



Year 10 Topic One - Bonding, Structures and Properties (GCSE Trilogy Chemistry)

Topic	Rationale (Layering, Why this why now?)	Knowledge goals: <i>You need to know....</i> <i>...that (Declarative) ... how to (Procedural)</i> <div style="text-align: center; background-color: yellow;">L ADDERING</div>	Key Tier 3 vocabulary	Core skills and enrichment opportunities.
<p>4.2 Bonding, Structures and Properties Chemical bonds are the glue that hold substances together. The attraction of one atom to another determines a substances chemical reactivity and its physical properties. Understanding how these can be determined by considering the atoms involved within the substance can be used to advance our understanding of materials science and where research may go in the immediate future.</p>	<div style="text-align: center; border: 1px solid red; padding: 2px; color: red; font-weight: bold;">← Linking</div> <p>Year 7 Properties of metals and non-metals</p> <p>Year 8 Periodic table</p> <p>Year 9 Atomic structure</p> <div style="text-align: center; border: 1px solid green; padding: 2px; color: green; font-weight: bold;">Looking →</div> <p>Year 11 Apply bonding knowledge and detailed use of nanoparticle</p> <p>Post 16 AS Bonding unit</p>	<p>Lesson 1 – Forming Ions <i>...that</i> ions are formed from the loss and gain of electrons into electron shells <i>...how to</i> represent ions using dot and cross diagrams <i>...how to</i> describe and explain ionic bond formation using dot and cross diagrams.</p>	Ion, positive, negative, cation, anion, transfer, noble gas, configuration, ionic	<p>a) Numeracy Analysis and evaluation of data based questions using graphs and/or tables for bonding properties.</p> <p>b) Literacy and reading Analysis and evaluation of data based questions using extended text for use of polymers and nanoparticles.</p> <p>c) Cultural Capital/Careers The development of new and diverse nanoparticles for use in everyday life.</p> <p>d) Cross curricular knowledge links Opportunities for learners to demonstrate their research skills</p> <p>e) Misconceptions When a substance dissolves or changes state no bonds are broken, this is often confused as FORCES between molecules are overcome when a change of state happens.</p>
		<p>Lesson 2 – Ionic Compounds <i>...that</i> ionic compounds can be represented in different ways <i>...that</i> the specific bonding in ionic compounds leads to different properties <i>...how to</i> construct the formula of common ionic compounds</p>	Giant, lattice, 3D, ions, conductivity, brittle, soluble, electrostatic	
		<p>Lesson 3 and 4 – Covalent Bonding <i>...that</i> covalent bonds are formed from the sharing of electrons <i>...how to</i> draw dot and cross diagrams to represent simple covalent molecules <i>...how to</i> explain the properties of simple covalent compounds in terms of structure and bonding</p>	Covalent, dot and cross, sharing, valence, intermolecular forces	
		<p>Lesson 5 – Polymers</p>	Polymer, manufactured, covalent, molecule, monomer, repeat unit	

		<p><i>...that</i> simple covalent molecules can form polymers <i>...how to</i> draw the structure of polymers and repeat units</p>	<p>polymerisation, thermosetting, thermosoftening, intermolecular</p>	<p>Non metals do-not conduct electricity however graphite, graphene and fullerenes made purely from carbon (a non-metal) can conduct electricity.</p> <p>To be stable each atom wants a full outer shell of electrons, hydrogen and helium need 2 electrons, however every other atom wants 8. You only need to know the first 20 elements as this rule works for them.</p> <p>In ionic bonding electrons are not shared, they are given and taken. It is then those differently charged ions that are attracted to each other forming the bond.</p> <p>Ionic compounds are not just two or three ions (NaCl is not 1 sodium ion and 1 chlorine ion), there are millions of ions that make up the compounds, the formula shown is the simplest way to write the ratio of ions.</p>
		<p>Lesson 6 – Giant Covalent Molecules <i>...that</i> carbon can exist in three different forms called allotropes <i>...that</i> the different bonding in these allotropes leads to the different properties of the allotropes <i>...how to</i> explain the properties of these allotropes in terms of structure and bonding</p>	<p>Brilliant, strong, hard, lubricant,</p>	
		<p>Lesson 7 – Nanoparticles <i>...that</i> nanoscience is the study of nano-sized particles <i>...how to</i> explain the properties of nanoparticles in terms of structure and bonding <i>...how to</i> calculate surface area to volume ratio HT</p>	<p>Nanoparticle, surface area to volume ratio</p>	
		<p>Lesson 8 – Metallic Bonding <i>...that</i> metallic bonding occurs in metals <i>...how to</i> explain the properties of metals in terms of structure and bonding</p>	<p>Delocalised, electrostatic, electron, conduction</p>	



Year 10 Topic Two Quantitative Chemistry (GCSE Trilogy Chemistry)

Topic	Rationale (Layering, Why this why now?)	Knowledge goals: <i>You need to know...</i> <i>...that (Declarative) ... how to (Procedural)</i> L ADDERING	Key Tier 3 vocabulary	Core skills and enrichment opportunities.
<p>4.3 Quantitative Chemistry Chemists use quantitative analysis to determine the formulae of compounds and the equations for reactions. Given this information, analysts can then use quantitative methods to determine the purity of chemical samples and to monitor the yield from chemical reactions. Identifying different types of chemical reactions allows chemists to make sense of how different chemicals react together, to establish patterns and to make predictions about the behaviour of other chemicals. Chemical equations provide a means of representing</p>	<p> Year 8 Periodic table Year 9 Atomic structure and periodic table</p> <p> Year 11 Apply quantitative knowledge across a broad range of questions.</p> <p>Post 16 Quantitative chemistry</p>	<p>Lesson 1 – Relative Atomic and Relative Formula Mass <i>...that</i> relative atomic masses are found on the periodic table <i>...how to</i> calculate relative atomic and relative formula mass</p>	<p>Mass number, formula mass, formula, equation, reactants, products</p>	<p>a) Numeracy A wide range of calculation on moles, RFM, reacting masses, limiting factors, concentration of solutions. Analysis and evaluation of data based questions using graphs and/or tables for quantitative questions.</p> <p>b) Literacy and reading</p> <p>c) Cultural Capital/Careers Chemical engineers, pharmaceuticals, toxicology, river water analysis</p> <p>d) Cross curricular knowledge links Rearranging equations, converting units, percentages all linked with maths skills</p> <p>e) Misconceptions When balancing equations you can't change how the compounds are</p>
		<p>Lesson 2 Conservation of Mass <i>...that</i> mass is conserved in a reaction <i>...how to</i> use chemical equations to evaluate conservation of mass</p>	<p>Conservation, mass, balanced</p>	
		<p>Lesson 3 – Conservation of Mass Practical <i>...that</i> mass does not always appear to be conserved in a reaction <i>...how to</i> complete a practical to investigate conservation of mass safely</p>	<p>Safety, crucible, balance, weighing boat</p>	

chemical reactions and are a key way for chemists to communicate chemical ideas.	<p><u>Lesson 4 - Introduction to Moles</u> <i>...that</i> a mole is a chemical quantity <i>...how to</i> calculate moles using the correct equation</p>	Mole, quantity, mass, relative atomic/formula mass, Avogadro's constant	made up – this means you can't add or take away any of the 'small numbers'.
	<p><u>Lesson 5 – Moles Lesson 2</u> <i>...how to</i> calculate moles using the correct equation <i>...how to</i> rearrange the moles equation <i>...how to</i> apply your knowledge to questions</p>	Mole, quantity, mass, relative atomic/formula mass, Avogadro's constant	Some reactions look like mass is lost however it is normally a product that is a gas escaping from wherever the reaction is happening.
	<p><u>Lesson 6 – Reacting Masses</u> <i>...that</i> moles can be used to calculate required masses of reagents and predicted masses of products <i>...how to</i> apply the moles equation to calculating reacting masses</p>	Moles, reacting masses, balanced equation, conservation	HT ONLY. A mole is just a number. As atoms are so small it is impossible to talk about 1 atom of a substance, we can only really talk about them in very large amounts. So, a mole was created as a standard, it stands for 6.02×10^{23} particles.
	<p><u>Lesson 7 – Percentage Element</u> <i>...that</i> elements exist in different percentages within compounds <i>...how to</i> calculate percentage of a given element in a compound</p>	Percentage, element, proportion,	Understanding the correct units and their conversions.
	<p><u>Lesson 8 – Concentration of Solutions</u></p>	Solutions, concentration, volume, solute, decimetre, cubic centimetre, mass	Appreciation of standard form and manipulation of standard form within calculations. Scale of what a decimetre is. Use of non-integers in balancing equations.



		<p><i>...that</i> cubic decimetres are a unit of concentration</p> <p><i>...how to</i> convert between units</p> <p><i>...how to</i> calculate the concentration of solutions.</p>		
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Year 10 Topic Three Chemical Changes (GCSE Chemistry)

Topic 5	Rationale (Layering, Why this why now?)	Knowledge goals: <i>You need to know....</i> <i>...that (Declarative)</i> <i>how to (Procedural)</i> LADDERING	Key Tier 3 vocabulary	Core skills and enrichment opportunities.
<p>4.4 Chemical Changes Understanding of chemical changes began when people began experimenting with chemical reactions in a systematic way and organising their results logically. Knowing about these different chemical changes meant that scientists could begin to predict exactly what new substances would be formed and use this knowledge to develop a wide range of different materials and processes</p>	<p> Year 7 Acids and alkalis Metals and non- metals Year 8 Types of reaction Year 9 Chemical changes, reactions of metals, reactivity series and acids and alkalis</p>	<p><u>Lesson 1 – Reactivity Series and Displacement Reactions</u> <i>...that</i> the reactivity series places metals in increasing order of reactivity and can be used to predict reactions. <i>....how to</i> use the reactivity series to predict whether or not a displacement reaction will happen.</p>	ionic compounds, reactivity series, displacement	<p>a) <u>Numeracy</u> Balancing ionic equations for more able students.</p> <p>b) <u>Literacy</u> Etymology of words to describe metallic properties e.g. lustre.</p> <p>c) <u>Reading</u> Methods, hazard warnings, extraction of aluminium reading to extract knowledge. Application of hydrogen homes.</p>
	<p> Year 11 Chemical changes – paper 1 Post 16 Acid, alkali titrations. Types of acid. Neutralisation reactions.</p>	<p><u>Lesson 2 – The Process of Electrolysis</u> <i>...that</i> electrolysis is a process which separates ionic compounds <i>.... how to</i> describe and explain the process of basic electrolysis <i>.... how to</i> represent the process at the electrodes using half equations</p>	Electrolysis, anode, cathode, anion, cation, electrolyte, electrodes, half equations	<p>d) <u>Cultural Capital/Careers</u> Hydrogen extraction for fuels (hydrogen homes)</p> <p>e) <u>Cross curricular knowledge links</u> Environmental impacts of large scale metal extraction – recycling metals and alternative metal extraction</p>
		<p><u>Lesson 3 – The Extraction of Aluminium</u> <i>...that</i> aluminium is a reactive emetal that requires electrolysis to be se[parated from its ores</p>	Bauxite, aluminium, electrodes, electrolysis, half equations	<p>f) <u>Misconceptions</u></p>



		<p>.... <i>how</i> the extraction of aluminium is adjusted and has special conditions</p>		<p>Not all metals are found as pure metal on Earth, most are found in rocks as metal oxides or metal carbonates which are called ores.</p>
		<p><u>Lesson 4 – Aqueous Electrolysis</u> <i>...that</i> aqueous solutions of ionic compounds can be separated using electrolysis <i>.... how to</i> predict the products of aqueous electrolysis</p>	<p>Aqueous, prediction, products, reactivity series, halogens</p>	<p>During electrolysis the metal is not always produced, if the metal is higher in reactivity than hydrogen then hydrogen is produced. A solution of the metal hydroxide would also be produced which is then later purified to produce the pure metal.</p>
		<p><u>Lesson 5 – Electrolysis Required Practical</u> <i>.... how to</i> predict the products of electrolysis then test the predictions using the practical equipment</p>	<p>Aqueous, hazards, risks, electrolyte, anode, cathode</p>	

Year 10 Topic Four Energy Changes (GCSE Trilogy Chemistry)

Topic	Rationale (Layering, Why this why now?)	Knowledge goals: <i>You need to know...</i> <i>...that (Declarative) ... how to (Procedural)</i> L ADDERING	Key Tier 3 vocabulary	Core skills and enrichment opportunities.
<p>4.5 Energy Changes Energy changes are an important part of chemical reactions. The interaction of particles often involves transfers of energy due to the breaking and formation of bonds.</p> <p>Reactions in which energy is released to the surroundings are exothermic reactions, while those that take in thermal energy are endothermic. These interactions between particles can produce heating or cooling effects that are used in a range of everyday applications.</p>	<p> Linking</p> <p>Year 8 Endothermic and exothermic reactions</p> <p> Looking</p> <p>Year 11 Apply energy change knowledge and detailed use of cells and batteries.</p> <p>Post 16 Energetics and electrochemistry</p>	<p>Lesson 1 – Exothermic and Endothermic <i>...that</i> exothermic reactions release heat energy and endothermic absorb heat energy from their surroundings. <i>... how to</i> draw reaction profiles for exothermic and endothermic reactions</p> <p>Lesson 2 – Bond Enthalpy Calculations HT Only <i>...that</i> bonding breaking is endothermic and bond formation is exothermic <i>...how to</i> calculate bond enthalpy changes</p> <p>Lesson 3 and 4 – Temperature Changes Practical <i>...how to</i> safely conduct a practical to investigate temperature changes in a reaction <i>... how to</i> draw a graph from which data can be extrapolated</p>	<p>Exothermic, endothermic, profiles, activation energy, surroundings</p> <p>Enthalpy, exothermic, endothermic, ΔH.</p> <p>Extrapolation, variables, hazard, risk, control</p>	<p>a) Numeracy Analysis and evaluation of data based questions using graphs and/or tables for energy transfer Carry out bond energy calculations</p> <p>b) Literacy and reading Reading methods in order to follow instructions. Student safety sheets in order to evaluate risks in a practical.</p> <p>c) Cultural Capital/Careers Food hygienist and preparation – hot and cold cans. Medics hot and cold packs. DofE – hand warmers</p> <p>d) Cross curricular knowledge links DT – Materials design of hot/cold cans PE – hot/cold packs</p>


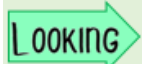
				<p>e) Misconceptions</p> <p>It requires energy to break bonds and releases energy when bonds are made. The enthalpy change is a balance between energy used from bond breaking and bond making.</p> <p>Endothermic reactions are cold as they take in thermal (heat) energy from the surroundings.</p>
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Year 10 Topic Five - Rate and extent of chemical change (GCSE Trilogy Chemistry)

Topic	Rationale (Layering, Why this why now?)	Knowledge goals: <i>You need to know...</i> <i>...that (Declarative) ... how to (Procedural)</i> LADDERING	Key Tier 3 vocabulary	Core skills and enrichment opportunities.
<p>4.6 Rate and extent of chemical change Chemical reactions can occur at vastly different rates. Whilst the reactivity of chemicals is a significant factor in how fast chemical reactions proceed, there are many variables that can be manipulated in order to speed them up or slow them down. Chemical reactions may also be reversible and therefore the effect of different variables needs to be established in order to identify how to maximise the yield of desired product. In industry, chemists and chemical engineers</p>	<p> Year 8 Rates of reaction</p> <p> Year 11 Apply rate and extent of chemical change knowledge to extended questions.</p> <p>Post 16 kinetics</p>	<p>Lesson 1 – Measuring Rate of Reaction <i>...that</i> mean rate of reaction can be determined by measuring quantity of mass used or product released <i>...how to</i> determine the rate of a chemical reaction by interpreting data</p>	Product, reactant, rate, mean, gradient	<p>a) Numeracy Analysis and evaluation of data based questions using graphs and/or tables for rates and chemical changes.</p> <p>Learners need to employ the use of suitable units when measuring and collecting data.</p> <p>There is a need for learners to develop their mathematical mastery to determine the gradient of a straight line.</p> <p>Learners will also need to be able to determine the intercept on a linear graph.</p> <p>b) Literacy and reading Analysis and evaluation of data based questions using extended text for use of changing conditions on the Haber process.</p>
		<p>Lesson 2 – Factors affecting rate of reaction <i>...that</i> the rate of reaction can be changed by altering conditions <i>...how to</i> use collision theory to explain the effect of changing conditions on the rate of reaction</p>	Collision, particle, energy, activation, rate, concentration, pressure, sufficient, catalyst, temperature, surface area, state	
		<p>Lesson 3 and 4 – Changing Surface Area <i>...how to</i> measure the rate of reaction during a practical for production of gaseous products <i>...how to</i> represent data using graphs</p>	Dependent, independent, control, variable, surface area, delivery tube	
		<p>Lesson 5, 6 and 7 – Changing Concentration <i>...how to</i> measure the rate of reaction during a practical which produces solid <i>...how to</i> represent data using graphs</p>	Dependent, independent, control, variable, rate, concentration, hydrochloric, thiosulphate. Erlenmeyer, obscure, hypothesis, conclusion	


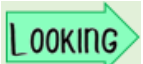
<p>determine the effect of different variables on reaction rate and yield of product. Whilst there may be compromises to be made, they carry out optimisation processes to ensure that enough product is produced within a sufficient time, and in an energy-efficient way.</p>	<p><i>...how to</i> describe and explain the shape of a graph</p>		<p>c) <u>Cultural Capital/Careers</u> How the Haber Process has had an impact on the global economy.</p> <p>d) <u>Cross curricular knowledge links</u> Opportunities for learners to demonstrate their research skills</p> <p>e) <u>Misconceptions</u> Not all reactions happen quickly, some take millions of years to happen!</p> <p>Mass and energy are never lost or created; however, it might look like the mass goes down during a reaction. But this is because a gas will be given off and has escaped.</p> <p>Catalysts are not part of the reaction; they just interact with the atoms to help them react.</p> <p>Particles collide all the time however not all collisions cause a reaction, this is because they don't have enough energy for the reaction to occur.</p>
	<p><u>Lesson 8 – Reversible Reactions</u> <i>... that</i> some chemical reactions are reversible <i>...how to</i> represent reversible reactions</p>	<p>Reactant, product, forward, backward, reversible, equilibrium, rate, anhydrous, hydrated</p>	
	<p><u>Lesson 9 – Equilibria HT ONLY</u> <i>... that</i> chemical reactions reach a state of equilibria <i>...how to</i> change the position of the equilibrium by applying Le Chateliers principle</p>	<p>Reactant, product, forward, backward, reversible, equilibrium, Le Chatelier.</p>	

Year 10 Topic Six Organic Chemistry (GCSE Trilogy Chemistry)

Topic 6	Rationale (Layering, Why this why now?)	Knowledge goals: <i>You need to know....</i> <i>...that (Declarative)</i> <i>... how to (Procedural)</i> L ADDERING	Key Tier 3 vocabulary	Core skills and enrichment opportunities.
<p>4.7 Organic Chemistry The chemistry of carbon compounds is so important that it forms a separate branch of chemistry. A great variety of carbon compounds is possible because carbon atoms can form chains and rings linked by C-C bonds. The main sources of organic compounds are living, or once-living materials from plants and animals. These sources include fossil fuels, a major source of feedstock for the petrochemical industry. Chemists take organic</p>	<p> Year 8 Elements, compounds, mixtures</p> <p>Year 9 Atomic structure, separating mixtures, organic and chemistry of the Atmosphere</p> <p> Post 16 Organic chemistry</p>	<p>Lesson 1 - Crude Oil <i>...that</i> crude oil is a non-renewable resource made from the remains of microscopic organisms living in the sea. <i>...how to</i> interpret data linked to the availability and use of crude oil over time. <i>...how to</i> apply knowledge to past examination questions</p>	Crude oil, heat , pressure, mixture, hydrocarbon	<p>a) Numeracy Interpreting charts and graphs on data linking crude oil and its uses. Using general formulae to predict formulae of alkanes and alkenes.</p> <p>b) Literacy Systematic naming of molecules in homologous series: meth-, eth-, prop-, etc. Key words in terms of properties of hydrocarbons and the etymology of these words.</p> <p>c) Reading Reading for information retrieval. Literacy homework.</p> <p>d) Cultural Capital/Careers Organic chemistry can help you get into careers in forensics, pharmaceuticals, making perfumes and flavours (Christmas dinner flavoured crisps!)</p> <p>(e) Cross curricular knowledge links DT: polymers as design materials. Geography – crude oil as a finite resources</p> <p>(f) Misconceptions</p>
		<p>Lesson 2 - Fractional Distillation <i>...that</i> crude oil can be separated into hydrocarbons of similar properties, called fractions. <i>...how to</i> describe the process of fractional distillation and explain the principles behind it. <i>...how to</i> apply knowledge to past examination questions</p>	crude oil, fractional distillation, fraction, alkane, mixture, separation	
		<p>Lesson 3 - Alkanes and Properties <i>...that</i> the properties of alkanes vary according to the length of the carbon chain. <i>...how to</i> distinguish between alkanes according to viscosity, flammability, boiling point. <i>...how to</i> apply knowledge to past examination questions</p>	Flammable, viscous, saturated	
		<p>Lesson 4 -Cracking Hydrocarbons <i>...that</i> long chain hydrocarbons can be split into smaller ones by cracking; thermal or catalytic. <i>...how to</i> construct cracking equations <i>...how to</i> distinguish between saturated and unsaturated compounds using bromine water. <i>...how to</i> apply knowledge to past examination questions</p>	Cracking, thermal, catalytic, saturated, unsaturated	



<p>molecules and modify to make new, useful materials such as polymers, pharmaceuticals, perfumes and flavourings, dyes and detergents.</p>		<p><u>Lesson 5 - Alkenes and Polymers</u> <i>...that</i> alkenes are carbon compounds containing a C=C bond <i>...that</i> polymers are formed from alkenes <i>...how to</i> apply knowledge to past examination questions</p>	<p>Unsaturated, cracking, thermal, catalytic, monomer, polymer.</p>	<p>Organic does not mean natural – it chemistry it refers to carbon chemistry.</p> <p>The “hydro” in hydrocarbons does not mean water – it means hydrogen.</p> <p>Saturated means no double bonds present – not a “saturated solution”</p> <p>Fractions themselves are a mixture of compounds with similar properties. Fractional distillation is separation, cracking is thermal decomposition.</p>
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Year 10 Topic Seven - Analysis (GCSE Trilogy Chemistry)

Topic 8 Analysis	Rationale (Layering, Why this why now?)	Knowledge goals: <i>You need to know....</i> <i>...that (Declarative) ... how to (Procedural)</i> L ADDERING	Key Tier 3 vocabulary	Core skills and enrichment opportunities.
<p>4.8 Chemical Analysis Chemists have developed a range of qualitative tests to detect specific chemicals. The tests are based on reactions that produce a gas with distinctive properties, or a colour change or an insoluble solid that appears as a precipitate. Instrumental methods provide fast, sensitive and accurate means of analysing chemicals. Forensic scientists and drug control scientists rely on such instrumental</p>	<p> Year 8 Reaction types</p> <p> Year 11 Chemical Analysis</p> <p>Post 16 Analysis using a range of chromatography techniques. Gas tests.</p>	<p>Lesson 1 - Pure Substances and Formulations <i>...that</i> a formulation is a specific mixture that has been designed as a useful product. Pure substances have a specific boiling point. Mixtures boil over a range of temperatures. <i>...how to</i> distinguish between a pure substance and a mixture. <i>...how to</i> apply knowledge to past exam questions</p>	<p>Pure, substance, melting point, boiling point, impure, mixture, product, purpose, fertilisers,</p>	<p>a) Numeracy Analysis and evaluation of data based questions using graphs and/or tables for analysis.</p> <p>b) Literacy Scientific literacy on gas formulae</p> <p>c) Reading Reading for learning on case studies.</p> <p>d) Cultural Capital/Careers Forensic science Food quality scientist</p> <p>e) Cross curricular knowledge links Food technology – food additives and food safety</p> <p>f) Misconceptions A pure substance in chemistry means that it is only one type of particle, pure in general language means it hasn't had anything extra added to it such as pure orange juice. Orange juice isn't pure in chemistry as it contains</p>
		<p>Lesson 2 - Testing for Common Gases <i>...that</i> carbon dioxide, oxygen, hydrogen and chlorine have specific tests which can be used to identify them <i>...how to</i> carry out the tests for carbon dioxide, hydrogen, chlorine and oxygen <i>...how to</i> apply knowledge to past exam questions</p>	<p>Hydrogen, chlorine, carbon dioxide</p>	
		<p>Lesson 3 and 4 - Chromatography <i>...that</i> chromatography can be used to separate mixtures and can give information to help identify substances. <i>...how to</i> calculate R_f values <i>...how to</i> set up an investigation to find the content/solubility of a dye and to calculate the R_f value. <i>...how to</i> apply knowledge to past exam questions</p>	<p>Solvent, solute, chromatography, stationary phase, mobile phase.</p>	



methods in their work.				sugars, water, pulp, and lots of other things.
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Year 10 Topic Eight Chemistry of the Atmosphere (GCSE Trilogy Chemistry)

