Curriculum Map: KS5 CHEMISTRY Years 12 and 13

Year 12 **Autumn Term**	**Module 1: Practical Skills in Chemistry** **Module 2: Foundations in Chemistry**
Spring Term	**Module 3 part 1: Development of the Periodic Table, its contents and how to use it to make predictions.** **Module 4 part 1: Basic Organic Chemistry concepts and Hydrocarbons;** **Module 3 part 2: Energy changes and Rates of reactions, how to measure and influence them** **Module 4 part 2: Alcohols, Haloalkanes and Analysis**
Summer Term	**Topic revision, preparation for exams** **Introduction to Modules 5 and 6**
Year 13 **Autumn Term**	**Module 5 part 1: Rates, Equilibrium and pH** **Module 6 part 1: Aromatic compounds, Carbonyls, Acids and Acid derivatives.**
Spring Term	**Module 5 part 2: Energy;** **part 3: Transition metals and Qualitative analysis of ions** **Module 6 part 2: Nitrogen compounds, Polymers and Synthesis;** **part 3: Analysis**
Summer Term	**Revision, exam focused study**
Throughout	**Practical Skills**

Curriculum Map: CHEMISTRY Year 12 Module 1 and PAGs: Practical Skills in Chemistry

	Autumn 1 (Module 1) Throughout both years (PAGs)
Content Declarative knowledge **'I know'**	**Module 1 and PAGs** **Outline of the practical skills that will be assessed in a written examination.** **The skill acquisition and assessment is supported by Practical Assessment Group (PAG) practicals, which are assessed in a supportive, formative way throughout the course to ensure that all students who wish to are able to achieve the practical endorsement for the qualification.** **I know:** The appropriate apparatus needed to record a range of measurements (eg mass, time, volume of liquids and gases, temperature)
Skills Procedural Knowledge **'I know how to'**	**I know how to:** Apply investigative approaches and methods to practical work Safely and correctly use a range of materials including corrosive, irritant, flammable and toxic substances Follow written practical instructions Make and record observations/measurements Keep appropriate records of experimental activities Present data in a scientific way Use appropriate software / devices to process data, carry out research and report findings Use online and offline research sources including websites, textbooks and other printed scientific sources of information Safely set up and use apparatus for measuring variables (including pH), for heating liquids (including flammable liquids), for titration, for distillation and refluxing, for filtration (including under reduced pressure) Use a volumetric flask and make up a standard solution Use acid-base indicators in titrations Purify a solid by recrystallisation Purify a liquid, including using a separating funnel Use melting point apparatus Use thin layer or paper chromatography Set up electrochemical cells and measure voltages Measure rates of reaction by initial rate method (eg clock reaction) and by a continuous monitoring method Plan a valid investigative experiment Evaluate results and draw conclusions Assess the validity of a set of data, given the variables controlled
Strategies Conditional Knowledge '**I know when to'**	**I know when to:** Cite sources of information in support of factual data presented
Key Questions	How can this correlation be investigated practically to obtain data and determine whether there is a causal link? How can a chemical be synthesised and purified? How can its purity be determined?

Assessment topics	Tested in every written assessment Assessed for individual key skills acquired in PAG practicals
Cross curricular links/Character Education	Citizenship: Critical assessment of media information: the scientific method

Curriculum Map: CHEMISTRY Year 12 Module 2: Foundations in Chemistry

	Autumn 1	Autumn 2
Content Declarative knowledge **'I know'**	**Module 2:** **A bridge from GCSE to A level, covering the basic chemical concepts and developing maths skills and practical techniques skills** **I know:** The definitions of the following terms, with their units where appropriate: relative atomic mass, isotopes, relative isotopic mass, amount of substance, mole (symbol 'mol', in terms of carbon-12 or in terms of 6.02 x 10^{23} elementary entities), Avogadro constant (N_A), molar mass, molar gas volume The different models for atomic structure and how these have changed over time The names and formulae for nitrate, carbonate, sulfate, hydroxide, ammonium, zinc and silver ions (NO_3^- CO_3^{2-} SO_4^{2-} OH^- NH_4^+ Zn^{2+} Ag^+) The formulae of common acids (HCl H_2SO_4 HNO_3 CH_3COOH) and common alkalis (NaOH KOH NH_3) That in aqueous solution, acids release H^+ ions and alkalis release OH^- ions That neutralisation is the reaction of (i) H^+ and OH^- to form H_2O (ii) acids and bases (incl carbonates, metal oxides and alkalis) to form salts The ideal gas equation: pV=nRT (and the SI units used) The techniques and procedures needed during experiments, involving the measurement of mass, volumes of solutions and gas volumes The rules for assigning and calculating oxidation number for species in elements, compounds and ions That the oxidation number for O in peroxides and H in metal hydrides is -1 That oxidation is loss of electron(s) and reduction is gain of electron(s) The number of electrons that fill the first four shells The definitions of the following terms: atomic orbital, ionic bonding, covalent bonding, electronegativity, hydrogen bonding The shapes of s- and p-orbitals, the number of orbitals in s-, p- and d- sub-shells and the number of electrons that fill the s-, p- and d- sub shells That the 'average bond enthalpy' is a measure of covalent bond strength The shapes of, and bond angles in, molecules and ions with up to 6 electron pairs around central atom and that lone pairs repel more than bonded pairs The shapes: linear, non-linear, trigonal planar, pyramidal, tetrahedral, octahedral That permanent dipole- dipole interactions and induced dipole – dipole interactions and both referred to as Van der Waals' forces That induced dipole-dipole interactions can be referred to as London (dispersion) forces That hydrogen bonding is intermolecular bonding between molecules containing N, O or F and the H atom of -NH -OH or HF	

