BIG IDEA:	**Reactions Rearrange Matter**
Prior Learning:	**C1.1 Particles:** • The three states of matter are solid, liquid and gas • Solids have a fixed shape, cannot flow and cannot be compressed. • Liquids are able to flow and take the shape of their container and cannot be compressed • Gases can flow and completely fill their container and can be compressed • Gas pressure occurs because of particles colliding with the walls of a container • Pressure in liquids increases with depth. • Atmospheric pressure decreases with increasing height as the weight of air above decreases with height. **C1.2 Elements, Atoms and Compounds:** • A molecule is two or more atoms chemically joined together – this can be an element (e.g. H_2) or a compound (e.g. H_2O) • A compound contains two or more elements chemically joined together in fixed proportions • The small subscript number after an element symbol is the number of atoms of that element are in one molecule **C1.3 Mixtures:** • A mixture consists of two or more types of atoms or compounds not chemically combined together* • A pure substance is made of one type of atom or compound A solution is composed of a solute and a solvent. • A solvent is the substance a solute dissolves in • A solute is the substance that dissolves in a solvent. • A saturated solution is a solution in which no more solute will dissolve • An unsaturated solution is a solution in which solute will dissolve • A substance is soluble if it will dissolve to form a solution • A substance is insoluble if it will not dissolve to form a solution • A solute dissolves when the solute particles fill in the spaces between the solvent particles **C2.1 Acids and Alkalis:** • In neutralisation reactions an acid reacts with an alkali to form a salt and water. **C2.2 Changing Substances:** • The number and type of atoms do not change in a chemical change and are only rearranged. • The total overall mass is conserved in a chemical change. • A chemical change can be identified if there is a change observed by a chemical test. • The test for hydrogen uses a burning splint held at the open end of a test tube of the gas. Hydrogen burns rapidly with a pop sound
Future Learning:	This unit forms the basis for students' quantitative study of chemistry, which from this point will begin to be interleaved with almost all chemistry topics they will study. In every area of chemistry, students will be required to convert between units and to take into consideration volume, concentrations of substances and molarity. The more difficult GCSE quantitative chemistry ideas are studied later, with another quantitative chemistry unit in year 11. Specific future GCSE topics which link closely to this unit include yield and atom economy, gases and volumes of gases, electrolysis and the study of what happens to solutions during electrolysis. All of these topics are developed in further depth over KS4 and into A-level.
Key misconceptions:	This area of chemistry is rife with mosconceptions, for a number of reasons. Firstly, students often have little confidence and shallow understanding of the Maths involved. including simple calcualtions that they will have encountered in their Maths lessons. Secondly, the nature of the chemistry is that what students are quantifying is quite abstact. They are calculating concentrations of particles that they cannot see, for example. Although learners may have met conservation of mass they still tend to refer to chemical reactions as losing mass. They understand that mass is conserved but not the number or species of atoms. They may think that the original substance vanishes 'completely and forever' in a chemical reaction. Chemical formulae are found difficult too as learners often misunderstand which atoms are affected by subscripts, this is compounded when using bracketed species e.g. $(NH_4)_3PO_4$. Students often lack an understanding of the basic concepts: that chemists need to measure amounts accurately, that matter is made from things invisible to the naked eye, that chemical reactions produce new substances.
Unit sequencing:	At the beginning of this unit, students will be introduced to state symbols in reactions which will then be used throughout the rest of this unit in varying contexts. Students have already used atomic and mass numbers to calculate numbers of subatomic particles and have learnt the meaning of relative atomic mass in C3.1, and this will be interleaved in lesson 2, practised, and developed further to introduce the calculation of relative formula mass. This serves as a simple introduction to quantitative chemistry, with a relatively simple process that can build students confidence, especially for those with a lack of confidence in Maths. Having explored relative atomic and formula mass, the method for calculating the percentage mass of an element in a compound is introduced. Lesson 7 uses the learning from C1.3 on mixtures and solubility to introduce the term concentration, without calculations and focusing purely on the meaning of the term in terms of particles per unit volume, and the units of concentration. Following on from the introduction to concentration, students will carry out some basic concentration calculations, using the last lesson's learning to convert between units of volume where required. Students will use the learning of rearranging equations to rearrange the equation where required. Lessons 8 to 10 interleave much of the learning from C2.1 (Acids and alkalis) as well as C2.2 (Reactions of Acids) to focus on the practical skill of making a soluble salt. As students are creating a solution as part of this practical method, it is placed after the learning about concentration, so that part of the activity can place this 'concentration' learning, and its related calculations, in context. The practical activity will bring together much of the earlier learning in this unit and allow students to practise balancing equations and answering questions of the reaction relating to conservation of mass, converting between cm3 and dm3 and concentration calculations.

