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Chemistry

Stage 6

Syllabus

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Board of Studies NSW
GPO Box 5300
Sydney NSW 2001
Australia

Tel: (02) 9367 8111
Fax: (02) 9367 8484
Internet: http://www.boardofstudies.nsw.edu.au

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Contents

1 The Higher School Certificate Program of Study

The purpose of the Higher School Certificate (HSC) program of study is to:

- provide a curriculum structure which encourages students to complete secondary education;
- foster the intellectual, social and moral development of students, in particular developing their:
  - knowledge, skills, understanding and attitudes in the fields of study they choose
  - capacity to manage their own learning
  - desire to continue learning in formal or informal settings after school
  - capacity to work together with others
  - respect for the cultural diversity of Australian society;
- provide a flexible structure within which students can prepare for:
  - further education and training
  - employment
  - full and active participation as citizens;
- provide formal assessment and certification of students' achievements;
- provide a context within which schools also have the opportunity to foster students' physical and spiritual development.

2 Rationale for Chemistry in the Stage 6 Curriculum

Chemistry in Science Stage 6 provides students with a contemporary and coherent understanding of matter and its interactions. It focuses on investigating the physical and chemical properties of substances, chemical reactions and processes, and the interaction of energy and matter, and attempts to explain and predict events at the atomic and molecular level.

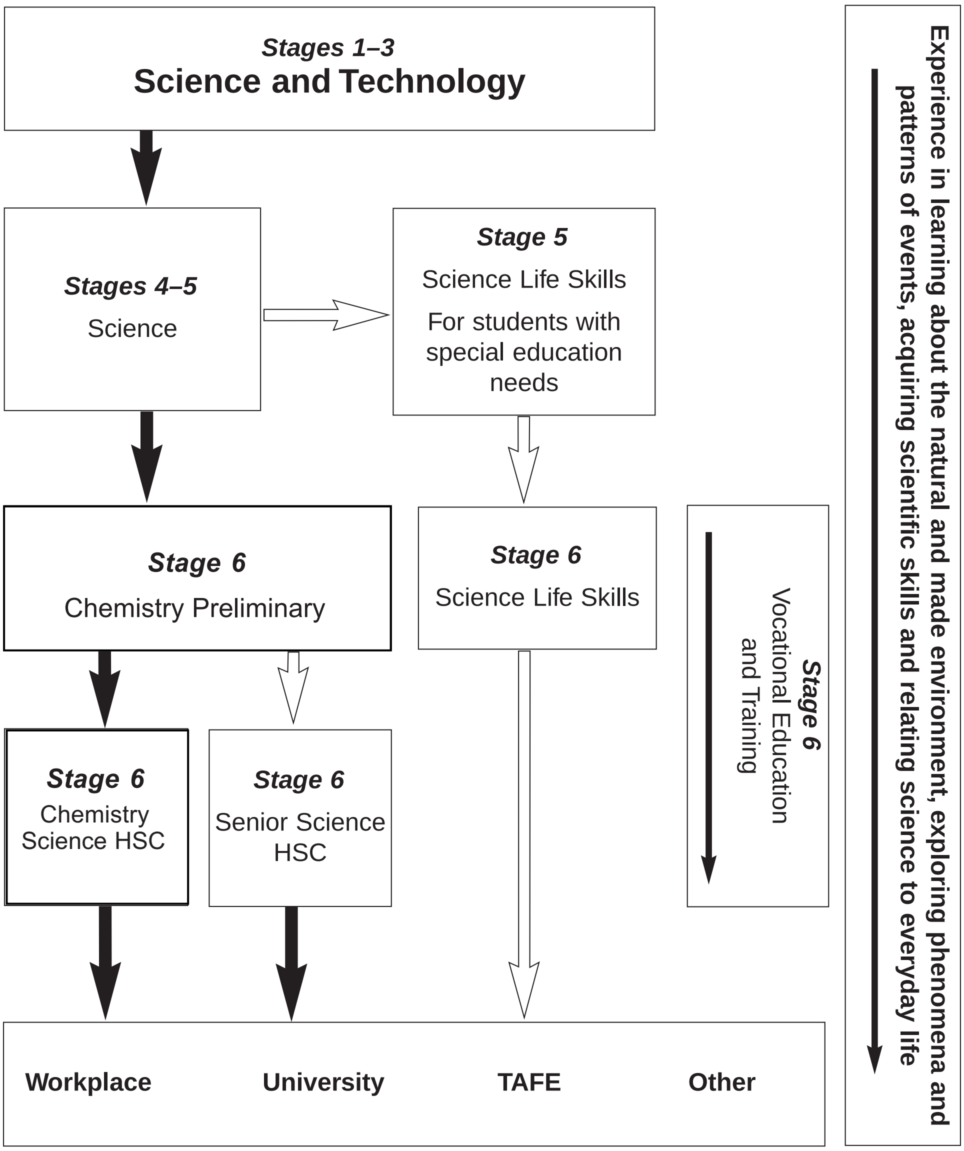
The study of Chemistry recognises that a study of the nature of materials includes natural and made substances, their structures, changes and environmental importance. The history and philosophy of science as it relates to the development of the understanding, utilisation and manipulation of chemical systems is important in developing current understanding in Chemistry and its applications in the contexts of technology, society and the environment.

Chemistry in Stage 6 draws upon and builds onto the knowledge and understanding, skills, and values and attitudes developed in Stages 4–5 Science. It further develops students' understanding of science as a continually developing body of knowledge, the role of experiment in deciding between competing theories, the provisional nature of scientific explanations, the interdisciplinary nature of science, the complex relationship between evidence and ideas and the impact of science on society.

The study of Chemistry involves the students working individually and with others in practical, field and interactive media experiences related to the theoretical concepts considered in the course. It is expected that students studying Chemistry will apply investigative and problem-solving skills, effectively communicate the theoretical concepts considered in the course and appreciate the contribution that a study of Chemistry makes to our understanding of the world.

The Chemistry Stage 6 course is designed for those students who have a substantial achievement level based on the Stages 4–5 Science course performance descriptors. The subject matter of the Chemistry course recognises the different needs and interests of students by providing a structure that builds upon the foundations laid in Stage 5 yet recognises that students entering Stage 6 have a wide range of abilities, circumstances and expectations.

3 Continuum of Learning for Chemistry Stage 6 Students



4 Aim

To provide learning experiences through which students will:

- acquire knowledge and understanding about fundamental concepts related to matter and its interactions, the historical development of those concepts and their application to personal, social, economic, technological and environmental situations
- progress from the consideration of specific data and knowledge to the understanding of models and concepts and to the use of generalised terms related to chemistry in their explanations, from the collection and organisation of information to problem-solving and from the use of simple communication skills to those which are more sophisticated
- develop positive attitudes towards the study of matter and its interactions, the environment and opinions held by others, recognising the importance of evidence and the use of critical evaluation of differing scientific opinions related to various aspects of chemistry.

