	Dallam School Curriculum Overview	**Department: Chemistry** **Year Group: 12**

Autumn		**Spring**	**Summer**
Foundations in chemistry	**Periodic table and energy**	**Core organic chemistry**	**Practical skills**
Master the prerequisite chemical concepts for all further chemistry study	**Examine periodic trends and physical chemistry within the theme of energy**	**Explore the applications of organic chemistry in everyday life**	**Learn how chemists work in practice**
By the end of this topic pupils will know *(key knowledge, including tier 3 vocabulary)*			
Atoms and reactions ➢ Isotopes are atoms of the same element with different numbers of neutrons and different masses. ➢ Definitions of relative isotopic mass and relative atomic mass. ➢ Names and formulae of common ions. ➢ The mole as the unit for amount of substance. ➢ The formula of common acids and neutralisation reactions. ➢ Oxidation is the process of electron loss. Reduction is the process of electron gain. ➢ Rules for calculating oxidation numbers and naming using Roman Numerals. **Electrons, bonding, and structure** ➢ The number of electrons that can fill the first four shells. ➢ The rules for filling atomic orbitals. ➢ Ionic bonding as the electrostatic attraction between positive and negative ions. ➢ Covalent bonding as the string electrostatic attraction between shared pairs of electrons and the nuclei of bonded atoms.	**The periodic table** ➢ The structure of the periodic table. ➢ Periodic trends in electron configuration and ionisation energy. ➢ The definition of first ionisation energy. ➢ Metallic bonding as strong electrostatic attraction between cations and delocalised electrons. ➢ Redox reactions and reactivity of Group 2 metals. ➢ Reactions of Group 2 compounds. ➢ Characteristics and physical properties of the halogens. ➢ Reactions and reactivity of halogens and their compounds. ➢ Characteristics and reactions of halide ions. ➢ Qualitative tests for ions on a test tube scale. **Physical chemistry** ➢ Enthalpy changes - ΔH of reaction, formation combustion and neutralisation. ➢ Bond enthalpies. ➢ Hess' Law for construction of enthalpy cycles.	**Basic concepts and hydrocarbons** ➢ IUPAC rules of nomenclature for systematically naming organic compounds. ➢ Types of isomerism. ➢ Types of covalent bond fission. ➢ Reaction mechanisms for homolytic fission and heterolytic fission. ➢ Dot notation for radical mechanisms. ➢ Properties and reactions of alkanes. ➢ Properties and reactions of alkenes including stereoisomerism, addition reactions, Markownikoff's rule, and polymerisation. **Alcohols, haloalkanes and analysis** ➢ Properties and reactions of alcohols, including combustion, oxidation, elimination, and substitution. ➢ Substitution reactions of haloalkanes. ➢ The mechanism for nucleophilic substitution. ➢ Environmental concerns from the use of organohalogen compounds. ➢ Infrared radiation causes covalent bonds to vibrate more and absorb energy.	*NB: this topic is taught concurrently with, and to support other topics in year 1 and 2.* **Techniques and procedures** ➢ Mole determination. ➢ Acid base titrations. ➢ Enthalpy determination. ➢ Qualitative analysis of ions. ➢ Synthesis of an organic liquid. ➢ Synthesis of an organic solid. ➢ Qualitative analysis of organic functional groups. ➢ Electrochemical cells. ➢ Rates of reaction – continuous monitoring method. ➢ Rates of reaction – initial rates method. ➢ pH measurement. ➢ Research skills. ***Keywords*** ➢ accurate, precise, uncertainty, error, measurement, reading, parallax, systematic, random, order of magnitude, estimate,

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➢ The shapes of simple molecules and ions. ➢ Electronegativity as the ability of an atom to attract bonding electrons in a covalent bond. ➢ Intermolecular forces based on dipole-dipole interactions including van der Waals' forces and London forces. ***Keywords*** ➢ isotopes, protons, neutrons, ionic, atomic number, relative isotopic mass, relative atomic mass, relative molecular mass, relative formula mass, mole, molar mass, molar gas volume, anhydrous, empirical, stoichiometric, oxidation, reduction ➢ energy level, shell, sub-shell, orbital, spin, dipole, polar, intermolecular, hydrogen bonding, lone pair, electronegativity	➢ Simple collision theory and the role of catalysts in reducing activation energy. ➢ The Boltzmann distribution model of particle energies. ➢ The meaning of dynamic equilibrium in closed systems. ➢ Le Chatelier's principle. ➢ Expressions for the equilibrium constant K_c. ***Keywords*** ➢ period, group, trend, ionisation energy, delocalised, diatomic, disproportionation, precipitation reaction ➢ enthalpy, activation energy, cycle, collision theory, catalyst, homogeneous, heterogeneous, Boltzmann distribution, dynamic equilibrium, equilibrium constant	***Keywords*** ➢ homologous series, functional group, alkyl group, aliphatic, alicyclic, aromatic, saturated, isomerism, radical, curly arrow, homolytic, heterolytic, electrophile, polymerisation ➢ polarity, volatility, nucleophile, radicals, aldehyde, ketone, carboxylic acid, spectroscopy, spectrum	