Unit code	Lesson code	Lesson title	What do my students need to know by the end of the lesson?	AQA specificaton references	What could help my students to understand this knowledge?	What do my students need to be able to do by the end of the lesson?	What prior knowledge do I expect my students to have? Where is this likely to have come from?	What are the core practical, enquiry and maths skills that students will learn and practise? Key: Skills in bold are taught for the first time here	What practical activities are planned? What apparatus and chemicals are required?	What misconceptions may students arrive at the lesson with? What could they leave the lesson thinking if we are not careful? How can I address this directly? NOTE: More misconceptions are discussed in the 'notes' section of the powerpoints	What exit ticket questions will the students be required to answer by the end of the lesson?	What alternative activities could I do in this lesson?	What keywords am I introducing in this lesson that students may find difficult?
n to Quantit	**C3.2.1**	**Prior Knowledge Review**	• Formulae show which elements are in compounds and the ratio of each element in the compound. • Chemical reactions always involve the formation of one or more new substances.			Interpret chemical formulae	Learners should be familiar with chemical symbols and formulae for elements and compounds. They should also be familiar with representing chemical reactions using formulae.		Demostration of reaction between lead nitrate and potassium iodide https://edu.rsc.org/resources/a-solid-solid-reaction-	Students experience difficulty in recognising when a chemical reaction occurs. Many do not discriminate consistently between a chemical change and a change of state, which chemists call a "physical change". Research (Johnson, 2000) concluded that	Ammonia, NH_3, contains: A. Three nitrogen atoms and one hydrogen atom. B. Three hydrogen atoms and three nitrogen atoms.		Compound, subscript, acid, chemical formula, neutralisation, metal
	C3.2.2	**Relative Formula Mass**	•The relative atomic mass of an element can be found as the mass number of an element on the periodic table •Relative atomic mass has the symbol Ar •The relative formula mass of a compound is the sum of the relative atomic masses of the atoms in the numbers shown in the formula •Relative formula mass has the symbol Mr •In a balanced chemical equation, the sum of the relative formula masses of the reactants in the quantities shown equals the sum of the relative formula masses of the products in the quantities shown	Chemistry 4.3.1.2 Trilogy 5.3.1.2	The Periodic Table provides all of the relative atomic masses (the larger number next to each element symbol)	Recall that relative atomic mass can be written as Ar and relative formula mass can be written as Mr. State the relative atomic mass of an element Calculate the relative formula mass for a compound.	4.1.1.6 Relative atomic mass Lesson C3.2.2 conservation of mass From C1.2: • A molecule is two or more atoms chemically joined together – this can be an element (e.g. H_2) or a compound (e.g. H_2O) • A compound contains two or more elements chemically joined together in fixed proportions • The small subscript number after an element symbol is the number of atoms of that element are in one molecule			Care needs to be taken with Mr which stands for both relative formula mass and relative molecular mass. RMM is for covalent molecules only and should be avoided at this level. Chemical formulae are found difficult too as learners often misunderstand which atoms are affected by subscripts, this is compounded when using bracketed species e.g. $(NH_4)_3PO_4$.	The relative formula mass for NH_3 is… (Ar: N = 14; H = 1) **A. 17** B. 15 C. 45 The relative formula mass for Fe_2O_3 is… (Ar: Fe = 56; O = 16) A. 384 **B. 160** C. 200 The percentage of carbon in carbon monoxide (CO) is… (Ar: C = 12; O = 16) A. 18% **B. 43%** C. 50%	Model compounds with different sized and coloured lego bricks pre-marked with symbol and Ar of different elements. Sum the Ars marked on the bricks to obtain the Mr.	Relative, formula, Mr
