BIG IDEA:	**Reactions rearrange matter**
Prior Learning:	The key prior knowledge for this unit is from C3.2, where students were introduced to relative atomic mass, relative formula mass and percentage by mass. They should also be familiar with the preparation of a dry soluble salt from this unit, which will be revisited in acid and alkali reactions. They should also be familiar with concentration from C3.2 and be able to calculate concentration in g/dm3.
Future Learning:	This unit contains the bulk of quantitative chemistry content, but not all. Quantitative chemistry will be revisited in C4.4 Energy Changes, with key calculations interleaved and percentage yield and atom economy introduced. Quantitative chemistry makes up a large part of A-Level chemistry. The ideas that underpin quantitative chemistry are essential to many different manufacturing processes. These will be reviewed when students meet controlling reactions and carbon chemistry in Y11.
Key misconceptions:	One of the biggest issues that students have with quantitative chemistry is the idea of the mole. When introduced as a purely mathematical concept, students can find this especially difficult. If it is introduced from the beginning as a ratio in reactions, where it is not just 1 molecule of a reactant reacting with one other single molecule, but 1 mole of each reacting. Throughout this unit, the mole ratio is revisited and it is always worth using a description of the mole that is more descriptive, such as comparing it to a dozen.
Unit sequencing:	The unit begins with a review of the key content from C3.2, where students met relative formula mass and percentage by mass. Relative atomic mass will be touched upon but there will be other opportunities to revisit this calculation, including in P4.4 Radioactivity. Higher tier students will then be introduced to the concept of the mole and the relationship between the mole, mass and relative formula mass, becoming familiar with this equation that will be required for the rest of the unit. Students then also revisit concentration from C3.2, both in terms of the concept and calculating it in g/dm3. Separate science students will then also go on to calculate concentration in mol/dm3, bringing together the concept of the mole with concentration, both of which have been covered now. Separate science students will also look at how balanced chemical equations can be used to determine an unknown concentration using the mole ratio. Higher tier students then look at the application of the mole, mass and Mr relationship, looking at reacting masses, followed by limiting reactants. Percentage yield and atom economy are not covered in this unit, as that can lead to confusion and overload of equations. Instead, quantitative chemistry will be slightly spread out to allow revisiting, with percentage yield and atom economy introduced at the start of C4.4 Energy Changes, where students will look more at balanced equations and bond energies. Students then have another review of acid reactions, as they can now use the new content from this topic to apply to acid reactions. This includes content from C2.2 and C4.2, where students looked at acids and displacement reactions. They will then look at acids, alkalis and neutralisation before separate science students use the acid-alkali neutralisation to determine the volume of an acid needed to neutralise a known volume and concentration of alkali. Separate science students will then bring this together with the content from earlier in the unit where they used the mole ratio to calculate an unknown concentration. Finally, higher tier students will look at strong and weak acids, bringing together many different pieces of knowledge from the unit, before finally separate science students meet the volumes of gases.

Lesson code	Lesson title	What do my students need to know by the end of the lesson?	AQA specificaton references	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 keywords am I introducing in this lesson that students may find difficult?
