Programme of study for Chemistry Year 13

Autumn (1st term)	Autumn (2nd term)	Spring (1st term)	Spring (2nd Term)	Summer (1st term)	Summer (2nd term)
Topic / Big Question: **Teacher 1:** Topic: Optical isomerism and aldehydes and ketones; Carboxylic acid and its derivatives **Teacher 2:** Topic: Rate equations	Topic / Big Question: **Teacher 1:** Topic: acids and bases **Teacher 2:** Topic: Continue Thermodynamics and Entropy Topic: electrode potential and electrochemical	Topic / Big Question: **Teacher 1:** Topic: Aromatic Chemistry Topic: Amines and polymers **Teacher 2:** Topic: transitions metals and reactions of ions in aqueous solutions	Topic / Big Question: **Teacher 1:** Continue with Amines and polymers. Topic: Amino acids, proteins, DNA **Teacher 2:** Topic: continue with transitions metals and reactions of ions in aqueous solutions	Topic / Big Question: **Teacher 1:** Topic: chromatography, organic synthesis and analysis. **Teacher 2:** Topic: properties of period 3 and their oxides	Topic / Big Question: Revision and public examinations
Skills (students should be able to do): AO1: Demonstrate knowledge and understanding of scientific ideas, processes, techniques and procedures. AO2: Apply knowledge and understanding of scientific ideas, processes, techniques and procedures: • in a theoretical context • in a practical context • when handling qualitative data • when handling quantitative data. AO3: Analyse, interpret and evaluate scientific information, ideas and evidence, including in relation. to issues, to:	Skills (students should be able to do): AO1: Demonstrate knowledge and understanding of scientific ideas, processes, techniques and procedures. AO2: Apply knowledge and understanding of scientific ideas, processes, techniques and procedures: • in a theoretical context • in a practical context • when handling qualitative data • when handling quantitative data. AO3: Analyse, interpret and evaluate scientific information, ideas and evidence, including in relation. to issues, to:	Skills (students should be able to do): AO1: Demonstrate knowledge and understanding of scientific ideas, processes, techniques and procedures. AO2: Apply knowledge and understanding of scientific ideas, processes, techniques and procedures: • in a theoretical context • in a practical context • when handling qualitative data • when handling quantitative data. AO3: Analyse, interpret and evaluate scientific information, ideas and evidence, including in relation. to issues, to:	Skills (students should be able to do): AO1: Demonstrate knowledge and understanding of scientific ideas, processes, techniques and procedures. AO2: Apply knowledge and understanding of scientific ideas, processes, techniques and procedures: • in a theoretical context • in a practical context • when handling qualitative data • when handling quantitative data. AO3: Analyse, interpret and evaluate scientific information, ideas and evidence, including in relation. to issues, to:	Skills (students should be able to do): AO1: Demonstrate knowledge and understanding of scientific ideas, processes, techniques and procedures. AO2: Apply knowledge and understanding of scientific ideas, processes, techniques and procedures: • in a theoretical context • in a practical context • when handling qualitative data • when handling quantitative data. AO3: Analyse, interpret and evaluate scientific information, ideas and evidence, including in relation. to issues, to:	Skills (students should be able to do):

