



# Subject Benchmark Statement

Chemistry

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## About this Statement

This document is a QAA Subject Benchmark Statement for Chemistry that defines what can be expected of a graduate in the subject, in terms of what they might know, do and understand at the end of their studies. Subject Benchmark Statements also describe the nature and characteristics of awards in a particular subject or area. Subject Benchmark Statements are published in QAA's capacity as a membership organisation on behalf of the higher education sector. A summary of the Statement is also available on the QAA website.

Key changes from the previous Subject Benchmark Statement include:

- a revised structure for the Statement which includes the introduction of cross-cutting themes of:
  - equality, diversity and inclusion
  - education for sustainable development
  - employability, entrepreneurship and enterprise education
- a comprehensive review updating the context and purposes of Chemistry, including course design and content in order to inform and underpin the revised benchmark standards.

## How can I use this document?

Subject Benchmark Statements are often used by higher education providers in the design and development of new courses in the relevant subject, as they provide a framework for specifying intended learning outcomes in an academic or vocational discipline. They are also used as a reference point when reviewing or revalidating degree courses. They may be used by external examiners in considering whether the design of a course and the threshold standards of achievement are comparable with other higher education providers. They also provide professional, statutory and regulatory bodies (PSRBs) with the academic standards expected of students.

Subject Benchmark Statements provide general guidance for articulating the learning outcomes associated with a course but are not intended to represent a national curriculum in a subject or to prescribe set approaches to teaching, learning or assessment. Instead, they allow for flexibility and innovation in course design within a framework agreed by the subject community.

You may want to read this document if you are:

- involved in the design, delivery and review of courses in Chemistry
- a prospective student thinking about undertaking a course in Chemistry
- an employer, to find out about the knowledge and skills generally expected of Chemistry graduates.

## Relationship to legislation

The responsibility for academic standards lies with the higher education provider who awards the degree. Higher education providers are responsible for meeting the requirements of legislation and any other regulatory requirements placed upon them by their relevant funding and regulatory bodies. This Statement does not interpret legislation, nor does it incorporate statutory or regulatory requirements.

The regulatory status of the Statement will differ with regard to the educational jurisdictions of the UK. In England, Subject Benchmark Statements are not sector-recognised standards as set out under the Office for Students' [regulatory framework](#). However, they are specified

as a key reference point, as appropriate, for academic standards in Wales under [Quality Assessment Framework for Wales](#) and in Scotland as part of the [Quality Enhancement Framework](#). Subject Benchmark Statements are part of the current quality requirements in Northern Ireland. Because the Statement describes outcomes and attributes expected at the threshold standard of achievement in a UK-wide context, many higher education providers will use them as an enhancement tool for course design and approval, and for subsequent monitoring and review, in addition to helping demonstrate the security of academic standards.

## **Additional reference points**

Higher education providers are likely to consider other reference points in addition to this Statement in designing, delivering and reviewing courses. These may include requirements set out by PSRBs and industry or employer expectations. QAA has also published [Advice and Guidance](#) to support the [Quality Code which will be helpful](#) when using this Statement, for example, in [course design](#), [learning and teaching](#), [external expertise](#) and [monitoring and evaluation](#).

Explanations of unfamiliar terms used in this Subject Benchmark Statement can be found in [QAA's Glossary](#). Sources of information about other requirements and examples of guidance and good practice are signposted within the Statement where appropriate.

# 1 Context and purposes of a Chemistry degree

## Context

1.1 Chemistry is the central science underpinning all aspects of life. It delivers huge societal impacts by allowing us to describe, understand and manipulate the world around us. It will continue to play an essential role in providing society with the toolkit for addressing sustainable development goals and global challenges, from improving health throughout life to clean energy production and storage. Chemistry graduates use their knowledge to gather state-of-the-art scientific information, design investigations to solve problems and disseminate their findings across a wide range of spheres.

## Purposes of a Chemistry degree

1.2 The points below should be seen within the context of providing relevant and representative material for all students undertaking Chemistry degrees, and creating an inclusive environment where all feel welcome, valued and provided with the opportunity to develop an enthusiasm for the subject.

1.3 The general aims of degree courses in Chemistry are to:

- establish in students an appreciation of the importance and sustainability of the chemical sciences in industrial, academic, economic, environmental and social contexts
- inspire and enthuse students with the power and utility of using chemical approaches to solving personal, human and global challenges
- highlight the importance of the multidisciplinary nature of chemistry by examining how it articulates with different disciplines and enable students to situate and deploy their knowledge and skills effectively within this wider context
- develop in students the skills needed for employment in chemical and non-chemical roles which require the exercise of professionalism, independent thought, personal responsibility and decision-making in complex and unpredictable circumstances.

1.4 The main aims of bachelor's degree with honours courses in Chemistry are to:

- provide students with broad and balanced knowledge and understanding of key chemical concepts
- develop in students a range of practical skills so that they can assess and mitigate risks and work safely and competently in the laboratory
- develop the ability to apply defined methodology to the solution of problems in chemistry
- develop planning and investigative skills that draw on the existing literature to develop new insights and propose avenues for further exploration
- provide students with a knowledge and skills base from which they can proceed to graduate employment or to further studies in chemistry or multidisciplinary areas involving chemistry
- develop an understanding of the interfaces between chemistry and other subjects in which chemical approaches contribute to progress.

