	Topic title	SUMMARY OF KNOWLEDGE ACQUISTION	APPROXIMATE DURATION	Term 1a								Term1b								Term 2a						Term 2b							Term 3a					Term 3b						
				1	2	3	4	5	6	7	8	1	2	3	4	5	6	7		1	2	3	4	5	6	1	2	3	4	5	6		1	2	3	4	5	1	2	3	4	5	6	7
Year 9																																												
1	Atomic Structure	Atoms, elements, compounds, mixtures, separating mixtures, purifying sea water the atomic model, P,E,N and calculating each	8					■	■																																			
2	The Periodic Table	History of the Periodic Table, the modern Periodi c Table, trends and patterns in Group 1	8							■	■																																	
3	Chemical changes - Meta	Metal oxides, the reactivity series, extraction of metals and reduction using carbon, displacement reactions and practical, acids and alkalis and neutralisation	10									■	■	■																														
4	Organic Chemistry	Crude oil, fractional distillation, properties of hydrocarbons, cracking, alkenes	7																							■	■																	
5	Chemistry of the Atmosph	Composition of the atmosphere, evolution of the atmosphere, combustion, pollutants	9																									■	■															
6	Chemical Analysis	Testing for common gases, mixtures, formulations and chromatography	9																											■	■													
Year 10																																												
1	Structure and Bonding	Structure of the atom recap, forming ions, giant ionic compounds, covalent bonding, simple and giant covalent, metallic bonding alloys and properties of all structures	16	■	■	■	■	■	■	■	■																																	
2	Quantitative Chemistry	Atomic mass, relative formula mass, moles, balancing equations, reacting masses, limiting reagents, concentration calculations, atom economy, percentage yield	9									■	■	■	■	■																												
3	Chemical Changes	Neutralisation and electrolysis	7														■	■		■																								
4	Energy Changes	Exothermic and endothermic reactions, reaction profiles and examples, temperature changes requried practical, bond energy calculations	5																		■	■	■																					
5	Revision for mocks, year	Revision of year 9 content and preparation for mock exams	5																					■	■																			
6	Rates of Reaction	The rate of reaction, collision theory, factors affecting rate of reaction, tangents to graphs, equilibria, Le Chatelier, reversible reactions	6																							■	■	■																
7	Chemical Analysis	Pure substances and formulations, chromatography	4																										■	■	■													
8	Organic Chemistry	Alkenes, reactions an polymers, carboxylic acids and alcohols, esters, biochemistry	8																														■	■	■	■								
9	Using Resources	The Earths resources, sustainable development, pure and potable water, reduce, reuse and recycle, LCAs	5																																		■	■	■	■				
	Revision for mocks, year	Revision of year 9 content and preparation for mock exams	7																																						■	■	■	■
Year 11																																												
1	Atomic Structure	Atoms, elements, compounds, mixtures, separating mixtures, purifying sea water the atomic model, P,E,N and calculating each	2	■	■																																							
2	The Periodic Table	History of the Periodic Table, the modern Periodi c Table, trends and patterns in Group 1	3			■	■																																					
3	Structure and Bonding	Structure of the atom recap, forming ions, giant ionic compounds, covalent bonding, simple and giant covalent, metallic bonding alloys and properties of all structures	5					■	■	■																																		
4	Quantitative Chemistry	Atomic mass, relative formula mass, moles, balancing equations, reacting masses, limiting reagents, concentration calculations, atom economy, percentage yield	6								■	■	■																															
5	Chemical Changes	Neutralisatio n, electrolysis	5											■	■																													
6	Energy Changes	Exothermic and endothermic reactions, reaction profiles and examples, temperature changes requried practical, bond energy calculations	5													■	■	■																										
7	Rates of Reaction	The rate of reaction, collision theory, factors affecting rate of reaction, tangents to graphs, equilibria, Le Chatelier, reversible reactions	4																	■	■																							
8	Organic Chemistry	Crude oil, fractional distillation, properties of hydrocarbons, cracking, alkenes	4																			■	■	■	■																			
9	Chemistry of the Atmosph	Composition of the atmosphere, evolution of the atmosphere, combustion, pollutants	4																							■	■																	
10	Chemical Analysis	Pure substances and formulations, testing for common gases , chromatography	4																									■	■															
11	Using Resources	The Earths resources, sustainable development, pure and potable water, purifying water and distillation, reduce, reuse and recycle, LCAs	8																											■	■													
12	Revision	Past paper preparation, mock exams and intervention																															■	■	■	■	■	■	■	■	■	■	■	■

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

Topic	Rationale (Layering, Why this why now?)	Knowledge goals: *You need to know….* *…that (Declarative)* *…. how to (Procedural)* LADDERING	Key Tier 3 vocabulary	Core skills and enrichment opportunities.
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.	LINKING **Year 7** Properties of metals and non-metals **Year 8** Periodic table **Year 9** Atomic structure LOOKING **Year 11** Apply bonding knowledge and detailed use of nanoparticle **Post 16** AS Bonding unit	**Lesson 1 – Forming Ions** *…that* ions are formed from the loss and gain of electrons into electron shells *…how to* represent ions using dot and cross diagrams	Ion, positive, negative, cation, anion, transfer, noble gas, configuration, ionic	**a) Numeracy** Analysis and evaluation of data based questions using graphs and/or tables for bonding properties. **b) Literacy and reading** Analysis and evaluation of data based questions using extended text for use of polymers and nanoparticles. **c) Cultural Capital/Careers** The development of new and diverse nanoparticles for use in everyday life. **d) Cross curricular knowledge links** Opportunities for learners to demonstrate their research skills **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.
		Lesson 2 – Ionic Compounds *…that* ionic compounds can be represented in different ways. *…how to* describe and explain ionic bond formation using dot and cross diagrams.	Giant, lattice, 3D, ions	
		Lesson 3 – Properties of Ionic Compounds *…that* the specific bonding in ionic compounds leads to different properties. *…how to* construct the formula of common ionic compounds.	Conductivity, brittle, soluble, electrostatic	
		Lesson 3 and 4 – Covalent Bonding *…that* covalent bonds are formed from the sharing of electrons *…how to* draw dot and cross diagrams to represent simple covalent molecules *…how to* explain the properties of simple covalent compounds in terms of structure and bonding	Covalent, dot and cross, sharing, valence, intermolecular forces	

				Non metals do-not conduct electricity however graphite, graphene and fullerenes made purely from carbon (a non-metal) can conduct electricity. 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. 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. 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. An ionic bond is the attraction between positive and negative ions (multiples of
		Lesson 5 – Polymers *…that* simple covalent molecules can form polymers *…how to* draw the structure of polymers and repeat units	Polymer, manufactured, covalent, molecule, monomer, repeat unit polymerisation, thermosetting, thermosoftening, intermolecular	
		Lesson 6 – Giant Covalent Molecules *…that* carbon can exist in three different forms called allotropes *…that* the different bonding in these allotropes leads to the different properties of the allotropes *…how to* explain the properties of these allotropes in terms of structure and bonding	Brilliant, strong, hard, lubricant,	
		Lesson 7 – Nanoparticles *…that* nanoscience is the study of nano-sized particles *…how to* explain the properties of nanoparticles in terms of structure and bonding *…how to* calculate surface area to volume ratio	Nanoparticle, surface area to volume ratio	
		Lesson 8 – Metallic Bonding *…that* metallic bonding occurs in metals *…how to* explain the properties of metals in terms of structure and bonding	Delocalised, electrostatic, electron, conduction	

		Lesson 9 – 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	Mixtures, properties, malleable, proportion, stainless, sonorous, malleable, ductile, reflective, conductor, catalyst, compound	each) however electrons must be transferred for those charges to appear.

Year 10 Two Quantitative (GCSE Chemistry)

Topic **Quantitative Chemistry**	**Rationale (Layering, Why this why now?)**	**Knowledge goals:** ***You need to know….*** *…that (Declarative)* *…. how to (Procedural)* Laddering	**Key Tier 3 vocabulary**	**Core skills and enrichment opportunities.**
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 communicate chemical ideas.	Linking **Year 8** Periodic table **Year 9** Atomic structure and periodic table, chemical changes, acids and alkalis Looking **Year 11** Apply quantitative knowledge across a broad range of questions. **Post 16** Quantitative chemistry	**Lesson 1 – Relative Atomic and Relative Formula Mass** *…that* relative atomic masses are found on the periodic table *…how to* calculate relative atomic and relative formula mass *…how to* calculate percentage element in a compound	Mass number, formula mass, formula, equation, reactants, products	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. b) **Literacy and reading** c) **Cultural Capital/Careers** Chemical engineers, pharmaceuticals, toxicology, river water analysis d) **Cross curricular knowledge links** Rearranging equations, converting units, percentages all linked with maths skills e) **Misconceptions** When balancing equations you can't change how the compounds are made up – this means you can't add
		Lesson 2 Conservation of Mass *…that* mass is conserved in a reaction *…how to* use chemical equations to evaluate conservation of mass	Conservation, mass, balanced	
		Lesson 3 – Conservation of Mass Practical *…that* mass does not always appear to be conserved in a reaction *…how to* complete a practical to investigate conservation of mass safely	Safety, crucible, balance, weighing boat	

		Lesson 4 - Introduction to Moles *…that* a mole is a chemical quantity *…how to* calculate moles using the correct equation *…how to* rearrange the moles equation *…how to* apply your knowledge to questions	Mole, quantity, mass, relative atomic/formula mass, Avogadro's constant	or take away any of the 'small numbers'. Some reactions look like mass is lost however it is normally a product that is a gas escaping from wherever the reaction is happening. 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 $6.02x10^{23}$ particles. Understanding the correct units and their conversions. Appreciation of standard form and manipulation of standard form within calculations. Scale of what a decimetre is. Use of non-integers in balancing equations.
		Lesson 5 – Reacting Masses *…that* moles can be used to calculate required masses of reagents and predicted masses of products *…how to* apply the moles equation to calculating reacting masses	Moles, reacting masses, balanced equation, conservation	
		Lesson 6 – Using Moles to Balance Equations *…that* moles can be used to calculate required masses of reagents and predicted masses of products *…how to* apply the moles equation to find stoichiometry to balance equations	Balancing, stoichiometry, moles	
		Lesson 7 – Limiting Reactants	Stoichiometry, limiting reactant, excess	

		…*that* quantity of product is limited by the quantity of reactant …*how to* apply the moles equation to find the limiting reactant in a reaction		
		Lesson 8 – Percentage Yield and Atom Economy …*that* reactions do not always produce a 100% yield …*how to* calculate percentage yield for given reactions …*how to* calculate atom economy for given reactions	Completion, reversible, yield, reactant, product, theoretical, atom economy	
		Lesson 9 – Concentration of Solutions …*that* cubic decimetres are a unit of concentration …*how to* convert between units …*how to* calculate the concentration of solutions.	Solutions, concentration, volume, solute, decimetre, cubic centimetre, mass	
		Lesson 10 – Titration Calculations …*that* the concentration of an unknown acid or alkali can be found via a titration reaction …*how to* calculate the concentration of an unknown using the concentration equations	Solutions, concentration, volume, solute, decimetre, cubic centimetre, mass,	

		Lesson 11 – Volume of Gases *…that* one mole of gas occupies a set volume *…how to* calculate the volume of gas using the moles equation	Volume, temperature, pressure, volumes, gaseous	

Year 10 Topic Three Chemical Changes (GCSE Chemistry)

Topic	**Rationale** **(Layering, Why this why now?)**	**Knowledge goals:** ***You need to know….*** *…that (Declarative)* *…. how to (Procedural)* Laddering	**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	Linking **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 Looking **Year 11** Chemical changes – paper 1 **Post 16** Acid, alkali titrations. Types of acid. Neutralisation reactions.	**<u>Lesson 1 – Reactivity Series and Displacement Reactions</u>** *…that* the reactivity series places metals in increasing order of reactivity and can be used to predict reactions. *….how to* use the reactivity series to predict whether or not a displacement reaction will happen.	ionic compounds, reactivity series, displacement	a) **<u>Numeracy</u>** Balancing ionic equations for more able students. b) **<u>Literacy</u>** Etymology of words to describe metallic properties e.g. lustre. c) **<u>Reading</u>** Methods, hazard warnings, extraction of aluminium reading to extract knowledge. Application of hydrogen homes. d) **<u>Cultural Capital/Careers</u>** Hydrogen extraction for fuels (hydrogen homes) e) **<u>Cross curricular knowledge links</u>** Environmental impacts of large scale metal extraction – recycling metals and alternative metal extraction f) **<u>Misconceptions</u>**
		<u>Lesson 2 – The Process of Electrolysis</u> *…that* electrolysis is a process which separates ionic compounds *…. how to* describe and explain the process of basic electrolysis *…. how to* represent the process at the electrodes using half equations	Electrolysis, anode, cathode, anion, cation, electrolyte, electrodes, half equations	
		<u>Lesson 3 – The Extraction of Aluminium</u> *…that* aluminium is a reactive emetal that requires electrolysis to be se[arated from its ores	Bauxite, aluminium, electrodes, electrolysis, half equations	

		…. *how* the extraction of aluminium is adjusted and has special conditions		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. 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.
		Lesson 4 – Aqueous Electrolysis …*that* aqueous solutions of ionic compounds can be separated using electrolysis …. *how to* predict the products of aqueous electrolysis	Aqueous, prediction, products, reactivity series, halogens	
		Lesson 5 – Electrolysis Required Practical …. *how to* predict the products of electrolysis then test the predictions using the practical equipment	Aqueous, hazards, risks, electrolyte, anode, cathode	
		Lesson 6 – Neutralisation, pH and Indicators …*that* acids, alkalis and bases are chemicals which react in neutralisation reactions …. *how to* explain the differences between strong and weak acids	Acid, alkali, base, pH, neutralisation, indicators, strong, weak	
		Lesson 7 and 8 – Titration Required Practical …*that* unknown concentrations can be determined using a titration reaction …. *how to* safely complete a titration practical to achieve concordant results	Titration, burette, pipette, indicator, end point, acid, alkali, concentration, concordant	

Year 10 Topic Four – Energy Changes (GCSE Chemistry)

Topic	Rationale (Layering, Why this why now?)	Knowledge goals: *You need to know….* *…that (Declarative)* *…. how to (Procedural)* Laddering	Key Tier 3 vocabulary	Core skills and enrichment opportunities.
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. 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.	Linking **Year 8** Endothermic and exothermic reactions Looking **Year 11** Apply energy change knowledge and detailed use of cells and batteries. **Post 16** Energetics	**Lesson 1 – Exothermic and Endothermic** *…that* exothermic reactions release heat energy and endothermic absorb heat energy from their surroundings. *…. how to* draw reaction profiles for exothermic and endothermic reactions	Exothermic, endothermic, profiles, activation energy, surroundings	**a) Numeracy** Analysis and evaluation of data based questions using graphs and/or tables for energy transfer Carry out bond energy calculations **b) Literacy and reading** Reading methods in order to follow instructions. Student safety sheets in order to evaluate risks in a practical. **c) Cultural Capital/Careers** Food hygienist and preparation – hot and cold cans. Medics hot and cold packs. DofE – hand warmers **d) Cross curricular knowledge links** DT – Materials design of hot/cold cans
		Lesson 2 – Bond Enthalpy Calculations *…that* bonding breaking is endothermic and bond formation is exothermic *…how to* calculate bond enthalpy changes	Enthalpy, exothermic, endothermic, ΔH.	
		Lesson 3 and 4 – Temperature Changes Practical *…how to* safely conduct a practical to investigate temperature changes in a reaction *…. how to* draw a graph from which data can be extrapolated	Extrapolation, variables, hazard, risk, control	

				PE – hot/cold packs
		Lesson 5 – Fuel Cells and Batteries *…that* cells and batteries use chemical reactions to produce an electrical current *…. how to* evaluate the use of hydrogen fuel cells *…how to* write half equations for the processes inside a hydrogen fuel cell	Fuel cell, battery, ions, half equations	**e) Misconceptions** 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. Endothermic reactions are cold as they take in thermal (heat) energy from the surroundings.

