# Scheme of work

## Chemistry – Chemical changes

This resource provides guidance for teaching the Chemical changes topic from our new GCSE Chemistry (8462). It has been updated from the draft version to reflect the changes made in the accredited specification. Sections 4.4.2.3, 4.4.2.4 and 4.4.3.3 have been amended as well as the learning outcomes and opportunities to develop and apply practical and enquiry skills of most sections.

The scheme of work is designed to be a flexible medium term plan for teaching content and development of the skills that will be assessed.

It is provided in Word format to help you create your own teaching plan – you can edit and customise it according to your needs. This scheme of work is not exhaustive; it only suggests activities and resources you could find useful in your teaching.

### 4.4 Chemical changes

#### 4.4.1 Reactivity of metals

| **Spec ref.** | **Summary of the specification content** | **Learning outcomes**  *What most candidates should be able to do* | **Suggested timing (hours)** | **Opportunities to develop Scientific Communication skills** | **Opportunities to develop and apply practical and enquiry skills** | **Self/peer assessment opportunities and resources**  *Reference to past questions that indicate success* |
| --- | --- | --- | --- | --- | --- | --- |
| 4.4.1.1 | Metals react with oxygen to produce metal oxides. The reactions are oxidation reactions because the metals gain oxygen. | Explain reduction and oxidation in terms of loss or gain of oxygen. | 0.5 | Define the following terms:   * oxidation * reduction.   Write word and balanced symbol equations for the reactions of metals with oxygen to produce metal oxides.  Use these to identify where reduction and oxidation has taken place. | Demo reactions:  [RSC Reacting metals with oxygen](http://www.rsc.org/learn-chemistry/resource/res00000705/reacting-elements-with-oxygen?cmpid=CMP00000783) | Video clips:  [BBC Bitesize Alkali metals and their reactions to air and water](http://www.bbc.co.uk/education/clips/zychyrd)  [BBC Bitesize How sodium reacts with water](http://www.bbc.co.uk/education/clips/zxkn34j) |
| 4.4.1.2 | When metals react with other substances the metal atoms form positive ions. The reactivity of a metal is related to its tendency to form positive ions. Metals can be arranged in order of their reactivity in a reactivity series. The metals potassium, sodium, lithium, calcium, magnesium, zinc, iron and copper can be put in order of their reactivity from their reactions with water and dilute acids.  The non-metals hydrogen and carbon are often included in the reactivity series.  A more reactive metal can displace a less reactive metal from a compound. | The reactions of metals with water and acids are limited to room temperature and do not include reactions with steam.  Recall and describe the reactions, if any, of potassium, sodium, lithium, calcium, magnesium, zinc, iron and copper with water or dilute acids, where appropriate, to place these metals in order of reactivity.  Explain how the reactivity of metals with water or dilute acids is related to the tendency of the metal to form its positive ion.  Deduce an order of reactivity of metals based on experimental results. | 1 | Draw the atomic structure of metals and the ion formed. Use these to describe how the ion has been formed.  Make links between the ability to form ions and the reactivity with water and acid.  Grade 9: explain the trends in reactivity of Group 1 in terms of atomic structure.  Describe what occurs in a displacement reaction, using suitable examples.  Explain why displacement occurs.  Compare the year of discovery of a metallic element with its position in the reactivity series.  Link discoveries to new technology such as the invention of the battery. | Demo, and where appropriate practically investigate, the reactivity of some of the metals with water and acid.  Use YouTube clips or let students investigate the reactivity of the remaining combinations.  Use findings to construct a reactivity series. Compare this to the actual reactivity series.  AT 6. Mixing of reagents to explore chemical changes and/or products. | Video clips:  [BBC Bitesize Reactivity of metals and their uses](http://www.bbc.co.uk/education/clips/zpjvcdm)  YouTube:  [The reactivity series](https://www.youtube.com/watch?v=2MawIDT5DFU)  [Exampro user guide PowerPoint](http://filestore.aqa.org.uk/resources/science/AQA-GCSE-SCIENCE-EXAMPRO-UG.PPTX) |
| 4.4.1.3 | Unreactive metals such as gold are found in the Earth as the metal itself but most metals are found as compounds that require chemical reactions to extract the metal.  Metals less reactive than carbon can be extracted from their oxides by reduction with carbon.  Reduction involves the loss of oxygen. | Knowledge and understanding are limited to the reduction of oxides using carbon.  Knowledge of the details of processes used in the extraction of metals is not required.  Interpret or evaluate specific metal extraction processes when given appropriate information.  Identify the substances which are oxidised or reduced in terms of gain or loss of oxygen.  WS 1.4, 4.1 | 1 | Describe how carbon is used to reduce metal oxides. Explain how this takes place in terms of movement of electrons.  Identify which products have been oxidised in extraction examples. Explain how this takes place in terms of movement of electrons. | Reduce iron oxide using carbon:  [RSC The reduction of iron oxide by carbon](http://www.rsc.org/learn-chemistry/resource/res00000419/the-reduction-of-iron-oxide-by-carbon?cmpid=CMP00000489)  Research different methods for extraction metals from their oxides.  Compare and contrast the methods, evaluating the methods in terms of environmental, economic and social impacts. | Video clip  YouTube: [Reduction of copper oxide](https://www.youtube.com/watch?v=6nEt6cW_GSw) |
| 4.4.1.4  (HT only) | Oxidation is the loss of electrons and reduction is the gain of electrons. | Write ionic equations for displacement reactions.  Identify in a given reaction, symbol equation or half equation which species are oxidised and which are reduced.  WS 4.1  MS 3a | 1 | Write balanced symbol equations/half equations for the displacement of metal oxides. Use these to identify which species has been oxidised or reduced. Give reasons for your answers. | Carry out simple displacement reactions. For these write ionic equations. | Video clips  YouTube: [What are Reduction and Oxidation?](https://www.youtube.com/watch?v=zYlOD1GWMBU)  [BBC Bitesize What is rust?](http://www.bbc.co.uk/education/clips/zc89wmn) |

