Senior Syllabus

Chemistry

2007 (amended 2014)
Contents

1. A view of science and science education ............................................. 1
2. Rationale ......................................................................................... 2
3. Global aims ..................................................................................... 3
4. General objectives ........................................................................... 4
5. Course organisation ......................................................................... 7
  5.1 Organising principles ................................................................... 7
  5.2 Course structure .......................................................................... 8
  5.3 Time allocation ............................................................................ 8
  5.4 Planning a course of study ............................................................ 8
  5.5 Planning and developing a unit of work ......................................... 9
  5.6 Composite classes ...................................................................... 12
  5.7 Work program requirements ......................................................... 12
6. Learning experiences ......................................................................... 13
  6.1 Teaching Chemistry .................................................................... 13
  6.2 Guidelines for learning experiences ............................................. 13
  6.3 Workplace health and safety ......................................................... 15
7. Assessment ....................................................................................... 16
  7.1 Underlying principles of exit assessment ..................................... 16
  7.2 Planning an assessment program ............................................... 18
  7.3 The assessment program .............................................................. 19
  7.4 Assessment techniques ................................................................. 19
  7.5 Special consideration .................................................................. 28
  7.6 Exit criteria ................................................................................ 28
  7.7 Determining exit levels of achievement ..................................... 29
  7.8 Requirements for verification folio ............................................. 30
  7.9 Standards associated with exit criteria ..................................... 31
8. Language education .......................................................................... 33
9. Quantitative concepts and skills ....................................................... 34
10. Educational equity ........................................................................ 36
11. Resources ..................................................................................... 37
Glossary ............................................................................................. 39
Appendix 1: Scientific literacy 43
   Scientific literacy 43
   Working scientifically 43
   Inquiry 44
   Scientific investigations 44

Appendix 2: Developing context-based units of work 47

Appendix 3: Indication of depth of treatment 50

References 57
Summary of syllabus amendments January 2014

The following table outlines the amendments made to Chemistry Senior Syllabus 2007. These amendments are a consequence of the directions of the Minister as outlined in the Queensland Government Response to the Education and Innovation Committee Report No. 25: The assessment methods used in senior mathematics, chemistry and physics in Queensland schools.

<table>
<thead>
<tr>
<th>Syllabus section</th>
<th>2014 update</th>
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<tbody>
<tr>
<td>Section 2: Rationale</td>
<td>An understanding of chemistry is relevant to a range of careers, including those in forensic science, environmental science, engineering, medicine, pharmacy and sports science. Additionally, chemistry knowledge is valuable in occupations that rely on an understanding of materials and their interactions, such as art, winemaking, agriculture and food technology. Some students will use this course as a foundation to pursue further studies in chemistry, and all students will become more informed citizens, able to use chemical knowledge to inform evidence-based decision making, and engage critically with contemporary scientific issues.</td>
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</tbody>
</table>
| Section 7.4: Assessment techniques | Modes of assessment
Assessment techniques may be presented in a variety of modes, e.g. written, spoken/signed and multimodal. An assessment response is communicated to an audience for a particular purpose, which may influence the type of text, language features and other textual features used in the response. Purposes may include analysing; persuading; arguing; informing; presenting investigative, experimental or field-based findings; creating; performing; showcasing; reviewing a text or situation; completing calculations or solving problems.
Referencing conventions must be followed regardless of the mode of assessment.

Written responses
Written responses require students to communicate a written assessment response to an audience for a particular purpose.

Spoken responses
Spoken responses require students to present a spoken assessment response to a live or virtual audience (i.e. through the use of technology) for a particular purpose.

Multimodal responses
A multimodal response uses a combination of at least two modes to communicate an assessment response to a live or virtual audience for a particular purpose.

Modes include:
- written
- spoken/signed
- nonverbal, e.g. physical, visual, auditory.

Each of the selected modes contributes significantly to the multimodal response.
Different technologies may be used in the creation or presentation of the response. Replication of a written document into an electronic or digital format does not constitute a multimodal response.

When making judgments about multimodal responses, teachers apply the standards to the entire response — that is, to all modes used to communicate the response.
### Supporting evidence

Supporting evidence is required to substantiate decisions made on spoken and multimodal responses for monitoring, verification and exit purposes. Evidence to support spoken or multimodal responses may include:

- research/data analyses
- notes or annotations
- summary of findings
- journal entries or log book
- seminar brief or conference paper
- a recording of the response (as appropriate).

<table>
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<tr>
<th>Section 7.4.1: Category 1: Extended experimental investigations (EEI)</th>
<th>An extended experimental investigation may run for a minimum of four weeks, or across the unit of work, and includes laboratory or field-based learning. The outcome of an extended experimental investigation is a written, spoken or multimodal response that demonstrates aspects of each of the three criteria. In each year of the course, no more than two EEIs may be undertaken. The assessment conditions in the table below refer to discussion, conclusions, evaluation and recommendations.[Conditions provided for each mode. See p. 21] Teachers can provide the research question or it may be initiated by the student. … and familiarising students with assessment expectations. [p. 22]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Section 7.4.3: Category 3: Extended response tasks (ERT)</td>
<td>The outcome of extended response tasks is a written, spoken or multimodal response that demonstrates aspects of each of the three criteria. [Conditions provided for each mode. See p. 24]</td>
</tr>
<tr>
<td>Section 7.4.8: Authentication of student work</td>
<td>It is essential that judgments of student achievement be made on genuine student assessment responses. Teachers must take reasonable steps to ensure that each student’s work is their own, particularly where students have access to electronic resources or when they are preparing responses to collaborative tasks. The QSA’s A–Z of Senior Moderation contains a strategy for authenticating student work [<a href="http://www.qsa.qld.edu.au/10773.html">www.qsa.qld.edu.au/10773.html</a>]. This provides information about various methods teachers can use to monitor that students’ work is their own. Particular methods outlined include: teachers seeing plans and drafts of student work student production and maintenance of evidence for the development of responses student acknowledgment of resources used. Teachers must ensure students use consistent, accepted conventions of in-text citation and referencing, where appropriate.</td>
</tr>
<tr>
<td>Section 7.8: Requirements for verification folio</td>
<td>assessment instruments, demonstrating a range of techniques, that include: at least one, but no more than two extended experimental investigations at least one supervised assessment.</td>
</tr>
</tbody>
</table>
1. A view of science and science education

Science is a social and cultural activity through which explanations of natural phenomena are generated. It incorporates ways of thinking that are both creative and critical. Scientists have a deep conviction that the universe is understandable.

Explanations of natural phenomena may be viewed as mental constructions based on personal experiences and result from a range of activities including observation, experimentation, imagination and discussion. The evolution of scientific understandings has occurred in definable episodes, with chance sometimes playing an important role.

Accepted scientific concepts, theories and models may be viewed as shared understandings that the scientific community perceive as viable in light of current available evidence. Scientific knowledge is subject to questioning by the scientific community and may be reconfirmed, challenged, modified or replaced. New understandings are continually arising and this is an essential characteristic of science.

Science education should help students envisage alternative futures and make informed decisions about science and its applications. It should help them make decisions that will influence the wellbeing of themselves, other living things and their environment.

Science education should:
- build upon students’ understandings of science and challenge these where necessary
- provide excitement, motivation and empowerment
- encourage a thirst for and a willingness to incorporate new and existing knowledge
- encourage critical reflection
- develop creative thinking skills
- provide a lens through which to view the world.
2. Rationale

The study of Chemistry engages students and teachers in an exciting and dynamic investigation of the material universe. Chemistry provides a platform and conduit in which humankind can interact with and explore matter. This is the essence of Chemistry. Chemistry helps us to understand the links between the macroscopic properties of the world, and the subatomic particles and forces that account for those properties. The application of chemistry enables us to make sense of the physical world. Understanding and applying chemical concepts, models, procedures and intellectual processes aids in humankind’s management of the planet’s limited resources and could provide the key to our continuing survival. Chemistry can provide a unifying feature across most scientific undertakings especially where “traditional” science boundaries are becoming blurred.

The study of Chemistry provides students with a means of enhancing their understanding of the world around them, a way of achieving useful knowledge and skills and a stepping stone for further study. It adds to and refines the development of students’ scientific literacy. An understanding of Chemistry is essential for many vocations.

Participating in a course of study derived from the Chemistry syllabus will immerse students in both the practical and contextual aspects of the discipline, through working scientifically and enacting scientific inquiries, investigations and experiments. It will facilitate the growth of student awareness of the constructions of chemical understandings from academic, personal, social and global perspectives. A course developed from this syllabus embraces the intrinsic “hands on” nature of the subject and provides students with opportunities to develop the key competencies1 in contexts that arise naturally from the subject matter.

This syllabus presents a framework to guide teachers as they construct context-based units of work. Courses will develop students’ understanding and appreciation of Chemistry in real-world, relevant contexts. It will encourage students to think creatively and rationally about Chemistry. Students will be challenged to understand and act responsibly on Chemistry-related problems and issues and to communicate effectively in a range of modes.

An understanding of chemistry is relevant to a range of careers, including those in forensic science, environmental science, engineering, medicine, pharmacy and sports science. Additionally, chemistry knowledge is valuable in occupations that rely on an understanding of materials and their interactions, such as art, winemaking, agriculture and food technology. Some students will use this course as a foundation to pursue further studies in chemistry, and all students will become more informed citizens, able to use chemical knowledge to inform evidence-based decision making, and engage critically with contemporary scientific issues.

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1 KC1: collecting, analysing and organising information; KC2: communicating ideas and information; KC3: planning and organising activities; KC4: working with others and in teams; KC5: using mathematical ideas and techniques; KC6: solving problems; KC7: using technology.
The global aims are statements of the long-term achievements, attitudes and values that are developed by students through studying Chemistry but which are not directly assessed by the school.

The overarching aim of studying any course in science, thereby including Chemistry, should be to develop in students an ongoing ability to extend their scientific literacy.

Accordingly, through a course of study in Chemistry, students should develop:

- the capacity to work scientifically in chemistry contexts
- the skills to engage in informed chemistry inquiry and investigation techniques safely beyond the school context
- an ability to engage in solving chemistry problems in everyday contexts
- an ability to use technology productively in chemistry contexts
- an ability to understand and appreciate the chemistry encountered in everyday life
- a capacity to work as part of a team engaging in cooperative activity
- an ability to communicate chemical understandings
- an appreciation of the issues and impacts of chemistry.
4. General objectives

The general objectives are a summary of what students should be able to achieve as a result of completing the course. They stem from a view of science and science education, the rationale and the global aims.

The objectives of the syllabus are categorised in the following dimensions:

- **Knowledge and conceptual understanding**
- **Investigative processes**
- **Evaluating and concluding**
- **Attitudes and values.**

The general objectives represent aspects of Chemistry that help students develop their scientific literacy. As students engage with the objectives in conjunction with each other, they also hone their abilities in working scientifically. They will become critically aware of the complexity and interconnectedness of chemistry and human influences on the planet. Students will develop an understanding of the historical influences of chemistry, current chemical developments and implications for chemistry in the future.

Progress in all dimensions should occur concurrently. Progress in any one dimension at times may be dependent on the qualities and skills developed in another. The complexity and sophistication of learning experiences in all dimensions must increase over the duration of the course.

The general objectives within the dimension *Attitudes and values* relate to the affective elements that the course aims to encourage. They are not directly assessed for the awarding of exit levels of achievement.

**Knowledge and conceptual understanding**

Students should acquire knowledge and construct understanding of facts, theories, concepts and principles of Chemistry. To work scientifically students require an understanding of underlying scientific knowledges, including the associated mathematical skills. They need to engage with the processes and phenomena observed in Chemistry through characteristics of data analysed. Students need to make informed judgments based on sound reasoning in order to direct them in their scientific endeavours and to engage with problem solving.

By the end of this course, students should be able to:

- **recall and interpret concepts, theories and principles of Chemistry** — this includes the abilities to remember, reproduce and interpret subject matter such as facts, definitions, formulas, terminology, concepts, theories, principles, laws, procedures, sequences, events, diagrams, symbols, figures, systems and patterns

- **describe and explain processes and phenomena of Chemistry** — this includes the abilities to compare and classify the concepts, theories and principles being explored based on primary and secondary data

- **link and apply algorithms, concepts, theories and schema of Chemistry** — this includes the abilities to adapt, translate and reconstruct understandings in order to find solutions.
Investigative processes

Students need to recognise the methodologies available to them to investigate scientifically. They need to be able to judge the worth of quantitative and qualitative data and interpret and apply the outcomes of such data. Students require the skills to manipulate and review data and scientific techniques so that they may improve their scientific knowledge. They need to synthesise the research that they have generated and be able to discuss the outcomes in relation to their initial purpose.

By the end of this course, students should be able to:

- **conduct and appraise chemical research tasks** — this includes the abilities to formulate questions, hypothesise, plan, manage, evaluate, refine and justify decisions made during investigations plus the critical reflection required to fulfil research goals

- **operate chemical equipment and technology safely** — this includes the abilities to safely select, adapt and apply technological, laboratory and fieldwork equipment, and consider its limitations; it also incorporates the ability to do this individually and in groups

- **use primary and secondary chemical data** — this includes the abilities to analyse and extrapolate from data, and identify relationships, patterns and anomalies in primary and secondary data.

