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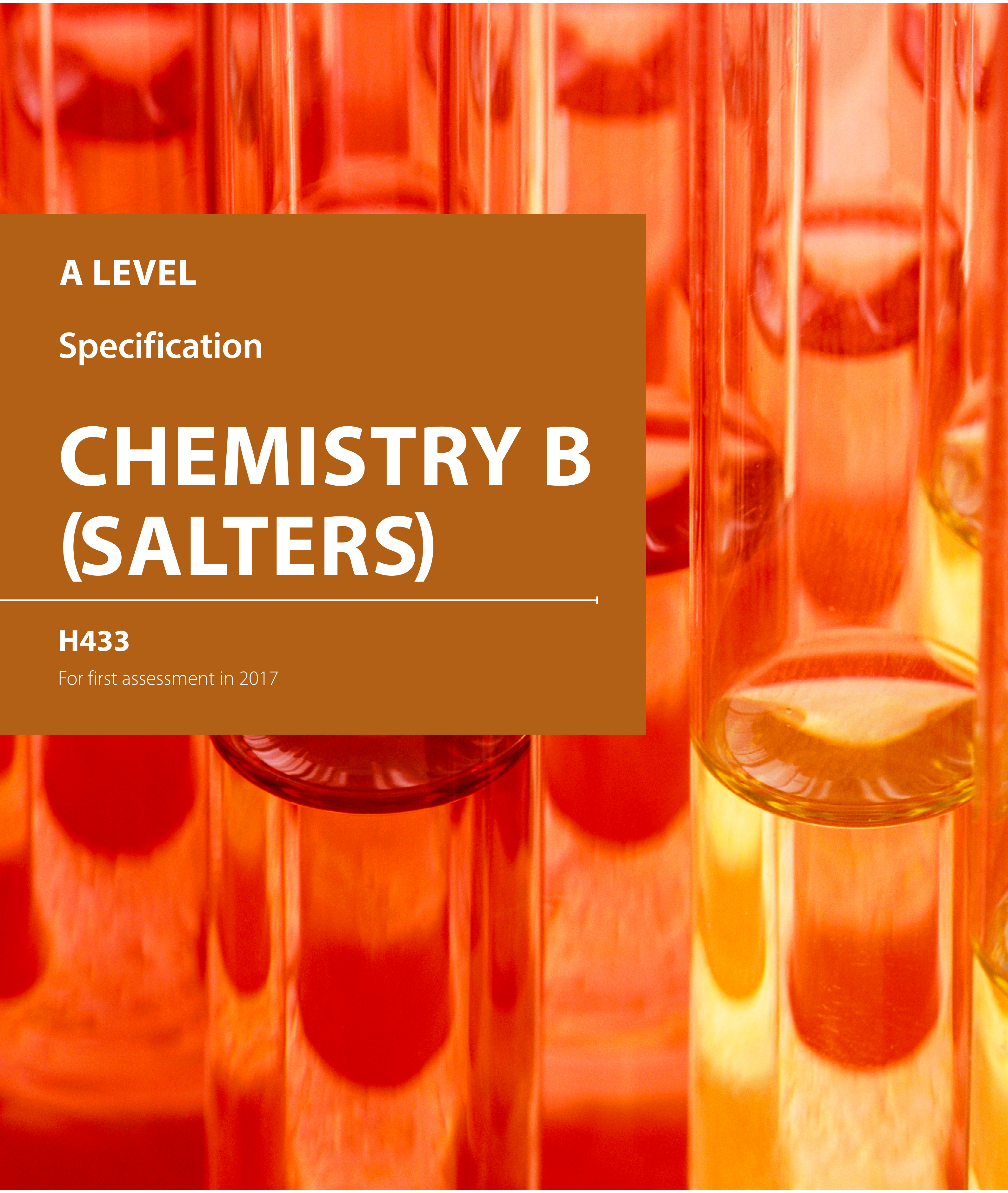

A LEVEL

Specification

CHEMISTRY B (SALTERS)

H433

For first assessment in 2017

Version 2.9 (March 2024)

Disclaimer

Specifications are updated over time. Whilst every effort is made to check all documents, there may be contradictions between published resources and the specification, therefore please use the information on the latest specification at all times. Where changes are made to specifications these will be indicated within the document, there will be a new version number indicated, and a summary of the changes. If you do notice a discrepancy between the specification and a resource please contact us at: resources.feedback@ocr.org.uk

We will inform centres about changes to specifications. We will also publish changes on our website. The latest version of our specifications will always be those on our website (ocr.org.uk) and these may differ from printed versions.

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Contents

Introducing…
A Level Chemistry B (Salters) (from September 2015)

Chemistry B (Salters) was first examined in 1992 as a new concept project examination. In contrast to the traditional 'topic-based' approach, Chemistry B (Salters) is 'context-led'. Chemical concepts are introduced within a relevant context, the course being written as a series of teaching modules based on contemporary issues in chemistry. Students study the chemistry in a spiral way so that chemical ideas, introduced in an early topic, are reinforced later. The 'drip-feed' approach to teaching and learning chemical principles allows candidates to revisit a particular topic several times during the course, each time taking their knowledge and understanding a step further.

Practical work done to support teaching of the content will serve to cover the requirements of the practical skills module (Module 1), which is assessed in written examinations and through the Practical Endorsement. Suitable supporting practical work is cross-referenced from appropriate learning outcomes throughout the specification. Additionally, cross-references are included to the mathematical criteria that are embedded in the assessment.

This Chemistry B (Salters) specification is supported by extensive new materials developed by the University of York Science Education Group.

This specification incorporates the Ofqual GCE Subject Level Conditions and Requirements for Chemistry.

Contact the team

We have a dedicated team of people working on our A Level Chemistry qualifications.

If you need specialist advice, guidance or support, get in touch as follows:

- **01223 553998**
- **scienceGCE@ocr.org.uk**
- **@OCR_science**

Teaching and learning resources

We recognise that the introduction of a new specification can bring challenges for implementation and teaching. Our aim is to help you at every stage and we're working hard to provide a practical package of support in close consultation with teachers and other experts, so we can help you to make the change.

Designed to support progression for all

Our resources are designed to provide you with a range of teaching activities and suggestions so you can select the best approach for your particular students. You are the experts on how your students learn and our aim is to support you in the best way we can.

We want to…

- Support you with a body of knowledge that grows throughout the lifetime of the specification
- Provide you with a range of suggestions so you can select the best activity, approach or context for your particular students
- Make it easier for you to explore and interact with our resource materials, in particular to develop your own schemes of work
- Create an ongoing conversation so we can develop materials that work for you.

Plenty of useful resources

You'll have four main types of subject-specific teaching and learning resources at your fingertips:

- Delivery Guides
- Transition Guides
- Topic Exploration Packs
- Lesson Elements.

Along with subject-specific resources, you'll also have access to a selection of generic resources that focus on skills development and professional guidance for teachers.

Skills Guides – we've produced a set of Skills Guides that are not specific to Chemistry, but each covers a topic that could be relevant to a range of qualifications – for example, communication, legislation and research. Download the guides at ocr.org.uk/skillsguides

Active Results – a free online results analysis service to help you review the performance of individual students or your whole school. It provides access to detailed results data, enabling more comprehensive analysis of results in order to give you a more accurate measurement of the achievements of your centre and individual students. For more details refer to ocr.org.uk/activeresults

Professional Development

Take advantage of our improved Professional Development Programme, designed with you in mind. Whether you want to come to face-to-face events, look at our new digital training or search for training materials, you can find what you're looking for all in one place at the CPD Hub.

An introduction to the new specifications:

We'll be running events to help you get to grips with our A Level Chemistry B (Salters) qualification.

These events are designed to help prepare you for first teaching and to support your delivery at every stage.

Watch out for details at **cpdhub.ocr.org.uk**.

To receive the latest information about the training we'll be offering, please register for A Level email updates at **ocr.org.uk/updates**.

1 Why choose an OCR A Level in Chemistry B (Salters)?

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1a. Why choose an OCR qualification?

Choose OCR and you've got the reassurance that you're working with one of the UK's leading exam boards. Our new A Level in Chemistry B (Salters) course has been developed in consultation with teachers, employers and Higher Education to provide students with a qualification that's relevant to them and meets their needs.

We're part of the Cambridge Assessment Group, Europe's largest assessment agency and a department of the University of Cambridge. Cambridge Assessment plays a leading role in developing and delivering assessments throughout the world, operating in over 150 countries.

We work with a range of education providers, including schools, colleges, workplaces and other institutions in both the public and private sectors. Over 13,000 centres choose our A levels, GCSEs and vocational qualifications including Cambridge Nationals and Cambridge Technicals.

Our Specifications

We believe in developing specifications that help you bring the subject to life and inspire your students to achieve more.

We've created teacher-friendly specifications based on extensive research and engagement with the teaching community. They're designed to be straightforward and accessible so that you can tailor the delivery of the course to suit your needs. We aim to encourage learners to become responsible for their own learning, confident in discussing ideas, innovative and engaged.

We provide a range of support services designed to help you at every stage, from preparation through to the delivery of our specifications. This includes:

- A wide range of high-quality creative resources including:
    - delivery guides
    - transition guides
    - topic exploration packs
    - lesson elements
    - …and much more.
- Access to Subject Advisors to support you through the transition and throughout the lifetime of the specification.
- CPD/Training for teachers to introduce the qualifications and prepare you for first teaching.
- Active Results – our free results analysis service to help you review the performance of individual students or whole schools.
- **ExamBuilder** – our new online past papers service that enables you to build your own test papers from past OCR exam questions.

All A level qualifications offered by OCR are accredited by Ofqual, the Regulator for qualifications offered in England. The accreditation number for OCR's A Level in Chemistry B (Salters) is QN: 601/5371/4.

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1b. Why choose an OCR A Level in Chemistry B (Salters)?

We appreciate that one size doesn't fit all so we offer two suites of qualifications in each science:

Chemistry A – a content-led approach. A flexible approach where the specification is divided into topics, each covering different key concepts of chemistry. Teaching of practical skills is integrated with the theoretical topics and they're assessed both through written papers and, for A level only, the Practical Endorsement.

Chemistry B (Salters) – a context-led approach. Learners study chemistry in a range of different contexts, conveying the excitement of contemporary chemistry. Ideas are introduced in a spiral way with topics introduced in an early part of the course reinforced later. The 'B' specification places a particular emphasis on an investigational and problem-solving approach to practical work and is supported by extensive new materials developed by the University of York Science Education Group.

All of our specifications have been developed with subject and teaching experts. We have worked in close consultation with teachers and representatives from Higher Education (HE) with the aim of including up-to-date relevant content within a framework that is interesting to teach and administer within all centres (large and small).

Our new A Level in Chemistry B (Salters) qualification builds on our existing popular course. We've based the redevelopment of our A level sciences on an understanding of what works well in centres large and small and have updated areas of content and assessment where stakeholders have identified that improvements could be made. We've undertaken a significant amount of consultation through our science forums (which include representatives from learned societies, HE, teaching and industry) and through focus groups with teachers. Our papers and specifications have been trialled in centres during development to make sure they work well for all centres and learners.

The content changes are an evolution of our legacy offering and will be familiar to centres already following our courses, but are also clear and logically laid out for centres new to OCR, with assessment models that are straightforward to administer. We have worked closely with teachers and HE representatives to provide high quality support materials to guide you through the new qualifications.

Aims and learning outcomes

OCR's A Level in Chemistry B (Salters) specification aims to encourage learners to:

- develop essential knowledge and understanding of different areas of the subject and how they relate to each other
- develop and demonstrate a deep appreciation of the skills, knowledge and understanding of scientific methods
- develop competence and confidence in a variety of practical, mathematical and problem solving skills
- develop their interest in and enthusiasm for the subject, including developing an interest in further study and careers associated with the subject
- understand how society makes decisions about scientific issues and how the sciences contribute to the success of the economy and society (as exemplified in 'How Science Works' (HSW)).

1c. What are the key features of this specification?

Our Chemistry B (Salters) specification has been designed so learners study chemistry in a range of different contexts, conveying the excitement of contemporary chemistry. The specification relates modern-day applications of chemistry and current research to the concepts needed for the study of chemistry at A Level.

The specification is structured in a series of teaching modules that allow the concepts to unfold throughout the course. Each module is intended to be taught through a chemical 'storyline'. The storylines address topics such as the use and development of fuels, and the use of metals in a wide range of applications including in medicines.

These storylines provide a structure in which to teach the chemical concepts that form the assessable content of the specification. Each storyline brings together concepts from different areas of chemistry, which allows the interconnections between these areas to become clear. As the course progresses, concepts are revisited and built upon in a range of different contexts.

Additionally, the Chemistry B (Salters) specification is designed to stimulate a wide range of practical work. Most storylines offer multiple opportunities for practical work that will help to illustrate the chemical concepts.

A learner of Chemistry B (Salters) will become familiar with exploring key chemistry ideas in a range of contexts. They are able to link chemical concepts together and develop their understanding behind the chemical content within these contexts. Questions within the assessments will be set in unfamiliar contexts, but due to the experience of learning in a range of contexts learners will be comfortable in the application of their chemical knowledge.

The Chemistry B (Salters) A Level specification requires learners to practise and demonstrate their chemical literacy skills. The ability to extract and manipulate data, interpret and use information and show comprehension by written communication with regard to logical presentations and the correct use of appropriate technical terms are important transferable skills. These skills are assessed across the written components of the assessment, with a particular focus on these skills in Component 02.

The specification:

- has ideas that are introduced within a spiral curriculum structure – topics introduced in an early part of the course and reinforced later
- continues to place a particular emphasis on the development of practical skills and chemical literacy
- is laid out clearly in a series of teaching modules with Additional guidance added where required to clarify assessment requirements
- is structured to allow the teaching modules to be taught through chemical 'storylines' that link the specification content with a wide range of contexts
- is co-teachable with the AS level
- embeds practical requirements within the teaching modules
- identifies Practical Endorsement requirements and how these can be integrated into teaching of content (see Section 5h)
- exemplifies the mathematical requirements of the course (see Section 5d)
- highlights opportunities for the introduction of key mathematical requirements (see Section 5e and the Additional guidance column for each module) into your teaching.

The Chemistry B (Salters) course is fully supported by a dedicated support package written and developed by the University of York Science Education Group, in collaboration with OCR and with sponsorship from the Salters' Institute of industrial chemistry.

Teacher support

The extensive support offered alongside this specification includes:

- **delivery guides** – providing information on assessed content, the associated conceptual development and contextual approaches to delivery
- **transition guides** – identifying the levels of demand and progression for different key stages for a particular topic and going on to provide links to high quality resources and 'checkpoint tasks' to assist teachers in identifying learners 'ready for progression'
- **lesson elements** – written by experts, providing all the materials necessary to deliver creative classroom activities
- **Active Results** (see Section 1a)
- **ExamBuilder** (see Section 1a)
- **mock examinations service** – a free service offering a practice question paper and mark scheme (downloadable from a secure location).

Along with:

- Subject Advisors within the OCR science team to help with course queries
- teacher training
- *Science Spotlight* (our termly newsletter)
- OCR Science community
- a consultancy service (to advise on Practical Endorsement requirements)
- Practical Skills Handbook
- Maths Skills Handbook.

1d. How do I find out more information?

Whether new to our specifications, or continuing on from our legacy offerings, you can find more information on our webpages at: **www.ocr.org.uk**

Visit our subject pages to find out more about the assessment package and resources available to support your teaching. The science team also release a termly newsletter *Science Spotlight* (despatched to centres and available from our subject pages).

Find out more?

Contact the Subject Advisors:

ScienceGCE@ocr.org.uk, 01223 553998.

Visit our Online Support Centre at **support.ocr.org.uk**

Check what CPD events are available: **www. cpdhub.ocr.org.uk**

Follow us on Twitter: **@OCR_science**

2 The specification overview

2a. Overview of A Level in Chemistry B (Salters) (H433)

Learners must complete all components (01, 02, 03 and 04) to be awarded the OCR A Level in Chemistry B.

Content Overview	Assessment Overview	
Development of practical skills in chemistry (Section 2c) **Storylines (Section 2d)** • Elements of life • Developing fuels • Elements from the sea • The ozone story • What's in a medicine? • The chemical industry • Polymers and life • Oceans • Developing metals • Colour by design **Chemical literacy (Section 2e)** **Practical Endorsement** See Section 2c, Section 5h and the Practical Skills Handbook.	Fundamentals of chemistry (01) 110 marks 2 hours 15 minutes written paper	**41%** of total A level
	Scientific literacy in chemistry (02) 100 marks 2 hours 15 minutes written paper	**37%** of total A level
	Practical skills in chemistry (03) 60 marks 1 hour 30 minutes written paper	**22%** of total A level
	Practical Endorsement in chemistry (04) (non exam assessment)	**Reported separately** (see section 5)

All components include synoptic assessment.

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2b. Content of A Level in Chemistry B (Salters) (H433)

The A Level in Chemistry B (Salters) specification content is divided into three sections (Section 2c, 2d and 2e). An overview of the context is provided at the start of each storyline in Section 2d along with a summary of the chemistry it contains. The assessable content is divided into two columns: **Learning outcomes** and **Additional guidance**.

The Learning outcomes in Sections 2c, 2d and 2e may all be assessed in the examinations (with the exception of some of the skills in module **1.2** which will be assessed directly through the Practical Endorsement). The Additional guidance column is included to provide further advice on delivery and the expected skills required from learners.

The details of the storyline contexts, where not directly related to the Learning outcomes, do not form part of the assessable content. These contexts are provided as a coherent and engaging teaching sequence, allowing the specification content to be covered in a way that integrates the various aspects of chemistry and relates the subject to modern applications and everyday experience. Learners will be expected to be able to apply their understanding of chemistry to unfamiliar contexts in the assessments.

References to HSW (Section 5) are included in the guidance to highlight opportunities to encourage a wider understanding of science.

The mathematical requirements in Section 5 are also referenced by the prefix M to link the mathematical skills required for A Level Chemistry to examples of chemistry content where those mathematical skills could be linked to learning.

The specification has been designed to be co-teachable with the standalone AS Level Chemistry B (Salters) qualification. Section 2c (1.1) and the first five teaching modules (in Section 2d) comprise the AS Level Chemistry B (Salters) course and learners studying the A level continue with the content of the additional five teaching modules and Section 2e (Chemical literacy). The internally assessed Practical Endorsement skills also form part of the full A Level (see Section 2c, 1.2).

