# Scheme of work

## Chemistry – Quantitative chemistry

This resource provides guidance for teaching the Quantitative chemistry topic from our new GCSE Chemistry (8462). It has been updated from the draft version to reflect the changes made in the accredited specification. In particular, 4.3.1.4 is new.

The scheme of work is designed to be a flexible medium term plan for teaching content and development of the skills that will be assessed.

It is provided in Word format to help you create your own teaching plan – you can edit and customise it according to your needs. This scheme of work is not exhaustive; it only suggests activities and resources you could find useful in your teaching.

### 4.3 Quantitative chemistry

### 4.3.1 Conservation of mass and the quantitative interpretation of chemical equations

| **Spec ref.** | **Summary of the specification content** | **Learning outcomes**  *What most candidates should be able to do* | **Suggested timing (hours)** | **Opportunities to develop Scientific Communication skills** | **Opportunities to develop and apply practical and enquiry skills** | **Self/peer assessment opportunities and resources**  *Reference to past questions that indicate success* |
| --- | --- | --- | --- | --- | --- | --- |
| 4.3.1.1 | 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. | Understand the use of the multipliers in equations in normal script before a formula and in subscript within a formula.  WS 1.2 | 2 | Explain the meaning of the law of conservation.  Write simple word equations.  Write simple symbol equations.  Balance symbol equations.  Extended writing:describe the equations given in terms of number of moles, reactants and products.  Grade 9:balance complex equations and add state symbols. | Model the law of conservation using molecular model kits.  Lego or Duplo bricks can be used to good effect.  Teacher demonstration.  The precipitation reaction:  can be performed on a balance. No change in total mass but obvious yellow precipitate observed. | Video clips:  [BBC Bitesize Conservation of mass in chemical reactions](http://www.bbc.co.uk/education/clips/z8rtfg8)  YouTube:  [The law of conservation of mass](https://www.youtube.com/watch?v=2S6e11NBwiw)  [Law of Conservation of Mass Experiment](https://www.youtube.com/watch?v=mcnga-bbNXk) |
| 4.3.1.2 | The relative formula mass (*M*r) of a compound is the sum of the relative atomic masses of the atoms in the numbers shown in the formula.  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. | Use relative atomic masses in the calculations specified in the subject content.  Be able to calculate the relative formula mass (*M*r) of a compound from its formula, given the relative atomic masses. | 1 | Review the definition of relative atomic mass.  Recall how to find the relative atomic mass from the Periodic Table.  Define the relative molecular mass.  Extended writing:write instructions to another student how to calculate the relative formula mass. | 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. | [Exampro user guide PowerPoint](http://filestore.aqa.org.uk/resources/science/AQA-GCSE-SCIENCE-EXAMPRO-UG.PPTX) |
| 4.3.1.3 | Some reactions may appear to involve a change in mass but this can usually be explained because a reactant or product is a gas and its mass has not been taken into account. For example: when a metal reacts with oxygen the mass of the oxide produced is greater than the mass of the metal or in thermal decompositions of metal carbonates carbon dioxide is produced and escapes into the atmosphere leaving the metal oxide as the only solid product. | Students should be able to explain any observed changes in mass in non-enclosed systems during a chemical reaction given the balanced symbol equation for the reaction and explain these changes in terms of the particle model.  WS 1.2 | 1 | Extended writing: use measurements of mass before and after an experiment to explain what has happened to the mass during the experiment and why it has happened. | Use magnesium ribbon to produce magnesium oxide. Measure the mass of the ribbon at the start of the experiment, burn the ribbon in a strong Bunsen flame (SAFETY required) and measure the mass of the ribbon at the end of the experiment.  Use HCl acid in a conical flask with CaCO3. Measure the mass of the reaction on a top pan balance as the reaction proceeds over two minutes.  Demonstrate combustion of paper in a large beaker to show mass may decrease because products are released to the air as gases.  Try balancing iron wool on a pair of scales (a makeshift one can be set up using a carefully balanced metre rule). Heat the iron wool strongly to observe the increase in mass of the oxide. | Video clip  YouTube:  [BBC Chemical reactions](https://www.youtube.com/watch?v=6td9NZ-YRjE)  Burning iron wool experiment at 7 minutes in. |
| 4.3.1.4 | Whenever a measurement is made there is always some uncertainty about the result obtained. | Represent the distribution of results and make estimations of uncertainty.  Use the range of a set of measurements about the mean as a measure of uncertainty. WS 3.4. | 0.5 |  | Class thiosulfate ‘disappearing cross’ experiment at a single fixed concentration using (a) pre-printed computer generated crosses (b) hand drawn crosses using different pens/pencils. |  |