Evaluating and concluding

Students who are working scientifically need to be able to make decisions about the knowledge they have gained and generated. They need to distinguish between a plausible conclusion and one based on pure supposition. Students need to be able to synthesise their thoughts and the thinking of others into a coherent whole, from which they can make judgments and propose future possibilities. They need to reach conclusions and explain the world in which they live, using science. They need to be able to adhere to communication and scientific conventions in communicating their decisions to selected audiences.

By the end of this course, students should be able to:

- **determine, analyse and evaluate the chemical interrelationships involved in Chemistry** — this includes the abilities to identify the chemistry involved, determine the simple and complex relationships that exist between concepts, principles, theories and schema and then to critically examine the associated implications

- **predict chemical outcomes and justify chemical conclusions and recommendations** — this includes the abilities to explore scenarios and consider possible outcomes, and then to provide justifications of conclusions and recommendations

- **communicate chemical information in a variety of ways** — this includes the abilities to select, use and present data and ideas to convey meaning, argument or a case to selected audiences in a range of formats.
Attitudes and values

Students should incorporate chemistry into their view of the world, and realise the impacts of chemistry on it. They should envision possible, probable and preferred futures and take responsibility for their own actions and decisions to promote ethical practices.

By the end of the course, students should be able to:

• retain openness to new chemical ideas, and develop intellectual honesty, integrity, collegiality, cooperation and respect for evidence and ethical conduct
• develop a level of sensitivity to the implications of chemistry for individuals and society and understand that chemistry is a human endeavour with consequent limitations
• develop a thirst for chemical knowledge, become flexible and persistent learners and appreciate the need for lifelong learning.
5. Course organisation

5.1 Organising principles

The syllabus provides a framework on which courses of study in Chemistry are constructed. The organising principles are:

- range of complexity
- accommodation of individual and group differences
- sequencing and development of key concepts and key ideas.

5.1.1 A range of complexity

Increasing complexity in both depth and scope of subject matter should be developed over the course of study in Chemistry. The increasing complexity will be reflected in the teaching and learning experiences and the assessment program developed by the school.

*Depth* refers to the development of knowledge and understandings from simple through to complex within and across the key concepts.

*Scope* refers to the development of the key concepts across at least two units of work. Where possible the development of key concepts should also range from specific to general. This may occur within a unit of work or across units of work.

5.1.2 Accommodation of individual and group differences

Each student will bring to Chemistry particular attitudes, knowledge and understandings based on their own experiences and culture. In developing courses schools should take into consideration the needs of individuals and class groups; the school context; the availability and selection of resources, both physical and human; teachers’ special areas of expertise and interest; learning experiences and teaching styles; assessment instrument design, and educational equity.

5.1.3 Sequencing and development of key concepts and key ideas

To ensure effective sequencing of the key concepts, they should be mapped across the two-year course of study. The sequencing of the key concepts in the course of study should develop in complexity, scope and depth over the two years. Key concepts need to be explored in at least two different units of work, preferably one in Year 11 and one in Year 12. Some key concepts may be included on more occasions than this, but when a key concept is not a significant aspect of a unit of work, it should not be the focus for assessment.

The associated key ideas should also be considered when structuring the units of work.
5.2 Course structure

5.2.1 Organisers
“Structure” and “Reactions” are organisers for grouping the key concepts.

5.2.2 Key concepts
The key concepts are accepted broad chemical understandings.

5.2.3 Key ideas
The key ideas are statements that illustrate the depth and scope of the key concepts.
The possible depth of subject matter is indicated in Appendix 3, where suggestions are provided under the key ideas.

Pages 10–11 show the relationships between the organisers, key concepts and key ideas.

5.3 Time allocation
The minimum number of hours of timetabled school time, including assessment, for a course of study developed from this syllabus is 55 hours per semester. A course of study will usually be completed over two years (220 hours).

5.4 Planning a course of study
In developing a course of study, teachers should also refer to the global aims and should incorporate and apply the organising principles.

A course of study in Chemistry is to be constructed by developing between six and 12 units of work. Through the units of work all the key concepts and key ideas will be progressively developed.

A substantial unit of work is at least 20 hours of timetabled school time. At least two substantial units, one in Year 11 and one in Year 12, must identify and demonstrate a context-based approach (see Appendix 2). Other units of work should be between 10 hours to a semester in length. They may draw upon a variety of approaches, including context-based, expository, demonstrative, problem solving, or inquiry.

A planned cohesive sequence of units of work provides the means for students to explore systematically the key concepts of Chemistry. The sequencing of learning and associated units of work ensures the course of study develops in complexity, scope and depth over the two years. A unit of work needs to allow students the opportunity to develop a depth of understanding through the exploration of the key concepts and associated key ideas. When key concepts and key ideas are substantially revisited, the depth and sophistication of understanding and/or the complexity should be increased.
5.4.1 Course organisation summary

- Six to 12 units of work should be completed over the two-year course of study.
- At least one substantial unit of work in Year 11 and one in Year 12 must be developed using a contextualised approach (at least 20 hours per unit of work).
- Each key concept is to be incorporated in at least two different units of work.
- The physical and human resources of the school should be considered.

5.5 Planning and developing a unit of work

A unit of work provides a detailed structure to facilitate the delivery of the key concepts and related key ideas which are being developed. It provides opportunities for students to apply and reinforce scientific investigation, scientific techniques and their knowledge and conceptual understandings through the selected learning experiences. It relates the learning experiences selected to earlier and later learning experiences, builds on students’ prior learning and conceptualisation, and provides the basis for further development.

The structure and delivery of the unit of work reflect the integrated nature of the learning experiences with the assessment techniques. The assessment technique should fit structurally with the organisation of the unit of work.

In planning and developing a unit of work, teachers should include the following in their consideration of the unit:

- general objectives being developed
- key concepts and key ideas to be developed
- assessment technique (and instrument) for the unit
- time available
- selection of learning experiences best suited to the development of the:
  - identified key concepts and key ideas
  - skills, abilities and knowledge the students require to effectively participate in the unit
  - assessment requirements of the unit
- learning environment and approach, e.g. individual, small group and whole-class activities, workshops, tutorial sessions, guest speakers, real-life situations, access to available resource centres
- specific resources to be used.
Organiser 1: Structure

All that physically exists is composed of matter, including stars, planets and all living organisms. People throughout history and in different cultures have classified the materials they have encountered in their daily existence (e.g. stone, iron, bronze, plastic). These classifications are based on the observed properties as well as the practical uses of these materials. Widespread applications of certain materials have been identified as milestones of various human cultures.

The history of the development of current atomic models of structure and bonding is one of human endeavour from the earliest times. A knowledge of the properties of a general category of matter allows the designing of new substances for specific purposes; for example new metal alloys, plastics, medicines and drugs, and construction materials. Substances previously unknown or whose effects were not understood or appreciated are continually being identified and described by chemists. An understanding at the atomic level provides an explanation of properties at the macroscopic level and this, in turn, provides a foundation for the design of new materials.

Key concept S1

All matter is composed of atoms.

Key ideas
S1.1— Matter is composed of atoms which, in turn, contain protons and neutrons in a nucleus, and electrons outside the nucleus.
S1.2—The number of positively charged protons is equal to the number of negatively charged electrons in a neutral atom, and determines all the chemical properties of an atom.
S1.3—An element is a substance in which all atoms have the same number of protons.
S1.4—Atoms of an element may contain different numbers of neutrons, and are known as isotopes.
S1.5—Every element is assigned a unique chemical symbol.
S1.6—The atomic mass of an atom is arbitrarily defined relative to the mass of the isotope carbon-12.
S1.7—In modern theories of atomic structure, electrons are viewed as occupying orbitals which are grouped in electron shells.

Key concept S2

Materials can be categorised and represented symbolically and their macroscopic properties can be explained and predicted from understandings about electronic structure and bonding.

Key ideas
S2.1—From theory of electronic structure it is predicted that elements will display periodic variations in their chemical and physical properties.
S2.2—The macroscopic properties are related to their microscopic properties.
S2.3—Pairs of atoms may be bound together by the sharing of electrons between them in a covalent bond.
S2.4—Two or more atoms bound together by one or more covalent bonds form a molecule, with definite size, shape and arrangement of bonds.
S2.5—An atom or group of atoms covalently bound together may gain or lose one or more electrons to form ions.
S2.6—Ionic bonding occurs when positive and negative ions are held together in a crystal lattice by electrostatic forces.
S2.7—When chemical bonds, whether ionic or covalent, are formed between different elements, a chemical compound is obtained, which can be represented by a chemical formula.
S2.8—Forces weaker than covalent bonding exist between molecules.
S2.9—The structure of a metal involves positive ions embedded in a sea of electrons.
S2.10—Materials may be elements, compounds or mixtures.
S2.11—in compounds containing carbon-hydrogen bonds (known as organic compounds), the carbon atoms bind to one another through single, double or triple covalent bonds to form chains or rings.
Organiser 2: Reactions

Whether a reaction will occur, and the nature and amounts of the products, depend critically on the natures of all reacting species, their amounts and the temperature. Knowledge of the atomic model, principles of mass conservation, and stoichiometry have developed because of the empirical methods used in measuring masses and volumes of reactants and products. Observations that the quantities of reactants influence chemical reactions led to the development of notions of Avogadro’s law, moles and molarity. Concentration affects reactions, as does the availability of energy.

Energy is the weave that holds the material fabric of the universe together. Chemical reactions, including those that sustain life, involve energy changes. First-hand laboratory experiences, as well as observation of everyday chemical reactions, reveal that some reactions proceed more quickly than others. Observation and measurement of reactions provide data that enables the construction of models to explain these different rates of reactions.

The exact nature of unknown substances can be determined by performing a sequence of reactions. There is an exciting atmosphere of challenge and discovery with this kind of chemical detective work which can be powerful and motivating for students interested in Chemistry.

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**Key concept R1**
Specific criteria can be used to classify chemical reactions.

**Key ideas**
- **R1.1**—Redox reactions involve a transfer of electrons and a change in oxidation number.
- **R1.2**—Precipitation reactions result in the appearance of a solid from reactants in aqueous solution.
- **R1.3**—Acid-base reactions involve transfer of protons from donors to acceptors.
- **R1.4**—Polymerisation reactions produce large molecules with repeating units.

**Key concept R2**
Chemical reactions involve energy changes.

**Key ideas**
- **R2.1**—All chemical reactions involve energy transformations.
- **R2.2**—The spontaneous directions of chemical reactions are towards lower energy and greater randomness.

**Key concept R3**
The mole concept and stoichiometry enable the determination of quantities in chemical processes.

**Key ideas**
- **R3.1**—The mole, defined arbitrarily using the isotope carbon-12, is the basic quantity in stoichiometric calculations.
- **R3.2**—Every chemical reaction can be represented by a balanced equation, whose coefficients indicate both the number of reacting particles and the reacting quantities in moles.
- **R3.3**—A balanced equation can be used when determining whether reagents are limiting or in excess.
- **R3.4**—The use of molarity for expressing concentration allows easy interconversions between volume of solution and moles of solute.
- **R3.5**—The ideal gas equation may be used to relate the volume of a gas at defined temperature and pressure to its quantity in moles.

**Key concept R4**
Specialised qualitative and quantitative techniques are used to determine the quantity, composition and type of reaction.

**Key ideas**
- **R4.1**—Techniques such as volumetric and gravimetric analysis are used to determine amounts of reactants and products.
- **R4.2**—Specialised techniques and instrumentation are used in chemical analysis.
- **R4.3**—Qualitative and quantitative testing may be used to determine the composition or type of material.

**Key concept R5**
Chemical reactions are influenced by the conditions under which they take place and, being reversible, may reach a state of equilibrium.

**Key ideas**
- **R5.1**—Chemical reactions occur at different rates and changing the nature of the reactants, temperature, or concentration, or introducing a catalyst, may alter these.
- **R5.2**—Life is maintained by chemical reactions, especially those catalysed by large molecules called enzymes.
- **R5.3**—Chemical reactions may be reversible.
- **R5.4**—Reversible chemical reactions may reach a state of dynamic balance known as equilibrium which, when disturbed, will be re-established.
5.6 **Composite classes**

In some schools, it may be necessary to combine students into a composite Year 11 and 12 class. This syllabus provides teachers with an opportunity to develop a course of study that caters for a variety of circumstances such as combined Year 11 and 12 classes, combined campuses, or modes of delivery involving periods of student-directed study.

The multilevel nature of such classes can prove advantageous to the teaching and learning process because:

- it provides opportunities for peer teaching
- it allows teachers to maximise the flexibility of the syllabus
- it provides opportunities for a mix of multilevel group work, and for independent work on appropriate occasions
- learning experiences and assessment can be structured to allow both Year 11 and Year 12 students to consider the key concepts and ideas at the level appropriate to the needs of students within each year level.

The following guidelines may prove helpful in designing a course of study for a composite class:

- The course of study could be written in a Year A/Year B format, if the school intends to teach the same unit of work to both cohorts.
- Place a unit of work at the beginning of each year that will allow new Year 11 students easy entry into the course.
- Learning experiences and assessment instruments need to cater for both year levels throughout the course. Even though techniques may be similar for both year levels, we recommend that a more extended and/or complex instrument be used with Year 12 students.

5.7 **Work program requirements**

A work program is the school’s plan of how the course will be delivered and assessed based on the school’s interpretation of the syllabus. It allows for the special characteristics of the individual school and its students.