1.5 The main aims of master's degree courses in Chemistry are to:

- extend students' comprehension of key chemical concepts and so provide them with an in-depth understanding of specialised areas of chemistry

- provide students with the ability to develop ideas, review literature, plan and carry out original investigations independently and assess and report the significance of outcomes
- develop in students the confidence and capability to solve unfamiliar problems, and where incomplete information is available
- instil a critical awareness of advances at the forefront of the chemical sciences
- develop students' ability to navigate and utilise the intersections between chemistry and other disciplines, such as biology, physics, business, environmental sciences, geoscience, medicine, pharmacy and education, to solve current problems
- prepare students effectively for professional employment or research degrees in the chemical sciences.

## **Characteristics of a Chemistry degree**

1.6 Each higher education provider awarding qualifications in chemistry defines the content, nature and organisation of its courses and modules. Consequently, Chemistry courses offered by individual higher education providers will have their own particular characteristics.

1.7 Chemistry is a very broad discipline and Chemistry courses should reflect this, both through the material covered and the learning, teaching and assessment methods used. Some Chemistry courses will provide students with a wide-ranging coverage of the full breadth of the discipline; others may allow students to specialise in a particular aspect of the subject that is reflected in the title of their award. Institutions may also offer courses that allow students to combine their study of chemistry with that in other disciplines through either interdisciplinary single honours courses, or through joint or combined honours courses.

1.8 Hands-on practical work forms an essential part of all Chemistry courses. It allows students to develop the necessary practical skills for a career in science. Indeed, there is an expectation that all Chemistry graduates will be competent and capable of safe and accurate working in a laboratory environment. Experimentation enables students to develop the tacit knowledge and transferable skills that are required for careers in all sectors. The abilities of Chemistry students are often developed most effectively through creative problem-solving in relation to experiments that have not generated the expected results. Consequently, a spiral approach to developing experimental capabilities, and independence in practical work is common in Chemistry courses. Practical sessions at the start of a course typically include detailed instructions, and experiments that generate results reliably over a wide range of conditions, allowing for mistakes to be made and learnt from. In contrast, final-year students are expected to work with precision under minimal supervision, solving problems as they arise.

1.9 Theoretical learning in chemistry includes a wide range of material that is central to the subject, underpinned and enabled by mathematical, spatial, information management, project planning, communication, and creative problem-solving skills. Chemistry courses thus enable graduates to integrate their knowledge of chemistry with practical and transferrable skills, to undertake a wide range of activities, projects and careers with great success and distinctive subject insights.

## **Equality, diversity and inclusion**

1.10 This Subject Benchmark Statement embeds consideration of equality and diversity matters throughout. Promoting equality of opportunity involves treating everyone with equal dignity and respect, while also raising aspirations and supporting achievement for people with diverse abilities, identities and backgrounds. An inclusive environment for learning anticipates the varied requirements of learners and aims to ensure that all students have

equal access to educational opportunities. Chemistry course providers, staff and students all have a role in, and responsibility for, promoting equality.

1.11 Chemistry, as a subject whose underpinnings rely upon objective observation, should be culturally and ethically neutral. However, its historical identity and application in wider society must be viewed and taught in an inclusive manner. Curricula should recognise the discoveries and contributions of chemical scientists with diverse backgrounds and identities, and acknowledge that different cultural backgrounds may provide different insights and lead to new discoveries. Furthermore, learners should have the opportunity to explore chemistry-related topics that inspire them and that allow them to situate their knowledge in the light of their aspirations, lived experiences or cultural backgrounds. They should also be encouraged to evaluate both the positive and negative impacts of the potential applications of chemical discoveries.

## **Education for sustainable development**

1.12 Chemistry is central to developing solutions to problems, and courses in Chemistry should inspire chemists to engage with the ongoing process of addressing personal, human and global challenges to create a better future. Chemistry courses may include topics drawn from the [UN Sustainable Development Goals](#), particularly those associated with health, energy, clean water and the environment. Education for sustainable development is thus an integral part of the study of chemistry, ensuring that graduates are equipped with the knowledge, skills and competencies that can enable them to generate innovative solutions to complex challenges. More information on education for sustainable development can be found in the QAA and Advance HE guidance [Education for Sustainable Development](#).

## **Employability, enterprise and entrepreneurship**

1.13 All Chemistry degree courses should equip students with the knowledge, skills, behaviours, characteristics and attributes that prepare them for life after graduation in an increasingly complex and ever-changing social, cultural and economic environment and enable them to make a meaningful and effective contribution to society. Chemistry graduates should be equipped not only with the discipline-specific knowledge and professional skills necessary for careers in the chemical sciences, but also the wider attributes to prepare them for careers in other sectors. Paragraph 3.8 provides details of the range of wider skills that may be expected in Chemistry graduates.

1.14 Enterprise and entrepreneurship education may also form part of Chemistry courses, particularly in multidisciplinary and joint honours degrees. Enterprise is the generation and development of ideas. It combines creativity, originality and innovation, adaptability and reflection, identification of and solutions to problems, expression, communication and practical action; all of which are central to Chemistry courses. Entrepreneurship is the application of those enterprise behaviours to create social, cultural or economic value. Entrepreneurship can take many forms. It is not restricted to commercial activity or wealth creation, but includes activity across the private, public and third sectors.

1.15 Enterprise and entrepreneurship education may cover a range of topics, including the development of business plans and project management, the assessment of benefits, the identification of stakeholders, product design, the balance between cost, price and wider value, financial, environmental or personal sustainability, commercialisation, and intellectual property. Ideally, but not necessarily, each of these topics may be illustrated and explored through applications of chemistry. More information on enterprise and entrepreneurship education can be found in the QAA document [Enterprise and Entrepreneurship Education: Guidance for UK Higher Education Providers](#).