Skills Procedural Knowledge **'I know how to'**	**I know how to:** Use the following terms correctly in explanations: relative atomic mass, isotopes, relative isotopic mass, relative formula mass, relative molecular mass (Mr), amount of substance, mole (symbol 'mol', in terms of carbon-12 or in terms of 6.02×10^{23} elementary entities), Avogadro constant (N_A), molar mass, molar gas volume, empirical formula, molecular formula, anhydrous, hydrated, water of crystallisation Derive the atomic structure of atoms and ions in terms of protons, neutrons and electrons (given atomic number, mass number and any ionic charge) Use models of atomic structure to explain atomic property trends Use mass spectrometry data to determine: relative isotopic masses, relative abundance of an isotope Predict ionic charge from position of element on periodic table Construct balanced chemical equations including state symbols, including for neutralisation reactions (incl. ionic equations) and redox reactions of metals with acids to form salt and hydrogen Use stoichiometric relationships in calculations Calculate the relative atomic mass of an element from relative abundances of its isotopes Calculate relative formula mass, relative molecular mass (Mr) from atomic masses Calculate empirical and molecular formulae from composition by mass (incl. elemental analysis data) or percentage compositions by mass and relative molecular mass Calculate the formula of a hydrated salt from percentage composition, mass composition or from experimental data Calculate amount of substance from mass, solution volume and concentration or gas volume (latter using the ideal gas equation to process data as required) Calculate percentage yield of a reaction, or related quantities from percentage yield Calculate atom economy of a reaction Calculate concentration of a solution (or other related values) from titration data, or raw experimental results Explain the concept of strong and weak acids in terms of relative dissociations Perform an acid-base titration, including preparation of a standard solution of required concentration Use a Roman numeral to indicate the magnitude of the oxidation number of an element where several options exist Write formulae from names which include a Roman numeral and vice versa Identify whether oxidation or reduction has taken place from electron movement or changes in oxidation number Interpret metal and acid redox equations, incl unfamiliar redox reactions, and make predictions of products in terms of oxidation numbers and electron loss/gain Use 'electrons in a box' representation and sub-shell notation (eg $1s^2\ 2s^2\ 2p^4$) Show the filling of orbitals in the first three shells and the 4s and 4p orbitals in order of increasing energy, including filling orbitals at the same energy singly before pairing Deduce the electron configuration of atoms and ions (when given the charge) up to atomic number (Z) =36, ions being limited to s- and p- blocks Construct 'dot-and-cross' diagrams for ionically bonded compounds, and for single and multiple covalent bonded substances and incl dative (coordinate) bonding Explain the existence of solid structures of giant ionic lattices Explain the effect of structure and bonding on physical properties of ionic substances