5 Objectives

Students will develop knowledge and understanding of:

1. the history of chemistry
2. the nature and practice of chemistry
3. applications and uses of chemistry
4. the implications of chemistry for society and the environment
5. current issues, research and developments in chemistry
6. atomic structure, the periodic table and bonding
7. energy
8. chemical reactions, including acid/base reactions and chemical equilibrium
9. carbon chemistry
10. stoichiometry.

Students will develop further skills in:

11. planning investigations
12. conducting investigations
13. communicating information and understanding
14. developing scientific thinking and problem-solving techniques
15. working individually and in teams.

Students will develop positive values about and attitudes towards:

16. themselves, others, learning as a lifelong process, chemistry and the environment.

6 Course Structure

The *Chemistry Stage 6 Syllabus* has a Preliminary course and a HSC course. The Preliminary and HSC courses are organised into a number of modules. The Preliminary modules consist of core content that would be covered in 120 indicative hours.

The HSC course consists of core and options organised into a number of modules. The core content covers 90 indicative hours with options covering 30 indicative hours. Students are required to complete one of the options.

Practical experiences are an essential component of both the Preliminary and HSC courses. Students will complete 80 indicative hours of practical/field work during the Preliminary and HSC courses with no less than 35 indicative hours of practical experiences in the HSC course. Practical experiences must include at least one open-ended investigation integrating the skills and knowledge and understanding outcomes in both the Preliminary and HSC courses.

Practical experiences should emphasise hands-on activities including:

- undertaking laboratory experiments, including the use of appropriate computer-based and digital technology
- fieldwork
- research using the library
- research using Internet and digital technologies
- the use of computer simulations for modelling or manipulating data
- using and reorganising secondary data
- the extraction and reorganisation of information in the form of flow charts, tables, graphs, diagrams, prose and keys
- the use of animation, video and film resources to capture/obtain information not available in other forms.

6.1 Preliminary Course

120 indicative hours

The Preliminary course incorporates the study of :

- The Chemical Earth (30 indicative hours)
- Metals (30 indicative hours)
- Water (30 indicative hours)
- Energy (30 indicative hours)

6.2 HSC Course

120 hours indicative time

The HSC course builds upon the Preliminary course. **The Preliminary course contains content that is considered assumed knowledge for the HSC course.** The HSC course incorporates the study of:

a) the core which constitutes 90 indicative hours and includes:

- Production of Materials (30 indicative hours)
- The Acidic Environment (30 indicative hours)
- Chemical Monitoring and Management (30 indicative hours)

b) ONE option, which constitutes 30 indicative hours and may comprise any one of the following:

- Industrial Chemistry
- Shipwrecks, Corrosion and Conservation
- The Biochemistry of Movement
- The Chemistry of Art
- Forensic Chemistry.

6.3 Overview

The following diagram summarises the relationship between the various elements of the course:

Aim

states the overall purpose of the syllabus

↓

Objectives

define in broad terms, the knowledge and understanding, skills, and values and attitudes

Outcomes

define the intended results of teaching

↓

Contents of each module

Contexts
to increase motivation, conceptual meaning, literacy or confidence

Prescribed Focus Areas
identify emphases that are applied to what is being learnt

Domain
contains knowledge and understanding, skills, and values and attitudes to be learnt

↓

An independent learner

creative, responsible, scientifically literate, confident, ready to take their place as a member of society

Context

Contexts are frameworks devised to assist students to make meaning of the Prescribed Focus Areas and Domain. Contexts are culturally bound and therefore communicate meanings that are culturally shaped or defined. Contexts draw on the framework of society in all aspects of everyday life. The contexts for each module encourage students to recognise and use their current understanding to further develop and apply more specialised scientific understanding and knowledge.

Prescribed Focus Areas

The Prescribed Focus Areas are different curriculum emphases or purposes designed to increase students' understanding of chemistry as an ever-developing body of knowledge, the provisional nature of scientific explanations in chemistry, the complex relationship between evidence and ideas in chemistry and the impact of chemistry on society.

The following Prescribed Focus Areas are developed in this syllabus:

History of chemistry

Knowledge of the historical background of chemistry is important for an adequate understanding of the development of ideas to explain matter and its interactions and the applications of these ideas in current technologies. Students should develop knowledge of:

- the developmental nature of our understanding about matter and its interactions
- the part that an understanding of matter and its interactions plays in shaping society
- how our understanding of matter and its interactions is influenced by society.

Nature and practice of chemistry

A study of chemistry should enable students to participate in scientific activities and develop knowledge of the practice of chemistry. Students should also develop knowledge of the provisional nature of explanations about natural phenomena and the complex relationships between:

- existing views and the evidence supporting these
- the process and methods of exploring, generating, testing and relating ideas
- the stimulation provided by technological advances and the constraints imposed on understanding in chemistry by limitations of current technology which necessitate the development of the required technology and technological advances.

Applications and uses of chemistry

Setting the study of chemistry into broader contexts allows students to deal with real problems and applications. The study of chemistry should increase students' knowledge of:

- the relevance, usefulness and applicability of discoveries and ideas related to chemistry
- how increases in our understanding in chemistry have led to the development of useful technologies and systems
- the contributions chemistry has made to society with particular emphasis on Australian achievements.

Implications for society and the environment

Chemistry has an impact on our society and the environment and students need to develop knowledge of the importance of positive values and practices in relation to society and the environment. The study of chemistry should enable students to develop:

- understanding of the impact and the role of chemistry in society and the environment
- skills in decision-making about issues concerning chemistry, society and the environment
- an awareness of the social and environmental responsibility of the chemist.

Current issues, research and developments in chemistry

Issues and developments related to chemistry are more readily known and more information is available to students than ever before about current issues, research and developments in chemistry. The syllabus should develop students' knowledge of:

- areas currently being researched in chemistry
- career opportunities in chemistry and related fields
- interpretation and critique of media coverage of events that require an understanding of some aspect of chemistry.

Domain

Knowledge and understanding

Chemistry presents a particular way of thinking about the world. It encourages students to use inference, deductive reasoning and creativity. It presumes that the interactions within and between matter in the universe occur in consistent patterns that can be understood through careful, systematic study.

The course extends the study developed in the Stages 4–5 Science course, particularly in relation to knowledge and understanding of: particle theory of matter; atomic theory; law of conservation of energy; properties of solids, liquids and gases; change of state; elements, compounds and mixtures; chemical reactions; and resource use.

The course builds upon the fundamental knowledge of structures and systems in matter as well as interrelationships between the living and non-living world developed in the Stages 4–5 Science course.

Skills

The Chemistry Stage 6 course involves the further development of the skills that students have developed in the Stages 4–5 Science course through a range of practical experiences in both the Preliminary and HSC courses. The skills developed in Stages 4–5 are fundamental to Stage 6 where a more sophisticated level will be developed.

