# *PLANNING SUPPORT BOOKLET*

**J258, J260**

**For first teaching in 2016**

This support material booklet is designed to accompany the OCR GCSE (9–1) in Chemistry B and Combined Science B (Twenty First Century Science).

***DISCLAIMER***

This resource was designed using the most up to date information from the specification at the time it was published. Specifications are updated over time, which means there may be contradictions between the resource and the specification, therefore please use the information on the latest specification at all times.If you do notice a discrepancy please contact us on the following email address: [resources.feedback@ocr.org.uk](mailto:resources.feedback@ocr.org.uk)

# Introduction

This support material is designed to accompany the new OCR GCSE (9-1) specification for first teaching from September 2016 for:

* [Chemistry B (Twenty First Century Science – J258)](http://www.ocr.org.uk/Images/234599-specification-accredited-gcse-twenty-first-century-science-suite-chemistry-b-j258.pdf)
* [Combined Science B (Twenty First Century Science – J260)](http://www.ocr.org.uk/Images/234597-specification-accredited-gcse-twenty-first-century-science-suite-combined-science-b-j260.pdf)

We recognise that the number of hours available in timetable can vary considerably from school to school, and year to year. As such, these ***suggested*** teaching hours have been developed on the basis of the experience of the Science Subject Specialist team in delivering GCSE sciences in school. The hours are what we consider ideal for providing the best opportunity for high quality teaching and engagement of the learners in all aspects of learning science.

While Combined Science is a double award GCSE formed from the three separate science GCSEs, the DfE required subject content is greater than a strict two-thirds of the separate science qualifications, hence the suggested hours here are greater than a strict two-thirds of the separate science hours.

The ***suggested*** hours take into account all aspects of teaching, including pre- and post-assessment. As a linear course, we would recommend on-going revision of key concepts throughout the course to support learner’s learning. This can help to minimise the amount of re-teaching necessary at the end of the course, and allow for focused preparation for exams on higher level skills (e.g. making conceptual links between the topics) and exam technique.

Actual teaching hours will also depend on the amount of practical work done within each topic and the emphasis placed on development of practical skills in various areas, as well as use of contexts, case studies and other work to support depth of understanding and application of knowledge and understanding. It will also depend on the level of prior knowledge and understanding that learners bring to the course.

Should you wish to speak to a member of the Science Subject Team regarding teaching hours and scheme of work planning, we are available at [scienceGCSE@ocr.org.uk](mailto:scienceGCSE@ocr.org.uk) or 01223 553998.

## Delivery guides

Delivery guides are individual teacher guides available from the qualification pages:

* <http://www.ocr.org.uk/qualifications/gcse-twenty-first-century-science-suite-chemistry-b-j258-from-2016/>
* <http://www.ocr.org.uk/qualifications/gcse-twenty-first-century-science-suite-combined-science-b-j260-from-2016/>

These Delivery guides provide further guidance and suggestions for teaching of individual chapters, including links to a range of activities that may be used and guidance on resolving common misconceptions.

## Ideas about Science (C7) and Practical Work (C8)

Ideas about Science (C7) and Practical Skills (C8) are not explicitly referenced in the high level planning table below, as these ideas and skills are expected to be developed in the context of Chapters C1-C6. Links to Ideas about Science and suggested practical activities are included in the outline scheme of work. Indications of where PAG activities can be carried out should not be seen as an exhaustive list.

Suggestions where the PAG activities can be included are given in the table below. This is by no means an exhaustive list of potential practical activities that can be used in teaching and learning of Chemistry.

Suggested activities are available under “Teaching and Learning Resources / Practical Activities” on the qualification page: <http://www.ocr.org.uk/qualifications/gcse-twenty-first-century-science-suite-chemistry-b-j258-from-2016/#resources>.

An optional activity tracker is available at <http://www.ocr.org.uk/Images/323481-gcse-chemistry-practical-tracker.zip>.

An optional learner record sheet is available at <https://www.ocr.org.uk/Images/295630-gcse-chemistry-student-record-sheet.doc>

A sample set of activities that gives learners the opportunity to cover all apparatus and techniques is available on the webpage at <https://www.ocr.org.uk/Images/552881-practical-skills-booklets.zip>

