can only form one co-ordinate bond. E.g. H_2O and NH_3. Multidentate ligand: Ligands that can form more than one co-ordinate bond. Redox titrations: A titration experiment to determine the concentration of an unknown solution by carrying out a redox reaction between the two reactants. Transition metal: A metal that can form one of more stable ions with a partially filled d sub-level.

							The larger the K_a value the stronger the acid, since it means the acid is largely dissociated into its ions. K_W : Ionic product of water. At 298K, Kw = 1.0×10^{-14} mol^2 dm^{-6} . Kw = $[H^+][OH^-]$ Monoprotic acid: An acid which can release only one H^+ upon dissociation, e.g. HCl. Neutralisation: A reaction between an acid and a base which react together to form water and a salt. The ionic equation for neutralisation: $H^+ + OH^- \rightarrow H_2O$ pH: A value expressing the acidity or alkalinity of a solution. A value of 0-6 implies an acidic solution, 7 implies a neutral solution and 8-14 implies an alkaline solution. pH curve: A graph that plots pH against volume of acid/base that is added to a solution will produce a pH curve. The curve usually has a vertical part which can be identified as the equivalence point. pH meter: An instrument which measures the pH of a solution. A digital pH meter is better than a universal indicator as it can give a more precise value. pH scale: The pH scale, from 0 to 14, is a measure of the hydrogen ion concentration which tells you about the acidity or alkalinity of a solution. It can be measured using a universal indicator or a pH probe. Strong acid: An acid which dissociates almost completely in water. This means nearly all the H^+ ions will be released. E.g.	

							HCl. Strong base: A base which ionises almost completely in water. E.g. NaOH. Titration: An experimental technique used to determine the concentration of an unknown solution by using a different solution with known concentration. Weak acid: Acids which only dissociate very slightly in water so that only a small number of H + ions are released. E.g. Ethanoic acid. Weak base: A base which only slightly ionises in water. E.g. NH3.	
			Year 12 Term 1 - Bonding	Year 12 - Term 2 - Group 7 - The Halogens	Year 12 - Term 3 - Organic Analysis	Year 13 Term 1 - Equilibrium constant Kp	Year 13 Term 2 - Buffers	Year 13 - Term 3 - Transition Metals - Shapes

			Co-ordinate bond: A co-ordinate (dative covalent) bond contains a shared pair of electrons with both electrons supplied by one atom. Covalent bond: A shared pair of electrons between two non-metals. Dipole: Difference in charge between the two atoms of a covalent bond caused by a shift in electron density in the bond due to the electronegativity difference between elements participating in bonding. Electron pair repulsion: Repulsion that exists between electron pairs due to the negatively charged electrons. This repulsion means electron pairs position themselves as far apart from each other as possible around the central metal atom. Electronegativity: The power of an atom to attract the electron density in a covalent bond towards itself. Electrostatic forces: The strong forces of attraction between oppositely charged ions. Hydrogen bonding: An interaction between a hydrogen atom and an electronegative atom, commonly nitrogen, fluorine or oxygen. The slightly positive hydrogen is attracted to the lone pair on the electronegative atom. Hydrogen bonds are stronger than van der Waals and dipole-dipole forces but weaker than ionic and covalent bonds. Intermolecular forces: The forces which exist between molecules. The strength of the intermolecular forces impact physical	Displacement: A chemical reaction in which one element replaces another element in a compound. Disproportionation: A reaction in which a substance is simultaneously reduced and oxidised. Electronegativity: The tendency of an atom to attract a bonding pair of electrons. Oxidising ability: Oxidising ability is the ability to act as an oxidising agent. Redox reaction: A reaction in which oxidation and reduction occur simultaneously. Reducing ability: Reducing ability is the ability to act as a reducing agent.	Alcohol: a molecule containing the -OH functional group. Aldehyde: a molecule containing the C=O functional group at the end of the molecule which causes the formation of a silver mirror when reacted with Tollens' reagent. Alkene: a molecule containing the C=C functional group. Alkenes cause bromine water to decolourise. Carboxylic Acid: a molecule containing the COOH functional group. Fingerprint Region: the region on an IR spectrum below 1500 cm -1 which is unique to each molecule. Functional Group: a group of atoms responsible for the characteristic reactions of a compound. Infrared Spectroscopy: a technique used to identify particular bonds and functional groups within a molecule. Infrared spectroscopy can also be used to identify impurities. Mass spectrometer: gives accurate information about relative isotopic mass and also about the relative abundance of isotopes. Mass Spectrometry: a technique used to identify compounds and determine relative molecular mass. Molecular Formula: the total number of atoms of each element in the compound. Relative atomic mass: The average mass of an atom of an element compared to 1/12th the mass of an atom of carbon-12. Relative molecular mass:	Catalyst: Increases the rate of reaction by providing an alternative reaction pathway with a lower activation energy. A catalyst does not affect the equilibrium constant since it increases the rate of the forward and backward reaction equally. Equilibrium: A reversible reaction is at equilibrium when the rate of the forward reaction equals the rate of the backward reaction. The concentrations of the reactants and products remain constant. Equilibrium constant (Kp): A value that expresses the relationship between the amounts of gaseous products and gaseous reactants present at equilibrium. Homogeneous system: A system where all the reactants and products are in the same phase. Mole fraction of gas: Value used to calculate partial pressure. Partial pressures: The pressure exerted by a particular gas in a mixture in a closed system. Related to mole fraction: Partial pressure = Mole fraction x Total pressure. Reversible reaction: A reaction in which the products can react together to form the original reactants. Total pressure: Sum of all partial pressures.	Buffer solution: A solution which resists change in pH when small amounts of strong acid/base are added. Acidic buffer: A buffer containing a weak acid and its conjugate base, e.g. a solution of acetic acid and sodium acetate. Basic buffer: A buffer containing a weak base and its conjugate acid, e.g. a solution of ammonia and ammonium chloride.	Cis-trans isomerism: A type of stereoisomerism. Octahedral complexes with four monodentate ligands of one type and two monodentate ligands of another type can show cis-trans isomerism. If the two odd ligands are opposite, it is the trans isomer. If the two odd ligands are next to each other, it is the cis isomer. Square planar complex ions that have two pairs of ligands also show cis-trans isomerism. When two paired ligands are opposite it is the trans isomer, when they're next to each other it is the cis isomer. Cisplatin: A transition metal compound which is used as an anti cancer drug. It has a square planar shape. Optical isomerism: Optical isomerism is a type of stereoisomerism which occurs when a substance exists in two forms that are non-superimposable mirror images. Complex ions can show optical isomerism when a central metal ion is coordinately bonded to three bidentate ligands.

			properties like boiling/melting point. Ion: An atom or molecule with an electric charge due to the loss or gain of electrons. Ionic bond: A metal atom loses electron(s) to form a positively charged ion and a non-metal atom gains these electron(s) to form a negatively charged ion. An ionic bond is formed between the oppositely charged ions. Ionic compound: Chemical compound formed of ions, held together by strong electrostatic forces. Lattice: A repeating regular arrangement of atoms/ions/molecules. This arrangement occurs in crystal structures. Macromolecular crystal structure: Giant covalent structures. Macromolecules have very high melting points because many strong covalent bonds have to be broken. Examples include diamond and graphite. Metallic bond: The bonds present in metals between the positive metal ions and negatively charged electrons. Permanent dipole-dipole forces: When molecules with polar covalent bonds interact with dipoles in other molecules dipole-dipole intermolecular forces are produced between the molecules. These intermolecular forces are generally stronger than van der Waals forces but weaker than hydrogen bonding. Polar bond: A covalent bond between two atoms in which the electrons in the bond are unevenly		The average mass of one molecule of an element or compound compared to 1/12th the mass of an atom of carbon-12. Wavenumber: represents the energy and frequency of infrared radiation absorbed by a bond in a molecule. This is the x-axis on IR spectra.			

			distributed. This causes a slight charge difference, inducing a dipole in the molecule. Simple molecular crystal structure: Structures in which the atoms are joined by strong covalent bonds. Weak intermolecular forces mean simple molecules have low melting and boiling points. Van der Waals: Also known as induced dipole–dipole, dispersion and London forces, van der Waals forces exist between all molecules. They arise due to fluctuations of electron density within a nonpolar molecule. These fluctuations may temporarily cause an uneven electron distribution, producing an instantaneous dipole. This dipole can induce a dipole in another molecule, and so on. VSEPR theory: Valence shell electron pair repulsion theory is used to deduce the geometry of molecules. Pairs of electrons in the outer shell of atoms arrange themselves as far apart as possible to minimise repulsion. Lone pair–lone pair repulsion is greater than lone pair–bond pair repulsion, which is greater than bond pair–bond pair repulsion.					
			Year 12 Term 1 - Redox	Year 12 Term 2 - Energetics		Year 13 - Term 1 - Optical isomerism	Year 13 - Term 2 - Amines	Year 13 - Term 3 - Transition Metals - Colour

			Half equation: A full redox equation can be split into two half-equations, one involving oxidation and the other involving reduction. Oxidation: Process involving the loss of electrons. Results in an increase in oxidation number. Oxidation state: The charge of an ion or a theoretical charge of an atom in a covalently bonded compound assuming the bond becomes ionic. Oxidising agent: Electron acceptors. The elements/compounds which accept electrons causing itself to be reduced. Redox reaction: A reaction in which both reduction and oxidation are occurring simultaneously. Reducing agent: Electron donors. The elements/compounds which donate electrons causing itself to be oxidised. Reduction: Process involving the gain of electrons. Results in a decrease in oxidation number.	Calorimetry: The process of measuring the amount of energy absorbed or released during a chemical reaction. Endothermic reaction: An endothermic reaction is one that takes in energy from the surroundings so the temperature of the surroundings decreases. In an endothermic reaction, the energy needed to break existing bonds is greater than the energy released from forming new bonds. Enthalpy change (ΔH): The heat energy change measured under conditions of constant pressure. Exothermic reaction: An exothermic reaction is one that transfers energy to the surroundings so the temperature of the surroundings increases. In an exothermic reaction, the energy released from forming new bonds is greater than the energy needed to break existing bonds. Hess's law: The enthalpy change of a reaction is independent of the route taken. Mean bond enthalpy: The enthalpy change when one mole of a specified covalent bond is broken averaged out across the range of compounds. Molar enthalpy change: The enthalpy change per mole of substance. Standard conditions: 100 kPa and a stated temperature (generally 298K). Standard enthalpy of combustion ($\Delta_c H^{\ominus}$): The enthalpy change when one mole of a substance is burned in excess oxygen under standard conditions. Standard enthalpy of		Chiral Carbon: an asymmetric carbon atom/ a carbon atom bound to 4 different groups. This may also be called a chiral centre. Displayed Formula: shows all the bonds between every atom in the compound. Enantiomers: molecules which are non-superimposable mirror images of one another. Enantiomers have different effects on a plane of polarised light. Optical isomerism: a type of stereoisomerism that occurs as a result of the presence of a chiral centre in a molecule. Optical isomers have different effects on a plane of polarised light. Racemic Mixture (racemate): a mixture containing equal amounts of enantiomers. Stereoisomers: compounds that only differ in their arrangement of atoms in space. Structural Formula: shows the arrangement of atoms in a molecule without the bonds drawn between them.	Aliphatic: organic compounds with carbon atoms joined in chains. Alkyl group: a group based on an alkane, where one hydrogen has been removed (this allows the group to attach to another atom in a chain). Amines: compounds based on ammonia where hydrogen atoms have been replaced by alkyl or aryl groups. Amines are weak bases that can act as nucleophiles. Aromatic: a compound containing at least one benzene ring. Aromatic Amines: an organic compound with the structure $R\text{-}NH_2$, where R is an aromatic ring. Aryl group: a group based on a benzene ring, where one hydrogen has been removed (this allows the group to attach to another atom in a chain). Lone Pair: a pair of valence electrons (outer-shell electrons) not involved in bonding. Nucleophile: an electron pair donor. Nucleophilic addition-elimination: a reaction in which a nucleophile is added to a molecule by breaking a π bond then a leaving group is removed to reform the π bond. Nucleophilic substitution: a reaction in which an electron-rich nucleophile attacks a positive charge or partial positive charge to replace an atom/ group of atoms. Primary aliphatic amines: an organic compound with the structure $R\text{-}NH_2$ (where R is an alkyl group). Primary ammonium salt:	Calibration curve: A calibration curve is used in colorimetry to plot the amount of absorbance vs concentrations of standard solutions. This is then used to measure the concentration of an unknown solution of your transition metal ion. Colorimeter: Instrument used in spectroscopy which calculates how much light is absorbed by the sample. Spectroscopy: A technique used to determine the concentration of a solution by measuring how much light it absorbs.

				formation (Δ f H Θ): The enthalpy change when one mole of a substance in its standard state under standard conditions is formed from its elements under standard conditions.			an organic compound formed when a halogenoalkane is reacted with ammonia. These salts have the general formula RNH3+X- (where R is an alkyl group and X- is the halide ion). Quaternary ammonium salts: an organic compound formed when a halogenoalkane reacts with a tertiary amine. These salts have the general formula R4N+X- (where R is an alkyl group and X- is the halide ion). Secondary ammonium salt: an organic compound formed when a halogenoalkane reacts with a primary amine. These salts have the general formula R2NH2+X- (where R is an alky group and X- is the halide ion). Tertiary ammonium salt: an organic compound formed when a halogenoalkane reacts with a secondary amine. These salts have the general formula R3NH+X- (where R is an alkyl group and X - is the halide ion)	
			Year 12 - Term 1 - Introduction to Organic Chemistry	Year 12 - Term 2 - Alkenes		Year 13 - Term 1 - Aldehydes and ketones	Year 13 - Term 2 - Polymers	Year 13 - Term 3 - Transition Metals - Variable Oxidation States and Catalysis

			Chain isomers: Isomers that occur due to the branching in the carbon chain. Displayed formula: A type of structural isomer that shows all the bonds between every atom in the compound. Empirical formula: The smallest whole number ratio of atoms of each element in a compound. E-Z isomerism: A type of stereoisomerism that occurs due to the restricted rotation around the carbon double bond. This results in two different groups on one end of the bond and two different groups on the other end. If the highest priority groups for each carbon are found on the same side of the molecule, then it is the Z-isomer. If the highest priority groups for each carbon are found on opposite sides of the molecule, then it is the E-isomer. Free-radical: An uncharged molecule or atom with an unpaired valence electron. Functional group: The group of atoms responsible for the characteristic reactions of a particular compound. Functional group isomers: Isomers that contain different functional groups. This means they belong to different homologous series. General formula: A type of empirical formula that represents the composition of any member of an entire class of compounds. Homologous series: A series of compounds with the same functional group and similar	Addition polymer: A polymer formed by addition polymerisation. Formed from monomers with C=C bonds. Addition polymerisation: The process by which addition polymers are formed. Lots of short chain monomers (alkenes) join together to form a long chain polymer by the 'opening up' of all the double carbon bonds. Alkenes: hydrocarbons with a double bond between two of the carbon atoms in their chain, causing them to be unsaturated. Carbocation: A carbon atom bearing a positive charge. Electrophile: Electron pair acceptor in an organic mechanism. Attracted to areas with a lot of electrons/high negative charge. Major/minor products: Major and minor products are formed from electrophilic addition due to the relative stabilities of the primary/secondary/tertiary carbocation intermediates. The major product is formed from the most stable intermediate and the minor product is formed from the least stable intermediate. Monomer: A short chain molecule that when bonded to other monomers forms a polymer. Plasticiser: A chemical added to polymers to improve flexibility and workability. Polymer: Large long-chain molecules made up of lots of small monomers joined together by covalent		Aldehyde: a molecule containing the C=O functional group at the end of the molecule. Carbonyl group: a functional group with a C=O double bond. Curly Arrow: used in mechanisms to show the movement of a pair of electrons. Enantiomers: molecules which are non-superimposable mirror images of one another. Hydroxynitrile: a molecule containing an alcohol group (OH) and a nitrile group (C≡N) bound to the same carbon. These can be formed in a nucleophilic addition reaction between a carbonyl and KCN followed by dilute acid (this reaction forms a mixture of enantiomers if an aldehyde or an unsymmetrical ketone is used). Ketone: a molecule containing the C=O functional group in the middle of the molecule. 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.	Addition Polymer: a long chain molecule formed when many monomers join together, where the polymer is the only product. Biodegradable: a substance that can be decomposed by bacteria or other living organisms. Condensation Polymer: a long chain molecule formed when monomers react together with the release of small molecules such as water. These polymers can be formed by a reaction between dicarboxylic acids and diols, dicarboxylic acids and diamines or between amino acids. Hydrolysis: a reaction which uses water to break down a compound. Intermolecular Forces: forces which act between molecules. These include permanent dipole-dipole forces, induced dipole-dipole forces and hydrogen bonding. Monomer: a small molecule that is used to form polymers. Polyalkene: a type of addition polymer formed when many alkene monomers are joined together. These polymers are chemically inert and non-biodegradable. Polyamide: a type of condensation polymer formed by the linkage of an amino group in one monomer and a carboxylic acid group of another (e.g. nylon 6,6 and Kevlar). These polymers can be broken down by hydrolysis and are biodegradable. Polyester: a type of condensation polymer formed by the linkage of an alcohol group in one monomer with a	Adsorption: The process of forming weak bonds by reactants to a surface of a solid catalyst. Autocatalysis: A reaction where the product of a reaction acts as a catalyst for the reaction. Catalyst poisoning: Impurities in a reaction mixture may bind to a heterogeneous catalyst's surface and block reactants from being adsorbed. Contact Process: An industrial process used to produce sulfuric acid. Heterogeneous catalysts: A catalyst that is in a different phase from the reactants. The reaction takes place on the active sites on the surface of the heterogeneous catalyst. Examples include iron in the Haber Process and vanadium(V) oxide in the Contact Process. Homogeneous catalysts: Catalysts that are in the same phase as the reactants - i.e. in the same physical state. They work by combining with the reactants to form an intermediate species which then reacts to form the products and re-form the catalyst. Variable oxidation states: Transition elements have variable oxidation states which means they can form ions with different oxidation states. For example, vanadium can form ions with the oxidation states +2, +3,+4 or +5, and this is because the energy levels of the 4s and 3d sub-levels are very similar so different numbers of electrons can be gained or lost using similar amounts of energy