Practical experiences are an essential component of both the Preliminary and HSC courses. Students will complete **80 indicative hours of practical/field work during the Preliminary and HSC courses** with no less than 35 indicative hours of practical experiences in the HSC course. Practical experiences have been designed to utilise and further develop students' expertise in each of the following skill areas:

- **planning investigations**
  This involves increasing students' skills in: planning and organising activities; effectively using time and resources; selecting appropriate techniques, materials, specimens and equipment to complete activities; establishing priorities between tasks; and identifying ways of reducing risks when using laboratory and field equipment.

- **conducting investigations**
  This involves increasing students' skills in locating and gathering information for a planned investigation. It includes increasing students' skills in performing first-hand investigations, gathering first-hand data and accessing and collecting information relevant to Chemistry from secondary sources using a variety of technologies.

- **communicating information and understanding**
  This involves increasing students' skills in processing and presenting information. It includes increasing students' skills in speaking, writing and using nonverbal communication such as diagrams, graphs and symbols to convey chemical information and understanding. Throughout the course students become increasingly efficient and competent in the use of both technical terminology and the form and style required for written and oral communication in Chemistry.

- **developing scientific thinking and problem-solving techniques**
  This involves further increasing students' skills in clarifying issues and problems relevant to Chemistry, framing a possible problem-solving process, developing creative solutions, anticipating issues that may arise and devising appropriate strategies to deal with those issues and working through the issues in a logical and coherent way.

- **working individually and in teams**
  This involves further increasing students' skills in identifying a collective goal, defining and allocating roles and assuming an increasing variety of roles in working as an effective member of a team within the agreed timeframe to achieve the goal. Throughout the course students are provided with further opportunities to improve their ability to communicate and relate effectively to each other in a team.

Values and attitudes

By reflecting about past, present and future involvement of chemistry with society, students are encouraged to develop positive values and informed critical attitudes. These include a responsible regard for both the living and non-living components of the environment, ethical behaviour, a desire for critical evaluation of the consequences of the applications of science and recognising their responsibility to conserve, protect and maintain the quality of all environments for future generations.

Students are encouraged to develop attitudes on which scientific investigations depend, such as curiosity, honesty, flexibility, persistence, critical thinking, willingness to suspend judgement, tolerance of uncertainty and an acceptance of the provisional status of scientific knowledge. Students need to balance these with commitment, tenacity, a willingness to take risks and make informed judgements and, at times, inflexibility. As well as knowing something of and/or about chemistry, students need to value and appreciate chemistry if they are to become scientifically literate persons.

6.4 Other Considerations

Safety Issues

Schools have a legal obligation in relation to safety. Teachers will need to ensure that they comply with the *Occupational Health and Safety Act 2000* (NSW) the *Occupational Health and Safety Regulation 2001*, the *Dangerous Goods Act 1975* (NSW), the *Dangerous Goods Regulation 1978* (NSW) and the *Hazardous Substances Regulation 1996* (NSW), as well as system and school requirements in relation to safety when implementing their programs.

Schools should refer to the resource package *Chemical Safety in Schools* (DET, 1999) to assist them in meeting their legislative obligations.

Animal Research Act

Schools have a legal responsibility in relation to the welfare of animals. All practical activities involving animals must comply with the *Animal Research Act 1985* (NSW) as described in the *Animals in Schools: Animal Welfare Guidelines for Teachers (2002)* produced on behalf of the Schools Animal Care and Ethics Committee (SACEC) by the NSW Department of Education and Training.

7 Objectives and Outcomes

7.1 Table of Objectives and Outcomes

	Objectives	Preliminary Course Outcomes	HSC Course Outcomes
Prescribed Focus Area	*Students will develop knowledge and understanding of:*	*A student:*	*A student:*
	1. the history of chemistry	P1. outlines the historical development of major principles, concepts and ideas in chemistry	H1. evaluates how major advances in scientific understanding and technology have changed the direction or nature of scientific thinking
	2. the nature and practice of chemistry	P2. applies the processes that are used to test and validate models, theories and laws of science with particular emphasis on first-hand investigations in chemistry	H2. analyses the ways in which models, theories and laws in chemistry have been tested and validated
	3. applications and uses of chemistry	P3. assesses the impact of particular technological advances on understanding in chemistry	H3. assesses the impact of particular advances in chemistry on the development of technologies
	4. implications for society and the environment	P4. describes applications of chemistry which affect society or the environment	H4. assesses the impacts of applications of chemistry on society and the environment
	5. current issues, research and developments	P5. describes the scientific principles employed in particular areas of research in chemistry	H5. describes possible future directions of chemical research
Domain: Knowledge	6. atomic structure and periodic table	P6 explains trends and relationships between elements in terms of atomic structure and bonding	H6. explains reactions between elements and compounds in terms of atomic structures and periodicity
	7. energy	P7. describes chemical changes in terms of energy inputs and outputs	H7. describes the chemical basis of energy transformations in chemical reactions
	8. chemical reactions	P8. describes factors that influence the type and rate of chemical reactions	H8. assesses the range of factors which influence the type and rate of chemical reactions
	9. carbon chemistry	P9. relates the uses of carbon to the unique nature of carbon chemistry	H9. describes and predicts reactions involving carbon compounds
	10. stoichiometry	P10. applies simple stoichiometric relationships	H10. analyses stoichiometric relationships

	Objectives	Preliminary Course Outcomes	HSC Course Outcomes
	Students will develop knowledge and understanding of:	*A student:*	*A student:*
Domain: Skills	11. planning investigations	P11. identifies and implements improvements to investigation plans	H11. justifies the appropriateness of a particular investigation plan
	12. conducting investigations	P12. discusses the validity and reliability of data gathered from first-hand investigations and secondary sources	H12. evaluates ways in which accuracy and reliability could be improved in investigations
	13. communicating information and understanding	P13. identifies appropriate terminology and reporting styles to communicate information and understanding	H13. uses terminology and reporting styles appropriately and successfully to communicate information and understanding
	14. developing scientific thinking and problem-solving	P14. draws valid conclusions from gathered data and information	H14. assesses the validity of conclusions from gathered data and information
	15. working individually and in teams	P15. implements strategies to work effectively as an individual or as a member of a team	H15. explains why an investigation is best undertaken individually or by a team
Domain: Values & Attitudes	16. themselves, others, learning as a lifelong process, chemistry and the environment	P16. demonstrates positive values about, and attitude towards, both the living and non-living components of the environment, ethical behaviour and a desire for a critical evaluation of the consequences of the applications of science	H16. justifies positive values about and attitude towards both the living and non-living components of the environment, ethical behaviour and a desire for critical evaluation of the consequences of the applications of science

7.2 Key Competencies

Chemistry provides the context within which to develop general competencies essential for the acquisition of effective, higher-order thinking skills necessary for further education, work and everyday life.

