# *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 topics, 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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| Chapters | 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.

# Outline Scheme of Work: C3 – Chemicals of the natural environment

## Total suggested teaching time – 23.5 / 19.5 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** |
| C3.2.6 | These [resources](https://www.tes.com/teaching-resource/c10-using-resources-metal-extraction-phytomining-and-bioleaching-aqa-9-1-11850548) include a power point on phytomining, an information sheet on the use of bacteria in metal extraction, and questions on both processes. |
| C3.3.1-3 | [Electrolysis storyboard challenge.](https://www.teachitscience.co.uk/resources/ks4/electrolysis/chemistry/electrolysis-storyboard-challenge/30918) A consolidation activity for students who have already studied electrolysis. The website does have a subscription option, but there is a free option also, where resources can be downloaded as a pdf. |
| C3.3.2/3/6 | [Video and teaching pack](https://ocr.org.uk/rpgchem2) for Electrolysis of molten zinc chloride practical. Can be used for actual or virtual practical (although the practical must be carried out in a fume cupboard, so in most classes it would have to be a virtual practical). In addition to the resources for carrying out the practical, it also includes preparation worksheets and a summary quiz. |
| C3.4.18 | Short [video](https://www.ocr.org.uk/Images/588246-c3-cup-elevate-video-bromine-test.mp4) showing the bromine test for an alkene. |
| **C3** | 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. |

### C3.1 How are atoms held together in a metal & C3.2 How are metals with different reactivities extracted? (7 hours – separate and combined)

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| --- | --- |
| Links to KS3 Subject content  * chemical reactions as the rearrangement of atoms * displacement reactions * how patterns in reactions can be predicted with reference to the Periodic Table * oxidation reactions * properties of ceramics, polymers and composites (qualitative). * representing chemical reactions using formulae and using equations * the order of metals and carbon in the reactivity series * the Periodic Table: periods and groups; metals and non-metals * the properties of metals and non-metals * the use of carbon in obtaining metals from metal oxides * the varying physical and chemical properties of different elements | |
| Links to Mathematical Skills  * N/A | Links to Practical Activity Groups (PAGs)  * PAG1: Investigate the reactivity of different metals with water and dilute acid * PAG1: Investigate the reactivity of Zn, Fe and Cu by heating each metal with oxides of each of the other two metals |