C4.3.1	Prior Knowledge Review: Relative Formula Mass and Percentage by Mass	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. 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 The percentage mass of an element in a compound can be calculated using the relative atomic mass and the relative formula mass, using the formula % by mass = Mr of element/Mr of compound x 100	4.3.1.2/5.3.1.2	Define relative atomic mass and relative formula mass Calculate relative formula mass Calculate percentage by mass	(C3.2) The relative atomic mass of an element can be found as the mass number of an element on the periodic table (C3.2) Relative atomic mass has the symbol Ar (C3.2) 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 (C3.2) Relative formula mass has the symbol Mr (C3.2) 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 (C3.2) The percentage mass of an element in a compound can be calculated using the relative atomic mass and the relative formula mass, using the formula % by mass = Mr of element/Mr of compound x 100				1. Choose the correct definition of relative formula mass. A. The average mass of atoms of an element compared to the mass of carbon-12 B. The sum of relative atomic masses in a compound C. The percentage of a compound is made of a particular element 2. Calculate the relative formula mass of carbon dioxide (CO2). C = 12, O = 16 A. 28 B. 44 C. 56 3. Calculate the percentage by mass of oxygen in carbon dioxide. A. 27.27% B. 36.36% C. 72.72 %	relative atomic mass relative formula mass percentage by mass
C4.3.2	*(HT) Introducing the Mole*	*Chemical amounts are measured in moles* *The symbol for the unit mole is mol* *The mass of one mole of a substance in grams in numerically equal to its relative formula mass* *One mole of a substance contains the same number of the stated particles, atoms, molecules or ions as one mole of any other substance.* *The number of atoms, molecules or ions in a mole of a given substance is the Avogadro constant.* *The value of the Avogadro constant is 6.02 x 1023 per mole.* *The measurement of amounts in moles can apply to atoms, molecules, ions, electrons, formulae and equations*	4.3.2.1/5.3.2.1	State the number of particles/atoms/molecules in one mole of a substance. State the units for moles. Describe the relationship between number of moles, mass in grams and relative formula mass. State that 1 mole of a substance contains 6.02 x 1023 particles. Convert decimal numbers into standard form. Calculate the mass of 1 mole of a substance.	(C3.1) 81. Recognise and use expressions in standard form. (C3.1) An atom is the smallest part of an element that can exist (C3.1) Atoms of each element are represented by a chemical symbol, for e.g., O represents an atom of oxygen, Na represents an atom of sodium. (C3.1) The chemical symbol for an element always starts with a capital letter (C3.1) The chemical symbol for an element sometimes has 2 letters. If this is the case, the first letter is a capital and the second is a lowercase letter. (C3.1) Compounds contain two or more elements chemically combined. (C3.1) Atoms are very small, having a radius of about 1x10-10 metres (C3.1) The mass number of an element is equal to the number of neutrons + protons in the nucleus of an atom of that element	97. Use SI units (eg kg, g, mg; km, m, mm; kJ, J) and IUPAC chemical nomenclature unless inappropriate. 82. Use ratios	Optional: Using a volumetric flask to prepare a standard solution http://science.cleapss.org.uk/Resource/GL317-Using-a-volumetric-flask-to-prepare-a-standard-solution.pdf	The mole is often taught in a mathematical way causing the chemical meaning to be obscured. Students who struggle to manipulate numbers and symbols will find this approach towards learning the mole very difficult to understand. (source: https://edu.rsc.org/download?ac=15564) The size of Avogadro's number is too large to be readily comprehended. Students can be given an impression of its size by the use of powerful visual images such as one mole of sand grains stretching for one mile (1.6km); one mole of marbles foming a layer 1500 km deep over the UK and Ireland. (source: https://edu.rsc.org/download?ac=15564)	1. Which of the following is true? A. The symbol for mole is mol. B. The symbol for mole is moles. C. The symbol for moles is m. 2. How many molecules in 1 mole of CO2? A. 44 B. 6.02 x1023 C. 1 3. Which number is the same as 6 x 103? A. 60300 B. 63000 C. 6000	mole mass amount relative formula mass Avogadro's number