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They will understand *(key concepts)*					
➢ How evidence has led to changes in the accepted models of atomic structure over time. ➢ The use of mass spectrometry in determining the relative abundances of isotopes. ➢ The terms empirical and molecular formula. ➢ A qualitative explanation of strong and weak acids in terms of relative dissociations. ➢ How to interpret redox equations to make predictions. ➢ The role of electrons in ionic and covalent bonding. ➢ Models to explain intermolecular bonding. ➢ How bonding and structure contribute to the properties of substances. ➢ How to use electron pair repulsion to explain the shapes of molecules and ions. ➢ How polar bonds and polar molecules arise. ➢ The anomalous properties of water resulting from hydrogen bonding.		➢ The trends in first ionisation energy across Periods 2 and 3 and down a group. ➢ How to explain the trend in reactivity of Group 2 metals. ➢ Uses of Group 2 compounds as bases, and their applications in agriculture. ➢ How to explain the trend in reactivity of the halogens. ➢ The benefits and risks of the use of chlorine in water treatment. ➢ Exothermic and endothermic reactions in terms of enthalpy changes associated with breaking and making of chemical bonds. ➢ How to construct and interpret enthalpy profile diagrams to show differences in the enthalpy of reactants compared with products. ➢ How to explain the effects of concentration and gas pressure on the rate of reaction using simple collision theory. ➢ The economic importance and sustainability benefits of catalysts. ➢ How to use the Boltzmann distribution model to explain the effect of temperature change and use of catalysts on the rate of reaction. ➢ How to use le Chatelier's principle to deduce the effect of a change in temperature, pressure, or concentration on the position of equilibrium.		➢ How to interpret and draw general, structural, displayed, and skeletal formula. ➢ How the absorption of infrared radiation by atmospheric gases drives the greenhouse effect. ➢ How to interpret an infrared spectrum of an organic compound to identify specific absorption peaks. ➢ How infrared spectroscopy is used to monitor gases causing air pollution and in modern breathalysers. ➢ How to interpret a mass spectrum of an organic compound to identify molecular ion peaks and determine molecular mass.	➢ How to use appropriate apparatus to record a range of measurements including mass, time, volume, and temperature. ➢ How to use a water bath and electric heater. ➢ How to measure pH using charts, pH meters, or pH probe on a data logger. ➢ How to use a volumetric flask to make up a standard solution. ➢ How to select and use acid-base indicators in titrations. ➢ How to purify a solid product by recrystallisation. ➢ How to use melting point apparatus. ➢ How to use thin layer chromatography. ➢ How to set up electrochemical cells and measure voltage. ➢ How to safety handle solids and liquids which are corrosive, irritant, flammable, and / or toxic. ➢ How to measure rates of reaction through a clock method and continuous monitoring. ➢ How to assess experimental uncertainties.

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They will know how to *(key skills)*					
➢ Determine the number of protons, neutrons, and electrons in atoms and ions. ➢ Calculate relative molecular mass and relative formular mass from relative atomic masses. ➢ Write the formulae of ionic compounds from ionic charges. ➢ Write balanced chemical equations for unfamiliar reactions given appropriate information. ➢ Determine the formula of a hydrated salt from data and experimental results. ➢ Calculate chemical quantities using the concept of amount of substance, including those involving mass, gas volume, solution volume and concentration. ➢ Prepare standard solutions of required concentration and carry out acid-base titrations. ➢ Write formulae using oxidation numbers. ➢ Deduce the electronic configuration of atoms and ions up to Z=36 using letters and numbers. ➢ Use dot-and-cross diagrams to explain ionic and covalent bonding.		➢ Test for common ions and anions on a test-tube scale. ➢ Determine the enthalpy change of reactions through experimental means. ➢ Use techniques and procedures for investigating reaction rates. ➢ Calculate enthalpy changes and related quantities. ➢ Calculate K_c from provided equilibrium concentrations. ➢ Estimate the position of the equilibrium from the magnitude of K_c.		➢ Use curly arrows to demonstrate electron flow in organic reactions. ➢ Use Quickfit apparatus for distillation and heating under reflux. ➢ Prepare and purify an organic liquid. ➢ Devise two-stage synthetic routes for preparing organic compounds. ➢ Deduce the structure of organic compounds from a range of analytical data.	➢ Follow written instructions to carry out experimental techniques or procedures. ➢ Select appropriate instrumentation to carry out investigative procedures and use suitable measurement strategies to ensure accurate results. ➢ Work methodically, in sequence, identifying practical issues and adjusting when necessary. ➢ Identify and control significant quantitative variables, and plan to take account of variables that cannot readily be controlled. ➢ Identify hazards and assess risks associated with these hazards. ➢ Obtain accurate, precise, and sufficient data and record this methodically in a logbook using appropriate units and conventions. ➢ Use appropriate software / tools to process data, carry out research and report findings. ➢ Cite sources of information to demonstrate that research has taken place, supporting planning and conclusions.