• make judgements and reach conclusions •develop and refine practical design and procedures.	• make judgements and reach conclusions •develop and refine practical design and procedures.	• make judgements and reach conclusions •develop and refine practical design and procedures.	• make judgements and reach conclusions •develop and refine practical design and procedures.	• make judgements and reach conclusions •develop and refine practical design and procedures.	
Key Learning Outcomes (students should know): Teacher 1: Optical isomerism, aldehydes and ketones, carboxylic acid and their derivatives draw the structural formulas and displayed formulas of enantiomers. Understand how racemic mixtures (racemates) are formed and why they are optically inactive. Write overall equations for reduction reactions using [H] as the reductant. Outline the nucleophilic addition mechanism for reduction reactions with $NaBH_4$ (the nucleophile should be shown as H-) write overall equations for the formation of hydroxynitriles using HCN.	Key Learning Outcomes (students should know): Teacher 1: Acids and bases Define acids and bases. convert concentration of hydrogen ions into pH and vice versa Calculate the pH of a solution of a strong acid from its concentration. Use Kw to calculate the pH of a strong base from its concentration. Construct an expression for Ka. Perform calculations relating the pH of a weak acid to the concentration of the acid and the dissociation constant, Ka. Convert Ka into pKa and vice versa. sketch and explain the shapes of typical pH curves.	Key Learning Outcomes (students should know): Teacher 1: Aromatic chemistry use thermochemical evidence from enthalpies of hydrogenation to account for this extra stability. Explain why substitution reactions occur in preference to addition reactions. outline the electrophilic substitution mechanisms of: nitration, including the generation of the nitronium ion. acylation using $AlCl_3$ as a catalyst. Teacher 1: Amines and polymers Explain the difference in base strength in terms of the availability of the lone pair of electrons on the N atom. outline the mechanisms of:	Key Learning Outcomes (students should know): Teacher 1: Amino acids, proteins and DNA. draw the structures of amino acids as zwitterions and the ions formed from amino acids: in acid solution in alkaline solution. draw the structure of a peptide formed from up to three amino acids. draw the structure of the amino acids formed by hydrolysis of a peptide. identify primary, secondary and tertiary structures in diagrams. explain how these structures are maintained by hydrogen bonding and S–S bonds. calculate rf values from chromatogram. Explain why a stereospecific active site can only bond to one	Key Learning Outcomes (students should know): Teacher 1: chromatography, organic synthesis and analysis. calculate Rf values from a chromatogram. compare retention times and Rf values with standards to identify different substances. Explain why chemists aim to design processes that do not require a solvent and that use non-hazardous starting materials. explain why chemists aim to design production methods with fewer steps that have a high percentage atom economy. Use reactions in this specification to devise a synthesis, with up to four steps, for an organic compound. explain why TMS is a suitable substance to use as a standard. use H^1NMR and C^{13} NMR spectra and chemical shift data from the Chemistry Data Booklet to	Key Learning Outcomes (students should know):

outline the nucleophilic addition mechanism for the reaction with KCN followed by dilute acid. Explain why nucleophilic addition reactions of KCN, followed by dilute acid, can produce a mixture of enantiomers. Be able to explain why carboxylic acids are weak acids and their reactions. Give reaction conditions to produce esters. Hydrolysis of esters Outline the mechanism of nucleophilic addition–elimination reactions of acyl chlorides with water, alcohols, ammonia and primary amines. Teacher 2: Rates define the terms order of reaction and rate constant. perform calculations using the rate equation. explain the qualitative effect of changes in temperature on the rate constant *k.* perform calculations using the equation $k=Ae^{-Ea/RT}$ understand that the equation $k=Ae^{-Ea/RT}$ can be rearranged into the form lnk=-Ea/RT+lnA and know how to use this rearranged equation with experimental data to plot a	Use pH curves to select an appropriate indicator. Explain qualitatively the action of acidic and basic buffers. Calculate the pH of acidic buffer solutions. Teacher 2 – thermodynamics and entropy Define the term enthalpy of hydration. perform calculations of an enthalpy change using these cycles. calculate entropy changes from absolute entropy values. use the relationship $\Delta G = \Delta H - T\Delta S$ to determine how ΔG varies with temperature use the relationship $\Delta G = \Delta H - T\Delta S$ to determine the temperature at which a reaction becomes feasible. Topic: Electrochemical cells Use E **θ** values to predict the direction of simple redox reactions. calculate the EMF of a cell. Write and apply the conventional representation of a cell. use given electrode data to deduce the reactions occurring	these nucleophilic substitution reactions The nucleophilic addition–elimination reactions of ammonia and primary amines with acyl chlorides. draw the repeating unit from monomer structure(s) draw the repeating unit from a section of the polymer chain. draw the structure(s) of the monomer(s) from a section of the polymer. Explain the nature of the intermolecular forces between molecules of condensation polymers. Explain why polyesters and polyamides can be hydrolysed but polyalkenes cannot. Teacher 2: Transition metals Be able to show equations for ligand exchange reactions. Explain the chelate effect, in terms of the balance between the entropy and enthalpy change in these reactions. Illustrate shapes of complex ions and explain the formation of shapes. Draw diagrams for cis and trans isomers.	enantiomeric form of a substrate or drug. Explain how hydrogen bonding between base pairs leads to the two complementary strands of DNA. Explain why cisplatin prevents DNA replication explain why such drugs can have adverse effects. Calculate rf values from a chromatogram. Compare retention times and Rf with standards to identify different substances. Teacher 2: Transition metals Be able to show equations for ligand exchange reactions. Explain the chelate effect, in terms of the balance between the entropy and enthalpy change in these reactions. Illustrate shapes of complex ions and explain the formation of shapes. Draw diagrams for cis and trans isomers. Explain how transition metal ion complexes can form colours. Use $\Delta E = h\,h\nu = hc/\lambda$ to perform calculations Be able to explain use of simple colorimeter.	suggest possible structures or part structures for molecules use integration data from H^1NMR spectra to determine the relative numbers of equivalent protons in the molecule. Use the n+1 rule to deduce the spin–spin splitting patterns of adjacent, non-equivalent protons, limited to doublet, triplet and quartet formation in aliphatic compounds. Teacher 2: Properties of period 3 and their oxides melting point of the oxides of the elements Na–S in terms of their structure and bonding explain the trends in the reactions of the oxides with water in terms of the type of bonding present in each oxide. Write equations for the reactions that occur between the oxides of the elements Na–S and given acids and bases.	

