QUALIFICATION AWAITING ACCREDITATION

OCR
Oxford Cambridge and RSA

GCSE (9–1)
Delivery Guide

TWENTY FIRST CENTURY SCIENCE CHEMISTRY B

J258
For first teaching in 2016

Chemicals of the natural environment

Version 1

Can also be used for teaching:
GCSE (9–1) TWENTY FIRST CENTURY COMBINED SCIENCE B

www.ocr.org.uk/chemistry

Introduction

GCSE (9–1)
TWENTY FIRST CENTURY SCIENCE CHEMISTRY B

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.

If you have any feedback on this Delivery Guide or suggestions for other resources you would like OCR to develop, please email resources.feedback@ocr.org.uk

QUALIFICATION AWAITING ACCREDITATION

'These draft qualifications have not yet been accredited by Ofqual. They are published (along with specimen assessment materials, summary brochures and sample resources) to enable teachers to have early sight of our proposed approach.

Further changes may be required and no assurance can be given at this time that the proposed qualifications will be made available in their current form, or that they will be accredited in time for first teaching in 2016 and first award in 2018.

Subtopic 1 – C3.1 How are atoms held together in a metal?

Subtopic 2 – C3.2 How are metals with different reactivities extracted?

Introduction

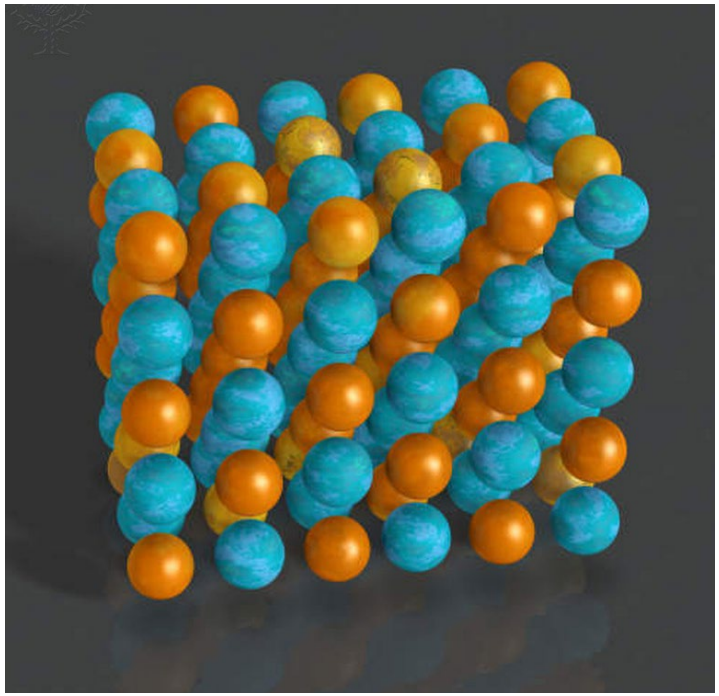
Subtopic 3 – C3.3 What are electrolytes and what happens during electrolysis?

Subtopic 4 – C3.4 Why is crude oil important as a source of new materials?

The images used throughout this guide have been provided to help aid learners' understanding and learning in this topic area.

A brief description is provided below each image.

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



Computer generated visualization of a metal crystal lattice.

General approaches:

This short topic can be explained quickly and should be incorporated with C3.2.

Common misconceptions or difficulties learners may have:

Learners will need to understand atomic structure to be able to understand the metallic bonding and the idea of delocalised electrons.

http://www.rsc.org/learn-chemistry/resource/res00001140/chemical-bonding

This resource includes information about some key misconceptions that have been uncovered by research and ideas about a variety of teaching approaches that may help avoid learners acquiring some common misconceptions.

