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OCR
Oxford Cambridge and RSA

GCSE (9–1)
Delivery Guide

GATEWAY SCIENCE CHEMISTRY A

J248
For first teaching in 2016

Chemical reactions

Version 2

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

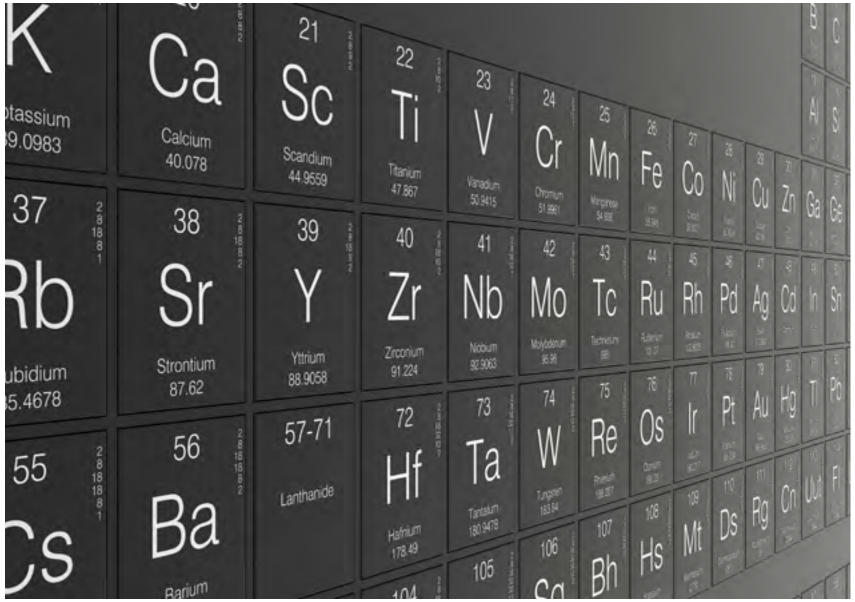
Delivery guides are designed to represent a body of knowledge about teaching a particular topic and contain:

- Content: A clear outline of the content covered by the delivery guide;
- Thinking Conceptually: Expert guidance on the key concepts involved, common difficulties learners may have, approaches to teaching that can help learners 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

Curriculum content Subtopic 1 – Introducing chemical reactions

C3.1a use chemical symbols to write the formulae of elements and simple covalent and ionic compounds
C3.1b 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 **half equations**
C3.1c use the names and symbols of common elements from a supplied periodic table to write formulae and balanced chemical equations where appropriate to include the first 20 elements, Groups 1, 7, and 0 and other common elements included within the specification
C3.1d use the formula of common ions to deduce the formula of a compound
C3.1e construct balanced ionic equations
C3.1f describe the physical states of products and reactants using state symbols (s, l, g and aq)
C3.1g recall and use the definitions of the Avogadro constant (in standard form) and of the mole to include the calculation of the mass of one atom/molecule
C3.1h explain how the mass of a given substance is related to the amount of that substance in moles and vice versa
C3.1i recall and use the law of conservation of mass
C3.1j explain any observed changes in mass in non-enclosed systems during a chemical reaction and explain them using the particle model
C3.1k deduce the stoichiometry of an equation from the masses of reactants and products and explain the effect of a limiting quantity of a reactant
C3.1l use a balanced equation to calculate masses of reactants or products



Approaches to teaching the content:

Understanding chemical formulae is crucial to the further study of chemistry. A careful approach is necessary here to ensure that learners fully understand how chemical formulae work and how they are used in the construction of equations to illustrate chemical reactions. What seems simple once grasped can prove difficult to get across. The use of subscript numbers to multiply elements in a formula and its extension to multiplying the contents of brackets is a major hurdle to a clear understanding. Use of simpler formulae to start and slowly introducing these more complex ideas when it is judged possible would seem logical. Getting the initial formulae correct is required to enable balancing of equations.