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| Chapter | Suggested teaching hoursSeparate / Combined | Comments and PAG opportunities |
| --- | --- | --- |
| **Chapter C1: Air and water** | | |
| C1.1 How has the Earth’s atmosphere changed over time, and why? | 8 / 8 | PAG 2 – Gas tests |
| C1.2 Why are there temperature changes in chemical reactions? | 6 / 3 |  |
| C1.3 What is the evidence for climate change, why is it occurring? **AND** C1.4 How can scientists help improve the supply of potable water? | 6 / 6 | PAG 2 – Gas tests |
|  | **Total 20 / 17** |  |
| **Chapter C2: Chemical patterns** | | |
| C2.1 How have our ideas about atoms developed over time? | 2.5 / 2.5 |  |
| C2.2 What does the Periodic Table tell us about the elements? | 5 / 5 | PAG 1 – Group 7 reactivity trends |
| C2.3 How do metals and non-metals combine to form compounds? | 4.5 / 4.5 |  |
| C2.4 How are equations used to represent chemical reactions? | 2 / 2 |  |
| C2.5 What are the properties of the transition metals? (separate science only) | 2 / 0 |  |
|  | **Total 16 / 14** |  |
| **Chapter C3: Chemicals of the naturals environment** | | |
| C3.1 How are the atoms held together in a metal? **AND** C3.2 How are metals with different reactivities extracted? | 7 / 7 |  |
| C3.3 What are electrolytes and what happens during electrolysis? | 6.5 / 6.5 | PAG 2 – Electrolysis |
| C3.4 Why is crude oil important as a source of new materials? | 10 / 6 | PAG 3 – Chromatography |
|  | **Total 23.5 / 19.5** |  |
| **Chapter C4: Material choices** | | |
| C4.1 How is data used to choose a material for a particular use? | 2.5 / 1.5 |  |
| C4.2 What are the different types of polymers? (separate science only) | 4 / 0 |  |
| C4.3 How do bonding and structure affect properties of materials? | 3 / 3 |  |
| C4.4 Why are nanoparticles so useful? | 4.5 / 4.5 |  |
| C4.5 What happens to products at the end of their useful life? | 5 / 4 |  |
|  | **Total 19 / 13** |  |
| **Chapter C5: Chemical analysis** | | |
| C5.1 How are chemicals separated and tested for purity? | 7 / 7 | PAG3, 4, 7 – Chromatography, distillation and production of salts |
| C5.2 How do chemists find the composition of unknown samples? (separate science only) | 6 / 0 | PAG 5 – Identification of unknown species |
| C5.3 How are the amounts of substances in reactions calculated? | 10 / 6.5 |  |
| C5.4 How are the amounts of chemicals in solution measured? | 10 / 7.5 | PAG 6 – Titration |
|  | **Total 33 / 21** |  |
| **Chapter C6: Making useful chemicals** | | |
| C6.1 What useful products can be made from acids? | 7.5 / 7.5 | PAG 7 – Production of salts |
| C6.2 How do chemists control the rate of reactions? | 11 / 9.5 | PAG 8 – Reaction rates |
| C6.3 What factors affect the yield of chemical reactions? **AND**  C6.4 How are chemicals made on an industrial scale? (separate science only) | 10 / 1.5 |  |
|  | **Total 28.5 / 18.5** |  |
| **GRAND TOTAL SUGGESTED HOURS – 140 / 103 hours** | | |

Separate science only learning outcomes are indicated throughout this document.

**Emboldened statements will only be assessed in Higher Tier papers.**

The grand total suggested hours is slightly different compared with the Chemistry A Gateway suggested hours. This will be due to additional learning outcomes and a greater emphasis on Ideas about Science in the Twenty First Century Suite over and above those in Gateway, which help to exemplify the contexts in each chapter.

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# Outline Scheme of Work: C6 Making useful chemicals

## Total suggested teaching time – 28.5 / 18.5 hours (separate / combined)

|  |  |
| --- | --- |
| Additional remote learning opportunities ***As a response to the Covid-19 outbreak, additional online learning opportunities were identified for each topic in June 2020.*** | |
| **Statement** | **Teaching activities** |
| C6.1.1-3 | [Video and teaching pack](https://ocr.org.uk/rpgchem4) for the practical: Effect of changing the concentration of hydrochloric acid on the rate of reaction with calcium carbonate. This includes advice for an actual and virtual practical. It also includes preparation worksheets and a summary quiz.  [Online interactive simulation](https://lab.concord.org/embeddable.html#interactives/sam/chemical-reactions/2-concentration-and-reaction-rate.jso) where students can control the concentration of particles and then measure the rate of reaction. Allows students to gather results at home to analyse.  [Online interactive simulation](https://lab.concord.org/embeddable.html#interactives/sam/chemical-reactions/3-temperature-and-reaction-rate.json) where students can control the temperature of particles and then measure the rate of reaction. Allows students to gather results at home to analyse. |
| C6.1.4 | Set of [RSC activities](https://edu.rsc.org/download?ac=12427) on acids and alkalis aimed at higher ability students. Most of the activities are practicals, but Activity 5 ‘Explaining Acid Strength’ is more of a comprehension type exercise. |
| C6.3.1 | [Video and teaching pack](https://ocr.org.uk/rpgchem3) for the practical: Reversible reaction between two cobalt species. This includes advice for an actual and virtual practical, but the virtual one would be better due to safety issues with cobalt chloride. It also includes preparation worksheets and a summary quiz.  [Equilibrium card sort activity](https://www.teachitscience.co.uk/resources/ks4/chemical-reactions-and-energetics/chemistry/equilibrium-card-sort/34686). Aimed at higher tier students to help them scaffold answers for various equilibrium-based questions. The website does have a subscription option, but there is a free option also, where resources can be downloaded as a pdf. |
| C6.4.2 | A [short video](https://www.youtube.com/watch?v=HAkaD6-7fgQ) explaining the compromise conditions involved in the Haber process and explaining how to interpret graphs of reaction conditions versus rate. |
| **C6** | A free [online learning platform](https://app.senecalearning.com/classroom/course/b151e0b0-16f2-11e8-ba22-0d7681702f4b/section/15d8a130-16f4-11e8-ba22-0d7681702f4b/session). Consists of revision questions. Covers the whole specification. You can choose which topics to answer questions on. |

