# GCSE Science – Schemes of Work

Chemistry

## Unit 3: Chemistry

*The suggested timings relate to the learning outcomes rather than to the activities.

| Spec Reference | Summary of the Specification Content | Learning Outcomes<br><br>*What most candidates should be able to do* | Suggested timing (hours) | ***Opportunities to develop Scientific Communication skills***<br>***Possible activities*** | Opportunities to apply Practical and Enquiry skills | Self/Peer assessment<br>Opportunities & resources<br>*reference to past questions that indicate success Candidates should:* |
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| C3.1 The periodic table. The modern periodic table has been developed from work begun by Newlands and Mendeleev. There are trends in chemical properties within the periodic table linked to how easily the element gains or loses electrons. | | | | | | |
| C3.1.1 The early periodic table | | | | | | |
| a | Newlands, and then Mendeleev, attempted to classify the elements by arranging them in order of their atomic weights. The list can be arranged in a table so that elements with similar properties are in columns, known as Groups. The table is called a periodic table because similar properties occur at | Explain the problems that early scientists encountered when studying the elements<br><br>Evaluate the work of Newlands and Mendeleev in terms of their contributions to the development of the modern periodic table. | 1 | Presenting and writing descriptions and explanations<br><br>What is the periodic table? In groups decide on 5 questions ( use the five 'Ws' Why, What, Where, When and Who). Swap with another group and answer the questions<br><br>Developing argument<br>• What were the strengths and weaknesses of Newlands and Mendeleev's work?<br>• The German chemist Lothar Meyer came up with a table | Developing explanations using ideas and models<br>Use Periodic table cards. To consider different ways to order the elements.<br><br>How did Newlands' organise the elements known to him?<br><br>Why didn't Newlands' ideas gain acceptance?<br><br>How did Mendeleev organise the elements? | Exampro Extra Online Chemistry Activity: The development of the periodic table<br>PPT C3 3.1.1<br>Foundation and Higher tier. (NB Higher questions also about explaining reactivity so could be used along side 3.1.3 |

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| b | regular intervals.<br><br>The early periodic tables were incomplete and some elements were placed in inappropriate groups if the strict order of atomic weights was followed. Mendeleev overcame some of the problems by leaving gaps for elements that he thought had not been discovered. | Explain why scientists regarded a periodic table of the elements first as a curiosity, then as a useful tool and finally as an important summary of the structure of atoms. | | that was almost the same as Mendeleev. Why was Meyer not recognised in the same way as Mendeleev? | What did Mendeleev do to produce a periodic table organised in a repeating pattern?<br><br>Were Mendeleev's predictions correct? | |
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| C3.1.2 The modern periodic table | | | | | | |
| a<br><br>b | When electrons, protons and neutrons were discovered early in the 20th century, the periodic table was arranged in order of atomic (proton) numbers. When this was done, all elements were placed in appropriate groups.<br><br>The modern periodic table can be seen as an arrangement of the elements in terms of their electronic | Link the structure of the periodic table and the electron configuration of the elements<br>Evaluate the modern periodic table as a means of obtaining greater understanding of chemical reactions | 1 | Presenting and writing descriptions and explanations<br>**Describe** the link between electron configuration and periodic table group number?<br>**Explain** why Group 0 are highly unreactive non- metals<br><br>Is the periodic table complete? | **Working critically with secondary evidence**<br><br>Research what Mendeleev predicted about his missing element (Ge), and what was discovered. Mendeleev also suggested other missing elements, which ones were they? and when was the last one discovered? | PPT C3 3.1.2<br>Foundation and Higher tier.<br>**Peer assessment**- present findings of research into the newly named elements Flerovium and Livermorium |

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| | structures. Elements in the same group have the same number of electrons in their highest occupied energy level (outer shell). | | | | | |

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| C3.1.3 Trends with the periodic table | | | | | | |
| a | The elements in Group 1 of the periodic table (known as the alkali metals):<br><br>• are metals with low density (the first three elements in the Group are less dense than water).<br>• react with non-metals to form ionic compounds in which the metal ion carries a charge of +1. The compounds | Describe physical and chemical properties of the Group 1 metals<br><br>Explain the trend in reactivity of the alkali metals<br><br>Explain the trends found within specified periodic table groups | 2 | | Working critically with primary evidence<br>Demo:<br>• Place sodium in water, to obtain ideas of density in water, release of hydrogen and formation hydroxides (revision from Unit 1 if required).<br>• Burn sodium in chlorine gas, show formation of compound, and discuss changes to Group 1 metal and also Group 7 non-metal.<br>• Observe a range of transition metals and | PPT C3 3.1.3<br>Foundation and Higher tier.<br><br>Opportunity for peer |