	Use electron pair repulsion theory to predict/explain molecular shapes and angles Use ideas about electronegativity to predict chemical bond type and explain polar bond and permanent dipole in molecules containing covalently bonded atoms Explain that a polar molecule needs polar bonds with dipoles that don't cancel out Explain intermolecular bonding/ forces in terms of permanent diploe-dipole interactions or induced dipole – dipole interactions Draw diagrams of hydrogen bonding and use ideas of this to explain macroscopic properties (eg density of ice vs water, relatively high mpt and bpt of water) Explain solid structures of simpler molecular lattices as covalent molecules attracted by intermolecular forces (eg water, I_2) Explain effect of structure and bonding on the physical properties of covalent compounds with simple molecular lattice structures (incl mpt, bpt solubility and conductivity)
Strategies Conditional Knowledge **'I know when to'**	**I know when to:** Use specific techniques to produce volume or mass data for calculations of formula mass and related quantities Explain properties in terms of covalent intramolecular bonds and when to explain in terms of intermolecular bonds (and which type of intermolecular bonds)
Key Questions	What is matter made from and how do substances react? What models can we use to help us make sense of observations and how have these models developed over time?
Assessment topics	Tested at the end of 2.1, 2.2 and end of Module 2 before end of term 1. Repeat testing in second half of term 2
Cross curricular links/Character Education	Maths skills in problem solving Understanding and explaining observations in qualitative and quantitative terms Using models to develop understanding and to make predictions Understanding of the scientific approach to problem solving and investigations

Curriculum Map: CHEMISTRY Year 12 Module 3: The Periodic Table and Energy

	Spring 1	Spring 2
Content Declarative knowledge **'I know'**	**Module 3:** **Development of the Periodic Table, its contents and how to use it to make predictions.** **Energy changes and rates of reactions, how to measure and influence them** **I know:** **Periodicity** That the periodic table is an arrangement of elements in order of increasing atomic number That periods show repeating trends of physical and chemical properties (periodicity) That groups have similar chemical properties The electronic configuration changes across Periods 2 and 3 The classification of elements into s-, p- and d-blocks Definitions for: first ionisation energy Potential applications and benefits of graphene **Group 2** The outer shell s^2 electron configuration and loss of 2 outer electrons in redox reactions to form 2+ ions The relative reactivities down the group Mg to Ba, shown by reactions with oxygen, water and dilute acids The trend in reactivity in terms of first and second ionisation energies down the group The action of water on Group 2 oxides and the approx. pH of any resulting solutions, including the trend of increasing alkalinity Some uses of Group 2 compounds as bases, including $Ca(OH)_2$ in agriculture to neutralise acid soils and $Mg(OH)_2$ and $CaCO_3$ as 'antiacids' **Group 7 The Halogens** That the halogens exist as diatomic molecules The outer shell s^2p^5 electron configuration and gain of 1 outer electron in many redox reactions to form 1- ions The trend in reactivity down the group as shown by reaction with other halide ions The definition of 'disproportionation' as the oxidation and reduction of the same element. Examples of this (including equations) for (i)reaction of chlorine with water as in water treatment (ii) reaction of chlorine with cold dilute aqueous solution of NaOH as used to form bleach and (iii) similar reactions to (i) and (ii) That chlorine kills bacteria (in water treatment), but there are hazards (toxic chlorine gas and possible carcinogenic risk from formation of chlorinated hydrocarbons). That the decision on chlorination of drinking water is an ethical issue including consideration of the 'right to choose' The precipitation reactions (including ionic equations) of the aqueous anions with aqueous silver ions, followed by aqueous ammonia and their use as a test for different halide ions **Qualitative Analysis** The tests for the ions: carbonate, sulfate and halide (including order, as $BaCO_3$ and Ag_2SO_4 are both insoluble) The test for the ammonium ions: by reaction with warm NaOH(aq) forming ammonia **Enthalpy Changes** That some chemical reactions are exothermic (ΔH negative) and some are endothermic (ΔH positive)	

