

GCSE



# WJEC GCSE in CHEMISTRY

APPROVED BY QUALIFICATIONS WALES

## SPECIFICATION

Teaching from 2016  
For award from 2018

This Qualifications Wales regulated qualification is not available to centres in England.





# WJEC GCSE in CHEMISTRY

For teaching from 2016

For award from 2018

This specification meets the GCSE Qualification Principles which set out the requirements for all new or revised GCSE specifications developed to be taught in Wales from September 2016.

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# GCSE CHEMISTRY (Wales)

## SUMMARY OF ASSESSMENT

There are two tiers of entry for this qualification:

Higher Tier – Grades A\* - D

Foundation Tier – Grades C - G

This GCSE qualification in Chemistry offers assessment at foundation and higher tier. In most cases, we would expect candidates to be assessed within the same tier. Exceptionally, it may be appropriate to enter some candidates for a combination of higher and foundation tier units.

### Unit 1: CHEMICAL SUBSTANCES, REACTIONS and ESSENTIAL RESOURCES

Written examination: 1 hour 45 minutes

45% of qualification

80 marks

A mix of short answer questions, structured questions, extended writing and data response questions with some set in a practical context. A tiered assessment.

### Unit 2: CHEMICAL BONDING, APPLICATION OF CHEMICAL REACTIONS and ORGANIC CHEMISTRY

Written examination: 1 hour 45 minutes

45% of qualification

80 marks

A mix of short answer questions, structured questions, extended writing and data response questions with some set in a practical context. A tiered assessment.

### Unit 3: PRACTICAL ASSESSMENT

10% of qualification

30 marks

Practical assessment that will be carried out in centres, but will be externally marked by WJEC. It will take place in the first half of the spring term (January – February). It is recommended that this should be in the final year of study. An untiered assessment.

This unified qualification will be available in the summer series each year. It will be awarded for the first time in Summer 2018.

**Qualification Accreditation Number: 601/8234/9**

# GCSE CHEMISTRY

## 1 INTRODUCTION

### 1.1 Aims and objectives

This WJEC GCSE Chemistry specification provides a broad, coherent, satisfying and worthwhile course of study. It encourages learners to develop confidence in, and a positive attitude towards, science and to recognise its importance in their own lives and to society.

Studying GCSE Chemistry provides the foundations for understanding the material world. Scientific understanding is changing our lives and is vital to the world's future prosperity, and all learners should be taught essential aspects of the knowledge, methods, processes and uses of science. They should be helped to appreciate how the complex and diverse phenomena of the natural world can be described in terms of a small number of key ideas relating to the sciences which are both inter-linked, and are of universal application. These key ideas include:

- the use of conceptual models and theories to make sense of the observed diversity of natural phenomena
- the assumption that every effect has one or more cause
- that change is driven by differences between different objects and systems when they interact
- that many such interactions occur over a distance without direct contact
- that science progresses through a cycle of hypothesis, practical experimentation, observation, theory development and review
- that quantitative analysis is a central element both of many theories and of scientific methods of inquiry.

This specification is intended to promote a variety of styles of teaching and learning so that the course is enjoyable for all participants. Learners will be introduced to a wide range of scientific principles which will allow them to enjoy a positive learning experience. Practical work is an intrinsic part of science. It is imperative that practical skills are developed throughout this course and that an investigatory approach is promoted.

## 1.2 Prior learning and progression

There are no previous learning requirements for this specification. Any requirements set for entry to a course based on this specification are at the discretion of the school/college.

This specification builds on subject content which is typically taught at Key Stage 3 and provides a suitable foundation for the study of Chemistry at either AS or A level. In addition, the specification provides a coherent, satisfying and worthwhile course of study for learners who do not progress to further study in this subject.

## 1.3 Equality and fair access

This specification may be followed by any learner, irrespective of gender, ethnic, religious or cultural background. It has been designed to avoid, where possible, features that could, without justification, make it more difficult for a learner to achieve because they have a particular protected characteristic.

The protected characteristics under the Equality Act 2010 are age, disability, gender reassignment, pregnancy and maternity, race, religion or belief, sex and sexual orientation.

The specification has been discussed with groups who represent the interests of a diverse range of learners, and the specification will be kept under review.

Reasonable adjustments are made for certain learners in order to enable them to access the assessments (e.g. candidates are allowed access to a Sign Language Interpreter, using British Sign Language). Information on reasonable adjustments is found in the following document from the Joint Council for Qualifications (JCQ): *Access Arrangements and Reasonable Adjustments: General and Vocational Qualifications*.

This document is available on the JCQ website ([www.jcq.org.uk](http://www.jcq.org.uk)). As a consequence of provision for reasonable adjustments, very few learners will have a complete barrier to any part of the assessment.

## 1.4 Welsh Baccalaureate

In following this specification, learners should be given opportunities, where appropriate, to develop the skills that are being assessed through the Core of the Welsh Baccalaureate:

- Literacy
- Numeracy
- Digital Literacy
- Critical Thinking and Problem Solving
- Planning and Organisation
- Creativity and Innovation
- Personal Effectiveness.

## 1.5 Welsh perspective

In following this specification, learners must consider a Welsh perspective if the opportunity arises naturally from the subject matter and if its inclusion would enrich learners' understanding of the world around them as citizens of Wales as well as the UK, Europe and the world.

## 2 SUBJECT CONTENT

This section outlines the knowledge, understanding and skills to be developed by learners studying GCSE Chemistry.

Learners should be prepared to apply the knowledge, understanding and skills specified in a range of theoretical, practical, industrial and environmental contexts. Practical work is an intrinsic part of this specification. It is vitally important in developing a conceptual understanding of many topics and it enhances the experience and enjoyment of science. The practical skills developed are also fundamentally important to learners going on to further study in science and related subjects, and are transferable to many careers.