Key competencies are embedded in the *Chemistry Stage 6 Syllabus* to enhance student learning and are explicit in the objectives and outcomes of the syllabus. The key competencies of ***collecting, analysing and organising information*** and ***communicating ideas and information*** reflect core processes of scientific inquiry and the skills identified in the syllabus assist students to continue to develop their expertise in these areas.

Students work as individuals and as members of groups to conduct investigations and, through this, the key competencies ***planning and organising activities*** and ***working with others and in teams*** are developed. During investigations, students use appropriate information technologies and so develop the key competency of using technology. The exploration of issues and investigation of problems contributes towards students' development of the key competency ***solving problems***. Finally when students analyse statistical evidence, apply mathematical concepts to assist analysis of data and information and construct table and graphs, they are developing the key competency ***using mathematical ideas and techniques***.

8 Content: Chemistry Stage 6 Preliminary Course

8.1 Chemistry Skills

During the Preliminary course it is expected that students will further develop skills in planning and conducting investigations, communicating information and understanding, scientific thinking and problem-solving and working individually and in teams. Each module specifies content through which skill outcomes can be achieved. Teachers should develop activities based on that content to provide students with opportunities to develop the full range of skills.

Preliminary Course Outcomes	Content
A student:	Students:
P11. identifies and implements improvements to investigation plans	**11.1 identify data sources to:** a) analyse complex problems to determine appropriate ways in which each aspect may be researched b) determine the type of data which needs to be collected and explain the qualitative or quantitative analysis that will be required for this data to be useful c) identify the orders of magnitude that will be appropriate and the uncertainty that may be present in the measurement of data d) identify and use correct units for data that will be collected e) recommend the use of an appropriate technology or strategy for data collection or gathering information that will assist efficient future analysis
	11.2 plan first-hand investigations to: a) demonstrate the use of the terms ‘dependent’ and ‘independent’ to describe variables involved in the investigation b) identify variables that need to be kept constant, develop strategies to ensure that these variables are kept constant, and demonstrate the use of a control c) design investigations that allow valid and reliable data and information to be collected d) design and trial procedures to undertake investigations and explain why a procedure, a sequence of procedures or repetition of procedures is appropriate e) predict possible issues that may arise during the course of an investigation and identify strategies to address these issues if necessary
	11.3 choose equipment or resources by: a) identifying and/or setting up the most appropriate equipment or combination of equipment needed to undertake the investigation b) carrying out a risk assessment of intended experimental procedures and identifying and addressing potential hazards c) identifying technology that could be used during investigations and determining its suitability and effectiveness for its potential role in the procedure or investigations d) recognising the difference between destructive and non-destructive testing of material and analysing potentially different results of these two procedures

A student:	Students:
P12. discusses the validity and reliability of data gathered from first-hand investigations and secondary sources	**12.1 perform first-hand investigations by:** a) carrying out the planned procedure, recognising where and when modifications are needed and analysing the effect of these adjustments b) efficiently undertaking the planned procedure to minimise hazards and wastage of resources c) disposing of any waste materials produced carefully and safely during the investigation d) identifying and using safe work practices during investigations
	12.2 gather first-hand information by: a) using appropriate data collection techniques, employing appropriate technologies including data loggers and sensors b) measuring, observing and recording results in accessible and recognisable forms, carrying out repeat trials as appropriate
	12.3 gather information from secondary sources by: a) accessing information from a range of resources including popular scientific journals, digital technologies and the Internet b) practising efficient data collection techniques to identify useful information in secondary sources c) extracting information from numerical data in graphs and tables as well as from written and spoken material in all its forms d) summarising and collating information from a range of resources e) identifying practising male and female Australian scientists, the areas in which they are currently working and information about their research
	12.4 process information to: a) assess the accuracy of any measurements and calculations and the relative importance of the data and information gathered b) identify and apply appropriate mathematical formulae and concepts c) best illustrate trends and patterns by selecting and using appropriate methods, including computer-assisted analysis d) evaluate the relevance of first-hand and secondary information and data in relation to the area of investigation e) assess the reliability of first-hand and secondary information and data by considering information from various sources f) assess the accuracy of scientific information presented in mass media by comparison with similar information presented in scientific journals
P13. identifies appropriate terminology and reporting styles to communicate information and understanding	**13.1 present information by:** a) selecting and using appropriate text types or combinations thereof, for oral and written presentations b) selecting and using appropriate media to present data and information c) selecting and using appropriate methods to acknowledge sources of information d) using symbols and formulae to express relationships and using appropriate units for physical quantities e) using a variety of pictorial representations to show relationships and presenting information clearly and succinctly f) selecting and drawing appropriate graphs to convey information and relationships clearly and accurately g) identifying situations where use of a curve of best fit is appropriate to present graphical information

A student:	Students:
P14. draws valid conclusions from gathered data and information	**14.1 analyse information to:** a) identify trends, patterns and relationships as well as contradictions in data and information b) justify inferences and conclusions c) identify and explain how data supports or refutes an hypothesis, a prediction or a proposed solution to a problem d) predict outcomes and generate plausible explanations related to the observations e) make and justify generalisations f) use models, including mathematical ones, to explain phenomena and/or make predictions g) use cause and effect relationships to explain phenomena h) identify examples of the interconnectedness of ideas or scientific principles
	14.2 solve problems by: a) identifying and explaining the nature of a problem b) describing and selecting from different strategies those which could be used to solve a problem c) using identified strategies to develop a range of possible solutions to a particular problem d) evaluating the appropriateness of different strategies for solving an identified problem
	14.3 use available evidence to: a) design and produce creative solutions to problems b) propose ideas that demonstrate coherence and logical progression and include correct use of scientific principles and ideas c) apply critical thinking in the consideration of predictions, hypotheses and the results of investigations d) formulate cause and effect relationships

8.2 The Chemical Earth

Contextual Outline

The Earth includes a clearly identifiable biosphere, lithosphere, hydrosphere and atmosphere. All of these are mixtures of thousands of substances and the use of this pool of resources requires the separation of useful substances. The processes of separation will be determined by the physical and chemical properties of the substances.

In order to use the Earth's resources effectively and efficiently, it is necessary to understand the properties of the elements and compounds found in mixtures that make up earth materials. Applying appropriate models, theories and laws of chemistry to the range of earth materials allows a useful classification of the materials and a better understanding of the properties of substances.

This module increases students' understanding of the nature, practice, applications and uses of chemistry.

