Chemistry Key Stage 4

Curriculum map

OAK NATIONAL ACADEMY

1. Philosophy

Six underlying attributes at the heart of Oak's curriculum and lessons.

Lessons and units are **knowledge and vocabulary rich** so that pupils build on what they already know to develop powerful knowledge.

Knowledge is **sequenced** and mapped in a **coherent** format so that pupils make meaningful connections.

Our **flexible** curriculum enables schools to tailor Oak's content to their curriculum and context.

Our curriculum is **evidence informed** through rigorous application of best practice and the science of learning.

We prioritise creating a **diverse** curriculum by committing to diversity in teaching and teachers, and the language, texts and media we use, so all pupils feel positively represented.

Creating an **accessible** curriculum that addresses the needs of all pupils is achieved to accessibility guidelines and requirements.

2. Units

KS4 Chemistry is formed of 10 units and this is the recommended sequence:

Unit Title	Recommended year group	Number of lessons
1 Atomic structure and periodic table	Year 10	20
2 Bonding, structure and the properties of Matter	Year 10	13
3 Quantitative Chemistry	Year 10	14
4 Chemical changes	Year 10	22
5 Energy changes	Year 10	10
6 The rate and extent of chemical change	Year 11	16
7 Organic Chemistry	Year 11	13
8 Chemical analysis	Year 11	12
9 Chemistry of the atmosphere	Year 11	8

3. Lessons

Unit 1 Atomic structure and periodic table — 20 Lessons

Lesson number	Lesson question	Pupils will learn
1.	**Atoms, elements and compounds**	• Define elements and compounds and identify them from diagrams • Name compounds from word equations and formulae • Identify reactants and products in equations
2.	**Chemical formulae and conservation of mass**	• Interpret chemical formulae • Apply conservation of mass to equations
3.	**Mixtures, filtration and crystallisation**	• Define, identify and describe mixtures • Explain the steps in the separation of mixtures of soluble and insoluble substances • Explain how mixtures of soluble and insoluble substances are represented and recognised

4.	**Separation by distillation**	• Describe how to separate a mixture of two or more liquids, identifying key equipment • Explain the processes and equipment involved • Apply particle theory to distillation
5.	**Separation by chromatography**	• Describe the process of chromatography • Carry out the chromatography of chlorophyll, explaining key steps • Interpret chromatograms
6.	**Atomic structure**	• Describe atoms using the nuclear model • State the charges and mass of the three subatomic particles • Use the periodic table to calculate the number of protons, neutrons and electrons for any given element
7.	**Development of the atomic model**	• Describe the development of the atomic model • Compare the nuclear model with the plum pudding model • Explain how new evidence from the scattering experiment led to a change in the atomic model

8.	**Isotopes**	• Define an isotope • Compare isotopes based on information given • Calculate RAM of isotopes given their abundance and give answers to a specified number of significant figures or decimal places
9.	**Isotopes case study lesson**	• Describe the work of Marie Curie and Frederick Soddy and explain how their work contributed to our understanding of isotopes and the atomic model
10.	**Electron Configuration and the Periodic Table**	• Describe what keeps electrons in their orbits • Draw and write the electron configuration for any of the first 20 elements • Describe the link between outer shell electron number, number of shells and location in the periodic table
11.	**Periodic Table development**	• Describe the layout of the modern periodic table • Compare the early versions of the periodic table with the modern one • Explain how the periodic table was developed as ideas changed

12.	**Why elements react**	• Explain the difference between metals and non-metals in terms of reactions and electrons • Explain why group 0 do not react in terms of electrons • Describe trends in physical properties of group 0
13.	**Group 1**	• Describe physical and chemical properties of the group 1 elements • Write equations to represent their reaction with water • Describe and explain trends in the properties and reactivity of group 1 elements
14.	**Group 7**	• Describe trends in physical properties of group 7 elements • Explain the trend in physical properties of group 7 elements
15.	**Group 7 Displacement**	• Describe trends in reactivity going down group 7 • Describe the results of a series of reactions of group 7 elements and their compounds • Write word and symbol equations to represent some reactions involving group 7 elements