	Definitions: activation energy, standard conditions, standard states, enthalpy change of reaction ($\Delta_r H$), enthalpy change of formation ($\Delta_f H$), enthalpy change of Combustion ($\Delta_c H$), enthalpy change of neutralisation ($\Delta_{neut} H$), average bond enthalpy That actual bond enthalpy may differ from the average value That exothermic reactions are associated with overall making of bonds and endothermic are associated with overall breaking of bonds **Reaction Rates** The effect on rate of concentration (incl gas pressure) and reason for this That a catalyst increases reaction rate without being used up and allows reaction to happen via a different route with lower activation energy The meaning of the terms 'homogeneous catalyst' and 'heterogenous catalyst' That catalysts are very important economically and for sustainable industrial reactions by lowering required temperatures and thus reducing energy demand, leading to reduction in fossil fuel combustion and CO_2 emissions, but that some catalysts can be toxic **Chemical Equilibrium** That a dynamic equilibrium exists in a closed system when the rate of the forward reaction equals the rate of the reverse reaction That when dynamic equilibrium is achieved, the concentrations of reactants and products do not change That adding a catalyst will increase the rate of forward and backwards reactions by the same amount, resulting in an unchanged position of equilibrium The expression for K_c for homogeneous reactions
Skills Procedural Knowledge **'I know how to'**	**I know how to:** **Periodicity** Explain the trend in first ionisation energy across Periods 2 and 3 and down a group, in terms of attraction, nuclear change and atomic radius (including small decrease as a result of s- and p- shell energies and p-orbital repulsion) Predict the number of electrons in each shell of an atom from the successive ionisation energies and thus determine the element's group. Describe metallic bonding as a strong electrostatic attractive between positive ions and delocalised electrons Draw a labelled model for a giant metallic lattice structure Describe solid giant covalent lattices of carbon (diamond, graphite, graphene) and silicon as networks of atoms bonded by strong covalent bonds Use the models of giant metallic/covalent lattices to explain physical properties, including mpt, bpt, solubility and electrical conductivity (in terms of type of particle present, relative strength of bonds/forces and mobility of particles involved Explain the variation in mpts across Periods 2 and 3 in terms of structure and bonding (giant metallic/giant covalent/simple molecular) **Group 2** Correctly use the term 'second ionisation energy' and write an equation for the change **Group 7 The Halogens** Explain the trend in the bpts of the halogens in terms of induced dipole-dipole interactions (London forces) Write full and ionic equations for redox reactions Explain the trend in reactivity down the group, from decreasing ease of formation of the 1- ion, in terms of attraction, atomic radius and electron shielding **Qualitative Analysis** Design a series of tests to identify unknown ions in a solution

	Enthalpy Changes Construct enthalpy profile diagrams showing the enthalpy change of reaction and activation energy Determine enthalpy changes directly from experimental results (including use of $q = mc\Delta T$) Design and carry out experiments to obtain data. Use average bond enthalpies in enthalpy calculations Use Hess' Law to construct enthalpy cycles to determine an unknown enthalpy value from given data **Reaction Rates** Calculate reaction rate from graphs of how a physical quantity changes with time Draw enthalpy profile diagrams to show the effect of a catalyst Design and carry out experiments to obtain data, including measurement of mass, gas volumes and time Draw a Boltzmann distribution curve and use this model to explain why reaction rate increases with catalyst and temperature **Chemical Equilibrium** Use le Chatelier's principle with homogeneous equilibria to deduce effect of changes in temperature, pressure or concentration Investigate changes to equilibrium resulting from changes in concentration and temperature (eg by assessing colour changes) Explain why there may be a compromise in industry between chemical equilibrium position and reaction rate in deciding optimum conditions Calculate K_c from equilibrium concentration data Estimate the position of equilibrium from the magnitude of K_c
Strategies Conditional Knowledge **'I know when to'**	**I know when to:** **Enthalpy Changes** Use Hess' law to solve an enthalpy problem **Reaction Rates** Use simple collision theory and when to use the Boltzmann distribution to explain effect on reaction rate
Key Questions	What does 'periodic' mean in the context of the Periodic Table and how can this be used to predict properties? How fast do chemical reactions happen and how can that speed be changed? How can we model what is happening in exothermic and endothermic reactions? Why do some reactions never go to completion and how can the yield in these reactions be increased?
Assessment topics	Tested at the end of Topic 3.1 and at the end of Topic 3.2 and in every subsequent Physical/Inorganic test
Cross curricular links/Character Education	**Links:** Geography – environmental analysis Ethics – decisions on chlorination of water History – development of periodic table, facts and key individuals involved Maths – trends, correlation, calculations, 3D structure visualisation

Curriculum Map: CHEMISTRY Year 12 Module 4: Core Organic Chemistry

	Spring 1	Spring 2
Content Declarative knowledge **'I know'**	**Module 4:** **Basic concepts and Hydrocarbons; Alcohols, Haloalkanes and Analysis** **I know:** The stems, suffix and prefixes for alkanes, alkenes, ketones, alcohols, aldehydes, and carboxylic acids The difference between aliphatic, alicyclic and aromatic The different types of covalent bond fission The bonds involved in alkanes That the boiling point of alkanes increases with chain length The different reactions of alkanes including combustion and radical substitution The bonds involved in alkenes The different addition reactions of alkenes The benefits for sustainability of waste polymers The products of combustion The products of oxidation of alcohols The products of a dehydration reaction The mechanism for nucleophilic substitution The factors that affect reactivity of haloalkanes The sources of CFCs and the effect on the atmosphere The basis of how infrared spectroscopy works	
Skills Procedural Knowledge **'I know how to'**	**I know how to:** Use IUPAC rules to name organic compounds Write structural, skeletal, displayed, general, empirical and molecular formula Determine structural and geometric isomers Represent radicals and the movement of electron pairs Represent the free radical substitution of alkanes Determine the product of an addition reaction Apply Markownikoffs rule to alkenes Draw addition polymerisation Identify a monomer from a section of addition polymer Classify alcohols Explain the properties of alcohols in terms of hydrogen bonding Produce an ester Name an ester based on the alcohol and carboxylic acid Test the reactivity of haloalkanes using hydrolysis Use Quickfit apparatus for organic synthesis Use a separating funnel	