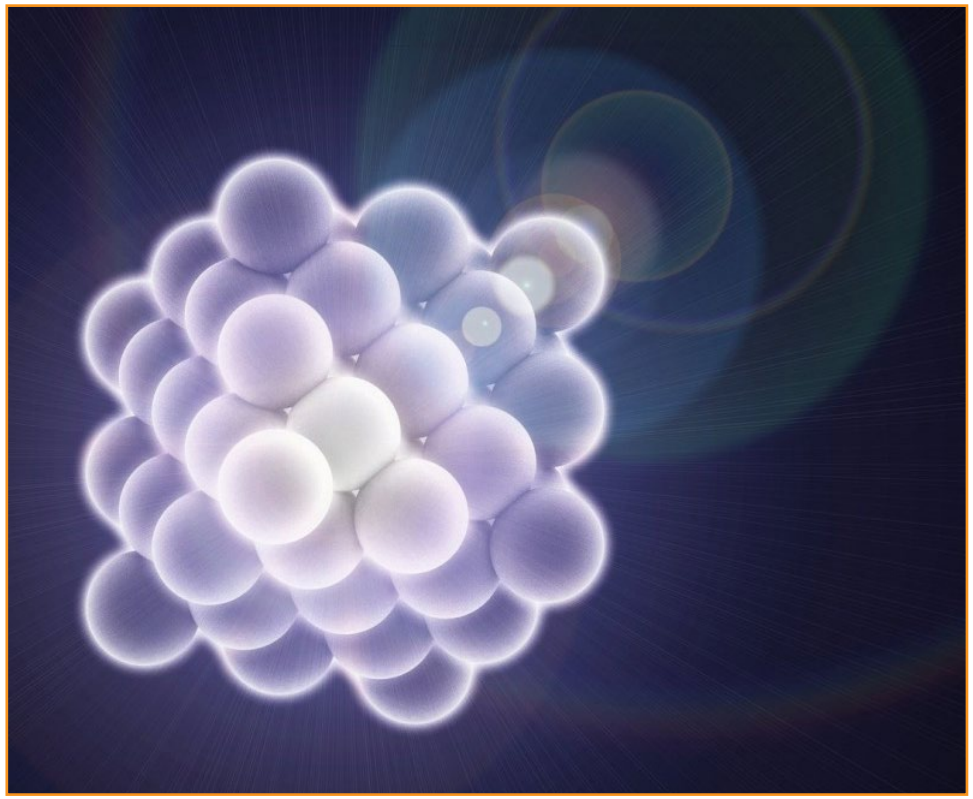
Conceptual links to other areas of the specification – useful ways to approach this topic to set learners up for topics later in the course:

This will be revisited when looking at metal extraction, and materials and their properties in C4. It is also a good idea for learners to compare with ionic and covalent bonding which are visited in other areas of the GCSE.

Atomium. This was the centrepiece of the 1958 World Exposition, held in Brussels, Belgium. It is 102 metres high & weighs 2400 metric tonnes. It represents the crystalline atomic lattice structure of iron. The architect, Andre Waterkeyn, designed the structure to symbolize the 20th century, in which the atom was fully mastered. Six of the spheres are accessible to the public.

Approaches to teaching the content

In this topic use the model of metal structure to explain properties of metals (IaS3). Include examples of metals and their properties to incorporate practical work where you can.



Platinum crystal, molecular model. Platinum atoms form a cubic close-packed, or face-centred cubic, crystal lattice. In this structure, a layer of atoms lies in the spaces between atoms in the layer below it, and the layer below that lies beneath the spaces in both the layers. The atoms are very tightly packed, filling 74% of the available space. Platinum is a precious metal, used in the chemical industry as a catalyst, and in jewellery.

Activity 1

Metallic Bonding video

Fuse School

https://www.youtube.com/watch?v=S08qdOTd0w0

A short 4 minute video to introduce metallic bonding.

Activity 2

Metallic Bonding lesson

TES

https://www.tes.com/us/teacher-lessons/metallic-bonding-7504956

This series of resources look in depth at metallic bonding and can be delivered over 2-3 lessons. They include a fun activity that requires learners to memorise a diagram of metallic bonding and to reproduce the diagram.
Possibly more suitable for high performing learners.

Activity 3

The model of metallic bonding

National Strategies

http://www.education.leeds.ac.uk/assets/files/research/cssme/ns-tu/modelling_matter.pdf

Lesson 5 in this activity introduces learners to the properties of metals. Through discussion, learners are made aware that these properties cannot be explained in terms of ionic or covalent bonding. A simple model of metallic bonding is introduced and used to explain some properties of metals.