16.	**Comparing the reactivities of Group 1 and 7 elements**	• Use electron configuration to explain the trends in reactivity in group 1 and 7 • Compare the trends in reactivity in group 1 and 7
17.	**Displacement reactions: Ionic equations**	• Write ionic equations for the displacement reactions
18.	**Transition elements**	• Describe typical properties of the transition elements • Compare transition elements and their compounds with those of with group 1 • Give uses of transition metals linked to their properties
19.	**Review (Part 1)**	• Revision of atomic structure and the maths skills covered in the unit
20.	**Review (Part 2)**	• Revision of separation techniques and the command words 'describe' and 'explain' in exam questions

Unit 2 Bonding, structure and the properties of Matter

13 Lessons

Lesson number	Lesson question	Pupils will learn
1.	**Ionic bonding introduction**	• Describe the formation of ions • Link the charge of ions to the place in the periodic table
2.	**Further ionic bonding**	• Describe the formation of an ionic bond • Represent ionic bonding using diagrams • Write formula for ionic compounds
3.	**Properties of ionic compounds**	• Describe some of the properties of ionic compounds • Explain some of the properties of ionic compounds using knowledge of the structure
4.	**Covalent bonding**	• Define a covalent bond • Draw and describe covalent bonds using structural, ball and stick and displayed formula • Describe the limitations of the different models

5.	**Simple covalent molecules**	• Explain why some covalent substances form molecules and others form giant structures • Describe the properties of simple covalent molecule • Explain their properties in terms of bonding
6.	**The giant covalent structures**	• Explain why some covalent substances form molecules and others form giant structures • Describe the properties of diamond and graphite • Explain the properties using knowledge of the bonding and structure • Relate properties of these carbon allotropes to their uses
7.	**Giant covalent structures: Graphene**	• Describe the structure of graphene and fullerenes • Describe and explain their properties • Describe the work of the scientists who discovered graphene
8.	**Polymers**	• Describe the structure of polymers • Explain the properties of polymers • Draw the formation of polymers given the monomer

9.	**Review (Part 1)**	• Review the content covered on ionic and covalent bonding • Compare the properties of ionic and covalent substances
10.	**Metallic bonding**	• Describe the structure and bonding of metals • Describe and explain the properties of metals • Explain why alloys are harder than pure metals
11.	**Solids, liquids and gases**	• Predict the state of substances at different temperatures, and the type of bonding present given melting and boiling point data • Describe what happens in terms of particles and forces during a change of state • (Higher tier only) Explain the limitations of the particle model in relation to changes of state
12.	**Nanoparticles (Triple Chemistry only)**	• Compare the dimensions of different sized particles • Describe some uses of nanoparticles • Evaluate the use of nanoparticles given appropriate information

13. Review (Part 2)

- Review ionic, covalent and metallic bonding
- Relate properties to their bonding
- Relate properties to their uses

Unit 3 Quantitative Chemistry

14 Lessons

Lesson number	Lesson question	Pupils will learn
1.	**Relative formula mass (FT only)**	• Use the periodic table and formulae to determine the relative formula mass of compounds • Work out percentage of given elements in a compound • Work out the mass of a particular element in a given mass of a compound
2.	**Relative formula mass (HT only)**	• Use the periodic table and formulae to determine the relative formula mass of compounds • Work out percentage of given elements in a compound • Work out the mass of a particular element in a given mass of a compound
3.	**Moles and Avogadro's constant (HT only)**	• Use 'Mass = Mr x moles' to find any one value given the other two • Use Avogadro's constant to calculate number of atoms/molecules in a given mass • Calculate the mass of a given number of atoms using the Avogadro constant

