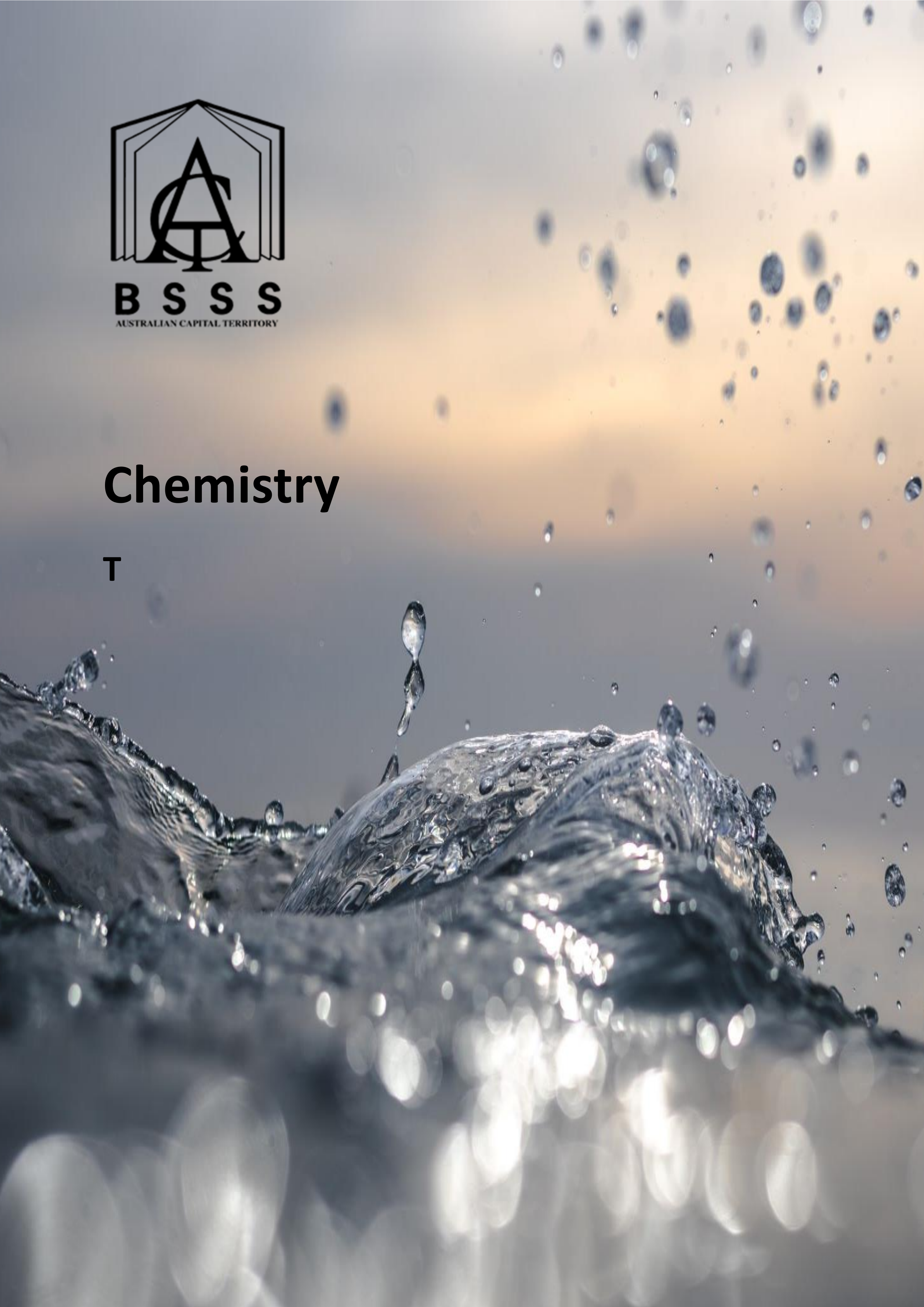

BSSS
AUSTRALIAN CAPITAL TERRITORY

Chemistry

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Cover Art provided by Canberra College student Aidan Giddings

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The ACT Senior Secondary System

The ACT senior secondary system recognises a range of university, vocational or life skills pathways.

The system is based on the premise that teachers are experts in their area: they know their students and community and are thus best placed to develop curriculum and assess students according to their needs and interests. Students have ownership of their learning and are respected as young adults who have a voice.

A defining feature of the system is school-based curriculum and continuous assessment. School-based curriculum provides flexibility for teachers to address students’ needs and interests. College teachers have an opportunity to develop courses for implementation across ACT schools. Based on the courses that have been accredited by the BSSS, college teachers are responsible for developing programs of learning. A program of learning is developed by individual colleges to implement the courses and units they are delivering.

Teachers must deliver all content descriptions; however, they do have flexibility to emphasise some content descriptions over others. It is at the discretion of the teacher to select the texts or materials to demonstrate the content descriptions. Teachers can choose to deliver course units in any order and teach additional (not listed) content provided it meets the specific unit goals.

School-based continuous assessment means that students are continually assessed throughout years 11 and 12, with both years contributing equally to senior secondary certification. Teachers and students are positioned to have ownership of senior secondary assessment. The system allows teachers to learn from each other and to refine their judgement and develop expertise.

Senior secondary teachers have the flexibility to assess students in a variety of ways. For example: multimedia presentation, inquiry-based project, test, essay, performance and/or practical demonstration may all have their place. College teachers are responsible for developing assessment instruments with task specific rubrics and providing feedback to students.

The integrity of the ACT Senior Secondary Certificate is upheld by a robust, collaborative and rigorous structured consensus-based peer reviewed moderation process. System moderation involves all Year 11 and 12 teachers from public, non-government and international colleges delivering the ACT Senior Secondary Certificate.

Only students who desire a pathway to university are required to sit a general aptitude test, referred to as the ACT Scaling Test (AST), which moderates student course scores across subjects and colleges. Students are required to use critical and creative thinking skills across a range of disciplines to solve problems. They are also required to interpret a stimulus and write an extended response.

Senior secondary curriculum makes provision for student-centred teaching approaches, integrated and project-based learning inquiry, formative assessment and teacher autonomy. ACT Senior Secondary Curriculum makes provision for diverse learners and students with mild to moderate intellectual disabilities, so that all students can achieve an ACT Senior Secondary Certificate.

The ACT Board of Senior Secondary Studies (BSSS) leads senior secondary education. It is responsible for quality assurance in senior secondary curriculum, assessment and certification. The Board consists of representatives from colleges, universities, industry, parent organisations and unions. The Office of the Board of Senior Secondary Studies (OBSSS) consists of professional and administrative staff who support the Board in achieving its objectives and functions.

ACT Senior Secondary Certificate

Courses of study for the ACT Senior Secondary Certificate:

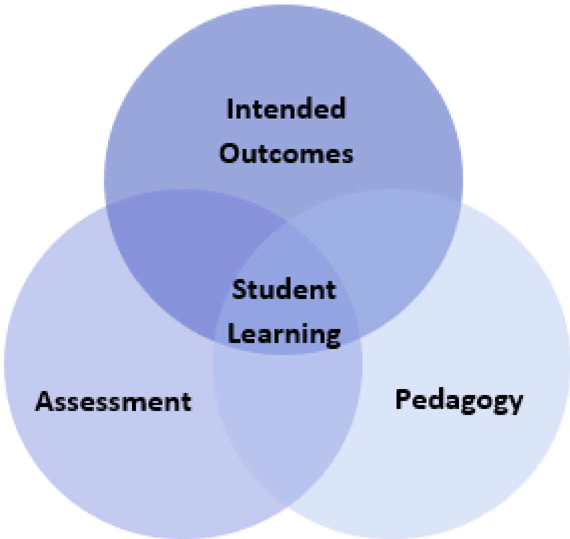
- provide a variety of pathways, to meet different learning needs and encourage students to complete their secondary education
- enable students to develop the essential capabilities for twenty-first century learners
- empower students as active participants in their own learning
- engage students in contemporary issues relevant to their lives
- foster students' intellectual, social and ethical development
- nurture students' wellbeing, and physical and spiritual development
- enable effective and respectful participation in a diverse society.

Each course of study:

- comprises an integrated and interconnected set of knowledge, skills, behaviours and dispositions that students develop and use in their learning across the curriculum
- is based on a model of learning that integrates intended student outcomes, pedagogy and assessment
- outlines teaching strategies which are grounded in learning principles and encompass quality teaching
- promotes intellectual quality, establish a rich learning environment and generate relevant connections between learning and life experiences
- provides formal assessment and certification of students' achievements.

Underpinning beliefs

- All students are able to learn.
- Learning is a partnership between students and teachers.
- Teachers are responsible for advancing student learning.