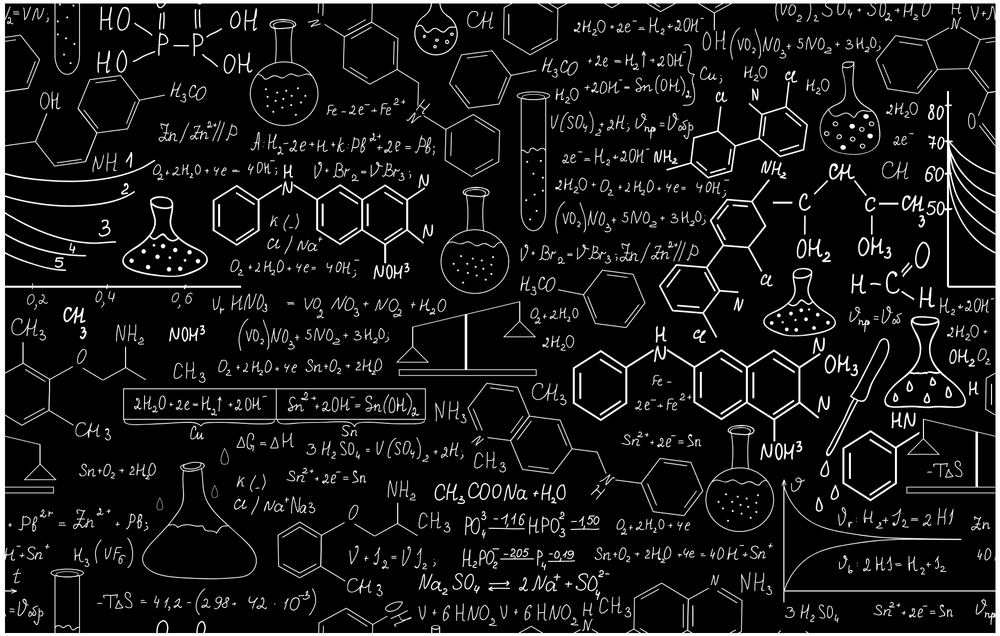
Ionic equations introduced here to higher tier learners for reactions such as precipitation require a clear understanding of how a chemical reaction is actually taking place and of the extraction of spectator ions due to their lack of participation in such reactions.

Common misconceptions or difficulties learners may have:

Learners may have understanding of the law of conservation of mass but they still rely on visible evidence and will refer to reactions losing mass. While they understand that mass is conserved, they don’t link this to conserving the number of individual atoms. Substances are seen to vanish ‘completely and forever in a chemical reaction. Chemical formulae are found difficult too as learners often misunderstand which atoms are affected by subscripts, this is compounded when using bracketed species e.g. $(NH_4)_3PO_4$.

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

Chemical formulae and equations underpin the study of chemistry. There is no part of chemistry to which they do not apply. The application of the mole is fundamental to any quantitative understanding of chemistry and will be used in the remainder of C3 and in the further quantitative elements in C5 notably 5.1; 5.2b &c and 5.3c.



Approaches to teaching the content:

The use of chemical jigsaws is a very useful way to introduce or revise the makeup of chemical formulae. Activity 1 uses materials developed by the RSC, sourced from Scientific and Chemical. Though this activity only covers ionic compounds there are kits for covalent too.

The RSC task in Activity 2 gives a measure of the misconceptions learners have regarding ionic bonding and allows for discussion to move beyond them.

Activity 3 is a short film containing a good illustration of the immensity of Avogadro's number and the value of the mole.

Two online quizzes give learners the opportunity for self-learning or for a fun piece of Assessment for Learning (AfL) on the subject of balancing equations.

Activity 1

Ionic bonding true or false

Learn Chemistry
http://www.rsc.org/learn-chemistry/resource/res00001095/ionic-bonding

This is a useful tool for assessing learners' understanding of ionic bonding.
Worksheets and answers are provided.

Activity 2

Mole video

Youtube
https://www.youtube.com/watch?v=TEI4jeETVmg

A short clip to introduce the mole with a good illustration of how big Avogadro's number is.

Activity 3

Calculating mass of an atom or molecule

Youtube
https://www.youtube.com/watch?v=vqTg4cYwHXY

A run through using silver and water of use of Avogadro's number to calculate Individual masses of particles.

Activity 4

Tutorial on ionic equations

Chemteam
http://www.chemteam.info/Equations/Net-Ionic-Equation.html

A lengthy online tutorial, as much for teachers to refresh their approach as to provide learners with activities.
Several worked examples at the end of the unit are very useful for learners.