A summary of the content for the A level course is as follows:

Section 2c – Development of practical skills in chemistry

- Practical skills assessed in a written examination
- Practical skills assessed in the practical endorsement

Section 2d – Storylines

- Elements of life
- Developing fuels
- Elements from the sea
- The ozone story
- What’s in a medicine?
- The chemical industry
- Polymers and life
- Oceans
- Developing metals
- Colour by design

Section 2e – Chemical literacy

Assessment of practical skills and the Practical Endorsement

Section 2c of the specification content relates to the practical skills learners are expected to gain throughout the course, which are assessed throughout the written examinations and also through the Practical Endorsement (see Section 5).

Practical activities are embedded within the learning outcomes in the teaching modules in Section 2d (Storylines). Suggestions for practical work are also highlighted in the additional guidance (italics) to encourage practical activities in the laboratory which contribute to the achievement of the Practical Endorsement (see Section 5h) as well as enhancing learners' understanding of chemical theory and practical skills.

Opportunities for carrying out activities that could count towards the Practical Endorsement are indicated throughout the specification. These are shown in the additional guidance column as **PAG1** to **PAG11** (Practical Activity Group, see Section 5h). There are a wide variety of opportunities to assess **PAG12** throughout the qualification.

Assessment of chemical literacy

Section 2e of the specification content relates to the chemical literacy skills learners are expected to gain throughout the course. These skills will be assessed throughout the written examinations. Learners will be expected to demonstrate the ability to extract and use data and information from sources, including those set in unfamiliar contexts. Additionally, learners should be able to demonstrate the understanding through appropriate written communication.

Opportunities to develop chemical literacy skills exist throughout the course. Development of these skills should feature in the teaching and learning of all areas of the specification.

2c. Development of practical skills in chemistry

Module 1: Development of practical skills in chemistry

Chemistry is a practical subject and the development of practical skills is fundamental to understanding the nature of chemistry. Chemistry B gives learners many opportunities to develop the fundamental skills needed to collect and analyse empirical data. Skills in planning, implementing, analysing and evaluating, as outlined in 1.1, will be assessed in the written papers.

2

1.1 Practical skills assessed in a written examination

Practical skills are embedded throughout all the content of this specification. Suggestions for practical activities are highlighted within Section 2d (Storylines) of the specification in the additional guidance (italics).

Learners will be required to develop a range of practical skills throughout the course in preparation for the written examinations.

1.1.1 Planning

	Learning outcomes	Additional guidance
	Learners should be able to demonstrate and apply their knowledge and understanding of:	
(a)	experimental design, including to solve problems set in a practical context	Including selection of suitable apparatus, equipment and techniques for the proposed experiment. Learners should be able to apply scientific knowledge based on the content of the specification to the practical context. HSW3
(b)	identification of variables that must be controlled, where appropriate	
(c)	evaluation that an experimental method is appropriate to meet the expected outcomes.	HSW6

1.1.2 Implementing

	Learning outcomes	Additional guidance
	Learners should be able to demonstrate and apply their knowledge and understanding of:	
(a)	how to use a wide range of practical apparatus and techniques correctly	As outlined in the Storylines content of the specification (Section 2d) and the skills required for the Practical Endorsement. HSW4
(b)	appropriate units for measurements	*M0.0*
(c)	presenting observations and data in an appropriate format.	HSW8

1.1.3 Analysis

	Learning outcomes	Additional guidance
	Learners should be able to demonstrate and apply their knowledge and understanding of:	
(a)	processing, analysing and interpreting qualitative and quantitative experimental results	Including reaching valid conclusions, where appropriate. HSW5
(b)	use of appropriate mathematical skills for analysis of quantitative data	Refer to Section 5 for a list of mathematical skills that learners should have acquired competence in as part of the course. HSW3
(c)	appropriate use of significant figures	*M1.1*
(d)	plotting and interpreting suitable graphs from experimental results, including:	*M3.2*
	(i) selection and labelling of axes with appropriate scales, quantities and units	
	(ii) measurement of gradients and intercepts.	*M3.3, M3.4, M3.5*

1.1.4 Evaluation

	Learning outcomes	Additional guidance
	Learners should be able to demonstrate and apply their knowledge and understanding of:	
(a)	how to evaluate results and draw conclusions	HSW6
(b)	the identification of anomalies in experimental measurements	
(c)	the limitations in experimental procedures	
(d)	precision and accuracy of measurements and data, including margins of error, percentage errors and uncertainties in apparatus	*M1.3*
(e)	the refining of experimental design by suggestion of improvements to the procedures and apparatus.	HSW3

1.2 Practical skills assessed in the practical endorsement

A range of practical experiences is a vital part of a learner's development as part of this course.

Learners should develop and practise a wide range of practical skills throughout the course as preparation for the Practical Endorsement, as well as for the written examinations.

The experiments and skills required for the Practical Endorsement will allow learners to develop and practise their practical skills, preparing learners for the written examinations.

Please refer to Section 5 (the Practical Endorsement) of this specification for the list of practical experiences all learners should cover during the course. Further advice and guidance on the Practical Endorsement can be found in the Practical Skills Handbook support booklet.

2

1.2.1 Practical skills

	Learning outcomes	Additional guidance
	Practical work carried out throughout the course will enable learners to develop the following skills:	
Independent thinking		
(a)	apply investigative approaches and methods to practical work	Including how to solve problems in a practical context. HSW3
Use and application of scientific methods and practices		
(b)	safely and correctly use a range of practical equipment and materials	See Section 5. Including identification of potential hazards. Learners should understand how to minimise the risks involved. HSW4
(c)	follow written instructions	
(d)	make and record observations/measurements	HSW8
(e)	keep appropriate records of experimental activities	See Section 5.
(f)	present information and data in a scientific way	
(g)	use appropriate software and tools to process data, carry out research and report findings	*M3.1* HSW3
Research and referencing		
(h)	use online and offline research skills including websites, textbooks and other printed scientific sources of information	
(i)	correctly cite sources of information	The Practical Skills Handbook provides guidance on appropriate methods for citing information.
Instruments and equipment		
(j)	use a wide range of experimental and practical instruments, equipment and techniques appropriate to the knowledge and understanding included in the specification.	See Section 5.

1.2.2 Use of apparatus and techniques

	Learning outcomes	Additional guidance
	*Through use of the apparatus and techniques listed below, and a minimum of 12 assessed practicals (see Section 5i), learners should be able to demonstrate all of the practical skills listed within 1.2.1 and CPAC (Section 5h, **Table 2**) as exemplified through:*	
(a)	use of appropriate apparatus to record a range of measurements (to include mass, time, volume of liquids and gases, temperature)	HSW4
(b)	use of a water bath or electric heater or sand bath for heating	HSW4
(c)	measurement of pH using pH charts, or pH meter, or pH probe on a data logger	HSW4
(d)	use of laboratory apparatus for a variety of experimental techniques including: **(i)** titration, using burette and pipette **(ii)** distillation and heating under reflux, including setting up glassware using retort stand and clamps **(iii)** qualitative tests for ions and organic functional groups **(iv)** filtration, including use of fluted filter paper, or filtration under reduced pressure	HSW4
(e)	use of a volumetric flask, including accurate technique for making up a standard solution	HSW4
(f)	use of acid–base indicators in titrations of weak/strong acids with weak/strong alkalis	HSW4
(g)	purification of: **(i)** a solid product by recrystallisation **(ii)** a liquid product, including use of a separating funnel	HSW4
(h)	use of melting point apparatus	HSW4
(i)	use of thin layer or paper chromatography	HSW4
(j)	setting up of electrochemical cells and measuring voltages	HSW4
(k)	safely and carefully handling solids and liquids, including corrosive, irritant, flammable and toxic substances	HSW4

(l) measurement of rates of reaction by at least two different methods, for example: HSW4

- **(i)** an initial rate method such as a clock reaction
- **(ii)** a continuous monitoring method.

2

2d. Storylines

The content in this section is supported by the resources produced by the University of York Science Education Group (published by Oxford University Press).

The storylines in this section are structured in order to allow teaching of the assessable content in a series of contexts. The contexts are designed to be engaging, and to illustrate the relevance of chemistry in our daily lives and its role in understanding the world around us. At the beginning of each storyline, an overview is given of the intended context and how it relates to the learning outcomes listed below. These context overviews do not form part of the assessable content.

The learning outcomes and additional guidance in each module form the assessable content of the specification; learners will not be expected to recall aspects of the storyline contexts that are not referred to in the learning outcomes. In the final examinations, learners could be assessed on the content of the specification within **any** appropriate context.

Elements of life (EL)

The Big Bang theory is used to introduce the question of where the elements come from. This leads to discussion of the concepts of atomic structure, nuclear fusion, and the use of mass spectrometry to determine the relative abundance of isotopes.

Next, looking at how we study the radiation we receive from outer space provides the context for discussion of atomic spectroscopy and electronic structure. A historical approach is then used to introduce the periodic table, including the links between electronic structure and physical properties. This is followed by studying some of the molecules found in space, providing the context for introducing bonding and structure and the shapes of molecules.

The storyline then turns to chemistry found closer to home. Ideas about the elements found in the human body and their relative amounts are used to introduce the concept of amount of substance and related calculations. The bodily fluids, blood and salt then provide a basis for studying salts; this context also incorporates sea water and uses of salts such as in bath salts, lithium batteries, barium meals, hand warmers and fertilisers. This also provides the context for discussing the chemistry of Group 2 elements, as well as amount of substance calculations involving concentration and acid–base titrations.

The chemical ideas in this module are:

- atomic structure, atomic spectra and electron configurations
- fusion reactions
- mass spectrometry and isotopes
- the periodic table and Group 2 chemistry
- bonding and the shapes of molecules
- chemical equations and amount of substance (moles)
- ions: formulae, charge density, tests
- titrations and titration calculations.

2

Elements of life (EL)

	Learning outcomes	Additional guidance
	Learners should be able to demonstrate and apply their knowledge and understanding of:	
Formulae, equations and amount of substance		
(a)	atomic number, mass number, isotope, Avogadro constant (N_A), relative isotopic mass, relative atomic mass (A_r), relative formula mass and relative molecular mass (M_r)	*M0.0, M0.1, M0.4*
(b)	**(i)** the concept of amount of substance (moles) and its use to perform calculations involving: masses of substances, empirical and molecular formulae, percentage composition, percentage yields, water of crystallisation **(ii)** the techniques and procedures used in experiments to measure masses of solids	*M0.0, M0.1, M0.2, M1.1, M2.2, M2.3, M2.4* **PAG1** • *experiments involving reacting masses and moles* In recognition of IUPAC's review, we will accept both the classical (carbon-12 based) and revised (Avogadro constant based) definitions of the mole in examinations from June 2018 onwards (see **https://iupac.org/new-definition-mole-arrived/**)
(c)	**(i)** the use of the concept of amount of substance (moles) to perform calculations involving: concentration (including titration calculations and calculations for making and diluting standard solutions) **(ii)** the techniques and procedures used in experiments to measure volumes of solutions; the techniques and procedures used in experiments to prepare a standard solution from a solid or more concentrated solution and in acid–base titrations	*M0.0, M0.1, M0.2, M1.1, M1.2, M1.3, M2.2, M2.3, M2.4* **PAG2** • *making up standard solutions and diluting solutions using volumetric apparatus* • *acid–base titrations*
(d)	balanced full and ionic chemical equations, including state symbols	*M0.2*
Atomic structure		
(e)	conventions for representing the distribution of electrons in atomic orbitals; the shapes of s- and p-orbitals	The 'electrons in boxes' model.
(f)	the electronic configuration, using sub-shells and atomic orbitals, of: **(i)** atoms from hydrogen to krypton **(ii)** ions of the s- and p-block of Periods 1 to 4 **(iii)** the outer sub-shell structures of s- and p-block elements of other periods	No explanation required. **See also DM(h).**

Elements of life (EL)

(g)	how knowledge of the structure of the atom developed in terms of a succession of gradually more sophisticated models; interpretation of these and other examples of such developing models	To include: • evidence for small dense nucleus (Geiger–Marsden experiment) • the make-up of atoms and ions in terms of protons, neutrons and electrons • evidence for electrons shells [from ionisation energies, **EL(q)**, and spectra, **EL(w)**].
(h)	fusion reactions: lighter nuclei join to give heavier nuclei (under conditions of high temperature and pressure); this is how certain elements are formed	Nuclear equations are required.

Bonding and structure

(i)	chemical bonding in terms of electrostatic forces; simple electron *'dot-and-cross'* diagrams to describe the electron arrangements in ions and covalent and dative covalent bonds	In covalent bonds there is a balance between the repulsive forces between the nuclei and the attractive forces between the nuclei and the electrons.
(j)	the bonding in giant lattice (metallic, ionic, covalent network) and simple molecular structure types; the typical physical properties (melting point, solubility in water, electrical conductivity) characteristic of these structure types	Explanations of physical properties limited to: • electrostatic attractions between molecules are weaker than electrostatic attractions in giant structures • charged particles able to move (electrons in metals; ions in molten or aqueous ionic substances).
(k)	use of the electron pair repulsion principle, based on *'dot-and-cross'* diagrams, to predict, explain and name the shapes of simple molecules (such as $BeCl_2$, BF_3, CH_4, NH_3, H_2O and SF_6) and ions (such as NH_4^+) with up to six outer pairs of electrons (any combination of bonding pairs and lone pairs); assigning bond angles to these structures	*M4.1* No treatment of hybridisation or molecular orbitals is expected but ideas of bond angles being altered by the lone pairs present should be included, for example the bond angles of: CH_4 (109.5°), NH_3 (107°), H_2O (104.5°).
(l)	structures of compounds that have a sodium chloride type lattice	Ionic bonding is the overall attraction in a lattice and is made up of attraction between ions of different charge and repulsion between ions of the same charge.

Elements of life (EL)

Inorganic chemistry and the periodic table

(m)	the periodic table as a list of elements in order of atomic (proton) number that groups elements together according to their common properties; using given information, make predictions concerning the properties of an element in a group; the classification of elements into s-, p- and d-blocks	
(n)	periodic trends in the melting points of elements in Periods 2 and 3, in terms of structure and bonding	
(o)	the relationship between the position of an element in the s- or p-block of the periodic table and the charge on its ion; the names and formulae of NO_3^-, SO_4^{2-}, CO_3^{2-}, OH^-, NH_4^+, HCO_3^-, Cu^{2+}, Zn^{2+}, Pb^{2+}, Fe^{2+}, Fe^{3+}; formulae and names for compounds formed between these ions and other given anions and cations	When used without oxidation states, 'nitrate' can be assumed to be NO_3^- and 'sulfate' can be assumed to be SO_4^{2-}.
(p)	a description and comparison of the following properties of the elements and compounds of Mg, Ca, Sr and Ba in Group 2: reactions of the elements with water and oxygen, thermal stability of the carbonates, solubilities of hydroxides and carbonates	• *test-tube or reduced scale reactions involving the elements of Group 2 and their compounds*
(q)	the term *ionisation enthalpy*; equations for the first ionisation of elements; explanation of trends in first ionisation enthalpies for Periods 2 and 3 and groups and the resulting differences in reactivities of s- and p-block metals in terms of their ability to lose electrons	Across a period, outermost electrons in the same shell are being more strongly attracted by more protons (explanation of the small drops mid-period **not** required). Down a group, electrons are in shells that are further from the nucleus and thus attracted less.
(r)	charge density of an ion and its relation to the thermal stability of the Group 2 carbonates	Smaller ions with the same charge have higher charge density and thus distort the large carbonate ion, so that the compound decomposes at lower temperature.
(s)	the solubility of compounds formed between the following cations and anions: Li^+, Na^+, K^+, Ca^{2+}, Ba^{2+}, Cu^{2+}, Fe^{2+}, Fe^{3+}, Ag^+, Pb^{2+}, Zn^{2+}, Al^{3+}, NH_4^+, CO_3^{2-}, SO_4^{2-}, Cl^-, Br^-, I^-, OH^-, NO_3^-; colours of any precipitates formed; use of these ions as tests e.g. Ba^{2+} as a test for SO_4^{2-}; a sequence of tests leading to the identification of a salt containing the ions above	Knowledge of the reaction of 3+ cations with CO_3^{2-} is **not** required. **PAG4** • *test-tube or reduced scale experiments involving precipitation reactions of the ions in EL(s) and the sequence of tests leading to identification*

Elements of life (EL)

Equilibria (acid–base)

(t)	the terms: *acid*, *base*, *alkali*, *neutralisation*; techniques and procedures for making soluble salts by reacting acids and bases and insoluble salts by precipitation reactions	Knowledge of the names and formulae of the mineral acids, HCl, HNO_3 and H_2SO_4 will be expected. • *making salts (including percentage yield)*
(u)	the basic nature of the oxides and hydroxides of Group 2 (Mg–Ba)	Description only, including equations, for reactions of Group 2 oxides and hydroxides with water and acids.

Energy and matter

(v)	the electromagnetic spectrum in order of increasing frequency and energy and decreasing wavelength: infrared, visible, ultraviolet	
(w)	transitions between electronic energy levels in atoms: **(i)** the occurrence of absorption and emission atomic spectra in terms of transition of electrons between electronic energy levels **(ii)** the features of these spectra, similarities and differences **(iii)** the relationship between the energy emitted or absorbed and the frequency of the line produced in the spectra, $\Delta E = h\nu$ **(iv)** the relationship between frequency, wavelength and the speed of electromagnetic radiation, $c = \nu\lambda$ **(v)** flame colours of Li^+, Na^+, K^+, Ca^{2+}, Ba^{2+}, Cu^{2+}	Similarities: both are line spectra; lines in same position for a given element; lines become closer at higher frequencies; series of lines representing transitions to or from a particular energy level. Differences: bright/coloured lines on a black background or black lines on coloured/bright background. • *flame tests for cations*

Modern analytical techniques

(x)	use of data from a mass spectrum to determine relative abundance of isotopes and calculate the relative atomic mass of an element.	*M1.2, M3.1*

2

Developing fuels (DF)

The use of fuels in cars provides the main context in this storyline, and is used to initially introduce the basic concept of enthalpy change. Food as 'fuel' for the body is then an alternative context in which to discuss quantitative aspects of enthalpy, including practical techniques and enthalpy cycles.

The storyline returns to the constituents of car fuels to introduce hydrocarbons and bond enthalpy, after which cracking provides the background to how petrol is produced.

Alkenes are then introduced in the context of saturated and unsaturated fats found in foods. This is followed by studying the polymerisation of alkenes in the context of synthetic polymers and their uses.

The storyline returns to car fuels to discuss combustion reactions and amount of substance calculations involving gases, shapes of hydrocarbons and isomerism, and the atmospheric pollutants produced in burning fuels. The storyline ends by considering the contribution of hydrogen and biofuels as potential fuels of the future.

