



# BROOK 6TH FORM & ACADEMY

A UNIVERSITY TECHNOLOGY COLLEGE

## AA – Chemistry –Year 13



### Autumn Term: 2024

#### Autumn term - 2024

#### 3.1 Physical Chemistry

- 3.1.1 Atomic structure
- 3.1.2 Amounts of substance

#### **Half term**

- 3.2.3 Bonding
- 3.1.4 Energetics
- 3.1.5 Kinetics
- 3.1.6 Chemical equilibria, Le Chatelier's principle and K<sub>c</sub>

#### Christmas break

### Winter Term: 2025

#### Winter term -2025

- 3.1.7 Oxidation, reduction and redox equations

#### 3.2 Inorganic chemistry

- 3.2.1 Periodicity
- 3.2.2 Group 2, the alkaline earth metals
- 3.2.3 Group 7(17), the halogens

### Spring Term: 2025

#### Spring term -2025

- 3.3 Organic chemistry
- 3.3.1 Introduction to organic chemistry
- 3.3.2 Alkanes
- 3.3.3 Halogenoalkanes
- 3.3.4 Alkenes
- 3.3.5 Alcohols
- 3.3.6 Organic analysis

## Curriculum Intent and Implementation

### Vision:

Our vision here in the Chemistry department is to inspire and equip students with the knowledge, skills, and enthusiasm necessary to understand and apply chemical principles through hands-on experiments, fostering a deeper appreciation of the scientific method and its impact on the world around us.

### Mission:

Our mission is to provide a stimulating and supportive learning environment where students can develop their practical chemistry skills, critical thinking, and scientific literacy. We aim to cultivate curiosity, innovation, and a lifelong passion for science through engaging and meaningful laboratory experiences. Through our practical chemistry curriculum, we aim to nurture inquisitive minds, develop competent and confident individuals, and inspire the next generation of scientists.

### Goals:

Develop Scientific skills:

We work hard to ensure that all students are helped to develop the following scientific Skills:

- Acquire essential laboratory techniques and safety practices.
- Promote precision, accuracy, and attention to detail in experimental work.
- Develop independent and collaborative problem-solving abilities.

Enhance Scientific Understanding

- All students are helped to reinforce their theoretical knowledge through practical application.
- Teachers must foster an understanding of the scientific method, including hypothesis formulation, experimental design, data collection, and analysis.
- Students are helped to see the relevance of chemistry in everyday life and its applications in various fields such as medicine, industry, and environmental science.

### Promote Inquiry and Critical Thinking:

Teachers at Brook sixth form stimulate curiosity and questioning, encourage students to analyse and interpret data, draw conclusions, and communicate findings effectively. Through class discussions, students are helped to develop the ability to critically evaluate scientific information and experimental outcomes.

### **Cultivate a Safe and Supportive Learning Environment:**

Here in the chemistry department, we understand the importance of safety and we take on the challenge to ensure all students understand and adhere to safety protocols. The science team provides equal opportunities for all students to participate and succeed in laboratory activities. We celebrate and welcome the diversity of our students, hence foster a collaborative and respectful atmosphere that supports diverse learning needs and styles.

### **Prepare our students for Future Endeavours:**

Here in the Chemistry department, we know that transferable skills are critical for science students as they equip them with versatile abilities that are valuable across various professional and academic fields. Whatever, endeavours our students may pursue in their future careers, we equip them with the skills and confidence needed for higher education and careers in science and related fields.

As a team, we aim at developing them into lifelong learners with the ability to adapt in an ever-changing scientific landscape. In addition, we encourage ethical and responsible conduct in scientific practice.

### **Implementation:**

#### **Constructive learning:**

We understand the need to place the learner in the centre of their learning journey. Therefore, the department adopt and implement the constructive learning approach in our lessons, enabling learners actively construct their own understanding and knowledge through experiences and reflecting on those experiences. We therefore emphasise of hands-on activities, critical thinking, and collaboration, allowing students to connect new information to prior knowledge and apply it in meaningful ways and ultimately take responsibility for their learning.

#### **Structured Curriculum:**

A well-organized sequence of practical activities aligned with theoretical lessons, progressing from fundamental techniques to more complex experiments. We work collaboratively at helping our learner link ideas across different areas of the curriculum.

#### **Resources and Support:**

We adapt learning to the very needs of individual students in order to help them reach their potential. In addition, we provide appropriate materials, equipment, and guidance to facilitate effective learning experiences.

#### **Assessment and Feedback:**

We aim at developing our students into reflective learners, through regular formative and summative assessments to monitor progress, identify areas for improvement, and provide constructive feedback.

Prior learning	Retrieval :	Inclusivity and Differentiations:
<p><u>Prior Knowledge]</u></p> <p><b>AS Chemistry</b> - 3.1.4 – Energetics.</p>	<p><b>Retrieval:</b> Starter- Retrieval at the start of each lesson/ Quizzes to retrieve previous knowledge/ opportunities in the lesson to link new knowledge to previous knowledge.</p> <p><b>Strategies:</b></p> <ul style="list-style-type: none"> <li>○ Spaced retrieval (to combats the forgetting curve)</li> <li>○ Retrieval mats/grids</li> <li>○ Draw it !..label it!</li> <li>○ Free recall Concept mapping</li> <li>○ Peer teaching</li> </ul> <p><b>Afl strategies:</b> Low/high stake Quizzes, Targeted Questioning, Peer Talk and responses Peer Assessment &amp; Self-Assessment, Thumb signs pose-pause –pounce, exit and self-peer assessment etc.</p>	<p><b>Inclusivity and Differentiations:</b> To ensure we provide a supportive environment and <b>meet</b> the individual learning needs of our SEND students we adopt the following strategies in our science lessons:</p> <ul style="list-style-type: none"> <li>○ Chunk information into manageable bite sized tasks</li> <li>○ Provide Visual /multisensory aids to help students develop understanding</li> <li>○ Provide tiered activities/HW that allows all learners to make progress at their own pace</li> <li>○ Flexible groupings to provide effective collaboration</li> <li>○ Provide text that caters to the reading ages of individual learners</li> </ul> <p><i>SEND support (K) and EHCP (E= stated) – for pupils with IEPs targets in their pupil past-ports are used to inform planning</i></p>
Literacy in Chemistry:	Reflection:	Numeracy Skills:
<ol style="list-style-type: none"> <li>1. <b>Response to six markers (two-week cycle)</b> <ul style="list-style-type: none"> <li>○ Teacher provide detailed feedback to a six marker response with focus on; <b>content, use of key terms, SPAG, presentation, command words and coherence, logical reasoning</b></li> <li>○ Student respond and improve their work</li> </ul> </li> <li>2. <b>Frayers model</b></li> <li>3. Writing descriptions/observation during experiments</li> <li>4. Lesson <b>key terms</b> provided during lessons</li> <li>5. Claim –Evidence –Reasoning</li> <li>6. <b>Read and translate</b> information into other formats</li> </ol>	<p>Students are encouraging to reflect and to evaluate their own and others' which work fosters reflective learning and helps them understand how to improve. The following strategies are employed:</p> <ul style="list-style-type: none"> <li>○ Peer on peer/self-assessment during lesson</li> <li>○ Teacher feedback and student respond to improve</li> <li>○ End of unit/end of topic assessments are used to help student reflect and improve</li> </ul>	<p><b>Experimental skills:</b> Practical sessions are used to develop the following skills:</p> <ul style="list-style-type: none"> <li>○ Choosing appropriate graph, identifying variables and controls</li> <li>○ Collecting and Recording data, interpreting and describing trends and drawing conclusions</li> <li>○ Observing safety protocols and setting up apparatus safely</li> <li>○ Carrying out repeats, testing reliability of test data and identifying anomalous data</li> <li>○ Drawing conclusions</li> <li>○ Calculating averages/mean</li> </ul>