The school’s work program must meet all syllabus requirements and must demonstrate that there will be sufficient scope and depth of student learning to meet the general objectives and the exit standards.

The requirements for work program approval can be accessed on our website, <www.qsa.qld.edu.au>. This information should be consulted before writing a work program. Updates of the requirements for work program approval may occur periodically.
6. Learning experiences

Learning experiences are action-oriented learning opportunities intended to contribute to the attainment of the general objectives, and are devised in consideration of the purposeful context for learning.

6.1 Teaching Chemistry

Effective learning in science requires a variety of teaching approaches, from direct instruction to student-centred learning, designed to make a particular aspect of science accessible to each particular group of learners (Shulman 1986; Goodrum, Hackling & Rennie 2001). The best outcomes are achieved when learners feel supported in their learning, when their views are listened to and respected, and when they are encouraged and feel confident to take risks within the learning process.

Students will be required to build upon or challenge their understandings when they study Chemistry. Providing a context in which they can do this better facilitates learning.

6.2 Guidelines for learning experiences

Learning experiences should draw on a range of pedagogical approaches, for example guided discovery, inquiry, cooperative learning, individualised instruction and direct instruction.

Learning experiences should be presented in a supportive environment where:

- students are encouraged to learn and their opinions and views are respected and listened to
- academic risk-taking is supported through scaffolding of thinking skills
- open communication is encouraged
- students are encouraged to learn by defining their own directions and setting goals for themselves
- students are encouraged to learn through intrinsic and extrinsic motivation.

Learning experiences should encompass elements across all the objectives over the two years, extending understandings through an increasing depth of study.

Learning experiences should progress developmentally from simple to more complex as the course of study progresses. Learning experiences should be constructed to facilitate or be in response to the:

- quantity and complexity of information that students must use
- skills required for information-gathering and sorting
- technological and safety skills required
- cognition required, especially the complexity or depth of the analysis, application, synthesis and evaluation of the information
- communication skills required.
The cognitive skills that support the general objectives of this syllabus should be specifically taught and embedded in the learning experiences throughout the course so students may demonstrate what they know and can do.

Where possible, learning experiences should be based in real-world contexts to which students can relate. Learning experiences should extend beyond the classroom and, where possible, beyond the school. Learning experiences should encourage active learning.

Learning experiences and assessment are not mutually exclusive. The process of assessment is a learning experience and should be treated as such. Assessment can be the culmination of a series of learning experiences. It could be a large and extended single learning experience worked on over time or a mechanism that generates independent, out-of-classroom, personalised and unique learning.

Assessment instruments should be scaffolded and supported by learning experiences that provide direction and the specific knowledge and abilities to fulfil instrument requirements. Learning experiences should encompass the requirements and modelling of assessment techniques that will be required in future summative assessment opportunities.

In selecting learning experiences, teachers have many opportunities to deal with the key employment competencies, some of which are essential to the study of Chemistry, especially:

- collecting, analysing and organising information
- communicating ideas and information
- planning and organising activities
- working with others and in teams
- solving problems.

Ideas for generic learning experiences that may be useful include:

- researching from primary and secondary sources
- accessing and using computers, including internet research
- undertaking national science initiatives
- developing decision-making skills
- interpreting data, from wide-ranging sources including media
- analysing current strategies or policies of the issue being investigated
- analysing strategies and evaluating effectiveness or improvements
- applying the principles of research ethics
- formulating hypotheses and testing them through fieldwork, experiments, interviews and research
- synthesising ideas in a variety of forms, e.g. oral, written, practical
- practising assessment instrument requirements, e.g. genre writing
- predicting impact of recommendations
- proposing and/or implementing strategies for improvement
- solving problems
- engaging in active research projects, independently and with groups and teams
- participating in forum discussions and debates
- sharing information mutually beneficial to the group
- advocating for change.
6.3 Workplace health and safety

In Chemistry, a significant amount of the course is devoted to practical investigative experiences in the laboratory. These experiences expose students to a variety of hazards from corrosive and poisonous substances to injury from glass and hot objects. Besides a teacher’s duty of care that derives from the Education (General Provisions) Act 1989, there are other legislative and regulatory requirements, for example the Workplace Health and Safety Act 1995, that will influence the nature and extent of practical work. Practical laboratory experiences should be selected and conducted with student safety in mind. A significant component of the course should allow students to gain knowledge about the dangers of chemical and laboratory procedures used. The safe handling of chemicals and equipment must be a priority.

The science safety requirements relating to teachers of science are explained in Aspects of Science Management: A Reference Manual for Schools, Education Queensland 1999, and in Workplace Health and Safety Guidelines — Curriculum — Core Module, Education Queensland 1999, on the following website:


It is the school’s responsibility to ensure that its practices meet current guidelines.
The purposes of assessment are to provide feedback to students and parents about learning that has occurred and to provide information on which to base judgments about how well students meet the general objectives of the course. In designing an assessment program, it is important that the assessment instruments, conditions and criteria are compatible with the general objectives and the learning experiences. Assessment then is an integral aspect of a course of study. It can be formative or summative. The distinction between formative and summative assessment lies in the purpose for which that assessment is used.

Formative assessment is used to provide feedback to students, parents, and teachers about achievement over the course of study. This enables students and teachers to identify the students’ strengths and weaknesses so students may improve their achievement and better manage their own learning. The formative techniques used should be similar to summative assessment techniques, which students will meet later in the course. This provides students with experience in responding to particular types of instruments, under appropriate conditions. Feedback on any early assessment tasks may be used in a formative sense to assist students’ preparation for later assessment tasks.

Summative assessment, while also providing feedback to students, parents and teachers, provides cumulative information on which levels of achievement are determined at exit from the course of study. It follows, therefore, that it is necessary to plan the range of assessment techniques and instruments to be used, when they will be administered, and how they contribute to the determination of exit levels of achievement. Students’ achievements are matched to the standards of exit criteria, which are derived from the general objectives of the course. Thus, summative assessment provides the information for certification at the end of the course.

### 7.1 Underlying principles of exit assessment

The policy on exit assessment requires consideration to be given to the following principles when devising an assessment program for the two-year course of study.

- Information is gathered through a process of continuous assessment.
- Balance of assessments is a balance over the course of study and not necessarily a balance over a semester or between semesters.
- Exit achievement levels are devised from student achievement in all areas identified in the syllabus as being mandatory.
- Assessment of a student’s achievement is in the significant aspects of the course of study identified in the syllabus and the school’s work program.
- Selective updating of a student’s profile of achievement is undertaken over the course of study.
- Exit assessment is devised to provide the fullest and latest information on a student’s achievement in the course of study.

These principles are to be considered together and not individually in the development of an assessment program. Exit assessment must satisfy concurrently the six principles associated with it.
7.1.1 Continuous assessment

The major principle is “continuous assessment”. The process of continuous assessment is the basis for the other five principles of balance, mandatory aspects of the syllabus, significant aspects of the course, selective updating, and fullest and latest information to exist and operate.

Continuous assessment is the means by which assessment instruments are administered at suitable intervals and by which information on student achievement is collected. It involves a continuous gathering of information and the making of judgments in terms of the stated criteria and standards throughout a two-year course of study.

Decisions about levels of achievement are based on information gathered, through the process of continuous assessment, at points in the course of study appropriate to the organisation of the learning experiences. Levels of achievement must not be based on students’ responses to a single assessment instrument at the end of a course or instruments set at arbitrary intervals that are unrelated to the developmental course of study.

7.1.2 Balance

Balance of assessments is a balance over the course of study and not necessarily a balance within a semester or between semesters.

Within the two-year course for Chemistry it is necessary to establish a suitable balance in the general objectives, assessment techniques, conditions, and across the criteria. The exit criteria are to have equal emphasis across the range of summative assessment. The exit assessment program must ensure an appropriate balance over the course of study as a whole.

7.1.3 Mandatory aspects of the syllabus

Judgment of student achievement at exit from a two-year course of study must be derived from information gathered about student achievement in those aspects stated in the syllabus as being mandatory, namely:

- the general objectives of Knowledge and conceptual understanding, Investigative processes, and Evaluating and concluding
- the key concepts.

The exit criteria and standards stated in Sections 7.6 and 7.9 must be used to make the judgment of student achievement at exit from a two-year course of study.

7.1.4 Significant aspects of the course of study

Significant aspects refer to those areas in the school’s course of study selected from the choices permitted by the syllabus. Significant aspects can complement mandatory aspects or be in addition to them. They will be determined by the context of the school and the needs of students at that school, and should provide a choice of learning experiences appropriate to the location of the school, the local environment and the resources available.

The significant aspects must be consistent with the general objectives of the syllabus and complement the developmental nature of learning in the course over two years.

7.1.5 Selective updating

In conjunction with the principle of fullest and latest information, information on student achievement should be selectively updated throughout the course.

Selective updating is related to the developmental nature of the course of study and operates within the context of continuous assessment. As subject matter is treated at increasing levels of
complexity, assessment information gathered at earlier stages of the course may no longer be representative of student achievement. The information therefore should be selectively and continually updated (not averaged) to accurately reflect student achievement.

The following conceptions of the principle of selective updating apply:

- A systemic whole subject-group approach in which considerations about the whole group of students are made according to the developmental nature of the course and, in turn, the assessment program. In this conception, developmental aspects of the course are revisited so that later summative assessment replaces earlier formative information.

- An act of decision-making about individual students — deciding from a set of assessment results the subset which meets syllabus requirements and typically represents a student’s achievements, thus forming the basis for a decision about a level of achievement. In the application of decisions about individual students, the set of assessment results does not have to be the same for all students. However, the subset which represents the typical achievement of a student must conform to the parameters outlined in the school’s work program.

Selective updating must not involve students reworking and resubmitting previously graded assessment instruments. Opportunities may be provided for students to complete and submit additional responses. Such responses may provide information for making judgments where achievement on an earlier instrument was unrepresentative or atypical, or there was insufficient information upon which to base a judgment.

### 7.1.6 Fullest and latest information

Judgments about student achievement made at exit from a school course of study must be based on the fullest and latest information available. This information is recorded on a student profile. “Fullest” refers to information about student achievement gathered across the range of general objectives. “Latest” refers to information about student achievement gathered from the most recent period in which the general objectives are assessed. As the assessment program in Chemistry is developmental, fullest and latest information will most likely come from Year 12.

Information recorded on a student profile will consist of the latest assessment data on mandatory and significant aspects of the course, which includes the data gathered in the summative assessment program that is not superseded.

### 7.2 Planning an assessment program

At the end of Year 12, judgments are made about how students have achieved in relation to the standards stated in the syllabus for each of the criteria. These summative judgments are based on achievement in each of the general objectives.

When planning an assessment program, schools must consider:

- general objectives (see Section 4)
- the learning experiences (see Section 6)
- the underlying principles of assessment (see Section 7.1)
- a variety of assessment techniques over the two-year course (see Section 7.4)
- conditions under which the assessment instrument is implemented
- the exit criteria and standards (see Sections 7.6 and 7.9)
- verification folio requirements (see Section 7.8).

Students should be conversant with the assessment techniques and have some knowledge of the criteria to be used in assessment instruments.
7.3 The assessment program

The assessment program must incorporate the underlying principles stated in Section 7.1 and is to consist of a balance of assessment techniques demonstrating the general objectives of Knowledge and conceptual understanding, Investigative processes, and Evaluating and concluding. Assessment techniques must be appropriate to the learning experiences and allow students to demonstrate achievement. Instruments are to be designed so that teachers are able to make valid judgments on students’ achievements of the general objectives and so gather information on which to base judgments about students’ exit achievement. These judgments must be consistent with the standards described in the exit criteria.

A student may be required to undertake assessment instruments individually or as a member of a group. Schools are to develop procedures and strategies to demonstrate individual authorship when responses to assessment instruments are generated from group activities.

7.4 Assessment techniques

Assessment techniques in this syllabus are grouped under categories. The categories do not present an exhaustive list of techniques.

Modes of assessment

Assessment techniques may be presented in a variety of modes, e.g. written, spoken/signed and multimodal. An assessment response is communicated to an audience for a particular purpose, which may influence the type of text, language features and other textual features used in the response. Purposes may include analysing; persuading; arguing; informing; presenting investigative, experimental or field-based findings; creating; performing; showcasing; reviewing a text or situation; completing calculations or solving problems.

Referencing conventions must be followed regardless of the mode of assessment.

Written responses

Written responses require students to communicate a written assessment response to an audience for a particular purpose.

Spoken responses

Spoken responses require students to present a spoken assessment response to a live or virtual audience (i.e. through the use of technology) for a particular purpose.

Multimodal responses

A multimodal response uses a combination of at least two modes to communicate an assessment response to a live or virtual audience for a particular purpose.

Modes include:

- written
- spoken/signed
- nonverbal, e.g. physical, visual, auditory.

Each of the selected modes contributes significantly to the multimodal response.

Different technologies may be used in the creation or presentation of the response. Replication of a written document into an electronic or digital format does not constitute a multimodal response.
When making judgments about multimodal responses, teachers apply the standards to the entire response — that is, to all modes used to communicate the response.