## 2 Distinctive features of a Chemistry degree

### Design

2.1 There are a variety of types of Chemistry courses across the UK. That diversity is a strength, in that it allows students to choose a course that aligns with their interests and is suited to their individual needs and aspirations. Some courses follow the traditional subdivisions of inorganic, organic and physical and analytical chemistry. Others are arranged as synthesis, measurement and application. Alternatively, material may be organised around applications, such as biological, computational, environmental, materials or medicinal chemistry. Some may lead with fundamental theory, and others with application, although all courses should include an appropriate combination of both.

2.2 There are a range of possible paths to degree courses. These include vocational, apprenticeships, academic or non-traditional routes. The majority of courses require A Level Chemistry or equivalent, but many courses provide alternatives for those choosing to study chemistry regardless of prior educational background. Foundation science years are delivered by both universities and colleges, to enable applicants without a relevant chemistry qualification to develop foundational knowledge prior to progressing onto an honours degree programme. Equally, applicants with limited knowledge of English may undertake international science foundation year courses allied with Chemistry degree providers. Such foundation courses can be studied as standalone programmes or may be integrated into the degree courses to enable direct progression to year one of the degree.

2.3 Undergraduates in Chemistry may choose to study a standard bachelor's degree with honours (FHEQ Level 6; FQHEIS Level 10) or an integrated master's degree with honours (FHEQ Level 7; FQHEIS Level 11). These each have distinct learning outcomes to reflect the level of the award. Bachelor's degrees should provide students with the subject-specific knowledge, understanding and skills, as well as the wider transferable skills and attributes that prepare graduates for a wide range of careers in many sectors. Integrated master's degree with honours courses (such as MChem, MSci) encompass both bachelor's degrees with honours and master's degree outcomes. An integrated master's degree is awarded after an extended course of study which allows students to study chemistry to a greater depth than is possible on a bachelor's course and to extend the opportunities to develop specialist knowledge, advanced skills and undertake project work. These master's degrees thus provide a coherent, integrated opportunity to develop a deeper level of understanding and experience, sufficient to prepare them for a professional career in the chemical sciences. Standalone master's (MSc and MRes) degree courses in Chemistry, are self-contained courses, normally involving one or two years of postgraduate study in a specialist area.

2.4 Some Chemistry courses will enable students to learn outside the formal academic environment through placement at an organisation in the chemical science sector, or to study at an international university. Such placements may last for a term, semester or an entire year. They typically take place in either the third or fourth year of a student's undergraduate programme. Both bachelor's and integrated master's degrees may include such periods of study, and this may or may not extend the period of the degree, depending on the expected learning undertaken during the year. Credit awarded during such study also varies according to the learning and assessment workload during the experience. Credit-bearing placements should, however, be integrated within the course of study, so that students can relate their experience to, and use the skills that they have developed in, their academic study. Many providers also offer or facilitate non-credit bearing industrial and research placement experiences during vacations to enhance student experience and development.



2.5 Where an institution offers several Chemistry courses, these will typically be based around a common core of shared compulsory modules, especially in the early years, with options in later years that allow students to specialise. That modularity enables both flexibility and efficiency of delivery and may even allow students to defer selection of award title until later years by retaining the option to transfer between cognate courses.

2.6 The academic component of degree apprenticeships in Chemistry should follow the guidelines in this Subject Benchmark Statement. Degree apprenticeships in higher education are covered explicitly in the [Characteristics Statement for Higher Education in Apprenticeships](#) which describes the general characteristics and distinctive features of apprenticeships in the UK.

## Accessibility

2.7 Equality of opportunity involves enabling access for people who have differing individual requirements as well as eliminating arbitrary and unnecessary barriers to successful learning. In accordance with this, Chemistry courses must ensure that all students are offered learning and assessment opportunities that are equally accessible to them, by means of inclusive design wherever possible and by means of reasonable individual adjustments where necessary. Learning and assessment experiences should be diverse to both reflect the variety of the subject and to increase accessibility for all. Indeed, to face the challenges of the twenty-first century, the subject needs as diverse a body as possible to contribute new ideas and innovations, drawn from the different insights and perspectives from all learners, regardless of disability or background.

2.8 Chemistry course teams must pay attention to ensuring that curricula, pedagogy, assessments and practical elements of courses are designed to be fully accessible, and that all learners are supported in the development of skills in the full range of verbal, spatial, numerical and other approaches required to solve chemical problems.

## Progression

2.9 Chemistry degree courses should be designed to promote academic and personal development. Initially, students will be expected to use their knowledge and understanding of simple concepts to solve well-defined problems. As the course advances, they will become confident in applying their knowledge and understanding, making connections between more challenging and complex concepts to enable them to solve ill-defined and open-ended problems. On graduation, students will be competent in a range of knowledge, understanding, experience and skills to equip them for a career in the chemical sciences, or indeed in other sectors.

2.10 The learning, teaching and assessment methods used should encourage a progressive acquisition of subject knowledge and skills by moving gradually from study methods that require a greater degree of support and assistance towards more independence and self-direction. That progression should be reinforced by strategies that:

- recognise the diversity of prior experience and the challenges of transition
- allow all students to achieve their potential and realise their ambitions, irrespective of their background or motivations for studying chemistry
- support academic and personal development as well as learning
- are matched to the documented learning outcomes or competencies for each level.

2.11 Students on a Chemistry degree course progress from one year or academic stage to the next by satisfying the regulations and processes for each institution. These must require the students to demonstrate that they have met the overall threshold standard for the

level of study. This will usually include successful completion and the award of credit for the full range of learning and assessment, including practical courses. Students may also be required to meet additional criteria, such as where the title of the programme and ultimate award refers to a particular specialism, or to be eligible to undertake a placement. The standard required to progress on an integrated master's degree course may also be higher than that for a bachelor's course.