Activity 5

Balancing equations 1

Learn Chemistry
http://www.rsc.org/learn-chemistry/resource/rwq00000062/generalk008-balancing-equations

An online quiz for learners to test their own understanding of balancing equations.
Formative comments given on submitting their responses.

Activity 6

Quantitative

Youtube
https://www.youtube.com/watch?v=KhK_OazhcMk

A short video looking at calculating masses from equations using ratios of moles.

Activity 7

Balancing equations 2

Learn Chemistry
http://www.rsc.org/learn-chemistry/resource/rwq00000063/generalk009-balancing-equations-2

A second online quiz on balancing equations. This is extension as the equations become more complex. Includes organic equations too.
Formative comments given on submitting their responses.

C3.2a distinguish between endothermic and exothermic reactions on the basis of the temperature change of the surroundings

C3.2b draw and label a reaction profile for an exothermic and an endothermic reaction to include activation energy, energy change, reactants and products

C3.2c explain activation energy as the energy needed for a reaction to occur

C3.2d calculate energy changes in a chemical reaction by considering bond making and bond breaking energies

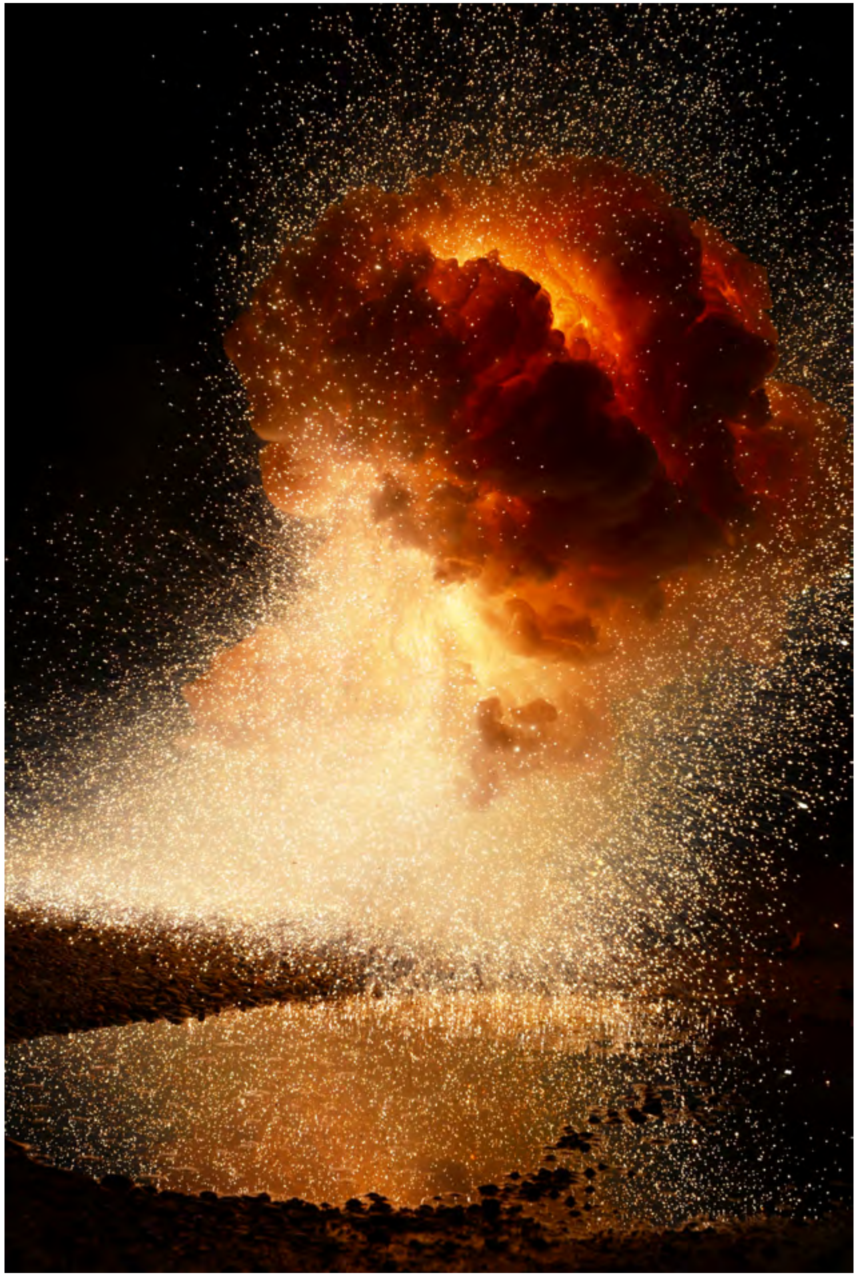
Approaches to teaching the content:

Learners need to understand that when chemical reactions are a result of first breaking followed by making bonds. Any differences in the energies involved result in either the emission or absorption of energy. An exothermic reaction gives out energy while an endothermic reaction draws in energy (from their surroundings). Thus exothermic reactions raise the temperature and endothermic reactions lower the temperature (of their surroundings).

The graphical representation of these energy changes is done using energy profile diagrams. Carefully done in stages drawing the lines for reactants and products with the ΔH indicated with the subsequent addition of the activation energy curve enable the learner to grasp both ideas from the same diagram. It needs to be made clear here that the top of the curve represents the point at which all the bonds are broken in preparation for bond making.

Common misconceptions or difficulties learners may have:

Learners' misconceptions stem from difficulties with the idea of conservation of energy and they think that energy is lost or used up. The fact that energy can only be transferred is lost due to the number of ways such energy can be transferred. Learners also misunderstand the changes involved in bond making (exothermic) and bond breaking (endothermic). Reactions requiring an initial input of energy such as burning hydrocarbons may be thought to be endothermic.



Approaches to teaching the content:

Exothermic reactions can be illustrated by means of some of the most exciting demonstrations in chemistry e.g. burning magnesium (white hot approx. 3000 °C and almost as hot as the sun!), exploding can (methane and air mixture). Endothermic reactions are rarer though the fact that solids can react with each other by simple agitation is worth demonstrating.

Activity 1

Endothermic reaction

Youtube
https://www.youtube.com/watch?v=GQkJI-Nq3Os

A short video demonstrating an endothermic reaction.
This is a solid/solid reaction rather than the usual dissolution used to demonstrate endothermic processes.

Activity 2

Exothermic reaction of aluminium and iodine

YouTube
https://www.youtube.com/watch?v=Z0TBu9NRNdQ

http://www.rsc.org/learn-chemistry/resource/res00000715/reaction-between-aluminium-and-iodine?cmpid=CMP00006598

A short video demonstrating an exothermic reaction.
The second link is instructions on how to demonstrate the reaction between aluminium and iodine in the classroom using a fume cupboard.
Aluminium iodide formation is a reaction that doesn't need an initial heat input.

Activity 3

Energy level diagrams

BBC
https://www.youtube.com/watch?v=ygyaMUuEyJM

A presentation including animations to show the development of energy profile diagrams.
An omission here is the activation energy required in an endothermic reaction and therefore this needs teasing out. It could be a very useful AfL tool.

Activity 4

Higher tier Bond energy calculations

BBC
https://www.youtube.com/watch?v=RlF4D9rcqK8

A useful short video covering bond energy calculations.
Useful for self-learning with some other useful links.

Activity 5

RSC Practical – Exothermic metal displacement reactions

Learn Chemistry

http://www.rsc.org/learn-chemistry/resource/res00001730/exothermic-metal-displacement-reactions?cmpid=CMP00005244

A practical covering the exothermic displacement of copper from copper sulphate solution by a number of metals.
Could be used as a simple introduction to calorimetry.