The chemical ideas in this module are:

- thermochemistry
- organic chemistry: names and combustion of alkanes, alkenes, alcohols
- heterogeneous catalysis
- reactions of alkenes
- addition polymers
- electrophilic addition
- gas volume calculations
- shapes of organic molecules, σ- and π-bonds
- structural and *E*/*Z* isomers
- dealing with polluting gases.

	Learning outcomes	Additional guidance
	Learners should be able to demonstrate and apply their knowledge and understanding of:	
Formulae, equations and amount of substance		
(a)	the concept of amount of substance in performing calculations involving: volumes of gases (including the ideal gas equation $pV = nRT$), balanced chemical equations, enthalpy changes; the techniques and procedures used in experiments to measure volumes of gases	*M0.0, M0.1, M0.4, M1.1, M2.2, M2.3, M2.4* The molar gas volume at room temperature and pressure, RTP (24.0 $dm^3\ mol^{-1}$) and the gas constant R (8.314 $J\ mol^{-1}\ K^{-1}$) are given on the *Data Sheet*. **PAG1** • *experiments involving reacting masses, moles and volumes of gases*
Bonding and structure		
(b)	the bonding in organic compounds in terms of σ- and π-bonds	*M4.2*
(c)	the relation of molecular shape to structural formulae and the use of solid and dashed wedges to represent 3-D shape	*M4.2*

Developing fuels (DF)

Energetics

(d)	the terms: *exothermic, endothermic, standard conditions, (standard) enthalpy change of reaction ($\Delta_r H$), (standard) enthalpy change of combustion ($\Delta_c H$), (standard) enthalpy change of formation ($\Delta_f H$), (standard) enthalpy change of neutralisation ($\Delta_{neut} H$)*	Enthalpy change of neutralisation is per mole of water formed.
(e)	the term *average bond enthalpy* and the relation of bond enthalpy to the length and strength of a bond; bond-breaking as an endothermic process and bond-making as exothermic; the relation of these processes to the overall enthalpy change for a reaction	*M2.4* Understanding of the meaning of 'average' in this context is required.
(f)	techniques and procedures for measuring the energy transferred when reactions occur in solution (or solids reacting with solutions) or when flammable liquids burn; the calculation of enthalpy changes from experimental results	*M0.0, M1.1, M2.3, M3.1, M3.2* Using the formula: $q = mc\Delta T$ **PAG3** • *experiments to measure the energy transferred when reactions occur in solution or when flammable liquids burn*
(g)	the determination of enthalpy changes of reaction from enthalpy cycles and enthalpy level diagrams based on Hess' law	*M0.0, M2.4* Including via enthalpy changes of formation, combustion and bond enthalpies. A statement of Hess' law is **not** required. • *experiments leading to Hess cycles*

Kinetics

(h)	the terms *catalyst*, *catalysis*, *catalyst poison, heterogeneous*	**See also OZ(g)**.
(i)	a simple model to explain the function of a heterogeneous catalyst	
(j)	the term *cracking*; the use of catalysts in cracking processes; techniques and procedures for cracking a hydrocarbon vapour over a heated catalyst	Specific examples of catalysts are **not** required • *cracking a hydrocarbon vapour over a heated catalyst and testing the product*

Inorganic chemistry and the periodic table

(k)	the origin of atmospheric pollutants from a variety of sources: particulates, unburnt hydrocarbons, CO, CO_2, NO_x, SO_x; the environmental implications and methods of reducing these pollutants	

2

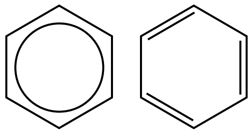
Developing fuels (DF)

2

Organic functional groups

(l) the terms *aliphatic*, *aromatic*, *arene*, *saturated, unsaturated, functional group* and *homologous series*

Arenes defined here as compounds containing groups represented as either of:



Unsaturated compounds contain C=C or C≡C.

(m) the nomenclature, general formulae and structural formulae for alkanes, cycloalkanes, alkenes and alcohols (names up to ten carbon atoms)

Organic reactions

(n) balanced equations for the combustion and incomplete combustion (oxidation) of alkanes, cycloalkanes, alkenes and alcohols

(o) the addition reactions of alkenes with the following, showing the greater reactivity of the C=C bond compared with C–C:

- **(i)** bromine to give a dibromo compound, including techniques and procedures for testing compounds for unsaturation using bromine water
- **(ii)** hydrogen bromide to give a bromo compound
- **(iii)** hydrogen in the presence of a catalyst to give an alkane (Ni with heat and pressure or Pt at room temperature and pressure)
- **(iv)** water in the presence of a catalyst to give an alcohol (concentrated H_2SO_4, then add water; or steam/H_3PO_4/heat and pressure)

PAG7, see also CD(f).

- *testing compounds for unsaturation using bromine water*

Polymers

(p) addition polymerisation and the relationship between the structural formula of the addition polymer formed from given monomer(s), and *vice versa*

Developing fuels (DF)

Organic mechanisms

(q)	the terms *addition, electrophile, carbocation*; the mechanism of electrophilic addition to alkenes using 'curly arrows'; how the products obtained when other anions are present can be used to confirm the model of the mechanism	Either a carbocation or a bromonium ion may be shown for bromination.

Isomerism

(r)	structural formulae (full, shortened and skeletal)	
(s)	structural isomerism and structural isomers	*M4.2, M4.3*
(t)	stereoisomerism in terms of lack of free rotation about C=C bonds when the groups on each carbon differ; description and naming as: **(i)** *E/Z* for compounds that have an H on each carbon of C=C **(ii)** *cis/trans* for compounds in which one of the groups on each carbon of C=C is the same	*M4.3* Knowledge of Cahn–Ingold–Prelog (CIP) priority rules will **not** be required.

Sustainability

(u)	the benefits and risks associated with using fossil fuels and alternative fuels (biofuels and hydrogen) making decisions about ensuring a sustainable energy supply.	If comparison with other energy sources is needed, suitable information will be given.

Elements from the sea (ES)

The presence of halide salts in the sea provides the entry to the properties of the halogens and reactions between halide ions. The manufacture of bromine and chlorine then provide the context for discussion of redox chemistry, electrolysis and the nomenclature of inorganic compounds.

The use of chlorine in bleach is used to introduce the concept of equilibrium and calculations of the equilibrium constant, as well as iodine–thiosulfate titrations. This leads into a discussion of the risks and benefits of using chlorine.

Finally, atom economy is introduced through the manufacture of hydrogen chloride and other hydrogen halides. The Deacon process for making HCl provides an opportunity to expand on ideas relating to the position of equilibrium.

The chemical ideas in this teaching module are:

- halogen chemistry
- redox chemistry and electrolysis
- equilibrium
- atom economy.

	Learning outcomes	Additional guidance
	Learners should be able to demonstrate and apply their knowledge and understanding of:	
Formulae, equations and amount of substance		
(a)	the concept of amount of substance in performing calculations involving atom economy; the relationship between atom economy and the efficient use of atoms in a reaction	*M0.2*
Redox		
(b)	the explanation (given the necessary information) of the chemical processes occurring during the extraction of the halogens from minerals in the sea	Recall of processes **not** required.
(c)	techniques and procedures in the electrolysis of aqueous solutions; half-equations for the processes occurring at electrodes in electrolysis of molten salts and aqueous solutions:	*M0.2* Cathode description in aqueous electrolysis: 'Group 1 and 2 and aluminium salts give hydrogen, other metals are plated'.
	(i) formation of oxygen or a halogen or metal ions at the anode	• *electrolysis of aqueous solutions*
	(ii) formation of hydrogen or a metal at the cathode	

Elements from the sea (ES)

(d)	redox reactions of s-, p- and d-block elements and their compounds in terms of electron transfer: **(i)** use of half-equations to represent simple oxidation and reduction reactions **(ii)** the definition of oxidation and reduction as loss and gain of electrons **(iii)** identification of oxidising and reducing agents	*M0.2* Recall of specific reactions is only needed if required elsewhere, e.g. **ES(j)**. 'Simple' means not involving acid–base, **see also ES(f).** • *test-tube or reduced scale redox reactions*
(e)	the oxidation states assigned to and calculated for specified atoms in formulae (including ions) and explanation of which species have been oxidised and which reduced in a redox reaction	
(f)	use of oxidation states to balance redox equations that do not also involve acid–base reactions; techniques and procedures in iodine–thiosulfate titrations	*M0.2* e.g. $3Ca + 2Al^{3+} \rightarrow 3Ca^{2+} + 2Al$ but not: $MnO_4^- + 5Fe^{2+} + 8H^+ \rightarrow Mn^{2+} + 5Fe^{3+} + 4H_2O$ **See also DM(c)**. • *iodine–thiosulfate titrations*
(g)	use of systematic nomenclature to name and interpret the names of inorganic compounds	e.g. copper(I) sulfide, sodium chlorate(I), lead(II) nitrate(V), potassium manganate(VII) but **not** complex ions.

Inorganic chemistry and the periodic table

(h)	a description of the following physical properties of the halogens: appearance and physical state at room temperature, volatility, solubility in water and organic solvents	Explanation **not** required. **See also OZ(d)**.
(i)	the relative reactivities of the halogens in terms of their ability to gain electrons	• *test-tube or reduced scale reactions involving the halogens and their compounds [related to **(i)** to **(m)**]*
(j)	the details of the redox changes which take place when chlorine, bromine and iodine react with other halide ions, including observations, equations and half-equations	
(k)	the reactions between halide ions (Cl^-, Br^- and I^-) and silver ions (Ag^+) and ionic equations to represent these precipitation reactions, the colours of the precipitates and the solubility of silver halides in ammonia	**PAG4**

(l)	the preparation of HC*l*; the preparation of HBr and HI by using the halide and phosphoric acid; the action of sulfuric acid on chlorides, bromides and iodides	Details of phosphoric acid (and equations involving it) are **not** required.
(m)	the properties of the hydrogen halides: different thermal stabilities, similar reaction with ammonia and acidity, different reactions with sulfuric acid	Sulfuric acid is reduced to SO_2 by HBr and H_2S by HI.
(n)	the risks associated with the storage and transport of chlorine; uses of chlorine which must be weighed against these risks, including: sterilising water by killing bacteria, bleaching	

Equilibria

(o)	the characteristics of dynamic equilibrium	
(p)	the equilibrium constant, K_c for a given homogeneous reaction; calculations of the magnitude of K_c and equilibrium concentrations using data provided; relation of position of equilibrium to size of K_c, using symbols such as >,<,>>,<<	*M0.1, M2.1* Units will **not** be required. **See also CI(h)**.
(q)	the use of K_c to explain the effect of changing concentrations on the position of a homogeneous equilibrium; extension of the ideas of ‘opposing change’ to the effects of temperature and pressure on equilibrium position.	*M0.3* e.g. ‘if a concentration term on the top becomes larger, one on the bottom must also become larger to keep K_c constant, so equilibrium position moves to the left’. • *qualitative experiments involving equilibrium reactions*

The ozone story (OZ)

An initial study of the composition of the atmosphere provides the opportunity to introduce composition by volume calculations for gases.

Discussion of ozone's role as a 'sunscreen' then leads to ideas of the principal types of electromagnetic radiation and their effects on molecules. This introduces a study of radical reactions, reaction kinetics and catalysis, set in the context of the ways in which ozone is made and destroyed in the atmosphere.

A consideration of CFCs and HFCs then provides the introduction to the chemistry of haloalkanes, including nucleophilic substitution, and intermolecular bonding.

The chemical ideas in this module are:

- composition by volume of gases
- the electromagnetic spectrum and the interaction of radiation with matter
- rates of reaction
- radical reactions
- intermolecular bonding
- haloalkanes
- nucleophilic substitution reactions
- the sustainability of the ozone layer.

2

	Learning outcomes	Additional guidance
	Learners should be able to demonstrate and apply their knowledge and understanding of:	
Bonding and structure		
(a)	the term *electronegativity*; qualitative electronegativity trends in the periodic table; use of relative electronegativity values to predict bond polarity in a covalent bond; relation of overall polarity of a molecule to its shape and the polarity of its individual bonds	
(b)	intermolecular bonds: *instantaneous dipole–induced dipole bonds* (including dependence on branching and chain length of organic molecules and M_r), *permanent dipole–permanent dipole bonds*	• *experiments to illustrate the formation of intermolecular bonds (including hydrogen bonds)*
(c)	intermolecular bonds: the formation of *hydrogen bonds* and description of hydrogen bonding, including in water and ice	
(d)	the relative boiling points of substances in terms of intermolecular bonds	This includes an explanation of the boiling points of the halogens.
Kinetics		
(e)	the term *activation enthalpy*; enthalpy profiles	Activation enthalpy is related to the energy that pairs of molecules must possess to react when they collide.

The ozone story (OZ)

(f)	the effect of concentration and pressure on the rate of a reaction, explained in terms of the collision theory; use of the concept of activation enthalpy and the Boltzmann distribution to explain the qualitative effect of temperature changes and catalysts on rate of reaction; techniques and procedures for experiments in reaction kinetics including plotting graphs to follow the course of a reaction	*M3.2* • *experiments on reaction kinetics*
(g)	the role of catalysts in providing alternative routes of lower activation enthalpy	**See also DF(h).**
(h)	the term *homogeneous catalysis* and the formation of intermediates	For example, the catalytic action of chlorine radicals on the breakdown of ozone.

Inorganic chemistry and the periodic table

(i)	calculations, from given data, of values for composition by volume of a component in a gas mixture measured in percentage concentration and in parts per million (ppm)	*M0.0, M0.1*

Organic functional groups

(j) the recognition of and formulae for examples of members of the following homologous series:

- **(i)** haloalkanes, including systematic nomenclature
- **(ii)** amines

Organic reactions

(k) the characteristic properties of haloalkanes, comparing fluoro-, chloro-, bromo- and iodo-compounds, considering the following aspects:

- **(i)** boiling points (depend on intermolecular bonds)
- **(ii)** nucleophilic substitution with water and hydroxide ions to form alcohols, and with ammonia to form amines

Reaction mechanisms

(l)	the terms *substitution* and *nucleophile*	
(m)	the use of the S_N2 mechanism as a model to explain nucleophilic substitution reactions of haloalkanes using ‘curly arrows’ and partial charges	Knowledge of the S_N1 mechanism or of the S_N1 or S_N2 nomenclature is **not** required.

The ozone story (OZ)

(n) the possible dependence of the relative reactivities of the haloalkanes on either bond enthalpy or bond polarity and how experimental evidence determines that the bond enthalpy is more important

- *experiments to illustrate the relative reactivity of the haloalkanes*

(o) homolytic and heterolytic bond fission

(p) the formation, nature and reactivity of radicals and:

- **(i)** explanation of the mechanism of a radical chain reaction involving initiation, propagation and termination
- **(ii)** the radical mechanism for the reaction of alkanes with halogens
- **(iii)** use of 'half curly arrows' in radical mechanisms

- *experiments involving an alkane and bromine*

(q) the chemical basis of the depletion of ozone in the stratosphere due to haloalkanes;
the ease of photodissociation of the haloalkanes (fluoroalkanes to iodoalkanes) in terms of bond enthalpy

The formation of halogen atoms and the catalytic role of these atoms (and other radicals) in ozone destruction. Simple equations of the breakdown process are required, e.g.

$CF_2Cl_2 \rightarrow CF_2Cl\bullet + \bullet Cl$
$\bullet Cl + O_3 \rightarrow \bullet ClO + O_2$
$\bullet ClO + O \rightarrow \bullet Cl + O_2$

Sustainability

(r) the formation and destruction of ozone in the stratosphere and troposphere; the effects of ozone in the atmosphere, including:

- **(i)** ozone's action as a sunscreen in the stratosphere by absorbing high-energy UV (and the effects of such UV, including on human skin)
- **(ii)** the polluting effects of ozone in the troposphere, causing problems including photochemical smog

Energy and matter

(s) the principal radiations of the Earth and the Sun in terms of the following regions of the electromagnetic spectrum: infrared, visible, ultraviolet

(t) the effect of UV and visible radiation promoting electrons to higher energy levels, sometimes causing bond breaking

(u) calculation of values for frequency, wavelength and energy of electromagnetic radiation from given data.

What's in a medicine? (WM)

A consideration of medicines from nature focuses on aspirin. The chemistry of the –OH group is introduced through reactions of salicin and salicylic acid, beginning with alcohols and continuing with phenols.

The discussion of chemical tests for alcohols and phenols leads to the introduction of IR and mass spectrometry as more powerful methods for identifying substances.

The storyline concludes by examining the synthesis of aspirin to illustrate organic preparative techniques, including a look at the principles of green chemistry.

The chemical ideas in this module are:

- the chemistry of the –OH group, phenols and alcohols
- carboxylic acids and esters
- mass spectrometry and IR spectroscopy
- organic synthesis, preparative techniques and thin layer chromatography
- green chemistry.

2

	Learning outcomes	Additional guidance
	Learners should be able to demonstrate and apply their knowledge and understanding of:	
Organic functional groups		
(a)	the formulae of the following homologous series: carboxylic acids, phenols, acid anhydrides, esters, aldehydes, ketones, ethers	**See also PL(k)**.
(b)	primary, secondary and tertiary alcohols in terms of the differences in structures	
Organic reactions		
(c)	the following properties of phenols:	**PAG7, see also CD(f)**.
	(i) acidic nature, and their reaction with alkalis but not carbonates (whereas carboxylic acids react with alkalis and carbonates)	
	(ii) test with neutral iron(III) chloride solution, to give a purple colouration	
	(iii) reaction with acid anhydrides (but not carboxylic acids) to form esters	

What's in a medicine? (WM)

(d) the following reactions of alcohols and two-step syntheses involving these reactions and other organic reactions in the specification: **(i)** with carboxylic acids, in the presence of concentrated sulfuric acid or concentrated hydrochloric acid (or with acid anhydrides) to form esters **(ii)** oxidation to carbonyl compounds (aldehydes and ketones) and carboxylic acids with acidified dichromate(VI) solution, including the importance of the condition (reflux or distillation) under which it is done **(iii)** dehydration to form alkenes using heated Al_2O_3 or refluxing with concentrated H_2SO_4 **(iv)** substitution reactions to make haloalkanes	**PAG7, see also CD(f)**. • *experiments involving reactions of the—OH group*
(e) techniques and procedures for making a solid organic product and for purifying it using filtration under reduced pressure and re-crystallisation (including choice of solvent and how impurities are removed); techniques and procedures for melting point determination and thin layer chromatography	**PAG6** • *the synthesis and purification of a solid organic compound e.g. aspirin* • *melting point determination* • *the technique of thin layer chromatography (TLC), location of spots and interpretation*
(f) techniques and procedures for preparing and purifying a liquid organic product including the use of a separating funnel and of Quickfit or reduced scale apparatus for distillation and heating under reflux	**PAG5** • *experiments to oxidise alcohols* • *preparation of an organic compound involving the process of heating under reflux* • *the principal stages in the purification of an organic liquid product e.g. in the preparation of a chloroalkane*
(g) the principles of green chemistry in industrial processes	*M0.2* Learners should be able to make suggestions based on (but **not** to quote verbatim) the 12 'principles of green chemistry'. Learners will be expected to analyse and use given information. **See also EL (b), ES (a)**

Reaction mechanisms

(h) the term *elimination reaction*	Example: alkenes from alcohols.