	C3.2.3	**Percentage by mass**	•The percentage mass of an element in a compound can be calculated using the relative atomic mass and the relative formula mass	Chemistry 4.3.1.2 Trilogy 5.3.1.2		Recall that relative atomic mass can be written as Ar and relative formula mass can be written as Mr. Calculate relative atomic mass and relative formula mass. Calculate the percentage by mass of an element in a compound.	From L2, students know how to find the relative atomic mass of an element and then how to calculate the relative formula mass of a compound. From C1.2: • A molecule is two or more atoms chemically joined together – this can be an element (e.g. H_2) or a compound (e.g. H_2O) • A compound contains two or more elements chemically joined together in fixed proportions • The small subscript number after an element symbol is the number of atoms of that element are in one molecule				What is the relative formula mass for NH_3? (Ar: N = 14; H = 1) **A. 17** B. 15 C. 45 Calculate the percentage by mass of carbon in C_2H_4. A. 28% **B. 85.7%** C. 42.8% Calculate the percentage by mass of carbon in carbon monoxide (CO). A. 18% **B. 43%** C. 0.43%		Relative formula mass, relative atomic mass, percentage, conservation of mass

C3.2.4	**Conservation of Mass**	•Chemical reactions always involve the formation of one or more new substances, and often involve a detectable energy change •Compounds contain two or more elements chemically combined in fixed proportions and can be represented by formulae using the symbols of the atoms from which they were formed •Compounds can only be separated into elements by chemical reactions •In chemical equations, the three states of matter are shown as state symbols (s), (l) and (g), with (aq) for aqueous solutions. •Aqueous means dissolved in water •The law of conservation of mass states that no atoms are lost or made during a chemical reaction, so the mass of the products equals the mass of the reactants •This means that chemical reactions can be represented by symbol equations which are balanced in terms of the numbers of atoms of each element involved on both sides of the equation •Mass is always conserved in chemical reactions •In a chemical reaction where a gas is produced, it may appear that the mass decreases throughout the reaction. In fact, this decreased mass will be due to the gas dissipating into the atmosphere. If the reaction is carried out in a closed container, this will not occur	Chemistry 4.3.1.1; Trilogy 5.3.1.1	Mass is always conserved, in every single chemical reaction, without exception. If it seems like the mass increases or decreases, look for the missing atoms!	Recognise state symbols. State the law of conservation of mass. Explain why the overall mass of a reaction sometimes appears to change.	Learners will have knowledge of conservation of mass, changes of state and chemical reactions. From C1.1: • The three states of matter are solid, liquid and gas • Solids have a fixed shape, cannot flow and cannot be compressed. • Liquids are able to flow and take the shape of their container and cannot be compressed • Gases can flow and completely fill their container and can be compressed From C2.2: • The number and type of atoms do not change in a chemical change and are only rearranged. • The total overall mass is conserved in a chemical change. From C3.1: • The relative atomic mass of an element is an average value that takes account of the abundance of the isotopes of the element.		Demonstration to show reaction where mass appears to be lost during a reaction: https://edu.rsc.org/resources/mass-changes-in-chemical-reactions/523.article or https://www.stem.org.uk/resources/elibrary/resource/33721/mass-changes-chemical-reactions Demonstration or class practical: RSC mass changes in chemical reactions	Although learners may have met the conservation of mass they still tend to refer to chemical reactions as losing mass. They understand that mass is conserved but not the number or species of atoms. They may think that the original substance vanishes 'completely and forever' in a chemical reaction. Chemical formulae are found difficult too as learners often misunderstand which atoms are affected by subscripts, this is compounded when using bracketed species e.g. (NH4)3PO4.	If 3 g of magnesium reacts with 2 g of oxygen, how many grams of magnesium oxide will be made? Mg(s) + O2(g) □ MgO(s) A. 1 g B. 6 g **C. 5 g** When copper carbonate is heated its mass decreases. Which of the following is false? **A. The loss in mass is due to a change in state.** B. The loss in mass is due to a formation of gas. C. The mass of products equals the mass of reactants. Which of the following is correctly balanced? A. 2P + 5O2 □ 2P2O5 B. 2P + 5O2 □ P2O5 **C. 4P + 5O2 □ 2P2O5**		Conservation of mass; formulae; compound, element;