Assumed Knowledge

Domain: knowledge and understanding

Refer to the Science Stages 4–5 Syllabus for the following:

5.7.1a describe features of and the location of protons, neutrons and electrons in the atom

5.7.2a identify the atom as the smallest unit of an element and distinguish between atoms and molecules

5.7.2b describe some relationships between elements using the periodic table

5.7.3a identify that a new compound is formed by rearranging atoms rather than creating matter

5.7.3b classify compounds into groups based on common chemical characteristics

5.7.3c construct word equations from observations and written descriptions of a range of chemical reactions

5.7.3d identify a range of common compounds using their common names and chemical formulae

5.7.3e qualitatively describe reactants and products in decomposition reactions

	Students learn to:	*Students:*
1. The living and non-living components of the Earth contain mixtures	• construct word and balanced formulae equations of chemical reactions as they are encountered • identify the difference between elements, compounds and mixtures in terms of particle theory • identify that the biosphere, lithosphere, hydrosphere and atmosphere contain examples of mixtures of elements and compounds • identify and describe procedures that can be used to separate naturally occurring mixtures of: - solids of different sizes - solids and liquids - dissolved solids in liquids - liquids - gases • assess separation techniques for their suitability in separating examples of earth materials, identifying the differences in properties which enable these separations • describe situations in which gravimetric analysis supplies useful data for chemists and other scientists • apply systematic naming of inorganic compounds as they are introduced in the laboratory • identify IUPAC names for carbon compounds as they are encountered	• gather and present information from first-hand or secondary sources to write equations to represent all chemical reactions encountered in the Preliminary course • identify data sources, plan, choose equipment and perform a first-hand investigation to separate the components of a naturally occurring or appropriate mixture such as sand, salt and water • gather first-hand information by carrying out a gravimetric analysis of a mixture to estimate its percentage composition • identify data sources, gather, process and analyse information from secondary sources to identify the industrial separation processes used on a mixture obtained from the biosphere, lithosphere, hydrosphere or atmosphere and use the evidence available to: - identify the properties of the mixture used in its separation - identify the products of separation and their uses - discuss issues associated with wastes from the processes used

	Students learn to:	*Students:*
2. Although most elements are found in combinations on Earth, some elements are found uncombined	• explain the relationship between the reactivity of an element and the likelihood of its existing as an uncombined element • classify elements as metals, non-metals and semi-metals according to their physical properties • account for the uses of metals and non-metals in terms of their physical properties	• plan and perform an investigation to examine some physical properties, including malleability, hardness and electrical conductivity, and some uses of a range of common elements to present information about the classification of elements as metals, non-metals or semi-metals • analyse information from secondary sources to distinguish the physical properties of metals and non-metals • process information from secondary sources and use a Periodic Table to present information about the classification of elements as: - metals, non-metals and semi-metals - solids, liquids and gases at 25˚C and normal atmospheric pressure

	Students learn to:	*Students:*
3. Elements in Earth materials are present mostly as compounds because of interactions at the atomic level	• identify that matter is made of particles that are continuously moving and interacting • describe qualitatively the energy levels of electrons in atoms • describe atoms in terms of mass number and atomic number • describe the formation of ions in terms of atoms gaining or losing electrons • apply the Periodic Table to predict the ions formed by atoms of metals and non-metals • apply Lewis electron dot structures to: - the formation of ions - the electron sharing in some simple molecules • describe the formation of ionic compounds in terms of the attraction of ions of opposite charge • describe molecules as particles which can move independently of each other • distinguish between molecules containing one atom (the noble gases) and molecules with more than one atom • describe the formation of covalent molecules in terms of sharing of electrons • construct formulae for compounds formed from: - ions - atoms sharing electrons	• analyse information by constructing or using models showing the structure of metals, ionic compounds and covalent compounds • construct ionic equations showing metal and non-metal atoms forming ions

	Students learn to:	*Students:*
4. Energy is required to extract elements from their naturally occurring sources	• identify the differences between physical and chemical change in terms of rearrangement of particles • summarise the differences between the boiling and electrolysis of water as an example of the difference between physical and chemical change • identify light, heat and electricity as the common forms of energy that may be released or absorbed during the decomposition or synthesis of substances and identify examples of these changes occurring in everyday life • explain that the amount of energy needed to separate atoms in a compound is an indication of the strength of the attraction, or bond, between them	• plan and safely perform a first-hand investigation to show the decomposition of a carbonate by heat, using appropriate tests to identify carbon dioxide and the oxide as the products of the reaction • gather information using first-hand or secondary sources to: - observe the effect of light on silver salts and identify an application of the use of this reaction - observe the electrolysis of water, analyse the information provided as evidence that water is a compound and identify an application of the use of this reaction • analyse and present information to model the boiling of water and the electrolysis of water tracing the movements of and changes in arrangements of molecules

	Students learn to:	*Students:*
5. The properties of elements and compounds are determined by their bonding and structure	• identify differences between physical and chemical properties of elements, compounds and mixtures • describe the physical properties used to classify compounds as ionic or covalent molecular or covalent network • distinguish between metallic, ionic and covalent bonds • describe metals as three-dimensional lattices of ions in a sea of electrons • describe ionic compounds in terms of repeating three-dimensional lattices of ions • explain why the formula for an ionic compound is an empirical formula • identify common elements that exist as molecules or as covalent lattices • explain the relationship between the properties of conductivity and hardness and the structure of ionic, covalent molecular and covalent network structures	• perform a first-hand investigation to compare the properties of some common elements in their elemental state with the properties of the compound(s) of these elements (eg magnesium and oxygen) • choose resources and process information from secondary sources to construct and discuss the limitations of models of ionic lattices, covalent molecules and covalent and metallic lattices • perform an investigation to examine the physical properties of a range of common substances in order to classify them as metallic, ionic or covalent molecular or covalent network substances and relate their characteristics to their uses

8.3 Metals

Contextual Outline

The cultural development of humans has been closely connected with their discovery of materials and invention of tools to the point where major advances in cultural achievement have been described in terms of the materials they learned to use. This has included their use of metals and discoveries of increasingly sophisticated methods of extraction of metals from their ores.

Because metals make up the majority of elements, an examination of the physical and chemical properties of metals is also an appropriate context in which to consider the organisation of the common Periodic Table. The development of a Periodic Table represented a breakthrough in the systematic organisation and study of chemistry and enabled scientists to predict the discovery of further elements.

This module increases students' understanding of the history, applications and use of chemistry and current issues, research and developments in chemistry.

Assumed Knowledge

Domain: knowledge and understanding

Refer to the Science Stages 4–5 Syllabus for the following:

5.7.1b distinguish between elements, using information about the numbers of protons, neutrons and electrons

5.7.3c construct word equations from observations and written descriptions of a range of chemical reactions

5.7.1d describe an appropriate model that has been developed to describe atomic structure

5.7.2b describe some relationships between elements using the Periodic Table

5.7.3e qualitatively describe reactants and products in the following chemical reactions:

- i) corrosion
- ii) acids on metals and acids on carbonates
- iii) neutralisation

