



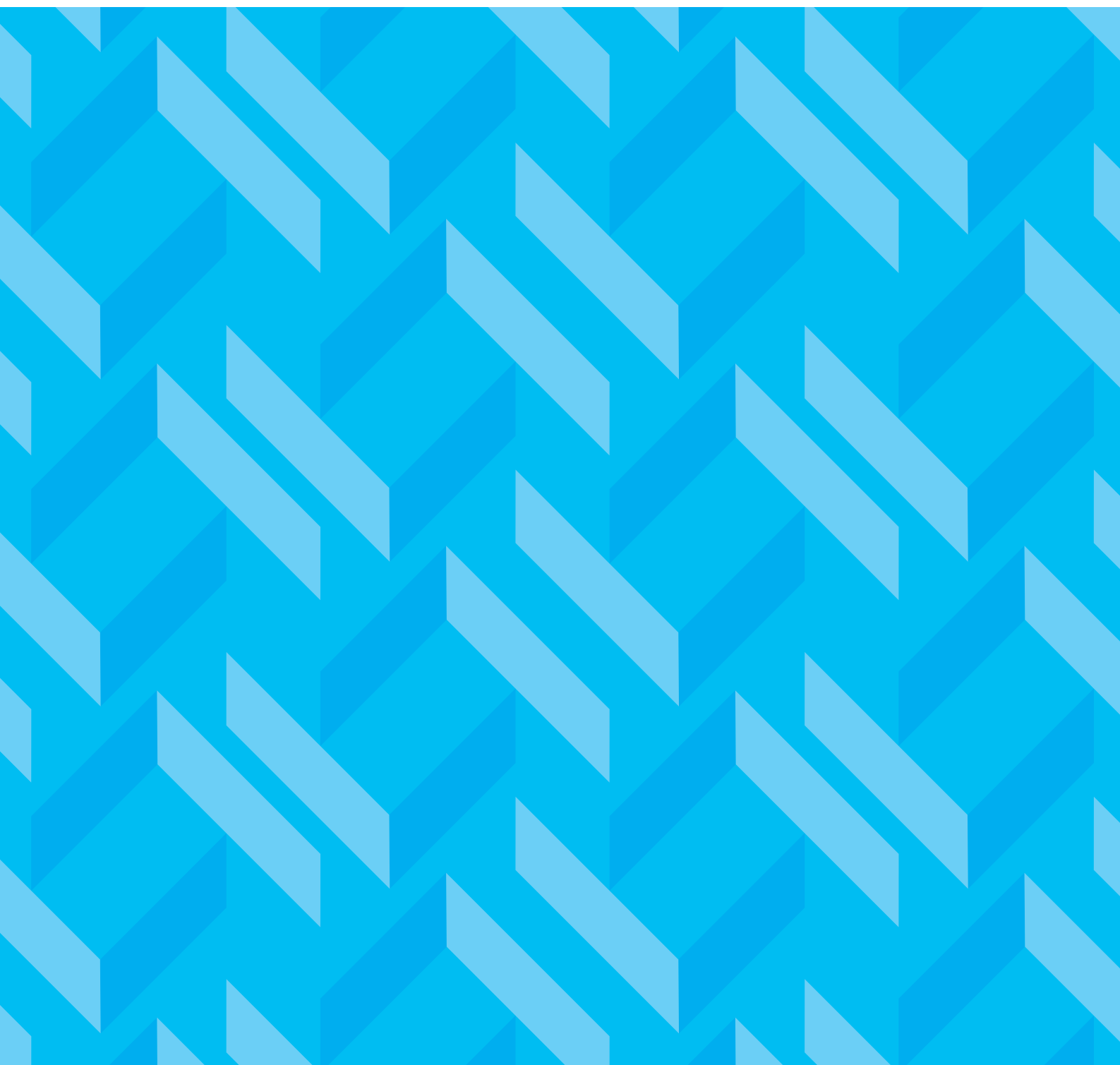
**GCE**

**Examinations from 2009**

First AS Award: Summer 2009

First A Level Award: Summer 2010

Chemistry



# Contents

## WJEC AS GCE in Chemistry WJEC A Level GCE in Chemistry

### 2009 & 2010

First AS Award - Summer 2009  
First A level Award - Summer 2010



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## GCE Chemistry

Subject/Option Entry Codes		English medium	Welsh medium
<i>AS "Cash in" entry</i>	2091	01	W1
<i>A Level "Cash in" entry</i>	3091	01	W1
CH1: Controlling and measuring chemical change	1091	01	W1
CH2: Properties, structure and bonding	1092	01	W1
CH3: AS Practical Chemistry			
CH3a WJEC set	1093	01	W1
CH3b Centre set	1093	02	W2
CH4: Analysing and building molecules	1094	01	W1
CH5: A level physical and inorganic chemistry	1095	01	W1
CH6: A2 Practical Chemistry			
CH6a WJEC set	1096	01	W1
CH6b Centre set	1096	02	W2

Availability of Assessment Units				
Unit	January 2009	June 2009	January 2010 & each subsequent year	June 2010 & each subsequent year
CH1	✓	✓	✓	✓
CH2		✓	✓	✓
CH3		✓		✓
CH4			✓	✓
CH5				✓
CH6				✓

### Qualification Accreditation Numbers

**Advanced Subsidiary: 500/2795/5**

**Advanced: 500/2502/8**

## SUMMARY OF ASSESSMENT

This specification is divided into a total of 6 units, 3 AS units and 3 A2 units. Weightings noted below are expressed in terms of the full A Level qualification. Marks are given as raw marks and uniform marks.

### AS (3 units)

<b>CH1</b>	20 %	1hr 30 min	Written Paper	80 marks (120 UM)
<b>Controlling and Using Chemical Changes</b>				
- Sections A (objective questions) and B, (structured questions) no choice.				
<b>CH2</b>	20 %	1hr 30 min	Written Paper	80 marks (120 UM)
<b>Properties, Structure and Bonding</b>				
- Sections A (objective questions) and B, (structured questions) no choice				
<b>CH3</b>	10 %	Internal assessment		60 marks (60 UM)
<b>AS Chemistry Practical Unit</b>				
Two exercises devised by centres and approved or selected from a list of exemplars, carried out at centres in a time of their choice and marked by the centre or by WJEC.				

### A LEVEL (the above plus a further 3 units)

<b>CH4</b>	20 %	1 hour 45 min	Written Paper	80 marks (120 UM)
<b>Spectroscopy and Organic Chemistry</b>				
- Sections A (3 structured questions, one based on a short passage) and B (2 extended-answer questions), no choice. Synoptic assessment included.				
<b>CH5</b>	20 %	1 hour 45 min	Written Paper	80 marks (120 UM)
<b>Physical and Inorganic Chemistry</b>				
- Sections A (3 structured questions, one based on a short passage) and B (2 extended-answer questions), no choice. Synoptic assessment included.				
<b>CH6</b>	10 %	Internal assessment		60 marks (60 UM)
<b>A2 Chemistry Practical Unit</b>				
Two exercises devised by centres and approved or selected from a list of exemplars, carried out at centres in a time of their choice and marked by the centre or by WJEC.				



# CHEMISTRY

## ***1*** INTRODUCTION

### **1.1 Criteria for AS and A Level GCE**

This specification has been designed to meet the general criteria for GCE AS and A level (A) and the subject criteria for AS/A Chemistry as issued by the regulators [July 2006]. The qualifications will comply with the grading, awarding and certification requirements of the Code of Practice for 'general' qualifications (including GCE).

The AS qualification will be reported on a five-grade scale of A, B, C, D, E. The A level qualification will be reported on a six-grade scale of A\*, A, B, C, D, E. The award of A\* at A level will provide recognition of the additional demands presented by the A2 units in term of 'stretch and challenge' and 'synoptic' requirements. Candidates who fail to reach the minimum standard for grade E are recorded as U (unclassified), and do not receive a certificate. The level of demand of the AS examination is that expected of candidates half way through a full A level course.

The AS assessment units will have equal weighting with the second half of the qualification (A2) when these are aggregated to produce the A level award. AS consists of three assessment units, referred to in this specification as CH1, CH2 and CH3. A2 also consists of three units and these are referred to as CH4, CH5 and CH6.

Assessment units may be retaken prior to certification for the AS or A level qualifications, in which case the better result will be used for the qualification award. Individual assessment unit results, prior to certification for a qualification, have a shelf-life limited only by the shelf-life of the specification.

The specification and assessment materials are available in English and Welsh.

### **1.2 Prior learning**

The specification is equally accessible to all irrespective of age, gender and ethnic, religious or cultural background. The specification is not age-specific and provides opportunities for life-long learning.

The specification builds on the knowledge, understanding and skills set out in the national curriculum Key Stage 4 programme of study for Science and Additional Science and related courses.

Mathematical requirements are specified in the subject criteria and repeated in Appendix 1 of this specification.

### 1.3 Progression

The six part structure of this specification (3 units for AS, and an additional 3 for the full A level) allows for both staged and end-of-course assessment and thus allows candidates to defer decisions about progression from AS to the full A level qualification.

This specification provides a suitable foundation for the study of Chemistry or a related area through a range of higher education courses (e.g. Chemistry, Medicine, Biochemistry, Molecular Biology, Chemical Engineering, etc., etc.) or direct entry into employment. In addition, the specification provides a coherent, satisfying and worthwhile course of study for candidates who do not progress to further study in this subject.

### 1.4 Rationale

The **AS specification** has been designed to serve both as the first half of a full A level course and also as a discrete course for those wishing to follow just one year of study.

The specification as a whole encourages candidates to understand that chemistry is concerned with the exploitation of the Earth's resources in the production of energy and new materials by the control and use of chemical reactions. Understanding the behaviour of materials allows chemists to design new materials for specific uses. In these respects, chemistry plays a vital role in providing an enhanced quality of life.

Inevitably, the application of many new developments in chemistry will give rise to consideration of ethical, social, cultural and environmental issues.

There is a growing awareness within the subject of the need to build sustainability into the development of chemical processes. This need is exemplified through the development of ideas concerning Green Chemistry.

Chemistry, in common with other sciences, uses the skills and techniques of data collection and analysis (and develops these through practical work) which result in the fact that scientific knowledge is some of the least tenuous that we have. Nevertheless, scientific models and theories change over time as new evidence becomes available.

The use of computer technology such as CD-Roms, the Internet, computer simulations and experimental monitoring, using, e.g., data-loggers, is encouraged.

### 1.5 The Wider Curriculum

Chemistry is a subject that by its nature requires candidates to consider individual, ethical, social, cultural and contemporary issues. The specification provides a framework for exploration of, and includes specific content through which educators may address, these issues; for example, development of new methods of synthesis with greater atom economy leading to less waste, lower energy input, use of sustainable resources, etc., the use of radioactive isotopes in medicine, the production of energy, nuclear power and the environmental consequences of the use of fossil fuels.

## 1.6 Prohibited combinations and overlap

Every specification is assigned a national classification code indicating the subject area to which it belongs. Centres should be aware that candidates who enter for more than one GCE qualification with the same classification code will only have one grade (the highest) counted for the purpose of the School and College Performance Tables. The classification code for this specification is 1110.

This specification does not overlap significantly with any other, although there will be elements of overlap, for example, with Applied Science, Biology and Physics. There are no prohibited combinations.

## 1.7 Equality and Fair Assessment

AS/A levels often require assessment of a broad range of competences. This is because they are general qualifications and, as such, prepare candidates for a wide range of occupations and higher level courses.

The revised AS/A level qualification and subject criteria were reviewed to identify whether any of the competences required by the subject presented a potential barrier to any disabled candidates. If this was the case, the situation was reviewed again to ensure that such competences were included only where essential to the subject. The findings of this process were discussed with disability groups and with disabled people.