4.	**Balancing equations using moles (HT only)**	• Write chemical formulae using knowledge of ion charges • Balance equations using the same number of atoms rule • Balance equations using moles
5.	**Reacting masses (HT only)**	• Predict the mass of product from a specified starting mass • Use a balanced equation to work out the quantity of reacting elements needed to produce a specified quantity of product
6.	**Reacting masses and yield (GCSE Chemistry)**	• Predict the mass of product from a specified starting mass • Use a balanced equation to work out the quantity of reacting elements needed to produce a specified quantity of product • (GCSE Chem only) Calculate the yield and suggest why the mass obtained may be less than that calculated
7.	**Atom economy**	• Balance equations using same number of atoms and moles • Calculate atom economy for given reactions • Choose and justify a reaction pathway

8.	**Concentration**	• Define the term 'concentration' • Calculate concentration from mass and volume • Work out the mass of a substance in a given volume of a solution of a known concentration
9.	**Titration calculations**	• Calculate mean volumes from experimental results • Calculate the uncertainty in the readings • Calculate the concentration of an unknown using a balanced equation and volumes of reacting solutions
10.	**Limiting reactants**	• Define a limiting reactant • Describe the effect of a limiting reactant on the amount of products it is possible to produce • Calculate the limiting reactant from a balanced symbol equation
11.	**Gas Volumes**	• Calculate the volume of a gas at room temperature and pressure from its mass and formula mass • Calculate volumes of gaseous reactants and products from a given volume of a gaseous reactant or product

12.	**Review (HT only)**	• Review of higher tier calculations content
13.	**Review (GCSE Chemistry)**	• Review of triple biology only content
14.	**Practical application of quantitative chemistry**	• Extension review on choosing the right concentration to make a named salt, covering limiting reactant, reacting mass, yield and atom economy

Unit 4 Chemical changes

22 Lessons

Lesson number	Lesson question	Pupils will learn
1.	**Redox**	• Describe oxidation and reduction in terms of oxygen • Identify where oxidation and reduction have happened given an equation • Explain how carbon can be used to extract metals from their ores using redox reactions
2.	**Investigating the reactivity of metals**	• Identify variables to change, measure and control to test the reactivity of metals • Write equations for the reactions of acids and metals, naming salts • Use observations to order metals in terms of reactivity
3.	**Displacement reactions of metals**	• Explain how the reactivity of a metal is related to forming ions • Record observations on whether or not displacement reactions occur • Write equations for displacement reactions

4.	**Redox (Higher tier)**	• Define redox in terms of electrons • Identify species that are oxidised or reduced in reactions • Write half equations to represent the reactions
5.	**Acid base reactions**	• Write word equations to represent the reactions of metal oxides and acids • Explain steps in a given method to produce a pure, dry sample of a soluble salt • Use ion charges to write formulae for salts
6.	**Observations from acid base reactions**	• Write equations to represent the reactions of metal carbonates and acids • Describe evidence for a chemical reaction • Describe the test for carbon dioxide and its positive result
7.	**Acid base ionic equations**	• Write balanced symbol equations for acid base reaction • Write ionic equations for acid base reactions

8.	**Making salts**	• Suggest corrections to a given method to make a salt • Write a method to prepare a salt using a metal carbonate or metal oxide • Write equations for the reactions
9.	**Acids, alkalis and the pH scale**	• Describe the use of universal indicator to classify substances and measure approximate pH values • Evaluate the use of universal indicator and suggest why a pH probe may be more accurate • Write equations to represent the reaction of acids and alkalis, including the ionic equation • Process secondary data, calculating means and uncertainty
10.	**Strong and weak acids**	• Describe how to use an indicator to classify substances as strong or weak acids • Explain what strong, weak, concentrated and dilute acids are • Make order of magnitude calculations to describe changes in pH

11.	**Titrations**	• Describe a method to find the concentration of an unknown acid or alkali • Explain the steps in the method
12.	**Processing titration results**	• Calculate means, uncertainties, and dealing with anomalies appropriately • Calculate the concentration of an unknown acid or alkali from data and equations provided • Suggest ways of improving the accuracy of a method
13.	**Electrolysis of molten compounds**	• Define the terms 'electrolysis' and 'electrolytes' • Describe the movement of ions during electrolysis • Explain what happens at the electrodes during electrolysis
14.	**Extraction of aluminium**	• Explain the use of electrolysis to extract metals • Describe the extraction of Aluminium from its ore, including the use of a mixture and the need to continually replace the anode • Explain why electrolysis is so expensive and describe measures that can be taken to reduce this

