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Oxford Cambridge and RSA

GCSE (9–1)

Delivery Guide

GATEWAY SCIENCE CHEMISTRY A

J248

For first teaching in 2016

Elements, compounds and mixtures

Version 1

Can also be used for teaching:
GCSE (9–1) GATEWAY SCIENCE COMBINED SCIENCE A

www.ocr.org.uk/chemistry

Introduction

GCSE (9–1)
GATEWAY SCIENCE CHEMISTRY A

Delivery guides are designed to represent a body of knowledge about teaching a particular topic and contain:

- Content: A clear outline of the content covered by the delivery guide;
- Thinking Conceptually: Expert guidance on the key concepts involved, common difficulties students may have, approaches to teaching that can help students understand these concepts and how this topic links conceptually to other areas of the subject;
- Thinking Contextually: A range of suggested teaching activities using a variety of themes so that different activities can be selected which best suit particular classes, learning styles or teaching approaches.

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Assessable mathematical learning outcomes

CM2.1i	arithmetic computation, ratio, percentage and multistep calculations permeates quantitative chemistry
CM2.1ii	provide answers to an appropriate number of significant figures
CM2.1iii	change the subject of a mathematical equation
CM2.1iv	arithmetic computation and ratio when determining empirical formulae, balancing equations

Assessable content

C2.1a	explain what is meant by the purity of a substance, distinguishing between the scientific and everyday use of the term 'pure'
C2.1b	use melting point data to distinguish pure from impure substances
C2.1c	calculate relative formula masses of species separately and in a balanced chemical equation
C2.1d	deduce the empirical formula of a compound from the relative numbers of atoms present or from a model or diagram and vice versa
C2.1e	explain that many useful materials are formulations of mixtures (to include alloys)
C2.1f	describe, explain and exemplify the processes of filtration, crystallisation, simple distillation, and fractional distillation (to include knowledge of the techniques of filtration, crystallisation, simple distillation and fractional distillation)
C2.1g	describe the techniques of paper and thin layer chromatography
C2.1h	recall that chromatography involves a stationary and a mobile phase and that separation depends on the distribution between the phases (to include identification of the mobile and stationary phases)
C2.1i	interpret chromatograms, including measuring Rf values (to include the recall and the use of the formula)
C2.1j	suggest suitable purification techniques given information about the substances involved
C2.1k	suggest chromatographic methods for distinguishing pure from impure substances (to include paper, thin layer (TLC) and gas chromatography)

Collecting the distillate

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Approaches to teaching the content:

This section looks at the scientific use of the word 'purity'.

Chemists are specific in their definition of purity being a single substance, element or compound. All pure materials (elements and compounds) have sharp and unique melting points and boiling points and these can be used to identify pure materials.

If a material is impure, then the melting point will usually be lower and less well defined (for example, salt and ice). Similarly, the boiling point will usually be higher.

While chemists are occupied with compounds and elements and their reactions, they also design mixtures that are vital to our modern society. Alloys such as steel (mainly iron and carbon) and materials like glass (mainly silicon dioxide, sodium oxide and calcium oxide) are mixtures that make up large proportions of most modern buildings. It is important to stress that these are mixtures and not compounds.

One difference between mixtures, and compounds and elements, is that mixtures can be separated. Methods such as filtration, crystallisation and simple chromatography are covered in Key Stage 3 and should be a matter of review in their explanation. More complex mixtures require more complex methods of separation such as fractional distillation, thin layer chromatography (TLC) or gas chromatography (GC).

Rf values are used in chromatographic techniques to identify pure substances, however it needs to be said that it is possible to have two Rfs the same value.

Common misconceptions or difficulties learners may have:

Learners are used to seeing retail packaging that uses the word pure in numerous contexts, and therefore they confuse the word 'pure' with 'un-tampered with' or 'natural'. They also fail to see that a solution is a mixture, especially if it only contains one solute.

Conceptual links to other areas of the specification – useful ways to approach this topic to set learners up for topics later in the course:

Separation techniques are used in all facets of industrial chemistry. A good foundation in how these techniques work give the learners a clear idea of why these methods are applied. Fractional distillation of crude oil is one of the most important industrial processes; a clear understanding of the separation of similar liquids by means of differing boiling points caused by differing intermolecular forces offers a number of links to other parts of the specification.

Pure substances have different properties

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Approaches to teaching the content:

Most chemicals have a small number of impurities. Chemists are often required to separate mixtures hence discussion of areas such as synthetic chemistry and forensics are useful in introducing the idea of complex methods of separation. The Practical Activity Groups (PAGs) C3, C4 and C7 cover most of the practical methods available in schools.