Curriculum content Subtopic 3 – Types of chemical reactions

C3.3a explain reduction and oxidation in terms of loss or gain of oxygen, identifying which species are oxidised and which are reduced including the concept of oxidising agent and reducing agent

C3.3b explain reduction and oxidation in terms of gain or loss of electrons, identifying which species are oxidised and which are reduced

C3.3c recall that acids form hydrogen ions when they dissolve in water and solutions of alkalis contain hydroxide ions

C3.3d describe neutralisation as acid reacting with alkali or a base to form a salt plus water

C3.3e recognise that aqueous neutralisation reactions can be generalised to hydrogen ions reacting with hydroxide ions to form water

C3.3f recall that carbonates and some metals react with acids and write balanced equations predicting products from given reactants

C3.3g use and explain the terms dilute and concentrated (amount of substance) and weak and strong (degree of ionisation) in relation to acids to include ratio of amount of acid to volume of solution

C3.3h recall that relative acidity and alkalinity are measured by pH

C3.3i describe neutrality and relative acidity and alkalinity in terms of the effect of the concentration of hydrogen ions on the numerical value of pH (whole numbers only)

C3.3j recall that as hydrogen ion concentration increases by a factor of ten the pH value of a solution decreases by a factor of one to include pH of titration curves

C3.3k describe techniques and apparatus used to measure pH

Approaches to teaching the content:

Linking the idea of gaining oxygen to being oxidised and the loss of oxygen to reduction is the first approach in enabling learners to understand redox reactions. The reactant providing the oxygen being the oxidant while the reactant receiving the oxygen is the reductant. Higher - level learners should also be aware that redox reactions are always accompanied by the loss (oxidation) and gain (reduction) of electrons thus enabling understanding of reactions (or half equations) not involving oxygen. The reactant losing electrons being the reductant while that gaining being the oxidant. Use the acronym OILRIG to identify which is being oxidised and which being reduced.

Learners need to be introduced to acid-base theory i.e. in aqueous solution those substances that release hydrogen ions are acidic while those that release hydroxide ions are alkaline. Learners should then be led to understand that the general reaction between acids and alkalis is the reaction between hydrogen ions and hydroxide ions to form water while the remaining (spectator) ions form a salt.

Learners should be made aware of the use of the term pH and the pH scale. This is useful, at higher level, to enable differentiation between the use of the words strength and concentration in relation to acids and bases. Weak bases are unable to provide solutions of pH at either end of the spectrum (ie 0-2 or 12-14) as they incapable of providing enough hydrogen or hydroxide ions, whereas even relatively weak solutions of strong acids and bases will have pH values approaching the extremes of the scale. In addition when the latter are diluted tenfold the pH value changes by a factor of one. Comparison should be made with tenfold dilution of weak acids and bases using a pH meter to make the difference in ionisation clear. All learners should be given the opportunity to see use a pH meter as well as use full range indicator paper or universal indicator solution.

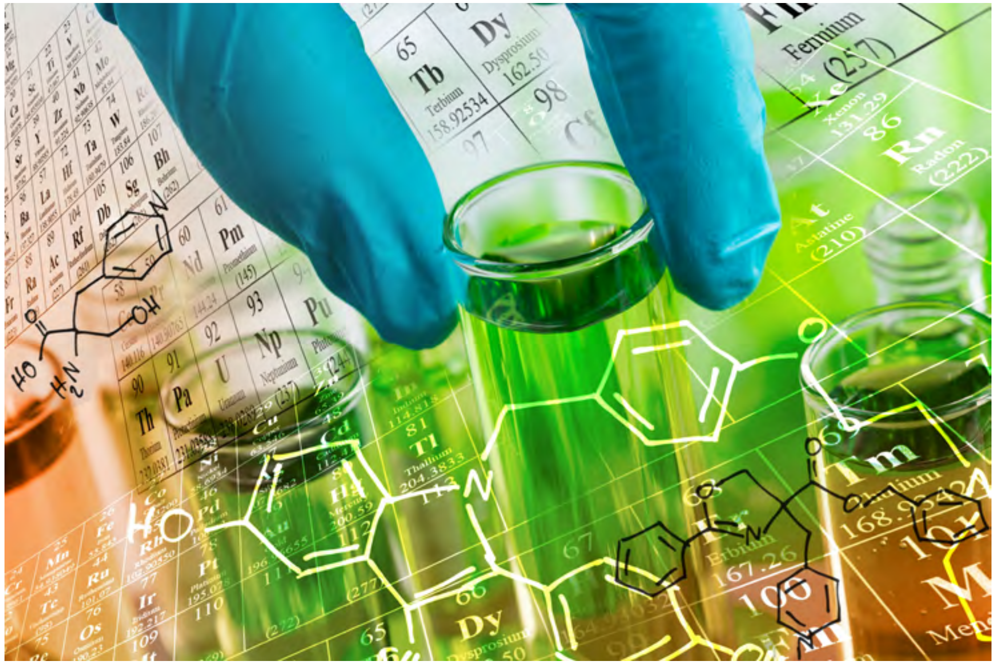
Common misconceptions or difficulties learners may have:

Learners have difficulty with the idea that the acid produces separate ions in solution and maintain the idea that hydrogen ions remain as part of the molecule. Understanding of pH is poor and learners tend to think that alkalis are less corrosive than acids. Learners also confuse the two ideas of concentration and strength of acids and bases. Common usage of the terms is interchanged often and it can be difficult to persuade learners that these terms are used in a more specific manner in chemistry.

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

Redox reactions are responsible for rusting and corrosion of metals thus this understanding links to 6.1 n and o. Discussion at this point of the faster reaction with oxygen of the more reactive metals will form the basis for understanding rusting later.

The strength of an acid used in determination of rate of reaction will determine the gradient of the line, weaker acids will be shallower. Thus full understanding of the nature of hydrogen ion release will be needed for 5.2 a and c.



Approaches to teaching the content:

Oxidation as defined by the addition of oxygen can easily be shown by simple combustion, the use of the thermite reaction is justified here, as it is a displacement reaction, Activities 1 and 2.

Taking the definition further to include the loss and gain of electrons is covered in Activity 3. The use of familiar household chemicals in Activity 4 gives learners a link to real-life, it also makes it clear that there are some very hazardous materials being stored and used in the home. Activity 5 gives access to changing a number of variables and performing virtual tests in a wide variety of situations and should be used to promote discussion to ensure clear learning. This simulation accesses a number of methods for measuring pH and can look at the change in pH for a change in concentration. This discussion and its impact is checked and improved using Activity 6. The latter half of the film linked in Activity 7 covers most of the necessary material regarding acids bases, pH and neutralisation.

Activity 1

Redox

BBC Bitesize

http://www.bbc.co.uk/education/guides/zqjsgk7/revision/4

A page giving the definitions of oxidation and reduction, reductant and oxidant and a link to a clip of the Thermite reaction.

Activity 2

Thermite demo

Learn Chemistry

http://www.rsc.org/learn-chemistry/resource/res00000724/the-thermite-reaction

All the instructions to carry out this exciting redox reaction.
To explore the transfer of oxygen between two metals.

Activity 3

Redox practical

Learn Chemistry

http://www.rsc.org/learn-chemistry/resource/res00000511/redox-reactions

A pair of microscale experiments providing a safe initial introduction to redox and the transfer of electrons.
Full documentation is provided for learners, teacher and technician.

Activity 4

pH simulation

Learn Chemistry

http://www.rsc.org/learn-chemistry/resources/phet/ph-scale-basics_en.html

Using common household materials to investigate the effect of concentration on pH.
This is a self-learning tool that can be accessed as a group in class or individually at school or at home.
To use the tool you need to click on the red button to add the substance, drag the pH probe into the substance and drag out the valves on the water pipe to add water.

Activity 5

Acid-base simulation

Learn Chemistry

http://www.rsc.org/learn-chemistry/resource/res00001457/acid-base-solutions-simulation

A simulation providing access to a wide range of situations and equipment allowing a great deal of discussion.
This is a self-learning tool that can be accessed as a group in class or individually at school or at home.

Activity 6

Acid base worksheet

Learn Chemistry

http://www.rsc.org/learn-chemistry/resource/res00001105/acid-strength

Worksheets and teacher instructions for a paper activity to aid in the clarification of misconceptions.