2.12 Subject to the regulations for the institution, students will usually be offered an opportunity to resit any failed assessments, particularly where that either prevents progression or qualification for an award. Students who are either not eligible to progress, or who choose to leave a course of study early, may be eligible for a Certificate of Higher Education, a Diploma of Higher Education, or an Ordinary or Pass degree, depending on the amount and type of credit successfully completed. Integrated master's degrees typically also offer a bachelor's degree with honours as an exit award for those who have attained sufficient credit but are not able to complete the course. Scottish bachelor's degrees with honours are typically designed to include four years of study, which relates to the structure of Scottish primary and secondary education.

## **Flexibility**

2.13 The diversity in the type of courses offered in chemistry is also reflected in a diversity of mode of delivery. While the majority are delivered full-time, some courses offer part-time and/or distance learning study. Courses may also offer students the opportunity to study abroad or industrial placements. The range of delivery methods (both face-to-face and digital) utilised are similarly diverse and appropriate for the needs of the learner, the material and their assessment. The progressive acquisition of knowledge and skills within the subject area also enables flexibility between courses, both within and between institutions, with mechanisms available for the transfer of credit between institutions. Courses also need to be sufficiently flexible to be able to respond to and anticipate change, both in the advancement of the subject and its interface with other disciplines and in the needs of its graduates and their employers, and should take account of learners' needs and make appropriate reasonable adjustments, as required.

## **Partnership**

2.14 Providers may operate in academic partnerships with further education and international colleges as described in paragraph 2.2 or with international degree providers to enable study abroad programmes. Some providers also offer partnership courses that give advanced standing to students with prior study abroad, for admission into year two or three of existing UK degree courses. Industrial collaborations may also be utilised for partnership delivery of degree apprenticeships. Providers are expected to develop processes for oversight to ensure that partners involved in degree delivery meet all relevant standards and expectations.

## **Monitoring and review**

2.15 A major feature of academic quality assurance and enhancement at a higher education institution is having in place monitoring and regular review processes for the courses it delivers. Degree-awarding bodies routinely collect and analyse information and undertake periodic course review according to their own needs. They will draw on a range of external reference points, including this Statement, to ensure that their provision aligns with sector norms, and meets regulatory and professional requirements. Monitoring and evaluation is a periodic assessment of a course, conducted internally or by external independent evaluators. Evaluation uses information from both current and historic

monitoring to develop an understanding of student achievement or inform future course planning.

2.16 Externality is an essential component of the quality assurance system in the UK. Higher education providers will use external reviewers as part of periodic review to gain an external perspective on any proposed changes and ensure threshold standards are achieved and content is appropriate for the subject.

2.17 External examination currently in use across the UK higher education sector also helps to ensure consistency in the way academic standards are secured by degree-awarding bodies. Typically, external examiners will be asked to comment on the types, principles and purposes of assessments being offered to students. They will consider the types of modules on offer to students, the outcomes of a cohort and how these compare to similar provision offered within the UK. External examiners produce a report each year and make recommendations for changes to modules and assessments (where appropriate). Subject Benchmark Statements, such as this one, can play an important role in supporting external examiners in advising on whether threshold standards are being met in a specific subject area.

2.18 Undergraduate Chemistry degree courses typically require more than one external examiner to cover the breadth of material.

2.19 Programme and course teams should also conduct regular monitoring and evaluation, with the support of independent evaluators, to ensure continuous quality enhancement. Evaluation of student performance data as well as student feedback and student voice alongside other measures of the student experience should be integrated with expert review (including that provided by external examiners) to ensure the curricula remain current, engaging and accessible. Historic data may also enable trend analysis to measure progress and identify emerging issues. Students and graduates, as well as employers and relevant professional bodies, should be actively involved in designing and delivering actions to develop and enhance courses of study.

2.20 Chemistry courses may be [accredited by the Royal Society of Chemistry](#). Typically, multidisciplinary and bachelor's Chemistry courses will only be accredited to partially meet the academic criteria for Chartered Chemist (CChem), whereas integrated master's courses in Chemistry will fully meet these criteria. Royal Society of Chemistry accreditations of course providers are usually conducted through a combination of site visits and desk-based reviews. Multidisciplinary courses may be accredited by more than one professional body.

### 3 Content, structure and delivery

3.1 Each higher education provider awarding qualifications in Chemistry defines the content, nature and organisation of its courses and modules. Consequently, Chemistry courses offered by individual higher education providers will have their own distinctive characteristics, both in terms of chemistry-specific content, and in underpinning and enabling knowledge and skills.

3.2 Chemistry is a diverse subject, and in an undergraduate curriculum it is impossible to cover all aspects in equal breadth and depth. The content indicated below should be regarded as foundational to a quality chemistry curriculum and elements should be further developed in later parts of the course, reflecting the research and teaching specialisms of the staff.

#### Subject knowledge and understanding

3.3 All undergraduate courses should include chemistry-specific content that ensures that graduates are able to:

- describe and discuss the full breadth of key chemical concepts confidently, accurately and in detail, using appropriate terminology
- describe, document and enact safe working practices, in terms of managing chemical toxicity, chemical stability and chemical reactivity, through knowledge-based risk assessments and practical activities
- consider and apply methods for waste reduction in practical activities, and deploy disposal techniques that protect laboratory workers and the environment
- explain and rationalise their understanding of classical and statistical thermodynamics, kinetics, quantum mechanics and spectroscopy and apply this to the solution of theoretical and practical problems to wider topics in chemistry
- predict likely and potential synthetic products, bond-forming reactions, mechanistic pathways, stereochemistry and reactivity, and use this knowledge to suggest synthetic pathways to target compounds and design experimental activities that test their predictions
- explain, design and deploy purification, isolation and characterisation strategies, in the light of physicochemical properties and trends of elements and compounds
- discuss periodic trends in chemistry, explain the consequences of these trends on reactivity, behaviour and physical properties and apply this knowledge to the solution of theoretical and practical problems
- describe atomic and molecular orbitals and their conceptual applications to structure, bonding and reaction pathways
- design, develop and carry out qualitative and quantitative sample preparation and purification, chemical measurement, metrology and analysis, with due regard to accuracy, precision, traceability and the effects of complex matrices and sample size
- explain the theoretical basis and limitations of a range of classical and instrumental analytical techniques, undertake practical analyses and measurement and communicate the outcomes using appropriate terminology and mathematical or graphical notation
- use computational techniques and tools, to aid further understanding and insight of chemical structure, bonding and reactivity