**Supporting evidence**

Supporting evidence is required to substantiate decisions made on spoken and multimodal responses for monitoring, verification and exit purposes. Evidence to support spoken or multimodal responses may include:

- research/data analyses
- notes or annotations
- summary of findings
- journal entries or log book
- seminar brief or conference paper
- a recording of the response (as appropriate).
7.4.1 Category 1: Extended experimental investigations (EEI)

<table>
<thead>
<tr>
<th>What is an extended experimental investigation?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Within this category, instruments are developed to investigate a hypothesis or to answer a practical research question. The focus is on planning the extended experimental investigation, problem solving and analysis of primary data generated through experimentation by the student. Experiments may be laboratory or field based. An extended experimental investigation may run for a minimum of four weeks, or across the unit of work, and includes laboratory or field-based learning.</td>
</tr>
<tr>
<td>The outcome of an extended experimental investigation is a written, spoken or multimodal response that demonstrates aspects of each of the three criteria.</td>
</tr>
<tr>
<td>In each year of the course, no more than two EEIs may be undertaken.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>What must a student do to complete an extended experimental investigation?</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Develop a planned course of action.</td>
</tr>
<tr>
<td>• Articulate the hypothesis or research question clearly and provide a statement of purpose for the investigation.</td>
</tr>
<tr>
<td>• Provide descriptions of the experiment.</td>
</tr>
<tr>
<td>• Show evidence of modifications or student design.</td>
</tr>
<tr>
<td>• Provide evidence of primary and secondary data collection and selection.</td>
</tr>
<tr>
<td>• Execute the experiment(s).</td>
</tr>
<tr>
<td>• Analyse data.</td>
</tr>
<tr>
<td>• Discuss the outcomes of the experiment(s).</td>
</tr>
<tr>
<td>• Evaluate and justify conclusion(s).</td>
</tr>
<tr>
<td>• Present information in a mode determined by the school.</td>
</tr>
</tbody>
</table>

The assessment conditions in the table below refer to discussion, conclusions, evaluation and recommendations.

<table>
<thead>
<tr>
<th>Mode</th>
<th>Year 11</th>
<th>Year 12</th>
</tr>
</thead>
<tbody>
<tr>
<td>Written:</td>
<td>800–1000 words</td>
<td>1000–1500 words</td>
</tr>
<tr>
<td>Spoken:</td>
<td>3–4 minutes</td>
<td>4–5 minutes</td>
</tr>
<tr>
<td>Multimodal:</td>
<td>3–5 minutes</td>
<td>5–7 minutes</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>What do teachers do when planning and implementing an extended experimental investigation?</th>
</tr>
</thead>
<tbody>
<tr>
<td>The teacher suggests topics/issues and provides some stimulus to trigger student interest.</td>
</tr>
<tr>
<td>Teachers can provide the research question or it may be initiated by the student. In those instances teachers should negotiate with students to ensure safety and the possibility of success. It is more likely that students will be able to generate their own research questions the further they progress in the course of study.</td>
</tr>
<tr>
<td>Teachers must allow some class time and provide some supervision at times for students to be able to effectively undertake each component of the extended experimental investigation. Teachers may allow elements of the extended experimental investigation to be conducted in small groups or pairs. However, independent student time will probably be required to complete the extended experimental investigation.</td>
</tr>
</tbody>
</table>
Teachers must implement strategies to ensure authentication of student work. Some strategies are annotated notes in response to issues that emerged during research (e.g. journals, experimental logs), teacher observation sheets, research checklists, and referencing and reference list.

Teachers must consult, negotiate and provide feedback before and during the research process to help ensure occupational health and safety requirements are followed, to provide ethical guidance and to monitor student work. Feedback and assistance should be provided judiciously, gradually being reduced with the development of student experience and confidence.

Scaffolding must be provided. When an extended experimental investigation is undertaken for the first time, the scaffolding should help students complete the assessment by modelling the extended experimental investigation process and familiarising students with assessment expectations. However, the scaffolding provided should not specify the chemistry, or lead the student through a series of steps dictating a solution. Scaffolding should be reduced from Year 11 to Year 12 to allow the student to better demonstrate independence in the research process. When an extended experimental investigation is revisited (most likely in Year 12) the scaffolding should be reduced and could be a series of generic questions.
7.4.2 Category 2: Supervised assessments (SA)

<table>
<thead>
<tr>
<th>What is a supervised assessment?</th>
</tr>
</thead>
<tbody>
<tr>
<td>The supervised assessment is an instrument that is written and conducted under supervised conditions to ensure authentication of student work.</td>
</tr>
<tr>
<td>Supervised assessments may draw on one, two or three of the criteria.</td>
</tr>
<tr>
<td>A supervised assessment could be constructed using one or more of the following four types of items:</td>
</tr>
</tbody>
</table>

1. **Short items**
   - Multiple-choice questions or items requiring single word, sentence or short paragraph (up to 50 words) responses

2. **Practical exercises**
   - Using graphs, tables, diagrams, data or the application of algorithms

3. **Paragraph responses**
   - These are used when explanation of greater complexity is required and should be between 50 and 150 words

4. **Responses to seen or unseen stimulus materials**
   - These may take the form of a series of short items, practical exercises and paragraph responses (see above) or more extended pieces of writing, such as essays. If an extended piece of writing is chosen, it is probably best if it is the only item on the supervised test, as this will better allow students to demonstrate the full range of standards.

Some considerations when the item is an extended piece of writing:
- extended pieces of writing should be in response to a question or statement and supplied sources
- the question or statement is not provided before the test (unseen) and should focus on asking the students to evaluate and justify
- perusal times may be required
- stimulus materials should be succinct enough to allow students to engage with them in the time provided for the supervised test, or if the stimulus materials are lengthy, they may need to be shared with students before the administration of the written task.

<table>
<thead>
<tr>
<th>For monitoring</th>
<th>For verification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recommended time: 1–1½ hours. For extended pieces of writing as responses to seen or unseen stimulus materials, 500–600 words is recommended.</td>
<td>Recommended time: 1½–2 hours. For extended pieces of writing as responses to seen or unseen stimulus materials, 600–800 words is recommended.</td>
</tr>
</tbody>
</table>

**What do teachers do when planning a supervised assessment?**

The teacher should:
- construct questions that are unambiguous
- format the paper to allow for ease of reading and responding
- consider the language needs of the students
- ensure the questions allow the full range of standards to be demonstrated.
7.4.3 Category 3: Extended response task (ERT)

What is an extended response task?

The extended response task is an assessment instrument developed in response to a Chemistry question, circumstance or issue. It is essentially non-experimental, but may draw on primary experimental data. Research and secondary data will often be the focus. The management of the extended response task should be mostly the responsibility of the student. Supervision by the teacher may be necessary at times. The extended response task may last from two weeks to the entirety of the unit of work.

The outcome of extended response tasks is a written, spoken or multimodal response that demonstrates aspects of each of the three criteria.

<table>
<thead>
<tr>
<th>Modes and types of responses</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Written</strong></td>
</tr>
<tr>
<td>Report: In the report, the student would make some form of decision regarding the question or issue under investigation and support the decision with logical argument. The report may be in response to observations made and conclusions drawn from a case study or studies, industrial visits, or field trips.</td>
</tr>
<tr>
<td>Assignment: Students provide a response to a specific question or issue. The response may be supported by appropriate tables of data, diagrams and flowcharts. The assignment could be a persuasive argument or informative text.</td>
</tr>
<tr>
<td>Article: Students create an article that would be suitable for a scientific magazine or publication that would run stories of scientific interest. Documentation of findings should be enhanced by the use of graphics, tables and pictures.</td>
</tr>
<tr>
<td><strong>Spoken</strong></td>
</tr>
<tr>
<td>For example debates, seminars, lessons, demonstrations.</td>
</tr>
<tr>
<td><strong>Multi-modal</strong></td>
</tr>
<tr>
<td>For example PowerPoint presentations, webpages, videos, computer simulations.</td>
</tr>
<tr>
<td>Spoken and multi-modal presentations would need to be supported by explanatory notes, references, data and diagrams.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mode</th>
<th>Year 11</th>
<th>Year 12</th>
</tr>
</thead>
<tbody>
<tr>
<td>Written</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Report</td>
<td>800–1000 words (discussions, conclusions and/or recommendations)</td>
<td>1000–1500 words (discussions, conclusions and/or recommendations)</td>
</tr>
<tr>
<td>Assignment</td>
<td>800–1000 words</td>
<td>1000–1500 words</td>
</tr>
<tr>
<td>Article</td>
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</tr>
<tr>
<td>Multi-modal</td>
<td>3–5 minutes</td>
<td>5–7 minutes</td>
</tr>
</tbody>
</table>
## What must a student do to complete an extended response task?

- gather and sort information and data from a variety of sources, demonstrating appropriate referencing
- process information, demonstrating an understanding of processes and phenomena
- interpret, analyse and synthesise data
- explain relationships between concepts, principles, theories and schema
- evaluate information and justify ideas
- communicate ideas.

## What do teachers do when planning and implementing an extended response task?

The teacher suggests topics and provides some stimulus to trigger student interest.

Teachers can provide the research question or it may be instigated by the student. In those instances teachers should negotiate with students to ensure safety and the possibility of success. It is more likely that students will be able to generate their own research questions the further they progress in the course of study.

Teachers must allow some class time for students to be able to effectively undertake each component of the extended response task. Teachers may allow elements of the extended response task to be conducted in small groups or pairs. However, independent student time will be required to complete the extended response task.

Teachers must implement strategies to ensure authentication of student work. Some strategies are annotated notes in response to issues that emerged during the extended response task (e.g. journals, experimental logs), teacher observation sheets, research checklists, and referencing and reference lists.

Teachers must consult, negotiate and provide feedback before and during the extended response task to provide ethical guidance and to monitor student work. Feedback and assistance should be provided judiciously, gradually being reduced with the development of student experience and confidence.

Scaffolding must be provided. When an extended response task is undertaken for the first time, the scaffolding should help students complete the assessment by modelling the extended response task process. However, the scaffolding provided should not specify the chemistry, or lead the student through a series of steps dictating a solution. Scaffolding should be reduced from Year 11 to Year 12 to allow the student to better demonstrate independence in the research process. When an extended response task is revisited (most likely in Year 12) the scaffolding should be reduced and could be a series of generic questions.
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7.4.4 Assessment instruments

Assessment instruments are developed by the school to provide:

- opportunities for students to demonstrate their understanding of Chemistry
- a level of challenge suitable for the whole range of students
- information about students’ demonstration of the achievement of the general objectives
- information on which teachers may make judgments about student achievement.

Assessment instruments are accompanied by:

- statements of the conditions of assessment that apply (Section 7.4.6)
- a detailed description of the instrument (Section 7.4.7)
- a detailed criteria sheet (Section 7.4.8)
- details of procedures for authentication of student responses (Section 7.4.9).

7.4.5 Conditions of assessment

Across the whole assessment program, teachers should establish a range of conditions. This can be done by systematically varying the factors that are most significant in establishing the conditions for an instrument, namely:

- the time allowed to prepare and complete the response
- access to resources, both material and human, during the preparation for and completion of the instrument.

Every instrument description must include clear statements of the assessment conditions that apply. These may include:

- time available for the preparation and completion of the response
- resources accessible and available (both material and human) during the preparation for and completion of the response
- location for the preparation and completion of the response, e.g. in class, at home
- whether the response is to be an individual or group production
- the strategy used to ensure student authorship, e.g. the degree of teacher supervision and teacher monitoring that will apply.

7.4.6 Instrument descriptions

Instrument descriptions are to:

- state all requirements, including the length and the conditions
- be congruent with the general objectives of the syllabus, the standards associated with exit and the school work program; this congruence ensures the essential relationship between learning, teaching and assessment practices.

7.4.7 Criteria sheets

Where criteria sheets specific to each instrument are developed, they should be provided to students before undertaking assessment.

These instrument-specific criteria sheets are to:

- be derived from the exit criteria
- describe standards congruent with the exit standards
• provide a clear specification of each of the five standards (A–E)
• inform teaching and learning practice
• be annotated to indicate student achievement
• provide the basis for teacher judgment about student achievement
• provide students with the opportunity to develop self-evaluative expertise.

The extent to which the exit standards are reflected in the criteria sheet will vary according to the general objectives associated with the instrument and according to the stage in the course at which the instrument is undertaken.

7.4.8 Authentication of student work

It is essential that judgments of student achievement be made on genuine student assessment responses. Teachers must take reasonable steps to ensure that each student’s work is their own, particularly where students have access to electronic resources or when they are preparing responses to collaborative tasks.

The QSA’s A–Z of Senior Moderation contains a strategy for authenticating student work <www.qsa.qld.edu.au/10773.html>. This provides information about various methods teachers can use to monitor that students’ work is their own. Particular methods outlined include:

• teachers seeing plans and drafts of student work
• student production and maintenance of evidence for the development of responses
• student acknowledgment of resources used.

Teachers must ensure students use consistent, accepted conventions of in-text citation and referencing, where appropriate.

7.5 Special consideration

Guidance about the nature and appropriateness of special consideration and special arrangements for particular students may be found in the Authority’s Policy on Special Consideration in School-based Assessments in Senior Certification (2006), available from <www.qsa.qld.edu.au/yourqsa/policy/special-c/docs/spec-con.pdf>. This statement also provides guidance on responsibilities, principles and strategies that schools may need to consider in their school settings.

To enable special consideration to be effective for students so identified, it is important that schools plan and implement strategies in the early stages of an assessment program and not at the point of deciding levels of achievement. The special consideration might involve alternative teaching approaches, assessment plans and learning experiences.