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| d | are white solids that dissolve in water to form colourless solutions<br>• react with water, releasing hydrogen<br>• form hydroxides that dissolve in water to give alkaline solutions.<br><br>Many transition elements have ions with different charges, form coloured compounds and are useful as catalysts. | Describe the characteristics and uses of transition metals<br><br>Compare the physical properties of group 1 metals and the transition metals | | Presenting and writing descriptions and explanations<br>Transition metals are sometimes described as 'everyday' metals. Is this a good description?<br>Present to the class on the topic- Transition metals – why we need them? | transition metal compounds.<br>Working critically with primary evidence<br>Compare the reaction of transition metals and Group 1 metals in water.<br><br>. | assessment:<br>Choose three transition metals and describe their physical and chemical properties. Explain how these properties link to their uses |

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| c | Compared with the elements in Group 1, transition elements:<br><br>▪ have higher melting points (except for mercury) and higher densities<br>▪ are stronger and harder<br>▪ are much less reactive and so do not react as vigorously with water or oxygen. | | | | | |
| e | The elements in Group 7 of the periodic table (known as the halogens) react | Describe the electronic configuration of the Group 7 halogens<br><br>Explain, using a model of ion | | Presenting and writing descriptions and explanations<br><br>Compare and contrast the elements fluorine, chlorine and iodine. | | Opportunity for peer assessment- After writing questions about chlorine (5Ws) peers |

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| f<br><br>g | with metals to form ionic compounds in which the halide ion carries a charge of .1.<br><br>In Group 7, the further down the group an element is:<br><br>▪ the less reactive the element<br>▪ the higher its melting point and boiling point.<br><br>A more reactive halogen can displace a<br>less reactive halogen from an aqueous solution of its salt. | formation, how a halide ion is formed<br><br>Describe the trends in reactivity and melting and boiling points in group VII<br><br>Use the idea of displacement to explain the relative reactivity of the halogens | | What do you already know about chlorine? Note down as many things as possible<br><br>Presenting and writing descriptions and explanations<br>Write balanced symbol equations for the displacement reactions observed<br><br>Predict what the characteristics of astatine would be and explain these predictions<br>Bromine can be obtained from sea water. Explain how this is possible. | Obtaining and presenting evidence<br>Investigate the reactivity order of the halogens through displacement reactions | evaluate the quality of answers from group work<br><br>Opportunity for peer assessment:<br>Within a group describe and explain where on the periodic table you would find the most reactive group 1 and group 7 elements. Assess |

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| h | HT only<br>The trends in reactivity within groups in the periodic table can be explained because the higher the energy level of the outer electrons:<br><br>▪ the more easily electrons are lost<br>▪ the less easily electrons are gained. | HT only<br>Explain the reactivity trends within both Group 1 and Group 7 in terms of the distance of the outer electron from the central, positively charged nucleus, and the attraction of the nucleus to those outer electrons. | | | | the quality of explanation relating to the movement of electrons |

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| C3.2 Water The water we drink is not pure water because it contains dissolved substances. It should be safe to drink water that has been treated. This means that the water does not contain anything that could cause us harm. Some of the dissolved substances are beneficial to our health but some cause hard water. | | | | | | |
| C3.2.1 Hard and soft water | | | | | | |
| b<br><br><br><br><br><br><br>a | Hard water contains dissolved compounds, usually of calcium or magnesium. The compounds are dissolved when water comes into contact with rocks.<br><br>Soft water readily forms lather with soap.<br>Hard water reacts with soap to form scum and so more soap is needed to form lather.<br>Soapless detergents do not form scum. | Explain how water becomes 'hard'<br><br>Evaluate the effect of both soft and hard water on soap | 1 | Presenting and writing descriptions and explanations<br>What is meant by scum?<br><br>Some waters are hard to lather and produce scum (hard water) some are easy (soft waters). Which metal ions make water hard?<br><br>Write definitions of 'hard water', and 'soft water'.<br><br>Where in England are the hard water areas? Can you explain this pattern? | Obtaining and presenting evidence<br>What causes a furred up kettle?<br>How much soap is needed to make lather? Investigate water samples from different parts of England<br><br>Planning an approach<br>Selecting and managing variables<br>Assessing risk and working safely<br>Given an unknown water sample , plan an experiment to investigate the hardness of the water compared to some known samples. | Exampro Extra Online Practical guide: Investigating hard water. |

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| c<br><br><br><br><br><br><br>d | There are two types of hard water. Permanent hard water remains hard when it is boiled. Temporary hard water is softened by boiling.<br><br>HT only<br>Temporary hard water contains hydrogencarbonate ions ($HCO_3^-$) that decompose on heating to produce carbonate ions which react with calcium and magnesium ions to form precipitates. | Explain the differences between temporary hard water and permanent hard water.<br><br><br><br><br>Explain the chemistry of temporary hard water | | Presenting and writing descriptions and explanations<br>What are stalactites and how do they happen? | Obtaining and presenting evidence<br>Investigation: Refer back to the kettle; why does this happen? Develop and investigate the hypothesis that heating the water produces the furring. Does it occur with all hard waters? | Opportunity of peer assessment:<br>Present to the group an answer to the following question: Is all rain acid rain? |
| e | Using hard water can increase costs | Evaluate the use of commercial water softeners | 1 | Presenting and writing descriptions and explanations | | Opportunity of peer assessment: |