	Dallam School Curriculum Overview	**Department: Chemistry** **Year Group: 13**

Autumn	Spring	Summer
Physical chemistry and transition elements		**Organic chemistry and analysis**
Conduct a quantitative treatment of rates of reaction, acids and bases, and enthalpy.		**Explore the processes used to synthesise organic molecules and the techniques used to identify and understand their structures.**

By the end of this topic pupils will know *(key knowledge, including tier 3 vocabulary)*

Rates of reaction

- Rate of reaction is defined as the change in concentration of a substance in unit time.
- A rate equation relates mathematically the rate of reaction to the concentration of the reactants.
- Reaction orders are integer numbers 0, 1, 2.
- The slowest step in a reaction is called the rate-determining step.
- The Arrhenius equation for the relationship between temperature and rate constant.
- Equation for calculating the equilibrium constants K_c and K_p.
- The partial pressure of a gas in a mixture is the pressure that the gas would have if it alone occupied the volume occupied by the whole mixture.

Acids, bases and buffers

- A Brønsted-Lowry acid is defined as a substance that can donate a proton.
- A Brønsted-Lowry base is defined as a substance that can accept a proton.
- Expressions for calculating pH, the acid dissociation constant K_a, and the ionic product of water K_w.
- Strong acids completely dissociate whilst weak acids only slightly dissociate when dissolved in water, giving an equilibrium mixture.
- A buffer solution is one where the pH does not change significantly if small amounts of acid or alkali are added to it.
- A carbonic acid – hydrogen carbonate equilibrium acts as a buffer in the control of blood pH.
- Types of titration curves.

Enthalpy

- Definitions of enthalpy change including formation, atomisation, sublimation, hydration, solution, ionisation, and electron affinity.

Structure, reactions, and synthesis of organic compounds

- The structure of benzene including the Kekulé model and delocalised model.
- IUPAC rules of nomenclature for systematically naming substitute aromatic compounds.
- The mechanisms of electrophilic substitution and nucleophilic addition.
- The properties and reactions of phenols.
- The reactions and characteristic tests for carbonyl compounds.
- The properties and reactions of carboxylic acids and esters.
- The basicity and preparation of amines.
- Reactions of amino acids.
- Structure of amides.
- Condensation polymerisation reactions to form polyesters and polyamides and the acid base hydrolysis of ester and amide groups in these polymers.
- Reactions used to increase the length of a carbon chain including the formation of C-C≡N, reactions of nitriles, alkylation, and acylation.
- Practical techniques preparation and purification of organic compounds including distillation, reflux, purification or organic liquids, purification of organic solids (recrystallisation), and measurement of melting and boiling points.

Analysis

- Types of chromatography.
- Qualitative tests for organic functional groups including alkenes, haloalkanes, phenols, carbonyl compounds, aldehydes, primary and secondary alcohols and aldehydes, and carboxylic acids.
- Different types of NMR spectroscopy (carbon-13 and proton).