Year 10 Topic Five - Rate and extent of chemical change (GCSE Chemistry)

Topic	**Rationale (Layering, Why this why now?)**	**Knowledge goals:** ***You need to know….*** *…that (Declarative)* *…. how to (Procedural)* LADDERING	**Key Tier 3 vocabulary**	**Core skills and enrichment opportunities.**
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	LINKING **Year 8** Rates of reaction LOOKING **Year 11** Apply rate and extent of chemical change knowledge to extended questions. **Post 16** kinetics	**Lesson 1 – Measuring Rate of Reaction** *…that* mean rate of reaction can be determined by measuring quantity of mass used or product released *…how to* determine the rate of a chemical reaction by interpreting data	Product, reactant, rate, mean, gradient	**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. **b) Literacy and reading** Analysis and evaluation of data based questions using extended text for use of changing conditions on the Haber process.
		Lesson 2 – Factors affecting rate of reaction *…that* the rate of reaction can be changed by altering conditions *…how to* use collision theory to explain the effect of changing conditions on the rate of reaction	Collision, particle, energy, activation, rate, concentration, pressure, sufficient, catalyst, temperature, surface area, state	
		Lesson 3 and 4 – Changing Surface Area *…how to* measure the rate of reaction during a practical for production of gaseous products *…how to* represent data using graphs	Dependent, independent, control, variable, surface area, delivery tube	
		Lesson 5, 6 and 7 – Changing Concentration *…how to* measure the rate of reaction during a practical which produces solid *…how to* represent data using graphs	Dependent, independent, control, variable, rate, concentration, hydrochloric, thiosulphate. Erlenmeyer, obscure, hypothesis, conclusion	

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.		*…how to* describe and explain the shape of a graph		c) **Cultural Capital/Careers** How the Haber Process has had an impact on the global economy. d) **Cross curricular knowledge links** Opportunities for learners to demonstrate their research skills e) **Misconceptions** Not all reactions happen quickly, some take millions of years to happen! 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. Catalysts are not part of the reaction; they just interact with the atoms to help them react. 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.
		Lesson 8 – Reversible Reactions *… that* some chemical reactions are reversible *…how to* represent reversible reactions	Reactant, product, forward, backward, reversible, equilibrium, rate, anhydrous, hydrated	
		Lesson 9 and 10 – Equilibria and Le Chateliers *… that* chemical reactions reach a state of equilibria *…how to* apply the three steps to success to Le Chateliers principle	Reactant, product, forward, backward, reversible, equilibrium, Le Chatelier.	
		Lesson 11 – Haber Process *… that* the Haber process is a major industrial reaction *…how to* explain the compromise conditions required in the Haber process	Haber process, ammonia, reactor, fertilisers	

Year 10 Topic Six - Organic (GCSE Chemistry)

Topic	**Rationale (Layering, Why this why now?)**	**Knowledge goals:** ***You need to know….*** *…that (Declarative)* *…. how to (Procedural)* LADDERING	**Key Tier 3 vocabulary**	**Core skills and enrichment opportunities.**
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 molecules and modify to make new, useful materials such as polymers, pharmaceuticals, perfumes and	LINKING **Year 8** Elements, compounds, mixtures **Year 9** Atomic structure, separating mixtures LOOKING **Year 10** Organic chemistry Using resources **Post 16** Organic chemistry	**Lesson 1 – Alkanes and Alkenes Review** *…that* hydrocarbons can be classified as alkenes and alkanes *…how to* differentiate between alkenes and alkanes	Alkanes, alkenes, double bond, unsaturated, saturated, functional group, homologous series	a) **Numeracy** Interpreting charts and graphs on data linking crude oil and its uses. Using general formulae to predict formulae of alkanes and alkenes. 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. c) **Reading** Reading for information retrieval. Literacy homework - Comparison and evaluation of the environmental impacts of production of ethanol from steam hydration of ethane and fermentation of glucose with yeast. d) **Cultural Capital/Careers** Organic chemistry can help you get into careers in forensics,
		Lesson 2 – Alkenes and their Reactions *…that* alkenes undergo reactions in which atoms are added to the carbons in the double bond *…how to* test for the presence of the alkene functional group *…how to* represent the polymerisation of alkenes and predict the products of addition polymerisation	Alkanes, alkenes, double bond, unsaturated, addition reactions, functional group, polymer	
		Lesson 3 – Alcohols, Carboxylic Acids and Esters *…that* alcohols, carboxylic acids and esters are homologous series with differing functional groups which affects their chemical reactivity *… how to* test for the different functional groups and write equations for their reactions	Functional group, carboxylic acid, ester, ethyl ethanoate, strong and weak acids, Combustion, oxidising agent, fermentation, glucose, yeast	
		Lesson 4 – Condensation Polymers *…that* condensation polymers are formed from two different monomers to give a polymer and water	Condensation polymerisation, monomers, repeat units	

flavourings, dyes and detergents.		… *how to* represent condensation polymers		pharmaceuticals, making perfumes and flavours (Christmas dinner flavoured crisps!) How synthetic polymers have had an impact on everyday life. History of the discovery of DNA as a polymer chain. (e) **Cross curricular knowledge links** DT: polymers as design materials. Geography – crude oil as a finite resources Biology – biochemistry, amino acids, proteins and DNA (f) **Misconceptions** Organic does not mean natural – it chemistry it refers to carbon chemistry. The "hydro" in hydrocarbons does not mean water – it means hydrogen. 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.
		Lesson 5 – Biochemistry *…that* polymers exist naturally, for example proteins and DNA *…how* natural polymers form … *how to* describe the structure of DNA in detail.	Amino acids, polypeptides, proteins, cellulose, starch, deoxyribonucleic acid, polymer chains, nucleotides, double helix	

Year 10 Topic Seven - Analysis (GCSE Chemistry)

Topic	**Rationale (Layering, Why this why now?)**	**Knowledge goals:** ***You need to know….*** *…that (Declarative)* *…. how to (Procedural)* Laddering	**Key Tier 3 vocabulary**	**Core skills and enrichment opportunities.**
4.8 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	Linking **Year 8** Reaction types Looking **Year 11** Chemical Analysis **Post 16** Analysis using a range of chromatography techniques. Gas tests.	**Lesson 1 – Pure Substances and Formulations** *…that* 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. *….how to* distinguish between a pure substance and a mixture.	Pure, substance, melting point, boiling point, impure, mixture, product, purpose, fertilisers,	a) **Numeracy** Analysis and evaluation of data based questions using graphs and/or tables for analysis. b) **Literacy** Scientific literacy on gas formulae c) **Reading** Reading for learning on case studies. d) **Cultural Capital/Careers** Forensic science e) **Cross curricular knowledge links** 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
		Lesson 2, 3, 4 – Required Practical – Testing for Ions *…that* positive metal and negative non-metal ions can be distinguished using indicative tests *….how to* use indicative tests to identify common ions *….how to* safely complete an indicative tests practical	Flame tests, metals, ions, solutions, precipitates, carbonates, halide, sulphates	
		Lesson 5 – Testing for Common Gases and Instrumental Analysis *…that* carbon dioxide, oxygen, hydrogen and chlorine have specific tests which can be used to identify them *…that* instrumental methods of analysis have advantages over traditional methods *….how to* analysis flame emission spectroscopy date to determine ions in a compound	Identification, instrumental, accurate, sensitive, rapid, flame emission spectroscopy, spectroscope, spectrum, concentrations, metal ions	

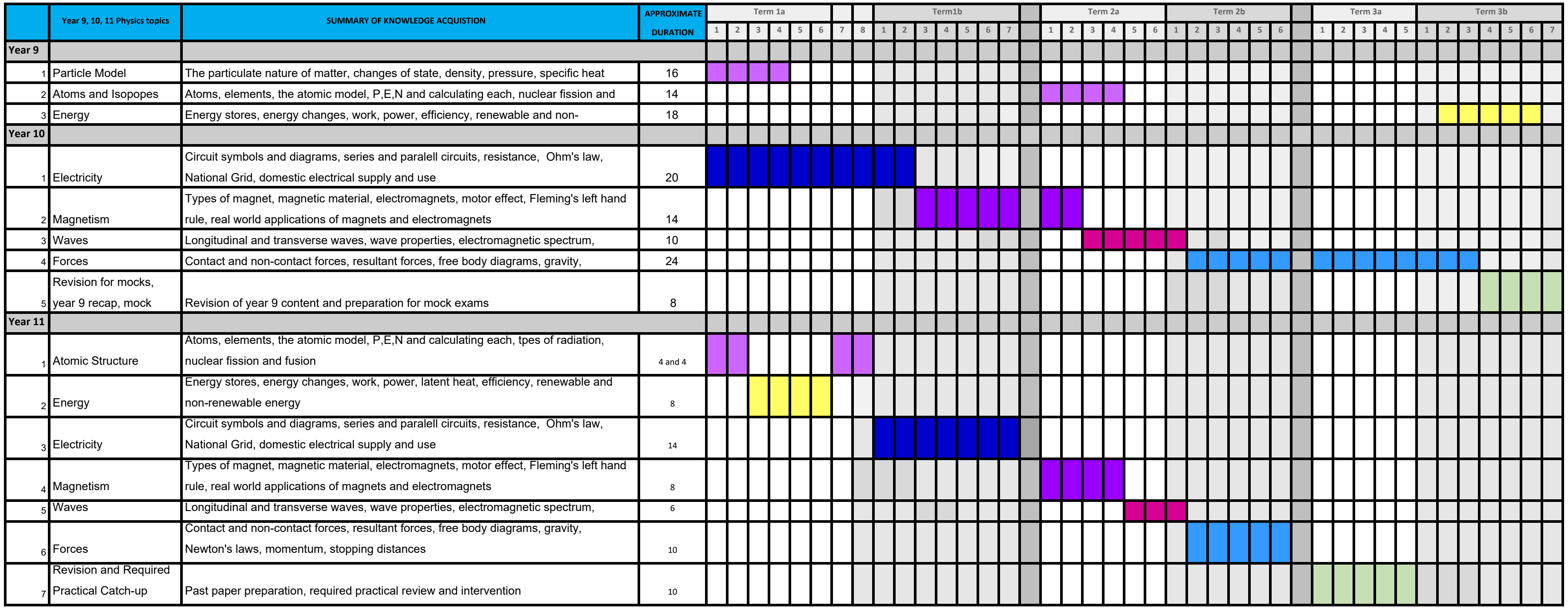
instrumental methods in their work.				sugars, water, pulp, and lots of other things. .