	Test for different functional groups Produce different products in multi-step reactions Use infrared spectra to identify compounds Use mass spectra to identify molecular ion peaks and fragmentation patterns
Strategies Conditional Knowledge '**I know when to'**	**I know when to:** Apply different stems, prefixes and suffixes to different organic compounds. Use CIP rules to identify isomers and when cis- and trans- nomenclature can be used Use specific techniques to produce a desired product
Key Questions	
Assessment topics	Tested at the end of Topic 4.1 and at the end of Topic 4.2 and in every subsequent Organic test.
Cross curricular links/Character Education	Geography – waste and climate change History – notable scientists and their contributions Food and design tech – esters

Curriculum Map: CHEMISTRY Year 13 Module 5: Physical Chemistry and Transition Elements

	Autumn 1	Autumn 2	Spring 1	Spring 2
Content Declarative knowledge **'I know'**	**Topic 5.1 Rates, Equilibrium and pH** **I know:** **Rates** The definitions of: rate constant, rate equation, overall order, half-life The shapes of concentration time graphs for orders 0, 1 and 2 The shapes of rate concentration graphs for orders 0, 1 and 2 The Arrhenius equation **Equilibrium** The definitions of: homogeneous, heterogeneous, equilibria, mole fraction, partial pressure The layout of a Kc and Kp expression The effect of changing conditions on Kc and Kp **pH** The definitions of: Bronsted Lowry acid and base, conjugate acid base pairs, monobasic, dibasic, tribasic, pH, buffer The layout of a Ka expression The equation for pH The layout for a Kw expression The composition of a buffer The shapes of the neutralisation / titration curves for strong and weak acids and bases The appropriate use of various indicators for neutralisation reactions		**Topic 5.2 Energy** **I know:** **Lattice Enthalpy** The definitions of: lattice enthalpy, first ionisation energy, enthalpy change of formation, enthalpy change of solution, enthalpy change of hydration **Enthalpy and Entropy** That entropy is a measure of the dispersal of energy in a system, which is greater the more disordered the system The Gibbs equation $\Delta G = \Delta H - T\Delta S$ That a process is feasible when ΔG is negative The limitations of prediction on feasibility, in terms of kinetics **Redox and Electrode Potentials** The definitions of: oxidising agent, reducing agent, standard electrode (redox) potential $E^{\ominus}$ That a fuel cell uses the energy from reaction of a fuel with oxygen to create a voltage The changes that take place at each electrode in a fuel cell	**Topic 5.3 Transition Metals and Qualitative Analysis of Ions** **I know:** **Test for ions:** The observation for positive tests for the following anions and cations: CO_3^{2-}, Cl^-, Br^-, I^-, SO_4^{2-}; NH_4^+; Cu^{2+}, Fe^{2+}, Fe^{3+}, Mn^{2+}, Cr^{3+} **Transition Metals** The electron configuration of atoms and ions of period 4: Sc-Zn The definition of Ti-Cu as transition elements (d-block element with at least one stable ion with an incomplete d-sub-shell) Examples of at least two transition elements which show: i) Existence of more than one oxidation state in compounds ii) Formation of coloured ions iii) Catalytic behaviour of element / its compound The importance of catalysts in industrial manufacture of chemicals The definition and correct usage of terms: ligand, coordinate (dative covalent) bonding, complex ion, coordination number, monodentate, bidentate The monodentate ligands: H_2O, Cl^- and NH_3 The bidentate ligand: $NH_2CH_2CH_2NH_2$ ('en') A range of octahedral, tetrahedral and square planar complexes including: Octahedral hexaaqua complexes, e.g. $[Cu(H_2O)_6]^{2+}$, $[Fe(H_2O)_6]^{3+}$ Tetrahedral tetrachloro complexes, e.g. $CuCl_4^{2-}$ and $CoCl_4^{2-}$ Square planar complexes of Pt, e.g. platin: $Pt(NH_3)_2Cl_2$