Separating mixtures

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Activity 1

Packaging Survey

To investigate the ingredients for a number of food or other products labelled as 'pure'.

Learners are requested to collect three or more labels from products claiming to be 'pure'. The ingredient panel should then be examined for each product and the ingredients listed in a table.

Activity 2

Definitions in Chemistry (designed for the more able learners)

Royal Society of Chemistry

http://www.rsc.org/learn-chemistry/resource/res00001088/definitions-in-chemistry

To discuss the definitions given for elements, compounds and mixtures.

Complete worksheet as a group (max 4).

Activity 3

Melting point determination

Royal Society of Chemistry

http://www.rsc.org/learn-chemistry/resource/res00001068/melting-point-determination

Video that can be used as a precursor to a possible practical activity.

Watch the RSC video on the technique of measuring a melting point. Prepare the sample by grinding to a powder, if necessary, using a pestle and mortar. Fill the capillary to 2-3 mm deep. Place in the melting point apparatus and heat at a rate of 2-3 degrees a minute. Record the temperature at the first drop of liquid and at complete melting of the solid. Check the range against the book value for benzoic acid.

One-mole quantities of five different compounds

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Assessable mathematical learning outcomes

CM2.2i	estimate size and scale of atoms and nanoparticles
CM2.2ii	represent three dimensional shapes in two dimensions and vice versa when looking at chemical structures e.g. allotropes of carbon
CM2.2iii	translate information between diagrammatic and numerical forms

Assessable content

C2.2a	describe metals and non-metals and explain the differences between them on the basis of their characteristic physical and chemical properties (to include physical properties, formation of ions and common reactions e.g. with oxygen to form oxides)
C2.2b	explain how the atomic structure of metals and non-metals relates to their position in the Periodic Table
C2.2c	explain how the position of an element in the Periodic Table is related to the arrangement of electrons in its atoms and hence to its atomic number (to include group number and period number)
C2.2d	describe and compare the nature and arrangement of chemical bonds in: i. ionic compounds ii. simple molecules iii. giant covalent structures iv. polymers v. metals
C2.2e	explain chemical bonding in terms of electrostatic forces and the transfer or sharing of electrons
C2.2f	construct dot and cross diagrams for simple covalent and binary ionic substances
C2.2g	describe the limitations of particular representations and models to include dot and cross diagrams, ball and stick models and two and three dimensional representations
C2.2h	explain how the reactions of elements are related to the arrangement of electrons in their atoms and hence to their atomic number
C2.2i	explain in terms of atomic number how Mendeleev's arrangement was refined into the modern Periodic Table

Metals and non-metals

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Approaches to teaching the content:

A hands-on experience with a number of metals and non-metals, recording their physical differences and testing for electrical conductance, is a good start to a general discussion of the more detailed difference in properties and reactions (see Activity 1: Properties of elements). Metals predominate in the Periodic Table and all lie to the left hand side, with non-metals to the right.

Learners should understand that chemical reactions are all governed by the movement of the outer shell electrons, whether they are lost or gained completely forming an ionic bond, or shared forming a covalent bond.

Learners should be familiar with demonstrations of electrostatic attraction from Key Stage 3 Physics; the use of balloons is an easy means of showing such attractions as a reminder. This should then be discussed by looking at the number of attractions involved in making an ionic compound to get a real idea of the strength of the bond.

Learners may already have met the idea that hydrocarbons come with different carbon chain lengths. This visualisation is quite useful in a general discussion of small and polymer molecules with the chain link being the shared pair(s) while each atom is the oval part of the chain.

Giant covalent structures require a form of three dimensional modelling, such as Molymods, to make their arrangements clear. Learners will need to appreciate that we are trying to visualise something so small that we are unable to see it. As a result, there must be a hint of caution in accepting simple models such as the ones used here. Differences between elements involved in compounds mean that reality is far more complex .