Year 10 Topic Eight - Earths resources and using resources (GCSE Chemistry)

Topic	**Rationale (Layering, why this why now?)**	**Knowledge goals:** ***You need to know….*** *…that (Declarative)* **…** *how to (Procedural)* Laddering	**Key Tier 3 vocabulary**	**Core skills and enrichment opportunities.**
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	Linking **Year 7** Fossil fuels **Year 9** Organic chemistry Looking **Year 11** Apply Earths resources and using resources knowledge. **Post 16** Polymers	**Lesson 1 – The Earths Resources** *…that* the Earth provides all the resources needed for human survival. *… how to* distinguish between finite and renewable sources.	Resources, warmth, shelter, food, transport, natural, agriculture, fuels, finite, renewable.	**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** How composites have had an impact on everyday life. The Haber process, its place in history and the modern impacts of fertiliser development.
		Lesson 2– Alternative Extraction of Metals *…that* the Earth's resources of metal ores is limited. *… how to* use alternative extraction methods to access low grade ores.	Metal ores, phytomining, bioleaching, bacteria, leachate, electrolysis, metal extraction.	
		Lesson 3 – Reduce, Reuse and Recycle and Life Cycle Assessments *…that* reducing, reusing, and recycling help to conserve resources. *… how to* evaluate ways of reducing the use of materials. *…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.	Life cycle assessment, manufacturing, packaging, lifetime, quantified, processing. Metals, glass, building materials, ceramics, quarrying, mining, recycled, melting, recasting, scrap, ore, extraction.	

environmental chemists' study how human activity has affected the Earth's natural cycles and how damaging effects can be minimalised.		**Lesson 4 – Materials** …*that* most everyday metals we use are alloys and they have specific uses. … *how to* interpret and evaluate the composition and uses of alloys. …*that* the properties of materials are related to their uses. … *how to* compare the physical properties of glass and clay ceramics, polymers, and composites.	Alloys, jewellery, proportion, carats, shaped, malleable, ductile, corrosion, resistant, density. Limestone, borosilicate, temperature, clay, pottery, conditions, density, thermosoftening, polymers, thermosetting, composites.	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. **d) Cross curricular knowledge links** 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. **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.
		Lesson 5 – Corrosion and its Prevention …*that* rusting is an example of corrosion. … *how to* prevent rusting.	Corrosion, environment, rusting, air, water, coating, barrier, electroplating, greasing, painting, reactive, galvanise, sacrificial protection.	
		Lesson 6 – The Haber Process …*that* the Haber process is used to manufacture ammonia, which is used to produce nitrogen-based fertilisers. … *how to* apply the principles of dynamic equilibrium to the Haber process. … *how to* explain the compromise conditions used in the Haber process.	Manufacture, fertiliser, Haber process, catalyst, pressure, reversible reaction, equilibrium	
		Lesson 7 – Production and Uses of NPK Fertilisers …*that* NPK fertilisers are used to improve agricultural productivity. …*that* phosphate rock must be treated and cannot be directly used as a fertiliser. … *how to* compare the industrial production of fertilisers with laboratory preparations.	Industrial, production, processes, fertilisers, formulations, preparation, laboratory	

		Lesson 8 – Potable Water *...that* potable water is different to pure water. *... how to* test the purity of water. *... how to* describe the differences between the treatment of ground water and freshwater.	Potable, pure, sterilising, desalination, reverse osmosis, filter.	
		Lesson 9 – Wastewater Treatment *...that* sewage can be treated to make it safe to drink. *... how to* purify wastewater.	Sewage, grit, sedimentation, anaerobic digestion, aerobic, effluent, sludge, agricultural.	
		Lesson 10 – Water RP *... how to* purify salt water by simple distillation. *... how to* test the purity of the water produced.	Distillation, Liebig condenser, evaporation, condensing, boiling point	



	Year 9, 10, 11 Physics topics	SUMMARY OF KNOWLEDGE ACQUISTION	APPROXIMATE DURATION	Term 1a								Term1b								Term 2a						Term 2b							Term 3a					Term 3b						
				1	2	3	4	5	6	7	8	1	2	3	4	5	6	7		1	2	3	4	5	6	1	2	3	4	5	6		1	2	3	4	5	1	2	3	4	5	6	7
Year 9																																												
1	Particle Model	The particulate nature of matter, changes of state, density, pressure, specific heat	16	■	■	■	■																																					
2	Atoms and Isopopes	Atoms, elements, the atomic model, P,E,N and calculating each, nuclear fission and	14																	■	■	■	■																					
3	Energy	Energy stores, energy changes, work, power, efficiency, renewable and non-	18																																				■	■	■	■	■	
Year 10																																												
1	Electricity	Circuit symbols and diagrams, series and paralell circuits, resistance, Ohm's law, National Grid, domestic electrical supply and use	20	■	■	■	■	■	■	■	■	■	■																															
2	Magnetism	Types of magnet, magnetic material, electromagnets, motor effect, Fleming's left hand rule, real world applications of magnets and electromagnets	14											■	■	■	■	■		■	■																							
3	Waves	Longitudinal and transverse waves, wave properties, electromagnetic spectrum,	10																			■	■	■	■	■																		
4	Forces	Contact and non-contact forces, resultant forces, free body diagrams, gravity,	24																								■	■	■	■	■		■	■	■	■	■	■	■	■				
5	Revision for mocks, year 9 recap, mock	Revision of year 9 content and preparation for mock exams	8																																						■	■	■	■
Year 11																																												
1	Atomic Structure	Atoms, elements, the atomic model, P,E,N and calculating each, tpes of radiation, nuclear fission and fusion	4 and 4	■	■					■	■																																	
2	Energy	Energy stores, energy changes, work, power, latent heat, efficiency, renewable and non-renewable energy	8			■	■	■	■																																			
3	Electricity	Circuit symbols and diagrams, series and paralell circuits, resistance, Ohm's law, National Grid, domestic electrical supply and use	14									■	■	■	■	■	■	■																										
4	Magnetism	Types of magnet, magnetic material, electromagnets, motor effect, Fleming's left hand rule, real world applications of magnets and electromagnets	8																	■	■	■	■																					
5	Waves	Longitudinal and transverse waves, wave properties, electromagnetic spectrum,	6																					■	■	■																		
6	Forces	Contact and non-contact forces, resultant forces, free body diagrams, gravity, Newton's laws, momentum, stopping distances	10																								■	■	■	■	■													
7	Revision and Required Practical Catch-up	Past paper preparation, required practical review and intervention	10																														■	■	■	■	■							

Topic 1 Particle model	**Rationale (layering, Why this why now?)**	**Knowledge goals:** ***You need to know….*** *…that (Declarative)* *…. how to (Procedural)* Laddering	**Key Tier 3 vocabulary**	**Core skills and enrichment opportunities.**
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!	Linking KS2 States of matter Simple physical properties of materials. Year 7 Particle model Separating Mixtures Year 8 Elements Periodic Table Year 9 KS4 Looking **Year 9** **Year 10** Atomic structure –chem Particle model - phy **Year 11** Rates - chem **Post 16** Kinetic theory Gas Laws Atomic structure	*…that* properties of solids, liquids and gases in terms of the particles in each state of matter. Particles are moving and have kinetic energy. *…. how to* link arrangement of the particles in each state of matter to their properties and be able to compare them.	Particle solids liquids gases forces of attraction density *Property*	**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. ***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. **Literacy and Reading** Improvement of vocabulary bank – tier 2 - BBC Bitesize – Particle Model, extended reading articles. Reading for understanding, exemplar question contexts.
		…that density is the mass which is contained in a given volume. A denser material will sink in a less dense material. *…. how to* calculate the density of a given material using: density = mass/volume. How to convert between g and Kg, and ml and l.	Density, mass, volume, formula.	
		…that displacement can be used to find the volume of an irregular object. *…. how to* practically determine the volume of an irregular shaped object. 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.	density displacement *regular irregular*	
		…that 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. *how to* determine what happens to temperature during changes of state. *..why* some substances have higher/lower melting and boiling points than others.	state temperature heat State, melt, evaporate, condense, freeze, sublimation.	
		…that 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. *how to* construct and interpret a heating/cooling curve.	internal kinetic potential *Independent, dependent, control, variables*	
		…that Specific Latent Heat is the energy absorbed by a substance during a change of state *how to calculate specific latent heat.*	specific latent heat Latent, heat, internal energy, mass, joules, kilograms, fusion, vaporisation, vapour	

		…that The amount of energy needed to heat a material is known as Specific Heat Capacity. *how to calculate how much energy is needed to heat up different materials. Use and rearrange the equation: Heat = mass x SHC x temp change*	*Capacity* Specific heat capacity	***Cultural Capital/Careers*** Archimedes 'Eureka moment.' Architect, Astronomer, Energy Analyst, Food Technology, Games Designer, Geophysicist, Meteorologist, Nuclear Engineer, Radiographer, School teacher, ***Cross curricular knowledge links*** Selection of materials for cooking pans – food technology. Heat transfer – DT – materials. **Misconceptions** 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.
		…. that the temperature of a gas is related to the average kinetic energy of the molecules how to.. explain qualitatively the relation between the temperature of a gas and its pressure at constant volume.		
		(Physics only) .. that increasing the volume in which a gas is contained, at constant temperature, can lead to a decrease in pressure. 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.		

Topic Electricity	**Rationale (layering, Why this why now?)**	**Knowledge goals:** ***You need to know….*** *…that (Declarative)* …. *how to (Procedural)* LADDERING	**Key Tier 3 vocabulary**	**Core skills and enrichment opportunities.**
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	LINKING KS2 States of matter Simple physical properties of materials. Year 7 Particle model Separating Mixtures Year 8 Elements Periodic Table Year 9 KS4 LOOKING **Year 9** **Year 10** Atomic structure –chem Particle model - phy **Year 11** Rates - chem **Post 16**	*…that* 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. …. *how* to draw circuit symbols	E.g. lamp, battery, diode Current, charge, coulombs, amperes, volts, components	***Numeracy*** 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. **Literacy** 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. ***Reading*** BBC Bitesize, The Illustrated Science Dictionary, World of Science, Horrible Science of Everything, The Science Boo Home Science Experiments
		…that Electric Current is flow of electrical charge and that charge flow, current and time are linked. …. *how to* use the equation : charge flow = current x time	Potential difference, resistance, ohms	
		…that potential Difference is amount of energy transferred to each coulomb of charge *how to place components in the circuit to measure current and potential difference* *RP3: Use circuit diagrams to set up and check appropriate circuits to investigate the factors affecting the resistance of electrical circuits.*	Circuit diagrams, Proportional Voltage Current Resistance Amps Ohms Volts	
		…that in some resistors the value of R remains constant but that in others it can change as the current changes. *…. How to use the equation: potential difference = current x resistance* *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.*	Graphs. Linear, non-linear, correlation,	
		…that there are two ways of joining electrical components, in series and in parallel. *how to* explain qualitatively why adding resistors in series increases the total resistance whilst adding resistors in parallel decreases the total resistance	Series, parallel,	
		…that 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. *how to* explain the difference between direct and alternating potential difference	Alternating current, direct current, Three core cable, insulation, appliance,	

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?		*… that* 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. *How to* describe, with examples, the relationship between the power ratings for domestic electrical appliances and the changes in stored energy when they are in use.	Transfer, work done,	Crisp Packet Fireworks. ***Cultural Capital/Careers*** ***Cross curricular knowledge links*** Electrician working on repairing some forklift trucks, Electricity plays a huge role in the robotics industry, and it is a fundamental concept. Engineer working in the medical prosthetics field. Working on the national power grid, Whether you are repairing or installing electrical cables, it's imperative that you understand the basics of electricity. 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. **Misconceptions** Misconception: current is ‘used up’ as it flows round the circuit 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. 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) Current flows instantly in all parts of a circuit when there is a complete circuit.
		… that the National Grid is a system of cables and transformers linking power stations to consumers. *How to …* explain why the National Grid system is an efficient way to transfer energy.	Cables, transformers (Higher only), consumers, efficiency, step up, step down	
		(Physics only) *.. that* when certain insulating materials are rubbed against each other they become electrically charged. How to ….explain how the transfer of electrons between objects can explain the phenomena of static electricity.	Electrically charge, negative, positive, electrons, repel, attract, non contact force, static,	
		(Physics only) *… that a* charged object creates an electric field around itself *How to …..* 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.	electric field pattern, Field, force, isolated charge, electrostatic phenomena, sparking	

Topic Atomic Structure	**Rationale (layering, Why this why now?)**	**Knowledge goals:** ***You need to know….*** *…that (Declarative)* *…. how to (Procedural)* Laddering	**Key Tier 3 vocabulary**	**Core skills and enrichment opportunities.**
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.	Linking KS2 Filtering, sieving, evaporating, dissolving, solutions. Year 7 Matter, separating mixtures. Year 8 Elements, periodic table. Year 9 KS4 Looking **Year 9** **Year 10** Structure and bonding **Year 11** Atomic structure Structure and bonding **Post 16** Atomic structure **Structure and bonding**	*…that* atoms are very small and consist of electrons, protons and neutrons. (sub-atomic particles) *how to* represent the sub-atomic particles and the structure of an atom, including the mass number, atomic number and isotopes.	Nucleus, protons, neutrons, electrons, electromagnetic radiation, energy levels	**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. **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. **Literacy and Reading** BBC Bitesize – Atomic structure, extended reading articles Parallel histories. **Cultural Capital/Careers** Careers including Nuclear power reactor operator, energy consultant, Laboratory manager, Research Scientist, Nuclear medicine, Radiation Safety officer, Optical engineer, Astronomer. **Cross curricular knowledge links** DT- Materials,
		…. that the model of the atom has changed over time due to new scientific experimental evidence. how to …. use evidence to explain why there have been changes in the atomic model.	*Electrical charge, elements, mass number, atomic number, isotopes, Scientific model,*	
		…. that some atomic nuclei are unstable and decay. how to….. apply knowledge to the uses of radiation and evaluate the best sources of radiation to use in a given situation.	alpha, beta, gamma, nuclear model,	
		….. that nuclear equations are used to represent radioactive decay. How to explain the concept of half-life and how it is related to the random nature of radio active decay. (HT ONLY) be able to calculate the net decline, expressed as a ratio, in a radioactive emission after a given number of half-lives.	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	
		… that radioactive contamination is the unwanted presence of materials containing radioactive atoms on other materials. *How to ..compare hazards associated with contamination and irradiation.*	Contamination, hazard, irradiation, contamination, precautions,	
		(Physics only)	Back ground radiation, cosmic rays, sieverts	

		… 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.*		Chemistry - Periodic table and atoms and bonding, 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]. Students’ views about the risk of radiation and radioactivematerials are based more strongly on everyday information than scientific ideas 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.
		(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.	Evaluation of perceived risks in relation to data and handling.	
		(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.	Uranium, plutonium, fission, fusion, kinetic energy, chain reaction, nuclear reactor.	