All of the content present in the Chemistry units of the Science (Double Award) specification (i.e. Units 2 and 5) is covered in this specification. In addition some of the content covered in Unit 1 of this specification overlaps with the content of Unit 1 of the Applied Science (Double Award) specification. This will allow learners if necessary to transfer between the different qualifications on offer in the GCSE Science suite in the first term of study.

This section includes specified practical work that must be undertaken by learners in order that they are suitably prepared for all assessments. The completion of this practical work will develop the practical skills listed in Appendix A.

Appendix B lists the mathematical requirements.

Some areas of content have been selected for assessment at higher tier only. This content is shown in **bold** type in the relevant content sections. All content may be examined at higher tier but that in bold will not be examined on foundation tier papers.

All content in the specification should be introduced in such a way that it develops learners' ability to:

- understand scientific concepts through the specific discipline of chemistry
- understand the nature, processes and methods of science, through different types of scientific enquiries that help them to answer scientific questions about the world around them
- apply observational, practical, modelling, enquiry and problem-solving skills in the laboratory and in other learning environments
- evaluate claims based on science through critical analysis of the methodology, evidence and conclusions, both qualitatively and quantitatively.

## 2.1 Unit 1

### **CHEMICAL SUBSTANCES, REACTIONS and ESSENTIAL RESOURCES**

**Written examination: 1 hour 45 minutes**  
**45% of qualification**

This unit includes the following topics:

- 1.1 The nature of substances and chemical reactions
- 1.2 Atomic structure and the Periodic Table
- 1.3 Water
- 1.4 The ever-changing Earth
- 1.5 Rate of chemical change
- 1.6 Limestone



## 1.1 THE NATURE OF SUBSTANCES AND CHEMICAL REACTIONS

### Overview

This topic brings together the fundamental ideas of Chemistry. It investigates the ideas of elements as pure substances; compounds as substances in which different atoms are chemically joined together and mixtures as substances in which particles are not chemically joined. It explores the ideas of separation of substances. The topic introduces ideas of measuring elements and compounds in terms of atomic and molecular masses, percentage composition and continues onto equations as a means of showing the rearrangement of atoms in reactions, including balancing equations. **For higher tier learners, there is an introduction to moles, the Avogadro constant and related mass calculations.** Conservation of mass is the key to understanding the information given by a chemical equation.

### Working Scientifically

In this topic, learners will use scientific vocabulary, terminology and definitions to describe elements, compounds and mixtures. In the investigation of separation methods, they can apply a knowledge of a range of techniques, instruments, apparatus, and materials. Writing chemical equations will enable them to correctly use formulae, symbols and correct nomenclature. In percentage composition, percentage yield and mass calculations, they will learn how to **use appropriate numbers of significant figures.**

### Mathematical Skills

Mathematical skills will be used in this topic to balance ionic formulae and chemical equations. Learners will calculate percentage compositions and relative atomic and molecular masses. They can use fractions in the calculations of  $R_f$  values. **Higher tier learners will be able to rearrange the subject of equations in mole calculations and combine these principles with the ideas of ratios in reacting mass calculations.**

**Learners should be able to demonstrate and apply their knowledge and understanding of:**

- elements as substances that cannot be broken down into simpler substances by chemical means and as the basic building blocks of all substances
- elements as substances made up of only one type of atom
- compounds as substances made of two or more different types of atom that are chemically joined and having completely different properties to its constituent elements
- how to represent elements using chemical symbols and simple molecules using chemical formulae
- how to represent simple molecules using a diagram and key
- how to write the formulae of ionic compounds given the formulae of the ions they contain

- (g) relative atomic mass and relative molecular (formula) mass
- (h) the percentage composition of compounds
- (i) atoms/molecules in mixtures not being chemically joined and mixtures being easily separated by physical processes such as filtration, evaporation, chromatography and distillation
- (j) chromatographic data analysis and  $R_f$  values
- (k) chemical reactions as a process of re-arrangement of the atoms present in the reactants to form one or more products, which have the same total number of each type of atom as the reactants
- (l) colour changes, temperature changes (exothermic/endothermic) and effervescence as evidence that a chemical reaction has taken place
- (m) how to represent chemical reactions using word equations
- (n) how to represent chemical reactions using balanced chemical equations where the total relative mass of reactants and products is equal
- (o) the percentage yield of a chemical reaction
- (p) **how to calculate the formula of a compound from reacting mass data**
- (q) **how to calculate the masses of reactants or products from a balanced chemical equation**
- (r) **the Avogadro constant and the mole and how to convert amount of substance in grams to moles and vice versa**

## 1.2 ATOMIC STRUCTURE AND THE PERIODIC TABLE

### Overview

This topic enables learners to understand the structure of the atom in detail and to link atomic and mass numbers to those of the sub-atomic particles. The arrangement of elements in the Periodic Table allows trends in properties of elements to be investigated. Reactions of Group 1 and Group 7 elements and simple qualitative tests are introduced. Learners should be able to write word and balanced symbol equations for all reactions described in this topic.

### Working Scientifically

There are opportunities here for learners to understand how scientific ideas have changed over time. They can identify patterns and trends and use these to make predictions. Writing chemical equations will enable them to correctly use formulae, symbols and correct nomenclature. They can plan and carry out practical work to identify substances in a problem solving context.

### Mathematical Skills

Simple order of magnitude calculations should be used in comparing the sizes of atoms with nuclei and with everyday objects. Learners use mathematical skills in this topic to balance ionic formulae and chemical equations. Trends in numerical data are explored and used to predict missing values.