Learning Principles

1. Learning builds on existing knowledge, understandings and skills.
   (Prior knowledge)
2. When learning is organised around major concepts, principles and significant real-world issues, within and across disciplines, it helps students make connections and build knowledge structures.
   (Deep knowledge and connectedness)
3. Learning is facilitated when students actively monitor their own learning and consciously develop ways of organising and applying knowledge within and across contexts.
   (Metacognition)
4. Learners' sense of self and motivation to learn affects learning.
   (Self-concept)
5. Learning needs to take place in a context of high expectations.
   (High expectations)
6. Learners learn in different ways and at different rates.
   (Individual differences)
7. Different cultural environments, including the use of language, shape learners' understandings and the way they learn.
   (Socio-cultural effects)
8. Learning is a social and collaborative function as well as an individual one.
   (Collaborative learning)
9. Learning is strengthened when learning outcomes and criteria for judging learning are made explicit and when students receive frequent feedback on their progress.
   (Explicit expectations and feedback)

General Capabilities

All courses of study for the ACT Senior Secondary Certificate should enable students to develop essential capabilities for twenty-first century learners. These 'capabilities' comprise an integrated and interconnected set of knowledge, skills, behaviours and dispositions that students develop and use in their learning across the curriculum.

The capabilities include:

- literacy
- numeracy
- information and communication technology (ICT)
- critical and creative thinking
- personal and social
- ethical behaviour
- intercultural understanding

Courses of study for the ACT Senior Secondary Certificate should be both relevant to the lives of students and incorporate the contemporary issues they face. Hence, courses address the following three priorities. These priorities are:

- Aboriginal and Torres Strait Islander histories and cultures
- Asia and Australia's engagement with Asia
- Sustainability

Elaboration of these General Capabilities and priorities is available on the ACARA website at www.australiancurriculum.edu.au.

Literacy

Literacy is important in students' development of *Science Inquiry Skills* and their understanding of content presented through the *Science Understanding* and *Science as a Human Endeavour* strands. Students gather, interpret, synthesise and evaluate information presented in a wide range of genres, modes and representations (including text, flow diagrams, symbols, graphs and tables). They evaluate information sources and compare and contrast ideas, information and opinions presented within and between texts. They communicate processes and ideas logically and fluently and structure evidence-based arguments, selecting genres and employing appropriate structures and features to communicate for specific purposes and audiences.

Numeracy

Numeracy is key to students' ability to apply a wide range of *Science Inquiry Skills*, including making and recording observations; ordering, representing and analysing data; and interpreting trends and relationships. They employ numeracy skills to interpret complex spatial and graphic representations, and to appreciate the ways in which chemical systems are structured, interact and change across spatial and temporal scales. They engage in analysis of data, including issues relating to reliability and probability, and they interpret and manipulate mathematical relationships to calculate and predict values.

Information and Communication Technology (ICT) Capability

ICT capability is a key part of *Science Inquiry Skills*. Students use a range of strategies to locate, access and evaluate information from multiple digital sources; to collect, analyse and represent data; to model and interpret concepts and relationships; and to communicate and share science ideas, processes and information. Through exploration of *Science as a Human Endeavour* concepts, students assess the impact of ICT on the development of science and the application of science in society, particularly with regard to collating, storing, managing and analysing large data sets.

Critical and Creative Thinking

Critical and creative thinking is particularly important in the science inquiry process. Science inquiry requires the ability to construct, review and revise questions and hypotheses about increasingly complex and abstract scenarios and to design related investigation methods. Students interpret and evaluate data; interrogate, select and cross-reference evidence; and analyse processes, interpretations, conclusions and claims for validity and reliability, including reflecting on their own processes and conclusions. Science is a creative endeavour and students devise innovative solutions to problems, predict possibilities, envisage consequences and speculate on possible outcomes as they develop *Science Understanding* and *Science Inquiry Skills.* They also appreciate the role of critical and creative individuals and the central importance of critique and review in the development and innovative application of science.

Personal and Social Capability

Personal and social capability is integral to a wide range of activities in Chemistry, as students develop and practise skills of communication, teamwork, decision-making, initiative-taking and self-discipline with increasing confidence and sophistication. In particular, students develop skills in both independent and collaborative investigation; they employ self-management skills to plan effectively, follow procedures efficiently and work safely; and they use collaboration skills to conduct investigations, share research and discuss ideas. In considering aspects of *Science as a Human Endeavour,* students also recognise the role of their own beliefs and attitudes in their response to science issues and applications, consider the perspectives of others, and gauge how science can affect people's lives.

Ethical Understanding

Ethical understanding is a vital part of science inquiry. Students evaluate the ethics of experimental science, codes of practice, and the use of scientific information and science applications. They explore what integrity means in science, and they understand, critically analyse and apply ethical guidelines in their investigations. They consider the implications of their investigations on others, the environment and living organisms. They use scientific information to evaluate the claims and actions of others and to inform ethical decisions about a range of social, environmental and personal issues and applications of science.

Intercultural Understanding

Intercultural understanding is fundamental to understanding aspects of *Science as a Human Endeavour*, as students appreciate the contributions of diverse cultures to developing science understanding and the challenges of working in culturally diverse collaborations. They develop awareness that raising some debates within culturally diverse groups requires cultural sensitivity, and they demonstrate open-mindedness to the positions of others. Students also develop an understanding that cultural factors affect the ways in which science influences and is influenced by society.

Cross-Curriculum Priorities

While the significance of the cross-curriculum priorities for chemistry varies, there are opportunities for teachers to select contexts that incorporate the key concepts from each priority.

Aboriginal and Torres Strait Islander Histories and Cultures

Through an investigation of contexts that draw on Aboriginal and Torres Strait Islander histories and cultures students can appreciate the role of Aboriginal and Torres Strait Islander Peoples' knowledge in developing richer understandings of the chemical diversity in the Australian environment, for example the chemical properties of plants used for bush medicines, or mineral ores used for decoration or artwork.

Asia and Australia's Engagement with Asia

Contexts that draw on Asian scientific research and development and collaborative endeavours in the Asia Pacific region provide an opportunity for students to investigate Asia and Australia's engagement with Asia. Students could examine the important role played by people of the Asia region in such areas as medicine, materials science, nanotechnology, energy security and food security. They could consider collaborative projects between Australian and Asian scientists and the contribution these make to scientific knowledge.

Sustainability

In chemistry, the sustainability cross-curriculum priority provides authentic contexts for exploring, investigating and understanding the function and interactions of chemical systems. Chemistry explores a wide range of chemical systems that operate at different time and spatial scales. By investigating the relationships between chemical systems and system components, and how systems respond to change, students develop an appreciation for the ways in which interactions between matter and energy connect Earth's biosphere, geosphere, hydrosphere and atmosphere. Students appreciate that chemical science and its applications provide the basis for decision making in many areas of society and that these decisions can impact on the Earth system. They understand the importance of using science to predict possible effects of human and other activity, such as ocean acidification, mineral extraction or use of fossil fuels, and to develop management plans, alternative technologies or approaches such as green chemistry that minimise these effects and provide for a more sustainable future.

Chemistry T

Rationale

Chemistry is the study of materials and substances, and the transformations they undergo through interactions and the transfer of energy. Chemists can use an understanding of chemical structures and processes to adapt, control and manipulate systems to meet particular economic, environmental and social needs. This includes addressing the global challenges of climate change and security of water, food and energy supplies, and designing processes to maximise the efficient use of Earth’s finite resources. Chemistry develops students' understanding of the key chemical concepts and models of structure, bonding, and chemical change, including the role of chemical, electrical and thermal energy. Students learn how models of structure and bonding enable chemists to predict properties and reactions and to adapt these for particular purposes.

Students explore key concepts and models through active inquiry into phenomena and through contexts that exemplify the role of chemistry and chemists in society. Students design and conduct qualitative and quantitative investigations both individually and collaboratively. They investigate questions and hypotheses, manipulate variables, analyse data, evaluate claims, solve problems and develop and communicate evidence-based arguments and models. Thinking in chemistry involves using differing scales including macro-, micro- and nano-scales; using specialised representations such as chemical symbols and equations; and being creative, as when designing new materials or models of chemical systems. The study of chemistry provides a foundation for undertaking investigations in a wide range of scientific fields and often provides the unifying link across interdisciplinary studies.

Some of the major challenges and opportunities facing Australia and the Asia-Pacific region at the beginning of the twenty-first century are inextricably associated with chemistry. Issues of sustainability on local, national and global levels are, and will continue to be, tackled by the application of chemical knowledge, using a range of technologies. These include issues such as the supply of clean drinking water, efficient production and use of energy, management of mineral resources, increasing acidification of the oceans, and climate change.

Studying senior secondary Science provides students with a suite of skills and understandings that are valuable to a wide range of further study pathways and careers. 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.

Goals

Chemistry aims to develop students':

- interest in and appreciation of chemistry and its usefulness in helping to explain phenomena and solve problems encountered in their ever-changing world
- understanding of the theories and models used to describe, explain and make predictions about chemical systems, structures and properties
- understanding of the factors that affect chemical systems, and how chemical systems can be controlled to produce desired products
- appreciation of chemistry as an experimental science that has developed through independent and collaborative research, and that has significant impacts on society and implications for decision making
- expertise in conducting a range of scientific investigations, including the collection and analysis of qualitative and quantitative data and the interpretation of evidence
- ability to evaluate and debate scientific arguments and claims in order to solve problems and generate informed, responsible and ethical conclusions
- ability to communicate chemical understanding and findings to a range of audiences, including through the use of appropriate representations, language and nomenclature.

Unit Titles

In Chemistry, students develop their understanding of chemical systems, and how models of matter and energy transfers and transformations can be used to describe, explain and predict chemical structures, properties and reactions. There are four units:

- Chemical Fundamentals
- Molecular Interactions and Reactions
- Equilibrium, Acids and Redox Reactions
- Structure, Synthesis and Design

Organisation of Content

Chemical Fundamentals

In this unit, students use models of atomic structure and bonding to explain the macroscopic properties of materials and to predict the products and explain the energy changes associated with chemical reactions.