- gain knowledge of a range of inorganic and organic substances, compounds and materials and their uses
- appreciate the contribution of chemistry to the innovations that characterise the modern world, and the potential of chemists to develop solutions to current and future challenges
- recognise the relationships and interfaces between chemistry and other subjects, such that they are able to operate effectively in a multidisciplinary environment.

3.4 Undergraduate courses may also include **specialist and supplementary** content that allows graduates to:

- consider and discuss the geographical and historical culture of chemistry and its impact on society
- specialise in one or more sub-branches of chemistry, such as green and sustainable chemistry, cheminformatics or chemistry education
- integrate and situate their understanding of chemistry within the context of other honour's subjects, such as biology, physics, geology, biomedical, environmental or pharmaceutical sciences or relate their knowledge to chemistry using vocations such as business and law.

## Underpinning and enabling knowledge and skills

3.5 Chemistry is an inherently creative discipline. Chemistry graduates are therefore innovative and enterprising in their outlook and excited by the challenge of finding solutions to problems. They are confident and resilient, and are capable of adapting to uncertainty, assessing risk and actively embracing change. They are self-motivated and independent, but also able to work effectively as part of a team. Chemistry graduates should be logical and analytical and be confident in the use of evidence to develop, support or refute arguments. They are constructive and objective in challenging the ideas of others and resilient and reflective when their own ideas are challenged. They are responsible and act with integrity, considering the impacts of their actions and decisions on both individuals and wider society. They value diversity in all of its forms, and respect and recognise the contributions of others. Chemistry degree courses, both through the nature of the discipline and the way that it is taught and assessed, allow students to develop these wider characteristics. Chemistry graduates are therefore highly sought after by employers in both the scientific and non-scientific sectors.

3.6 Students should be made explicitly aware of the opportunities for academic and personal development that the course provides, allowing them to reflect on their strengths and the opportunities for further development, and so enhance their employability. Students should also be given support, whether through the formal curriculum or through extracurricular activities, in applying for and making the transition to further study or employment through, for example, advice on applications and practice in interviews.

3.7 In some courses, support for the development and practice of these skills may be embedded within the chemistry content. Chemistry requires students to engage with a range of challenging and sometimes abstract concepts and ideas, developing a sense of enquiry, an openness to new ideas and a sense of the intellectual and personal reward in tackling and overcoming demanding problems. Experimental and investigative work allows students to learn from their experience to overcome practical problems, building resilience and confidence in tackling unfamiliar problems.

3.8 Bachelor's degrees with honours courses should therefore include enabling content that ensures that graduates are able to:

- navigate, utilise and collate digital information tools to source information and data
- select, examine and critique the research literature and other sources of information to maintain currency of knowledge, extend learning and support the development of solutions to specified problems
- deploy mathematical concepts, processes and tools, such as the manipulation of equations, calculus, and graphical and statistical analysis, to solve chemical problems and evaluate chemical data
- choose and deploy methods for data analysis and manipulation, potentially including coding and scripting, for presentation, communication and problem-solving purposes
- collaborate and work successfully in a group environment, contributing positively and flexibly to team outputs
- communicate effectively, selecting appropriate content, media and methods for the audience, purpose and subject
- comprehend the nature of and discriminate between different forms of published information, recognising the contribution of peer review to shaping the scientific literature
- realise the nature and value of their own and other's intellectual property and the importance of acting with academic integrity
- act professionally, with due regard for legal, ethical and societal responsibilities, modelling good practice that promotes positive perceptions of chemistry and chemists.

3.9 In addition, master's degrees with honours courses should build on the transferrable skills developed above to ensure that graduates are able to:

- develop innovative approaches to solving advanced problems, sometimes in the absence of complete information
- develop persuasive arguments, and articulate their positions, synthesising their knowledge and skills to provide a convincing narrative for their ideas
- interrogate and integrate diverse sources of scientific literature alongside other information sources, in order to design and develop methods for investigation and analysis, including in areas outside their current specialist knowledge
- develop generalisable strategies for solving problems where there is not a unique solution, including the identification and sourcing of additional information required
- plan and manage their own and group work effectively
- demonstrate preparedness for research, doctoral study or equivalent employment.

## **Project and dissertation**

3.10 All honours degree students are expected to engage in an element of independent open-ended investigative work through a project/research-based assignment relevant to chemistry. This is likely to be in the student's final year of study and to involve data collection and analysis from laboratory or literature work. It may cover areas outside of laboratory research such as chemistry education, theoretical and computer modelling, citizen science projects or in the public understanding of science. Interpretation of the information is within the context of current knowledge. At master's level, the project is expected to include an element of originality. Outputs may take the form of dissertations or review and research articles. Typically, some form of oral defence by viva, poster presentation or talk will also be included. At master's level, the quality (but not necessarily the format) of the presentation

and critical evaluation in the written report/dissertation should be equivalent to that of a peer-reviewed publication.