straight-line graph with slope –Ea/R use concentration–time graphs to deduce the rate of a reaction. use initial concentration–time data to deduce the initial rate of a reaction. use rate–concentration data or graphs to deduce the order (0, 1 or 2) with respect to a reactant. derive the rate equation for a reaction from the orders with respect to each of the reactants. Use the orders with respect to reactants to provide information about the rate determining/limiting step of a reaction. Topic: thermodynamics: define each of the above terms and lattice enthalpy. construct Born–Haber cycles to calculate lattice enthalpies using these enthalpy changes. construct Born–Haber cycles to calculate one of the other enthalpy changes compare lattice enthalpies from Born–Haber cycles with those from calculations based on a perfect ionic model to provide evidence for covalent character in ionic compounds.	in non-rechargeable and rechargeable cells. deduce the EMF of a cell. Explain how the electrode reactions can be used to generate an electric current.	Explain how transition metal ion complexes can form colours. Use **Δ** E=h *h*ν = *hc*/λ to perform calculations Be able to explain use of simple colorimeter. Perform calculations for these redox titrations and similar redox reactions. calculate entropy changes from absolute entropy values. use the relationship $\Delta G = \Delta H - T\Delta S$ to determine how ΔG varies with temperature Use the relationship $\Delta G = \Delta H - T\Delta S$ to determine the temperature at which a reaction becomes feasible. Explain the importance of variable oxidation states in catalysis. Explain, with the aid of equations, how V_2O_5 acts as a catalyst in the contact process. Explain, with the aid of equations, how Fe^{2+} ions catalyse the reaction between I- and $S_2O_8^{2-}$ Explain, with the aid of equations, how Mn2+ ions autocatalyse the react ion between $C_2O_4^{2-}$ and MnO_4- Teacher 2: Reactions of ions in aqueous solution	Perform calculations for these redox titrations and similar redox reactions. calculate entropy changes from absolute entropy values. use the relationship $\Delta G = \Delta H - T\Delta S$ to determine how ΔG varies with temperature Use the relationship $\Delta G = \Delta H - T\Delta S$ to determine the temperature at which a reaction becomes feasible. Explain the importance of variable oxidation states in catalysis. Explain, with the aid of equations, how V_2O_5 acts as a catalyst in the contact process. Explain, with the aid of equations, how Fe^{2+} ions catalyse the reaction between I- and $S_2O_8^{2-}$ Explain, with the aid of equations, how Mn2+ ions autocatalyse the react ion between $C_2O_4^{2-}$ and MnO_4- Teacher 2: Reactions of ions in aqueous solution Explain, in terms of the charge/size ratio of the metal ion, why the acidity of $[M(H2O)_6]^{3+}$ is greater than that of $[M(H2O)_6]^{2+}$ Describe and explain the simple test reactions of: M2+(aq) ions, limited to M=Fe and Cu, and of M3+(aq) ions, limited to m=Al		