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| | because more soap is needed. When temporary hard water is heated it can produce scale that reduces the efficiency of heating systems and kettles. | Consider and evaluate the environmental, social and economic aspects of water quality and hardness | | How do bath salts soften water?<br>Why do you need to add salt to a dishwasher?<br>Draw an annotated particle diagram to show how an ion-exchange column works<br>Adverts sometime say that calcium is good for teeth, bones and overall good health. Explain how this can be when calcium is a metal which reacts easily with water. | | Write a TV advert for a product similar to Calgon<br><br>Commercials for Calgon can be found on their website at www.calgon.co.uk |
| f | Hard water has some benefits because calcium compounds are good for the development and maintenance of bones and teeth and also help to reduce heart disease. | | | | | |
| g | Hard water can be made soft by removing the | | | | | |

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| | dissolved calcium and magnesium ions. This can be done by:<br>▪ adding sodium carbonate, which reacts with the calcium and magnesium ions to form a precipitate of calcium carbonate and magnesium carbonate<br>▪ using commercial water softeners such as ion exchange columns containing hydrogen ions or sodium ions, which replace the calcium and magnesium | | | | | |

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| | ions when hard water passes through the column. | | | | | |

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| C3.2.2 Purifying water | | | | | | |
| a<br><br><br><br><br>d<br><br><br>b | Water of the correct quality is essential for life. For humans, drinking water should have sufficiently low levels of dissolved salts and microbes.<br><br>Pure water can be produced by distillation.<br><br>Water filters containing carbon, silver and ion exchange resins can remove some dissolved substances from tap water to | Describe how water filters remove dissolved substances from tap water.<br><br>Explain why water quality needs to be controlled<br><br>Explain how water purification is achieved by filtration and chlorination<br><br>Evaluate the economic consequences of high water quality | 2 | Presenting and writing descriptions and explanations<br><br>Complete a flowchart to **describe** and **explain** the process of water purification. Watch video clip or a video on water purification.<br><br>**Discuss** whether all our water supply needs to be of 'drinking quality'? **Explain** whether or not tap water is 'pure'.<br><br>**Describe** how water filters remove dissolved substances from tap water **Explain** why the carbon in charcoal filters is broken into tiny pieces? Microscopic silver is a very effective | Obtaining and presenting evidence<br>Working critically with primary evidence<br>Demonstrate distillation of salt water Key point Economics in terms of energy requirements and vast volumes needed means it is not viable to produce drinking eater from except in extreme circumstances.<br><br>Evaporate the distilled water on a watch glass to dryness to assess how good the product is.<br><br>Watch glass and heating equipment to evaporate some | A video on water purification can be found on www.teachersdomain.org/asset/ess05_vid_h2otreatment<br>PPT C 3 3.2<br>Foundation and Higher tier<br>Opportunity for peer assessment: **Presenting and writing arguments** |

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| c | improve the taste and quality.<br><br>Chlorine may be added to drinking water to reduce microbes and fluoride may be added to improve dental health. | Evaluate the evidence for and against the addition of fluoride to drinking water. | | sterilising agent. Suggest a reason why all of our water supply is not treated in this way.<br>How do 'home filtration' systems work?<br>Explain whether you think they are needed or not.<br><br>Evaluate the economic consequences of high water quality | of the distillate to dryness. | Using the news clip as stimulus, prepare your arguments as to whether fluoride should or should not be added to drinking water<br>http://www.bbc.co.uk/learningzone/clips/tackling-child-tooth-decay-fluoride-in-drinking-water/6031.html |
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| C3.3 Calculating and explaining energy changes<br>Knowing the amount of energy involved in chemical reactions is useful so that resources are used efficiently and economically. It is possible to measure the amount of energy experimentally or to calculate it. | | | | | | |
| C3.3.1 Energy from reactions | | | | | | |
| a | The relative amounts of energy released when substances burn can be measured by simple calorimetry, eg by heating water in a glass or metal container. This method can be used to compare the amount of energy produced by fuels and foods. | Describe how the energy released in chemical reactions can be measured using calorimetry<br><br>Calculate the energy released in chemical reactions | 2 | Presenting and writing descriptions and explanations<br>Use all your senses too **describe** what happens when something burns.<br><br>**Calculate** the energy released in chemical reactions using the equation<br><br>Presentation: **Research** the advantages and disadvantages associated with the burning of different types of fuels in the home. | Selecting and managing variables<br>Assessing risk and working safely<br>Obtaining and presenting evidence<br>Plan, obtain and compare the energy released when:<br>• burning two fuels.<br>• burning different foods<br>Working critically with primary evidence<br>Discuss causes of error in the method, understanding the importance of controling variables. Produce a list saying how to improve the control of | Exampro Extra Online Practical guide: Calculating energy from burning fuels. |