	Students learn to:	*Students:*
1. Metals have been extracted and used for many thousands of years	• outline and examine some uses of different metals through history, including contemporary uses, as uncombined metals or as alloys • describe the use of common alloys including steel, brass and solder and explain how these relate to their properties • explain why energy input is necessary to extract a metal from its ore • identify why there are more metals available for people to use now than there were 200 years ago	• gather, process, analyse and present information from secondary sources on the range of alloys produced and the reasons for the production and use of these alloys • analyse information to relate the chronology of the Bronze Age, the Iron Age and the modern era and possible future developments
2. Metals differ in their reactivity with other chemicals and this influences their uses	• describe observable changes when metals react with dilute acid, water and oxygen • describe and justify the criteria used to place metals into an order of activity based on their ease of reaction with oxygen, water and dilute acids • identify the reaction of metals with acids as requiring the transfer of electrons • outline examples of the selection of metals for different purposes based on their reactivity, with a particular emphasis on current developments in the use of metals • outline the relationship between the relative activities of metals and their positions on the Periodic Table • identify the importance of first ionisation energy in determining the relative reactivity of metals	• perform a first-hand investigation incorporating information from secondary sources to determine the metal activity series • construct word and balanced formulae equations for the reaction of metals with water, oxygen, dilute acid • construct half-equations to represent the electron transfer reactions occurring when metals react with dilute hydrochloric and dilute sulfuric acids

	Students learn to:	*Students:*
3. As metals and other elements were discovered, scientists recognised that patterns in their physical and chemical properties could be used to organise the elements into a Periodic Table	• identify an appropriate model that has been developed to describe atomic structure • outline the history of the development of the Periodic Table including its origins, the original data used to construct it and the predictions made after its construction • explain the relationship between the position of elements in the Periodic Table, and: - electrical conductivity - ionisation energy - atomic radius - melting point - boiling point - combining power (valency) - electronegativity - reactivity	• process information from secondary sources to develop a Periodic Table by recognising patterns and trends in the properties of elements and use available evidence to predict the characteristics of unknown elements both in groups and across periods • use computer-based technologies to produce a table and a graph of changes in one physical property across a period and down a group

4. For efficient resource use, industrial chemical reactions must use measured amounts of each reactant

Students learn to:

- define the mole as the number of atoms in exactly 12g of carbon-12 (Avogadro's number)
- compare mass changes in samples of metals when they combine with oxygen
- describe the contribution of Gay-Lussac to the understanding of gaseous reactions and apply this to an understanding of the mole concept
- recount Avogadro's law and describe its importance in developing the mole concept
- distinguish between empirical formulae and molecular formulae

Students:

- process information from secondary sources to interpret balanced chemical equations in terms of mole ratios
- perform a first-hand investigation to measure and identify the mass ratios of metal to non-metal(s) in a common compound and calculate its empirical formula
- solve problems and analyse information from secondary sources to perform calculations involving Avogadro's number and the equation for calculating the number of moles of a substance:

$$n = \frac{m}{M}$$

- process information from secondary sources to investigate the relationship between the volumes of gases involved in reactions involving a metal and relate this to an understanding of the mole

	Students learn to:	*Students:*
5. The relative abundance and ease of extraction of metals influences their value and breadth of use in the community	• define the terms mineral and ore with reference to economic and non-economic deposits of natural resources • describe the relationship between the commercial prices of common metals, their actual abundances and relative costs of production • explain why ores are non-renewable resources • describe the separation processes, chemical reactions and energy considerations involved in the extraction of copper from one of its ores • recount the steps taken to recycle aluminium	• discuss the importance of predicting yield in the identification, mining and extraction of commercial ore deposits • justify the increased recycling of metals in our society and across the world • analyse information to compare the cost and energy expenditure involved in the extraction of aluminium from its ore and the recycling of aluminium

8.4 Water

Contextual Outline

The first astronauts who viewed the Earth from space commented on the beauty of our water-rich blue planet. Earth's position in the solar system enables its retention of water in solid, liquid and gaseous forms on and around its surface. The particular properties of the water molecule assisted the evolution of life and continue to support life processes by maintaining a narrow temperature range on the Earth’s surface.

The concepts of bonding and intermolecular forces are used to increase understanding of the special nature of the water molecule. The chemistry of solutions is examined in greater detail.

This module increases students’ understanding of the nature and practice of chemistry and the implications of chemistry for society and the environment.

Assumed Knowledge

Domain: knowledge and understanding

Refer to the Science Stages 4–5 Syllabus for the following:

5.7.3e qualitatively describe the reactants and products in precipitation reactions

	Students learn to:	*Students:*
1. Water is distributed on Earth as a solid, liquid and gas	• define the terms solute, solvent and solution • identify the importance of water as a solvent • compare the state, percentage and distribution of water in the biosphere, lithosphere, hydrosphere and atmosphere • outline the significance of the different states of water on Earth in terms of water as: - a constituent of cells and its role as both a solvent and a raw material in metabolism - a habitat in which temperature extremes are less than nearby terrestrial habitats - an agent of weathering of rocks both as liquid and solid - a natural resource for humans and other organisms	• perform an investigation involving calculations of the density of water as a liquid and a solid using: $\text{density} = \dfrac{\text{mass}}{\text{volume}}$ • analyse information by using models to account for the differing densities of ice and liquid water • plan and perform an investigation to identify and describe the effect of anti-freeze or salt on the boiling point of water
2. The wide distribution and importance of water on Earth is a consequence of its molecular structure and hydrogen bonding	• construct Lewis electron dot structures of water, ammonia and hydrogen sulfide to identify the distribution of electrons • compare the molecular structure of water, ammonia and hydrogen sulfide, the differences in their molecular shapes and in their melting and boiling points • describe hydrogen bonding between molecules • identify the water molecule as a polar molecule • describe the attractive forces between polar molecules as dipole-dipole forces • explain the following properties of water in terms of its intermolecular forces: - surface tension - viscosity - boiling and melting points	• process information from secondary sources to graph and compare the boiling and melting points of water with other similar sized molecules • identify data and process information from secondary sources to model the structure of the water molecule and effects of forces between water molecules • choose equipment and perform first-hand investigations to demonstrate the following properties of water: - surface tension - viscosity

	Students learn to:	*Students:*
3. Water is an important solvent	• explain changes, if any, to particles and account for those changes when the following types of chemicals interact with water: - a soluble ionic compound such as sodium chloride - a soluble molecular compound such as sucrose - a soluble or partially soluble molecular element or compound such as iodine, oxygen or hydrogen chloride - a covalent network structure substance such as silicon dioxide - a substance with large molecules, such as cellulose or polyethylene • analyse the relationship between the solubility of substances in water and the polar nature of the water molecule	• perform a first-hand investigation to test the solubilities in water of a range of substances that include ionic, soluble molecular, insoluble molecular, covalent networks and large molecules • process information from secondary sources to visualise the dissolution in water of various types of substances and solve problems by using models to show the changes that occur in particle arrangement as dissolution occurs