### Learners should be able to demonstrate and apply their knowledge and understanding of:

- (a) atoms containing a positively charged nucleus with orbiting negatively charged electrons
- (b) atomic nuclei containing protons and neutrons
- (c) the relative masses and relative charges of protons, neutrons and electrons
- (d) atoms having no overall electrical charge
- (e) the terms atomic number, mass number and isotope
- (f) how the numbers of protons, neutrons and electrons present in an atom are related to its atomic number and mass number
- (g) **how to calculate the relative atomic mass of elements with more than one isotope**
- (h) elements being arranged in order of increasing atomic number and in groups and periods in the modern Periodic Table, with elements having similar properties appearing in the same groups
- (i) metals being found to the left and centre of the Periodic Table and non-metals to the right, with elements having intermediate properties appearing between the metals and non-metals in each period
- (j) the electronic structures of the first 20 elements

- (k) how the electronic structure of any element is related to its position in the Periodic Table
- (l) the similarities and trends in physical and chemical properties of elements in the same group as illustrated by Group 1 and Group 7
- (m) many reactions, including those of Group 1 elements and many of those of Group 7 elements, involve the loss or gain of electrons and the formation of charged ions
- (n) **the trends in reactivity of Group 1 and Group 7 elements in terms of their readiness to lose or gain an electron**
- (o) the reactions of the alkali metals with air/oxygen, the halogens and water
- (p) the test used to identify hydrogen gas
- (q) the reactions of halogens with alkali metals and with iron
- (r) **the relative reactivities of chlorine, bromine and iodine as demonstrated by displacement reactions**
- (s) the properties and uses of chlorine and iodine
- (t) the identification of  $\text{Li}^+$ ,  $\text{Na}^+$ ,  $\text{K}^+$ ,  $\text{Ca}^{2+}$  and  $\text{Ba}^{2+}$  ions by flame tests and  $\text{Cl}^-$ ,  $\text{Br}^-$  and  $\text{I}^-$  ions by their reactions with silver nitrate solution (including ionic equations)
- (u) the unreactive nature of the Group 0 gases and the uses of helium, neon and argon

### **SPECIFIED PRACTICAL WORK**

- Identification of unknown ionic compounds using flame tests and chemical tests for ions

## 1.3 WATER

### Overview

The first section of this topic deals with the composition and treatment of the water supply, including fluoridation. Different types of water hardness are investigated, with relevant knowledge of the ions involved. **Higher tier learners should be able to write word and balanced symbol equations relating to the removal of hardness.**

### Working Scientifically

Learners can consider the ethical issue of water fluoridation in this topic, using this to explain every day and technological applications of science; to evaluate associated personal, social, economic and environmental implications; and to make decisions based on the evaluation of evidence and arguments. They can plan experiments or devise procedures to make observations and test hypotheses.

### Mathematical Skills

Work on solubility curves gives learners the opportunity to plot variables and interpret data. They can analyse results of investigations into different types of water hardness and use these to determine hardness levels in unknown samples.

**Learners should be able to demonstrate and apply their knowledge and understanding of:**

- (a) the composition of water in 'natural' water supplies, including dissolved gases, ions, microorganisms and pollutants
- (b) the need for a sustainable water supply to include reducing our water consumption, reducing the environmental impacts of abstracting, distributing and treating water
- (c) the treatment of the public water supply using sedimentation, filtration and chlorination
- (d) the arguments for and against the fluoridation of the water supply in order to prevent tooth decay
- (e) desalination of sea water to supply drinking water including the sustainability of this process on a large scale
- (f) the separation of water and other miscible liquids by distillation
- (g) simple methods to determine solubility and produce solubility curves
- (h) the interpretation of solubility curves
- (i) the causes of hardness in water and how to distinguish between hard and soft waters by their action with soap
- (j) the difference between temporary and permanent hardness

- (k) the processes used to soften water to include boiling, adding sodium carbonate and ion exchange; the advantages and disadvantages of different methods of water softening **and the explanation of how these methods work**
- (l) the health benefits of hard water and its negative effects, e.g. on boiler elements

**SPECIFIED PRACTICAL WORK**

- Determination of the amount of hardness in water using soap solution

## 1.4 THE EVER-CHANGING EARTH

### Overview

This topic explores the structure of the Earth and the composition of the atmosphere, looking at changes in both over time. They gain an understanding of how a balance of processes maintains the composition of the atmosphere and the effects upon this of human activity.

### Working Scientifically

This topic contributes to an understanding of how scientific methods and theories develop over time. Learners will be able to develop scientific explanations and understanding of familiar and unfamiliar facts.

### Mathematical Skills

Standard form can be used to express the age of the Earth in years and the time over which continents have moved and the atmosphere has evolved. Plotting data on graphs and identifying trends can be incorporated.

### Learners should be able to demonstrate and apply their knowledge and understanding of:

- (a) the large scale structure of the Earth in terms of solid iron core, molten iron outer core, mantle and crust
- (b) the theory of plate tectonics and how it developed from Alfred Wegener's earlier theory of continental drift
- (c) the processes occurring at conservative, destructive and constructive plate boundaries where plates slide past one another, move towards one another and move apart respectively
- (d) the formation of the original atmosphere by gases, including carbon dioxide and water vapour, being expelled from volcanoes
- (e) the present composition of the atmosphere and how the composition of the atmosphere has changed over geological time
- (f) the roles of respiration, combustion and photosynthesis in the maintenance of the levels of oxygen and carbon dioxide in the atmosphere
- (g) the environmental effects and consequences of the emission of carbon dioxide and sulfur dioxide into the atmosphere through the combustion of fossil fuels
- (h) the measures used to address the problems of global warming and acid rain
- (i) the air as a source of nitrogen, oxygen, neon and argon
- (j) the tests used to identify oxygen gas and carbon dioxide gas

## 1.5 RATE OF CHEMICAL CHANGE

### Overview

An understanding of reaction rates is essential in Chemistry. This topic explores the effects of variables on rates and is a chance for a wide range of investigative practical work to be carried out.

