# *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 natural 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: C4 – Material choices

## Total suggested teaching time – 19 / 13 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** |
| C4.2.3 | [Video and teaching pack](https://ocr.org.uk/rpgchem5) for Making nylon – an example of condensation polymerisation. Can be used for actual or virtual practical and in addition to the resources for carrying out the practical, it also includes preparation worksheets and a summary quiz. |
| C4.3.6 | Short [animation](https://www.ocr.org.uk/Images/588247-c4-cup-elevate-video-diamond-crystal-structure.mp4) showing the 3D structure of diamond.  Short [animated video](https://www.ocr.org.uk/Images/588249-c4-cup-elevate-video-structure-of-graphite.mp4) showing the structure of graphite |
| C4.4.4 | [Animated video](https://www.ocr.org.uk/Images/588248-c4-cup-elevate-video-buckminsterfullerine-molecule.mp4) showing the structure of Buckminsterfullerene. |
| C4.5.4 | An [RSC activity](https://edu.rsc.org/resources/assessing-the-life-cycle-of-fashion/4010470.article) on assessing the life cycle of fashion. Involves reading an article and completing worksheets based on it. |
| **C4** | 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. |

### C4.1 How is data used to choose a material for a particular use?

### (2.5 / 1.5 hours – separate / combined)

|  |  |
| --- | --- |
| Links to KS3 Subject content  * properties of ceramics, polymers and composites (qualitative). | |
| Links to Mathematical Skills  * N/A | Links to Practical Activity Groups (PAGs)  * N/a |

| Suggested timings | Statementsbold – Higher Tier only | Teaching activities | Notes |
| --- | --- | --- | --- |
| C4  Topic 1  2.5 / 1.5 hours (separate / combined) | C4.1.1. compare quantitatively the physical properties of glass and clay ceramics, polymers, composites and metals, including melting point, softening temperature (for polymers), electrical conductivity, strength (in tension or compression), stiffness, flexibility, brittleness, hardness, density, ease of reshaping  C4.1.2. explain how the properties of materials are related to their uses and select appropriate materials given details of the usage required  C4.1.3. describe the composition of some important alloys in relation to their properties and uses, including steel (separate science only)  IaS4: The range of materials developed by chemists enhances the quality of life.  IaS3: Use and limitations of a model to represent alloy structure. | An [OCR delivery guide](http://www.ocr.org.uk/qualifications/gcse-twenty-first-century-science-suite-chemistry-b-j258-from-2016/delivery-guide/) for this section is available on the [qualification page](http://www.ocr.org.uk/qualifications/gcse-twenty-first-century-science-suite-chemistry-b-j258-from-2016). The [Scheme of work builder](http://www.ocr.org.uk/qualifications/gcse-twenty-first-century-science-suite-chemistry-b-j258-from-2016/scheme-of-work/) is also available that links specification learning outcomes directly to resources.  The ‘[How plastics work](http://science.howstuffworks.com/plastic.htm/printable)‘ article from howstuffworks provides a useful introduction to the topic for teachers and learners.  