The Royal Society of Chemistry's Response to the NCCA Leaving Certificate Chemistry consultation

February 2024

The purpose of the consultation was to gather feedback that would help inform the work of the development group for Leaving Certificate Chemistry in refining the draft specification prior to approval and publication.

Unanswered questions are omitted for clarity.

Clarity and coherence in the specification

There are three design features of the specification, which aim to support curricular coherence and clarity; namely the overview of each strand, the students learn about column and the learning outcomes themselves. Considered along with the other sections of the document [the Rationale, Aims, Key Competencies, Teaching and Learning and Assessment], the students learn about column builds on the overview and indicates what students will be learning. The learning outcomes state what students should know, understand and be able to do at the end of the course.

Please provide specific feedback / observations / comments on the extent to which the strand overview and students learn about column bring clarity to the learning outcomes in an appropriate way.

There is room for further clarification, especially in relation to the timing required considering the number of learning outcomes and 160 hours of class time (minus 20 for project). It is unclear which experiments are expected to be completed in these 160 hours of class time. For example, all of the experimental investigations (EI) are listed as learning outcomes (students should be able to). Therefore, the proposed specification implies that all these investigations need to be completed by the students. However, there are some learning outcomes that are clearly an experiment but do not have the subscript EI, so it is unclear how these should be treated e.g. IM5 (e) Conduct an experiment to create a simple Galvanic cell and explain its operation.

The knowledge about science; continuity from junior cycle and the unifying strand

To ensure continuity from junior cycle, the knowledge about science in the unifying strand is the same as that set out in the Nature of Science strand in junior cycle. Progression from junior cycle is signposted through the strand overview and the provision of the extra detail in the students learn about column.

This strand builds on the unifying strand from Junior Cycle Science and continues to bring to life the practices and norms underpinning the facts, concepts, laws, and theories of science. Building on existing knowledge students develop an appreciation of science as a process; a way of knowing and doing and an awareness that the discipline of science includes the nature of scientific knowledge as well as how this knowledge is generated, established and communicated. In senior cycle it is expected that students will be able to meet these learning outcomes with a greater degree of independence. (page 16)

The Unifying Strand: The Nature of Science (pages 16-18)

In this strand, students learn about

U1. Understanding about Chemistry (page 16)

U2. Investigating in Chemistry (page 17)

U3. Communicating in Chemistry (page 17)

U4. Chemistry in Society (page 18)

U5. Abstraction to Representation (page 18)

Please provide specific feedback / observations / comments on the knowledge about science specified in the unifying strand.

Our curriculum framework proposes three core components of a chemistry curriculum at 16-18; the way in which chemistry operates as a science; the body of knowledge that constitutes chemical concepts; and the interactions between chemistry and the world. We are satisfied that this proposed 'Unifying Strand' will develop student understanding of how chemistry operates as a science.

We are pleased to see the development of safe laboratory practice as a key learning outcome, reinforcing the importance of practical chemistry and the development of associated skills. HE and industry groups have also previously cited safe working practices as one of the most important skills to gain before further work or study in the chemical sciences. However, with most schools without a technician, we are concerned about whether these aims can be achieved without the appropriate resourcing.

Models are central to scientific thought; an appreciation of the development and use of models is essential to understanding how knowledge in chemistry is produced. They are constructed to make sense of empirical findings and are continually used to make predictions and devise hypotheses for testing. Therefore, we are pleased to see modelling referred to in both U1 and U2.

Whilst we acknowledge that some quantitative skills are referred to in the 'Unifying Strand' (particularly in U2), we would like to see a stronger emphasis on mathematical skills that are intended to be developed throughout this qualification. Chemistry is constructed using mathematical models and principles, and so has a strong quantitative basis. Therefore, the curriculum should include mathematical content, which builds upon past study in mathematics, is appropriate to the chemistry content and prepares students well for the next phase of their study. Many students who study chemistry at 16–19 also study maths and they should be able to apply their mathematical skills with confidence to a chemical context in a challenging and satisfying way. However, a 16–19 chemistry course should also allow students who are not studying mathematics to excel so that mathematical content should be clearly applied and conceptualised. Although there are certain specific examples of the use of maths in places in the four contextual strands, we feel these skills are unifying and should be reflected in this first strand.

Cross-cutting themes and the knowledge from Chemistry

Health, Sustainability and Technology have been chosen as cross-cutting themes. These themes have been specifically chosen to show the relevance of Chemistry to students' lives coherent with the Rationale and Aims set out on pages 2 and 3.

The themes act as lenses through which students explore the application of the knowledge from Chemistry. (Page 13)

Please provide specific feedback / observations / comments on the cross-cutting themes sustainability, health and technology.