Topic **Energy**	**Rationale (layering, Why this why now?)**	**Knowledge goals:** ***You need to know….*** *…that (Declarative)* *…. how to (Procedural)* Laddering	**Key Tier 3 vocabulary**	**Core skills and enrichment opportunities.**
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.	Linking **KS2** Basic concept of heat / thermal energy Year 7 Energy costs and transfers. Year 8 Heating and cooling. Looking **Year 9** Energy transfers Types of energy Efficiency **Year 10 and Year 11** Paper 1 - energy **Post 16** Work done, potential energy, conservation of energy, mechanical energy, power, efficiency	*…that* 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. *….how to* describe all the changes involved in the way energy is stored when a system changes, for common situations.	Kinetic, Thermal, Chemical, Gravitational potential, Elastic potential, Electrostatic, Magnetic, nuclear, mechanical, radiation, electrical	**Subject specific skills** Practical skills – use a range of new equipment to measure the specific heat capacity of different materials. **Numeracy** Use, apply and rearrange energy equations. Convert between magnitudes of units. Interpret pie charts and other data sources on energy. **Literacy** and **Reading** Extended reading articles - Just Deserts, Unplugged, Out in the Cold, **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. **Cross curricular knowledge links** DT: Knowledge of principles of energy when designing bespoke items eg playground items, safety equipment (seatbelts). **Common Misconceptions**
		…that 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. *….how to 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.	Limit of proportionality, spring constant, gravitational field strength, joule, m/s, specific heat capacity	
		…that 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. *….how to* use & apply the equation: $\Delta E = m c \Delta \theta$ RP1. Investigation to determine the specific heat capacity of one or more materials	Δ -Delta (change in) Θ – Theta (Temperature)	
		…that 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. *….how to* use and apply the equations: Power (W) = work done (J) ÷ time (s) and: Power (W) = energy transferred (J) ÷ time (s). Convert between watts & kW	Power, watts, time, energy transfer,	

Misconception	Comment
The terms "energy" and "force" 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

		...*that* 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. ....*how to* apply the equation Work done = force x distance and identify the appropriate units.	Work done, energy ,friction, Newton, Joule.
		...*that* useful energy: is energy transferred to where it is wanted in the way that it is wanted ....*how to* explain the impact of friction on moving items and how it can be reduced. RP2: (Physics only) : Investigate the effectiveness of different materials as thermal insulators and the factors that may affect the thermal insulation properties	Friction, dissipated, wasted, transfer, thermal energy store. Thermal conductivity. Lubrication. Insulators & conductors.
		...*that* some energy will be wasted during transfers and the energy efficiency for any energy transfer can be calculated. ....*how to use both equations:* efficiency = useful output energy transfer/ total in put energy transfer	Efficiency
		...*that* non-renewable energy sources cannot be replaced. Fossil fuels are running out and alternatives need to be found. ....*how to* evaluate the advantages & disadvantages of a range of renewable energies using text and data charts.	Non-renewable, fossil fuels, nuclear power, global warming, global dimming, emissions. Solar, hydro-electric, wind, tidal, geothermal, renewable,

	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.
An object at rest has no energy.	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!'
The only type of potential energy is gravitational.	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 enery in fuels (not released until they are burned), potential elastic energy in a stretched spring (not released until the spring is....
Gravitational potential energy depends only on the height of an object and kinetic energy only on the speed.	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!

				Doubling the speed of a moving object doubles the kinetic energy.	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!
				Energy can be changed completely from one form to another useful (no energy losses as unwanted energy).	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.

Topic Forces	**Rationale (layering, Why this why now?)**	**Knowledge goals: *You need to know….*** *…that (Declarative)* *…. how to (Procedural)* Laddering	**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.	Linking **KS2** Moving objects, types of forces **KS3** Speed, types of forces, Looking **KS4** – Forces, work, scalars, vectors, atmosphere **Post 16** Forces, momentum, moments	*…that* Scalar quantities have magnitude only. Vector quantities have magnitude and an associated direction. *how to* describe the interaction between pairs of objects which produce a force on each object.	Scalar and vector, Contact and non-contact forces, Weight and gravity	**Cultural Capital/Careers** Mechanic, aerospace engineer, computer game designer. car safety designer **Cross curricular knowledge links** PE – Sports and motion, Maths – formulas and algebra. **Numeracy** 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. **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. Use prefixes and powers of ten for orders of magnitude.
		…that Weight is the force acting on an object due to gravity. *…. how to* use the equation - weight = mass × gravitational field strength	quantatively and qualitatively.	
		…that 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. *…. how to* calculate the resultant of two forces that act in a straight line, (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.	Resultant force, Free body diagrams, **HT Only**	
		…that when a force causes an object to move through a distance work is done on the object. … *how to* use the calculation work done = force × distance (W = Fs)	work	
		…that 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. *…how to* describe the difference between elastic deformation and	Force, work, newtons, joules, displacement, frictional forces	

		inelastic deformation caused by stretching forces by using the equations force = spring constant × extension. ($F = ke$)	
		...*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. ... *how to* calculate work done in stretching (or compressing) a spring (up to the limit of proportionality) using the equation: RP6 - Investigate the relationship between force and extension for a spring.	Compressing, elastic deformation, inelastic deformation, directly proportional
		...*that* 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. ....*how to* use the calculation to work out the size of the moment - moment of a force = force × distance. ($M = Fd$) **(Physics only)**	**Physics only** Turning forces, moments Leavers and gears, perpendicular distance, pivot,
		...*that* A fluid can be either a liquid or a gas. The pressure in fluids causes a force normal (at right angles) to any surface. ....*how to* calculate the pressure at the surface of a fluid using the equation: pressure = force normal to a surface area of that surface $p = F A$.	Pressure in a fluid Pressure in a gas Upthrust, pascals, density, submerged objects,
		.......that 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. .....how to 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. [$p = h \rho g$]	Atmospheric pressure
		...*that* there is a difference between distance and displacement and a difference between scalar and vector quantities.	HT Distance and displacement Speed and velocity

Common Misconceptions

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 interchangable - to a pupil so are their units and numerical values! The doctors and other professions are included in the blame for this!

		....how to use the calculation to work out the distance travelled in a specific time for an object moving at constant speed distance travelled = s peed × time, $s = v t$ (HT only) Students should be able to explain qualitatively, with examples, that motion in a circle involves constant speed but changing velocity	Distance time graphs, Velocity time graphs, gradient,
		...that 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. *....how to* draw distance–time graphs from measurements and extract and interpret lines and slopes of distance–time graphs, translating information between graphical and numerical form. *(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.*	HT Estimating magnitudes, uniform acceleration, terminal velocity
		...... that the average acceleration of an object can be calculated using the equation: acceleration = change in velocity/ time taken $a = \Delta v / t$ *.... how to* calculate the acceleration of an object from the gradient of a velocity–time graph. (HT only) The distance travelled by an object (or displacement of an object) can be calculated from the area under a velocity–time graph. **(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.**	HT
		.... that 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.	HT

The five senses are infallible.	Optical illusions are good on this one!
There is only one way to measure perimeter.	.... and that is 'all of the way' round - mathematical calculation is suspect!
Only the area of rectangular shapes can be measured in square units.	The idea of measuring a circle in square units give some children problems
Surface area can be found only for two-dimensional objects.	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.
You cannot measure the volume of some objects because they do not have "regular" lengths, widths, or heights.	They need to think of volume as an occupied 'space' rather than a mathematical construct - displacement can experiments are fun!
The density of two samples of the same substance with different volumes or shapes cannot be the same.	Density is a concept difficulty for many... practical hands on experience is vital.

		(HT only) The tendency of objects to continue in their state of rest or of uniform motion is called inertia. …. 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 $F = m a$ *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.*		
		… that they can evaluate the effect of various factors on thinking distance based on given data. *….how to* calculate stopping distance (HT only) estimate the forces involved in the deceleration of road vehicles in typical situations on a public road **(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.** **(Physics only) Students will be required to interpret graphs relating speed to stopping distance for a range of vehicles.**	Resultant forces, stationary, resistive forces, uniform velocity, inertia. Thinking distance, breaking distance, stopping distance. Reaction times, Energy transfers	
		Momentum (HT only) *… 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. *…..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 *(Physics only)* complete calculations involving an event, such	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: *You need to know….*** *…that (Declarative)* *…. how to (Procedural)* LADDERING	**Key Tier 3 vocabulary**	**Core skills and enrichment opportunities.**
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.	LINKING KS2 Magnets, KS3 Magnets, magnetic materials, compasses LOOKING **KS4** Magnets, Induced magnets, induced current, motor and generator effect. **Post 16** Magnetic Fields, Magnetic Field Strength, The Force on a Moving Charge	*…that* 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 *how to* describe the attraction and repulsion between unlike and like poles for permanent magnets and the difference between permanent and induced magnets.	Poles, fields, North, South, repel, attract, non-contact force, induced magnet, Iron, Nickel, Cobalt.	**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. **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 **Literacy and Reading** BBC Bitesize – Magnetism, extended reading articles Parallel histories. **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. **Cross curricular knowledge links** Geography – Earths magnetic field, **Misconceptions** Misconception Discussion of the problem Possible Activities
		…that when a current flows through a conducting wire a magnetic field is produced around the wire. *…. how to* 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.	Current, solenoid, iron core.	
		…that 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. *…. how to* 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	Fleming's left-hand rule, magnetic flux density, force.	
		…that a coil of wire carrying a current in a magnetic field tends to rotate. *…..how to explain how a moving-coil loudspeaker and headphones work.* (Physics only)	Physics only Rotation, conductor, coil, loudspeakers, headphones, pressure. Rotation, conductor, coil, loudspeakers, headphones, pressure.	

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<td>...that 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.
how to 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.
(Physics only)</td>
<td>Physics only
Potential difference, current, conductor, generator, induced.
Potential difference, current, conductor, generator, induced.</td>
<td rowspan="3">
<table>
<tr><td>All metals are attracted to a magnet.</td><td>Only iron, nickel and cobalt and their alloys are attracted to a magnet</td><td>Circus of material to test</td></tr>
<tr><td>All silver coloured items are attracted to a magnet.</td><td>as above</td><td>as above</td></tr>
<tr><td>All magnets are made of iron.</td><td>iron is a soft magnetic material - wouldn't work!</td><td>Make magnets - iron and steel - by stroking</td></tr>
<tr><td>Larger magnets are stronger than smaller magnets.</td><td></td><td>part of a circus - weak big one and strong small one!</td></tr>
<tr><td>The magnetic and geographic poles of the earth are located at the same place.</td><td></td><td>Web search on navigation of seas and how magnetic pole 'moves'</td></tr>
<tr><td>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.</td><td></td><td>Make a model of the earth and put a magnet within it so that search compasses point north</td></tr>
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<td>...that the generator effect is used in an alternator to generate ac and in a dynamo to generate dc.
how to explain how the generator effect is used in an alternator to generate ac and in a dynamo to generate dc</td>
<td>Potential difference, current, conductor, generator, induced, transformers, coil, efficient, eddy currents.</td>
</tr>
<tr>
<td>...that 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 Vp and Vs depends on the ratio of the number of turns on each coil, np and ns.
......how to use the equations vp/ vs = np/ ns potential difference, Vp and Vs in volts, V. In a step-up transformer
Vs > Vp In a step-down transformer Vs < Vp
Vs × Is = V p × I p</td>
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Topic	**Rationale (layering, Why this why now?)**	**Knowledge goals:** ***You need to know….*** *…that (Declarative)* *…. how to (Procedural)* Laddering	**Key Tier 3 vocabulary**	**Core skills and enrichment opportunities.**
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?	Linking KS2 Space, our universe, day and night KS3 Space, our universe, day and night Looking **KS4** **Post 16**	*…that* 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. *how to explain* 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	Planets, dwarf planets, stars, asteroids, comets, moons, meteoroids, meteors, galaxy, Milky Way, The Universe. Satellites, artificial satellites, natural satellites, orbits, velocity.	**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. **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 **Literacy and Reading** BBC Bitesize –Space Physics, extended reading articles Parallel histories. **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, **Cross curricular knowledge links**
		…. that a star goes through a life cycle and the life cycle is determined by the size of the star. How to explain how fusion processes lead to the formation of new elements.	Hydrogen, Helium, attraction, repulsion, energy, pressure, heat.	
		….. that gravity provides the force that allows planets and satellites (both natural and artificial) to maintain their circular orbits. How to … describe the similarities and distinctions between the planets, their moons, and artificial satellites	Nebula, protostar, main sequence star, red giant, white dwarf, black dwarf, neutron star, supernovae, black hole, elements, Iron.	
		… that there is an observed increase in the wavelength of light from most distant galaxies. This effect is called red-shift. how to… explain qualitatively the red-shift of light from galaxies that are receding and how red-shift provides evidence for the Big Bang model.	Wavelength, expansion, Doppler effect, Big Bang, dark mass, dark energy, supernovae.	

				Geography – Earths 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.

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<th>Topic
Waves</th>
<th>Rationale (layering, Why this why now?)</th>
<th>Knowledge goals: <i>You need to know….</i>
<i>…that (Declarative)</i> <i>…. how to (Procedural)</i>
Laddering</th>
<th>Key Tier 3 vocabulary</th>
<th>Core skills and enrichment opportunities.</th>
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<td rowspan="4">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.</td>
<td rowspan="4">Linking
<u>KS2</u>
Basic concepts of waves and movement

<u>KS3</u>
Energy and waves, light waves, sound waves.

Looking

<u>KS4</u>
Waves in air, fluids and solids, properties, uses and dangers of waves.

<u>Post 16</u>
Diffraction gratings, coherence, path difference, phase difference. industrial application of diffraction gratings, including emission Spectra and identification of</td>
<td><i>…that</i> waves may be either transverse or longitudinal.

<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.</td>
<td>Parallel, Perpendicular, Wavelength, Amplitude, Peaks, Troughs, Compressions, Rarefaction, Normal</td>
<td rowspan="4"><u>Subject specific skills</u>
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.

<u>Numeracy</u>
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.

<u>Literacy and Reading</u>

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.

<u>Cultural Capital/Careers</u>

Careers include sonographer, seismologist or a seismographer, opticians or ophthalmologists

<u>Cross curricular knowledge links</u>

Geography, earthquakes and convection currents, coastal erosion

<u>Common Misconceptions</u>
<table>
<tr><td>Misconception</td><td>Possible Activities</td></tr>
<tr><td>Loudness and pitch of sounds are confused with each other.</td><td>Reinforcement of correct scientific vocabulary</td></tr>
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<tr>
<td><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.

<i>…. how to</i> use the equations to work out period

(Physics only) show how, changes in velocity, frequency and wavelength, in transmission of sound waves from one medium to another, are inter-related.</td>
<td>Reflect, refract, Incident Medium, Sound,</td>
</tr>
<tr>
<td><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.

<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.

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.</td>
<td>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</td>
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<td><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></td>
<td>Physics only</td>
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	gases. Concept and applications of stationary wave resonance.	*how to* 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. RP9: Investigate the reflection of light by different types of surface and the refraction of light by different substances	
		...*that* sound waves can travel through solids causing vibrations in the solid. *how to* 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.	Physics only
		...*that* waves are used for detection and exploration. *how to* 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.	Ultrasound waves, Seismic waves, P-waves and S-waves. Echo sounding.
		...*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. ...*how to* give examples that illustrate the transfer of energy by electromagnetic waves. RP10: Investigate how the amount of infrared radiation absorbed or radiated by a surface depends on the nature of that surface.	radio, microwave, infrared, visible light (red to violet), ultraviolet, Xrays and gamma rays
		...*that Electromagnetic waves all have many uses and applications due to their individual properties*	• radio waves – television and radio

Hitting an object harder changes its pitch.	Practical - getting them to sing the note when hit with different force
In a telephone, actual sounds are carried through the wire rather than electrical pulses	
Human voice sounds are produced by a large number of vocal chords.	
Sound moves faster in air than in solids (air is "thinner" and forms less of a barrier).	
Sound moves between particles of matter (in empty space) and then 'bumps into' the next matter particle.	
In wind instruments, the instrument itself vibrates not the internal air column	
The pitch of whistles or sirens on moving vehicles is changed by the driver as the vehicle passes.	
The pitch of a tuning fork will change as it "slows down", (i.e. "runs" out of energy)	Practical - getting them to sing the note until it dies
As sound waves move, the air moves along with them.	