#### 4.4.2 Reactions of acids

| **Spec ref.** | **Summary of the specification content** | **Learning outcomes**  *What most candidates should be able to do* | **Suggested timing (hours)** | **Opportunities to develop Scientific Communication skills** | **Opportunities to develop and apply practical and enquiry skills** | **Self/peer assessment opportunities and resources**  *Reference to past questions that indicate success* |
| --- | --- | --- | --- | --- | --- | --- |
| 4.4.2.1 | Acids react with some metals to produce salts and hydrogen. | Knowledge of reactions limited to those of magnesium, zinc and iron with hydrochloric and sulfuric acids.  (HT only) Explain in terms of gain or loss of electrons, that these are redox reactions.  (HT only) Identify which species are oxidised and which are reduced in given chemical equations.  WS 4.1 | 1 |  | Investigate the reactions of the following metals with sulfuric acid:   * magnesium * zinc * iron.   Write word and balanced symbol equations for these reactions.  Use the balanced symbol equations to identify which species have been oxidised and which have been reduced.  Explain why each species has been oxidised or reduced. |  |
| 4.4.2.2 | Acids are neutralised by alkalis (eg soluble metal hydroxides) and bases (eg insoluble metal hydroxides and metal oxides) to produce salts and water, and by metal carbonates to produce salts, water and carbon dioxide.  The particular salt produced in any reaction between an acid and a base or alkali depends on:   * the acid used (hydrochloric acid produces chlorides, nitric acid produces nitrates, sulfuric acid produces sulfates) * the positive ions in the base, alkali or carbonate. | Predict products from given reactants.  Use the formulae of common ions to deduce the formulae of salts. | 2 | Define the term neutralisation.  Using common reactants, predict the products. | Investigate the following reactions:   * acids + soluble metal hydroxide * acid + insoluble metal hydroxide * acids + metal carbonates.   Write word and balanced symbol equations for these reactions. | Video clips:  [BBC Bitesize Acids and alkalis](http://www.bbc.co.uk/education/clips/zfgtfg8)  [BBC Bitesize Neutralisation](https://www.youtube.com/watch?v=_cB2vSaalXg)  [BBC Bitesize How neutralisation is used in diving apparatus](http://www.bbc.co.uk/education/clips/zpq34wx) |
| 4.4.2.3 | Soluble salts can be made from acids by reacting them with solid insoluble substances, such as metals, metal oxides, hydroxides or carbonates.  The solid is added to the acid until it no more reacts and the excess solid is filtered off to produce a solution of the salt.  Salt solutions can be crystallised to produce solid salts. | Describe how to make pure, dry samples of named soluble salts from information provided.  WS 2.3, 2.4 | 2 | Extended writing:describe how to make a pure, dry sample of a soluble salt.  Define the terms:   * soluble * insoluble.   Explain what is meant by a soluble salt.  Explain why reactants are often used in excess. | **Required practical 1:**  Preparation of a pure, dry sample of a soluble salt from an insoluble oxide or carbonate using a Bunsen burner to heat dilute acid and a water bath or electric heater to evaporate the solution.  AT skills covered by this practical activity: 2, 3, 4 and 6 |  |