			chemical properties. Molecular formula: Total number of atoms of each element in the compound. Position isomer: Isomers where the carbon backbone of the isomers are the same but the important groups are at different positions on the backbone. Skeletal formula: A diagram representation of an organic compound in which lines represent bonds between atoms and atoms are represented by their symbol. Hydrogens are assumed to be at the end of the line if no other atomic symbol is present. Stereoisomerism: Occurs when two double bonded carbon atoms each have two different atoms or groups attached to them. Includes E/Z isomerism. This is a consequence of a restricted rotation around the C=C double bond. Structural formula: A formula which shows the arrangement of atoms in the molecule of a compound but does not show all the bonds between them. Structural isomerism: Structural isomers are compounds which have the same molecular formula but a different structural formula.	bonds. Repeat unit: The part of a polymer whose repetition would produce the complete polymer chain. Unsaturated: Organic compounds are unsaturated if they have at least one double carbon bond (C=C).			carboxylic acid group of another (e.g. Terylene). These polymers can be broken down by hydrolysis and are biodegradable. Polymer: a large molecule made from many small units that have been bonded together. Repeating Unit: a structure within a polymer that appears over and over again. Joining many repeat units together would form the polymer.	
			Year 12 - Term 1 - Alkanes	Year 12 - Term 2 - Alcohols		Year 13 - Term 1 - Carboxylic acids and derivatives	Year 13 - Term 2 - Amino Acids and Proteins	Year 13 - Term 3 - Reactions of ions in aqueous solution

			Catalytic converter: A device fitted in a car to reduce the amount of emissions from an internal combustion engine. They use expensive metals like platinum and rhodium as the heterogeneous catalyst. The catalyst is mounted on a ceramic honeycomb to maximise the surface area. Catalytic cracking: A type of cracking that takes place at a slight pressure, high temperature and in the presence of a zeolite catalyst and is used mainly to produce motor fuels and aromatic hydrocarbons. Combustion of alkanes: Combustion of alkanes releases 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 the complete combustion, whereas carbon monoxide and carbon particulates can be produced in incomplete combustion. Cracking: A process which involves breaking C-C bonds in alkanes to produce shorter chained alkanes and alkenes. 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. Fractional distillation: A method of separating a mixture of substances according to their different boiling points. Commonly used to	Alcohols: Alcohols contain the functional group –OH. Biofuel: A fuel derived from living matter. Examples include ethanol produced from the fermentation of glucose. Carbon-neutral fuel: 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. Classification of alcohols: Alcohols can be classified as primary, secondary or tertiary depending on how many carbon groups are bonded to the carbon that the -OH group is bonded to. Distillation: An experimental procedure used to separate a mixture of liquids. The liquids separate out due to their different boiling points. Fermentation of glucose: An industrial process to produce ethanol. Glucose is extracted from sugar cane. Yeast provides the enzymes needed for fermentation and then the glucose produces ethanol and carbon dioxide. The reaction must be carried out anaerobically and at a warm temperature Hydration of alkenes: An industrial process that can be used to produce alcohols. The alkene is reacted with steam in the presence of an acid catalyst. Hydration of ethene Oxidation of alcohols: Alcohols can undergo oxidation with acidified potassium dichromate(VI). The products formed depend on which classification		Alcohol: a molecule containing the OH functional group. Biodiesel: a mixture of methyl esters of long-chain carboxylic acids. Biodiesel is produced by reacting vegetable oils with methanol in the presence of a catalyst. Carboxylic Acids: molecules containing the -COOH functional group. Carboxylic acids are weak acids that form CO 2 when reacted with carbonates. Esters: molecules containing the R-COO-R’ functional group which can be formed when carboxylic acids and alcohols react in the presence of an acid catalyst.	Active Site: the region of an enzyme where the substrate binds. Amino Acid: an organic compound containing both a carboxyl group (-COOH) and an amino group (-NH 2). Catalyst: a substance which speeds up the rate of a reaction without being used up. Enzymes are biological catalysts. Developing Agents: these are used to locate amino acids on a chromatogram (e.g. ninhydrin and ultraviolet light). Enantiomers: molecules that are non-superimposable mirror images of one another. Enzyme: a biological catalyst made of proteins. Enzymes have stereospecific active sites that bind to a certain substrate molecule. Enzyme Inhibitor: a substance that reduces the activity of an enzyme. This might be a drug which blocks the active site, preventing a substrate molecule binding. Hydrolysis: a reaction in which water is used to break a bond. Ligand: an ion or molecule that binds to a metal atom by donating a pair of electrons and forming a coordinate bond. Peptide Link: a bond which forms between the carboxyl group (-COOH) of one amino acid and the amino group (-NH 2) of another in a protein. When peptide links are hydrolysed, the constituent amino acids are formed. Primary Protein Structure: the sequence of a chain of amino acids that make up a protein,	Amphoteric: A substance is called amphoteric if it is able to react as a base and as an acid. Metal aqua ions: Metal ions in aqueous solution.

			separate crude oil into different fractions. Hydrocarbons: Compounds made up of carbon and hydrogen atoms only. Saturated: Organic compounds are saturated if all the carbon-carbon bonds are single C-C bonds. Alkanes are saturated hydrocarbons. Thermal cracking: A type of cracking that takes place at high pressure and high temperature and produces a high percentage of alkenes.	the alcohol is. Primary alcohols can be oxidised to aldehydes which can be further oxidised to carboxylic acids, secondary alcohols can be oxidised to ketones and tertiary alcohols are not easily oxidised			contains peptide bonds. Protein: a molecule made up of amino acids joined by peptide bonds. Hydrogen bonding and sulfur-sulfur bonds are important to maintain the structure of proteins. Secondary Protein Structure: the structure of a protein when hydrogen bonds form between the amino acid chains. There are 2 types of secondary protein structure: α-helix and β-pleated sheet. Substrate: a molecule that binds to the active site of an enzyme during a reaction. Tertiary Protein Structure: the three dimensional structure of a protein. This contains ionic bonds, disulfide bridges, hydrogen bonding and induced dipole-dipole interactions. Thin Layer Chromatography: a technique which uses a solvent and a plastic sheet coated in silica to separate and identify compounds such as amino acids. Zwitterion: a molecule which has separate positively and negatively charged groups.	
			Year 12 - Term 1 - Halogenoalkanes			Year 13 - Term 1 - Acylation	Year 13 - Term 2 - DNA	Year 13 - Term 3 - Organic Sythesis

			Chlorofluorocarbons: Chlorofluorocarbons, also known as CFCs, are chemicals containing carbon, chlorine and fluorine atoms . Electrophile : Electron pair acceptor in an organic mechanism. Attracted to areas with a lot of electrons/high negative charge. Elimination: A reaction in which a molecule loses atoms or groups of atoms to form a C=C bond. Free radicals : A species with an unpaired electron. Represented in mechanisms by a single dot. 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 initially 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. Nucleophile: An atom or molecule that donates an electron pair to form a covalent bond. Attracted to electron-deficient areas. Nucleophilic substitution: The reaction of an electron pair donor (the nucleophile) with an electron pair acceptor (the electrophile). Involves one species being replaced with another species. Ozone: Ozone is formed			Acid Anhydride: a molecule containing the functional group RC(=O)OC(=O)R Acyl Chloride: a molecule containing the functional group RC(=O)Cl 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. Nucleophile: an electron pair donor Nucleophilic addition-elimination: a reaction in which a nucleophile is added to a molecule by breaking a π bond then a leaving group is removed to reform the π bond. Primary Amide: a molecule containing the functional group RC(=O)NH2 Recrystallisation: a technique used to purify a compound. A sample is dissolved in the minimum volume of hot solvent then filtered. The filtrate is then cooled before being filtered under reduced pressure. The residue on the filter paper is the purified compound.	DNA (deoxyribonucleic acid): a polymer of nucleotide linked by covalent bonds between the phosphate group of one nucleotide and the 2-deoxyribose of another nucleotide. The resulting polymer has a sugar-phosphate-sugar-phosphate chain with the bases (adenine, cytosine, guanine and thymine) attached to the sugars in the chain. DNA has a double helix structure which is made up of 2 complementary strands. Hydrogen Bonding: a type of intermolecular bond formed between a hydrogen atom in one molecule and an electronegative atom in another. Hydrogen bonding between base pairs leads to complementary strands of DNA. Nucleotide: a molecule made from a phosphate ion bound to 2-deoxyribose which is bonded to one of the 4 bases of DNA (adenine, cytosine, guanine and thymine). Pentose Sugar: a sugar molecule that contains 5 carbon atoms.	Atom Economy: The measure of the amount of starting materials that end up as useful products. Organic Compound: a carbon-containing compound. Solvent: a liquid which can dissolve other substances. Synthesis: combining different elements and compounds to build new molecules

			naturally in the upper atmosphere. It is beneficial because it absorbs ultraviolet radiation and this prevents harmful radiation reaching the earth. Polar bond: A covalent bond where the electrons are not distributed equally.					
						Year 13 - Term 1 - Aromatic chemistry	Year 13 - Term 2 - Action of anticancer drugs	Year 13 - Term 3 - NMR

						Acyl Group: a group with the structure RC(O)- , where R is an alkyl group. Addition Reaction: a reaction in which molecules combine to form a single product. Aromatic Compound: a compound containing at least one benzene ring. Benzene: a 6 membered carbon ring (C6H6) containing a delocalised π system. Benzene has a planar structure and a bond length between a single and double bond. Delocalisation of the p electrons into the π system makes benzene more stable than expected. Delocalisation of p electrons: in benzene, the empty p orbital on each carbon atom overlaps with the others to form a delocalised π system which contains 6 electrons. Electrophile: an electron pair acceptor. Electrophilic Substitution: a reaction in which an electrophile replaces an atom / group of atoms in a compound. Enthalpy of Hydrogenation: the enthalpy change that takes place when one mole of an unsaturated compound reacts completely with hydrogen to form a saturated compound. Friedel-Crafts Acylation: an important synthetic reaction involving an electrophilic aromatic substitution reaction between benzene and acyl chlorides or anhydrides, used to form acylated benzene rings. AlCl3 is used as a catalyst. Monosubstituted benzene	Cisplatin: a complex of Pt(II) which is used as an anticancer drug. Cisplatin prevents DNA replication in cancer cells by a ligand replacement reaction with DNA (during this reaction, a bond forms between platinum and a nitrogen atom in guanine).	Aliphatic Compound: an organic compound that is made up of straight or branched chains. CCl4 : a solvent commonly used in 1H NMR spectroscopy. 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. Deuterated Solvent: a solvent in which all hydrogen atoms are replaced with deuterium. Doublet: a signal on a 1 H NMR spectra made up of 2 peaks, indicating that there is 1 adjacent non-equivalent proton. Equivalent protons: protons that are in the same environment. Integrated NMR Spectrum: shows the area under each peak on a 1 H NMR spectrum, indicating the relative number of 1 H atoms in each environment 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 1 H 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 1 H nuclei are analysed. Quartet: a signal on a 1

						ring: a benzene ring with one hydrogen replaced by another group, e.g. C6H5NO2 Nitration: Nitration is important for synthesis, particularly for manufacturing explosives and for forming amines. Benzene can undergo nitration via an electrophilic substitution reaction, using concentrated nitric acid and a concentrated sulfuric acid catalyst at 50°C. Substitution Reaction: a reaction in which one atom/ group of atoms is replaced by another atom / group of atoms.		H NMR spectra made up of 4 peaks, indicating that there are 3 adjacent non-equivalent protons. Singlet: a signal on a 1 H NMR spectra made up of 1 peak, indicating that there are no 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 1 H NMR spectrum is split into a multiplet according to the n+1 rule. TMS (tetramethlysilane): the standard for calibrating chemical shift values in NMR. Triplet: a signal on a 1 H NMR spectra made up of 3 peaks, indicating that there are 2 adjacent non-equivalent protons.
								Year 13 - Term 3 - Chromatography

								Chromatography: a technique used to separate and identify components in a mixture. Column Chromatography (CC): a type of chromatography in which a column is packed with a solid and a solvent moves down the column. Gas Chromatography (GC): 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: a technique that measures the mass to charge ratio of gaseous ions. Mobile Phase: a substance that moves through the chromatography system to separate the mixture. This may be a gas (GC) or a liquid (TLC and CC). Retention Time: The time taken for a sample to travel from the inlet to the detector in GC. Rf 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. Rf = distance moved by substance ÷ distance moved by solvent Stationary Phase: a substance through which the mobile phase moves in chromatography. Thin-layer Chromatography (TLC): a type of chromatography in which a plate is coated with a solid and a solvent moves up the plate.