| Suggested timings | Statements bold – Higher Tier only | Teaching activities | Notes |
| --- | --- | --- | --- |
| C3  Topic 1 and 2  7 hours (separate and combined) | C3.1.1. describe the nature and arrangement of chemical bonds in metals  C3.1.2. explain how the bulk properties of metals are related to the type of bonds they contain  C3.2.1. deduce an order of reactivity of metals based on experimental results including reactions with water, dilute acid and displacement reactions with other metals  C3.2.2. explain how the reactivity of metals with water or dilute acids is related to the tendency of the metal to form its positive ion to include potassium, sodium, calcium, aluminium, magnesium, zinc, iron, lead, [hydrogen], copper, silver  C3.2.3. use the names and symbols of common elements and compounds and the principle of conservation of mass to write formulae and balanced chemical equations **and ionic equations**  C3.2.4. explain, using the position of carbon in the reactivity series, the principles of industrial processes used to extract metals, including the extraction of zinc  C3.2.5. explain why electrolysis is used to extract some metals from their ores  **C3.2.6. evaluate alternative biological methods of metal extraction (bacterial and phytoextraction)**  IaS3: use the model of metal structure to explain properties of metals  IaS4: impacts of metal extraction on the environment, the measures scientists are taking to mitigate them, and the risks, costs and benefits of different courses of action | Introduce the idea of bonds forming as the products form, the products being more energetically stable than the separated atoms, and bonds being due to electrostatic interactions between nuclei and outer-shell electrons. The model of the ‘full outer shell’ is useful for initial explanations of simple structures (e.g. binary salts, small covalent molecules etc), but does tend to embed misconceptions about, for example, atom stability and anthropomorphising chemical substances (‘the sodium atom is unstable’, ‘it wants a full outer shell’). Careful use of language and emphasis that this is a model is recommended.  The Fuse School have some useful presentations on [metallic bonding](https://www.youtube.com/watch?v=S08qdOTd0w0).  This ‘Spot the bonding’ activity looks at [bonding in general](http://www.rsc.org/learn-chemistry/resource/res00001097/spot-the-bonding). Links can be made to the previously discussed ionic substances and now metallic substances, with reference to structure and bonding, and how these affect macroscopic properties.  Balancing equations may need to be consolidated – use of mini-white boards for rapid feedback/formative assessment might be appropriate here.  Investigation of the displacement reactions of metals is likely a repeat of practicals carried out in Key Stage 3, and can be extended here to measure temperature change, focusing on careful observation and recording skills, and possibly linking to ideas of rate of reaction. Learners should be able to develop word and symbol equations and make predictions about which reactions will occur, supported by this the Chemical Misconceptions ‘[Word equations’ resource](http://www.rsc.org/learn-chemistry/resource/res00001087/word-equations).  Reactions of metals in acids can be investigated with the Nuffield ‘[Metals and acids experiment’](http://www.rsc.org/learn-chemistry/resource/res00000446/metals-and-acids-experiment?cmpid=CMP00005351). Equally, the [Extracting metals from rocks](http://www.rsc.org/learn-chemistry/resource/res00000478/extracting-metals-from-rocks?cmpid=CMP00005111) is appropriate. An [RSC video](https://www.youtube.com/watch?v=vqFD_ly-qw0) on copper refining provides some useful background and context. A video from the Fuseschool giving some information on bioleaching and phytomining, can be found [here](https://www.youtube.com/watch?v=XF399zN36LE)  Detailed notes on the industrial extraction of zinc, amongst other metals, are available at [docbrown.info](http://www.docbrown.info/page04/Mextractd.htm) and could form the basis of a research activity for learners, splitting the discussed metals amongst the class and having the learners complete a short presentation/poster. | Chemists use a model of metal structure to explain the properties of metals (IaS3). In the model, metal atoms are arranged closely together in a giant structure, held together by attraction between the positively charged atoms and a ‘sea’ of negatively charged electrons. Metals are malleable and ductile because the ions can slide over each other but still be held together by the electrons; they conduct electricity and heat because their electrons are free to move; and they have high boiling points and melting points due to the strong electrostatic attraction between metal ions and the electrons. These properties of metals make them useful.  Metals can be placed in an order of reactivity by looking at their reactions with water, dilute acid and compounds of other metals. The relative reactivity of metals enables us to make predictions about which metals react fastest or which metal will displace another.  When metals react they form ionic compounds. The metal atoms lose one or more electrons to become positive ions. The more easily this happens the more reactive the metal.  These reactions can be represented by word and symbol equations including state symbols. **Ionic equations show only the ions that change in the reaction and show the gain or loss of electrons. They are useful for representing displacement reactions because they show what happens to the metal ions during the reaction.**  The way a metal is extracted depends on its reactivity. Some metals are extracted by reacting the metal compound in their ores with carbon.  Carbon is a non-metal but can be placed in the reactivity series of the metals between aluminium and zinc.  Metals below carbon in the reactivity series are extracted from their ores by displacement by carbon. The metal in the ore is reduced and carbon is oxidised.  Highly reactive metals above carbon in the reactivity series are extracted by electrolysis.  Scientists are developing methods of extracting the more unreactive metals from their ores using bacteria or plants. These methods can extract metals from waste material, reduce the need to extract ‘new’ ores, reduce energy costs, and reduce the amount of toxic metals in landfill. However, these methods do not produce large quantities of metals quickly (IaS4). |

# Outline Scheme of Work: C3 – Chemicals of the natural environment

## Total suggested teaching time – 23.5 / 19.5 hours (separate / combined)

### C3.3 – What are electrolytes and what happens during electrolysis? (6.5 hours – separate and combined)

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| --- | --- |
| Links to KS3 Subject content  * chemical reactions as the rearrangement of atoms * conservation of mass changes of state and chemical reactions. * representing chemical reactions using formulae and using equations * the varying physical and chemical properties of different elements | |
| Links to Mathematical Skills  * N/A | Links to Practical Activity Groups (PAGs)  * PAG2: investigate what type of substances are electrolytes * PAG2: investigate the effects of concentration of aqueous solution, current, voltage on the electrolysis of sodium chloride |