Testing properties of materials will likely have been covered at KS3 (or earlier), so practical investigation of some aspects may not be necessary – the ‘[Properties of materials](http://www.rsc.org/learn-chemistry/resource/res00001792/the-properties-of-materials?cmpid=CMP00005337)‘ chapter from the That’s Chemistry resource provides some background. Areas for investigation could include i) the extension characteristics of different polymers; ii) electrical conductivity of different substances (polymer, graphite, ionic solids/solutions/molten (the latter by demonstration with zinc chloride)); iii) malleability/brittleness of substances; iv) [polymer density](http://www.rsc.org/learn-chemistry/resource/res00000385/identifying-polymers?cmpid=CMP00005147).; v) [Hair strength](http://www.ocr.org.uk/Images/72966-experiment-card-hair.pdf) This [document](http://outreach.materials.ox.ac.uk/LearningResources/downloads/MaterialsScienceandthenewGCSEScienceSpecifications.doc) from the Department of Materials at Oxford University poses some interesting research questions for extension materials. Demonstration of some material properties that may lead to spectacular destruction of materials (e.g. brittleness of ceramics) would be advised.  Composite materials can be investigated by making concrete, for example with a practical one from the [Royal Society of Chemistry](http://www.rsc.org/learn-chemistry/resource/res00002022/making-concrete?cmpid=CMP00006759). Other interesting composite materials include [filigree glass](https://www.youtube.com/watch?v=RXtCqI-iMJ4) and [reinforced concrete](http://www.explainthatstuff.com/steelconcrete.html),  The Practical Chemistry project ‘[Modelling alloys with plasticine’](http://www.rsc.org/learn-chemistry/resource/res00001755/modelling-alloys-with-plasticine?cmpid=CMP00005265) is a useful activity for discussing steel. Additionally, solder can be made in the ‘[Making an alloy’](http://www.rsc.org/learn-chemistry/resource/res00001742/making-an-alloy-solder?cmpid=CMP00006705) activity. [A short video](https://www.youtube.com/watch?v=1rrPv5AlVXg) on Shape Memory Alloys from University of Nottingham demonstrates the properties of these materials. | Our society uses a large range of materials and products that have been developed, tested and modified by the work of chemists. Materials used to make a particular product need to meet a specification which describes the properties the material needs to make it suitable for a particular use. This chapter looks at a range of different materials and investigates their properties in the context of their suitability for making consumer products. The chapter also considers how the life cycle of a product is assessed in its journey from raw material to final disposal.  Topic C4.1 considers the variety of materials that we use. Learners use data and information about the properties of ‘pure’ and composite materials to consider their suitability for making consumer products. Ceramics, glass, polymers, materials with giant structure and polymers are all considered.  Composites have a very broad range of uses as they allow the properties of several materials to be combined. Composites may have materials combined on a bulk scale (for example using steel to reinforce concrete) or have nanoparticles incorporated in a material or embedded in a matrix.  The range of uses of metals has been extended by the development of alloys. Alloys have different properties to pure metals due to the disruption of the metal lattice by atoms of different sizes. Chemists can match an alloy to the specification of properties for a new product. |