C4.3.3	*(HT) Calculating moles*	*number of moles = mass ÷ relative formula mass* *The mass of a substance can be calculated from the number of moles, using the relative formula mass* *The equation number of moles = mass ÷ relative formula mass can be rearranged to mass = number of moles x relative formula mass*	4.3.2.1/5.3.2.1	Recall the equation linking mass, Mr and number of moles. Convert amounts of substance in mol to their mass, given the Mr. Calculate the amount of substance in a given mass, in mol.	(C3.2) Relative atomic mass has the symbol Ar (C3.2) 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 (C3.2) Relative formula mass has the symbol Mr (C3.1) The mass number of an element is equal to the number of neutrons + protons in the nucleus of an atom of that element			Students mght calculate molar mass by dividing or multiplying the total of atomic masses by the coefficient shown in the chemical equation. The idea of proportionality can be introduced by showing a reaction in with "2As" make "1C". Students are asked what would be produced if only "1A" was available. Once the idea that reactions occur in proportion was developed, Rowell and Dawson introduce the idea that the number of particles involved might be very large. At this point, they return to their original reaction and ask students to imagine that these are atoms of chemical elements. The conservation of number of atoms and masses are emphasised at each point (Source: https://edu.rsc.org/download?ac=15564). 1. Show students elements in a whole-number mass ratio Have ready pre-weighed samples of familiar chemical elements and compounds clearly labelled with symbols, formulae and Ar / Mr values. Include two elements with Ar values in a simple whole number ratio – copper (assume Ar = 64) and sulfur (Ar= 32)are good examples. Start two columns on a board, one for each element, writing the symbol at the top of each and the Ar value then the ratio (2:1) underneath. Ask students to imagine one atom of each element and to state what the ratio of the masses will be (2:1). This is easy! Next ask if it is possible to weigh one atom conventionally. The answer is no. Explain that chemists need to be able to compare masses that can be measured easily. 2. Show that the ratio remains fixed, regardless of the number of atoms.Extend the columns by writing increasingly large numbers of atoms - the number could be written once for both columns, or separately in each. The numbers should go up to 1	1. What is the relative formula mass of NO2? (Ar: N = 14; O = 16) A. 30 B. 44 C. 46 2. What is the mass of 0.02 mol of Na2CO3? (Mr: 106) A. 2.12 g B. 21.2 g C. 5 300 g 3. What is the amount of substance in 26.5 g of Na2CO3? (Mr: 106) A. 4 mol B. 0.25 mol C. 2 809 mol	mole mass amount relative formula mass Avogadro's number
C4.3.4	Prior Knowledge Review: 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	4.3.2.5/5.3.2.5	Define concentration. Convert between cm3 and dm3. Calculate concentration from a given mass and volume	(C3.2) Many chemical reactions take place in solutions (C3.2) The concentration of a solution tells you how much solute is dissolved in a given volume of solution (C3.2) Concentration can be defined as the mass of solute per unit volume of solvent. (C3.2) Volume means the amount of space that a substance takes up, and can be measured in cm3, dm3, m3, L or mL. (C3.2) 1 dm3 is equal to 1 L and equal to 1000 cm3 (C3.2) To convert from dm3 to cm3 the number should be multiplied by 1000 (C3.2) To convert from cm3 to dm3 the number should be divided by 1000 (C3.2) 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)	97. Use SI units (eg kg, g, mg; km, m, mm; kJ, J) and IUPAC chemical nomenclature unless inappropriate.			1. Select the answer below which is equal to 0.05 dm3. A. 500 cm3 B. 50 cm3 C. 0.00005 cm3 2. 10 g of a solute was used to make a solution with a volume of 25 dm3. What was the concentration of the solution? A. 250 g/dm3 B. 0.4 g/dm3 C. 2.5 g/dm3 3. 200 cm3 of a solution has a concentration of 25 g/cm3. What mass of solute was dissolved in it? A. 5000 g B. 125 g	mass volume concentration solute solution