### 3.1.8.1 Born-Haber Cycles

Time taken	Learning Outcome	Learning activity with opportunity to develop skills	Practical	Skills
Week 1 03/09/24 To 09/09/24	<p><b>Students should be able to:</b></p> <ul style="list-style-type: none"> <li>define lattice enthalpy (formation and dissociation), enthalpy of formation, ionisation enthalpy, enthalpy of atomisation, bond enthalpy, electron affinity, enthalpy of solution, hydration enthalpy</li> <li>draw and use Born–Haber cycles to find missing values of enthalpy changes</li> <li>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.</li> </ul>	<ul style="list-style-type: none"> <li>Write equations to represent enthalpy changes</li> <li>- Apply knowledge and understanding).</li> <li>Construct Born-Haber cycles and use them to calculate missing enthalpy change values</li> <li>Change the subject of an equation</li> <li>Compare and comment on values of enthalpy changes from Born–Haber cycles with those calculated theoretically using the perfect ionic model</li> <li>- Analyse, interpret and evaluate data to make judgements).</li> <li>Construct and use cycles involving the solution of ionic compounds in water to find missing enthalpy change values</li> <li>Change the subject of an equation).</li> </ul> <p><b>Rich question</b> – predict the relative magnitude of the lattice enthalpy of the following compounds: aluminium oxide, potassium oxide, sodium chloride, sodium oxide.</p> <p><b>Rich question</b> – 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.</p>		Evaluative skills

### 3.1.8.2 Gibbs free-energy change $\Delta G$ and entropy change $\Delta S$

Time	Learning Outcome	Activities	Practical	Skills
	<p><b>Students should be able to:</b></p> <ul style="list-style-type: none"> <li>• describe entropy in terms of disorder</li> <li>• predict whether reactions have an increase or decrease in entropy</li> <li>• calculate the entropy change for a reaction</li> <li>• calculate the Gibbs free-energy change for a reaction at a given temperature</li> <li>• determine whether a reaction is feasible at a given temperature</li> <li>• calculate the temperature at which a reaction becomes feasible</li> <li>• use entropy changes to explain why some endothermic reactions are feasible.</li> </ul>	<ul style="list-style-type: none"> <li>• Rank given substances in terms of entropy</li> <li>• Use entropy values to calculate the entropy change for a reaction</li> <li>• Change the subject of an equation;</li> <li>• Substitute numerical values into algebraic equations).</li> <li>• Predict, where possible, whether reactions have an increase or decrease in entropy</li> <li>• Use the equation <math>\Delta G = \Delta H - T\Delta S</math> to determine whether reactions are feasible at given temperatures, and determine the temperature at which reactions become feasible</li> <li>• Change the subject of an equation;</li> <li>• Substitute numerical values into algebraic equations using appropriate units for physical quantities).</li> <li>• Plot graphs of <math>\Delta G</math> versus T to determine <math>\Delta H</math> and <math>\Delta S</math></li> <li>• Determine the slope and intercept of a linear graph).</li> <li>• Forecast how temperature affects the feasibility of reactions given the sign of the enthalpy and entropy changes</li> <li>• Apply the equation <math>\Delta G = \Delta H - T\Delta S</math> to state changes to find <math>\Delta H</math>, <math>\Delta S</math>, melting and/or boiling</li> <li>• Change the subject of an equation;</li> <li>• Substitute numerical values into algebraic equations using appropriate units for physical quantities).</li> <li>• Determine <math>\Delta H</math> and <math>\Delta S</math> for the vaporization of water using a kettle</li> <li>• ).</li> </ul>		<p>Processing and analyse data using appropriate mathematical skills</p>

### 3.1.9.1 Rate equations

Learning objective	Learning Outcome	Learning activity with opportunity to develop skills	Practical
<p><b>Week 2:</b> 09/09/24 To 16/09/24</p> <p>Understand rate equations and order of reaction.</p> <p>Deduce order of reaction, rate equations and rate constants from rate data.</p> <p>Describe how the rate constant changes with temperature.</p> <p>Use the Arrhenius equation.</p>	<p><b>Students should be able to:</b></p> <ul style="list-style-type: none"> <li>• define the terms order of reaction and rate constant</li> <li>• describe how changing concentration of a reagent affects the rate when the order with respect that reagent is 0, 1 or 2</li> <li>• determine the values and units for rate constants given appropriate data</li> <li>• describe how rate constants change with temperature</li> <li>• perform calculations using the Arrhenius equation</li> <li>• plot straight line graphs of <math>\ln k</math> versus <math>1/T</math> to determine the activation energy of a reaction.</li> </ul>	<ul style="list-style-type: none"> <li>• Describe how changes in concentration will affect reaction rates given the rate equation</li> <li>• Use rate equations to determine reaction rates or rate constants (with units) using initial rate data</li> <li>• Students use a graph of concentration–time and calculate the rate constant of a zero-order reaction by determination of the gradient.</li> <li>• Students can measure the activation energy for the catalysed and uncatalysed reaction of iodine with peroxodisulphate(VI) ions by experiment and plotting graphs</li> </ul>	

### 3.1.9.2 Determination of rate equation

Learning objective	Learning Outcome	Learning activity with opportunity to develop skills	Practical
<p>Understand that rate equations have to be determined by experiment.</p> <p>Link rate equations to mechanisms.</p> <p>Determine rate using concentration-time graphs.</p> <p>Use rate-concentration graphs to deduce order for a reagent.</p>	<p><b>Students should be able to:</b></p> <ul style="list-style-type: none"> <li>• explain that rate equations can only be determined by experiment</li> <li>• use concentration-time graphs to find rates (including initial rates)</li> <li>• use initial rate data to determine rate equations</li> <li>• use rate-concentration data/graphs to find orders of reaction with respect to a reagent</li> <li>• link rate equations to mechanism and determine rate determining steps.</li> </ul>	<ul style="list-style-type: none"> <li>• Determine rate equations, rate constants (with units) using initial rate data</li> <li>• Students do the iodine clock reaction and determine the order of reaction for a reactant</li> <li>• - Plot and interpret graphs; PS 3.2 - Process and analyse data using appropriate mathematical skills</li> <li>• Translate information between graphical, numerical and algebraic forms;</li> <li>• Plot two variables from experimental or other data.</li> <li>• Determine the slope and intercept of a linear graph AT a, k, l).</li> <li>• Students can react calcium carbonate or magnesium with acid of different concentrations and plot volume of gas formed against time for continuous monitoring. Initial rates could be found from these plots and compared</li> <li>• Identify variables including those that must be controlled; PS 3.1 - Plot and interpret graphs;</li> <li>• - Process and analyse data using appropriate mathematical skills; MS3.1 - Translate information between graphical, numerical and algebraic forms;</li> <li>• Plot two variables from experimental or other data;</li> <li>• Determine the slope and intercept of a linear graph;</li> <li>• Calculate rate of change from a graph showing a linear relationship; Draw and use the slope of a tangent to a curve as a measure of rate of change.</li> <li>• Students would be given data to plot and interpret in terms of order with respect to a reactant.</li> <li>• Alternatively, students could just be given appropriate graphs and asked to derive order(s)</li> <li>• Students calculate the rate constant of a zero-order reaction by determining the gradient of a concentration–time graph</li> <li>• Determine the slope and intercept of a linear graph;</li> <li>• Calculate rate of change from a graph showing a linear relationship).</li> <li>• Students plot concentration–time graphs from collected or supplied data and draw an appropriate best-fit curve. Students draw tangents to such curves to deduce rates at different times</li> <li>• - Draw and use the slope of a tangent to a curve as a measure of rate of change).</li> </ul>	<p><b>Required practical 7:</b> Measure the rate of a reaction by an initial rate method, and a continuous monitoring method.</p>