3.11 Undergraduate projects will tend to be based around the professional and research interests of the staff members and will be subject to personal support and supervision from individual staff, as well as research-group members, where appropriate. Students at master's level are expected to take more ownership of the development and direction of their project, and to contribute more effectively in discussion and planning sessions.

3.12 Projects may also be undertaken in collaboration with industry. Team projects are also used both to develop skills in the early parts of the degree, and sometimes as synoptic elements of bachelor's degrees. Synoptic master's projects, however, are expected to be individual and include a significant element of originality.

3.13 Projects will typically be underpinned by relevant training, some of which will take place in the penultimate year of the degree, while other aspects are integrated into the project experience. This may include:

- development of project-specific advanced experimental skills
- sourcing, evaluation and discussion of the scientific literature and other prior work on which the project is to be based
- planning, including evaluation of costs, hazards and environmental effects
- written and verbal communication skills development and coaching
- introduction to the local and wider research community, and approaches to collaboration and dissemination, including with non-chemists
- discussion of the context and potential impact of the project.

3.14 The amount of workload and credits awarded to the project may vary but can typically be:

- 25% of the final year of a bachelor's degrees with honours
- 50% of the final year of an integrated master's degrees with honours
- 33% of a standalone taught MSc in Chemistry.

## Teaching and learning

3.15 Teaching and learning strategies are designed to provide students with appropriate subject knowledge, understanding, abilities and academic and professional skills for chemistry-based professions. This Subject Benchmark Statement does not aim to be prescriptive about which teaching or learning methods are used by a particular course. Higher education providers use appropriate teaching methods to ensure that students are engaged, motivated and challenged to learn as well as delivering the course learning outcomes. Such methods must be made explicit to students and be subject to regular internal and external review. Attention should be paid in the design process to ensure that teaching methods support achievement of the learning outcomes and are inclusive and accessible to all students.

3.16 A wide range of teaching methodologies, both innovative and well-established, are appropriate to the teaching of chemistry, recognising that, among other features, the subject retains a strong visual and practical component. The tools selected are very much customised to the needs of the material, which is diverse in kind, requiring varying proportions of verbal, quantitative and spatial skills to be deployed during learning. Current strategies aim to be student-centred, utilising a range of delivery methods as appropriate. Some live synchronous sessions may be delivered remotely, whereas others will be face to face, and in many cases live sessions will be recorded for later use or revision purposes.

Live face-to-face sessions may also be simulcasted to increase accessibility. Pre-sessional student activities are considered good practice to motivate and engage students with independent learning activities in advance of consolidation or extension work during the session. In many circumstances any one live session may incorporate a range of different activity types.

3.17 Synchronous learning activities may include:

- lectures
- problem classes, workshops, seminars and tutorials
- laboratory classes
- computer workshop sessions
- case studies and problem-based learning
- peer and collaborative learning
- interactive sessions, including debates and oral/poster presentations
- field work and visits.

3.18 Asynchronous learning materials and activities may include:

- textbooks
- digital media resources – both produced by staff and selected from external sources
- recordings of taught sessions and practical demonstrations
- computer modelling and simulations
- virtual and remote experiments
- diagnostic and practice tests and exercises
- pre-laboratory and pre-sessional exercises
- other self-study materials.

3.19 Blended or multimodal activities may include:

- open-ended project work, some of which may be team-based
- work-based and other placements
- reflective practice and portfolio building
- research projects.

3.20 Such teaching and learning strategies are not fixed but should be responsive to changes in technology and current research around teaching pedagogy. There is therefore an expectation that all staff who contribute to student learning and assessment, including technical demonstrators, temporary and visiting lecturers as well as academic staff, should have access to both subject-specific and educational professional development resources and opportunities.

## **Assessment**

3.21 The assessment of students' achievement in chemistry aligns with learning outcomes and is appropriate to the knowledge, abilities, academic and professional skills that the course aims to develop. The diversity of assessment deployed across chemistry courses should reflect this.

3.22 The increasingly digital world we live in requires students to be future-ready through the development of general IT literacy and coding skills. The latter is becoming an increasingly common expectation of graduates in scientific fields and students should be provided opportunities to engage with these concepts in their studies. The digital world presents unique opportunities to diversify the methods by which we assess students. It is strongly encouraged that assessments make full use of a range of formats that enables



students of all backgrounds and characteristics to demonstrate their learning and develop to their fullest potential. Many assessments may be completed using a word processor, as well as spreadsheets and specialist graphical, drawing, modelling and information management software. However, others will require paper-based responses where formulae, diagrams and reaction schemes are drafted by hand.

3.23 Evidence on which the assessment of student achievement is based includes (but is not limited to):

- a 'seen' and 'unseen' invigilated examinations or examination questions (with 'open book' or without learning materials)
- b remote timed examination papers, which may or may not be invigilated or proctored
- c laboratory reports
- d problem-solving exercises, including real-world problems from industrial or other partners
- e oral presentations and examinations, viva voce and poster defence
- f planning, conducting and reporting of project work (including research proposals, and aspects of the dissertation)
- g literature surveys and evaluations
- h outputs from collaborative work
- i essay assignments
- j portfolios of chemical activities undertaken (for example, wikis)
- k preparation and display of posters or electronic visual media
- l reflective and scientific reports on external placements
- m peer assessment
- n reflective logs
- o production of online and other media outputs such as video and audio
- p practical skills assessments based on outcomes (yield, accuracy, precision) achieved.

3.24 Assessment drives learning and, wherever possible, it should support the development of skills and concepts required specifically for a career in chemistry but also of more general skills that enhance the wider employability of Chemistry graduates. Some examples of relevant skills and the assessment types that require them are shown in the mapping table below.

