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GCSE (9–1)
Transition Guide

TWENTY FIRST CENTURY SCIENCE CHEMISTRY B

J258
For first teaching in 2016

KS3–KS4 focus
Material choices

Version 1

www.ocr.org.uk/chemistry

GCSE (9–1)

TWENTY FIRST CENTURY SCIENCE CHEMISTRY B

Key Stage 3 to 4 Transition guides focus on how a particular topic is covered at the different key stages and provide information on:

- Differences in the demand and approach at the different levels;
- Useful ways to think about the content at Key Stage 3 which will help prepare students for progression to Key Stage 4;
- Common student misconceptions in this topic.

Transition guides also contain links to a range of teaching activities that can be used to deliver the content at Key Stage 3 and 4 and are designed to be of use to teachers of both key stages. Central to the transition guide is a Checkpoint task which is specifically designed to help teachers determine whether students have developed deep conceptual understanding of the topic at Key Stage 3 and assess their 'readiness for progression' to Key Stage 4 content on this topic. This checkpoint task can be used as a summative assessment at the end of Key Stage 3 teaching of the topic or by Key Stage 4 teachers to establish their students' conceptual starting point.

Key Stage 3 to 4 Transition Guides are written by experts with experience of teaching at both key stages.

Key Stage 3 Content

- distinguish between an object and the material from which it is made
- identify and name a variety of everyday materials, including wood, plastic, glass, metal, water, and rock
- describe the simple physical properties of a variety of everyday materials
- compare and group together a variety of everyday materials on the basis of their simple physical properties
- have observed that some materials change state when they are heated or cooled, and measured the temperature at which this happens in degrees Celsius (°C)
- compare and group together everyday materials on the basis of their properties, including their hardness, solubility, transparency, conductivity (electrical and thermal), and response to magnets
- identify and compare the suitability of a variety of everyday materials, including wood, metal, plastic, glass, brick, rock, paper and cardboard for particular use
- know the differences between atoms, elements and compounds
- recognise chemical symbols and formulae for some elements and compounds
- know about the properties of ceramics, polymers and composites (qualitative).

Key Stage 4 Content

IaS2: Identify patterns in data related to polymers and allotropes of carbon.

IaS3: Development of nanoparticles and graphene relied on imaginative thinking.

IaS3: Use and limitations of a model to represent alloy structure.

IaS3: Use and limitations of a model to represent the structures of a range of materials.

IaS4: Discuss the potential benefits and risks of developments in nanotechnology

IaS4: The range of materials developed by chemists enhances the quality of life.

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

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)

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)

Key Stage 4 Content

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

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 fullerenes and graphene in terms of their structures

C4.4.5. explain the possible risks associated with some nanoparticulate materials including: possible effects on health due to their size and surface area reasons that there is more data about uses of nanoparticles than about possible health effects the relative risks and benefits of using nanoparticles for different purposes

Key Stage 4 Content

C4.4.6. estimate size and scale of atoms and nanoparticles including the ideas that: nanotechnology is the use and control of structures that are very small (1 to 100 nanometres in size) 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

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 the use of water, energy and the environmental impact of each stage in a life cycle, including its manufacture, transport and disposal incineration, landfill and electricity generation schemes 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

Comment

At key stage 3, learners are expected to identify and name a variety of everyday materials, and describe their properties. This is extended at key stage 4, to include the formation of polymers, alloys and nanoparticles. Learners will be familiar with the materials that they identify in key stage 3, such as wood, metals, glass, rock and ceramics, and the properties that they exhibit will be observable and make sense in the everyday world. Many of the materials introduced in key stage 4 will be new to the learners, and the differences in properties because of the molecular structure will need to be modelled to be understood. For example, the differences in the structure of diamond, graphite, graphene and silicon dioxide. Learners could use plasticine or molecule building kits to model the structures of diamond and graphite to see why graphite is soft and diamond is hard.

Learners will have tested the properties of plastic at key stage 3, but possibly not different types of plastic. Some learners may not be aware that there are different types of plastic, and that these are formed in different ways, and have different properties. A good way to introduce this topic may be to have different types of plastic in the classroom, and show the learners how to identify the type of plastic by looking at the number printed on it, e.g. 1 is PET. This also leads onto the topic of recycling plastic.

At key stage 3, learners will be familiar with the idea of atoms, elements and compounds, and will have drawn particle diagrams of elements and compounds. They will need to build on this knowledge now in order to explain the formation of plastics by addition polymerisation and condensation polymerisation. One way of understanding these processes is to model them using plasticine or molecule building kits, and then making some plastics in the classroom.

Modelling kits can also be useful in explaining bonds between atoms in molecules, and why some bonds are stronger than others. Learners can then relate their knowledge of the properties of materials to the bonds within and between molecules. For example, the learners can see that the carbon atoms tend to form four bonds, oxygen two bonds and hydrogen one bond.

At key stage 4, learners will be encouraged to think about the future of materials, and their safety. For example, learners will be asked to think about the benefits and drawbacks of using nanotechnology. Learners will find it difficult to imagine nanoparticles, and even how small they are. There are many good videos designed for the 14-16 age group which can help with this. The drawbacks and benefits of using nanoparticles might suit a research project, but be aware there are some websites that do not represent a balanced view of the matter. It might be best to give a list of some reliable websites before learners do their own research. This could also be a good opportunity to hold a debate in the classroom.