### 3.1.10 Equilibrium constant $K_p$ for homogeneous systems

Learning objective	Learning Outcome	Learning activity with opportunity to develop skills	Practical
<p>Week 3: 16/09/24 To 23/09/24</p> <p>Understand the concept of and calculate partial pressures using mole fractions.</p> <p>Write expressions for and calculate <math>K_p</math> including units.</p> <p>Perform calculations involving <math>K_p</math>.</p> <p>Predict how changes in conditions affect the position of an equilibrium and the value of <math>K_p</math>.</p> <p>The effect of a catalyst affects an equilibrium and <math>K_p</math>.</p>	<p><b>Students should be able to:</b></p> <ul style="list-style-type: none"> <li>• calculate equilibrium quantities, mole fractions and partial pressures for equilibrium mixtures</li> <li>• write an expression for <math>K_p</math> for a reaction and calculate the value of <math>K_p</math> with units</li> <li>• predict and justify how changes in temperature and pressure affect the position of an equilibrium, and how this may or may not affect the value of <math>K_p</math></li> <li>• understand how a catalyst affects an equilibrium and the value of <math>K_p</math>.</li> </ul>	<ul style="list-style-type: none"> <li>• Given initial amounts of substances and one substance at equilibrium, find the quantity of each reagent at equilibrium</li> <li>• Calculate mole fractions and then partial pressures in order to determine <math>K_p</math>, with units</li> <li>• Substitute numerical values into algebraic equations using appropriate units for physical quantities).</li> <li>• For given equilibria with enthalpy change data, predict the effect on the position of an equilibrium and the value of <math>K_p</math>.</li> </ul>	

### 3.1.11.1 Electrode potentials and cells

Learning objective	Learning Outcome	Learning activity with opportunity to develop skills	Practical
	<p><b>Students should be able to:</b></p> <ul style="list-style-type: none"> <li>• understand that there is a potential difference between two half cells (electrodes) that are joined</li> <li>• use cell notation to represent cells</li> <li>• understand that potentials are measured relative to the Standard Hydrogen Electrode</li> <li>• understand that the potential of an electrode is affected by conditions</li> <li>• know the standard conditions under which potentials are measured</li> <li>• know that electrode potential is listed in order in the electrochemical series</li> <li>• use the electrochemical series to predict the direction of simple redox reactions.</li> </ul>	<ul style="list-style-type: none"> <li>• Students make simple cells and use them to measure EMF and unknown electrode potentials</li> <li>• Solve problems set in practical contexts;</li> <li>• Set up electrochemical cells and measuring voltages).</li> <li>• Students write the standard cell notation for cells.</li> <li>• Students predict how changes in conditions will affect EMF .</li>   <li>• Students could use <math>E</math> values to predict the direction of simple redox reactions, then test these predictions by simple test-tube reactions</li> </ul>	<ul style="list-style-type: none"> <li>• Students could be asked to plan and carry out an experiment to investigate the effect of changing conditions, such as concentration or temperature, in a voltaic cell such as <math>Zn Zn^{2+}  Cu^{2+} Cu</math> (AO2 - Apply knowledge and understanding;</li> </ul>

### 3.1.11.2 Commercial applications of electrochemical cells

Learning objective	Learning Outcome	Learning activity with opportunity to develop skills	Practical
<p>That cells can be used as a source of energy.</p> <p>That cells can be non-rechargeable or rechargeable.</p> <p>That fuel cells can be used to generate an electric current.</p> <p>That there are benefits and risks associated with using these cells.</p>	<p><b>Students should be able to:</b></p> <ul style="list-style-type: none"> <li>• calculate the EMF and cell reaction for a commercial cell given the half-equations</li> <li>• explain how some cells can be recharged</li> <li>• explain how a hydrogen fuel cell works</li> <li>• evaluate the benefits and risks associated with using non-rechargeable, rechargeable and fuel cells.</li> </ul>	<ul style="list-style-type: none"> <li>• Students make simple cells and use them to measure EMF and unknown electrode potentials</li> <li>• Students write the standard cell notation for cells</li>   <li>• Students predict how changes in conditions will affect EMF</li>   <li>• Students could be asked to plan and carry out an experiment to investigate the effect of changing conditions, such as concentration or temperature, in a voltaic cell such as <math>Zn Zn^{2+}  Cu^{2+} Cu</math></li> <li>• - Apply knowledge and understanding to Solve problems set in practical contexts; PS 2.4 - Identify variables including those that must be controlled).</li> <li>• Students could use <math>E</math> values to predict the direction of simple redox reactions, then test these predictions by simple test-tube reactions..</li> </ul>	<p><b>Required practical 8:</b> Measuring the EMF of an electrochemical cell</p>

### 3.1.12 Acids and bases

#### 3.1.12.1 Brønsted-Lowry acid-base equilibria in aqueous solutions

Learning objective	Learning outcome	Learning activity with opportunity to develop skills	Practical
<p>Week 4: 23/09/24 To 30/09/24</p> <p>The idea of acids as proton donors and bases as proton acceptors.</p>	<p><b>Students should be able to:</b></p> <ul style="list-style-type: none"> <li>define Brønsted-Lowry acids and bases</li> <li>identify species as Brønsted-Lowry acids or bases in proton transfer reactions.</li> </ul>	<ul style="list-style-type: none"> <li>Identify which species acts as the acid and which as the base in Brønsted-Lowry acid-base reactions (AO2 - Apply knowledge and understanding).</li> </ul>	

#### 3.1.12.2 Definition and determination of pH

Learning objective	Learning outcome	Learning activity with opportunity to develop skills	Practical
<p>Calculate the pH of strong acids from concentration and vice versa.</p>	<p><b>Students should be able to:</b></p> <ul style="list-style-type: none"> <li>calculate pH of a strong acid from its concentration</li> <li>calculate the concentration of a strong acid from its pH</li> <li>calculate the pH of when a strong acid is diluted.</li> </ul>	<ul style="list-style-type: none"> <li>Identify acids as being strong or weak and monoprotic or diprotic (AO2 - Apply knowledge and understanding).</li> <li>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).</li> <li>Calculate the concentration of strong acids from the 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).</li> </ul>	

### 3.1.12.3 The ionic product of water $K_w$

Learning objective	Learning outcome	Learning activity with opportunity to develop skills	Practical
Use $K_w$ to calculate the pH of strong bases.	<p><b>Students should be able to:</b></p> <ul style="list-style-type: none"> <li>show that <math>K_w = [H^+][OH^-]</math></li> <li>use <math>K_w</math> to find the pH of strong bases from its concentration, and vice versa</li> <li>calculate the pH of water at different temperatures</li> </ul>	<ul style="list-style-type: none"> <li>Derive the expression <math>K_w = [H^+][OH^-]</math> (AO1 - Demonstrate knowledge and understanding).</li> <li>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).</li> <li>Calculate the pH of water at different temperatures (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).</li> <li>Explain how the pH and neutrality of water is or is not affected by changes in temperature (AO2 - Apply knowledge and understanding).</li> </ul>	

### 3.1.12.4 Weak acids and bases; $K_a$ for weak acids

Learning objective	Learning outcome	Learning activity with opportunity to develop skills	Practical
<p><b>Week 5:</b> 30/09/24 To 07/10/24</p> <p>Understand the term <i>weak</i> in relation to acids and bases.</p> <p>Use <math>K_a</math> to find the pH of weak acids from the concentration and vice versa.</p> <p>Relate <math>K_a</math> to <math>pK_a</math></p>	<p><b>Students should be able to:</b></p> <ul style="list-style-type: none"> <li>write expressions for <math>K_a</math> for stated weak acids</li> <li>perform calculations linking <math>K_a</math> to concentration and pH</li> <li>convert <math>K_a</math> values to <math>pK_a</math> and vice versa</li> <li>calculate the pH of water at different temperatures.</li> </ul>	<ul style="list-style-type: none"> <li>Explain the difference between strong and weak acids and bases (AO1 - Demonstrate knowledge and understanding).</li> <li>Derive expressions for <math>K_a</math> for stated acids</li> <li>Perform calculations linking <math>K_a</math> to concentration and pH</li> <li>- Use calculators to find and use power, exponential and logarithmic functions;</li> <li>- Use logarithms in relation to quantities that range over several orders of magnitude).</li> <li>Convert <math>K_a</math> values to <math>pK_a</math> and vice versa, and use these values to rank acids in order of strength</li> <li>- Use calculators to find and use power, exponential and logarithmic functions;</li> <li>- Use logarithms in relation to quantities that range over several orders of magnitude).</li> <li>Measure <math>K_a</math> of a weak acid by measuring pH at half neutralisation</li> <li>- Measure pH using pH charts, or pH meter, or pH probe on a data logger;</li> <li>- Know and understand how to use a wide range of experimental and practical instruments, equipment and techniques.</li> </ul>	