### Working Scientifically

Learners will be able to use scientific theories and explanations to develop hypotheses, plan experiments or devise procedures to make observations and test hypotheses. They will apply a knowledge of a range of techniques, instruments, apparatus, and materials to select those appropriate to the experiment, carry out experiments appropriately having due regard to the correct manipulation of apparatus, the accuracy of measurements and health and safety considerations.

### Mathematical Skills

Skills used in this topic include finding arithmetic means and constructing and interpreting tables of data and line graphs. Learners should interpret the slope of a graph to compare rates. **Higher tier learners should be able to draw and use the slope of a tangent to a curve as a measure of rate of change.** Surface areas and volumes of variously-sized cubes should be investigated in explaining the effect of decreasing particle size on reaction rate.

**Learners should be able to demonstrate and apply their knowledge and understanding of:**

- practical methods used to determine the rate of reaction – gas collection, loss of mass and precipitation (including using data-logging apparatus)
- the effect of changes in temperature, concentration (pressure) and surface area on rate of reaction
- the particle theory in explaining changes of rate as a result of changes in temperature, concentration (pressure) and surface area
- catalysts as substances that increase the rate of a reaction while remaining chemically unchanged **and that they work by lowering the energy required for a collision to be successful (details of energy profiles are not required)**
- enzymes as biological catalysts which catalyse particular reactions under particular conditions
- the wide-ranging uses of enzymes

### SPECIFIED PRACTICAL WORK

- Investigation of the factors that affect the rate of a reaction using a gas collection method
- Investigation of the factors that affect the rate of the reaction between dilute hydrochloric acid and sodium thiosulfate



## 1.6 LIMESTONE

### Overview

This topic explores in detail the reactions and uses of limestone. Social and environmental aspects relating the quarrying of limestone provide opportunities for discussion and debate. Learners should be able to write word and balanced symbol equations for all reactions described in this topic.

### Working Scientifically

Learners can use their knowledge to explain every day and technological applications of science; to evaluate associated personal, social, economic and environmental implications; and to make decisions based on the evaluation of evidence and arguments. They can plan experiments or devise procedures to make observations and test hypotheses.

### Mathematical Skills

Mathematical skills will be used in this topic to balance ionic formulae and chemical equations; and to interpret experimental results.

### Learners should be able to demonstrate and apply their knowledge and understanding of:

- (a) the trend in stabilities of metal carbonates and their thermal decomposition to produce oxides and carbon dioxide
- (b) calcium carbonate, calcium oxide and calcium hydroxide as the chemical names for limestone, quicklime and slaked lime respectively
- (c) the cycle of reactions involving limestone and products made from it, including the exothermic reaction of quicklime with water and the reaction of limewater with carbon dioxide
- (d) the uses of limestone in the production of iron and steel, in road-building, to neutralise soil acidity and to make cement
- (e) the social, economic and environmental benefits and drawbacks of limestone quarrying

### SPECIFIED PRACTICAL WORK

- Investigation of thermal stabilities of calcium carbonate, copper(II) carbonate and sodium carbonate

## 2.2 Unit 2

### **CHEMICAL BONDING, APPLICATION OF CHEMICAL REACTIONS and ORGANIC CHEMISTRY**

**Written examination: 1 hour 45 minutes**  
**45% of qualification**

This unit includes the following topics:

- 2.1 Bonding, structure and properties
- 2.2 Acids, bases and salts
- 2.3 Metals and their extraction
- 2.4 Chemical reactions and energy
- 2.5 Crude oil, fuels and organic chemistry
- 2.6 Reversible reactions, industrial processes and important chemicals

#### **NOTE**

All content relating to formulae and equations and calculations based upon them (specified in Unit 1.1) is required for Unit 2.

All chemical tests specified in Unit 1 are required for Unit 2.

## 2.1 BONDING, STRUCTURE AND PROPERTIES

### Overview

This topic explores the changes to atoms and electron structure during bonding, both ionic and covalent and links this to the resulting structures of substances. A good understanding of bonding is fundamental to explaining why chemical reactions happen.

### Working Scientifically

Learners will use ideas, theories and models to explain abstract and complex concepts in this topic. They will be able to develop their skill in the clear explanation of ideas and use diagrams to illustrate their explanations. There are opportunities to explain every day and technological applications of science; to evaluate associated personal, social, economic and environmental implications; and to make decisions based on the evaluation of evidence and arguments.

### Mathematical Skills

Skills in converting units and using multiplying factors will be used in this topic to understand the sizes involved in nanotechnology. Learners will use prefixes and powers of ten for orders of magnitude (milli-, micro- and nano-). They should use simple order of magnitude calculations in comparing nano-scale particles with individual atoms and with everyday objects.

### Learners should be able to demonstrate and apply their knowledge and understanding of:

- (a) the properties of metals, ionic compounds, simple molecular covalent substances and giant covalent substances
- (b) the 'sea' of electrons/lattice of positive ions structural model for metals in explaining their physical properties
- (c) electronic structure in explaining how ionic bonding takes place (and how this is represented using dot and cross diagrams)
- (d) the accepted structural model for giant ionic structures in explaining the physical properties of ionic compounds
- (e) electronic structure in explaining how covalent bonds are formed (and how this is represented using dot and cross diagrams)
- (f) the intermolecular bonding structural model for simple molecular structures in explaining the physical properties of simple molecular substances
- (g) the properties of diamond, graphite, fullerenes, carbon nano-tubes and graphene and how these are explained in terms of structure and bonding
- (h) individual atoms not having the same properties as bulk materials as demonstrated by diamond, graphite, fullerenes, carbon nano-tubes and graphene having different properties despite all containing only carbon atoms, and by nano-scale silver particles exhibiting properties not seen in bulk silver

- (i) the properties and uses of nano-scale particles of silver and titanium dioxide
- (j) the possible risks associated with the use of nano-scale particles of silver and titanium dioxide, and of potential future developments in nanoscience**
- (k) the properties and uses of smart materials including thermochromic pigments, photochromic pigments, polymer gels, shape memory alloys and shape memory polymers

## 2.2 ACIDS, BASES AND SALTS

### Overview

In this topic, learners will investigate the reactions of acids in depth. Neutralisation theory and titration concepts are introduced, giving ample opportunity both for practical investigations and for learners to develop their understanding of reaction processes. Learners should be able to write word and balanced symbol equations **(including ionic equations where relevant)** for all reactions described in this topic.