| 4.4.2.4 | Acids produce hydrogen ions (H+) in aqueous solutions.  Aqueous solutions of alkalis contain hydroxide ions (OH–).  The pH scale, from 0 to 14, is a measure of the acidity or alkalinity of a solution, and can be measured using universal indicator or a pH probe.  A solution with pH 7 is neutral. Aqueous solutions of acids have pH values of less than 7 and aqueous solutions of alkalis have pH values greater than 7.  In neutralisation reactions between an acid and an alkali, hydrogen ions react with hydroxide ions to produce water. This reaction can be represented by the equation:  H+ (aq) + OH– (aq) H2O (l) | Describe the use of universal indicator or a wide range indicator to measure the approximate pH of a solution.  Use the pH scale to identify acidic or alkaline solutions.  WS 1.2, 2.6, 4.1  . | 2 | Define the following terms:   * acid * base * alkali * neutral.   Recall the pH numbers for the following solutions:   * acidic * alkaline * neutral.   Write the symbol equation for the neutralisation of an acid and an alkali. | Measure the pH of a variety of the following solutions:   * acidic * alkaline * neutral.   Practical: measure the pH change when a strong acid neutralises a strong alkali.  This is best done using a data logger and pH probe or digital pH meter. AT3. | Video clips:  [BBC Bitesize Acidic, alkaline or neutral](http://www.bbc.co.uk/education/clips/zcswmp3)  YouTube:  [What are Indicators and how do we use them?](https://www.youtube.com/watch?v=xYQlvTblgCY) |
| 4.4.2.5 | The volumes of acid and alkali solutions that react with each other can be measured by titration using a suitable indicator. | Describe how to carry out titrations using strong acids and strong alkalis only (sulfuric, hydrochloric and nitric acids only) to find the reacting volumes accurately.  (HT Only) Calculate the chemical quantities in titrations involving concentrations in mol/dm3 and in g/dm3.  WS 2.4, 2.6  MS 1a, 1c, 2a | 2 |  | **Required practical 2:**  Determination of the reacting volumes of solutions of a strong acid and a strong alkali by titration.  (HT only) determination of the concentration of one of the solutions in mol/dm3 and g/dm3 from the reacting volumes and the known concentration of the other solution.  AT skills covered by this practical activity: 1 and 8 |  |
| 4.4.2.6  (HT only) | A strong acid is completely ionised in aqueous solution. Examples of strong acids are hydrochloric, nitric and sulfuric acids.    A weak acid is only partially ionised in aqueous solution. Examples of weak acids are ethanoic, citric and carbonic acids.  For a given concentration of aqueous solutions, the stronger an acid, the lower the pH.  As the pH decreases by one unit, the hydrogen ion concentration of the solution increases by a factor of 10. | Use and explain the terms dilute and concentrated (in terms of amount of substance), and weak and strong (in terms of the degree of ionisation) in relation to acids.  Describe neutrality and relative acidity in terms of the effect on hydrogen ion concentration and the numerical value of pH (whole numbers only).  WS 4.1  MS 2h | 1 | Explain the meaning of the following terms:   * dilute * concentrated * weak * strong.   Explain why strong acids are completely ionised in aqueous solutions but a weak acid is only partially ionised.  Recall examples of strong and weak acids.  Describe neutrality in terms on hydrogen ion concentration.  Describe relative acidity in terms of hydrogen ion concentration. | Use universal indicator or a pH probe to measure the pH of hydrochloric acid, ethanoic acid, sodium hydroxide and ammonium hydroxide. Be careful to use the same concentration of each.  Measure the pH of different acids at different concentrations.  Compare the rate of reaction when magnesium is dipped in hydrochloric acid and ethanoic acid of the same concentration.  AT 8 |  |