### 3.1.12.5 pH curves, titrations and indicators

Learning objective	Learning outcome	Learning activity with opportunity to develop skills	Practical
<p>Calculate the pH of the solution formed when strong or weak acids react with strong bases.</p> <p>Sketch pH curves and choose suitable indicators for titrations.</p>	<p><b>Students should be able to:</b></p> <ul style="list-style-type: none"> <li>calculate pH of a mixture of a strong acid with a strong base</li> <li>calculate the pH of a mixture of a weak acid with a strong base</li> <li>sketch pH curves for titrations of strong/weak acids with strong/weak bases</li> <li>choose a suitable indicator for acid-base titrations.</li> </ul>	<ul style="list-style-type: none"> <li>Perform calculations to find the pH of mixtures of strong/weak acids with strong bases, with either excess acid or base</li> <li>Use calculators to find and use power, exponential and logarithmic functions.</li> <li>Use logarithms in relation to quantities that range over several orders of magnitude).</li> <li>Produce pH curves by experiment</li> <li>Measure pH using pH charts, or pH meter, or pH probe on a data logger</li> <li>Sketch pH curves for given acid and base combinations, and choose a suitable indicator</li> </ul>	<p><b>Required practical 9:</b></p> <p>Investigate how pH changes when a weak acid reacts with a strong base and when a strong acid reacts with a weak base</p>
Extension		<ul style="list-style-type: none"> <li>Write spreadsheets to calculate the pH during a titration and to plot the pH curve</li> </ul>	

### 3.1.12.6 Buffer action

Learning objective	Learning outcome	Learning activity with opportunity to develop skills	Practical
<p><b>Week 6:</b> <b>07/10/24</b> <b>To</b> <b>14/10/24</b></p> <p>Know what buffer solutions are, how they are made and what they are used for.</p> <p>Explain how acidic and basic buffer solutions work.</p> <p>Calculate the pH of acidic buffer solutions.</p>	<p><b>Students should be able to:</b></p> <ul style="list-style-type: none"> <li>describe what a buffer solution is and how it is made</li> <li>explain qualitatively how acidic/basic buffer solutions work</li> <li>know some uses of buffer solutions</li> <li>calculate the pH of a buffer solution.</li> </ul>	<ul style="list-style-type: none"> <li>Describe how buffer solutions are made, how they work and what they are used for</li> <li>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</li> <li>Use logarithms in relation to quantities that range over several orders of magnitude).</li> <li>Students could prepare a solution of a specific pH and then test the solution to check its pH and buffer action</li> <li>Use calculators to find and use power, exponential and logarithmic functions</li> <li>Use logarithms in relation to quantities that range over several orders of magnitude</li> <li>Measure pH using pH charts, or pH meter, or pH probe on a data logger</li> <li>- Know and understand how to use a wide range of experimental and practical instruments, equipment and techniques).</li> </ul>	

## 3.2 Inorganic chemistry

### 3.2.4 Properties of Period 3 elements and their oxides

Learning objective	Learning outcome	Learning activity with opportunity to develop skills	Practical
<p>Reactions of Na and Mg with water.</p> <p>Reactions of Na, Mg, Al, Si, P and S with oxygen.</p> <p>Melting points of period 3 oxides.</p> <p>Reactions of period 3 oxides with water.</p>	<p><b>Students should be able to:</b></p> <ul style="list-style-type: none"> <li>describe and write equations for reactions of Na and Mg with water</li> <li>describe and write equations for reactions of Na, Mg, Al, Si, P and S with oxygen</li> <li>describe and explain the trend in melting points of period 3 oxides</li> <li>write equations for the reactions of period 3 oxides with water and describe the pH of the solutions formed</li> <li>describe the structure and bonding of period 3 oxides, and link this to how they react with water.</li> </ul>	<ul style="list-style-type: none"> <li>Practical opportunity: react specified period 3 elements with water and oxygen; react specified oxides with water.</li> <li>Plot a graph of melting points of period 3 oxides and annotate it with explanation of the relative melting points.</li> <li>Complete tables including equations to show how period 3 elements react with water and/or oxygen, and how period 3 oxides react with water.</li> </ul>	

### 3.2.5 Transition metals

#### 3.2.5.1 General properties of the transition metals

Learning objective	Learning outcome	Learning activity with opportunity to develop skills	Practical
<p><b>Week 7:</b> 14/10/24 to 21/10/24</p> <p>Give the electron structure of transition metals and their ions.</p> <p>Know the characteristic properties of transition metals.</p> <p>Understand the terms complex, ligand co-ordinate bond, and co-ordination number.</p>	<p><b>Students should be able to:</b></p> <ul style="list-style-type: none"> <li>write the electron structure of first row transition metals and their ions</li> <li>describe what a transition metal is in terms of electron structure</li> <li>describe the characteristic properties of transition metals</li> <li>define the terms ligand, complex, co-ordinate bond and co-ordination number.</li> </ul>	<ul style="list-style-type: none"> <li>State the electron structure of first row transition metals and their ions</li> <li>Explain why the elements Ti–Cu have properties characteristic of transition metals, and what those characteristics are</li> <li>Identify the oxidation state of the metal, the ligands and co-ordination number in a series of complexes</li> <li>Identify an element from the series Ti–Cu and find examples for that element to confirm its characteristic properties</li> </ul>	

### 3.2.5.2 Substitution reactions

Learning objective	Learning outcome	Learning activity with opportunity to develop skills	Practical
<p>Understand the different types of ligands.</p> <p>Understand ligand exchange.</p> <p>Know about oxygen transfer by haemoglobin.</p> <p>Understand the chelate effect.</p>	<p><b>Students should be able to:</b></p> <ul style="list-style-type: none"> <li>explain the difference between, and give examples of monodentate, bidentate and multidentate ligands</li> <li>explain what happens in a ligand substitution (exchange) reaction and why there may be a change in co-ordination number</li> <li>describe what haem is, how oxygen is carried in blood and why carbon monoxide is toxic</li> <li>describe and explain the chelate effect in terms of enthalpy and entropy changes.</li> </ul>	<ul style="list-style-type: none"> <li>Give examples of monodentate, bidentate and multidentate ligands</li> <li>Students should carry out substitution reactions of metal aqua complexes with monodentate ligands (from ammonia and concentrated hydrochloric acid) to consider whether there is a change in co-ordination number and whether all the water ligands are substituted (</li> <li>Students could carry out test-tube reactions of complexes with monodentate, bidentate and multidentate ligands to compare ease of substitution</li> </ul>	

### 3.2.5.3 Shapes of complex ions

Learning objective	Learning outcome	Learning activity with opportunity to develop skills	Practical
<p>Know the shapes of complexes with 2/4/6 ligands.</p> <p>Understand how complexes can show <i>cis-trans</i> (<i>E-Z</i>) or optical isomerism.</p>	<p><b>Students should be able to:</b></p> <ul style="list-style-type: none"> <li>sketch examples of octahedral, tetrahedral, square planar and linear complexes</li> <li>know how some complexes can show <i>cis-trans</i> (<i>E-Z</i>) or optical isomerism</li> <li>know the complexes in cisplatin and Tollen's reagent.</li> </ul>	<ul style="list-style-type: none"> <li>Give examples of and sketch the shape of octahedral, tetrahedral, square planar and linear complexes</li> <li>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).</li> <li>Explain how <i>cis-trans</i> (<i>E-Z</i>) isomerism arises in some octahedral and square planar complexes, including cisplatin, and draw the isomers.</li> <li>Explain how optical isomerism arises in some octahedral complexes with bidentate ligands, and draw the isomers</li> <li>Students can use Molymod kits to make models of isomers</li> <li>Use angles and shapes in regular 2D and 3D structures; MS4.2 - Visualise and represent 2D and 3D forms including two-</li> </ul>	

dimensional representations of 3D objects; MS4.3 - Understand the symmetry of 2D and 3D shapes).