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| b | Energy is normally measured in joules (J). | | | | the identified variables<br>**Working critically with secondary evidence**<br>Use given data to decide which fuel is better for a given purpose | |
| c | The amount of energy produced by a chemical reaction in solution can be calculated from the measured temperature change of the solution when the reagents are mixed in an insulated container. This method can be used for reactions of solids | Represent energy changes on | 1<br><br>1 | | **Obtaining and presenting evidence**<br>Investigate the energy given out in a neutralisation reaction<br>**Working critically with primary evidence**<br>Calculate the energy given out in a neutralisation reaction | Opportunity to assess QWC<br>Research and then present a written explanation about the use of neutralisation reactions in one of the following areas:<br>• maintaining the environment<br>• supporting |

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| | with water or for neutralisation reactions. | energy level diagrams | | | | agriculture<br>• for health reasons |
| d | Simple energy level diagrams can be used to show the relative energies of reactants and products, the activation energy and the overall energy change of a reaction. | | | Developing explanations using ideas and models<br>**Draw** an energy level diagram for a combustion reaction.<br>**Draw** an energy level diagram for a neutralisation reaction<br>Presenting and writing descriptions and explanations<br>Armed forces will often use special packs which will heat up food rations when they are on missions. **Explain** how such flameless heaters might work.<br>**Research** an endothermic reaction and draw an energy diagram for the reaction | Developing explanations using ideas and models<br>Demonstrate a number of exothermic and endothermic reactions. Draw an energy level diagram for each reaction. | Exampro Extra Online Chemistry Activity: Energy level diagrams. |

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| h<br><br><br><br><br>i | Catalysts provide a different pathway for a chemical reaction that has a lower activation energy.<br><br><br><br>Hydrogen can be burned as a fuel in combustion engines:<br><br>*hydrogen + oxygen* □*water*<br><br>It can also be used in fuel cells that produce electricity to power vehicles. | Represent the effect of a catalyst on an energy level diagram. | 1 | Presenting and writing descriptions and explanations<br><br>**Represent** the reaction as an energy level diagram, showing the uncatalysed reaction with high activation energy (hurdle), and the catalysed reaction having a lower activation energy (hurdle) to pass.<br><br>Petrol is a highly flammable fuel that produces explosive vapours. It must be transported, stored and handled with care. Explain to what extent this statement would also apply to hydrogen.<br><br>**Explain** why hydrogen powered cars may need a larger fuel tank than petrol driven cars<br><br>Presenting and writing arguments | Working critically with primary evidence<br>What happens when we use a catalyst? Using a catalyst, eg $MnO_2$ with $H_2O_2$, to demonstrate the effect on therate of reaction.<br>Developing explanations using ideas and models<br>**Discuss:** the idea of activation energy as a hurdle of energy that the reacting particles have to overcome before collisions become reactions (collision theory link here).<br>Applications, Implications and cultural understanding<br>Compare the advantages and disadvantages of using hydrogen to fuel cars compared with other fuels | PPT C3 3.3<br>Foundation and Higher tier<br><br><br><br><br><br><br>Opportunity for peer assessment:<br>Presenting and writing arguments<br>Consider the social, economic and environmental consequences of using fuels |

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| | | | | Consider the social, economic and environmental consequences of using fuels | | |
| f<br><br><br><br><br><br>g | HT only<br>In an exothermic reaction, the energy released from forming new bonds is greater than the energy needed to break existing bonds.<br><br>In an endothermic reaction, the energy needed to break existing bonds is greater than the energy released from forming new bonds. | HT only<br>Describe the energy changes due to bond breaking and bond making during chemical reactions<br><br>Calculate the energy transferred in reactions using supplied bond energies. | 1 | HT only<br>Presenting and writing descriptions and explanations<br><br>Discuss: the need for energy to break the bonds in hydrochloric acid. Draw energy level diagram showing the atoms separated,.<br>I<br><br>Use given data to calculate the energy transferred in reactions.<br>Explain the steps needed in order to make these calculations | Working critically with secondary evidence<br>Why do chemical reactions have energy changes? Use Zinc reacting with hydrochloric acid as example. Make molymods modelsto represent the atoms and molecules in the balanced equation (useful to get student to give you the equation first). | Opportunity for peer assessment:<br>Explore, discuss and give viewpoints on the following:<br>Are endothermic reactions energy thieves? |
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| C3.4 Further analysis and quantitative chemistry A range of chemical tests can be used for the detection and identification of elements and compounds. Titrations can be used to find the amounts of acid or alkali in a solution. | | | | | | |
| C3.4.1 Analysing substances | | | | | | |
| a | Flame tests can be used to identify metal ions. Lithium, sodium, potassium, calcium and barium compounds produce distinctive colours in flame tests:<br><br>▪ lithium compounds result in a crimson flame<br>▪ sodium compounds result in a yellow flame<br>▪ potassium compounds result in a lilac flame<br>▪ calcium | Describe the expected results of flame tests.<br><br>Explain how flame tests can be used to identify metal ions | 1 | Discussion: What is already known by the group about the link between forensic crime and analytical chemistry? Use TV programmes like CSI to elicit what pupils are already aware of.<br><br>Presenting and writing descriptions and explanations<br><br>Explain how flame tests can be used to identify metal ions | Obtaining and presenting evidence<br>Carry out flame tests on named metal ions to find out the flame colouration. Use the technique to identify two unknown compounds. | Opportunity for self assessment. Use a video clip of a firework display to predict the elements contained within the different fireworks |