	KS4 prior learning	**By the end of the term, students can:**	Year 12 Term 1 - Atomic Structure	Year 12 - Term 2 - Periodicity	Year 12 Term 3 - Equilibria	Year 13 Term 1 - Thermodynamics	Year 13 Term 2 - Electrode potentials and electrochemical cells	Year 13 - Term 3 - Period 3 elements and their Oxides
		Recall the **knowledge**:	The chemical properties of elements depend on their atomic structure and in particular on the arrangement of electrons around the nucleus. The arrangement of electrons in orbitals is linked to the way in which elements are organised in the Periodic Table. Knowledge and understanding of atomic structure has evolved over time. An atom consists of a nucleus containing protons and neutrons surrounded by electrons. Chemists can measure the mass of atoms and molecules to a high degree of accuracy in a mass spectrometer. The mass spectrometer gives accurate information about relative isotopic mass and also about the relative abundance of isotopes. Mass spectrometry can be used to identify elements. Mass spectrometry can be used to determine relative molecular mass.	In the Periodic Table, elements are arranged in order of increasing atomic number. Elements can be grouped into periods (horizontal rows) and groups (vertical columns). Periodicity is a regularly repeating pattern of atomic, physical, and chemical properties with increasing atomic number. The Periodic Table can be split into s-, p-, d-, and f- blocks. Which is determined by which orbital the highest energy electron is in. Across period 3, the trend in meting point relates to the structure of the elements. The melting point increases from Na to Al as the ionic charge and the number of delocalised electrons increases. Silicon has a giant covalent structure with strong covalent bonds. P4, S8, and Cl2 are all simple molecular covalent substances. From P4 to S8 there are more electrons and stronger Van der Waals forces. From S8 to Cl2 to Ar there are fewer electrons and weaker Van der Waals forces. Across the period, the atomic radius decreases as effective nuclear charge increases and there is no increase in shielding. Across the period, the ionisation energy increases as nuclear charge increases -	A study of equilibria indicates how far reactions will go. Many chemical reactions are reversible. In a reversible reaction at equilibrium the forward and reverse reactions proceed at equal rates and the concentrations of reactants and products remain constant. Le Chatelier's principle can be used to predict the effects of changes in temperature, pressure and concentration on the position of equilibrium in homogeneous reactions. A catalyst does not affect the position of equilibrium. The equilibrium constant Kc is deduced from the equation for a reversible reaction. The concentration, in mol dm–3, of a species X involved in the expression for Kc is represented by [X] The value of the equilibrium constant is not affected either by changes in concentration or addition of a catalyst.	Lattice enthalpy can be defined as either enthalpy of lattice dissociation or enthalpy of lattice formation. Born–Haber cycles are used to calculate lattice enthalpies. Cycles are used to calculate enthalpies of solution for ionic compounds from lattice enthalpies and enthalpies of hydration. ΔH, whilst important, is not sufficient to explain feasible change. Entropy change, ΔS, accounts for the above deficiency, illustrated by physical changes and chemical changes. The balance between entropy and enthalpy determines the feasibility of a reaction given by the relationship: ΔG = ΔH – TΔS (derivation not required). For a reaction to be feasible, the value of ΔG must be zero or negative.	Redox reactions take place in electrochemical cells where electrons are transferred from the reducing agent to the oxidising agent indirectly via an external circuit. A potential difference is created that can drive an electric current to do work. Electrochemical cells have very important commercial applications as a portable supply of electricity to power electronic devices such as mobile phones, tablets and laptops. On a larger scale, they can provide energy to power a vehicle. Cells are used to measure electrode potentials by reference to the standard hydrogen electrode. Standard electrode potential, EΘ, refers to conditions of 298 K, 100 kPa and 1.00 mol dm−3 solution of ions. Standard electrode potentials can be listed as an electrochemical series. Electrochemical cells can be used as a commercial source of electrical energy. The simplified electrode reactions in a lithium cell: Positive electrode: Li+ + CoO2 + e– → Li+[CoO2]– Negative electrode: Li → Li+ + e– Cells can be non-	Sodium and Magnesium react with water. All of the Period 3 elements can react with oxygen to form oxides Sodium burns with a yellow flame, magnesium burns with a white flame, aluminium with a brilliant white flame and sulfur with a blue flame. Sodium oxide and magnesium oxide react with water to form hydroxides Aluminium oxide and silicon dioxide are both insoluble and do not react with water due to the strong covalent bonds When the non-metal oxides react with water, acidic solutions are formed. The basic oxides act as bases and neutralise acids The acidic oxides act as acids and neutralise bases Al2O3 is an amphoteric oxide and can act as either an acid or base. It neutralises both acids and bases

				Aluminium is an exception as the 3s electrons shield the 3p electron - Sulfur is an exception as an electron is being removed from an p orbital containing 2 electrons, so there is electron-pair repulsion			rechargeable (irreversible), rechargeable or fuel cells. Fuel cells are used to generate an electric current and do not need to be electrically recharged.	
			Year 12 Term 1 - Amount of Substance	Year 12 - Term 2 - Group 2 - Alkaline Earth Metals	Year 12 Term 3 - Kinetics	Year 13 Term 1 - Rate Equations	Year 13 Term 2 - Acids and Bases	Year 13 - Term 3 - Transition Metals - General Properties and Substitution Reactions
			The mole is a useful quantity because one mole of a substance always contains the same number of entities of the substance. An amount in moles can be measured out by mass in grams, by volume in dm3 of a solution of known concentration and by volume in dm3 of a gas. Calculated results can only be reported to the limits of the least accurate measurement. The Avogadro constant is the number of particles in a mole. The concentration of a substance in solution can be measured in mol dm–3. The ideal gas equation is $pV = nRT$ with the variables in SI units. Empirical formula is the simplest whole number ratio of atoms of each element in a compound. Molecular formula is the actual number of atoms of each element in a compound.	The elements in Group 2 are called the alkaline earth metals. The trends in the solubilities of the hydroxides and the sulfates of these elements are linked to their use. All Group 2 elements have 2 electrons in their outer s-subshell. Down the group ionisation energy decreases, as the atomic radius and shielding increases, decreasing the attraction of the electron to the nucleus. Melting point also decrease down the group due to the increased atomic radii and shielding, so metallic bonding is weaker. Group 2 elements react with water to form hydroxides and hydrogen gas. The solubility of group 2 hydroxides increases down group 2. The solubility of group 2 sulfates decreases down group 2. $Mg(OH)_2$ (milk of magnesia) is used to neutralise excess hydrochloric acid in the stomach, relieving indigestion Titanium oxide reacts with carbon and chlorine to form titanium chloride,	The study of kinetics enables chemists to determine how a change in conditions affects the speed of a chemical reaction. Whilst the reactivity of chemicals is a significant factor in how fast chemical reactions proceed, there are variables that can be manipulated in order to speed them up or slow them down. Reactions can only occur when collisions take place between particles having sufficient energy. This energy is called the activation energy. Maxwell–Boltzmann distribution of molecular energies in gases. A catalyst is a substance that increases the rate of a chemical reaction without being changed in chemical composition or amount. Catalysts work by providing an alternative reaction route of lower activation energy	The rate of a chemical reaction is related to the concentration of reactants by a rate equation of the form: $Rate = k[A]^m [B]^n$ where m and n are the orders of reaction with respect to reactants A and B and k is the rate constant. The orders m and n are restricted to the values 0, 1, and 2. The rate constant k varies with temperature as shown by the equation: $k = Ae^{-Ea/RT}$ where A is a constant, known as the Arrhenius constant, Ea is the activation energy and T is the temperature in K. The rate equation is an experimentally determined relationship. The orders with respect to reactants can provide information about the mechanism of a reaction.	An acid is a proton donor. A base is a proton acceptor. Acid–base equilibria involve the transfer of protons. The concentration of hydrogen ions in aqueous solution covers a very wide range. Therefore, a logarithmic scale, the pH scale, is used as a measure of hydrogen ion concentration. $pH = -\log_{10}[H^+]$ Water is slightly dissociated. Kw is derived from the equilibrium constant for this dissociation. $K_w = [H^+][OH^-]$ The value of Kw varies with temperature. Weak acids and weak bases dissociate only slightly in aqueous solution. Ka is the dissociation constant for a weak acid. $pK_a = -\log_{10} K_a$ pH curves for acid–base titrations in all combination of weak and strong monoprotic acids and bases can be used to determine equivalence points and identify	Transition metal characteristics of elements Ti–Cu arise from an incomplete d sub-level in atoms or ions. The characteristic properties include: complex formation; formation of coloured ions; variable oxidation state; catalytic activity. A ligand is a molecule or ion that forms a co-ordinate bond with a transition metal by donating a pair of electrons. A complex is a central metal atom or ion surrounded by ligands. Co-ordination number is number of co-ordinate bonds to the central metal atom or ion. H_2O, NH_3 and Cl^- can act as monodentate ligands. The ligands NH_3 and H_2O are similar in size and are uncharged. Exchange of the ligands NH_3 and H_2O occurs without change of co-ordination number (eg Co^{2+} and Cu^{2+}). Substitution may be incomplete (eg the formation of $[Cu(NH_3)_4(H_2O)_2]^{2+}$). The Cl^- ligand is larger than the uncharged ligands NH_3 and H_2O Exchange of the ligand

				which is purified by fractional distillation and then reduced to titanium using magnesium. Ca(OH)2 (hydrated lime) is used to neutralise acidic soil. CaO and CaCO3 can be used to remove SO3 from flue gases. BaSO4 can be ingested to visual soft tissue in imaging. Acidified BaCl2 can be used to test for the presence of sulphate ions as barium sulphate, a white precipitate, will be formed. The solution needs to be acidified to remove any sulphites or carbonates, which would result in the formation of a white precipitate.			suitable indicators for titrations	H2O by Cl– can involve a change of co-ordination number (eg Co2+, Cu2+ and Fe3+). Ligands can be bidentate (eg H2NCH2CH2NH2 and C2O42–). Ligands can be multidentate (eg EDTA4–). Haem is an iron(II) complex with a multidentate ligand. Oxygen forms a co-ordinate bond to Fe(II) in haemoglobin, enabling oxygen to be transported in the blood. Carbon monoxide is toxic because it replaces oxygen co-ordinately bonded to Fe(II) in haemoglobin. Bidentate and multidentate ligands replace monodentate ligands from complexes. This is called the chelate effect.
			Year 12 Term 1 - Bonding	Year 12 - Term 2 - Group 7 - The Halogens	Year 12 - Term 3 - Organic Analysis	Year 13 Term 1 - Equilibrium constant Kp	Year 13 Term 2 - Buffers	Year 13 - Term 3 - Transition Metals - Shapes
			Ionic bonding involves electrostatic attraction between oppositely charged ions in a lattice. A single covalent bond contains a shared pair of electrons. Multiple bonds contain multiple pairs of electrons. A co-ordinate (dative covalent) bond contains a shared pair of electrons with both electrons supplied by one atom. Metallic bonding involves attraction between delocalised electrons and positive ions arranged in a lattice. There are four types of crystal structure - ionic; metallic; macromolecular (giant covalent); molecular.	The halogens exist as diatomic (X2) molecules Down the group electronegativity decreases, as atomic radius and shielding increases, reducing the force on electrons. So oxidising ability also decreases. Down the group boiling point increases, as the molecules have a greater surface area and electrons for stronger Van der Waals forces. A more reactive halogen will displace the halide ion of a less reactive halogen from solution Sodium halides will react with concentrated sulphuric acid. Halide ions react with	Chemical tests can be used to distinguish functional groups. Mass spectrometry can be used to determine the molecular formula of a compound. Bonds in a molecule absorb infrared radiation at characteristic wavenumbers. 'Fingerprinting' allows identification of a molecule by comparison of spectra.	The equilibrium constant Kp is deduced from the equation for a reversible reaction occurring in the gas phase. Kp is the equilibrium constant calculated from partial pressures for a system at constant temperature	A buffer solution maintains an approximately constant pH, despite dilution or addition of small amounts of acid or base. Acidic buffer solutions contain a weak acid and the salt of that weak acid. Basic buffer solutions contain a weak base and the salt of that weak base.	Transition metal ions commonly form octahedral complexes with small ligands (eg H2O and NH3). Octahedral complexes can display cis–trans isomerism (a special case of E–Z isomerism) with monodentate ligands and optical isomerism with bidentate ligands. Transition metal ions commonly form tetrahedral complexes with larger ligands (eg Cl–). Square planar complexes are also formed and can display cis–trans isomerism. Cisplatin is the cis isomer. Ag+ forms the linear

			Pairs of electrons in the outer shell of atoms arrange themselves as far apart as possible to minimise repulsion. Lone pair–lone pair repulsion is greater than lone pair–bond pair repulsion, which is greater than bond pair–bond pair repulsion. Electronegativity is the power of an atom to attract the pair of electrons in a covalent bond. The electron distribution in a covalent bond between elements with different electronegativities will be unsymmetrical. This produces a polar covalent bond, and may cause a molecule to have a permanent dipole. Forces between molecules - permanent dipole–dipole forces; • induced dipole–dipole (van der Waals, dispersion, London) forces; hydrogen bonding. The melting and boiling points of molecular substances are influenced by the strength of these intermolecular forces. Hydrogen bonding is important in the low density of ice.	silver nitrate solution to form a silver halide precipitate Dilute nitric acid removes any soluble impurities that could interfere with the test to identify halide ions Chlorine can dissolve in water to form hydrochloric acid and chloric(I) acid (disproportion reaction). Chloric(I) acid is an oxidising agent that kills bacteria and sanitises water Sodium chlorate(I) has a bleaching action which allows it to be an active ingredient in household bleach. Chlorine prevents the spread of waterborne disease and sanitises water. However, it is added without direct customer consent, chlorine is a respiratory irritant and it could react to form chlorinated hydrocarbons, implicated in cancers				complex [Ag(NH3)2]+ as used in Tollens' reagent.
			Year 12 Term 1 - Redox	Year 12 Term 2 - Energetics		Year 13 - Term 1 - Optical isomerism	Year 13 - Term 2 - Amines	Year 13 - Term 3 - Transition Metals - Colour
			Oxidation is the process of electron loss and oxidising agents are electron acceptors. Reduction is the process of electron gain and reducing agents are electron donors. Redox reactions involve a transfer of electrons from	Reactions can be endothermic or exothermic. Enthalpy change (ΔH) is the heat energy change measured under conditions of constant pressure. Standard enthalpy changes refer to		Optical isomerism is a form of stereoisomerism and occurs as a result of chirality in molecules, limited to molecules with a single chiral centre. An asymmetric carbon atom is chiral and gives rise to optical isomers	Amines are compounds based on ammonia where hydrogen atoms have been replaced by alkyl or aryl groups. Amines can be thought of as derivates of ammonia, in which one or more of the hydrogens is replaced by an alkyl or	Transition metal ions can be identified by their colour. Colour arises when some of the wavelengths of visible light are absorbed and the remaining wavelengths of light are transmitted or reflected. d electrons move from

			the reducing agent to the oxidising agent. The change in the oxidation state of an element in a compound or ion is used to identify the element that has been oxidised or reduced in a given reaction. Separate half-equations are written for the oxidation or reduction processes. Half-equations can then be combined to give an overall equation for any redox reaction.	standard conditions ie 100 kPa and a stated temperature (eg $\Delta H298\Theta$). The heat change, q, in a reaction is given by the equation $q = mc\Delta T$ where m is the mass of the substance that has a temperature change ΔT and a specific heat capacity c.		(enantiomers), which exist as non super-imposable mirror images and differ in their effect on plane polarised light. A mixture of equal amounts of enantiomers is called a racemic mixture (racemate).	aryl group. The number of substituted hydrogens is the basis of classifying amines. If the R group is an alkyl group (methyl, ethyl, etc) then then it is an aliphatic amine; if it is an aryl group (benzene ring or phenyl) then it is an aromatic amine Aliphatic and aromatic amines share similar chemical reactions and the aryl group can strongly influence the chemistry and reactivity of the amine group. Primary amines can be prepared from different reactions including The reaction of halogenoalkanes with ammonia or the reduction of nitriles. The reaction of halogenoalkanes with ammonia is a nucleophilic substitution reaction in which the nitrogen lone pair in ammonia acts as a nucleophile and replaces the halogen in the halogenoalkane. When a halogenoalkane is reacted with excess, hot ethanolic ammonia under pressure a primary amine is formed. Nitriles contain a -CN functional group which can be reduced to an $-NH_2$ group. The nitrile vapour and hydrogen gas are passed over a nickel catalyst or $LiAlH_4$ in dry ether can be used to form a primary amine. Phenylamine is an organic compound consisting of a benzene ring and an amine (NH_2) functional group. It can be produced in a three-step synthesis reaction followed by the separation of	the ground state to an excited state when light is absorbed. The energy difference between the ground state and the excited state of the d electrons is given by: $\Delta E = h\nu = hc/\lambda$ Changes in oxidation state, co-ordination number and ligand alter ΔE and this leads to a change in colour. The absorption of visible light is used in spectroscopy. A simple colorimeter can be used to determine the concentration of coloured ions in solution.