Molecular Interactions and Reactions

In this unit, they continue to develop their understanding of bonding models and the relationship between structure, properties and reactions, including consideration of the factors that affect the rate of chemical reactions.

In Units 3 and 4, students further develop their knowledge of chemical processes introduced in Units 1 and 2, including considering energy transfers and transformations, calculations of chemical quantities, rates of reaction and chemical systems.

Equilibrium, Acids and Redox Reactions

In this unit, students investigate models of equilibrium in chemical systems; apply these models in the context of acids and bases and redox reactions, including electrochemical cells; and explain and predict how a range of factors affect these systems.

Structure, Synthesis and Design

In this unit, students use models of molecular structure, chemical reactions and energy changes to explain and apply synthesis processes, particularly with consideration of organic synthesis; and they consider current and future applications of chemical design principles.

Mathematical skills expected of students studying Chemistry

The chemistry curriculum requires students to use the mathematical skills they have developed through the F-10 Australian Curriculum: Mathematics, in addition to the numeracy skills they have developed through the *Science Inquiry Skills* strand of the Australian Curriculum: Science.

Within the *Science Inquiry Skills* strand, students are required to gather, represent and analyse numerical data to identify the evidence that forms the basis of their scientific arguments, claims or conclusions. In gathering and recording numerical data, students are required to make measurements with an appropriate degree of accuracy and to represent measurements using appropriate units.

Students may need to be taught when it is appropriate to join points on a graph and when it is appropriate to use a line of best fit. They may also need to be taught how to construct a straight line that will serve as the line of best fit for a set of data presented graphically.

Students may need to be taught to interpret logarithmic scales and to use a calculator to substitute a value to evaluate a logarithmic expression as they are required in pH calculations (Unit 3), but are not part of the Year 10 Australian Curriculum: Mathematics.

Assessment

The identification of criteria within the achievement standards and assessment task types and weightings, provide a common and agreed basis for the collection of evidence of student achievement.

Assessment Criteria (the dimensions of quality that teachers look for in evaluating student work) provide a common and agreed basis for judgement of performance against unit and course goals, within and across colleges. Over a course, teachers must use all these criteria to assess students' performance but are not required to use all criteria on each task. Assessment criteria are to be used holistically on a given task and in determining the unit grade.

Assessment Tasks elicit responses that demonstrate the degree to which students have achieved the goals of a unit based on the assessment criteria. The Common Curriculum Elements (CCE) is a guide to developing assessment tasks that promote a range of thinking skills (see Appendix C). It is highly desirable that assessment tasks engage students in demonstrating higher order thinking.

Rubrics are constructed for individual tasks, informing the assessment criteria relevant for a particular task and can be used to assess a continuum that indicates levels of student performance against each criterion.

Assessment Criteria

Students will be assessed on the degree to which they demonstrate an understanding of:

- concepts, models and application
- contexts
- inquiry skills.

Assessment Task Types

Suggested tasks

Individual tasks may incorporate one or more of the following:

- models
- commentary
- debate
- portfolio/journal
- field work
- investigation
- document/source analysis
- practical report
- role play
- research report
- test/quiz
- seminar/workshop/lecture
- poster
- response to stimulus
- essay
- multimedia presentation
- creative response
- interview
- discussion forum
- rationale/validation
- practical skills

It is recommended that a student conceived investigation be undertaken at least once during a minor and twice during a major. This investigation may either be theoretical or practical, or a combination of both.

Weightings in A/T/M 1.0 and 0.5 Units:

No task to be weighted more than 45% for a standard 1.0 unit.

Additional Assessment Information

Requirements

- For a standard unit (1.0), students must complete a minimum of three assessment tasks and a maximum of five.
- For a half standard unit (0.5), students must complete a minimum of two and a maximum of three assessment tasks.
- Students must experience a variety of task types and different modes of communication to demonstrate the Achievement Standards in both theoretical and practical tasks.
- All Achievement Standards must be demonstrated in standard (1.0) or half-standard (0.5) units.
- Task types need to be selected to address all Achievement Standards within the Concepts, Models & Applications, Contexts and Inquiry Skills strands across a standard (1.0) or half-standard (0.5) unit.
- For tasks completed in unsupervised conditions, schools need to have mechanisms to uphold academic integrity, for example: student declaration, plagiarism software, oral defence, interview, or other validation tasks.

Achievement Standards

Years 11 and 12 achievement standards are written for A/T courses.

A Year 12 student in any unit is assessed using the Year 12 achievement standards. A Year 11 student in any unit is assessed using the Year 11 achievement standards. Year 12 achievement standards reflect higher expectations of student achievement compared to the Year 11 achievement standards. Years 11 and 12 achievement standards are differentiated by cognitive demand, the number of dimensions and the depth of inquiry.

An achievement standard cannot be used as a rubric for an individual assessment task. Assessment is the responsibility of the college. Student tasks may be assessed using rubrics or marking schemes devised by the college. A teacher may use the achievement standards to inform development of rubrics. The verbs used in achievement standards may be reflected in the rubric. In the context of combined Years 11 and 12 classes, it is best practice to have a distinct rubric for Years 11 and 12. These rubrics should be available for students prior to completion of an assessment task so that success criteria are clear.

BSSS Achievement Standards for Science T Course – Year 11

	A student who achieves an **A** grade typically	A student who achieves a **B** grade typically	A student who achieves a **C** grade typically	A student who achieves a **D** grade typically	A student who achieves an **E** grade typically
Concepts, Models & Applications	• evaluates the fundamental properties and functions of system components, processes and interactions, and the effects of factors across a range of scales	• analyses the fundamental properties and functions of system components, processes and interactions, and the effects of factors across a range of scales	• explains the fundamental properties and functions of system components, processes and interactions and the effects of factors across a range of scales	• describes the fundamental properties and functions, and with some description of system components, processes and interactions, and the effects of factors across a range of scales	• identifies the fundamental properties and functions of system and identifies components, processes and interactions, and the effects of factors across a range of scales
	• evaluates the nature, functions, limitations and applications of theories and models using evidence, in unfamiliar contexts	• analyses the nature, functions, limitations and applications of theories and models using evidence, in familiar contexts	• explains the nature, functions, limitations and applications of theories and models using evidence, in familiar contexts	• describes the nature, functions, limitations and applications of theories and models with supporting evidence	• identifies the nature, functions, applications, and some possible limitations of theories and models, with some evidence
	• analyses evidence with reference to models and/or theories, and develops evidence-based conclusions and evaluates limitations	• assesses evidence with reference to models and/or theories, and develops evidence-based conclusions and discusses limitations	• explains evidence with reference to models and/or theories, and develops evidence-based conclusions and identifies limitations	• describes evidence, and develops conclusions with some reference to models and/or theories	• identifies evidence, and asserts conclusions with little or no reference to models and/or theories
Contexts	• evaluates epistemology, role of peer review, collaboration and technology in developing knowledge	• analyses epistemology, role of peer review and technology in developing knowledge	• explain epistemology, role of peer review and technology in developing knowledge	• describes the role of peer review in developing knowledge	• identifies that scientific knowledge has changed over time
	• evaluates the influence of social, economic, ethical and cultural factors on Science	• analyses the influence of social, economic, ethical and cultural factors on Science	• explains the influence of social, economic, ethical and cultural factors on Science	• describes the influence of social, economic, ethical and cultural factors on Science	• identifies the influence of social, economic, ethical and cultural factors on Science
Inquiry Skills	• designs, conducts and improves safe, ethical and original inquiries individually and collaboratively, that collect valid, reliable data in response to a complex question	• designs, conducts and improves safe, ethical inquiries individually and collaboratively, that collect valid, reliable data in response to a question	• plans and conducts safe, ethical inquiries individually and collaboratively, that collect valid data in response to a familiar question	• follows a procedure to conduct safe, ethical inquiries individually and collaboratively, to collect data in response to a simple question with varying success	• follows a procedure to conduct safe, ethical inquiries individually and collaboratively, to collect data with little or no connection to a question
	• analyses causal and correlational relationships, anomalies, reliability and validity of data and representations, and analyses errors	• analyses causal and correlational relationships, anomalies, reliability and validity of data and representations, and discusses errors	• explains causal and correlational relationships, anomalies, reliability and validity of data and representations, and cites common errors	• describes trends, relationships and anomalies in data, identifies anomalies, and some possible sources of error	• identifies trends and relationships in data, with little or no reference to sources of error
	• analyses processes and claims, and provides a critique based on evidence, and analyses alternatives	• assesses processes and claims, and provides a critique with reference to evidence, and analyses alternatives	• explains processes and claims, and identifies alternatives with reference to reliable evidence	• describes processes and claims, and identifies the need for improvements with some reference to evidence	• identifies processes and the need for some improvements, with little or no reference to evidence
	• reflects with insight on own thinking and that of others, and evaluates planning, time management, and use of appropriate work strategies to work independently and collaboratively	• reflects on their own thinking and analyses planning, time management, use of appropriate work strategies to work independently and collaboratively	• reflects on their own thinking and explains planning, time management, use of appropriate work strategies to work independently and collaboratively	• reflects on their own thinking, with reference to planning and the use of appropriate work strategies to work independently and collaboratively	• reflects on their own thinking with little or no reference to planning, time management, and use of work strategies to work independently and collaboratively
	• communicates concisely, effectively and accurately, demonstrating scientific literacy in a range of modes, styles, representations, and genres for specific audiences and purposes, with appropriate evidence and accurate referencing	• communicates clearly and accurately, demonstrating scientific literacy in a range of modes, styles, representations and genres for specific audiences and purposes, with appropriate evidence and accurate referencing	• communicates accurately demonstrating scientific literacy, in a range of modes, styles, representations, and genres for specific purposes, with appropriate evidence and mostly consistent referencing	• communicates demonstrating some scientific literacy, in a range of modes, representations, and genres with some evidence and inconsistent referencing	• communicates demonstrating limited scientific literacy, in a range of modes and representations, with inconsistent and inaccurate referencing