### 3.2.5.4 Formation of coloured ions

Learning objective	Learning outcome	Learning activity with opportunity to develop skills	Practical
<p><b>Week 8:</b> 07/10/24 to 14/10/24</p> <p>Understand why transition metal ions are coloured and what affects the colour.</p> <p>Use colorimetry to measure concentration of solutions.</p>	<p><b>Students should be able to:</b></p> <ul style="list-style-type: none"> <li>• explain why transition metal complexes are coloured</li> <li>• describe factors that affect the colour of transition metal ions</li> <li>• describe how colorimetry can be used to find the concentration of coloured ions in solution.</li> </ul>	<ul style="list-style-type: none"> <li>• Explain using diagrams and the equation <math>\Delta E = h\nu (= hc/\lambda)</math> why transition metal complexes are coloured and what factors affect the colour</li> <li>• Use a graph of absorption versus concentration to determine the concentration of the solution.</li> <li>• Use a colorimeter to produce a calibration curve and then find the concentration of a coloured solution, eg containing copper(II) ions</li> <li>• Use appropriate apparatus to record a range of measurements; AT d –</li> <li>• 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).</li> </ul>	

### 3.2.5.5 Variable oxidation states

Learning objective	Learning outcome	Learning activity with opportunity to develop skills	Practical
<p>Know what happens when vanadate(V) is reduced by zinc in acidic solution.</p> <p>How the redox potential for a transition metal is affected by the pH and ligand.</p> <p>The reduction of silver (I) in Tollen's reagent to test for aldehydes.</p>	<p><b>Students should be able to:</b></p> <ul style="list-style-type: none"> <li>• describe and explain what happens when vanadate(V) ions are reduced by zinc in acidic solution</li> <li>• understand how the redox potential of a transition metal ion is affected by changes in pH and ligand</li> <li>• describe and explain the use of <math>\text{Ag}(\text{NH}_3)_2^+</math> in Tollen's reagent to distinguish between aldehydes and ketones</li> </ul>	<ul style="list-style-type: none"> <li>• Students should react an acidified solution of ammonium vanadate(V) with zinc to observe colour changes, identify vanadium species and write redox reactions for each reduction reaction (AO1 - Demonstrate knowledge and understanding; AT k - Safely and carefully handle solids and liquids, including corrosive, irritant, flammable and toxic substances; AT d).</li> <li>• Compare redox potentials for <math>\text{Cr}^{3+}</math> at different pH values and different ligands (AO2 - Apply knowledge and understanding).</li> <li>• Test aldehydes and ketones with Tollens reagent (AO1 - Demonstrate knowledge and understanding; AT k - Safely and carefully handle solids and liquids, including corrosive, irritant, flammable and toxic substances; AT d).</li> </ul>	

<p>Redox titrations, including calculations, of <math>\text{MnO}_4^-</math> with <math>\text{Fe}^{2+}</math> and <math>\text{C}_2\text{O}_4^{2-}</math> in acidic solution.</p>	<ul style="list-style-type: none"> <li>perform titrations and associated calculations for redox reactions of <math>\text{MnO}_4^-</math> with <math>\text{Fe}^{2+}</math> and <math>\text{C}_2\text{O}_4^{2-}</math> in acidic solution.</li> </ul>	<ul style="list-style-type: none"> <li>Carry out redox titrations, including associated titrations, of <math>\text{Fe}^{2+}</math> with <math>\text{MnO}_4^-</math> in acidic solution (eg analysis of iron in iron tablets, analysis of iron in lawn sand, analysis of iron in steel, finding the <math>M_r</math> of hydrated ammonium (II) sulfate) (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).</li> <li>Carry out redox titrations, including associated titrations, of <math>\text{C}_2\text{O}_4^{2-}</math> with <math>\text{MnO}_4^-</math> in acidic solution (eg finding the <math>M_r</math> of ethanedioic acid)</li> <li>- 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 –</li> <li>Evaluate results and draw conclusions with reference to measurement uncertainties and errors; MS2.3 – substitute numerical values into algebraic equations).</li> </ul>	
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### 3.2.5.6 Catalysts

Learning objective	Learning outcome	Learning activity with opportunity to develop skills	Practical
<p><b>Week 9:</b> 11/11/24 to 18/10/24</p> <p>Understand what heterogeneous catalysts are and how they work, including examples and how they can become poisoned.</p> <p>Understand what homogeneous catalysts are, with specific examples.</p>	<p><b>Students should be able to:</b></p> <ul style="list-style-type: none"> <li>describe what a heterogeneous catalyst is and the role of active sites and the support medium</li> <li>explain, with the aid of equations, how <math>\text{V}_2\text{O}_5</math>, acts as a catalyst in the Contact Process</li> <li>describe the use of Fe in the Haber process</li> <li>explain how heterogeneous catalysts can become poisoned</li> <li>describe what a homogeneous catalyst is and how reactions proceed through an intermediate species</li> <li>describe, with the aid of equations, how <math>\text{Fe}^{2+}</math> catalyses the reaction between <math>\text{I}^-</math> and <math>\text{S}_2\text{O}_8^{2-}</math></li> <li>describe, with the aid of equations, how <math>\text{Mn}^{2+}</math> catalyses the reaction between <math>\text{C}_2\text{O}_4^{2-}</math> and <math>\text{MnO}_4^-</math></li> </ul>	<ul style="list-style-type: none"> <li>Create a set of notes on how heterogeneous and homogeneous catalysts work, including the specific examples required:</li> <li><math>\text{V}_2\text{O}_5</math> in the contact process.</li> <li><math>\text{Fe}^{2+}</math> ions in the reaction of <math>\text{I}^-</math> with <math>\text{S}_2\text{O}_8^{2-}</math>.</li> <li><math>\text{Mn}^{2+}</math> ions in the reaction of <math>\text{C}_2\text{O}_4^{2-}</math> and <math>\text{MnO}_4^-</math></li> <li>Students could investigate <math>\text{Mn}^{2+}</math> as the autocatalyst in the reaction between ethanedioic acid and acidified potassium manganate(VII)</li> </ul>	

### 3.2.6 Reactions of ions in aqueous solution

Learning objective	Learning outcome	Learning activity with opportunity to develop skills	Practical
<p>The nature of meta-aqua ions.</p> <p>The relative acidity of metal-aqua ions.</p> <p>The reaction of metal-aqua ions (<math>\text{Fe}^{2+}</math>, <math>\text{Cu}^{2+}</math>, <math>\text{Al}^{3+}</math>, <math>\text{Fe}^{3+}</math>) with bases <math>\text{OH}^-</math>, <math>\text{NH}_3</math>, <math>\text{CO}_3^{2-}</math>.</p> <p>The character of metal hydroxides as basic or amphoteric.</p>	<p><b>Students should be able to:</b></p> <ul style="list-style-type: none"> <li>understand that metal ions exist as metal-aqua ions in aqueous solution</li> <li>the hydrolysis of metal-aqua ions in aqueous solution giving acidic solutions</li> <li>explain why <math>[\text{M}(\text{H}_2\text{O})_6]^{3+}</math> ions are more acidic than <math>[\text{M}(\text{H}_2\text{O})_6]^{2+}</math> ions</li> <li>describe and explain reactions of <math>[\text{M}(\text{H}_2\text{O})_6]^{2+}</math> (<math>\text{M} = \text{Cu}, \text{Fe}</math>) and <math>[\text{M}(\text{H}_2\text{O})_6]^{3+}</math> (<math>\text{M} = \text{Al}, \text{Fe}</math>) with the bases <math>\text{OH}^-</math>, <math>\text{NH}_3</math>, <math>\text{CO}_3^{2-}</math></li> <li>describe if and how metal hydroxides (<math>\text{Cu}(\text{II})</math>, <math>\text{Fe}(\text{II})</math>, <math>\text{Al}(\text{III})</math>, <math>\text{Fe}(\text{III})</math>) react with <math>\text{H}^+</math> and <math>\text{OH}^-</math>, and so whether these metal hydroxides are basic or amphoteric.</li> </ul>	<ul style="list-style-type: none"> <li>Students could measure the pH of solution of metal aqua ions (of equal concentration) and explain the difference in pH</li> <li>Students could complete a series of test-tube reactions of iron(II) and iron(III) ions with reagents such as <math>\text{Mg}</math>, <math>\text{Na}_2\text{CO}_3</math> to exemplify the difference in pH; AT d,k).</li> <li>Students could carry out test-tube reactions of metal-aqua ions with <math>\text{NaOH}</math>, <math>\text{NH}_3</math> and <math>\text{Na}_2\text{CO}_3</math></li> <li>Students could identify unknown substances (containing cations and anions on the specification) using reagents</li> <li>Students could produce precipitates of metal hydroxides and then test how they react with acid and alkali to determine whether they are basic or amphoteric</li> </ul>	<p><b>Required practical 11</b></p> <p>Carry out simple test-tube reactions to identify transition metal ions in aqueous solution.</p>