7.6 Exit criteria

The following exit criteria must be used in making judgments about a student’s level of achievement at exit from a course in Chemistry.

Knowledge and conceptual understanding

This criterion refers to the student’s ability to acquire knowledge about facts, theories, concepts and principles of Chemistry, to engage with the theories and issues of Chemistry, and to interpret the interrelationships occurring within Chemical contexts.
Investigative processes
This criterion refers to the student’s ability to recognise the methodologies available to them, conduct experimental processes safely, judge the worth of qualitative data, and interpret and apply the outcomes of quantitative data.

Evaluating and concluding
This criterion refers to the student’s ability to synthesise their thoughts and the thinking of others, determine interrelationships, propose solutions and justify decisions, and communicate their findings.

All criteria make equal contribution to the determination of levels of exit achievement.

7.7 Determining exit levels of achievement

On completion of the course of study, the school is required to award each student an exit level of achievement from one of the five categories:

- Very High Achievement
- High Achievement
- Sound Achievement
- Limited Achievement
- Very Limited Achievement.

The school must award an exit standard for each of the criteria: Knowledge and conceptual understanding, Investigative processes, and Evaluating and concluding, based on the principles of assessment described in this syllabus. The criteria are derived from the general objectives and are described in Section 4. The standards associated with the three exit criteria are described in the matrix in Section 7.9. When teachers are determining a standard for each criterion, it is not always necessary for the student to have met each descriptor for a particular standard; the standard awarded should be informed by how the qualities of the work match the descriptors overall.

For Year 11, particular standards descriptors may be selected from the matrix and/or adapted to suit the task. These standards are used to inform the teaching and learning process. For Year 12 tasks, students should be provided with opportunities to understand and become familiar with the expectations for exit. The exit standards are applied to the summative body of work selected for exit.

The seven key competencies* referred to in the rationale are embedded in the descriptors in the standards matrix. The descriptors refer mainly to aspects of Knowledge and conceptual understanding, Investigative processes, and Evaluating and concluding.

When standards have been determined in each of the criteria of Knowledge and conceptual understanding, Investigative processes, and Evaluating and concluding, the following table is used to award exit levels of achievement, where A represents the highest standard and E the lowest. The table indicates the minimum combination of standards across the criteria for each level.

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* KC1: collecting, analysing and organising information; KC2: communicating ideas and information; KC3: planning and organising activities; KC4: working with others and in teams; KC5: using mathematical ideas and techniques; KC6: solving problems; KC7: using technology.
Awarding exit levels of achievement

<table>
<thead>
<tr>
<th>Level</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>VHA</td>
<td>Standard A in any two criteria and no less than a B in the remaining criterion</td>
</tr>
<tr>
<td>HA</td>
<td>Standard B in any two criteria and no less than a C in the remaining criterion</td>
</tr>
<tr>
<td>SA</td>
<td>Standard C in any two criteria and no less than a D in the remaining criterion</td>
</tr>
<tr>
<td>LA</td>
<td>At least Standard D in any two criteria</td>
</tr>
<tr>
<td>VLA</td>
<td>Standard E in the three criteria</td>
</tr>
</tbody>
</table>

7.8 Requirements for verification folio

A verification folio is a collection of a student’s responses to assessment instruments on which the level of achievement is based. Each folio should contain student responses to a variety of assessment instruments demonstrating achievement in the criteria Knowledge and conceptual understanding, Investigative processes, and Evaluating and concluding, over a range of topics. The variety of assessment instruments is necessary to provide a range of opportunities from which students may demonstrate achievement.


Students’ verification folios for Chemistry must contain:
- student responses to a minimum of four and a maximum of six summative assessment instruments
- assessment instruments demonstrating a range of techniques that includes:
  - at least one, but no more than two extended experimental investigations
  - at least one supervised assessment
- at least one assessment instrument that is derived from the Year 12 contextualised unit of work
- a criteria sheet for each assessment instrument which provides evidence of how students meet standards associated with the assessment criterion involved in that instrument
- a student profile that records achievement in the assessment instruments across all assessment criteria used to substantiate the proposed interim level of achievement.

7.8.1 Post-verification assessment

In addition to the contents of the verification folio, there must be subsequent summative assessment in the exit folio. In Chemistry, at least one instrument must be completed after verification. Preparation for this assessment often commences before fourth term. It is desirable for the assessment instrument to include all criteria.
## 7.9 Standards associated with exit criteria

<table>
<thead>
<tr>
<th>Criterion</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Knowledge and conceptual understanding</strong></td>
<td>The student work has the following characteristics:</td>
<td>The student work has the following characteristics:</td>
<td>The student work has the following characteristics:</td>
<td>The student work has the following characteristics:</td>
<td>The student work has the following characteristics:</td>
</tr>
<tr>
<td></td>
<td>• reproduction and interpretation of complex and challenging concepts, theories and principles</td>
<td>• reproduction and interpretation of complex or challenging concepts, theories and principles</td>
<td>• reproduction of concepts, theories and principles</td>
<td>• reproduction of simple ideas and concepts</td>
<td>• reproduction of isolated facts</td>
</tr>
<tr>
<td></td>
<td>• comparison and explanation of complex concepts, processes and phenomena</td>
<td>• comparison and explanation of concepts processes and phenomena</td>
<td>• explanation of simple processes and phenomena</td>
<td>• description of simple processes and phenomena</td>
<td>• recognition of isolated simple phenomena</td>
</tr>
<tr>
<td></td>
<td>• linking and application of algorithms, concepts, principles, theories and schema to find solutions in complex and challenging situations.</td>
<td>• linking and application of algorithms, concepts, principles, theories and schema to find solutions in complex or challenging situations.</td>
<td>• application of algorithms, principles, theories and schema</td>
<td>• application of algorithms, principles, theories and schema.</td>
<td>• application of simple given algorithms.</td>
</tr>
<tr>
<td><strong>Investigative processes</strong></td>
<td>The student work has the following characteristics:</td>
<td>The student work has the following characteristics:</td>
<td>The student work has the following characteristics:</td>
<td>The student work has the following characteristics:</td>
<td>The student work has the following characteristics:</td>
</tr>
<tr>
<td></td>
<td>• formulation of justified significant questions/hypotheses which inform design and management of investigations</td>
<td>• formulation of justified questions/hypotheses which inform design and management of investigations.</td>
<td>• formulation of questions and hypotheses to select and manage investigations</td>
<td>• implementation of given investigations</td>
<td>• guided use of given procedures</td>
</tr>
<tr>
<td></td>
<td>• assessment of risk, safe selection and adaptation of equipment, and appropriate application of technology to gather, record and process valid data</td>
<td>• assessment of risk, safe selection of equipment, and appropriate application of technology to gather, record and process data.</td>
<td>• assessment of risk, safe selection of equipment, and appropriate application of technology to gather and record data</td>
<td>• safe use of equipment and technology to gather and record data</td>
<td>• safe directed use of equipment to gather data</td>
</tr>
<tr>
<td></td>
<td>• systematic analysis of primary and secondary data to identify relationships between patterns, trends, errors and anomalies.</td>
<td>• analysis of primary and secondary data to identify patterns, trends, errors and anomalies.</td>
<td>• analysis of primary and secondary data to identify obvious patterns, trends, errors.</td>
<td>• identification of obvious patterns and errors.</td>
<td>• recording of data.</td>
</tr>
<tr>
<td>Criterion</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
<td>E</td>
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<tr>
<td>-------------------------------</td>
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<td>-------------------------------------------------------------------</td>
<td>-------------------------------------------------------------------</td>
<td>-------------------------------------------------------------------</td>
</tr>
<tr>
<td></td>
<td>The student work has the following characteristics:</td>
<td>The student work has the following characteristics:</td>
<td>The student work has the following characteristics:</td>
<td>The student work has the following characteristics:</td>
<td>The student work has the following characteristics:</td>
</tr>
<tr>
<td></td>
<td>• analysis and evaluation of complex scientific interrelationships</td>
<td>• analysis of complex scientific interrelationships</td>
<td>• description of scientific interrelationships</td>
<td>• identification of simple scientific interrelationships</td>
<td>• identification of obvious scientific interrelationships</td>
</tr>
<tr>
<td></td>
<td>• exploration of scenarios and possible outcomes with justification of conclusions/recommendations</td>
<td>• explanation of scenarios and possible outcomes with discussion of conclusions/recommendations</td>
<td>• description of scenarios and possible outcomes with statements of conclusion/recommendation</td>
<td>• identification of scenarios or possible outcomes</td>
<td>• statements about outcomes</td>
</tr>
<tr>
<td></td>
<td>• discriminating selection, use and presentation of scientific data and ideas to make meaning accessible to intended audiences through innovative use of range of formats.</td>
<td>• selection, use and presentation of scientific data and ideas to make meaning accessible to intended audiences in range of formats.</td>
<td>• selection, use and presentation of scientific data and ideas to make meaning accessible in range of formats.</td>
<td>• presentation of scientific data or ideas in range of formats.</td>
<td>• presentation of scientific data or ideas.</td>
</tr>
</tbody>
</table>

and anomalies.
8. Language education

Teachers of Senior English have a special responsibility for language education. However, it is the responsibility of all teachers to develop and monitor students’ abilities to use the forms of language appropriate to their own subject areas. Their responsibility entails developing the following skills:

- ability in the selection and sequencing of information required in the various forms (such as reports, essays, interviews and seminar presentations)
- the use of technical terms and their definitions
- the use of correct grammar, spelling, punctuation and layout.

Students should understand and use appropriate scientific terms and phrases wherever the need arises. In order to achieve understanding of scientific terms, it may be necessary for students to develop their own glossaries as they progress through a course in Chemistry. Assessment in Chemistry needs to take into consideration appropriate use of language.

Students should be engaged in learning experiences which involve them in:

<table>
<thead>
<tr>
<th>Drawing upon sources of information, such as:</th>
<th>Using language for the purposes of:</th>
<th>Presenting information in forms such as:</th>
</tr>
</thead>
<tbody>
<tr>
<td>observations</td>
<td>restating information</td>
<td>laboratory and field notes and reports</td>
</tr>
<tr>
<td>demonstrations</td>
<td>reporting results</td>
<td>formal reports</td>
</tr>
<tr>
<td>experiments</td>
<td>giving instructions</td>
<td>letters</td>
</tr>
<tr>
<td>textbooks</td>
<td>formulating a hypothesis</td>
<td>abstracts</td>
</tr>
<tr>
<td>handbooks of data</td>
<td>designing an experiment</td>
<td>biographies</td>
</tr>
<tr>
<td>manuals of procedures</td>
<td>explaining a relationship</td>
<td>précis</td>
</tr>
<tr>
<td>product brochures</td>
<td>arguing a proposition</td>
<td>reviews</td>
</tr>
<tr>
<td>specification sheets</td>
<td>proposing action</td>
<td>oral presentations</td>
</tr>
<tr>
<td>computer files</td>
<td>defending a position</td>
<td>seminars</td>
</tr>
<tr>
<td>journal articles</td>
<td>justifying a stand</td>
<td>discussions</td>
</tr>
<tr>
<td>magazines</td>
<td>evaluating an argument</td>
<td>expositions</td>
</tr>
<tr>
<td>newspapers</td>
<td>developing an idea</td>
<td>demonstrations</td>
</tr>
<tr>
<td>broadcast media</td>
<td>interpreting a theory</td>
<td>charts</td>
</tr>
<tr>
<td>internet</td>
<td>persuading</td>
<td>graphs</td>
</tr>
<tr>
<td>CD-ROMs</td>
<td>making conclusions</td>
<td>sketches</td>
</tr>
<tr>
<td>advertisements</td>
<td>following instructions</td>
<td>models</td>
</tr>
<tr>
<td>videos or films</td>
<td>predicting the results of an experiment</td>
<td>photographs</td>
</tr>
<tr>
<td>lectures</td>
<td>evaluating scientific arguments</td>
<td>electronic media</td>
</tr>
<tr>
<td>interviews</td>
<td></td>
<td></td>
</tr>
<tr>
<td>discussions</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
9. Quantitative concepts and skills

Success in dealing with life and work depends on the development and integration of a range of abilities, such as being able to:

- comprehend basic concepts and terms underpinning the areas of number, space, probability and statistics, measurement and algebra
- extract, convert or translate information given in numerical or algebraic forms, diagrams, maps, graphs or tables
- calculate, apply algebraic procedures, implement algorithms
- use calculators and computers
- use skills or apply concepts from one problem or one subject domain to another.

Some subjects focus on the development and application of numerical and other mathematical concepts and skills. These subjects may provide a basis for the general development of such quantitative skills or have a distinct aim, such as to prepare students to cope with the quantitative demands of their personal lives or to participate in a specific workplace environment.

Nevertheless, in all subjects students are to be encouraged to develop their understanding and to learn through the incorporation — to varying degrees — of mathematical strategies and approaches. Similarly, students should be presented with experiences that stimulate their mathematical interest and hone those quantitative skills that contribute to operating successfully within each of their subject domains.

The distinctive nature of a subject may require that new mathematical concepts be introduced and new skills be developed. In many cases, however, it will be a matter of teachers, in the context of their own subjects, having to encourage the use of quantitative skills and understandings that were developed previously by their students. Within appropriate learning contexts and experiences in the subject, opportunities are to be provided for the revision, maintenance, and extension of such skills and understandings.