BSSS Achievement Standards for Science T Course – Year 12

	*A student who achieves an **A** grade typically*	*A student who achieves a **B** grade typically*	*A student who achieves a **C** grade typically*	*A student who achieves a **D** grade typically*	*A student who achieves an **E** grade typically*
Concepts, Models & Applications	• evaluates the properties and functions of system components, processes and interactions, and the interplay and effects of factors across a range of scales • evaluates applications, limitations, and predictions of theories and models to explain systems and create solutions, with evidence, in unfamiliar contexts • evaluates evidence with reference to analysis of models and/or theories, and develops evidence-based conclusions and evaluates limitations	• analyses the properties and functions of system components, processes and interactions, and the interplay and effects of factors across a range of scales • analyses applications, limitations, and predictions of theories and models to explain systems and create plausible solutions, with evidence in familiar contexts • analyses evidence with reference to models and/or theories, and develops evidence-based conclusions and discusses limitations	• explains the fundamental properties and functions of system components, processes and interactions, and the effects of factors across a range of scales • explains applications, limitations, and predictions of theories and models to explain systems and create plausible solutions in familiar contexts • explains evidence with reference to models and/or theories, and develops evidence-based conclusions and identifies limitations	• describes the fundamental properties and functions of system components, processes and interactions, and the effects of one or more factors • describes the nature, functions, limitations and applications of theories and models to create solutions to problems with supporting evidence • describes evidence, and develops conclusions with some reference to models and/or theories	• identifies the fundamental properties and functions of system components, processes and interactions, and some affective factors • identifies the nature, functions, limitations and applications of theories and models, and suggest solutions to problems with supporting evidence • identifies evidence, and asserts conclusions with little or no reference to models and/or theories
Contexts	• evaluates epistemology, role of peer review, collaboration, and technology in developing knowledge • evaluates the influence of social, economic, ethical and cultural factors on Science	• analyses epistemology, role of peer review and technology in developing knowledge • analyses the influence of social, economic, ethical and cultural factors on Science	• explains epistemology, role of peer review and technology in developing knowledge • explains the influence of social, economic, ethical and cultural factors on Science	• describes role of peer review and technology in developing knowledge • describes the influence of social, economic, ethical and cultural factors on Science	• identifies that scientific knowledge has changed over time • identifies the influence of social, economic, ethical and cultural factors on Science
Inquiry Skills	• designs, conducts and improves safe, ethical and original inquiries individually and collaboratively, that collect valid, reliable data in response to a complex question • evaluates cause and correlation, anomalies, reliability and validity of data and representations, and evaluates errors • evaluates processes and claims, and provides a critique based on evidence, and evaluates alternatives • reflects with insight on own thinking and that of others, evaluates planning, time management, and use of appropriate independent and collaborative work strategies • communicates concisely, effectively and accurately, with scientific literacy in a range of modes, representations, and genres for specific audiences and purposes, and accurate referencing	• designs, conducts and improves safe, ethical inquiries individually and collaboratively, that collect valid, reliable data in response to a question • analyses cause and correlation, anomalies, reliability and validity of data and representations, and analyses errors • analyses processes and claims, and provides a critique with reference to evidence, and analyses alternatives • reflects on their own thinking and analyses planning, time management, and use of appropriate independent and collaborative work strategies • communicates clearly and accurately, with scientific literacy in a range of modes, representations and genres for specific audiences and purposes, and accurate referencing	• plans and conducts safe, ethical inquiries individually and collaboratively, that collect valid data in response to a familiar question • explains causal and correlational relationships, anomalies, reliability and validity of data and representations, and discusses common errors • explains processes and claims, and identifies alternatives with reference to reliable evidence • reflects on their own thinking and explains planning, time management, and use of appropriate independent and collaborative work strategies • communicates accurately demonstrating scientific literacy, in a range of modes, representations, and genres for specific purposes, and mostly consistent referencing	• follows a procedure to conduct safe, ethical inquiries individually and collaboratively, to collect data in response to a simple question with varying success • describes trends, relationships and anomalies in data, identifies anomalies, and cites sources of error • describes processes and claims, and identifies the need for improvements with some reference to evidence • reflects on their own thinking, with reference to planning and the use of appropriate independent and collaborative work strategies • communicates demonstrating some scientific literacy, in a range of modes, representations, and genres with some evidence and inconsistent referencing	• follows a procedure to conduct safe, ethical inquiries individually and collaboratively, to collect data with little or no connection to a question • identifies trends and relationships in data with reference to sources of error • identifies processes and the need for some improvements, with little or no reference to evidence • reflects on their own thinking with little or no reference to planning, time management, and use of appropriate independent and collaborative work strategies • communicates demonstrating limited scientific literacy, in a range of modes and representations, with inconsistent and inaccurate referencing

Chemical Fundamentals Value 1.0

Chemical Fundamentals a Value 0.5

Chemical Fundamentals b Value 0.5

Unit Description

Chemists design and produce a vast range of materials for many purposes, including for fuels, cosmetics, building materials and pharmaceuticals. As the science of chemistry has developed over time, there has been an increasing realisation that the properties of a material depend on, and can be explained by, the material's structure. A range of models at the atomic and molecular scale enable explanation and prediction of the structure of materials and how this structure influences properties and reactions. In this unit, students relate matter and energy in chemical reactions, as they consider the breaking and reforming of bonds as new substances are produced. Students can use materials that they encounter in their lives as a context for investigating the relationships between structure and properties.

Through the investigation of appropriate contexts, students explore how evidence from multiple disciplines and individuals and the development of ICT and other technologies have contributed to developing understanding of atomic structure and chemical bonding. They explore how scientific knowledge is used to offer reliable explanations and predictions, and the ways in which it interacts with social, economic, cultural and ethical factors.

Students use science inquiry skills to develop their understanding of patterns in the properties and composition of materials. They investigate the structure of materials by describing physical and chemical properties at the macroscopic scale, and use models of structure and primary bonding at the atomic and sub-atomic scale to explain these properties. They are introduced to the mole concept as a means of quantifying matter in chemical reactions.

Specific Unit Goals

By the end of this unit, students:

- understand how the atomic model and models of bonding explain the structure and properties of elements and compounds
- understand the concept of enthalpy, and apply this to qualitatively and quantitatively describe and explain energy changes in chemical reactions
- understand how models and theories have developed based on evidence from a range of sources, and the uses and limitations of chemical knowledge in a range of contexts
- use science inquiry skills to design, conduct, evaluate and communicate investigations into the properties of elements, compounds and mixtures and the energy changes involved in chemical reactions
- evaluate, with reference to empirical evidence, claims about chemical properties, structures and reactions
- communicate, predict and explain chemical phenomena using qualitative and quantitative representations in appropriate modes and genres.

Content Descriptions

Further elaboration of the content of this unit is available on the ACARA Australian Curriculum website.

Science Inquiry Skills

- identify, research and refine questions for investigation; propose hypotheses; and predict possible
- design investigations, including the procedure/s to be followed, the materials required, and the type and amount of primary and/or secondary data to be collected; conduct risk assessments; and consider research ethics
- conduct investigations, including the use of devices to accurately measure temperature change and mass, safely, competently and methodically for the collection of valid and reliable data
- represent data in meaningful and useful ways, including using appropriate graphic representations and correct units and symbols; organise and process data to identify trends, patterns and relationships; identify sources of random and systematic error and estimate their effect on measurement results; and select, synthesise and use evidence to make and justify conclusions
- interpret a range of scientific and media texts, and evaluate processes, claims and conclusions by considering the quality of available evidence; and use reasoning to construct scientific arguments
- select, construct and use appropriate representations including chemical symbols and formulae, molecular structural formulae, physical and graphical models of structures, chemical equations and thermochemical equations, to communicate conceptual understanding, solve problems and make predictions
- select and use appropriate mathematical representations to solve problems and make predictions, including calculating percentage composition from relative atomic masses and using the mole concept to calculate the mass of reactants and products
- communicate to specific audiences and for specific purposes using appropriate language, nomenclature, genres and modes, including scientific reports

Science as a Human Endeavour

- science is a global enterprise that relies on clear communication, international conventions, peer review and reproducibility
- development of complex models and/or theories often requires a wide range of evidence from multiple individuals and across disciplines
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- the use of scientific knowledge is influenced by social, economic, cultural and ethical considerations
- the use of scientific knowledge may have beneficial and/or harmful and/or unintended consequences
- scientific knowledge can enable scientists to offer valid explanations and make reliable predictions
- scientific knowledge can be used to develop and evaluate projected economic, social and environmental impacts and to design action for sustainability