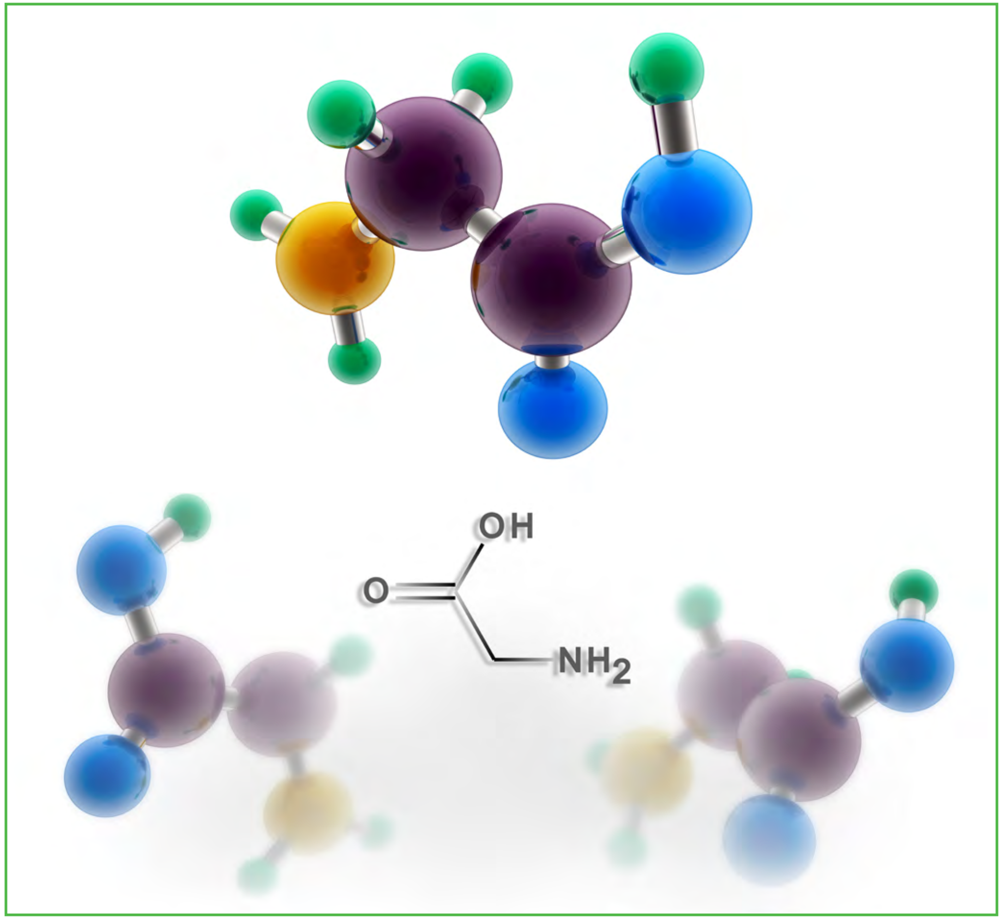
Learners should realise that the early Periodic Tables were arranged by atomic mass, as this was all the information they had. However, Mendeleev realised that there were some anomalies when the elements were arranged in this way, and so he actually exchanged a number of elements even though the atomic mass seemingly put them in the wrong place. It was only when scientists discovered protons, neutrons and electrons that enabled Mendeleev's table to be developed into the modern Periodic Table.

Common misconceptions or difficulties learners may have:

There is a difficulty for learners in understanding what is happening at the atomic level; the great number of models needed to explain atoms and bonding makes this idea even harder. Learners may not realise that the nucleus remains unchanged in the bonding process. They may also think that a chemical bond is a physical thing like the stick in ball and stick model. Ion pairs, such as Na^+ and Cl^-, are often described as molecules. Learners also lack an appreciation of the 3D dimensions of compounds which, since this is an AS topic, may not be explicitly taught.

Conceptual links to other areas of the specification – useful ways to approach this topic to set learners up for topics later in the course:

The material covered in this section is the basis of all understanding of chemistry. Though the ideas are not taken to their fullest extent, they need to be clearly understood as they underpin everything that is to come in the future study of chemistry. Elements react according to their need to gain the stable octet. How they react produces a huge range of new materials, all with differing properties due to the nature of the bonding involved. This is to be dealt with in the next section.