Because of the mathematical underpinnings of this subject it will require the development and use of a wide range of mathematical concepts. For example:

**Quantitative relationships.** Chemical principles are often expressed in terms of quantities. Chemical quantities include numbers of particles, mass, concentration of a solution, pressure, volume, electronegativity, energy of reactions and standard reduction potentials. Relationships between chemical quantities are identified and used for analysis.

**Algebra.** An important tool of chemistry is algebra. Algebraic equations as formulas are used to express quantitative relationships. These allow manipulation of chemical quantities in order to analyse data and predict outcomes.

**Graphical analysis.** The relationship between quantities is often best explored by plotting observed data which can make linear, trigonometric, logarithmic, hyperbolic or parabolic relationships apparent (e.g. the changes in rates of chemical reactions).
**Measurement.** Precise and accurate measurement of chemical quantities is essential in uncovering relationships between quantities or predicting one from the other. Students should consider error management strategies and where appropriate understand the role of significant figures.

**Geometry.** The physical and chemical properties of chemical substances are largely influenced by their shape. (e.g. the polarity of a molecule and subsequent intermolecular forces.) This can be demonstrated by the construction of chemical models requiring the use of geometric skills.

**Number.** The manipulation of numbers is one of the most fundamental skills of chemistry. Chemistry explores the universe from the extremely small to the extremely large, from sub-microscopic to supernovae. The extent of this range relies on the use of exponential or logarithmic approaches in considering and comparing these events.
10. Educational equity

Equity means fair treatment of all. In developing work programs from this syllabus, schools are urged to consider the most appropriate means of incorporating the following notions of equity.

Schools need to provide opportunities for all students to demonstrate what they know and what they can do. All students, therefore, should have equitable access to educational programs and human and material resources. Teachers should ensure that the particular needs of the following groups of students are met: female students; male students; Aboriginal students; Torres Strait Islander students; students from non–English-speaking backgrounds; students with disabilities; students with gifts and talents; geographically isolated students; and students from low socioeconomic backgrounds.

The subject matter chosen should include, whenever possible, the contributions and experiences of all groups of people. Learning contexts and community needs and aspirations should also be considered when selecting subject matter. In choosing appropriate learning experiences teachers can introduce and reinforce non-racist, non-sexist, culturally sensitive and unprejudiced attitudes and behaviour. Learning experiences should encourage the participation of students with disabilities and accommodate different learning styles.

It is desirable that the resource materials chosen recognise and value the contributions of both females and males to society and include the social experiences of both sexes. Resource materials should also reflect the cultural diversity within the community and draw from the experiences of the range of cultural groups in the community.

Efforts should be made to identify, investigate and remove barriers to equal opportunity to demonstrate achievement. This may involve being proactive in finding out about the best ways to meet the special needs, in terms of learning and assessment, of particular students. The variety of assessment techniques in the work program should allow students of all backgrounds to demonstrate their knowledge and skills in a subject in relation to the criteria and standards stated in this syllabus. The syllabus criteria and standards should be applied in the same way to all students.

Teachers may find the following resources useful for devising an inclusive work program:


11. Resources

The selection of resource material to support a course in Chemistry will be governed to some extent by local factors. It is unlikely that there is a single student or teacher resource which can be universally applied to all schools’ programs. Schools should draw upon their own resources as well as those described below.

**Text and reference books**

A wide variety of textbooks and resource materials that could be used as sources of information about Chemistry are available. Book suppliers provide information regarding current publications.

**World Wide Web**

Many interactive and static websites can be used to enhance a course in Chemistry and often include useful resources. Some particularly useful sites include:

- TeachNET
  <http://www.cew.wisc.edu/teachnet/>
- Accelerating-Intelligence News
  <www.Kurzweilai.net>
- WebElements™ periodic table
  <http://www.webelements.com/>
- Royal Society of Chemistry
  <http://www.chemsoc.org/>

**Newspaper reports**

Local and national newspapers include pages, columns and features about chemistry. The compilation of news files on particular topics can broaden students’ knowledge and provide a valuable source of material for developing assessment instruments.

**Periodicals**

Many useful teaching strategies are reported in the *Australian Science Teachers’ Journal* as well as the respective state science teachers’ journals such as *The Queensland Science Teacher*. These journals often contain details and information about free materials, teaching kits and some worthwhile commercial packages. Useful topics may also be found in science research journals and discipline-specific journals. Lists of these are contained in listings of periodicals held in most libraries.

Commonwealth Science and Industrial Research Organisation (CSIRO) publications contain articles of direct relevance to the topics of this syllabus. Other publications from various sources such as the Australian Academy of Science, conservation and environmental groups and scientific organisations may contain recent and useful information.

Popular science periodicals such as *Scientific American* and *New Scientist* provide information on areas of latest research. *Australasian Science* and the CSIRO periodical *Helix* contain relevant articles. School librarians should be able to provide assistance with identifying and locating other useful periodicals.
Electronic media and learning technology
A wide range of videos, DVDs and television recordings are available on a variety of topics related to Chemistry. A variety of computer software programs and CD-ROMs may be useful for a course in Chemistry, as learning tools, to gain access to information presented in a variety of forms and to assist students in gaining ICT skills. Educational program distributors are able to supply updated resource lists.

The ABC television series “Catalyst” usually contains items of value. Documentaries produced by the National Geographic Society and similar bodies are telecast frequently and copies of these programs are available, for educational use, at a reasonable cost.

“The Science Show” and “Ockham’s Razor” are regular radio series (on ABC Radio National) pitched at an appropriate level.

Organisations and community resources
A variety of government and community organisations provide personnel, advice, resources and information to assist in constructing and implementing a course in Chemistry. The Queensland Museum, for example, provides a valuable storehouse of materials and expert knowledge. Links with community groups and organisations not only provide relevant and up-to-date resources for students but also help to improve the credibility of the course in the eyes of the community.

There may be protocols that must be observed when working with Aboriginal and Torres Strait Islander organisations and community groups, for example meeting with the elders before an activity is conducted. One such set of protocols may be found in the Aboriginal and Torres Strait Islander Studies Senior Syllabus.

A number of centres have been set up in capital cities and in mobile format. For example Questacon — the National Science and Technology Centre in Canberra, and the Queensland Museum Sciencentre in Brisbane, offer information and programs for schools.

Professional associations

The Royal Australian Chemical Institute is the professional association for chemists in Australia. Various grades of membership are open to Chemistry teachers and these also provide a subscription to the Institute’s journal Chemistry in Australia. Details may be found at <www.raci.org.au>.
Glossary

Algorithm
Process or set of rules to be used; systematic procedure to solve a problem in a finite number of steps; step-by-step approach.

Analyse
Break up a whole into its parts; examine in detail to determine the nature of; look more deeply into and detect the relationships between parts.

Assessment instrument
Particular methods developed and used by a school to gather information about student achievement.

Assessment techniques
The methods (categories) identified in the syllabus to gather evidence about student achievement. Senior syllabuses describe suitable techniques and prescribe the mix of assessment techniques for verification folios.

Communicate
Convey information about; make known; impart; reveal clearly; manifest.

Compare
Display recognition of similarities and differences and recognise the significance of these similarities and differences.

Concept
Abstract idea or a mental symbol, typically associated with a corresponding representation in language or symbology, that denotes all of the objects in a given category or class of entities, interactions, phenomena, or relationships between them. Concepts are abstract in that they omit the differences of the things in their extension, treating them as if they were identical. They are universal in that they apply equally to everything in their extension. Concepts are also the basic elements of propositions. Concepts are discursive and result from reason. Concepts help to integrate apparently unrelated observations and phenomena into viable hypotheses and theories.

Conclusion
Final result or summing up; inference deduced from previous information; reasoned judgment.

Contextualised
A context is a framework for linking concepts and learning experiences that enables students to identify and understand the application of chemistry to their world. A context is a group of related situations, phenomena, technical applications and social issues likely to be encountered by students. A context provides a meaningful application of concepts in real-world situations.

Contrast
Display recognition of differences by deliberate juxtaposition of contrary elements.

Criteria (singular: “criterion”)
A criterion is a property, dimension or characteristic by which something is judged or appraised. In senior syllabuses, the criteria are the significant dimensions of the subject, described in the rationale and used to categorise the general objectives and exit criteria.

Criteria sheets
Developed from the standards associated with exit criteria to describe the attributes of student work anticipated at each level of achievement for the particular assessment instrument.
Data
In the context of the Chemistry syllabus, data is thought of as documented information or evidence of any kind that lends itself to scientific interpretation. Data may be quantitative or qualitative.

Decision
The process of coming to a conclusion or determination about something, resolving or forming conclusions, providing a judgment or an answer; a choice formed after considering various alternatives.

Deduce
Infer; reach a conclusion which is necessarily true provided a set of assumptions is true.

Demonstrate
Explain process; prove or show to be true; provide evidence.

Describe
Give an account of in speech or writing; convey an idea or impression of; characterise; represent pictorially; depict; trace the form or outline of.

Depth
The development of knowledge and understandings from simple through to complex.

Determine
Come to a resolution or decide.

Discuss
Consider a particular topic in speaking or writing; talk or write about a topic to reach a decision.

Estimate
Calculate an approximate amount or quantity.

Evaluate
Establish the value, quality, importance, merit, relevance or appropriateness of information, data or arguments based on logic as opposed to subjective preference.

Exemplify
Show or illustrate, using examples.

Exit level of achievement
The standard reached by students at exit, judged by matching standards in student work with the exit criteria and standards stated in a syllabus.

Explain
Make clear or understandable; show knowledge in detail.

Formative assessment
Used to provide feedback to students, parents and teachers about achievement over the course of study. This enables students and teachers to identify the students’ strengths and weaknesses so students may improve their achievement and better manage their own learning.

General objectives
General objectives are those which the school is intended to pursue directly and student achievement of these is assessed by the school.

Hypothesis (plural: “hypotheses”)
A tentative explanation for a phenomenon, used as a basis for further investigation.

Identify
Recognise, name or select.

Illustrate
Make clear or intelligible; exemplify.
Interpret
Give meaning to information presented in various forms — words, symbols, pictures, graphs, etc

Investigative process
The process of examining or inquiring into something with organisation, care and precision; the questions chosen should be of interest to students, should encourage additional questioning, and should challenge students to explore a range of solutions.

Justify
Provide sound reasons based on logic or theory to support response; prove or show statements are just or reasonable; convince.

Key competencies
Defined skills essential for effective participation in adult life, including further education and employment.

Key concepts
Accepted broad scientific (chemical) understandings.

Key ideas
Statements that illustrate the depth and scope of the key concepts.

Moderation
Name given to the quality assurance process for senior secondary studies used by the QSA to ensure that:
- Authority subjects taught in schools are of the highest possible standard
- student results in the same subject match the requirements of the syllabus and are comparable across the state
- the process used is transparent and publicly accountable.

Qualitative
Concerned with quality; based on verbal analysis.

Quantitative
Concerned with measurement; based on mathematical analysis.

Phenomenon (plural: “phenomena”)  
An observable or detectable event.

Primary data
Information that does not already exist, collected under research guidelines.

Processes
Events where there are (chemical) changes determined by the atomic and molecular composition and structure of the substances involved.

Reliability
Ability to be trusted to be accurate or correct or to provide a correct result.

Scaffolding
The scaffolding analogy comes from the building industry, and refers to the process of supporting a student’s learning to solve a problem or perform a task that could not be accomplished by that student alone. The aim is to support the student as much as necessary while they build their understanding and ability to use the new learning, and then gradually reduce the support until the student can use the new learning independently.
Secondary data
The result of research that involves the summary, collation and/or synthesis of existing research rather than primary research (where data is collected from, for example, research subjects or experiments).

Solutions
Answers to problems, investigations, research or questions.

Standard
A fixed reference point for use in assessing or describing the quality of something. In senior syllabuses, standards are usually described at five points within each exit criterion.

Student profile of achievement
This records information about student performance on instruments undertaken periodically throughout the course of study. Techniques are chosen to sample the significant aspects of a course across relevant exit criteria to ensure balance in assessment. In particular, it is important that the profile of achievement illustrates how assessment of significant aspects is selectively updated and eventually leads to summative assessment within each exit criterion.

Summative assessment
Provides cumulative information on which levels of achievement are determined at exit from the course of study. It follows, therefore, that it is necessary to plan the range of assessment instruments to be used, when they will be administered, and how they will contribute to the determination of exit levels of achievement.

Synthesise
Assemble constituent parts into a coherent, unique and/or complex entity. The term entity includes a system, theory, communication, plan, set of operations.

Theory
A set of facts, propositions or principles analysed in their relation to one another and used, especially in science, to explain phenomena.

Unit of work
A unit of work is a 6–12 week planned program of study. The learning experiences, and where possible the assessment, is generated through a purposeful context for learning.

Validity
Sound, reasonable, relevant, defensible, well grounded, able to be supported with logic or theory.

Verification
Towards the end of Year 12, school submissions, one for each Authority subject, are sent to the relevant (usually district) review panels, who review the material to confirm that the standards assigned to students’ work are in line with the descriptors in the syllabus. These submissions comprise folios of the work of sample students about to exit from the course of study, together with the school’s judgment of the value of the work of each of those students.