Science Understanding

Properties and structure of atoms

- trends in the observable properties of elements are evident in periods and groups in the periodic table
- the structure of the periodic table is based on the electron configuration of atoms, and shows trends, including in atomic radii and valencies
- atoms can be modelled as a nucleus surrounded by electrons in distinct energy levels, held together by electrostatic forces of attraction between the nucleus and electrons; atoms can be represented using electron shell diagrams (all electron shells or valence shell only) or electron charge clouds
- flame tests and atomic absorption spectroscopy are analytical techniques that can be used to identify elements; these methods rely on electron transfer between atomic energy levels
- the properties of atoms, including their ability to form chemical bonds, are explained by the arrangement of electrons in the atom and in particular by the stability of the valence electron shell
- isotopes are atoms of an element with the same number of protons but different numbers of neutrons; different isotopes of elements are represented using atomic symbols (for example, C 6 12, C 6 13)
- isotopes of an element have the same electron configuration and possess similar chemical properties but have different physical properties, including variations in nuclear stability
- mass spectrometry involves the ionisation of substances and generates spectra which can be analysed to determine the isotopic composition of elements
- the relative atomic mass of an element is the ratio of the weighted average mass per atom of the naturally occurring form of the element to 1 12 the mass of an atom of carbon-12; relative atomic masses reflect the isotopic composition of the element

Properties and structure of materials

- materials are either pure substances with distinct measurable properties (for example, melting and boiling point, reactivity, strength, density) or mixtures with properties dependent on the identity and relative amounts of the substances that make up the mixture
- differences in the properties of substances in a mixture, such as particle size, solubility, magnetism, density, electrostatic attraction, melting point and boiling point, can be used to separate them
- the type of bonding within substances explains their physical properties, including melting and boiling point, conductivity of both electricity and heat, strength and hardness
- nanomaterials are substances that contain particles in the size range 1–100 nm and have specific properties relating to the size of these particles
- chemical bonds are caused by electrostatic attractions that arise because of the sharing or transfer of electrons between participating atoms; the valency is a measure of the number of bonds that an atom can form
- ions are atoms or groups of atoms that are electrically charged due to an imbalance in the number of electrons and protons; ions are represented by formulae which include the number of constituent atoms and the charge of the ion (for example, O^{2-}, SO_4^{2-})
- the properties of ionic compounds (for example, high melting point, brittleness, ability to conduct electricity when liquid or in solution) are explained by modelling ionic bonding as ions arranged in a crystalline lattice structure with forces of attraction between oppositely charged ions

- the characteristic properties of metals (for example, malleability, thermal conductivity, electrical conductivity) are explained by modelling metallic bonding as a regular arrangement of positive ions (cations) made stable by electrostatic forces of attraction between these ions and the electrons that are free to move within the structure
- covalent substances are modelled as molecules or covalent networks that comprise atoms which share electrons, resulting in electrostatic forces of attraction between electrons and the nucleus of more than one atom
- elemental carbon exists as a range of allotropes, including graphite, diamond and fullerenes, with significantly different structures and physical
- carbon forms hydrocarbon compounds, including alkanes and alkenes, with different chemical properties that are influenced by the nature of the bonding within the molecules

Chemical reactions: reactants, products and energy change

- all chemical reactions involve the creation of new substances and associated energy transformations, commonly observable as changes in the temperature of the surroundings and/or the emission of light
- endothermic and exothermic reactions can be explained in terms of the Law of Conservation of Energy and the breaking and reforming of bonds; heat energy released or absorbed can be represented in thermochemical equations
- fuels, including fossil fuels and biofuels, can be compared in terms of their energy output, suitability for purpose, and the nature of products of combustion
- a mole is a precisely defined quantity of matter equal to Avogadro's number of particles; the mole concept and the Law of Conservation of Mass can be used to calculate the mass of reactants and products in a chemical reaction

A guide to reading and implementing content descriptions

Content descriptions specify the knowledge, understanding and skills that students are expected to learn and that teachers are expected to teach. Teachers are required to develop a program of learning that allows students to demonstrate all the content descriptions. The lens which the teacher uses to demonstrate the content descriptions may be either guided through provision of electives within each unit or determined by the teacher when developing their program of learning.

A program of learning is what a college provides to implement the course for a subject. It is at the discretion of the teacher to emphasis some content descriptions over others. The teacher may teach additional (not listed) content provided it meets the specific unit goals. This will be informed by the student needs and interests.

Assessment

Refer to pages 10-12.

Molecules Value 1.0

Molecules a **Value 0.5**

Molecules b **Value 0.5**

Unit Description

In this unit, students develop their understanding of the physical and chemical properties of materials including gases, water and aqueous solutions, acids and bases. Students explore the characteristic properties of water that make it essential for physical, chemical and biological processes on Earth, including the properties of aqueous solutions. They investigate and explain the solubility of substances in water and compare and analyse a range of solutions. They learn how rates of reaction can be measured and altered to meet particular needs, and use models of energy transfer and the structure of matter to explain and predict changes to rates of reaction. Students gain an understanding of how to control the rates of chemical reactions, including through the use of a range of catalysts.

Through the investigation of appropriate contexts, students explore how evidence from multiple disciplines and individuals and the development of ICT and other technologies have contributed to developing understanding of intermolecular forces and chemical reactions. They explore how scientific knowledge is used to offer reliable explanations and predictions, and the ways in which it interacts with social, economic, cultural and ethical factors.

Students use a range of practical and research inquiry skills to investigate chemical reactions, including the prediction and identification of products and the measurement of the rate of reaction. They investigate the behaviour of gases, and use the kinetic theory to predict the effects of changing temperature, volume and pressure in gaseous systems.

Specific Unit Goals

By the end of this unit, students:

- understand how models of the shape and structure of molecules and intermolecular forces can be used to explain the properties of substances, including the solubility of substances in water
- understand how kinetic theory can be used to explain the behaviour of gaseous systems, and how collision theory can be used to explain and predict the effect of varying conditions on the rate of reaction
- understand how models and theories have developed based on evidence from multiple disciplines, and the uses and limitations of chemical knowledge in a range of contexts
- use science inquiry skills to design, conduct, evaluate and communicate investigations into the properties and behaviour of gases, water, aqueous solutions and acids and the factors that affect the rate of chemical reactions
- evaluate, with reference to empirical evidence, claims about chemical properties, structures and reactions
- communicate, predict and explain chemical phenomena using qualitative and quantitative representations in appropriate modes and genres.

Content Descriptions

Further elaboration of the content of this unit is available on the ACARA Australian Curriculum website.

Science Inquiry Skills

- identify, research, construct and refine questions for investigation; propose hypotheses; and predict possible outcomes
- design investigations, including the procedure/s to be followed, the materials required, and the type and amount of primary and/or secondary data to be collected; conduct risk assessments; and consider research ethics
- conduct investigations, including measuring ph and the rate of formation of products, identifying the products of reactions, and testing solubilities, safely, competently and methodically for the collection of valid and reliable data
- represent data in meaningful and useful ways, including using appropriate graphic representations and correct units and symbols; organise and process data to identify trends, patterns and relationships; identify sources of random and systematic error; identify anomalous data; estimate the effect of error on measured results; and select, synthesise and use evidence to make and justify conclusions
- interpret a range of scientific and media texts, and evaluate processes, claims and conclusions by considering the quality of available evidence; and use reasoning to construct scientific arguments
- select, construct and use appropriate representations, including physical and graphical models of molecules, energy profile diagrams, electron dot diagrams, ionic formulae, chemical formulae, chemical equations and phase descriptors for chemical species to communicate conceptual understanding, solve problems and make predictions
- select and use appropriate mathematical representations to solve problems and make predictions, including using the mole concept to calculate the mass of chemicals and/or volume of a gas (at standard temperature and pressure) involved in a chemical reaction, and using the relationship between the number of moles of solute, concentration and volume of a solution to calculate unknown values
- communicate to specific audiences and for specific purposes using appropriate language, nomenclature, genres and modes, including scientific reports

Science as a Human Endeavour

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Science Understanding

Intermolecular forces and gases

- observable properties, including vapour pressure, melting point, boiling point and solubility, can be explained by considering the nature and strength of intermolecular forces within a substance
- the shapes of molecules can be explained and predicted using three-dimensional representations of electrons as charge clouds and using valence shell electron pair repulsion (vsepr) theory
- the polarity of molecules can be explained and predicted using knowledge of molecular shape, understanding of symmetry, and comparison of the electronegativity of elements
- the shape and polarity of molecules can be used to explain and predict the nature and strength of intermolecular forces, including dispersion forces, dipole-dipole forces and hydrogen bonding
- data from chromatography techniques (for example, thin layer, gas and high-performance liquid chromatography) can be used to determine the composition and purity of substances; the separation of the components is caused by the variation of strength of the interactions between atoms, molecules or ions in the mobile and stationary phases
- the behaviour of gases, including the qualitative relationships between pressure, temperature and volume, can be explained using kinetic theory