			The use of cis-platin as an anti-cancer drug and its action in binding to DNA preventing cell division Ligand substitution reactions and their colour changes, specifically **(i)** $[Cu(NH_3)_4(H_2O)_2]^{2+}$ and $[CuCl_4]^{2-}$ from $[Cu(H_2O)_6]^{2+}$ and **(ii)** $[Cr(NH_3)_6]^{3+}$ from $[Cr(H_2O)_6]^{3+}$ Reactions and their colour changes, specifically of aqueous Cu^{2+} , Fe^{2+}, Fe^{3+}, Mn^{2+} and Cr^{3+} with aqueous sodium hydroxide and aqueous ammonia **(i)** precipitation reactions **(ii)** complex formation with excess aqueous sodium hydroxide and aqueous ammonia Redox reactions and colour changes for: **(i)** interconversions between Fe^{2+} and Fe^{3+} **(ii)** interconversions between Cr^{3+} and $Cr_2O_7^{2-}$ **(iii)** reduction of Cu^{2+} to Cu^{+} , disproportionation of Cu^{+} to Cu^{2+} and Cu

Skills Procedural Knowledge '**I know how to'**	**I know how to:** **Rates** Deduce the rate equation from experimental data Explain what a rate equation shows Calculate the rate of reaction using experimental data and graphs using tangents Calculate the value and units of a rate constant Find the half-life from a concentration time graph Use half-lives to calculate the rate constant Deduce the order of a reaction from the shape of the graph Determine the rate constant for a first order reaction from the gradient Suggest a mechanism for a multistep reaction using the rate equation Plot an Arrhenius graph and use it to determine the activation energy Calculate the pH of a buffer solution Explain the control of blood pH by the carbonic acid hydrogen carbonate buffer solution **Equilibrium** Write Kc and Kp expressions for equilibrium reactions Determine the units for Kc and Kp **pH** Write Ka expressions for acid - base reactions Identify an acid and its conjugate base Use a Ka and Kw expressions to find the pH of strong and weak acids and strong bases Select the appropriate indicator for a variety of neutralisation experiments	**I know how to:** **Lattice Enthalpy** Use lattice enthalpy as a measure of ionic bonding strength Use the terms and symbols for lattice enthalpy, enthalpy change of formation, ionisation energy, enthalpy change of atomisation, electron affinity, enthalpy change of solution, enthalpy change of hydration Apply conservation of energy to determine enthalpy changes: i)Construct Born-Haber cycles to calculate unknown energy values ii)Use enthalpy change of solution and relevant energy terms to construct enthalpy cycles and calculate unknown energy terms Explain qualitatively the effect of ionic change and radius on value of lattice enthalpy and enthalpy change of hydration **Enthalpy and Entropy** Explain the difference in size of the entropy of (i) solids, liquids and gases (ii) reactants and products in a reaction where there is a change in the number of gaseous molecules Calculate the entropy change of a system, given relevant data Use temperature and changes in entropy and enthalpy to calculate the free energy change of a reaction, predict reaction feasibility and determine temperatures for feasibility **Redox and Electrode Potentials** Construct redox equations using half-equations and oxidation numbers Interpret and predict reactions involving electron transfer Carry out redox titrations including Fe^{2+} /MnO_4^- and $I_2/S_2O_3^{2-}$	**I know how to:** **Test for ions:** Test for the following anions and cations: CO_3^{2-} , Cl^-, Br^-, I^-, SO_4^{2-} NH_4^+, Cu^{2+} , Fe^{2+} , Fe^{3+} , Mn^{2+} , Cr^{3+} **Transition Elements** Write and draw complex ions with monodentate and bidentate ligands including unfamiliar ligands, specifically with six-fold coordination with an octahedral shape and four-fold coordination with either tetrahedral or square planar shape. Draw 3D diagrams to illustrate stereoisomerism, including those with bidentate and multidentate ligands eg: *cis–trans* isomerism e.g. $Pt(NH_3)_2Cl_2$ and optical isomerism e.g. $[Ni(NH_2CH_2CH_2NH_2)_3]^{2+}$ Explain the biochemical importance of iron in haemoglobin, including ligand substitution involving oxygen and carbon monoxide Interpret and predict unfamiliar reactions including ligand substitution, precipitation and redox