### 3.3 Organic Chemistry

#### 3.3.7 Optical isomerism

Learning objective	Learning outcome	Learning activity with opportunity to develop skills	Practical
<p>Week 10: 18/11/24 to 25/11/24</p> <p>The cause and nature of optical isomerism.</p> <p>The similarities and differences in the properties of enantiomers.</p> <p>The formation of racemic mixtures.</p>	<p><b>Students should be able to:</b></p> <ul style="list-style-type: none"> <li>explain the cause of optical isomerism</li> <li>identify molecules that exhibit optical isomerism/those that are optically active.</li> <li>draw pairs of optical isomers in 3D</li> <li>describe how enantiomers affect plane polarised light</li> <li>explain what a racemic mixture is, how they can be formed, and their effect on plane polarised light.</li> </ul>	<ul style="list-style-type: none"> <li>Students make models of mirror image molecules of some chiral and non-chiral molecules to see if they are non-superimposable or not (</li> <li>Students identify whether molecules exhibit optical isomerism, and where they do draw the two enantiomers in 3D</li> <li>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).</li> <li>Students could see how passing polarised light through a solution of sucrose affects the plane of the light (PS 1.2 - Apply scientific knowledge to practical contexts).</li> <li>Students could use Molymod models to show how a racemic mixture is formed when ethanal reacts with HCN</li> <li>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).</li> </ul>	

#### 3.3.8 Aldehydes and ketones

Learning objective	Learning outcome	Learning activity with opportunity to develop skills	Practical
<p>Know about the oxidation of aldehydes.</p> <p>Know about the reduction of aldehydes and ketones with NaBH<sub>4</sub>, including mechanism.</p> <p>Know about the reaction of aldehydes and ketones</p>	<p><b>Students should be able to:</b></p> <ul style="list-style-type: none"> <li>write equations and know reagents and conditions to oxidise aldehydes to carboxylic acids</li> <li>know how to distinguish aldehydes and ketones</li> <li>write equations, know reagents and conditions and outline the mechanism to reduce aldehydes</li> </ul>	<ul style="list-style-type: none"> <li>Students write equations for the oxidation of aldehydes (using reagents acidified potassium dichromate(VI) / Tollen's reagent / Fehling's solution) (AO2 - Apply knowledge and understanding).</li> <li>Students could carry out test-tube reactions of Tollen's reagent and Fehling's solution to distinguish aldehydes and ketones (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).</li> </ul>	

with KCN then acid, including mechanism.	<p>and ketones to alcohols with NaBH<sub>4</sub></p> <ul style="list-style-type: none"> <li>• write equations, know reagents and conditions and outline the mechanism for reaction of aldehydes and ketones with KCN and acid</li> <li>• understand why reaction of aldehydes and ketones with KCN followed by acid can form a racemic mixture</li> <li>• students understand the hazards of using KCN</li> </ul>	<ul style="list-style-type: none"> <li>• Students write equations and mechanisms for the reduction of aldehydes and ketones using NaBH<sub>4</sub> (AO2 - Apply knowledge and understanding).</li> <li>• Students write equations and mechanisms for the reaction of aldehydes and ketones with KCN followed by acid (AO2 - Apply knowledge and understanding).</li> <li>• Students could use Molymod models to show how a racemic mixture is formed when ethanol reacts with HCN (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).</li> <li>• Students could research why KCN/HCN are highly toxic (AO3 - Analyse, interpret and evaluate scientific information).</li> </ul>	
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### 3.3.9 Carboxylic acids and derivatives

#### 3.3.9.1 Carboxylic acids and esters

Learning objective	Learning outcome	Learning activity with opportunity to develop skills	Practical
<p>Week 11: 25/11/24 to 29/11/24</p> <p>Draw the structure of and name carboxylic acids and esters.</p> <p>Know that carboxylic acids are weak acids.</p> <p>Know how esters are made from carboxylic acids.</p> <p>Know some uses of esters.</p> <p>Know how esters are hydrolysed.</p>	<p><b>Students should be able to:</b></p> <ul style="list-style-type: none"> <li>• draw the structure of and name carboxylic acids and esters</li> <li>• know how carboxylic acids react with carbonates</li> <li>• write equations for the reaction of carboxylic acids with alcohols to form esters</li> <li>• know some common uses of esters</li> <li>• write equations for the hydrolysis of esters in acidic or alkaline conditions</li> <li>• understand the structure of animals fats and vegetable oils</li> <li>• know how soap and biodiesel are made and write equations for these reactions for specified fats/oils.</li> </ul>	<ul style="list-style-type: none"> <li>• Students draw and name carboxylic acids and esters (AO2 - Apply knowledge and understanding).</li> <li>• Students 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; 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).</li> <li>• Students research uses of esters and the presence of esters in fruit (AO2 - Apply knowledge and understanding).</li> <li>• Students write equations for the hydrolysis of given esters in acidic and alkaline conditions (AO2 - Apply knowledge and understanding).</li> <li>• Students make soap by hydrolysis of castor oil (AO2 - Apply knowledge and understanding; AT k - Safely and</li> </ul>	

<p>Know that vegetable oils and animal fats are esters of fatty acids and glycerol</p> <p>Know how soap and biodiesel are made from vegetable oil and animals fats</p>		<p>carefully handle solids and liquids, including corrosive, irritant, flammable and toxic substances; AT d).</p> <ul style="list-style-type: none"> <li>• Students make biodiesel (AO2 - Apply knowledge and understanding; AT k - Safely and carefully handle solids and liquids, including corrosive, irritant, flammable and toxic substances; AT d).</li> <li>• Students write equations for production of soap and/or biodiesel from specified fats/oils (AO2 - Apply knowledge and understanding).</li> <li>• Students could identify an unknown ester by determination of boiling point followed by hydrolysis and then purifying and finding the melting point of the carboxylic acid formed (eg for example methyl benzoate) (AO3 - Analyse, interpret and evaluate scientific information; 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).</li> </ul>	
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### 3.3.9.2 Acylation