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| | compounds result in a red flame<br>▪ Barium compounds result in a green flame. | | | | | |
| b<br><br><br><br><br><br><br><br>c | Aluminium, calcium and magnesium ions form white precipitates with sodium hydroxide solution but only the aluminium hydroxide precipitate dissolves in excess sodium hydroxide solution.<br><br>Copper(II), iron(II) and iron(III) ions form coloured precipitates with sodium hydroxide solution. Copper forms a blue | Describe the identification of metal ions using sodium hydroxide solution<br><br><br><br><br><br><br>Describe the expected results of precipitation tests. | 1 | Presenting and writing descriptions and explanations<br><br>Explain how you could use sodium hydroxide solution to distinguish between solutions of magnesium nitrate and aluminium nitrate.<br><br>A laboratory technician is analysing some mineral water to find out if there are any calcium ions present. Should they use a flame test or add sodium hydroxide. Explain the answer. | Obtaining and presenting evidence<br>Adding sodium hydroxide solution to solutions of metal ions and observe what happens after each addition. | |

| Spec Reference | Summary of the Specification Content | Learning Outcomes<br><br>*What most candidates should be able to do* | Suggested timing (hours) | ***Opportunities to develop Scientific Communication skills***<br>***Possible activities*** | Opportunities to apply Practical and Enquiry skills | Self/Peer assessment<br>**Opportunities & resources**<br>*reference to past questions that indicate success Candidates should:* |
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| | precipitate, iron(II) a green precipitate and iron(III) a brown precipitate. | | | | | |
| d<br><br><br><br><br><br>e | Carbonates react with dilute acids to form carbon dioxide. Carbon dioxide produces a white precipitate with limewater. This turns limewater cloudy.<br><br>Halide ions in solution produce precipitates with silver nitrate solution in the presence of dilute nitric acid. Silver chloride is white, | Describe how the presence of carbonate, sulfate and halide ions may be detected<br><br>Interpret and evaluate the results of chemical analyses to identify elements and compounds | 1 | Presenting and writing descriptions and explanations<br><br>Write word, then symbol equations for each reaction observed | Obtaining and presenting evidence<br>Demonstration of effect of acid on carbonates, and limewater test as a revision. Introduction to testing halide and sulfate ions.<br><br>Applications, Implications and cultural understanding<br>What is a barium meal? Find out why patients may be given a barium meal and explain the chemistry behind this technique<br>Working critically with primary/secondary evidence | Opportunity for peer assessment: Safe working practices and risk assessment when carrying out the experiments. |

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| f | silver bromide is cream and silver iodide is yellow.<br><br>Sulfate ions in solution produce a white precipitate with barium chloride solution in the presence of dilute hydrochloric acid. | | | | Explain how silver nitrate solution can be used to detect halide ions.<br>Why does the solution need to be acidified by dilute nitric acid?<br>**Applications, Implications and cultural understanding**<br>Make links between these chemical reactions and traditional film based photography. What can you find out about how these photographs were produced | |
| g | The volumes of acid and alkali solutions that react with each other can be measured by titration using a suitable indicator. | Describe how to carry out a titration involving hydrochloric acid, sodium hydroxide solution and phenolphthalein indicator | 1 | **Presenting and writing descriptions and explanations**<br><br>**Describe** how to carry out a titration involving hydrochloric acid, sodium hydroxide solution and phenolphthalein indicator | **Obtaining and presenting evidence**<br>How much is in the solution?<br>Class titration practical to establish idea that the volumes of acid and alkali can be measured using a suitable indicator. | PPT 3.4 Foundation and Higher tier<br>Q2 F gives opportunities for developing QWC |