### Working Scientifically

In this topic, learners will use scientific vocabulary, terminology and definitions to describe chemical methods and reactions. They can apply a knowledge of a range of techniques, instruments, apparatus, and materials. Writing chemical equations will enable them to correctly use formulae, symbols and correct nomenclature.

### Mathematical Skills

Mathematical skills will be used in this topic to balance ionic formulae and chemical equations and **higher tier learners will carry out calculations involving solution volumes and concentrations.**

**Learners should be able to demonstrate and apply their knowledge and understanding of:**

- (a) substances as acidic, alkaline or neutral in terms of the pH scale, including acid/alkali strength
- (b) solutions of acids containing hydrogen ions and alkalis containing hydroxide ions
- (c) the reactions of dilute acids with metals and how these relate to the metals' position in the reactivity series
- (d) the neutralisation of dilute acids with bases (including alkalis) and carbonates
- (e) **neutralisation as the reaction of hydrogen ions with hydroxide ions to form water**  
$$\text{H}^+(\text{aq}) + \text{OH}^-(\text{aq}) \rightarrow \text{H}_2\text{O}(\text{l})$$
- (f) the acid/carbonate reaction as a test for acidic substances and  $\text{CO}_3^{2-}$  ions
- (g) the preparation of crystals of soluble salts, such as copper(II) sulfate, from insoluble bases and carbonates
- (h) the names of the salts formed by hydrochloric acid, nitric acid and sulfuric acid
- (i) the test used to identify  $\text{SO}_4^{2-}$  ions
- (j) titration as a method to prepare solutions of soluble salts and to determine relative **and actual** concentrations of solutions of acids/alkalis

- (k) **the concentration of a solution in mol dm<sup>-3</sup>**
- (l) **calculations involving neutralisation reactions in solution, using a balanced chemical equation**
- (m) the distinction between the description of acids as dilute or concentrated (amount of substance) and strong or weak (degree of ionisation)
- (n) the similarities and differences in the reactions of strong and weak acids e.g. hydrochloric acid and ethanoic acid
- (o) the preparation of insoluble salts by precipitation reactions

#### **SPECIFIED PRACTICAL WORK**

- Preparation of crystals of a soluble salt from an insoluble base or carbonate
- Titration of a strong acid against a strong base using an indicator

## 2.3 METALS AND THEIR EXTRACTION

### Overview

This topic considers the processes involved in extracting metals, based upon initial work with reactivity series and related reactions. It includes an introduction to electrolysis and its uses in the extraction of aluminium and other applications. Learners should be able to write word and balanced symbol equations **(including ionic equations where relevant)** for all reactions described in this topic.

### Working Scientifically

In this topic, learners will use scientific vocabulary, terminology and definitions to describe extraction processes. They can explain every day and technological applications of science; evaluate associated personal, social, economic and environmental implications; and make decisions based on the evaluation of evidence and arguments.

### Mathematical Skills

Mathematical skills will be used in this topic to balance ionic formulae and chemical equations. **Higher tier learners will be able to link these ideas to calculation work and ratios in reacting masses.**

**Learners should be able to demonstrate and apply their knowledge and understanding of:**

- (a) ores found in the Earth's crust as the source of most metals and that these metals can be extracted using chemical reactions
- (b) some unreactive metals (e.g. gold) being found in their native form and that the difficulty involved in extracting metals increases as their reactivity increases
- (c) the relative reactivities of metals as demonstrated by displacement (e.g. iron nail in copper(II) chloride solution) and competition reactions (e.g. thermit reaction)
- (d) reduction and oxidation in terms of removal or gain of oxygen
- (e) the industrial extraction of iron in the blast furnace, including the combustion, reduction, decomposition and neutralisation reactions
- (f) electrolysis of molten ionic compounds e.g. lead(II) bromide (including electrode equations)
- (g) reduction and oxidation in terms of gain or loss of electrons
- (h) the industrial extraction of aluminium using electrolysis, including the use of cryolite to dissolve alumina
- (i) the properties and uses of iron (steel), aluminium, copper and titanium
- (j) the general properties of transition metals, including their ability to form ions with different charges

- (k) **the identification of  $\text{Cu}^{2+}$ ,  $\text{Fe}^{2+}$  and  $\text{Fe}^{3+}$  ions by their precipitation reactions with aqueous  $\text{OH}^-$**
- (l) an alloy being a mixture made by mixing molten metals, whose properties can be modified by changing its composition
- (m) the electrolysis of water (including electrode equations)
- (n) electrolysis of aqueous solutions such as copper(II) chloride (including electrode equations)
- (o) **electrolysis of aqueous solutions involving competing ions such as sodium chloride (including electrode equations)**
- (p) the use of electrolysis in electroplating, **purification of copper and the manufacture of sodium hydroxide (and hydrogen gas and chlorine gas)**
- (q) factors affecting economic viability and sustainability of extraction processes e.g. siting of plants, fuel and energy costs, greenhouse emissions and recycling

#### **SPECIFIED PRACTICAL WORK**

- Determination of relative reactivities of metals through displacement reactions
- Investigation into electrolysis of aqueous solutions and electroplating



## 2.4 CHEMICAL REACTIONS AND ENERGY

### Overview

This topic looks at the energy changes that happen during chemical reactions. It explains why reactions are exothermic or endothermic in terms of the energy associated with chemical bonds.