### C6.1 What useful products can be made from acids?

### (7.5 hours – separate and combined)

|  |  |
| --- | --- |
| Links to KS3 Subject content  * chemical reactions as the rearrangement of atoms * defining acids and alkalis in terms of neutralisation reactions * representing chemical reactions using formulae and using equations * the chemical properties of metal and non-metal oxides with respect to acidity * the pH scale for measuring acidity/alkalinity; and indicators | |
| Links to Mathematical Skills  * M3c | Links to Practical Activity Groups (PAGs)  * PAG7: Producing salts |

| Suggested timings | Statements bold – Higher Tier only | Teaching activities | Notes |
| --- | --- | --- | --- |
| C6  Topic 1  7.5 hours (separate and combined) | C6.1.1. recall that acids react with some metals and with carbonates and write equations predicting products from given reactants  C6.1.2. describe practical procedures to make salts to include appropriate use of filtration, evaporation, crystallisation and drying  C6.1.3. use the formulae of common ions to deduce the formula of a compound  C6.1.4. recall that relative acidity and alkalinity are measured by pH including the use of universal indicator and pH meters  **C6.1.5. use and explain the terms dilute and concentrated (amount of substance) and weak and strong (degree of ionisation) in relation to acids including differences in reactivity with metals and carbonates**  **C6.1.6. use the idea that as hydrogen ion concentration increases by a factor of ten the pH value of a solution decreases by one**  **C6.1.7. describe neutrality and relative acidity and alkalinity in terms of the effect of the concentration of hydrogen ions on the numerical value of pH (whole numbers only)** | Various practical activities can be used to support learning in this Topic, for example   * Reactions of acids and preparation of salts * pH testing * Investigating strong and weak acid reactivity * use of indicators to test strong and weak acids, making standard solutions using volumetric flasks.   Preparing [ammonium sulfate by neutralisation](http://www.rsc.org/learn-chemistry/resource/res00001760/preparing-a-soluble-salt-by-neutralisation?cmpid=CMP00005270) covers several practical techniques and chemical concepts. Equally, [reactions of acids with oxides and carbonates](http://www.rsc.org/learn-chemistry/resource/res00001762/preparing-salts-by-neutralisation-of-oxides-and-carbonates?cmpid=CMP00005272) can be carried out.  OCR have an activity on [making salts](https://www.ocr.org.uk/Images/363963-making-salts-lesson-element.doc).  The difference between concentration and acid strength is simply demonstrated by reaction of magnesium with hydrochloric acid and ethanoic acid of the same concentration (e.g. 0.5 mol dm–3). Such a demonstration can also be used to introduce the idea of equilibrium if the acids are used in excess, and writing of ionic equations. A basic introduction to rates is also possible if the mass of the reaction mixture is monitored over time, and a time/mass graph plotted (data loggers would be particularly useful here).  Ethanoic acid can be [investigated in greater depth](http://www.rsc.org/learn-chemistry/resource/res00000462/the-acidic-reactions-of-ethanoic-acid?cmpid=CMP00005925), by using a range of other reagents.  An interesting [practical investigation](http://www.rsc.org/learn-chemistry/resource/res00000621/universal-indicators?cmpid=CMP00000643) is available on making universal indicator.  Activities from Keith Taber’s Chemical Misconceptions book cover relevant theory, including [types of chemical reactions](http://www.rsc.org/learn-chemistry/resource/res00001089/types-of-chemical-reaction), [revising acids](http://www.rsc.org/learn-chemistry/resource/res00001086/revising-acids) and [acid strength](http://www.rsc.org/learn-chemistry/resource/res00001105/acid-strength). Kristy Turner and Catherine Smith’s Starters for Ten publication also includes useful [activities](http://www.rsc.org/learn-chemistry/resource/res00001358/advanced-starters-for-ten?cmpid=CMP00002956).  If Chapter 5 has already been studied, titration can be further developed here looking at weak acids against strong alkalis and vice versa. For example, a [microscale vinegar titration](http://science.cleapss.org.uk/Resource-Info/PP019-Analysis-of-vinegar-small-scale.aspx) is available from CLEAPSS (login required).  An OCR delivery guide for this [whole topic](http://www.ocr.org.uk/qualifications/gcse-twenty-first-century-science-suite-chemistry-b-j258-from-2016/delivery-guide/) is available on the [qualification page](http://www.ocr.org.uk/qualifications/gcse-twenty-first-century-science-suite-chemistry-b-j258-from-2016/). | This chapter considers the laboratory and large-scale production of useful chemicals. Topic C6.1 begins with the laboratory synthesis of salts from acid reactions, and also looks at the characteristics of both acids and bases.  Many products that we use every day are based on the chemistry of acid reactions. Products made using acids include cleaning products, pharmaceutical products and food additives. In addition, acids are made on an industrial scale to be used to make bulk chemicals such as fertilisers.  Acids react in neutralisation reactions with metals, hydroxides and carbonates. All neutralisation reactions produce salts, which have a wide range of uses and can be made on an industrial scale.  **The strength of an acid depends on the degree of ionisation and hence the concentration of H+ ions, which determines the reactivity of the acid. The pH of a solution is a measure of the concentration of H+ ions in the solution. Strong acids ionise completely in solution, weak acids do not. Both strong and weak acids can be prepared at a range of different concentrations (i.e. different amounts of substance per unit volume).**  **Weak acids and strong acids of the same concentration have different pH values. Weak acids are less reactive than strong acids of the same concentration (for example they react more slowly with metals and carbonates).**  Links can be made to other sections of the specification, for example:   * Writing formulae, balanced symbol and ionic equations.(C3.2) * Concentration of solutions (C5.4) |