Topic	Rationale (Layering, Why this why now?)	Knowledge goals: <i>You need to know...</i> <i>...that (Declarative)</i> <i>how to (Procedural)</i> LADDERING	Key Tier 3 vocabulary	Core skills and enrichment opportunities.
<p>4.8 Chemistry of the Atmosphere The Earth's atmosphere is dynamic and forever changing. The causes of these changes are sometimes man-made and sometimes part of natural cycles. Scientists use software to predict weather and climate change as there are many variables that can influence this. The problems caused by increased levels of air pollutants require scientists and</p>	<p></p> <p>Year 7 Materials</p> <p>Year 8 Earth – climate</p>	<p>Lesson 1 - Composition of the Atmosphere <i>...that</i> the atmosphere is a mixture of gases <i>...that</i> theories about what was in the Earth's early atmosphere and how the atmosphere was formed have changed over time. <i>...how to</i> interpret graphs and charts which compare atmospheres. <i>...how to</i> apply knowledge to past exam questions</p>	Composition, atmosphere	<p>a) Numeracy Construct and interpret tables, graphs and charts on the composition of atmosphere of planets in the solar system.</p> <p>b) Literacy Scientific literacy – CO and CO₂</p>
	<p></p> <p>Year 10 Earth's resources Chemical changes</p>	<p>Lesson 2 - Evolution of the Atmosphere <i>...that</i> the Earth's atmosphere evolved from early Earth to modern Earth <i>...how to</i> interpret evidence and evaluate different theories about the Earth's early atmosphere. <i>...how to</i> apply knowledge to past exam questions</p>	Evolution, dissolving, sedimentary photosynthesis	<p>c) Reading Reading and summarising accounts on the development of the atmosphere and the effects of climate change.</p> <p>d) Cultural Capital/Careers Climate scientist. COP 25. International government agreements on mitigating climate change. George Monbiot – political activist on climate change and the environment.</p>
	<p>Post 16 Organic chemistry, biofuels</p>	<p>Lesson 3 - Carbon Dioxide and the Greenhouse Effect <i>...that</i> climate change is impacted by the greenhouse effect, <i>...how to</i> describe and explain the greenhouse effect and its consequences. <i>...how to</i> apply knowledge to past exam questions</p>	Carbon dioxide, methane, radiation, greenhouse gases, greenhouse effect.	<p>e) Cross curricular knowledge links Geography – climate change</p>
		<p>Lesson 4 - Global Warming and Climate Change <i>...that</i> climate change is having a significant impact on the way we live, the weather and the habitats in our world. <i>...how to</i> evaluate the impact climate change will have on agriculture, animals, ecosystems, coastal regions and water supplies. <i>...how to</i> apply knowledge to past exam questions</p>	climate change, environment, impact, precipitation, ecosystem	<p>(f) Misconceptions</p>

<p>engineers to develop solutions that help mitigate human activity.</p>		<p><u>Lesson 5 - Products of Combustion</u> <i>...that</i> combustion of fuels releases harmful products <i>...how to</i> prove the products of complete combustion <i>...how to</i> link named emissions with the associated consequence. <i>...how to</i> apply knowledge to past exam questions</p>	<p>Pollutants, emissions, combustion, global dimming, Sulphur dioxide Nitrogen oxides, Carbon monoxide</p>	<p>The gas we breath in for respiration isn't the largest part of our atmosphere The proportion of gases has stayed the same for around 200 million years, it has only started to change over the last 200 in a very small way Global warming and cooling are natural and have happened in cycles since Earth was a ball of molten rock, the argument is that humans have impacted on this cycle. Climate change and global warming are different, climate change is changes to the weather that can have drastic consequences, and global warming is the average warming of the Earth that causes climate change.</p>
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Year 10 Topic Nine - Earths resources and using resources (GCSE Trilogy Chemistry)

Topic	Rationale (Layering, why this why now?)	Knowledge goals: <i>You need to know...</i> <i>...that (Declarative) ... how to (Procedural)</i> L ADDERING	Key Tier 3 vocabulary	Core skills and enrichment opportunities.
<p>4.10 Earths resources and using resources. Industries use the Earth's natural resources to manufacture useful products. To operate sustainability, chemists seek to minimise the use of limited resources, use of energy, waste, and environmental impact in the manufacture of these products. Chemists also aim to develop ways of disposing of products at the end of their useful life in ways that ensure that materials and stored energy are utilised. Pollution, disposal of waste products and changing land use has a significant effect on the environment, and environmental chemists' study how human activity</p>	<p> Year 7 Fossil fuels Year 9 Organic chemistry  Year 11 Apply Earths resources and using resources knowledge. Post 16 polymers</p>	<p><u>Lesson 1 – The Earth's Resources</u> <i>...that</i> the Earth provides all the resources needed for human survival. <i>... how to</i> distinguish between finite and renewable sources.</p>	<p>Resources, warmth, shelter, food, transport, natural, agriculture, fuels, finite, renewable.</p>	<p>a) Numeracy Extract and interpret information about resources from charts, graphs, and tables. Use orders of magnitude to evaluate significance of data. b) Literacy and reading Analysis and evaluation of data-based questions using extended text for LCAs and metal extraction methods. Methods to produce potable water, comparison, and evaluation. Reading for information retrieval. c) Cultural Capital/Careers Access to potable water and purification of water sources in different locations around the global – the challenges and implications of water safe for everyone to drink.</p>
		<p><u>Lesson 2 – Potable Water</u> <i>...that</i> potable water is different to pure water. <i>... how to</i> test the purity of water. <i>... how to</i> describe the differences between the treatment of ground water and freshwater</p>	<p>Potable, pure, sterilising, desalination, reverse osmosis, filter.</p>	
		<p><u>Lesson 3 – Wastewater Treatment</u> <i>...that</i> sewage can be treated to make it safe to drink. <i>... how to</i> purify wastewater.</p>	<p>Sewage, grit, sedimentation, anaerobic digestion, aerobic, effluent, sludge, agricultural.</p>	
		<p><u>Lesson 4 – Water RP</u> <i>... how to</i> purify salt water by simple distillation. <i>... how to</i> test the purity of the water produced.</p>	<p>Distillation, Liebig condenser, evaporation, condensing, boiling point</p>	
		<p><u>Lesson 5– Alternative Extraction of Metals</u></p>	<p>Metal ores, phytomining, bioleaching, bacteria, leachate, electrolysis, metal extraction.</p>	

has affected the Earth's natural cycles and how damaging effects can be minimalised.

...that the Earth's resources of metal ores is limited.
... how to use alternative extraction methods to access low grade ores.

Lesson 6 – Life Cycle Assessments
...that life cycle assessments are carried out to assess environmental impact of products
... how to carry out a life cycle assessment for shopping bags made of paper and plastic.



Lesson 7 – Reducing the Use of Resources
...that reducing, reusing, and recycling help to conserve resources.
... how to evaluate ways of reducing the use of materials.

Life cycle assessment, manufacturing, packaging, lifetime, quantified, processing.



Metals, glass, building materials, ceramics, quarrying, mining, recycled, melting, recasting, scrap, ore, extraction.

d) Cross curricular knowledge links
 Sustainable development – geography



e) Misconceptions
 Water has been cycled through the water cycle millions of times; it can be purified easily.
 The reduction of energy use in cleaning water and recycling materials will reduce the amount of carbon dioxide produced.
 Fossil fuels will run out as it is a non-renewable resource, it can be made still however it takes longer to make it than the time we use it in.

Topic 1 Particle model	Rationale (layering, Why this why now?)	Knowledge goals: <i>You need to know...</i> <i>...that (Declarative)</i> <i>how to (Procedural)</i> L ADDERING	Key Tier 3 vocabulary	Core skills and enrichment opportunities.
<p>The particle model is widely used to predict the behaviour of solids, liquids and gases and this has many applications in everyday life. It helps us to explain a wide range of observations and engineers use these principles when designing vessels to withstand high pressures and temperatures, such as submarines and spacecraft. It also explains why it is difficult to make a good cup of tea high up a mountain!</p>	<p> LINKING</p> <p>KS2 States of matter Simple physical properties of materials. Year 7 Particle model Separating Mixtures Year 8 Elements Periodic Table</p> <p>Year 9</p> <p>KS4  LOOKING</p> <p>Year 9 Year 10 Atomic structure –chem Particle model - phy Year 11 Rates - chem Post 16 Kinetic theory Gas Laws Atomic structure</p>	<p><i>...that</i> properties of solids, liquids and gases in terms of the particles in each state of matter. Particles are moving and have kinetic energy. <i>.... how to</i> link arrangement of the particles in each state of matter to their properties and be able to compare them.</p>	<p>Particle solids liquids gases forces of attraction density <i>Property</i></p>	<p>Subject specific skills Use a variety of models to solve problems, make predictions and to develop scientific explanations and understanding of familiar and unfamiliar facts. Recognise/draw/interpret diagrams. Translate from data to a representation with a model. Use models in explanations, or match features of a model to the data from experiments or observations that the model describes or explains.</p> <p>Numeracy be able to recall and apply equations to changes where mass is conserved. Use an appropriate number of significant figures, find arithmetic means, construct and interpret frequency tables and diagrams, bar charts and histograms, understand the principles of sampling as applied to scientific data, understand simple probability. Recognise and use expressions in standard form. Use ratios, fractions and percentages. Substitute numerical values into algebraic equations using appropriate units for physical quantities. Solve algebraic equations. Translate information between graphical and numeric form.</p> <p>Literacy and Reading Improvement of vocabulary bank – tier 2 - BBC Bitesize – Particle Model, extended reading articles. Reading for understanding, exemplar question contexts.</p>
		<p><i>...that</i> density is the mass which is contained in a given volume. A denser material will sink in a less dense material. <i>.... how to</i> calculate the density of a given material using: density = mass/volume. How to convert between g and Kg, and ml and l.</p>	<p>Density, mass, volume, formula.</p>	
		<p><i>...that</i> displacement can be used to find the volume of an irregular object. <i>.... how to</i> practically determine the volume of an irregular shaped object.</p>	<p>density displacement <i>regular irregular</i></p>	
		<p>RP 5. use appropriate apparatus to make and record the measurements needed to determine the densities of regular and irregular solid objects and liquids. Volume should be determined from the dimensions of regularly shaped objects, and by a displacement technique for irregularly shaped objects. Dimensions to be measured using appropriate apparatus such as a ruler, micrometer or Vernier callipers.</p>		
		<p><i>...that</i> If enough energy is added to or removed from an arrangement of particles a change of state can occur. Evaporation occurs when particles near the surface of the liquid have enough energy to escape. <i>how to</i> determine what happens to temperature during changes of state. <i>..why</i> some substances have higher/lower melting and boiling points than others.</p>	<p>state temperature heat State, melt, evaporate, condense, freeze, sublimation.</p>	
		<p><i>...that</i> the total kinetic energy and potential energy of all the particles (atoms and molecules) that make up a system is known as the internal energy. <i>how to</i> construct and interpret a heating/cooling curve.</p>	<p>internal kinetic potential <i>Independent, dependent, control, variables</i></p>	
		<p><i>...that</i> Specific Latent Heat is the energy absorbed by a substance during a change of state <i>how to</i> calculate specific latent heat.</p>	<p>specific latent heat Latent, heat, internal energy, mass, joules, kilograms, fusion, vaporisation, vapour</p>	



		<p><i>...that</i> The amount of energy needed to heat a material is known as Specific Heat Capacity.</p> <p><i>how to</i> calculate how much energy is needed to heat up different materials. Use and rearrange the equation: $Heat = mass \times SHC \times temp\ change$</p>	<p><i>Capacity</i> Specific heat capacity</p>	<p><u>Cultural Capital/Careers</u> Archimedes 'Eureka moment.' Architect, Astronomer, Energy Analyst, Food Technology, Games Designer, Geophysicist, Meteorologist, Nuclear Engineer, Radiographer, School teacher,</p> <p><u>Cross curricular knowledge links</u> Selection of materials for cooking pans – food technology. Heat transfer – DT – materials.</p> <p><u>Misconceptions</u> If a solid or liquid is heated, the particles get bigger. This is not the case. At higher temperatures, they move about more and take up more space, but they do not get bigger. Students tend to overestimate the space between the particles in liquids. They regard a liquid as half-way between a solid and a gas. This is not the case. The particles in a liquid are close together, although they are free to move and change place. Students confuse 'melting' and 'dissolving'. Students find it difficult to accept that most of a gas is empty space.</p>
		<p>.... that the temperature of a gas is related to the average kinetic energy of the molecules</p> <p>how to.. explain qualitatively the relation between the temperature of a gas and its pressure at constant volume.</p>		
		<p><i>(Physics only)</i> .. that increasing the volume in which a gas is contained, at constant temperature, can lead to a decrease in pressure.</p> <p>how to... calculate the change in the pressure of a gas or the volume of a gas (a fixed mass held at constant temperature) when either the pressure or volume is increased or decreased.</p>		

Topic Electricity	Rationale (layering, Why this why now?)	Knowledge goals: <i>You need to know....</i> <i>...that (Declarative)</i> <i>.... how to (Procedural)</i> L ADDERING	Key Tier 3 vocabulary	Core skills and enrichment opportunities.
<p>Electric charge is a fundamental property of matter everywhere. Understanding the difference in the microstructure of conductors, semi conductors and insulators makes it possible to design components and build electric circuits. Many circuits are powered with mains electricity but portable electrical devices must use batteries of some kind. Electrical power fills the modern world with artificial light and sound, information and entertainment, remote sensing and control. The fundamentals of</p>	<p> Linking</p> <p>KS2 States of matter Simple physical properties of materials. Year 7 Particle model Separating Mixtures Year 8 Elements Periodic Table Year 9</p> <p>KS4  Looking</p> <p>Year 9 Year 10 Atomic structure –chem Particle model - phy Year 11 Rates - chem Post 16</p>	<p><i>...that</i> circuit symbols act as a language for drawing circuit diagrams. This allows people anywhere in the world to build the same circuit, even if the components look different.</p> <p><i>.... how</i> to draw circuit symbols</p>	<p>E.g. lamp, battery, diode Current, charge, coulombs, amperes, volts, components</p>	<p><u>Numeracy</u> Students need to be able to recall and apply equations. Interpreting observations and other data (presented in verbal, diagrammatic, graphical, symbolic or numerical form), including identifying patterns and trends, making inferences and drawing conclusions. Use data to make predictions. Recognise or describe patterns and trends in data presented in a variety of tabular, graphical and other forms. Draw conclusions from given observations.</p> <p><u>Literacy</u> Presenting reasoned explanations including relating data to hypotheses. Comment on the extent to which data is consistent with a given hypothesis. Identify which of two or more hypotheses provides a better explanation of data in a given context. Being objective, evaluating data in terms of accuracy, precision, repeatability and reproducibility and identifying potential sources of random and systematic error.</p> <p><u>Reading</u> BBC Bitesize, The Illustrated Science Dictionary, World of Science, Horrible Science of Everything, The Science Boo Home Science Experiments</p>
		<p><i>...that</i> Electric Current is flow of electrical charge and that charge flow, current and time are linked.</p> <p><i>.... how to</i> use the equation : charge flow = current x time</p>	<p>Potential difference, resistance, ohms</p>	
		<p><i>...that</i> potential Difference is amount of energy transferred to each coulomb of charge</p> <p><i>how to place components in the circuit to measure current and potential difference</i></p> <p><i>RP3: Use circuit diagrams to set up and check appropriate circuits to investigate the factors affecting the resistance of electrical circuits.</i></p>	<p>Circuit diagrams, Proportional Voltage Current Resistance Amps Ohms Volts</p>	
		<p><i>...that in some resistors the value of R remains constant but that in others it can change as the current changes.</i></p> <p><i>.... How to use the equation: potential difference = current x resistance</i></p> <p><i>RP4: use circuit diagrams to construct appropriate circuits to investigate the I–V characteristics of a variety of circuit elements, including a filament lamp, a diode and a resistor at constant temperature.</i></p>	<p>Graphs. Linear, non-linear, correlation,</p>	
		<p><i>...that</i> there are two ways of joining electrical components, in series and in parallel.</p> <p><i>how to</i> explain qualitatively why adding resistors in series increases the total resistance whilst adding resistors in parallel decreases the total resistance</p>	<p>Series, parallel,</p>	
<p><i>...that</i> Mains electricity is an ac supply. In the United Kingdom the domestic electricity supply has a frequency of 50 Hz and is about 230 V.</p> <p><i>how to</i> explain the difference between direct and alternating potential difference</p>	<p>Alternating current, direct current, Three core cable, insulation, appliance,</p>			

<p>electromagnetism were worked out by scientists of the 19th century. However, power stations, like all machines, have a limited lifetime. If we all continue to demand more electricity this means building new power stations in every generation – but what mix of power stations can promise a sustainable future?</p>	<p>... <i>that</i> the power transfer in any circuit device is related to the potential difference across it and the current through it, and to the energy changes over time.</p> <p><i>How to</i> describe, with examples, the relationship between the power ratings for domestic electrical appliances and the changes in stored energy when they are in use.</p>	Transfer, work done,	Crisp Packet Fireworks.
	<p>... <i>that</i> the National Grid is a system of cables and transformers linking power stations to consumers.</p> <p><i>How to ...</i> explain why the National Grid system is an efficient way to transfer energy.</p>	Cables, transformers (Higher only), consumers, efficiency, step up, step down	<p><u>Cultural Capital/Careers</u></p> <p><u>Cross curricular knowledge links</u></p> <p>Electrician working on repairing some forklift trucks, Electricity plays a huge role in the robotics industry, and it is a fundamental concept.</p> <p>Engineer working in the medical prosthetics field.</p> <p>Working on the national power grid, Whether you are repairing or installing electrical cables, it's imperative that you understand the basics of electricity.</p> <p>Electrical engineers will design the circuit boards that go inside both our everyday items that we'll find in our house, but also highly technical pieces of equipment.</p>
	<p><i>(Physics only)</i></p> <p>.. <i>that</i> when certain insulating materials are rubbed against each other they become electrically charged.</p> <p>How toexplain how the transfer of electrons between objects can explain the phenomena of static electricity.</p>	Electrically charge, negative, positive, electrons, repel, attract, non contact force, static,	<p><u>Misconceptions</u></p> <p>Misconception: current is 'used up' as it flows round the circuit</p> <p>Current is not used up: the current is the same all the way round a series circuit. If current is used up, then bulbs near the 'start' of the circuit should be brighter than those near the 'end'. Providing the bulbs are identical, then they will all be the same brightness.</p>
	<p><i>(Physics only)</i></p> <p>... <i>that</i> a charged object creates an electric field around itself</p> <p><i>How to</i> explain how the concept of an electric field helps to explain the non-contact force between charged objects as well as other electrostatic phenomena such as sparking.</p>	electric field pattern, Field, force, isolated charge, electrostatic phenomena, sparking	<p>Misconception: current starts from one end of a battery and flows through each component of a circuit in turn, until it gets back to the other end of a battery (e.g. battery to wire, then bulb, then wire, then bulb, then wire back to battery)</p> <p>Current flows instantly in all parts of a circuit when there is a complete circuit.</p>


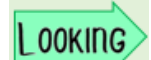
Topic Atomic Structure	Rationale (layering, Why this why now?)	Knowledge goals: <i>You need to know....</i> <i>...that (Declarative) ... how to (Procedural)</i> L ADDERING	Key Tier 3 vocabulary	Core skills and enrichment opportunities.
<p>Ionising radiation is hazardous but can be very useful. Although radioactivity was discovered over a century ago, it took many nuclear physicists several decades to understand the structure of atoms, nuclear forces and stability. Early researchers suffered from their exposure to ionising radiation. Rules for radiological protection were first introduced in the 1930s and subsequently improved. Today radioactive materials are widely used in medicine, industry, agriculture and electrical power generation.</p>	<p> LINKING</p> <p>KS2 Filtering, sieving, evaporating, dissolving, solutions. Year 7 Matter, separating mixtures. Year 8 Elements, periodic table. Year 9 KS4</p> <p> LOOKING</p> <p>Year 9 Year 10 Structure and bonding Year 11 Atomic structure Structure and bonding Post 16 Atomic structure Structure and bonding</p>	<p><i>...that</i> atoms are very small and consist of electrons, protons and neutrons. (sub-atomic particles)</p> <p><i>how to</i> represent the sub-atomic particles and the structure of an atom, including the mass number, atomic number and isotopes.</p>	<p>Nucleus, protons, neutrons, electrons, electromagnetic radiation, energy levels</p>	<p>Subject specific skills Use a variety of models to solve problems, make predictions and to develop scientific explanations and understanding of familiar and unfamiliar facts. Recognise/draw/interpret diagrams. Translate from data to a representation with a model. Use models in explanations, or match features of a model to the data from experiments or observations that the model describes or explains.</p> <p>Numeracy Use an appropriate number of significant figures, find arithmetic means, construct and interpret frequency tables and diagrams, bar charts and histograms, understand the principles of sampling as applied to scientific data, understand simple probability. Recognise and use expressions in standard form. Use ratios, fractions and percentages. Substitute numerical values into algebraic equations using appropriate units for physical quantities. Solve algebraic equations. Translate information between graphical and numeric form.</p> <p>Literacy and Reading BBC Bitesize – Atomic structure, extended reading articles Parallel histories.</p> <p>Cultural Capital/Careers Careers including Nuclear power reactor operator, energy consultant, Laboratory manager, Research Scientist, Nuclear medicine, Radiation Safety officer, Optical engineer, Astronomer.</p> <p>Cross curricular knowledge links DT- Materials,</p>
		<p>.... that the model of the atom has changed over time due to new scientific experimental evidence.</p> <p>how to use evidence to explain why there have been changes in the atomic model.</p>	<p><i>Electrical charge, elements, mass number, atomic number, isotopes, Scientific model,</i></p>	
		<p>.... that some atomic nuclei are unstable and decay.</p> <p>how to..... apply knowledge to the uses of radiation and evaluate the best sources of radiation to use in a given situation.</p>	<p>alpha, beta, gamma, nuclear model,</p>	
		<p>..... <i>that</i> nuclear equations are used to represent radioactive decay.</p> <p>How to explain the concept of half-life and how it is related to the random nature of radio active decay.</p> <p>(HT ONLY) be able to calculate the net decline, expressed as a ratio, in a radioactive emission after a given number of half-lives.</p>	<p>Radiation, radioactive decay, Becquerel, count rate, Geiger-Muller tube, decays, Balanced equations, atomic numbers, mass numbers. Emission, daughter elements, Radioactive isotopes, count rate, half-life</p>	
		<p><i>... that radioactive contamination is the unwanted presence of materials containing radioactive atoms on other materials.</i></p> <p><i>How to ..compare hazards associated with contamination and irradiation.</i></p> <p><i>(Physics only)</i></p>	<p>Contamination, hazard, irradiation, contamination, precautions,</p>	
		<p><i>(Physics only)</i></p>	<p>Back ground radiation, cosmic rays, sieverts</p>	