		Complete structured and non-structured titration calculations, including non-familiar redox systems Carry out measurements of cell potentials of metals and non-metals in contact with their ions in aqueous solution and of ions of the same element in different oxidation states in contact with a platinum electrode. Calculate the standard cell potential by combining two $E^{\ominus}$ values Apply electrode potential principles to modern storage cells	
Strategies Conditional Knowledge **'I know when to'**	**I know when to:** **Rates** Calculate the gradient to find the rate of reaction Use the shape of a graph to infer the order of the reaction Use the Arrhenius equation to find an unknown **Equilibrium** Use Kp, and Kc expressions to solve complex problems. **pH** Use Kp, and Kc expressions to solve complex problems. Use practical skills to determine unknown concentrations of acids and bases.	**I know when to:** **Lattice Enthalpy** Use an enthalpy cycle to obtain an unknown enthalpy value that may not be accessible via experimental measurement **Enthalpy and Entropy** Convert units prior to use in free energy calculations **Redox and Electrode Potentials** Use a combination of equations and standard electrode potentials to determine whether a reaction is feasible and know when this cannot be used due to limitations of such predictions	
Key Questions	How do you measure reaction speeds and influence them? How do equilibrium reactions work, and how can they be manipulated to obtain best yields in reactions? How are equilibrium reactions critical to living organisms?	How can we use a model of bonding to determine energy changes that cannot be experimentally measured? How can we predict the feasibility of chemical change? How is a redox titration used ? How do batteries and fuel cells work?	Why are the compounds of transition elements coloured? How can transition element ions and compounds be identified? Why are many transition elements able to be used as catalysts?
Assessment topics	End of topic test	End of topic test	End of topic test
Cross curricular links/Character Education	Links: Biology - buffers Maths – rearranging equations, logs, problem solving	Links: Engineering - energy storage Maths – rearranging equations, problem solving	Links: Biology – importance of iron in blood and ligand substitution problem of CO, cancer treatment Maths: spatial visualisation, symmetry

Curriculum Map: CHEMISTRY Year 13 Module 6: Organic Chemistry and Analysis

	Autumn 1	Autumn 2	Spring 1	Spring 2
Content Declarative knowledge **'I know'**	**Topic 6.1 Aromatic Compounds, Carbonyls, Acids and Acid Derivatives.** **I know:** **Aromatic Compounds** The definitions of: benzene, model, substitution reaction, benzene derivative, electrophilic substitution, Friedel-Crafts reaction, phenol, directing group, delocalised The Kekulé model of benzene, structure of phenol, electrophilic substitutions mechanism, carbon -carbon bond lengths in benzene, hydrogenation data for benzene **Carbonyl compounds** The definitions of: nucleophile, oxidation, nucleophilic addition What a carbonyl group is and how to identify it, the nucleophilic addition mechanism of carbonyls, reducing agent $NaBH_4$, oxidising conditions for carbonyls, the alcohol products from reduction of aldehydes and ketones **Carboxylic acids and esters** The definitions of: carboxylic acid, base, ester, hydrolysis, esterification, acyl chloride The structure of a carboxylic acids, esters and acyl chlorides The chemical reactions of carboxylic acids The physical properties of carboxylic acids The reagents required to make ethanoyl chloride		**Topic 6.2 Nitrogen Compounds, Polymers and Synthesis** **I know:** **Amines** The definitions of: amine, alkyl ammonium salt, (Lewis base), Bronsted-Lowry base, dative bond **Amino acids, Amides and Chirality** The definitions of: amino acid, zwitterion, isoelectric point, amide, optical isomers, chiral molecules, polarised light, enantiomers, stereoisomerism, racemate/racemic mixture The general formula for an amino acid **Polyesters and Polyamides** The definitions of: repeat unit, condensation polymerisation, polyester, polyamide **Carbon-Carbon bond formation** The definitions of: nitrile, cyanide The nomenclature for nitriles The nucleophilic substitution and addition mechanisms of nitriles and cyanide groups The reduction and hydrolysis conditions for nitriles. **Organic synthesis** The definitions of: distillation, reflux, recrystallisation, synthetic route Lab equipment required for distillation, reflux, filtration under pressure, melting point determinations, safe heating of a flammable substance	**Topic 6.3 Analysis** **I know:** **Chromatography and qualitative analysis** The definitions of: R_f value, retention time, TLC, GC-MS, stationary phase, mobile phase, qualitative analysis The conditions required to run TLC and GC What information can be derived from these analyses **Spectroscopy** The definitions of: TMS, chemical shift, deuterium, NMR, equivalent protons The spin-spin coupling = n+1 rule The meaning of singlet, doublet, triplet, quartet, multiplet What information can be derived from IR, MS and nmr analyses