A molecular model of Glycine

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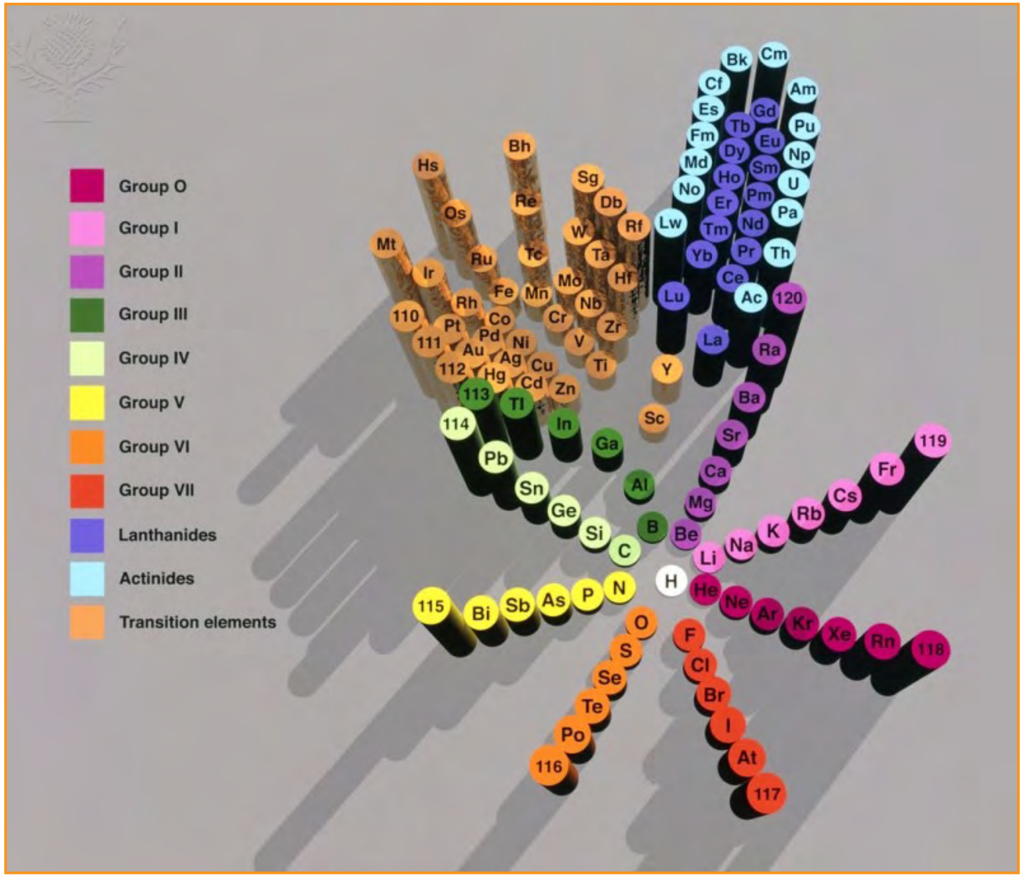
Approaches to teaching the content:

An element can be identified by means of its combined Group and Period numbers (for example, Ca is in the position defined by being in Group 2 and Period 4). This in turn defines the element in terms of electron configuration as being in:

- **Period 4** which means that **there are four electron shells, the first three of which are full** (2, 8, 8, 2)
- Group 2 which means that **there are two electrons in** its outer shell.

This can then be taken to indicate the Atomic Number of the element, **as this is the number of protons matching the** number of **electrons** (in this case, **20**).



Periodic table of elements

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Activity 1

Properties of elements

A tray containing a number of metallic and non-metallic elements to be examined and their characteristics noted. All to be tested for electrical conductance.

This is a brief look at elements and their physical properties.

Inspect each element and write a physical description, test each element with supplied circuit and record whether or not they conduct electricity.

Try heating some of the materials provided under suitable conditions to compare melting points (Higher level). Research melting points of elements as seen in the tray and compare non-metal versus metals.

Activity 2

Ionic bonding

Learner.org

http://www.learner.org/interactives/periodic/groups_interactive.html

This is a useful online version of ionic jigsaws complete with feedback.

Follow the on-screen instructions to learn how to put the common ions together to form ionic compound formulae.