							phenylamine from the reaction mixture. Aromatic amines are used to make a class of synthetic dyes called azo dyes. Azo dyes contain an azo functional group, R-N=N-R, in which the R groups can be alkyl, aryl or a mixture of both.	
			Year 12 - Term 1 - Introduction to Organic Chemistry	Year 12 - Term 2 - Alkenes		Year 13 - Term 1 - Aldehydes and ketones	Year 13 - Term 2 - Polymers	Year 13 - Term 3 - Transition Metals - Variable Oxidation States and Catalysis
			Hydrocarbons can be aliphatic, alicyclic- carbon atoms form a ring or aromatic. Homologous series are compounds with the same functional group and similar chemical and physical properties. They differ by the number of repeating units they contain. A functional group is the group of atoms responsible for the characteristic reactions of a compound. IUPAC rules are used to name a compound. General formula is the simplest algebraic formula for a homologous series Structural formula gives the minimum detail on the arrangement of atoms in a molecule, without drawing any bonds Molecular formula shows the number and types of atoms of each element in a compound. However, it does not give any information on how the molecule is bonded together. Skeletal formula is a simplified formula used to represent organic molecules. Lines represent bonds between atoms, junctions are carbon atoms. Other	Alkenes are unsaturated hydrocarbons. Bonding in alkenes involves a double covalent bond, a centre of high electron density. In alkenes, the high electron density of the carbon–carbon double bond leads to attack on these molecules by electrophiles. Electrophilic addition reactions of alkenes with HBr, H_2SO_4 and Br_2. Bromine is used to test for unsaturation. There is the formation of major and minor products in addition reactions of unsymmetrical alkenes. Addition polymers are formed from alkenes and substituted alkenes. Addition polymers are unreactive. Knowledge and understanding of the production and properties of polymers has developed over time. Poly(chloroethene), commonly known as PVC, has many uses and its properties can be modified using a plasticiser.		Aldehydes are readily oxidised to carboxylic acids. Chemical tests to distinguish between aldehydes and ketones include Fehling's solution and Tollens' reagent. Aldehydes can be reduced to primary alcohols, and ketones to secondary alcohols, using $NaBH_4$ in aqueous solution. These reduction reactions are examples of nucleophilic addition. Carbonyl compounds undergo nucleophilic addition reactions with KCN, followed by dilute acid, to produce hydroxynitriles. Aldehydes and unsymmetrical ketones form mixtures of enantiomers when they react with KCN followed by dilute acid.	Condensation polymerisation is a type of reaction whereby a polymer is produced by repeated condensation reactions between monomers. Natural condensation polymers are all formed by elimination of water. Although the process of condensation polymerisation involves the elimination of a small molecule Condensation polymers can be identified because the monomers are linked by ester or amide bonds. Condensation polymers can be formed by: dicarboxylic acids and diols; dicarboxylic acids and diamines; amino acids Polyester is formed by the reaction between dicarboxylic acid monomers and diol monomers. Polyester is produced by linking these monomers with ester bonds / links Polyamides are polymers where repeating units are bonded together by amide links. An amide link - also known as a peptide link - is the key functional group in a polyamide. A diamine and a dicarboxylic acid are	Transition elements show variable oxidation states. Vanadium species in oxidation states IV, III and II are formed by the reduction of vanadate(V) ions by zinc in acidic solution. The redox potential for a transition metal ion changing from a higher to a lower oxidation state is influenced by pH and by the ligand. The reduction of $[Ag(NH_3)_2]^+$ (Tollens' reagent) to metallic silver is used to distinguish between aldehydes and ketones. Redox titrations of Fe^{2+} and $C_2O_4^{2-}$ are carried out with MnO_4^- Transition metals and their compounds can act as heterogeneous and homogeneous catalysts. A heterogeneous catalyst is in a different phase from the reactants and the reaction occurs at active sites on the surface. The use of a support medium to maximise the surface area of a heterogeneous catalyst and minimise the cost. V_2O_5 acts as a heterogeneous catalyst in the Contact process. Fe is used as a heterogeneous catalyst in

			labels are omitted. Displayed formula shows the relative positioning of atoms and the bonds between them. All atoms and bonds are shown Empirical formula the simplest whole-number ratio of each element present in a compound. Isomers are compounds with the same molecular formula but a different arrangement of atoms. Structural isomers are compounds with the same molecular formula but a different structural formula. Chain isomers- These are molecules with the same molecular formula but a different arrangement of the carbon chain. Chains can be straight or branched. Position isomers- These are molecules with the same functional group attached to a different position on the carbon chain. Functional group isomers- These are molecules with the same molecular formula but different functional groups. Stereoisomers are organic compounds with the same molecular and structural formulae but a different arrangement of atoms in space. E/Z isomerism is a type of stereoisomerism that can arise in alkenes due to the restricted rotation around the C=C bond. If a carbon atom has two of the same substituent attached, it will not show E/Z isomerism. Substituents can be assigned priorities based on atomic mass using Cahn-Ingold-Prelog rules to name E/Z isomers. The greater the atomic				required to form a polyamide. Proteins are vital biological molecules with varying functions within the body. They are essentially polymers made up of amino acid monomers. Amino acids have an aminocarboxylic acid structure. Dipeptides can be produced by polymerising 2 amino acids together. The amine group (-NH2) and acid group (-COOH) of each amino acid is used to polymerise with another amino acid. Polypeptides are made through polymerising more than 2 amino acids together. Polyesters such as Terylene, also known as polyethylene terephthalate (or PET) is a thermoplastic which can be repeatedly heated to soften and melt it and cooled to solidify it Terylene can be extruded to form fine fibres for use in artificial fabrics or moulded into fizzy drinks bottles and containers The best known example of an artificial polyamide is nylon. Nylon-6,6 contains a diamine and dicarboxylic acid, each of which contains six carbon atoms. Nylon-6,6 proved to be a cheap substitute for silk which is used to make ropes, twines, Velcro® and is often added to natural fibres in clothing and carpets to make them last longer Aromatic polyamides are a group of polymers known as aramids and include Kevlar®. The general name derives from the fact that they involve benzene rings	the Haber process. Heterogeneous catalysts can become poisoned by impurities that block the active sites and consequently have reduced efficiency; this has a cost implication. A homogeneous catalyst is in the same phase as the reactants. When catalysts and reactants are in the same phase, the reaction proceeds through an intermediate species.

			mass, the higher the priority When the highest priority groups are on different sides of the double bond, the isomer is an E-isomer. When the highest priority groups are on the same side of the double bond, the isomer is a Z-isomer.				(from arenes) linked via amide bonds. They are very tough and lightweight and used to make bulletproof vests (Kevlar®) Condensation polymers such as Nylon-6,6 and Kevlar® are long chain molecules which can be drawn out to form fibres. During this process the linear molecules align and become increasingly linked by hydrogen bonds between adjacent chains. The causes the strength of the fibre to increase during the drawing process.	
			Year 12 - Term 1 - Alkanes	Year 12 - Term 2 - Alcohols		Year 13 - Term 1 - Carboxylic acids and derivatives	Year 13 - Term 2 - Amino Acids and Proteins	Year 13 - Term 3 - Reactions of ions in aqueous solution
			Alkanes are saturated hydrocarbons. Alkanes are the main constituent of crude oil, which is an important raw material for the chemical industry. Alkanes are also used as fuels. Petroleum is a mixture consisting mainly of alkane hydrocarbons that can be separated by fractional distillation. Cracking involves breaking C–C bonds in alkanes. Thermal cracking takes place at high pressure and high temperature and produces a high percentage of alkenes. Catalytic cracking takes place at a slight pressure, high temperature and in the presence of a zeolite catalyst and is used mainly to produce motor fuels and aromatic hydrocarbons. Combustion of alkanes and other organic	Alcohols can be made by hydration of alkenes. Ethanol can be produced by the reaction of ethene and steam using a phosphoric acid catalyst. Ethanol can also be made by fermentation of glucose and is used as a biofuel. Alcohols are classified as primary, secondary and tertiary. Primary alcohols can be oxidised to aldehydes which can be further oxidised to carboxylic acids. Secondary alcohols can be oxidised to ketones. Tertiary alcohols are not easily oxidised. Acidified potassium dichromate(VI) is a suitable oxidising agent. Alkenes can be formed from alcohols by acid-catalysed elimination reactions. Alkenes produced by this method can be used to produce addition polymers without using		Carboxylic acids are weak acids but will liberate CO_2 from carbonates. Carboxylic acids and alcohols react, in the presence of an acid catalyst, to give esters. Common uses of esters include in solvents, plasticisers, perfumes and food flavourings. Vegetable oils and animal fats are esters of propane-1,2,3-triol (glycerol). Esters can be hydrolysed in acid or alkaline conditions to form alcohols and carboxylic acids or salts of carboxylic acids. Vegetable oils and animal fats can be hydrolysed in alkaline conditions to give soap (salts of long-chain carboxylic acids) and glycerol. Biodiesel is a mixture of methyl esters of long-chain carboxylic acids. Biodiesel is produced by reacting vegetable oils	Amino acids have both acidic and basic properties, including the formation of zwitterions. Proteins are sequences of amino acids joined by peptide links. Proteins have primary, secondary (α-helix and β–pleated sheets) and tertiary structures. Hydrolysis of the peptide link produces the constituent amino acids. Amino acids can be separated and identified by thin-layer chromatography. Amino acids can be located on a chromatogram using developing agents such as ninhydrin or ultraviolet light and identified by their Rf values. Enzymes are proteins. The action of enzymes as catalysts, including the concept of a stereospecific active site that binds to a substrate molecule. The principle of a drug	In aqueous solution, the following metal-aqua ions are formed: $[M(H_2O)_6]^{2+}$, limited to M = Fe and Cu $[M(H_2O)_6]^{3+}$, limited to M = Al and Fe The acidity of $[M(H_2O)_6]^{3+}$ is greater than that of $[M(H_2O)_6]^{2+}$ Some metal hydroxides show amphoteric character by dissolving in both acids and bases (eg hydroxides of Al^{3+}).

			compounds can be complete or incomplete. The internal combustion engine produces a number of pollutants including NOx, CO, carbon and unburned hydrocarbons. These gaseous pollutants from internal combustion engines can be removed using catalytic converters. Combustion of hydrocarbons containing sulfur leads to sulfur dioxide that causes air pollution. Chlorine reacts with methane in a free-radical substitution mechanism involving initiation, propagation and termination steps.	monomers derived from crude oil.		with methanol in the presence of a catalyst.	acting as an enzyme inhibitor by blocking the active site.	
			Year 12 - Term 1 - Halogenoalkanes			Year 13 - Term 1 - Acylation	Year 13 - Term 2 - DNA	Year 13 - Term 3 - Organic Synthesis
			Halogenoalkanes have many uses, including as refrigerants, as solvents and in pharmaceuticals. The use of some halogenoalkanes has been restricted due to the effect of chlorofluorocarbons (CFCs) on the atmosphere. Halogenoalkanes contain polar bonds. Halogenoalkanes undergo substitution reactions with the nucleophiles OH–, CN– and NH3. Halogenoalkanes take part in concurrent substitution and elimination reactions of a halogenoalkane. Ozone, formed naturally in the upper atmosphere, is beneficial because it absorbs ultraviolet radiation. Chlorine atoms are			Carboxylic acids have derivative molecules where the -OH group is replaced by another group. There are three main derivatives: 1) Acid anhydrides formed when water is removed from two carboxylic acids 2) Acyl chlorides – react violently due to the very polar -COCl group 3) Amides – react to form N substituted amides Acyl chlorides and acid anhydrides react with water, alcohols, ammonia and primary amines in nucleophilic addition–elimination reactions In these reactions the addition of the nucleophile leads to the elimination of a prdocut under aqueous conditions Acyl chloride + water =	A nucleotide is made up from a phosphate ion bonded to 2-deoxyribose which is in turn bonded to one of the four bases adenine, cytosine, guanine and thymine. A single strand of DNA (deoxyribonucleic acid) is a polymer of nucleotides linked by covalent bonds between the phosphate group of one nucleotide and the 2-deoxyribose of another nucleotide. This results in a sugar-phosphate-sugar-phosphate polymer chain with bases attached to the sugars in the chain. DNA exists as two complementary strands arranged in the form of a double helix	The synthesis of an organic compound can involve several steps.

			formed in the upper atmosphere when ultraviolet radiation causes C–Cl bonds in chlorofluorocarbons (CFCs) to break. Chlorine atoms catalyse the decomposition of ozone and contribute to the hole in the ozone layer. The results of research by different groups in the scientific community provided evidence for legislation to ban the use of CFCs as solvents and refrigerants. Chemists have now developed alternative chlorine-free compounds.			carboxylic acid Acyl chloride + alcohol = ester Acyl chloride + ammonia = amide Acyl chloride + amine = N-substituted amide Aspirin is an ester produced from salicylic acid and ethanoic anhydride. Ethanoyl chloride can also be used to produce aspirin however it is not used in industry as it is expensive and produces harmful HCl fumes as part of the reaction. Ethanoic anhydride is much safer for industrial use		
						Year 13 - Term 1 - Aromatic chemistry	Year 13 - Term 2 - Action of anticancer drugs	Year 13 - Term 3 - NMR
						Benzene is an aromatic compound consisting of a ring of six carbon atoms with six hydrogen atoms and a ring of delocalised electrons Each bond in the benzene ring has an intermediate length in between that of a double bond and a single bond The outer electron from the p orbital of each carbon atom is delocalised to form the central ring. The ring structure makes benzene very stable compared to other molecules of a similar size When benzene was first discovered its structure was not known. It was predicted from empirical measurements that it had a structure similar to cyclohexatriene with three double bonds and three single bonds. The enthalpy change of hydrogenation for benzene was predicted to	The Pt(II) complex cisplatin is used as an anticancer drug. Cisplatin prevents DNA replication in cancer cells by a ligand replacement reaction with DNA in which a bond is formed between platinum and a nitrogen atom on guanine. Society needs to assess the balance between the benefits and the adverse effects of drugs, such as the anticancer drug cisplatin	Nuclear magnetic resonance (NMR) gives information about the position of 13C or 1H atoms in a molecule. 13C NMR gives simpler spectra than 1H NMR. The δ scale is used for recording chemical shift. Chemical shift depends on the molecular environment. Integrated spectra indicate the relative numbers of 1H atoms in different environments. 1H NMR spectra are obtained using samples dissolved in deuterated solvents or CCl4 Tetramethylsilane (TMS) is used as a standard.

						be three times the enthalpy change of cyclohexene -360kJ/mol but it was later discovered to be -208kJ/mol leading to the conclusion of the different unusual structure. Compounds that contain benzene as part of their structure have high melting points due to the stability of the delocalised ring, but low boiling points as they are non polar and often cannot be dissolved in water. The delocalised ring is susceptible to attack from electrophiles in electrophilic substitution reactions. The mechanism means aromatic amines and nitrobenzene can be produced from benzene. Nitrobenzene is formed from the reaction of benzene with the electrophile NO2+. This is a reactive intermediate produced from the reaction of concentrated sulfuric acid with concentrated nitric acid. When heated there can be the substitution of the NO2+ electrophile onto the benzene ring, removing a hydrogen ion. The delocalised electron ring in benzene can act as a nucleophile, leading to attack on acyl chlorides. This is known as Friedal-Crafts acylation which takes place using a reactive intermediate produced from the acyl chloride and an aluminium chloride catalyst that is then attached by the benzene ring	

								Year 13 - Term 3 - Chromatography
								Chromatography can be used to separate and identify the components in a mixture. Types of chromatography include: thin-layer chromatography (TLC) – a plate is coated with a solid and a solvent moves up the plate column chromatography (CC) – a column is packed with a solid and a solvent moves down the column gas chromatography (GC) – a column is packed with a solid or with a solid coated by a liquid, and a gas is passed through the column under pressure at high temperature. Separation depends on the balance between solubility in the moving phase and retention by the stationary phase. Retention times and Rf values are used to identify different substances. The use of mass spectrometry to analyse the components separated by GC.
	KS4 prior learning	**By the end of the term, students can:**	Year 12 Term 1 - Atomic Structure	Year 12 - Term 2 - Periodicity	Year 12 Term 3 - Equilibria	Year 13 Term 1 - Thermodynamics	Year 13 Term 2 - Electrode potentials and electrochemical cells	Year 13 - Term 3 - Period 3 elements and their Oxides