| Suggested timings | Statementsbold – Higher Tier only | Teaching activities | Notes |
| --- | --- | --- | --- |
| C3 – Topic 3  6.5 hours (separate and combined) | C3.3.1. describe electrolysis in terms of the ions present and reactions at the electrodes  C3.3.2. predict the products of electrolysis of binary ionic compounds in the molten state  C3.3.3. recall that metals (or hydrogen) are formed at the cathode and non-metals are formed at the anode in electrolysis using inert electrodes  **C3.3.4. use the names and symbols of common elements and compounds and the principle of conservation of mass to write half equations**  **C3.3.5. explain reduction and oxidation in terms of gain or loss of electrons, identifying which species are oxidised and which are reduced**  C3.3.6. explain how electrolysis is used to extract some metals from their ores including the extraction of aluminium  C3.3.7. describe competing reactions in the electrolysis of aqueous solutions of ionic compounds in terms of the different species present, including the formation of oxygen, chlorine and the discharge of metals or hydrogen linked to their relative reactivity  C3.3.8. describe the technique of electrolysis of an aqueous solution of a salt | Electrolysis is traditionally demonstrated with [lead bromide](http://www.rsc.org/learn-chemistry/resource/res00001725/electrolysing-molten-lead-ii-bromide?cmpid=CMP00005239), although [zinc chloride](http://www.rsc.org/learn-chemistry/resource/res00000826/electrolysis-of-molten-zinc-chloride?cmpid=CMP00005020) is a safer alternative.  OCR have a Topic Exploration pack on [electrolysis](https://www.ocr.org.uk/Images/363951-electrolysis-topic-exploration-pack.docx) containing guidance on teaching and other suggested activities. The [Particles and Elements transition guide](http://www.ocr.org.uk/Images/223681-particles-atoms-and-elements-transition-guide.pdf) can also be of use.  [Electrolysis of copper sulfate](http://www.rsc.org/learn-chemistry/resource/res00000476/electrolysis-of-copper-ii-sulfate-solution?cmpid=CMP00005019) can be carried out qualitatively, or extended to a quantitative investigation, looking at the link between current and mass of copper sulfate deposited on the cathode. Making accurate measurements can be challenging, and this would provide an opportunity to develop/refine learners’ manipulative skills.  Competing reactions under electrolysis can be challenging for learners – [practical work](http://www.rsc.org/learn-chemistry/resource/res00000737/identifying-the-products-of-electrolysis?cmpid=CMP00005149) can help, along with making the conceptual link between electrolysis as ‘normal’ chemical reaction in reverse and linking with reactivity series (e.g. reactivity series of metals, reactivity trends in Group 7).  Spending time on ensuring a firm understanding of the terminology is useful – mind/concept [maps](http://mind42.com/public/bce9f084-0f78-4835-bf11-dbdc3035b643) can be useful as a learning tool as well as for revision.  Balancing equations may need to be consolidated – the [OCR activity](http://www.ocr.org.uk/Images/179564-balancing-equations-teacher-instructions.pdf) (and [here](http://www.ocr.org.uk/Images/179630-balancing-equations-activity-powerpoint.ppt) and [here](http://www.ocr.org.uk/Images/179563-balancing-equations-activity.doc)) may be helpful. Detailed notes on half equations are available from [knockhardy](http://www.knockhardy.org.uk/ppointsnew_htm_files/REDOXPP.PPT) – this is an A-level resource but may be useful for information and directing higher ability students to (also this [summary sheet](http://www.knockhardy.org.uk/sci_htm_files/08e0.pdf)).  Aluminium extraction is discussed in this [RSC video](https://www.youtube.com/watch?v=WaSwimvCGA8). Detailed information about aluminium can be found at the [RSC Periodic Table](http://www.rsc.org/periodic-table), [Webelements](https://www.webelements.com/) and this [Lenntech site](http://www.lenntech.com/periodic/elements/al.htm). | Electrolysis is explained in Topic C3.3, and learners learn about the wide variety of products made by electrolysis.  Electrolysis is used to extract reactive metals from their ores. Electrolysis is the decomposition of an electrolyte by an electric current. Electrolytes include molten and dissolved ionic compounds. In both cases the ions are free to move.  During electrolysis non-metal ions lose electrons to the anode to become neutral atoms. Metal (or hydrogen) ions gain electrons at the cathode to become neutral atoms. The addition or removal of electrons can be used to identify which species are reduced and which are oxidised. These changes can be summarised using half equations.  Electrolysis is used to extract reactive metals from their molten compounds. During the electrolysis of aluminium, aluminium oxide is heated to a very high temperature. Positively charged aluminium ions gain electrons from the cathode to form atoms. Oxygen ions lose electrons at the anode and form oxygen molecules which react with carbon electrodes to form carbon dioxide. The process uses a large amount of energy for both the high temperature and the electricity involved in electrolysis.  Some extraction methods, such as the recovery of metals from waste heaps, give a dilute aqueous solution of metals ions.  When an electric current is passed through an aqueous solution the water is electrolysed as well as the ionic compound. Less reactive metals such as silver or copper form on the negative electrode. If the solution contains ions of more reactive metals, hydrogen gas forms from the hydrogen ions from the water. Similarly, oxygen usually forms at the positive electrode from hydroxide ions from the water. A concentrated solution of chloride ions forms chlorine at the positive electrode. |