Activity 3

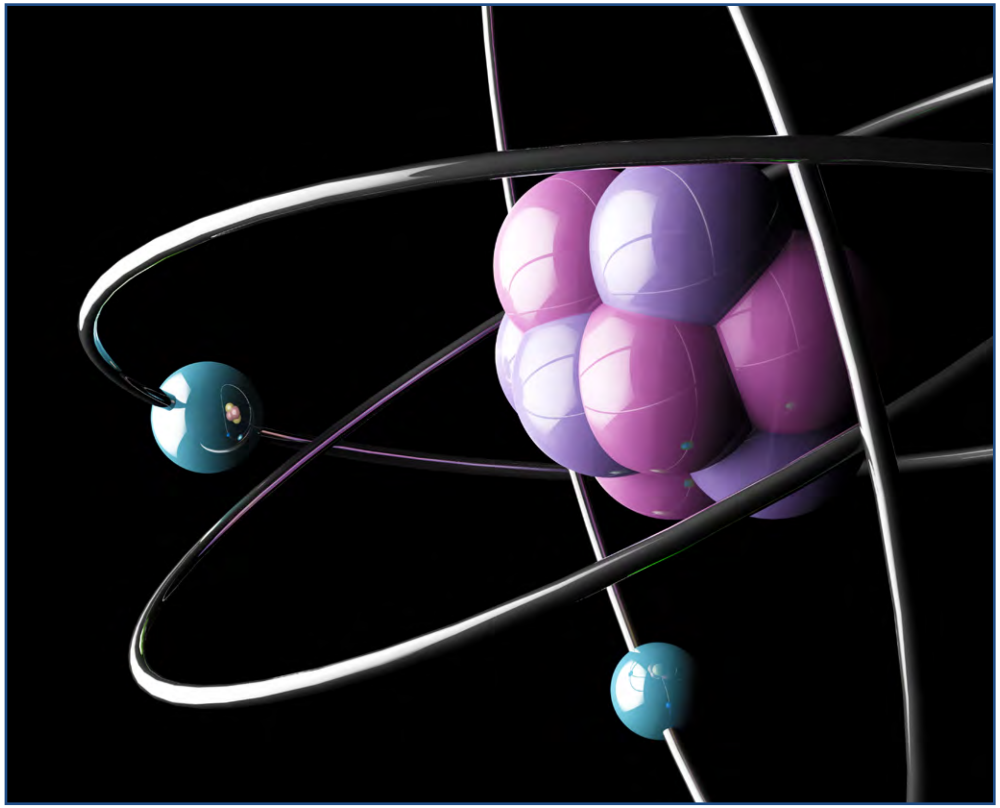
Exploring chemical bonding

SEP Lessons

http://seplessons.ucsf.edu/node/2241

An activity that enables learners to build upon the use of the Bohr model for atoms, ions and compounds.

The worksheets are downloadable prior to the lesson. Some preparation may be necessary beforehand but would be better done by the learners.



A nucleus with orbiting electrons

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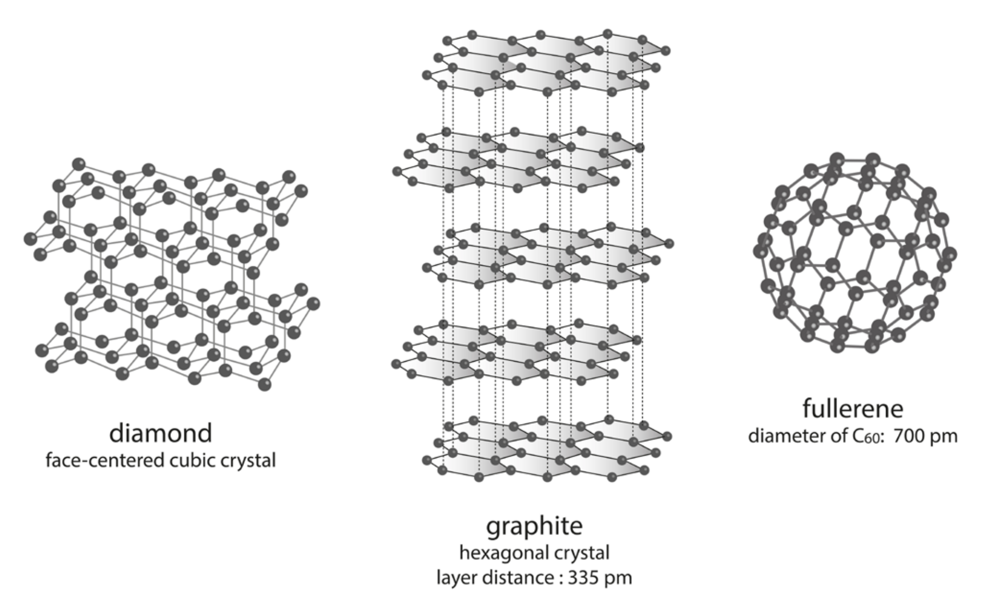
Assessable mathematical learning outcomes

CM2.3i	represent three dimensional shapes in two dimensions and vice versa when looking at chemical structures e.g. allotropes of carbon
*CM2.3ii	relate size and scale of atoms to objects in the physical world
*CM2.3iii	estimate size and scale of atoms and nanoparticles
*CM2.3iv	interpret, order and calculate with numbers written in standard form when dealing with nanoparticles
*CM2.3v	use ratios when considering relative sizes and surface area to volume comparisons
*CM2.3vi	calculate surface areas and volumes of cubes