What we want our students to do	Chemistry, like all sciences, is a practical subject. Throughout the course students will carry out practical activities including measuring energy changes in chemical reactions; tests for identifying different types of compound; different methods for measuring rates of reaction; studying electrochemical cells; preparation of organic solids and liquids; an advanced form of chromatography for more accurate results.	Demonstrate excellence in these **skills**:	Describe the structure of atoms in terms of protons, neutrons and electrons Recall the relative mass and relative charge of protons, neutrons and electrons. Define atoms and ions in terms of numbers of protons, neutrons and electrons, as well as atomic number and mass number (including isotopes) Describe how a time of flight mass spectrometer works Identify elements and calculate relative atomic mass from mass spectroscopy data Find the relative formula mass of compounds from mass spectroscopy data Give the electron structure of atoms and ions up to Z=36 in terms of s, p and d sub-shells Explain how data from ionisation energies provides evidence for electron structure Give the electron structure of atoms and ions up to Z=36 in terms of s, p and d sub-shells Explain how data from ionisation energies provides evidence for electron structure.	Classify an element as an s, p,d or f block element using its electron structure. Describe and explain the trends across Period 3 in atomic radius, ionisation energy, melting points.	Describe what is meant the term dynamic equilibrium. Explain how changes in temperature, pressure and concentration affect the position of a system at equilibrium. Explain why compromise conditions of temperature and pressure may be used for a reversible reaction in an industrial process. Write an expression for Kc for a homogeneous equilibrium, including its units. Calculate the moles and concentration of reagents at equilibrium. Calculate the value of Kc. Predict qualitatively how the value of Kc will change, if at all, as the position of an equilibrium moves as conditions are changed.	Define lattice enthalpy (formation and dissociation), enthalpy of formation, ionisation enthalpy, enthalpy of atomisation, bond enthalpy, electron affinity, enthalpy of solution, hydration enthalpy Draw and use Born–Haber cycles to find missing values of enthalpy changes Comment on the covalent character of an ionic compounds by comparing lattice enthalpies found using Born–Haber cycles with those calculated theoretically using the perfect ionic model. Describe entropy in terms of disorder Predict whether reactions have an increase or decrease in entropy Calculate the entropy change for a reaction Calculate the Gibbs free-energy change for a reaction at a given temperature Determine whether a reaction is feasible at a given temperature Calculate the temperature at which a reaction becomes feasible Use entropy changes to explain why some endothermic reactions are feasible.	State that there is a potential difference between two half cells (electrodes) that are joined Use cell notation to represent cells Understand that potentials are measured relative to the Standard Hydrogen Electrode Understand that the potential of an electrode is affected by conditions Use the electrochemical series to predict the direction of simple redox reactions. Calculate the EMF and cell reaction for a commercial cell given the half-equations Explain how some cells can be recharged Explain how a hydrogen fuel cell works Evaluate the benefits and risks associated with using non-rechargeable, rechargeable and fuel cells.	Describe and write equations for reactions of Na and Mg with water Describe and write equations for reactions of Na, Mg, Al, Si, P and S with oxygen Describe and explain the trend in melting points of period 3 oxides Write equations for the reactions of period 3 oxides with water and describe the pH of the solutions formed Describe the structure and bonding of period 3 oxides, and link this to how they react with water.
			Year 12 Term 1 - Amount of Substance	Year 12 - Term 2 - Group 2 - Alkaline Earth Metals	Year 12 Term 3 - Kinetics	Year 13 Term 1 - Rate Equations	Year 13 Term 2 - Acids and Bases	Year 13 - Term 3 - Transition Metals - General Properties and Substitution Reactions

			Define relative atomic mass (Ar) Define relative molecular mass (Mr) Determine relative molecular mass (Mr) of a substance using relative atomic mass (Ar) values. Carry out calculations using the Avogadro constant. Carry out calculations using mass of substance, Mr, and amount in moles Carry out calculations using concentration, volume and amount of substance in a solution. Carry out calculations using the ideal gas equation. Explain the difference between empirical and molecular formulae Carry out calculations to find empirical formula from data giving composition by mass or percentage by mass. Carry out calculations to find molecular formula from the empirical formula and relative molecular mass. Write balanced equations. Write ionic equations. Carry out calculations for reactions involving masses, percentage yields, atom economies, volumes of gases, concentrations & volumes of solutions. State economic, ethical and environmental advantages for society and industry of processes with a high atom economy.	State and explain trends in atomic radius, first ionisation energy and melting point from Mg–Ba State the role of Mg in the extraction of Ti Describe and write equations for the reactions of Mg–Ba with water State the solubility of Group 2 sulfates and hydroxides Desribe uses of $Mg(OH)_2$ and $BaSO_4$ in medicine; $BaSO_4$ in testing for sulfate ions; $Ca(OH)_2$ in agriculture; Mg in the extraction of Ti; $CaO/CaCO_3$ in removing SO_2 from flue gases.	Explain that reactions can only take place when particles collide with energy greater than or equal to the activation energy. Draw and interpret Maxwell–Boltzmann distribution curves. Define the term rate of reaction Explain how and why temperature affects the rate of reactions using Maxwell–Boltzmann distributions. Explain how and why concentration of solutions affects the rate of reactions. Explain how and why pressure of gases affects the rate of reactions. State what a catalyst is. Explain how and why a catalyst affects the rate of reactions.	Define the terms order of reaction and rate constant Describe how changing concentration of a reagent affects the rate when the order with respect that reagent is 0, 1 or 2 Determine the values and units for rate constants given appropriate data Describe how rate constants change with temperature Perform calculations using the Arrhenius equation Plot straight line graphs of ln k versus 1/T to determine the activation energy of a r	Define Brønsted–Lowry acids and bases Identify species as Brønsted–Lowry acids or bases in proton transfer reactions Calculate pH of a strong acid from its concentration Calculate the concentration of a strong acid from its pH Calculate the pH of when a strong acid is diluted Use Kw to find the pH of strong bases from its concentration, and vice versa Calculate the pH of water at different temperatures Write expressions for Ka for stated weak acids Perform calculations linking Ka to concentration and pH Convert Ka values to pKa and vice versa Calculate the pH of water at different temperatures Calculate pH of a mixture of a strong acid with a strong base Calculate the pH of a mixture of a weak acid with a strong base Sketch pH curves for titrations of strong/weak acids with strong/weak bases Choose a suitable indicator for acid-base titrations.	Write the electron structure of first row transition metals and their ions Describe what a transition metal is in terms of electron structure Describe the characteristic properties of transition metals Define the terms ligand, complex, co-ordinate bond and co-ordination number. Explain the difference between, and give examples of monodentate, bidentate and multidentate ligands Explain what happens in a ligand substitution (exchange) reaction and why there may be a change in co-ordination number Describe what haem is, how oxygen is carried in blood and why carbon monoxide is toxic Describe and explain the chelate effect in terms of enthalpy and entropy changes.
			Year 12 Term 1 - Bonding	Year 12 - Term 2 - Group 7 - The Halogens	Year 12 - Term 3 - Organic Analysis	Year 13 Term 1 - Equilibrium constant Kp	Year 13 Term 2 - Buffers	Year 13 - Term 3 - Transition Metals - Shapes

			Describe the structure of ionic compounds. Explain the properties of ionic compounds using an understanding of ionic bonding. Predict the formula of simple ions based on the position of the element in the Periodic Table and knowledge of common compound ions. Write the formula of ionic compounds. Describe the nature of covalent bonds, including co-ordinate and multiple bonds. Represent molecules by diagrams where lines represent each covalent bond, with an arrow to represent a co-ordinate bond. Describe the structure of molecular substances. Explain the properties of molecular substances. Describe the nature of metallic bonding. Describe the structure of metals. Explain the properties of metals. Describe and explain the properties of ionic, molecular, giant covalent and metallic substances, in terms of melting/boiling points and conductivity. Describe in detail and draw the structures of diamond, graphite, ice, iodine, magnesium and sodium chloride. Derive, name and sketch the shape of molecules and ions with up to six electron pairs surrounding the central atom, including bond angles. Explain using VSEPR theory why molecules and ions have the shapes that they do, including the effect on the bond angles of the great	Describe and explain the trends down Group 7 in electronegativity and boiling points Describe and explain the trends in oxidising power of the halogens, illustrated by displacement reactions of halide ions Describe and explain the trends in reducing power of the halide ions, illustrated by reactions of concentrated sulfuric acid with solid sodium halides Describe and explain how halide ions can be identified using acidified silver nitrate and the solubility of silver halides in ammonia Explain why the silver nitrate used is acidified. Describe the reactions of chlorine with water Explain why chlorine is used in water treatment Evaluate advantages and disadvantages of adding chemicals to water State the reaction of sodium hydroxide with water and uses of the solution formed.	Carry out test-tube reactions in the specification to distinguish alcohols, aldehydes, alkenes and carboxylic acids, and interpret the observations from these reactions. Use precise atomic masses and the precise molecular mass to determine the molecular formula of a compound. Identify functional groups from infra-red spectra. Describe how the "fingerprint" region of a spectrum can be used. Explain the link between absorption of infrared radiation by bonds in CO2, methane and water vapour and global warming	Derive partial pressure from mole fraction and total pressure Construct an expression for Kp for a homogeneous system in equilibrium Perform calculations involving Kp Predict the qualitative effects of changes in temperature and pressure on the position of equilibrium Predict the qualitative effects of changes in temperature on the value of Kp Explain that, whilst a catalyst can affect the rate of attainment of an equilibrium, it does not affect the value of the equilibrium constant.	Describe what a buffer solution is and how it is made Explain qualitatively how acidic/basic buffer solutions work State some uses of buffer solutions Calculate the pH of a buffer solution	Sketch examples of octahedral, tetrahedral, square planar and linear complexes Explain how some complexes can show cis-trans (E–Z)¬ or optical isomerism Desribe the complexes in cisplatin and Tollen's reagent

			repulsion by lone (non-bonding) pairs. Define and understand the concept of electronegativity. Explain why some covalent bonds are polar and deduce whether a bond is polar. Explain why some molecules are polar and deduce whether a molecule has a permanent dipole. Explain how each of the intermolecular forces arise. Explain how the melting points are influenced by these intermolecular forces. Explain the anomalous nature of ice and how its low density can be explained through a knowledge of hydrogen bonding.					
			Year 12 Term 1 - Redox	Year 12 Term 2 - Energetics		Year 13 - Term 1 - Optical isomerism	Year 13 - Term 2 - Amines	Year 13 - Term 3 - Transition Metals - Colour
			Determine oxidation states Write redox half equations Combine redox half equations to produce full equations Identify reduction and oxidation processes	Define enthalpy change and standard conditions. Define standard enthalpy changes of combustion and formation. Recall the equation $q = mc\Delta T$ Calculate ΔH for reactions using calorimetry experiment data. Calculate enthalpy changes using mean bond enthalpies Explain why most bond enthalpies are mean values.		Explain the cause of optical isomerism Identify molecules that exhibit optical isomerism/that are optically active. Draw pairs of optical isomers in 3D Describe how enantiomers affect plane polarised light Explain what a racemic mixture is, how they can be formed, and their effect on plane polarised light	Write equations and give conditions for the preparation of primary aliphatic amines from both halogenoalkanes and nitriles Write equations and give conditions for the production of aromatic amines and identify their use in making dyes Place amines in order of base strength and explain this order. Identify the various amines and quaternary ammonium salts formed when ammonia and amines react with halogenoalkanes State the mechanism for reactions of ammonia and amines with halogenoalkanes Describe the use of	Explain why transition metal complexes are coloured Describe factors that affect the colour of transition metal ions Describe how colorimetry can be used to find the concentration of coloured ions in solution.

							quaternary ammonium salts Identify the products of and write equations for acylation reactions of ammonia and amines with acyl chlorides and acid anhydrides Outline the mechanism for the acylation reactions	
			Year 12 - Term 1 - Introduction to Organic Chemistry	Year 12 - Term 2 - Alkenes		Year 13 - Term 1 - Aldehydes and ketones	Year 13 - Term 2 - Polymers	Year 13 - Term 3 - Transition Metals - Variable Oxidation States and Catalysis
			Give the empirical, molecular, general, structural, displayed and skeletal structure of organic molecules. Describe the characteristics of a homologous series. Draw the structure of, and name organic molecules with chains and rings with up to six carbon atoms each. Define structural isomerism and stereoisomerism. Draw the structure of and name chain, position and functional group isomers. Explain the cause of E–Z isomerism. Draw the structure of and name E–Z isomers (using Cahn–Ingold–Prelog priority rules).	Draw alkenes Write equations and mechanisms for reactions of alkenes with HBr, H_2SO_4 and HBr. Explain the potential formation of major and minor products in these reactions. Describe what a polymer is. Identify the repeating unit of an addition polymer given the monomer structure and vice versa. Name polymers from the name of the monomer Explain how polymers have developed over time Give some uses of PVC and how plasticisers can change its properties Explain why addition polymers are unreactive Explain the nature of the intermolecular forces between polyalkene molecules.		Write equations and know reagents and conditions to oxidise aldehydes to carboxylic acids State how to distinguish aldehydes and ketones Write equations, know reagents and conditions and outline the mechanism to reduce aldehydes and ketones to alcohols with $NaBH_4$ Write equations, know reagents and conditions and outline the mechanism for reaction of aldehydes and ketones with KCN and acid Explain why reaction of aldehydes and ketones with KCN followed by acid can form a racemic mixture Describe the hazards of using KCN	Identify the repeating unit and linkages in polyesters and polyamides given the monomer(s) Identify monomer(s) needed the make a condensation polymer given the repeating unit State the repeating units in Terylene, nylon 6,6 and Kevlar State some uses of condensation polymers Explain the nature of the intermolecular forces between molecules of condensation polymers. Explain why polyalkenes cannot be hydrolysed and so are non-biodegradable Explain why polyesters and polyamides can be hydrolysed and so are biodegradable Evaluate the advantages and disadvantages of different methods of disposing of polymers	Describe and explain what happens when vanadate(V) ions are reduced by zinc in acidic solution Explain how the redox potential of a transition metal ion is affected by changes in pH and ligand Describe and explain the use of $Ag(NH_3)_2^+$ in Tollen's reagent to distinguish between aldehydes and ketones Perform titrations and associated calculations for redox reactions of MnO_4^- with Fe^{2+} and $C_2O_4^{2-}$ in acidic solution. Describe what a heterogeneous catalyst is and the role of active sites and the support medium Explain, with the aid of equations, how V_2O_5, acts as a catalyst in the Contact Process Describe the use of Fe in the Haber process Explain how heterogeneous catalysts can become poisoned Describe what a homogeneous catalyst is and how reactions proceed through an intermediate species Describe, with the aid of equations, how Fe^{2+}

								catalyses the reaction between I– and S2O82– Describe, with the aid of equations, how Mn2+ catalyses the reaction between C2O42– and MnO4–
			Year 12 - Term 1 - Alkanes	Year 12 - Term 2 - Alcohols		Year 13 - Term 1 - Carboxylic acids and derivatives	Year 13 - Term 2 - Amino Acids and Proteins	Year 13 - Term 3 - Reactions of ions in aqueous solution
			Explain that alkanes are saturated hydrocarbons. Explain how the alkanes in crude oil are separated by fractional distillation.explain the commercial benefits of cracking. Describe how thermal and catalytic cracking are completed and the types of compounds that are produced. Write equations for the complete and incomplete combustion of alkanes. Explain how a number of pollutants including NOx, CO, C and unburned hydrocarbons are formed in the internal combustion engine and how their emissions can be reduced. Explain why SO2 may be formed when fuels are burned and how it can be removed from flue gases. Write equations for the reaction of halogens with alkanes Erite equations to show the mechanism for the reaction of halogens with alkanes and represent the unpaired electron in a radical using a dot.	Write equations and give conditions for the production of alcohols by hydration of alkenes Outline the mechanism for formation of ethanol from reaction of ethene with steam with an acid catalyst Write an equation, give and justify conditions for the production of ethanol by fermentation of glucose Compare the two methods of producing ethanol Explain the meaning of the term biofuel Evaluate the use of ethanol as a biofuel Show using equations how ethanol made by fermentation can be regarded as carbon neutral but that in reality it is notClassify alcohols as primary, secondary or tertiary. identify products and write equations for oxidation reactions of alcohols. Use chemical tests to distinguish aldehydes and ketones. Identify products of alcohol elimination reactions Write equations and mechanism for alcohol elimination reactions Explain how addition polymers can be made		Draw the structure of and name carboxylic acids and esters State how carboxylic acids react with carbonates Write equations for the reaction of carboxylic acids with alcohols to form esters List some common uses of esters Write equations for the hydrolysis of esters in acidic or alkaline conditions Describe the structure of animals fats and vegetable oils Describe how soap and biodiesel are made and write equations for these reactions for specified fats/oils.	Draw the structure of given amino acids in acidic solution, alkaline solution and as zwitterions Describe the primary, secondary and tertiary structure of proteins, including the importance of hydrogen bonds and S-S bonds Draw the structure of peptides formed from amino acids State that peptide link can be hydrolysed producing amino acids Identify the amino acids given when a peptide is hydrolysed State that amino acids can be separated and identified by thin-layer chromatography, including the use of Rf values Explain that enzymes are proteins which act through a stereospecific active site that binds to a substrate Explain how drugs, which can be designed with the aid of computers, can act to inhibit enzymes by blocking active sites, but that the correct enantiomer is required	State that metal ions exist as metal-aqua ions in aqueous solution Explain why [M(H2O)6]3+ ions are more acidic than [M(H2O)6]2+ ions Describe and explain reactions of [M(H2O)6]2+ (M = Cu, Fe) and [M(H2O)6]3+ (M = Al, Fe) with the bases OH–, NH3, CO32– Describe if and how metal hydroxides (Cu(II), Fe(II), Al(III), Fe(III)) react with H+ and OH–, and so whether these metal hydroxides are basic or amphoteric.