Skills	Assessment type															
	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p
Oral and written communication	x	x	x		x	x		x	x			x		x	x	
Team and group working			x					x			x	x	x		x	
Numeracy	x	x	x	x		x		x			x	x			x	
Project planning and management						x	x		x			x			x	
Practical			x			x						x		x		x
Problem-solving (unseen/heterogeneous data)	x	x	x	x												
Enquiry				x	x	x	x	x			x	x		x	x	
IT literacy			x		x	x	x	x		x	x	x		x	x	

3.25 At master's level, there is a strong emphasis on requiring students to apply their knowledge of chemistry to the solution of unfamiliar problems. Assessment of the full range of research skills is also considered crucial in determining whether master's level learning outcomes have been achieved.

## 4 Benchmark standards

### Introduction

4.1 This Subject Benchmark Statement sets out the standards that a student will have demonstrated when they are awarded an honours degree in Chemistry. Demonstrating these standards over time will show that a student has achieved the range of knowledge, understanding and skills expected of graduates in Chemistry.

4.2 The vast majority of students will perform significantly better than the minimum threshold standards. Each higher education provider has its own method of determining what appropriate evidence of this achievement will be and should refer to [Annex D: Outcome classification descriptions for FHEQ Level 6 and FQHEIS Level 10 degrees](#) which sets out common descriptions of the four main degree outcome classifications for bachelor's degrees with honours: 1st, 2:1, 2:2 and 3rd.

4.3 Tables 1 and 2 articulate standards at the levels of 'threshold' and 'excellent'. These are defined as:

- threshold standard: the minimum required to gain an honours degree; graduates at this level demonstrate an acceptable level of ability and skills
- excellent standard: the level required to gain a first-class degree; graduates at this level consistently demonstrate advanced knowledge, understanding and skills.

4.4 The benchmark standards defined in Tables 1 and 2 are for the main course content and characteristics as outlined in paragraphs 1.3 and 3.3. The tables do not constitute a checklist, nor do they imply any particular weighting to each outcome. Courses include the full range of content and skills, but their point of introduction and the level of engagement is decided by curriculum designers.

4.5 To reach a given standard at the point of completion of an honours degree in the subjects covered by this Statement, students demonstrate achievement across the main outcomes in Tables 1 and 2, interpreted for the specific degree course. However, higher education providers use a range of algorithms to decide final classifications, so a lower performance in one outcome may be compensated for by a higher performance in another.

4.6 The standards in these tables should be read in conjunction with Sections 1 and 3, and paragraphs 4.1 to 4.5.

**Table 1: Benchmark standards - on graduating with a bachelor's degree with honours in Chemistry, graduates should be able to:**

<b>Benchmark standard</b>	<b>Threshold</b>	<b>Excellent</b>
Describe and discuss the full breadth of key chemical concepts (as covered in 3.3) confidently, accurately and in detail, using appropriate terminology.	Recall basic knowledge and theories in chemistry based on the course contents and use these in the discussion or explanation of familiar concepts with appropriate terminology.	Use and apply in-depth knowledge of concepts and theories in chemistry to discuss and predict outcomes covering most essential aspects of the course and show evidence of enquiry beyond this.
Apply knowledge and understanding of reactivity, trends, concepts and methodologies to the solution of theoretical and practical problems.	Adequately define and solve routine problems, applying a range of methods and concepts taught within the course.	Devise and evaluate solutions to solve both routine and unfamiliar problems using a range of methods.
Describe, document and enact safe working practices, in terms of managing chemical toxicity, chemical stability and chemical reactivity and waste reduction and disposal through knowledge-based risk assessments and practical activities.	Produce and follow risk assessments for completing practical work in a safe and reliable manner with significant reliance on guidance.	Produce and follow risk assessments for completing practical work in a safe and reliable manner with limited reliance on guidance.
Explain, design and deploy synthesis, purification, isolation and characterisation strategies, in the light of physicochemical properties and trends of elements and compounds.	Suggest and attempt synthesis, purification, isolation and characterisation strategies accurately with a degree of independence and justify choice/use of technique.	Design, evaluate and complete synthesis, purification, isolation and characterisation strategies accurately with a high degree of autonomy and efficiency.
Explain the theoretical basis and limitations of a range of classical and instrumental analytical techniques; design, develop and carry out qualitative and quantitative sample preparation and purification, chemical measurement, metrology and analysis, with due regard to accuracy, precision, traceability, and the effects of complex matrices and sample size using appropriate terminology and mathematical or graphical notation.	Suggest, carry out and report qualitative and quantitative sample preparation and purification, chemical measurement, metrology and appropriate analysis accurately with a degree of independence.	Design, optimise, carry out and report qualitative and quantitative sample preparation and purification, chemical measurement, metrology and appropriate analysis accurately with a high degree of autonomy and efficiency.
Use computational techniques and tools, to aid further understanding and insight of chemical structure, bonding and reactivity.	Use computational techniques and tools to investigate familiar chemical concepts covered in course content	Select and use appropriate computational techniques and tools to investigate complex chemical concepts and evaluate and