Aqueous solutions and acidity

- water is a key substance in a range of chemical systems because of its unique properties, including its boiling point, density in solid and liquid phases, surface tension, and ability to act as a solvent
- the unique properties of water can be explained by its molecular shape and hydrogen bonding between molecules
- the concentration of a solution is defined as the amount of solute divided by the amount of solution; this can be represented in a variety of ways including by the number of moles of the solute per litre of solution ($mol\ l^{-1}$) and the mass of the solute per litre of solution ($g\ l^{-1}$)
- the presence of specific ions in solutions can be identified using analytical techniques based on chemical reactions, including precipitation and acid-base reactions)
- the solubility of substances in water, including ionic and molecular substances, can be explained by the intermolecular forces between species in the substances and water molecules, and is affected by changes in temperature
- the ph scale is used to compare the levels of acidity or alkalinity of aqueous solutions; the ph is dependent on the concentration of hydrogen ions in the solution
- patterns of the reactions of acids and bases (for example, reactions of acids with bases, metals and carbonates) allow products to be predicted from known reactants

Rates of chemical reactions

- varying the conditions present during chemical reactions can affect the rate of the reaction and in some cases the identity of the products
- the rate of chemical reactions can be quantified by measuring the rate of formation of products or the depletion of reactants
- collision theory can be used to explain and predict the effect of concentration, temperature, pressure and surface area on the rate of chemical reactions by considering the structure of the reactants and the energy of particles
- the activation energy is the minimum energy required for a chemical reaction to occur and is related to the strength of the existing chemical bonds; the magnitude of the activation energy influences the rate of a chemical reaction

- energy profile diagrams can be used to represent the enthalpy changes and activation energy associated with a chemical reaction
- catalysts, including enzymes and metal nanoparticles, affect the rate of certain reactions by providing an alternative reaction pathway with a reduced activation energy, hence increasing the proportion of collisions that lead to a chemical change

A guide to reading and implementing content descriptions

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Assessment

Refer to pages 10-12.

Equilibrium and Redox Reactions Value 1.0

Equilibrium and Redox Reactions a Value 0.5

Equilibrium and Redox Reactions b Value 0.5

Unit Description

The idea of reversibility of reaction is vital in a variety of chemical systems at different scales, ranging from the processes that release carbon dioxide into our atmosphere to the reactions of ions within individual cells in our bodies. Processes that are reversible will respond to a range of factors and can achieve a state of dynamic equilibrium. In this unit, students investigate acid-base equilibrium systems and their applications. They use contemporary models to explain the nature of acids and bases, and their properties and uses. This understanding enables further exploration of the varying strengths of acids and bases. Students investigate the principles of oxidation and reduction reactions and the production of electricity from electrochemical cells.

Through the investigation of appropriate contexts, students explore the ways in which models and theories related to acid-base and redox reactions, and their applications, have developed over time and through interactions with social, economic, cultural and ethical considerations. They explore the ways in which chemistry contributes to contemporary debate in industrial and environmental contexts, including the use of energy, evaluation of risk and action for sustainability, and they recognise the limitations of science in providing definitive answers in different contexts.

Students use science inquiry skills to investigate the principles of dynamic chemical equilibrium and how these can be applied to chemical processes and systems. They investigate a range of electrochemical cells, including the choice of materials used and the voltage produced by these cells. Students use the pH scale to assist in making judgments and predictions about the extent of dissociation of acids and bases and about the concentrations of ions in an aqueous solution.

Specific Unit Goals

By the end of this unit, students:

- understand the characteristics of equilibrium systems, and explain and predict how they are affected by changes to temperature, concentration and pressure
- understand the difference between the strength and concentration of acids, and relate this to the principles of chemical equilibrium
- understand how redox reactions, galvanic and electrolytic cells are modelled in terms of electron transfer
- understand how models and theories have developed over time and the ways in which chemical knowledge interacts with social, economic, cultural and political considerations in a range of contexts
- use science inquiry skills to design, conduct, evaluate and communicate investigations into the properties of acids and bases, redox reactions and electrochemical cells, including volumetric analysis
- evaluate, with reference to empirical evidence, claims about equilibrium systems and justify evaluations
- communicate, predict and explain chemical phenomena using qualitative and quantitative representations in appropriate modes and genres.

Content Descriptions

Further elaboration of the content of this unit is available on the ACARA Australian Curriculum website.

Science Inquiry Skills

- identify, research, construct and refine questions for investigation; propose hypotheses; and predict possible outcomes
- design investigations, including the procedure/s to be followed, the materials required, and the type and amount of primary and/or secondary data to be collected; conduct risk assessments; and consider research ethics
- conduct investigations, including using volumetric analysis techniques and constructing electrochemical cells, safely, competently and methodically for the collection of valid and reliable data
- represent data in meaningful and useful ways, including using appropriate graphic representations and correct units and symbols; organise and process data to identify trends, patterns and relationships; identify and distinguish between random and systematic errors, and estimate their effect on measured results; discuss how the nature of the procedure and the sample size may influence uncertainty and limitations in data; and select, synthesise and use evidence to make and justify conclusions
- interpret a range of scientific texts, and evaluate processes, claims and conclusions by considering the quality of available evidence, including confidence intervals in secondary data; and use reasoning to construct scientific arguments
- select, construct and use appropriate representations, including half-equations, balanced chemical equations, equilibrium constants and expressions, ph, oxidation numbers, standard electrode potentials and cell diagrams, to communicate conceptual understanding, solve problems and make predictions
- select and use appropriate mathematical representations to solve problems and make predictions, including calculating cell potentials under standard conditions, using the mole concept to calculate moles, mass, volume and concentrations from volumetric analysis data, determining the yield of incomplete reactions, and calculating the ph of solutions of strong acids and bases
- communicate to specific audiences and for specific purposes using appropriate language, nomenclature, genres and modes, including scientific

Science as a Human Endeavour

- ICT and other technologies have dramatically increased the size, accuracy and geographic
- temporal scope of data sets with which scientists work
- models and theories are contested and refined or replaced when new evidence challenges them, or when a new model or theory has greater explanatory power
- the acceptance of scientific knowledge can be influenced by the social, economic, and cultural context in which it is considered
- people can use scientific knowledge to inform the monitoring, assessment and evaluation of risk
- science can be limited in its ability to provide definitive answers to public debate; there may be insufficient reliable data available, or interpretation of the data may be open to question
- international collaboration is often required when investing in large-scale science projects or addressing issues for the Asia-Pacific region

- scientific knowledge can be used to develop and evaluate projected economic, social and environmental impacts and to design action for sustainability

Science Understanding

Chemical equilibrium systems

- chemical systems may be open or closed and include physical changes and chemical reactions which can result in observable changes to the system
- all physical changes are reversible, whereas only some chemical reactions are reversible
- over time, physical changes and reversible chemical reactions reach a state of dynamic equilibrium in a closed system, with the relative concentrations of products and reactants defining the position of equilibrium
- the reversibility of chemical reactions can be explained by considering the activation energies of the forward and reverse reactions
- the effect of changes of temperature on chemical systems at equilibrium can be explained by considering the enthalpy changes for the forward and reverse reactions
- the effect of changes of concentration and pressure on chemical systems at equilibrium can be explained and predicted by applying collision theory to the forward and reverse reactions
- the effects of changes of temperature, concentration of chemicals and pressure on equilibrium systems can be predicted using le chatelier's principle
- equilibrium position can be predicted qualitatively using equilibrium constants
- acids are substances that can act as proton (hydrogen ion) donors and can be classified as monoprotic or polyprotic depending on the number of protons donated by each molecule of the acid
- the strength of acids is explained by the degree of ionisation at equilibrium in aqueous solution, which can be represented with chemical equations and equilibrium constants (ka)
- the relationship between acids and bases in equilibrium systems can be explained using the brønsted-lowry model and represented using chemical equations that illustrate the transfer of hydrogen ions
- the ph scale is a logarithmic scale and the ph of a solution can be calculated from the concentration of hydrogen ions; k_w can be used to calculate the concentration of hydrogen ions from the concentration of hydroxide ions in a solution
- acid-base indicators are weak acids or bases where the acidic form is of a different colour to the basic form
- volumetric analysis methods involving acid-base reactions rely on the identification of an equivalence point by measuring the associated change in ph, using chemical indicators or ph meters, to reveal an observable end point

Oxidation and reduction

- a range of reactions, including displacement reactions of metals, combustion, corrosion, and electrochemical processes, can be modelled as redox reactions involving oxidation of one substance and reduction of another substance
- oxidation can be modelled as the loss of electrons from a chemical species, and reduction can be modelled as the gain of electrons by a chemical species; these processes can be represented using half-equations

- the ability of an atom to gain or lose electrons can be explained with reference to valence electrons, consideration of energy, and the overall stability of the atom, and can be predicted from the atom's position in the periodic table
- the relative strength of oxidising and reducing agents can be determined by comparing standard electrode potentials
- electrochemical cells, including galvanic and electrolytic cells, consist of oxidation and reduction half-reactions connected via an external circuit that allows electrons to move from the anode (oxidation reaction) to the cathode (reduction reaction)
- galvanic cells, including fuel cells, generate an electrical potential difference from a spontaneous redox reaction; they can be represented as cell diagrams including anode and cathode half-equations
- fuel cells can use metal nanoparticles as catalysts to improve the efficiency of energy production
- cell potentials at standard conditions can be calculated from standard electrode potentials; these values can be used to compare cells constructed from different materials
- electrolytic cells use an external electrical potential difference to provide the energy to allow a non-spontaneous redox reaction to occur, and can be used in small-scale and industrial situations

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Assessment

Refer to pages 10-12.