				from alkenes made this way without using monomers derived from crude oil.				
			Year 12 - Term 1 - Halogenoalkanes			Year 13 - Term 1 - Acylation	Year 13 - Term 2 - DNA	Year 13 - Term 3 - Organic Sythesis
			Draw and name halogenoalkanes. Write equations and mechanisms for reactions of halogenoalkanes with OH- , CN– and NH3. Explain the relative rate of reaction of halogenoalkanes. Write equations and mechanisms for elimination reaction of halogenoalkanes using OH– Explain the concurrent nature of elimination and substitution when halogenoalkanes react with OH– and explain the different roles of the OH– in these reactions. State the role of ozone in the atmosphere Describe how chlorine free radicals can be formed in the atmosphere from compounds such as CFCs. Explain the mechanism for the depletion of ozone by chlorine free radicals Evaluate the role of chemists in the introduction of legislation to ban the use of CFCs and to find replacements.			Draw the structure of and name acid anhydrides, acyl chlorides and amides Identify the products of and write equations for acylation reactions of water, alcohols, ammonia and amines with acyl chlorides and acid anhydrides Outline the mechanism for the acylation reactions of acyl chlorides • state advantages of using ethanoic anhydride rather than ethanoyl chloride in the production of aspirin • prepare and purity an organic solid and test its purity.	Identify the components of DNA Explain how the two DNA strands interact with hydrogen bonds between base pairs.	Devise synthetic routes, with up to four steps, to make specific organic compounds using the reactions in the specification Explain why processes are designed to avoid solvents, non-hazardous starting materials and have steps with high atom economy

						Year 13 - Term 1 - Aromatic chemistry	Year 13 - Term 2 - Action of anticancer drugs	Year 13 - Term 3 - NMR
						Describe the structure of benzene and explain how delocalisation makes benzene more stable than the theoretical cyclohexa-1,3,5-triene Use thermochemical evidence from enthalpies of hydrogenation to account for this extra stability Explain why benzene undergoes substitution reactions in preference to addition reactions. Write equations and outline mechanisms for nitration and Friedel-Crafts acylation reactions of aromatic compounds. (including equations for the formation of electrophiles) Understand the usefulness of nitration and Friedel-Crafts acylation reactions	Describe how DNA replicates in simple terms Explain how the anti-cancer drug cisplatin prevents DNA replication Explain why some drugs can have adverse effects and appreciate the balance between benefits and adverse effects of any drug.	Recall the use of TMS and the δ scale for chemical shift Explain the use of deuterated solvents or CCl4 Use the n+1 rule to deduce spin-spin splitting patterns of adjacent, non-equivalent protons in aliphatic compounds Deduce the structure of compounds using 1H NMR to deduce structures including the number, position, relative intensity and splitting of signals Deduce the structure of compounds using 13C NMR to deduce structures including the number and position of signals.
								Year 13 - Term 3 - Chromatography
								Describe the similarities and differences between thin-layer, column and gas chromatography Explain how chromatography works Use retention times and Rf values to identify substances Describe the use of mass spectroscopy to analyse substances separated by gas chromatography

	KS4 prior learning	**By the end of the term, students can:**	Year 12 Term 1 - Atomic Structure	Year 12 - Term 2 - Periodicity	Year 12 Term 3 - Equilibria	Year 13 Term 1 - Thermodynamics	Year 13 Term 2 - Electrode potentials and electrochemical cells	Year 13 - Term 3 - Period 3 elements and their Oxides
Key assessment questions:			How can we tell what is inside an atom if we can't see it?	Is helium an s or p block element?	What is the relationship between kinetics and equilibrium? Why are compromise conditions used in industrial processes?	For an ionic compound with covalent character, deduce whether the lattice enthalpy will have a greater or smaller magnitude than that calculated theoretically from the perfect ionic model.	What are the advantages and disadvantages of hydrogen fuel cells?	How are the properties of the period 3 oxides different?
			Year 12 Term 1 - Amount of Substance	Year 12 - Term 2 - Group 2 - Alkaline Earth Metals	Year 12 Term 3 - Kinetics	Year 13 Term 1 - Rate Equations	Year 13 Term 2 - Acids and Bases	Year 13 - Term 3 - Transition Metals - General Properties and Substitution Reactions
			How can a standard solution be prepared? How can the concentration of an acid be determined? How can the moles of water in a hydrated salt be determined? How can experimental error be used to confirm whether practical results are accurate?	Why can't other group 2 compounds be used in place of barium sulfate in medicine?	How have the factors that affect the rate of chemical reaction have changed methods of storage and cooking of food?	How can the order of a reaction with respect to a given reactant be determined using the initial rates method and a continuous rates method?	Water is a covalently-bonded, simple molecular substance so why can it conduct electricity? Why can drinking absolutely pure water can kill you?	How does an iron complex behave as a two-way respiratory carrier?
			Year 12 Term 1 - Bonding	Year 12 - Term 2 - Group 7 - The Halogens	Year 12 - Term 3 - Organic Analysis	Year 13 Term 1 - Equilibrium constant Kp	Year 13 Term 2 - Buffers	Year 13 - Term 3 - Transition Metals - Shapes

			Which of the following ionic compounds have the highest and lowest melting points: sodium chloride, potassium chloride; magnesium chloride – explain your reasoning? The ammonium ion has three covalent N–H bonds and one co-ordinate N–H bond – how does the strength of the covalent bonds compare to the co-ordinate bond – explain your reasoning? Which metals have the highest and lowest melting points – sodium, potassium, magnesium – explain your reasoning?	Explain the advantages and disadvantages of adding chlorine and fluorine to water supplies without customer consent	How has our understanding of organic molecules, their structure and the way they react, has been enhanced by organic analysis?	How is Kp used in industry?	How is a buffer used in our blood?	Despite the effectiveness of cisplatin as an anticancer agent, its trans-isomer, transplatin, is clinically ineffective - explain why
			Year 12 Term 1 - Redox	Year 12 Term 2 - Energetics		Year 13 - Term 1 - Optical isomerism	Year 13 - Term 2 - Amines	Year 13 - Term 3 - Transition Metals - Colour
			Why is acidified dichromate used to distinguish between primary and secondary alcohols and not simply dichromate?	How are accurate values found for the energy content in food and fuels?		Compare enantiomers to your right and left hand	Describe the chemistry of shampoo and conditioner	Why are fireworks different colours?
			Year 12 - Term 1 - Introduction to Organic Chemistry	Year 12 - Term 2 - Alkenes		Year 13 - Term 1 - Aldehydes and ketones	Year 13 - Term 2 - Polymers	Year 13 - Term 3 - Transition Metals - Variable Oxidation States and Catalysis
				How do the properties of polymers affect their uses?		Why is KCN preferred to HCN?	Why is kevlar tougher than a speeding bullet?	How is the use of heterogeneous catalysts in industry different to the use of homogeneous catalysts?
			Year 12 - Term 1 - Alkanes	Year 12 - Term 2 - Alcohols		Year 13 - Term 1 - Carboxylic acids and derivatives	Year 13 - Term 2 - Amino Acids and Proteins	Year 13 - Term 3 - Reactions of ions in aqueous solution
			How would life be different without crude oil, fractional distillation and cracking?	How does a roadside breathalyser work?				Plan a series of tests to identify unknown transition metal ions in aqueous solution
			Year 12 - Term 1 - Halogenoalkanes			Year 13 - Term 1 - Acylation	Year 13 - Term 2 - DNA	Year 13 - Term 3 - Organic Sythesis
			CFCs are still used in some countries – how can we stop this?			How is aspirin produced in industry?	Why is DNA helical?	How is cost, sustainability, speed and safety determine the route to an organic molecule?

						Year 13 - Term 1 - Aromatic chemistry	Year 13 - Term 2 - Action of anticancer drugs	Year 13 - Term 3 - NMR
						How was the structure of benzene discovered?	Why is hair loss a side effect of chemotherapy?	How is a D2O shake used?
								Year 13 - Term 3 - Chromatography
								How pure is your aspirin tablet?
	KS4 prior learning	**By the end of the term, students can:**	Year 12 Term 1 - Atomic Structure	Year 12 - Term 2 - Periodicity	Year 12 Term 3 - Equilibria	Year 13 Term 1 - Thermodynamics	Year 13 Term 2 - Electrode potentials and electrochemical cells	Year 13 - Term 3 - Period 3 elements and their Oxides
Disciplinary Rigour		What makes your subject different to other subjects? What are the expectations for students in your subject area in the KS5 qualification specification?	AO1 - Write the electron structure of atoms and ions with Z=1-36 AO1 - Demonstrate knowledge and understanding of scientific ideas to write explanations for trends in ionisation energies down a group and across a period. AO2 - Identify atoms and ions from numbers of protons, neutrons and electrons, and vice versa AO2 - Apply knowledge and understanding to determine which Group an element is in using successive ionisation energy data AO2 - Apply knowledge and understanding to determine the relative atomic mass of elements using isotope abundance data (this could include data for elements found in meteorites to show some difference) quoting answers to a suitable number of significant figures for data provided AO2 - Apply knowledge and understanding to look at the mass spectra of compounds to determine the relative formula mass AO3 - Evaluate how and why atomic structure	AO2 - Demonstrate knowledge and understanding to write the electron structure of elements and state which block they belong to AO1 - Demonstrate knowledge and understanding of scientific ideas; AO2 - Demonstrate knowledge and understanding; MS3.2 – Plot two variables from experimental or other data to plot data on graphs for atomic radius, first ionisation energy and melting point and explain those trends	AO2 - Demonstrate knowledge and understanding to predict and explain the effect of changes in temperature, pressure and concentration on the position of an equilibrium AO2 - Demonstrate knowledge and understanding; AT k - Safely and carefully handle solids and liquids, including corrosive, irritant, flammable and toxic substances to carry out test-tube equilibrium shifts to show the effect of concentration and temperature AO2 - Demonstrate knowledge and understanding to write expressions for Kc and derive units for a variety of equilibria AO2 - Demonstrate knowledge and understanding to calculate the moles and concentration of reagents at equilibrium given initial quantities and the quantity of one reagent at equilibrium AO2 - Demonstrate knowledge and understanding; MS2.3 - Substitute numerical values into algebraic equations using	AO2 - Apply knowledge and understanding - Write equations to represent enthalpy changes. AO2 - Apply knowledge and understanding; MS2.2 Change the subject of an equation - Construct Born-Haber cycles and use them to calculate missing enthalpy change values. AO3 - Analyse, interpret and evaluate data to make judgements - Compare and comment on values of enthalpy changes from Born–Haber cycles with those calculated theoretically using the perfect ionic model AO2 - Apply knowledge and understanding MS2.2 Change the subject of an equation - Construct and use cycles involving the solution of ionic compounds in water to find missing enthalpy change values. AO2 - Apply knowledge and understanding - Rank given substances in terms of entropy AO2 - Apply knowledge and understanding MS2.2 Change the subject of an equation; MS2.3 Substitute numerical	AO2 - Apply knowledge and understanding; PS 1.1 - Solve problems set in practical contexts; AT j - Set up electrochemical cells and measuring voltages - make simple cells and use them to measure EMF and unknown electrode potentials. AO2 - Apply knowledge and understanding - write the standard cell notation for cells AO2 - Apply knowledge and understanding - predict how changes in conditions will affect EMF AO2 - Apply knowledge and understanding - use E values to predict the direction of simple redox reactions, then test these predictions by simple test-tube reactions	AO2 - Apply knowledge and understanding - Plot a graph of melting points of period 3 oxides and annotate it with explanation of the relative melting points. AO2 - Apply knowledge and understanding- Complete tables including equations to show how period 3 elements react with water and/or oxygen, and how period 3 oxides react with water.

			model developed over time MS1.1 - Use an appropriate number of significant figures to find relative masses MS1.2 - Find arithmetic means to find relative masses		appropriate units for physical quantities to calculate Kc from data. AO2 - Demonstrate knowledge and understanding to predict qualitatively how the value of Kc will change, if at all, as the position of an equilibrium moves as conditions are changed AO3 - Analyse, interpret and evaluate scientific information to explain how conditions in temperature and pressure are a compromise in examples of industrial processes	values into algebraic equations - Use entropy values to calculate the entropy change for a reaction. AO2 - Apply knowledge and understanding - Predict, where possible, whether reactions have an increase or decrease in entropy. AO2 - Apply knowledge and understanding; MS2.2 - Change the subject of an equation; MS2.3 - Substitute numerical values into algebraic equations using appropriate units for physical quantities - Use the equation $\Delta G = \Delta H - T\Delta S$ to determine whether reactions are feasible at given temperatures, and determine the temperature at which reactions become feasible. MS3.3 - Determine the slope and intercept of a linear graph - Plot graphs of ΔG versus T to determine ΔH and ΔS. AO2 - Apply knowledge and understanding - Forecast how temperature affects the feasibility of reactions given the sign of the enthalpy and entropy changes AO2 - Apply knowledge and understanding; MS2.2 - Change the subject of an equation; MS2.3 - Substitute numerical values into algebraic equations using appropriate units for physical quantities - Apply the equation $\Delta G = \Delta H - T\Delta S$ to state changes to find ΔH, ΔS, melting and/or boiling points.		