# Outline Scheme of Work: C4 – Material choices

## Total suggested teaching time – 19 / 13 hours (separate / combined)

### C4.2 – What are the different types of polymers? (separate science only) (4 hours – separate only)

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

| Suggested timings | Statementsbold – Higher Tier only | Teaching activities | Notes |
| --- | --- | --- | --- |
| C4  Topic 2  4 hours (separate only) | C4.2.1. recall the basic principles of addition polymerisation by reference to the functional group in the monomer and the repeating units in the polymer (separate science only)  C4.2.2. deduce the structure of an addition polymer from a simple monomer with a double bond and vice versa (separate science only)  **C4.2.3. explain the basic principles of condensation polymerisation by reference to the functional groups of the monomers, the minimum number of functional groups within a monomer, the number of repeating units in the polymer, and simultaneous formation of a small molecule (separate science only) [Learners are not expected to recall the formulae of dicarboxylic acid, diamine and diol monomers]**  C4.2.4. recall that DNA is a polymer made from four different monomers called nucleotides and that other important naturally-occurring polymers are based on sugars and amino-acids (separate science only) | An [OCR delivery guide](http://www.ocr.org.uk/qualifications/gcse-twenty-first-century-science-suite-chemistry-b-j258-from-2016/delivery-guide/) for this section is available on the [qualification page](http://www.ocr.org.uk/qualifications/gcse-twenty-first-century-science-suite-chemistry-b-j258-from-2016). The [Scheme of work builder](http://www.ocr.org.uk/qualifications/gcse-twenty-first-century-science-suite-chemistry-b-j258-from-2016/scheme-of-work/) is also available that links specification learning outcomes directly to resources.  Many websites have useful introductory videos such as [CrashCourse](https://www.youtube.com/watch?v=rHxxLYzJ8Sw) and [FuseSchool](https://www.youtube.com/watch?v=nz1ucI6gCIg) on polymers and [StatedClearly](https://www.youtube.com/watch?v=zwibgNGe4aY) on DNA.  Demonstration of cracking paraffin and testing the gaseous products for unsaturation helps makes the link from discussion of crude oil to polymer synthesis – a [bench scale](http://www.rsc.org/learn-chemistry/resource/res00000681/cracking-hydrocarbons?cmpid=CMP00005002) and [micro-scale](http://www.rsc.org/learn-chemistry/resource/res00001717/cracking-hydrocarbons-on-a-microscale?cmpid=CMP00005231) version are available. Additionally, starch could be broken down by enzyme hydrolysis with testing for starch/sugars. Demonstrations/practicals of polymer formation include the [nylon rope trick](http://www.rsc.org/learn-chemistry/resource/res00000755/making-nylon-the-nylon-rope-trick?cmpid=CMP00000834) and [polymerisation of polyols](http://www.rsc.org/learn-chemistry/resource/res00000479/addition-polymerisation?cmpid=CMP00004755).  Testing properties of different polymer fibres – see previous topic.  Teaching polymers allows for use of modelling and role play. For example, give each student a paper clip monomer which gets passed around adding onto the chain until there is apolymer(paper clip). Molymods provide a useful way of learners realising that only one of the bonds in the double bond breaks. . Making [stop-motion animations](https://www.youtube.com/watch?v=nASPhhkkwcs) can engage learners creative, scientific and communication skills. For role-play, learners double bond by holding hands, all crowd together (high pressure). A catalyst (teacher or single learner) then breaks one double bond, the free hand breaks the next and so on, the chain grows until the whole class is holding hands in a chain.  Learners should know that the monomers are unsaturated, whereas the polymers are saturated. Learners will need practice changing monomer structure into polymer and polymer structure into monomer, and naming polymers, for example polyethene, polyvinyl chloride and polystyrene. The Royal Society of Chemistry [Inspirational Chemistry](http://www.rsc.org/Education/Teachers/Resources/Inspirational/?e=1) project contains many useful resources, included a [monomer-polymer cardsort](http://www.rsc.org/Education/Teachers/Resources/Inspirational/resources/3.1.4.pdf).  For research/independent work/homework, learners could be assigned a different polymer to research and present the discovery of and use of in society, including disadvantages. Many [websites](https://www2.chemistry.msu.edu/faculty/reusch/virttxtjml/polymers.htm) are available – this one goes well beyond the chemistry required, but contains a useful table of different polymers. | Topic C4.2 moves on to look in detail at materials made using polymers. The topic covers the chemical reactions that happen when addition and condensation polymers form, and also studies naturally occurring polymers. This topic links closely to the discussion of bonding and structure in Topic C4.3.  Polymers are long chain molecules that occur naturally and can also be made synthetically. Monomers based on alkenes from crude oil can be used to make a wide range of addition polymers that are generally known as ‘plastics’. Addition polymers form when the double bonds in small molecules open to join the monomers together into a long chain.  **Condensation polymers were developed to make materials that are substitutes for natural fibres such as wool and silk.**  **Condensation polymers usually form from two different monomer molecules which contain different functional groups. The OH group from a carboxylic acid monomer and an H atom from another monomer join together to form a water molecule. Monomers that react with carboxylic acid monomers include alcohols (to make polyesters) and amines (to make polyamides). To make a polymer, each monomer needs two functional groups. The structure of the repeating unit of a condensation polymer can be worked out from the formulae of its monomers and vice versa.**  Many natural polymers are essential to life. Genes are made of DNA, a polymer of four nucleotide monomers. Proteins (which are similar in structure to polyamides) are polymers of amino acids. Carbohydrates, including starch and cellulose, are polymers of sugars.  Links can be made to other Chapters/Subjects:   * The extraction and processing of crude oil, including the formation of alkenes by cracking. (C3.4) * Functional groups including carboxylic acids and alcohols. (C3.4) * Structure and function of DNA, and protein synthesis (B1.1) * The synthesis and breakdown of carbohydrates and proteins (B3.3) |