		Explain, in terms of the charge/size ratio of the metal ion, why the acidity of $[M(H2O)_6]^{3+}$ is greater than that of $[M(H2O)_6]^{2+}$ Describe and explain the simple test reactions of: M2+(aq) ions, limited to M=Fe and Cu, and of M3+(aq) ions, limited to m=Al and Fe, with the bases OH^-, NH_3 and CO_3^{2-}	and Fe, with the bases OH^-, NH_3 and CO_3^{2-}		

Autumn Term – centrally planned, standardised and teacher marked piece(s) of work	Spring Term – centrally planned, standardised and teacher marked piece(s) of work	Summer Term – centrally planned, standardised and teacher marked piece(s) of work
Optical isomerism, aldehydes and ketones end of topic test Linear exams Thermodynamics end of topic test Acids and bases end of topic test	Linear exams Aromatic end of topic test Transition metals and reactions of ions end of topic test	Amino acids, proteins and DNA end of topic test Period 3 and their oxides end of topic test.

Building understanding: Rationale / breakdown for your sequence of lessons:
Teacher 1 delivers physical chemistry and organic chemistry. Teacher 2 delivers inorganic and physical chemistry. This is split in the same way as how the examination papers are.

Physical chemistry is interleaved throughout the two years and taught by both teachers.

Teacher 1:

Optical Isomerism, aldehydes and ketones and carboxylic acids and their derivatives: Starting with optical isomerism, which deals with stereoisomerism, sets the stage for understanding the spatial arrangement of atoms in organic compounds. It introduces the concept of chirality, which is fundamental in organic chemistry. Aldehydes and ketones follow optical isomerism as they are among the simplest organic functional groups. They provide a foundational understanding of the carbonyl group and related reactions. The knowledge of isomerism can be applied here as well, especially with enantiomers. Building upon the understanding of aldehydes and ketones, the study of carboxylic acids and their derivatives introduces students to a broader class of organic compounds. This topic explores the reactions, nomenclature, and properties of carboxylic acids and related functional groups.

Acids and Bases: The study of acids and bases is important as it covers the principles of acidity and basicity, which are fundamental to understanding organic reactions and chemical equilibria. It's introduced here as it's relevant to carboxylic acids and other organic functional groups.

Aromatic Chemistry: Aromatic chemistry is introduced next. This is because it deals with a unique class of organic compounds, benzene and its derivatives, and their aromaticity. Students can apply their knowledge of acids and bases in the context of Lewis acid-base reactions with aromatic compounds.

Amines and polymers: Amines introduce students to the chemistry of nitrogen-containing compounds that include those with a benzene ring, which is an essential part of organic chemistry. They also present the opportunity to explore different types of isomerism, such as geometric isomerism in some cases. The study of polymers comes next. It's relevant because it's derived from organic compounds, and understanding polymer chemistry is crucial for both organic chemistry and materials science. This topic connects theoretical knowledge to practical applications.

Amino Acids, Proteins, and DNA: Exploring amino acids, proteins, and DNA is placed here as it connects organic chemistry to biochemistry. Understanding the structure and properties of amino acids is crucial for comprehending the biochemistry of proteins and DNA.

Chromatography: The introduction of chromatography follows because it's a widely used technique for separating and analysing organic compounds. Students can apply their knowledge of organic functional groups and structure to chromatographic separations.

Organic Synthesis and Analysis: Finally, the sequence concludes with organic synthesis and analysis, allowing students to bring together the knowledge they've acquired throughout the course. This provides a practical application of organic chemistry by teaching students how to design and execute synthetic routes and analyse the products.

In summary, this sequencing builds from fundamental organic chemistry concepts to biochemistry and practical techniques. It ensures that students have a comprehensive understanding of organic chemistry and its applications, as well as the ability to synthesize and analyse organic compounds, in line with the increasing complexity of the topics.

Teacher 2:

Rate Equations: Students begin the course by reviewing kinetics, which is what they covered at the end of year 12. After students have a grasp of reaction rates, they delve into rate equations. This topic allows them to apply mathematical expressions to describe how the rate of a chemical reaction depends on the concentrations of reactants. It builds on the principles introduced in kinetics and provides a more quantitative aspect of reaction rates.