Skills Procedural Knowledge '**I know how to'**	**I know how to:** **Aromatic Compounds** Explain how the Kekulé model evolved into the current delocalised model Name aromatic compounds using IUPAC rules. Draw mechanisms for halogenation and nitration of arenes, taking into consideration 2-/4- or 3- directing effects Explain the relative resistance to bromination of benzene compared with alkenes Explain why a halogen carrier is required in some reactions Identify the reactions of phenol Explain the reactions of phenol **Carbonyl compounds** Draw a reduction mechanism for aldehydes and ketones Predict the organic products for nucleophilic addition reactions of aldehydes and ketones Design chemical tests to prove the presence of aldehyde or a ketone functional group **Carboxylic acids and esters** How to name carboxylic acids, esters and acyl chlorides Explain the water solubility of carboxylic acids using the concept of hydrogen bonding State and explain the various reaction conditions for esterification and hydrolysis and predict the products Prepare an acyl chloride using $SOCl_2$ State and explain the use of acyl chlorides in the preparation of esters, carboxylic acids, primary and secondary amides	**I know how to:** **Amines** Explain the basicity of amines Prepare primary amines by substitution or reduction Name amines Name the salts of amines (which are dependent upon the acid used to make them) Predict the main product during amine preparation from halogenoalkane substitution reactions Draw the 3D structure of an amine Write balanced equations for the formation of primary amines from halogenoalkanes **Amino acids, Amides and Chirality** Identify chiral centres and draw 3D enantiomers in a mirror plane Predict the reactivity of an amino acid in different reaction conditions Explain how a zwitterion is formed Draw amino acids Draw and name amides **Polyesters and Polyamides** Draw a monomer, repeat unit, polymer chain Identify a polyester link Identify a polyamide link Prepare polyesters and polyamides Hydrolyse polyesters and polyamides Predict the rates of polyester and polyamide hydrolysis in different conditions **Carbon-Carbon bond formation** Identify if the CN will be a nitrile or cyanide group. Draw the nitrile group and name compounds containing it Explain how racemic mixtures can be made during nucleophilic addition reactions of carbonyls with cyanide Explain the reduction conditions of nitrile groups	**I know how to:** **Chromatography and qualitative analysis** How to calculate R_f values Explain the positions of components on a TLC plate Explain the retention times of components in a GC trace **Spectroscopy** Interpret ^{1}H and ^{13}C nmr Predict ^{1}H and ^{13}C nmr for a given molecules Identify OH and NH groups in nmr traces using proton exchange with D_2O

		Organic synthesis Design a synthetic route Safely use the lab equipment to perform distillation, reflux, filtration under pressure, melting point determination	
Strategies Conditional Knowledge **'I know when to'**	**I know when to:** **Aromatic Compounds** Use and interpret experimental evidence to describe the structure of benzene Interpret electrophilic substitution reactions of aromatic compounds and predict mechanisms Select reaction conditions depending on the reagents and the desired product Include a halogen carrier in acylation and alkylation reaction conditions and when it is not needed **Carbonyl compounds** Use chemical tests to identify the presence of aldehyde and ketone functional groups **Carboxylic acids and esters** Use the 'alcohol method' for esterification and when an acyl chloride method is required	**I know when to:** **Amines** Select reduction to form amines and when to select substitution **Amino acids, Amides and Chirality** Stop looking for further enantiomers of a molecule Evaluate the issues surrounding the optical isomers and their uses in pharmaceuticals **Polyesters and Polyamides** Evaluate the environmental impact of polyester and polyamide hydrolysis **Carbon-Carbon bond formation** Select the nucleophilic substitution and when to choose the addition mechanism with CN containing groups. **Organic synthesis** Consider the merits of an alternative synthesis method to the one that you have	**I know when to:** **Chromatography and qualitative analysis** Use different qualitative tests to identify different organic functional groups. **Spectroscopy** Use elemental analysis, mass spectra, IR and NMR to deduce structure of organic compounds and what information each technique can supply
Key Questions	Can you explain, using a variety of evidence, why the model of benzene has changed over time? Can you draw, name and identify a range of organic molecules with different functional groups?	Can you draw, name and identify a range of organic molecules with different functional groups? Can you evaluate the environmental impact of using addition and condensation polymers? Can you plan a series of reactions in an organic synthesis to make a desired product?	Can you use multiple analysis sources to identify the structure of a given compound?

Assessment topics	6.1 End of topic test 6.1 is also assessed in the Spring term PPE	6.2 and 6.3 Combined end of topic test	6.2 and 6.3 Combined end of topic test
Cross curricular links/Character Education	Links: A Level Biology: amino acids and polymers Basic Maths skills – substituting numbers into formulae to calculate quantities, ratios, Interpreting graphical data	Links: Maths – 3D structures	Links: Maths – 3D structures, problem solving