			Year 12 Term 1 - Amount of Substance	Year 12 - Term 2 - Group 2 - Alkaline Earth Metals	Year 12 Term 3 - Kinetics	Year 13 Term 1 - Rate Equations	Year 13 Term 2 - Acids and Bases	Year 13 - Term 3 - Transition Metals - General Properties and Substitution Reactions
			MS0.1 - Carry out calculations using numbers in standard and ordinary form e.g. using the Avogadro constant. MS0.4 - Carry out calculations using the Avogadro constant. MS1.1 - Report calculations to an appropriate number of significant figures, given raw data quoted to varying numbers of significant figures. MS0.0 - Recognise and make use of appropriate units in ideal gas calculations MS2.2 - Change the subject of the ideal gas equation MS2.3 - Substitute numerical values into the ideal gas equation using appropriate units for physical quantities AO2 - Apply knowledge and understanding to determine the relative formula mass (Mr) of substances using relative atomic mass values AO2 - Apply knowledge and understanding to calculate the mass (in g) of atoms/ions using the masses sub atomic particles, quoting answers to a suitable number of significant figures for data provided AO2 - Apply knowledge and understanding to measure out 1 mole (and other mole quantities) of different substances AO2 - Apply knowledge and understanding to undertake calculations involving Avogadro constant, involving mass, Mr and moles, and involving concentration, volume and amount of	AO1 - Demonstrate knowledge and understanding of scientific ideas; AO2 - Demonstrate knowledge and understanding; MS3.2 – Plot data on graphs for atomic radius, first ionisation energy and melting point and explain those trends AO2 - Demonstrate knowledge and understanding; AT k - Safely and carefully handle solids and liquids, including corrosive, irritant, flammable and toxic substances - test for sulfate ions using acidified barium chloride and record results AO2 - Demonstrate knowledge and understanding; AT d - Use laboratory apparatus for qualitative tests for ions; AT k - Safely and carefully handle solids and liquids, including corrosive, irritant, flammable and toxic substances - identify “unknown” group 2 compounds by their reactions with NaOH and sulfate ions AO3 - Analyse, interpret and evaluate scientific information - research uses of the following: Mg(OH)2 and BaSO4 in medicine; BaSO4 in testing for sulfate ions; Ca(OH)2 in agriculture; Mg in the extraction of Ti; CaO/CaCO3 in removing SO2 from flue gases	AO1 - Demonstrate knowledge and understanding to explain why reactions do or do not take place using collision theory. AO2 - Demonstrate knowledge and understanding; MS3.1 - Translate information between graphical, numerical and algebraic forms to draw and Maxwell–Boltzmann curves at different temperatures, pressures and number of particles, identifying the most probable energy and particles with E ≥ Ea. AO2 - Demonstrate knowledge and understanding to use Maxwell–Boltzmann curves to explain why a small increase in temperature leads to a large increase in reaction rate. AO2 - Demonstrate knowledge and understanding; PS 2.4 - Identify variables including those that must be controlled; PS 3.1 - Plot and interpret graphs; MS3.2 – Plot two variables from experimental data; AT l - Measure rates of reaction to investigate the effect of temperature on the rate of reaction. AO2 - Demonstrate knowledge and understanding to use collision theory, including diagrams, to explain why an increase in solution concentration leads to an increase in reaction rate. AO2 - Demonstrate knowledge and understanding to use collision theory, including	AO2 - Apply knowledge and understanding - Describe how changes in concentration will affect reaction rates given the rate equation. AO2 - Apply knowledge and understanding; MS0.0 - Recognise and make use of appropriate units in calculation; MS2.3 – substitute numerical values into algebraic equations; MS2.4 - Solve algebraic equations - Use rate equations to determine reaction rates or rate constants (with units) using initial rate data AO2 - Apply knowledge and understanding; MS3.3 - Determine the slope of a linear graph; MS3.4 - Calculate rate of change from a graph showing a linear relationship -use a graph of concentration–time and calculate the rate constant of a zero-order reaction by determination of the gradient. AO2 - Apply knowledge and understanding; MS0.0 - Recognise and make use of appropriate units in calculation; MS2.3 – substitute numerical values into algebraic equations; MS2.4 - Solve algebraic equations - Determine rate equations, rate constants (with units) using initial rate data AO2 - Apply knowledge and understanding; PS 2.4 - Identify variables including those that must be controlled; PS 3.1 - Plot and interpret graphs; PS 3.2 - Process and analyse data using appropriate mathematical	AO2 - Apply knowledge and understanding - Identify which species acts as the acid and which as the base in Brønsted-Lowry acid-base reactions AO2 - Apply knowledge and understanding - Identify acids as being strong or weak and monoprotic or diprotic. AO2 - Apply knowledge and understanding; MS0.4 - Use calculators to find and use power, exponential and logarithmic functions; MS2.5 - Use logarithms in relation to quantities that range over several orders of magnitude - Calculate the pH of strong acids from the acid concentration, including examples where the acids are diluted. AO2 - Apply knowledge and understanding; MS0.4 - Use calculators to find and use power, exponential and logarithmic functions; MS2.5 - Use logarithms in relation to quantities that range over several orders of magnitude - Calculate the concentration of strong acids from the pH. AO1 - Demonstrate knowledge and understanding - Derive the expression Kw = [H+][OH–] AO2 - Apply knowledge and understanding; MS0.4 - Use calculators to find and use power, exponential and logarithmic functions; MS2.5 - Use logarithms in relation to quantities that range over several	AO1 - Demonstrate knowledge and understanding - State the electron structure of first row transition metals and their ions. AO1 - Demonstrate knowledge and understanding - Explain why the elements Ti–Cu have properties characteristic of transition metals, and what those characteristics are AO2 - Apply knowledge and understanding - Identify the oxidation state of the metal, the ligands and co-ordination number in a series of complexes. AO3 - Analyse, interpret and evaluate scientific information, ideas and evidence - identify an element from the series Ti–Cu and find examples for that element to confirm its characteristic properties. AO1 - Demonstrate knowledge and understanding - Give examples of monodentate, bidentate and multidentate ligands.

			substance and quoting the final results to the appropriate number of significant figures for data provided AO2 - Apply knowledge and understanding to rearrange the ideal gas equation, work in appropriate units and quote answers to an appropriate number of significant figures AO2 - Apply knowledge and understanding; PS 3.2 – process & analyse data using appropriate mathematical skills to find the empirical formula of a metal oxide AO2 - Apply knowledge and understanding; MS0.2 - Use ratios, fractions and percentages to find empirical formulae (and molecular formulae where relevant) from data AO2 - Apply knowledge and understanding to balance equations, including ones where formulae are given and some where they are not AO2 - Apply knowledge and understanding to write ionic equations from given equations AO2 - Apply knowledge and understanding; MS1.1 - Use an appropriate number of significant figures; MS2.3 - Substitute numerical values into algebraic equations using appropriate units for physical quantities to find masses, percentage yields, atom economies, volumes of gases, concentrations & volumes AO2 - Apply knowledge and understanding; PS 3.2 - Process and analyse data to find the Mr of a hydrated salt by heating		diagrams, to explain why an increase in gas pressure leads to an increase in reaction rate. AO2 - Demonstrate knowledge and understanding to use a Maxwell–Boltzmann curve to explain how a catalyst increases the rate of a reaction AO3 - Analyse, interpret and evaluate scientific information to research the use of catalysts in catalytic converters in cars	skills; MS3.1 - Translate information between graphical, numerical and algebraic forms; MS3.2 - Plot two variables from experimental or other data; MS3.3 - Determine the slope and intercept of a linear graph AT a, k, l – carry out the iodine clock reaction and determine the order of reaction for a reactant AO2 - Apply knowledge and understanding; PS 2.4 - Identify variables including those that must be controlled; PS 3.1 - Plot and interpret graphs; PS 3.2 - Process and analyse data using appropriate mathematical skills; MS3.1 - Translate information between graphical, numerical and algebraic forms; MS3.2 - Plot two variables from experimental or other data; MS3.3 - Determine the slope and intercept of a linear graph; MS3.4 - Calculate rate of change from a graph showing a linear relationship; MS3.5 - Draw and use the slope of a tangent to a curve as a measure of rate of change; AT a, k, l - Carry out a reaction between an acid and a carbonate with acid of different concentrations and plot volume of gas formed against time for continuous monitoring. AO2 - Apply knowledge and understanding; MS3.1 - Translate information between graphical, numerical and algebraic forms; MS3.2 - Plot two variables from experimental or other data; MS3.3 - Determine the slope and intercept of a linear graph; MS3.4 - Calculate rate of change from a graph	orders of magnitude - Calculate the pH of strong bases from the base concentration and vice versa, including dilutions. AO2 - Apply knowledge and understanding; MS0.4 - Use calculators to find and use power, exponential and logarithmic functions; MS2.5 - Use logarithms in relation to quantities that range over several orders of magnitude - Calculate the pH of water at different temperatures. AO2 - Apply knowledge and understanding - Explain how the pH and neutrality of water is or is not affected by changes in temperature. AO1 - Demonstrate knowledge and understanding - Explain the difference between strong and weak acids and bases. AO1 - Demonstrate knowledge and understanding - Derive expressions for Ka for stated acids. AO2 - Apply knowledge and understanding; MS0.4 - Use calculators to find and use power, exponential and logarithmic functions; MS2.5 - Use logarithms in relation to quantities that range over several orders of magnitude - Perform calculations linking Ka to concentration and pH AO2 - Apply knowledge and understanding; MS0.4 - Use calculators to find and use power, exponential and logarithmic functions; MS2.5 - Use logarithms in relation to quantities that range over several orders of magnitude -	

			to constant mass AO2 - Apply knowledge and understanding; PS 3.2 - Process and analyse data; PS 3.3 - Consider margins of error, accuracy and precision of data; AT d - Use laboratory apparatus for a variety of experimental techniques including titration, using burette and pipette; AT f - Use acid–base indicators in titrations of weak/strong acids with weak/strong alkalis) to make up a volumetric solution and carry out a simple acid–base titration AO2 - Apply knowledge and understanding; PS 3.2 - Process and analyse data using appropriate mathematical skills; PS 3.3 - Consider margins of error, accuracy and precision of data; AT d - Use laboratory apparatus for a variety of experimental techniques including titration, using burette and pipette ; AT f - Use acid–base indicators in titrations of weak/strong acids with weak/strong alkalis.			showing a linear relationship; MS3.5 - Draw and use the slope of a tangent to a curve as a measure of rate of change - derive order(s) from appropriate graphs MS3.3 - Determine the slope and intercept of a linear graph; MS3.4 - Calculate rate of change from a graph showing a linear relationship - calculate the rate constant of a zero-order reaction by determining the gradient of a concentration–time graph. MS3.5 - Draw and use the slope of a tangent to a curve as a measure of rate of change - lot concentration–time graphs from collected or supplied data and draw an appropriate best-fit curve. Draw tangents to such curves to deduce rates at different times	Convert Ka values to pKa and vice versa, and use these values to rank acids in order of strength. AO2 - Apply knowledge and understanding; AT c - Measure pH using pH charts, or pH meter, or pH probe on a data logger; PS 4.1 - Know and understand how to use a wide range of experimental and practical instruments, equipment and techniques; AT d - Measure Ka of a weak acid by measuring pH at half neutralisation. AO2 - Apply knowledge and understanding; MS0.4 - Use calculators to find and use power, exponential and logarithmic functions; MS2.5 - Use logarithms in relation to quantities that range over several orders of magnitude - Perform calculations to find the pH of mixtures of strong/weak acids with strong bases, with either excess acid or base. AO2 - Apply knowledge and understanding; AT c - Measure pH using pH charts, or pH meter, or pH probe on a data logger; AT d, k, a - Produce pH curves by experiment. AO2 - Apply knowledge and understanding - Sketch pH curves for given acid and base combinations, and choose a suitable indicator.	
			Year 12 Term 1 - Bonding	Year 12 - Term 2 - Group 7 - The Halogens	Year 12 - Term 3 - Organic Analysis	Year 13 Term 1 - Equilibrium constant Kp	Year 13 Term 2 - Buffers	Year 13 - Term 3 - Transition Metals - Shapes

			AO1 - Demonstrate knowledge and understanding of scientific ideas to describe differences between ionic and covalent bonding AO1 - Demonstrate knowledge and understanding of scientific ideas to describe similarities and differences between covalent and co-ordinate bonds AO2 - Apply knowledge and understanding to explain the properties of ionic compounds AO2 - Apply knowledge and understanding to write the formula of ionic compounds, including those with common compound ions AO2 - Apply knowledge and understanding to draw diagrams of molecules showing covalent and co-ordinate bonds as lines/arrows respectively (“stick” diagrams) AO2 - Apply knowledge and understanding to explain the properties of molecular substances AO2 - Apply knowledge and understanding to describe differences between metallic, ionic and covalent bonding AO2 - Apply knowledge and understanding to explain the properties of metals AO2 - Apply knowledge and understanding to sketch the structures of diamond, graphite, ice, iodine, magnesium and sodium chloride as solids and label the diagrams to explain their melting/boiling points and conductivity. AO2 - Apply knowledge and understanding to determine which type of	AO1 - Demonstrate knowledge and understanding of scientific ideas; AO2 - Demonstrate knowledge and understanding; MS3.2 – Plot two variables from experimental or other data - plot data on graphs for electronegativity and boiling point and explain those trends AO2 - Demonstrate knowledge and understanding; AT d - Use laboratory apparatus for qualitative tests for ions; AT k - Safely and carefully handle solids and liquids, including corrosive, irritant, flammable and toxic substances; PS 2.2 - Present results of test-tube reactions in appropriate ways - carry out tests for halide ions using acidified silver nitrate, including the use of ammonia to distinguish the silver halides formed. AO2 - Demonstrate knowledge and understanding; AT d - Use laboratory apparatus for qualitative tests for ions; AT k - Safely and carefully handle solids and liquids, including corrosive, irritant, flammable and toxic substances; PS 2.2 - Present results of test-tube reactions in appropriate ways - complete a series of test-tube reactions to identify some anions and cations AO3 - Analyse, interpret and evaluate scientific information - investigate and evaluate the treatment of drinking water with chlorine.	AO2 - Apply knowledge and understanding of scientific ideas; AT b - Use water bath or electric heater or sand bath for heating; AT d - Use laboratory apparatus for qualitative tests for organic functional groups; AT k - Safely and carefully handle solids and liquids, including corrosive, irritant, flammable and toxic substances; PS 2.2 - Present results of reactions in appropriate ways; PS 2.3 - Evaluate results and draw conclusions - carry out test-tube reactions in the specification to distinguish alcohols, aldehydes, alkenes and carboxylic acids. AO2 - Apply knowledge and understanding of scientific ideas - Write equations for the reactions occurring. AO2 - Apply knowledge and understanding of scientific ideas; MS1.1 - Use an appropriate number of significant figures - use precise atomic masses to calculate the precise molecular mass of a compound in order to determine the molecular formula. AO2 - Apply knowledge and understanding of scientific ideas - identify functional groups from infra-red spectra. AO3 - Analyse, interpret and evaluate scientific information - research the relative effect of different gases on global warming.	AO2 - Apply knowledge and understanding - Given initial amounts of substances and one substance at equilibrium, find the quantity of each reagent at equilibrium AO2 - Apply knowledge and understanding; MS2.3 - Substitute numerical values into algebraic equations using appropriate units for physical quantities - Calculate mole fractions and then partial pressures in order to determine Kp, with units. AO2 - Apply knowledge and understanding - For given equilibria with enthalpy change data, predict the effect on the position of an equilibrium and the value of Kp	AO2 - Apply knowledge and understanding - Describe how buffer solutions are made, how they work and what they are used for. AO2 - Apply knowledge and understanding; MS0.4 - Use calculators to find and use power, exponential and logarithmic functions; MS2.5 - Use logarithms in relation to quantities that range over several orders of magnitude - Calculate the pH of a buffer solution given details about quantities of the reagents it is made from, and changes in pH when small amounts of acid/alkali are added to buffer solutions. AO2 - Apply knowledge and understanding; MS0.4 - Use calculators to find and use power, exponential and logarithmic functions; MS2.5 - Use logarithms in relation to quantities that range over several orders of magnitude; AT c - Measure pH using pH charts, or pH meter, or pH probe on a data logger; AT e - Use volumetric flask, including accurate technique for making up a standard solution; PS 1.1 - Solve problems set in practical contexts; PS 4.1 - Know and understand how to use a wide range of experimental and practical instruments, equipment and techniques - prepare a solution of a specific pH and then test the solution to check its pH and buffer action.	AO1 - Demonstrate knowledge and understanding; MS4.1 - Use angles and shapes in regular 2D and 3D structures; MS4.2 - Visualise and represent 2D and 3D forms including two-dimensional representations of 3D objects; MS4.3 - Understand the symmetry of 2D and 3D shape - Give examples of and sketch the shape of octahedral, tetrahedral, square planar and linear complexes. AO2 - Apply knowledge and understanding - Explain how cis–trans (E–Z) isomerism arises in some octahedral and square planar complexes, including cisplatin, and draw the isomers. AO2 - Apply knowledge and understanding - Explain how optical isomerism arises in some octahedral complexes with bidentate ligands, and draw the isomers.

			structure a substance has from its properties using data and/or experimentally AO2 - Apply knowledge and understanding; MS4.1 - Use angles and shapes in regular 2D and 3D structures; MS4.2 - Visualise and represent 2D and 3D forms including two-dimensional representations of 3D objects; MS4.3 - Understand the symmetry of 2D and 3D shapes to deduce, sketch and name the shapes of given molecules and ions, including bond angles. AO2 - Apply knowledge and understanding to predict and explain the trend in electronegativity down a group and across a period. AO2 - Apply knowledge and understanding to predict whether covalent bonds are polar or not. AO2 - Apply knowledge and understanding; ; MS4.3 - Understand the symmetry of 2D and 3D shapes to predict whether molecules have permanent dipoles or not. AO2 - Apply knowledge and understanding to explain why ice floats on water by reference to hydrogen bonding					
			Year 12 Term 1 - Redox	Year 12 Term 2 - Energetics		Year 13 - Term 1 - Optical isomerism	Year 13 - Term 2 - Amines	Year 13 - Term 3 - Transition Metals - Colour