15.	**Electrolysis of solutions**	• Predict the products of the electrolysis of given solutions • Electrolyse solutions of ionic compounds and identify the products • Explain how the products are obtained
16.	**Developing an electrolysis hypothesis**	• Develop a hypothesis to test • Electrolyse given solutions, collecting and identifying the products • Apply knowledge to other related hypotheses
17.	**Electrolysis half equations**	• Write ionic equations for the reactions at the electrodes • Identify chemical species that are oxidised or reduced
18.	**Reactivity and acid base reactions review**	• Review of the content on reactivity, acid base reactions and making salt • Define endothermic and exothermic reactions and give examples of each type
19.	**Electrolysis review**	• Review of learning on electrolysis, metal extraction and electrolysis of solutions

20.	**Chemical change higher tier review**	• Revision of higher tier content in the unit, including redox and half equations and strong and weak acids
21.	**Humphry Davy and Laban Roomes applications of electrolysis**	• Describe the work of Humphrey Davey and Laban Roomes with electrolysis • Describe and explain products at the electrodes
22.	**Writing a method**	• Describe the key features of method writing • Write a method to test a hypothesis and write a procedural method

Unit 5 Energy changes

10 Lessons

Lesson number	Lesson question	Pupils will learn
1.	**Exothermic and endothermic reactions**	• Define endothermic and exothermic reactions and give examples of each type • Describe some everyday uses of exothermic and endothermic reactions • Evaluate applications of exothermic and endothermic reactions
2.	**Required Practical: Temperature change (Part 1)**	• Investigate one of the variables affecting the temperature change, identifying variables to change, measure and control • Process and display results appropriately
3.	**Required Practical: Temperature change (Part 2)**	• Draw conclusions from data provided • Explain the changes in temperature during the experiment • Evaluate the equipment and method used, explaining suggestions for improvement

4.	**Writing a method to test a hypothesis**	• Identify variables to change, measure and control • Write a method to test a given hypothesis • Design a table to collect and record results
5.	**Energy level diagrams**	• Draw and interpret energy level diagrams to represent endothermic and exothermic reactions • Define activation energy and label it on a diagram • Explain why reactions are endothermic or exothermic overall
6.	**Calculating bond energies**	• Calculate bond energy values and use them to predict whether a reaction will be exothermic or endothermic • Relate bond energies to the correct part of energy level diagrams • Explain why bond energy calculations have a margin of error

7.	**Fuel cells**	• Describe how cells and batteries can be made and how the voltage can vary • Describe how a fuel cell works • Write the half equations for the electrode reactions in a fuel cell • Evaluate the use of hydrogen fuel cells in comparison with rechargeable cells and batteries
8.	**Review combined**	• Review of the foundation and higher tier content
9.	**Review chemistry**	• Review of all content in the unit, including triple science
10.	**Case study**	• Look at the scientists and engineers using endothermic and exothermic reactions in their work

Unit 6 The rate and extent of chemical change

16 Lessons

Lesson number	Lesson question	Pupils will learn
1.	**Rate of reaction**	• Describe evidence for a chemical reaction • Describe how to measure rates of reaction • Calculate the rate of the reaction from data or graphs
2.	**Rate of reaction using graphs and tangents**	• Draw tangents to a curve • Use the tangent to calculate rate of reaction
3.	**Collision theory**	• Define activation energy • Describe factors that can affect the rate of reaction • Explain how these factors affect rate using collision theory
4.	**Planning an investigation to find rate of reaction**	• Write a method to test a hypothesis • Describe patterns in data • Explain patterns using collision theory

5.	**Rate of reaction required practical (Part 1)**	• Develop a hypothesis that can be tested • Display data appropriately • Describe and explain the effect of concentration on the rate of reaction
6.	**Rate of reaction required practical (Part 2)**	• Describe how to measure the rate of reaction using a change in colour or turbidity • Process and display data appropriately, explaining choice of graph • Describe and explain the effect of concentration on the rate of reaction • Check for reproducibility in data collected
7.	**Effect of changing surface area on rate of reaction**	• Identify variables to change, measure and control to test a hypothesis • Process and display data appropriately • Use the data to describe and explain the effect of changing surface area on the rate of reaction