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Physical chemistry and transition elements	**Organic chemistry and analysis**	
Conduct a quantitative treatment of rates of reaction, acids and bases, and enthalpy.	**Explore the processes used to synthesise organic molecules and the techniques used to identify and understand their structures.**	
➢ Lattice enthalpy can be used as a measure of ionic bond strength. ➢ Born-Haber cycles can be used to indirectly calculate lattice enthalpy. ➢ Trends in lattice enthalpies. ➢ Entropy is a measure of disorder. ➢ Gibbs free energy is a term that combines the effect of enthalpy and entropy, and which determines the feasibility of a reaction. For any spontaneous change, ΔG is negative. **Redox** ➢ Reducing agents are electron donors / oxidising agents are electron acceptors. ➢ The structure of an electrochemical cell. ➢ The components of a standard hydrogen electrode. **Transition elements** ➢ The general properties of transition metals. ➢ Complex formation involving transition metal ions. ➢ Shapes of complex ions. ➢ Isomerism in complex ions. ➢ The process of ligand substitution. ➢ Precipitation reactions between complex ions and sodium hydroxide / ammonia. ***Keywords*** ➢ rate constant, order, half-life, rate-determining step, equilibrium constant, partial pressure, mole fraction ➢ conjugate acid-base pairs, monobasic, dibasic, tribasic, dissociation constant, strong, weak, buffer, neutralisation ➢ enthalpy, entropy, Gibbs free energy, feasibility, spontaneous, endothermic, exothermic ➢ fuel cell, redox, electrode, potential, oxidation, reducing agent, oxidising agent ➢ complex, ligand, co-ordination number, unidentate, bidentate, multidentate, octahedral, tetrahedral, square planar, linear, cis-trans, optical, cisplatin	***Keywords*** ➢ benzene, aromatic, delocalised, π-system, electrophilic, nucleophilic, substitution, addition, nitration, halogenation, bromination, phenol, carbonyl, ester, hydrolysis, polymer, esterification, polymerisation, chiral, reduction ➢ retention factor, retention time, chromatogram, spectroscopy, NMR, spectrum, chemical shift	

Autumn	Spring	Summer
Physical chemistry and transition elements	**Organic chemistry and analysis**	
Conduct a quantitative treatment of rates of reaction, acids and bases, and enthalpy.	**Explore the processes used to synthesise organic molecules and the techniques used to identify and understand their structures.**	
They will understand *(key concepts)*		
➢ How to deduce the order from a concentration-time graph. ➢ The effect of temperature of the rate constant. ➢ Different techniques for investigating rates of reaction (mass change, colorimetry, electrical conductivity, optical activity). ➢ The effect of changing conditions on the value of K_c or K_p and the position of equilibrium. ➢ The role of H^+ in the reactions of acids with metals and bases. ➢ How to calculate the pH of strong / weak acids / bases, and pure water. ➢ The circumstances under which K_a approximations break down. ➢ How buffer solutions and indicator solutions work. ➢ How to interpret titration curves. ➢ How to construct and interpret Born-Haber cycles. ➢ How to use balanced chemical equations to predict changes in entropy. ➢ The effect of temperature on the feasibility of a reaction. ➢ How to balance redox equations and combine half equations. ➢ How to use electrode potentials to predict the feasibility of a redox reaction. ➢ Advantages and limitations of fuel cells. ➢ How cisplatin us used as an anticancer drug. ➢ Biochemical importance of ligand substitution in haemoglobin. ➢ Transition elements show variable oxidation state.	➢ How to use reaction mechanisms to explain organic reactions. ➢ How acyl chlorides are used in the synthesis and formation of esters and carboxylic acids. ➢ How to identify chiral centres in a molecule and explain optical isomerism. ➢ How to apply the mechanisms of nucleophilic substitution and nucleophilic addition to formation of C-C≡N. ➢ How Friedel Crafts reactions introduce a reactive functional group onto the benzene ring. ➢ How to describe multi-stage synthetic routes for preparing organic compounds. ➢ Use Quickfit apparatus for distillation and heating under reflux. ➢ Purify organic solids using techniques of filtration under reduced pressure, recrystallisation, and measurement of melting points. ➢ How to analyse carbon-13 NMR spectra of organic molecules. ➢ How to analysis high resolution proton NMR spectra to determine possible structures for the molecule. ➢ The choices of solvents used in NMR. ➢ How TMS is used to calibrate an NMR spectrum. ➢ How to combine the techniques of elemental analysis, mass spectra, IR spectra and NMR spectra to deduce the structures of organic compounds.	
They will know how to *(key skills)*		
➢ Calculate the rate constant from a rate equation. ➢ Calculate rates of reaction from concentration-time graphs. ➢ Calculate orders from experimental initial rate data. ➢ Calculate orders when two reactant concentrations are changed simultaneously. ➢ Calculate K_c and K_p and their units. ➢ Calculate K_a, K_w, and pH. ➢ Calculate the pH of a buffer and how this changes upon additional of small volumes of acid or alkali. ➢ Construct a pH curve. ➢ Select a suitable indicator when conducting titrations. ➢ Calculate Gibbs free energy change ΔG, and entropy change ΔS of reactions. ➢ Carry out redox titrations for thiosulfate and manganate. ➢ Measure cell potentials.	➢ Prepare and purify organic compounds using techniques including distillation, reflux, recrystallisation. ➢ Determine the purity of an organic compound through measurement of the measurement of melting or boiling points. ➢ Interpret TLC chromatograms in terms of R_f values. ➢ Interpret gas chromatograms in terms of retention times, including the creation and use of external calibration curves.	