C4.3.5	Taking it Further: Calculating Concentration	The concentration of a solution can be measured in mol/dm3 The amount in moles of solute or the mass in grams of solute in a given volume of solution can be calculated from its concentration in mol/dm3 The concentration of a solution in mol/dm3 is related to the mass of the solute and the volume of the solution.	4.3.4	Calculate concentration in mol/dm3. Calculate the mass of solute from a concentration in mol/dm3. Explain how the concentration of a solution is related to the mass of solute and the volume of the solution.	(C3.2) Many chemical reactions take place in solutions (C3.2) The concentration of a solution tells you how much solute is dissolved in a given volume of solution (C3.2) Concentration can be defined as the mass of solute per unit volume of solvent. (C3.2) Volume means the amount of space that a substance takes up, and can be measured in cm3, dm3, m3, L or mL. (C3.2) 1 dm3 is equal to 1 L and equal to 1000 cm3 (C3.2) To convert from dm3 to cm3 the number should be multiplied by 1000 (C3.2) To convert from cm3 to dm3 the number should be divided by 1000 (C3.2) 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) (C3.2) The mass in grams of solute in a given volume of solution can be calculated from its concentration in g/dm3 (C3.2) The mass in grams of solute in a given volume of solution can be calculated from its concentration in g/dm3				1. Calculate the concentration of a 750 cm3 solution that contains 1.5 mol of solute. A. 1.5 mol/dm3 B. 0.02 g/dm3 C. 2 mol/dm3 2. Calculate the number of moles in 2 dm3 of 0.5 mol/dm3 solution. A. 4 mol B. 1 mol C. 0.25 mol 3. 80 g of sodium hydroxide (Mr = 40) is dissolved in solution. How many moles of solute are in the solution? A. 2 mol B. 0.5 mol C. 3200 mol	mass volume concentration moles solution
C4.3.6	Taking it Further: Calculating Unknown Concentrations	If the volumes of two solutions that react completely are known and the concentration of one solution is known, the concentration of the other solution can be calculated.	4.3.4	Deduce the molar ratio of acid: alkali in a neutralisation reaction Use molar ratio to calculate the number of moles of acid that react with a known number of moles of alkali Calculate the concentration of one reactant in a neutralisation reaction, when the concentration and volume of the other reactant is known.	(C3.2) Many chemical reactions take place in solutions (C3.2) The concentration of a solution tells you how much solute is dissolved in a given volume of solution (C3.2) Concentration can be defined as the mass of solute per unit volume of solvent. (C3.2) Volume means the amount of space that a substance takes up, and can be measured in cm3, dm3, m3, L or mL. (C3.2) 1 dm3 is equal to 1 L and equal to 1000 cm3 (C3.2) To convert from dm3 to cm3 the number should be multiplied by 1000 (C3.2) To convert from cm3 to dm3 the number should be divided by 1000 (C3.2) 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) (C3.2) The mass in grams of solute in a given volume of solution can be calculated from its concentration in g/dm3 (C3.2) The mass in grams of solute in a given volume of solution can be calculated from its concentration in g/dm3	97. Use SI units (eg kg, g, mg; km, m, mm; kJ, J) and IUPAC chemical nomenclature unless inappropriate.			1. What is the equation that links concentration, number of moles and volume? A. Concentration = (number of moles)/volume B. Number of moles = concentration/volume C. Concentration =number of moles × volume 2. Calculate the number of moles in 100 cm3 of 0.2 mol/dm3 solution. A. 20 mol B. 2 mol C. 0.02 mol 3. Sodium hydroxide reacts with hydrochloric acid: NaOH + HCl □ NaCl + H2O What is the mole ratio of alkali to acid in this reaction? A. 1:1 B. 4:2 C. Need more information	mass volume concentration moles molar ratio

C4.3.7	*(HT) Amounts of Substances in Equations*	*The masses of reactants and products can be calculated from balanced symbol equations. Chemical equations can be interpreted in terms of moles. For example: $Mg + 2HCl$ $MgCl_2 + H_2$ shows that one mole of magnesium reacts with two moles of hydrochloric acid to produce one mole of magnesium chloride and one mole of hydrogen gas. The balancing numbers in a symbol equation can be calculated from the masses of reactants and products by converting the masses in grams to amounts in moles and converting the numbers of moles to simple whole number ratios.