8.	**Effect of changing temperature on rate of reaction**	• Describe and explain the effect of temperature on rates of reaction, using particle theory • Interpret secondary data on the effect of temperature on the rate of reaction • Explain the observations using particle theory
9.	**Effect of changing pressure on rate of reaction**	• Recognise reactions involving gases • Describe and explain the effect of pressure on gaseous reaction • Apply knowledge to novel reactions
10.	**Catalysts**	• Describe what a catalyst is and how it affects the rate of a reaction • Explain why more than one catalyst is often needed • Describe the test for oxygen gas • Draw a reaction profile for a reaction with and without a catalyst

11.	**Reversible reactions**	• Describe what is meant by a reversible reaction and how to represent it • Explain how reversible exothermic and endothermic reactions are linked • Explain what is meant by 'dynamic equilibrium'
12.	**Le Chatelier's principle: Effect of changing concentration and temperature**	• State and apply Le Chatelier's principle to any reversible reaction • Describe the effect on equilibrium of changes to temperature and concentration • Choose and explain the conditions needed to achieve a high yield
13.	**Le Chatelier's principle: Effect of changing pressure**	• Describe the effect on equilibrium of changes to pressure • Choose and explain the conditions needed to achieve a high yield

14.	**Le Chatelier's principle: Uses in industry**	• Explain the effect of changes in pressure on the equilibrium of gaseous reactions • Describe the conditions for optimum yield for a given reaction • Explain why optimum yield conditions are not always the ones chosen
15.	**The Rate and extent of chemical change: Review (Part 1)**	• Review of collision theory and rates of reaction
16.	**The Rate and extent of chemical change: Review (Part 2)**	• Review of higher tier content in the unit, including using tangents to calculate rates and Le Chatelier's principle

Unit 7 Organic Chemistry

13 Lessons

Lesson number	Lesson question	Pupils will learn
1.	**Crude oil and alkanes**	• Describe the composition of crude oil • Define and recognise hydrocarbons and recall their general formula • Draw and name the first four hydrocarbons • Describe trends in physical properties of the hydrocarbons
2.	**Fractional distillation**	• Describe how crude oil is separated into fractions • Describe trends in the physical and chemical properties of the fractions of crude oil • Describe uses for the different fractions of crude oil
3.	**Cracking**	• Explain why cracking is necessary • Describe the process and products of cracking • Describe the test for alkenes and its positive result • Represent cracking using equations

4.	**Uses of hydrocarbons**	• Write equations for the complete combustion of hydrocarbons, identifying oxidation • Describe uses for the alkenes produced in cracking
5.	**Review (Part 1)**	• A review of the key ideas from the first 4 lessons of the organic chemistry unit
6.	**Reactions of alkenes**	• Draw and name alkenes • Compare the combustion of alkenes with that of alkanes • Describe and draw the reaction of alkenes with hydrogen, water and the halogens
7.	**Alcohols**	• Draw and name alcohols • Describe the production of alcohol from sugar • Describe the uses of alcohols and reactions with sodium, water and oxidising agents
8.	**Properties and combustion of alcohols**	• Describe the combustion of alcohols • Identify variables to change, measure and control to test a hypothesis • Evaluate data collected and make suggestions on how to improve it

9.	**Carboxylic acids**	• Name and draw carboxylic acids • Describe the properties and reactions of carboxylic acids • Explain why carboxylic acids are weak acids
10.	**Natural and addition polymers**	• Describe the process of addition polymerisation • Draw and name polymers • Recognise monomers from given polymers
11.	**Condensation polymers**	• Describe the process of condensation polymerisation • Draw and name condensation polymers & the small molecules produced • Draw and describe polymerisation of amino acids • Describe the natural polymers starch, cellulose and DNA
12.	**Review (Part 2)**	• Create synoptic links between this topic and other parts of GCSE chemistry
13.	**Review (Part 3)**	• Review the triple science content from this topic