		<p>... that background radiation is around us all of the time and this is affected by occupation and / or location. How to explain why the hazards associated with radioactive material differ according to the half-life involved.</p>		<p>Chemistry - Periodic table and atoms and bonding,</p> <p>Misconceptions – the electrons in an atom orbit the nucleus like planets in our solar system orbit the sun [electron shells represent the specific amounts of energy electrons have, not where electrons are located]; the nucleus of an atom is equivalent to a nucleus in a cell [they are not analogous].</p> <p>Students' views about the risk of radiation and radioactivematerials are based more strongly on everyday information than scientific ideas</p> <p>For example, some students see certain medical applications, such as radiotherapy, as inherently dangerous. Or, they may think that a nuclear power station is as dangerous as a nuclear bomb. Most students follow mass media on a regular basis and the general descriptions of their views show that they are dominated by incoherent bits of information about radioactivity from the media or films. scientific notions play a small or non-existent part.</p>
		<p>(Physics only) that nuclear radiations are used in medicine How to evaluate the perceived risks of using nuclear radians in relation to given data and consequences.</p>	<p>Evaluation of perceived risks in relation to data and handling.</p>	
		<p>(Physics only) that nuclear fission is the splitting of a large and unstable nucleus and that nuclear fusion is the joining of two light nuclei to form heavier nucleus. How to draw and interpret diagrams representing nuclear fission and how a chain reaction may occur.</p>	<p>Uranium, plutonium, fission, fusion, kinetic energy, chain reaction, nuclear reactor.</p>	

Topic Energy	Rationale (layering, Why this why now?)	Knowledge goals: <i>You need to know....</i> <i>...that (Declarative)</i> <i>.... how to (Procedural)</i> L ADDERING	Key Tier 3 vocabulary	Core skills and enrichment opportunities.						
<p>The concept of energy emerged in the 19th century. The idea was used to explain the work output of steam engines. It also became a key tool for understanding chemical reactions and biological systems. Limits to the use of fossil fuels and global warming are critical problems for this century. Physicists & engineers are working hard to identify ways to reduce our energy usage.</p>	<p> LINKING</p> <p>KS2 Basic concept of heat / thermal energy Year 7 Energy costs and transfers. Year 8 Heating and cooling.</p>	<p><i>...that</i> energy can be stored and transferred in a variety of ways and there are changes in the way energy is stored when a system changes.</p> <p><i>....how to</i> describe all the changes involved in the way energy is stored when a system changes, for common situations.</p>	<p>Kinetic, Thermal, Chemical, Gravitational potential, Elastic potential, Electrostatic, Magnetic, nuclear, mechanical, radiation, electrical</p>	<p>Subject specific skills</p> <p>Practical skills – use a range of new equipment to measure the specific heat capacity of different materials.</p> <p>Numeracy Use, apply and rearrange energy equations. Convert between magnitudes of units. Interpret pie charts and other data sources on energy.</p> <p>Literacy and Reading Extended reading articles - Just Deserts, Unplugged, Out in the Cold,</p> <p>Cultural Capital/Careers Links to engineering related careers and apprenticeships, oil rig engineer, nutritionists or designers will need a good understanding of energy stores and transfers as well.</p> <p>Cross curricular knowledge links DT: Knowledge of principles of energy when designing bespoke items eg playground items, safety equipment (seatbelts).</p> <p>Common Misconceptions</p> <table border="1" data-bbox="1469 1134 2085 1469"> <thead> <tr> <th>Misconception</th> <th>Comment</th> </tr> </thead> <tbody> <tr> <td>The terms "<u>energy</u>" and "<u>force</u>" are interchangeable.</td> <td>The commonest example of this is the thinking of friction as energy - 'kinetic energy is transferred to friction' is a common mistake.</td> </tr> <tr> <td>Work</td> <td>From the non-scientific point of view, "work" is synonymous</td> </tr> </tbody> </table>	Misconception	Comment	The terms " <u>energy</u> " and " <u>force</u> " are interchangeable.	The commonest example of this is the thinking of friction as energy - 'kinetic energy is transferred to friction' is a common mistake.	Work	From the non-scientific point of view, "work" is synonymous
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	Work	From the non-scientific point of view, "work" is synonymous								
<p> LOOKING</p> <p>Year 9 Energy transfers Types of energy Efficiency</p>	<p><i>...that</i> the amount of kinetic energy in a moving object, the amount of elastic potential energy stored in a stretched spring and the amount of gravitational potential energy gained by an object raised above ground level can be calculated.</p> <p><i>....how to</i> calculate the amount of energy associated with a moving object, a stretched spring and an object raised above ground level. Use and rearrange the associated equations.</p>	<p>Limit of proportionality, spring constant, gravitational field strength, joule, m/s, specific heat capacity</p>								
<p>Year 10 and Year 11 Paper 1 - energy</p>	<p><i>...that</i> the specific heat capacity of a substance is the amount of energy required to raise the temperature of one kilogram of a substance by one degree Celsius.</p> <p><i>....how to</i> use & apply the equation: $\Delta E = m c \Delta \theta$</p> <p>RP1. Investigation to determine the specific heat capacity of one or more materials</p>	<p>Δ -Delta (change in) θ – Theta (Temperature)</p>								
<p>Post 16 Work done, potential energy, conservation of energy, mechanical energy, power, efficiency</p>	<p><i>...that</i> power is the energy transferred by a device in a second & is measured in watts. Power is defined as the rate at which energy is transferred or the rate at which work is done.</p> <p><i>....how to</i> use and apply the equations: Power (W) = work done (J) ÷ time (s) and: Power (W) = energy transferred (J) ÷ time (s). Convert between watts & kW</p>	<p>Power, watts, time, energy transfer,</p>								

		<p>...<i>that</i> work done is the energy transferred when a force moves through a given distance. Energy is measured in Joules. Friction opposes motion. Work done to overcome friction is mainly transferred to thermal energy stores by heating.</p> <p>....<i>how to</i> apply the equation Work done = force x distance and identify the appropriate units.</p>	<p>Work done, energy ,friction, Newton, Joule.</p>		<p>with "labour". It is hard to convince someone that more work is probably being done dancing for one hour than studying an hour for a test. The fact that you only 'do work' when moving against gravity or another force - so walking on the level or going down a slope is not work is hard for them to grasp.</p>
		<p>...<i>that</i> useful energy: is energy transferred to where it is wanted in the way that it is wanted</p> <p>....<i>how to</i> explain the impact of friction on moving items and how it can be reduced.</p> <p>RP2: (Physics only) : Investigate the effectiveness of different materials as thermal insulators and the factors that may affect the thermal insulation properties</p>	<p>Friction, dissipated, wasted, transfer, thermal energy store. Thermal conductivity. Lubrication. Insulators & conductors.</p>	<p>An object at rest has no energy.</p>	<p>They commonly associate energy of an object with its movement - they were told they had lots of energy when they ran around as young children - and when tired and still they said things like, 'I have no energy left!'</p>
		<p>...<i>that</i> some energy will be wasted during transfers and the energy efficiency for any energy transfer can be calculated.</p> <p>....<i>how to use both equations:</i> $\text{efficiency} = \frac{\text{useful output energy transfer}}{\text{total in put energy transfer}}$</p>	<p>Efficiency</p>	<p>The only type of potential energy is gravitational.</p>	<p>At one time 'potential energy' was GPE! Now we have to ensure they know of all of the types of energy that is potential because it is stored up ready to be released - potential chemical energy in fuels (not released until they are burned), potential elastic energy in a stretched spring (not released until the spring is....</p>
		<p>...<i>that</i> non-renewable energy sources cannot be replaced. Fossil fuels are running out and alternatives need to be found.</p> <p>....<i>how to</i> evaluate the advantages & disadvantages of a range of renewable energies using text and data charts.</p>	<p>Non-renewable, fossil fuels, nuclear power, global warming, global dimming, emissions. Solar, hydro-electric, wind, tidal, geothermal, renewable,</p>	<p>Gravitational potential energy depends only on the height of an object and kinetic energy only on the speed.</p>	<p>The mass and gravitational field strength often get overlooked. A circus of objects with the same GPE can be useful - as can a set of caculations of objects of equal KE - to set that up practically would be difficult!</p>

				<p>Doubling the speed of a moving object doubles the kinetic energy.</p>	<p>The squared factor causes many a problem! You need to work through questions on this - at GCSE stopping distances need a good grasp of this - but most want to drive - so it is a topic they actually try hard to understand!</p>
				<p>Energy can be changed completely from one form to another useful (no energy losses as unwanted energy).</p>	<p>Even when electricity is used in a heater there is some 'wasted' energy involved - light, sound Many think that energy is truly lost in many energy transformations because things "use up" energy.</p>

Topic Forces	Rationale (layering, Why this why now?)	Knowledge goals: <i>You need to know....</i> <i>...that (Declarative)</i> ... <i>how to (Procedural)</i> L ADDERING	Key Tier 3 vocabulary	Core skills and enrichment opportunities.
<p>Engineers analyse forces when designing a great variety of machines and instruments, from road bridges and fairground rides to atomic force microscopes. Anything mechanical can be analysed in this way. Recent developments in artificial limbs use the analysis of forces to make movement possible.</p>	<p> KS2 Moving objects, types of forces</p> <p>KS3 Speed, types of forces,</p> <p> KS4 – Forces, work, scalars, vectors, atmosphere</p> <p>Post 16 Forces, momentum, moments</p>	<p><i>...that</i> Scalar quantities have magnitude only. Vector quantities have magnitude and an associated direction.</p> <p><i>how to</i> describe the interaction between pairs of objects which produce a force on each object.</p>	<p>Scalar and vector, Contact and non-contact forces, Weight and gravity</p>	<p>Cultural Capital/Careers</p> <p>Mechanic, aerospace engineer, computer game designer. car safety designer</p> <p>Cross curricular knowledge links</p> <p>PE – Sports and motion, Maths – formulas and algebra.</p> <p>Numeracy</p> <p>Recognise and use expressions in standard form. Use ratios, fractions and percentages.</p> <p>Substitute numerical values into algebraic equations using appropriate units for physical quantities. Solve algebraic equations.</p> <p>Translate information between graphical and numeric form.</p> <p>Literacy and Reading</p> <p>Understand scientific methods and theories and how they develop over time. Use a variety of models to make predictions and develop scientific explanations and understanding.</p> <p>Use scientific vocabulary, terminology and definitions. Use prefixes and powers of ten for orders of magnitude.</p>
		<p><i>...that</i> Weight is the force acting on an object due to gravity.</p> <p><i>... how to</i> use the equation - weight = mass × gravitational field strength</p>	<p>quantatively and qualitatively.</p>	
		<p><i>...that</i> a number of forces acting on an object may be replaced by a single force, called the resultant force, that has the same effect as all the original forces acting together.</p> <p><i>... how to</i> calculate the resultant of two forces that act in a straight line,</p> <p>(HT only) describe examples of the forces acting on an isolated object or system and use free body diagrams to describe qualitatively examples where several forces lead to a resultant force on an object.</p>	<p>Resultant force, Free body diagrams,</p> <p>HT Only</p>	
		<p><i>...that</i> when a force causes an object to move through a distance work is done on the object.</p> <p><i>... how to</i> use the calculation work done = force × distance (W = Fs)</p>	<p>work</p>	
		<p><i>...that</i> to change the shape of an object more than one force has to be applied and that the extension of an elastic object, such as a spring, is directly proportional to the force applied, provided that the limit of proportionality is not exceeded.</p> <p><i>...how to</i> describe the difference between elastic deformation and</p>	<p>Force, work, newtons, joules, displacement, frictional forces</p>	

		inelastic deformation caused by stretching forces by using the equations force = spring constant × extension. ($F = ke$)		Common Misconceptions <table border="1"> <tr> <td>Measurement is only linear.</td> <td>Double the dimensions of an object and they think the curved surface area (csa) and volume also double - they find the fact that csa increases by a factor of 4 and volume (and therefore the mass) by a factor of 8 surprising.</td> </tr> <tr> <td>Any quantity can be measured as accurately as you want.</td> <td>.... all you have to do is use a modern 'digital' instrument - they think 'old' instruments are out of date and useless. They find the accuracy of precision instruments being related to construction difficult to understand - it needs to be 'new' and 'electronic' to be any good in their eyes!</td> </tr> <tr> <td>You can measure to any proportion of the smallest unit shown on the measuring device.</td> <td>They think they can estimate a third or quarter of a scale division - put them right on this!</td> </tr> <tr> <td>You should start at the end of the measuring device when measuring distance.</td> <td>Zero errors due to 'bashed' metre rulers always give a problem - so do ones that are constructed with a 'gap' to allow for wear and tear!</td> </tr> <tr> <td>Some objects cannot be measured because of their size or inaccessibility.</td> <td>They think an object must be "touched" to measure it. Use of trig to measure the height of a tree is sometimes suspect!</td> </tr> <tr> <td>Mass is a quantity that you get by weighing an object.</td> <td>In general speak they are interchangeable - to a pupil so are their units and numerical values! The doctors and other professions are included in the blame for this!</td> </tr> </table>	Measurement is only linear.	Double the dimensions of an object and they think the curved surface area (csa) and volume also double - they find the fact that csa increases by a factor of 4 and volume (and therefore the mass) by a factor of 8 surprising.	Any quantity can be measured as accurately as you want. all you have to do is use a modern 'digital' instrument - they think 'old' instruments are out of date and useless. They find the accuracy of precision instruments being related to construction difficult to understand - it needs to be 'new' and 'electronic' to be any good in their eyes!	You can measure to any proportion of the smallest unit shown on the measuring device.	They think they can estimate a third or quarter of a scale division - put them right on this!	You should start at the end of the measuring device when measuring distance.	Zero errors due to 'bashed' metre rulers always give a problem - so do ones that are constructed with a 'gap' to allow for wear and tear!	Some objects cannot be measured because of their size or inaccessibility.	They think an object must be "touched" to measure it. Use of trig to measure the height of a tree is sometimes suspect!	Mass is a quantity that you get by weighing an object.	In general speak they are interchangeable - to a pupil so are their units and numerical values! The doctors and other professions are included in the blame for this!
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		<p>...<i>that</i> the extension of an elastic object, such as a spring, is directly proportional to the force applied, provided that the limit of proportionality is not exceeded.</p> <p>... <i>how to</i> calculate work done in stretching (or compressing) a spring (up to the limit of proportionality) using the equation:</p> <p>RP6 - Investigate the relationship between force and extension for a spring.</p>	Compressing, elastic deformation, inelastic deformation, directly proportional													
		<p>...<i>that</i> a force or a system of forces may cause an object to rotate. The turning effect of a force is called the moment of the force.</p> <p>....<i>how to</i> use the calculation to work out the size of the moment - moment of a force = force × distance. ($M = Fd$)</p> <p>(Physics only)</p>	Physics only Turning forces, moments Leavers and gears, perpendicular distance, pivot,													
		<p>...<i>that</i> A fluid can be either a liquid or a gas. The pressure in fluids causes a force normal (at right angles) to any surface.</p> <p>....<i>how to</i> calculate the pressure at the surface of a fluid using the equation: pressure = force normal to a surface area of that surface $p = F/A$.</p>	Pressure in a fluid Pressure in a gas Upthrust, pascals, density, submerged objects,													
		<p>.....<i>that</i> the atmosphere is a thin layer (relative to the size of the Earth) of air round the Earth. The atmosphere gets less dense with increasing altitude.</p> <p>....<i>how to</i> describe a simple model of the Earth's atmosphere, atmospheric pressure and how it varies with height above a surface. How to calculate the pressure due to a column of liquid using the equation - pressure = height of the column × density of the liquid × gravitational field strength. [$p = h \rho g$]</p>	Atmospheric pressure													
		<p>...<i>that</i> there is a difference between distance and displacement and a difference between scalar and vector quantities.</p>	HT Distance and displacement Speed and velocity													

	<p>....<i>how to</i> use the calculation to work out the distance travelled in a specific time for an object moving at constant speed distance travelled = speed × time, $s = vt$</p> <p>(HT only) Students should be able to explain qualitatively, with examples, that motion in a circle involves constant speed but changing velocity</p>	Distance time graphs, Velocity time graphs, gradient,	<p>The five senses are infallible.</p> <p>There is only one way to measure perimeter.</p>	<p><u>Optical illusions</u> are good on this one!</p> <p>... and that is 'all of the way' round - mathematical calculation is suspect!</p>
	<p>...<i>that</i> If an object moves along a straight line, the distance travelled can be represented by a distance–time graph and that the speed of an object can be calculated from the gradient of its distance–time graph.</p> <p>....<i>how to</i> draw distance–time graphs from measurements and extract and interpret lines and slopes of distance–time graphs, translating information between graphical and numerical form.</p> <p>(HT only) If an object is accelerating, its speed at any particular time can be determined by drawing a tangent and measuring the gradient of the distance–time graph at that time.</p>	HT Estimating magnitudes, uniform acceleration, terminal velocity	<p>Only the area of rectangular shapes can be measured in square units.</p> <p>Surface area can be found only for two-dimensional objects.</p>	<p>The idea of measuring a circle in square units give some children problems</p> <p>Surface area is a concept used only in mathematics classes! Practical making of wrapping for an object helps with this - it is limited to rectangular shapes, but it helps - they have done 'nets' in maths.</p>
	<p>..... <i>that</i> the average acceleration of an object can be calculated using the equation: acceleration = change in velocity/ time taken $a = \Delta v / t$</p> <p>.... <i>how to</i> calculate the acceleration of an object from the gradient of a velocity–time graph.</p> <p>(HT only) The distance travelled by an object (or displacement of an object) can be calculated from the area under a velocity–time graph.</p> <p>(Physics only) Students should be able to: Draw and interpret velocity–time graphs for objects that reach terminal velocity and interpret the changing motion in terms of the forces acting.</p>	HT	<p>You cannot measure the volume of some objects because they do not have "regular" lengths, widths, or heights.</p>	<p>They need to think of volume as an occupied 'space' rather than a mathematical construct - displacement can experiments are fun!</p>
	<p>.... <i>that</i> Newton’s First Law: states that the resultant force acting on an object is zero and if the object is stationary, the object remains stationary or the object is moving, the object continues to move at the same speed and in the same direction. So the object continues to move at the same velocity.</p>	HT	<p>The density of two samples of the same substance with different volumes or shapes cannot be the same.</p>	<p>Density is a concept difficulty for many... practical hands on experience is vital.</p>

		<p>(HT only) The tendency of objects to continue in their state of rest or of uniform motion is called inertia.</p> <p>.... that Newton's Second Law states that the acceleration of an object is proportional to the resultant force acting on the object, and inversely proportional to the mass of the object. As an equation : resultant force = mass × acceleration $F = m a$</p> <p><i>RP7: investigate the effect of varying the force on the acceleration of an object of constant mass, and the effect of varying the mass of an object on the acceleration produced by a constant force.</i></p>		
		<p>... that they can evaluate the effect of various factors on thinking distance based on given data.</p> <p>....how to calculate stopping distance</p> <p>(HT only) estimate the forces involved in the deceleration of road vehicles in typical situations on a public road</p> <p>(Physics only) Students should be able to estimate how the distance for a vehicle to make an emergency stop varies over a range of speeds typical for that vehicle.</p> <p>(Physics only) Students will be required to interpret graphs relating speed to stopping distance for a range of vehicles.</p>	<p>Resultant forces, stationary, resistive forces, uniform velocity, inertia. Thinking distance, breaking distance, stopping distance. Reaction times, Energy transfers</p>	
		<p>Momentum (HT only)</p> <p>... that momentum is a property of moving objects and conservation of momentum states that in a closed system, the total momentum before an event is equal to the total momentum after the event. This is called conservation of momentum.</p> <p>....how to use the equation that momentum is defined by – momentum = mass × velocity ($p = m v$). Students should also be able to use the concept of momentum as a model to describe and explain examples of momentum in an event, such as a collision</p> <p>(Physics only) complete calculations involving an event, such</p>	<p>Mass, momentum, velocity, conservation Deceleration, closed system, momentum, safety features,</p>	

as the collision of two objects.

Changes in momentum (physics only)

When a force acts on an object that is moving, or able to move, a change in momentum occurs.



The equations $F = m \times a$ and $a = \frac{v - u}{t}$

combine to give the equation $F = \frac{m \Delta v}{\Delta t}$


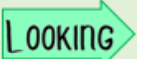
where $m\Delta v =$ change in momentum

ie force equals the rate of change of momentum.

Students should be able to apply equations relating force, mass, velocity and acceleration to explain how the changes involved are inter-related.