Activity 4

Making a moving model

The Science Teacher

http://thescienceteacher.co.uk/metallic-bonding/

This activity encourages learners to produce a 'moving model' of metallic structures on PowerPoint.

Activity 5

Metallic bonding plenary

RSC – Starters for ten

http://www.rsc.org/learn-chemistry/resource/res00000954/starters-for-ten#!cmpid=CMP00001408

Although more designed for A Level learners these Starters for 10 can be used for GCSE. Page 6 of this activity provides some text on metallic bonding which could be used as a plenary to check learners' understanding. They can make corrections to the errors in the text. Answers are also provided.

Activity 6

What is the bonding like in iron?

RSC

http://www.rsc.org/education/teachers/resources/aflchem/

An assessment for Learning (AfL) activity from the RSC. Offers a range of ideas to get learners to apply their knowledge of metallic bonding.

Activity 7

Metal practicals

Nuffield

http://www.nationalstemcentre.org.uk/elibrary/resource/2998/metals

An old but useful resource for practical work on metals and their properties. It covers

1. Getting metals from rocks
2. Reducing some metal ores
3. Does carbon always win?
4. Using a stronger oxygen grabber
5. The story so far
6. What makes metals useful?
7. A closer look at the properties of metals

There is a Learner and Teacher guide.

Activity 8

Metals, Non metals and metalloids

The Chemistry Teacher

http://thechemistryteacher.net/graphics/WebsiteBinder2.pdf

A useful and detailed worksheet on metals, non metals and metalloids. Includes answers.

Abstract texture of the oxidated copper on the walls of the underground copper mine in Roros, Norway

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)

Metal compound solutions. The volumetric flasks contain solutions of an assortment of metals. The five at left are salts of transition metals, which tend to have coloured ions. From left, they are nickel, chromium, cobalt, vanadium and manganese. The three at right are the salts of non-transition metals, whose ions are generally colourless. From right they are calcium, sodium and magnesium. This difference is due to the arrangement of electrons in the ions.

General approaches:

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 gain 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).

Common misconceptions or difficulties learners may have:

Learners have met reactivity series and displacement at Key Stage 3 but it is a good opportunity to revisit and check any misconceptions they may have before moving on to electrolysis. Recapping the periodic table, and atomic structure is also important to ensure the development of an understanding of an ion is clear. The more practice that can be given the better the understanding which will help when electrolysis is developed in this and the next topic. Balancing equations and ionic equations have appeared earlier in the specification and will appear again, so spending time on ensuring the skills are in place will aid further understanding later. The use of bioleaching and phytoextraction have been present in other GCSE courses to Twenty First Century before this new course and is an interesting concept within which to visit the range of extraction methods. Most focus around the extraction of copper.

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

Reactivity series is covered in Key Stage 3.

Atomic structure and electron configuration is visited earlier in this course and is key before looking at the formation of positive ions from metals. It is also key before introducing electrolysis.

This links into reduction, and electrolysis is revisited later into this topic which is then further developed at A Level with the introduction of electrode potentials.

Approaches to teaching the content

There are lots of opportunities for practical work, Although reactivity series is covered at Key Stage 3 it is a good opportunity to include practical work and develop learners understanding. You could introduce risk assessments and other working scientifically skills here due to learners having prior conceptual knowledge.

Investigate the reactivity of different metals with water and dilute acid.

Investigate the reactivity of Zn, Fe and Cu by heating each metal with oxides of each of the other two metals.

These contexts will really help to build the opportunity for building confidence in writing balanced equations as they will have seen and carried out the reactions as well.

It is a really good opportunity as well to ensure learners are clear on the 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 (IaS4).

Two trucks transport gold ore from open cast mine. Barrick Cowal Gold Mine in New South Wales, Australia.

Activity 1

Infographic on reactivity series

Compound Chem

http://compoundchem.tumblr.com/image/113276713921

This infographic gives a detailed coverage of the reactivity series. This could be used to summarise the topic.

Activity 2

Reactivity Series experiment

RSC and Nuffield Foundation

http://www.nuffieldfoundation.org/practical-chemistry/metals-and-reactivity-series

Just type 'reactivity series' on the search engine to give you a long list of practicals which can be used to teach the reactivity series.