**4.3.2 Use of amount of substance in relation to masses of pure substances**

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| --- | --- | --- | --- | --- | --- | --- |
| 4.3.2.1  (HT only) | Chemical amounts are measured in moles. The symbol for the unit mole is mol.  The mass of one mole of a substance in grams is 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. | Understand that the measurement of amounts in moles can apply to atoms, molecules, ions, electrons, formulae and equations, for example that in one mole of carbon (C) the number of atoms is the same as the number of molecules in one mole of carbon dioxide (CO2).  Be able to use the relative formula mass of a substance to calculate the number of moles in a given mass of that substance and vice versa.  WS 4.1, 4.2, 4.3, 4.5, 4.6  MS 1a, 1b, 2a, 3b, 3c | 1 | Define one mole in terms of *M*r and *A*r  Calculate the number of moles in a substance using the relative formula mass.  Extended writing:write instructions to another student how to calculate the number of moles using the relative formula mass | Measure out and compare 1 mole of elements like iron, sulfur, magnesium, copper, aluminium and so on.  Measure out and compare one mole of common compounds, water, sodium chloride, calcium carbonate and so on. | Video clips  YouTube:  [What is a mole?](https://www.youtube.com/watch?v=UI4SSAgYy_s)  [Avogadro’s number – The mole](https://www.youtube.com/watch?v=3Cq1Std7Mb8) |
| 4.3.2.2  (HT only) | The masses of reactants and products can be calculated from balanced symbol equations.  Chemical equations can be interpreted in terms of moles. For example:  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. | Calculate the masses of substances shown in a balanced symbol equation.  Calculate the masses of reactants and products from the balanced symbol equation and the mass of a given reactant or product.  MS 1a, 1c, 3b, 3c | 1 | Balance chemical equations and use these to calculate the masses of substances present.  Extended writing:write instructions to another student use balanced chemical equations to calculate the masses of substances present. |  | Video clip  YouTube:  [Calculating Masses in Reactions](https://www.youtube.com/watch?v=6KRcO3e36ZU) |
| 4.3.2.3  (HT only) | 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. | Be able to balance an equation given the masses of reactants and products.  Change the subject of a mathematical equation.  MS 3b, 3c | 1 | Use the masses of substances present in a reaction to write a balanced equation. |  |  |
| 4.3.2.4  (HT only) | 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 reactant that is completely used up is called the limiting reactant because it limits the amount of products. | Be able to explain the effect of a limiting quantity of a reactant on the amount of products it is possible to obtain in terms of amounts in moles or masses in grams.  WS 4.1 | 0.5 | Define the term limiting reactant.  Link the limiting reactant to the number of moles.  Link the limiting reactant to the masses in grams. | Use a small strip of magnesium ribbon in 20 ml HCl acid. Identify which reactant is the limiting reactant and state the reason for this choice. |  |
| 4.3.2.5 | Many chemical reactions take place in solutions. The concentration of a solution can be measured in mass per given volume of solution, eg grams per dm3 (g/dm3). | Calculate the mass of solute in a given volume of solution of known concentration in terms of mass per given volume of solution.  (HT only)  Explain how the mass of a solute and the volume of a solution is related to the concentration of the solution  MS 1c, 3c | 0.5 | Explain the meaning of concentration and the unit grams per dm3  Be able to convert cm3 into dm3.  Use the equation:    to calculate the concentration of a solution.  Rearrange the equation:    to make mass the subject.  Extended writing:write instructions to another student on how to calculate the concentration, or how to rearrange the equation to calculate mass.  Discuss the differences of the word ‘concentration’ and ‘strength’ in science and everyday language. | To demonstrate the idea of concentration students could make different concentrations of tea, coffee or a dark squash like blackcurrant.  Students often confuse the concept of ‘concentration’ with ‘strength’. | Video clip  YouTube:  [Concentration formula and calculations](https://www.youtube.com/watch?v=XCX0PkZdUjM) |