Topic Magnetism and Electromagnetism	Rationale (layering, Why this why now?)	Knowledge goals: <i>You need to know....</i> <i>...that (Declarative) how to (Procedural)</i> LADDERING	Key Tier 3 vocabulary	Core skills and enrichment opportunities.					
<p>Electromagnetic effects are used in a wide variety of devices. Engineers make use of the fact that a magnet moving in a coil can produce electric current and also that when current flows around a magnet it can produce movement. It means that systems that involve control or communications can take full advantage of this.</p>	<p> Linking</p> <p><u>KS2</u> Magnets,</p> <p><u>KS3</u> Magnets, magnetic materials, compasses</p>	<p><i>...that</i> the poles of a magnet are the places where the magnetic forces are strongest and two magnets are brought close together they exert a force on each other</p> <p><i>how to</i> describe the attraction and repulsion between unlike and like poles for permanent magnets and the difference between permanent and induced magnets.</p>	<p>Poles, fields, North, South, repel, attract, non-contact force, induced magnet, Iron, Nickel, Cobalt.</p>	<p>Subject specific skills Use a variety of models to solve problems, make predictions and to develop scientific explanations and understanding of familiar and unfamiliar facts. Recognise/draw/interpret diagrams. Translate from data to a representation with a model. Use models in explanations, or match features of a model to the data from experiments or observations that the model describes or explains.</p>					
	<p> Looking</p> <p>KS4 Magnets, Induced magnets, induced current, motor and generator effect.</p>	<p><i>...that</i> when a current flows through a conducting wire a magnetic field is produced around the wire.</p> <p><i>... how to</i> describe how the magnetic effect of a current can be demonstrated by drawing the magnetic field pattern for a straight wire carrying a current and for a solenoid.</p>	<p>Current, solenoid, iron core.</p>	<p>Numeracy Use an appropriate number of significant figures, find arithmetic means, construct and interpret frequency tables and diagrams, bar charts and histograms, understand the principles of sampling as applied to scientific data, understand simple probability</p>					
	<p>Post 16</p> <p>Magnetic Fields, Magnetic Field Strength, The Force on a Moving Charge</p>	<p><i>...that</i> when a conductor carrying a current is placed in a magnetic field the magnet producing the field and the conductor exert a force on each other. This is called the motor effect.</p> <p><i>... how to</i> show that Fleming's left-hand rule represents the relative orientation of the force, the current in the conductor and the magnetic field. Students should be able to recall the equation: force = magnetic flux density × current × length $F = B I l$</p>	<p>Fleming's left-hand rule, magnetic flux density, force.</p>	<p>Literacy and Reading BBC Bitesize – Magnetism, extended reading articles Parallel histories.</p> <p>Cultural Capital/Careers Careers including Engineers in terms of building all sorts of machines that have electric motors and generators. Sound engineers, transmission of electricity at high voltages in transformers that form the backbone of the National Grid. Fun and sorting materials.</p>					
		<p><i>...that</i> a coil of wire carrying a current in a magnetic field tends to rotate.</p> <p><i>....how to</i> explain how a moving-coil loudspeaker and headphones work.</p> <p>(Physics only)</p>	<p>Physics only</p> <p>Rotation, conductor, coil, loudspeakers, headphones, pressure. Rotation, conductor, coil, loudspeakers, headphones, pressure.</p>	<p>Cross curricular knowledge links Geography – Earths magnetic field,</p> <p>Misconceptions</p> <table border="1" data-bbox="1550 1300 2172 1423"> <thead> <tr> <th data-bbox="1550 1300 1736 1348">Misconception</th> <th data-bbox="1736 1300 1899 1412">Discussion of the problem</th> <th data-bbox="1899 1300 2172 1412">Possible Activities</th> </tr> </thead> <tbody> <tr> <td> </td> <td> </td> <td> </td> </tr> </tbody> </table>	Misconception	Discussion of the problem	Possible Activities		
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		<p><i>...that</i> If an electrical conductor moves relative to a magnetic field or if there is a change in the magnetic field around a conductor, a potential difference is induced across the ends of the conductor. If the conductor is part of a complete circuit, a current is induced in the conductor. This is called the generator effect.</p> <p><i>how to</i> recall the factors that affect the size of the induced potential difference/induced current and recall the factors that affect the direction of the induced potential difference/induced current.</p> <p>(Physics only)</p>	<p>Physics only</p> <p>Potential difference, current, conductor, generator, induced. Potential difference, current, conductor, generator, induced.</p>	<p>All metals are attracted to a magnet.</p>	<p>Only iron, nickel and cobalt and their alloys are attracted to a magnet</p>	<p>Circus of material to test</p>
<p><i>...that</i> the generator effect is used in an alternator to generate ac and in a dynamo to generate dc.</p> <p><i>how to</i> explain how the generator effect is used in an alternator to generate ac and in a dynamo to generate dc</p>	<p>Potential difference, current, conductor, generator, induced, transformers, coil, efficient, eddy currents.</p>	<p>All silver coloured items are attracted to a magnet.</p>	<p>as above</p>	<p>as above</p>		
<p><i>...that</i> a basic transformer consists of a primary coil and a secondary coil wound on an iron core and that ratio of the potential differences across the primary and secondary coils of a transformer V_p and V_s depends on the ratio of the number of turns on each coil, n_p and n_s.</p> <p><i>.....how to</i> use the equations $v_p/v_s = n_p/n_s$ potential difference, V_p and V_s in volts, V. In a step-up transformer $V_s > V_p$ In a step-down transformer $V_s < V_p$ $V_s \times I_s = V_p \times I_p$</p>		<p>All magnets are made of iron.</p>	<p>iron is a soft magnetic material - wouldn't work!</p>	<p>Make magnets - iron and steel - by stroking</p>		
<p>Larger magnets are stronger than smaller magnets.</p>		<p>part of a circus - weak big one and strong small one!</p>				
<p>The magnetic and geographic poles of the earth are located at the same place.</p>		<p>Web search on navigation of seas and how magnetic pole 'moves'</p>				
<p>The magnetic pole of the earth in the northern hemisphere is a north pole, and the pole in the southern hemisphere is a south pole.</p>		<p>Make a model of the earth and put a magnet within it so that search compasses point north</p>				

Topic	Rationale (layering, Why this why now?)	Knowledge goals: <i>You need to know....</i> <i>...that (Declarative) ... how to (Procedural)</i> LADDERING	Key Tier 3 vocabulary	Core skills and enrichment opportunities.
<p>Questions about where we are, and where we came from, have been asked for thousands of years. In the past century, astronomers and astrophysicists have made remarkable progress in understanding the scale and structure of the universe, its evolution and ours. New questions have emerged recently. ‘Dark matter’, which bends light and holds galaxies together but does not emit electromagnetic radiation, is everywhere – what is it? And what is causing the universe to expand ever faster?</p>	<p> Linking KS2 Space, our universe, day and night</p> <p>KS3 Space, our universe, day and night</p> <p> Looking KS4</p> <p>Post 16</p>	<p><i>...that</i> within our solar system there is one star, the Sun, plus the eight planets and the dwarf planets that orbit around the Sun. Natural satellites, the moons that orbit planets, are also part of the solar system.</p> <p><i>how to explain</i> how, at the start of a star's life cycle, the dust and gas drawn together by gravity causes fusion reactions and that that fusion reactions lead to an equilibrium between the gravitational collapse of a star and the expansion of a star due to fusion energy</p>	<p>Planets, dwarf planets, stars, asteroids, comets, moons, meteoroids, meteors, galaxy, Milky Way, The Universe. Satellites, artificial satellites, natural satellites, orbits, velocity.</p>	<p>Subject specific skills Use a variety of models such as representational, spatial, descriptive, computational and mathematical to solve problems, make predictions and to develop scientific explanations and understanding of familiar and unfamiliar facts. Recognise/draw/interpret diagrams. Translate from data to a representation with a model. Use models in explanations, or match features of a model to the data from experiments or observations that the model describes or explains. Make predictions or calculate quantities based on the model or show its limitations. Give examples of ways in which a model can be tested by observation or experiment.</p> <p>Numeracy Use scientific vocabulary, terminology and definitions. WS 4.2 Recognise the importance of scientific quantities and understand how they are determined. Use SI units (eg kg, g, mg; km, m, mm; kJ, J) and IUPAC chemical nomenclature unless inappropriate. Use prefixes and powers of ten for orders of magnitude (eg tera, giga, mega, kilo, centi, milli, micro and nano). Interconvert units. Use an appropriate number of significant figures in calculation</p> <p>Literacy and Reading BBC Bitesize –Space Physics, extended reading articles Parallel histories.</p> <p>Cultural Capital/Careers Space systems engineer, Space lawyer, Software engineer, commercial strategist, human spaceflight and microgravity programme manager, Glaciologist, ExoMars delivery manager, Emerging Technology lead,</p> <p>Cross curricular knowledge links</p>
		<p><i>... that a</i> star goes through a life cycle and the life cycle is determined by the size of the star.</p> <p><i>How to</i> explain how fusion processes lead to the formation of new elements.</p>	<p>Hydrogen, Helium, attraction, repulsion, energy, pressure, heat.</p>	
		<p><i>.... that</i> gravity provides the force that allows planets and satellites (both natural and artificial) to maintain their circular orbits.</p> <p><i>How to ...</i> describe the similarities and distinctions between the planets, their moons, and artificial satellites</p>	<p>Nebula, protostar, main sequence star, red giant, white dwarf, black dwarf, neutron star, supernovae, black hole, elements, Iron.</p>	
		<p><i>... that</i> there is an observed increase in the wavelength of light from most distant galaxies. This effect is called red-shift.</p> <p><i>how to...</i> explain qualitatively the red-shift of light from galaxies that are receding and how red-shift provides evidence for the Big Bang model.</p>	<p>Wavelength, expansion, Doppler effect, Big Bang, dark mass, dark energy, supernovae.</p>	

Geography – Earth's magnetic field, Chemistry – chemical compounds,

Misconceptions

Astronauts are weightless in orbit

Reality: anywhere mass and space exist, gravity exists.

The Sun is Yellow



Reality: white is the true colour of the Sun.

It would be dangerous to fly through an asteroid belt

In the Asteroid Belt of the Solar System, which is between the orbits of Mars and Jupiter, the average distance between objects is again a massive 600,000 miles (965,606.4 km). So no, it wouldn't be dangerous to fly through an asteroid belt.

You would instantly freeze in space

Reality: you wouldn't freeze instantly in the space, despite its average temperature is so low (3K or -270 °C; -454 °F). Because there's no matter in the space, so the heat does not leave the body quickly enough. You only lose heat via thermal radiation. Of course, you would get colder and eventually freeze but very, very slowly.

Topic Waves	Rationale (layering, Why this why now?)	Knowledge goals: <i>You need to know...</i> <i>...that (Declarative) how to (Procedural)</i> LADDERING	Key Tier 3 vocabulary	Core skills and enrichment opportunities.				
<p>Wave behaviour is common in both natural and man-made systems. Waves carry energy from one place to another and can also carry information. Designing comfortable and safe structures such as bridges, houses and music performance halls requires an understanding of mechanical waves. Modern technologies such as imaging and communication systems show how we can make the most of electromagnetic waves.</p>	<p> LINKING</p> <p><u>KS2</u> Basic concepts of waves and movement</p> <p><u>KS3</u> Energy and waves, light waves, sound waves.</p> <p> LOOKING</p> <p><u>KS4</u> Waves in air, fluids and solids, properties, uses and dangers of waves.</p> <p><u>Post 16</u> Diffraction gratings, coherence, path difference, phase difference. industrial application of diffraction gratings, including emission Spectra and identification of</p>	<p><i>...that</i> waves may be either transverse or longitudinal.</p> <p><i>how to</i> describe the difference between longitudinal and transverse waves and describe wave motion in terms of their amplitude, wavelength, frequency and period.</p>	<p>Parallel, Perpendicular, Wavelength, Amplitude, Peaks, Troughs, Compressions, Rarefaction, Normal</p>	<p>Subject specific skills Describe a practical procedure for a specified purpose. Explain why a given practical procedure is well designed for its specified purpose. Explain the need to manipulate and control variables.</p> <p>Numeracy Use an appropriate number of significant figures, find the arithmetic mean and range of a set of data, construct and interpret frequency tables and diagrams, bar charts and histograms, change the subject of an equation, substitute numerical values into algebraic equations using appropriate units for physical quantities. Practical use of ray boxes and numeracy skills used throughout, such as calculating the speed of a wave.</p> <p>Literacy and Reading Understand scientific methods and theories and how they develop over time. Use a variety of models to make predictions and develop scientific explanations and understanding. Use scientific vocabulary, terminology and definitions.</p> <p>Cultural Capital/Careers Careers include sonographer, seismologist or a seismographer, opticians or ophthalmologists</p> <p>Cross curricular knowledge links Geography, earthquakes and convection currents, coastal erosion</p> <p>Common Misconceptions</p> <table border="1" data-bbox="1435 1262 2175 1414"> <thead> <tr> <th>Misconception</th> <th>Possible Activities</th> </tr> </thead> <tbody> <tr> <td>Loudness and pitch of sounds are confused with each other.</td> <td>Reinforcement of correct scientific vocabulary</td> </tr> </tbody> </table>	Misconception	Possible Activities	Loudness and pitch of sounds are confused with each other.	Reinforcement of correct scientific vocabulary
		Misconception	Possible Activities					
		Loudness and pitch of sounds are confused with each other.	Reinforcement of correct scientific vocabulary					
		<p><i>...that</i> the frequency of a wave is the number of waves passing a point each second and the wave speed is the speed at which the energy is transferred through the medium.</p> <p><i>... how to</i> use the equations to work out period</p> <p>(Physics only) show how, changes in velocity, frequency and wavelength, in transmission of sound waves from one medium to another, are inter-related.</p>	<p>Reflect, refract, Incident Medium, Sound,</p>					
<p><i>...that</i> there is a method to measure the speed of sound waves in air and to measure the speed of ripples on a watersurface.</p> <p><i>... how to</i> make observations to identify the suitability of apparatus to measure the frequency, wavelength and speed of waves in a ripple tank and waves in a solid and take appropriate measurements.</p> <p>RP8: make observations to identify the suitability of apparatus to measure the frequency, wavelength and speed of waves in a ripple tank and waves in a solid and take appropriate measurements.</p>	<p>Ultrasound, S-waves, P-Waves, Seismic waves, Radio Waves, Microwaves, Infrared, Visible light, Ultraviolet, X-Rays, Gamma Rays. Practical applications Velocity, Frequency, wavelength Real, Virtual, inverted Speed, transparent, translucent, Absorption, filters, opaque. Infrared, Energy</p>							
<p><i>...that waves can be reflected at the boundary between two different materials and waves can be absorbed or transmitted at the boundary between two different materials.</i></p>	<p>Physics only</p>							



gases. Concept and applications of stationary wave resonance.	<p><i>how to</i> construct ray diagrams to illustrate the reflection of a wave at a surface. And how to describe the effects of reflection, transmission and absorption of waves at material interfaces.</p> <p>RP9: Investigate the reflection of light by different types of surface and the refraction of light by different substances</p>		<p>Hitting an object harder changes its pitch.</p> <p>Practical - getting them to sing the note when hit with different force</p>
	<p><i>...that</i> sound waves can travel through solids causing vibrations in the solid.</p> <p><i>how to</i> describe, with examples, processes which convert wave disturbances between sound waves and vibrations in solids. Examples may include the effect of sound waves on the ear drum and explain why such processes only work over a limited frequency range and the relevance of this to human hearing.</p>	Physics only	<p>In a telephone, actual sounds are carried through the wire rather than electrical pulses</p> <p>Human voice sounds are produced by a large number of vocal chords.</p> <p>Sound moves faster in air than in solids (air is "thinner" and forms less of a barrier).</p> <p>Sound moves between particles of matter (in empty space) and then 'bumps into' the next matter particle.</p>
	<p><i>...that</i> waves are used for detection and exploration.</p> <p><i>how to</i> explain in qualitative terms, how the differences in velocity, absorption and reflection between different types of wave in solids and liquids can be used both for detection and exploration of structures which are hidden from direct observation.</p>	Ultrasound waves, Seismic waves, P-waves and S-waves. Echo sounding.	<p>In wind instruments, the instrument itself vibrates not the internal air column</p> <p>The pitch of whistles or sirens on moving vehicles is changed by the driver as the vehicle passes.</p>
	<p><i>...that</i> Electromagnetic waves are transverse waves that transfer energy from the source of the waves to an absorber, they form a continuous spectrum and all types of electromagnetic wave travel at the same velocity through a vacuum (space) or air.</p> <p><i>...how to</i> give examples that illustrate the transfer of energy by electromagnetic waves.</p> <p>RP10: Investigate how the amount of infrared radiation absorbed or radiated by a surface depends on the nature of that surface.</p>	radio, microwave, infrared, visible light (red to violet), ultraviolet, Xrays and gamma rays	<p>The pitch of a tuning fork will change as it "slows down", (i.e. "runs" out of energy)</p> <p>Practical - getting them to sing the note until it dies</p> <p>As sound waves move, the air moves along with them.</p>
	<p><i>...that</i> Electromagnetic waves all have many uses and applications due to their individual properties</p>	• radio waves – television and radio	<p>The pupil of the eye is a black object or a spot on the surface of the eye.</p> <p>Idea it is the gap in the centre of the iris.</p> <p>Observation of how the pupil changes size in different light intensities (Care they don't blind each other!) Discuss eye exams in an optician -</p>

		<p><i>...how to</i> give brief explanations why each type of electromagnetic wave is suitable for the practical application.</p>	<ul style="list-style-type: none"> • microwaves – satellite communications, cooking food • infrared – electrical heaters, cooking food, infrared cameras • visible light – fibre optic communications • ultraviolet – energy efficient lamps, sun tanning • X-rays and gamma rays – medical imaging and treatments. 			<p>how s/he looks through the pupil</p>
		<p><i>...that</i> a lens forms an image by refracting light.</p> <p><i>...how to</i> construct ray diagrams to illustrate the similarities and differences between convex and concave lenses.</p>	<p>Physics only</p>	<p>The eye receives upright images on the retina.</p>	<p>Ray diagrams can be used to show how the image is inverted</p>	<p>Use vid-clips to show full visual system</p>
		<p><i>...that</i> each colour within the visible light spectrum has its own narrow band of wavelength and frequency.</p> <p><i>...how to</i> explain:</p> <ul style="list-style-type: none"> • how the colour of an object is related to the differential absorption, transmission and reflection of different wavelengths of light by the object • the effect of viewing objects through filters or the effect on light of passing through filters 	<p>Physics only</p>	<p>The lens is the only part of the eye responsible for focusing light.</p>	<p>Cornea is primary refractor</p>	<p>Discuss sight correction using lasers - resculpting of the cornea - use a glass ball to refract light.</p>
		<p><i>...that</i> all bodies (objects), no matter what temperature, emit and absorb infrared radiation. A perfect black body is an object that absorbs all of the radiation incident on it.</p> <p><i>...how to</i> explain:</p> <ul style="list-style-type: none"> • that all bodies (objects) emit radiation • that the intensity and wavelength distribution of any emission depends on the temperature of the body 	<p>Physics only</p>	<p>The lens forms an image (picture) on the retina. The brain then "looks" at this image and that is how we see.</p>	<p>Correct terminology for image interpretation needs to be reinforced</p>	<p>Use vid-clips to show full visual system - discuss how blindness can happen to people with perfect eyes</p>
				<p>The eye is the only organ involved in sight; the brain is only for thinking.</p>	<p>Correct terminology for image interpretation needs to be reinforced</p>	<p>Use vid-clips to show full visual system - discuss how blindness can happen to people with perfect eyes</p>
				<p>A white light source, such as sunlight, an incandescent or fluorescent bulb, candle flame etc. produces light made up of exactly the same spectrum of colours.</p>	<p>Spectra of sources differ according to the electron transitions involved</p>	<p>Use a series of light sources and compare the spectra or what strips of multicoloured cloth look like under them - discuss how clothing looks different under different light sources. Could look at spectra from stars...</p>
				<p>When white light passes through a coloured filter colour is added to the light.</p>	<p>Filters subtract</p>	<p>Use multiple filters</p>

				<p>The rules for mixing color paints and crayons are the same as the rules for mixing coloured lights. So the primary colors for mixing coloured lights are red, blue and yellow.</p>		
				<p>The shades of grey in a black and white newspaper picture are produced by using inks with different shades of gray.</p>		<p>Use a magnifying glass to look at the dots</p>
				<p>The different colors appearing in coloured pictures printed in magazines and newspapers are produced by using different inks with all the corresponding colors.</p>		<p>Use a magnifying glass to look at the dots</p>
				<p>Colour is a property of an object, and is independent of both the illuminating light and the receiver (eye).</p>		<p>Look at coloured objects under different coloured light sources.</p>
				<p>White light is colourless and clear, enabling you to see the "true" color of an object.</p>		


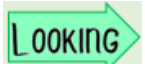
				<p>Explanations of visual phenomena involving color perception usually involve only the properties of the object being observed, and do not include the properties of the eye-brain system.</p>		<p>Talk about colour blindness - use colour blindness tests.</p>
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Year 11 Topic One - Rate and extent of chemical change (GCSE Trilogy Chemistry)

Topic	Rationale (Layering, Why this why now?)	Knowledge goals: <i>You need to know...</i> <i>...that (Declarative) ... how to (Procedural)</i> LADDERING	Key Tier 3 vocabulary	Core skills and enrichment opportunities.
<p>4.6 Rate and extent of chemical change Chemical reactions can occur at vastly different rates. Whilst the reactivity of chemicals is a significant factor in how fast chemical reactions proceed, there are many variables that can be manipulated in order to speed them up or slow them down. Chemical reactions may also be reversible and therefore the effect of different variables needs to be established in order to identify how to maximise the yield of desired product. In industry, chemists and chemical engineers</p>	<p> Year 8 Rates of reaction</p>	<p>Measuring Rate of Reaction <i>...that</i> mean rate of reaction can be determined by measuring quantity of mass used or product released <i>...how to</i> determine the rate of a chemical reaction by interpreting data <i>... how to</i> apply knowledge to past examination questions</p>	<p>Product, reactant, rate, mean, gradient</p>	<p>a) Numeracy Analysis and evaluation of data based questions using graphs and/or tables for rates and chemical changes. Learners need to employ the use of suitable units when measuring and collecting data. There is a need for learners to develop their mathematical mastery to determine the gradient of a straight line. Learners will also need to be able to determine the intercept on a linear graph.</p>
	<p> Year 11 Apply rate and extent of chemical change knowledge to extended questions.</p>	<p>Factors affecting rate of reaction <i>...that</i> the rate of reaction can be changed by altering conditions <i>...how to</i> use collision theory to explain the effect of changing conditions on the rate of reaction <i>... how to</i> apply knowledge to past examination questions</p>	<p>Collision, particle, energy, activation, rate, concentration, pressure, sufficient, catalyst, temperature, surface area, state</p>	
	<p>Post 16 Rate of reaction and kinetics</p>	<p>Changing Surface Area <i>...how to</i> measure the rate of reaction during a practical for production of gaseous products <i>...how to</i> represent data using graphs <i>... how to</i> apply knowledge to past examination questions</p>	<p>Dependent, independent, control, variable, surface area, delivery tube</p>	


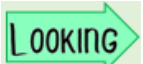
<p>determine the effect of different variables on reaction rate and yield of product. Whilst there may be compromises to be made, they carry out optimisation processes to ensure that enough product is produced within a sufficient time, and in an energy-efficient way.</p>	<p><u>Changing Concentration</u> <i>...how to</i> measure the rate of reaction during a practical which produces solid <i>...how to</i> represent data using graphs <i>...how to</i> describe and explain the shape of a graph <i>... how to</i> apply knowledge to past examination questions</p>	<p>Dependent, independent, control, variable, rate, concentration, hydrochloric, thiosulphate. Erlenmeyer, obscure, hypothesis, conclusion</p>	<p>c) <u>Cultural Capital/Careers</u> How the Haber Process has had an impact on the global economy.</p> <p>d) <u>Cross curricular knowledge links</u> Opportunities for learners to demonstrate their research skills</p> <p>e) <u>Misconceptions</u> Not all reactions happen quickly, some take millions of years to happen!</p> <p>Mass and energy are never lost or created; however, it might look like the mass goes down during a reaction. But this is because a gas will be given off and has escaped.</p> <p>Catalysts are not part of the reaction; they just interact with the atoms to help them react.</p> <p>Particles collide all the time however not all collisions cause a reaction, this is because they don't have enough energy for the reaction to occur.</p>
	<p><u>Reversible Reactions</u> <i>... that</i> some chemical reactions are reversible <i>...how to</i> represent reversible reactions <i>... how to</i> apply knowledge to past examination questions</p>	<p>Reactant, product, forward, backward, reversible, equilibrium, rate, anhydrous, hydrated</p>	
	<p><u>Equilibria and Le Chateliers</u> <i>... that</i> chemical reactions reach a state of equilibria <i>...how to</i> apply the three steps to success to Le Chateliers principle <i>... how to</i> apply knowledge to past examination questions</p>	<p>Reactant, product, forward, backward, reversible, equilibrium, Le Chatelier.</p>	

Year 11 Topic Two Organic Chemistry (GCSE Trilogy Chemistry)

Topic 6	Rationale (Layering, Why this why now?)	Knowledge goals: <i>You need to know....</i> <i>...that (Declarative) ... how to (Procedural)</i> L ADDERING	Key Tier 3 vocabulary	Core skills and enrichment opportunities.
<p>4.7 Organic Chemistry The chemistry of carbon compounds is so important that it forms a separate branch of chemistry. A great variety of carbon compounds is possible because carbon atoms can form chains and rings linked by C-C bonds. The main sources of organic compounds are living, or once-living materials from plants and animals. These sources include fossil fuels, a major source of feedstock for the petrochemical industry. Chemists take organic</p>	<p> Year 8 Elements, compounds, mixtures</p> <p>Year 9 Atomic structure, separating mixtures, organic and chemistry of the Atmosphere</p> <p>Year 10 Organic chemistry Using resources</p> <p> Post 16 Organic chemistry</p>	<p>Crude Oil <i>...that</i> crude oil is a non-renewable resource made from the remains of microscopic organisms living in the sea. <i>...how to</i> interpret data linked to the availability and use of crude oil over time. <i>...how to</i> apply knowledge to past examination questions</p>	<p>Crude oil, heat , pressure, mixture, hydrocarbon</p>	<p>a) Numeracy Interpreting charts and graphs on data linking crude oil and its uses. Using general formulae to predict formulae of alkanes and alkenes.</p> <p>b) Literacy Systematic naming of molecules in homologous series: meth-, eth-, prop-, etc. Key words in terms of properties of hydrocarbons and the etymology of these words.</p> <p>c) Reading Reading for information retrieval. Literacy homework.</p> <p>d) Cultural Capital/Careers Organic chemistry can help you get into careers in forensics, pharmaceuticals, making perfumes and flavours (Christmas dinner flavoured crisps!)</p> <p>(e) Cross curricular knowledge links DT: polymers as design materials. Geography – crude oil as a finite resources</p> <p>(f) Misconceptions</p>
		<p>Fractional Distillation <i>...that</i> crude oil can be separated into hydrocarbons of similar properties, called fractions. <i>...how to</i> describe the process of fractional distillation and explain the principles behind it. <i>...how to</i> apply knowledge to past examination questions</p>	<p>crude oil, fractional distillation, fraction, alkane, mixture, separation</p>	
		<p>Alkanes and Properties <i>...that</i> the properties of alkanes vary according to the length of the carbon chain. <i>...how to</i> distinguish between alkanes according to viscosity, flammability, boiling point. <i>...how to</i> apply knowledge to past examination questions</p>	<p>Flammable, viscous, saturated</p>	
		<p>Cracking Hydrocarbons <i>...that</i> long chain hydrocarbons can be split into smaller ones by cracking; thermal or catalytic. <i>...how to</i> construct cracking equations <i>...how to</i> distinguish between saturated and unsaturated compounds using bromine water. <i>...how to</i> apply knowledge to past examination questions</p>	<p>Cracking, thermal, catalytic, saturated, unsaturated</p>	



molecules and modify to make new, useful materials such as polymers, pharmaceuticals, perfumes and flavourings, dyes and detergents.	<p><u>Alkenes and Polymers</u> <i>...that</i> alkenes are carbon compounds containing a C=C bond <i>...that</i> polymers are formed from alkenes <i>...how to</i> apply knowledge to past examination questions</p>	Unsaturated, cracking, thermal, catalytic, monomer, polymer.	Organic does not mean natural – it chemistry it refers to carbon chemistry. The “hydro” in hydrocarbons does not mean water – it means hydrogen.
	<p><u>Balancing Combustion Equations</u> <i>...the</i> products of complete and incomplete combustion of hydrocarbons. <i>...how to</i> construct word equations to represent the combustion of hydrocarbons. <i>...how to</i> balance equations to show combustion of hydrocarbons. <i>...how to</i> apply knowledge to past examination questions</p>	Combustion, complete, incomplete	Saturated means no double bonds present – not a “saturated solution” Fractions themselves are a mixture of compounds with similar properties. Fractional distillation is separation, cracking is thermal decomposition.