C3.2.5	**Balancing Equations**	• The law of conservation of mass states that no atoms are lost or made during a chemical reaction, so the mass of the products equals the mass of the reactants • This means that chemical reactions can be represented by symbol equations which are balanced in terms of the numbers of atoms of each element involved on both sides of the equation • Mass is always conserved in chemical reactions	Chemistry 4.3.1.1; Trilogy 5.3.1.1	The Law of conservation of mass (previous lesson) states that matter cannot be created or destroyed. In every chemical reaction, the atoms that are in the reactants are the same atoms that are in the products. When balancing an equation, you can only change the coefficients, not any subscript numbers!	Identify the number of atoms of each element in a chemical formula. Describe the significance of placing a coefficient in front of a chemical formula in an equation. Balance chemical equations.	From C2.2: • The number and type of atoms do not change in a chemical change and are only rearranged. • The total overall mass is conserved in a chemical change. From C3.1: • The relative atomic mass of an element is an average value that takes account of the abundance of the isotopes of the element.			Chemical formulae are found difficult too as learners often misunderstand which atoms are affected by subscripts, this is compounded when using bracketed species e.g. (NH4)3PO4.	1. Predict the products of the following equation: Zn + 2 HCl → **A. ZnCl2 + H2** B. ZnCl + H2 C. ZnCl + H 2. How many hydrogen atoms make up the products of this reaction? 8 CO + 17 H2 → C8H18 + 8 H2O A. 28 B. 16 **C. 34** 3. Which equation demonstrates the law of conservation of mass? A. CH4 + 2 O2 → CO2 + H2O B. CH4 + O2 → CO2 + 2 H2O **C. CH4 + 2 O2 → CO2 + 2 H2O**		Reactant Product Atom Element Coefficient Subscript
C3.2.6	**Uncertainty**	• Whenever a measurement is made, there is always some uncertainty about the result obtained			Describe the two ways of estimating uncertainty Estimate the uncertainty from a measuring instrument Estimate the uncertainty from a set of repeat measurements		**73. Apply the idea that whenever a measurement is made, there is always some uncertainty about the result obtained.** **74. Use the range of a set of measurements about the mean as a measure of uncertainty.**			Which is the best definition of uncertainty? A. The mean and the range of a data set B. The range of a data set divided by two **C. The range of values within which the true value lies** Estimate the uncertainty of this data set. **A. 3 g** B. 6 g C. 105 g Estimate the uncertainty of this instrument. A. 1 cm B. 0.1 cm **C. 0.05 cm**		Uncertainty, instrument, repeat, resolution, range
C3.2.7	**Introducing Concentration**	•Many chemical reactions take place in solutions •The concentration of a solution tells you how much solute is dissolved in a given volume of solution •Concentration can be defined as the mass of solute per unit volume of solvent. •Volume means the amount of space that a substance takes up, and can be measured in cm3, dm3, m3, L or mL. •1 dm3 is equal to 1 L and equal to 1000 cm3 •To convert from dm3 to cm3 the number should be multiplied by 1000 •To convert from cm3 to dm3 the number should be divided by 1000 •The concentration of a solution can be measured in mass per given volume of solution, e.g., grams per dm3 (g/dm3 or g dm-3) •The mass in grams of solute in a given volume of solution can be calculated from its concentration in g/dm3	Chemistry 4.3.2.5 Trilogy 5.3.2.5	Be careful when referring to concentrated solutions not to use the word 'strong'. This has a different meaning and can foster misconception in students. When referring to acids for example, a strong acid is one that fully dissociates to form H3O+ ions in aqueous solution, where as a weak acid only does so partially. A concentrated acid, on the other hand, is one that has a very high concentration of H3O+ ions in aqueous solution.	Convert units of volume between dm3 and cm3. Describe what is meant by 'concentration'. Recall the unit of concentration.	