In *GCE Chemistry* practical assistants may be used for manipulating equipment and making observations. Technology may help visually impaired students to take readings and make observations.

Reasonable adjustments are made for disabled candidates in order to enable them to access the assessments. For this reason, very few candidates will have a complete barrier to any part of the assessment. Information on reasonable adjustments is found in the Joint Council for Qualifications document *Regulations and Guidance Relating to Candidates who are eligible for Adjustments in Examinations*. This document is available on the JCQ website ([www.jcq.org.uk](http://www.jcq.org.uk)).

Candidates who are still unable to access a significant part of the assessment, even after exploring all possibilities through reasonable adjustments, may still be able to receive an award. They would be given a grade on the parts of the assessment they have taken and there would be an indication on their certificate that not all of the competences have been addressed. This will be kept under review and may be amended in future.

AS and A level specifications in Chemistry aim to encourage students to:

- (a) develop their interest in, and enthusiasm for the subject, including developing an interest in further study and careers in the subject.
- (b) appreciate how society makes decisions about scientific issues and how Chemistry contributes to the success of the economy and society.
- (c) develop and demonstrate a deeper appreciation of the skills, knowledge and understanding of *How Science Works*.
- (d) develop essential knowledge and understanding of different areas of the subject and how they relate to each other.

#### How Science Works

A further aim of the AS and A specifications in Chemistry is to encourage students to understand *How Science Works*. The skills, knowledge and understanding of *How Science Works* include the requirement that candidates should:

- use theories, models and ideas to develop and modify scientific explanations.
- use knowledge and understanding to pose scientific questions, define scientific problems, present scientific arguments and scientific ideas.
- use appropriate methodology, including ICT, to answer scientific questions and solve scientific problems.
- carry out experimental and investigative activities, including appropriate risk management, in a range of contexts.
- analyse and interpret data to provide evidence, recognising correlations and causal relationships.
- evaluate methodology, evidence and data, and resolve conflicting evidence.
- appreciate the tentative nature of scientific knowledge.
- communicate information and ideas in appropriate ways using appropriate terminology.
- consider applications and implications of science and appreciate their associated benefits and risks.
- consider ethical issues in the treatment of humans, other organisms and the environment.
- appreciate the role of the scientific community in validating new knowledge and ensuring integrity.
- appreciate the ways in which society uses science to inform decision-making.

## 3

**ASSESSMENT OBJECTIVES**

Candidates must meet the following assessment objectives in the context of the content detailed in Section 4 of the specification:

**AO1: Knowledge and understanding of science and of How Science Works**

Candidates should be able to:

- (a) recognise, recall and show understanding of scientific knowledge.
- (b) select, organise and communicate relevant information in a variety of forms.

**AO2: Application of knowledge and understanding of science and of How Science Works**

Candidates should be able to:

- (a) analyse and evaluate scientific knowledge and processes.
- (b) apply scientific knowledge and processes to unfamiliar situations including those related to issues.
- (c) assess the validity, reliability and credibility of scientific information.

**AO3: How Science Works**

Candidates should be able to:

- (a) demonstrate and describe ethical, safe and skilful practical techniques and processes, selecting appropriate qualitative and quantitative methods.
- (b) make, record and communicate reliable and valid observations and measurements with appropriate precision and accuracy.
- (c) analyse, interpret, explain and evaluate the methodology, results and impact of their own and others' experimental and investigative activities in a variety of ways.

**Weightings**

Assessment objective weightings are shown below as % of the full A level.

Unit	Unit weighting	AO1	AO2	AO3
CH1	20	8.75	8.75	2.5
CH2	20	8.75	8.75	2.5
CH3	10	1	1	8
CH4	20	6.25	11.25	2.5
CH5	20	6.25	11.25	2.5
CH6	10	1	1	8
<b>Total</b>	<b>100</b>	<b>32</b>	<b>42</b>	<b>26</b>

**Assessment objective weightings shown as a raw mark breakdown.**

<b>Unit</b>	<b>raw mark</b>	<b>AO1</b>	<b>AO2</b>	<b>AO3</b>
<b>CH1</b>	<b>80</b>	<b>30 - 35</b>	<b>30 - 35</b>	<b>6 - 12</b>
<b>CH2</b>	<b>80</b>	<b>30 - 35</b>	<b>30 - 35</b>	<b>6 - 12</b>
<b>CH3</b>	<b>60</b>	<b>6 - 12</b>	<b>6 - 12</b>	<b>42 - 48</b>
<b>CH4</b>	<b>80</b>	<b>20 - 25</b>	<b>40 - 45</b>	<b>6 - 12</b>
<b>CH5</b>	<b>80</b>	<b>20 - 25</b>	<b>40 - 45</b>	<b>6 - 12</b>
<b>CH6</b>	<b>60</b>	<b>6 - 12</b>	<b>6 - 12</b>	<b>42 - 48</b>

# 4 SPECIFICATION CONTENT

Note that throughout the list of content, the following markers are used to indicate the additional requirements shown.

† Balanced chemical equations are required.

\* Ion / electron half equations are required.

## AS

### UNIT CH1 – Controlling and Using Chemical Changes (in order to make things, produce energy and solve environmental problems)

#### Preamble

This unit begins with some important fundamental ideas about atoms and the use of the mole concept in calculations.

Three key principles governing chemical change are then studied, viz., the position of equilibrium between reactants and products, the energy changes associated with a chemical reaction and the rate at which reactions take place.

These principles are then applied to some important problems in the fields of chemical synthesis, obtaining energy and the maintenance of the environment.

## TOPIC 1

### 1.1 Basic ideas about atoms

#### Learning outcomes

#### Topic 1.1

Candidates should be able to:

- (a) describe electrons, protons and neutrons in terms of their relative charges and masses, and the distribution of charges and mass within atoms;
- (b) understand the terms *atomic number*, *mass number*, *isotope*, and the connection between atomic numbers and mass numbers;
- (c) deduce, given atomic and mass numbers, the numbers of protons, neutrons and electrons in specified isotopes;
- (d) explain the formation of ions from atoms by the loss or gain of electrons;
- (e) describe the nature of  $\alpha$  - and  $\beta$  - particles and of  $\gamma$  - radiation and recall their behaviour in electric fields and their relative penetrating powers;
- (f) describe and explain the changes in mass number and atomic number resulting from  $\alpha$  - and  $\beta$  - particle emission;
- (g) describe the adverse consequences for living cells of exposure to  $\gamma$  - radiation and to  $\alpha$  - and  $\beta$  - emitters;
- (h) explain what is meant by the half-life of a radioactive isotope; perform simple calculations involving integral numbers of half-lives;
- (i) apply their knowledge of radioactive decay and half-life ((e) - (h)) to contexts in health, medicine, radio-dating and analysis;
- (j) understand and explain the significance of standard molar ionisation energies of gaseous atoms and their variation from one element to another;
- (k) describe and explain how information about the electronic structure of atoms may be deduced from values of successive ionisation energies;
- (l) describe the shapes of *s* and *p* orbitals;
- (m) recall the appropriate *s*, *p* and *d* orbital occupations for elements 1 - 36 (using 'arrows in boxes' or otherwise) and relate these to position in the Periodic Table.
- (n) explain the origin of emission and absorption spectra in terms of electron transitions between atomic energy levels;
- (o) describe and interpret the visible atomic spectrum of the hydrogen atom (first 4 lines in the Balmer Series only);
- (p) recall the direct proportionality between energy and frequency, as implied by  $E = hf$ , and the inverse relationship between frequency and wavelength;  
(*No calculations will be set.*)
- (q) show understanding of the relationship between the frequency of the convergence limit of the Lyman Series and the ionisation energy of the hydrogen atom.

**1.2 Chemical calculations****Learning outcomes****Topic 1.2**

Candidates should be able to:

- (a) understand the terms *relative atomic mass*, *relative isotopic mass*, *relative molecular mass* and *molar mass*, based on the  $^{12}_6\text{C}$  scale, and of the Avogadro constant, and define the mole in terms of the  $^{12}_6\text{C}$  isotope;
- (b) explain the principles of the mass spectrometer and understand its uses, including the determination of the relative abundance of isotopes, relative isotopic and relative atomic masses, and describe and explain the mass spectrum of the chlorine molecule;
- (c) derive *empirical* and *molecular* formulae from given data;
- (d) carry out the interconversion of grams to moles (and vice-versa) for any given species;
- (e) understand and use concentration data, expressed in terms of either mass or moles, per unit volume;
- (f) calculate the mass of one reagent reacting with a given mass of another or forming a given mass of product(s), given the stoichiometry of the process;
- (g) use the molar volume to calculate the number of moles in a given volume of a gas, at a given temperature and pressure or the volume of gas from a given number of moles;
- (h) calculate the atom economy and percentage yield of a reaction using supplied data.

N.B. The use of the skills listed in outcomes 1.2 (c) to (h) will be expected in **all** units of the AS and A2 specification.

**TOPIC 2****2.1 Chemical equilibrium and acid-base reactions****Learning outcomes****Topic 2.1**

Candidates should be able to:

- understand the terms reversible reaction and dynamic equilibrium;
- recall and understand Le Chatelier's principle and apply it qualitatively to deduce the effects of changes in temperature and in pressure or concentration, on a system at equilibrium;
- understand the nature of acids as donors of  $\text{H}^+(\text{aq})$  and bases as acceptors of  $\text{H}^+(\text{aq})$  and apply this to their behaviour in aqueous solution;
- appreciate the usefulness of the pH scale in describing the degree of acidity to the general public;
- use the concept of the mole in calculations involving acid - base titration data;
- recall outline details of experimental procedures in acid-base titrations, including apparatus and methods used;
- recall that carbon dioxide is an acidic gas and its interaction with water including its effect on the carbonate/hydrogen carbonate equilibrium in sea-water.

**2.2 Energetics****Learning outcomes****Topic 2.2**

Candidates should be able to:

- appreciate the principle of conservation of energy and construct simple energy cycles;
- understand that chemical reactions are accompanied by energy changes, frequently in the form of heat, and that these may be either exothermic or endothermic and depend partly on the physical states of reactants and products;
- define standard conditions;
- understand the term enthalpy change of reaction and the specific terms enthalpy change of combustion and standard molar enthalpy change of formation,  $\Delta H_f^\circ$  (formal definitions are not required);

- recall details of experimental procedures for determining enthalpy changes in aqueous solution, and calculate such enthalpy changes from experimental data using

$$\Delta H = -\frac{mc\Delta T}{n}$$

where  $m$  and  $c$  are the mass and specific heat capacity of, for example, the water used,  $\Delta T$  is the incremental change in temperature, and  $n$  is the number of moles;

- state Hess's Law and use it to calculate enthalpy changes from energy cycles;
- understand the concept of average bond enthalpy (energy) and use Hess's Law to carry out simple calculations involving such quantities.

**2.3 Kinetics****Learning outcomes****Topic 2.3**

Candidates should be able to:

- (a) name the factors affecting reaction rates, including light in some cases;
- (b) outline a method of measuring the rate of a given reaction, explaining the principles involved;
- (c) calculate initial rates from graphs of concentration against time and understand how the results can give the relationship between rate and reactant concentrations;
- (d) describe simple collision theory and qualitatively explain the effects of changes in concentration (or pressure) and temperature on rate by means of this theory;
- (e) define activation energy, describe the concept of energy profiles and recall that  $\Delta H = E_f - E_b$ ;
- (f) explain the rapid increase in rate with temperature in terms of changes in the energy distribution curve;
- (g) recall the function of a catalyst and understand that at any temperature the presence of a catalyst:
  - (i) provides an alternative faster reaction pathway and thus increases the rate of both the forward and back reactions, normally by lowering the activation energy (lower energy profile);
  - (ii) does not affect the position of equilibrium;
  - (iii) does affect the time taken to reach equilibrium;
- (h) recall that catalysts may be homogeneous or heterogeneous and be able to give one example of each type;
- (i) appreciate the importance of finding new and better catalysts, including the use of enzymes, in achieving some of the goals of green chemistry, e.g., allowing the possibility of lower temperatures (less energy consumption), lower pressures, etc.;
- (j) appreciate the distinction between what may be deduced from **equilibrium** data and what may be deduced from **kinetic** data.