What's in a medicine? (WM)

Modern analytical techniques

(i) interpretation and prediction of mass spectra: **(i)** the M^+ peak and the molecular mass **(ii)** that other peaks are due to positive ions from fragments **(iii)** the M+1 peak being caused by the presence of ^{13}C	*M3.1* Calculations based on M+1 peak will **not** be required. **See also PL(r)**.
(j) the effect of specific frequencies of infrared radiation making specific bonds in organic molecules vibrate (more); interpretation and prediction of infrared spectra for organic compounds, in terms of the functional group(s) present.	*M3.1* IR absorptions will be given on the *Data Sheet*.

The chemical industry (CI)

The storyline opens with a look at crop production and the nitrogen cycle, which leads into consolidation of redox concepts from the first year and introduces nitrogen chemistry.

The industrial production of nitric acid and sulfuric acid – both used in the fertiliser industry – then form the context for developing understanding of rates, including determination of rate equations and equilibria, consolidating K_c and the introduction of how to determine units.

These ideas are finally drawn together by looking at the industrial production of ethanoic acid. Overall, the three industrial processes allow for an overview of the effects of factors on the rate and equilibrium yields of reactions, leading to a consideration of the best conditions for an industrial process. The processes also allow learners to look at the costs of an industrial process, including hazards and the effect of these processes on society.

The chemical ideas in this module are:

- aspects of nitrogen chemistry
- kinetics
- equilibrium and equilibrium constant calculations
- effects of factors on the rate and equilibrium yields of reactions; consideration of the best conditions for an industrial process
- analysis of costs, benefits and risks of industrial processes.

2

	Learning outcomes	Additional guidance
	Learners should be able to demonstrate and apply their knowledge and understanding of:	
Kinetics		
(a)	the terms: **(i)** *rate of reaction* **(ii)** *rate constant*, including units **(iii)** *order of reaction* (both overall and with respect to a given reagent), use of '$\propto$' **(iv)** *rate equations* of the form: rate = $k[A]^m[B]^n$ where m and n are integers; calculations based on the rate equation; the rate constant k increasing with increasing temperature	*M0.0, M2.2, M2.3, M2.4*
(b)	the use of given data to calculate half-lives for a reaction	*M3.1*
(c)	techniques and procedures for experiments in reaction kinetics; use of experimental data [graphical methods (including rates from tangents of curves), half-lives or initial rates when varying concentrations are used] to find the rate of reaction, order of a reaction (zero-, first- or second-order), rate constant and construction of a rate equation for the reaction	*M3.1, M3.2, M3.3, M3.4, M3.5* **PAG9/10** • *experiments to determine the change of rate of reaction over time* • *experiments where the results can be used to calculate rate, orders of reaction, the rate constant and the activation enthalpy*

The chemical industry (CI)

(d) the Arrhenius equation and the determination of E_a and A for a reaction, given data on the rate constants at different temperatures	*M0.4, M2.5, M3.1, M3.2, M3.3, M3.4* The Arrhenius equation is given on the *Data Sheet*.
(e) the term *rate-determining step*; relation between rate-determining step and the orders and possible mechanism for a reaction	
Equilibrium	
(f) the effect of changes of temperature and pressure (if any) on the magnitude of the equilibrium constant; the fact that addition of catalysts has no effect on the position of equilibrium or the magnitude of the equilibrium constant	*M0.3*
(g) the determination of the most economical operating conditions for an industrial process using principles of equilibrium and rates of reaction	Data for the industrial process will be given.
(h) calculations, including units, involving K_c and initial and equilibrium concentrations for homogeneous equilibria; techniques and procedures for experiments to determine equilibrium constants	*M0.0, M2.3* • *experiments to measure* K_c
Inorganic chemistry and the periodic table	
(i) the chemical reactions occurring during industrial processes	Learners should be able to use given information, no recall is required.
(j) the following aspects of nitrogen chemistry: **(i)** bonding in nitrogen gas, ammonia and the ammonium ion **(ii)** the appearance and names of the oxides of nitrogen, N_2O, NO, NO_2 **(iii)** interconversion of the nitrate(V) ion, nitrate(III) ion, ammonium ion, oxides of nitrogen **(iv)** tests for nitrate(V) and ammonium ions	Test for nitrate(V): warm with Devarda's alloy and NaOH. Test for ammonium: warm with NaOH. In both cases, ammonia is evolved. • *test-tube or reduced scale reactions of nitrogen compounds to support CI(j)*

The chemical industry (CI)

Sustainability

(k) given examples of industrial processes: **(i)** costs of raw materials, energy costs, costs associated with plant, co-products and by-products **(ii)** the benefits and risks associated with the process in terms of benefits to society of the product(s) and hazards involved.	Learners will be expected to analyse and use given information.

Polymers and life (PL)

The storyline begins with the uses of condensation polymers such as nylons and polyesters, introducing the chemistry of carboxylic acids, phenols, esters, amines and amides, as well as naming of other organic groups. Surgical stitches that 'disappear' in the body then form the context for discussing hydrolysis of polymers.

The storyline then turns to the chemistry of proteins. Amino acid chemistry, optical isomerism and the structure of proteins are introduced in relation to the structure of insulin. The storyline then moves to testing for glucose in urine as a basis for introducing enzyme catalysis. Various examples of medicines that work as enzyme inhibitors are then used to discuss molecular recognition.

The storyline continues with the development of models of the DNA and RNA structures and a description of the Human Genome project.

Finally, aspirin – discussed in WM – is revisited as the context for a more detailed discussion of mass spectrometry, as well as introduction of proton and carbon-13 NMR and the use of combined techniques in structural analysis.

The chemical ideas in this module are:

- condensation polymers
- organic functional groups
- amines and amides
- acid–base equilibria
- amino acid and protein chemistry
- optical isomerism
- enzyme catalysis and molecular recognition
- the structure and function of DNA and RNA
- structural analysis.

Learning outcomes	Additional guidance
Learners should be able to demonstrate and apply their knowledge and understanding of:	
Structure and bonding	
(a) **(i)** amino acid chemistry: • the general structure of amino acids • proteins as condensation polymers formed from amino acid monomers • the formation and hydrolysis of the peptide link between amino acid residues in proteins	• *experiments involving the hydrolysis of peptides* **PAG6** • *the technique of paper chromatography*
(ii) techniques and procedures for paper chromatography	
(b) the primary, secondary and tertiary structure of proteins; the role of intermolecular bonds in determining the secondary and tertiary structures, and hence the properties of proteins	

Polymers and life (PL)

(c) DNA and RNA as condensation polymers formed from nucleotides, which are monomers having three components (phosphate, sugar and base): **(i)** the phosphate units join by condensation with deoxyribose or ribose to form the phosphate–sugar backbone in DNA and RNA **(ii)** the four bases present in DNA and RNA join by condensation with the deoxyribose or ribose in the phosphate–sugar backbone **(iii)** two strands of DNA form a double-helix structure through base pairing	Monomers of DNA and RNA are given on the *Data Sheet.*
(d) the significance of hydrogen bonding in the pairing of bases in DNA and relation to the replication of genetic information; how DNA encodes for RNA which codes for an amino acid sequence in a protein	Some triplet base codes are given on the *Data Sheet.*
(e) molecular recognition (the structure and action of a given pharmacologically active material) in terms of: **(i)** the pharmacophore and groups that modify it **(ii)** its interaction with receptor sites **(iii)** the ways that species interact in three dimensions (size, shape, bond formation, orientation)	
Kinetics	
(f) the shape of the rate versus substrate concentration curve for an enzyme-catalysed reaction; techniques and procedures for experiments involving enzymes	At low concentrations of substrate the order with respect to the substrate is one, at higher concentrations of substrate the order with respect to the substrate is zero. • *kinetics experiments involving enzymes*
(g) the characteristics of enzyme catalysis, including: specificity, temperature sensitivity, pH sensitivity, competitive inhibition; explanation of these characteristics of enzyme catalysis in terms of a three-dimensional active site (part of the tertiary structure)	
Equilibria (acid–base)	
(h) the acidic nature of carboxylic acids, and their reaction with metals, alkalis and carbonates	**PAG7, see also CD(f).** • *test-tube experiments involving carboxylic acids*

(i) the acid–base properties of amino acids and their existence as zwitterions

- *test-tube experiments involving amino acids*

(j) the basic nature of the amino group; the reaction of amines with acids

In terms of a lone pair on the nitrogen accepting a proton to give a cation.

PAG7, see also CD(f).
- *test-tube experiments involving amines*

Organic functional groups

(k) the formulae and systematic nomenclature of members of the following homologous series: carboxylic acids, phenols, acyl chlorides, acid anhydrides, esters, aldehydes, ketones, diols, dicarboxylic acids, primary amines, diamines; naming nylon structures

The structures of nylon-6,6 nylon-6,10 and nylon-6.

(l) the formulae for the following functional groups: primary amide, secondary amide

Organic reactions

(m) the hydrolysis of esters and amides by both aqueous acids and alkalis, including salt formation where appropriate

- *the hydrolysis of an ester or amide e.g. nylon*

(n) the reactions of acyl chlorides with amines and alcohols

PAG7, see also CD(f).
- *test-tube experiments on the reactions of amines and amides*

Polymers

(o) the differences between addition and condensation polymerisation

(p) the relationship between the structural formula of a condensation polymer and the structural formulae of its monomer(s) and *vice versa*

Isomerism

(q) optical isomerism:

M4.2, M4.3

- **(i)** diagrams to represent optical stereoisomers of molecules
- **(ii)** the use of the term *chiral* as applied to a molecule and identifying carbon atoms that are chiral centres in molecules
- **(iii)** enantiomers as non-superimposable mirror image molecules

Modern analytical techniques

(r) the further interpretation and prediction of mass spectra: **(i)** use of the high-resolution value of the M^+ peak to work out a molecular formula **(ii)** the mass differences between peaks indicating the loss of groups of atoms	*M3.1* **See also WM(i)**.
(s) proton and carbon-13 nuclear magnetic resonance (NMR) spectra for the determination of molecular structure	*M3.1* Including splitting patterns up to quartets for proton NMR using the 'n + 1' rule; further explanation of splitting **not** required. All carbon-13 NMR spectra that are assessed will be proton decoupled.
(t) the combination of spectroscopic techniques (mass spectrometry, IR and NMR) to determine the structure of organic molecules.	

Oceans (O)

The storyline begins by looking at how the oceans have been and are surveyed, and what we know about their composition. This leads into a discussion of the solution of ionic solids, focusing on the energy changes involved.

A study of the role of the oceans in redistributing energy from the Sun next forms the context for introducing the greenhouse effect. The absorption of CO_2 by the oceans also provides the basis for introduction of acid–base equilibria, including Brønsted–Lowry theory, pH calculations, strong and weak acids, and buffers. The role of calcium carbonate in seashells as a carbon store then leads into understanding of solubility products.

Finally, the storyline returns to the redistribution of energy by the oceans, forming the basis of an in-depth discussion of ideas relating to entropy.

The chemical ideas in this module are:

- dissolving and associated enthalpy changes
- the greenhouse effect
- acid–base equilibria and pH
- solubility products
- entropy.

	Learning outcomes	Additional guidance
	Learners should be able to demonstrate and apply their knowledge and understanding of:	
Energetics		
(a)	the factors determining the relative solubility of a solute in aqueous and non-aqueous solvents	Intermolecular bonds, ion–dipole bonds and ionic bonds should be considered.
(b)	the terms *hydrated ions*, *enthalpy change of solution* ($\Delta_{sol}H$), *lattice enthalpy* ($\Delta_{LE}H$) and *enthalpy change of hydration of ions* ($\Delta_{hyd}H$), and:	*M2.4* Lattice enthalpy defined as an exothermic quantity.
	(i) the solution of an ionic solid in terms of enthalpy cycles and enthalpy level diagrams involving these terms	**PAG3** • *experiments involving enthalpy changes of solution*
	(ii) use of these enthalpy cycles to perform calculations	
	(iii) techniques and procedures for measuring the energy transferred in experiments involving enthalpy changes in solution	
(c)	the dependence of the lattice enthalpy of an ionic compound and the enthalpy change of hydration of ions on the charge density of the ions	The greater the charge density of the ions: • the greater the electrostatic attraction and the more exothermic the lattice enthalpy • the greater the attraction of water molecules and the more exothermic the hydration enthalpy.

Oceans (O)

(d) qualitative entropy changes (of the system); entropy as a measure of the number of ways that molecules and their associated energy quanta can be arranged

(e) qualitative predictions of the $\Delta_{sys}S$ for a reaction in terms of:

- **(i)** the differences in magnitude of the entropy of a solid, a liquid and a gas
- **(ii)** the difference in number of particles of gaseous reactants and products

(f) the expressions: $\Delta_{tot}S = \Delta_{sys}S + \Delta_{surr}S$ and $\Delta_{surr}S = -\Delta H/T$;
calculations using these expressions;
the relation of the feasibility of a reaction to the sign of $\Delta_{tot}S$

M0.0, M2.2, M2.3

- *experiments to determine what drives reactions*

(g) calculation of $\Delta_{sys}S$ for a reaction given the entropies of reactants and products

M2.4

(h) the term *solubility product* for ionic compounds; solubility product calculations; techniques and procedures for determining solubility products

M2.2, M2.3

- *experiments involving solubility products*

Equilibria (acid–base)

(i) the Brønsted–Lowry theory of acids and bases:

- **(i)** acids as proton donors and bases as proton acceptors
- **(ii)** the identification of the proton donor and proton acceptor in an acid–base reaction
- **(iii)** the terms *conjugate acid* and *conjugate base*

(j) the terms *strong acid, strong base*;
equations for their ionisation in water

(k) the term *weak acid* and equations for its ionisation in water;
acidity constant ('dissociation constant') K_a, pK_a;
techniques and procedures to measure the pH of a solution

PAG11

- *experiments involving K_a and the pH of acids and alkalis*

(l) the term pH, and pH calculations involving:

- **(i)** strong acids
- **(ii)** strong bases, using K_w
- **(iii)** weak acids (including calculating any of the terms pH, K_a and concentration from any two others, being aware of the approximations made)

M0.1, M0.4, M2.5
The value of K_w is given on the *Data Sheet.*
Quadratic equations are **not** required.

(m) buffer solutions based on solutions of weak acids and their salts:

- **(i)** the meaning of the term *buffer*
- **(ii)** how buffers work (including in everyday applications)
- **(iii)** buffer solution calculations

M0.4, M2.5

- *experiments involving buffer solutions*

Energy and matter

(n) the 'greenhouse effect', in terms of:

- **(i)** solar energy reaching Earth mainly as visible and UV
- **(ii)** Earth absorbing some of this energy, heating up and radiating IR
- **(iii)** greenhouse gases (e.g. carbon dioxide and methane) in the troposphere absorbing some of this IR, in the 'IR window'
- **(iv)** absorption of IR by greenhouse gas molecules increases the vibrational energy of their bonds, the energy is transferred to other molecules by collisions, thus increasing their kinetic energy and raising the temperature
- **(v)** greenhouse gas molecules also re-emitting some of the absorbed IR in all directions, some of which heats up the Earth
- **(vi)** increased concentrations of greenhouse gases leading to an enhanced greenhouse effect.

Developing metals (DM)

The storyline begins with metals in ancient times and their subsequent use in coinage and weaponry, moving on to modern uses of metals including dental alloys. Transition metals and their properties are introduced in this context.

The storyline continues with redox chemistry and electrochemical cells, studied in the context of cells from Volta through modern-day usage of cells to electrochemistry in the mouth.

Finally, the topic of pigments leads into discussion of transition metal chemistry and complexes. The storyline ends with a review of biologically important complexes such as haemoglobin and *cis*-platin and the role of metals as catalysts in car exhaust systems.

The chemical ideas in this module are:

- redox titrations
- cells and electrode potentials
- d-block chemistry
- colorimetry.