# Outline Scheme of Work: C6 Making useful chemicals

## Total suggested teaching time – 28.5 / 18.5 hours (separate / combined)

### C6.2 How do chemists control the rate of reactions? (11 / 9.5 hours – separate / combined)

|  |  |
| --- | --- |
| Links to KS3 Subject content  * chemical reactions as the rearrangement of atoms * representing chemical reactions using formulae and using equations * what catalysts do | |
| Links to Mathematical Skills  * M1a * M1c * M2b * M4a * M4b * M4c * M4d * M4e | Links to Practical Activity Groups (PAGs)  * PAG8: Measuring rates of reaction |

| Suggested timings | Statements bold – Higher Tier only | Teaching activities | Notes |
| --- | --- | --- | --- |
| C6  Topic 2 Part 1  7 hours (separate and combined) | C6.2.1. describe the effect on rate of reaction of changes in temperature, concentration, pressure, and surface area on rate of reaction  C6.2.2. explain the effects on rates of reaction of changes in temperature, concentration and pressure in terms of frequency and energy of collision between particles  C6.2.3. explain the effects on rates of reaction of changes in the size of the pieces of a reacting solid in terms of surface area to volume ratio  C6.2.4. describe the characteristics of catalysts and their effect on rates of reaction  C6.2.5. identify catalysts in reactions  C6.2.6. explain catalytic action in terms of activation energy  C6.2.7. suggest practical methods for determining the rate of a given reaction including:  for reactions that produce gases:  i. gas syringes or collection over water can be used to measure the volume of gas produced  ii. mass change can be followed using a balance  **measurement of physical factors:**  **iii. colour change**  **iv. formation of a precipitate**  IaS3: Use the particle model to explain factors that affect rates of reaction  IaS4: The use of catalysts supports more sustainable industrial processes. | The rates of reaction topic usually allows for lots of practical work to be carried out, data collected and interpreted, and for good use of modelling to explain chemical principles.  This topic formed the basis of a case-study by David Paterson on developing independent learning, with associated [ASE School Science Review and teaching resources](http://bit.ly/greensheets) made available.  A [series of articles](http://www.rsc.org/eic/2015/12/chemical-reaction-rates-part-one) by Steve Hacker published in Education in Chemistry contain useful background and ideas, including on rates and equilibrium.  Commonly used practicals allow for measuring of rates of reaction, focussing on a variety of different factors:   * [effect of concentration](http://www.rsc.org/learn-chemistry/resource/res00000743/the-effect-of-concentration-on-reaction-rate) * [effect of temperature](http://www.rsc.org/learn-chemistry/resource/res00000448/the-effect-of-temperature-on-reaction-rate) * [effect of concentration and temperature](http://www.rsc.org/learn-chemistry/resource/res00000413/the-effect-of-concentration-and-temperature-on-reaction-rate) * [measuring gas volume](http://www.rsc.org/learn-chemistry/resource/res00001916/the-rate-of-reaction-of-magnesium-with-hydrochloric-acid?cmpid=CMP00006119) * [iodine clock investigation](http://www.rsc.org/learn-chemistry/resource/res00000744/iodine-clock-Investigate)   Additionally, the effect of surface area on the rate of reaction can easily be demonstrated with three identical setups of a conical flask with acid on a balance, adding equal masses of large, small and powdered marble chips and monitoring the changes in mass over time.  Practical/demonstrations involving changes in pressure are not commonly carried out, but learners can understand the concept by relation to concentration.  The ‘[Reactions and rates’](https://phet.colorado.edu/en/simulation/reactions-and-rates) pHET demonstration can be useful before, during and after lessons for pre and post lesson learning and consolidation.  Many good activities exist for demonstrating the effect of catalysts, including the [decomposition of hydrogen peroxide](http://www.rsc.org/learn-chemistry/resource/res00000831/hydrogen-peroxide-decomposition?cmpid=CMP00002415).  Collision theory can be effectively demonstrated with modelling using the learners as particles moving around a large contained area – halls or gyms work well. Collisions are modelled as high-fiving as they ‘collide’ and conditions can be altered by changing the number of learners, their speed and the available area for them to move. Counting the number of high-fives in a fixed time, and looking for the patterns allows for a fun introduction to collision theory. The effect of particle density and speed of particle movement in relation to successful collision per second (rate of reaction) can then be made clear.  . | In Topic C6.2, the story moves on to study how chemists manage the rate of reaction when these reactions take place, in the context of managing conditions both in the laboratory and in industry. This chapter gives the opportunity for a wide range of practical investigation and mathematical analysis of rates.  Controlling rate of reaction enables industrial chemists to optimise the rate at which a chemical product can be made safely.  The rate of a reaction can be altered by altering conditions such as temperature, concentration, pressure and surface area. A model of particles colliding helps to explain why and how each of these factors affects rate; for example, increasing the temperature increases the rate of collisions and, more significantly, increases the energy available to the particles to overcome the activation energy and react.  A catalyst increases the rate of a reaction but can be recovered, unchanged, at the end. Catalysts work by providing an alternative route for a reaction with a lower activation energy. Energy changes for uncatalysed and catalysed reactions have different reaction profiles.  The use of a catalyst can reduce the economic and environmental cost of an industrial process, leading to more sustainable ‘green’ chemical processes.  Links can be made to other sections of the specification, for example:   * Endothermic and exothermic reactions and energy level diagrams. (C1) |
| C6  Topic 2  4 / 2.5 hours (separate / combined) | C6.2.8. interpret rate of reaction graphs  **C6.2.9. interpret graphs of reaction conditions versus rate (separate science only) (an understanding of orders of reaction is not required)**  C6.2.10. use arithmetic computation and ratios when measuring rates of reaction  C6.2.11. draw and interpret appropriate graphs from data to determine rate of reaction  C6.2.12. determine gradients of graphs as a measure of rate of change to determine rate  C6.2.13. use proportionality when comparing factors affecting rate of reaction  C6.2.14. describe the use of enzymes as catalysts in biological systems and some industrial processes | Graph plotting can be a perennial problem for some students, and back to basics tutoring of some may be necessary to ensure they are getting this key skill right. The [OCR Maths Skills Handbook for GCSE Sciences](http://www.ocr.org.uk/Images/310651-mathematical-skills-handbook.pdf) includes a useful section on graph drawing. Measuring rates by drawing tangents to curves will likely prove challenging for many at the start, but plenty of practice and working in small groups usually helps the learners to understand and develop this skill.  The ‘[Reactions and rates’](https://phet.colorado.edu/en/simulation/reactions-and-rates) pHET demonstration can be useful before, during and after lessons for pre and post lesson learning and consolidation.  The Royal Society of Chemistry [Assessment for Learning](http://www.rsc.org/Education/Teachers/Resources/Aflchem/) resource contains a useful section on [Rate of reaction graphs](http://www.rsc.org/learn-chemistry/resource/res00000095/afl-rate-of-reaction-graphs?cmpid=CMP00000123).  An OCR delivery guide for this [whole topic](http://www.ocr.org.uk/qualifications/gcse-twenty-first-century-science-suite-chemistry-b-j258-from-2016/delivery-guide/) is available on the [qualification page](http://www.ocr.org.uk/qualifications/gcse-twenty-first-century-science-suite-chemistry-b-j258-from-2016/). | Rate of reaction can be determined by measuring the rate at which a product is made or the rate at which a reactant is used. Some reactions involve a colour change or form a solid in a solution; the rate of these reactions can be measured by timing the changes that happen in the solutions by eye or by using apparatus such as a colorimeter. Reactions that make gases can be followed by measuring the volume of gas or the change in mass over time.  On graphs showing the change in a variable such as concentration over time, the gradient of a tangent to the curve is an indicator of rate of change at that time. The average rate of a reaction can be calculated from the time taken to make a fixed amount of product.  Links can be made to other sections of the specification, for example:   * enzymes in biological processes (B3.1) |