# Outline Scheme of Work: C4 – Material choices

## Total suggested teaching time – 19 / 13 hours (separate / combined)

### C4.3 – How do bonding and structure affect properties of materials?

### (3 hours – separate and combined)

|  |  |
| --- | --- |
| Links to KS3 Subject content  * properties of ceramics, polymers and composites (qualitative) * 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)  * N/A |

| Suggested timings | Statementsbold – Higher Tier only | Teaching activities | Notes |
| --- | --- | --- | --- |
| C4  Topic 3  3 hours (separate and combined) | C4.3.1. explain how the bulk properties of materials (including strength, melting point, electrical and thermal conductivity, brittleness, flexibility, hardness and ease of reshaping) are related to the different types of bonds they contain, their bond strengths in relation to intermolecular forces and the ways in which their bonds are arranged, recognising that the atoms themselves do not have these properties  C4.3.2. recall that carbon can form four covalent bonds  C4.3.3. explain that the vast array of natural and synthetic organic compounds occurs due to the ability of carbon to form families of similar compounds, chains and rings  C4.3.4. describe the nature and arrangement of chemical bonds in polymers with reference to their properties including strength, flexibility or stiffness, hardness and melting point of the solid  C4.3.5. describe the nature and arrangement of chemical bonds in giant covalent structures  C4.3.6. explain the properties of diamond and graphite in terms of their structures and bonding, include melting point, hardness and (for graphite) conductivity and lubricating action  C4.3.7. represent three dimensional shapes in two dimensions and vice versa when looking at chemical structures e.g. allotropes of carbon  C4.3.8. describe and compare the nature and arrangement of chemical bonds in ionic compounds, simple molecules, giant covalent structures, polymers and metals  IaS2: Identify patterns in data related to polymers and allotropes of carbon.  IaS3: Use and limitations of a model to represent the structures of a range of materials. | An [OCR delivery guide](http://www.ocr.org.uk/qualifications/gcse-twenty-first-century-science-suite-chemistry-b-j258-from-2016/delivery-guide/) for this section is available on the [qualification page](http://www.ocr.org.uk/qualifications/gcse-twenty-first-century-science-suite-chemistry-b-j258-from-2016). The [Scheme of work builder](http://www.ocr.org.uk/qualifications/gcse-twenty-first-century-science-suite-chemistry-b-j258-from-2016/scheme-of-work/) is also available that links specification learning outcomes directly to resources.  Research and use of data on properties of materials may provide interesting context as independent research/homework – the [MatWeb](http://www.matweb.com/) website contains many data sheets. The Royal Society of Chemistry [Alchemy project](http://www.rsc.org/Education/Teachers/Resources/Alchemy/index2.htm) has a section on nylon and on polythene.  The structures and properties of the carbon allotropes diamond, graphite and fullerenes (see Topic 4) can be explored on the [NanoAge](http://www.thenanoage.com/carbon.htm)  website, and [Molymod models](http://www.rapidonline.com/molymod-crystal-structure-molecular-model-kits-525540) of these structures is recommended to give the learners a good understanding of the differences in the structures. Comparing diamond and graphite allows covalent bonding, intermolecular bonding, physical properties (including boiling point, solubility), electrical conductivity etc to be considered. There are many useful websites, for example from [BBC Bitesize](http://www.bbc.co.uk/schools/gcsebitesize/science/add_ocr_gateway/chemical_economics/nanochemistryrev1.shtml)..  This activity looks at [ionic bonding](http://www.rsc.org/learn-chemistry/resource/res00001095/ionic-bonding) and this one on [bonding in general](http://www.rsc.org/learn-chemistry/resource/res00001097/spot-the-bonding).  The Fuse School have some useful summary presentations on [ionic bonding](https://www.youtube.com/watch?v=zpaHPXVR8WU), [covalent bonding](https://www.youtube.com/watch?v=0HfN3CvXP2M) and [metallic bonding](https://www.youtube.com/watch?v=S08qdOTd0w0).  [This presentation](http://www.knockhardy.org.uk/gcse_htm_files/gorgpps.pps) is a general introduction to organic chemistry. While it goes into much more detail than required here, this may help lay the groundwork for later study of carbon chemistry. | *This topic and the next bring together ideas already developed elsewhere about bonding and structure. If these ideas need more thorough revision, more time than suggested here may need to be used.*  Topic C4.3 extends the study of properties to looking at bonding and structure in order to explain why a particular material behaves as it does. Learners learn about the bonding in metals, polymers and giant covalent structures and link the bonding and structure to the properties of the materials. They consider the usefulness of diagrams and models of bonding and structure to chemists who need to investigate and predict properties of materials so that they can make judgements about their usefulness or model likely changes in their properties if their structures are modified. A range of materials are studied, including new materials such as fullerenes and graphene.  Different materials can be made from the same atoms but have different properties if they have different types of bonding or structures. Chemists use ideas about bonding and structure when they predict the properties of a new material or when they are researching how an existing material can be adapted to enhance its properties.  Carbon is an unusual element because it can form chains and rings with itself. This leads to a vast array of natural and synthetic compounds of carbon with a very wide range of properties and uses. ‘Families’ of carbon compounds are homologous series.  Polymer molecules have the same strong covalent bonding as simple molecular compounds, but there are more intermolecular forces between the molecules due to their length. The strength of the intermolecular forces affects the properties of the solid.  Giant covalent structures contain many atoms bonded together in a three-dimensional arrangement by covalent bonds. The ability of carbon to bond with itself gives rise to a variety of materials which have different giant covalent structures of carbon atoms. These are allotropes, and include diamond and graphite. These materials have different properties which arise from their different structures.  Links can be made to other Chapters:   * ionic bonding and structure (C2.3) * metallic bonding (C3.1) * covalent bonds and intermolecular forces (C3.4) * the alkanes as a homologous series. (C3.4)   *The Learning outcome C4.3.8 consolidates the chemistry on bonding that will have been built up in previous Chapters, so won’t necessarily need considering in full detail again.* |