Thermodynamics and Entropy: Moving on to thermodynamics, specifically the study of energy changes and entropy, is a logical step. This topic helps students understand the driving forces of chemical reactions, the concepts of enthalpy, entropy, and Gibbs free energy, and how these variables relate to the spontaneity and equilibrium of chemical reactions. Having a strong foundation in kinetics and rate equations aids in grasping the energetic aspects of chemical processes.

Electrode Potential: Transitioning to electrode potential involves understanding redox reactions and electrochemistry. It builds upon the knowledge of kinetics and thermodynamics and introduces the concept of electrode potential, which is vital for understanding the behaviour of electrochemical cells and reactions.

Transition Metals: The topic of transition metals comes next because it is essential for understanding complex ions and coordination chemistry. It introduces students to the unique properties and reactivity of transition metals, expanding their knowledge of chemical bonding and coordination compounds.

Properties of Period 3 and Their Oxides: Period 3 elements and their oxides are studied towards the end of the sequence because it brings together many concepts learned throughout the course. Students can apply their understanding of bonding, periodic trends, and redox reactions to explore the properties of elements in this period and their oxides, which helps consolidate their knowledge of chemistry.

In summary, the sequencing of these topics aims to provide students with a structured and logical progression, building from fundamental principles (kinetics) to more complex concepts (thermodynamics, electrode potential, transition metals) and concluding with a topic (period 3 elements and their oxides) that allows them to apply their comprehensive knowledge of chemistry.

Home – Learning:	Home – Learning:	Home – Learning:	Home – Learning:	Home – Learning:	Home – Learning:
Chemsheets booklet on kinetics.	Chemsheets booklet on thermodynamics	Assessed home-learning on optical isomerism, aldehydes	Assessed home learning on Amino acid, DNA and proteins.	NMR booklet	

<table>
<tr><td></td><td>chemsheets booklet on acids and bases</td><td>and ketones and carboxylic acids and their derivatives.</td><td>Chemsheets transition metals booklet.</td><td></td><td></td></tr>
<tr><td colspan="6">Reading / High Quality Text:
On regular occasion, students are given pre-learning reading on topics to encourage them to become more independent in their learning. Students are shown how to tackle exam questions through underlining keywords and command words. Understanding of these command words are tested in our connector/starter activities as well.
In chemistry exams, in each paper there is a 6-mark question where quality of written communication is assessed. This is taught through modelling techniques of looking at previous students work and assessing where the marks are given and what makes a good answer.

Students are also encouraged to use Jim Clark's book as a reference for calculations in chemistry.</td></tr>
<tr><td colspan="2">Numeracy:
20% of the course is related to mathematical skills.

draw different forms of isomers and identify chiral centres from a 2D or 3D.
representation.

They also understand the symmetry from looking at 2D and 3D structures of optical isomers by identifying the chiral carbon.

Order of reaction calculations

Graph drawing to use Arrhenius equation.

Change the subject of an equation Students may be tested on their ability to carry out structured and unstructured mole. calculations, e.g., calculate a rate constant k
from a rate equation.

Solve algebraic equations by calculating a rate constant k from a rate equation.

determine the order of a reaction from graph and derive a rate expression from a graph.

Draw and use the slope of a tangent to a curve as a measure of rate of change

pH calculations, which also involve using, exponential and logarithmic functions.

Drawing a graph to determine value of ka.</td><td colspan="2">Numeracy:

Hydrogenation calculations to determine stability of kekulè structure.

Redox titration calculations</td><td colspan="2">Numeracy:

Redox titration calculations

Using NMR spectra and integration line to identify ratio of carbons and hydrogens in a compound.</td></tr>
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Solve algebraic equations by carrying out Hess's law calculations. Entropy calculations – rearranging equation Electrode potential calculations and calculations on feasibility of a reaction.		

Enrichment / opportunities to develop cultural capital (including careers, WRL and SMSC):

Enrichment workshops, lectures and visits will be organised as part of the science week programme and students are encouraged to read chemistry review magazine that can be found in the sixth form library. This magazine contains useful articles and exam tips.