Activity 3

Metal Reactivity Series Menomics

Mnemonicate

https://www.youtube.com/watch?v=XWjQUgq2u9E

A short video clip to help learners use mnemonics to learn the order of the reactivity series.

Activity 4

Zinc Extraction

http://xlttmt.blogspot.co.uk/2012/08/extraction-of-zinc-from-zinc-blende.html

Information that could be used for learners to develop their understanding of zinc extraction.

Activity 5

Metals Extraction

You Tube

https://www.youtube.com/watch?v=8PkhbKw1oEc

An 18 minute video on extraction of metals.

Activity 6

Extraction of reactive metals website

http://www.patana.ac.th/parents/curriculum/Chemistry/units/LR706.html

A website with interactive questions focusing on the extraction of the reactive metals with electrolysis. There are interactive questions and good visuals which could be used.

Activity 7

Aluminium extraction

RSC

https://www.youtube.com/watch?v=WaSwimvCGA8

A video which focuses on the extraction of aluminium by electrolysis. Along with infographics from http://www.docbrown.info/page04/Mextractb.htm learners can create an explanation of how aluminium is extracted.

Activity 8

Reactions with metals

S-cool

http://www.patana.ac.th/parents/curriculum/Chemistry/units/LR706.html

A range of animations that can be used to help learners consolidate their understanding of reactions with oxygen, water and acids.

Activity 9

Conservation of mass video

TED- Talks

https://www.youtube.com/watch?v=2S6e11NBwiw

A short video which recaps atoms, molecules and reactions. Links to E-mc^2 and big bang, so a nice overview and link of prior knowledge.

Activity 10

Balancing equations worksheet

Stemsheets.com

http://stemsheets.com/science/balancing-equations-worksheet

An editable and downloadable worksheet on balancing equations.

Activity 11

Balancing equations simulation

PhET

http://phet.colorado.edu/sims/html/balancing-chemical-equations/latest/balancing-chemical-equations_en.html

A simple animation which allows you to demonstrate balancing of making ammonia, combustion of methane and separating water. There is also an interactive game of three levels for practice.

Activity 12

Balancing equations idea

Science Teaching Junkie

http://www.scienceteachingjunkie.com/2013/10/a-science-teaching-junkie-flash-freebie.html

A blog explaining a range of activities to model building chemical equations with lego blocks.

Activity 13

Balancing equations

http://www.pleasval.k12.ia.us/highschool/teachers/hoffmanjoshua/Phys%20Sci/Chemistry/Unit%206-%20Reactions/MMBalancing.pdf

An activity to build confidence in balancing equations using M&Ms.

Activity 14

Phytomining activity

TES

https://www.tes.com/teaching-resource/phytomining-6141878

An excellent range of activities that lead to self-assessed questions on phytomining.

Activity 15

Bioleaching Research activity

Python Mining

http://www.pythongroup.ca/mining-news/article/id/56

A good website covering the use of bioleaching, the process, the environmental aspects as well as advantages and disadvantages. Could be used as prior reading or as the basis of a research activity.

Activity 16

Pyhtomining and bioleaching, flow diagram and Qs

TES

https://www.tes.com/teaching-resource/bioleaching-and-phytomining-6368022

Cards for learners to create a flow-chart on how pure copper is obtained from low-grades ores via bioleaching and phytomining.

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
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 PAG2

Aluminium production. Furnaces and electrolysis being used to produce aluminium at the Tajik Aluminum Plant in Tajikstan. The factory was founded in 1975. Production has varied over the years depending on the supply of aluminium ore (alumina). The factory accounts for a large proportion of the manufacturing capacity of Tajikstan, as well as much of its exports, and employs thousands of people. Pollution from the factory has caused health problems for workers and those living in the surrounding areas.

General approaches:

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.

Common misconceptions or difficulties learners may have:

The electrolysis topic is a difficult concept for learners. They need to have a grasp of ions and the relative charges. If they have not gained this basic understanding then electrolysis will be difficult. It is important to revisit ions before introducing electrolysis as a consolidation. Preparing for linear exams requires learners to revisit content at regular intervals and apply into new situations. Understanding of ions, and ionic compounds, which ensure learners can grasp products from electrolysis as well as the movement of ions and the introduction of redox.