# Outline Scheme of Work: C4 – Material choices

## Total suggested teaching time – 19 / 13 hours (separate / combined)

### C4.4 – Why are nanoparticles so useful?

### (4.5 hours – separate and combined)

|  |  |
| --- | --- |
| Links to KS3 Subject content  * representing chemical reactions using formulae and using equations | |
| Links to Mathematical Skills  * M1b * M1c * M1d * M5c | Links to Practical Activity Groups (PAGs)  * N/A |

| Suggested timings | Statementsbold – Higher Tier only | Teaching activities | Notes |
| --- | --- | --- | --- |
| C4  Topic 4  4.5 hours (separate and combined) | C4.4.1. compare ‘nano’ dimensions to typical dimensions of atoms and molecules  C4.4.2. describe the surface area to volume relationship for different-sized particles and describe how this affects properties  C4.4.3. describe how the properties of nanoparticulate materials are related to their uses including properties which arise from their size, surface area and arrangement of atoms in tubes or rings  C4.4.4. explain the properties of fullerenes and graphene in terms of their structures  C4.4.5. explain the possible risks associated with some nanoparticulate materials including:  **a)** possible effects on health due to their size and surface area  **b)** reasons that there is more data about uses of nanoparticles than about possible health effects  **c)** the relative risks and benefits of using nanoparticles for different purposes  C4.4.6. estimate size and scale of atoms and nanoparticles including the ideas that:  **a)** nanotechnology is the use and control of structures that are very small (1 to 100 nanometres in size)  **b)** data expressed in nanometres is used to compare the sizes of nanoparticles, atoms and molecules  C4.4.7. interpret, order and calculate with numbers written in standard form when dealing with nanoparticles  C4.4.8. use ratios when considering relative sizes and surface area to volume comparisons  C4.4.9. calculate surface areas and volumes of cubes  IaS3: Development of nanoparticles and graphene relied on imaginative thinking.  IaS4: Discuss the potential benefits and risks of developments in nanotechnology | An [OCR delivery guide](http://www.ocr.org.uk/qualifications/gcse-twenty-first-century-science-suite-chemistry-b-j258-from-2016/delivery-guide/) for this section is available on the [qualification page](http://www.ocr.org.uk/qualifications/gcse-twenty-first-century-science-suite-chemistry-b-j258-from-2016). The [Scheme of work builder](http://www.ocr.org.uk/qualifications/gcse-twenty-first-century-science-suite-chemistry-b-j258-from-2016/scheme-of-work/) is also available that links specification learning outcomes directly to resources.  Good introductions to nanotechnology and sources of information include ‘[The strange new world of nanoscience](https://www.youtube.com/watch?v=70ba1DByUmM)‘, ‘[How nanotechology works](http://science.howstuffworks.com/nanotechnology.htm)‘ and ‘[What is nanotechnology?](http://www.crnano.org/whatis.htm)‘  A survey of the uses of fullerenes is available from the [understandingnano.com](http://www.understandingnano.com/buckyballs-fullerenes.html) website.  