Verification folio
This is the collection of documents (tests, reports, assignments, checklists and other assessment instruments) used to make the decision about a student’s level of achievement. At October verification, the folio will contain 4–6 pieces of work that conform to the underlying principles of assessment as outlined in Section 7.8. Usually these pieces of work will be common to all submitted folios.

Work program
The school’s program of study in Authority and Authority-registered subjects for which the students’ results may be recorded on QSA certificates (requirements are listed on the QSA website).
Appendix 1: Scientific literacy

In *The National Review of the Status and Quality of Teaching and Learning of Science in Australian Schools*, Goodrum, Hackling, & Rennie (2001), argued that the broad purpose of teaching science in the compulsory years of schooling is to develop scientific literacy for all students. Likewise, the report *Re-imagining Science Education: Engaging students in science for Australia’s future* (Tytler 2007) suggested that scientific literacy should be used as a focus for driving change in school science, citing the pace of technological advancement and global issues as reasons for a focus on developing scientifically informed citizens.

The explanations provided in this appendix are not considered to be exhaustive or totally definitive. However, to assist in the implementation of this syllabus a shared understanding amongst science teachers needs to be established. It is with this intent that these explanations are provided.

**Scientific literacy**

The overarching aim of any study of any science, including this course of study in Chemistry, is to develop students’ scientific literacy. The defining and redefining of the meaning of scientific literacy is ongoing, but on page 15 of their report, Goodrum, Hackling and Rennie provide a useful definition that considers and builds upon both the National Science Council’s 1996 definition and that provided by the OECD in 1999. They define it as

the capacity for persons to be interested in and understand the world around them, to engage in the discourses of and about science, to be sceptical and questioning of claims made by others about scientific matters, to be able to identify questions and draw evidence based conclusions, and to make informed decisions about the environment and their own health and well being.

The National Science Education Standards (1996, p. 22) explains further that

Scientific literacy implies that a person can identify scientific issues underlying national and local decisions and express positions that are scientifically and technologically informed.

Scientific literacy is not a static quality. It is a way of thinking and a way of viewing and interacting with the world. Scientific literacy is encouraged and developed through working scientifically.

**Working scientifically**

Working scientifically encompasses the analytical approaches of scientific inquiry and investigation with conceptual and behavioural understandings and dispositions. In the context of this syllabus it stems from the global aims and includes the assessable general objectives as well as attitudes and values.
Working scientifically is a challenging interaction between

existing beliefs, the goal of better understanding, and the processes and methods of exploring, generating, testing and relating ideas. It involves a number of attitudes: valuing ideas and seeking explanations; respecting evidence and logical reasoning; open-mindedness, critical-mindedness and persistence; scepticism about evidence and arguments; honesty and openness to new ideas; creativity and lateral thinking; ethical behaviour; regard for the consequences of decisions and the wellbeing of the living and non-living components of the environment; accepting the provisional nature of knowledge (Curriculum Corporation 1994, p. 15).

Further, in the Years 1 to 10 Science Key Learning Area Syllabus, working scientifically is described as:

[encompassing] the practices and dispositions of science. These include a complex assortment of activities, mental processes, routines and protocols that are the essence of the scientific enterprise. Because it is a hallmark of the activities of scientists, “working scientifically” features prominently in effective science education. When “working scientifically”, students make sense of the phenomena they experience as they investigate, understand and communicate. They develop an appreciation of “working scientifically” when they learn the concepts of science through engaging in the widest range of active learning experiences. Engaging in science in this way contributes to students’ sense of awe and wonder about the beauty and power of the universe (Queensland Schools Curriculum Council 1996, p. 1).

Inquiry

Research has demonstrated that learning occurs best in science when “learners build upon their existing knowledge or restructure what they know as a result of their understanding being extended or challenged in some way” (Goodrum, Hackling and Rennie 2001, p. 18). Using an inquiry approach is an effective way to attain this goal. Inquiry is an overarching term used to describe a teaching and learning process that incorporates skills necessary for students to have in science classrooms. An inquiry can be defined as “a systematic investigation into an idea (problem) or issue. Inquiry-based learning encompasses the processes of posing problems, gathering information, thinking creatively about possibilities, making decisions and justifying conclusions.” (Department of Education Tasmania 2006).

Inquiry is used in exploring science issues, solving science problems, conducting science experiments and conducting science generally. The skills of scientific inquiry include:

questioning, predicting, hypothesising, investigating and gathering evidence, organising data to elicit patterns, testing and refining ideas, developing explanations for natural phenomena and communicating these to others (Curriculum Corporation, 2006, p. 2).

Scientific inquiries are often considered synonymous with scientific investigations.

Scientific investigations

Investigation of scientific questions and problems allows students to embark on a meaningful and intellectually stimulating interpretation of their surroundings involving use of scientific techniques and procedures and leading to the development of knowledge, concepts, ideas, theories and principles in Chemistry. The construction of knowledge and understanding therefore allows more questions to be investigated. The two areas are linked essentially in the teaching and learning of Chemistry, resulting in students who can respond critically and creatively to changes in material use, society and technology.

The syllabus emphasises the linkage and integration between investigative- and knowledge-based chemistry and promotes individual, group and societal understanding of the role it plays in the state of the environment, the quality of human life, social and economic practices and the direction of technological change. Students who complete the course should be able to
understand and act responsibly on chemical problems and issues. They should communicate effectively in a variety of media and modes and be empowered with the ability to investigate problems and apply chemical concepts in order to make sound decisions in the future.

Experimental investigations involve specialised sets of knowledge and skills particular to the area of science under study, and are often seen as a subset of scientific investigations. Experiments produce primary data.

The common aspects of scientific investigations

It has been demonstrated that effective learning in the sciences can be conducted through scientific investigations.

All investigations have three similar phases which can be loosely grouped as follows:

- the establishment of an interest, issue, question or problem to be examined, explored, investigated or solved
- the processes and methodologies associated with the above
- the discussion and critical reflection of the outcomes.

Investigations use particular ways of thinking and problem solving, and are an effective strategy for:

- the development of higher-order thinking skills
- increasing student involvement and ownership of the curriculum
- encompassing effective teaching and learning principles
- recognising and catering for individual difference.

Investigations help shape learning. They may occur as a classroom activity over a lesson, an activity or activities that occur over a few lessons, or over a longer time. They may be the focus of a unit or an assessment, or be part of an assessment.

An investigation may range from being very teacher-directed, to one that has some elements that are student-managed, to those that are totally open ended requiring a high degree of student independence.

Using scientific investigations

Learning that leads to a deep understanding is acquired through the active construction of meaning by students. An important method of constructing meaning is through processes of investigation. These processes take account of students’ construction of new knowledge on the basis of their previous understandings about a topic, and allows time for new knowledge to be clarified.

Investigations will commonly be initiated by a general exploration of the area of interest until an issue, question or problem can be defined. The teacher may start this off, but students’ involvement in specifying the topic, purpose and audience is to be encouraged. As a result of further collection of information and identification of the scientific skills, processes, concepts or strategies integral to the scientific investigation, tentative research questions should be posed, or a hypothesis formulated, and appropriate research techniques selected. Research questions and hypotheses are tentative because they could be changed as a result of issues that emerge during the investigation. With the research question or hypothesis in mind, the student conducts detailed research which will often include experiments in Chemistry.

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2 As an example, the inquiry process outlined in the Years 1–10 Science Key Learning Area Syllabus is:
- investigating
- understanding
- communicating.
Scientific investigations require students to be involved in selecting an appropriate way of gathering information from a diverse range of primary sources (experimental data, statistics, surveys and questionnaires) and secondary sources (print and electronic material). Scientific investigation requires careful analysis of the information acquired. Emphasis should be placed on making the student aware of ways in which application of a scientific inquiry and investigation process may serve to determine outcomes. In analysing data collected by others, the student should be aware of variables that can affect the collection and validity of this data and avoid making unwarranted generalisations. The student also needs to be critical of the source of that data. Decision making must be supported by the processing of data and evidence. The student may wish to make further recommendations, take action on the conclusions reached, suggest follow-up research or modifications to the research and experimentation undertaken.

The process of scientific investigation is not a linear one. Rather, it involves a recursive and reflective return to earlier steps, either to monitor progress or to adapt and adjust the questions or hypothesis in relation to new information. Such metacognitive reflection applies not only to the conclusions of the research but also to the conduct of the scientific investigation itself.

**Possible scientific investigation models**

Not all units of work need be explored through *Investigative processes*. Choosing to use an approach and the selection of a model will depend on the context being studied and the nature of the proposed scientific investigation. The models below can be used in Chemistry.

<table>
<thead>
<tr>
<th>Experimental investigation</th>
<th>Hypothesis-based inquiry</th>
<th>Inquiry process</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Define the question.</td>
<td>• Set down the topic being investigated and the objectives for studying the topic.</td>
<td>• Decide on the research issue:</td>
</tr>
<tr>
<td>• Gather information and resources.</td>
<td>• Establish and refine the hypothesis as a statement or question.</td>
<td>– identify the topic or issue</td>
</tr>
<tr>
<td>• Form hypothesis.</td>
<td>• Gather and analyse data relevant to the hypothesis.</td>
<td>– locate a range of sources</td>
</tr>
<tr>
<td>• Perform experiment and collect data.</td>
<td>• Synthesise and evaluate data relevant to the hypothesis.</td>
<td>– frame a research question or hypothesis and select the research techniques.</td>
</tr>
<tr>
<td>• Analyse data.</td>
<td>• Confirm or reject the hypothesis and establish generalisations or conclusions.</td>
<td>• Conduct the research:</td>
</tr>
<tr>
<td>• Interpret data and draw conclusions that serve as a starting point for new hypotheses.</td>
<td>• Determine the best way to present the outcomes of the data gathering, testing and conclusions.</td>
<td>– gather data, collect evidence</td>
</tr>
<tr>
<td>• Publish/present results.</td>
<td>• If the hypothesis is rejected, reflect on possible modifications.</td>
<td>– analyse and evaluate evidence</td>
</tr>
<tr>
<td></td>
<td></td>
<td>– produce findings.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Make judgments:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>– make decisions or draw conclusions</td>
</tr>
<tr>
<td></td>
<td></td>
<td>– evaluate and justify.</td>
</tr>
</tbody>
</table>
Appendix 2: Developing context-based units of work

The syllabus requires that at least two units of work, one in Year 11 and one in Year 12, are contextualised. These units of work each need to be of at least 20 hours duration. The following information is provided to help teachers develop context-based units of work.

**Contexts for learning**

Students respond positively to tasks that they perceive to be purposeful and interesting to them. Therefore science activities and investigations should be conducted within a context that has relevance to the students (Goodrum, Hackling and Rennie 2001, p. 20)

Context-based learning provides students with opportunities to learn in circumstances that are relevant and interesting to them. The scientific knowledge and understanding of the students is developed, consolidated and refined in, about and through the context. It allows the teacher to use pedagogical approaches suitable to the situation, with multiple approaches often appropriate.

**What is a context?**

A context is a framework for linking concepts and learning experiences that enables students to identify and understand the application of chemistry to their world.

The contextualised approach asks students to look at their world and identify the chemistry within it to develop a deep and transferable understanding of the key concepts and ideas of chemistry. Contexts are central to student learning and an integral part of the learning process. Students shape and are shaped by the contexts in which these educational endeavours occur.

**What is a purposeful context for learning?**

A purposeful context for learning provides a framework within which the key concepts and key ideas of chemistry can be meaningfully explored. Learning occurs best when the learner considers it to be real and relevant. Units of work developed through purposeful contexts help learners to better engage with Chemistry, while allowing them to understand the importance of chemistry in their life.

The assessment for the unit should be derived from the learning experiences developed around the context for learning. In the development of contexts for learning, schools should consider student population, school resources, local environments and social and technological implications and issues. Each context for learning should complement other learning through the development of key concepts and key ideas.
A purposeful context for learning:
- has relevance and consequence beyond the classroom
- is grounded in Chemistry
- reflects the interests and needs of students
- is topical and current or is of scientific historical importance.

It can be developed using:
- a key question or series of questions
- investigation(s)
- hypotheses to be tested
- a problem or problems to be solved
- design challenges
- topical, interesting issues.

Selecting contexts for learning

Questions to consider when establishing a purposeful context for learning

Does the purposeful context for learning:
- have the potential to allow students to explore significant concepts and understandings about their world?
- allow the key concepts and key ideas to be developed?
- lend itself to some form of direct experience through which students can gather first-hand information?
- provide relevance in some way to the lives of these students both now and in the future?
- provide understandings that are valuable and useful in the world beyond school?
- have the potential to really engage and interest students?
- link back in some way to an overall school plan?
- allow for critical reflection and action?
- complement other contexts being selected and not just a variation of a context?
- conflict with others being developed by other classes or subjects within the school?
- cater for the future needs of students?
- suitably challenge your students?
- take students beyond their existing experiences and interests?

Other considerations

- Is this a purposeful context for learning that the students have already explored in some depth? How can I ensure that this experience is developed rather than repeated?
- Can I adequately resource this purposeful context for learning? Do we have a suitable collection of quality resources that I can use to supplement my teaching?
☐ Is there anyone I know who could help me to find out more about the purposeful context for learning? For example, community resources (factories, industries, government utilities such as power stations, museums, hospitals, government departments, CSIRO, universities, training providers, expert speakers).

☐ Is this purposeful context for learning inclusive? Does it avoid alienation of any cultural or religious group? Does it allow for the equal participation of girls and boys?