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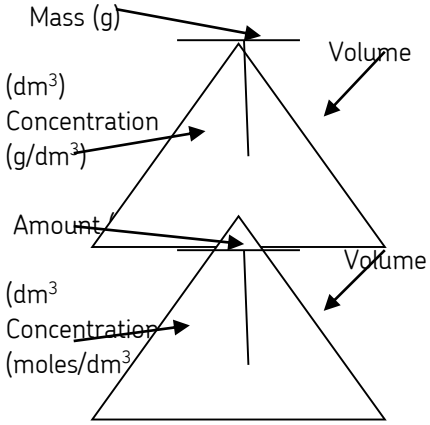
| | | | | | How Science Works: Titration should be carried out three times to allow for calculation of a mean. | |
| h | HT only<br>If the concentration of one of the reactants is known, the results of a titration can be used to find the concentration of the other reactant. | HT only<br>Calculate the chemical quantities in titrations involving concentrations (in moles per $dm^3$) and masses (in grams per $dm^3$). | 1 | Use the triangle method to explain to a partner how to calculate concentrations of solutions through titrations<br>  <br><br>Calculate concentrations from own titration data | | Opportunity for self-assessment<br>Car battery acid is concentrated sulfuric acid. 25$cm^3$ of 0.1 mol/$dm^3$ sodium hydroxide solution was neutralised by 10.00 $cm^3$ of diluted battery acid.<br>Calculate the concentration of the diluted battery acid. |

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| C3.5 The production of ammonia In industrial processes, energy requirements and emissions need to be considered both for economic reasons and for sustainable development. | | | | | | |
| C3.5.1 Making ammonia | | | | | | |
| a<br><br><br><br><br><br><br>b | The raw materials for the Haber process are nitrogen and hydrogen. Nitrogen is obtained from the air, and hydrogen may be obtained from natural gas or other sources.<br><br>The purified gases are passed over a catalyst of iron at a high temperature (about 450°C) and a high pressure (about 200 atmospheres). Some of the hydrogen and | Describe how ammonia is made in the Haber process<br><br>Explain the environmental, industrial and economic importance of ammonia | 2 | Presenting and writing descriptions and explanations<br><br>**Describe** how ammonia is made using the Haber process. Use a flow chart to show the process.<br>**Explain** where the raw materials come from and what factors are used to speed up the rate of the reaction<br><br>**Research** the work of Fritz Haber- evaluate the effect of political influences on his discoveries | Applications, Implications and cultural understanding<br>Is ammonia an important chemical? Discuss its uses.<br><br>Working critically with primary evidence<br>Show effect of adding acid, then alkali to bromine water to demonstrate what is meant by | Further resources and a video on ammonia can be found on the RSC Alchemy website at www.rsc.org/Education/Teachers/Resources/Alchemy/index.htm<br><br>Exampro Extra Online Practical guide: demonstrating an equilibrium reaction. PPT C3 3.5 |

| Spec Reference | Summary of the Specification Content | Learning Outcomes<br><br>*What most candidates should be able to do* | Suggested timing (hours) | ***Opportunities to develop Scientific Communication skills***<br>***Possible activities*** | Opportunities to apply Practical and Enquiry skills | Self/Peer assessment<br>Opportunities & resources<br>*reference to past questions that indicate success Candidates should:* |
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| | nitrogen reacts to form ammonia. The reaction is reversible, so ammonia breaks down again into nitrogen and hydrogen:<br><br>nitrogen + hydrogen ⇌ ammonia<br><br>On cooling, the ammonia liquefies and is removed. The remaining hydrogen and nitrogen are recycled. | | | | equilibrium. | Foundation Tier |
| c | HT only<br>When a reversible reaction occurs in a | HT only<br>Describe and explain the effects of changing the conditions of | 2 | Developing explanations using ideas and models<br>Describe how to make the most | | Video: Show RSC ammonia video again to refresh and revise process |

| Spec Reference | Summary of the Specification Content | Learning Outcomes<br><br>*What most candidates should be able to do* | Suggested timing (hours) | ***Opportunities to develop Scientific Communication skills***<br>***Possible activities*** | Opportunities to apply Practical and Enquiry skills | Self/Peer assessment<br>**Opportunities & resources**<br>*reference to past questions that indicate success Candidates should:* |
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| d<br><br>e | closed system, equilibrium is reached when the reactions occur at exactly the same rate in each direction.<br><br>The relative amounts of all the reacting substances at equilibrium depend on the conditions of the reaction.<br><br>If the temperature is raised, the yield from the endothermic reaction increases and the yield from the exothermic reaction decreases. | temperature and pressure on a given reaction or process.<br><br>Evaluate the conditions used in industrial processes in terms of energy requirements. | | ammonia, as cheaply as possible, in the most environmentally friendly way as possible<br><br>Presenting and writing descriptions and explanations<br>Ammonia is made in the Haber process at a temperature of 450°C and a pressure of 200 atmospheres. **Explain** why both temperature and pressure are compromise conditions.<br><br>**Evaluate** the conditions used in industrial processes in terms of energy requirements. | | Exampro Extra Online Chemistry Activity: conditions for equilibrium reactions.<br>RSC Alchemy worksheet can be found at www.rsc.org/Education/Teachers/Resources/Alchemy/am/question.doc<br><br>PPT C3 3.5 Higher Tier |