The structures and properties of the fullerene carbon allotropes can be explored on the [Edinformatics](http://www.edinformatics.com/math_science/carbon.htm) website, and [Molymod models](http://www.rapidonline.com/molymod-crystal-structure-molecular-model-kits-525540) of these structures is recommended to give the learners a good understanding of the differences in the structures. Comparing graphene and fullerenes allows covalent bonding, intermolecular bonding, physical properties (including boiling point, solubility), electrical conductivity etc to be considered. This topic gives plenty of opportunity for extension, especially when considering classification of structures – e.g. when does a simple covalent structure (C60) become a giant covalent structure (carbon nanotubes)? There are many useful websites, for example [here](http://www.bbc.co.uk/schools/gcsebitesize/science/add_ocr_gateway/chemical_economics/nanochemistryrev1.shtml). Learners can make their own models of buckyballs, for example [here](http://www.instructables.com/id/Knex-Buckyball/) . Properties of the carbon allotropes makes useful research and presentation projects – the award of the [2010 Physics Nobel Prize](http://www.nobelprize.org/nobel_prizes/physics/laureates/2010/press.html) for graphene can provide a useful context for discussing Ideas about Science.  Benefits and potential harmful effects of nanoparticles makes for a good research project – there are plenty of online sources available, for example from the [GreenFacts](http://copublications.greenfacts.org/en/nanotechnologies/l-2/6-ealth-effects-nanoparticles.htm) website, and provide a useful opportunity to discuss sources of bias.  This [page from Chemwiki](http://chemwiki.ucdavis.edu/Core/Analytical_Chemistry/Chemical_Reactions/Properties_of_Matter) gives useful clarification of chemical and physics properties, and [this page](http://www.dummies.com/how-to/content/how-materials-change-in-nanoscale.html) helps introduce the ideas around how nanoscale materials can have substantially different properties  Surface-area to volume ratios can be investigated with this [activity](http://www.nnin.org/education-training/k-12-teachers/nanotechnology-curriculum-materials/surface-area-volume-ratio) from the National Nanotechology Infrastructure Network.  The [Chemistry’s Interfaces: The Nano Frontier resources](http://www.rsc.org/learn-chemistry/resource/res00000946/chemistrys-interfaces-the-nano-frontier-c-pbl?cmpid=CMP00001525) is aimed at Higher Education, but may provide some inspiration for particularly able or interested learners. | Topic C4.4 looks specifically at the nature and uses of nanoparticles – see the note in Topic C4.3 on timing.  Nanoparticles have a similar scale to individual molecules. Their extremely small size means they can penetrate into biological tissues and can be incorporated into other materials to modify their properties. Nanoparticles have a very high surface area to volume ratio. This makes them excellent catalysts.  Fullerenes form nanotubes and balls. The ball structure enables them to carry small molecules, for example carrying drugs into the body. The small size of fullerene nanotubes enables them to be used as molecular sieves and to be incorporated into other materials (for example to increase strength of sports equipment). Graphene sheets have specialised uses because they are only a single atom thick but are very strong with high electrical and thermal conductivity.  Developing technologies based on fullerenes and graphene required leaps of imagination from creative thinkers (IaS3).  There are concerns about the safety of some nanoparticles because not much is known about their effects on the human body. Judgements about a particular use for nanoparticles depend on balancing the perceived benefit and risk (IaS4). |