Learning objective	Learning outcome	Learning activity with opportunity to develop skills	Practical
<p>Week 12: 02/12/24 to 09/12/24</p> <p>Draw the structure of and name acid anhydrides, acyl chlorides and amides.</p> <p>Understand acylation reactions of water, alcohols, ammonia and amines with acyl chlorides and acid anhydrides, including the mechanism for acyl chlorides.</p>	<p><b>Students should be able to:</b></p> <ul style="list-style-type: none"> <li>draw the structure of and name acid anhydrides, acyl chlorides and amides</li> <li>identify the products of and write equations for acylation reactions of water, alcohols, ammonia and amines with acyl chlorides and acid anhydrides</li> <li>outline the mechanism for the acylation reactions of acyl chlorides</li> <li>state advantages of using ethanoic anhydride rather than ethanoyl chloride in the production of aspirin</li> <li>prepare and purify an organic solid and test its purity.</li> </ul>	<ul style="list-style-type: none"> <li>Students draw and name acid anhydrides, acyl chlorides and amides (AO2 - Apply knowledge and understanding).</li> <li>Students write equations and outline mechanisms for acylation reactions of water, alcohols, ammonia and amines with acyl chlorides and acid anhydrides; some of these reactions could be demonstrated.</li> <li>Students prepare, purify and test the purity of aspirin by melting point determination (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.</li> </ul>	<p><b>Required practical 10</b> Preparation of - a pure organic solid and test of its purity - a pure organic liquid.</p>

### 3.3.10 Aromatic Chemistry

#### 3.3.10.1 Bonding

Learning objective	Learning outcome	Learning activity with opportunity to develop skills	Practical
<p>Understand the structure of benzene and evidence for delocalisation.</p>	<p><b>Students should be able to:</b></p> <ul style="list-style-type: none"> <li>describe the structure of benzene and explain how delocalisation makes benzene more stable than the theoretical cyclohexa-1,3,5-triene</li> <li>use thermochemical evidence from enthalpies of hydrogenation to account for this extra stability</li> <li>explain why benzene undergoes substitution reactions in preference to addition reactions.</li> </ul>	<ul style="list-style-type: none"> <li>Name a range of aromatic compounds with common functional groups (AO2 - Apply knowledge and understanding).</li> <li>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).</li> </ul>	

### 3.3.10.2 Electrophilic substitution

Learning objective	Learning outcome	Learning activity with opportunity to develop skills	Practical
<p>Week 10: 09/12/24 to 16/12/24</p> <p>Know nitration and Friedel-Crafts acylation reactions of aromatic compounds, including the mechanism and usefulness.</p>	<p><b>Students should be able to:</b></p> <ul style="list-style-type: none"> <li>• write equations and outline mechanisms for nitration and Friedel-Crafts acylation reactions of aromatic compounds. (including equations for the formation of electrophiles)</li> <li>• understand the usefulness of nitration and Friedel-Crafts acylation reactions</li> </ul>	<ul style="list-style-type: none"> <li>• Write equations (including for the formation of electrophiles) and mechanisms for nitration and Friedel-Crafts acylation reactions given the starting material and products</li> <li>• Students could carry out the preparation of methyl 3-nitrobenzoate by nitration of methyl benzoate, purification by recrystallisation and determination of melting point (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 - Safely and carefully handle solids and liquids, including corrosive, irritant, flammable and toxic substances).</li> </ul>	

### 3.3.11 Amines

#### 3.3.11.1 Preparation

Learning objective	Learning outcome	Learning activity with opportunity to develop skills	Practical
<p>Know how primary aliphatic amines are made from halogenoalkanes and from nitriles.</p> <p>Know how aromatic amines are produced and their use in making dyes.</p>	<p><b>Students should be able to:</b></p> <ul style="list-style-type: none"> <li>• write equations and give conditions for the preparation of primary aliphatic amines from both halogenoalkanes and nitriles</li> <li>• write equations and give conditions for the production of aromatic amines and identify their use in making dyes.</li> </ul>	<ul style="list-style-type: none"> <li>• Identify reagents and conditions and write equations to make specified primary aliphatic amines from halogenoalkanes and nitriles (</li> <li>• Identify reagents and conditions and write equations to make specified aromatic amines (AO2 - Apply knowledge and understanding).</li> <li>• Research the use of aromatic amines in making dyes (AO3 - Analyse, interpret and evaluate scientific information).</li> </ul>	
Christmas break		•	

### 3.3.11.2 Base properties

Learning objective	Learning outcome	Learning activity with opportunity to develop skills	Practical
Compare the base strength of amines.	<b>Students should be able to:</b> <ul style="list-style-type: none"><li>• place amines in order of base strength and explain this order.</li></ul>	<ul style="list-style-type: none"><li>• Given pairs of amines, students should identify the stronger base giving reasons for their choice (AO2 - Apply knowledge and understanding).</li></ul>	

### 3.3.11.3 Nucleophilic properties

Learning objective	Learning outcome	Learning activity with opportunity to develop skills	Practical
<p>Understand how amines react with halogenoalkanes, acyl chlorides and acid anhydrides, including mechanisms.</p>	<p><b>Students should be able to:</b></p> <ul style="list-style-type: none"> <li>• identify the various amines and quaternary ammonium salts formed when ammonia and amines react with halogenoalkanes</li> <li>• give the mechanism for reactions of ammonia and amines with halogenoalkanes</li> <li>• recognise the use of quaternary ammonium salts</li> <li>• identify the products of and write equations for acylation reactions of ammonia and amines with acyl chlorides and acid anhydrides</li> <li>• outline the mechanism for the acylation reactions</li> </ul>	<ul style="list-style-type: none"> <li>• 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).</li> <li>• Students could research the use of quaternary ammonium salts (AO3 - Analyse, interpret and evaluate scientific information).</li> <li>• Students 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 (AO2 - Apply knowledge and understanding).</li> <li>• Practical opportunity: The preparation of N-phenylethanamide.</li> </ul>	

### 3.3.12 Polymers

#### 3.3.12.1 Condensation polymers

Learning objective	Learning outcome	Learning activity with opportunity to develop skills	Practical
<p>Understand how condensation polymers are formed including linkages in polyesters and polyamides.</p> <p>Identify the repeating unit given monomer(s) and vice versa.</p>	<p><b>Students should be able to:</b></p> <ul style="list-style-type: none"> <li>• identify the repeating unit and linkages in polyesters and polyamides given the monomer(s)</li> <li>• identify monomer(s) needed to make a condensation polymer given the repeating unit</li> <li>• know the repeating units in Terylene, nylon 6,6 and Kevlar</li> <li>• know some uses of condensation polymers</li> <li>• explain the nature of the intermolecular forces between molecules of condensation polymers.</li> </ul>	<ul style="list-style-type: none"> <li>• Draw the structure of repeating units in polyesters and polyamides given the monomer(s) and vice versa (AO2 - Apply knowledge and understanding).</li> <li>• Students could make nylon 6,6 (AO2 - Apply knowledge and understanding); AT k - Safely and carefully handle solids and liquids, including corrosive, irritant, flammable and toxic substances; AT d).</li> <li>• Students could each make a model of a monomer using Molymods and then students collectively join them together to make a long polymer chain (AO2 - Apply knowledge and understanding).</li> </ul>	

#### 3.3.12.2 Biodegradability and disposal of polymers

Learning objective	Learning outcome	Learning activity with opportunity to develop skills	Practical
<p>Understand why polyalkenes are not biodegradable.</p> <p>Understand why polyesters and polyamides are biodegradable.</p> <p>Evaluate different methods of disposing of polymers.</p>	<p><b>Students should be able to:</b></p> <ul style="list-style-type: none"> <li>• explain why polyalkenes cannot be hydrolysed and so are non-biodegradable</li> <li>• explain why polyesters and polyamides can be hydrolysed and so are biodegradable</li> <li>• evaluate the advantages and disadvantages of different methods of disposing of polymers.</li> </ul>	<ul style="list-style-type: none"> <li>• Students can create a summary table to compare and explain the biodegradability of different types of polymers (AO1 - Demonstrate knowledge and understanding of scientific ideas).</li> <li>• Students can research and summarise different methods of disposing of polymers, including recycling, considering advantages, disadvantages and sustainability (AO3 - Analyse, interpret and evaluate scientific information).</li> </ul>	