Unit 8 Chemical analysis

12 Lessons

Lesson number	Lesson question	Pupils will learn
1.	**Pure and impure formulations**	• Identify pure and impure substances using diagrams or data • Describe how to test for purity • Describe and give examples of formulations
2.	**Chromatography**	• Describe how to correctly use chromatography to separate mixtures • Interpret chromatograms to determine the contents of a provided mixture
3.	**Interpreting chromatograms**	• Identify mistakes in practical set up and suggest how to rectify them • Interpret chromatography data, identifying pure substances and mixtures • Calculate Rf values and using significant figures appropriately

4.	**Testing gases**	• Describe the tests for oxygen, carbon dioxide, hydrogen and chlorine and their positive results • Write and balance chemical equations to represent some of the reactions.
5.	**Review (Part 1)**	• A review of the key ideas from the first 4 lessons of the analysis unit
6.	**Identifying positive ions**	• Describe how to identify metal ions using flame tests and precipitation • Name the colours produced by given metal ions in flame tests • Write and balance chemical equations for the reactions of metal salts with sodium hydroxide
7.	**Testing for negative ions**	• Describe the tests for anions - carbonate, halide and sulphate • Safely carry out the tests and record the results • Describe the positive results
8.	**Review (Part 2)**	• Review of the cation and anion tests

9.	**Ion identification problems**	• Safely carry out a series of a series of chemical tests to identify unknown solutions • Describe the tests used and the positive results • Write chemical formula for the identified compounds
10.	**Flame emission spectroscopy**	• Evaluate the use of instrumental methods to identify unknowns • Describe uses of flame emission spectroscopy • Interpret results from spectroscopy analysis to identify unknowns
11.	**Scientist profile: Angela Lamb**	• Look at the work of Angela Lamb on analytical techniques
12.	**Review (Part 3)**	• Review of the triple chemistry only content

Unit 9 Chemistry of the atmosphere

8 Lessons

Lesson number	Lesson question	Pupils will learn
1.	**The Earth's atmosphere**	• Compare the composition of Earth's early atmosphere with its current composition • Describe and explain the changes in the composition of the atmosphere over Earth's history • Evaluate different theories about the Earth's early atmosphere • Describe and explain the formation of limestone, coal, crude oil and natural gas
2.	**The Greenhouse Effect**	• Describe the greenhouse effect • Describe the reasons for and the impacts of increasing greenhouse gases on the temperature of the Earth's atmosphere • Evaluate the strength of the evidence for the link between CO2 levels and global temperature rise

3.	**Climate change**	• Describe potential consequences of climate change • Define the carbon footprint in a range of contexts • Suggest ways of reducing carbon footprints in different contexts and why actions to reduce carbon footprints may be limited
4.	**Pollutants**	• Describe how carbon monoxide, soot, sulphur dioxide and nitrogen oxides are produced and released into the atmosphere • Predict the products of the combustion of a fuel given appropriate information • Describe the problems caused by these pollutants
5.	**Maths Skills**	• Describe and explain patterns in graphs • Recap maths skills such as mean calculation
6.	**Alice Wilson**	• A look at the work of geologist Alice Wilson and her contribution to our understanding of the evolution of the Earth
7.	**Review (Part 1)**	• Review of changes to the atmosphere and the greenhouse effect

8. Review (Part 2)

- Review of global warming and the source and problems caused by named atmospheric pollutants

Unit 10 Using Resources

18 Lessons

Lesson number	Lesson question	Pupils will learn
1.	**Finite resources**	• State ways in which natural products are supported or replaced by man-made products • Extract and interpret information in charts, graphs and tables • Evaluate the use of finite and renewable resources
2.	**Life cycle assessments**	• Describe some ways of reducing our use of finite resources • Evaluate ways of reducing our use of limited resources • Carry out life cycle assessments given appropriate information
3.	**The importance of recycling**	• Describe ways of recycling • Describe the impacts of recycling in terms of environmental impact and sustainable development