### 4.4.3 Electrolysis

| **Spec ref.** | **Summary of the specification content** | **Learning outcomes**  *What most candidates should be able to do* | **Suggested timing (hours)** | **Opportunities to develop Scientific Communication skills** | **Opportunities to develop and apply practical and enquiry skills** | **Self/peer assessment opportunities and resources**  *Reference to past questions that indicate success* |
| --- | --- | --- | --- | --- | --- | --- |
| 4.4.3.1 | When an ionic compound is melted or dissolved in water, the ions are free to move about within the liquid or solution. These liquids and solutions are able to conduct electricity and are called electrolytes.  Passing an electric current through electrolytes causes the ions to move to the electrodes. Positively charged ions move to the negative electrode (the cathode), and negatively charged ions move to the positive electrode (the anode). Ions are discharged at the electrodes producing elements. This process is called electrolysis. | **(**HT only) **Throughout 4.4.3:** Higher Tier students should be able to write half equations for the reactions occurring at the electrodes during electrolysis, and may be required to complete and balance supplied half equations.  WS 4.1 | 1 | Explain why solid ionic compounds cannot conduct electricity but ionic compounds can conduct electricity when melted or dissolved in water.  Define the term electrolyte.  Describe how an electric current can pass through an ionic compound.  Explain what happens to positive and negative ions during electrolysis and how elements form from their ions. | Carry out the electrolysis of solutions following the RSC method:  [RSC Electrolysis of solutions](http://www.rsc.org/learn-chemistry/resource/res00000466/the-electrolysis-of-solutions?cmpid=CMP00000536)  Write balanced symbol equations for these reactions.  Write half equations for the reactions that occur at each electrode. | Video clips:  [BBC Bitesize Electrolysis and electroplating](http://www.bbc.co.uk/education/clips/zd2cd2p)  YouTube:  [GCSE Science Revision Electrolysis of a Solution](https://www.youtube.com/watch?v=Tq1qfOG9DoY) |
| 4.4.3.2 | When a simple ionic compound (eg lead bromide) is electrolysed in the molten state using inert electrodes, the metal (lead) is produced at the cathode and the non-metal (bromine) is produced at the anode. | Students should be able to predict the products of the electrolysis of binary ionic compounds in the molten state. | 0.5 | Calculate the atom economy for simple examples.  Extended writing: write instructions to another student how to calculate the atom economy giving explained examples. | Demo the electrolysis of lead bromide. A safer alternative for practical work is anhydrous zinc chloride.  Write balanced half equations for the reactions that occur at both electrodes. | Video clip:  YouTube: [Electrolysis of Molten Compounds](https://www.youtube.com/watch?v=87K8QsMl8nc) |
| 4.4.3.3 | Metals can be extracted from molten compounds using electrolysis. Electrolysis is used if the metal is too reactive to be extracted by reduction with carbon or if the metal reacts with carbon. Large amounts of energy are used in the extraction process to melt the compounds and to produce the electrical current.  Aluminium is manufactured by the electrolysis of a molten mixture of aluminium oxide and cryolite using carbon as the positive electrode (anode). | Explain why a mixture is used as the electrolyte.  Explain why the positive electrode must be continually replaced.  WS 1.4, 4.1 | 1 | Recall the reactivity series.  Give reasons why some metals have to be extracted by electrolysis.  Extended writing: describe how aluminium is extracted from its ore.  Write balanced half equations for the reactions that occur at both electrodes.  Extended writing: describe how reactive metal elements were discovered by electrolysis.  Construct a timeline. | Research how aluminium is extracted from its ore.  Write balanced half equations for the reactions that occur at both electrodes. |  |
| 4.4.3.4 | The ions discharged when an aqueous solution is electrolysed using inert electrodes depend on the relative reactivity of the elements involved.  At the negative electrode (cathode), hydrogen is produced if the metal is more reactive than hydrogen.  At the positive electrode (anode), oxygen is produced unless the solution contains halide ions when the halogen is produced.  This happens because in the aqueous solution water molecules break down producing hydrogen ions and hydroxide ions that are discharged. | Be able to predict the products of the electrolysis of aqueous solutions containing a single ionic compound.  WS 2.1, 2.2, 2.3, 2.4, 2.6 | 2 | Define the term aqueous.  Extended writing: describe how an aqueous solution is electrolysed.  Explain why the following atoms could be produced:   * hydrogen * oxygen. | **Required practical 3:**  Investigate what happens when aqueous solutions are electrolysed using inert electrodes. This should be an investigation involving developing a hypothesis.  AT skills covered by this practical activity: 3, 7 and 8. |  |
| 4.4.3.5  (HT only) | During electrolysis, at the cathode (negative electrode), positively charged ions gain electrons and so the reactions are reductions.  At the anode (positive electrode), negatively charged ions lose electrons and so the reactions are oxidations.  Reactions at electrodes can be represented by half equations, for example:  2H+ + 2e- H2  and  4OH- O2 + 2H2O + 4e-  or  4OH- – 4e- O2 + 2H2O |  | 1 | Explain thoroughly what happens at the following electrodes using suitable examples and half equations:   * cathode * anode. |  |  |