C3.2.3 relative formula mass; C3.2.4 Conservation of mass; C3.2.5 Balancing Equations C3.2.6 Uncertainty From C1.3: • A mixture consists of two or more types of atoms or compounds not chemically combined together* • A pure substance is made of one type of atom or compound A solution is composed of a solute and a solvent. • A solvent is the substance a solute dissolves in • A solute is the substance that dissolves in a solvent. • A saturated solution is a solution in which no more solute will dissolve • An unsaturated solution is a solution in which solute will dissolve • A substance is soluble if it will dissolve to form a solution • A substance is insoluble if it will not dissolve to form a solution • A solute dissolves when the solute particles fill in the spaces between the solvent particles	100. Interconvert units.	To investigate the volume of an irregular object.		Salt dissolves in water. Which word describes salt best? **A. soluble** B. insoluble C. solvent 5 g of solute is dissolved in 200cm3 of solution. Which of these quantities has the same volume as this solution? **A. 0.2 dm3** B. 200000 cm3 C. 0.005 kg Select the answer below which is equal to 0.05 dm3. A. 500 cm3 **B. 50 cm3** C. 0.00005 cm3		Concentration, solution, dilute, solute, solvent,
C3.2.8	**Concentration Calculations**	• The mass in grams of solute in a given volume of solution can be calculated from its concentration in g/dm3			Calculate the concentration of a solution, given the mass of solute and volume of solvent. Rearrange equations.		66. Change the subject of an equation			250cm3 of a solution with a concentration of 10 g/dm3 would contain: A. 2500 g solute **B. 2.5 g solute** C. 250 g solute 5 g of solute is dissolved in 200cm3 of solution. The concentration of the solution is: **A. 25 g/dm3** B. 0.025 g/dm3 C. 0.25 g/dm3 The amount of NaOH in 20 cm3 of a 0.18 mol/dm3 solution is: A. 3.6 mol B. 360 mol **C. 0.0036 mol**	Concentration formula and calculations video: https://www.youtube.com/watch?v=XCX0PkZdUjM	Concentration, solution, dilute, solute, solvent,

	C3.2.9	**Salts**	• Soluble salts can be made from acids by reacting them with solid insoluble substances, such as metals, metal oxides, hydroxides or carbonates.	Chemistry 4.4.2.3 Trilogy 5.4.2.3	A precipitate is an insoluble solid which may be formed on mixing/ reacting two solutions	Recall the difference between soluble and insoluble salts. Describe dissolving in terms of particles. Describe a chemical reaction to produce a soluble salt.	C2.1 Acids are neutralised by alkalis (eg soluble metal hydroxides) and bases (eg insoluble metal hydroxides and metal oxides) to produce salts and water, and by metal carbonates to produce salts, water and carbon dioxide. The particular salt produced in any reaction between an acid and a base or alkali depends on: • the acid used (hydrochloric acid produces chlorides, nitric acid produces nitrates, sulfuric acid produces sulfates) • the metal ion in the base, alkali or carbonate.		Demo: sugar cube dissolving in 100ml water in beaker. Stir using stirring rod. Possible demo: copper sulfate solution in bottle/beaker, copper oxide in bottle/beaker, bottle hydrochloric acid (showing the different states and colours to link to the neutralisation reaction) Possible stretch demo: Preparation of an insoluble salt (silver chloride). See notes in ppt for apparatus/chemicals required, method and safety information.	Students often confuse the terms 'dissolve' and 'melt'. The talk task in this lesson forces students into a cognitive conflict by asking them to differentiate between these terms.	An insoluble salt… A. dissolves in water to form a solution. **B. cannot dissolve in water.** C. are alkalis. Copper sulphate is a salt. Which of the following would not be involved in a reaction to make copper sulfate. **A. Hydrochloric acid** B. Copper oxide C. Sulfuric acid Which is true of an aqueous solution of copper sulfate? A. It is molten (melted) copper sulphate salt **B. It is copper sulphate dissolved in water** C. Answers A and B are the same thing.		Soluble, insoluble, dissolve, melt, aqueous, neutralisation