**TOPIC 3      Application of the principles studied in unit 1 to problems encountered in the production of chemicals and of energy.**

**Learning outcomes**

**Topic 3**

**When supplied with relevant data**, candidates should be able to:

- (a) apply principles from Topics 1 and 2 to a wide range of processes;
- (b) evaluate the social, economic and environmental impact of chemical synthesis and the production of energy;
- (c) appreciate the role of Green Chemistry in helping to achieve sustainability.

## UNIT CH2 – Properties, Structure and Bonding

The uses to which materials can be put depend on their properties, which in turn depend on the bonding and structure within the material. By understanding the relationship between these factors, chemists are able to design new materials.

The types of forces that can exist between particles are studied, along with several types of solid structures, in order to illustrate how these factors influence properties.

The building blocks of materials are the elements and the relationship of their properties to their position in the Periodic Table is illustrated by a study of the elements of the s-block and Group 7.

An introduction to organic chemistry provides the basis for an understanding of how the properties of carbon compounds can be modified by the introduction of functional groups.

## TOPIC 4 BONDING

### 4.1 Chemical Bonding

#### Learning outcomes

#### Topic 4.1

Candidates should be able to:

- (a) describe ionic and covalent bonding (including coordinate bonding) and represent this in terms of appropriate 'dot and cross' diagrams;
- (b) describe qualitatively the nature of the attractive and repulsive forces between ions in an ionic crystal;
- (c) show an understanding of the covalent bond in terms of the sharing (and spin pairing) of electrons and show awareness of the forces of attraction and repulsion within the molecule;
- (d) understand the concepts of electronegativity and of bond polarity, recall that bond polarity is largely determined by differences in electronegativity and use given values to predict such polarities;
- (e) appreciate that many bonds are intermediate in character between purely ionic and purely covalent and understand the way in which the electron density distribution varies with the ionic character of the bond.

**4.2 Forces between molecules.****Learning outcomes****Topic 4.2**

Candidates should be able to:

- (a) explain the concept of a dipole and give a simple account of van der Waals' forces (dipole-dipole, induced dipole-induced dipole);
- (b) explain the nature of hydrogen bonding and recall the types of elements with which it occurs e.g. with hydrogen attached to highly electronegative atoms;
- (c) describe and explain the influence of hydrogen bonding on boiling points and solubility;
- (d) appreciate that forces **within** molecules generally influence their chemical properties, whilst forces **between** molecules usually affect their physical properties;
- (e) appreciate the relative orders of magnitude of the strength of covalent bonds, hydrogen bonds and van der Waals' forces.

**4.3 Shapes of Molecules.****Learning outcomes****Topic 4.3**

Candidates should be able to:

- (a) explain what is meant by the terms *lone pairs* and *bonding pairs* of electrons and recall and explain the sequence of repulsions between: two bonding pairs; a bonding pair and a lone pair; two lone pairs;
- (b) explain the VSEPR principle in terms of minimising the total repulsions between electrons in the valence shell of a given molecule or ion, giving examples where appropriate;
- (c) recall and explain the shapes of the species listed (recall of exact bond angles is required for  $\text{BF}_3$ ,  $\text{CH}_4$ ,  $\text{SF}_6$  and  $\text{NH}_4^+$ ) and apply the VSEPR principle to predict or explain the shapes of other specified simple species involving up to six electron pairs in the valence shell of the central atom.

**4.4 Solubility of compounds in water.****Learning outcomes****Topic 4.4**

Candidates should be able to:

- (a) use a simple model to explain the ability of certain solutes to dissolve in water either by virtue of hydrogen bonding or dipolar forces and apply this to explain the solubility of ethanol and sodium chloride, and the insolubility (immiscibility) of hydrocarbons, in water;
- (b) understand and use solubility both qualitatively and quantitatively (i.e. in terms of mass or moles per unit volume) and understand the recovery of soluble salts from aqueous solution by crystallisation.

**TOPIC 5 Solid Structures.**

**Learning outcomes**

**Topic 5**

Candidates should be able to:

- (a) recall and describe the crystal structures of sodium chloride and caesium chloride, including the crystal coordination numbers and a simple explanation of the differences in terms of the relative sizes of the cations;
- (b) recall and describe the structures of diamond and graphite and know that iodine forms a molecular crystal;
- (c) recall and describe the structure of carbon nanotubes and appreciate the analogy with the graphite structure;
- (d) understand and explain the simple 'electron sea' model for bonding in metals and use it to explain their physical properties;
- (e) explain the relationship between physical properties (e.g. hardness, volatility and electrical conductance) and structure and bonding for the examples above;
- (f) understand that a so-called 'smart' material is able to exhibit a change in properties with a change in conditions (temperature, pH, etc) and this is often caused by a change in structure;
- (g) understand that nano-sized materials often exhibit different properties which can lead to new uses.

**TOPIC 6****6.1 The Periodic Table.****Learning outcomes****Topic 6.1**

Candidates should be able to:

- (a) describe the Periodic Table in terms of the arrangement of elements in groups and periods on the basis of their electronic structure and the classification of elements into *s*, *p* and *d* blocks;
- (b) understand the general trends in ionisation energy, melting temperature, and electronegativity, across periods and down groups;
- (c) recall the occurrence of elements as metals or non-metals in different parts of the Periodic Table, realise that metallic oxides are generally basic and non-metallic oxides acidic;
- (d) assign oxidation states (numbers) to the atoms in a compound or ion and use these to decide which species have been oxidised and which reduced in a redox reaction;
- (e) understand and explain the nature of oxidation and reduction in terms of electron transfer.

## 6.2 Trends in properties of the elements of the s-block and Group 7 (17).

### Learning outcomes

### Topic 6.2

Candidates should be able to:

- (a) recall the typical behaviour of the elements of Groups 1 and 2 with  $O_2$ ,  $H_2O$  and Group 2 elements with dilute acids (*excluding nitric acid*) and the trends in their general reactivity †;
- (b) describe the reactions of the aqueous cations,  $Mg^{2+}$ ,  $Ca^{2+}$  and  $Ba^{2+}$  with  $OH^-$ ,  $CO_3^{2-}$  and  $SO_4^{2-}$  †;
- (c) recall the formulae of the oxides and hydroxides of Groups 1 and 2 and appreciate their basic character;
- (d) recall the flame colours shown by compounds of Li, Na, K, Ca, Sr and Ba (and that Mg compounds show no colour) and describe their use in qualitative analysis;
- (e) show an awareness of the importance of calcium carbonate and phosphate minerals as skeletons for living systems and the consequent formation of carbonate rocks and the importance of calcium and magnesium in biochemistry;
- (f) recall the trend in volatility shown by the elements Cl, Br and I and relate to chemical bonding;
- (g) recall and explain the tendency of the halogens (F – I) to react by forming anions ( $F^-$ ,  $Cl^-$ ,  $Br^-$ ,  $I^-$ ), and recollect that this reactivity decreases on descent of the group \*;
- (h) recall the reactions of the halogens with metals, their displacement reactions with halides, and explain the group trends and displacements in terms of the relative oxidising power †\*;
- (i) understand the displacement reactions of  $Cl_2$  and  $Br_2$  in terms of redox †\*;
- (j) recall the nature of the reaction between aqueous  $Ag^+$  and halide ( $Cl^-$ ,  $Br^-$ ,  $I^-$ ) ions\* followed by dilute aqueous  $NH_3$ , and understand the analytical importance of these reactions in qualitative analysis (*ionic equations required for precipitation reactions only*).

## TOPIC 7

### 7.1 Organic compounds and their reactions.

#### Learning outcomes

#### Topic 7.1

Candidates should be able to:

- (a) write displayed, shortened and skeletal structural formulae of simple alkanes, alkenes, halogenoalkanes, primary alcohols and carboxylic acids given their systematic names, and vice versa;
- (b) describe the effect of increasing hydrocarbon chain length and of the above functional groups on physical properties, melting and boiling temperature and solubility;
- (c) describe structural isomerism and be able to write down the structural isomers of non-cyclic organic compounds (up to and including C<sub>6</sub> homologues) including those of different chemical class;
- (d) describe *E-Z* isomerism in alkenes, give an example, and discuss such isomerism in terms of restricted rotation about the C = C bond, and appreciate that *E-Z* isomers may have different physical and chemical properties;
- (e) derive empirical formulae from elemental composition data and use such results, together with additional data, to deduce molecular formulae;
- (f) identify reactants as electrophilic, nucleophilic or radical in type, explain the basis of this classification, and give examples of each;
- (g) classify the following types of functional group reactions and describe their nature: electrophilic addition, elimination, oxidation, hydrolysis;
- (h) describe the total oxidation of primary alcohols, RCH<sub>2</sub>OH, to carboxylic acids, RCOOH. (*Knowledge of the properties of aldehydes is not, at this stage, required*);
- (i) recognise the following functional group tests by the indicated reactions:

C = C addition of Br<sub>2</sub>(aq);

–X (Cl, Br, I) hydrolysis by aqueous base, followed by reaction with AgNO<sub>3</sub>(aq) / HNO<sub>3</sub>(aq).

**7.2 Hydrocarbons****Learning outcomes****Topic 7.2**

Candidates should be able to:

- (a) understand and explain the meaning of the terms homolytic and heterolytic bond fission;
- (b) describe in outline the general nature of petroleum, its separation into useful fractions by fractional distillation, and the cracking process;
- (c)
  - (i) describe the photochlorination of methane †;
  - (ii) recall the mechanism of the reaction as far as  $\text{CH}_2\text{Cl}_2$  and be aware that the reaction may proceed to  $\text{CCl}_4$ ;
- (d) describe the structure of and bonding in ethene (*hybridisation is not appropriate here*);
- (e) classify the addition reactions of  $\text{Br}_2$  and  $\text{HBr}$  (involving heterolytic fission), with ethene and propene, and relate the orientation of the normal addition of  $\text{HBr}$  to propene to the recalled mechanism of the reaction and the relative stabilities of the possible carbocations (carbonium ions) involved;
- (f) recall the catalytic hydrogenation (reduction) of alkenes and the preparation of ethene by elimination of  $\text{HBr}$  from bromoethane †;
- (g) understand the nature of alkene polymerisation and show an awareness of the wide range of important polymers of alkenes and substituted alkenes.

**7.3 Halogenoalkanes.****Learning outcomes****Topic 7.3**

Candidates should be able to:

- (a) describe the formation of a chloroalkane by direct chlorination of alkanes †\*;
- (b) describe the substitution reaction between  $\text{OH}^-$  and 1-chlorobutane and explain this on the basis of the recalled mechanism. †\*;
- (c) show an awareness of the wide use of halogenoalkanes as solvents, the toxicity of some of them, the use of CFCs as refrigerants and in aerosols, and their use in anaesthetics as well as the adverse environmental effects of CFCs;
- (d) understand the adverse environmental effects of CFCs and explain these in terms of the relative bond strengths of the  $\text{C-H}$ ,  $\text{C-F}$ , and  $\text{C-Cl}$  bonds involved;
- (e) show an awareness of the use of organohalogen compounds as pesticides and polymers and assess their environmental impact.