4.	**Phytomining and bioleaching**	• Describe the processes of phytomining and bioleaching to extract metals • Compare alternative methods of metal extraction using information given • Link the processes to displacement and energy change graphs
5.	**Rusting**	• Describe experiments to prove the need for oxygen and water for rusting to occur • Interpret results from rusting experiments • Describe methods of preventing corrosion, including sacrificial protection
6.	**Alloys**	• State uses of the alloys bronze, brass and steel • Interpret and evaluate the composition and uses of alloys given appropriate information • Explain why alloys are more useful than pure metals
7.	**Polymers**	• Give uses for different types of polymer • Explain how low density and high density poly(ethene) are both produced from ethene • Explain the difference between thermosoftening and thermosetting polymers in terms of their structures

8.	**Glass, ceramics and composites**	• Describe the production of glass • Give some uses for composites • Compare quantitatively the physical properties of glass and clay ceramics, polymers, composites and metals • Explain how the properties of materials are related to their uses and select appropriate materials
9.	**Safe drinking water**	• Distinguish between pure and potable water • Describe and explain the steps involved in the treatment of safe drinking water • Test water for pH and dissolved solid content, and calculate the concentration of dissolved solids
10.	**Required practical on potable water**	• Describe methods of producing potable water from salty water • Describe how to carry out the distillation of a water sample • Describe the differences between the water samples before and after distillation and how to test for these

11.	**Wastewater treatment**	• State components of wastewater that can cause problems in the environment • Describe how wastewater is treated to make it safe to release into the environment • Compare the treatments of waste, ground and salt water in terms of ease of producing potable water
12.	**Making ammonia and the Haber Process**	• Name the source of the reactants in the Haber process • Describe the importance of the Haber process • Describe the conditions and reactions involved in the Haber process
13.	**The economics of the Haber Process**	• Predict the effect of temperature, concentration and pressure on yield and rate of reaction in the Haber process • Interpret graphs of reaction conditions versus rate • Explain why industrial conditions for the Haber process are a compromise, taking into account multiple factors

14.	**Making fertilisers in the lab and in industry**	• State the use and composition of NPK fertilisers • Describe the production of NPK fertilisers, naming reactants and products • Compare the industrial production of fertilisers with laboratory preparations of the same compounds given appropriate information
15.	**Review lesson**	• Review the combined science content
16.	**Review lesson: Chemistry content**	• Review the triple chemistry only content
17.	**Exam skills: Compare and evaluate**	• Exam skills lesson focusing on the command verbs 'compare' and 'evaluate'
18.	**Case study: Kitty Hach Darrow**	• A look at the work of Kitty Hach Darrow on water purification methods

4. Learn More

Contents

1. Introduction to Oak's Key stage 4 science curriculum principles

Below are a set of principles we have sought to apply in our curriculum planning within science. These are adapted for science from the generic principles guiding all Oak lessons.

2. Coherence and flexibility

We strive to support schools by giving them an online learning offer that can be flexible to fit alongside their existing curriculum. We need to balance this together with coherence, as complete flexibility would imply only standalone lessons, where none can build upon any other. In striking this balance, we will lean towards giving the maximum flexibility possible. All units will have revision lessons at the end to consolidate knowledge, which can be standalone if only that topic has been taught, and, where disciplinary knowledge is woven into the units, there will be reminders of previously used scaffolds and prompts.

3. Subjects first

The science curriculum is structured into biology, chemistry and physics units, with working scientifically skills taught in context throughout. This will be made explicit to the pupils within lessons. In terms of science's relationship and overlap with other subjects (e.g. geography and maths), we will not be able to create cross-curricular coherence as the units can be taught in multiple orders. Therefore, cross curricular topics (such as Earth science) will not cohere with other subjects (e.g. geography).

4. Knowledge organisation

The units in the science curriculum are grouped by key stage, with a suggested route through, organised within year groups. In Key Stage 4, units are sequenced according to the AQA specification (with two exceptions, P3 Particles and B7 Ecology). In most circumstances, the units within a given year can be sequenced flexibly, but there is an assumption in the creation of the units that knowledge in any given year is building on units from previous years (i.e. that units in year 5 are planned with the assumption that units in year 4 have been taught). If following a different exam board at KS4, we will provide a suggested route through at a later date.