	C3.2.10	**Making Soluble Salts**	•Soluble salts can be made from acids by reacting them with solid insoluble substances, such as metals, metal oxides, hydroxides or carbonates •To produce a soluble salt, an insoluble salt is reacted with acid until no more reacts and the excess solid is filtered off to produce a solution of the salt. The solution is the crystallised to produce solid salt. •Copper oxide reacts with sulphuric acid solution to produce copper sulphate and water •This reaction can be represented with the equation $CuO(s) + H_2SO_4(aq) \rightarrow CuSO_4(aq) + H_2O(l)$ •Copper sulphate solution is a blue liquid •Copper sulphate crystals are blue	Chemistry 4.4.2.3 Trilogy 5.4.2.3		Prepare a pure, dry sample of crystals of a soluble salt. Describe the key techniques required to prepare a sample of dry, soluble salt, including filtration, evaporation and crystallisation. Explain why each step of the procedure is necessary.	C2.1 Acids are neutralised by alkalis (eg soluble metal hydroxides) and bases (eg insoluble metal hydroxides and metal oxides) to produce salts and water, and by metal carbonates to produce salts, water and carbon dioxide. The particular salt produced in any reaction between an acid and a base or alkali depends on: • the acid used (hydrochloric acid produces chlorides, nitric acid produces nitrates, sulfuric acid produces sulfates) • the positive ions in the base, alkali or carbonate. C2.2 Acids and metals Acids react with some metals to produce salts and hydrogen Acids are neutralised by alkalis (e.g. soluble metal hydroxides) and bases (e.g. insoluble metal hydroxides and metal oxides) to produce salts and water, and by metal carbonates to produce salts, water and carbon dioxide. The particular salt produced in any reaction between an acid and a base or alkali depends on the acid and metal in the base, alkali or carbonate Hydrochloric acid produces chloride salts, nitric acid produces nitrate salts, and sulphuric acid produces sulphate salts.	14. a. Describe a practical procedure for a specified purpose. b. Include a coherent and sensible order of steps, with sufficient detail to obtain valid results, including suggested equipment 44. Preparation of a pure dry sample of a soluble salt. 19. Identify names and uses of basic lab equipment and apparatus	Preparation of a pure, dry sample of a soluble salt from an insoluble oxide or carbonate using a Bunsen burner to heat dilute acid and a water bath or electric heater to evaporate the solution.		Which of the following is a precaution when preparing a soluble salt? A. Concentrated acid is corrosive. **B. Allow hot glassware to cool before touching it.** C. Concentrated acid can cause chemical burns. After which process/technique are you left with a copper oxide residue? A. crystallisation B. evaporation **C. filtration** Once the copper sulfate solution is prepared, why do we evaporate off some water using the Bunsen burner? A. to make the solution stronger B. to make the reaction happen faster **C. to make the solution more concentrated**		Evaporation, crystallisation, filtration, concentrated, solution
	C3.2.11	**Making Soluble Salts 2**				Justify the techniques used for the practical activity to prepare a pure, dry sample of a soluble salt Explain how to measure volumes of liquid accurately. Evaluate the quality of crystals produced.		37. Safe use of equipment to separate mixtures using evaporation 38. Safe use of equipment to separate mixtures using filtration 39. Safe use of equipment to separate mixtures using crystallisation 23. Measure volumes of liquids accurately 25. Measure mass accurately	Give each group of students a conical flask, beaker and graduated cylinder (all 100 ml) to demonstrate accurate measurement of liquid volume		Answer the following questions. Which piece of equipment would give the most precise measurement of volume? **A. Graduated cylinder** B. Beaker C. Both A and B What volume of water is in the graduated cylinder pictured? **A. 6.6 mL** B. 7.2 mL C. 7 mL Why do we need to heat the acid when preparing a solution of copper sulphate? A. So the water starts to evaporate for crystallisation **B. So the reaction happens faster** C. So that bigger crystals will form	What if activity - Salted butterflies. Could be used as a homework before this lesson.	Meniscus, accurate, justify, concentration, volume, crystals
	C3.2.12	**Feedback Lesson**									What is the correct equation for calculating the mass of a substance when given the amount of substance?		Concentration, relative formula mass, soluble salt, mass