# Outline Scheme of Work: C6 Making useful chemicals

## Total suggested teaching time – 28.5 / 18.5 hours (separate / combined)

### C6.3 What factors affect the yield of chemical reactions? AND C6.4 How are chemicals made on an industrial scale?

### (10 / 1.5 hours – separate / combined)

|  |  |
| --- | --- |
| Links to KS3 Subject content  * chemical reactions as the rearrangement of atoms * representing chemical reactions using formulae and using equations * the properties of metals and non-metals | |
| Links to Mathematical Skills  * M1a * M1c * M3b * M3c | Links to Practical Activity Groups (PAGs)  * N/A |

| Suggested timings | Statements bold – Higher Tier only | Teaching activities | Notes |
| --- | --- | --- | --- |
| C6  Topic 3 and 4  Part 1  6 / 1.5 hours (separate / combined) | C6.3.1. recall that some reactions may be reversed by altering the reaction conditions including:  a) reversible reactions are shown by the symbol ⇌  b) reversible reactions (in closed systems) do not reach 100% yield  C6.3.2. recall that dynamic equilibrium occurs when the rates of forward and reverse reactions are equal  **C6.3.3. predict the effect of changing reaction conditions (concentration, temperature and pressure) on equilibrium position and suggest appropriate conditions to produce a particular product, including:**  **a) catalysts increase rate but do not affect yield**  **b) the disadvantages of using very high temperatures or pressures**  C6.4.1. recall the importance of nitrogen, phosphorus and potassium compounds in agricultural production (separate science only)  C6.4.2. (separate science only) explain the importance of the Haber process in agricultural production and the benefits and costs of making and using fertilisers, including:  a) the balance between demand and supply of food worldwide  b) the sustainability and practical issues of producing and using synthetic and natural fertilisers on a large scale  c) the environmental impact of over-use of synthetic fertilisers (eutrophication) | Various YouTube videos are available to introduce the ideas around equilibrium, for example from [FuseSchool](https://www.youtube.com/watch?v=wlD_ImYQAgQ) (and [here](https://www.youtube.com/watch?v=7zuUV455zFs) and [here](https://www.youtube.com/watch?v=XhQ02egUs5Y) specifically on Le Chatelier’s principle) and [CrashCourse](https://www.youtube.com/watch?v=g5wNg_dKsYY). The [BBC Bitesize website](http://www.bbc.co.uk/bitesize/higher/chemistry/reactions/equilibrium/revision/1/) also provides some brief notes.  An alternative method is to use the pHET [Reaction and Rates](http://phet.colorado.edu/en/simulation/legacy/reactions-and-rates) app and this [lesson plan](https://phet.colorado.edu/en/contributions/view/3055) (free signin required) to allow learners a chance to engage with the ideas before consolidating in class. An additional pHET activity ([Reversible Reactions](http://phet.colorado.edu/en/simulation/legacy/reversible-reactions)) is a similar simple modelling app.  The OCR Lesson Element ‘[Equilibrium’](http://www.ocr.org.uk/Images/179798-equilibrium-activity.doc) (and [here](http://www.ocr.org.uk/Images/179794-equilibrium-activity-game-and-pieces-.pdf) and [here](http://www.ocr.org.uk/Images/179799-equilibrium-activity-teacher-instructions.pdf)) has some short starter activities and a board game that helps introduce and consolidate the ideas around equilibrium.  The [equilibrium between chromate and dichromate ions](http://www.rsc.org/learn-chemistry/resource/res00001710/an-equilibrium-involving-chromate-vi-and-dichromate-vi-ions?cmpid=CMP00005224) and how it can be affected by the addition of hydrogen ions and hydroxide ions is useful teacher demonstration of what is happening as the equilibrium point is being reached.  Changing the effect of pressure/concentration is generally more easily understood than that of temperature. The Haber process is usually used when discussing this. Examination of yield data on changing conditions in the process helps to reinforce ideas on how the equilibrium position can be changed.The set of pages on reversible reactions based on Haber from [BBC Bitesize](http://www.bbc.co.uk/schools/gcsebitesize/science/add_aqa_pre_2011/chemreac/reversiblereacrev1.shtml) contain some potentially useful animations.  Plotting the [yield of ammonia](http://wps.prenhall.com/wps/media/objects/3312/3391885/blb1506.html) at different pressures and temperatures can lead into discussions about trade-off between yield and rate. [BBC Bitesize](https://www.bbc.co.uk/bitesize/guides/ztbqfcw/revision/4) has couple of animations on how conditions affect yield. More detailed information is available from [Chemguide](http://www.chemguide.co.uk/physical/equilibria/haber.html) and the [Royal Society of Chemistry Alchemy project video](http://www.rsc.org/learn-chemistry/resource/res00000017/ammonia?cmpid=CMP00001797#!cmpid=CMP00001682). | Topic C6.3 looks at reversible reactions, with particular emphasis on the large-scale production of ammonia.  