The pupil of the eye is a black object or a spot on the surface of the eye.	Idea it is the gap in the centre of the iris.	Observation of how the pupil changes size in different light intensities (Care they don't blind each other!) Discuss eye exams in an optician -

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<td>...how to give brief explanations why each type of electromagnetic wave is suitable for the practical application.</td>
<td>• 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.</td>
<td rowspan="4">
<table>
<tr><td></td><td></td><td>how s/he looks through the pupil</td></tr>
<tr><td>The eye receives upright images on the retina.</td><td>Ray diagrams can be used to show how the image is inverted</td><td>Use vid-clips to show full visual sytem</td></tr>
<tr><td>The lens is the only part of the eye responsible for focusing light.</td><td>Cornea is primary refractor</td><td>Discuss sight correction using lasers - resculpting of the cornea - use a glass ball to refract light.</td></tr>
<tr><td>The lens forms an image (picture) on the retina. The brain then "looks" at this image and that is how we see.</td><td>Correct terminology for image interpretation needs to be reinforced</td><td>Use vid-clips to show full visual sytem - discuss how blindness can happen to people with perfect eyes</td></tr>
<tr><td>The eye is the only organ involved in sight; the brain is only for thinking.</td><td>Correct terminology for image interpretation needs to be reinforced</td><td>Use vid-clips to show full visual sytem - discuss how blindness can happen to people with perfect eyes</td></tr>
<tr><td>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.</td><td>Spectra of sources differ according to the electron transitions involved</td><td>Use a series of light sources and compare the spectra or what stips of multicoloured cloth look like under them - discuss how clothing looks different under different light sources.
Could look at spectra from stars...</td></tr>
<tr><td>When white light passes through a coloured filter colour is added to the light.</td><td>Filters subtract</td><td>Use multiple filters</td></tr>
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<tr>
<td>...that a lens forms an image by refracting light.
...how to construct ray diagrams to illustrate the similarities and differences between convex and concave lenses.</td>
<td>Physics only</td>
</tr>
<tr>
<td>...that each colour within the visible light spectrum has its own narrow band of wavelength and frequency.
...how to explain:
• 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</td>
<td>Physics only</td>
</tr>
<tr>
<td>...that 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.
...how to explain:
• that all bodies (objects) emit radiation
• that the intensity and wavelength distribution of any emission depends on the temperature of the body</td>
<td>Physics only</td>
</tr>
</table>

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.		
The shades of grey in a black and white newspaper picture are produced by using inks with different shades of gray.		Use a magnifying glass to look at the dots
The different colors appearing in coloured pictures printed in magazines and newspapers are produced by using different inks with all the corresponding colors.		Use a magnifying glass to look at the dots
Colour is a property of an object, and is independent of both the illuminating light and the receiver (eye).		Look at coloured objects under different coloured light sources.
White light is colourless and clear, enabling you to see the "true" color of an object.		

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<tr><td></td><td></td><td></td><td></td><td><table><tr><td>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.</td><td></td><td>Talk about colour blindness - use colour blindness tests.</td></tr></table></td></tr>
</table>

	Topic title	SUMMARY OF KNOWLEDGE ACQUISTION	APPROXIMATE DURATION (Lessons)	Term 1a								Term1b								Term 2a						Term 2b							Term 3a					Term 3b						
				1	2	3	4	5	6	7	8	1	2	3	4	5	6	7		1	2	3	4	5	6	1	2	3	4	5	6		1	2	3	4	5	1	2	3	4	5	6	7
Year 9																																												
1	Atomic Structure	Atoms, elements, compounds, mixtures, separating mixtures, purifying sea water the atomic model, P,E,N and calculating each	8					🟪	🟪																																			
2	The Periodic Table	History of the Periodic Table, the modern Periodi c Table, trends and patterns in Group 1	8							🟨	🟨																																	
3	Chemical changes - Metals	Metal oxides, the reactivity series, extraction of metals and reduction using carbon, displacement reactions and practical, acids and alkalis and neutralisation	10									🟥	🟥	🟥																														
4	Organic Chemistry	Crude oil, fractional distillation, properties of hydrocarbons, cracking, alkenes	7																							🟧	🟧																	
5	Chemistry of the Atmosphere	Composition of the atmosphere, evolution of the atmosphere, combustion, pollutants	9																									🟨	🟨															
6	Chemical Analysis	Testing for common gases, mixtures, formulations and chromatography	9																											🟩	🟩													
Year 10																																												
1	Structure and Bonding	Structure of the atom recap, forming ions, giant ionic compounds, covalent bonding, simple and giant covalent, metallic bonding alloys and properties of all structures	16	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦																																	
2	Quantitative Chemistry	Atomic mass, relative formula mass, moles, balancing equations, reacting masses, limiting reagents, concentration calculations, atom economy, percentage yield	9									🟪	🟪	🟪	🟪	🟪																												
3	Chemical Changes	Neutralisation and electrolysis	7														🟥	🟥		🟥																								
4	Energy Changes	Exothermic and endothermic reactions, reaction profiles and examples, temperature changes requried practical, bond energy calculations	5																		🟦	🟦	🟦																					
5	Revision for mocks, year 9 recap, mock week	Revision of year 9 content and preparation for mock exams	5																					🟦	🟦																			
6	Rates of Reaction	The rate of reaction, collision theory, factors affecting rate of reaction, tangents to graphs, equilibria, Le Chatelier, reversible reactions	6																							🟩	🟩	🟩																
7	Chemical Analysis	Pure substances and formulations, chromatography	4																										🟩	🟩	🟩													
8	Organic Chemistry	Alkenes, reactions an polymers, carboxylic acids and alcohols, esters, biochemistry	8																														🟫	🟫	🟫	🟫								
9	Using Resources	The Earths resources, sustainable development, pure and potable water, reduce, reuse and recycle, LCAs	5																																		🟥	🟥	🟥	🟥				
	Revision for mocks, year 9 recap, mock week	Revision of year 9 content and preparation for mock exams	7																																						🟦	🟦	🟦	🟦
Year 11																																												
1	Atomic Structure	Atoms, elements, compounds, mixtures, separating mixtures, purifying sea water the atomic model, P,E,N and calculating each	2	🟪	🟪																																							
2	The Periodic Table	History of the Periodic Table, the modern Periodi c Table, trends and patterns in Group 1	3			🟨	🟨																																					
3	Structure and Bonding	Structure of the atom recap, forming ions, giant ionic compounds, covalent bonding, simple and giant covalent, metallic bonding alloys and properties of all structures	5					🟦	🟦	🟦																																		
4	Quantitative Chemistry	Atomic mass, relative formula mass, moles, balancing equations, reacting masses, limiting reagents, concentration calculations, atom economy, percentage yield	6								🟪	🟪	🟪																															
5	Chemical Changes	Neutralisation, electrolysis	5											🟥	🟥																													
6	Energy Changes	Exothermic and endothermic reactions, reaction profiles and examples, temperature changes requried practical, bond energy calculations	5													🟦	🟦	🟦																										
7	Rates of Reaction	The rate of reaction, collision theory, factors affecting rate of reaction, tangents to graphs, equilibria, Le Chatelier, reversible reactions	4																	🟩	🟩																							
8	Organic Chemistry	Crude oil, fractional distillation, properties of hydrocarbons, cracking, alkenes	4																			🟧	🟧	🟫	🟫																			
9	Chemistry of the Atmosphere	Composition of the atmosphere, evolution of the atmosphere, combustion, pollutants	4																							🟨	🟨																	
10	Chemical Analysis	Pure substances and formulations, testing for common gases , chromatography	4																									🟩	🟩															
11	Using Resources	The Earths resources, sustainable development, pure and potable water, purifying water and distillation, reduce, reuse and recycle, LCAs	8																											🟥	🟥													
12	Revision	Past paper preparation, mock exams and intervention																															🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦

Year 11 4.6 - Rate and extent of chemical change (GCSE Chemistry)

Topic	Rationale (layering, Why this why now?)	Knowledge goals: *You need to know….* *…that (Declarative)* *…. how to (Procedural)* LADDERING	Key Tier 3 vocabulary	Core skills and enrichment opportunities.
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 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.	LINKING Year 8 Rates of reaction **Year 10** Rate and extent of chemical change knowledge LOOKING **Post 16** kinetics	Apply how to determine the rate of a chemical reaction to extended questions.	Product, reactant, rate, mean, tangent, gradient, slope	***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. ***Literacy and reading*** Analysis and evaluation of data based questions using extended text for use of changing conditions on the Harber process.
		Apply how to use collision theory and factors affecting the rate of reaction to extended questions.	Collision, particle, energy, activation, rate, concentration, pressure, sufficient, catalyst, temperature, surface area, state	
		Apply how to measure the rate of reaction during a practical for a solid or gaseous products to extended questions. **Required Practical –RATES**	Dependent, independent, control, variable, rate, concentration, hydrochloric, thiosulphate. Erlenmeyer , obscure, hypothesis, conclusion	
		Apply how to represent reversible reactions to extended questions. Apply that energy is transferred in reversible reactions to extended questions.	Reactant, product, forward, backward, reversible, equilibrium, rate, anhydrous, hydrated	
		Apply that the equilibrium position can be altered by changing conditions to extended questions.	Equilibrium, dynamic, pressure, temperature, catalyst, shift, forward, backward	
		Apply that in the Haber Process the equilibrium position can be altered by changing conditions to extended questions.	Le Chatelier (HT), equilibrium, position, shift, rate, pressure, catalyst, temperature, compromise, condition, qualitative(HT)	

				Cultural Capital/Careers How the Haber Process has had an impact on the global economy. ***Cross curricular knowledge links*** Opportunities for learners to demonstrate their research skills

Y11 4.7 Organic Chemistry

Topic	**Rationale (layering, Why this why now?)**	**Knowledge goals: *You need to know….*** *…that (Declarative) …. how to (Procedural)* Laddering	**Key Tier 3 vocabulary**	**Core skills and enrichment opportunities.**
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. This branch of chemistry gets its name from the fact that the main sources of organic compounds are living, or once-living materials from plants and animals. These sources include fossil fuels which are a major source of feedstock for the petrochemical industry. Chemists are able to take organic molecules and modify them in many ways to make new and useful materials such as polymers, pharmaceuticals,	Linking Year 7 Fossil fuels Year 9 Organic chemistry **Year 10** Organic chemistry and use of organic reactions. Looking **Post 16** Organic chemistry	Apply that alkenes undergo polymerisation and properties of polymers to extended questions.	Homologous series, alkene, unsaturated, polymerisation, thermosetting, thermo-softening, monomer, polymer, repeat unit, polymer structure	***Numeracy*** Analysis and evaluation of data based questions using graphs and/or tables for organic chemistry. ***Literacy and reading*** Analysis and evaluation of data based questions using extended text for different organic reactions. Comparison and evaluation of the environmental impacts of production of ethanol from steam hydration of ethane and fermentation of glucose with yeast. ***Cultural Capital/Careers*** How synthetic polymers have had an impact on everyday life. History of the discovery of DNA as a polymer chain.
		Apply that alkenes react in different ways to extended questions.	Functional group, combustion, complete, incomplete, addition reactions	
		Apply how to draw alcohols, acids and esters functional groups and explain their properties to extended questions.	Functional group, carboxylic acid, ester, ethyl ethanoate, strong and weak acids	
		Apply that alcohols, acids and esters react in different ways to extended questions.	Combustion, oxidising agent, fermentation, glucose, yeast	
		Apply how to draw condensation polymers to extended questions.	Condensation polymerisation, monomers, repeat units	
		Apply how Amino acids and sugars react together to extended questions.	Amino acids, polypeptides, proteins, cellulose, starch	

perfumes and flavourings, dyes and detergents.		Apply how natural Polymers form and the structure of DNA to extended questions.	Deoxyribonucleic acid, polymer chains, nucleotides, double helix	***Cross curricular knowledge links*** Opportunities for learners to demonstrate their research skills

Y11 4.8 Chemical analysis

Topic	**Rationale (layering, Why this why now?)**	**Knowledge goals:** ***You need to know….*** *…that (Declarative)* *…. how to (Procedural)* Laddering	**Key Tier 3 vocabulary**	**Core skills and enrichment opportunities.**
4.8 Chemical analysis Analysts have developed a range of qualitative tests to detect specific chemicals in order to determine the purity of substances and the presence of gases. Purity of samples can be checked using chromatography Chemical 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, and are particularly useful when the amount of chemical being analysed is small. Forensic scientists and drug control	Linking Year 7 Separating g mixtures Year 9 Analysis **Year 10** Analysis and use of chemical tests in sample analysis Looking **Post 16** Group 2 and group 7	Apply that you can distinguish between pure and impure substances to extended questions.	Pure, substance, melting point, boiling point, distinguish, impure	***Numeracy*** Analysis and evaluation of data based questions using graphs and/or tables for analysis. calculation of Rf values ***Literacy and reading*** Analysis and evaluation of data based questions using extended text for chromatography. ***Cultural Capital/Careers*** Research the composition of the following formulations: • Fuel • Cleaning agents • Paints • Medicines Research the use of different spectroscopic techniques ***Cross curricular knowledge links*** Opportunities for learners to demonstrate their research skills
		Apply that we have formulations, what are they and why are they useful to extended questions.	Mixture, product, purpose, fertilisers,	
		Apply that you can separate mixtures using simple paper chromatography to extended questions. **REQUIRED PRACTICAL - CHROMATOGRAPHY**	Separation, identification, stationary, mobile, phase, retention factor, soluble, solvent, solute, solution dissolve, chromatograms	
		Apply how to identify common atmospheric gases to extended questions.	Hydrogen, oxygen, carbon dioxide, chlorine, splint, burning, glowing, lime water, calcium hydroxide, cloudy, precipitate, litmus paper, bleach	

scientists rely on such instrumental methods in their work.				
		Apply how to use flame tests to identify positive ions to extended questions. **REQUIRED PRACTICAL – IDENTIFYING IONS**	Flame tests, metals, species, ions	
		Apply how to use sodium hydroxide to identify positive ions to extended questions. **REQUIRED PRACTICAL – IDENTIFYING IONS**	Solutions, coloured, white precipitates	
		Apply how to identify negative ions to extended questions. **REQUIRED PRACTICAL – IDENTIFYING IONS**	Carbonates, halides, sulfates	
		Apply that there are some advantages to using instrumental methods over chemical methods to extended questions.	Identification, instrumental, accurate, sensitive, rapid	
		Apply that flame emission spectroscopy can be used to identify ions to extended questions.	Flame emission spectroscopy, spectroscope, spectrum, concentrations, metal ions	