We are pleased to see sustainability as one of the core themes of this proposed qualification. Our 'Green Shoots' report, which included educators from Ireland and the UK, highlighted that young people wanted sustainability and climate change to be a priority in a chemistry curriculum. Additionally, 69% of surveyed educators felt that there was currently too little content in the chemistry curriculum at 16-19 that directly relates to these topics.

Alongside the specific chemistry content that explores climate change and sustainability, we would want to see content across the qualification exemplified and contextualised around sustainability where appropriate.

The knowledge of Chemistry; the four contextual strands. (pages 18 - 43)

The learning outcomes in the four contextual strands; Nature of Matter, Behaviour of Matter, Interactions of Matter and Matter in our World, identify the knowledge of Chemistry; i.e. the core concepts, models and theories that describe, explain and predict chemical phenomena.

Please provide specific feedback/observations/comments on what students are expected to learn in the contextual strands. If mentioning specific topics/learning outcomes please use appropriate coding

We are satisfied with the broad content included in strand 1; it contains everything we'd expect for learners to start building good foundational knowledge at this advanced level.

Strand 2 is also structured as a foundational unit, building up learner understanding of bonding, the forces between molecules, and how this affects the properties and behaviour of matter. We are satisfied that there are no obvious omissions from these concepts.

We feel that strand 3 omits some foundational concepts that, if not learned, would put learners progressing to higher education in chemistry at a disadvantage compared to their peers internationally, such as the nations of the UK. For example:

- IM1 – there is no reference to Gibbs free energy or entropy. This is a basic fundamental concept that introduces learners to whether a reaction is feasible. Omitting this puts this qualification at odds with level 3 qualifications across the UK, putting learners at disadvantage if pursuing further study in chemistry.

- IM2 – the proposed rates of reaction content seem limited and doesn't seem to build on material learned in Junior Certificate (these being the effect of variables on rate, basic measurement of rate). We would expect a level 3 qualification to at least include rate laws, orders of reaction, and associated calculations involving rate laws.

- IM4 – the categorisation of acid-base systems does not move past first principles, seemingly not building on or add complexity to material learned in the Junior Certificate. This could be a potential learning outcome that could be sacrificed to make room in the qualification for the topics mentioned above.

- Further topics that could be omitted to make room for this suggested content include radioactivity (NM2), parts of the periodic table content e.g. its development and properties of specific groups (NM3, level 2 content), allotropy (BM1, level 2 content), combustion (IM1, level 2 content), and identifying organic compounds (MW2, recall - something teachers have asked for less of).

Strand 4 mainly focuses on the bulk of the organic chemistry content, the applications of this chemistry, and the chemical environment. The organic chemistry content broadly aligns with our curriculum framework and includes key concepts such as functional group interconversions and the use of curly arrows. In the final MW3 section, we noted that the content doesn't cover decision making (chemistry being affected by different decisions, requiring weighting of evidence and constructing arguments) which is something our curriculum experts strongly recommended to include. We feel this would complement the topics you have proposed and illustrate the difficult balancing act scientists are often faced with.

The knowledge of Chemistry; the four contextual strands. (pages 18 - 43)

The learning outcomes in the four contextual strands are common apart from those specified for Higher Level only, which are emboldened.

Please provide specific feedback / observations / comments on the appropriateness of the learning outcomes specified as common and those that are emboldened as Higher Level only. If mentioning specific topics / learning outcomes please use appropriate coding.

In NM2, by limiting the more advanced electronic structure model (s, p, d) to Higher Level only, the opportunity to build on ideas developed in level 2 is limited and understanding remains at a basic level. We believe this should be content for all.

The nature of metallic bonding in BM1 seems a basic concept to limit to Higher Level only; the proposed learning objective also doesn’t seem to build on/add to level 2 understanding.

We also noted that much of the quantitative content in strands 3 and 4 have been marked as Higher Level only. These include using bond enthalpy data and calculating enthalpy changes using Hess’s law (IM1 e & f), using the mathematical model of Kc and solving problems involving the mathematical model for Kc (IM3, b & c), deducing a mathematical representation for Kw (IM4, e), solving mathematical problems involving pH for dilute aqueous solutions (IM4, i), deducing mathematical representations for Ka and Kb (IM4, j), solving and analysing volumetric problems (MW1, c), investigating how to find percentage aspirin in an aspirin tablet (MW2, p). While we appreciate that the inclusion of all these learning objectives in the Ordinary Level is not realistic as there is a restriction on the amount of content, we do feel that by identifying these concepts as Higher Level only there are limited opportunities in strands 3 and 4 for Ordinary Level students to apply their mathematical skills in chemistry contexts. We would ask that this is reviewed.