Industrial processes are managed to get the best yield as quickly and economically as possible. Chemists select the conditions that give the best economic outcome in terms of safety, maintaining the conditions and equipment, and energy use.  The reactions in some processes are reversible. This can be problematic in industry because the reactants never completely react to make the products. This wastes reactants and means that the products have to be separated out from the reactants, which requires extra stages and costs.  Data about yield and rate of chemical processes are used to choose the best conditions to make a product. On industrial scales, very high temperatures and pressures are expensive to maintain due to the cost of energy and because equipment may fail under extreme conditions. Catalysts can be used to increase the rate of reaction without affecting yield.  Chemical engineers choose the conditions that will make the process as safe and efficient as possible, reduce the energy costs and reduce the waste produced at all stages of the process.  Topic C6.4 develops all the ideas in the chapter together to look at both how the conditions and ‘routes’ for a chemical process are chosen by thinking about the economic and environmental issues surrounding the production of chemicals on a large scale.  Nitrogen, phosphorus and potassium are essential plant nutrient elements; they are lost from the soil when crops use them for growth and then are harvested. Fertilisers are added to the soil to replace these essential elements.  The world demand for food cannot be met without the use of synthetic fertilisers. Natural fertilisers are not available in large enough quantities, their supply is difficult to manage and transport and their composition is variable. However, fertilisers can cause environmental harm when overused; if they are washed into rivers they cause excessive weed growth, which can lead to the death of the organisms that live there. |
| C6  Topic 3 and 4  Part 1  (continued) | **C6.4.3. (separate science only) explain how the commercially used conditions for the Haber process are related to the availability and cost of raw materials and energy supplies, control of equilibrium position and rate including:**  **a) the sourcing of raw materials and production of the feedstocks; nitrogen (from air), and hydrogen (from natural gas and steam)**  **b) the effect of a catalyst, temperature and pressure on the yield and rate of reaction**  **c) the separation of the ammonia and recycling of unreacted nitrogen and hydrogen**  **C6.4.4. explain the trade-off between rate of production of a desired product and position of equilibrium in some industrially important processes (separate science only)**  IaS2: Make predictions from data and graphs about yield of chemical products  IaS4: Consider the risks and costs of different operating conditions in an ammonia plant.  IaS4: Production of fertilisers to enhance the quality of people’s lives  IaS4: Evaluation of industrial processes in terms of sustainability, risk, costs and benefits. | A brief summary of the importance of nitrogen, phosphorus and potassium can be found at the [Noble Foundation website](http://www.noble.org/ag/soils/back2basics/) and the [Organica Garden Supply website](http://www.organicagardensupply.com/disease-pests/plant-nutrient-deficiencies-with-photos/) including images of NPK deficient plants. Learners may have covered this at KS3, for example growing tomato plants in mineral deficient soils.  A useful starting point for research about fertilizers is the [Essential Chemical Industry online](http://www.essentialchemicalindustry.org/materials-and-applications/fertilizers.html) website. [Nitric acid production](http://www.rsc.org/learn-chemistry/resource/res00000025/nitric-acid?cmpid=CMP00001805) is included in the Alchemy project.  Examine historical, social, moral or economic reasons leading to the need to produce ammonia as a starting point for fertiliser production. Fritz Haber is an [interesting case study](http://www.bbc.co.uk/news/world-13015210) in how scientists’ work is not in isolation from the rest of society. The Aus-e-tute website contains a useful [list of uses of ammonia](http://www.ausetute.com.au/haberpro.html).  An OCR delivery guide for this [whole topic](http://www.ocr.org.uk/qualifications/gcse-twenty-first-century-science-suite-chemistry-b-j258-from-2016/delivery-guide/) is available on the [qualification page](http://www.ocr.org.uk/qualifications/gcse-twenty-first-century-science-suite-chemistry-b-j258-from-2016/). | Ammonia is one of the most important compounds used to make synthetic fertilisers. Ammonia is made in the Haber process, which involves a reversible reaction.  **To get the greatest output as quickly and economically as possible chemical engineers consider the rate and the position of equilibrium for the reaction. In practice, industrial processes rarely reach equilibrium. In the Haber process unreacted reactants are continuously separated from the ammonia and recycled so that the nitrogen and hydrogen are not wasted.**  Industrial processes need to be as economically profitable as possible.  Links can be made to other sections of the specification, for example:   * Calculations of yields (C5.1) |