# Outline Scheme of Work: C4 – Material choices

## Total suggested teaching time – 19 / 13 hours (separate / combined)

### C4.5 – What happens to products at the end of their useful life?

### (5 / 4 hours – separate / combined)

|  |  |
| --- | --- |
| Links to KS3 Subject content  * oxidation reactions * representing chemical reactions using formulae and using equations | |
| Links to Mathematical Skills  * N/A | Links to Practical Activity Groups (PAGs)  * N/A |

| Suggested timings | Statementsbold – Higher Tier only | Teaching activities | Notes |
| --- | --- | --- | --- |
| C4  Topic 5  5 / 4 hours (separate / combined) | C4.5.1. describe the conditions which cause corrosion and the process of corrosion, and explain how mitigation is achieved by creating a physical barrier to oxygen and water and by sacrificial protection (separate science only)  C4.5.2. explain reduction and oxidation in terms of loss or gain of oxygen, identifying which species are oxidised and which are reduced  **C4.5.3. explain reduction and oxidation in terms of gain or loss of electrons, identifying which species are oxidised and which are reduced**  C4.5.4. describe the basic principles in carrying out a life-cycle assessment of a material or product including  **a)** the use of water, energy and the environmental impact of each stage in a life cycle, including its manufacture, transport and disposal  **b)** incineration, landfill and electricity generation schemes  **c)** biodegradable and non-biodegradable materials  C4.5.5. interpret data from a life-cycle assessment of a material or product  C4.5.6. describe the process where PET drinks bottles are reused and recycled for different uses, and explain why this is viable  C4.5.7. evaluate factors that affect decisions on recycling with reference to products made from crude oil and metal ores  IaS4: Use the example of applying scientific solutions to the problem of corrosion of metals to explain the idea of improving sustainability  IaS4: use life cycle assessments to compare the sustainability of products and processes | An [OCR delivery guide](http://www.ocr.org.uk/qualifications/gcse-twenty-first-century-science-suite-chemistry-b-j258-from-2016/delivery-guide/) for this section is available on the [qualification page](http://www.ocr.org.uk/qualifications/gcse-twenty-first-century-science-suite-chemistry-b-j258-from-2016). The [Scheme of work builder](http://www.ocr.org.uk/qualifications/gcse-twenty-first-century-science-suite-chemistry-b-j258-from-2016/scheme-of-work/) is also available that links specification learning outcomes directly to resources.  Learners will likely have covered rusting at KS3, so a discussion may be sufficient here. The Practical Chemistry project ‘[The causes of rusting](http://www.rsc.org/learn-chemistry/resource/res00000434/the-causes-of-rusting?cmpid=CMP00006665)‘ provides a useful starting point if you wish to carry out practical investigations of the factors needed for rusting and/or the effectiveness of corrosion prevention (barrier and sacrificial protection methods).  Discussion of redox reactions – [FuseSchool](https://www.youtube.com/watch?v=0lYXFJDDYAQ) has a useful introduction, as does [CrashCourse](https://www.youtube.com/watch?v=lQ6FBA1HM3s), although there is some advanced organic chemistry in here.  There are numerous websites for learners to research the problems of disposal of plastic waste, for example the [British Plastics Federation](http://www.bpf.co.uk/sustainability/plastics_recycling.aspx), local council websites and a report from the [Department for Environment, Food and Rural Affairs](https://www.gov.uk/government/publications/2010-to-2015-government-policy-waste-and-recycling/2010-to-2015-government-policy-waste-and-recycling). Include all your local facilities e.g. land fill and recycling points etc. A box of different products would allow learners to sort different types of plastics and identify how their properties relate to their uses? What can they see as the problems of an industrial scale recycling process for plastics?  