Electrode potentials are required here to ensure there is a grasp of 'competing' due to reactivity. Learners should have met this in displacement in Key Stage 3 so developing this understanding is key. The use of practical work to get voltage readings will allow learners to put this into an appropriate context. Those learners working at higher ability will be able to grasp some simple AS work on electrode potentials. However care should be taken to not go above the requirement at GCSE unless the learners can cope with this.

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

This links with atomic structure and electronic configuration, salts, and ionic compounds, solubility as well as basic electrical understanding. Electrolysis gives a way of applying their understanding of all these concepts in a new situation. Using metal extraction is an important context to introduce this too but ensuring there is clear understanding this is not the only context.

Approaches to teaching the content

There is a lot of opportunity for practical work here. It is very helpful for learners to have a visualisation of the process and to actually witness gas being generated at the cathode and metal deposit on the anode.

There are electrolysis demonstrations and class practicals that can be done to visualise this concept. Some opportunity for investigation suggested in the specification are to investigate what type of substances are electrolytes and investigate the effects of concentration of aqueous solution, current, voltage on the electrolysis of sodium chloride.

There is opportunity to develop the skills for PAG 2 as well.

The context of metal extraction is very important to consider and there is a lot of information available for this. Putting it into the context of extracting metal from waste will enable learners to develop an understanding of environmental impact as well.

ore conveyor in open pit mining

Activity 1

Colourful electrolysis

RSC

http://www.rsc.org/learn-chemistry/resource/res00000735/colourful-electrolysis?cmpid=CMP00004981

This experiment looks at the electrolysis of brine (sodium chloride solution) by using universal indicator to track the products produced.

Activity 2

Electrolyte or not investigation

RSC/Nuffield Foundation

http://www.rsc.org/learn-chemistry/resource/res00001789/which-substances-conduct-electricity?cmpid=CMP00005299

This experiment enables learners to distinguish between electrolytes and non-electrolytes and to verify that covalent substances never conduct electricity even when liquefied, whereas ionic compounds conduct in the molten state.

Activity 3

Electrolysis Info cards

http://www.learnhive.net/learn/icse-grade-10/chemistry/electrolysis

A series of infocards – although these are not downloadable, they give great ideas for making your own resource, or providing facts which learners then build into their own infocards.

Activity 4

Electrolysis board game

TES

https://www.tes.com/teaching-resource/electrolysis-board-game-edexcel-c1-6426424

A different way of getting to know some useful information about electrolysis. Although designed for a different specification questions are provided which can be altered for any tier or specification. It is intentional that there are only a few questions so that they are recycled during the game to ensure learners have learnt the answers.

Activity 5

Electrolysis video

You Tube

http://scientiflix.com/post/121229322096/how-can-water-be-turned-into-fuel-what-is

An explanation of electrolysis in terms of splitting water and using it for a fuel. Good chance to look at different uses of electrolysis and promote discussion.

Activity 6

Ionic compound puzzles

http://bcpshelpdeskhighschoolscience.weebly.com/uploads/6/3/4/6/6346142/activity_-_naming_compounds_-_ion_puzzle_activity.doc

If learners are still having difficulty working out what ions are in ionic compounds then try this puzzle. It can easily be adapted into a card sort or matching activity for those learners who need it.

Activity 7

Oxidation and Reduction

RSC

http://sd67.bc.ca/teachers/barcuri/Chem12/UNIT%205/Workbook%20-%20Oxidation%20and%20Reduction%20Reactions.doc

A whole workbook of activities which could be used to teach redox and oxidation. Can easily be adapted and made into shorter activities tailored to the needs of learners.

Activity 8

Redox infographic

http://image.slidesharecdn.com/reactivityseriespdf-150326041156-conversion-gate01/95/ib-chemistry-on-redox-reactivity-series-and-displacement-reaction-14-638.jpg?cb=1427343133

Designed for IB chemistry but this infographic is a clear summary of redox with examples. This could be easily adapted to be made into a graphic organiser/gap fill activity for learners to use to record their understanding of redox.