Y11 4.10 Earths resources and using resources

Topic	Rationale (layering, Why this why now?)	Knowledge goals: *You need to know….* *…that (Declarative)* *…. how to (Procedural)* LADDERING	Key Tier 3 vocabulary	Core skills and enrichment opportunities.
4.10 Earths resources and using resources Industries use the Earth's natural resources to manufacture useful products. In order 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 natural cycles and how damaging effects can be minimalised.	Year 7 Fossil fuels Year 9 Organic chemistry **Year 10** Earth's resources and using resources LOOKING **Post 16** polymers	Apply how the Earth's resources used and sustained to extended questions.	Resources, warmth, shelter, food, transport, natural, agriculture, fuels, finite, renewable.	***Numeracy*** Analysis and evaluation of data based questions using graphs and/or tables for using resources. ***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 ***Cultural Capital/Careers*** How composites have had an impact on everyday life. ***Cross curricular knowledge links*** Opportunities for learners to demonstrate their research skills
		Apply how to produce potable water to extended questions.	Potable, pure, sterilising, desalination, reverse osmosis, filter.	
		Apply how to treat waste water treatment to extended questions.	Sewage, grit, sedimentation, anaerobic digestion, aerobic, effluent, sludge, agricultural.	
		Apply how to use alternative methods of metal extraction to extended questions.	Metal ores, phytomining, bioleaching, bacteria, leachate, electrolysis, metal extraction.	
		Apply how to analyse a life cycle assessment to extended questions.	Life cycle assessment, manufacturing, packaging, lifetime, quantified, processing.	
		Using resources Apply how to reduce the use of resources to extended questions.	Metals, glass, building materials, ceramics, quarrying, mining, recycled, melting, recasting, scrap, ore, extraction.	
		Apply how Corrosion occurs and its prevention to extended questions.	Corrosion, environment, rusting, air, water, coating, barrier, electroplating, greasing, painting, reactive, galvanise.	
		Apply that alloys are useful materials to extended questions.	Alloys, jewellery, proportion, carats, shaped, malleable, ductile, corrosion, resistant, density.	

		Apply how to make and use ceramics, polymers and composites to extended questions.	Limestone, borosilicate, temperature, clay, pottery, conditions, density, thermosoftening, polymers, thermosetting, composites.	
		How to change conditions in the Haber process to extended questions.	Manufacture, fertiliser, haber process, catalyst, pressure, reversible reaction, equilibrium	
		How to produce and uses of NPK fertilisers to extended questions.	Industrial, production, processes, fertilisers, formulations, preparation, laboratory	

Year 11 4.2 - Bonding, Structures and Properties (GCSE Chemistry)

Topic	Rationale (layering, Why this why now?)	Knowledge goals: *You need to know….* *…that (Declarative)* *…. how to (Procedural)* LADDERING	Key Tier 3 vocabulary	Core skills and enrichment opportunities.
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.	LINKING Year 7 Properties of metals and non-metals Year 8 Periodic table Year 9 Atomic structure **Year 10** Bonding, structures and properties knowledge LOOKING **Post 16** AS Bonding unit	Apply that the atom has a set structure to extended questions.	Proton, Neutron, Electron, Negligible	***Numeracy*** Analysis and evaluation of data based questions using graphs and/or tables for bonding properties. ***Literacy and reading*** Analysis and evaluation of data based questions using extended text for use of polymers and nanoparticles. ***Cultural Capital/Careers*** The development of new and diverse nanoparticles for use in everyday life. ***Cross curricular knowledge links*** Opportunities for learners to demonstrate their research skills
		Apply that ions and ionic bonds are formed to extended questions.	Ion, positive, negative, cation, anion, transfer, noble gas, configuration, ionic	
		Apply that Ionic compounds so giant ionic lattices have set properties to extended questions.	Giant, lattice, 3D, ions, conductivity, brittle, soluble, electrostatic	
		Apply how to draw covalent bonding dot and cross diagrams to extended questions.	Venn diagram, covalent, share	
		Apply that simple covalent molecules can form polymers to extended questions.	Polymer, manufactured, covalent, molecule, monomer, polymerisation, thermosetting, thermosoftening, intermolecular	
		Apply that Giant covalent structures have set properties including diamond and graphite to extended questions.	Brilliant, strong, hard, lubricant,	
		Apply that Nanoparticles have set properties to include graphene, fullerenes and nanotubes to extended questions.	Pure, element, lubricant, delocalised, covalent	

		Apply how to draw Metallic bonding to extended questions. Apply that metals have set properties to extended questions.	Delocalised, electrostatic, electron, conduction	
		Apply that Alloys form including steels to extended questions.	Mixtures, properties, malleable, proportion, stainless	
		Apply that transition elements have a range of properties to extended questions.	Sonorous, malleable, ductile, reflective, conductor, catalyst, compound	

Y11 Quantitative Chemistry

Topic	**Rationale (layering, Why this why now?)**	**Knowledge goals:** ***You need to know….*** *…that (Declarative)* *…. how to (Procedural)* Laddering	**Key Tier 3 vocabulary**	**Core skills and enrichment opportunities.**
4.3.1 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	Linking Year 8 Periodic table Year 9 Atomic structure **Year 10** Quantitative chemistry Looking **Post 16** Quantitative chemistry	Apply how to calculate relative atomic and relative formula mass to extended questions.	Mass number, formula mass, formula, equation, reactants, products	***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. ***Literacy and reading*** Analysis and evaluation of data based questions using extended text for titrations, reacting masses and limiting reagents. ***Cultural Capital/Careers*** How titrations and limiting reagents are used in industry. ***Cross curricular knowledge links*** Opportunities for learners to demonstrate their research skills
		Apply that we need to know percentage yield and atom economy to extended questions.	Completion, reversible, yield, reactant, product, theoretical, atom economy	
		Apply how to calculate moles and what they are to extended questions.	Moles, mol, substance, Avogadro	
		Apply how to apply moles to work out reacting masses to extended questions.	Balanced, equation, moles, masses, grams	
		Apply how to apply moles to balance equations to extended questions.	Balancing, equation, converting, reactants, products	
		Apply how to apply moles to work out limiting factors to extended questions to extended questions.	Limiting reagents, reactants, quantity	

a key way for chemists to communicate chemical ideas.				
		Apply how to use moles to work out the number of moles of gas to extended questions.	Volume, temperature, pressure, volumes, gaseous	
		Apply how to calculate the concentration of solutions to extended questions.	Solutions, concentration, volume, solute	
		Apply how to determine the concentration of acids and bases using titrations to extended questions.	Mass, solute, solution, titration, burette, pipette, indicator, end point	

Year 11 4.4 Chemical Changes

Topic	**Rationale (layering, Why this why now?)**	**Knowledge goals: *You need to know….*** *…that (Declarative)* *…. how to (Procedural)* Laddering	**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	Linking Year 7 Properties of acids and alkalis Year 8 Metal extraction Year 9 Metal and acid chemical changes **Year 10** Chemical changes Acids and electrolysis Looking **Post 16** Redox, acid and bases	Apply how to read the pH scale to extended questions.	pH, hydrogen ions, concentration, neutralisation reaction,	***Numeracy*** Analysis and evaluation of data based questions using graphs and/or tables for metal extraction, electrolysis and titrations. Practice order of magnitude calculations ***Literacy and reading*** Analysis and evaluation of data based questions using extended text for use of electrolysis and titrations ***Cultural Capital/Careers*** Research the extraction of aluminium and explain why the process is energy intensive ***Cross curricular knowledge links*** Opportunities for learners to demonstrate their research skills
		Apply how to accurately calculate the amount of acid needed to neutralise and alkali to extended questions. **REQUIRED PRACTICAL TITRATION**	Burette, pipette, indicator, endpoint, titrations, concentration	
		Apply that there is a difference between a strong and weak acid to extended questions.	ionisation, strong and weak acids, neutrality, relative acidity, dilute and concentrated	
		Apply how to represent the process of electrolysis at each electrode to extended questions.	Ionic compound, electrolysis, electrolytes, ions, discharge, electrodes, half equations, molten, aqueous.	

		Apply how to extract aluminium using electrolysis to extended questions. Apply that aqueous solutions produce different products during electrolysis to extended questions. Apply how to carry out electrolysis to extended questions. **REQUIRED PRATICAL ELECTROLYSIS**	Electrode, half equations, oxidation, reduction	

YEAR 11 - 4.5 ENENRGY CHANGES

Topic	**Rationale** **(layering, Why this why now?)**	**Knowledge goals:** ***You need to know….*** *…that (Declarative)* *…. how to (Procedural)* Laddering	**Key Tier 3 vocabulary**	**Core skills and enrichment opportunities.**
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. 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.	Linking Year 8 Endothermic and exothermic reactions **Year 10** Energy changes, cells and batteries. Looking **Post 16** Energetics	Apply that energy is transferred during exothermic and endothermic reactions to extended questions.	• Exothermic • Endothermic.	***Numeracy*** Analysis and evaluation of data based questions using graphs and/or tables for energy transfer Carry out bond energy calculations ***Literacy and reading*** Analysis and evaluation of data based questions using extended text for use of cells, batteries and fuel cells. ***Cultural Capital/Careers*** The development of cells, batteries and fuel cells.
		Apply that energy transfer reactions have everyday uses to extended questions.	activation energy energy level	
		Apply how to draw reaction profiles for exothermic and endothermic reactions to extended questions. **RP CALORMETRY**	reaction profiles	
		Apply how to carry out bond energy calculations to extended questions.	Energy change	
		Apply how to interpret data, evaluate the use and plan an investigation for chemical cells and batteries to extended questions.	Energy transferred Chemical reaction. Cells and batteries Voltage. Electrode and electrolyte. Alkaline batteries	for use in everyday life. ***Cross curricular knowledge links***

Cells, batteries and fuel cells. Some interactions between ions in an electrolyte result in the production of electricity. Cells and batteries use these chemical reactions to provide electricity. Electricity can also be used to decompose ionic substances and is a useful means of producing elements that are too expensive to extract any other way.		Apply how to evaluate the use of hydrogen fuel cells to extended questions. Apply how to write half equations in hydrogen fuel cells to extended questions.	Fuel cells Oxidation oxidised electrochemically half equations Electrode	Opportunities for learners to demonstrate their research skills

	Year 9, 10, 11 Physics topics	SUMMARY OF KNOWLEDGE ACQUISTION	APPROXIMATE DURATION	Term 1a								Term1b								Term 2a						Term 2b							Term 3a					Term 3b						
				1	2	3	4	5	6	7	8	1	2	3	4	5	6	7		1	2	3	4	5	6	1	2	3	4	5	6		1	2	3	4	5	1	2	3	4	5	6	7
Year 9																																												
1	Particle Model	The particulate nature of matter, changes of state, density, pressure, specific	16	🟪	🟪	🟪	🟪																																					
2	Atoms and	Atoms, elements, the atomic model, P,E,N and calculating each, nuclear fission	14																	🟪	🟪	🟪	🟪																					
3	Energy	Energy stores, energy changes, work, power, efficiency, renewable and non-renewable energy	18																																				🟨	🟨	🟨	🟨	🟨	
Year 10																																												
1	Electricity	Circuit symbols and diagrams, series and paralell circuits, resistance, Ohm's law, National Grid, domestic electrical supply and use	20	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦																															
2	Magnetism	Types of magnet, magnetic material, electromagnets, motor effect, Fleming's left hand rule, real world applications of magnets and electromagnets	14											🟪	🟪	🟪	🟪	🟪		🟪	🟪																							
3	Waves	Longitudinal and transverse waves, wave properties, electromagnetic	10																			🟥	🟥	🟥	🟥	🟥																		
4	Forces	Contact and non-contact forces, resultant forces, free body diagrams, gravity, Newton's laws	24																								🟦	🟦	🟦	🟦	🟦		🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦				
5	Revision for mocks, year 9 recap, mock week	Revision of year 9 content and preparation for mock exams	8																																					🟩	🟩	🟩	🟩
Year 11																																												
1	Atomic Structure	Atoms, elements, the atomic model, P,E,N and calculating each, tpes of radiation, nuclear fission and fusion	4 and 4	🟪	🟪					🟪	🟪																																	
2	Energy	Energy stores, energy changes, work, power, latent heat, efficiency, renewable and non-renewable energy	8			🟨	🟨	🟨	🟨																																			
3	Electricity	Circuit symbols and diagrams, series and paralell circuits, resistance, Ohm's law, National Grid, domestic electrical supply and use	14									🟦	🟦	🟦	🟦	🟦	🟦	🟦																										
4	Magnetism	Types of magnet, magnetic material, electromagnets, motor effect, Fleming's left hand rule, real world applications of magnets and electromagnets	8																	🟪	🟪	🟪	🟪																					
5	Waves	Longitudinal and transverse waves, wave properties, electromagnetic	6																					🟥	🟥	🟥																		
6	Forces	Contact and non-contact forces, resultant forces, free body diagrams, gravity, Newton's laws, momentum, stopping distances	10																								🟦	🟦	🟦	🟦	🟦													
7	Revision and Required Practical	Past paper preparation, required practical review and intervention	10																														🟩	🟩	🟩	🟩	🟩							