Year 11 Topic Three Analysis (GCSE Trilogy Chemistry)

Topic 8 Analysis	Rationale (Layering, Why this why now?)	Knowledge goals: <i>You need to know....</i> <i>...that (Declarative) ... how to (Procedural)</i> L ADDERING	Key Tier 3 vocabulary	Core skills and enrichment opportunities.
<p>4.8 Chemical Analysis Chemists have developed a range of qualitative tests to detect specific chemicals. The tests are based on reactions that produce a gas with distinctive properties, or a colour change or an insoluble solid that appears as a precipitate. Instrumental methods provide fast, sensitive and accurate means of analysing chemicals. Forensic scientists and drug control scientists rely on such instrumental</p>	<p> LINKING</p> <p>Year 8 Reaction types</p> <p> LOOKING</p> <p>Year 11 Chemical Analysis</p> <p>Post 16 Analysis using a range of chromatography techniques. Gas tests.</p>	<p>Pure Substances and Formulations <i>...that</i> a formulation is a specific mixture that has been designed as a useful product. Pure substances have a specific boiling point. Mixtures boil over a range of temperatures. <i>...how to</i> distinguish between a pure substance and a mixture. <i>...how to</i> apply knowledge to past exam questions</p>	<p>Pure, substance, melting point, boiling point, impure, mixture, product, purpose, fertilisers,</p>	<p>a) Numeracy Analysis and evaluation of data based questions using graphs and/or tables for analysis.</p> <p>b) Literacy Scientific literacy on gas formulae</p> <p>c) Reading Reading for learning on case studies.</p> <p>d) Cultural Capital/Careers Forensic science Food quality scientist</p> <p>e) Cross curricular knowledge links Food technology – food additives and food safety</p> <p>f) Misconceptions A pure substance in chemistry means that it is only one type of particle, pure in general language means it hasn't had anything extra added to it such as pure orange juice. Orange juice isn't pure in chemistry as it contains</p>
		<p>Testing for Common Gases <i>...that</i> carbon dioxide, oxygen, hydrogen and chlorine have specific tests which can be used to identify them <i>...how to</i> carry out the tests for carbon dioxide, hydrogen, chlorine and oxygen <i>...how to</i> apply knowledge to past exam questions</p>	<p>Hydrogen, chlorine, carbon dioxide</p>	
		<p>Chromatography <i>...that</i> chromatography can be used to separate mixtures and can give information to help identify substances. <i>...how to</i> calculate R_f values <i>...how to</i> set up an investigation to find the content/solubility of a dye and to calculate the R_f value. <i>...how to</i> apply knowledge to past exam questions</p>	<p>Solvent, solute, chromatography, stationary phase, mobile phase.</p>	


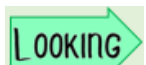
methods in their work.				sugars, water, pulp, and lots of other things.
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Year 11 Topic Four Chemistry of the Atmosphere (GCSE Trilogy Chemistry)

Topic	Rationale (Layering, Why this why now?)	Knowledge goals: <i>You need to know....</i> <i>...that (Declarative)</i> <i>.... how to (Procedural)</i> L ADDERING	Key Tier 3 vocabulary	Core skills and enrichment opportunities.
<p>4.8 Chemistry of the Atmosphere The Earth's atmosphere is dynamic and forever changing. The causes of these changes are sometimes man-made and sometimes part of natural cycles. Scientists use software to predict weather and climate change as there are many variables that can influence this. The problems caused by increased levels of air pollutants require scientists and</p>	<p> Year 7 Materials</p> <p>Year 8 Earth – climate</p> <p>Year 10 Earth's resources Chemical changes</p> <p> Post 16 Organic chemistry, biofuels</p>	<p><u>Composition of the Atmosphere</u> <i>... that</i> the atmosphere is a mixture of gases <i>...that</i> theories about what was in the Earth's early atmosphere and how the atmosphere was formed have changed over time. <i>...how to</i> interpret graphs and charts which compare atmospheres. <i>...how to</i> apply knowledge to past exam questions</p>	Composition, atmosphere	<p>a) <u>Numeracy</u> Construct and interpret tables, graphs and charts on the composition of atmosphere of planets in the solar system.</p> <p>b) <u>Literacy</u> Scientific literacy – CO and CO₂</p>
		<p><u>Evolution of the Atmosphere</u> <i>...that</i> the Earth's atmosphere evolved from early Earth to modern Earth <i>...how to</i> interpret evidence and evaluate different theories about the Earth's early atmosphere. <i>...how to</i> apply knowledge to past exam questions</p>	Evolution, dissolving, sedimentary photosynthesis	<p>c) <u>Reading</u> Reading and summarising accounts on the development of the atmosphere and the effects of climate change.</p>
		<p><u>Carbon Dioxide and the Greenhouse Effect</u> <i>...that</i> climate change is impacted by the greenhouse effect, <i>...how to</i> describe and explain the greenhouse effect and its consequences. <i>...how to</i> apply knowledge to past exam questions</p>	Carbon dioxide, methane, radiation, greenhouse gases, greenhouse effect.	<p>d) <u>Cultural Capital/Careers</u> Climate scientist. COP 25. International government agreements on mitigating climate change. George Monbiot – political activist on climate change and the environment.</p>
		<p><u>Global Warming and Climate Change</u> <i>...that</i> climate change is having a significant impact on the way we live, the weather and the habitats in our world. <i>....how to</i> evaluate the impact climate change will have on agriculture, animals, ecosystems, coastal regions and water supplies. <i>...how to</i> apply knowledge to past exam questions</p>	climate change, environment, impact, precipitation, ecosystem	<p>e) <u>Cross curricular knowledge links</u> Geography – climate change</p> <p>(f) <u>Misconceptions</u></p>


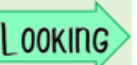
<p>engineers to develop solutions that help mitigate human activity.</p>		<p><u>Products of Combustion</u> <i>...that</i> combustion of fuels releases harmful products <i>...how to</i> prove the products of complete combustion <i>...how to</i> link named emissions with the associated consequence. <i>...how to</i> apply knowledge to past exam questions</p>	<p>Pollutants, emissions, combustion, global dimming, Sulphur dioxide Nitrogen oxides, Carbon monoxide</p>	<p>The gas we breath in for respiration isn't the largest part of our atmosphere The proportion of gases has stayed the same for around 200 million years, it has only started to change over the last 200 in a very small way Global warming and cooling are natural and have happened in cycles since Earth was a ball of molten rock, the argument is that humans have impacted on this cycle. Climate change and global warming are different, climate change is changes to the weather that can have drastic consequences, and global warming is the average warming of the Earth that causes climate change.</p>
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Year 11 Topic Five Earths Resources (GCSE Trilogy Chemistry)

Topic	Rationale (Layering, why this why now?)	Knowledge goals: <i>You need to know....</i> <i>...that (Declarative) ... how to (Procedural)</i> L ADDERING	Key Tier 3 vocabulary	Core skills and enrichment opportunities.
<p>4.10 Earths resources Industries use the Earth's natural resources to manufacture useful products. To operate sustainability, chemists seek to minimise the use of limited resources, use of energy, waste, and environmental impact in the manufacture of these products. Chemists also aim to develop ways of disposing of products at the end of their useful life in ways that ensure that materials and stored energy are utilised. Pollution, disposal of waste products and changing land use has a significant effect on the environment, and environmental chemists' study how human activity has affected the Earth's</p>	<p> Linking</p> <p>Year 7 Fossil fuels Year 9 Organic chemistry</p> <p> Looking</p> <p>Year 11 Apply Earths resources and using resources knowledge.</p> <p>Post 16 Sustainability, polymers</p>	<p>The Earth's Resources <i>...that</i> the Earth provides all the resources needed for human survival. <i>... how to</i> distinguish between finite and renewable sources. <i>... how to</i> apply knowledge to past exam questions.</p>	<p>Resources, warmth, shelter, food, transport, natural, agriculture, fuels, finite, renewable.</p>	<p>a) Numeracy Extract and interpret information about resources from charts, graphs, and tables. Use orders of magnitude to evaluate significance of data.</p> <p>b) Literacy and reading Analysis and evaluation of data-based questions using extended text for LCAs and metal extraction methods. Methods to produce potable water, comparison, and evaluation. Reading for information retrieval.</p> <p>c) Cultural Capital/Careers How composites have had an impact on everyday life. The Haber process, its place in history and the modern impacts of fertiliser development. Access to potable water and purification of water sources in different locations around the</p>
		<p>Potable Water <i>...that</i> potable water is different to pure water. <i>... how to</i> test the purity of water. <i>... how to</i> describe the differences between the treatment of ground water and freshwater <i>... how to</i> apply knowledge to past exam questions.</p>	<p>Potable, pure, sterilising, desalination, reverse osmosis, filter.</p>	
		<p>Wastewater Treatment <i>...that</i> sewage can be treated to make it safe to drink. <i>... how to</i> purify wastewater. <i>... how to</i> apply knowledge to past exam questions.</p>	<p>Sewage, grit, sedimentation, anaerobic digestion, aerobic, effluent, sludge, agricultural.</p>	
		<p>Water RP <i>...how to</i> purify salt water by simple distillation.</p>	<p>Distillation, Liebig condenser, evaporation, condensing, boiling point</p>	

<p>natural cycles and how damaging effects can be minimalised.</p>	<p>... <i>how to</i> test the purity of the water produced. ... <i>how to</i> apply knowledge to past exam questions.</p>		<p>global – the challenges and implications of water safe for everyone to drink.</p>
	<p><u>Alternative Extraction of Metals</u> ...<i>that</i> the Earth’s resources of metal ores is limited. ... <i>how to</i> use alternative extraction methods to access low grade ores. ... <i>how to</i> apply knowledge to past exam questions.</p>	<p>Metal ores, phytomining, bioleaching, bacteria, leachate, electrolysis, metal extraction.</p>	<p>d) <u>Cross curricular knowledge links</u> The Haber process, its place in history and the modern impacts of fertiliser development – links to History and Geography. Design Technology – materials and their uses.</p>
	<p><u>Life Cycle Assessments</u> ...<i>that</i> life cycle assessments are carried out to assess environmental impact of products. ... <i>how to</i> carry out a life cycle assessment for shopping bags made of paper and plastic. ... <i>how to</i> apply knowledge to past exam questions.</p>	<p>Life cycle assessment, manufacturing, packaging, lifetime, quantified, processing.</p>	<p>e) <u>Misconceptions</u> Water has been cycled through the water cycle millions of times; it can be purified easily. The reduction of energy use in cleaning water and recycling materials will reduce the amount of carbon dioxide produced.</p>
	<p><u>Reducing the Use of Resources</u> ...<i>that</i> reducing, reusing, and recycling help to conserve resources. ... <i>how to</i> evaluate ways of reducing the use of materials. ... <i>how to</i> apply knowledge to past exam questions.</p>	<p>Metals, glass, building materials, ceramics, quarrying, mining, recycled, melting, recasting, scrap, ore, extraction.</p>	<p>Fossil fuels will run out as it is a non-renewable resource, it can be made still however it takes longer to make it than the time we use it in.</p>



Year 11 Topic Six Atomic Structure and the Periodic Table (GCSE Trilogy Chemistry)

Topic	Rationale (Layering, Why this why now?)	Knowledge goals: <i>You need to know....</i> <i>...that (Declarative) ... how to (Procedural)</i> LADDERING	Key Tier 3 vocabulary	Core skills and enrichment opportunities.
<p>4.1 Atomic Structure and the Periodic Table</p> <p>The periodic table provides chemists with a structured organisation of the known chemical elements from which they can make sense of their physical and chemical properties</p> <p>The historical development of the periodic table and models of atomic structure provide good examples of how scientific ideas and explanations develop over time as new</p>	<p></p> <p>Year 7</p> <p>Matter, separating mixtures.</p> <p>Year 8</p> <p>Elements, periodic table.</p> <p>Year 9</p> <p>Atomic Structure and the Periodic Table</p> <p></p> <p>Post 16</p> <p>Atomic structure Structure and bonding</p>	<p><u>Compounds and Formulae</u></p> <p><i>...that</i> Elements are materials made up of one type of atom. Compounds contain two or more different types of atom, chemically bonded together</p> <p><i>... how to</i> distinguish between compounds and elements and write simple chemical formulae. Interpret particle diagrams.</p> <p><i>... how to</i> apply knowledge to past examination questions</p>	<p>Atom, element, compound</p>	<p>a) <u>Numeracy</u> Electronic configuration</p> <p>b) <u>Literacy</u> Learn significant number of subject specific vocabulary and use in correct context.</p> <p>c) <u>Reading</u> Describe how scientific models develop over time. Reading in different formats e.g. timeline.</p> <p>d) <u>Cultural Capital/Careers</u> Understand the historical significance and contributions of Dalton and Mendeleev to the development of the periodic Table.</p> <p>e) <u>Cross curricular knowledge links</u> DT – materials</p> <p>f) <u>Misconceptions</u> Chemicals are not bad for you, everything is made up of chemicals.</p> <p>We can't see atoms and haven't been able to until</p>
		<p><u>Separating Mixtures</u></p> <p><i>...that</i> a mixture is made up of two or more substances that are not chemically joined together. Mixtures can be separated according to their properties.</p> <p><i>... how to</i> select the best method for separation of a given mixture, including appropriate apparatus.</p> <p><i>...why</i> a particular method is most appropriate.</p> <p><i>... how to</i> apply knowledge to past examination questions</p>	<p>Mixture, purity, separation, evaporation, filtration, evaporation, chromatography Solute, solvent, solution.</p>	
		<p><u>Structure of the Atom</u></p> <p><i>...that</i> the atom can be describes in terms of sub atomic particles. Isotopes are atoms of elements with the same number of protons but different numbers of neutrons.</p> <p><i>...how to</i> calculate the numbers of protons, electrons and neutrons in an atom.</p> <p><i>... how to</i> apply knowledge to past examination questions</p>	<p>Protons, electrons, neutrons, isotopes, sub atomic particle, electronically neutral.</p>	

evidence emerges.	<p><u>Developing the Atomic Model</u> <i>...that</i> the model of the atom has changed over time, starting with Dalton's idea of atoms being tiny solid balls to the plum pudding model to the Bohr model of the atom that is used today. <i>...how to</i> compare models of the atom over time. <i>... how to</i> apply knowledge to past examination questions</p>	Plum pudding, Bohr, nuclear model, Rutherford.	<p>around 2018, scientists have used other practical techniques to be able to predict what we know about atoms.</p> <p>Theories of atoms have changed over time, a theory is not just an idea, and it has experimental evidence behind it.</p> <p>There is not only one type of atom but 118 known types, these types are called elements.</p>
	<p><u>Electron Configuration</u> <i>...that</i> electrons have a specific arrangement in the atom, occupying the lowest energy level first and filling up a shell before moving to the next. <i>...how to</i> arrange the electrons of the first 20 elements. <i>... how to</i> apply knowledge to past examination questions</p>	Electrons, shells, energy levels Electron configuration. occupy	
	<p><u>The Periodic Table</u> <i>...that</i> the Periodic table is arranged in columns called groups and rows called periods. The structure of the Periodic table has changed over time. <i>...how to</i> the scientists John Newlands, and Dimitri Mendeleev contributed to the development of the Periodic table. <i>... how to</i> apply knowledge to past examination questions</p>	Period, group	
	<p><u>Group 1 Elements</u> <i>...that</i> group 1 are known as the alkali metals and react in a similar way, but the reactivity increases down the group. <i>...how to</i> account for the increase in reactivity down group 1. <i>... how to</i> apply knowledge to past examination questions</p>	Electron configuration, shielding, reactivity.	
	<p><u>Group 7 Elements</u> <i>...that</i> group 7 elements are known as the halogens and undergo displacement reactions. Group 7</p>	Reactivity, electrons, displacement.	

		<p>elements react in a similar way, but the level of reactivity decreases down the group. <i>...how to</i> explain the trend in reactivity down group 7. <i>.... how to</i> apply knowledge to past examination questions</p>		
		<p><u>Group 0 and Transition Metals</u> <i>...that</i> transition metals are less reactive, denser, harder, and stronger than group 1 metals. Transition metals can be used as catalysts and have coloured compounds. <i>...that</i> Group 0 are known as the Noble gases, have full shells of electrons. <i>...how to</i> compare the reactivity of group 1 and the transition metals. Explain the unreactivity of group 0 <i>.... how to</i> apply knowledge to past examination questions</p>	<p>Transition metal Noble gases Electron configuration</p>	

Year 11 Topic Seven Structure, Bonding and the Properties of Matter (GCSE Trilogy Chemistry)

Topic	Rationale (Layering, Why this why now?)	Knowledge goals: <i>You need to know....</i> <i>...that (Declarative)</i> <i>.... how to (Procedural)</i> LADDERING	Key Tier 3 vocabulary	Core skills and enrichment opportunities.
<p>4.2 Structure, Bonding and the Properties of Matter</p> <p>Chemical bonds are the glue that hold substances together. The attraction of one atom to another determines a substances chemical reactivity and its physical properties. Understanding how these can be determined by considering the atoms involved within the substance can be used to advance our understanding of materials science and where research may go in the immediate future.</p>	<p> Linking</p> <p>Year 7 Properties of metals and non-metals</p> <p>Year 8 Periodic table</p> <p>Year 9 Atomic structure</p> <p>Year 10 Structure and Bonding</p>	<p>Forming Ions</p> <p><i>...that</i> ions are formed from the loss and gain of electrons into electron shells</p> <p><i>...how to</i> represent ions using dot and cross diagrams</p> <p><i>...how to</i> describe and explain ionic bond formation using dot and cross diagrams.</p> <p><i>.... how to</i> apply knowledge to past examination questions</p>	<p>Ion, positive, negative, cation, anion, transfer, noble gas, configuration, ionic</p>	<p>a) Numeracy Analysis and evaluation of data based questions using graphs and/or tables for bonding properties.</p> <p>b) Literacy and reading Analysis and evaluation of data based questions using extended text for use of polymers and nanoparticles.</p> <p>c) Cultural Capital/Careers The development of new and diverse nanoparticles for use in everyday life.</p> <p>d) Cross curricular knowledge links Opportunities for learners to demonstrate their research skills</p> <p>e) Misconceptions When a substance dissolves or changes state no bonds are broken, this is often confused as FORCES between molecules are overcome when a change of state happens.</p> <p>Non metals do-not conduct electricity however graphite, graphene and</p>
	<p> Looking</p> <p>Post 16 AS Bonding unit</p>	<p>Ionic Compounds</p> <p><i>...that</i> ionic compounds can be represented in different ways</p> <p><i>...that</i> the specific bonding in ionic compounds leads to different properties</p> <p><i>...how to</i> construct the formula of common ionic compounds</p> <p><i>.... how to</i> apply knowledge to past examination questions</p>	<p>Giant, lattice, 3D, ions, conductivity, brittle, soluble, electrostatic</p>	
	<p>Covalent Bonding</p> <p><i>...that</i> covalent bonds are formed from the sharing of electrons</p> <p><i>...how to</i> draw dot and cross diagrams to represent simple covalent molecules</p> <p><i>...how to</i> explain the properties of simple covalent compounds in terms of structure and bonding</p> <p><i>.... how to</i> apply knowledge to past examination questions</p>	<p>Covalent, dot and cross, sharing, valence, intermolecular forces</p>		



		<p><u>Polymers</u> <i>...that</i> simple covalent molecules can form polymers <i>...how to</i> draw the structure of polymers and repeat units <i>.... how to</i> apply knowledge to past examination questions</p>	<p>Polymer, manufactured, covalent, molecule, monomer, repeat unit polymerisation, thermosetting, thermosoftening, intermolecular</p>	<p>fullerenes made purely from carbon (a non-metal) can conduct electricity.</p> <p>To be stable each atom wants a full outer shell of electrons, hydrogen and helium need 2 electrons, however every other atom wants 8. You only need to know the first 20 elements as this rule works for them.</p> <p>In ionic bonding electrons are not shared, they are given and taken. It is then those differently charged ions that are attracted to each other forming the bond.</p> <p>Ionic compounds are not just two or three ions (NaCl is not 1 sodium ion and 1 chlorine ion), there are millions of ions that make up the compounds, the formula shown is the simplest way to write the ratio of ions.</p>
		<p><u>Giant Covalent Molecules</u> <i>...that</i> carbon can exist in three different forms called allotropes <i>...that</i> the different bonding in these allotropes leads to the different properties of the allotropes <i>...how to</i> explain the properties of these allotropes in terms of structure and bonding <i>.... how to</i> apply knowledge to past examination questions</p>	<p>Brilliant, strong, hard, lubricant,</p>	
		<p><u>Nanoparticles</u> <i>...that</i> nanoscience is the study of nano-sized particles <i>...how to</i> explain the properties of nanoparticles in terms of structure and bonding <i>...how to</i> calculate surface area to volume ratio <i>.... how to</i> apply knowledge to past examination questions</p>	<p>Nanoparticle, surface area to volume ratio</p>	
		<p><u>Metallic Bonding</u> <i>...that</i> metallic bonding occurs in metals <i>...how to</i> explain the properties of metals in terms of structure and bonding <i>.... how to</i> apply knowledge to past examination questions</p>	<p>Delocalised, electrostatic, electron, conduction</p>	

Alloys and Transition Metals

...that alloys are mixture of metals and either metals or non-metals
...how to explain the properties of alloys in terms of structure and bonding
...that transition metals have a range of properties
.... how to apply knowledge to past examination questions