**7.4 Alcohols.****Learning outcomes****Topic 7.4**

Candidates should be able to:

- (a) describe the physical properties of the lower alcohols, solubility in water and relatively low volatility, and relate this to the existence of hydrogen bonding;
- (b) recall a method for the industrial preparation of ethanol from ethene;
- (c) recall the dehydration reaction (elimination) of primary alcohols †;
- (d) show awareness of the importance of ethanol-containing drinks in society, their ethanol content, breathalysers, and the effects of ethanol excess.

**TOPIC 8 Analytical techniques****Learning outcomes****Topic 8**

Candidates should be able to:

- (a) use **given** mass spec data in the elucidation of structure;
- (b) use **given** characteristic i.r. vibrational frequencies (expressed in  $\text{cm}^{-1}$ ), to identify simple groupings in organic molecules.

## A Level

### UNIT CH4 Spectroscopy and Organic Chemistry (Analysing and building molecules)

This unit builds on the foundation ideas of spectroscopy and basic organic chemistry introduced at AS level and goes on to explore these concepts in more detail.

It also explores the use of these topics in structure elucidation, in synthesis and in industrial and environmental applications.

### TOPIC 9 Spectroscopy

#### Learning outcomes

#### Topic 9

Candidates should be able to:

- (a) recall the energy gradation across the electromagnetic spectrum from u.v. to visible to i.r. spectra;
- (b) appreciate that energy levels can be split by a magnetic field, that certain nuclei, including  $^1\text{H}$ , possess intrinsic spin, and that measurements of the magnitudes of the interactions between the nuclear spin and the magnetic field are the basis of nuclear magnetic resonance spectroscopy;
- (c) explain why some substances are coloured in terms of the wavelengths of visible light absorbed;
- (d) explain the meaning of the term chromophore and give examples of chromophores in organic species, e.g.  $-\text{N}=\text{N}-$  in conjugated systems, including azo dyes.

**TOPIC 10 Isomerism and aromaticity****Learning outcomes****Topic 10**

Candidates should be able to:

- (a) give the systematic names of all simple compounds, including benzene derivatives, containing the functional groups occurring in this Unit;
- (b) understand the term stereoisomerism as embracing both E–Z and optical isomerism;
- (c) explain what is meant by a chiral centre, recall that this gives rise to optical isomerism, and be able to identify chiral centres in given molecules, and understand what is meant by an enantiomer;
- (d) recall that enantiomers rotate plane-polarised light in opposite directions and that equimolar amounts of enantiomers form racemic mixtures;
- (e) describe the structure of, and bonding in, benzene;
- (f) calculate the delocalisation or resonance energy of benzene from given enthalpy data;
- (g) describe and classify the nitration and halogenation reactions of benzene as electrophilic substitution, and recall the mechanism for these reactions †\*;  
(*The equation for the formation of  $\text{NO}_2^+$  is not required.*)
- (h) describe the Friedel-Crafts alkylation of benzene †\*;
- (i) compare benzene and alkenes with respect to benzene's resistance to addition and explain this resistance in terms of  $\pi$  electron delocalisation;
- (j) compare the ease of alkaline hydrolysis of chloroalkanes and chlorobenzene and explain the difference in terms of the C – Cl bond strength, and rationalise the greater strength of the C – Cl bond in the latter case;

**TOPIC 11    Organic compounds containing oxygen**

**11.1    Alcohols and phenol.**

**Learning outcomes**

**Topic 11.1**

Candidates should be able to:

- (a) describe the methods of forming primary and secondary alcohols from halogenoalkanes and carbonyl compounds \*;
- (b) recall:
  - (i) the reactions of primary and secondary alcohols with hydrogen halides, ethanoyl chloride and carboxylic acids (to give sweet smelling esters) †;
  - (ii) the dehydration reaction (elimination) of alcohols †;
- (c) describe the oxidation reactions of primary and secondary alcohols;
- (d) show an awareness of the use of ethanol as a biofuel;
- (e) explain the acidity of phenol and describe its reactions with bromine and with ethanoyl chloride;
- (f) recall the colour reaction of some phenols with  $\text{FeCl}_3$  solution and the use of this test to distinguish phenols from alcohols.

**11.2 Aldehydes and ketones.****Learning outcomes****Topic 11.2**

Candidates should be able to:

- (a) describe the formation of aldehydes and ketones by the oxidation of primary and secondary alcohols respectively;
- (b) describe how aldehydes and ketones may be distinguished by their relative ease of oxidation using Tollens' reagent and Fehling's reagent \*;
- (c) recall the use of  $\text{NaBH}_4$  to reduce aldehydes and ketones and state the organic products formed \*;
- (d) describe the reaction of aldehydes and ketones with 2,4-dinitrophenylhydrazine reagent as a nucleophilic addition-elimination (condensation) reaction and explain the use of this reaction in showing the presence of a carbonyl group and in identifying specific aldehydes and ketones by determining the melting temperatures of the purified products;
- (e) describe and understand the mechanism of the addition of HCN to carbonyl compounds as an example of a nucleophilic addition reaction †;
- (f) describe how the triiodomethane (iodoform) test is carried out and explain its use in detecting  $\text{CH}_3\text{CO}$  – groups or their precursors.

**11.3 Carboxylic acid and derivatives.****Learning outcomes****Topic 11.3**

Candidates should be able to:

- (a)
  - (i) describe the physical properties of lower carboxylic acids (volatility and solubility) and relate these to the presence of hydrogen bonding;
  - (ii) discuss and show understanding of the relative acidities of carboxylic acids, phenol, alcohols and water, and appreciate that carboxylic acids liberate  $\text{CO}_2$  from carbonates and hydrogencarbonates but that phenol does not;
  - (iii) recall that phenols in aqueous solution give colour reactions with iron(III) chloride solution;
  
- (b) recall the following listed processes and apply knowledge of them to the elucidation of organic problems:
  - (i) the formation of carboxylic acids from alcohols and aldehydes \*;
  - (ii) the formation of aromatic carboxylic acids by the oxidation of methyl side-chains with alkaline  $\text{Mn}^{\text{VII}}$  and subsequent acidification\*;
  - (iii) methods of converting the acids to esters and acid chlorides, and the hydrolyses of these compounds †\*;
  - (iv) the behaviour of acids on reduction with  $\text{LiAlH}_4$ ; acid decarboxylation and its use in structure determination \*;
  
- (c) recall the following listed processes and apply knowledge of them to the elucidation of organic problems:
  - (i) methods of converting carboxylic acids to amides;
  - (ii) formation of nitriles from halogenoalkanes;
  - (iii) the reduction of nitriles with  $\text{LiAlH}_4$  and the hydrolysis of nitriles and amides;
  
- (d) recall the industrial importance of ethanoic anhydride and polyesters.

**TOPIC 12    Organic compounds containing nitrogen**
**Learning outcomes**
**Topic 12**

Candidates should be able to:

- (a) describe the preparation of primary aliphatic (†) and aromatic amines from halogenoalkanes and nitrobenzenes respectively;
- (b) recall that, and explain why, amines are basic;
- (c) recall the ethanoylation reaction of primary amines using ethanoyl chloride †;
- (d) compare the reaction of primary aliphatic and aromatic amines with cold nitric(III) acid (nitrous acid), describe the coupling of benzenediazonium salts with phenols such as naphthalen-2-ol and aromatic amines and the importance of this reaction for azo dyes; recall the role of the  $-N=N-$  chromophore in azo dyes and be aware that this group links two aromatic rings;
- (e) recall the general formulae of  $\alpha$ -amino acids and discuss their amphoteric and zwitterionic nature;
- (f) write down the possible dipeptides formed from two different  $\alpha$ -amino acids;
- (g) understand the formation of polypeptides and proteins and have an outline understanding of primary, secondary and tertiary protein structure;
- (h) show an awareness of the importance of proteins in living systems, e.g. as enzymes;
- (i) recall in outline the mode the synthesis and the industrial importance of polyamides and understand the similarity of the  $-\overset{\text{H}}{\underset{|}{\text{N}}}-\overset{\text{O}}{\underset{||}{\text{C}}}-$  linkage to that in naturally occurring proteins.

**TOPIC 13    Organic synthesis and analysis**
**Learning outcomes**
**Topic 13**

Candidates should be able to:

- (a) derive empirical formulae from elemental composition data and deduce molecular formulae from these results plus additional data such as titration values, gas volumes, mass spectrometric molecular ion values and gravimetric results;
  - (b) use given mass spectral data to elucidate the structure of simple organic molecules (up to and including C<sub>8</sub> molecules, with one chlorine atom);
  - (c) interpret given simple infrared spectra using characteristic group frequencies (supplied in cm<sup>-1</sup>) : O–H(str), N–H (str), C ≡ N (str), C=O (str) and N–H (bend) [str = stretch] and use these to identify groupings in organic molecules;
  - (d) understand that n.m.r. spectra can give information regarding the environment and number of equivalent hydrogen atoms in organic molecules and use such supplied information in structure determination \*;
- \* *Candidates will be supplied with simplified n.m.r. spectra of relevant compounds and with a table listing the approximate positions of commonly encountered resonances. They may also be supplied with an indication of the relative peak areas of each resonance and with a note that the splitting of any resonance into n components indicates the presence of n-1 hydrogen atoms on one **adjacent** carbon, nitrogen or oxygen atom.  
Questions may be set showing spectra at low resolution where splitting is not shown.*
- (e) outline the general reaction conditions and basic techniques of manipulation, separation and purification used in organic chemistry, and recall the essential safety requirements during these operations;
  - (f) understand the use of melting temperatures as a determination of purity;
  - (g) propose sequential organic conversions by combining a maximum of three reactions in the specification;
  - (h) deduce percentage yields in preparative processes;
  - (i) show understanding of the wide applicability of spectroscopic techniques to analytical problems in industry, medicine and the environment;
  - (j) understand and be able to explain and exemplify the distinction between condensation polymerisation and addition polymerisation;
  - (k) give, as examples of important industrial and processes, the outline chemistry and any necessary conditions of the manufacture of polyesters (e.g. PET) and polyamides (e.g. Nylon 6 and 6,6) starting from compound(s) containing the respective two functional groups;
  - (l) outline the uses of thin layer chromatography (TLC), gas chromatography and high-performance liquid chromatography (HPLC) in analysis (details of the theory of chromatography and of the methods used are not required) and be able to find the composition of mixtures by use of retardation factor (R<sub>f</sub>), retention time and peak area.

**TOPIC 14    The process of how science works**

**Learning outcomes**

**Topic 14**

Candidates should be able to:

- (a) understand and use the methods scientists employ in determining the accuracy, reliability and validity of their own and others' work;
- (b) appreciate the methods scientists employ in developing their own and others' work to produce new materials and applications, for example in natural product synthesis, using computational chemistry and in aspects of nanotechnology.

**UNIT CH5 Physical and inorganic chemistry**

This unit develops ideas of redox, kinetics, energy changes and equilibria.

The inorganic chemistry of some elements in various sections of the Periodic Table is studied.

**TOPIC 15****15.1 Redox and standard electrode potential.****Learning outcomes****Topic 15.1**

Candidates should be able to:

- (a) describe redox in terms of electron transfer, use oxidation states (numbers) to identify redox reactions and decide which species have been oxidised and which reduced;
- (b) write ion-electron half equations for redox reactions for which stoichiometric information is supplied, and use titration and other data to carry out appropriate calculations;
- (c) show awareness that electrode processes represent oxidations and reductions;
- (d) recall and use the redox systems specified below, including the appropriate colour change and ion/electron half-equations  
 $\text{Cu}^{2+}(\text{aq})|\text{Cu}(\text{s}); \quad \text{Zn}^{2+}(\text{aq})|\text{Zn}(\text{s}); \quad \text{H}^{+}(\text{aq})|\text{H}_2(\text{g}) \text{ Pt}; \quad \text{Fe}^{3+}(\text{aq}), \text{Fe}^{2+}(\text{aq})|\text{Pt};$   
 $\text{MnO}_4^{-}(\text{aq}), \text{Mn}^{2+}(\text{aq})|\text{Pt}; \quad \text{X}_2(\text{g})|2\text{X}^{-}(\text{aq}) (\text{X} = \text{Cl}^{-}, \text{Br}^{-}, \text{I}^{-});$
- (e) use redox systems in addition to those in (d), for which all relevant information is supplied;
- (f) describe simple electrochemical cells involving;
  - (i) metal/metal ion electrodes, and
  - (ii) electrodes based on different oxidation states of the same element.
- (g) explain and use the term standard electrode potential especially
  - (i) the use of the standard hydrogen electrode in determining standard electrode potential;
  - (ii) to calculate standard potentials of cells formed by combining different electrodes and;
  - (iii) to predict the feasibility of specified reactions.