# Outline Scheme of Work: C3 – Chemicals of the natural environment

## Total suggested teaching time – 23.5 / 19.5 hours (separate / combined)

### C3.4 – Why is crude oil important as a source of new materials (10 / 6 hours – separate / combined)

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| Links to KS3 Subject content  * chemical reactions as the rearrangement of atoms * combustion reactions * properties of ceramics, polymers and composites (qualitative). * representing chemical reactions using formulae and using equations * the production of carbon dioxide by human activity and the impact on climate. * the varying physical and chemical properties of different elements | |
| Links to Mathematical Skills  * M1c * M4a * M5b | Links to Practical Activity Groups (PAGs)  * PAG 3 – Fractional distillation of crude oil |

| Suggested timings | Statementsbold – Higher Tier only | Teaching activities | Notes |
| --- | --- | --- | --- |
| C3  Topic 4 – Part 1  3 hours (separate and combined) | C3.4.1. recall that crude oil is a main source of hydrocarbons and is a feedstock for the petrochemical industry  C3.4.2. explain how modern life is crucially dependent upon hydrocarbons and recognise that crude oil is a finite resource  C3.4.3. describe and explain the separation of crude oil by fractional distillation  C3.4.5. use ideas about energy transfers and the relative strength of chemical bonds and intermolecular forces to explain the different temperatures at which changes of state occur  C3.4.14. explain how the bulk properties of simple molecules are related to the covalent bonds they contain and their bond strengths in relation to intermolecular forces  C3.4.15. describe the production of materials that are more useful by cracking  IaS3: decision making in the context of the use of crude oil for fuels and as a feedstock  IaS4: cracking as a positive application of science, to reduce extraction of crude oil and so conserves oil reserves | As fossil fuels have likely been covered prior to KS4, research/independent work with short learner presentations is a useful introduction to this topic – this [short video](http://scicast.org.uk/films/2009/04/formation-of-crude-oil.html) might provide inspiration!  The [RSC video on oil refinery](https://www.youtube.com/watch?v=b5xScdRbXEU) is a little dated, but remains a good introduction to the topic. An interactive tour of the [Fawley refinery](http://resources.schoolscience.co.uk/exxonmobil/index.html) provides opportunity for independent work. The [footprints-science](http://www.footprints-science.co.uk) website provides a wealth of resources, including relevant animations on [fractional distillation](http://www.footprints-science.co.uk/index.php?module=2&type=Fractional%20distillation&section=Section1&info=6).  Discussion of the link between state change and intra/intermolecular bonding can be aided by the use of models. For example, cut some wool up into various lengths to represent the different alkanes in crude oil and squash into a small beaker. Learners can then separate them out (fractional distillation) without cutting them (cracking). Use of molecular models allows for similar modelling and the introduction of covalent bonds.  Cracking of hydrocarbons can be carried out as a demonstration or practical, either at [bench-scale](http://www.rsc.org/learn-chemistry/resource/res00000681/cracking-hydrocarbons?cmpid=CMP00005002) or [micro-scale](http://www.rsc.org/learn-chemistry/resource/res00001717/cracking-hydrocarbons-on-a-microscale?cmpid=CMP00005231). Selection of data from the [petroleum.co.uk](http://www.petroleum.co.uk/) website would allow for analysis of secondary data in homework/research projects. | Finally, Topic C3.4 covers the separation of crude oil into fractions and the use of these fractions to make other chemicals and polymers. Within this context learners study the properties of simple molecules in relation to covalent bonding and intermolecular forces.  Crude oil is a mixture of hydrocarbons. It is used as a source of fuels and as a feedstock for making chemicals (including polymers) for a very wide range of consumer products. Almost all of the consumer products we use involve the use of crude oil in their manufacture or transport.  Crude oil is finite. If we continue to burn it at our present rate it will run out in the near future. Crude oil makes a significant positive difference to our lives, but our current use of crude oil is not sustainable. Decisions about the use of crude oil must balance short-term benefits with the need to conserve this resource for the future.  