Learners are also asked to look at oxidation and reduction in different materials. This can be a difficult concept for learners to understand but can be shown with a simple experiment. For example, methylene blue changes colour when oxidised and reduced. Oxidation is commonly seen as rust, and learners will be asked to find out ways of preventing corrosion. This can be done as an investigation, with learners testing different variables to see which is the best at preventing corrosion. This links into the topic of recycling and the life cycle of a material. Learners usually find this topic interesting and could carry this out as an investigation or a presentation.

Activities

Properties of materials

The Royal Society of Chemistry (RSC)

Resources: https://www.stem.org.uk/elibrary/resource/33462

A selection of experiments for learners to test the properties of everyday materials, including testing for strength, flexibility and elasticity.

Materials class clips

BBC

Resources: http://www.bbc.co.uk/education/topics/zgvbkqt/resources/1

26 short video clips about different aspects of materials, such as composites, alloys and plastics.

Solids, liquids and gases

ABPI

Resources: https://www.abpischools.org.uk/topic/solids-liquids-gases/3/1

A range of classroom investigations, looking at melting, solidification and evaporation. These investigations allow learners to plan their own experiments, using a wide range of variables.

Chembalancer and element quiz

Fun Based Learning

Resources: http://funbasedlearning.com/chemistry/

Online games to help learners revise chemical symbols and balancing equations.

Checkpoint task

These tasks focus on the behaviour of particles in a solid, liquid, or gas, and the reactions between molecules. Both activities use different coloured sweets to represent atoms.

In task one, learners arrange their sweets on a piece of plain paper to represent a gas, a liquid, and a solid. It does not matter which colours they choose at this point. Learners are demonstrating that they understand how particles behave in these different states. This is underpinned by the learners describing in their own words what is happening as the particles change state. The extension activity encourages learners to remember the change of state graph for water, and what each part of the graph means.

Task two is about atoms, elements and compounds. Each different coloured sweet now represents a different element. Learners can use the sweets to represent an atom, an element and a compound. Learners are then asked to represent the reaction between hydrogen and oxygen, using the sweets. They should use one colour to represent hydrogen and a different colour to represent oxygen. After hydrogen and oxygen react together, the learners should move the sweets to show that hydrogen and oxygen have now formed a compound, hydrogen peroxide. Note, this is used instead of water at this stage to minimise the complication of balancing equations with the first example. This should show the learners that no atoms are lost in the making of a new product. All of the original atoms are still present at the end of the reaction. Learners should then recall the word equation for this reaction and the chemical equation.

This idea is built upon using other reactions involving hydrogen, oxygen, magnesium, chlorine and carbon. The extension activity is to balance the equations. By moving the atoms around during the reaction, this should make balancing the equations easier.

www.ocr.org.uk/Images/379832-material-choices-checkpoint-activity.doc

Activities

The strength of hair

OCR

Resources: http://www.ocr.org.uk/Images/72966-experiment-card-hair.pdf

A class experiment to test the tensile strength of learners' hair. Learners can design their own experiment to look at different variables, such as different hair colours. Testing hair gives learners an opportunity to test a familiar material, and practise the skill of planning an investigation.

Plastic from milk

STEM

Resources: https://www.stem.org.uk/elibrary/resource/28167

A method of making plastic from milk, suitable for all levels at GCSE. This method is easy to do using classroom equipment and is a good introduction to plastics. Learners can look at the properties of the plastic that they have made.

How to build a model of the molecular structure of graphite

eHow

Resources: http://www.ehow.com/how_4487816_build-model-molecular-structure-graphite.html

A step by step method of building a model of graphite using toothpicks and sweets. This model helps to demonstrate the structure of graphite to learners, and relate this to its properties.

Nanotechnology song

The Science Museum

Resources: https://www.stem.org.uk/elibrary/resource/28722

An engaging song about the science of nanotechnology. A good introduction to the topic. The song discusses nano dimensions compared to typical dimensions, and gives some examples of nanoparticles.

The strange new world of Nanoscience

Cambridge University

Resources: https://www.youtube.com/watch?v=70ba1DByUmM

A 15 minute video on nanoscience, showing how nanomaterials are commonly found in nature and increasingly in technology. Details of the importance of surface area-to-volume ratio are discussed and techniques to image at the atomic level.

An oxidation and reduction reaction

The Royal Society of Chemistry (RSC)

Resources: http://www.rsc.org/learn-chemistry/resource/res00000467/an-oxidation-and-reduction-reaction?cmpid=CMP00000537

An experiment to show the oxidation and reduction of methylene blue. A good introduction to oxidation and reduction as the methylene blue changes colour to colourless when reduced and back to blue when oxidised. Learners can see the loss and gain of oxygen and relate this to reduction and oxidation.

Activities

Urea-methanal polymerisation

Nuffield Foundation

Resources: http://www.rsc.org/learn-chemistry/resource/res00001784/urea-methanal-polymerisation?cmpid=CMP00005294

A 15 minute teacher demonstration to show the formation of a thermosetting plastic by condensation polymerisation. This is only required for single science students, and shows the principles of condensation polymerisation.

Modelling alloys with plasticine

Nuffield Foundation and RSC

Resources: http://www.rsc.org/learn-chemistry/resource/res00001755/modelling-alloys-with-plasticine?cmpid=CMP00005265

A classroom experiment using plasticine mixed with sand as a model to demonstrate how the properties of a material can change when mixed with another material. The learners look at the properties of the plasticine and observe how the properties change when the plasticine is mixed with sand.

Nanobubbles and drug delivery

BBC

Resources: http://www.bbc.co.uk/education/clips/z7kfgk7

A 6 minute video describing how nanotechnology can be used to deliver drugs to specific areas of the body, and how this is being used to treat cancer. A good way of showing how the properties of nanoparticles are related to their uses.

Resources, links and support

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