| Spec Reference | Summary of the Specification Content | Learning Outcomes<br><br>*What most candidates should be able to do* | Suggested timing (hours) | ***Opportunities to develop Scientific Communication skills***<br>***Possible activities*** | Opportunities to apply Practical and Enquiry skills | Self/Peer assessment<br>**Opportunities & resources**<br>*reference to past questions that indicate success Candidates should:* |
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| f<br><br><br><br><br><br><br>g<br><br><br><br><br><br><br>h | HT only<br>If the temperature is lowered, the yield from the endothermic reaction decreases and the yield from the exothermic reaction increases.<br><br>In gaseous reactions, an increase in pressure will favour the reaction that produces the least number of molecules as shown by the symbol equation for that reaction.<br><br>These factors, together with reaction rates, are important | | | | | |

| Spec Reference | Summary of the Specification Content | Learning Outcomes<br><br>*What most candidates should be able to do* | Suggested timing (hours) | ***Opportunities to develop Scientific Communication skills***<br>***Possible activities*** | Opportunities to apply Practical and Enquiry skills | Self/Peer assessment<br>**Opportunities & resources**<br>*reference to past questions that indicate success Candidates should:* |
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| | when determining the optimum conditions in industrial processes, including the Haber process. | | | | | |

| Spec Reference | Summary of the Specification Content | Learning Outcomes<br><br>*What most candidates should be able to do* | Suggested timing (hours) | ***Opportunities to develop Scientific Communication skills***<br>***Possible activities*** | Opportunities to apply Practical and Enquiry skills | Self/Peer assessment<br>**Opportunities & resources**<br>*reference to past questions that indicate success Candidates should:* |
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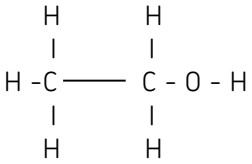
| C3.6 Alcohols, carboxylic acids and esters Alcohols and carboxylic acids are important organic chemicals that have many uses. Alcohols react with carboxylic acids to produce esters. | | | | | | |
| C3.6.1 Alcohols | | | | | | |
| a | Alcohols contain the functional group –OH. Methanol, ethanol and propanol are the first three members of a homologous series of alcohols. | Recognise the structure and formula of alcohols in the following forms:<br><br>  <br><br>$CH_3CH_2OH$ | 1 | | Developing explanations using ideas and models<br>Select alcohols from a series of cards showing organic structural formulae. Identify the functional group –OH<br>Use molymod kits to make models of methanol. and ethanol. Compare to methane and ethane<br>Make a model of propanol. | |
| b | Methanol, ethanol and propanol:<br><br>▪ dissolve in water to form a neutral solution | Describe key reactions of alcohols<br><br>Describe some properties and uses of alcohols | | Presenting and writing arguments<br><br>What are alcohols?<br>Are alcohols useful to us?<br><br>Write and balance equations for the burning of methanol and propanol in | Obtaining and presenting evidence<br>Working critically with primary evidence<br><br>▪ reactions of alcohols with water, sodium or | |

| Spec Reference | Summary of the Specification Content | Learning Outcomes<br><br>*What most candidates should be able to do* | Suggested timing (hours) | ***Opportunities to develop Scientific Communication skills***<br>***Possible activities*** | Opportunities to apply Practical and Enquiry skills | Self/Peer assessment<br>Opportunities & resources<br>*reference to past questions that indicate success Candidates should:* |
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| | ▪ react with sodium to produce hydrogen<br>▪ burn in air<br>▪ are used as fuels and solvents and ethanol is the main alcohol in alcoholic drinks. | | | air. | magnesium to produce hydrogen gas<br>▪ that they burn in air<br>▪ solvent effect on, eg on grass stains.<br>**Applications, Implications and cultural understanding**<br>Ethanol is used as a fuel and can be made from crops.<br>**Evaluate** using ethanol made in this way against fuels made from crude oil. | |
| c | Ethanol can be oxidised to ethanoic acid, either by chemical oxidising agents or by microbial action. Ethanoic acid is the main acid in vinegar. | Recognise the structure and formula of carboxylic acids methanoic acid, ethanoic acid and propanoic acid | | **Presenting and writing descriptions and explanations**<br>What are carboxylic acids? Name some carboxylic acids that you might meet in everyday life.<br>**Explain** to a partner how you can recognise a carboxylic acid from a | **Obtaining and presenting evidence**<br>**Practical:** Oxidise ethanol with potassium dichromate to form ethanoic acid<br>**Developing explanations using ideas and models**<br>**Describe** and **explain** how | |