**15.2 Redox reactions.****Learning outcomes****Topic 15.2**

Candidates should be able to:

- (h) describe the use of  $\text{Cr}_2\text{O}_7^{2-}$  as an oxidising agent, including
  - (i) the appropriate ion/electron half equation for the  $\text{Cr}_2\text{O}_7^{2-} \rightarrow \text{Cr}^{3+}$  conversion
  - (ii) its reaction with  $\text{Fe}^{2+}$  to produce  $\text{Fe}^{3+}$  and
  - (iii) the interconversion reaction  $\text{Cr}_2\text{O}_7^{2-} \rightleftharpoons \text{CrO}_4^{2-}$  and recall the colours of all the above listed species; †
- (i) describe the redox reaction between acidified  $\text{MnO}_4^-$  and  $\text{Fe}^{2+}$ ; †
- (j) describe the redox reaction between  $\text{Cu}^{2+}$  and  $\text{I}^-$  and the determination of the liberated iodine with  $\text{S}_2\text{O}_3^{2-}$ ; †
- (k) carry out titration calculations for all reactions specified in **15.2** and for other redox reactions where all necessary data is supplied.

**15.3 Applications.****Learning outcomes****Topic 15.3**

Candidates should be able to:

- (l) appreciate the very wide range of occurrence of redox processes in chemistry;
- (m) explain the principles underlying the operation of the hydrogen fuel cell in terms of the electrode half reactions  $2\text{H}^+ + 2\text{e}^- \rightleftharpoons \text{H}_2$  and  $\text{O}_2 + 4\text{H}^+ + 4\text{e}^- \rightleftharpoons 2\text{H}_2\text{O}$  in the presence of a platinum catalyst, its potential use for storing energy and generating electricity and heat, and the benefits and drawbacks of its use (*details of cell construction not required*).

**TOPIC 16 Chemistry of the p – block****16.1 General.****Learning outcomes****Topic 16.1**

Candidates should be able to:

- (a) derive the electron configurations of the p-block elements up to Ar and the general outer configuration for each p block group ( $s^2p^1$ ,  $s^2p^2$ ,  $s^2p^3$  etc);
- (b) show knowledge of the increasing stability of the inert pair ( $ns^2$ ) cations on descent of Groups 3, 4 and 5;
- (c) show understanding of why the maximum number of electron pairs which can surround a central atom is greater in Row 3 (Na-Ar) than in Row 2 (Li-Ne), using examples drawn from the Group 5 halides;
- (d) explain the term amphoteric behaviour and illustrate this behaviour using reactions of  $Al^{3+}$  and  $Pb^{2+}$ .

**16.2 Group 3 (13).****Learning outcomes****Topic 16.2**

Candidates should be able to:

- (e) understand the electron deficient nature of Group 3 systems such as  $BF_3$ ,  $BCl_3$  and monomeric  $AlCl_3$  and their electron acceptor properties;
- (f) explain the ready formation of the  $Al_2Cl_6$  dimer, its structure and its bonding;
- (g) understand the formation of donor-acceptor compounds such as  $NH_3 \cdot BF_3$ ;
- (h) recall that the affinity of  $AlCl_3$  for chlorine species results in industrially important catalysts such as
  - (i) the chlorination of benzene and
  - (ii) low melting temperature ionic liquids, containing the chloroaluminate(III) ion,  $AlCl_4^-$ , which are being developed as “clean technology” solvents and catalysts for processes such as the polymerisation of alkenes;
- (i) explain how boron nitride, BN, forms hexagonal and cubic structures corresponding to graphite and diamond respectively and, because of its hardness, chemical inertness, high melting temperature and semiconductor properties, is finding increasing use as lubricant, as wear-resistant coating and as nanotubes for wire sleeving, catalyst support and semiconduction;
- (j) recognise that in none of the cases (f) to (i) above is the compound electron deficient.

**16.3 Group 4 (14).****Learning outcomes****Topic 16.3**

Candidates should be able to:

- (k) describe the change in relative stability of oxidation states II and IV down Group 4, as shown by reactions of CO as a reducing agent with oxides and Pb(IV) as an oxidising agent in the reaction of PbO<sub>2</sub> with concentrated hydrochloric acid †;
- (l) recall the nature, physical and acid-base properties of CO<sub>2</sub> and PbO; †
- (m) describe the types of bonding in the chlorides CCl<sub>4</sub>, SiCl<sub>4</sub> and PbCl<sub>2</sub> and their reactions with water ;†
- (n) recall the reactions of Pb<sup>2+</sup>(aq) with aqueous NaOH, Cl<sup>-</sup> and I<sup>-</sup>. †

**16.4 Group 7 (17).****Learning outcomes****Topic 16.4**

Candidates should be able to:

- (o) explain the trends in oxidising power of the halogens and displacement reactions in terms of position in the group and  $E^\ominus$  values;
- (p) recall the reactions of chlorine, Cl<sub>2</sub>, with both cold and warm aqueous NaOH and the various disproportionation reactions involved; †
- (q) show a knowledge of the relationship of the bleaching and bacterial action of Cl<sub>2</sub> and chlorate(I) (ClO<sup>-</sup>) to their oxidising power and the use of chlorate(V) as a weed killer;
- (r) recall the behaviour of sodium halides (NaCl, NaBr and NaI only) with concentrated sulfuric acid (the formation and subsequent reactions of HX, the products and their oxidation states) and explain the differences in terms of  $E^\ominus$  values;  
(Equations not required)
- (s) show an awareness of the very wide range of halogen containing compounds of commercial and industrial importance.

**TOPIC 17 d block transition elements**
**Learning outcomes**
**Topic 17**

Candidates should be able to:

- (a) recall that transition elements (except Cu) possess partly filled *d*-orbitals and derive the electronic configuration of any first row transition metal ion using a Periodic Table;
- (b) recall that 4*s* electrons are lost more readily than 3*d* electrons in ion formation;
- (c) explain why various oxidation states are possible in transition elements;
- (d) recall that transition metals and their compounds are often good catalysts, give an example, and explain why this is so in terms of partially filled *d*-shells and variable oxidation states;
- (e) recall that many complexes are formed by co-ordinate bonding between transition metal ions and ligands;
- (f) describe the bonding, colour and formulae of the approximately octahedral complex ions  $[\text{Cu}(\text{H}_2\text{O})_6]^{2+}$  and  $[\text{Cu}(\text{NH}_3)_4(\text{H}_2\text{O})_2]^{2+}$ , the approximately tetrahedral ion  $[\text{CuCl}_4]^{2-}$ , and other complexes where relevant information is supplied;
- (g)
  - (i) explain the origins of colour in transition metal complexes and give a qualitative account of this for octahedral 6-coordinate species in terms of the splitting of the *d*-orbitals involved, and;
  - (ii) show understanding of the spectroscopic consequences of (i) above and explain that in many cases the colours of such transition metal complexes arise from *d-d* transitions between the split *d*-orbital levels \*;
- (h) describe the reactions of  $\text{Cr}^{3+}$ ,  $\text{Fe}^{2+}$ ,  $\text{Fe}^{3+}$  and  $\text{Cu}^{2+}$  with excess aqueous  $\text{OH}^-$ ; †
- (i) show an awareness of the economic importance of transition metals and their importance as trace elements in living systems, and give one example of economic importance and one example of trace element importance.

Note:

*\*The simple electrostatic model is adequate to account for the *d*-orbital splitting. Candidates should be able appropriately to allocate electrons to the split *d*-orbitals using the arrows in boxes technique but consideration of the factors leading to high or low spin behaviour will not be required.*

**TOPIC 18    Chemical kinetics****Learning outcomes****Topic 18**

Candidates should be able to:

- (a) describe in outline the variety of methods for studying reaction kinetics e.g. the iodine clock reaction, colorimetry and other spectroscopic techniques, pressure and volume changes;
- (b) calculate rates from numerical or graphical data (including drawing tangents to concentration-time curves);
- (c) recall and apply the general rate equation,  $\text{rate} = k[\text{A}]^m [\text{B}]^n$ , define rate, rate constant and reaction order, and give the units of rate constants up to, and including, second order;
- (d)
  - (i) calculate rate constants and integral orders of reaction (0, 1 or 2) from given rate data;
  - (ii) appreciate that orders of reaction may only be found through rate measurement and not from stoichiometric equations;
- (e) distinguish clearly between rate and equilibrium and between the effects of temperature change on rates and on the position of equilibrium;
- (f) explain and use the concept of rate determining step;
- (g) deduce the kinetics that would apply to a suggested mechanism or, conversely, suggest a mechanism consistent with a determined or given reaction order in simple cases and show an understanding of how kinetic evidence may support a proposed mechanism.

**TOPIC 19 Energy changes****19.1 Enthalpy changes for solids and solutions.****Learning outcomes****Topic 19.1**

Candidates should be able to:

- (a) understand the use of the terms enthalpy change of atomisation, lattice formation and breaking, hydration and solution (*formal definitions are not required*);
- (b) explain how enthalpy changes of solution are related to lattice breaking enthalpies and hydration enthalpies of the ions;
- (c) show understanding of the way in which the solubilities of ionic solids in water depend upon the balance between the lattice breaking enthalpies and the hydration enthalpies of the ions;
- (d) apply Hess's Law (Born-Haber cycle) to the formation of simple ionic compounds and carry out appropriate calculations (data will be supplied as necessary);
- (e) appreciate that the exothermicity or endothermicity of  $\Delta H_f^\circ$  may be used as a qualitative indication of the stability of the compound in question and recognise that the most stable ionic compounds will be those formed most exothermically from their elements.

**19.2 Entropy and feasibility of reactions.****Learning outcomes****Topic 19.2**

Candidates should be able to:

- (f) appreciate that the entropy,  $S$ , of a chemical system is to a large degree determined by the freedom possessed by the molecules or atoms within the system, and that for all natural changes entropy increases towards a maximum (*definitions not required*);
- (g) recognise that molecules or atoms in a solid have much more restricted freedom than in a gas and that, other factors being equal, entropy increases in the sequence  

$$S(\text{solid}) < S(\text{liquid}) < S(\text{gas});$$
- (h) apply the equation relating free energy change,  $\Delta G$ , to the entropy change,  $\Delta S$ ,  

$$\Delta G = \Delta H - T\Delta S$$
and understand that, for a reaction:  
if  $\Delta G$  is negative the reaction occurs spontaneously;  
if  $\Delta G$  is positive the reaction does not occur spontaneously;
- (i) understand that, because of the entropy change, endothermic processes such as the boiling of liquids, the solution of some salts and the thermal decomposition of oxysalts may still occur spontaneously.