*	4.3.2.2/5.3.2.2 4.3.2.3/5.3.2.3	Describe chemical reactions in terms of number of moles Calculate number of moles in reactions Calculate masses of reactants or products from balanced symbol equations	(C3.2) Mass is always conserved in chemical reactions (C3.2) In a chemical reaction where a gas is produced, it may appear that the mass decreases throughout the reaction. (C3.2) 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 (C3.2) In a chemical reaction where a gas in a reactant, it may appear that the total mass increases (C3.2) 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 (C3.2) A subscript number within a chemical formula only applies to the part of the formula directly next to it on the left. (C3.2) A coefficient is a 'big' number placed to the left of a chemical formula (C3.2) A coefficient applies to the element or whole compound beside which it is placed (C3.2) Balancing an equation is the action of changing the coefficients of a chemical equation so that the equation reflects the Law of Conservation of Mass (C3.1) 81. Recognise and use expressions in standard form.	78. a. Measurements are affected by random error due to results varying in unpredictable ways; these errors can be reduced by making more measurements and reporting a mean value. b. Measurements can also be affected by systematic error. 97. Use SI units (eg kg, g, mg; km, m, mm; kJ, J) and IUPAC chemical nomenclature unless inappropriate.	Optional practicals: Finding the formula of magnesium oxide http://science.cleapss.org.uk/Resource/PP063-Finding-the-Formula-of-Magnesium-Oxide.pdf Finding the percentage water in a hydrated salt http://science.cleapss.org.uk/Resource/PP039-Finding-the-water-in-a-hydrated-salt.pdf		$2 Mg + O_2 \rightarrow 2 MgO$ 1. 12 g of magnesium burns in oxygen. Calculate the number of moles of magnesium that reacted. A. 12 mol B. 2 mol C. 0.5 mol 2. Calculate the number of moles of oxygen that would have reacted. A. 1.0 mol B. 0.5 mol C. 0.25 mol 3. Calculate the mass of oxygen that would have reacted. A. 4 g B. 8 g C. 128 g	mass moles Mr mole ratio
C4.3.8	*(HT) Limiting Reactants*	*A reaction finishes when one of the reactant is all used up. The other reactant has nothing left to react with, so some of it is left over The reactant that is completely used up is called the limiting reactant because it limits the amount of products. The reactant that is left over is described as being in excess In a chemical reaction involving two reactants, it is common to use an excess of one of the reactants to ensure that all of the other reactant is used. The mass of a product formed in a reaction depends upon the mass of the limiting reactant The maximum mass of a product formed in a reaction can be calculated using the balanced equation, the mass of the limiting reactant and the relative formula mass of the limiting reactant and the product*	4.3.2.4/5.3.2.4	Calculate number of moles in reactions Use calculations to identify limiting reactants Calculate masses of products	(C3.2) Mass is always conserved in chemical reactions (C3.2) In a chemical reaction where a gas is produced, it may appear that the mass decreases throughout the reaction. (C3.2) 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 (C3.2) In a chemical reaction where a gas in a reactant, it may appear that the total mass increases (C3.2) 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 (C3.2) A subscript number within a chemical formula only applies to the part of the formula directly next to it on the left. (C3.2) A coefficient is a 'big' number placed to the left of a chemical formula (C3.2) A coefficient applies to the element or whole compound beside which it is placed (C3.2) Balancing an equation is the action of changing the coefficients of a chemical equation so that the equation reflects the Law of Conservation of Mass			When given masses of reactants and products for a particular reaction, and asked to preduct the mass of products when a different reacting mass was provided, many students just added the two reactant figures, and had not realised the need to apply reacting mass reasoning.	$2 Mg + O_2 \rightarrow 2 MgO$ 48 g of magnesium burns in 100 g of oxygen. 1. Calculate the number of moles of magnesium present. A. 0.5 mol B. 1 mol C. 2 mol 2. Calculate the number of moles of oxygen present. A. 6.25 mol B. 3.125 mol C. 0.32 mol 3. Which is the limiting reactant? A. Mg B. O_2 C. MgO	mass moles Mr mole ratio limiting reactant