Activity 7

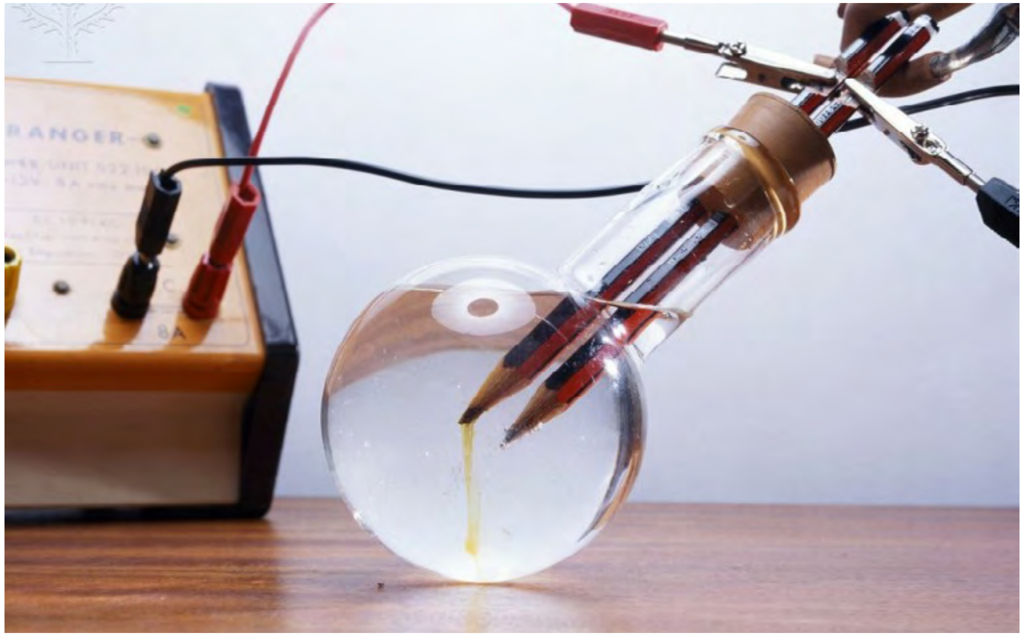
Acids and bases

Youtube

https://www.youtube.com/watch?v=0YR62F_QNKA

From 10.15 this film discusses aspects of neutralisation and acid reactions with metals, bases and carbonates.

C3.4a recall that metals (or hydrogen) are formed at the cathode and non-metals are formed at the anode in electrolysis using inert electrodes include the terms cations and anions
C3.4b predict the products of electrolysis of binary ionic compounds in the molten state to include compounds such as $NaCl$
C3.4c describe competing reactions in the electrolysis of aqueous solutions of ionic compounds in terms of the different species present to include the electrolysis of aqueous $NaCl$ and $CuSO_4$ using inert electrodes
C3.4d describe electrolysis in terms of the ions present and reactions at the electrodes
C3.4e describe the technique of electrolysis using inert and non-inert electrodes



Approaches to teaching the content:

Learners often find electrolysis one of the most difficult areas of chemistry to understand thus the approach needs to be well constructed. Learners need to understand that electrolysis is the splitting of chemical reagents using electricity. That this is carried out using electrodes either in molten salts or their aqueous solutions. That the electrodes used might be inert electrodes such as graphite (carbon) or metal. That each electrode carries an electrical charge, which promotes the movement of ions within the reagent or its solution. That the cathode is negatively charged and attracts the movement of positive ions called cations towards it, while the positively charged anode attracts negatively charged ions called anions. Predominantly metals (and hydrogen) carry positive charges (Cu^{2+}) thus these react at the cathode to produce the metal (or hydrogen) and non-metals carry negative charges (Cl^{-}) and are released at the anode.

The products of electrolysis may be dependant on the state in which the reagent is electrolysed and/or the respective position of the elements in the reagent with respect to the Reactivity Series. Molten binary salts such as sodium chloride only release two ions, in this case Na^{+} and Cl^{-} thus the only possible products are sodium at the cathode and chlorine at the anode. However in aqueous solution the metal's position in relation to hydrogen determines whether the metal or hydrogen are produced at the cathode, more reactive metals (Al Na Mg) will remain in solution as ions while hydrogen is released, less reactive metals (Cu and Ag) will be deposited on the cathode. Meanwhile the anions are ranked in terms of their stability with reference to that of hydroxide ions. Simple ions of the elements tend to produce the element at the anode, while oxyanions such as SO_4^{2-} are very stable and the hydroxide is decomposed to produce oxygen and water at the anode.

Common misconceptions or difficulties learners may have:

Learners find this area of chemistry very difficult in part due to the need to understand the competing reactions involved in aqueous electrolysis and as molten electrolysis is somewhat constrained they will probably only perform aqueous electrolysis. Learners also find it difficult to understand that ions are able to conduct electrical current, despite their being charged. They think that electrons must be released when ions are formed and these carry the current.