Activity 9

Electrolysis of copper (II) sulphate

RSC

http://www.rsc.org/learn-chemistry/resource/res00000476/electrolysis-of-copper-ii-sulfate-solution?cmpid=CMP00005019

This experiment enables learners to carry out the electrolysis of copper(II) sulfate solution and to link their findings with the industrial electrolytic refining of copper.

Activity 10

The products of electrolysis

RSC

http://www.rsc.org/learn-chemistry/resource/res00000737/identifying-the-products-of-electrolysis

This resource details how learners can carry out the electrolysis of a range of solutions and how they can identify the products formed at each electrode. This practical experience should lead learners to be able to write simple ionic equations.

Activity 11

Purification of copper using electrolysis

Fuse School

https://www.youtube.com/watch?v=qqmKqpA61GI

A video looking at the purification of copper using electrolysis.

Activity 12

Factors affecting electrolysis

http://ibchem.com/IB/ibnotes/full/red_htm/19.3.htm

Although designed for IB chemists this website has detailed information about factors affecting electrolysis. Some of the information goes above and beyond that which is needed for this specification but is useful background reading.

Activity 13

Interactive investigation into factors affecting rate of electrolysis.

http://www.yenka.com/activities/Electrolysis_Variables_-_Activity/

An interactive simulation looking at solutions, electrodes, concentration and voltage as factors which affect the rate of electrolysis. A good research tool for learners to use for prior information before planning their own investigation.

Activity 14

Electrolysis of Brine

Doc Brown

http://www.docbrown.info/page01/ExIndChem/electrochemistry03.htm

This website could be used for a research or prior reading activity. There is detailed information on the electrolysis of brine and some useful infographics.

Activity 15

Aluminium extraction

RSC

https://www.youtube.com/watch?v=WaSwimvCGA8

A video which focuses on the extraction of aluminium by electrolysis. Along with infographics from http://www.docbrown.info/page04/Mextractb.htm learners can create an explanation of how aluminium is extracted.

Activity 16

Questions on using electrolysis for the extraction of metals

Chemactive.com

http://chemactive.com/worksheets/gcse/physics/electricity_questions.pdf

A range of questions about electrolysis. There are both low demand and high demand questions which could be adapted.

Activity 17

Introduction to redox potentials

Chemguide

http://www.chemguide.co.uk/physical/redoxeqia/introduction.html

These pages explain simple electrode potentials. This is mainly for developing knowledge and includes more detail than needed.

Activity 18

Electricity from pairs of metals.

http://www.bbc.co.uk/bitesize/standard/chemistry/metals/making_electricity/revision/1/

A straightforward explanation on the electricity from pairs of metals. As well as information there is an animation, video and questions on this page.

Activity 19

An Electrifying experiment

http://outreach.materials.ox.ac.uk/LearningResources/ElectricalPropertiesMaterials/anelectrifyingexperience.php

This experiment has been developed to show how cells generate electricity by chemical reactions involved in the corrosion of metals. This links metals with electrolysis and which is the most reactive.

Activity 20

Simple electrode potentials experiment

http://outreach.materials.ox.ac.uk/LearningResources/Resourcesunderdevelopment/underdev.php

Look at the reactivity series and corrosion activities here for another experiment introducing simple electrode potentials.

Activity 21

Summary of reactivity of metals and voltage reasings

http://www.yenka.com/activities/Cells_-_Activity/

This involves animations of different electrolysis cells using different metals and seeing which voltage readings are given. There are online activities and questions which can be filled in.

C3.1.1	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 PAG3
C3.4.4	describe the fractions of crude oil as largely a mixture of compounds of formula C_nH_{2n+2} which are members of the alkane homologous series
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
C3.3.6	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 M1c
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 M5b
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 M4a
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
C3.4.16	recognise functional groups and identify members of the same homologous series
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
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
C3.4.19	recall that it is the generality of reactions of functional groups that determine the reactions of organic compounds

CONTRAIL Condensation Trails From Airplane Exhaust. The main products of hydrocarbon fuel combustion are carbon dioxide and water vapor. At high altitudes the vapor emerges in a cold environment It then condenses into water droplets or ice crystals forming contrails.