Crude oil is a mixture. It needs to be separated into groups of molecules of similar size called fractions. This is done by fractional distillation. Fractional distillation depends on the different boiling points of the hydrocarbons, which in turn is related to the size of the molecules and the intermolecular forces between them.  The fractions are mixtures, mainly of alkanes, with a narrow range of boiling points.  Cracking long chain alkanes makes smaller more useful molecules that are in great demand as fuels (for example petrol). Cracking also yields alkenes – hydrocarbons with carbon-carbon double bonds. Alkenes are much more reactive than alkanes and can react to make a very wide range of products including polymers. Without cracking, we would need to extract a lot more crude oil to meet demand for petrol and would waste some longer chain alkanes which are not as useful. |
| C3  Topic 4 – Part 2  3 hours (separate and combined) | C3.4.4. describe the fractions of crude oil as largely a mixture of compounds of formula CnH2n+2 which are members of the alkane homologous series  C3.4.6. deduce the empirical formula of a compound from the relative numbers of atoms present or from a model or diagram and vice versa  C3.4.7. use arithmetic computation and ratio when determining empirical formulae  C3.4.8. describe the arrangement of chemical bonds in simple molecules  C3.4.9. explain covalent bonding in terms of the sharing of electrons  C3.4.10. construct dot and cross diagrams for simple covalent substances  C3.4.11. represent three dimensional shapes in two dimensions and vice versa when looking at chemical structures for simple molecules  C3.4.12. describe the limitations of dot and cross diagrams, ball and stick models and two and three dimensional representations when used to represent simple molecules  C3.4.13. translate information between diagrammatic and numerical forms  IaS3: the use of models to represent functional groups in homologous series | Building up the alkane homologous series with molecular models or card cut-out atoms and bonds allows learners to work out the general formula from their own modelling. They will also be able to get a feel for empirical formula, which should support their conceptual understanding when empirical formulae are derived from experimental data.  Collection of empirical formula data is traditionally from the [combustion of magnesium experiment](http://www.rsc.org/learn-chemistry/resource/res00000718/the-change-in-mass-when-magnesium-burns?cmpid=CMP00005934), although modification of this simple demonstration on the [combustion of iron wool](http://www.rsc.org/learn-chemistry/resource/res00000717/the-combustion-of-iron-wool?cmpid=CMP00006661) may provide suitable data. [Reduction of copper oxide](http://www.rsc.org/learn-chemistry/resource/res00000727/finding-the-formula-of-copper-ii-oxide?cmpid=CMP00006606) with methane is a third alternative, and allows discussion of redox in an interesting context. Many possible [worksheets](https://www.creative-chemistry.org.uk/documents/N-m07-10.pdf) are available with calculation practice – as ever double check for accuracy before use. As moles won’t necessarily have been covered (Chapter 5), scaffolded calculations may be appropriate.  Whichever experiment you use, go through how to calculate empirical formulae from their results (these will not be completely accurate but can lead to discussions of incomplete reactions and experimental error). Also review the number of moles of the element in the different masses of the substance and the percentage composition.  To introduce covalent bonding, first link back to the theory of formation of ions, and then move on to discussion of non-metals reacting together to gain full outer-shells *via* sharing of electrons. Work through various simple covalent molecules in turn, allowing learners who grasp the concept quickly to work independently. Suggested substances include H2, F2, HF, H2O, NH3, CH4, C2H6, CO2, C2H4, O2, N2, HCOOH, CO (this involves a dative bond). Plenty of worksheets are available online, including this [general bonding one](http://www.rsc.org/learn-chemistry/resource/res00000954/starters-for-ten?cmpid=CMP00001408) from the RSC Starters for Ten project. Several good videos exist to help learners consolidate their understanding, for example from [FuseSchool](https://www.youtube.com/watch?v=VbifG53cBR4) and [CrashCourse](https://www.youtube.com/watch?v=QXT4OVM4vXI).  