C4.3.9	Prior Knowledge Review: Acid Reactions	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.		Write word equations for reactions with acids. Use reactants to name salts. Predict the products of chemical reactions.	(C4.2) Acids react with some metals to produce salts and hydrogen. (C2.2) The chemical formula for hydrochloric acid is HCl (C2.2) The chemical formula for nitric acid is HNO_3 (C2.2) The chemical formula for sulphuric acid is H_2SO_4 (C2.2) Acids react with some metals to produce salts and hydrogen gas (C2.2) Acids are neutralised by alkalis (e.g. soluble metal hydroxides) and bases (e.g. insoluble metal hydroxides and metal oxides) to produce salts, water and carbon dioxide (C2.2) Alkalis and bases can be metal oxides or metal hydroxides				1. Name the salt that would be produced when hydrochloric acid reacted with potassium hydroxide. A. Potassium hydride B. Potassium chloride C. Potassium chlorine 2. The products of which reaction would give a positive squeaky pop test? A. Nitric acid + calcium oxide B. Nitric acid + calcium carbonate C. Nitric acid + calcium 3. Which of these is not a neutralisation reaction? A. Acid + metal B. Acid + metal hydroxide C. Acid + metal carbonate	acid base alkali neutralisation chemical formula
C4.3.10	Acids, Alkalis and Neutralisation	Acids produce hydrogen ions (H^+) in aqueous solutions. Aqueous solutions of alkalis contain hydroxide ions (OH^-). The pH scale, from 0 to 14, is a measure of the acidity or alkalinity of a solution, and can be measured using universal indicator or a pH probe. A solution with pH 7 is neutral. Aqueous solutions of acids have pH values of less than 7 and aqueous solutions of alkalis have pH values greater than 7. In neutralisation reactions between an acid and an alkali, hydrogen ions react with hydroxide ions to produce water. A neutralisation reaction can be represented by the equation $H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$	4.4.2.4/5.4.2.4	Use the pH scale to identify acids and alkalis Identify ions produced by acids and alkalis in solution Describe what happens in a neutralisation reaction	(C4.2) Acids react with some metals to produce salts and hydrogen. (C2.2) The chemical formula for hydrochloric acid is HCl (C2.2) The chemical formula for nitric acid is HNO_3 (C2.2) The chemical formula for sulphuric acid is H_2SO_4 (C2.2) Acids react with some metals to produce salts and hydrogen gas (C2.2) Acids are neutralised by alkalis (e.g. soluble metal hydroxides) and bases (e.g. insoluble metal hydroxides and metal oxides) to produce salts, water and carbon dioxide (C2.2) Alkalis and bases can be metal oxides or metal hydroxides (C4.2) An ion is a charged atom or group of atoms			Many students have more difficulty naming or recognising bases, compared to naming acids. ""Neutralisation means an acid is breaking down""	1. Identify the ion that is produced by acids in aqueous solutions. A. H^+ B. OH^- C. H_2O 2. Name the salt that would be produced when sulfuric acid reacts with lithium hydroxide? A. Lithium hydride B. Lithium sulfide C. Lithium sulfate 3. What is the correct ionic equation when an acid is neutralised by an alkali? A. $H_2O \rightarrow H^+ + OH^-$ B. $H + OH \rightarrow H_2O$ C. $H^+ + OH^- \rightarrow H_2O$	acid alkali neutralisation hydrogen ion hydroxide ion
C4.3.11/C4.3.12	Taking it Further: Acid Alkali Titration Required Practical	The volumes or concentrations of acid and alkali solutions that react with each other can be measured by titration using a suitable indicator. A titration is an example of quantitative analysis. A pipette is used to accurately measure a certain volume of acid or alkali A pipette filler is used to fill the pipette safely A conical flask is used to contain the liquid from the pipette. A burette is used to add small, measured volumes of one reactant to the other reactant in the conical flask Before starting the titration, the burette should be rinsed with the solution it is going to contain and clamped vertically. Once filled the tap should be flushed to remove any air bubbles. Only a few drops of indicator should be added to conical flask. This is because many indicators are weak acids or alkalis, and too much would affect the outcome of the titration. The indicator shows by a colour change when all of the alkali in the conical flask has been neutralised. This is called the end point. A white tile is placed under the conical flask so that any colour change can be seen clearly An appropriate indicator to use for an acid-alkali titration is phenolphthalein. Phenolphthalein is pink in alkaline solutions and colourless in acidic solutions The difference between the burette reading at the start and the reading at the end of the titration gives the volume of acid (or alkali) added. This volume is called a titre. The first titre is usually ignored, as it is a rough result. Results that are within 0.2cm^3 of each other are called concordant results. Multiple titrations are usually carried out, and an average (mean) titre is calculated for any that are within 0.2 cm^3 of each other.	