Mixtures, properties, malleable, proportion, stainless, sonorous, malleable, ductile, reflective, conductor, catalyst, compound


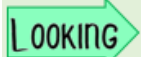
Year 11 Topic Eight Quantitative Chemistry (GCSE Trilogy Chemistry)

Topic	Rationale (Layering, Why this why now?)	Knowledge goals: <i>You need to know...</i> <i>...that (Declarative)</i> ... <i>how to (Procedural)</i> L ADDERING	Key Tier 3 vocabulary	Core skills and enrichment opportunities.
4.3 Quantitative Chemistry Chemists use quantitative analysis to determine the formulae of compounds and the equations for reactions. Given this information, analysts can then use quantitative methods to determine the purity of chemical samples and to monitor the yield from chemical reactions. Identifying different types of chemical reactions allows chemists to make sense of how different chemicals react together, to establish patterns and to make predictions about the behaviour of other chemicals. Chemical equations provide a means of representing chemical reactions and are a key way for chemists to	 Year 8 Periodic table Year 9 Atomic structure and periodic table, chemical changes, acids and alkalis Year 10 Quantitative	<u>Relative Atomic and Relative Formula Mass</u> <i>...that</i> relative atomic masses are found on the periodic table <i>...how to</i> calculate relative atomic and relative formula mass <i>...how to</i> calculate percentage element in a compound <i>... how to</i> apply knowledge to past examination questions	Mass number, formula mass, formula, equation, reactants, products	<u>Numeracy</u> A wide range of calculation on moles, RFM, reacting masses, limiting factors, concentration of solutions. Analysis and evaluation of data based questions using graphs and/or tables for quantitative questions. <u>Literacy and reading</u> <u>Cultural Capital/Careers</u> Chemical engineers, pharmaceuticals, toxicology, river water analysis <u>Cross curricular knowledge links</u> Rearranging equations, converting units, percentages all linked with maths skills <u>Misconceptions</u> When balancing equations you can't change how the compounds are made up – this means you can't add
	 Post 16 Quantitative chemistry	<u>Conservation of Mass</u> <i>...that</i> mass is conserved in a reaction <i>...how to</i> use chemical equations to evaluate conservation of mass <i>... how to</i> apply knowledge to past examination questions	Conservation, mass, balanced	
	<u>Conservation of Mass Practical</u> <i>...that</i> mass does not always appear to be conserved in a reaction	Safety, crucible, balance, weighing boat		

communicate chemical ideas.	<p><i>...how to</i> complete a practical to investigate conservation of mass safely</p> <p><i>.... how to</i> apply knowledge to past examination questions</p>		<p>or take away any of the 'small numbers'.</p> <p>Some reactions look like mass is lost however it is normally a product that is a gas escaping from wherever the reaction is happening.</p>
	<p><u>Introduction to Moles</u></p> <p><i>...that</i> a mole is a chemical quantity</p> <p><i>...how to</i> calculate moles using the correct equation</p> <p><i>...how to</i> rearrange the moles equation</p> <p><i>.... how to</i> apply knowledge to past examination questions</p>	<p>Mole, quantity, mass, relative atomic/formula mass, Avogadro's constant</p>	<p>HT ONLY. A mole is just a number. As atoms are so small it is impossible to talk about 1 atom of a substance, we can only really talk about them in very large amounts. So, a mole was created as a standard, it stands for 6.02×10^{23} particles.</p>
	<p><u>Reacting Masses</u></p> <p><i>...that</i> moles can be used to calculate required masses of reagents and predicted masses of products</p> <p><i>...how to</i> apply the moles equation to calculating reacting masses</p> <p><i>.... how to</i> apply knowledge to past examination questions</p>	<p>Moles, reacting masses, balanced equation, conservation</p>	<p>Understanding the correct units and their conversions.</p> <p>Appreciation of standard form and manipulation of standard form within calculations.</p> <p>Scale of what a decimetre is.</p> <p>Use of non-integers in balancing equations.</p>
	<p><u>Concentration of Solutions</u></p> <p><i>...that</i> cubic decimetres are a unit of concentration</p> <p><i>...how to</i> convert between units</p>	<p>Solutions, concentration, volume, solute, decimetre, cubic centimetre, mass</p>	

		<p><i>...how to</i> calculate the concentration of solutions.</p> <p><i>... how to</i> apply knowledge to past examination questions</p>		
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Year 11 Topic Nine Chemical Changes (GCSE Trilogy Chemistry)

Topic 5	Rationale (Layering, Why this why now?)	Knowledge goals: <i>You need to know...</i> <i>...that (Declarative) ... how to (Procedural)</i> L ADDERING	Key Tier 3 vocabulary	Core skills and enrichment opportunities.
4.4 Chemical Changes Understanding of chemical changes began when people began experimenting with chemical reactions in a systematic way and organising their results logically. Knowing about these different chemical changes meant that scientists could begin to predict exactly what new substances would be formed and use this knowledge to develop a wide range of different materials and processes	<div style="text-align: center;"></div> <p>Year 7 Acids and alkalis Metals and non- metals</p> <p>Year 8 Types of reaction</p> <p>Year 9 Chemical changes, reactions of metals, reactivity series and acids and alkalis</p> <div style="text-align: center;"></div> <p>Post 16 Acid, alkali titrations. Types of acid. Neutralisation reactions.</p>	<p><u>Metals and Metal Oxides</u> <i>...that</i> metals have distinct properties. <i>...how to</i> distinguish between group 1 and transition metals. <i>... how to</i> apply knowledge to past exam questions.</p>	Metals, transition metals, groups, oxidation, catalyst	<p>a) <u>Numeracy</u> Balancing ionic equations for more able students.</p> <p>b) <u>Literacy</u> Etymology of words to describe metallic properties e.g. lustre.</p> <p>c) <u>Reading</u> Methods, hazard warnings, extraction of aluminium reading to extract knowledge. Application of hydrogen homes.</p> <p>d) <u>Cultural Capital/Careers</u> Hydrogen extraction for fuels (hydrogen homes)</p> <p>e) <u>Cross curricular knowledge links</u> Environmental impacts of large scale metal extraction – recycling metals and alternative metal extraction</p> <p>f) <u>Misconceptions</u></p>
		<p><u>Metals in Acid</u> <i>...that</i> metals react with acids to produce a salt and hydrogen. <i>...that</i> metal reactivity depends upon the position in the reactivity series. <i>...how to</i> construct word equations. <i>... how to</i> apply knowledge to past exam questions.</p>	Reactivity, metal, acid, product, reactant, salt, hydrogen	
		<p><u>Reactivity Series and Displacement Reactions</u> <i>...that</i> the reactivity series places metals in increasing order of reactivity and can be used to predict reactions.</p>	ionic compounds, reactivity series, displacement	


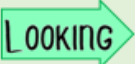
		<p><i>... how to</i> use the reactivity series to predict whether a displacement reaction will happen.</p> <p><i>... how to</i> apply knowledge to past exam questions.</p>		<p>Not all metals are found as pure metal on Earth, most are found in rocks as metal oxides or metal carbonates which are called ores.</p> <p>During electrolysis the metal is not always produced, if the metal is higher in reactivity than hydrogen then hydrogen is produced. A solution of the metal hydroxide would also be produced which is then later purified to produce the pure metal.</p>
		<p>Extracting Metals</p> <p><i>...that</i> the position of a metal in the reactivity series determines the method of extraction from its ore.</p> <p><i>.....how to</i> evaluate the social, economic and environmental impacts of quarrying.</p> <p><i>... how to</i> apply knowledge to past exam questions.</p>	<p>Reactivity series, metal, ore extraction, displace</p>	
		<p>The Process of Electrolysis</p> <p><i>...that</i> electrolysis is a process which separates ionic compounds.</p> <p><i>.... how to</i> describe and explain the process of basic electrolysis</p> <p><i>.... how to</i> represent the process at the electrodes using half equations</p> <p><i>... how to</i> apply knowledge to past exam questions.</p>	<p>Electrolysis, anode, cathode, anion, cation, electrolyte, electrodes, half equations</p>	
		<p>Extracting Aluminium</p>	<p>Bauxite, aluminium, electrodes, electrolysis, half equations</p>	

		<p><i>...that</i> aluminium is a reactive metal that requires electrolysis to be separated from its ores.</p> <p><i>.... how</i> the extraction of aluminium is adjusted and has special conditions</p> <p><i>... how to</i> apply knowledge to past exam questions.</p>		
		<p><u>Aqueous Electrolysis</u></p> <p><i>...that</i> aqueous solutions of ionic compounds can be separated using electrolysis.</p> <p><i>.... how to</i> predict the products of aqueous electrolysis</p> <p><i>... how to</i> apply knowledge to past exam questions.</p>	Aqueous, prediction, products, reactivity series, halogens	
		<p><u>Electrolysis RP</u></p> <p><i>.... how to</i> predict the products of electrolysis then test the predictions using the practical equipment.</p> <p><i>... how to</i> apply knowledge to past exam questions.</p>	Aqueous, hazards, risks, electrolyte, anode, cathode	
		<p><u>Acids, Alkalis and Bases</u></p> <p><i>...that</i> acids, alkalis, and bases are chemicals which react in neutralisation reactions.</p>	Acid, alkali, base, pH, neutralisation, indicators, strong, weak	



		<p>... <i>how to</i> explain the differences between strong and weak acids.</p> <p>... <i>how to</i> apply knowledge to past exam questions.</p>		
		<p><u>Indicators and pH Scale</u></p> <p>...<i>that</i> indicators are chemicals which change colour to indicate pH of acids and alkalis.</p> <p>...<i>how to</i> use the pH scale to indicate the pH of acids and alkalis.</p> <p>... <i>how to</i> apply knowledge to past exam questions.</p>	Indicators, litmus, universal indicators, acids, alkalis	
		<p><u>Neutralisation and Naming Salts</u></p> <p>...<i>that</i> a salt is formed from an acid and a base. The metal and the acid determine the salt formed.</p> <p>...<i>how to</i> construct word equations for neutralisation reactions.</p> <p>... <i>how to</i> apply knowledge to past exam questions.</p>	Neutralisation, salts, word equations	
		<p><u>Making a soluble salt RP</u></p> <p>...<i>how to</i> prepare a pure, dry sample of a soluble salt from an insoluble oxide or carbonate.</p>	evaporation, crystallisation, base, neutralisation, excess	

		<i>... how to</i> apply knowledge to past exam questions.		
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Year 11 Topic Ten Energy Changes (GCSE Chemistry)

Topic	Rationale (Layering, Why this why now?)	Knowledge goals: <i>You need to know....</i> <i>...that (Declarative)</i> ... <i>how to (Procedural)</i> L ADDERING	Key Tier 3 vocabulary	Core skills and enrichment opportunities.
<p>4.5 Energy Changes Energy changes are an important part of chemical reactions. The interaction of particles often involves transfers of energy due to the breaking and formation of bonds.</p> <p>Reactions in which energy is released to the surroundings are exothermic reactions, while those that take in thermal energy are endothermic. These interactions between particles can produce heating or cooling effects that are used in a range of everyday applications.</p>	<p> Linking</p> <p>Year 8 Endothermic and exothermic reactions</p>	<p><u>Exothermic and Endothermic</u> <i>...that</i> exothermic reactions release heat energy and endothermic absorb heat energy from their surroundings. <i>... how to</i> draw reaction profiles for exothermic and endothermic reactions <i>... how to</i> apply knowledge to past examination questions</p>	<p>Exothermic, endothermic, profiles, activation energy, surroundings</p>	<p>a) <u>Numeracy</u> Analysis and evaluation of data based questions using graphs and/or tables for energy transfer Carry out bond energy calculations</p> <p>b) <u>Literacy and reading</u> Reading methods in order to follow instructions. Student safety sheets in order to evaluate risks in a practical.</p> <p>c) <u>Cultural Capital/Careers</u> Food hygienist and preparation – hot and cold cans. Medics hot and cold packs. DofE – hand warmers</p> <p>d) <u>Cross curricular knowledge links</u> DT – Materials design of hot/cold cans</p>
	<p> Looking</p> <p>Post 16 Energetics</p>	<p><u>Bond Enthalpy Calculations</u> <i>...that</i> bonding breaking is endothermic and bond formation is exothermic <i>...how to</i> calculate bond enthalpy changes <i>... how to</i> apply knowledge to past examination questions</p>	<p>Enthalpy, exothermic, endothermic, ΔH.</p>	
		<p><u>Temperature Changes RP</u> <i>...how to</i> safely conduct a practical to investigate temperature changes in a reaction</p>	<p>Extrapolation, variables, hazard, risk, control</p>	



		<p>.... <i>how to</i> draw a graph from which data can be extrapolated</p> <p>.... <i>how to</i> apply knowledge to past examination questions</p>		<p>PE – hot/cold packs</p> <hr/> <p>e) <u>Misconceptions</u></p> <p>It requires energy to break bonds and releases energy when bonds are made. The enthalpy change is a balance between energy used from bond breaking and bond making.</p> <p>Endothermic reactions are cold as they take in thermal (heat) energy from the surroundings.</p>
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Topic 1 Particle model	Rationale (layering, Why this why now?)	Knowledge goals: <i>You need to know....</i> <i>...that (Declarative)</i> <i>how to (Procedural)</i> L ADDERING	Key Tier 3 vocabulary	Core skills and enrichment opportunities.
<p>The particle model is widely used to predict the behaviour of solids, liquids and gases and this has many applications in everyday life. It helps us to explain a wide range of observations and engineers use these principles when designing vessels to withstand high pressures and temperatures, such as submarines and spacecraft. It also explains why it is difficult to make a good cup of tea high up a mountain!</p>	<p style="text-align: center;"></p> <p>KS2 States of matter Simple physical properties of materials. Year 7 Particle model Separating Mixtures Year 8 Elements Periodic Table Year 9 KS4  Year 9 Year 10 Atomic structure –chem Particle model - phy Year 11 Rates - chem Post 16 Kinetic theory Gas Laws Atomic structure</p>	<p><i>...that</i> properties of solids, liquids and gases in terms of the particles in each state of matter. Particles are moving and have kinetic energy. <i>.... how to</i> link arrangement of the particles in each state of matter to their properties and be able to compare them.</p>	<p>Particle solids liquids gases forces of attraction density <i>Property</i></p>	<p>Subject specific skills Use a variety of models to solve problems, make predictions and to develop scientific explanations and understanding of familiar and unfamiliar facts. Recognise/draw/interpret diagrams. Translate from data to a representation with a model. Use models in explanations, or match features of a model to the data from experiments or observations that the model describes or explains.</p> <p>Numeracy be able to recall and apply equations to changes where mass is conserved. Use an appropriate number of significant figures, find arithmetic means, construct and interpret frequency tables and diagrams, bar charts and histograms, understand the principles of sampling as applied to scientific data, understand simple probability. Recognise and use expressions in standard form. Use ratios, fractions and percentages. Substitute numerical values into algebraic equations using appropriate units for physical quantities. Solve algebraic equations. Translate information between graphical and numeric form.</p> <p>Literacy and Reading Improvement of vocabulary bank – tier 2 - BBC Bitesize – Particle Model, extended reading articles. Reading for understanding, exemplar question contexts.</p>
		<p><i>...that</i> density is the mass which is contained in a given volume. A denser material will sink in a less dense material. <i>.... how to</i> calculate the density of a given material using: density = mass/volume. How to convert between g and Kg, and ml and l.</p>	<p>Density, mass, volume, formula.</p>	
		<p><i>...that</i> displacement can be used to find the volume of an irregular object. <i>.... how to</i> practically determine the volume of an irregular shaped object.</p>	<p>density displacement <i>regular irregular</i></p>	
		<p>RP 5. use appropriate apparatus to make and record the measurements needed to determine the densities of regular and irregular solid objects and liquids. Volume should be determined from the dimensions of regularly shaped objects, and by a displacement technique for irregularly shaped objects. Dimensions to be measured using appropriate apparatus such as a ruler, micrometer or Vernier callipers.</p>		
		<p><i>...that</i> If enough energy is added to or removed from an arrangement of particles a change of state can occur. Evaporation occurs when particles near the surface of the liquid have enough energy to escape. <i>how to</i> determine what happens to temperature during changes of state. <i>..why</i> some substances have higher/lower melting and boiling points than others.</p>	<p>state temperature heat State, melt, evaporate, condense, freeze, sublimation.</p>	
		<p><i>...that</i> the total kinetic energy and potential energy of all the particles (atoms and molecules) that make up a system is known as the internal energy. <i>how to</i> construct and interpret a heating/cooling curve.</p>	<p>internal kinetic potential <i>Independent, dependent, control, variables</i></p>	
<p><i>...that</i> Specific Latent Heat is the energy absorbed by a substance during a change of state <i>how to</i> calculate specific latent heat.</p>	<p>specific latent heat Latent, heat, internal energy, mass, joules, kilograms, fusion, vaporisation, vapour</p>			



		<p><i>...that</i> The amount of energy needed to heat a material is known as Specific Heat Capacity.</p> <p><i>how to</i> calculate how much energy is needed to heat up different materials. Use and rearrange the equation: $Heat = mass \times SHC \times temp\ change$</p>	<p><i>Capacity</i> Specific heat capacity</p>	<p><u>Cultural Capital/Careers</u> Archimedes 'Eureka moment.' Architect, Astronomer, Energy Analyst, Food Technology, Games Designer, Geophysicist, Meteorologist, Nuclear Engineer, Radiographer, School teacher,</p> <p><u>Cross curricular knowledge links</u> Selection of materials for cooking pans – food technology. Heat transfer – DT – materials.</p> <p><u>Misconceptions</u> If a solid or liquid is heated, the particles get bigger. This is not the case. At higher temperatures, they move about more and take up more space, but they do not get bigger. Students tend to overestimate the space between the particles in liquids. They regard a liquid as half-way between a solid and a gas. This is not the case. The particles in a liquid are close together, although they are free to move and change place. Students confuse 'melting' and 'dissolving'. Students find it difficult to accept that most of a gas is empty space.</p>
		<p>.... that the temperature of a gas is related to the average kinetic energy of the molecules</p> <p>how to.. explain qualitatively the relation between the temperature of a gas and its pressure at constant volume.</p>		
		<p>(Physics only) .. that increasing the volume in which a gas is contained, at constant temperature, can lead to a decrease in pressure.</p> <p>how to... calculate the change in the pressure of a gas or the volume of a gas (a fixed mass held at constant temperature) when either the pressure or volume is increased or decreased.</p>		

Topic Electricity	Rationale (layering, Why this why now?)	Knowledge goals: <i>You need to know....</i> <i>...that (Declarative)</i> <i>.... how to (Procedural)</i> L ADDERING	Key Tier 3 vocabulary	Core skills and enrichment opportunities.
<p>Electric charge is a fundamental property of matter everywhere. Understanding the difference in the microstructure of conductors, semi conductors and insulators makes it possible to design components and build electric circuits. Many circuits are powered with mains electricity but portable electrical devices must use batteries of some kind. Electrical power fills the modern world with artificial light and sound, information and entertainment, remote sensing and control. The fundamentals of</p>	<p> Linking</p> <p>KS2 States of matter Simple physical properties of materials. Year 7 Particle model Separating Mixtures Year 8 Elements Periodic Table Year 9</p> <p>KS4  Looking</p> <p>Year 9 Year 10 Atomic structure –chem Particle model - phy Year 11 Rates - chem Post 16</p>	<p><i>...that</i> circuit symbols act as a language for drawing circuit diagrams. This allows people anywhere in the world to build the same circuit, even if the components look different.</p> <p><i>.... how</i> to draw circuit symbols</p>	<p>E.g. lamp, battery, diode Current, charge, coulombs, amperes, volts, components</p>	<p><u>Numeracy</u> Students need to be able to recall and apply equations. Interpreting observations and other data (presented in verbal, diagrammatic, graphical, symbolic or numerical form), including identifying patterns and trends, making inferences and drawing conclusions. Use data to make predictions. Recognise or describe patterns and trends in data presented in a variety of tabular, graphical and other forms. Draw conclusions from given observations.</p> <p><u>Literacy</u> Presenting reasoned explanations including relating data to hypotheses. Comment on the extent to which data is consistent with a given hypothesis. Identify which of two or more hypotheses provides a better explanation of data in a given context. Being objective, evaluating data in terms of accuracy, precision, repeatability and reproducibility and identifying potential sources of random and systematic error.</p> <p><u>Reading</u> BBC Bitesize, The Illustrated Science Dictionary, World of Science, Horrible Science of Everything, The Science Boo Home Science Experiments</p>
		<p><i>...that</i> Electric Current is flow of electrical charge and that charge flow, current and time are linked.</p> <p><i>.... how to</i> use the equation : charge flow = current x time</p>	<p>Potential difference, resistance, ohms</p>	
		<p><i>...that</i> potential Difference is amount of energy transferred to each coulomb of charge</p> <p><i>how to place components in the circuit to measure current and potential difference</i></p> <p><i>RP3: Use circuit diagrams to set up and check appropriate circuits to investigate the factors affecting the resistance of electrical circuits.</i></p>	<p>Circuit diagrams, Proportional Voltage Current Resistance Amps Ohms Volts</p>	
		<p><i>...that in some resistors the value of R remains constant but that in others it can change as the current changes.</i></p> <p><i>.... How to use the equation: potential difference = current x resistance</i></p> <p><i>RP4: use circuit diagrams to construct appropriate circuits to investigate the I–V characteristics of a variety of circuit elements, including a filament lamp, a diode and a resistor at constant temperature.</i></p>	<p>Graphs. Linear, non-linear, correlation,</p>	
		<p><i>...that</i> there are two ways of joining electrical components, in series and in parallel.</p> <p><i>how to</i> explain qualitatively why adding resistors in series increases the total resistance whilst adding resistors in parallel decreases the total resistance</p>	<p>Series, parallel,</p>	
<p><i>...that</i> Mains electricity is an ac supply. In the United Kingdom the domestic electricity supply has a frequency of 50 Hz and is about 230 V.</p> <p><i>how to</i> explain the difference between direct and alternating potential difference</p>	<p>Alternating current, direct current, Three core cable, insulation, appliance,</p>			

<p>electromagnetism were worked out by scientists of the 19th century. However, power stations, like all machines, have a limited lifetime. If we all continue to demand more electricity this means building new power stations in every generation – but what mix of power stations can promise a sustainable future?</p>	<p>... <i>that</i> the power transfer in any circuit device is related to the potential difference across it and the current through it, and to the energy changes over time.</p> <p><i>How to</i> describe, with examples, the relationship between the power ratings for domestic electrical appliances and the changes in stored energy when they are in use.</p>	Transfer, work done,	Crisp Packet Fireworks.
	<p>... <i>that</i> the National Grid is a system of cables and transformers linking power stations to consumers.</p> <p><i>How to ...</i> explain why the National Grid system is an efficient way to transfer energy.</p>	Cables, transformers (Higher only), consumers, efficiency, step up, step down	<p><u>Cultural Capital/Careers</u></p> <p><u>Cross curricular knowledge links</u></p> <p>Electrician working on repairing some forklift trucks, Electricity plays a huge role in the robotics industry, and it is a fundamental concept.</p> <p>Engineer working in the medical prosthetics field.</p> <p>Working on the national power grid, Whether you are repairing or installing electrical cables, it's imperative that you understand the basics of electricity.</p> <p>Electrical engineers will design the circuit boards that go inside both our everyday items that we'll find in our house, but also highly technical pieces of equipment.</p>
	<p><i>(Physics only)</i></p> <p>.. <i>that</i> when certain insulating materials are rubbed against each other they become electrically charged.</p> <p>How toexplain how the transfer of electrons between objects can explain the phenomena of static electricity.</p>	Electrically charge, negative, positive, electrons, repel, attract, non contact force, static,	<p><u>Misconceptions</u></p> <p>Misconception: current is 'used up' as it flows round the circuit</p> <p>Current is not used up: the current is the same all the way round a series circuit. If current is used up, then bulbs near the 'start' of the circuit should be brighter than those near the 'end'. Providing the bulbs are identical, then they will all be the same brightness.</p>
	<p><i>(Physics only)</i></p> <p>... <i>that</i> a charged object creates an electric field around itself</p> <p><i>How to</i> explain how the concept of an electric field helps to explain the non-contact force between charged objects as well as other electrostatic phenomena such as sparking.</p>	electric field pattern, Field, force, isolated charge, electrostatic phenomena, sparking	<p>Misconception: current starts from one end of a battery and flows through each component of a circuit in turn, until it gets back to the other end of a battery (e.g. battery to wire, then bulb, then wire, then bulb, then wire back to battery)</p> <p>Current flows instantly in all parts of a circuit when there is a complete circuit.</p>