**TOPIC 20    Equilibria****20.1    General Equilibria.****Learning outcomes****Topic 20.1**

Candidates should be able to:

- (a) deduce expressions for the equilibrium constants,  $K_p$  and  $K_c$  in terms of partial pressures or of concentrations, as appropriate;
- (b) appreciate that  $K_p$  or  $K_c$  are constant for a given system at any fixed temperature and understand the effect of temperature changes on  $K_p$  or  $K_c$  for exothermic and endothermic reactions;
- (c) calculate values of  $K_p$  and  $K_c$  or of quantities present at equilibrium, given appropriate data (no manipulations of mole fraction or of degree of dissociation will be required);
- (d) show ability to use given or calculated values of  $K_p$  and  $K_c$  to estimate qualitatively the location of the position of equilibrium for a system;
- (e) recognise that for a reaction with  $\Delta G$  negative (see 19.2 (h))  $K_p$  and  $K_c$  will have large values as the products predominate and that for a reaction with  $\Delta G$  positive  $K_p$  and  $K_c$  will have small values as the reactants predominate;
- (f) appreciate the distinction between what may be deduced from **equilibrium** data and what may be deduced from **kinetic** data;
- (g) integrate and evaluate supplied kinetics, energetics and equilibria data for environmental and industrial chemical processes.

**20.2 Acid-Base Equilibria.****Learning outcomes****Topic 20.2**

Candidates should be able to:

- (h) understand and apply the Lowry-Brønsted theory of acids and bases (limited to aqueous solutions);
- (i) recall the definition of pH and calculate pH values from those of  $[H^+ (aq)]$  and vice versa;
- (j) understand and appreciate the distinction between the terms concentrated/dilute and strong/weak and explain the differences in behaviour between strong and weak acids and bases, using  $K_a$ ;
- (k) appreciate the significance of the ionic product of water,  $K_w$ , and understand that neutralisation involves  $H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$ ;
- (l) explain and use pH,  $K_w$  and  $K_a$  in calculations involving strong and weak acids, and use pH and  $K_w$  in calculations involving strong bases;
- (m) recall the forms of the acid - base titration curves for the systems: strong acid /strong base (e.g. HCl/NaOH), strong acid/ weak base (e.g. HCl/NH<sub>3</sub>) and weak acid/strong base (e.g. CH<sub>3</sub>COOH/NaOH), explaining these in terms of the appropriate acid and base strengths;
- (n) understand the mode of action of buffer solutions, exemplified by the CH<sub>3</sub>COONa / CH<sub>3</sub>COOH and NH<sub>3</sub>/NH<sub>4</sub><sup>+</sup> systems, appreciate their importance, and carry out appropriate calculations using pH,  $K_w$  and  $K_a$ ;
- (o) recall, and explain qualitatively, typical pH values exhibited by solutions of salts of  
 strong acid / strong base (e.g. NaCl)  
 strong acid / weak base (e.g. NH<sub>4</sub>Cl) and  
 weak acid / strong base (e.g. CH<sub>3</sub>COONa);
- (p) understand the working of an indicator and select suitable indicators for specified acid-base titrations, given appropriate pH values.

## 5 SCHEME OF ASSESSMENT

AS and A level qualifications are available to candidates following this specification.

### AS

The AS is the first half of an A level course. It will contribute 50% of the total A level marks. Candidates must complete the following **three units** in order to gain an AS qualification.

		Weighting Within AS	Weighting Within A level
<b>CH1</b>	Controlling and Using Chemical Changes	40	20
<b>CH2</b>	Properties, Structure and Bonding	40	20
<b>CH3</b>	AS Practical Chemistry	20	10

#### **CH1: Written Paper (1hr 30min) 80 raw marks 120 um**

The paper has two sections A and B. Section A consists of short answer objective questions. Section B consists of structured questions. There will be no choice.

#### **CH2: Written Paper (1hr 30min) 80 raw marks 120 um**

The paper has two sections A and B. Section A consists of short answer objective questions. Section B consists of structured questions. There will be no choice.

#### **CH3: Internally Assessed Practical Work 60 raw marks 60 um**

This unit will consist of two practical exercises that may be taken from exemplars produced by WJEC, modifications of these or centre devised tasks (using the exemplars as a standard). In the latter two cases, approval must be obtained from WJEC.

Each task carries 30 raw marks and must be marked according to a mark scheme devised or approved by WJEC.

## A Level

The A level specification consists of two parts: Part 1 (AS) and Part 2 (A2).

Part 1 (AS) may be taken separately and added to A2 at a further examination sitting to achieve an A level qualification, or alternatively, both the AS and A2 may be taken at the same sitting.

Candidates must complete the AS units outlined above plus a further two units to complete A level Chemistry. The A2 units will contribute 50% of the total A level marks.

		Weighting within A2	Weighting within A level
CH4*	Spectroscopy and Organic Chemistry	40	20
CH5*	Physical and Inorganic Chemistry	40	20
CH6*	A2 Practical Chemistry	20	10

\*Includes synoptic assessment

### CH4: Written Paper (1hr 45min) 80 raw marks 120 um

The paper has two sections A and B. Section A consists of structured questions. Section B consists of two questions of 20 raw marks each which are designed to produce extended responses drawing on understanding of a range of concepts. There will be no choice.

### CH5: Written Paper (1hr 45min) 80 raw marks 120 um

The paper has two sections A and B. Section A consists of structured questions. Section B consists of two questions of 20 raw marks each which are designed to produce extended responses drawing on understanding of a range of concepts. There will be no choice.

### CH6: Internally Assessed Practical Work 60 raw marks 60 um

This unit will consist of two practical exercises that may be taken from exemplars produced by WJEC, modifications of these or centre devised tasks (using the exemplars as a standard). In the latter two cases, approval must be obtained from WJEC.

Each task carries 30 raw marks and must be marked according to a mark scheme devised or approved by WJEC.

## Synoptic Assessment

There is a requirement to formally assess synopticity at A2. The definition of synoptic assessment in the context of Chemistry is given below.

Synoptic assessment requires candidates to make and use connections **within** and **between** different areas of the subject at AS and A2, for example, by:

- applying knowledge and understanding of more than one area to a particular situation or context;
- using knowledge and understanding of principles and concepts in planning experimental and investigative work and in the analysis and evaluation of data;
- bringing together scientific knowledge and understanding from different areas of the subject and applying them.

The practical work in CH6 is considered to be synoptic due to the bringing together of knowledge from different areas of the subject and the use of a variety of acquired skills.

Synoptic questions in particular may incorporate concepts and ideas which are designed to be more challenging for candidates. Such questions may provide credit for extra insight and appreciation of the inter-relatedness of different aspects of the subject and creativity of thought.

## Quality of Written Communication

Candidates will be required to demonstrate their competence in written communication in all assessment units where they are required to produce extended written material.

Mark schemes for these units include the following specific criteria for the assessment of written communication.

- legibility of text; accuracy of spelling, punctuation and grammar; clarity of meaning;
- selection of a form and style of writing appropriate to purpose and to complexity of subject matter;
- organisation of information clearly and coherently; use of specialist vocabulary where appropriate.

All assessment objectives subsume the use of written communication. Use of appropriate language, punctuation and grammar is expected as the means by which ideas can be expressed and logical argument shown in answers to questions. Marks will not be awarded unless the meaning is clearly conveyed.

Mark-schemes therefore will, where appropriate, be constructed to allow for the presentation of coherent accounts, cogent argument, appropriate format, use of scientific terminology and clarity.

### Availability of Units

Availability of Assessment Units				
Unit	January 2009	June 2009	January 2010 & each subsequent year	June 2010 & each subsequent year
<b>CH1</b>	✓	✓	✓	✓
<b>CH2</b>		✓	✓	✓
<b>CH3</b>		✓		✓
<b>CH4</b>			✓	✓
<b>CH5</b>				✓
<b>CH6</b>				✓

### Awarding, Reporting and Re-sitting

The overall grades for the GCE AS qualification will be recorded as a grade on a scale from A to E. The overall grades for the GCE A level qualification will be recorded on a grade scale from A\* to E. Results not attaining the minimum standard for the award of a grade will be reported as U (Unclassified). Individual unit results and the overall subject award will be expressed as a uniform mark on a scale common to all GCE qualifications (see table below). The grade equivalence will be reported as a lower case letter ((a) to (e)) on results slips, but not on certificates:

	Max. UM	A	B	C	D	E
Units 1, 2, 4 and 5 (weighting 20%)	120	96	84	72	60	48
Units 3 and 6 (weighting 10%)	60	48	42	36	30	24
AS Qualification	300	240	210	180	150	120
A Qualification	600	480	420	360	300	240

At A level, Grade A\* will be awarded to candidates who have achieved a Grade A in the overall A level qualification and 90% of the total uniform marks for the A2 units.

Candidates may re-sit units prior to certification for the qualification, with the best of the results achieved contributing to the qualification. Individual unit results, prior to certification of the qualification have a shelf-life limited only by the shelf-life of the specification.

**6****KEY SKILLS**

Key Skills are integral to the study of AS/A level Chemistry and may be assessed through the course content and the related scheme of assessment as defined in the specification. The following key skills can be developed through this specification at level 3:

- Communication
- Application of Number
- Problem Solving
- Information and Communication Technology
- Working with Others
- Improving Own Learning and Performance

Mapping of opportunities for the development of these skills against Key Skills evidence requirement is provided in 'Exemplification of Key Skills for Chemistry', available on the WJEC website.

## **7** **PERFORMANCE DESCRIPTIONS**

### **Introduction**

Performance descriptions have been created for all GCE subjects. They describe the learning outcomes and levels of attainment likely to be demonstrated by a representative candidate performing at the A/B and E/U boundaries for AS and A2.

In practice most candidates will show uneven profiles across the attainments listed, with strengths in some areas compensating in the award process for weaknesses or omissions elsewhere. Performance descriptions illustrate expectations at the A/B and E/U boundaries of the AS and A2 as a whole; they have not been written at unit level.

Grade A/B and E/U boundaries should be set using professional judgement. The judgement should reflect the quality of candidates' work, informed by the available technical and statistical evidence. Performance descriptions are designed to assist examiners in exercising their professional judgement. They should be interpreted and applied in the context of individual specifications and their associated units. However, performance descriptions are not designed to define the content of specifications and units.

The requirement for all AS and A level specifications to assess candidates' quality of written communication will be met through one or more of the assessment objectives.

The performance descriptions have been produced by the regulatory authorities in collaboration with the awarding bodies.