4.4.2.5	Describe a method to carry out a titration Identify concordant results Explain the most appropriate apparatus to use for a given function	(C4.2) Acids react with some metals to produce salts and hydrogen. (C2.2) The chemical formula for hydrochloric acid is HCl (C2.2) The chemical formula for nitric acid is HNO_3 (C2.2) The chemical formula for sulphuric acid is H_2SO_4 (C2.2) Acids react with some metals to produce salts and hydrogen gas (C2.2) Acids are neutralised by alkalis (e.g. soluble metal hydroxides) and bases (e.g. insoluble metal hydroxides and metal oxides) to produce salts, water and carbon dioxide (C4.3) Alkalis and bases can be metal oxides or metal hydroxides (C4.3) Acids produce hydrogen ions (H^+) in aqueous solutions. (C4.3) Aqueous solutions of alkalis contain hydroxide ions (OH^-). (C4.3) The pH scale, from 0 to 14, is a measure of the acidity or alkalinity of a solution, and can be measured using universal indicator or a pH probe. (C4.3) A solution with pH 7 is neutral. Aqueous solutions of acids have pH values of less than 7 and aqueous solutions of alkalis have pH values greater than 7. (C4.3) In neutralisation reactions between an acid and an alkali, hydrogen ions react with hydroxide ions to produce water. (C4.3) A neutralisation reaction can be represented by the equation $H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$	43. Use of appropriate qualitative reagents and techniques to analyse and identify unknown samples or products including gas tests, flame tests, precipitation reactions, and the determination of concentrations of strong acids and strong alkalis 44. Preparation of a pure dry sample of a soluble salt 23. Measure volumes of liquids accurately 97. Use SI units (eg kg, g, mg; km, m, mm; kJ, J) and IUPAC chemical nomenclature unless inappropriate. 77. Apply the following ideas to evaluate data to suggest improvements to procedures and techniques. a. An accurate measurement is one that is close to the true value. b. Measurements are precise if they cluster closely. c. Measurements are repeatable when repetition, under the same conditions by the same investigator, gives similar results. d. Measurements are reproducible if similar results are obtained by different investigators with different equipment. 73. Apply the idea that whenever a measurement is made, there is always some uncertainty about the			1. What is the end point of a titration? A. When the acid/alkali has been completely neutralised B. When all of the acid/alkali has been used up C. The volume used to complete the titration 2. Which explains why an indicator such as phenolphthalein is used for titration rather than Universal Indicator? A. It has an obvious colour change B. It speeds up the reaction C. It is cheaper and easier to obtain 3. Which is the most appropriate piece of apparatus to measure a volume of 25 cm^3? A. A measuring cylinder B. A conical flask C. A pipette	acid alkali titration neutralisation titre concordant phenolphthalein
C4.3.13	Taking it Further: Titration Calculations	The chemical quantities can be calculated in titrations involving concentrations in mol/dm^3 and in g/dm^3.	4.4.2.5	Explain the purpose of a titration. Use the equation that links concentration, volume and amount of substance. Use mole ratios to calculate an unknown concentration.					1. What is the purpose of a titration? A. To determine an unknown concentration B. To determine how long it takes for an acid to react with an alkali C. To produce a neutralisation reaction 2. What is the function of an indicator in a titration? A. To signify the end point of a titration B. To speed up the titration C. To show the concentration of a substance 3. What is the concentration of 25 cm^3 sodium hydroxide solution that neutralises 20 cm^3 of 0.2 mol/dm^3 hydrochloric acid solution? The equation for the reaction is: $NaOH + HCl \rightarrow NaCl + H_2O$ A. 0.004 mol/dm^3 B. 0.00001 mol/dm^3 C. 0.16 mol/dm^3	acid alkali titration neutralisation titre concentration moles