2

	Learning outcomes	Additional guidance
	Learners should be able to demonstrate and apply their knowledge and understanding of:	
Formulae, equations and amount of substance		
(a)	manganate(VII) titrations; non-structured calculations based on these and any other types of titration	*M0.1, M1.1, M2.2, M2.3* • *manganate(VII) titrations*
Bonding and structure		
(b)	the term *coordination number*, the shapes and bond angles of complexes with coordination numbers 4 (square planar and tetrahedral) and 6 (octahedral)	
Redox		
(c)	balancing half-equations and full equations for redox processes that also include acid–base reactions by using oxidation states or other methods	*M0.2* e.g. $MnO_4^- + 5e^- + 8H^+ \rightarrow Mn^{2+} + 4H_2O$ and $MnO_4^- + 5Fe^{2+} + 8H^+ \rightarrow Mn^{2+} + 5Fe^{3+} + 4H_2O$ **This supplements ES(f)**.
(d)	simple electrochemical cells: **(i)** involving metal ion/metal half-cells **(ii)** involving half-cells based on different oxidation states of the same element in aqueous solution with a platinum or other inert electrode, acidified if necessary **(iii)** techniques and procedures to set up and use electrochemical cells	**PAG8** • *setting up and using electrochemical cells*

(e)	the action of an electrochemical cell in terms of half-equations and external electron flow and the ion flow in the salt bridge	
(f)	the term *standard electrode potential* and its measurement using a hydrogen electrode; use of standard electrode potentials to: **(i)** calculate E_{cell} **(ii)** predict the feasibility of redox reactions, and the reasons why a reaction may not occur **(iii)** explain rusting, and its prevention, in terms of electrochemical processes	Details of the set-up of the hydrogen electrode are **not** required, just the equation for the reaction. Learners should know the standard conditions. • *experiments in which electrode potentials are used to predict or interpret reactions* • *experiments on rusting*
	Inorganic chemistry and the periodic table	
(g)	transition metals as d-block elements forming one or more stable ions which have incompletely filled d-orbitals; the common oxidation states of iron (+2 and +3) and copper (+1 and +2) and the colours of their aqueous ions, if any	Learners should also be able to use given data about transition metals and their compounds.
(h)	electronic configurations, using sub-shells and atomic orbitals, for ions of the first row of the d-block elements; the existence of variable oxidation states, in terms of the stability of d-orbital electron arrangements	The electron configurations of Cu and Cr may be required. **See also EL(f)**.
(i)	the terms *ligand*, *complex/complex ion* and *ligand substitution*	Learners should know the formulae of the following examples of complex ions from the chemistry of: iron: $[Fe(H_2O)_6]^{2+}$, $[Fe(H_2O)_6]^{3+}$; and copper: $[Cu(H_2O)_6]^{2+}$, $[Cu(NH_3)_4]^{2+}$, $[CuCl_4]^{2-}$. They should be able to write similar formulae for other complexes, given suitable information. • *test-tube or reduced scale reactions involving iron, copper and other transition metals and their compounds, including the formation of complex ions*
(j)	the formation of complexes in terms of coordinate (dative) bonding between ligand and central metal ion; ligand substitution equations; the terms *bidentate* and *polydentate* as applied to ligands	Learners should know the structure of ethanedioate and how it acts as a bidentate ligand. Formulae of other multidentate ligands will be given. • *experiments to determine formulae of complexes of transition metals*

Developing metals (DM)

(k) the colour changes in, and ionic equations for, the reactions of: Fe^{2+}(aq), Fe^{3+}(aq) and Cu^{2+}(aq) ions with sodium hydroxide solution and ammonia solution	[Iron(II) hydroxide and iron(III) hydroxide do not form complexes with ammonia.]
(l) the catalytic activity of transition metals and their compounds	Homogeneous catalysis in terms of variable oxidation states. Heterogeneous catalysis in terms of the ability of transition metals to use (3)d and (4)s electrons of the atoms on the catalyst surface to form weak bonds to reactants. • *experiments involving catalysts*
(m) **(i)** the ions of transition metals in solution are often coloured; **(ii)** the origins of colour in transition metal complexes in terms of the splitting of the d-orbitals by the ligands and transitions between the resulting electronic energy levels	Details of how the d-electrons split in a particular complex are **not** required.
Energy and matter	
(n) techniques and procedures to measure concentrations of solutions using a colorimeter or visible spectrophotometer.	*M3.1, M3.2* **PAG9** • *using a colorimeter to measure the concentration of a coloured solution*

2

Colour by design (CD)

A study of dyes and dyeing and the use of chemistry to provide colour to order. The storyline begins by looking at biological pigments, such as found in carrots, to examine the origins of colour in delocalised systems in organic molecules. This discussion moves into the structure of benzene, where the storyline touches on how scientific ideas develop.

The storyline then moves on to synthetic dyes, including picric acid, chrysodin and mauveine. The concepts explored in this context includes electrophilic substitution reactions of benzene, and formation of diazonium compounds. At this point, the storyline also takes a look at the overall structure of dye molecules and how dyes attach themselves to fibres.

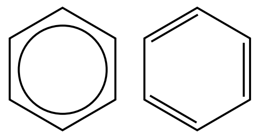
Food dyes and food testing then form the context for studying the structure of fats and oils and the principles of gas–liquid chromatography. The storyline ends with reactions of carbonyl compounds, and case studies to illustrate the synthesis of organic molecules.

The chemical ideas in this module are:

- the chemical origins of colour in organic compounds
- aromatic compounds and their reactions
- dyes and dyeing
- diazonium compounds
- fats and oils
- gas–liquid chromatography
- carbonyl compounds and their reactions
- organic synthesis and polyfunctional compounds.

Learning outcomes	Additional guidance
Learners should be able to demonstrate and apply their knowledge and understanding of:	
Bonding and structure	
(a) how some dyes attach themselves to fibres in terms of intermolecular bonds, ionic bonds and covalent bonding	Details of dye structures will be given.
(b) the structure of a dye molecule in terms of the chromophore and:	
(i) functional groups that modify the chromophore	
(ii) functional groups that affect the solubility of the dye	
(iii) functional groups that allow the dye to bond to fibres	
Organic functional groups	
(c) fats and oils consist mainly of mixed esters of propane-1,2,3-triol with varying degrees of unsaturation	

Colour by design (CD)

(d) the formulae of arenes and their derivatives (aromatic compounds):	
(i) the delocalisation of electrons in these compounds	
(ii) how delocalisation accounts for their characteristic properties	Limited to undergoing substitution (often slowly) rather than addition reactions in **(ii)**.
(e) the two common representations of the benzene molecule and their relation to:	The common representations to be considered are: 
(i) the shape of the molecule	
(ii) bonding in the molecule (including a treatment of enthalpy change of hydrogenation)	
(f) naming the individual functional groups mentioned elsewhere in the specification within a polyfunctional molecule and making predictions about the properties of the polyfunctional molecule; testing for these functional groups in a compound, using reactions mentioned in the specification	**PAG7** • *test-tube reactions to identify or distinguish between unknown organic compounds with functional groups mentioned in the specification*
Organic reactions	
(g) the following electrophilic substitution reactions of arenes and the names of the benzene derivatives formed:	Naming of acylated products is **not** required. • *reactions involving aromatic compounds*
(i) halogenation of the ring	
(ii) nitration, including the mechanism	
(iii) sulfonation	
(iv) Friedel–Crafts alkylation and acylation	
(h) the formation of diazonium compounds and the coupling reactions that these undergo to form azo dyes	• *test-tube reactions involving dye making and dyeing*
(i) the following reactions involving carbonyl compounds (aldehydes and ketones):	Formulae of (all) products required, but **not** equations.
(i) oxidation of aldehydes to carboxylic acids using acidified dichromate, under reflux	**PAG7, see also CD(f)**. • *test-tube reactions of carbonyl compounds*
(ii) reaction with Fehling's solution and Tollens' reagent	
(iii) reaction with cyanide ions to form the cyanohydrin	

Colour by design (CD)

(j) use of organic reactions and reaction conditions mentioned here and elsewhere in the specification to suggest and explain synthetic routes for preparing organic compounds

Further reactions that learners are expected to consider are given on the *Data Sheet.*

Reaction mechanisms

(k) the mechanism of the nucleophilic addition reaction between a carbonyl compound and CN^-, using 'curly arrows' and partial charges

(l) organic mechanisms:

- **(i)** use of the following terms to classify organic reactions: *addition, condensation, elimination, substitution, oxidation, reduction, hydrolysis*
- **(ii)** use of 'curly arrows' and partial charges, where appropriate, to describe unfamiliar mechanisms, given appropriate information

Energy and matter

(m) the origins of colour (and UV absorption) in organic molecules

In terms of:

- transitions between electronic energy levels
- the relationship between the extent of delocalisation in the chromophore and the energy absorbed.

Modern analytical techniques

(n) the general principles of gas–liquid chromatography:

- **(i)** sample injected into inert carrier gas stream
- **(ii)** column consisting of high boiling liquid on porous support
- **(iii)** detection of the emerging compounds (sometimes involving mass spectrometry)
- **(iv)** distinguishing compounds by their retention times.

2e. Chemical literacy (CL)

Throughout the course, learners will be given opportunities to practise and demonstrate their chemical literacy skills. 'Chemical literacy' means the ability to comprehend a passage of text of A Level standard, to extract information from it and to use this information. Use of the information may take the form e.g. of a calculation or to construct an argument. Chemical literacy also involves being able to answer questions logically and with due regard for the correct use of technical terms.

Chemical literacy will be formally assessed across the three written components in the A Level assessment. Aspects of the assessment that relate to chemical literacy include:

– extended response items assessed through Level of Response mark schemes, which reward responses that are coherent, relevant, substantiated and logically structured, with the correct use of technical terms

– questions set in unfamiliar contexts

– questions assessing the comprehension of a longer passage of text, specifically the pre-release Advance Notice article included in Component 02

– questions assessing comprehension of and use of data from the Practical Insert in Component 03.

Chemical literacy skills may be assessed within the context of any of the learning outcomes included in Section 2d, and in conjunction with assessment of any of the practical skills in Section 2c.

2

	Learning outcomes	Additional guidance
	Learners should be able to read a scientific article or the Practical Insert and:	
(a)	extract and manipulate data	
(b)	interpret and use information	
(c)	show comprehension by written communication with regard to logical presentation and the correct use of appropriate technical terms.	Including comprehension of parts of the Advance Notice article that are outside the specification but which are of a similar A level standard.

2

2f. Prior knowledge, learning and progression

This specification has been developed for learners who wish to continue with a study of chemistry at Level 3 in the National Qualifications Framework (NQF). The A level specification has been written to provide progression from GCSE Science, GCSE Additional Science, GCSE Further Additional Science, GCSE Chemistry or from AS Level Chemistry. Learners who have successfully taken other Level 2 qualifications in Science or Applied Science with appropriate chemistry content may also have acquired sufficient knowledge and understanding to begin the A Level Chemistry course.

There is no formal requirement for prior knowledge of chemistry for entry onto this qualification. Other learners without formal qualifications may have acquired sufficient knowledge of chemistry to enable progression onto the course.

Some learners may wish to follow a chemistry course for only one year as an AS, in order to broaden their curriculum, and to develop their interest and understanding of different areas of the subject. Others may follow a co-teachable route, completing the one-year AS course and/or then moving to the two-year A level.

The A Level Chemistry course will prepare learners for progression to undergraduate courses in Chemistry, Biochemistry, Medicine, Dentistry, Engineering, Pharmacy, one of the other sciences or related subjects. For learners wishing to follow an apprenticeship route or those seeking direct entry into chemical science careers, this A level provides a strong background and progression pathway.

There are a number of Science specifications at OCR. Find out more at **www.ocr.org.uk**

3 Assessment of OCR A Level in Chemistry B (Salters)

3a. Forms of assessment

All three externally assessed components (01–03) contain some synoptic assessment, some extended response questions and some stretch and challenge questions.

Stretch and challenge questions are designed to allow the most able learners the opportunity to demonstrate the full extent of their knowledge and skills.

Stretch and challenge questions will support the awarding of the A* grade at A level, addressing the need for greater differentiation between the most able learners.

3

Fundamentals of chemistry (Component 01)

This component is worth 110 marks and is split into two sections and assesses content from across all teaching modules. Learners answer all questions.

Section A contains multiple choice questions. This section of the paper is worth 30 marks.

Section B includes short answer question styles (structured questions, problem solving, calculations, practical) and extended response questions. This section of the paper is worth 80 marks.

Scientific literacy in chemistry (Component 02)

This component assesses content from across all teaching modules and places a particular emphasis on scientific literacy. Learners answer all questions. This component includes a pre-release Advance Notice article (see Section 5) worth 20 to 25 marks.

Question styles include short answer (structured questions, problem solving, calculations, practical) and extended response questions. This component is worth 100 marks.

Practical skills in chemistry (Component 03)

This component assesses content from across all teaching modules and places a particular emphasis on practical skills. Learners answer all questions. This component is worth 60 marks.

Question styles include short answer (structured questions, problem solving, calculations, practical) and extended response questions.

Practical Endorsement in chemistry (Component 04)

Performance in this component is reported separately to the performance in the A level as measured through externally assessed components 01 to 03. This non-exam assessment component rewards the development of practical competency in chemistry and is teacher assessed. Learners demonstrate competence in the range of skills and techniques specified in Section 1.2 of the specification by carrying out a minimum of 12 assessed practical activities. The Practical Endorsement is teacher assessed against the Common Practical Assessment Criteria as specified in Section 5h.

Learners may work in groups but must demonstrate and record independent evidence of their competency. Teachers who award a pass to their learners must be confident that each learner consistently and routinely exhibits the competencies listed in Section 5h and has demonstrated competence in all the skills detailed in section 1.2.1 and in all the apparatus and techniques detailed in Section 1.2.2 before completion of the A level course. The practical activities provided by OCR are all mapped against the specification and assessment criteria.

3

3b. Assessment objectives (AO)

There are three assessment objectives in OCR's A Level in Chemistry B (Salters). These are detailed in the table below.

Learners are expected to demonstrate their ability to:

	Assessment Objective
AO1	Demonstrate knowledge and understanding of scientific ideas, processes, techniques and procedures.
AO2	Apply knowledge and understanding of scientific ideas, processes, techniques and procedures: • in a theoretical context • in a practical context • when handling qualitative data • when handling quantitative data.
AO3	Analyse, interpret and evaluate scientific information, ideas and evidence, including in relation to issues, to: • make judgements and reach conclusions • develop and refine practical design and procedures.

AO weightings in A Level in Chemistry B (Salters)

The relationship between the assessment objectives and the components are shown in the following table:

Component	% of A Level in Chemistry B (Salters) (H433)		
	AO1	**AO2**	**AO3**
Fundamentals of chemistry (H433/01)	17–19	16–17	6–7
Scientific literacy in chemistry (H433/02)	9–10	15–17	12–13
Practical skills in chemistry (H433/03)	4–6	9–10	8–9
Practical endorsement in chemistry (H433/04)*	N/A	N/A	N/A
Total	**30–35**	**40–44**	**26–29**

* The Practical Endorsement is assessed and reported separately from the overall A level grade (see Section 5).

3c. Total qualification time

Total qualification time (TQT) is the total amount of time, in hours, expected to be spent by a learner to achieve a qualification. It includes both guided learning hours and hours spent in preparation, study, and assessment. The total qualification time for A Level in Chemistry B (Salters) is 360 hours. The total guided learning time is 360 hours.

3d. Qualification availability outside of England

This qualification is available in England. For Wales and Northern Ireland please check the Qualifications in Wales Portal (QIW) or the Northern Ireland Department of Education Performance Measures / Northern Ireland Entitlement Framework Qualifications Accreditation Number (NIEFQAN) list to see current availability.

3e. Language

This qualification is available in English only. All assessment materials are available in English only and all candidate work must be in English.

3f. Assessment availability

There will be one examination series available each year in May/June to **all** learners. All examined components must be taken in the same examination series at the end of the course.

This specification will be certificated from the June 2017 examination series onwards.

3g. Retaking the qualification

Learners can retake the qualification as many times as they wish. Learners must retake all examined components but they can choose either to retake the Practical Endorsement or carry forward their most recent results (see Section 4d).

Candidates can choose either to retake the Practical Endorsement or to carry forward their result for the Practical Endorsement by using the carry forward entry option (see Section 4a). The result for the Practical Endorsement may be carried forward for the lifetime of the specification.

A candidate who is retaking A Level Chemistry B (Salters) may re-use a previous result for the Practical Endorsement, even if it was awarded by another awarding organisation or if it was awarded for an alternative suite [e.g. a Practical Endorsement pass result from A Level Chemistry B (Salters) could be re-used for retaking A Level Chemistry A].

3h. Assessment of extended responses

The assessment materials for this qualification provide learners with the opportunity to demonstrate their ability to construct and develop a sustained and coherent line of reasoning which is coherent, relevant, substantiated and logically structured. The marks for extended responses are integrated into the marking criteria.

Extended response questions are included in all externally assessed components, including two questions in each component assessed using questions marked by Level of Response, in which the quality of the extended response is explicitly rewarded. These questions will be clearly identified in the assessment papers.

3i. Synoptic assessment

Synoptic assessment tests the learners' understanding of the connections between different elements of the subject.

Synoptic assessment involves the explicit drawing together of knowledge, understanding and skills learned in different parts of the A level course. The emphasis of synoptic assessment is to encourage the development of the understanding of the subject as a discipline. All components within Chemistry B (Salters) contain an element of synoptic assessment.

3

Synoptic assessment requires learners to make and use connections within and between different areas of chemistry, 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.

3j. Calculating qualification results

A learner's overall qualification grade for A Level in Chemistry B (Salters) will be calculated by adding together their marks from the three examined components taken to give their total weighted mark.

This mark will then be compared to the qualification level grade boundaries for the entry option taken by the learner and for the relevant exam series to determine the learner's overall qualification grade.

A learner's result for their Practical Endorsement in chemistry component will not contribute to their overall qualification grade.

4 Admin: what you need to know

The information in this section is designed to give an overview of the processes involved in administering this qualification so that you can speak to your exams officer. All of the following processes require you to submit something to OCR by a specific deadline.

More information about the processes and deadlines involved at each stage of the assessment cycle can be found in the Administration area of the OCR website.

OCR's *Admin overview* is available on the OCR website at http://www.ocr.org.uk/administration.

4a. Pre-assessment

Estimated entries

Estimated entries are your best projection of the number of learners who will be entered for a qualification in a particular series. Estimated entries should be submitted to OCR by the specified deadline. These do not incur a cost and do not commit your centre in any way.

Updated arrangements for monitoring the Practical Endorsement

Full details on the monitoring and the implementation of the practical endorsement are available on the Positive about Practical pages at https://www.ocr.org.uk/subjects/science/positive-about-practical. Lead teachers are required to have undertaken the free online training for A level science teachers, available here: https://practicalendorsement.ocr.org.uk/login/index.php. The lead teacher should also ensure that all other teachers of that science within the centre are familiar with the requirements so that standards are applied consistently.

The awarding organisations (AOs) use information from centre entries for the A levels in biology, chemistry and physics from the previous summer examination series to jointly plan monitoring visits for the current two-year cycle and the subsequent cycles. Most centres will be monitored for a different science than that which was monitored in the previous monitoring cycle. Large centres will continue to be monitored for biology, chemistry and physics in each cycle. The first contact with a centre will be from the AO with which the science to be monitored was entered in the prior summer series. This first contact will be with the exams officer (or other nominated school contact).

It is the responsibility of a centre that is new, or is switching exam boards, or that only offers one or two science A levels to let AOs know, so that appropriate monitoring can be scheduled.

Final entries

Final entries provide OCR with detailed data for each learner, showing each assessment to be taken. It is essential that you use the correct entry code, considering the relevant entry rules.

Final entries must be submitted to OCR by the published deadlines or late entry fees will apply.

All learners taking A Level in Chemistry B (Salters) must be entered for one of the entry options shown on the following table:

Entry option		Component		
Entry code	**Title**	**Code**	**Title**	**Assessment type**
H433	Chemistry B (Salters)	01	Fundamentals of chemistry	External assessment
		02	Scientific literacy in chemistry	External assessment
		03	Practical skills in chemistry	External assessment
		04	Practical Endorsement in chemistry	Non-exam assessment (Visiting monitoring)
H433C	Chemistry B (Salters)	01	Fundamentals of chemistry	External assessment
		02	Scientific literacy in chemistry	External assessment
		03	Practical skills in chemistry	External assessment
		80	Practical Endorsement in chemistry – Carried Forward*	Non-exam assessment (Carried Forward)

*The carry forward option will be available for the first time from June 2018.

Private candidates

Private candidates may enter for OCR assessments.

A private candidate is someone who pursues a course of study independently but takes an examination or assessment at an approved examination centre. A private candidate may be a part-time student, someone taking a distance learning course, or someone being tutored privately. They must be based in the UK.