			AO2 - Demonstrate knowledge and understanding to determine the oxidation state of each element in substances and ions. AO2 - Demonstrate knowledge and understanding to determine and then combine redox half equations	AO2 - Apply knowledge and understanding to list examples of endothermic and exothermic reactions . AO2 - Apply knowledge and understanding to draw enthalpy profiles for exothermic and endothermic reactions. AO2 - Apply knowledge and understanding to write balanced chemical equations, to include state symbols, to represent the changes shown by standard enthalpy changes of formation and combustion AO2 - Apply knowledge and understanding; MS0.0 - Recognise and make use of appropriate units in calculation ; MS1.1 - Use an appropriate number of significant figures; MS2.3 - Substitute numerical values into algebraic equations using appropriate units for physical quantities to calculate molar enthalpy changes using provided data from calorimetry experiments. AO2 - Apply knowledge and understanding; MS1.3 - Identify uncertainties in measurements and use simple techniques to determine uncertainty when data are combined; MS3.2 – Plot two variables from experimental data; PS 3.1 - Plot and interpret graphs; PS 3.2 - Process and analyse data using appropriate mathematical skills; PS 3.3 - Consider margins of error, accuracy and precision of data to determine enthalpy of combustion of alcohols AO2 - Apply knowledge		AO2 - Apply knowledge and understanding; MS4.2 - Visualise and represent 2D and 3D forms including two-dimensional representations of 3D objects; MS4.3 - Understand the symmetry of 2D and 3D shapes - make models of mirror image molecules of some chiral and non-chiral molecules to see if they are non-superimposable or not. AO2 - Apply knowledge and understanding; MS4.2 - Visualise and represent 2D and 3D forms including two-dimensional representations of 3D objects; MS4.3 - Understand the symmetry of 2D and 3D shapes - Identify whether molecules exhibit optical isomerism, and where they do draw the two enantiomers in 3D.	AO2 - Apply knowledge and understanding - Identify reagents and conditions and write equations to make specified primary aliphatic amines from halogenoalkanes and nitriles. AO2 - Apply knowledge and understanding - Identify reagents and conditions and write equations to make specified aromatic amines. AO2 - Apply knowledge and understanding - Given pairs of amines, identify the stronger base giving reasons for their choice. AO2 - Apply knowledge and understanding - Identify the amines and quaternary ammonium salts that can be formed when ammonia and amines react with halogenoalkanes and how changing conditions can affect the main product; outline the mechanism to form these products. AO2 - Apply knowledge and understanding - write equations and mechanisms for acylation reactions of water, alcohols, ammonia and amines with acyl chlorides and acid anhydrides; some of these reactions could be demonstrated	AO1 - Demonstrate knowledge and understanding - Explain using diagrams and the equation ΔE = hv (= hc/λ) why transition metal complexes are coloured and what factors affect the colour AO2 - Apply knowledge and understanding; AT a - Use appropriate apparatus to record a range of measurements; AT d - Use laboratory apparatus for a variety of experimental techniques; PS 3.1 - Plot and interpret graphs; MS3.2 - Plot two variables from experimental or other data - Use a colorimeter to produce a calibration curve and then find the concentration of a coloured solution, e.g. containing copper(II) ions.

				and understanding; AT a - Use appropriate apparatus to record a range of measurements (to include mass, time, volume of solutions, temperature); MS1.3 - Identify uncertainties in measurements and use simple techniques to determine uncertainty when data are combined; MS3.2 – Plot two variables from experimental data; PS 3.1 - Plot and interpret graphs; PS 3.2 - Process and analyse data using appropriate mathematical skills; PS 3.3 - Consider margins of error, accuracy and precision of data to find ΔH for a reaction using Hess's law and calorimetry. AO2 - Apply knowledge and understanding of Hess's Law to calculate ΔH for reactions using enthalpies of formation, enthalpies of combustion and mean bond enthalpies.				
			Year 12 - Term 1 - Introduction to Organic Chemistry	Year 12 - Term 2 - Alkenes		Year 13 - Term 1 - Aldehydes and ketones	Year 13 - Term 2 - Polymers	Year 13 - Term 3 - Transition Metals - Variable Oxidation States and Catalysis

			AO2 - Demonstrate knowledge and understanding; MS 4.2 – visualise and represent 2D and 3D forms including 2D representations of 3D objects - Give the empirical, molecular, general, structural, displayed and skeletal structure of organic molecules given one or more of these for each molecule. AO2 - Demonstrate knowledge and understanding; MS 4.2 – visualise and represent 2D and 3D forms including 2D representations of 3D objects - Make models of organic compounds. AO2 - Demonstrate knowledge and understanding - name molecules given their structure, or draw the structure given the name AO2 - Demonstrate knowledge and understanding; MS 4.2 – visualise and represent 2D and 3D forms including 2D representations of 3D objects - Make models of isomers. AO2 - Demonstrate knowledge and understanding; MS 4.2 – visualise and represent 2D and 3D forms including 2D representations of 3D objects - Draw and name isomers, including using CIP rules to name E–Z¬ isomers. AO2 - Demonstrate knowledge and understanding- Identify pairs (or groups) of compounds which exhibit each type of isomerism	AO2 - Demonstrate knowledge and understanding; MS4.1 - Use angles and shapes in regular 2D and 3D structures of alkenes - Draw and name alkenes, including E–Z isomers. AO2 - Apply knowledge and understanding of scientific ideas - Write equations for reactions of alkenes with HBr, H_2SO_4 and HBr AO2 - Apply knowledge and understanding of scientific ideas - Draw mechanisms for reactions of alkenes with HBr, H_2SO_4 and HBr, including explaining why there may be major and minor products AO2 - Apply knowledge and understanding of scientific ideas; AT k - Safely and carefully handle solids and liquids, including corrosive, irritant, flammable and toxic substances - test organic compounds for unsaturation using bromine water and record their observations AO2 - Apply knowledge and understanding of scientific ideas - Draw the structure of the monomer, repeating unit of the polymer and a section of the polymer chain given one of the others; AO3 -Analyse, interpret and evaluate scientific information - research uses of PVC and how plasticisers change its properties		AO2 - Apply knowledge and understanding - write equations for the oxidation of aldehydes (using reagents acidified potassium dichromate(VI) / Tollen's reagent / Fehling's solution) AO2 - Apply knowledge and understanding; AT b - Use water bath for heating; AT d - Use laboratory apparatus for a variety of experimental techniques including qualitative tests organic functional groups; AT k - carry out test-tube reactions of Tollens' reagent and Fehling's solution to distinguish aldehydes and ketones. AO2 - Apply knowledge and understanding - write equations and mechanisms for the reduction of aldehydes and ketones using $NaBH_4$ AO2 - Apply knowledge and understanding - write equations and mechanisms for the reaction of aldehydes and ketones with KCN followed by acid	AO2 - Apply knowledge and understanding - draw the structure of repeating units in polyesters and polyamides given the monomer(s) and vice versa. AO1 - Demonstrate knowledge and understanding of scientific ideas - compare and explain the biodegradability of different types of polymers AO3 - Analyse, interpret and evaluate scientific information - research and summarise different methods of disposing of polymers, including recycling, considering advantages, disadvantages and sustainability	AO1 - Demonstrate knowledge and understanding; AT k - Safely and carefully handle solids and liquids, including corrosive, irritant, flammable and toxic substances; AT d - Test aldehydes and ketones with Tollens reagent. AO2 - Apply knowledge and understanding; AT d - Use laboratory apparatus for a variety of experimental techniques including titration, using burette and pipette; AT e - Use volumetric flask, including accurate technique for making up a standard solution; AT k; PS 2.3 - Evaluate results and draw conclusions with reference to measurement uncertainties and errors; MS2.3 – substitute numerical values into algebraic equations - Carry out redox titrations, including associated titrations, of Fe^{2+} with $MnO_4^–$ in acidic solution (e.g. analysis of iron in iron tablets, analysis of iron in lawn sand, analysis of iron in steel, finding the Mr of hydrated ammonium (II) sulfate) and carry out redox titrations, including associated titrations, of $C_2O_4^{2–}$ with $MnO_4^–$ in acidic solution AO2 - Apply knowledge and understanding - investigate Mn^{2+} as the autocatalyst in the reaction between ethanedioic acid and acidified potassium manganate(VII)
			Year 12 - Term 1 - Alkanes	Year 12 - Term 2 - Alcohols		Year 13 - Term 1 - Carboxylic acids and derivatives	Year 13 - Term 2 - Amino Acids and Proteins	Year 13 - Term 3 - Reactions of ions in aqueous solution

			AO2 - Demonstrate knowledge and understanding; MS 4.2 – visualise and represent 2D and 3D forms including 2D representations of 3D objects - Draw and name alkanes AO1 - Demonstrate knowledge and understanding of scientific ideas - Describe and explain how alkanes in crude oil are separated by fractional distillation AO2 - Demonstrate knowledge and understanding; AT k - Safely and carefully handle solids and liquids, including corrosive, irritant, flammable and toxic substances).- Practical opportunity: Crack some paraffin AO1 - Demonstrate knowledge and understanding of scientific ideas - Construct a table to compare thermal and catalytic cracking in terms of conditions and products AO2 - Demonstrate knowledge and understanding - write balanced equations for the complete and incomplete combustion of alkanes. AO1 - Demonstrate knowledge and understanding of scientific ideas; AO3 - Analyse, interpret and evaluate scientific information - Construct a table to show why pollutants may be formed when fuels are burned and how these can be reduced AO2 - Demonstrate knowledge and understanding - Write balanced equations for reactions of alkanes with	AO2 - Apply knowledge and understanding of scientific ideas - Write equations for the production of alcohols from alkenes. AO1 - Demonstrate knowledge and understanding of scientific ideas - produce a summary table to compare and contrast the two methods of making ethanol. AO1 - Demonstrate knowledge and understanding of scientific ideas - Outline the mechanism to make ethanol from reaction of ethene with steam with an acid catalyst AO3 - Analyse, interpret and evaluate scientific information - Evaluate the use of biofuels. AO1 - Demonstrate knowledge and understanding of scientific ideas - Show by use of chemical equation that the formation of ethanol by fermentation can be thought of as being carbon neutral, but why it is not in reality. AO2 - Apply knowledge and understanding of scientific ideas - Draw and name alcohols and classify them as primary, secondary or tertiary AO2 - Apply knowledge and understanding of scientific ideas - Write equations to show oxidation reactions of alcohols AO2 - Apply knowledge and understanding of scientific ideas; AT b - Use water bath or electric heater or sand bath for heating; AT d - Use laboratory apparatus for qualitative tests for organic functional groups; AT k - Safely and carefully handle solids		AO2 - Apply knowledge and understanding - draw and name carboxylic acids and esters. AO2 - Apply knowledge and understanding; AT g - Purify a liquid product, including use of separating funnel; AT k - Safely and carefully handle solids and liquids, including corrosive, irritant, flammable and toxic substances; AT d - write equations for, and make esters by reactions of alcohols with carboxylic acids in test tubes; or an ester could be collected and purified using a separating funnel and distillation. AO2 - Apply knowledge and understanding - research uses of esters AO2 - Apply knowledge and understanding - write equations for the hydrolysis of given esters in acidic and alkaline conditions. AO2 - Apply knowledge and understanding; AT k - Safely and carefully handle solids and liquids, including corrosive, irritant, flammable and toxic substances; AT d - make biodiesel. AO2 - Apply knowledge and understanding - write equations for production of soap and/or biodiesel from specified fats/oils	AO2 - Apply knowledge and understanding - Given the structure of the amino acid, draw the structure of the species formed in acidic solution, alkaline solution and as a zwitterion AO2 - Apply knowledge and understanding - Draw the structure of peptides formed from joining amino acids together. AO2 - Apply knowledge and understanding - Identify amino acids formed when peptides are hydrolysed AO2 - Apply knowledge and understanding - Identify the primary, secondary and tertiary parts of the structure of some proteins. AO2 - Apply knowledge and understanding; AT i - Use thin-layer or paper chromatography- carry out some thin-layer chromatography of some amino acids to identify an unknown amino acid. AO2 - Apply knowledge and understanding - model enzyme action	AO2 - Apply knowledge and understanding; AT d,k - identify unknown substances (containing cations and anions on the specification) using reagents.

			halogens. AO2 - Demonstrate knowledge and understanding - Write balanced equations to show the steps in the mechanism for these reactions	and liquids, including corrosive, irritant, flammable and toxic substances - Carry out test-tube reactions to distinguish tertiary alcohols from primary and secondary by reaction with acidified potassium dichromate(VI). AO2 - Apply knowledge and understanding of scientific ideas; AT b - Use water bath or electric heater or sand bath for heating; AT d - Use laboratory apparatus for qualitative tests for organic functional groups; AT k - Safely and carefully handle solids and liquids, including corrosive, irritant, flammable and toxic substances - Carry out test-tube reactions to distinguish aldehydes from ketones by reaction with Tollens' reagent and Fehling's solution. AO2 - Apply knowledge and understanding of scientific ideas - Identify alkenes formed from elimination of alcohols and write equations and mechanism for their production. AO2 - Apply knowledge and understanding of scientific ideas; AT b - Use water bath or electric heater or sand bath for heating; AT d - Use laboratory apparatus for a variety of experimental techniques including distillation and heating under reflux, including setting up glassware using retort stand and clamps; AT g - Purify a liquid product, including use of separating funnel; AT k - Safely and carefully handle solids and liquids, including corrosive,				

				irritant, flammable and toxic substances - carry out the preparation of cyclohexene from cyclohexanol, including purification using a separating funnel and by distillation.				
			Year 12 - Term 1 - Halogenoalkanes			Year 13 - Term 1 - Acylation	Year 13 - Term 2 - DNA	Year 13 - Term 3 - Organic Sythesis

			AO2 - Demonstrate knowledge and understanding - Draw and name halogenoalkanes. AO2 - Demonstrate knowledge and understanding - Write equations and mechanisms for reactions of halogenoalkanes with OH- , CN– and NH3 AO2 - Demonstrate knowledge and understanding - write equations and mechanisms for reactions of halogenoalkanes with OH–, both for elimination and substitution reactions. AO1 - Demonstrate knowledge and understanding of scientific ideas - investigate the presence and role of ozone in the atmosphere. AO1 - Demonstrate knowledge and understanding of scientific ideas - write equations and mechanisms for the formation of chlorine free radicals and the destruction of ozone AO1 - Demonstrate knowledge and understanding of scientific ideas - understand why suitable replacements for CFCs do not destroy ozone AO3 - Analyse, interpret and evaluate scientific information - investigate the role of chemists in the introduction of legislation to ban the use of CFCs and in finding replacements			AO2 - Apply knowledge and understanding; AT d - Use laboratory apparatus for a variety of experimental techniques including distillation and heating under reflux, including setting up glassware using retort stand and clamps; AT d - Use laboratory apparatus for a variety of experimental techniques including filtration, including use of fluted filter paper, or filtration under reduced pressure; AT k - AO2 - Apply knowledge and understanding - draw and name acid anhydrides, acyl chlorides and amides - prepare, purify and test the purity of aspirin by melting point determination	AO2 - Apply knowledge and understanding - model DNA	AO2 - Apply knowledge and understanding - Devise synthetic routes, including reaction conditions, to make organic compounds using reactions in the specification. A03 - Analyse, interpret and evaluate scientific information - Describe features of processes that improve sustainability.
						Year 13 - Term 1 - Aromatic chemistry	Year 13 - Term 2 - Action of anticancer drugs	Year 13 - Term 3 - NMR

						AO2 - Apply knowledge and understanding - Draw enthalpy diagrams to show the relative stability of cyclohexane, cyclohexene, cyclohexa-1,4-diene, benzene and the theoretical cyclohexa-1,3,5-triene. AO2 - Apply knowledge and understanding - Write equations (including for the formation of electrophiles) and mechanisms for nitration and Friedel-Crafts acylation reactions given the starting material and products	AO3 - Analyse, interpret and evaluate scientific information- Evaluate the benefits and adverse effects of using drugs such as cisplatin	AO2 - Apply knowledge and understanding - Predict the number, position, relative intensity and splitting of signals in the 1H NMR spectrum of compounds. AO2 - Apply knowledge and understanding - Predict the number and position of signals in the 13C NMR spectrum of compounds AO2 - Apply knowledge and understanding; MS3.1 Translate information between graphical, numerical and algebraic forms - Use data from NMR, and other analytical methods on the specification, to deduce the structure of compounds
								Year 13 - Term 3 - Chromatography
								AO2 - Apply knowledge and understanding; AT i - Use thin-layer or paper chromatography - Separate mixtures and identify substances (e.g. amino acids) by thin-layer chromatography.