C4.3.14	*(HT) Strong and Weak Acicds*	*A strong acid is completely ionised in aqueous solution. This means that the acid splits up into its ions. Another word for ionised is dissociated. Examples of strong acids are hydrochloric, nitric and sulfuric acids. A weak acid is only partially ionised in aqueous solution. Examples of weak acids are ethanoic, citric and carbonic acids. The higher the concentration of H^+ ions in a solution, the lower the pH The lower the concentration of H^+ ions in a solution, the higher the pH The higher the concentration of OH^- ions in an alkaline solution, the higher the pH For a given concentration of aqueous solutions, the stronger an acid, the lower the pH. As the pH decreases by one unit, the hydrogen ion concentration of the solution increases by a factor of 10. In a dilute acid, the acid molecules are mixed with a large volume of water, so there is a low concentration of H^+ ions In a concentrated acid, little or no water molecules are mixed with the acid molecules. This means the concentration of H^+ ions is high.*	4.4.2.6/5.4.2.5	Explain the difference between a strong acid and weak acid. Explain the factors that affect pH of an acid. Explain the difference between strength and concentration.	(C4.3) Acids produce hydrogen ions (H^+) in aqueous solutions. (C4.3) Aqueous solutions of alkalis contain hydroxide ions (OH^-). (C4.3) The pH scale, from 0 to 14, is a measure of the acidity or alkalinity of a solution, and can be measured using universal indicator or a pH probe. (C4.3) A solution with pH 7 is neutral. Aqueous solutions of acids have pH values of less than 7 and aqueous solutions of alkalis have pH values greater than 7. (C4.3) In neutralisation reactions between an acid and an alkali, hydrogen ions react with hydroxide ions to produce water. (C4.3) A neutralisation reaction can be represented by the equation $H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$			""Hydrogen ions are present in acids, but acids remain molecular in solution"" Students might confuse weak and dilute, and strong and concentrated. It should help that students have recently studied concentration. Sequential 1:10 dilutions of a strong acid, strong base, weak acid and a weak base will allow the pH change to be showed for each dilution (change of 1 pH). A strong acid or base will require more dilutions to reach the same pH value. Teachers often adopt the simplistic description of the mole as a counting unit. The mole is not strictly defined as a number, but rather a an amount of substance corresponding to a number of atoms, ions or particles.	1. What is a strong acid? A. An acid that contains lots of solute per unit volume B. An acid that has lots of H^+ ions C. An acid that fully dissociates in solution 2. Which of these is not a strong acid? A. Hydrochloric acid B. Sulfuric acid C. Ethanoic acid 3. Which of these will have the lowest pH? A. 1 mol/dm^3 ethanoic acid B. 1 mol/dm^3 hydrochloric acid C. 2 mol/dm^3 hydrochloric acid	acid strong weak concentrated dilute ionise dissociate

C4.3.15	Taking it Further: Volumes of Gases	Equal amounts in moles of gases occupy the same volume under the same conditions of temperature and pressure. Room temperature is $20^{\circ}C$ Room pressure is 1 atmosphere Rtp' means 'at room temperature and pressure' The volume of one mole of any gas at room temperature and pressure is 24 dm3 This volume (24 dm3) is called the molar volume of a gas The volume of gas at rtp = number of moles x 24 The volumes of gaseous reactants and products can be calculated from the balanced equation for the reaction. The volume of a gas at room temperature and pressure can be calculated from its mass and relative formula mass	4.3.5	State the volume of 1 mole of gas at room temperature and pressure. Calculate the volume of different numbers of moles of a gas. Use chemical equations to calculate volume and number of moles of gas		98. Relate derived quantities with the formulae to calculate those quantities 97. Use SI units (eg kg, g, mg; km, m, mm; kJ, J) and IUPAC chemical nomenclature unless inappropriate.			1. What is the volume of one mole of gas at rtp? A. 22 dm3 B. 24 dm3 C. 6.02 x 1023 dm3 2. Calculate the number of moles in 0.12 dm3 carbon dioxide gas at rtp. A. 0.0027 mol B. 0.005 mol C. 200 mol 3. What two factors must remain constant for 1 mole of two different gases to have the same volume? A. Temperature and pressure B. Temperature and mass C. Pressure and mass	volume mole molar volume rtp pressure temperature