The A Level Chemistry B (Salters) qualification requires learners to complete a Practical Endorsement incorporating a minimum of 12 practical activities, allowing them to demonstrate a range of practical skills, use of apparatus and techniques to fulfil the Common Practical Assessment Criteria.

The Practical Endorsement is an essential part of the course and will allow learners to develop skills for further study or employment, as well as imparting important knowledge that is part of the specification.

Private candidates need to contact OCR approved centres to establish whether they are prepared to host them as a private candidate. The centre may charge for this facility and OCR recommends that the arrangement is made early in the course.

Further guidance for private candidates may be found on the OCR website: http://www.ocr.org.uk

Head of Centre Annual Declaration

The practical science statement is contained within the NEA Centre Declaration Form which can be found on the OCR website at www.ocr.org.uk/formsfinder. By signing the form, the centre is confirming that they are meeting all the requirements detailed in the specification, including that they have provided all candidates the opportunity to undertake the prescribed practical activities.

Please see the JCQ publication *Instructions for conducting non-examination assessments* for further information.

Any failure by a centre to provide a practical science statement to OCR in a timely manner (by means of an NEA Centre Declaration Form) will be treated as malpractice and/or maladministration [under General Condition A8 (*Malpractice and maladministration*)].

NEA Centre Declaration Form: Practical Science Statement

Centres must provide a written **practical science statement** confirming that reasonable opportunities have been provided to all learners being submitted for entry for assessment to undertake at least **twelve** appropriate practical activities.

The practical science statement is contained within the NEA Centre Declaration Form, this form can be found on the OCR website at www.ocr.org.uk/formsfinder.

By signing the form, the centre is confirming that:

a) At least twelve practical activities have been completed by each candidate enabling them to demonstrate competence in all skills, apparatus and techniques as specified in OCR's A Level science specifications.

b) Whilst undertaking the practical activities, all candidates have written and retained a record of their work.

Centres should have records confirming points (a) to (b) above available as they may be requested as part of the monitoring process.

Any failure by a centre to provide a practical science statement to OCR in a timely manner (by means of an NEA Centre Declaration Form) will be treated as malpractice and/or maladministration [under General Condition A8 (*Malpractice and maladministration*)].

Collecting evidence of student performance to ensure resilience in the qualifications system

Regulators have published guidance on collecting evidence of student performance as part of long-term contingency arrangements to improve the resilience of the qualifications system. You should review and consider this guidance when delivering this qualification to students at your centre.

For more detailed information on collecting evidence of student performance please visit our website at: https://www.ocr.org.uk/administration/general-qualifications/assessment/

4b. Accessibility and special consideration

Reasonable adjustments and access arrangements allow learners with special educational needs, disabilities or temporary injuries to access the assessment and show what they know and can do, without changing the demands of the assessment.

Applications for these should be made before the examination series. Detailed information about eligibility for access arrangements can be found in the JCQ *Access Arrangements and Reasonable Adjustments.*

Special consideration is a post-assessment adjustment to marks or grades to reflect temporary injury, illness or other indisposition at the time the assessment was taken. Detailed information about eligibility for special consideration can be found in the JCQ *A guide to the special consideration process* and JCQ *Reasonable Adjustments for GCE A-level sciences – Endorsement of practical skills.*

4c. External assessment arrangements

Regulations governing examination arrangements are contained in the JCQ publication *Instructions for conducting examinations*.

Learners are permitted to use a scientific or graphical calculator for components 01, 02 and 03. Calculators are subject to the rules in the document *Instructions for Conducting Examinations* published annually by JCQ (www.jcq.org.uk).

4d. Admin of non-exam assessment

Regulations governing arrangements for internal assessments are contained in the JCQ *Instructions for conducting non-examination assessments*. Appendix 1 of this document gives specific details for the Practical Skills Endorsement for A Level sciences designed for use in England.

OCR's *Admin overview* is available on the OCR website at **http://www.ocr.org.uk/administration**.

Carrying forward the Practical Endorsement in Chemistry

Learners who are retaking the qualification can choose to either retake the endorsement or carry forward their most recent result for that component (even if it was awarded by another awarding organisation or if it was awarded for an alternative suite).

To carry forward the result, you must use the carry forward entry option (see table in Section 4a).

4

4e. Results and certificates

Grade scale

A level qualifications are graded on the scale: A*, A, B, C, D, E, where A* is the highest. Learners who fail to reach the minimum standard for E will be Unclassified (U). Only subjects in which grades A* to E are attained will be recorded on certificates.

Results for the A Level Sciences Practical Endorsements will be shown independently of the qualification grade on the certificate. Candidates who fulfil the requirements and reach the minimum standard will be awarded a Pass grade. Candidates who fail to reach the minimum standard will be recorded as 'Not Classified' and this will also be reported on the certificate.

Results

Results are released to centres and learners for information and to allow any queries to be resolved **before** certificates are issued.

Centres will have access to the following results information for each learner:

- the grade for the qualification
- the raw mark for each component
- the total weighted mark for the qualification.

The following supporting information will be available:

- raw mark grade boundaries for each component
- weighted mark grade boundaries for each entry option.

Until certificates are issued, results are deemed to be provisional and may be subject to amendment. A learner's final results will be recorded on an OCR certificate.

The qualification title will be shown on the certificate as 'OCR Level 3 Advanced GCE in Chemistry B (Salters)'.

4f. Post-results services

A number of post-results services are available:

- **Review of results** – If you are not happy with the outcome of a learner's results, centres may request a review of marking.
- **Missing and incomplete results** – This service should be used if an individual subject result for a learner is missing, or the learner has been omitted entirely from the results supplied.
- **Access to scripts** – Centres can request access to marked scripts.
- **Practical Endorsement** – Since monitoring and any potential request for further visits take place throughout the period of the qualification, there is no post-results service provided.

4g. Malpractice

Any breach of the regulations for the conduct of examinations and coursework may constitute malpractice (which includes maladministration) and must be reported to OCR as soon as it is detected.

Detailed information on malpractice can be found in the *Suspected Malpractice in Examinations and Assessments: Policies and Procedures* published by JCQ.

5 Appendices

5a. Overlap with other qualifications

There is a small degree of overlap between the content of this specification and those for other AS level/A level Sciences.

Examples of overlap include:

Biology

- The ozone story: Climate change.
- What's in a Medicine: Chromatography.
- Polymers and life, Oceans: Amino acids, proteins, DNA, enzyme catalysis.
- Oceans: pH, buffers, climate change.

Geology

- The ozone story / Oceans: Climate change, the atmosphere.

Physics

- Elements of life: Atomic structure, Atomic emission spectra.

Science

- Elements of life: Atomic structure.
- Developing fuels: enthalpy changes, catalysis, the development of renewable alternatives to finite energy resources.
- The ozone story: Climate change, the atmosphere, rates of reaction, catalysis.
- What's in a Medicine: Infrared spectroscopy, chromatography.
- Oceans: Climate change.
- Polymers and life: Amino acids, DNA, proteins.

5b. Avoidance of bias

The A level qualification and subject criteria have been reviewed in order to identify any feature which could disadvantage learners who share a protected Characteristic as defined by the Equality Act 2010. All reasonable steps have been taken to minimise any such disadvantage.

5c. Chemistry B (Salters) data sheet

Data Sheet for Chemistry B (Salters)

GCE Advanced Subsidiary and Advanced Level

Chemistry B (Salters) (H033 / H433)

The information in this sheet is for the use of candidates following Chemistry B (Salters) (H033 / H433).

Copies of this sheet may be used for teaching.

General Information

Molar gas volume = 24.0 $dm^3\ mol^{-1}$ at RTP

Avogadro constant, $N_A = 6.02 \times 10^{23}\ mol^{-1}$

Specific heat capacity of water, $c = 4.18\ J\ g^{-1}\ K^{-1}$

Planck constant, $h = 6.63 \times 10^{-34}\ J\ Hz^{-1}$

Speed of light in a vacuum, $c = 3.00 \times 10^{8}\ m\ s^{-1}$

Ionic product of water, $K_w = 1.00 \times 10^{-14}\ mol^2\ dm^{-6}$ at 298 K

1 tonne = 10^6 g

Arrhenius equation: $k = Ae^{-Ea/RT}$ or $\ln k = -E_a/RT + \ln A$

Gas constant, $R = 8.314\ J\ mol^{-1}\ K^{-1}$

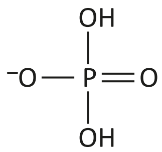
Triplet base codes (codons) for some amino acids used in mRNA

Glycine	GGU
Alanine	GCC
Leucine	CUG
Serine	UCG
Aspartic acid	GAU
Glutamine	CAA
Valine	GUC

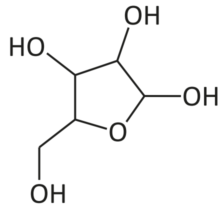
Characteristic infrared absorptions in organic molecules

Bond	Location	Wavenumber / cm^{-1}
C–H	Alkanes	2850–2950
	Alkenes, arenes	3000–3100
C–C	Alkanes	750–1100
C=C	Alkenes	1620–1680
aromatic C=C	Arenes	Several peaks in range 1450–1650 (variable)
C=O	Aldehydes	1720–1740
	Ketones	1705–1725
	Carboxylic acids	1700–1725
	Esters	1735–1750
	Amides	1630–1700
	Acyl chlorides and acid anhydrides	1750–1820
C–O	Alcohols, ethers, esters and carboxylic acids	1000–1300
C≡N	Nitriles	2220–2260
C–X	Fluoroalkanes	1000–1350
	Chloroalkanes	600–800
	Bromoalkanes	500–600
O–H	Alcohols. phenols	3200–3600 (broad)
	Carboxylic acids	2500–3300 (broad)
N–H	Primary amines	3300–3500
	Amides	*ca*. 3500

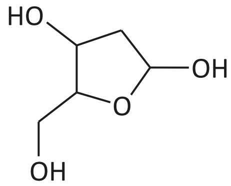
Monomers of DNA and RNA



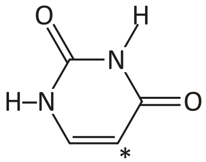
phosphate



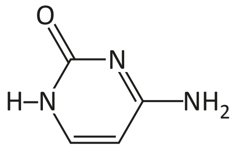
ribose



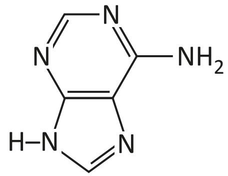
deoxyribose



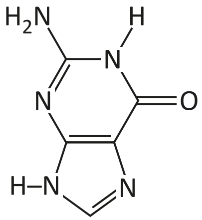
uracil



cytosine



adenine



guanine

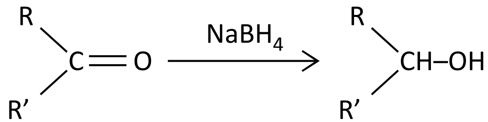
(thymine has a CH_3 at position *)

Some useful organic reactions

1 $\quad$ R–Br + CN^{-} $\longrightarrow$ R–CN + Br^{-}

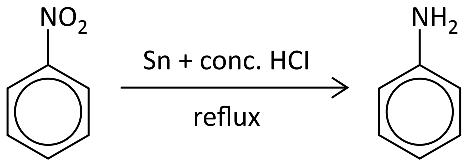
2 $\quad$ R–CN $\xrightarrow[\text{reflux}]{H^{+}(aq)}$ R–COOH

3

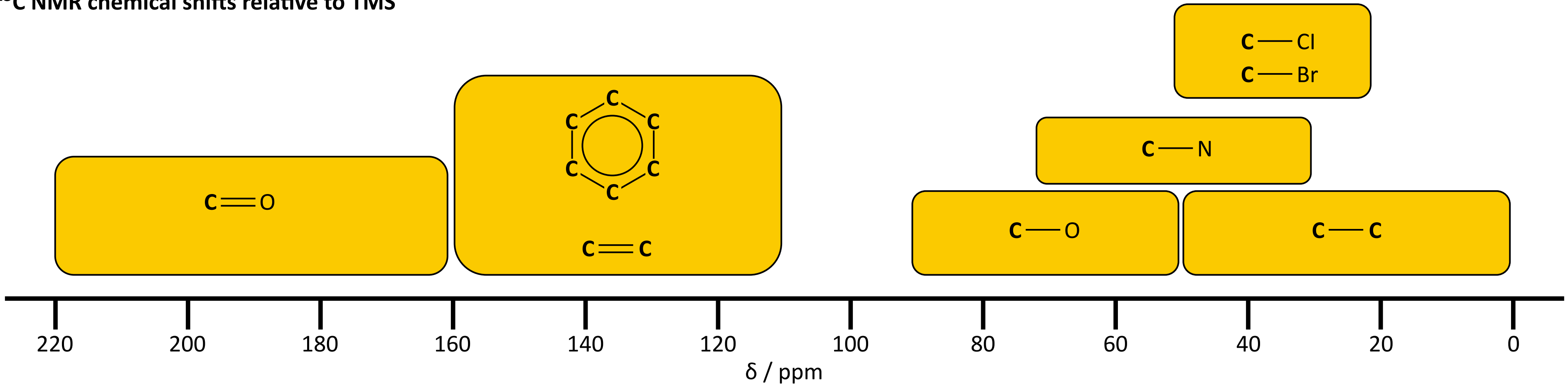


4 $\quad$ R–COOH + $SOCl_2$ $\longrightarrow$ R–COCl + SO_2 + HCl

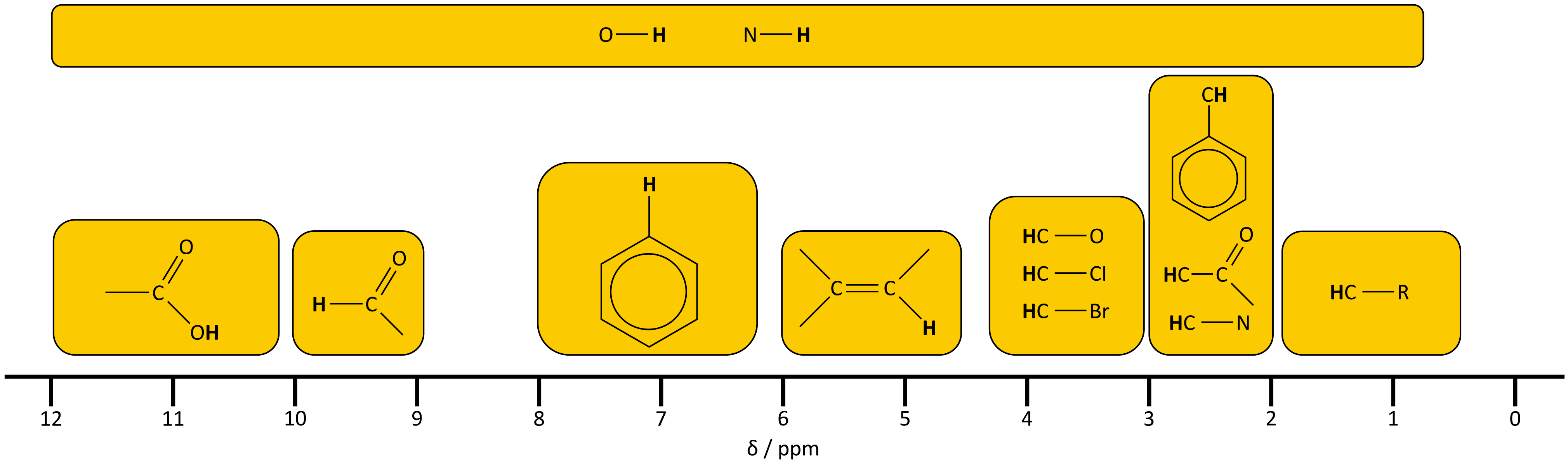
5



^{13}C NMR chemical shifts relative to TMS



^{1}H NMR chemical shifts relative to TMS



Chemical shifts are variable and can vary depending on the solvent, concentration and substituents. As a result, shifts may be outside the ranges indicated above.
OH and **NH** chemical shifts are very variable and are often broad. Signals are not usually seen as split peaks.
Note that **CH** bonded to ‘shifting groups’ on either side, e.g. O–CH_2–C=O, may be shifted more than indicated above.

The Periodic Table of the Elements

Key
atomic number
Symbol
name
relative atomic mass

(1) 1	(2) 2	3	4	5	6	7	8	9	10	11	12	(3) 13	(4) 14	(5) 15	(6) 16	(7) 17	(0) 18
1 **H** hydrogen 1.0																	2 **He** helium 4.0
3 **Li** lithium 6.9	4 **Be** beryllium 9.0											5 **B** boron 10.8	6 **C** carbon 12.0	7 **N** nitrogen 14.0	8 **O** oxygen 16.0	9 **F** fluorine 19.0	10 **Ne** neon 20.2
11 **Na** sodium 23.0	12 **Mg** magnesium 24.3											13 **Al** aluminium 27.0	14 **Si** silicon 28.1	15 **P** phosphorus 31.0	16 **S** sulfur 32.1	17 **Cl** chlorine 35.5	18 **Ar** argon 39.9
19 **K** potassium 39.1	20 **Ca** calcium 40.1	21 **Sc** scandium 45.0	22 **Ti** titanium 47.9	23 **V** vanadium 50.9	24 **Cr** chromium 52.0	25 **Mn** manganese 54.9	26 **Fe** iron 55.8	27 **Co** cobalt 58.9	28 **Ni** nickel 58.7	29 **Cu** copper 63.5	30 **Zn** zinc 65.4	31 **Ga** gallium 69.7	32 **Ge** germanium 72.6	33 **As** arsenic 74.9	34 **Se** selenium 79.0	35 **Br** bromine 79.9	36 **Kr** krypton 83.8
37 **Rb** rubidium 85.5	38 **Sr** strontium 87.6	39 **Y** yttrium 88.9	40 **Zr** zirconium 91.2	41 **Nb** niobium 92.9	42 **Mo** molybdenum 95.9	43 **Tc** technetium	44 **Ru** ruthenium 101.1	45 **Rh** rhodium 102.9	46 **Pd** palladium 106.4	47 **Ag** silver 107.9	48 **Cd** cadmium 112.4	49 **In** indium 114.8	50 **Sn** tin 118.7	51 **Sb** antimony 121.8	52 **Te** tellurium 127.6	53 **I** iodine 126.9	54 **Xe** xenon 131.3
55 **Cs** caesium 132.9	56 **Ba** barium 137.3	57–71 lanthanoids	72 **Hf** hafnium 178.5	73 **Ta** tantalum 180.9	74 **W** tungsten 183.8	75 **Re** rhenium 186.2	76 **Os** osmium 190.2	77 **Ir** iridium 192.2	78 **Pt** platinum 195.1	79 **Au** gold 197.0	80 **Hg** mercury 200.6	81 **Tl** thallium 204.4	82 **Pb** lead 207.2	83 **Bi** bismuth 209.0	84 **Po** polonium	85 **At** astatine	86 **Rn** radon
87 **Fr** francium	88 **Ra** radium	89–103 actinoids	104 **Rf** rutherfordium	105 **Db** dubnium	106 **Sg** seaborgium	107 **Bh** bohrium	108 **Hs** hassium	109 **Mt** meitnerium	110 **Ds** darmstadtium	111 **Rg** roentgenium	112 **Cn** copernicium		114 **Fl** flerovium		116 **Lv** livermorium		

57 **La** lanthanum 138.9	58 **Ce** cerium 140.1	59 **Pr** praseodymium 140.9	60 **Nd** neodymium 144.2	61 **Pm** promethium 144.9	62 **Sm** samarium 150.4	63 **Eu** europium 152.0	64 **Gd** gadolinium 157.2	65 **Tb** terbium 158.9	66 **Dy** dysprosium 162.5	67 **Ho** holmium 164.9	68 **Er** erbium 167.3	69 **Tm** thulium 168.9	70 **Yb** ytterbium 173.0	71 **Lu** lutetium 175.0
89 **Ac** actinium	90 **Th** thorium 232.0	91 **Pa** protactinium	92 **U** uranium 238.1	93 **Np** neptunium	94 **Pu** plutonium	95 **Am** americium	96 **Cm** curium	97 **Bk** berkelium	98 **Cf** californium	99 **Es** einsteinium	100 **Fm** fermium	101 **Md** mendelevium	102 **No** nobelium	103 **Lr** lawrencium

5d. How Science Works (HSW)

How Science Works was conceived as being a wider view of science in context, rather than just straightforward scientific enquiry. It was intended to develop learners as critical and creative thinkers, able to solve problems in a variety of contexts.