Topic 1 Particle model	**Rationale (layering, Why this why now?)**	**Knowledge goals: *You need to know….*** …that (Declarative) …. how to (Procedural) Laddering	**Key Tier 3 vocabulary**	**Core skills and enrichment opportunities.**
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!	Linking <u>KS2</u> States of matter Simple physical properties of materials. <u>Year 7</u> Particle model Separating Mixtures <u>Year 8</u> Elements Periodic Table Year 9 KS4 Looking **Year 9** **Year 10** Atomic structure –chem Particle model - phy **Year 11** Rates - chem **Post 16** Kinetic theory Gas Laws Atomic structure	…that properties of solids, liquids and gases in terms of the particles in each state of matter. Particles are moving and have kinetic energy. …. how to link arrangement of the particles in each state of matter to their properties and be able to compare them.	Particle solids liquids gases forces of attraction density *Property*	<u>**Subject specific skills**</u> 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. <u>***Numeracy***</u> 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. <u>**Literacy and Reading**</u> Improvement of vocabulary bank – tier 2 - BBC Bitesize – Particle Model, extended reading articles. Reading for understanding, exemplar question contexts.
		…that density is the mass which is contained in a given volume. A denser material will sink in a less dense material. …. how to calculate the density of a given material using: density = mass/volume. How to convert between g and Kg, and ml and l.	Density, mass, volume, formula.	
		…that displacement can be used to find the volume of an irregular object. …. how to practically determine the volume of an irregular shaped object. 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.	density displacement *regular irregular*	
		…that 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. how to determine what happens to temperature during changes of state. ..why some substances have higher/lower melting and boiling points than others.	state temperature heat State, melt, evaporate, condense, freeze, sublimation.	
		…that 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. how to construct and interpret a heating/cooling curve.	internal kinetic potential *Independent, dependent, control, variables*	
		…that Specific Latent Heat is the energy absorbed by a substance during a change of state how to *calculate specific latent heat.*	specific latent heat Latent, heat, internal energy, mass, joules, kilograms, fusion, vaporisation, vapour	

		…that The amount of energy needed to heat a material is known as Specific Heat Capacity. *how to calculate how much energy is needed to heat up different materials. Use and rearrange the equation: Heat = mass x SHC x temp change*	*Capacity* Specific heat capacity	***Cultural Capital/Careers*** Archimedes 'Eureka moment.' Architect, Astronomer, Energy Analyst, Food Technology, Games Designer, Geophysicist, Meteorologist, Nuclear Engineer, Radiographer, School teacher, ***Cross curricular knowledge links*** Selection of materials for cooking pans – food technology. Heat transfer – DT – materials. **Misconceptions** 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.
		…. that the temperature of a gas is related to the average kinetic energy of the molecules how to.. explain qualitatively the relation between the temperature of a gas and its pressure at constant volume.		
		(Physics only) .. that increasing the volume in which a gas is contained, at constant temperature, can lead to a decrease in pressure. 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.		

Topic Electricity	**Rationale (layering, Why this why now?)**	**Knowledge goals: *You need to know….*** *...that (Declarative)* *.... how to (Procedural)* Laddering	**Key Tier 3 vocabulary**	**Core skills and enrichment opportunities.**
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	Linking KS2 States of matter Simple physical properties of materials. Year 7 Particle model Separating Mixtures Year 8 Elements Periodic Table Year 9 KS4 Looking **Year 9** **Year 10** Atomic structure –chem Particle model - phy **Year 11** Rates - chem **Post 16**	*...that* 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. *.... how* to draw circuit symbols	E.g. lamp, battery, diode Current, charge, coulombs, amperes, volts, components	***Numeracy*** 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. **Literacy** 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. ***Reading*** BBC Bitesize, The Illustrated Science Dictionary, World of Science, Horrible Science of Everything, The Science Boo Home Science Experiments
		...that Electric Current is flow of electrical charge and that charge flow, current and time are linked. *.... how to* use the equation : charge flow = current x time	Potential difference, resistance, ohms	
		...that potential Difference is amount of energy transferred to each coulomb of charge *how to place components in the circuit to measure current and potential difference* *RP3: Use circuit diagrams to set up and check appropriate circuits to investigate the factors affecting the resistance of electrical circuits.*	Circuit diagrams, Proportional Voltage Current Resistance Amps Ohms Volts	
		...that in some resistors the value of R remains constant but that in others it can change as the current changes. *.... How to use the equation: potential difference = current x resistance* *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.*	Graphs. Linear, non-linear, correlation,	
		...that there are two ways of joining electrical components, in series and in parallel. *how to* explain qualitatively why adding resistors in series increases the total resistance whilst adding resistors in parallel decreases the total resistance	Series, parallel,	
		...that 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. *how to* explain the difference between direct and alternating potential difference	Alternating current, direct current, Three core cable, insulation, appliance,	

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?		… *that* 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. *How to* describe, with examples, the relationship between the power ratings for domestic electrical appliances and the changes in stored energy when they are in use.	Transfer, work done,	Crisp Packet Fireworks. ***Cultural Capital/Careers*** ***Cross curricular knowledge links*** Electrician working on repairing some forklift trucks, Electricity plays a huge role in the robotics industry, and it is a fundamental concept. Engineer working in the medical prosthetics field. Working on the national power grid, Whether you are repairing or installing electrical cables, it's imperative that you understand the basics of electricity. 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. **Misconceptions** Misconception: current is 'used up' as it flows round the circuit 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. 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) Current flows instantly in all parts of a circuit when there is a complete circuit.
		… *that* the National Grid is a system of cables and transformers linking power stations to consumers. *How to …* explain why the National Grid system is an efficient way to transfer energy.	Cables, transformers (Higher only), consumers, efficiency, step up, step down	
		(Physics only) *.. that* when certain insulating materials are rubbed against each other they become electrically charged. How to ….explain how the transfer of electrons between objects can explain the phenomena of static electricity.	Electrically charge, negative, positive, electrons, repel, attract, non contact force, static,	
		(Physics only) *… that a* charged object creates an electric field around itself *How to …..* 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.	electric field pattern, Field, force, isolated charge, electrostatic phenomena, sparking	

Topic Atomic Structure	**Rationale (layering, Why this why now?)**	**Knowledge goals:** ***You need to know….*** *…that (Declarative)* *…. how to (Procedural)* Laddering	**Key Tier 3 vocabulary**	**Core skills and enrichment opportunities.**
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.	Linking KS2 Filtering, sieving, evaporating, dissolving, solutions. Year 7 Matter, separating mixtures. Year 8 Elements, periodic table. Year 9 KS4 Looking **Year 9** **Year 10** Structure and bonding **Year 11** Atomic structure Structure and bonding **Post 16** Atomic structure **Structure and bonding**	*…that* atoms are very small and consist of electrons, protons and neutrons. (sub-atomic particles) *how to* represent the sub-atomic particles and the structure of an atom, including the mass number, atomic number and isotopes.	Nucleus, protons, neutrons, electrons, electromagnetic radiation, energy levels	**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. **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. **Literacy and Reading** BBC Bitesize – Atomic structure, extended reading articles Parallel histories. **Cultural Capital/Careers** Careers including Nuclear power reactor operator, energy consultant, Laboratory manager, Research Scientist, Nuclear medicine, Radiation Safety officer, Optical engineer, Astronomer. **Cross curricular knowledge links** DT- Materials,
		…. that the model of the atom has changed over time due to new scientific experimental evidence. how to …. use evidence to explain why there have been changes in the atomic model.	*Electrical charge, elements, mass number, atomic number, isotopes, Scientific model,*	
		…. that some atomic nuclei are unstable and decay. how to….. apply knowledge to the uses of radiation and evaluate the best sources of radiation to use in a given situation.	alpha, beta, gamma, nuclear model,	
		….. that nuclear equations are used to represent radioactive decay. How to explain the concept of half-life and how it is related to the random nature of radio active decay. (HT ONLY) be able to calculate the net decline, expressed as a ratio, in a radioactive emission after a given number of half-lives.	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	
		… that radioactive contamination is the unwanted presence of materials containing radioactive atoms on other materials. *How to ..compare hazards associated with contamination and irradiation.*	Contamination, hazard, irradiation, contamination, precautions,	
		(Physics only)	Back ground radiation, cosmic rays, sieverts	

		… 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.*		Chemistry - Periodic table and atoms and bonding, 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]. Students' views about the risk of radiation and radioactivematerials are based more strongly on everyday information than scientific ideas 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.
		(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.	Evaluation of perceived risks in relation to data and handling.	
		(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.	Uranium, plutonium, fission, fusion, kinetic energy, chain reaction, nuclear reactor.	

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<th>Topic
Energy</th>
<th>Rationale (layering, Why this why now?)</th>
<th>Knowledge goals: <i>You need to know….</i>
<i>…that (Declarative)</i> <i>…. how to (Procedural)</i>
Laddering</th>
<th>Key Tier 3 vocabulary</th>
<th>Core skills and enrichment opportunities.</th>
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<td rowspan="4">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.</td>
<td rowspan="4">Linking
<u>KS2</u>
Basic concept of heat / thermal energy
<u>Year 7</u>
Energy costs and transfers.
<u>Year 8</u>
Heating and cooling.
Looking
Year 9
Energy transfers
Types of energy
Efficiency
Year 10 and Year 11
Paper 1 - energy
Post 16
Work done, potential energy, conservation of energy, mechanical energy, power, efficiency</td>
<td><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.
<i>….how to</i> describe all the changes involved in the way energy is stored when a system changes, for common situations.</td>
<td>Kinetic, Thermal, Chemical, Gravitational potential, Elastic potential, Electrostatic, Magnetic, nuclear, mechanical, radiation, electrical</td>
<td rowspan="4"><u>Subject specific skills</u>
Practical skills – use a range of new equipment to measure the specific heat capacity of different materials.
<u>Numeracy</u>
Use, apply and rearrange energy equations. Convert between magnitudes of units.
Interpret pie charts and other data sources on energy.
<u>Literacy</u> and <u>Reading</u>
Extended reading articles - Just Deserts, Unplugged, Out in the Cold,
<u>Cultural Capital/Careers</u>
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.
<u>Cross curricular knowledge links</u>
DT: Knowledge of principles of energy when designing bespoke items eg playground items, safety equipment (seatbelts).
<u>Common Misconceptions</u>
<table>
<tr><td>Misconception</td><td>Comment</td></tr>
<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>
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<td><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.
<i>….how to calculate the amount of energy associated with a moving object, a stretched spring and an object raised above ground level.</i>
Use and rearrange the associated equations.</td>
<td>Limit of proportionality, spring constant, gravitational field strength, joule, m/s, specific heat capacity</td>
</tr>
<tr>
<td><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.
<i>….how to</i> use & apply the equation: $\Delta E = m c \Delta \theta$
RP1. Investigation to determine the specific heat capacity of one or more materials</td>
<td>Δ -Delta (change in)
Θ – Theta (Temperature)</td>
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<tr>
<td><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.
<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</td>
<td>Power, watts, time, energy transfer,</td>
</tr>
</table>

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<td>*…that* 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.

….how to apply the equation Work done = force x distance and identify the appropriate units.</td>
<td>Work done, energy ,friction, Newton, Joule.</td>
<td rowspan="4">
<table>
<tr><td></td><td>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.</td></tr>
<tr><td>An object at rest has no energy.</td><td>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!'</td></tr>
<tr><td>The only type of potential energy is gravitational.</td><td>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 enery in fuels (not released until they are burned), potential elastic energy in a stretched spring (not released until the spring is....</td></tr>
<tr><td>Gravitational potential energy depends only on the height of an object and kinetic energy only on the speed.</td><td>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!</td></tr>
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<td>*…that* useful energy: is energy transferred to where it is wanted in the way that it is wanted

….how to explain the impact of friction on moving items and how it can be reduced.

RP2: (Physics only) : Investigate the effectiveness of different materials as thermal insulators and the factors that may affect the thermal insulation properties</td>
<td>Friction, dissipated, wasted, transfer, thermal energy store. Thermal conductivity. Lubrication. Insulators & conductors.</td>
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<td>*…that* some energy will be wasted during transfers and the energy efficiency for any energy transfer can be calculated.

….how to use both equations:
efficiency = useful output energy transfer/
total in put energy transfer</td>
<td>Efficiency</td>
</tr>
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<td>*…that* non-renewable energy sources cannot be replaced. Fossil fuels are running out and alternatives need to be found.

….how to evaluate the advantages & disadvantages of a range of renewable energies using text and data charts.</td>
<td>Non-renewable, fossil fuels, nuclear power, global warming, global dimming, emissions. Solar, hydro-electric, wind, tidal, geothermal, renewable,</td>
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				Doubling the speed of a moving object doubles the kinetic energy.	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!
				Energy can be changed completely from one form to another useful (no energy losses as unwanted energy).	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.