It is disappointing that the majority of the practical chemistry opportunities in MW2 have been marked for Higher Level only. For example, only Higher Level learners experience preparing an ester, synthesising a carboxylic acid, or extracting pure aspirin. This means Ordinary Level learners will not have the opportunity to develop an understanding of basic organic synthesis techniques. Again, we would ask that this is reviewed.

Additional Assessment Component (AAC)

The Additional Assessment Component of LC Chemistry provides an opportunity for students to display evidence of their learning throughout the course, in particular, the learning set out as outcomes in the unifying strand. It involves students completing a piece of work in a specified time period towards the end of the course as evidence of their ability to conduct scientific research on a particular issue and to use appropriate primary data to investigate aspects of that issue. It has been designed, to exploit its potential to be motivating and relevant for students, to draw together the learning outcomes and cross-cutting themes of the course and to spotlight potential career paths by highlighting the relevance of learning in Chemistry to their lives. (Page 45)

Please provide specific feedback / observations / comments on the challenges associated with introducing an AAC.

We would like more clarification about this. If the AAC requires all students to conduct individual practical lab projects, it may also disadvantage schools without a technician. Some teachers have commented to us that individual lab projects will involve significant lab time that isn't always available in schools as it currently stands. This is especially the case when all the lab science subjects will be conducting their projects at the same time.

Widening the appeal of Chemistry

In addition to its potential to support the development of scientific literacy necessary for twenty-first century citizenship, it is hoped therefore, that this specification will appeal to a broad range of learners with a diverse range of post-school aspirations.

Please provide specific feedback / observations / comments on the likelihood of the draft specification to appeal to a broader range of students with a diverse range of post-school aspirations.

Our 'Chemistry for all' outreach study explored the impact of five years of outreach activities to widen participation in chemistry. It showed that targeting students from less advantaged backgrounds can draw them into the chemistry pipeline and strengthen their identity with chemistry. Student perceptions of chemistry and the existing dominant representations of chemistry were found to have an effect on student aspiration in the subject.

The Aspires research project led by Professor Louise Archer at UCL also concluded that identifying and challenging dominant representations of STEM is one of the key ways to improve STEM aspirations in young people.

We want to see awarding and regulatory bodies provide examples in curricula of successful people in chemistry who have 'worked hard' rather than rely on 'natural cleverness'. We also want to see a diversity of people (including across age, ethnicity, gender and other aspects of people's identities, characteristics, and circumstances) portrayed as contributing to chemistry and working in it and with it. We would hope that during the development of this qualification, careful consideration is made to the exemplification and contextualisation of the content.

Our 'Green Shoots' report, which included educators from Ireland and the UK, surveyed young people and their educators on the state of climate and sustainability education in chemistry. It revealed that young people are extremely concerned about climate change, with 75% feeling anxious about the future of the planet. 66% of 17 and 18 year olds who were studying chemistry at the time would like more detailed coverage of sustainability and climate change in their chemistry lessons. Therefore, we are pleased to see sustainability as a core theme of this proposed qualification. However as stated previously, alongside the specific chemistry content that explores climate change and sustainability we would want to see content across the qualification exemplified and contextualised around sustainability where appropriate.

Timing

The specification has been designed for a minimum of 180 hours of class contact time with 20 hours dedicated to the completion of the Additional Assessment Component.

Please provide specific feedback / observations / comments on the likelihood of 180 hours of class time being sufficient to achieve the learning specified in the draft specification. If you think it is unlikely that 180 hours of class time is sufficient to achieve the learning specified in the draft specification, please indicate specific topics / learning outcomes that might be edited (removed, merged, reframed) and include a rationale for your suggestions.

We have received several responses from teachers who are concerned about the timing. With the large numbers of learning outcomes* and only 160 hours of class time (minus 20 for project), with 27 learning outcomes as experiments, teachers feel this would result in a very heavy workload for the time available. If a student were to miss a week of school for illness or otherwise, they would miss large sections of the course, with no time to revise. There is also concern from teachers that this course will put schools without a technician at a disadvantage even more than the old course.

We acknowledge that this feedback on timing is in conflict against our earlier comments on the knowledge strands and what we have identified as missing content. However, we believe this essential content can be included while at the same time being mindful of the timing constraints; for example, there is some proposed content that repeats what is learned at level 2, could this be adapted or removed to make space in the qualification:

- IM4 – the categorisation of acid-base systems does not move past first principles, seemingly not building on or add complexity to material learned in the Junior Certificate.

- NM2 - radioactivity (also risk of repetition with physics)

- NM3 - parts of the periodic table content e.g. its development and properties of specific groups

- BM1 - allotropy

- IM1 - combustion

- MW2 - identifying organic compounds (recall - something teachers have asked for less of).

*64 main sections in the “student learn about” column and 127 individual learning outcomes (excluding the unifying stand) in the “student should be able to” column