| Spec Reference | Summary of the Specification Content | Learning Outcomes<br><br>*What most candidates should be able to do* | Suggested timing (hours) | ***Opportunities to develop Scientific Communication skills***<br>***Possible activities*** | Opportunities to apply Practical and Enquiry skills | Self/Peer assessment<br>**Opportunities & resources**<br>*reference to past questions that indicate success Candidates should:* |
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| a | Ethanoic acid is a member of the carboxylic acids, which have the functional group – COOH. | | | range of structural formulae | carboxylic acid can be made from alcohols. | |

| Spec Reference | Summary of the Specification Content | Learning Outcomes<br><br>*What most candidates should be able to do* | Suggested timing (hours) | ***Opportunities to develop Scientific Communication skills***<br>***Possible activities*** | Opportunities to apply Practical and Enquiry skills | Self/Peer assessment<br>**Opportunities & resources**<br>*reference to past questions that indicate success Candidates should:* |
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| C3.6.2 Carboxylic acids | | | | | | |
| b | Carboxylic acids:<br><br>▪ dissolve in water to produce acidic solutions<br>▪ react with carbonates to produce carbon dioxide | Represent the structures of carboxylic acids in the following forms:<br><br>H<br>I<br>H –C – C = O<br>I I<br>H O – H<br><br>$CH_3COOH$<br><br>Describe the reactions of carboxylic acids with water and carbonates | 1 | | Developing explanations using ideas and models<br>Make models of methanoic and ethanoic acid<br>Obtaining and presenting evidence<br>Demonstration to show:<br>▪ carboxylic acids dissolve in water to form acidic solutions<br>▪ sodium carbonate produces $CO_2$ gas .<br><br>Applications, Implications and cultural understanding<br>Explain why brewing wine and beer need to ferment without oxygen present. | |

| Spec Reference | Summary of the Specification Content | Learning Outcomes<br><br>*What most candidates should be able to do* | Suggested timing (hours) | ***Opportunities to develop Scientific Communication skills***<br>***Possible activities*** | Opportunities to apply Practical and Enquiry skills | Self/Peer assessment<br>Opportunities & resources<br>*reference to past questions that indicate success Candidates should:* |
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| b<br><br><br><br><br><br>c | Carboxylic acids:<br><br>▪ react with alcohols in the presence of an acid catalyst to produce esters<br><br>HT only<br>Carboxylic acids:<br><br>▪ do not ionise completely when dissolved in water and so are weak acids.<br>▪ aqueous solutions of weak acids have a higher pH value than aqueous solutions | Describe the reaction and conditions necessary for the reaction between carboxylic acids and alcohols<br><br><br><br><br>Explain why aqueous solutions of weak acids have a higher pH than those of strong acids with the same concentration | | Presenting and writing descriptions and explanations<br><br>Describe the reaction and conditions necessary for the reaction between carboxylic acids and alcohols<br><br>Explain why aqueous solutions of weak acids have a higher pH than those of strong acids with the same concentration | | |

| Spec Reference | Summary of the Specification Content | Learning Outcomes<br><br>*What most candidates should be able to do* | Suggested timing (hours) | ***Opportunities to develop Scientific Communication skills***<br>***Possible activities*** | Opportunities to apply Practical and Enquiry skills | Self/Peer assessment<br>**Opportunities & resources**<br>*reference to past questions that indicate success Candidates should:* |
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| | of strong acids with the same concentration. | | | | | |

| Spec Reference | Summary of the Specification Content | Learning Outcomes<br><br>*What most candidates should be able to do* | Suggested timing (hours) | ***Opportunities to develop Scientific Communication skills***<br>***Possible activities*** | Opportunities to apply Practical and Enquiry skills | Self/Peer assessment<br>**Opportunities & resources**<br>*reference to past questions that indicate success Candidates should:* |
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| C3.6.3 Esters | | | | | | |
| a | Ethyl ethanoate is the ester produced from ethanol and ethanoic acid. Esters have the functional group –COO –.<br><br>They are volatile compounds with distinctive smells and are used as flavourings and perfumes. | Describe esters as having the functional group –OO-<br><br>Describe how esters are made from reacting an alcohol with a carboxylic acid<br><br>Describe some properties and uses of esters | 1 | Presenting and writing descriptions and explanations<br><br>Use molymod kits to model the reaction between ethanol and ethanoic acid<br><br>**Describe** the properties and uses of esters.<br><br>**Explain** why esters are smelly chemicals? | Obtaining and presenting evidence<br>Mix equal quantities of ethanol and ethanoic acid in test tubes. Add three drops of concentrated $H_2SO_4$(aq). Leave to stand for 10 minutes, add spatula of sodium hydrogen carbonate to neutralise the acid, then ask students to safely smell it. Pour mixture into a beaker of water and ask pupils to smell it again, to show water helps carry the scent.<br><br>Applications, Implications and cultural understanding<br>Why does milk smell fruity before it goes off?<br>What are esters used for? | PPT C3 3.6<br>Foundation and Higher Tier |