Assessable content

C2.3a	recall that carbon can form four covalent bonds
C2.3b	explain that the vast array of natural and synthetic organic compounds occur due to the ability of carbon to form families of similar compounds, chains and rings
C2.3c	explain the properties of diamond, graphite, fullerenes and graphene in terms of their structures and bonding
C2.3d	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
C2.3e	use data to predict states of substances under given conditions (to include data such as temperature and how this may be linked to changes of state)
C2.3f	explain how the bulk properties of materials (ionic compounds; simple molecules; giant covalent structures; polymers and metals) 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 (to include recognition that the atoms themselves do not have the bulk properties of these materials)
*C2.3g	compare 'nano' dimensions to typical dimensions of atoms and molecules
*C2.3h	describe the surface area to volume relationship for different-sized particles and describe how this affects properties
*C2.3i	describe how the properties of nanoparticulate materials are related to their uses
*C2.3j	explain the possible risks associated with some nanoparticulate materials

*Separate Chemistry Statements only



Example molecules

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Approaches to teaching the content:

This section deals with the macroscopic properties of materials arising from their structure. Learners should be led to understanding that what we can see or measure in terms of physical shape and properties is a reflection of the nature of the bonding within each substance.

Chemists, in making substances useful to society, exploit these qualities. This is particularly the case with compounds containing carbon. Carbon's ability to bond to itself and a wide range of other elements using single, double and triple bonds producing a huge range of useful products is the basis of organic chemistry and learners should realise its importance.

Learners should be made aware of the importance of Nanochemistry and the fact that this is not the only preserve of carbon chemistry, that there a wider range of Nano-particles e.g. use of gold and ZnO. They should also be aware not only of the benefits but also the potential dangers of their use. This is such a fast moving area of science that it should be researched by the learners as an activity.

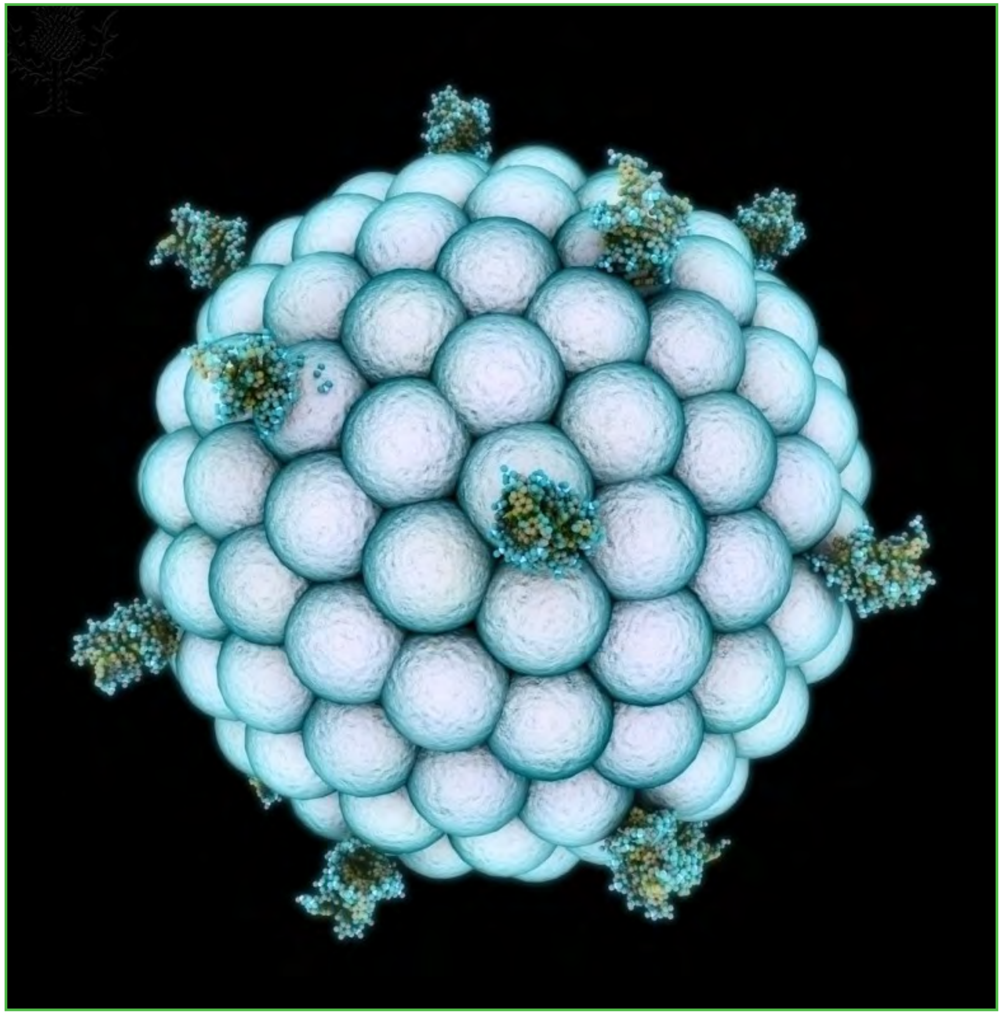
Common misconceptions or difficulties learners may have:

The fact that changes of state encompasses both bond breaking and the weakening of intermolecular forces gives rise to confusion, especially when linking changes of state in covalent molecules.