Topic Atomic Structure	Rationale (layering, Why this why now?)	Knowledge goals: <i>You need to know....</i> <i>...that (Declarative) ... how to (Procedural)</i> L ADDERING	Key Tier 3 vocabulary	Core skills and enrichment opportunities.
<p>Ionising radiation is hazardous but can be very useful. Although radioactivity was discovered over a century ago, it took many nuclear physicists several decades to understand the structure of atoms, nuclear forces and stability. Early researchers suffered from their exposure to ionising radiation. Rules for radiological protection were first introduced in the 1930s and subsequently improved. Today radioactive materials are widely used in medicine, industry, agriculture and electrical power generation.</p>	<p> LINKING</p> <p><u>KS2</u> Filtering, sieving, evaporating, dissolving, solutions. <u>Year 7</u> Matter, separating mixtures. <u>Year 8</u> Elements, periodic table. <u>Year 9</u> KS4</p> <p> LOOKING</p> <p>Year 9 Year 10 Structure and bonding Year 11 Atomic structure Structure and bonding Post 16 Atomic structure Structure and bonding</p>	<p><i>...that</i> atoms are very small and consist of electrons, protons and neutrons. (sub-atomic particles)</p> <p><i>how to</i> represent the sub-atomic particles and the structure of an atom, including the mass number, atomic number and isotopes.</p>	<p>Nucleus, protons, neutrons, electrons, electromagnetic radiation, energy levels</p>	<p>Subject specific skills Use a variety of models to solve problems, make predictions and to develop scientific explanations and understanding of familiar and unfamiliar facts. Recognise/draw/interpret diagrams. Translate from data to a representation with a model. Use models in explanations, or match features of a model to the data from experiments or observations that the model describes or explains.</p>
		<p>.... that the model of the atom has changed over time due to new scientific experimental evidence.</p> <p>how to use evidence to explain why there have been changes in the atomic model.</p>	<p><i>Electrical charge, elements, mass number, atomic number, isotopes, Scientific model,</i></p>	<p>Numeracy Use an appropriate number of significant figures, find arithmetic means, construct and interpret frequency tables and diagrams, bar charts and histograms, understand the principles of sampling as applied to scientific data, understand simple probability. Recognise and use expressions in standard form. Use ratios, fractions and percentages.</p>
		<p>.... that some atomic nuclei are unstable and decay.</p> <p>how to..... apply knowledge to the uses of radiation and evaluate the best sources of radiation to use in a given situation.</p>	<p>alpha, beta, gamma, nuclear model,</p>	<p>Substitute numerical values into algebraic equations using appropriate units for physical quantities. Solve algebraic equations. Translate information between graphical and numeric form.</p>
		<p><i>.... that</i> nuclear equations are used to represent radioactive decay.</p> <p>How to explain the concept of half-life and how it is related to the random nature of radio active decay.</p>	<p>Radiation, radioactive decay, Becquerel, count rate, Geiger-Muller tube, decays, Balanced equations, atomic numbers, mass numbers. Emission, daughter elements, Radioactive isotopes, count rate, half-life</p>	<p>Literacy and Reading BBC Bitesize – Atomic structure, extended reading articles Parallel histories.</p>
		<p>(HT ONLY) be able to calculate the net decline, expressed as a ratio, in a radioactive emission after a given number of half-lives.</p>	<p>Contamination, hazard, irradiation, contamination, precautions,</p>	<p>Cultural Capital/Careers Careers including Nuclear power reactor operator, energy consultant, Laboratory manager, Research Scientist, Nuclear medicine, Radiation Safety officer, Optical engineer, Astronomer.</p>
		<p><i>... that radioactive contamination is the unwanted presence of materials containing radioactive atoms on other materials.</i></p> <p><i>How to ..compare hazards associated with contamination and irradiation.</i></p>	<p>Back ground radiation, cosmic rays, sieverts</p>	<p>Cross curricular knowledge links DT- Materials,</p>
		<p><i>(Physics only)</i></p>		

		<p><i>... that background radiation is around us all of the time and this is affected by occupation and / or location. How to explain why the hazards associated with radioactive material differ according to the half-life involved.</i></p>		<p>Chemistry - Periodic table and atoms and bonding,</p> <p>Misconceptions – the electrons in an atom orbit the nucleus like planets in our solar system orbit the sun [electron shells represent the specific amounts of energy electrons have, not where electrons are located]; the nucleus of an atom is equivalent to a nucleus in a cell [they are not analogous].</p> <p>Students' views about the risk of radiation and radioactivematerials are based more strongly on everyday information than scientific ideas</p> <p>For example, some students see certain medical applications, such as radiotherapy, as inherently dangerous. Or, they may think that a nuclear power station is as dangerous as a nuclear bomb. Most students follow mass media on a regular basis and the general descriptions of their views show that they are dominated by incoherent bits of information about radioactivity from the media or films. scientific notions play a small or non-existent part.</p>
		<p>(Physics only) that nuclear radiations are used in medicine How to evaluate the perceived risks of using nuclear radians in relation to given data and consequences.</p>	<p>Evaluation of perceived risks in relation to data and handling.</p>	
		<p>(Physics only) that nuclear fission is the splitting of a large and unstable nucleus and that nuclear fusion is the joining of two light nuclei to form heavier nucleus. How to draw and interpret diagrams representing nuclear fission and how a chain reaction may occur.</p>	<p>Uranium, plutonium, fission, fusion, kinetic energy, chain reaction, nuclear reactor.</p>	

Topic Energy	Rationale (layering, Why this why now?)	Knowledge goals: <i>You need to know....</i> <i>...that (Declarative)</i> <i>.... how to (Procedural)</i> L ADDERING	Key Tier 3 vocabulary	Core skills and enrichment opportunities.						
<p>The concept of energy emerged in the 19th century. The idea was used to explain the work output of steam engines. It also became a key tool for understanding chemical reactions and biological systems. Limits to the use of fossil fuels and global warming are critical problems for this century. Physicists & engineers are working hard to identify ways to reduce our energy usage.</p>	<p> Linking</p> <p>KS2 Basic concept of heat / thermal energy <u>Year 7</u> Energy costs and transfers. <u>Year 8</u> Heating and cooling.</p>	<p><i>...that</i> energy can be stored and transferred in a variety of ways and there are changes in the way energy is stored when a system changes.</p> <p><i>....how to</i> describe all the changes involved in the way energy is stored when a system changes, for common situations.</p>	<p>Kinetic, Thermal, Chemical, Gravitational potential, Elastic potential, Electrostatic, Magnetic, nuclear, mechanical, radiation, electrical</p>	<p>Subject specific skills</p> <p>Practical skills – use a range of new equipment to measure the specific heat capacity of different materials.</p> <p>Numeracy Use, apply and rearrange energy equations. Convert between magnitudes of units. Interpret pie charts and other data sources on energy.</p> <p>Literacy and Reading Extended reading articles - Just Deserts, Unplugged, Out in the Cold,</p> <p>Cultural Capital/Careers Links to engineering related careers and apprenticeships, oil rig engineer, nutritionists or designers will need a good understanding of energy stores and transfers as well.</p> <p>Cross curricular knowledge links DT: Knowledge of principles of energy when designing bespoke items eg playground items, safety equipment (seatbelts).</p> <p>Common Misconceptions</p> <table border="1" data-bbox="1469 1133 2085 1468"> <thead> <tr> <th>Misconception</th> <th>Comment</th> </tr> </thead> <tbody> <tr> <td>The terms "<u>energy</u>" and "<u>force</u>" are interchangeable.</td> <td>The commonest example of this is the thinking of friction as energy - 'kinetic energy is transferred to friction' is a common mistake.</td> </tr> <tr> <td>Work</td> <td>From the non-scientific point of view, "work" is synonymous</td> </tr> </tbody> </table>	Misconception	Comment	The terms " <u>energy</u> " and " <u>force</u> " are interchangeable.	The commonest example of this is the thinking of friction as energy - 'kinetic energy is transferred to friction' is a common mistake.	Work	From the non-scientific point of view, "work" is synonymous
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<p> Looking</p> <p>Year 9 Energy transfers Types of energy Efficiency</p>	<p><i>...that</i> the amount of kinetic energy in a moving object, the amount of elastic potential energy stored in a stretched spring and the amount of gravitational potential energy gained by an object raised above ground level can be calculated.</p> <p><i>....how to</i> calculate the amount of energy associated with a moving object, a stretched spring and an object raised above ground level. Use and rearrange the associated equations.</p>	<p>Limit of proportionality, spring constant, gravitational field strength, joule, m/s, specific heat capacity</p>	<p>Cross curricular knowledge links DT: Knowledge of principles of energy when designing bespoke items eg playground items, safety equipment (seatbelts).</p> <p>Common Misconceptions</p>							
<p>Year 10 and Year 11 Paper 1 - energy</p>	<p><i>...that</i> the specific heat capacity of a substance is the amount of energy required to raise the temperature of one kilogram of a substance by one degree Celsius.</p> <p><i>....how to</i> use & apply the equation: $\Delta E = m c \Delta \theta$</p> <p>RP1. Investigation to determine the specific heat capacity of one or more materials</p>	<p>Δ -Delta (change in) θ – Theta (Temperature)</p>	<p>Common Misconceptions</p> <table border="1"> <thead> <tr> <th>Misconception</th> <th>Comment</th> </tr> </thead> <tbody> <tr> <td>The terms "<u>energy</u>" and "<u>force</u>" are interchangeable.</td> <td>The commonest example of this is the thinking of friction as energy - 'kinetic energy is transferred to friction' is a common mistake.</td> </tr> <tr> <td>Work</td> <td>From the non-scientific point of view, "work" is synonymous</td> </tr> </tbody> </table>	Misconception	Comment	The terms " <u>energy</u> " and " <u>force</u> " are interchangeable.	The commonest example of this is the thinking of friction as energy - 'kinetic energy is transferred to friction' is a common mistake.	Work	From the non-scientific point of view, "work" is synonymous	
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<p>Post 16 Work done, potential energy, conservation of energy, mechanical energy, power, efficiency</p>	<p><i>...that</i> power is the energy transferred by a device in a second & is measured in watts. Power is defined as the rate at which energy is transferred or the rate at which work is done.</p> <p><i>....how to</i> use and apply the equations: Power (W) = work done (J) ÷ time (s) and: Power (W) = energy transferred (J) ÷ time (s). Convert between watts & kW</p>	<p>Power, watts, time, energy transfer,</p>	<p>Common Misconceptions</p> <table border="1"> <thead> <tr> <th>Misconception</th> <th>Comment</th> </tr> </thead> <tbody> <tr> <td>The terms "<u>energy</u>" and "<u>force</u>" are interchangeable.</td> <td>The commonest example of this is the thinking of friction as energy - 'kinetic energy is transferred to friction' is a common mistake.</td> </tr> <tr> <td>Work</td> <td>From the non-scientific point of view, "work" is synonymous</td> </tr> </tbody> </table>	Misconception	Comment	The terms " <u>energy</u> " and " <u>force</u> " are interchangeable.	The commonest example of this is the thinking of friction as energy - 'kinetic energy is transferred to friction' is a common mistake.	Work	From the non-scientific point of view, "work" is synonymous	
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		<p>...<i>that</i> work done is the energy transferred when a force moves through a given distance. Energy is measured in Joules. Friction opposes motion. Work done to overcome friction is mainly transferred to thermal energy stores by heating.</p> <p>....<i>how to</i> apply the equation Work done = force x distance and identify the appropriate units.</p>	<p>Work done, energy ,friction, Newton, Joule.</p>		<p>with "labour". It is hard to convince someone that more work is probably being done dancing for one hour than studying an hour for a test. The fact that you only 'do work' when moving against gravity or another force - so walking on the level or going down a slope is not work is hard for them to grasp.</p>
		<p>...<i>that</i> useful energy: is energy transferred to where it is wanted in the way that it is wanted</p> <p>....<i>how to</i> explain the impact of friction on moving items and how it can be reduced.</p> <p>RP2: (Physics only) : Investigate the effectiveness of different materials as thermal insulators and the factors that may affect the thermal insulation properties</p>	<p>Friction, dissipated, wasted, transfer, thermal energy store. Thermal conductivity. Lubrication. Insulators & conductors.</p>	<p>An object at rest has no energy.</p>	<p>They commonly associate energy of an object with its movement - they were told they had lots of energy when they ran around as young children - and when tired and still they said things like, 'I have no energy left!'</p>
		<p>...<i>that</i> some energy will be wasted during transfers and the energy efficiency for any energy transfer can be calculated.</p> <p>....<i>how to use both equations:</i> $\text{efficiency} = \frac{\text{useful output energy transfer}}{\text{total in put energy transfer}}$</p>	<p>Efficiency</p>	<p>The only type of potential energy is gravitational.</p>	<p>At one time 'potential energy' was GPE! Now we have to ensure they know of all of the types of energy that is potential because it is stored up ready to be released - potential chemical energy in fuels (not released until they are burned), potential elastic energy in a stretched spring (not released until the spring is....</p>
		<p>...<i>that</i> non-renewable energy sources cannot be replaced. Fossil fuels are running out and alternatives need to be found.</p> <p>....<i>how to</i> evaluate the advantages & disadvantages of a range of renewable energies using text and data charts.</p>	<p>Non-renewable, fossil fuels, nuclear power, global warming, global dimming, emissions. Solar, hydro-electric, wind, tidal, geothermal, renewable,</p>	<p>Gravitational potential energy depends only on the height of an object and kinetic energy only on the speed.</p>	<p>The mass and gravitational field strength often get overlooked. A circus of objects with the same GPE can be useful - as can a set of caculations of objects of equal KE - to set that up practically would be difficult!</p>

				<p>Doubling the speed of a moving object doubles the kinetic energy.</p>	<p>The squared factor causes many a problem! You need to work through questions on this - at GCSE stopping distances need a good grasp of this - but most want to drive - so it is a topic they actually try hard to understand!</p>
				<p>Energy can be changed completely from one form to another useful (no energy losses as unwanted energy).</p>	<p>Even when electricity is used in a heater there is some 'wasted' energy involved - light, sound Many think that energy is truly lost in many energy transformations because things "use up" energy.</p>

Topic Forces	Rationale (layering, Why this why now?)	Knowledge goals: <i>You need to know....</i> <i>...that (Declarative)</i> ... <i>how to (Procedural)</i> L ADDERING	Key Tier 3 vocabulary	Core skills and enrichment opportunities.
Engineers analyse forces when designing a great variety of machines and instruments, from road bridges and fairground rides to atomic force microscopes. Anything mechanical can be analysed in this way. Recent developments in artificial limbs use the analysis of forces to make movement possible.	 <p>KS2 Moving objects, types of forces</p> <p>KS3 Speed, types of forces,</p>  <p>KS4 – Forces, work, scalars, vectors, atmosphere</p> <p>Post 16 Forces, momentum, moments</p>	<p><i>...that</i> Scalar quantities have magnitude only. Vector quantities have magnitude and an associated direction.</p> <p><i>how to</i> describe the interaction between pairs of objects which produce a force on each object.</p>	Scalar and vector, Contact and non-contact forces, Weight and gravity	<p>Cultural Capital/Careers</p> <p>Mechanic, aerospace engineer, computer game designer. car safety designer</p> <p>Cross curricular knowledge links</p> <p>PE – Sports and motion, Maths – formulas and algebra.</p> <p>Numeracy</p> <p>Recognise and use expressions in standard form. Use ratios, fractions and percentages.</p> <p>Substitute numerical values into algebraic equations using appropriate units for physical quantities. Solve algebraic equations.</p> <p>Translate information between graphical and numeric form.</p> <p>Literacy and Reading</p> <p>Understand scientific methods and theories and how they develop over time. Use a variety of models to make predictions and develop scientific explanations and understanding.</p> <p>Use scientific vocabulary, terminology and definitions. Use prefixes and powers of ten for orders of magnitude.</p>
		<p><i>...that</i> Weight is the force acting on an object due to gravity.</p> <p><i>... how to</i> use the equation - weight = mass × gravitational field strength</p>	quantatively and qualitatively.	
		<p><i>...that</i> a number of forces acting on an object may be replaced by a single force, called the resultant force, that has the same effect as all the original forces acting together.</p> <p><i>... how to</i> calculate the resultant of two forces that act in a straight line,</p> <p>(HT only) describe examples of the forces acting on an isolated object or system and use free body diagrams to describe qualitatively examples where several forces lead to a resultant force on an object.</p>	Resultant force, Free body diagrams, HT Only	
		<p><i>...that</i> when a force causes an object to move through a distance work is done on the object.</p> <p><i>... how to</i> use the calculation work done = force × distance (W = Fs)</p>	work	
		<p><i>...that</i> to change the shape of an object more than one force has to be applied and that the extension of an elastic object, such as a spring, is directly proportional to the force applied, provided that the limit of proportionality is not exceeded.</p> <p><i>...how to</i> describe the difference between elastic deformation and</p>	Force, work, newtons, joules, displacement, frictional forces	

	<p>inelastic deformation caused by stretching forces by using the equations $\text{force} = \text{spring constant} \times \text{extension}$. ($F = ke$)</p>		<p>Common Misconceptions</p> <table border="1"> <tr> <td>Measurement is only linear.</td> <td>Double the dimensions of an object and they think the curved surface area (csa) and volume also double - they find the fact that csa increases by a factor of 4 and volume (and therefore the mass) by a factor of 8 surprising.</td> </tr> <tr> <td>Any quantity can be measured as accurately as you want.</td> <td>.... all you have to do is use a modern 'digital' instrument - they think 'old' instruments are out of date and useless. They find the accuracy of precision instruments being related to construction difficult to understand - it needs to be 'new' and 'electronic' to be any good in their eyes!</td> </tr> <tr> <td>You can measure to any proportion of the smallest unit shown on the measuring device.</td> <td>They think they can estimate a third or quarter of a scale division - put them right on this!</td> </tr> <tr> <td>You should start at the end of the measuring device when measuring distance.</td> <td>Zero errors due to 'bashed' metre rulers always give a problem - so do ones that are constructed with a 'gap' to allow for wear and tear!</td> </tr> <tr> <td>Some objects cannot be measured because of their size or inaccessibility.</td> <td>They think an object must be "touched" to measure it. Use of trig to measure the height of a tree is sometimes suspect!</td> </tr> <tr> <td>Mass is a quantity that you get by weighing an object.</td> <td>In general speak they are interchangeable - to a pupil so are their units and numerical values! The doctors and other professions are included in the blame for this!</td> </tr> </table>	Measurement is only linear.	Double the dimensions of an object and they think the curved surface area (csa) and volume also double - they find the fact that csa increases by a factor of 4 and volume (and therefore the mass) by a factor of 8 surprising.	Any quantity can be measured as accurately as you want. all you have to do is use a modern 'digital' instrument - they think 'old' instruments are out of date and useless. They find the accuracy of precision instruments being related to construction difficult to understand - it needs to be 'new' and 'electronic' to be any good in their eyes!	You can measure to any proportion of the smallest unit shown on the measuring device.	They think they can estimate a third or quarter of a scale division - put them right on this!	You should start at the end of the measuring device when measuring distance.	Zero errors due to 'bashed' metre rulers always give a problem - so do ones that are constructed with a 'gap' to allow for wear and tear!	Some objects cannot be measured because of their size or inaccessibility.	They think an object must be "touched" to measure it. Use of trig to measure the height of a tree is sometimes suspect!	Mass is a quantity that you get by weighing an object.	In general speak they are interchangeable - to a pupil so are their units and numerical values! The doctors and other professions are included in the blame for this!
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	<p><i>...that</i> the extension of an elastic object, such as a spring, is directly proportional to the force applied, provided that the limit of proportionality is not exceeded.</p> <p><i>... how to</i> calculate work done in stretching (or compressing) a spring (up to the limit of proportionality) using the equation:</p> <p>RP6 - Investigate the relationship between force and extension for a spring.</p>	<p>Compressing, elastic deformation, inelastic deformation, directly proportional</p>													
	<p><i>...that</i> a force or a system of forces may cause an object to rotate. The turning effect of a force is called the moment of the force.</p> <p><i>....how to</i> use the calculation to work out the size of the moment - moment of a force = force \times distance. ($M = Fd$)</p> <p>(Physics only)</p>	<p>Physics only</p> <p>Turning forces, moments Leavers and gears, perpendicular distance, pivot,</p>													
	<p><i>...that</i> A fluid can be either a liquid or a gas. The pressure in fluids causes a force normal (at right angles) to any surface.</p> <p><i>....how to</i> calculate the pressure at the surface of a fluid using the equation: pressure = force normal to a surface area of that surface $p = F/A$.</p>	<p>Pressure in a fluid Pressure in a gas Upthrust, pascals, density, submerged objects,</p>													
	<p><i>.....that</i> the atmosphere is a thin layer (relative to the size of the Earth) of air round the Earth. The atmosphere gets less dense with increasing altitude.</p> <p><i>....how to</i> describe a simple model of the Earth's atmosphere, atmospheric pressure and how it varies with height above a surface. How to calculate the pressure due to a column of liquid using the equation - pressure = height of the column \times density of the liquid \times gravitational field strength. [$p = h \rho g$]</p>	<p>Atmospheric pressure</p>													
	<p><i>...that</i> there is a difference between distance and displacement and a difference between scalar and vector quantities.</p>	<p>HT Distance and displacement Speed and velocity</p>													

	<p>....<i>how to</i> use the calculation to work out the distance travelled in a specific time for an object moving at constant speed distance travelled = speed × time, $s = v t$</p> <p>(HT only) Students should be able to explain qualitatively, with examples, that motion in a circle involves constant speed but changing velocity</p>	Distance time graphs, Velocity time graphs, gradient,	<p>The five senses are infallible.</p> <p>There is only one way to measure perimeter.</p>	<p><u>Optical illusions</u> are good on this one!</p> <p>... and that is 'all of the way' round - mathematical calculation is suspect!</p>
	<p>...<i>that</i> If an object moves along a straight line, the distance travelled can be represented by a distance–time graph and that the speed of an object can be calculated from the gradient of its distance–time graph.</p> <p>....<i>how to</i> draw distance–time graphs from measurements and extract and interpret lines and slopes of distance–time graphs, translating information between graphical and numerical form.</p> <p>(HT only) If an object is accelerating, its speed at any particular time can be determined by drawing a tangent and measuring the gradient of the distance–time graph at that time.</p>	HT Estimating magnitudes, uniform acceleration, terminal velocity	<p>Only the area of rectangular shapes can be measured in square units.</p> <p>Surface area can be found only for two-dimensional objects.</p>	<p>The idea of measuring a circle in square units give some children problems</p> <p>Surface area is a concept used only in mathematics classes! Practical making of wrapping for an object helps with this - it is limited to rectangular shapes, but it helps - they have done 'nets' in maths.</p>
	<p>..... <i>that</i> the average acceleration of an object can be calculated using the equation: acceleration = change in velocity/ time taken $a = \Delta v / t$</p> <p>.... <i>how to</i> calculate the acceleration of an object from the gradient of a velocity–time graph.</p> <p>(HT only) The distance travelled by an object (or displacement of an object) can be calculated from the area under a velocity–time graph.</p> <p>(Physics only) Students should be able to: Draw and interpret velocity–time graphs for objects that reach terminal velocity and interpret the changing motion in terms of the forces acting.</p>	HT	<p>You cannot measure the volume of some objects because they do not have "regular" lengths, widths, or heights.</p> <p>The density of two samples of the same substance with different volumes or shapes cannot be the same.</p>	<p>They need to think of volume as an occupied 'space' rather than a mathematical construct - displacement can experiments are fun!</p> <p>Density is a concept difficulty for many... practical hands on experience is vital.</p>
	<p>.... <i>that</i> Newton’s First Law: states that the resultant force acting on an object is zero and if the object is stationary, the object remains stationary or the object is moving, the object continues to move at the same speed and in the same direction. So the object continues to move at the same velocity.</p>	HT		

		<p>(HT only) The tendency of objects to continue in their state of rest or of uniform motion is called inertia.</p> <p>.... that Newton's Second Law states that the acceleration of an object is proportional to the resultant force acting on the object, and inversely proportional to the mass of the object. As an equation : resultant force = mass × acceleration $F = m a$</p> <p><i>RP7: investigate the effect of varying the force on the acceleration of an object of constant mass, and the effect of varying the mass of an object on the acceleration produced by a constant force.</i></p>		
		<p>... that they can evaluate the effect of various factors on thinking distance based on given data.</p> <p>....how to calculate stopping distance</p> <p>(HT only) estimate the forces involved in the deceleration of road vehicles in typical situations on a public road</p> <p>(Physics only) Students should be able to estimate how the distance for a vehicle to make an emergency stop varies over a range of speeds typical for that vehicle.</p> <p>(Physics only) Students will be required to interpret graphs relating speed to stopping distance for a range of vehicles.</p>	Resultant forces, stationary, resistive forces, uniform velocity, inertia. Thinking distance, breaking distance, stopping distance. Reaction times, Energy transfers	
		<p><i>Momentum (HT only)</i></p> <p>... that momentum is a property of moving objects and conservation of momentum states that in a closed system, the total momentum before an event is equal to the total momentum after the event. This is called conservation of momentum.</p> <p>....how to use the equation that momentum is defined by – momentum = mass × velocity ($p = m v$). Students should also be able to use the concept of momentum as a model to describe and explain examples of momentum in an event, such as a collision</p> <p><i>(Physics only) complete calculations involving an event, such</i></p>	Mass, momentum, velocity, conservation Deceleration, closed system, momentum, safety features,	

as the collision of two objects.