	and report outcomes using appropriate terminology.	report outcomes using appropriate terminology.
Engage with the chemical literature.	Identify and select appropriate resources and sources of chemical information.	Identify and select appropriate resources and sources of chemical information with a high degree of independence.
Complete independent open-ended investigative work through a project/research-based assignment relevant to chemistry.	Complete an open-ended investigative project/research-based assignment.	Complete an open-ended investigative project/research-based assignment with a high level of independence.
Appreciate the contribution of chemistry to the innovations that characterise the modern world, and the potential of chemists to develop solutions to current and future challenges.	Identify and discuss application of chemistry in solving current and future challenges in the world.	Explain and suggest ways in which chemistry can contribute to solving current and future challenges in the world.
Recognise the relationships and interfaces between chemistry and other subjects, such that they are able to operate effectively in a multidisciplinary environment.	Identify and explain relationships between chemistry and other subjects as relevant to course content.	Evaluate and explain contribution of chemistry to multidisciplinary issues.
Deploy mathematical concepts, processes and tools, such as the manipulation of equations, calculus, graphical and statistical analysis, to solve chemical problems and evaluate chemical data.	Select and use mathematical concepts, processes and tools to solve familiar chemical problems and evaluate chemical data, usually accurately.	Consistently and accurately select and use mathematical concepts, processes and tools to solve familiar chemical problems and evaluate chemical data.
Choose and deploy methods for data analysis and manipulation, potentially including coding and scripting, for presentation, communication and problem-solving purposes.	Select and correctly use methods for data analysis and manipulation with some guidance.	Select, evaluate and correctly use methods for data analysis and manipulation in complex and unpredictable situations.
Collaborate and work successfully in a group environment, contributing positively and flexibly to team outputs.	Provide useful contributions to team outputs.	Provide clear and valuable contributions to team outputs exhibiting teamwork and/or leadership skills.
Communicate effectively, selecting appropriate content, media and methods for the audience, purpose and subject.	Communicate information, ideas, problems and solutions verbally, electronically and in writing, with clear expression and style.	Communicate information, ideas, problems and solutions to an accomplished level verbally, electronically and in writing, in an accurate, fluent and sophisticated style, at a level consistently appropriate for audience.
Act professionally, with due regard for legal, ethical and societal responsibilities, modelling good practice that promotes positive perceptions of chemistry and chemists.		

4.7 There are a range of master's courses (integrated and standalone), but all students should have attained the thresholds in Table 1. Master's courses further develop transferable skills and depth of knowledge, in particular, mastery of one or more specialist areas or applications of chemistry and independence in project-based work.

**Table 2: Benchmark standards - In addition to Table 1, on graduating with a master's degree in Chemistry, graduates should be able to:**

<b>Outcome</b>	<b>Threshold</b>	<b>Excellent</b>
Develop, integrate, synthesise and apply the systematic and broad understanding of relevant and state-of-the-art chemical concepts to solve more complex problems.	With significant support and guidance.	With a high degree of independence and autonomy.
Interrogate and integrate diverse sources of scientific literature alongside other information sources, in order to design and develop methods for investigation and analysis, including in areas at the forefront of knowledge and outside their current specialist knowledge.		
Project planning, including, as appropriate, evaluation of ethics, hazards and environmental effects and appreciation of costs.		
Development of advanced experimental and investigative skills as appropriate for project.		
Discussion of the background, context, methods, results and potential impact of a significant research project.		

## 5 List of references and further resources

QAA and Advance HE (2021) Education for Sustainable Development Guidance  
[www.advance-he.ac.uk/guidance/teaching-and-learning/transforming-assessment](http://www.advance-he.ac.uk/guidance/teaching-and-learning/transforming-assessment)

HEA (2016) Framework for Embedding employability in higher education  
[www.heacademy.ac.uk/system/files/downloads/embedding-employability-in-he.pdf](http://www.heacademy.ac.uk/system/files/downloads/embedding-employability-in-he.pdf)

QAA (2018) Enterprise and Entrepreneurship Education: Guidance for UK Higher Education Providers  
[www.qaa.ac.uk/docs/qaas/enhancement-and-development/enterprise-and-entrepreneurship-education-2018.pdf](http://www.qaa.ac.uk/docs/qaas/enhancement-and-development/enterprise-and-entrepreneurship-education-2018.pdf)

QAA (2019) Characteristics Statement: Higher Education in Apprenticeships  
[www.qaa.ac.uk/docs/qaa/quality-code/characteristics-statement-apprenticeships.pdf](http://www.qaa.ac.uk/docs/qaa/quality-code/characteristics-statement-apprenticeships.pdf)

QAA (2019) Annex D: Outcome classification descriptions for FHEQ Level 6 and FQHEIS Level 10 degrees  
[www.qaa.ac.uk/docs/qaa/quality-code/annex-d-outcome-classification-descriptions-for-fheq-level-6-and-fqheis-level-10-degrees.pdf](http://www.qaa.ac.uk/docs/qaa/quality-code/annex-d-outcome-classification-descriptions-for-fheq-level-6-and-fqheis-level-10-degrees.pdf)

## 6 Membership of the Advisory Groups for the Subject Benchmark Statement for Chemistry

### Membership of the Advisory Group for the Subject Benchmark Statement for Chemistry (2022)

Professor Lizzy Ostler (Chair)	University of Brighton
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### Membership of the Advisory Group for the Subject Benchmark Statement for Chemistry (2019)

The fourth edition, published in 2019, was revised by QAA to align the content with the revised UK Quality Code for Higher Education, published in 2018. Proposed revisions were checked and verified with a member of the benchmarking and review group for the Subject Benchmark Statement for Chemistry from 2014.

Professor Colin Pulham	University of Edinburgh
Dr Alison Felce	QAA

### Membership of the Advisory Group for the Subject Benchmark Statement for Chemistry (2014)

Details provided below are as published in the third edition of the Subject Benchmark Statement.

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### **Membership of the Advisory Group for the Subject Benchmark Statement for Chemistry (2007)**

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### **Membership of the Advisory Group for the Subject Benchmark Statement for Chemistry (2000)**

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Professor M I Page	University of Huddersfield
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Professor D Phillips	Imperial College London
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