General approaches:

Crude oil is 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. The first four alkanes show typical properties of a homologous series: each subsequent member increases in size by CH_2, 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 'balls 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.

Common misconceptions or difficulties learners may have:

Learners will not have met hydrocarbons before this, but will understand the idea of fuels and many of the products which are made from crude oil.

Fractional distillation is a good opportunity to revisit learners' understanding of separation techniques. A detailed explanation of fractional distillation is a good way of consolidating the learners' understanding of intermolecular forces. This is a difficult concept for learners to grasp initially but is key for them to be able to explain boiling points.

Calculation of empirical formula requires learners to have a solid understanding of moles which is an area that previously was not in Twenty First Century Chemistry. Recap of moles and developing learner confidence in using it is vital for further study.

Bonding is another area that learners can find difficult to grasp. The use of models can help with this, again this will be revisited in other areas of the specification so it is important to develop their understanding well and revisit at every opportunity.

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

There is a lot in this section of the course which are fundamental chemistry skills set in a relevant context for the learners.

Empirical formula has not really been introduced before in the Twenty First Century GCSE content, and learners will require an understanding of moles. This would be a good opportunity to revisit learners understanding of moles in a new context.

Bonding has been seen in other topics, and this again is a good opportunity to revisit and build on the learners knowledge. Using hydrocarbons for dot cross diagrams requires understanding of electron configuration and atomic structure so recapping this at this opportunity would also help.

Approaches to teaching the content

There are a wide range of practical activities that can be done in this topic. Fractional distillation and cracking can be performed as demonstrations or class activities depending on equipment and ability of learners.

Introducing the models of the organic molecules in this topic is a good opportunity to develop the use and limitations of models to represent bonding in simple molecules (IaS3). As they develop their understanding of new organic molecules they will be able to use these models to help them with the development of their understanding of empirical formula as well from a visual point of view.

Our use of crude oil is vital to our lives. It is important to develop the learners' skills in decision making in the context of the use of crude oil for fuels and as a feedstock (IaS3). This can be done through research opportunities, and analysis of data relating to supply and demand.

An image of an industrial pump jack pumping crude oil in a farm field of yellow canola in Alberta Canada

Activity 1

Alkanes and Alkenes video

Fuse School

https://www.youtube.com/watch?v=Sfm3eHe57PU

A short video which summarises Alkanes and Alkenes. Could be used to consolidate, or as a recap, a starter or as a flipped learning activity.

Activity 2

Fractional distillation

Fuse School

https://www.youtube.com/watch?v=PYMWUz7TC3A

A short video which summarises Fractional distillation. Could be used to consolidate, or as a recap, a starter or as a flipped learning activity.

Activity 3

Crude oil fractions and their uses

Fuse School

https://www.youtube.com/watch?v=JZdvsQzOKuk

A short video which summarises crude oil and the uses of the fractions. Could be used to consolidate, or as a recap, a starter or as a flipped learning activity.

Activity 4

Fractional distillation experiment

RSC/Nuffield

http://www.rsc.org/learn-chemistry/resource/res00000754/the-fractional-distillation-of-crude-oil?cmpid=CMP00006603

This could be carried out as a demonstration or as a class experiment. There are alternatives in the CLEAPSS Laboratory Handbook Section 13 Mainly Chemistry http://www.cleapss.org.uk/attachments/article/0/Sec13.pdf
This is a good opportunity for PAG 3

Activity 5

Crude oil from Algae

Pacific Northwest National Laboratory

http://www.pnnl.gov/news/release.aspx?id=1029

An interesting article which could be used as an extension activity for learners to look at supply and demand of crude oil.

Activity 6

Crude oil questions

Chemactive

http://chemactive.com/worksheets/gcse/chemistry/oil_questions.pdf

A group of questions high and low demand. Could easily be used and adapted to suit your learners for short plenaries, or recap activities.

Activity 7

Fractional distillation Picture Relay

Learner resource 1

www.ocr.org.uk/Images/293886-chemicals-of-the-natural-environment-learner-resource.doc

Print out the picture, put learners in pairs. One pair draws (Learner A) and the other has to remember (Learner B). Learner B comes up and looks at the image for 30 seconds, then goes back to Learner A who they then describe what they have seen. They can go back and revisit up to 4 times. Then peer/self assess against the image which could be displayed on the board.