Developing ideas and theories to explain the operation of matter and how its composition, structure, properties and changes it undergoes, constitutes the basis of life and all nature. *How Science Works* develops the critical analysis and thinking of evidence to support or refute ideas and theories. Learners should be aware of the importance that peer review and repeatability have in giving confidence to this evidence.

Learners are expected to understand the variety of sources of data available for critical analysis to provide evidence and the uncertainty involved in its measurement. They should also be able to link that evidence to contexts influenced by culture, politics and ethics.

Understanding *How Science Works* requires an understanding of how scientific evidence can influence ideas and decisions for individuals and society, which is linked to the necessary skills of communication for audience and for purpose with appropriate scientific terminology.

HSW Statement	Examples of coverage in the first five modules (AS)	Examples of coverage in the second five modules
HSW1 Use theories, models and ideas to develop scientific explanations.	Developing models to explain atomic structure (**EL**). How elements are formed (**EL**). Using a simple model to explain the function of a catalyst (**DF**). Using collision theory to explain rates (**OZ**). S_N2 reactions as a model (**OZ**). Using models to explain depletion of ozone (**OZ**).	Using mechanisms to explain chemical reactions (**CD**). Using models to explain the structure of benzene (**CD**). Models of DNA and RNA (**PL**). Using the Brønsted–Lowry theory of acids and bases to explain equilibria (**O**).
HSW2 Use knowledge and understanding to pose scientific questions, define scientific problems, present scientific arguments and scientific ideas.	Using '*dot-and-cross*' diagrams to explain shapes of molecules (**EL**). Explaining atomic spectra in terms of electron transitions (**EL**). Calculations of enthalpy changes from experimental techniques (**DF**).	Solving spectroscopic problems using a range of data (**PL**). Explaining the significance of hydrogen bonding in the pairing of bases in DNA (**PL**). Using scientific knowledge to modify the chromophore in relation to dyes (**CD**).
HSW3 Use appropriate methodology, including information and communication technology (ICT), to answer scientific questions and solve scientific problems.	Using oxidation states to balance simple redox equations (**ES**). Using ideas of 'opposing change' to predict the effect of changing conditions on equilibrium position (**ES**).	Solving kinetics problems (**CI**). Solving entropy problems (**O**). Solving titration problems (**DM**).

5

HSW Statement	Examples of coverage in the first five modules (AS)	Examples of coverage in the second five modules
HSW4 Carry out experimental and investigative activities, including appropriate risk management, in a range of contexts.	Techniques and procedures for making soluble and insoluble salts (**EL**). Use of tests to identify salts (**EL**). Techniques and procedures in iodine and thiosulfate titrations (**ES**). Techniques and procedures in the electrolysis of aqueous solutions (**ES**). Techniques and procedures for making and purifying a solid organic product (**WM**).	Techniques and procedures for experiments in reaction kinetics (**CI**). Techniques and procedures for measuring the energy transferred in enthalpy experiments (**O**). Techniques and procedures to set up and use electrochemical cells (**DM**). Techniques and procedures to measure concentrations of solutions using a colorimeter (**DM**).
HSW5 Analyse and interpret data to provide evidence, recognising correlations and causal relationships.	Using a graph of first ionisation enthalpy against atomic number to deduce electronic configurations (**EL**). Using experimental observations to explain the reactions between sodium halides and concentrated sulfuric acid (**ES**). Use of data from MS to determine relative abundance (**EL**).	Solving more advanced spectroscopic problems (**PL**). Organic syntheses (**CD**). Determining best conditions for an industrial process (**CI**).
HSW6 Evaluate methodology, evidence and data, and resolve conflicting evidence.	Evaluating evidence from the Geiger–Marsden experiment to develop a model for the structure of the atom (**EL**). Evaluating experimental evidence to decide whether the rate of hydrolysis of haloalkanes depends on bond enthalpy or bond polarity (**OZ**).	Evaluating evidence for the structure of benzene (**CD**). Interpreting and using information from chemical texts (**CL**).
HSW7 Know that scientific knowledge and understanding develop over time.	Developing models of atomic structure (**EL**).	Developing models of the structure of benzene (**CD**).
HSW8 Communicate information and ideas in appropriate ways using appropriate terminology.	Drawing '*dot and cross*' diagrams for simple molecules (**EL**). Explaining the effect of chlorine atoms on the ozone layer (**OZ**).	Drawing organic mechanisms (**CD**). Showing comprehension of a chemical text (**CL**). Explain rusting and its prevention (**DM**). Explain synthetic routes for preparing organic compounds (**CD**).

HSW Statement	Examples of coverage in the first five modules (AS)	Examples of coverage in the second five modules
HSW9 Consider applications and implications of science and evaluate their associated benefits and risks.	Considering the benefits and risks of using fossil fuels and alternative fuels (**DF**). Considering the risks associated with the transport and use of chlorine (**ES**).	Considering the benefits and risks associated with industrial processes (**CI**). How buffers work (including in everyday applications) (**O**). The formation of diazonium compounds (**CD**).
HSW10 Consider ethical issues in the treatment of humans, other organisms and the environment.	Considering the environmental implications of atmospheric pollutants (**DF**). Extraction of minerals from the sea (**DF**). Polluting effects of ozone in the troposphere (**OZ**). Considering the use of chlorine in sterilising water (**ES**). The principles of green chemistry (**WM**).	Considering sustainability issues in the chemical industry (**CI**). Considering the greenhouse effect of carbon dioxide (**O**).
HSW11 Evaluate the role of the scientific community in validating new knowledge and ensuring integrity.	Considering the depletion of ozone in the stratosphere due to haloalkanes (**OZ**).	Considering the effect of increased concentration of carbon dioxide in the atmosphere on an enhanced greenhouse effect (**O**).
HSW12 Evaluate the ways in which society uses science to inform decision making.	Evaluating the effect of ozone in the stratosphere (**OZ**).	Evaluating the effect of greenhouse gases in the atmosphere (**O**).

5e. Mathematical requirements

In order to be able to develop their skills, knowledge and understanding in A Level Chemistry, learners 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 of coverage below.

The assessment of quantitative skills will include at least 20% Level 2 (or above) mathematical skills for chemistry (see later for a definition of 'Level 2' mathematics). These skills will be applied in the context of the relevant chemistry.

All mathematical content will be assessed within the lifetime of the specification. Skills shown in **bold** type will only be tested in the full A level course, not the standalone AS level course.

This list of examples is not exhaustive and is not limited to Level 2 examples. These skills could be developed in other areas of specification content from those indicated.

	Mathematical skill to be assessed	Exemplification of the mathematical skill in the context of A Level Chemistry (assessment is not limited to the examples below)	Areas of the specification which exemplify the mathematical skill (assessment is not limited to the examples below)
M0 – Arithmetic and numerical computation			
M0.0	Recognise and make use of appropriate units in calculation	Learners may be tested on their ability to: • convert between units e.g. cm^3 to dm^3 as part of volumetric calculations • **give units for an equilibrium constant or a rate constant** • understand that different units are used in similar topic areas, so that conversions may be necessary e.g. entropy in $J\ mol^{-1}\ K^{-1}$ and enthalpy changes in $kJ\ mol^{-1}$.	1.1.2(b) EL(a,b,c), DF(a,f), CI(a,h), O(f)
M0.1	Recognise and use expressions in decimal and ordinary form	Learners may be tested on their ability to: • use an appropriate number of decimal places in calculations • carry out calculations using numbers in standard and ordinary form, e.g. use of Avogadro's constant • **understand standard form when applied to areas such as (but not limited to) K_w** • understand that significant figures need retaining when making conversions between standard and ordinary form, e.g. 0.0050 $mol\ dm^{-3}$ is equivalent to $5.0 \times 10^{-3}\ mol\ dm^{-3}$.	EL(a), ES(p) O(l), DM(a)

	Mathematical skill to be assessed	Exemplification of the mathematical skill in the context of A Level Chemistry (assessment is not limited to the examples below)	Areas of the specification which exemplify the mathematical skill (assessment is not limited to the examples below)
M0.2	Use ratios, fractions and percentages	Learners may be tested on their ability to: • calculate percentage yields • calculate the atom economy of a reaction • construct and/or balance equations using ratios.	EL(b,c,d), ES(a), WM(g)
M0.3	Estimate results	Learners may be tested on their ability to: • **evaluate the effect of changing experimental parameters on measurable values, e.g. how the value of K_c would change with temperature given different specified conditions.**	ES(q), CI(f)
M0.4	Use calculators to find and use power, **exponential and logarithmic functions**	Learners may be tested on their ability to: • carry out calculations using the Avogadro constant • **carry out pH and pK_a calculations** • **make appropriate mathematical approximations in buffer calculations.**	EL(a), CI(d), O(l,m)
M1 – Handling data			
M1.1	Use an appropriate number of significant figures	Learners may be tested on their ability to: • report calculations to an appropriate number of significant figures given raw data quoted to varying numbers of significant figures • understand that calculated results can only be reported to the limits of the least accurate measurement.	1.1.3(c) EL(b,c), DF(a,f), DM(a)
M1.2	Find arithmetic means	Learners may be tested on their ability to: • calculate weighted means, e.g. calculation of an atomic mass based on supplied isotopic abundances • select appropriate titration data (i.e. identification of outliers) in order to calculate mean titres.	EL(c,x)

	Mathematical skill to be assessed	Exemplification of the mathematical skill in the context of A Level Chemistry (assessment is not limited to the examples below)	Areas of the specification which exemplify the mathematical skill (assessment is not limited to the examples below)
M1.3	Identify uncertainties in measurements and use simple techniques to determine uncertainty when data are combined	Learners may be tested on their ability to: • determine uncertainty when two burette readings are used to calculate a titre value.	1.1.4(d), EL(c)
M2 – Algebra			
M2.1	Understand and use the symbols: =, <, <<, >>, >, ∝, ~, ⇌	No exemplification required.	
M2.2	Change the subject of an equation	Learners may be tested on their ability to: • carry out structured and unstructured mole calculations • **calculate a rate constant *k* from a rate equation.**	EL(b,c), DF(a), CI(a), O(f,h)
M2.3	Substitute numerical values into algebraic equations using appropriate units for physical quantities	Learners may be tested on their ability to: • carry out enthalpy change calculations • calculate the value of an equilibrium constant K_c • **carry out rate calculations.**	EL(b,c), DF(f), ES(p), CI(a,h), O(h)
M2.4	Solve algebraic equations	Learners may be tested on their ability to: • carry out Hess' law calculations • **calculate a rate constant *k* from a rate equation.**	EL(b,c), DF(g), CI(a)
M2.5	**Use logarithms in relation to quantities that range over several orders of magnitude**	Learners may be tested on their ability to: • **carry out pH and pK_a calculations.**	CI(d), O(l,m)
M3 – Graphs			
M3.1	Translate information between graphical, numerical and algebraic forms	Learners may be tested on their ability to: • interpret and analyse spectra • **determine the order of a reaction from a graph and derive rate expression.**	EL(x), WM(i,j), PL(r,s) CI(c)

	Mathematical skill to be assessed	Exemplification of the mathematical skill in the context of A Level Chemistry (assessment is not limited to the examples below)	Areas of the specification which exemplify the mathematical skill (assessment is not limited to the examples below)
M3.2	Plot two variables from experimental or other data	Learners may be tested on their ability to: • plot graphs from collected or supplied data to follow the course of a reaction • draw lines of best fit • extrapolate and interpolate • **construct calibration curves.**	1.1.3(d), OZ(f), CI(c,d), DM(n)
M3.3	**Determine the slope and intercept of a linear graph**	Learners may be tested on their ability to: • **calculate values for E_a and A from the gradient and intercept of a graph using the Arrhenius equation.**	1.1.3(d), CI(c,d)
M3.4	**Calculate rate of change from a graph showing a linear relationship**	Learners may be tested on their ability to: • **calculate the rate constant of a first-order reaction by determination of the gradient of a rate–concentration graph.**	1.1.3(d), CI(c,d)
M3.5	**Draw and use the slope of a tangent to a curve as a measure of rate of change**	Learners may be tested on their ability to: • **calculate the rate of a reaction from the gradient of a concentration–time graph for a first or second order reaction.**	CI(c)
M4 – Geometry and trigonometry			
M4.1	Use angles and shapes in regular 2-D and 3-D structures	Learners may be tested on their ability to: • predict/identify shapes of and bond angles in molecules with and without a lone pair(s), for example NH_3, CH_4, H_2O etc.	EL(k)
M4.2	Visualise and represent 2-D and 3-D forms including 2-D representations of 3-D objects	Learners may be tested on their ability to: • draw different forms of isomers • **identify chiral centres from a 2-D or 3-D representation.**	DF(c,s), PL(q)
M4.3	Understand the symmetry of 2-D and 3-D shapes	Learners may be tested on their ability to: • describe the types of stereoisomerism shown by molecules/complexes • **identify chiral centres from a 2-D or 3-D representation.**	DF(s,t), PL(q)

Definition of Level 2 mathematics

Within A Level Chemistry, 20% of the marks available within written examinations will be for assessment of mathematics (in the context of chemistry) at a Level 2 standard, or higher. Lower level mathematical skills will still be assessed within examination papers but will not count within the 20% weighting for chemistry.

The following will be counted as Level 2 (or higher) mathematics:

- application and understanding requiring choice of data or equation to be used
- problem solving involving use of mathematics from different areas of maths and decisions about direction to proceed
- questions involving use of A level mathematical content (as of 2012), e.g. use of logarithmic equations.

The following will not be counted as Level 2 mathematics:

- simple substitution with little choice of equation or data
- structured question formats using GCSE mathematics (based on 2012 GCSE mathematics content).

Additional guidance on the assessment of mathematics within chemistry is available on the OCR website as a separate resource, the Maths Skills Handbook.

5f. Advance Notice for component 02

The A Level in Chemistry B (Salters) specification places a particular emphasis on the development of scientific literacy skills, which are assessed at the end of the course using a pre-release Advance Notice article (also included as part of the examination paper for component H433/02). The Advance Notice will be a scientific article/s related to the 'Storylines' within the specification and questions related to the Advance Notice will be worth 20–25 marks.

The Advance Notice will be available for download *via* the OCR website on 13 March each year (starting from 13 March 2017 for the first A level assessment in June 2017) to enable teachers and learners sufficient time to work through the information provided.

The instructions for teachers and candidates that will accompany the Advance Notice article are summarised below:

Notes for guidance (candidates)

1. This leaflet contains an article/s which is needed in preparation for questions in the externally assessed examination H433/02 Scientific literacy in chemistry.

2. You will need to read the article carefully and also have covered the Learning outcomes for A Level in Chemistry B (Salters). The examination paper will contain questions on the article/s. You will be expected to apply your knowledge and understanding of the work covered in A Level in Chemistry B (Salters) to answer these questions. There are 20–25 marks available on the question paper for these questions.

3. You can seek advice from your teacher about the content of the article and you can discuss it with others in your class. You may also investigate the topic yourself using any resources available to you.

4. You will not be able to bring your copy of the article, or other materials, into the examination. The examination paper will contain a fresh copy of the article as an insert.

5. You will not have time to read this article for the first time in the examination if you are to complete the examination paper within the specified time. However, you should refer to the article when answering the questions.

Notes for guidance (teachers)

1. This Advance Notice material should be issued to candidates on or after the date shown on the front cover of the candidate instructions sheet at the discretion and convenience of the centre. Candidates can be given the material at any point, but it is suggested that this should be at least four weeks before the examination date.

2. Candidates will need to read the article carefully. Time can be built into the teaching programme to introduce the article content. Candidates should be able to discuss the article freely and be given support and advice in the interpretation of the content so that they are able to answer the questions based on the article in the externally assessed examination. Candidates should also be encouraged to investigate the topics covered in the article for themselves.

3. Candidates will be expected to apply their knowledge and understanding of the content in A Level in Chemistry B (Salters) to questions based on the article. There are 20–25 marks available on the paper for these questions.

The Advance Notice material must not be taken into the examination. The examination paper H433/02 will contain a fresh copy of the article, as an insert. Candidates should be reminded that they do not have sufficient time during the examination to read the article for the first time. They should, however, refer to the article printed in the insert in the examination paper to help them to answer the questions.

5g. Health and Safety

In UK law, health and safety is primarily the responsibility of the employer. In a school or college the employer could be a local education authority, the governing body or board of trustees. Employees (teachers/lecturers, technicians etc) have a legal duty to cooperate with their employer on health and safety matters. Various regulations, but especially the COSHH Regulations 2002 (as amended) and the Management of Health and Safety at Work Regulations 1999, require that before any activity involving a hazardous procedure or harmful microorganisms is carried out, or hazardous chemicals are used or made, the employer must carry out a risk assessment. A useful summary of the requirements for risk assessment in school or college science can be found at **http://www.ase.org.uk/resources/health-and-safety-resources/risk-assessments/**

For members, the CLEAPSS® guide, *PS90, Making and recording risk assessments in school science*[1] offers appropriate advice.