Changes in momentum (physics only)

When a force acts on an object that is moving, or able to move, a change in momentum occurs.



The equations $F = m \times a$ and $a = \frac{v - u}{t}$

combine to give the equation $F = \frac{m \Delta v}{\Delta t}$


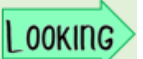
where $m\Delta v =$ change in momentum

ie force equals the rate of change of momentum.

Students should be able to apply equations relating force, mass, velocity and acceleration to explain how the changes involved are inter-related.

Topic Magnetism and Electromagnetism	Rationale (layering, Why this why now?)	Knowledge goals: <i>You need to know....</i> <i>...that (Declarative) how to (Procedural)</i> LADDERING	Key Tier 3 vocabulary	Core skills and enrichment opportunities.					
<p>Electromagnetic effects are used in a wide variety of devices. Engineers make use of the fact that a magnet moving in a coil can produce electric current and also that when current flows around a magnet it can produce movement. It means that systems that involve control or communications can take full advantage of this.</p>	<p> Linking</p> <p><u>KS2</u> Magnets,</p> <p><u>KS3</u> Magnets, magnetic materials, compasses</p>	<p><i>...that</i> the poles of a magnet are the places where the magnetic forces are strongest and two magnets are brought close together they exert a force on each other</p> <p><i>how to</i> describe the attraction and repulsion between unlike and like poles for permanent magnets and the difference between permanent and induced magnets.</p>	<p>Poles, fields, North, South, repel, attract, non-contact force, induced magnet, Iron, Nickel, Cobalt.</p>	<p>Subject specific skills Use a variety of models to solve problems, make predictions and to develop scientific explanations and understanding of familiar and unfamiliar facts. Recognise/draw/interpret diagrams. Translate from data to a representation with a model. Use models in explanations, or match features of a model to the data from experiments or observations that the model describes or explains.</p>					
	<p> Looking</p> <p>KS4 Magnets, Induced magnets, induced current, motor and generator effect.</p>	<p><i>...that</i> when a current flows through a conducting wire a magnetic field is produced around the wire.</p> <p><i>... how to</i> describe how the magnetic effect of a current can be demonstrated by drawing the magnetic field pattern for a straight wire carrying a current and for a solenoid.</p>	<p>Current, solenoid, iron core.</p>	<p>Numeracy Use an appropriate number of significant figures, find arithmetic means, construct and interpret frequency tables and diagrams, bar charts and histograms, understand the principles of sampling as applied to scientific data, understand simple probability</p>					
	<p>Post 16</p> <p>Magnetic Fields, Magnetic Field Strength, The Force on a Moving Charge</p>	<p><i>...that</i> when a conductor carrying a current is placed in a magnetic field the magnet producing the field and the conductor exert a force on each other. This is called the motor effect.</p> <p><i>... how to</i> show that Fleming's left-hand rule represents the relative orientation of the force, the current in the conductor and the magnetic field. Students should be able to recall the equation: force = magnetic flux density × current × length $F = B I l$</p>	<p>Fleming's left-hand rule, magnetic flux density, force.</p>	<p>Literacy and Reading BBC Bitesize – Magnetism, extended reading articles Parallel histories.</p> <p>Cultural Capital/Careers Careers including Engineers in terms of building all sorts of machines that have electric motors and generators. Sound engineers, transmission of electricity at high voltages in transformers that form the backbone of the National Grid. Fun and sorting materials.</p>					
		<p><i>...that</i> a coil of wire carrying a current in a magnetic field tends to rotate.</p> <p><i>....how to</i> explain how a moving-coil loudspeaker and headphones work.</p> <p>(Physics only)</p>	<p>Physics only</p> <p>Rotation, conductor, coil, loudspeakers, headphones, pressure. Rotation, conductor, coil, loudspeakers, headphones, pressure.</p>	<p>Cross curricular knowledge links Geography – Earths magnetic field,</p> <p>Misconceptions</p> <table border="1" data-bbox="1552 1297 2179 1425"> <thead> <tr> <th data-bbox="1552 1297 1731 1425">Misconception</th> <th data-bbox="1742 1297 1899 1425">Discussion of the problem</th> <th data-bbox="1910 1297 2179 1425">Possible Activities</th> </tr> </thead> <tbody> <tr> <td> </td> <td> </td> <td> </td> </tr> </tbody> </table>	Misconception	Discussion of the problem	Possible Activities		
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		<p><i>...that</i> If an electrical conductor moves relative to a magnetic field or if there is a change in the magnetic field around a conductor, a potential difference is induced across the ends of the conductor. If the conductor is part of a complete circuit, a current is induced in the conductor. This is called the generator effect.</p> <p><i>how to</i> recall the factors that affect the size of the induced potential difference/induced current and recall the factors that affect the direction of the induced potential difference/induced current.</p> <p>(Physics only)</p>	<p>Physics only</p> <p>Potential difference, current, conductor, generator, induced. Potential difference, current, conductor, generator, induced.</p>	<p>All metals are attracted to a magnet.</p>	<p>Only iron, nickel and cobalt and their alloys are attracted to a magnet</p>	<p>Circus of material to test</p>
		<p><i>...that</i> the generator effect is used in an alternator to generate ac and in a dynamo to generate dc.</p> <p><i>how to</i> explain how the generator effect is used in an alternator to generate ac and in a dynamo to generate dc</p>	<p>Potential difference, current, conductor, generator, induced, transformers, coil, efficient, eddy currents.</p>	<p>All magnets are made of iron.</p>	<p>iron is a soft magnetic material - wouldn't work!</p>	<p>Make magnets - iron and steel - by stroking</p>
		<p><i>...that</i> a basic transformer consists of a primary coil and a secondary coil wound on an iron core and that ratio of the potential differences across the primary and secondary coils of a transformer V_p and V_s depends on the ratio of the number of turns on each coil, n_p and n_s.</p> <p><i>.....how to</i> use the equations $v_p/v_s = n_p/n_s$ potential difference, V_p and V_s in volts, V. In a step-up transformer $V_s > V_p$ In a step-down transformer $V_s < V_p$ $V_s \times I_s = V_p \times I_p$</p>		<p>Larger magnets are stronger than smaller magnets.</p>		<p>part of a circus - weak big one and strong small one!</p>
				<p>The magnetic and geographic poles of the earth are located at the same place.</p>		<p>Web search on navigation of seas and how magnetic pole 'moves'</p>
				<p>The magnetic pole of the earth in the northern hemisphere is a north pole, and the pole in the southern hemisphere is a south pole.</p>		<p>Make a model of the earth and put a magnet within it so that search compasses point north</p>

Topic	Rationale (layering, Why this why now?)	Knowledge goals: <i>You need to know....</i> <i>...that (Declarative) ... how to (Procedural)</i> L ADDERING	Key Tier 3 vocabulary	Core skills and enrichment opportunities.
<p>Questions about where we are, and where we came from, have been asked for thousands of years. In the past century, astronomers and astrophysicists have made remarkable progress in understanding the scale and structure of the universe, its evolution and ours. New questions have emerged recently. ‘Dark matter’, which bends light and holds galaxies together but does not emit electromagnetic radiation, is everywhere – what is it? And what is causing the universe to expand ever faster?</p>	<p> Linking</p> <p>KS2 Space, our universe, day and night</p> <p>KS3 Space, our universe, day and night</p> <p> Looking</p> <p>KS4</p> <p>Post 16</p>	<p><i>...that</i> within our solar system there is one star, the Sun, plus the eight planets and the dwarf planets that orbit around the Sun. Natural satellites, the moons that orbit planets, are also part of the solar system.</p> <p><i>how to explain</i> how, at the start of a star's life cycle, the dust and gas drawn together by gravity causes fusion reactions and that that fusion reactions lead to an equilibrium between the gravitational collapse of a star and the expansion of a star due to fusion energy</p>	<p>Planets, dwarf planets, stars, asteroids, comets, moons, meteoroids, meteors, galaxy, Milky Way, The Universe. Satellites, artificial satellites, natural satellites, orbits, velocity.</p>	<p>Subject specific skills Use a variety of models such as representational, spatial, descriptive, computational and mathematical to solve problems, make predictions and to develop scientific explanations and understanding of familiar and unfamiliar facts. Recognise/draw/interpret diagrams. Translate from data to a representation with a model. Use models in explanations, or match features of a model to the data from experiments or observations that the model describes or explains. Make predictions or calculate quantities based on the model or show its limitations. Give examples of ways in which a model can be tested by observation or experiment.</p> <p>Numeracy Use scientific vocabulary, terminology and definitions. WS 4.2 Recognise the importance of scientific quantities and understand how they are determined. Use SI units (eg kg, g, mg; km, m, mm; kJ, J) and IUPAC chemical nomenclature unless inappropriate. Use prefixes and powers of ten for orders of magnitude (eg tera, giga, mega, kilo, centi, milli, micro and nano). Interconvert units. Use an appropriate number of significant figures in calculation</p> <p>Literacy and Reading BBC Bitesize –Space Physics, extended reading articles Parallel histories.</p> <p>Cultural Capital/Careers Space systems engineer, Space lawyer, Software engineer, commercial strategist, human spaceflight and microgravity programme manager, Glaciologist, ExoMars delivery manager, Emerging Technology lead,</p> <p>Cross curricular knowledge links</p>
		<p><i>... that a</i> star goes through a life cycle and the life cycle is determined by the size of the star.</p> <p><i>How to</i> explain how fusion processes lead to the formation of new elements.</p>	<p>Hydrogen, Helium, attraction, repulsion, energy, pressure, heat.</p>	
		<p><i>.... that</i> gravity provides the force that allows planets and satellites (both natural and artificial) to maintain their circular orbits.</p> <p><i>How to ...</i> describe the similarities and distinctions between the planets, their moons, and artificial satellites</p>	<p>Nebula, protostar, main sequence star, red giant, white dwarf, black dwarf, neutron star, supernovae, black hole, elements, Iron.</p>	
		<p><i>... that</i> there is an observed increase in the wavelength of light from most distant galaxies. This effect is called red-shift.</p> <p><i>how to...</i> explain qualitatively the red-shift of light from galaxies that are receding and how red-shift provides evidence for the Big Bang model.</p>	<p>Wavelength, expansion, Doppler effect, Big Bang, dark mass, dark energy, supernovae.</p>	

Geography – Earth's magnetic field, Chemistry – chemical compounds,

Misconceptions

Astronauts are weightless in orbit

Reality: anywhere mass and space exist, gravity exists.

The Sun is Yellow



Reality: white is the true colour of the Sun.

It would be dangerous to fly through an asteroid belt

In the Asteroid Belt of the Solar System, which is between the orbits of Mars and Jupiter, the average distance between objects is again a massive 600,000 miles (965,606.4 km). So no, it wouldn't be dangerous to fly through an asteroid belt.

You would instantly freeze in space

Reality: you wouldn't freeze instantly in the space, despite its average temperature is so low (3K or -270 °C; -454 °F). Because there's no matter in the space, so the heat does not leave the body quickly enough. You only lose heat via thermal radiation. Of course, you would get colder and eventually freeze but very, very slowly.

Topic Waves	Rationale (layering, Why this why now?)	Knowledge goals: <i>You need to know...</i> <i>...that (Declarative) how to (Procedural)</i> LADDERING	Key Tier 3 vocabulary	Core skills and enrichment opportunities.				
<p>Wave behaviour is common in both natural and man-made systems. Waves carry energy from one place to another and can also carry information. Designing comfortable and safe structures such as bridges, houses and music performance halls requires an understanding of mechanical waves. Modern technologies such as imaging and communication systems show how we can make the most of electromagnetic waves.</p>	<p> LINKING</p> <p><u>KS2</u> Basic concepts of waves and movement</p> <p><u>KS3</u> Energy and waves, light waves, sound waves.</p> <p> LOOKING</p> <p><u>KS4</u> Waves in air, fluids and solids, properties, uses and dangers of waves.</p> <p><u>Post 16</u> Diffraction gratings, coherence, path difference, phase difference. industrial application of diffraction gratings, including emission Spectra and identification of</p>	<p><i>...that</i> waves may be either transverse or longitudinal.</p> <p><i>how to</i> describe the difference between longitudinal and transverse waves and describe wave motion in terms of their amplitude, wavelength, frequency and period.</p>	<p>Parallel, Perpendicular, Wavelength, Amplitude, Peaks, Troughs, Compressions, Rarefaction, Normal</p>	<p>Subject specific skills Describe a practical procedure for a specified purpose. Explain why a given practical procedure is well designed for its specified purpose. Explain the need to manipulate and control variables.</p> <p>Numeracy Use an appropriate number of significant figures, find the arithmetic mean and range of a set of data, construct and interpret frequency tables and diagrams, bar charts and histograms, change the subject of an equation, substitute numerical values into algebraic equations using appropriate units for physical quantities. Practical use of ray boxes and numeracy skills used throughout, such as calculating the speed of a wave.</p> <p>Literacy and Reading Understand scientific methods and theories and how they develop over time. Use a variety of models to make predictions and develop scientific explanations and understanding. Use scientific vocabulary, terminology and definitions.</p> <p>Cultural Capital/Careers Careers include sonographer, seismologist or a seismographer, opticians or ophthalmologists</p> <p>Cross curricular knowledge links Geography, earthquakes and convection currents, coastal erosion</p> <p>Common Misconceptions</p> <table border="1" data-bbox="1435 1262 2168 1414"> <thead> <tr> <th>Misconception</th> <th>Possible Activities</th> </tr> </thead> <tbody> <tr> <td>Loudness and pitch of sounds are confused with each other.</td> <td>Reinforcement of correct scientific vocabulary</td> </tr> </tbody> </table>	Misconception	Possible Activities	Loudness and pitch of sounds are confused with each other.	Reinforcement of correct scientific vocabulary
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		<p><i>...that</i> the frequency of a wave is the number of waves passing a point each second and the wave speed is the speed at which the energy is transferred through the medium.</p> <p><i>how to</i> use the equations to work out period</p> <p>(Physics only) show how, changes in velocity, frequency and wavelength, in transmission of sound waves from one medium to another, are inter-related.</p>	<p>Reflect, refract, Incident Medium, Sound,</p>					
<p><i>...that</i> there is a method to measure the speed of sound waves in air and to measure the speed of ripples on a watersurface.</p> <p><i>how to</i> make observations to identify the suitability of apparatus to measure the frequency, wavelength and speed of waves in a ripple tank and waves in a solid and take appropriate measurements.</p> <p>RP8: make observations to identify the suitability of apparatus to measure the frequency, wavelength and speed of waves in a ripple tank and waves in a solid and take appropriate measurements.</p>	<p>Ultrasound, S-waves, P-Waves, Seismic waves, Radio Waves, Microwaves, Infrared, Visible light, Ultraviolet, X-Rays, Gamma Rays. Practical applications Velocity, Frequency, wavelength Real, Virtual, inverted Speed, transparent, translucent, Absorption, filters, opaque. Infrared, Energy</p>							
<p><i>...that waves can be reflected at the boundary between two different materials and waves can be absorbed or transmitted at the boundary between two different materials.</i></p>	<p>Physics only</p>							

gases. Concept and applications of stationary wave resonance.	<p><i>how to</i> construct ray diagrams to illustrate the reflection of a wave at a surface. And how to describe the effects of reflection, transmission and absorption of waves at material interfaces.</p> <p>RP9: Investigate the reflection of light by different types of surface and the refraction of light by different substances</p>		<p>Hitting an object harder changes its pitch.</p> <p>Practical - getting them to sing the note when hit with different force</p>
	<p>...that sound waves can travel through solids causing vibrations in the solid.</p> <p><i>how to</i> describe, with examples, processes which convert wave disturbances between sound waves and vibrations in solids. Examples may include the effect of sound waves on the ear drum and explain why such processes only work over a limited frequency range and the relevance of this to human hearing.</p>	Physics only	<p>In a telephone, actual sounds are carried through the wire rather than electrical pulses</p> <p>Human voice sounds are produced by a large number of vocal chords.</p> <p>Sound moves faster in air than in solids (air is "thinner" and forms less of a barrier).</p> <p>Sound moves between particles of matter (in empty space) and then 'bumps into' the next matter particle.</p>
	<p>...that waves are used for detection and exploration.</p> <p><i>how to</i> explain in qualitative terms, how the differences in velocity, absorption and reflection between different types of wave in solids and liquids can be used both for detection and exploration of structures which are hidden from direct observation.</p>	Ultrasound waves, Seismic waves, P-waves and S-waves. Echo sounding.	<p>In wind instruments, the instrument itself vibrates not the internal air column</p> <p>The pitch of whistles or sirens on moving vehicles is changed by the driver as the vehicle passes.</p>
	<p>...that Electromagnetic waves are transverse waves that transfer energy from the source of the waves to an absorber, they form a continuous spectrum and all types of electromagnetic wave travel at the same velocity through a vacuum (space) or air.</p> <p>...how to give examples that illustrate the transfer of energy by electromagnetic waves.</p> <p>RP10: Investigate how the amount of infrared radiation absorbed or radiated by a surface depends on the nature of that surface.</p>	radio, microwave, infrared, visible light (red to violet), ultraviolet, Xrays and gamma rays	<p>The pitch of a tuning fork will change as it "slows down", (i.e. "runs" out of energy)</p> <p>Practical - getting them to sing the note until it dies</p> <p>As sound waves move, the air moves along with them.</p>
	<p>...that Electromagnetic waves all have many uses and applications due to their individual properties</p>	• radio waves – television and radio	<p>The pupil of the eye is a black object or a spot on the surface of the eye.</p> <p>Idea it is the gap in the centre of the iris.</p> <p>Observation of how the pupil changes size in different light intensities (Care they don't blind each other!) Discuss eye exams in an optician -</p>

		<p><i>...how to</i> give brief explanations why each type of electromagnetic wave is suitable for the practical application.</p>	<ul style="list-style-type: none"> • microwaves – satellite communications, cooking food • infrared – electrical heaters, cooking food, infrared cameras • visible light – fibre optic communications • ultraviolet – energy efficient lamps, sun tanning • X-rays and gamma rays – medical imaging and treatments. 			<p>how s/he looks through the pupil</p>
		<p><i>...that</i> a lens forms an image by refracting light.</p> <p><i>...how to</i> construct ray diagrams to illustrate the similarities and differences between convex and concave lenses.</p>	<p>Physics only</p>	<p>The eye receives upright images on the retina.</p>	<p>Ray diagrams can be used to show how the image is inverted</p>	<p>Use vid-clips to show full visual system</p>
		<p><i>...that</i> each colour within the visible light spectrum has its own narrow band of wavelength and frequency.</p> <p><i>...how to</i> explain:</p> <ul style="list-style-type: none"> • how the colour of an object is related to the differential absorption, transmission and reflection of different wavelengths of light by the object • the effect of viewing objects through filters or the effect on light of passing through filters 	<p>Physics only</p>	<p>The lens forms an image (picture) on the retina. The brain then "looks" at this image and that is how we see.</p>	<p>Correct terminology for image interpretation needs to be reinforced</p>	<p>Use vid-clips to show full visual system - discuss how blindness can happen to people with perfect eyes</p>
		<p><i>...that</i> each colour within the visible light spectrum has its own narrow band of wavelength and frequency.</p> <p><i>...how to</i> explain:</p> <ul style="list-style-type: none"> • how the colour of an object is related to the differential absorption, transmission and reflection of different wavelengths of light by the object • the effect of viewing objects through filters or the effect on light of passing through filters 	<p>Physics only</p>	<p>The eye is the only organ involved in sight; the brain is only for thinking.</p>	<p>Correct terminology for image interpretation needs to be reinforced</p>	<p>Use vid-clips to show full visual system - discuss how blindness can happen to people with perfect eyes</p>
		<p><i>...that</i> all bodies (objects), no matter what temperature, emit and absorb infrared radiation. A perfect black body is an object that absorbs all of the radiation incident on it.</p> <p><i>...how to</i> explain:</p> <ul style="list-style-type: none"> • that all bodies (objects) emit radiation • that the intensity and wavelength distribution of any emission depends on the temperature of the body 	<p>Physics only</p>	<p>A white light source, such as sunlight, an incandescent or fluorescent bulb, candle flame etc. produces light made up of exactly the same spectrum of colours.</p>	<p>Spectra of sources differ according to the electron transitions involved</p>	<p>Use a series of light sources and compare the spectra or what strips of multicoloured cloth look like under them - discuss how clothing looks different under different light sources. Could look at spectra from stars...</p>
				<p>When white light passes through a coloured filter colour is added to the light.</p>	<p>Filters subtract</p>	<p>Use multiple filters</p>

				<p>The rules for mixing color paints and crayons are the same as the rules for mixing coloured lights. So the primary colors for mixing coloured lights are red, blue and yellow.</p>		
				<p>The shades of grey in a black and white newspaper picture are produced by using inks with different shades of gray.</p>		<p>Use a magnifying glass to look at the dots</p>
				<p>The different colors appearing in coloured pictures printed in magazines and newspapers are produced by using different inks with all the corresponding colors.</p>		<p>Use a magnifying glass to look at the dots</p>
				<p>Colour is a property of an object, and is independent of both the illuminating light and the receiver (eye).</p>		<p>Look at coloured objects under different coloured light sources.</p>
				<p>White light is colourless and clear, enabling you to see the "true" color of an object.</p>		

				<p>Explanations of visual phenomena involving color perception usually involve only the properties of the object being observed, and do not include the properties of the eye-brain system.</p>		<p>Talk about colour blindness - use colour blindness tests.</p>
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