Learners could be organised into groups to research and debate a proposal such as “The development of a plastic recycling plant should be supported by our local council”, along the lines of the [SATIS Limestone Enquiry](https://www.stem.org.uk/elibrary/resource/25907/science-and-technology-in-society-6) activity (free login required).  Life-cycle assessment is discussed [here](http://www.gdrc.org/uem/lca/lca-define.html) by the Global Development Research Centre and on the [BBC Bitesize website](http://www.bbc.co.uk/schools/gcsebitesize/science/21c_pre_2011/materials/makinglifecycleassessmentsrev1.shtml).  The BPF website contains some information on [PET drinks bottles](http://www.bpf.co.uk/sustainability/PET_Plastic_Bottles_Facts_Not_Myths.aspx). Many school uniforms are made from recycled polyester, including PET, making for an interesting context. The STEM Learning website has a collection of available resources on [Sustainability and life cycle assessment](https://www.stem.org.uk/elibrary/list/45775/sustainability-and-life-cycle-assessment), including the ‘[The Paper Cup Company](https://www.stem.org.uk/elibrary/resource/25377/the-paper-cup-company)‘ activity. | Topic C4.5 considers the life cycle of materials. The learners learn about the corrosion of metals such as iron and look at ways of extending the life of metal products by working to prevent corrosion. They also learn how the impact of our manufacture, use and disposal of consumer products is assessed using life cycle assessments.  Iron is the most widely used metal in the world. The useful life of products made from iron is limited because iron corrodes. This involves an oxidation reaction with oxygen from the air. Barrier methods to prevent corrosion extend the useful life of metal products, which is good for consumers and has a positive outcome in terms of the life cycle assessment.  Sacrificial protection uses a more reactive metal such as zinc to oxidise in preference to iron. This continues to prevent corrosion even if the coating on the metal is damaged.  Life cycle assessments (LCAs) are used to consider the overall impact of our making, using and disposing of a product. LCAs involve considering the use of resources and the impact on the environment of all stages of making materials for a product from raw materials, making the finished product, the use of the product, transport and the method used for its disposal at the end of its useful life.  It is difficult to make secure judgments when writing LCAs because there is not always enough data and people do not always follow recommended disposal advice (IaS4).  Some products can be recycled at the end of their useful life. In recycling, the products are broken down into the materials used to make them; these materials are then used to make something else. Reusing products uses less energy than recycling them. Reusing and recycling both affects the LCA.  Recycling conserves resources such as crude oil and metal ores, but will not be sufficient to meet future demand for these resources unless habits change.  The viability of a recycling process depends on a number of factors: the finite nature of some deposits of raw materials (such as metal ores and crude oil), availability of the material to be recycled, economic and practical considerations of collection and sorting, removal of impurities, energy use in transport and processing, scale of demand for new product, environmental impact of the process.  IaS4: Products made from recycled materials do not always have a lower environmental impact than those made from new resources (IaS4). |

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