Topic Forces	**Rationale (layering, Why this why now?)**	**Knowledge goals: *You need to know….*** *…that (Declarative)* *…. how to (Procedural)* Laddering	**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.	Linking **KS2** Moving objects, types of forces **KS3** Speed, types of forces, Looking **KS4** – Forces, work, scalars, vectors, atmosphere **Post 16** Forces, momentum, moments	*…that* Scalar quantities have magnitude only. Vector quantities have magnitude and an associated direction. *how to* describe the interaction between pairs of objects which produce a force on each object.	Scalar and vector, Contact and non-contact forces, Weight and gravity	**Cultural Capital/Careers** Mechanic, aerospace engineer, computer game designer. car safety designer **Cross curricular knowledge links** PE – Sports and motion, Maths – formulas and algebra. **Numeracy** 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. **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. Use prefixes and powers of ten for orders of magnitude.
		…that Weight is the force acting on an object due to gravity. *…. how to* use the equation - weight = mass × gravitational field strength	quantatively and qualitatively.	
		…that 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. *…. how to* calculate the resultant of two forces that act in a straight line, (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.	Resultant force, Free body diagrams, **HT Only**	
		…that when a force causes an object to move through a distance work is done on the object. … *how to* use the calculation work done = force × distance (W = Fs)	work	
		…that 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. *…how to* describe the difference between elastic deformation and	Force, work, newtons, joules, displacement, frictional forces	

		inelastic deformation caused by stretching forces by using the equations force = spring constant × extension. (F = ke)	
		...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. ... how to calculate work done in stretching (or compressing) a spring (up to the limit of proportionality) using the equation: RP6 - Investigate the relationship between force and extension for a spring.	Compressing, elastic deformation, inelastic deformation, directly proportional
		...that 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. ....how to use the calculation to work out the size of the moment - moment of a force = force × distance. (M = Fd) **(Physics only)**	**Physics only** Turning forces, moments Leavers and gears, perpendicular distance, pivot,
		...that A fluid can be either a liquid or a gas. The pressure in fluids causes a force normal (at right angles) to any surface. ....how to 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.	Pressure in a fluid Pressure in a gas Upthrust, pascals, density, submerged objects,
		.......that 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. .....how to 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. [$p = h \rho g$]	Atmospheric pressure
		...that there is a difference between distance and displacement and a difference between scalar and vector quantities.	HT Distance and displacement Speed and velocity

Common Misconceptions

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 interchangable - 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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<td>….how to use the calculation to work out the distance travelled in a specific time for an object moving at constant speed distance travelled = s peed × time, $s = v t$

(HT only) Students should be able to explain qualitatively, with examples, that motion in a circle involves constant speed but changing velocity</td>
<td>Distance time graphs, Velocity time graphs, gradient,</td>
<td rowspan="4">
<table>
<tr><td>The five senses are infallible.</td><td><u>Optical illusions</u> are good on this one!</td></tr>
<tr><td>There is only one way to measure perimeter.</td><td>.... and that is 'all of the way' round - mathematical calculation is suspect!</td></tr>
<tr><td>Only the area of rectangular shapes can be measured in square units.</td><td>The idea of measuring a circle in square units give some children problems</td></tr>
<tr><td>Surface area can be found only for two-dimensional objects.</td><td>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.</td></tr>
<tr><td>You cannot measure the volume of some objects because they do not have "regular" lengths, widths, or heights.</td><td>They need to think of volume as an occupied 'space' rather than a mathematical construct - displacement can experiments are fun!</td></tr>
<tr><td>The density of two samples of the same substance with different volumes or shapes cannot be the same.</td><td>Density is a concept difficulty for many... practical hands on experience is vital.</td></tr>
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<td>…that 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.

….how to draw distance–time graphs from measurements and extract and interpret lines and slopes of distance–time graphs, translating information between graphical and numerical form.

(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.</td>
<td>HT
Estimating magnitudes, uniform acceleration, terminal velocity</td>
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<td>…… that the average acceleration of an object can be calculated using the equation: acceleration = change in velocity/ time taken $a = \Delta v / t$

…. how to calculate the acceleration of an object from the gradient of a velocity–time graph.

(HT only) The distance travelled by an object (or displacement of an object) can be calculated from the area under a velocity–time graph.

(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.</td>
<td>HT</td>
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<td>…. that 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.</td>
<td>HT</td>
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		(HT only) The tendency of objects to continue in their state of rest or of uniform motion is called inertia. …. 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 $F = m a$ *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.*		
		… that they can evaluate the effect of various factors on thinking distance based on given data. *….how to* calculate stopping distance (HT only) estimate the forces involved in the deceleration of road vehicles in typical situations on a public road **(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.** **(Physics only) Students will be required to interpret graphs relating speed to stopping distance for a range of vehicles.**	Resultant forces, stationary, resistive forces, uniform velocity, inertia. Thinking distance, breaking distance, stopping distance. Reaction times, Energy transfers	
		Momentum (HT only) *… 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. *…..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 *(Physics only)* complete calculations involving an event, such	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:** ***You need to know….*** *…that (Declarative)* *…. how to (Procedural)* LADDERING	**Key Tier 3 vocabulary**	**Core skills and enrichment opportunities.**
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.	LINKING KS2 Magnets, KS3 Magnets, magnetic materials, compasses LOOKING **KS4** Magnets, Induced magnets, induced current, motor and generator effect. **Post 16** Magnetic Fields, Magnetic Field Strength, The Force on a Moving Charge	*…that* 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 *how to* describe the attraction and repulsion between unlike and like poles for permanent magnets and the difference between permanent and induced magnets.	Poles, fields, North, South, repel, attract, non-contact force, induced magnet, Iron, Nickel, Cobalt.	**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. **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 **Literacy and Reading** BBC Bitesize – Magnetism, extended reading articles Parallel histories. **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. **Cross curricular knowledge links** Geography – Earths magnetic field, **Misconceptions** Misconception Discussion of the problem Possible Activities
		…that when a current flows through a conducting wire a magnetic field is produced around the wire. *…. how to* 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.	Current, solenoid, iron core.	
		…that 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. *…. how to* 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 $F = B I l$	Fleming's left-hand rule, magnetic flux density, force.	
		…that a coil of wire carrying a current in a magnetic field tends to rotate. *…..how to explain how a moving-coil loudspeaker and headphones work.* (Physics only)	Physics only Rotation, conductor, coil, loudspeakers, headphones, pressure. Rotation, conductor, coil, loudspeakers, headphones, pressure.	

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<td><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.
<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.
(Physics only)</td>
<td>Physics only
Potential difference, current, conductor, generator, induced.
Potential difference, current, conductor, generator, induced.</td>
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<table>
<tr><td>All metals are attracted to a magnet.</td><td>Only iron, nickel and cobalt and their alloys are attracted to a magnet</td><td>Circus of material to test</td></tr>
<tr><td>All silver coloured items are attracted to a magnet.</td><td>as above</td><td>as above</td></tr>
<tr><td>All magnets are made of iron.</td><td>iron is a soft magnetic material - wouldn't work!</td><td>Make magnets - iron and steel - by stroking</td></tr>
<tr><td>Larger magnets are stronger than smaller magnets.</td><td></td><td>part of a circus - weak big one and strong small one!</td></tr>
<tr><td>The magnetic and geographic poles of the earth are located at the same place.</td><td></td><td>Web search on navigation of seas and how magnetic pole 'moves'</td></tr>
<tr><td>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.</td><td></td><td>Make a model of the earth and put a magnet within it so that search compasses point north</td></tr>
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<td><i>…that</i> the generator effect is used in an alternator to generate ac and in a dynamo to generate dc.
<i>how to</i> explain how the generator effect is used in an alternator to generate ac and in a dynamo to generate dc</td>
<td>Potential difference, current, conductor, generator, induced, transformers, coil, efficient, eddy currents.</td>
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<td><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 Vp and Vs depends on the ratio of the number of turns on each coil, np and ns.
<i>……how to</i> use the equations vp/ vs = np/ ns potential difference, Vp and Vs in volts, V. In a step-up transformer
Vs > Vp In a step-down transformer Vs < Vp
Vs × Is   = V p × I p</td>
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Topic	**Rationale (layering, Why this why now?)**	**Knowledge goals: *You need to know….*** *…that (Declarative)* *…. how to (Procedural)* Laddering	**Key Tier 3 vocabulary**	**Core skills and enrichment opportunities.**
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?	Linking KS2 Space, our universe, day and night KS3 Space, our universe, day and night Looking **KS4** **Post 16**	*…that* 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. *how to explain* 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	Planets, dwarf planets, stars, asteroids, comets, moons, meteoroids, meteors, galaxy, Milky Way, The Universe. Satellites, artificial satellites, natural satellites, orbits, velocity.	**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. **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 **Literacy and Reading** BBC Bitesize –Space Physics, extended reading articles Parallel histories. **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, **Cross curricular knowledge links**
		…. that a star goes through a life cycle and the life cycle is determined by the size of the star. How to explain how fusion processes lead to the formation of new elements.	Hydrogen, Helium, attraction, repulsion, energy, pressure, heat.	
		….. that gravity provides the force that allows planets and satellites (both natural and artificial) to maintain their circular orbits. How to … describe the similarities and distinctions between the planets, their moons, and artificial satellites	Nebula, protostar, main sequence star, red giant, white dwarf, black dwarf, neutron star, supernovae, black hole, elements, Iron.	
		… that there is an observed increase in the wavelength of light from most distant galaxies. This effect is called red-shift. how to… explain qualitatively the red-shift of light from galaxies that are receding and how red-shift provides evidence for the Big Bang model.	Wavelength, expansion, Doppler effect, Big Bang, dark mass, dark energy, supernovae.	

				Geography – Earths 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: *You need to know….*** *…that (Declarative)* *…. how to (Procedural)* Laddering	**Key Tier 3 vocabulary**	**Core skills and enrichment opportunities.**
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.	Linking KS2 Basic concepts of waves and movement KS3 Energy and waves, light waves, sound waves. Looking KS4 Waves in air, fluids and solids, properties, uses and dangers of waves. Post 16 Diffraction gratings, coherence, path difference, phase difference. industrial application of diffraction gratings, including emission Spectra and identification of	*…that* waves may be either transverse or longitudinal. *how to* describe the difference between longitudinal and transverse waves and describe wave motion in terms of their amplitude, wavelength, frequency and period.	Parallel, Perpendicular, Wavelength, Amplitude, Peaks, Troughs, Compressions, Rarefaction, Normal	**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. **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. **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. **Cultural Capital/Careers** Careers include sonographer, seismologist or a seismographer, opticians or ophthalmologists **Cross curricular knowledge links** Geography, earthquakes and convection currents, coastal erosion **Common Misconceptions** Misconception Possible Activities Loudness and pitch of sounds are confused with each other. Reinforcement of correct scientific vocabulary
		…that 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. *…. how to* use the equations to work out period (Physics only) show how, changes in velocity, frequency and wavelength, in transmission of sound waves from one medium to another, are inter-related.	Reflect, refract, Incident Medium, Sound,	
		…that there is a method to measure the speed of sound waves in air and to measure the speed of ripples on a watersurface. *…. how to* 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. 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.	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	
		…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.	Physics only	

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<td rowspan="5">gases. Concept and applications of stationary wave resonance.</td>
<td>*how to* 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.

RP9: Investigate the reflection of light by different types of surface and the refraction of light by different substances</td>
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<tr><td>Hitting an object harder changes its pitch.</td><td>Practical - getting them to sing the note when hit with different force</td></tr>
<tr><td>In a telephone, actual sounds are carried through the wire rather than electrical pulses</td><td></td></tr>
<tr><td>Human voice sounds are produced by a large number of vocal chords.</td><td></td></tr>
<tr><td>Sound moves faster in air than in solids (air is "thinner" and forms less of a barrier).</td><td></td></tr>
<tr><td>Sound moves between particles of matter (in empty space) and then 'bumps into' the next matter particle.</td><td></td></tr>
<tr><td>In wind instruments, the instrument itself vibrates not the internal air column</td><td></td></tr>
<tr><td>The pitch of whistles or sirens on moving vehicles is changed by the driver as the vehicle passes.</td><td></td></tr>
<tr><td>The pitch of a tuning fork will change as it "slows down", (i.e. "runs" out of energy)</td><td>Practical - getting them to sing the note until it dies</td></tr>
<tr><td>As sound waves move, the air moves along with them.</td><td></td></tr>
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<tr><td>The pupil of the eye is a black object or a spot on the surface of the eye.</td><td>Idea it is the gap in the centre of the iris.</td><td>Observation of how the pupil changes size in different light intensities (Care they don't blind each other!) Discuss eye exams in an optician -</td></tr>
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<td>*...that* sound waves can travel through solids causing vibrations in the solid.

how to 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.</td>
<td>Physics only</td>
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<td>*...that* waves are used for detection and exploration.

how to 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.</td>
<td>Ultrasound waves, Seismic waves, P-waves and S-waves. Echo sounding.</td>
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<td>*...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.

...how to give examples that illustrate the transfer of energy by electromagnetic waves.

RP10: Investigate how the amount of infrared radiation absorbed or radiated by a surface depends on the nature of that surface.</td>
<td>radio, microwave, infrared, visible light (red to violet), ultraviolet, Xrays and gamma rays</td>
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<td>*...that Electromagnetic waves all have many uses and applications due to their individual properties*</td>
<td>• radio waves – television and radio</td>
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<td>...how to give brief explanations why each type of electromagnetic wave is suitable for the practical application.</td>
<td>• 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.</td>
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<tr><td></td><td></td><td>how s/he looks through the pupil</td></tr>
<tr><td>The eye receives upright images on the retina.</td><td>Ray diagrams can be used to show how the image is inverted</td><td>Use vid-clips to show full visual sytem</td></tr>
<tr><td>The lens is the only part of the eye responsible for focusing light.</td><td>Cornea is primary refractor</td><td>Discuss sight correction using lasers - resculpting of the cornea - use a glass ball to refract light.</td></tr>
<tr><td>The lens forms an image (picture) on the retina. The brain then "looks" at this image and that is how we see.</td><td>Correct terminology for image interpretation needs to be reinforced</td><td>Use vid-clips to show full visual sytem - discuss how blindness can happen to people with perfect eyes</td></tr>
<tr><td>The eye is the only organ involved in sight; the brain is only for thinking.</td><td>Correct terminology for image interpretation needs to be reinforced</td><td>Use vid-clips to show full visual sytem - discuss how blindness can happen to people with perfect eyes</td></tr>
<tr><td>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.</td><td>Spectra of sources differ according to the electron transitions involved</td><td>Use a series of light sources and compare the spectra or what stips of multicoloured cloth look like under them - discuss how clothing looks different under different light sources.
Could look at spectra from stars...</td></tr>
<tr><td>When white light passes through a coloured filter colour is added to the light.</td><td>Filters subtract</td><td>Use multiple filters</td></tr>
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<td>...that a lens forms an image by refracting light.

...how to construct ray diagrams to illustrate the similarities and differences between convex and concave lenses.</td>
<td>Physics only</td>
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<td>...that each colour within the visible light spectrum has its own narrow band of wavelength and frequency.

...how to explain:
• 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</td>
<td>Physics only</td>
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<td>...that 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.

...how to explain:
• that all bodies (objects) emit radiation
• that the intensity and wavelength distribution of any emission depends on the temperature of the body</td>
<td>Physics only</td>
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				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.		
				The shades of grey in a black and white newspaper picture are produced by using inks with different shades of gray.		Use a magnifying glass to look at the dots
				The different colors appearing in coloured pictures printed in magazines and newspapers are produced by using different inks with all the corresponding colors.		Use a magnifying glass to look at the dots
				Colour is a property of an object, and is independent of both the illuminating light and the receiver (eye).		Look at coloured objects under different coloured light sources.
				White light is colourless and clear, enabling you to see the "true" color of an object.		

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<td>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.</td>
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<td>Talk about colour blindness - use colour blindness tests.</td>
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