### Working Scientifically

Learners will use ideas, theories and models to explain abstract and complex concepts in this topic.

### Mathematical Skills

Learners will reinforce their understanding of chemical equations in determining the number of bonds of each type present in reactants and products. They will use arithmetical skills to calculate the energy changes associated with reactions.

**Learners should be able to demonstrate and apply their knowledge and understanding of:**

- (a) exothermic and endothermic reactions in terms of temperature change and energy transfer to or from the surroundings
- (b) energy profiles for exothermic and endothermic reactions
- (c) the activation energy as the energy needed for a reaction to occur
- (d) the use of bond energy data to calculate overall energy change for a reaction and to identify whether it is exothermic or endothermic

## 2.5 CRUDE OIL, FUELS AND ORGANIC CHEMISTRY

### Overview

This topic provides an introduction to the skills and knowledge, including the representation and naming of organic structures, needed in organic chemistry. The formation and fractional distillation of crude oil, cracking and polymerisation are explored and the products of each process explained. **Higher tier learners will be introduced to the concept of isomerism.** Learners should be able to write word and balanced symbol equations for combustion, cracking, addition and fermentation reactions and symbol equations representing polymerisation.

### Working Scientifically

There are opportunities here for learners to use theories, models and ideas to develop scientific explanations; to communicate information and ideas in appropriate ways using appropriate terminology

### Mathematical Skills

Mathematical skills will be used in this topic to balance organic formulae and chemical equations. Ideas of general formulae and the relationships involved can be investigated.

**Learners should be able to demonstrate and apply their knowledge and understanding of:**

- (a) crude oil as a complex mixture of hydrocarbons that was formed over millions of years from the remains of simple marine organisms
- (b) the fractional distillation of crude oil
- (c) fractions as containing mixtures of hydrocarbons (alkanes) with similar boiling points
- (d) the trends in properties of fractions with increasing chain length and the effect on their usefulness as fuels
- (e) the global economic and political importance and social and environmental impact of the oil industry
- (f) the combustion reactions of hydrocarbons and other fuels
- (g) how to determine experimentally the energy per gram released by a burning fuel
- (h) the combustion reaction of hydrogen and its use as an energy source including its advantages and disadvantages as a fuel
- (i) the fire triangle in fire-fighting and fire prevention
- (j) the cracking of some fractions to produce smaller and more useful hydrocarbon molecules, including monomers (alkenes) which can be used to make plastics

- (k) the general formula  $C_nH_{2n+2}$  for alkanes and  $C_nH_{2n}$  for alkenes
- (l) the names and molecular and structural formulae for simple alkanes and alkenes
- (m) **isomerism in more complex alkanes and alkenes**
- (n) **the names of more complex alkanes and alkenes**
- (o) the addition reactions of alkenes with hydrogen and bromine and the use of bromine water in testing for alkenes
- (p) the addition polymerisation of ethene and other monomers to produce polythene, poly(propene), poly(vinylchloride) and poly(tetrafluoroethene)
- (q) the general properties of plastics and the uses of polythene, poly(propene), poly(vinylchloride) and poly(tetrafluoroethene)
- (r) the environmental issues relating to the disposal of plastics, in terms of their non-biodegradability, increasing pressure on landfill for waste disposal, and how recycling addresses these issues as well as the need to carefully manage the use of finite natural resources such as crude oil
- (s) how ethanol (an alcohol) is made from sugars by fermentation using yeast
- (t) the use of potassium dichromate(VI) in testing for alcohols
- (u) the use of ethanol in alcoholic drinks and the social and economic impact of these drinks
- (v) the uses of ethanol as a solvent and as a fuel and the social, economic and environmental factors that affect the development of bioethanol fuel
- (w) the names and molecular and structural formulae for alcohols, **including positional isomers**
- (x) the microbial oxidation of ethanol to ethanoic acid (a carboxylic acid)
- (y) **the use of infrared spectroscopy to identify the presence of certain bonds in organic molecules thereby indicating whether they may be alkanes, alkenes, alcohols or carboxylic acids**

#### **SPECIFIED PRACTICAL WORK**

- Determination of the amount of energy released by a fuel

## 2.6 REVERSIBLE REACTIONS, INDUSTRIAL PROCESSES AND IMPORTANT CHEMICALS

### Overview

This topic enables learners to understand the principle of reversible reactions with a basic introduction to equilibria. **Higher tier learners can analyse data relating to factors affecting yields of reversible reactions and understand resulting commercial decisions.** Uses of fertilisers and the associated advantages and disadvantages are explored. Learners should be able to write word and balanced symbol equations for the Haber process, the contact process and for the production of nitrogenous fertilisers.

### Working Scientifically

Learners can use their knowledge to explain every day and technological applications of science; evaluate associated personal, social, economic and environmental implications; and make decisions based on the evaluation of evidence and arguments. They will interpret data presented in graphical or numerical form, identify patterns and trends, make inferences and draw conclusions.

### Mathematical Skills

Trends in numerical data are explored and used to make conclusions. Learners will link balanced symbol equations for important reactions to the full range of calculations covered in the specification.