☐ Can the purposeful context for learning be dealt with effectively in my given timeframe?

☐ Do I have the expertise, familiarity or confidence to develop this purposeful context for learning?
Appendix 3:
Indication of depth of treatment

In the following table, suggestions for subject matter are provided under the key ideas. Where the subject matter is evident from the text of a key idea, suggestions for subject matter are not provided.

Some subject matter applies to a number of key ideas and, in this table, the subject matter provided is placed in dot-point form under the key idea considered most applicable.

The subject matter listed is not exhaustive.

<table>
<thead>
<tr>
<th>Structure</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Key concept S1 — All matter is composed of atoms.</strong></td>
</tr>
<tr>
<td><strong>Key ideas</strong></td>
</tr>
<tr>
<td>S1.1 Matter is composed of atoms which, in turn, contain protons and neutrons in a nucleus, and electrons outside the nucleus.</td>
</tr>
<tr>
<td>S1.2 The number of positively charged protons is equal to the number of negatively charged electrons in a neutral atom, and determines all the chemical properties of an atom.</td>
</tr>
<tr>
<td>S1.3 An element is a substance in which all atoms have the same number of protons.</td>
</tr>
<tr>
<td>S1.4 Atoms of an element may contain different numbers of neutrons, and are known as isotopes.</td>
</tr>
<tr>
<td>• mass number</td>
</tr>
<tr>
<td>• radioactivity</td>
</tr>
<tr>
<td>S1.5 Every element is assigned a unique chemical symbol.</td>
</tr>
<tr>
<td>S1.6 The atomic mass of an atom is arbitrarily defined relative to the mass of the isotope carbon-12.</td>
</tr>
<tr>
<td>S1.7 In modern theories of atomic structure, electrons are viewed as occupying orbitals which are grouped in electron shells.</td>
</tr>
<tr>
<td>• electron configuration</td>
</tr>
</tbody>
</table>
### Key concept S2 — Materials can be categorised and represented symbolically, and their macroscopic properties can be explained and predicted from understandings about electronic structure and bonding.

**Key ideas**

**S2.1** From theory of electronic structure it is predicted that elements will display periodic variations in their chemical and physical properties.
- the trends across a period or down a group in the periodic table for properties such as melting or boiling point, reactivity, ionisation energy, atomic radius, metallic character, nature of oxides
- terms used to describe groups and periods of the periodic table; alkali metals, alkali earth metals, halogens, noble gases, lanthanides and actinides
- the relationship between the number of valence electrons for an element, its position in the periodic table, and its chemical properties
- properties of an element (e.g. combining power, general reactivity) and relationship to its position in the periodic table
- anomalies in the properties of an element

**S2.2** The macroscopic properties are related to their microscopic and atomic properties.
- classification of materials in appropriate bonding categories
- common macroscopic properties
- comparison of models of bonding in metallic, ionic, covalent molecular and covalent network substances
- the properties of solids, liquids and gases using the kinetic particle theory and relating the theory to phase changes
- the physical properties of different types of materials

**S2.3** Pairs of atoms may be bound together by the sharing of electrons between them in a covalent bond.
- single and multiple covalent bonds

**S2.4** Two or more atoms bound together by one or more covalent bonds form a molecule, with definite size, shape and arrangement of bonds.
- how a dipole arises with reference to electronegativity, polar bonds and the effect of molecular shape
- polar and non-polar covalent bonds and molecules
- electron dot diagrams and Lewis valence structures for simple inorganic and organic molecules
- shapes of simple covalent molecules
- VSEPR theory to predict molecular shape

**S2.5** An atom or group of atoms covalently bound together may gain or lose one or more electrons to form ions.

**S2.6** Ionic bonding occurs when positive and negative ions are held together in a crystal lattice by electrostatic forces.

**S2.7** When chemical bonds, whether ionic or covalent, are formed between different elements, a chemical compound is obtained, which can be represented by a chemical formula.
- chemical formulas’ interpretation
- naming a molecular compound given its formula and vice versa
- anions and cations and the symbols/formulas and charges on those designated to be learnt
- formulas’ deduction for ionic substances
S2.8 Forces weaker than covalent bonding exist between molecules.
- Van der Waal’s dispersion forces, dipole-dipole forces, hydrogen bonding and the factors affecting their strength
- the properties of polar and non-polar compounds and models of intermolecular bonding to explain these properties
- molar heats of fusion and vaporisation, specific heat capacity, melting point, boiling point, vapour pressure and surface tension, and the relationship these physical properties have with the strength of intermolecular forces

S2.9 The structure of a metal involves positive ions embedded in a sea of electrons.
- the properties of metals (thermal, conductivity, electrical conductivity, lustre, physical state, ductility, malleability) and relationships to structure
- ways in which metals can be modified and the effects of this on their properties
- alloys

S2.10 Materials may be elements, compounds or mixtures.
- elements, mixtures and compounds can be differentiated experimentally
- operation techniques of different types of mixtures
- composition of pure substances and mixtures
- mixtures can be liquid or non-liquid

S2.11 In compounds containing carbon-hydrogen bonds (known as organic compounds), the carbon atoms bind to one another through single, double or triple covalent bonds to form chains or rings.
- the general formulas for alkanes, alkenes, alkynes, alkanols, carboxylic acids, esters, amines, aldehydes and ketones
- IUPAC rules to name alkanes, alkenes, alkynes and simple alkanols, carboxylic acids, carboxylic acids, esters, amines, aldehydes and ketones
- structural isomerism, geometric isomerism, functional groups, homologous series, saturated and unsaturated, substitution, addition, elimination
- simple physical properties of alkanes, alkenes, alkanols, acids and relation of these properties to structure
- simple chemical properties of alkanes, alkenes, alkanols, acids and esters
- structural features and simple chemistry of some biochemical molecules (e.g. amino acids, proteins, fats, carbohydrates, nucleic acids)
- primary, secondary and tertiary alkanols
- the main products of several chemical reactions, such as substitution, addition, and oxidation, of a selection of simple organic compounds
- equations for the formation:
  - of alkanes, alkenes and alkynes from each other
  - and oxidation of alkanols
  - of alkyl halides (halocarbons)
  - of esters
- the nature of single and multiple covalent bonds in organic molecules
### Reactions

**Key concept R1 — Specific criteria can be used to classify chemical reactions.**

**Key ideas**

**R1.1** Redox reactions involve a transfer of electrons and a change in oxidation number.
- electron transfer
- oxidation (including rules for assignment)
- oxidation and reduction (redox)
- oxidising agent (oxidant) and reducing agent (reductant) with common examples
- half reactions and balanced net equations
- electrochemical cells (galvanic and electrolytic)
- electrodes (anode and cathode)
- salt bridge
- notation for half and whole electrochemical cells
- standard reduction potentials ($E^o$)
- reactivity series
- displacement reaction of metals
- commercial cells and batteries
- electroplating
- corrosion of metals
- sacrificial anodes, cathodic protection
- electrolytic refinement of metals

**R1.2** Precipitation reactions result in the appearance of a solid from reactants in aqueous solution.
- examples of common precipitates (AgCl, BaSO$_4$)
- simple solubility rules
- concept of $K_{sp}$
- complete and net ionic equations
- spectator ions
- applications of precipitation reactions in qualitative and quantitative (gravimetric) inorganic analysis

**R1.3** Acid-base reactions involve transfer of protons from donors to acceptors.
- define acids and bases using Bronsted-Lowry theory
- identify acid-base conjugate pairs
- concept of strong and weak acids and bases
- examples of strong (HCl, HNO$_3$, H$_2$SO$_4$) and weak (HF, CH$_3$CO$_2$H) acids and strong (NaOH, KOH) and weak (NH$_3$) bases
- definitions of $K_w$ and pH
- definitions of $K_a$, $K_b$
- relate the strength of acids and bases to the strength of their conjugates
- reactions of acids with metals
- safety precautions in handling acids and bases
**R1.4** Polymerisation reactions produce large molecules with repeating units.
- explain the terms monomer, polymer, polymerisation, repeat unit
- recall simple physical properties of addition and condensation polymers and relate these properties to structure
- use the following terms appropriately to describe the structure and properties of polymers: thermoset, thermoplastic, elastomer, vulcanisation, amorphous, crystalline
- describe the effects of chain length, side branches and crosslinking on polymer properties
- amino acids and proteins

**Key concept R2 — Chemical reactions involve energy changes.**

**Key ideas**

**R2.1** All chemical reactions involve energy transformations.
- the law of conservation of energy
- the terms exothermic, endothermic, combustion, enthalpy, entropy, activated complex, activation energy
- $\Delta H$ and identify whether a reaction is exothermic or endothermic given $\Delta H$ values
- potential energy-reaction coordinate diagrams change if a catalyst is present in a reaction
- the origin of heat of reaction in terms of the breaking and forming of bonds and bond energy
- enthalpy changes in a reaction in relationship to bond energies
- the relationship between amount and heat of reaction
- thermochemical equations including heat of reaction in them
- heats and molar heats of formation and combustion and neutralisation
- calorimetry and its use in measuring and calculating the heat content of fuels
- specific heat (Q) capacity
- Hess's law of the heats of summation

**R2.2** The spontaneous directions of chemical reactions are towards lower energy and greater randomness.
- entropy and enthalpy considerations to explain the spontaneity of reactions
Key concept R3 — The mole concept and stoichiometry enable the determination of quantities in chemical processes.

**Key ideas**

| R3.1 | The mole, defined arbitrarily using the isotope carbon-12, is the basic quantity in stoichiometric calculations.  
| | • Avogadro’s number, relative atomic mass, relative molecular mass and relative formula mass, molar mass, molar volume, molarity, empirical and molecular formulas, percentage composition |
| R3.2 | Every chemical reaction can be represented by a balanced equation, whose coefficients indicate both the number of reacting particles and the reacting quantities in moles.  
| | • law of conservation of mass  
| | • coefficients, subscripts of state, formulas  
| | • molecular and ionic equations, half and net ionic equations |
| R3.3 | A balanced equation can be used when determining whether reagents are limiting or in excess. |
| R3.4 | The use of molarity for expressing concentration allows easy interconversions between volume of solution and moles of solute.  
| | • concentrations (molarity, percentage volume, percentage mass, ppm)  
| | • dilution, concentrated, dilute, saturated, solubility |
| R3.5 | The ideal gas equation may be used to relate the volume of a gas at defined temperature and pressure to its quantity in moles.  
| | • gas properties: compressibility, diffusion, solubility  
| | • kinetic theory of particles, temperature and energy, zero and Kelvin temperature scale  
| | • real and ideal gases  
| | • STP and SLC, molar volume  
| | • gas laws: Boyle’s, Charles’s, Gay-Lusac’s and Avogadro’s hypothesis  
| | • combined gas equation and ideal gas equation |

Key concept R4 — Specialised qualitative and quantitative techniques are used to determine the quantity, composition and type.

**Key ideas**

| R4.1 | Techniques such as volumetric and gravimetric analysis are used to determine amounts of reactants and products.  
| | • equivalence and end-points, titre, aliquot, standard solution, primary standard  
| | • titrations: back, redox, acid base precipitation, excess/limiting reagents  
| | • equipment, procedures and errors  
| | • empirical and molecular formulas |
| R4.2 | Specialised techniques and instrumentation are used in chemical analysis.  
| | • spectroscopy and colorimetry: mass spectrometry, IR spectroscopy, UV spectroscopy, atomic absorption spectroscopy, line spectra, absorption and emission, calibration  
| | • chromatography: thin layer chromatography, gas chromatography, stationary and mobile phases, adsorption, retention time, Rf |
| R4.3 | Qualitative and quantitative testing may be used to determine the composition or type of material. |
Key concept R5 — *Chemical reactions are influenced by the conditions under which they take place and, being reversible, may reach a state of equilibrium.*

### Key ideas

**R5.1** Chemical reactions occur at different rates, and changing the nature of the reactants, temperature, or concentration, or introducing a catalyst may alter these.
- rate of reaction, collision theory, units, average reaction rate
- factors — nature of reactants, concentration or pressure, the surface area, temperature, catalysts/inhibitors
- activation energy, reaction coordinates, PE v. reaction coordinate diagrams, reaction mechanisms, intermediates, Arrhenius distributions
- graphs of rate data

**R5.2** Life is maintained by chemical reactions especially those catalysed by large molecules called enzymes.
- enzymes, specificity, substrates, active site, denaturation

**R5.3** Chemical reactions may be reversible.
- steady state and dynamic equilibrium
- phase changes, gas phase reactions, redox, acid-base, solubility processes and reactions in aqueous solution – precipitation
- saturated, unsaturated, dilute, concentrated, strong electrolyte, weak electrolyte, non-electrolyte, strong and weak acids
- the equilibrium law and application
- equilibrium constants — Keq, Ksp, Kw, Ka
- extent of reactions, solubility of salts
- equilibrium concentrations

**R5.4** Reversible chemical reactions may reach a state of dynamic balance known as equilibrium which, when disturbed, will be re-established.
- Le Chatelier’s principle, position of an equilibrium: concentration, pressure, temperature and presence of catalysts
- reaction quotient Q and the equilibrium constant K
- collision frequency theory
References


Queensland Schools Curriculum Council 1996, *Years 1 to 10 Science Key Learning Area Syllabus*, Author, Brisbane.