Structure, Synthesis and Design — Value 1.0

Structure, Synthesis and Design a — Value 0.5

Structure, Synthesis and Design b — Value 0.5

Unit Description

Current and future applications of chemistry include the development of specialised techniques to create, or synthesise, new substances to meet the specific needs of society, including pharmaceuticals, fuels, polymers and nanomaterials. In this unit, students focus on the principles and application of chemical synthesis, particularly in organic chemistry. This involves considering where and how functional groups can be incorporated into already existing carbon compounds in order to generate new substances with properties that enable them to be used in a range of contexts.

Through the investigation of appropriate contexts, students explore the ways in which models and theories related to chemical synthesis, structure and design, and associated applications, have developed over time and through interactions with social, economic, cultural and ethical considerations. They explore the ways in which chemistry contributes to contemporary debate regarding current and future uses of local, regional and international resources, evaluation of risk and action for sustainability, and they recognise the limitations of science in providing definitive answers in different contexts.

Students use science inquiry skills to investigate the principles and application of chemical structure, synthesis and design. They select and use data from instrumental analysis to determine the identity and structure of a range of organic materials. They make predictions based on knowledge of types of chemical reactions and investigate chemical reactions qualitatively and quantitatively.

Specific Unit Goals

By the end of this unit, students:

- understand how the presence of functional groups and the molecular structure of organic compounds are related to their properties
- understand addition, condensation and oxidation reactions, and predict the products of these reactions
- understand how knowledge of chemical systems is used to design synthesis processes, and how data from analytical techniques provides information about chemical structure
- understand how models and theories have developed over time and the ways in which chemical knowledge interacts with social, economic, cultural and ethical considerations in a range of contexts
- use science inquiry skills to design, conduct, evaluate and communicate investigations into reactions and the identification of organic compounds, including analysis of secondary data derived from chemical analysis
- evaluate, with reference to empirical evidence, claims about organic synthesis and chemical design, and justify evaluations
- communicate, predict and explain chemical phenomena using qualitative and quantitative representations in appropriate modes and genres

Content Descriptions

Further elaboration of the content of this unit is available on the ACARA Australian Curriculum website.

Science Inquiry Skills

- identify, research, construct and refine questions for investigation; propose hypotheses; and predict possible outcomes
- design investigations, including the procedure/s to be followed, the materials required, and the type and amount of primary and/or secondary data to be collected; conduct risk assessments; and consider research ethics
- conduct investigations, including using organic synthesis methods and collating data from chemical analyses, safely, competently and methodically for the collection of valid and reliable data
- represent data in meaningful and useful ways, including using appropriate graphic representations and correct units and symbols; organise and analyse data to identify patterns and relationships; identify and distinguish between random and systematic errors, and estimate their effect on measured results; discuss how the nature of the procedure and the sample size may influence uncertainty and limitations in data; and select, synthesise and use evidence from a range of sources to make and justify conclusions
- interpret a range of scientific and media texts, and evaluate processes, claims and conclusions by considering the quality of available evidence; and use reasoning to construct scientific arguments
- select, construct and use appropriate representations, including physical, virtual and graphical models of primary, secondary and tertiary structures, structural formulas, chemical equations, systematic nomenclature (using iupac conventions) and spectra, to communicate conceptual understanding, solve problems and make predictions
- select and use appropriate mathematical representations to solve problems and make predictions, including using the mole concept to calculate quantities in chemical reactions, including multi-step reactions, and the percentage yield of synthesis reactions
- communicate to specific audiences and for specific purposes using appropriate language, nomenclature, genres and modes, including scientific reports

Science as a Human Endeavour

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- temporal scope of data sets with which scientists work
- models and theories are contested and refined or replaced when new evidence challenges them, or when a new model or theory has greater explanatory power
- the acceptance of scientific knowledge can be influenced by the social, economic and cultural context in which it is considered
- people can use scientific knowledge to inform the monitoring, assessment and evaluation of risk
- science can be limited in its ability to provide definitive answers to public debate; there may be insufficient reliable data available, or interpretation of the data may be open to question
- international collaboration is often required when investing in large-scale science projects or addressing issues for the Asia-Pacific region
- scientific knowledge can be used to develop and evaluate projected economic, social and environmental impacts and to design action for sustainability

Science Understanding

Properties and structure of organic materials

- organic molecules have a hydrocarbon skeleton and can contain functional groups, including alcohols, carboxylic acids, esters, amines and amides
- each class of organic compounds displays characteristic chemical properties and undergoes specific reactions based on the functional groups present; these reactions, including acid-base and oxidation reactions, can be used to identify the class of the organic compound
- organic materials including proteins, carbohydrates and synthetic polymers display properties including strength, density and biodegradability that can be explained by considering the primary, secondary or tertiary structures of the material
- data from analytical techniques, including mass spectrometry, x-ray crystallography and infrared spectroscopy, can be used to determine the structure of organic molecules, often using evidence from more than one technique

Chemical synthesis and design

- chemical synthesis involves the selection of particular reagents to form a product with specific properties (for example, pharmaceuticals, fuels, cosmetics, cleaning products)
- designing chemical synthesis processes involves constructing reaction pathways that may include more than one chemical reaction
- designing chemical synthesis processes includes identifying reagents and reaction conditions in order to maximise yield and purity of product
- the yield of a chemical synthesis reaction can be calculated by comparing stoichiometric quantities with actual quantities
- green chemistry principles include the design of chemical synthesis processes that use renewable raw materials, limit the use of potentially harmful solvents and minimise the amount of unwanted products
- organic molecules, including polymers, can be synthesised using addition and condensation reactions
- fuels (for example, biodiesel, ethanol, hydrogen) can be synthesised from organic or inorganic sources using a range of chemical reactions including addition, oxidation and esterification
- molecular manufacturing processes, including protein synthesis, involve the positioning of molecules to facilitate a specific chemical reaction; such methods have the potential to synthesise specialised products (for example, carbon nanotubes, nanorobots, chemical sensors used in medicine)

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A program of learning is what a college provides to implement the course for a subject. It is at the discretion of the teacher to emphasis some content descriptions over others. The teacher may teach additional (not listed) content provided it meets the specific unit goals. This will be informed by the student needs and interests.

Assessment

Refer to pages 10-12.

Appendix A – Implementation Guidelines

Available course patterns

A standard 1.0 value unit is delivered over at least 55 hours. To be awarded a course, students must complete at least the minimum units over the whole minor, major, major/minor or double major course.

Course	Number of standard units to meet course requirements
Minor	Minimum of 2 units
Major	Minimum of 3.5 units

Units in this course can be delivered in any order.

Prerequisites for the course or units within the course

Nil.

Arrangements for students continuing study in this course

Students who studied the previous course may undertake any units in this course provided there is no duplication of content.

Duplication of Content Rules

Students cannot be given credit towards the requirements for a Senior Secondary Certificate for a unit that significantly duplicates content in a unit studied in another course. The responsibility for preventing undesirable overlap of content studied by a student rests with the principal and the teacher delivering the course. Students will only be given credit for covering the content once.

Guidelines for Delivery

Program of Learning

A program of learning is what a school provides to implement the course for a subject. This meets the requirements for context, scope and sequence set out in the Board endorsed course. Students follow programs of learning in a college as part of their senior secondary studies. The detail, design and layout of a program of learning are a college decision.

The program of learning must be documented to show the planned learning activities and experiences that meet the needs of particular groups of students, taking into account their interests, prior knowledge, abilities and backgrounds. The program of learning is a record of the learning experiences that enable students to achieve the knowledge, understanding and skills of the content descriptions. There is no requirement to submit a program of learning to the OBSSS for approval. The Principal will need to sign off at the end of Year 12 that courses have been delivered as accredited.

Content Descriptions

Are all content descriptions of equal importance? No. It depends on the focus of study. Teachers can customise their program of learning to meet their own students' needs, adding additional content descriptions if desired or emphasising some over others. A teacher must balance student needs with their responsibility to teach all content descriptions. It is mandatory that teachers address all content descriptions and that students engage with all content descriptions.

Half standard 0.5 units

Half standard units appear on the course adoption form but are not explicitly documented in courses. It is at the discretion of the college principal to split a standard 1.0 unit into two half standard 0.5 units. Colleges are required to adopt the half standard 0.5 units. However, colleges are not required to submit explicit documentation outlining their half standard 0.5 units to the BSSS. Colleges must assess students using the half standard 0.5 assessment task weightings outlined in the framework. It is the responsibility of the college principal to ensure that all content is delivered in units approved by the Board.

Moderation

Moderation is a system designed and implemented to:

- provide comparability in the system of school-based assessment
- form the basis for valid and reliable assessment in senior secondary schools
- involve the ACT Board of Senior Secondary Studies and colleges in cooperation and partnership
- maintain the quality of school-based assessment and the credibility, validity and acceptability of Board certificates.