### 4.3.3 Yield and atom economy of chemical reactions

| **Spec ref.** | **Summary of the specification content** | **Learning outcomes**  *What most candidates should be able to do* | **Suggested timing (hours)** | **Opportunities to develop Scientific Communication skills** | **Opportunities to develop and apply practical and enquiry skills** | **Self/peer assessment opportunities and resources**  *Reference to past questions that indicate success* |
| --- | --- | --- | --- | --- | --- | --- |
| 4.3.3.1 | Even though no atoms are gained or lost in a chemical reaction, it isn’t always possible to obtain the calculated amount of a product because:   * the reaction may not go to completion because it is reversible * some of the product may be lost when it is separated from the reaction mixture * some of the reactants may react in ways different to the expected reaction.   The amount of a product obtained is known as the yield. When compared with the maximum theoretical amount as a percentage, it is called the percentage yield. | Calculate the percentage yield of a product from the actual yield of a reaction.  (HT only)  Calculate the theoretical amount of a product from a given amount of reactant and the balanced equation for the reaction.  WS 4.2, 4.6  MS 1a, 1c, 2a, 3c | 1 | Describe how atoms are lost or gained in a chemical reaction.  Explain why atoms can be lost or gained in a chemical reaction.  Calculate the theoretical yield for simple examples.  Extended writing: write instructions to another student how to calculate the theoretical yield giving explained examples. | Use Lego as a model for chemical reactions demonstrating the loss of product and use the model as a simple introduction to yield calculations.  The same can be applied to atom economy. | Video clips  YouTube:  [Theoretical yield and losses](https://www.youtube.com/watch?v=3QNKmMNO5wA)  [Percentage yield](https://www.youtube.com/watch?v=pFmCn-cwOW8) |
| 4.3.3.2 | The atom economy (atom utilisation) is a measure of the amount of starting materials that end up as useful products. It is important for sustainable development and for economic reasons to use reactions with high atom economy.  The percentage atom economy of a reaction is calculated using the balanced equation for the reaction as follows: | Calculate the atom economy of a reaction to form a desired product from the balanced equation.  (HT only)  Explain why a particular reaction pathway is chosen to produce a specified product given appropriate data such as atom economy (if not calculated), yield, rate, equilibrium position and usefulness of by-products.  WS 4.1, 4.2  MS 1a, 1c, 3c | 1 | Calculate the atom economy for simple examples.  Extended writing: write instructions to another student how to calculate the atom economy giving explained examples. | Identify a chemical reaction that has a high atom economy and research the positives to industry of producing a high yield of useful product.  Identify a chemical reaction that has a low atom economy and research the negatives to industry of producing a low yield of useful product and ways the reactions has been improved to increase the yield of useful product. | Video clip  YouTube:  [What is the Atom Economy?](https://www.youtube.com/watch?v=Zuyk4hfbjSA) |

**4.3.4 Using concentrations of solutions in mol/dm3**

| **Spec ref.** | **Summary of the specification content** | **Learning outcomes**  *What most candidates should be able to do* | **Suggested timing (hours)** | **Opportunities to develop Scientific Communication skills** | **Opportunities to develop and apply practical and enquiry skills** | **Self/peer assessment opportunities and resources**  *Reference to past questions that indicate success* |
| --- | --- | --- | --- | --- | --- | --- |
| 4.3.4  (HT only) | 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.  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. | Explain how the concentration of a solution in mol/dm3 is related to the mass of the solute and the volume of the solution.  WS 4.2, 4.3, 4.6  MS 1a, 1c, 3b, 3c | 1 | Explain the meaning of concentration and the unit mol per dm3.  Be able to convert cm3 into dm3.  Use the equation    to calculate the concentration of a solution.  Rearrange the equation    to make number of moles the subject.  Extended writing:write instructions to another student on how to calculate the concentration, or how to rearrange the equation to calculate number of moles  Extended writing: write instructions to another student on how to carry out a titration. Include reasons for using a burette instead of other measuring equipment.  Grade 9:explain why indicators eg methyl orange and phenolphthalein are used instead of Universal indicator. | Titrate HCl with NaOH using an indicator of methyl orange.  Use the titre results and know volumes of NaOH and concentration, to calculate the concentration of the HCl. | Video clip  YouTube:  [Concentration formula and calculations](https://www.youtube.com/watch?v=XCX0PkZdUjM) |

### 4.3.5 Use amount of substance in relation to volume of gases

| **Spec ref.** | **Summary of the specification content** | **Learning outcomes**  *What most candidates should be able to do* | **Suggested timing (hours)** | **Opportunities to develop Scientific Communication skills** | **Opportunities to develop and apply practical and enquiry skills** | **Self/peer assessment opportunities and resources**  *Reference to past questions that indicate success* |
| --- | --- | --- | --- | --- | --- | --- |
| 4.3.5  (HT only) | Equal amounts in moles of gases occupy the same volume under the same conditions of temperature and pressure.  The volume of one mole of any gas at room temperature and pressure (20 °C and 1 atmosphere pressure) is 24 dm3.  The volumes of gaseous reactants and products can be calculated from the balanced equation for the reaction. | Calculate the volume of a gas at room temperature and pressure from its mass and relative formula mass  Calculate volumes of gaseous reactants and products from a balanced equation and a given volume of a gaseous reactant or product.  Change the subject of a mathematical equation.  WS 1.2, 4.1, 4.2, 4.3, 4.6  MS 1a, 1c, 3c, 3d | 0.5 | Recall the equation:  Use the equation:  volume of gas at rtp = number of moles x molar gas volume (24 dm3)  for simple examples.  Extended writing:write instructions to another student on how to calculate the volume of a gas.  Use balanced equations and known volume of reactant/product to calculate the volumes of gaseous reactants/ products. |  | YouTube:  [Molar volumes of gases](https://www.youtube.com/watch?v=UCmYSIjOnUA)  YouTube:  [Calculating gas volume](https://www.youtube.com/watch?v=_CyIgvYNolE) |