| C6  Topic 3 and 4  4 hours (separate ONLY) | C6.4.5. define the atom economy of a reaction (separate science only)  C6.4.6. (separate science only) calculate the atom economy of a reaction to form a desired product from the balanced equation using the formula:  equation  C6.4.7. use arithmetic computation when calculating atom economy (separate science only)  **C6.4.8. 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, usefulness of by-products and evaluate the sustainability of the process (separate science only)**  C6.4.9. (separate science only) describe the industrial production of fertilisers as several integrated processes using a variety of raw materials and compare with laboratory syntheses. including:  a) demand for fertilisers (including ammonium sulfate) is often met from more than one process  b) some fertilisers are made as a bi-product or waste product of another process  c) process flow charts are used to summarise industrial processes and give information about raw materials, stages in the process, products, by-products and waste  d) lab processes prepare chemicals in batches, industrial processes are usually continuous.  C6.4.10. compare the industrial production of fertilisers with laboratory syntheses of the same products (separate science only) | Chemguide contains a [good summary](http://www.chemguide.co.uk/physical/equilibria/haber.html) of the compromise conditions used in the Haber process for the production of ammonia.  The University of York [Essential Chemical Industry](http://www.essentialchemicalindustry.org/index.php) online provides an excellent resource for research/independent/project work to look at other examples of compromises necessary in the chemical industry.  The RSC [Inspirational Chemistry](http://www.rsc.org/education/teachers/resources/inspirational/) project includes a section on [atom economy](http://www.rsc.org/education/teachers/resources/inspirational/resources/6.6.1.doc).  The OCR ‘[Atom economy and percentage yield’](https://www.ocr.org.uk/Images/233797-atom-economy-and-percentage-yield.pdf) delivery guide, although an A-level resource, still contains many resources that would be relevant and useful.  Production of fertilizers from raw materials is an interesting synoptic challenge for learners. Start them with raw materials (methane, air, water, sulfur) and any information they haven’t already met (e.g. reforming of methane to hydrogen, Ostwald process for nitric acid production) and set them the challenge of designing an industrial pathway to ammonium sulfate and ammonium nitrate.  Use the videos on industrial production of fertilizers to compare with the laboratory based preparation (e.g. [OCR PAG 3 – separation techniques](https://www.ocr.org.uk/Images/358305-pag-activity-chemistry-separation-techniques-suggestion-1.docx)).  An OCR delivery guide for this [whole topic](http://www.ocr.org.uk/qualifications/gcse-twenty-first-century-science-suite-chemistry-b-j258-from-2016/delivery-guide/) is available on the [qualification page](http://www.ocr.org.uk/qualifications/gcse-twenty-first-century-science-suite-chemistry-b-j258-from-2016/). | Topic 6.4 concludes with the manufacture of fertilisers as a context for considering how chemists reach decisions about the optimum processes for large- scale production of bulk chemicals.  Atom economy is an indicator of the amount of useful product that is made in a reaction. This is a theoretical value based on the reaction equation and is used alongside data about yields and efficiency when processes are evaluated.  **Modern processes incorporate ‘green chemistry’ ideas, to provide a sustainable approach to production. Sustainability is a measure of how a process is able to meet current demand without having a long term impact on the environment. Reactions with high atom economy are more sustainable. Other issues which affect the sustainability of a process include; whether or not the raw materials are renewable; the impact of other competing uses for the same raw materials; the nature and amount of by-products or wastes; the energy inputs or outputs.**  Synthetic fertilisers contain salts that are made in acid-base reactions and can be synthesised on a laboratory scale. Scaling up of fertiliser manufacture for industrial production uses some similar processes to the laboratory preparation, but these are adapted to handle the much larger quantities involved.  Links can be made to other sections of the specification, for example:   * Haber Process (C4.3) * Yield (C5.3) |

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