As stated above, the substantive knowledge (i.e. the science content) will be taught in units, and the disciplinary knowledge (i.e. working scientifically) is taught in context. Hierarchical elements of working scientifically will be reflected in the units and therefore this will be built up accordingly. While this will take account of prior learning assumptions from the previous key stage, or units, there will also be reminders of prompts and scaffolds to help pupils.

5. Knowledge selection

We are seeking to support schools to deliver the National Curriculum to children who cannot attend school. Our choice of what to teach will primarily be guided by the content specified in the National Curriculum, but we have also chosen to broaden this to increase challenge and build aspiration (e.g. include more physics at KS1 and 2, introduce some KS4 concepts in KS3).

6. Inclusive and ambitious

We want Oak to be able to support all children. Our units will be pitched so that children with different starting points can access them. Pupils need to have a large amount of subject knowledge stored in their long-term memory in order to become competent at any subject, and this is especially true of science where application is often an application of knowledge. For this reason, these lessons are designed to teach science in a clear and deliberate fashion, emphasising secure content knowledge before moving onto tasks. In this approach the teacher is the subject expert and the emphasis is on instruction and explanation, followed by deliberate practice supported by modelling, guided practice and scaffolding. Models and analogies will be used where appropriate to allow pupils to visualise or contextualise abstract ideas.

7. Pupil engagement

We need pupils to be thinking during science lessons - both to engage with the subject and to strengthen memory of what is being learnt. Our lessons will not be video lectures. We seek to exercise pupils' minds throughout their lessons (based on the principles described in point 5 above). This will involve questions and tasks throughout instruction, just as we would with classroom teaching.

8. Motivation through learning

Like all teachers, we recognise that good presentation helps pupils keep participating in our lessons. However, we are teachers, not entertainers. We seek to motivate pupils through our subjects. We believe that science is inherently interesting, and we aim to build this interest through our teaching. In science, we will provide opportunities where possible for pupils to engage in home experimentation. We will begin each unit with a summary of the relevant careers for that unit, including those outside of science itself. Units will also include short case studies of work by current and past scientists that reflect the diversity of backgrounds of our pupils. Finally, we will try to be explicit about the real life relevance of each unit so that it is clear why this knowledge is important.

9. Additional information about sequence

The science curriculum has been planned on the following basis:

- Before KS3, pupils have been taught the latest KS2 National Curriculum (2014)

As a result of this work, the science curriculum has the following features:

- It takes a year-by-year approach to teaching the curriculum.
- The content of each year's units is based on the expectation that the relevant content for each given year is taught by the end of the previous year.
- In KS4, the units are based on the AQA specification, and are ordered to ensure that paper 1 content is taught first. In the suggested sequence, they appear in the same order as the specification, except for B7 Ecology and P3 Particles. (This is to allow for teaching of Ecology when weather conditions are more likely to be favourable for outdoor sampling work, and to teach Particles as the first physics topic as it contains content foundational to other units)
- There is no expectation that any given unit in one science (e.g. physics) is taught before any given unit in another (e.g. biology). Any crossover material (e.g. atoms in KS4 physics and chemistry) will only assume the previous key stage's knowledge
- Many topics within any given year can be taught in a different sequence if schools wish. However, the lesson by lesson materials have been written with the suggested route in mind, and schools will have to consider this in their decisions.
- Each year is divided into topics across biology, chemistry, and physics, but equally weighted across these three disciplines
- Working scientifically is integrated into all the topics and can be identified in the learning outcomes in the topic summaries where relevant.
- The working scientifically programme of study is covered throughout.
- The precise ordering between each science (as opposed to within it) is flexible, and a matter for schools to determine. It is expected that schools will alter this according to their staffing context and curriculum time allocation in year 10 and 11.
- We suggest teaching the first three units of KS4 science at the end of year 9 to support you in managing the large amount of content in KS4 science.