**Learners should be able to demonstrate and apply their knowledge and understanding of:**

- (a) what is meant by a reversible reaction
- (b) the production of ammonia by the reversible reaction of nitrogen and ammonia in the Haber process
- (c) **the factors involved in choosing conditions to ensure the most economical production of ammonia (Le Chatelier's principle not required)**
- (d) the test used to identify ammonia gas
- (e) the production of sulfuric acid by the contact process; a three-stage process including the reversible formation of sulfur trioxide
- (f) the broad range of uses of sulfuric acid, including in the production of fertilisers, paints, dyes, fibres, plastics and detergents
- (g) concentrated sulfuric acid as a dehydrating agent in its reaction with sugar and hydrated copper(II) sulfate
- (h) the production of nitrogenous fertilisers such as ammonium sulfate and ammonium nitrate by neutralisation of ammonia solution
- (i) the identification of  $\text{NH}_4^+$  ions by addition of aqueous  $\text{OH}^-$
- (j) the benefits of nitrogenous fertilisers for crop growth and the problems that arise when they are washed into waterways

## 2.3 Unit 3

### **PRACTICAL ASSESSMENT**

#### **10% of qualification**

This assessment gives learners the opportunity to demonstrate their ability to work scientifically. This will include experimental skills and strategies and skills in analysis and evaluation.

The practical assessment is untiered and will take place in the first half of the spring term (January – February). It is recommended that this should be in the final year of study. Each year, WJEC will provide two tasks based on the content of GCSE Chemistry. Learners are only required to submit **one** task so centres can select which one they wish to use with their learners.

The tasks will be externally marked by WJEC and will change on an annual basis.

The details required for the planning and administration of the practical assessment will be provided to centres at appropriate times prior to the assessment.

Each task comprises two sections:

#### **Section A - Obtaining results (6 marks)**

Learners will be permitted to work in groups of no more than three, to obtain results from a given experimental method. This will be carried out under a limited level of control i.e. learners may work with others to obtain results but they must provide their own responses to the questions set. Teacher assistance should not normally be required, but may be given if equipment failure occurs. Section A will be completed in one session of 60 minutes duration.

#### **Section B - Analysing and evaluating results (24 marks)**

Learners will be assessed on their ability to analyse and evaluate the data obtained in section A. They will require access to their section A assessment in order to complete this. Section B will be carried out under a high level of control i.e. learners must work individually. This section is to be completed with no teacher feedback or assistance allowed and under formal supervision. Section B will be completed in one session of 60 minutes duration.

## 3 ASSESSMENT

### 3.1 Assessment objectives and weightings

Below are the assessment objectives for this specification. Learners must:

#### AO1

Demonstrate knowledge and understanding of scientific ideas, processes, techniques and procedures

#### AO2

Apply knowledge and understanding of scientific ideas, processes, techniques and procedures

#### AO3

Analyse, interpret and evaluate scientific information, ideas and evidence, including in relation to issues, to:

- make judgements and reach conclusions
- develop and refine practical design and procedures

The table below shows the weighting of each assessment objective for each unit and the qualification as a whole.

|                          | <b>AO1</b> | <b>AO2</b> | <b>AO3</b> |
|--------------------------|------------|------------|------------|
| <b>Unit 1</b>            | 18%        | 18%        | 9%         |
| <b>Unit 2</b>            | 18%        | 18%        | 9%         |
| <b>Unit 3</b>            | 4%         | 4%         | 2%         |
| <b>Overall weighting</b> | <b>40%</b> | <b>40%</b> | <b>20%</b> |

For each series:

- the weighting for the assessment of mathematical skills will be a minimum of 20%
- the weighting for the assessment of practical skills will be a minimum of 15%.

The ability to select, organise and communicate information and ideas coherently using scientific convention and vocabulary will be tested across the assessment objectives.

For each series, writing accurately will be assessed in specified questions that require extended writing (i.e. QER questions) in Units 1 and 2.

Writing accurately takes into account the candidate's use of specialist language. It also takes into account the candidate's spelling, punctuation and grammar.

## 4 TECHNICAL INFORMATION

### 4.1 Making entries

This is a unitised qualification which allows for an element of staged assessment.

Assessment opportunities will be available in the summer assessment period each year, until the end of the life of the specification.

Unit 1 will be available in 2017 (and each year thereafter). Unit 2 and Unit 3 will be available in 2018 (and each year thereafter) and the qualification will be awarded for the first time in Summer 2018.

There are two tiers of entry available for this qualification: Higher Tier (Grades A\* - D) and Foundation Tier (Grades C - G). Unit 3 (practical assessment) is untiered. In most cases, we would expect candidates to be assessed within the same tier. Exceptionally, it may be appropriate to enter some candidates for a combination of higher and foundation tier units.

At least 40% of the assessment must be taken at the end of the course to satisfy the requirement for terminal assessment and the results from the terminal assessment must contribute to the subject award.

Candidates may re-sit units ONCE ONLY prior to certification for the qualification, with the better result contributing to the qualification. Individual unit results, prior to the certification of the qualification, have a shelf-life limited only by that of the qualification.

A candidate may retake the whole qualification more than once.

The entry codes appear below.

|                            | Title   | Entry codes    |              |
|----------------------------|---|----------------|--------------|
|                            |   | English-medium | Welsh-medium |
| Unit 1                     | Chemical Substances, Reactions and Essential Resources (Foundation Tier)                    | 3410U1         | 3410N1       |
|                            | Chemical Substances, Reactions and Essential Resources (Higher Tier)                        | 3410UA         | 3410NA       |
| Unit 2                     | Chemical Bonding, Application of Chemical Reactions and Organic Chemistry (Foundation Tier) | 3410U2         | 3410N2       |
|                            | Chemical Bonding, Application of Chemical Reactions and Organic Chemistry (Higher Tier)     | 3410UB         | 3410NB       |
| Unit 3                     | Practical Assessment  | 3410U3         | 3410N3       |
| GCSE Qualification cash-in |   | 3410QS         | 3410CS       |

The current edition of our *Entry Procedures and Coding Information* gives up-to-date entry procedures.