Another common misconception is that ionic solids do not conduct because there are no free electrons.

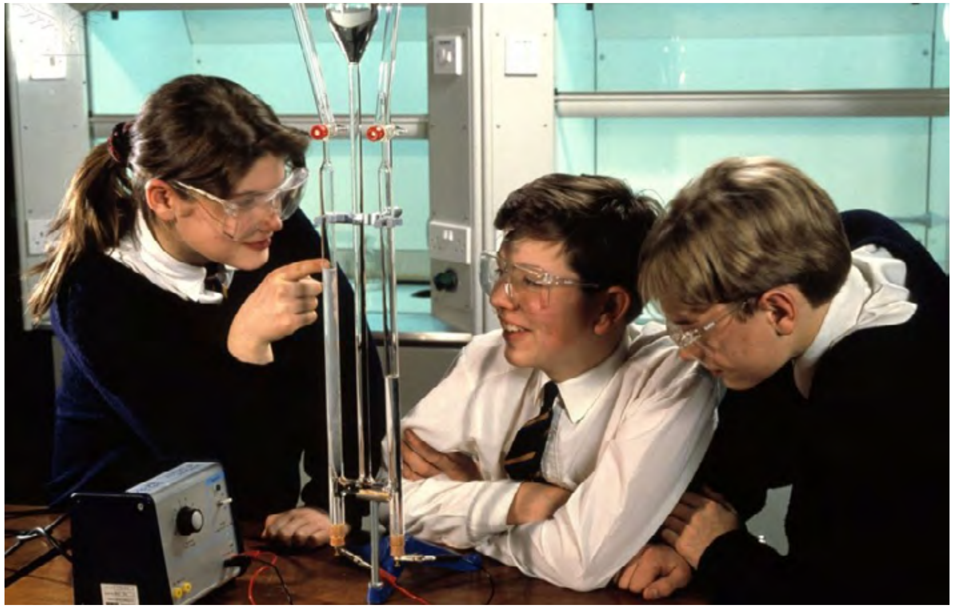
Conceptual links to other areas of the specification – useful ways to approach this topic to set learners up for topics later in the course:

The electrolytic separation of metals from their ores is required knowledge for 6.1b. Understanding the electrolysis of a variety of materials such as copper sulphate solution at this point makes the later expansion more comprehensible.

Galvanising is the electrolytic deposition of zinc on steel objects to form an impermeable layer to protect the steel from corrosion 6.1o.

Approaches to teaching the content:

The study of electrolysis has the capacity to provide good experience of practical work and given a reasonable knowledge of the terminology (Activity 1) this can lead to an interesting learning experience for the learners. Activity 2 is a hands-on look at electrolysis in solution and how ions compete to be discharged. While learners need an understanding of the electrolysis of molten solutions the temperatures involved and the level of hazard in the products usually mean that these are done as a demonstration. There are sufficient instructions available to mount something suitable. Activities 3 and 4 look at the reactions involved at both metal electrodes and inert electrodes using copper sulphate as the electrolyte. Activity 5 is a short piece that can be recommended for self-learning, dealing with half equations as seen at the electrodes.



Activity 1

Electrolysis definitions

Youtube
https://www.youtube.com/watch?v=AktF-vwTYo8

Short animated video dealing with the language of electrolysis.

Activity 2

Electrolysis practical.

Learn Chemistry
http://www.rsc.org/learn-chemistry/resource/res00001759/preferential-discharge-of-cations-during-electrolysis

Full details given for this activity which provides the learner with experience of competing reactions.

Activity 3

Electrolysis with metal electrodes

Youtube
https://www.youtube.com/watch?v=_guay80X0hs

Demonstration and discussion of the reactions in this reaction.

Activity 4

Electrolysis with inert electrodes

Youtube
https://www.youtube.com/watch?v=Q62UfP-ZADY

A very short film useful for discussing the differences.

Activity 5

Video on half equations

Youtube
https://www.youtube.com/watch?v=2caOl2n8aho

A useful tutorial on half equations.

The small print

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