Moderation commences within individual colleges. Teachers develop assessment programs and instruments, apply assessment criteria, and allocate Unit Grades, according to the relevant Course Framework. Teachers within course teaching groups conduct consensus discussions to moderate marking or grading of individual assessment instruments and unit grade decisions.

The Moderation Model

Moderation within the ACT encompasses structured, consensus-based peer review of Unit Grades for all accredited courses over two Moderation Days. In addition to Moderation Days, there is statistical moderation of course scores, including small group procedures, for T courses.

Moderation by Structured, Consensus-based Peer Review

Consensus-based peer review involves the review of student work against system wide criteria and standards and the validation of Unit Grades. This is done by matching student performance with the criteria and standards outlined in the Achievement Standards, as stated in the Framework. Advice is then given to colleges to assist teachers with, or confirm, their judgments. In addition, feedback is given on the construction of assessment instruments.

Preparation for Structured, Consensus-based Peer Review

Each year, teachers of Year 11 are asked to retain originals or copies of student work completed in Semester 2. Similarly, teachers of a Year 12 class should retain originals or copies of student work completed in Semester 1. Assessment and other documentation required by the Office of the Board of Senior Secondary Studies should also be kept. Year 11 work from Semester 2 of the previous year is presented for review at Moderation Day 1 in March, and Year 12 work from Semester 1 is presented for review at Moderation Day 2 in August.

In the lead up to Moderation Day, a College Course Presentation (comprised of a document folder and a set of student portfolios) is prepared for each A, T and M course/units offered by the school and is sent into the Office of the Board of Senior Secondary Studies.

The College Course Presentation

The package of materials (College Course Presentation) presented by a college for review on Moderation Days in each course area will comprise the following:

- a folder containing supporting documentation as requested by the Office of the Board through memoranda to colleges, including marking schemes and rubrics for each assessment item
- a set of student portfolios containing marked and/or graded written and non-written assessment responses and completed criteria and standards feedback forms. Evidence of all assessment responses on which the Unit Grade decision has been made is to be included in the student review portfolios.

Specific requirements for subject areas and types of evidence to be presented for each Moderation Day will be outlined by the Board Secretariat through the *Requirements for Moderation Memoranda* and Information Papers.

Visual evidence for judgements made about practical performances

(also refer to BSSS Website Guidelines)

It is a requirement that schools' judgements of standards to practical performances (A/T/M) be supported by visual evidence (still photos or video).

The photographic evidence submitted must be drawn from practical skills performed as part of the assessment process.

Teachers should consult the BSSS website for current information regarding all moderation requirements including subject specific and photographic evidence.

Appendix B – Course Developers

Name	College
Jacqueline Millard	Melba Copland Secondary School
Dr Kathryn White	Merici College
Ian Stace-Winkles	St Francis Xavier College

Appendix C – Common Curriculum Elements

Common curriculum elements assist in the development of high-quality assessment tasks by encouraging breadth and depth and discrimination in levels of achievement.

Organisers	Elements	Examples
create, compose and apply	apply	ideas and procedures in unfamiliar situations, content and processes in non-routine settings
	compose	oral, written and multimodal texts, music, visual images, responses to complex topics, new outcomes
	represent	images, symbols or signs
	create	creative thinking to identify areas for change, growth and innovation, recognise opportunities, experiment to achieve innovative solutions, construct objects, imagine alternatives
	manipulate	images, text, data, points of view
analyse, synthesise and evaluate	justify	arguments, points of view, phenomena, choices
	hypothesise	statement/theory that can be tested by data
	extrapolate	trends, cause/effect, impact of a decision
	predict	data, trends, inferences
	evaluate	text, images, points of view, solutions, phenomenon, graphics
	test	validity of assumptions, ideas, procedures, strategies
	argue	trends, cause/effect, strengths and weaknesses
	reflect	on strengths and weaknesses
	synthesise	data and knowledge, points of view from several sources
	analyse	text, images, graphs, data, points of view
	examine	data, visual images, arguments, points of view
	investigate	issues, problems
organise, sequence and explain	sequence	text, data, relationships, arguments, patterns
	visualise	trends, futures, patterns, cause and effect
	compare/contrast	data, visual images, arguments, points of view
	discuss	issues, data, relationships, choices/options
	interpret	symbols, text, images, graphs
	explain	explicit/implicit assumptions, bias, themes/arguments, cause/effect, strengths/weaknesses
	translate	data, visual images, arguments, points of view
	assess	probabilities, choices/options
	select	main points, words, ideas in text
identify, summarise and plan	reproduce	information, data, words, images, graphics
	respond	data, visual images, arguments, points of view
	relate	events, processes, situations
	demonstrate	probabilities, choices/options
	describe	data, visual images, arguments, points of view
	plan	strategies, ideas in text, arguments
	classify	information, data, words, images
	identify	spatial relationships, patterns, interrelationships
	summarise	main points, words, ideas in text, review, draft and edit

Appendix D – Glossary of Verbs

Verbs	Definition
Analyse	Consider in detail for the purpose of finding meaning or relationships, and identifying patterns, similarities and differences
Apply	Use, utilise or employ in a particular situation
Argue	Give reasons for or against something
Assess	Make a Judgement about the value of
Classify	Arrange into named categories in order to sort, group or identify
Compare	Estimate, measure or note how things are similar or dissimilar
Compose	The activity that occurs when students produce written, spoken, or visual texts
Contrast	Compare in such a way as to emphasise differences
Create	Bring into existence, to originate
Critically analyse	Analysis that engages with criticism and existing debate on the issue
Demonstrate	Give a practical exhibition an explanation
Describe	Give an account of characteristics or features
Discuss	Talk or write about a topic, taking into account different issues or ideas
Evaluate	Examine and judge the merit or significance of something
Examine	Determine the nature or condition of
Explain	Provide additional information that demonstrates understanding of reasoning and /or application
Extrapolate	Infer from what is known
Hypothesise	Put forward a supposition or conjecture to account for certain facts and used as a basis for further investigation by which it may be proved or disproved
Identify	Recognise and name
Interpret	Draw meaning from
Investigate	Planning, inquiry into and drawing conclusions about
Justify	Show how argument or conclusion is right or reasonable
Manipulate	Adapt or change
Plan	Strategize, develop a series of steps, processes
Predict	Suggest what might happen in the future or as a consequence of something
Reflect	The thought process by which students develop an understanding and appreciation of their own learning. This process draws on both cognitive and affective experience
Relate	Tell or report about happenings, events or circumstances
Represent	Use words, images, symbols or signs to convey meaning
Reproduce	Copy or make close imitation
Respond	React to a person or text
Select	Choose in preference to another or others
Sequence	Arrange in order
Summarise	Give a brief statement of the main points
Synthesise	Combine elements (information/ideas/components) into a coherent whole
Test	Examine qualities or abilities
Translate	Express in another language or form, or in simpler terms
Visualise	The ability to decode, interpret, create, question, challenge and evaluate texts that communicate with visual images as well as, or rather than, words

Appendix E – Glossary for ACT Senior Secondary Curriculum

Courses will detail what teachers are expected to teach and students are expected to learn for year 11 and 12. They will describe the knowledge, understanding and skills that students will be expected to develop for each learning area across the years of schooling.

Learning areas are broad areas of the curriculum, including English, mathematics, science, the arts, languages, health and physical education.

A **subject** is a discrete area of study that is part of a learning area. There may be one or more subjects in a single learning area.

Frameworks are system documents for Years 11 and 12 which provide the basis for the development and accreditation of any course within a designated learning area. In addition, frameworks provide a common basis for assessment, moderation and reporting of student outcomes in courses based on the framework.

The **course** sets out the requirements for the implementation of a subject. Key elements of a course include the rationale, goals, content descriptions, assessment, and achievement standards as designated by the framework.

BSSS courses will be organised into units. A unit is a distinct focus of study within a course. A standard 1.0 unit is delivered for a minimum of 55 hours generally over one semester.

Core units are foundational units that provide students with the breadth of the subject.

Additional units are avenues of learning that cannot be provided for within the four core 1.0 standard units by an adjustment to the program of learning.

An **independent study unit** is a pedagogical approach that empowers students to make decisions about their own learning. Independent study units can be proposed by a student and negotiated with their teacher but must meet the specific unit goals and content descriptions as they appear in the course.

An **elective** is a lens for demonstrating the content descriptions within a standard 1.0 or half standard 0.5 unit.

A **lens** is a particular focus or viewpoint within a broader study.

Content descriptions refer to the subject-based knowledge, understanding and skills to be taught and learned.

A **program of learning** is what a college develops to implement the course for a subject and to ensure that the content descriptions are taught and learned.

Achievement standards provide an indication of typical performance at five different levels (corresponding to grades A to E) following completion of study of senior secondary course content for units in a subject.

ACT senior secondary system **curriculum** comprises all BSSS approved courses of study.

Appendix F – Course Adoption

Conditions of Adoption

The course and units of this course are consistent with the philosophy and goals of the college and the adopting college has the human and physical resources to implement the course.

Adoption Process

Course adoption must be initiated electronically by an email from the principal or their nominated delegate to bssscertification@ed.act.edu.au. A nominated delegate must CC the principal.

The email will include the **Conditions of Adoption** statement above, and the table below adding the **College** name, and circling the **Classification/s** required.

College:	
Course Title:	Chemistry
Classification:	T
Accredited from:	2014
Framework:	Science