Conceptual links to other areas of the specification – useful ways to approach this topic to set learners up for topics later in the course:

Learners with a sound understanding of the nature of changes of state can better explain the differences in boiling point encountered in the fractional distillation of crude oil.

Relating particle size by means of surface area to volume ratios, links to rates of reaction versus surface area of reactant; also the use of Nano-particles as support for catalysts.



A nanoparticle

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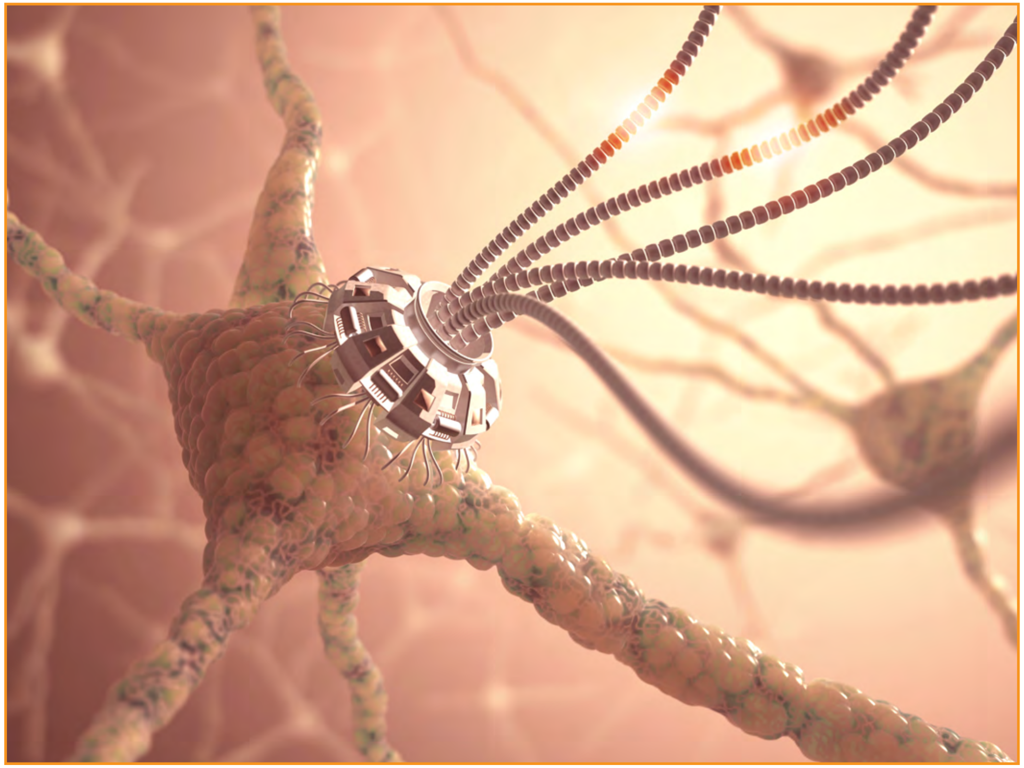
Approaches to teaching the content

Learners should be aware from Key Stage 3 that carbon atoms can bond to each other as well as other elements to form up to four bonds per atom of C. This leads not only to a huge range of possible substances but also to a large number of allotropes (C2.3a, C2.3b and C2.3c). The NBC video covers the discovery of the latest two of the latter and some of their impact on materials science (C2.3c). Further understanding of the extent of nanotechnology and the use of other types of beneficial nanoparticles can be brought about in the 'Inspirational nanotechnology' activity, using the RSC worksheets (C2.3f, C2.3g and C2.3i). There are a number of GCSE targeted websites that deal with the suspected dangers and this could be an excellent opportunity to research and debate these as a class (C2.3j).



Nanotechnology

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Activity 1

Inspirational nanotechnology

Royal Society of Chemistry

http://www.rsc.org/learn-chemistry/resource/res00001933/nanotechnology?cmpid=CMP00006191

This is a range of worksheets providing a wide-ranging look at nanotechnology other than nanotubes.