Discussion of 2D and 3D representations of simple molecules can lead into discussion of the limitation of these models, for example not showing bond angles correctly (2D diagrams) and incorrectly representing relative atomic sizes and bonds as a physical object. | The first four alkanes show typical properties of a homologous series: each subsequent member increases in size by CH2, they have a general formula and show trends in their physical and chemical properties.  The molecular formula of an alkane shows the number of atoms present in each molecule. These formulae can be simplified to show the simplest ratio of carbon to hydrogen atoms. This type of formula is an empirical formula (IaS4).  Small molecules like alkanes and many of those met in chapter C1 contain non-metal atoms which are bonded to each other by covalent bonds. A covalent bond is a strong bond between two atoms that formed from a shared pair of electrons.  A covalent bond can be represented by a dot and cross diagram. Molecules can be shown as molecular or empirical formulae, displayed formulae (which show all of the bonds in the molecule) or in a 3 dimensional ‘ball and stick’ model.  Simple molecules have strong covalent bonds joining the atoms within the molecule, but they only have weak intermolecular forces. No covalent bonds are broken when simple molecules boil. The molecules move apart when given enough energy to overcome the intermolecular forces. This explains their low melting and boiling points. |
| C3  Topic 4 – Part 3  4 hours (separate and combined) | C3.4.16. recognise functional groups and identify members of the same homologous series (separate science only)  C3.4.17. name and draw the structural formulae, using fully displayed formulae, of the first four members of the straight chain alkanes and alkenes, alcohols and carboxylic acids (separate science only)  C3.4.18. predict the formulae and structures of products of reactions (combustion, addition across a double bond and oxidation of alcohols to carboxylic acids) of the first four and other given members of these homologous series (separate science only)  C3.4.19. recall that it is the generality of reactions of functional groups that determine the reactions of organic compounds (separate science only) | Detailed notes on organic substances are widely available, for example from [chemguide](http://www.chemguide.co.uk/organicprops/alcohols/background.html) and [knockhardy](http://www.knockhardy.org.uk/sci_htm_files/08oic.pdf). These are A-level chemistry websites so need to be used selectively, but are invaluable for particular keen learners.  It is worth distinguishing clearly between molecular, structural and fully displayed formulae when practicing the drawing of the required organic substances. Interesting discussion can be had over the first member of the alkene series having drawn methane, methanol and methanoic acid (methene?!). Learners could be extended by introducing isomerism, and challenged to identify all the isomers of, for example, heptane (nine in total). As ever with structure, molymods or similar are very helpful.  Writing word and symbol equations for combustion, addition and oxidation reactions of the organic substances will provide good opportunities to consolidate balancing equations. Demonstration / practical activities can add variety to an otherwise possibly dry topic, including reaction of bromine water with various hydrocarbons (perhaps as part of the cracking lesson), and [investigating the oxidation of alcohols](http://www.rsc.org/learn-chemistry/resource/res00000553/a-microscale-oxidation-of-alcohols?cmpid=CMP00005960).  Regular revision of the nomenclature and basic properties of organic substances is recommended – sites such as [Quizlet](https://quizlet.com/5121323/flashcards) can help with this out of class. | Alkanes and alkenes burn in plenty of air to make carbon dioxide and water. The double bond makes alkenes more reactive than alkanes. Addition across the double bond means that alkenes decolourise bromine water and can form polymers.  An alcohol has a structure like an alkane, but with one hydrogen replaced by an OH group. Alcohols burn to make carbon dioxide and water, and can also be oxidised to make carboxylic acids.  All of these compounds are useful to make consumer products. They have different properties due to their different functional groups. Alkanes do not have a functional group and so are unreactive. The functional group of alkenes – the double bond – is used for addition reactions. The OH functional group in alcohols give them a range of uses including their use as solvents that are miscible with water. The carboxylic acid functional group behaves as a weak acid, and these acids are found in foods and personal care products. |

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