## AS performance descriptions for chemistry

	Assessment objective 1	Assessment objective 2	Assessment objective 3
<b>Assessment objectives</b>	<p><b>Knowledge and understanding of science and of How science works</b> Candidates should be able to:</p> <ul style="list-style-type: none"> <li>• recognise, recall and show understanding of scientific knowledge</li> <li>• select, organise and communicate relevant information in a variety of forms.</li> </ul>	<p><b>Application of knowledge and understanding of science and of How science works</b> Candidates should be able to:</p> <ul style="list-style-type: none"> <li>• analyse and evaluate scientific knowledge and processes</li> <li>• apply scientific knowledge and processes to unfamiliar situations including those related to issues</li> <li>• assess the validity, reliability and credibility of scientific information.</li> </ul>	<p><b>How science works</b> Candidates should be able to:</p> <ul style="list-style-type: none"> <li>• demonstrate and describe ethical, safe and skilful practical techniques and processes, selecting appropriate qualitative and quantitative methods</li> <li>• make, record and communicate reliable and valid observations and measurements with appropriate precision and accuracy</li> <li>• analyse, interpret, explain and evaluate the methodology, results and impact of their own and others' experimental and investigative activities in a variety of ways.</li> </ul>
<b>A/B boundary performance descriptions</b>	<p>Candidates characteristically:</p> <ol style="list-style-type: none"> <li>a) demonstrate knowledge and understanding of most principles, concepts and facts and from the AS specification</li> <li>b) select relevant information from the AS specification</li> <li>c) organise and present information clearly in appropriate forms</li> <li>d) write equations for most straightforward reactions using scientific terminology.</li> </ol>	<p>Candidates characteristically:</p> <ol style="list-style-type: none"> <li>a) apply principles and concepts in familiar and new contexts involving only a few steps in the argument</li> <li>b) describe significant trends and patterns shown by data presented in tabular or graphical form; interpret phenomena with few errors; and present arguments and evaluations clearly</li> <li>c) comment critically on statements, conclusions or data</li> <li>d) carry out accurately most structured calculations specified for AS</li> <li>e) use a range of chemical equations</li> <li>f) translate successfully data presented as prose, diagrams, drawings, tables or graphs from one form to another.</li> </ol>	<p>Candidates characteristically:</p> <ol style="list-style-type: none"> <li>a) devise and plan experimental and investigative activities, selecting appropriate techniques</li> <li>b) demonstrate safe and skilful practical techniques</li> <li>c) make observations and measurements with appropriate precision and record these methodically</li> <li>d) interpret, explain, evaluate and communicate the results of their own and others' experimental and investigative activities, in appropriate contexts.</li> </ol>
<b>E/U boundary performance descriptions</b>	<p>Candidates characteristically:</p> <ol style="list-style-type: none"> <li>a) demonstrate knowledge and understanding of some principles and facts from the AS specification</li> <li>b) select some relevant information from the AS specification</li> <li>c) present information using basic terminology from the AS specification</li> <li>d) write equations for some straightforward reactions.</li> </ol>	<p>Candidates characteristically:</p> <ol style="list-style-type: none"> <li>a) apply a given principle to material presented in familiar or closely related contexts involving only a few steps in the argument</li> <li>b) describe some trends or patterns shown by data presented in tabular or graphical form</li> <li>c) identify, when directed, inconsistencies in conclusions or data</li> <li>d) carry out some steps within calculations</li> <li>e) use simple chemical equations</li> <li>f) translate data successfully from one form to another, in some contexts</li> </ol>	<p>Candidates characteristically:</p> <ol style="list-style-type: none"> <li>a) devise and plan some aspects of experimental and investigative activities</li> <li>b) demonstrate safe practical techniques</li> <li>c) make observations and measurements and record them</li> <li>d) interpret, explain and communicate some aspects of the results of their own and others' experimental and investigative activities, in appropriate contexts.</li> </ol>

## A2 performance descriptions for chemistry

Assessment objectives	Assessment objective 1	Assessment objective 2	Assessment objective 3
<p><b>A/B boundary performance descriptions</b></p>	<p><b>Knowledge and understanding of science and of How science works</b> Candidates should be able to:</p> <ul style="list-style-type: none"> <li>• recognise, recall and show understanding of scientific knowledge</li> <li>• select, organise and communicate relevant information in a variety of forms.</li> </ul>	<p><b>Application of knowledge and understanding of science and of How science works</b> Candidates should be able to:</p> <ul style="list-style-type: none"> <li>• analyse and evaluate scientific knowledge and processes</li> <li>• apply scientific knowledge and processes to unfamiliar situations including those related to issues</li> <li>• assess the validity, reliability and credibility of scientific information.</li> </ul>	<p><b>How science works</b> Candidates should be able to:</p> <ul style="list-style-type: none"> <li>• demonstrate and describe ethical, safe and skilful practical techniques and processes, selecting appropriate qualitative and quantitative methods</li> <li>• make, record and communicate reliable and valid observations and measurements with appropriate precision and accuracy</li> <li>• analyse, interpret, explain and evaluate the methodology, results and impact of their own and others' experimental and investigative activities in a variety of ways.</li> </ul>
<p><b>E/U boundary performance descriptions</b></p>	<p>Candidates characteristically:</p> <ol style="list-style-type: none"> <li>a) demonstrate detailed knowledge and understanding of most principles, concepts and facts from the A2 specification</li> <li>b) select relevant information from the A2 specification</li> <li>c) organise and present information clearly in appropriate forms using scientific terminology</li> <li>d) write equations for most chemical reactions.</li> </ol>	<p>Candidates characteristically:</p> <ol style="list-style-type: none"> <li>a) apply principles and concepts in familiar and new contexts involving several steps in the argument</li> <li>b) describe significant trends and patterns shown by complex data presented in tabular or graphical form; interpret phenomena with few errors; and present arguments and evaluations clearly</li> <li>c) evaluate critically the statements, conclusions or data</li> <li>d) carry out accurately complex calculations specified for A level</li> <li>e) use chemical equations in a range of contexts</li> <li>f) translate successfully data presented as prose, diagrams, drawings, tables or graphs, from one form to another</li> <li>g) select a wide range of facts, principles and concepts from both AS and A2 specifications</li> <li>h) link together appropriate facts principles and concepts from different areas of the specification.</li> </ol>	<p>Candidates characteristically:</p> <ol style="list-style-type: none"> <li>a) devise and plan experimental and investigative activities, selecting appropriate techniques</li> <li>b) demonstrate safe and skilful practical techniques</li> <li>c) make observations and measurements with appropriate precision and record these methodically</li> <li>d) interpret, explain, evaluate and communicate the results of their own and others' experimental and investigative activities, in appropriate contexts.</li> </ol>

## 8

**INTERNAL ASSESSMENT GUIDELINES**

In the AS year the practical chemistry assessments are designed to address areas of the subject requiring more quantitative treatment than that usually used at GCSE, and as a consequence more emphasis is placed on proficiency in particular techniques. In the A2 year, when candidates have acquired a fuller base in both theory and experiment, the subject material is necessarily somewhat more demanding, and greater opportunities are provided for more significant planning and evaluation by the candidates.

***Number and Nature of Assessments*****AS**

Candidates will be required to undergo **two** assessments of their ability in practical chemistry.

Each experiment will be equally weighted.

**A level GCE**

Candidates will be required to undergo **two** assessments of their ability in practical chemistry.

One experiment should be selected covering each of the broad areas of inorganic chemistry and organic chemistry and the associated physical principles in the A2 year. The experimental and investigative activities will include opportunities to draw together knowledge and understanding and skills from across the full AS/A specification in a synoptic manner. Both experiments will be equally weighted.

For both AS and A2, centres are to supply work which is taken from exemplars and associated mark schemes issued by WJEC, a modification of these or centre-devised exercises of the same standard.

Where centres choose to mark the work, a sample must be submitted to WJEC for moderation by the date given in the *Examination Timetables* booklet.

Alternatively, centres can submit the work to WJEC for marking by the date given in the *Examination Timetables* booklet.

In the case of centre-devised or modified exercises, fully detailed experiments, mark schemes and skill area analysis must be forwarded to the AS/A level Section at the WJEC by the 31<sup>st</sup> of October in the year immediately preceding the AS/A award.

**Timing of Assessments**

No strict time limit is envisaged.

Candidates may be assessed at any time during the course, in accordance with the following considerations and requirements:

- candidates must be given an opportunity to acquire a given skill before they are assessed;
- it is not necessary to assess all candidates at the centre in the same sessions nor need the same exercises be used;
- the date of submission of marks will be in early May of the year of examination. This date will be printed each year in the *Examination Timetables* booklet.

### Repeated assessment

A candidate can present a specific experiment for assessment once only, and not improve the standard by repeated presentation for assessment.

Repetition of the same experiment should only be allowed in the case of either faulty equipment or chemicals, which have affected the candidate(s) results.

When a candidate is allowed to repeat an experiment, both the original and the repeated scripts should be retained, (and sent, if so required, for moderation) together with an explanation of the problems encountered.

### For centre-marked practical work, the following arrangements apply:

The Board will issue, to each centre, forms AS TMI CH3 and A2 TMI CH6 (see Appendix).

- AS TMI CH3 (AS) is for the recording of the marks gained in each exercise by each candidate entered for assessment unit CH3. A2 TMI CH6 (A2) is for the recording of marks gained in each exercise by each candidate entered for assessment unit CH6. Each candidate's final work mark is to be submitted as a total mark gained by two exercises in the case of assessment unit CH3 (AS) and a total mark gained by two exercises in the case of unit CH6 (A2).  
Estimated marks are not allowed under any circumstances.
- AS TMI CH3 (AS) and A2 TMI CH6 (A2) are to be submitted to the moderator by the date printed each year in the *Examinations Timetables* booklet.

NOTE: Within a scheme of internal work it should be possible, under normal circumstances, to accommodate for occasional absence by offering an alternative opportunity for assessment.

- Authentication

The teacher is required to sign AS TMI CH3 (AS) and/or A2 TMI CH6 (A2) on which the candidate's marks are recorded, in order to authenticate the work to be each candidate's own work and to verify that all readings or measurements recorded were made by that particular candidate.

To be able to so authenticate work, all the work must have been carried out under centre supervision and the teacher must, at all other times, have retained the scripts.

Where it has been necessary to supply assistance to an individual candidate, this must be recorded on the candidate's work, by the supervisor, and marks deducted accordingly. At the start of the course, candidates must be informed of the WJEC regulations concerning malpractice.

Each candidate is required to sign a coversheet for each exercise to state that the work is his/her own.

### **Retention of work**

Centres should retain candidates' work until after the results of the examination are published and any appeals have been completed.

### **Re-use of marks**

- Enhanced performance for Units CH3 (AS) and CH6 (A2):

In the case of candidates re-entering the examination in the year immediately following their first attempt, centres must submit for AS two and A2 two assessments. These must include one or two new assessments at AS and one or two new assessments in the case of A2.

### **Candidates in specific circumstances**

- Centre transfer: The record of practical work done by candidates transferring centres during the course should be obtained from the original centre, and the work re-marked, if necessary, for internal moderation.
- Candidates in special circumstances: The centre should complete the prescribed form for candidates who have disabilities or who may merit special consideration for other reasons.
- Other cases: Centres with candidates whose circumstances differ from those above should communicate with the Board as soon as possible.

## **MODERATION**

### **Objective**

The purpose of moderation is to ensure that the assessments carried out locally are brought to a common standard across all centres.

### **Preliminary internal moderation**

In centres where more than one teacher is involved in assessment, preliminary internal moderation to ensure a common standard for the centre must be carried out before the marks are submitted to the Board. This can be done by the trial marking of common pieces of work and the use of reference and archive materials. **The rank order** of candidates supplied on AS TMI CH3 (AS) and A2 TMI CH6 (A2) must be that for **the centre as a whole**.

### Submission to the Moderator

Centres will be informed of the name and address of the moderator to whom the following items should be sent:

- the completed form(s) AS TMI CH3 (AS) and/or A2 TMI CH6 (A2), with the **candidates in the sample highlighted**;
- full details of the assessed experiments; \*
- marking schemes; \*
- teacher results for experiments involving quantitative data;
- **all** the original marked work of a **sample** of candidates including the date(s) on which it was carried out. The allocation of each mark in each experiment must be clearly discernible on each candidate's work.

\* the experiments and marking schemes **must** have received written approval from the WJEC by the 31<sup>st</sup> of October in the year immediately preceding the AS/A award.

The selection of candidates' work in the sample must be as stated in the *GCE AS/A Internal Assessment* Booklet of the WJEC.

The date by which the above items must be submitted to the moderator will be printed each year in the *Examination Timetables* booklet.

### Inspection of the marked sample of work

The moderator will inspect the marked sample of work and only if the sample does not accord with the principles and requirements of the Board will the centre be required to submit the work of all its candidates. In such a case, it is possible that all the marks at the centre will need adjustment.

### Inspection of candidates' work

Centres are required to send **all** the **assessed** practical work of a **sample** of its candidates to the moderator. It is essential that the work of each candidate bears the relevant cover sheet, TMI CH3 (AS) or TMI CH6 (A2) (see Appendix), with the following information clearly displayed:

- \* the candidate's name;
- \* the candidate's number;
- \* the centre name;
- \* the centre number;
- \* a declaration, signed by the candidate and teacher to the effect that the work, and any readings or measurements taken, are the candidate's own.

In addition, to assist the moderation process, the work should be grouped by candidate (not by experiment).