Choice of which sheets might be useful is left to the teacher and the amount of detail required to be given. However these sheets cover a number of modern uses of 'nanotechnology' in common everyday materials rather than the more esoteric nanotube technology below.

Activity 2

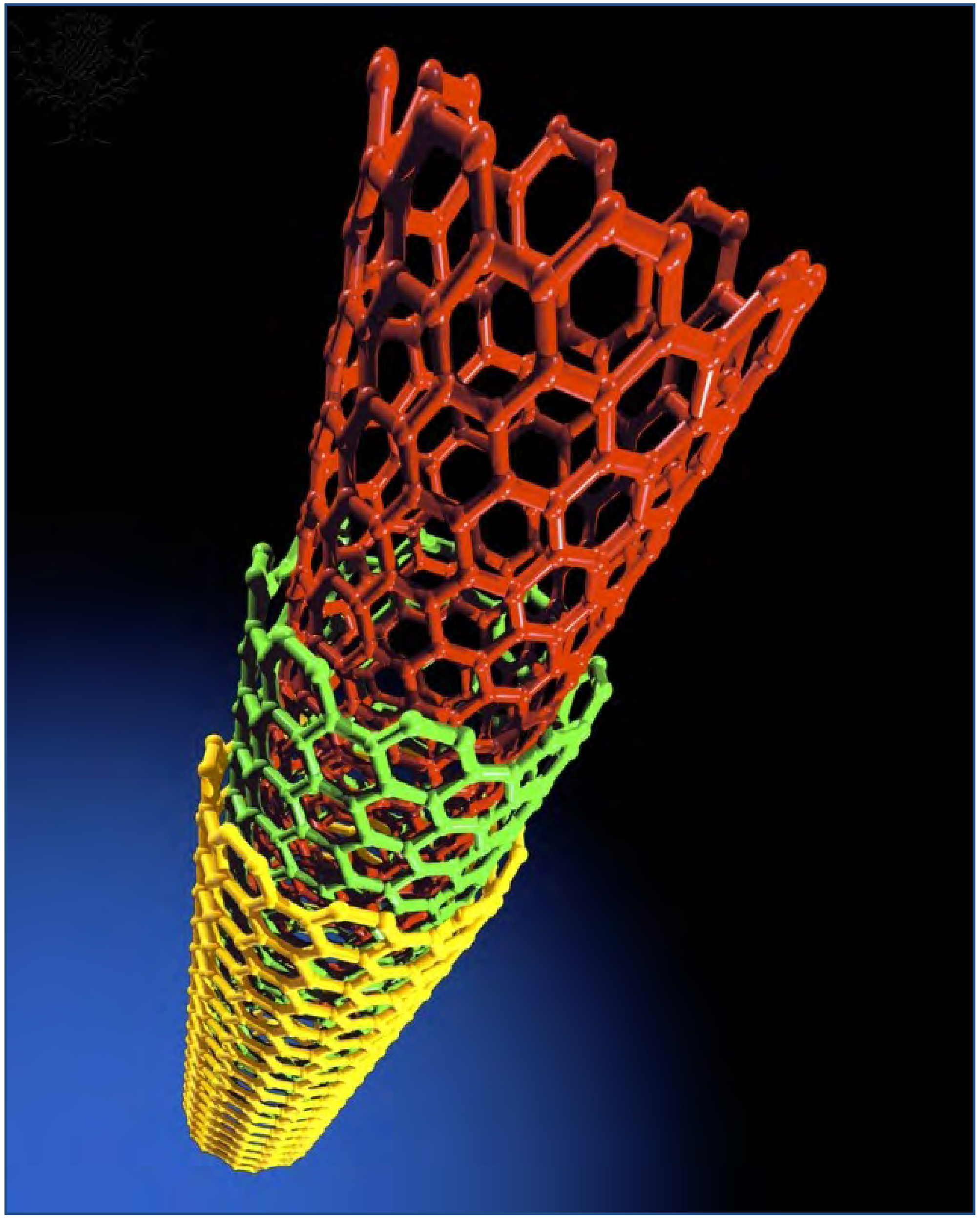
Diamonds, Pencils and Buckyballs: A look at Buckminsterfullerene

NBC

http://nbclearn.com/portal/site/learn/freeresources/chemistry-now/buckyballs-and-graphene

Short video (approx. 6 minutes) covering the discovery of C_{60}, nanotubes and their size and potential uses.

Learners should ideally make notes.



Nanotube technology

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