### 3.3.13 Amino acids, proteins and DNA

#### 3.3.13.1 Amino acids

Learning objective	Learning outcome	Learning activity with opportunity to develop skills	Practical
<p>Understand the structure of amino acids.</p> <p>Draw the structure of given amino acids in acidic solution, alkaline solution and as zwitterions.</p>	<p><b>Students should be able to:</b></p> <ul style="list-style-type: none"> <li>draw the structure of given amino acids in acidic solution, alkaline solution and as zwitterions.</li> </ul>	<ul style="list-style-type: none"> <li>Given the structure of the amino acid, students show draw the structure of the species formed in acidic solution, alkaline solution and as a zwitterion (AO2 - Apply knowledge and understanding).</li> </ul>	

#### 3.3.13.2 Proteins

Learning objective	Learning outcome	Learning activity with opportunity to develop skills	Practical
<p>Understand the structure of proteins.</p> <p>Understand how peptide links can be hydrolysed to release amino acids.</p> <p>Know how to use thin-layer chromatography to separate and identify amino acids.</p>	<p><b>Students should be able to:</b></p> <ul style="list-style-type: none"> <li>describe the primary, secondary and tertiary structure of proteins, including the importance of hydrogen bonds and S-S bonds</li> <li>draw the structure of peptides formed from amino acids</li> <li>know that peptide link can be hydrolysed producing amino acids</li> <li>identify the amino acids given when a peptide is hydrolysed</li> <li>know that amino acids can be separated and identified by thin-layer chromatography, including the use of <math>R_f</math> values.</li> </ul>	<ul style="list-style-type: none"> <li>Draw the structure of peptides formed from joining amino acids together (AO2 - Apply knowledge and understanding).</li> <li>Identify amino acids formed when peptides are hydrolysed (AO2 - Apply knowledge and understanding).</li> <li>Identify the primary, secondary and tertiary parts of the structure of some proteins (AO2 - Apply knowledge and understanding).</li> <li>Students can carry out some thin-layer chromatography of some amino acids to identify an unknown amino acid (AO2 - Apply knowledge and understanding; AT i - Use thin-layer or paper chromatography).</li> </ul>	

### 3.3.13.3 Enzymes

Learning objective	Learning outcome	Learning activity with opportunity to develop skills	Practical
<p>Understand the structure of enzymes.</p> <p>Understand the action of enzymes in terms of active sites.</p> <p>Understand the principle of drug action and the use of computer aided design.</p>	<p><b>Students should be able to:</b></p> <ul style="list-style-type: none"> <li>• explain that enzymes are proteins which act through a stereospecific active site that binds to a substrate</li> <li>• 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.</li> </ul>	<ul style="list-style-type: none"> <li>• Use a right handed glove with their right/left hands to model enzyme action (AO2 - Apply knowledge and understanding).</li> </ul>	

### 3.3.13.4 DNA

Learning objective	Learning outcome	Learning activity with opportunity to develop skills	Practical
<p>Understand the structure of the components of DNA (given on data sheet).</p> <p>Understand the nature of nucleotides.</p> <p>Understand the structure of single DNA strands and the arrangement of these together in the double helix structure.</p>	<p><b>Students should be able to:</b></p> <ul style="list-style-type: none"> <li>• identify the components of DNA</li> <li>• explain how the two DNA strands interact with hydrogen bonds between base pairs.</li> </ul>	<ul style="list-style-type: none"> <li>• Make a 2D or 3D model of DNA using cut out components (AO2 - Apply knowledge and understanding).</li> <li>• Label a diagram of DNA to show the components and the hydrogen bonding between base pairs (AO1 - Demonstrate knowledge and understanding of scientific ideas).</li> </ul>	

## 3.3.13.5 Action of anti-cancer drugs

Learning objective	Learning outcome	Learning activity with opportunity to develop skills	Practical
Understand how DNA replicates and how anti-cancer drug cisplatin prevents this.	<p><b>Students should be able to:</b></p> <ul style="list-style-type: none"> <li>describe how DNA replicates in simple terms</li> <li>explain how the anti-cancer drug cisplatin prevents DNA replication</li> <li>explain why some drugs can have adverse effects and appreciate the balance between benefits and adverse effects of any drug.</li> </ul>	<ul style="list-style-type: none"> <li>Write notes to accompany a sequence of diagrams showing DNA replication (AO1 - Demonstrate knowledge and understanding of scientific ideas).</li> <li>Write notes to accompany a diagram showing the action of cisplatin (AO1 - Demonstrate knowledge and understanding of scientific ideas).</li> <li>Evaluate the benefits and adverse effects of using drugs such as cisplatin (AO3 - Analyse, interpret and evaluate scientific information).</li> </ul>	

## 3.3.14 Organic synthesis

Learning objective	Learning outcome	Learning activity with opportunity to develop skills	Practical
Devise synthetic routes to make specified compounds.	<p><b>Students should be able to:</b></p> <ul style="list-style-type: none"> <li>devise synthetic routes, with up to four steps, to make specific organic compounds using the reactions in the specification</li> <li>explain why processes are designed to avoid solvents, non-hazardous starting materials and have steps with high atom economy.</li> </ul>	<ul style="list-style-type: none"> <li>Devise synthetic routes, including reaction conditions, to make organic compounds using reactions in the specification (AO2 - Apply knowledge and understanding).</li> <li>Describe features of processes that improve sustainability (AO3 - Analyse, interpret and evaluate scientific information).</li> </ul>	

### 3.3.15 Nuclear magnetic resonance spectroscopy

Learning objective	Learning outcome	Learning activity with opportunity to develop skills	Practical
<p>Using <math>^1\text{H}</math> and <math>^{13}\text{C}</math> NMR to deduce information about the structure of organic molecules.</p> <p>Understand similarities and differences between <math>^1\text{H}</math> and <math>^{13}\text{C}</math> NMR.</p> <p>Understand the use of TMS and suitable solvents.</p>	<p><b>Students should be able to:</b></p> <ul style="list-style-type: none"> <li>understand the use of TMS and the <math>\delta</math> scale for chemical shift</li> <li>understand the use of deuterated solvents or <math>\text{CCl}_4</math></li> <li>use the n+1 rule to deduce spin-spin splitting patterns of adjacent, non-equivalent protons in aliphatic compounds</li> <li>deduce the structure of compounds using <math>^1\text{H}</math> NMR to deduce structures including the number, position, relative intensity and splitting of signals</li> <li>deduce the structure of compounds using <math>^{13}\text{C}</math> NMR to deduce structures including the number and position of signals.</li> </ul>	<ul style="list-style-type: none"> <li>Predict the number, position, relative intensity and splitting of signals in the <math>^1\text{H}</math> NMR spectrum of compounds</li> <li>Predict the number and position of signals in the <math>^{13}\text{C}</math> NMR spectrum of compounds (AO2 - Apply knowledge and understanding).</li> <li>Use data from NMR, and other analytical methods on the specification, to deduce the structure of compounds (AO2 - Apply knowledge and understanding; MS3.1 Translate information between graphical, numerical and algebraic forms).</li> </ul>	

### 3.3.16 Chromatography

Learning objective	Learning outcome	Learning activity with opportunity to develop skills	Practical
<p>Describe the similarities and differences between thin-layer, column and gas chromatography.</p> <p>Explain how chromatography works.</p>	<p><b>Students should be able to:</b></p> <ul style="list-style-type: none"> <li>describe the similarities and differences between thin-layer, column and gas chromatography</li> <li>explain how chromatography works</li> <li>use retention times and <math>R_f</math> values to identify substances</li> <li>describe the use of mass spectroscopy to analyse substances separated by gas chromatography.</li> </ul>	<ul style="list-style-type: none"> <li>Produce a summary to compare similarities and differences between thin-layer, column and gas chromatography (AO1 - Demonstrate knowledge and understanding of scientific ideas).</li> <li>Separate mixtures and identify substances (eg amino acids) by thin-layer chromatography (AO2 - Apply knowledge and understanding; AT i -</li> </ul>	<p><b>Required practical 12</b> Separation of species by thin-layer chromatography</p>

<p>Use chromatography to separate and identify substances.</p>		<p>Use thin-layer or paper chromatography).</p> <ul style="list-style-type: none"><li>• Use retention time and <math>R_f</math> data to identify substances separated by chromatography.</li></ul>	
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