## 4.2 Grading, awarding and reporting

There are two tiers of entry available for this qualification: Higher Tier (Grades A\* - D) and Foundation Tier (Grades C - G). In most cases, we would expect candidates to be assessed within the same tier. Exceptionally, it may be appropriate to enter some candidates for a combination of higher and foundation tier units.

The Uniform Mark Scale (UMS) is used in unitised specifications as a device for reporting, recording and aggregating candidates' unit assessment outcomes. The UMS is used so that candidates who achieve the same standard will have the same uniform mark, irrespective of when the unit was taken.

Individual unit results reported on UMS have the following grade equivalences:

| Grade              | MAX. | A*  | A   | B   | C   | D  | E  | F  | G  |
|--------------------|------|-----|-----|-----|-----|----|----|----|----|
| <b>Units 1 - 2</b> | 180  | 162 | 144 | 126 | 108 | 90 | 72 | 54 | 36 |
| <b>Unit 3</b>      | 40   | 36  | 32  | 28  | 24  | 20 | 16 | 12 | 8  |

For Units 1 - 2, which are tiered, the maximum uniform mark available on the foundation tier of the assessment will be 125 (i.e. 1 mark less than the minimum mark needed to achieve a grade B on the unit). As Unit 3 is untiered, the full range of uniform marks is available in the unit.

GCSE qualifications are reported on an eight point scale from A\* - G, where A\* is the highest grade. Results not attaining the minimum standard for the award will be reported as U (unclassified) and learners will not receive a certificate.

The uniform marks obtained for each unit are added up and the subject grade is based on this total. The total results reported on UMS will have the following grade equivalences:

| UMS total            | A*  | A   | B   | C   | D   | E   | F   | G  |
|----------------------|-----|-----|-----|-----|-----|-----|-----|----|
| <b>Subject Award</b> | 360 | 320 | 280 | 240 | 200 | 160 | 120 | 80 |



# APPENDIX A

## Working Scientifically

### 1. Development of scientific thinking

- understand how scientific methods and theories develop over time
- use a variety of models such as representational, spatial, descriptive, computational and mathematical to solve problems, make predictions and to develop scientific explanations and understanding of familiar and unfamiliar facts
- appreciate the power and limitations of science and consider any ethical issues which may arise
- explain every day and technological applications of science; evaluate associated personal, social, economic and environmental implications; and make decisions based on the evaluation of evidence and arguments
- evaluate risks both in practical science and the wider societal context, including perception of risk in relation to data and consequences
- recognise the importance of peer review of results and of communicating results to a range of audiences

### 2. Experimental skills and strategies

- use scientific theories and explanations to develop hypotheses
- plan experiments or devise procedures to make observations, produce or characterise a substance, test hypotheses, check data or explore phenomena
- apply a knowledge of a range of techniques, instruments, apparatus, and materials to select those appropriate to the experiment
- carry out experiments appropriately having due regard to the correct manipulation of apparatus, the accuracy of measurements and health and safety considerations
- make and record observations and measurements using a range of apparatus and methods
- evaluate methods and suggest possible improvements and further investigations

### 3. Analysis and evaluation

- apply the cycle of collecting, presenting and analysing data, including:
  - presenting observations and other data using appropriate methods
  - translating data from one form to another
  - carrying out and representing mathematical analysis
  - representing distributions of results and make estimations of uncertainty
  - interpreting observations and other data (presented in verbal, diagrammatic, graphical, symbolic or numerical form), including identifying patterns and trends, making inferences and drawing conclusions
  - presenting reasoned explanations including relating data to hypotheses
  - being objective, evaluating data in terms of accuracy, precision, repeatability and reproducibility and identifying potential sources of random and systematic error
  - communicating the scientific rationale for investigations, methods used, findings and reasoned conclusions through paper-based and electronic reports and presentations using verbal, diagrammatic, graphical, numerical and symbolic forms

### 4. Scientific vocabulary, quantities, units, symbols and nomenclature

- use scientific vocabulary, terminology and definitions
- recognise the importance of scientific quantities and understand how they are determined
- use SI units (e.g. kg, g, mg; km, m, mm; kJ, J) and IUPAC chemical nomenclature unless inappropriate
- use prefixes and powers of ten for orders of magnitude (e.g. tera, giga, mega, kilo, centi, milli, micro and nano)
- interconvert units
- **use an appropriate number of significant figures in calculation**

# APPENDIX B

## Mathematical Skills

This table shows the mathematical skills which can be assessed. Skills which will be assessed at higher tier only are shown in bold type.

|          | Skill   |
|----------|---|
| <b>1</b> | <i>Arithmetic and numerical computation</i>   |
|          | Recognise and use expressions in decimal form   |
|          | Recognise expressions in standard form  |
|          | Use ratios, fractions and percentages   |
| <b>2</b> | <i>Handling data</i>  |
|          | <b>Use an appropriate number of significant figures</b>   |
|          | Find arithmetic means   |
|          | Construct and interpret tables and diagrams   |
|          | Make order of magnitude calculations  |
| <b>3</b> | <i>Algebra</i>  |
|          | <b>Change the subject of an equation</b>  |
|          | Substitute numerical values into algebraic equations and solve them using appropriate units for physical quantities |
| <b>4</b> | <i>Graphs</i>   |
|          | Translate information between graphical and numeric form  |
|          | Plot two variables from experimental or other data  |
|          | Interpret the slope of a linear graph   |
|          | <b>Draw and use the slope of a tangent to a curve as a measure of rate of change</b>                                |
| <b>5</b> | <i>Geometry and trigonometry</i>  |
|          | Calculate areas of triangles and rectangles, surface areas and volumes of cubes                                     |