	Students learn to:	*Students:*
4. The concentration of salts in water will vary according to their solubility, and precipitation can occur when the ions of an insoluble salt are in solution together	• identify some combinations of solutions which will produce precipitates, using solubility data • describe a model that traces the movement of ions when solution and precipitation occur • identify the dynamic nature of ion movement in a saturated dissolution • describe the molarity of a solution as the number of moles of solute per litre of solution using: $c = \frac{n}{V}$ • explain why different measurements of concentration are important	• construct ionic equations to represent the dissolution and precipitation of ionic compounds in water • present information in balanced chemical equations and identify the appropriate phase descriptors (s), (l), (g), and (aq) for all chemical species • perform a first-hand investigation, using micro-techniques, to compare the solubility of appropriate salts in solution through precipitation reactions • carry out simple calculations to describe the concentration of given solutions, given masses of solute and volumes of solution • perform a first-hand investigation to make solutions to specified volume-to-volume and mass-to-volume specifications and dilute them to specified concentrations (cV = constant) • calculate mass and concentration relationships in precipitation reactions as they are encountered

5. Water has a higher heat capacity than many other liquids

Students learn to:

- explain what is meant by the specific heat capacity of a substance
- compare the specific heat capacity of water with a range of other solvents
- explain and use the equation

$$\Delta H = -mC\Delta T$$

- explain how water's ability to absorb heat is used to measure energy changes in chemical reactions
- describe dissolutions which release heat as exothermic and give examples
- describe dissolutions which absorb heat as endothermic and give examples
- explain why water's ability to absorb heat is important to aquatic organisms and to life on earth generally
- explain what is meant by thermal pollution and discuss the implications for life if a body of water is affected by thermal pollution

Students:

- choose resources and perform a first-hand investigation to measure the change in temperature when substances dissolve in water and calculate the molar heat of solution
- process and present information from secondary sources to assess the limitations of calorimetry experiments and design modifications to equipment used

8.5 Energy

Contextual Outline

Anthropologists and palaeontologists tell us that one of the important cultural achievements of early humans was the discovery of fire and the invention of ways to use fire. Burning is then one of the most common and oldest chemical reactions. People meet this in their everyday life in such varied ways as lighting a match, cooking with gas and using fires.

The arrival of the industrial revolution and the increased need for fuels to power machinery mean that humans have become increasingly dependent on fuels. Heat is a major product of the burning process. Most burning of fuels in our society is done to produce heat for powering machinery, cooking or providing warmth. The efficiency with which this is done is becoming of increasing concern to society because fossil fuels, which have been the mainstay fuels, are finite and non-renewable.

People are becoming increasingly concerned about the damage done to the Earth's environment by careless and inefficient use of fossil fuels. Strategies for the efficient use of fuels can be assessed in the light of the factors that drive chemical reactions, including combustion. As fossil fuels are carbon compounds, an understanding of the structure and properties of simple carbon compounds assists understanding of the issues associated with the use of these fuels.

This module increases students' understanding of the applications and uses of chemistry and the implications of chemistry for society and the environment.

Assumed Knowledge

Domain: knowledge and understanding
Refer to the Science Stages 4–5 Syllabus for the following:

5.7.3a identify that a new compound is formed by rearranging atoms rather than by creating matter

5.7.3b classify compounds into groups based on common chemical characteristics

5.7.3c construct word equations from observations and written descriptions of a range of reactions

5.7.3d identify a range of common compounds using their common names and chemical formulae

5.7.3e qualitatively describe reactants and products in combustion and decomposition reactions

5.11.2a relate pollution to contamination by unwanted substances.

	Students learn to:	*Students:*
1. Living organisms make compounds which are important sources of energy	• outline the role of photosynthesis in transforming light energy to chemical energy and recall the raw materials for this process • outline the role of the production of high energy carbohydrates from carbon dioxide as the important step in the stabilisation of the sun's energy in a form that can be used by animals as well as plants • identify the photosynthetic origins of the chemical energy in coal, petroleum and natural gas	• process and present information from secondary sources on the range of compounds found in either coal, petroleum or natural gas and on the location of deposits of the selected fossil fuel in Australia
2. There is a wide variety of carbon compounds	• identify the position of carbon in the Periodic Table and describe its electron configuration • describe the structure of the diamond and graphite allotropes and account for their physical properties in terms of bonding • identify that carbon can form single, double or triple covalent bonds with other carbon atoms • explain the relationship between carbon's combining power and ability to form a variety of bonds and the existence of a large number of carbon compounds	• perform a first-hand investigation, analyse information and use available evidence to model the differences in atomic arrangement of diamond, graphite and fullerenes • process and present information from secondary sources on the uses of diamond and graphite and relate their uses to their physical properties • identify data, and choose resources from secondary sources such as molecular model kits, digital technologies or computer simulations to model the formation of single, double and triple bonds in simple carbon compounds

	Students learn to:	*Students:*
3. A variety of carbon compounds are extracted from organic sources	• describe the use of fractional distillation to separate the components of petroleum and identify the uses of each fraction obtained • identify and use the IUPAC nomenclature for describing straight-chained alkanes and alkenes from C1 to C8 • compare and contrast the properties of alkanes and alkenes C1 to C8 and use the term 'homologous series' to describe a series with the same functional group • explain the relationship between the melting point, boiling point and volatility of the above hydrocarbons, and their non-polar nature and intermolecular forces (dispersion forces) • assess the safety issues associated with the storage of alkanes C1 to C8 in view of their weak intermolecular forces (dispersion forces)	• perform a first-hand investigation and gather first-hand information using the process of fractional distillation to separate the components of a mixture such as ethanol and water • plan, identify and gather data from secondary sources to model the structure of alkanes and alkenes C1 to C8 • process and present information from secondary sources and use available evidence to identify safety issues associated with the storage of alkanes

	Students learn to:	*Students:*
4. Combustion provides another opportunity to examine the conditions under which chemical reactions occur	• describe the indicators of chemical reactions • identify combustion as an exothermic chemical reaction • outline the changes in molecules during chemical reactions in terms of bond-breaking and bond-making • explain that energy is required to break bonds and energy is released when bonds are formed • describe the energy needed to begin a chemical reaction as activation energy • describe the energy profile diagram for both endothermic and exothermic reactions • explain the relationship between ignition temperature and activation energy • identify the sources of pollution which accompany the combustion of organic compounds and explain how these can be avoided • describe chemical reactions by using full balanced chemical equations to summarise examples of complete and incomplete combustion	• solve problems and perform a first-hand investigation to measure the change in mass when a mixture such as wood is burned in an open container • identify the changes of state involved in combustion of a burning candle • perform first-hand investigations to observe and describe examples of endothermic and exothermic chemical reactions

	Students learn to:	*Students:*
5. The rate of energy release is affected by factors such as types of reactants	• describe combustion in terms of slow, spontaneous and explosive reactions and explain the conditions under which these occur • explain the importance of collisions between reacting particles as a criterion for determining reaction rates • explain the relationship between temperature and the kinetic energy of particles • describe the role of catalysts in chemical reactions, using a named industrial catalyst as an example • explain the role of catalysts in changing the activation energy and hence the rate of chemical reaction	• solve problems, identify data, perform first-hand investigations and gather first-hand data where appropriate, to observe the impact on reaction rates of: - changing temperature - changing concentration - size of solid particles - adding catalysts • process information from secondary sources to investigate the conditions under which explosions occur and relate these to the importance of collisions between reacting particles • analyse information and use the available evidence to relate the conditions under which explosions occur to the need for safety in work environments where fine particles mix with air • analyse information from secondary sources to develop models to simulate the role of catalysts in changing the rate of chemical reactions

9 Content: Chemistry Stage 6 HSC Course

9.1 Chemistry Skills

During the HSC course it is expected that students will further develop skills in planning and conducting investigations, communicating information and understanding, scientific thinking and problem-solving and working individually and in teams. Each module specifies content through which skill outcomes can be achieved. Teachers should develop activities based on that content to provide students with opportunities to develop the full range of skills.