Activity 8

Crude oil diagrams

http://d--h.info/?p=20333

This website although not particularly user friendly has a link to a nice summary video about crude oil. If you click on the links 1-67 below the video you can find a range of diagrams that could be used to support the teaching of this topic.

Activity 9

How to do empirical formulae

http://www.showme.com/sh/?h=tRsHV1E

https://www.youtube.com/watch?v=WVpLq9ablgw

Two videos explaining worked examples of how to do empirical formulae. The second link has more detail about the terms before the calculation.

Activity 10

Empirical formulae questions

http://www.creative-chemistry.org.uk/gcse/documents/Module7/N-m07-10.pdf

http://chemistry.about.com/od/chemistry-test-questions/tp/Empirical-Formula-Practice-Test-Questions.htm

http://www.chemsheets.co.uk/Chemsheets%20GCSE%20073%20(Empirical%20formulas).pdf

All of these links include clear worked examples and questions on empirical formulae

Link 1 is a worksheet
Link 2 is online examples
Link 3 is another worksheet and although this is a site requiring sign up this worksheet is a free example.

Activity 11

Different types of chemical formulae

Compound chem

http://www.compoundchem.com/2014/04/11/a-brief-guide-to-types-of-organic-chemistry-formula/

A useful infographic for learners to understand the different ways that chemical molecules can be represented. A bit higher knowledge than needed but still useful.

Activity 12

Organic molecule card game

Pacific Northwest National Laboratory
http://www.ellenjmchenry.com/homeschool-freedownloads/chemistry-games/organicmoleculegame.php

A really simple game that could be used to help learners build up structural formula of hydrocarbons (just ignore the **O, Cl, N, Br** cards when you print it out).

Activity 13

Animated hydrocarbons

http://www.animatedphysics.com/live/examine_molecules.htm

A good visual for seeing the shape of hydrocarbons. There are other molecules here too but you don't need them at this stage, but useful when looking at different functional groups.

Activity 14

Different functional groups

Compound chemistry

http://www.compoundchem.com/2014/01/24/functional-groups-in-organic-compounds/

A good summary infographic of different functional groups. Obviously there are many more than those needed but a good diagram which can be used with learners.

Activity 15

Summary website

http://www.chemistryrules.me.uk/junior/organic.htm#Jun org - alkene react

A really good website with lots of examples of combustion reactions, addition reactions and oxidation of alcohols and carboxylic acids. Could be used to introduce these reactions, as a research activity or as a self directed study.

Activity 16

Foldables

https://s-media-cache-ak0.pinimg.com/originals/a9/b0/56/a9b056eab1177121b6ea7ada531d3487.jpg

This image shows how 'foldables'can be used to help learners recall the structure of hydrocarbons and other. This link shows lots of alternative foldable activities http://www.greenninja.org/workshop2012/archive2012/TL-foldables!!!%5B1%5D.pdf

Activity 17

Bonding

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

An interesting activity which allows learners to practice the idea of dot cross diagrams for simple molecules. All the templates and instructions are included on the site.

Activity 18

Cracking video

https://www.youtube.com/watch?v=Ehcq4cARkMI

A short video that summarises cracking. Could be used to introduce the idea of cracking. It also gives a nice summary of hydrocarbons and crude oil.

Activity 19

Cracking worksheets

https://www.tes.com/teaching-resource/cracking-hydrocarbons-6191463

This is a series of lesson slides explaining cracking using the Wallace and Gromit characters to engage the learners. It includes work sheets to print out to accompany the slides. Practical instructions are included too. This resource could be adapted for other lessons.

Activity 20

Cracking practical

http://www.rsc.org/learn-chemistry/resource/res00000681/cracking-hydrocarbons?cmpid=CMP00005002

Could be done as either a class practical or demo depending on the apparatus available in your centre, or the ability of your learners. Alternatively you could do this as a microscale practical http://www.rsc.org/learn-chemistry/resource/res00001717/cracking-hydrocarbons-on-a-microscale?cmpid=CMP00005231

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