### Amended marks

If any marks submitted by a centre have been amended, the centre will be informed of the changes and will receive a report submitted by the moderator. The moderator may also wish to draw the attention of other centres to aspects of their assessments. If no comments are received by the centre, it may be assumed that the assessment was satisfactory.

### Return of work

All the materials submitted for **moderation** by the centre will be returned early in the Autumn term following the examination.

## Guidance on devising internal assessment tasks

### Rationale

It is intended that candidates experience as wide a range of meaningful practical activity as can be reasonably expected at this level.

Assessments should be devised in such a way that their combination reflects this diversity.

Assessments should be based around the essential skills of Planning, Implementing, Analysing and Evaluating, with a raw mark total of 30 marks, such that the breakdown into assessment objectives is AO1 – 3 marks, AO2 – 3 marks and AO3 – 24 marks.

QWC should be integrated into each assessment.

### AS internal assessments

All candidates must complete **two** AS internal assessments, each with a raw mark total of 30 (see above).

The assessments should be taken from the areas of **quantitative analysis and stoichiometry, thermochemistry** or **kinetics** and should be based around quantitative measurement such that the raw mark breakdown is approximately as follows:

Planning [5]; Implementing [15]; Analysing [5]; Evaluating [5].

The 3 AO1 and 3 AO2 marks should be part of the *Planning* and *Evaluating* sections (see WJEC exemplars for guidance).

A detailed mark scheme should be prepared, indicating where the AO1 and AO2 marks are allocated. Please see the mark schemes of the WJEC set tasks for examples.

### A2 internal assessments

All candidates must complete **two** A2 internal assessments, each with a raw mark total of 30 (see above).

The tasks must be selected so that

- one is based on **organic** chemistry and the other on **inorganic** chemistry (and any associated physical chemistry in each case);
- to ensure a broad experience for the candidate, one task should involve the preparation and analysis of a compound and one should involve devising and applying a procedure to identify several unknowns.

#### 1. Tasks involving preparation and analysis of a compound

The allocation of marks should be approximately as follows:

Planning [5]; Implementing [15]; analysing [5]; Evaluating [5].

The bulk of the *Implementing* marks should be for the quality of the measurements taken, e.g., titres for inorganic tasks or melting temperature and % yield for organic tasks, which should be marked on a sliding scale (see WJEC exemplars O1 and I1 for guidance).

2. **Tasks involving planning and carrying out procedures to identify unknowns**

The allocation of marks should be approximately as follows:

Planning [9]; Implementing [6]; Analysing [12]; Evaluating [3].

**It is essential that different candidates are given different unknowns from a list or that those given are labelled differently for each candidate.**

In these tasks, the emphasis is on planning an efficient and suitable procedure and identifying the unknowns by drawing correct inferences from observations made (see WJEC exemplars O2 and I2 for guidance).

**N.B. For this type of assessment, centres should not repeat the same task in consecutive years at A2.**

For each task, a detailed mark scheme should be prepared, indicating where the AO1 and AO2 marks are allocated. Please see the mark schemes of the WJEC set tasks for examples.

The 3 AO1 and 3 AO2 marks should be part of the *Planning* and *Evaluating* sections (see WJEC exemplars for guidance).

**General**

Centres contemplating devising internal assessment tasks are encouraged to contact WJEC for advice during their development.

**For practical work marked by WJEC, the following arrangements apply:**

Centres are required to send **all** the practical work its candidates to the marker. It is essential that the work of each candidate bears the relevant cover sheet, BMI CH3 (AS) or BMI CH6 (A2) (see Appendix), with the following information clearly displayed:

- \* the candidate's name;
- \* the candidate's number;
- \* the centre name;
- \* the centre number;
- \* a declaration, signed by the candidate and teacher to the effect that the work is the candidate's own including any readings taken or observations made.

The two assessments for each candidate and the relevant cover sheet should be attached to each other by means of a treasury tag at the top left-hand corner. All the work of all candidates should then be sent.

Centres will be informed of the name and address of the marker.

## Information Technology

Practical work offers the opportunity for centres, to encourage candidates to use information technology. In the case of assessed exercises this could be up to one experiment for AS and one experiment for A2. The candidate would be expected to comment on the limitations of any software used.

When a Word Processing package is used, e.g., in order to improve presentation, all the candidate's original work, done under supervised conditions, should be retained and sent, if so required, by the sampling process for moderation.

## Safety and Hazardous Substances

**Supervisors must, of course, themselves ensure safe working procedures are always followed and that all practical work fulfils the requirements of the COSHH regulations and the Health and Safety at Work Act.**

Attention is drawn to the publication, *Control of Substances Hazardous to Health (COSHH): Guidance to Schools* [ISBN 0 11 885511 5] published by the Health and Safety Commission, and available from HMSO and other booksellers. This booklet is published to help employers and managers in the school sector understand and apply the responsibilities they are assuming under current safety legislation; it contains an appendix of references. There are a number of publications, including one published by The Royal Society of Chemistry, available from booksellers and libraries for all users of chemicals. The following are cited as useful in dealing with specific substances and situations likely to be encountered in educational establishments:

*Safety in Science Education* DfEE 1996 HMSO [ISBN 0 11 270915X].

*Topics in Safety* (2nd edition) [ISBN 0 86357 104 2] from the Association for Science Education, College Lane, Hatfield, Herts AL10 9AA.

*Hazards* from CLEAPSS, Brunel University, Kingston Lane, Uxbridge UB8 3PH.

## APPENDIX

### Appendix 1: Mathematical content for Chemistry

- 1 In order to be able to develop their skills, knowledge and understanding in science, students need to have been taught, and to have acquired competence in, the appropriate areas of mathematics relevant to the subject as indicated in the table in 7 below.
- 2 Arithmetic and numerical computation
  - (a) recognise and use expressions in decimal and standard form
  - (b) use ratios, fractions and percentages
  - (c) make estimates of the results of calculations (without using a calculator)
  - (d) use calculators to find and use power, exponential and logarithmic functions
- 3 Handling data
  - (a) use an appropriate number of significant figures
  - (b) find arithmetic means
- 4 Algebra
  - (a) understand and use the symbols: =, <, <<, >>, ∞, ~
  - (b) change the subject of an equation
  - (c) substitute numerical values into algebraic equations using appropriate units for physical quantities
  - (d) solve simple algebraic equations
  - (e) use logarithms in relation to quantities which range over several orders of magnitude.
- 5 Graphs
  - (a) translate information between graphical, numerical and algebraic forms
  - (b) plot two variables from experimental or other data
  - (c) understand that  $y = mx + c$  represents a linear relationship
  - (d) determine the slope and intercept of a linear graph
  - (e) calculate rate of change from a graph showing a linear relationship
  - (f) draw and use the slope of a tangent to a curve as a measure of rate of change
- 6 Geometry and trigonometry
  - (a) appreciate angles and shapes in regular 2-D and 3-D structures
  - (b) visualise and represent 2-D and 3-D forms including two-dimensional representations of 3-D objects
  - (c) understand the symmetry of 2-D and 3-D shapes





WELSH JOINT EDUCATION COMMITTEE  
General Certificate of Education  
Advanced Subsidiary 200...

CYD-BWYLLGOR ADDYSG CYMRU  
Tystysgrif Addysg Gyffredinol  
Uwch Gyfrannol 200...

**AS CHEMISTRY  
ASSESSMENT UNIT CH3**

**TMI CH3**

**CANDIDATE COVER SHEET  
TEACHER MARKED INTERNAL ASSESSMENT 200....**

Centre Name: ..... Centre Number: .....

Candidate's Name(in full): ..... Candidate Number: .....

Title of Experiment (in brief)	Mark	
		<b>TOTAL MARK</b>

Teacher marked AS internal assessment **must** consist of **two** experiments **only**, which have been **previously approved by WJEC**. These two experiments should be **attached** behind the cover sheet using *toggles/treasury tags*. *Plastic wallets should **not** be used.*

**NOTICE TO CANDIDATE**

The work you submit for assessment must be your own.

**If you copy from someone else, allow another candidate to copy from you, or if you cheat in any other way, you may be disqualified from at least the subject concerned.**

**Declaration by candidate**

I have read and understood the **Notice to Candidate** (above). I have produced the attached work without assistance other than that which my teacher has explained is acceptable within the specification.

**Candidate's signature:**

.....

**Date:**

.....

**Declaration by teacher**

I confirm that the candidate's work was conducted under the conditions laid out by the specification.

I have authenticated the candidate's work and am satisfied that to the best of my knowledge the work produced is solely that of the candidate including any readings taken or observations made.

**Teacher's signature:**

.....

**Date:**

.....

A2 CHEMISTRY  
ASSESSMENT UNIT CH6

TMI CH6

CANDIDATE COVER SHEET  
TEACHER MARKED INTERNAL ASSESSMENT 200....

Centre Name: \_\_\_\_\_ Centre Number: \_\_\_\_\_

Candidate's Name(in full): \_\_\_\_\_ Candidate Number: \_\_\_\_\_

	Title of Experiment (in brief)	Mark	
Inorganic			
Organic			
			<b>TOTAL MARK</b>

Teacher marked A2 internal assessment **must** consist of **two** experiments **only**, which have been **previously approved by WJEC**. These two experiments should be **attached** behind the cover sheet using *toggles/treasury tags*. *Plastic wallets should **not** be used.*

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Candidate's signature: \_\_\_\_\_

Date: \_\_\_\_\_

**Declaration by teacher**

I confirm that the candidate's work was conducted under the conditions laid out by the specification.

I have authenticated the candidate's work and am satisfied that to the best of my knowledge the work produced is solely that of the candidate including any readings taken or observations made.

Teacher's signature: \_\_\_\_\_

Date: \_\_\_\_\_

WELSH JOINT EDUCATION COMMITTEE  
General Certificate of Education  
Advanced Subsidiary 200...

CYD-BWYLLGOR ADDYSG CYMRU  
Tystysgrif Addysg Gyffredinol  
Uwch Gyfrannol 200...

**AS CHEMISTRY  
ASSESSMENT UNIT CH3**

**BMI CH3**

**CANDIDATE COVER SHEET  
WJEC MARKED INTERNAL ASSESSMENT 200....**

Centre Name: ..... Centre Number: .....

Candidate's Name(in full): ..... Candidate Number: .....

Title of Experiment (in brief)	Mark Examiner use only	
		<b>TOTAL MARK</b>

WJEC marked AS internal assessment **must** consist of **two** experiments **only**, which have been **previously approved by WJEC**. These two experiments should be **attached** behind the cover sheet *using toggles/treasury tags*. *Plastic wallets should **not** be used.*

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**Date:**

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**Teacher's signature:**

.....

**Date:**

.....

A2 CHEMISTRY  
ASSESSMENT UNIT CH6

BMI CH6

CANDIDATE COVER SHEET  
WJEC MARKED INTERNAL ASSESSMENT 200....

Centre Name: \_\_\_\_\_ Centre Number: \_\_\_\_\_

Candidate's Name(in full): \_\_\_\_\_ Candidate Number: \_\_\_\_\_

	Title of Experiment (in brief)	Mark Examiner use only
Inorganic		
Organic		
		<b>TOTAL MARK</b>

WJEC marked A2 internal assessment **must** consist of **two** experiments **only**, which have been **previously approved by WJEC**. These two experiments should be **attached** behind the cover sheet *using toggles/treasury tags*. *Plastic wallets should **not** be used.*

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**Declaration by candidate**

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Candidate's signature: .....

Date: .....

**Declaration by teacher**

I confirm that the candidate's work was conducted under the conditions laid out by the specification.

I have authenticated the candidate's work and am satisfied that to the best of my knowledge the work produced is solely that of the candidate including any readings taken or observations made.

Teacher's signature: .....

Date: .....