Most education employers have adopted nationally available publications as the basis for their Model Risk Assessments.

Where an employer has adopted model risk assessments an individual school or college then has to review them, to see if there is a need to modify or adapt them in some way to suit the particular conditions of the establishment.

Such adaptations might include a reduced scale of working, deciding that the fume cupboard provision was inadequate or the skills of the candidates were insufficient to attempt particular activities safely. The significant findings of such risk assessment should then be recorded in a "*point of use text*", for example on schemes of work, published teachers guides, work sheets, etc. There is no specific legal requirement that detailed risk assessment forms should be completed for each practical activity, although a minority of employers may require this.

Where project work or investigations, sometimes linked to work-related activities, are included in specifications this may well lead to the use of novel procedures, chemicals or microorganisms, which are not covered by the employer's model risk assessments. The employer should have given guidance on how to proceed in such cases. Often, for members, it will involve contacting CLEAPSS®.

[1] These, and other CLEAPSS® publications, are on the CLEAPSS® Science Publications website **www.cleapss.org.uk**. Note that CLEAPSS® publications are only available to members. For more information about CLEAPSS® go to **www.cleapss.org.uk**.

5h. Practical endorsement

The Practical Endorsement is common across Chemistry A and Chemistry B (Salters). It requires a minimum of 12 practical activities to be completed from the Practical Activity Groups (PAGs) defined below (**Fig. 1**).

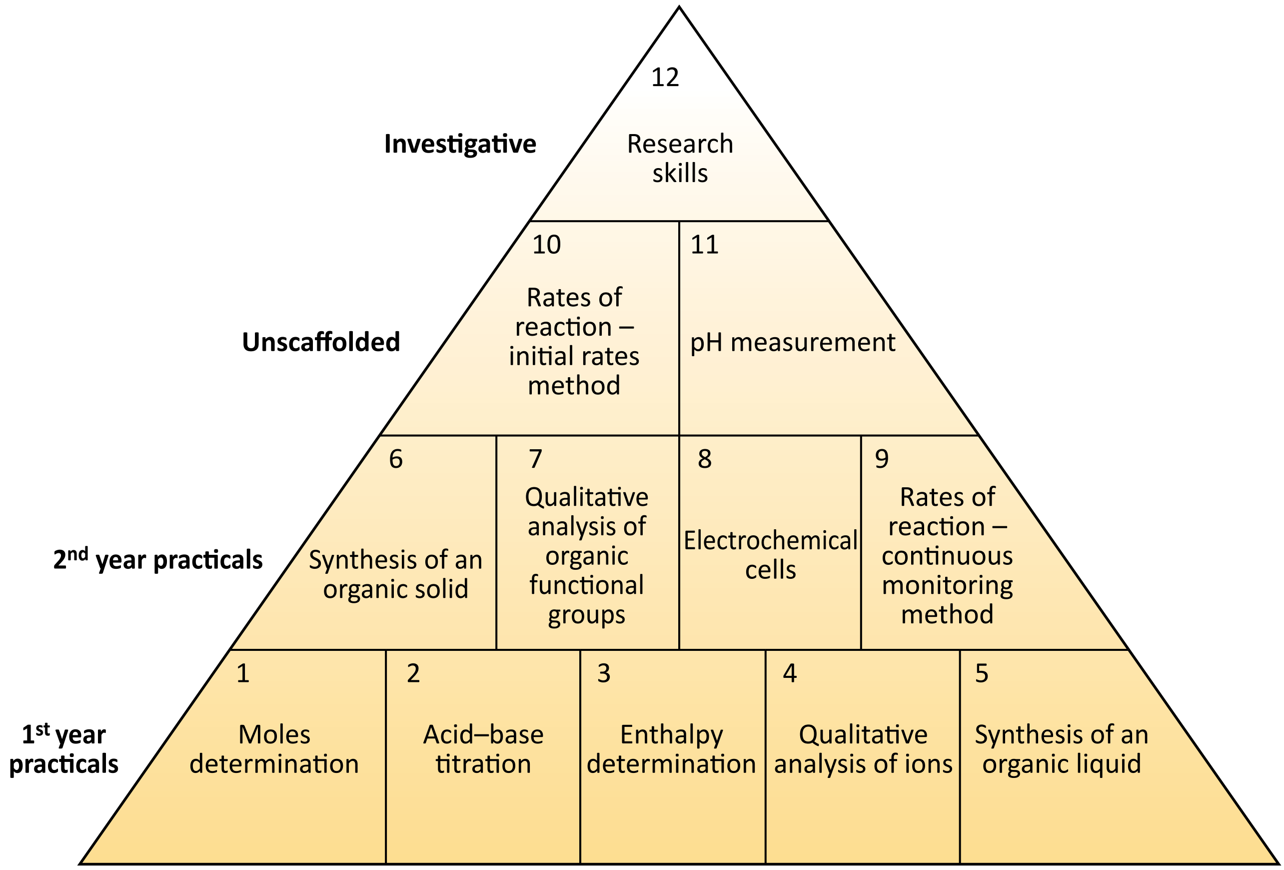


Fig. 1 OCR's Practical Activity Groups (PAGs), also see **Table 1**

Table 1 Practical activity requirements for the OCR Chemistry Practical Endorsement

Practical activity group (PAG)	Techniques/skills covered (minimum)	Example of a suitable practical activity (a range of examples will be available from the OCR website and centres can devise their own activity)	Specification reference (examples)
1 Moles determination	• Measurement of mass • Measurement of volume of gas	Determination of the composition of copper(II) carbonate	EL(b), DF(a)
2 Acid–base titration	• Measurement of volume of a liquid • Use of volumetric flask, including accurate technique for making up a standard solution • Titration, using burette and pipette • Use of acid–base indicators in titrations of weak/strong acids with weak/strong bases	Titration of sodium hydrogencarbonate against hydrochloric acid	EL(c)
3 Enthalpy determination	• Measurement of temperature	Determination of the enthalpy change of neutralisation	DF(f), O(b)
4 Qualitative analysis of ions	• Use of apparatus for qualitative tests for ions • Make and record qualitative observations	Identification of the anions and cations present in a mixture of Group 2 salts	EL(s), ES(k)
5 Synthesis of an organic liquid	• Heating under reflux[1] • Purification using a separating funnel • Distillation • Risk assessment	Synthesis of a haloalkane	WM(f)
6 Synthesis of an organic solid	• Purification by recrystallisation • Use of melting point apparatus • Use of thin layer or paper chromatography • Filtration • Heating under reflux[1] • Risk assessment	Synthesis of aspirin	WM(e), PL(a)
7 Qualitative analysis of organic functional groups	• Use of apparatus for qualitative tests for organic functional groups • Heating using water bath or electric heater • Make and record observations	Identifying functional groups in a series of unknown organic compounds	CD(f) also with: DF(o), WM(c),(d), PL(h),(j),(n), CD(i)

Practical activity group (PAG)	Techniques/skills covered (minimum)	Example of a suitable practical activity (a range of examples will be available from the OCR website and centres can devise their own activity)	Specification reference (examples)
8 Electrochemical cells	• Set up of electrochemical cells and measurement of voltages	The effect of concentration on the cell potential of an electrochemical cell	DM(d)
9 Rates of reaction – continuous monitoring method	• Measurement of rate of reaction by a continuous monitoring method • Measurement of time • Use of appropriate software to process data[2]	Finding the half-life of a reaction	CI(c), DM(n)
10 Rates of reaction – initial rates method	• Measurement of rate of reaction by an initial rate method • Use of appropriate software to process data[2] • Identify and control variables	Finding the order and rate constant for a reaction	CI(c)
11 pH measurement	• Measurement of pH	Identifying unknown solutions via pH measurements	O(k)
12 Research skills	• Apply investigative approaches • Use online and offline research skills • Correctly cite sources of information	How long does it take iron tablets to break down in the stomach?	Opportunities throughout specification

[1,2] These techniques/skills may be covered in *either* of the groups indicated.

The technique, '*Safely and carefully handling solids and liquids, including corrosive, irritant, flammable and toxic substances* ***(1.2.2 k)***' needs to be covered across the selection of activities.

It is expected that the following skills will be developed across <u>all</u> activities, regardless of the exact selection of activities. The ability to:

- safely and correctly use a range of practical equipment and materials **(1.2.1 b)**
- follow written instructions **(1.2.1 c)**
- make and record observations/measurements **(1.2.1 d)**
- keep appropriate records of experimental activities **(1.2.1 e)**
- present information and data in a scientific way **(1.2.1 f)**
- use a wide range of experimental and practical instruments, equipment and techniques **(1.2.1 j)**.

The practical activities can be completed at any point during the two year A level course at the discretion of the centre. Candidates starting from a standalone AS can count A level practical activities carried out during the AS year towards the A level Practical Endorsement provided that they are appropriately recorded. It is recommended therefore that candidates starting AS maintain a record of practical activities carried out (e.g. this could be in the form of a 'log book' or 'practical portfolio') that could be counted towards the Practical Endorsement. For candidates who then decide to follow a full A level, having started from AS, they can carry this record with them into their A level study.

The assessment of practical skills is a compulsory requirement of the course of study for A level qualifications in chemistry. It will appear on all students' certificates as a separately reported result, alongside the overall grade for the qualification. The arrangements for the assessment of practical skills are common to all awarding organisations. These arrangements include:

- A minimum of 12 practical activities to be carried out by each student which, together, meet the requirements of Appendices 5b (*Practical skills identified for direct assessment and developed through teaching and learning,* covered in Section **1.2.1**) and 5c (*Use of apparatus and techniques*, covered in Section **1.2.2**) from the prescribed subject content, published by the Department for Education. The required practical activities are defined by each awarding organisation (see **Fig. 1** and **Table 1**)
- Teachers will assess students against Common Practical Assessment Criteria (CPAC) issued by the awarding organisations. The CPAC (see **Table 2**) are based on the requirements of Appendices 5b and 5c of the subject content requirements published by the Department for Education, and define the minimum standard required for the achievement of a pass.
- Each student will keep an appropriate record of their practical work, including their assessed practical activities
- Students who demonstrate the required standard across all the requirements of the CPAC, incorporating all the skills, apparatus and techniques (as defined in Sections 1.2.1 and 1.2.2), will receive a 'Pass' grade (note that the practical activity tracker available from OCR allows confirmation that the activities selected cover all the requirements).
- There will be no direct assessment of practical skills for AS qualifications
- Students will answer questions in the AS and A level examination papers that assess the requirements of Appendix 5a (*Practical skills identified for indirect assessment and developed through teaching and learning*, covered in Section **1.1**) from the prescribed subject content, published by the Department for Education. These questions may draw on, or range beyond, the practical activities included in the specification.

In order to achieve a pass, students will need to:

- develop these competencies by carrying out a minimum of 12 practical activities (**PAG1** to **PAG12**), which allow acquisition of all the skills, apparatus and techniques outlined in the requirements of the specification (Sections 1.2.1 and 1.2.2)
- consistently and routinely exhibit the competencies listed in the CPAC (**Table 2**) before the completion of the A-level course
- keep an appropriate record of their practical work, including their assessed practical activities
- be able to demonstrate and/or record independent evidence of their competency, including evidence of independent application of investigative approaches and methods to practical work.

The practical activities prescribed in the subject specification (**PAG1** to **PAG12**) will provide opportunities for demonstrating competence in all the skills identified, together with the use of apparatus and techniques for each subject. However, students can also demonstrate these competencies in any additional practical activity undertaken throughout the course of study which covers the requirements of appendix 5b and 5c (covered in Sections 1.2.1 and 1.2.2).

Students may work in groups but teachers who award a pass to their students need to be confident of individual students' competence.

Table 2 Common Practical Assessment Criteria (CPAC) for the assessment of practical competency in A Level sciences

Competency	Practical Mastery
	In order to be awarded a Pass a Learner must, by the end of the practical science assessment, consistently and routinely meet the criteria in respect of each competency listed below. A Learner may demonstrate the competencies in any practical activity undertaken as part of that assessment throughout the course of study. Learners may undertake practical activities in groups. However, the evidence generated by each Learner must demonstrate that he or she independently meets the criteria outlined below in respect of each competency. Such evidence – **a)** will comprise both the Learner's performance during each practical activity and his or her contemporaneous record of the work that he or she has undertaken during that activity, and **b)** must include evidence of independent application of investigative approaches and methods to practical work.
(1) Follows written procedures	**a)** Correctly follows instructions to carry out experimental techniques or procedures.
(2) Applies investigative approaches and methods when using instruments and equipment	**a)** Correctly uses appropriate instrumentation, apparatus and materials (including ICT) to carry out investigative activities, experimental techniques and procedures with minimal assistance or prompting. **b)** Carries out techniques or procedures methodically, in sequence and in combination, identifying practical issues and making adjustments when necessary. **c)** Identifies and controls significant quantitative variables where applicable, and plans approaches to take account of variables that cannot readily be controlled. **d)** Selects appropriate equipment and measurement strategies in order to ensure suitably accurate results.
(3) Safely uses a range of practical equipment and materials	**a)** Identifies hazards and assesses risks associated with these hazards, making safety adjustments as necessary, when carrying out experimental techniques and procedures in the lab or field. **b)** Uses appropriate safety equipment and approaches to minimise risks with minimal prompting.
(4) Makes and records observations	**a)** Makes accurate observations relevant to the experimental or investigative procedure. **b)** Obtains accurate, precise and sufficient data for experimental and investigative procedures and records this methodically using appropriate units and conventions.
(5) Researches, references and reports	**a)** Uses appropriate software and/or tools to process data, carry out research and report findings. **b)** Cites sources of information, demonstrating that research has taken place, supporting planning and conclusions.

Choice of activity

Centres can include additional skills, apparatus and techniques within an activity (PAG) beyond those listed as the minimum in **Table 1** or in the published practical activities. They may also carry out more than the minimum 12 practical activities required to meet the Practical Endorsement.

To achieve a Pass within the Practical Endorsement, candidates must have demonstrated competence in all the skills, apparatus and techniques detailed in Sections 1.2.1 and 1.2.2 of the specification by carrying out a minimum of 12 assessed practical activities (covering all of **PAG1** to **PAG12**) and achieved the level of competence defined within the Common Practical Assessment Criteria (**Table 2**).

The minimum of 12 activities can be met by:

(i) using OCR suggested activities (provided as resources from Interchange, or by contacting pass@ocr.org.uk should you be unable to access Interchange)

(ii) modifying OCR suggested activities to match available equipment whilst fulfilling the same skills, apparatus and techniques and CPAC

(iii) using activities devised by the centre and mapped against Section 1.2 of the specification and the CPAC

(iv) using activities from external sources such as the learned societies, mapped against Section 1.2 of the specification and the CPAC

Centres can receive guidance on the suitability of their own practical activities or against any of the options within **(ii)** to **(iv)** above through our free practical assessment support service by emailing pass@ocr.org.uk.

Where centres devise their own practical activity or use an alternative activity, that practical activity must be of a level of demand appropriate for A level.

Practical Activity Groups 1 to 12 can be achieved through more than one centre devised practical activity, and centres are not limited to 12 practical activities such that a centre could, for instance, split **PAG6** into two activities of their own (rather than one) with the two activities fulfilling the requirements. Alternatively it could be possible that an extended activity may cover the requirements of more than one group, in which case the centre could then select an additional activity from another group to achieve the required minimum of 12 practical activities.

5i Revision of the requirements for practical work

OCR will review the Practical Endorsement detailed in Section 5h of this specification following any revision by the Secretary of State of the skills, apparatus or techniques specified in respect of A Level Chemistry B (Salters).

OCR will revise the Practical Endorsement if appropriate.

If any revision to the Practical Endorsement is made, OCR will produce an amended specification which will be published on the OCR website. OCR will then use the following methods to communicate the amendment to centres: subject information update emailed sent to all Examinations Officers, e-alerts to centres that have registered to teach the qualification and social media.

Summary of updates

Date	Version	Section	Title of section	Change
Dec 2017	2	Multiple		Changes to generic wording and OCR website links throughout the specification. No changes have been made to any assessment requirements.
April 2018	2.1	2d	Storylines	Correction of minor typographical errors and amendment to learning outcome **Polymers and life (PL)(c)(ii)**
May 2018	2.2	4a	Head of Centre Annual Declaration	Update in line with new NEA Centre Declaration form.
August 2018	2.3	3d 4d	Retaking the qualification Admin of non-exam assessment	Update to the wording for carry forward rules.
January 2019	2.4	2d	Storylines	Guidance on the new definition of moles **Formulae, equations and amount of substance (b)(i)**
October 2019	2.5	2d	Storylines	Additional guidance for OZ (q)
May 2020	2.6	1d 4d	How do I find out more information? Post-results services	Insert a Online Support Centre link Enquiry about results changed to Review of results Update to specification covers to meet digital accessibility standards.
December 2020	2.7	4a	Pre-assessment	Changes to practical endorsement requirements and advice.
				Update to specification covers to meet digital accessibility standards
April 2023	2.8	3c	Total qualification time	Update to include total qualification time and guided learning hours to comply with QiW regulations
March 2024	2.9	3d, 3e 4a Checklist	Qualification availability, Language Pre-assessment	Inclusion of disclaimer regarding availability and language Update to include resilience guidance Inclusion of Teach Cambridge

5

YOUR CHECKLIST

Our aim is to provide you with all the information and support you need to deliver our specifications.

- [ ] Bookmark OCR website for all the latest information and news on AS and A Level Chemistry B
- [ ] Sign up for Teach Cambridge: our personalised and secure website that provides teachers with access to all planning, teaching and assessment support materials
- [ ] Be among the first to hear about support materials and resources as they become available – register for Chemistry updates
- [ ] Find out about our professional development
- [ ] View our range of skills guides for use across subjects and qualifications
- [ ] Discover our new online past paper service
- [ ] Learn more about Active Results
- [ ] Visit our Online Support Centre

Download high-quality, exciting and innovative AS and A Level Chemistry resources from ocr.org.uk/alevelchemistryb

Free resources and support for our A Level Chemistry qualification, developed through collaboration between our Chemistry Subject Advisors, teachers and other subject experts, are available from our website. You can also contact our Chemistry Subject Advisors for specialist advice, guidance and support, giving you individual service and assistance whenever you need it.

Contact the team at:

01223 553998

scienceGCE@ocr.org.uk

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To stay up to date with all the relevant news about our qualifications, register for email updates at **ocr.org.uk/updates**

Visit our Online Support Centre at **support.ocr.org.uk**