HSC Course Outcomes	Content
A student:	*Students:*
H11. justifies the appropriateness of a particular investigation plan	11.1 **identify data sources to:** a) analyse complex problems to determine appropriate ways in which each aspect may be researched b) determine the type of data which needs to be collected and explain the qualitative or quantitative analysis that will be required for this data to be useful c) identify the orders of magnitude that will be appropriate and the uncertainty that may be present in the measurement of data d) identify and use correct units for data that will be collected e) recommend the use of an appropriate technology or strategy for data collection or gathering information that will assist efficient future analysis
	11.2 **plan first-hand investigations to:** a) demonstrate the use of the terms ‘dependent’ and ‘independent’ to describe variables involved in the investigation b) identify variables that need to be kept constant, develop strategies to ensure that these variables are kept constant, and demonstrate the use of a control c) design investigations that allow valid and reliable data and information to be collected d) design and trial procedures to undertake investigations and explain why a procedure, a sequence of procedures or repetition of procedures is appropriate e) predict possible issues that may arise during the course of an investigation and identify strategies to address these issues if necessary
	11.3 **choose equipment or resources by:** a) identifying and/or setting up the most appropriate equipment or combination of equipment needed to undertake the investigation b) carrying out a risk assessment of intended experimental procedures and identifying and addressing potential hazards c) identifying technology that could be used during investigations and determining its suitability and effectiveness for its potential role in the procedure or investigations d) recognising the difference between destructive and non-destructive testing of material and analysing potentially different results of these two procedures

H12. evaluates ways in which accuracy and reliability could be improved in investigations	12.1 **perform first-hand investigations by:** a) carrying out the planned procedure, recognising where and when modifications are needed and analysing the effect of these adjustments b) efficiently undertaking the planned procedure to minimise hazards and wastage of resources c) disposing carefully and safely of any waste materials produced during the investigation d) identifying and using safe work practices during investigations
	12.2 **gather first-hand information by:** a) using appropriate data collection techniques, employing appropriate technologies including data loggers and sensors b) measuring, observing and recording results in accessible and recognisable forms, carrying out repeat trials as appropriate
	12.3 **gather information from secondary sources by:** a) accessing information from a range of resources including popular scientific journals, digital technologies and the Internet b) practising efficient data collection techniques to identify useful information in secondary sources c) extracting information from numerical data in graphs and tables as well as from written and spoken material in all its forms d) summarising and collating information from a range of resources e) identifying practising male and female Australian scientists, the areas in which they are currently working and information about their research
	12.4 **process information to:** a) assess the accuracy of any measurements and calculations and the relative importance of the data and information gathered b) identify and apply appropriate mathematical formulae and concepts c) best illustrate trends and patterns by selecting and using appropriate methods, including computer-assisted analysis d) evaluate the relevance of first-hand and secondary information and data in relation to the area of investigation e) assess the reliability of first-hand and secondary information and data by considering information from various sources f) assess the accuracy of scientific information presented in mass media by comparison with similar information presented in scientific journals
H13. uses terminology and reporting styles appropriately and successfully to communicate information and understanding	13.1 **present information by:** a) selecting and using appropriate text types or combinations thereof, for oral and written presentations b) selecting and using appropriate media to present data and information c) selecting and using appropriate methods to acknowledge sources of information d) using symbols and formulae to express relationships and using appropriate units for physical quantities e) using a variety of pictorial representations to show relationships and presenting information clearly and succinctly f) selecting and drawing appropriate graphs to convey information and relationships clearly and accurately g) identifying situations where use of a curve of best fit is appropriate to present graphical information

H14. assesses the validity of conclusions from gathered data and information	14.1 **analyse information to:** a) identify trends, patterns and relationships as well as contradictions in data and information b) justify inferences and conclusions c) identify and explain how data supports or refutes an hypothesis, a prediction or a proposed solution to a problem d) predict outcomes and generate plausible explanations related to the observations e) make and justify generalisations f) use models, including mathematical ones, to explain phenomena and/or make predictions g) use cause and effect relationships to explain phenomena h) identify examples of the interconnectedness of ideas or scientific principles
	14.2 **solve problems by:** a) identifying and explaining the nature of a problem b) describing and selecting from different strategies those which could be used to solve a problem c) using identified strategies to develop a range of possible solutions to a particular problem d) evaluating the appropriateness of different strategies for solving an identified problem
	14.3 **use available evidence to:** a) design and produce creative solutions to problems b) propose ideas that demonstrate coherence and logical progression and include correct use of scientific principles and ideas c) apply critical thinking in the consideration of predictions, hypotheses and the results of investigations d) formulate cause and effect relationships

9.2 Production of Materials

Contextual Outline

Humans have always exploited their natural environment for all their needs including food, clothing and shelter. As the cultural development of humans continued, they looked for a greater variety of materials to cater for their needs.

The twentieth century saw an explosion in both the use of traditional materials and in the research for development of a wider range of materials to satisfy technological developments. Added to this was a reduction in availability of the traditional resources to supply the increasing world population.

Chemists and chemical engineers continue to play a pivotal role in the search for new sources of traditional materials such as those from the petrochemical industry. As the fossil organic reserves dwindle, new sources of the organic chemicals presently used have to be found. In addition, chemists are continually searching for compounds to be used in the design and production of new materials to replace those that have been deemed no longer satisfactory for needs.

This module increases students' understanding of the implications of chemistry for society and the environment and the current issues, research and developments in chemistry.

1. Fossil fuels provide both energy and raw materials such as ethylene, for the production of other substances

Students learn to:

- construct word and balanced formulae equations of chemical reactions as they are encountered
- identify the industrial source of ethylene from the cracking of some of the fractions from the refining of petroleum
- identify that ethylene, because of the high reactivity of its double bond, is readily transformed into many useful products
- identify that ethylene serves as a monomer from which polymers are made
- identify polyethylene as an addition polymer and explain the meaning of this term
- outline the steps in the production of polyethylene as an example of a commercially and industrially important polymer
- identify the following as commercially significant monomers:
  - vinyl chloride
  - styrene

  by both their systematic and common names
- describe the uses of the polymers made from the above monomers in terms of their properties

Students:

- gather and present information from first-hand or secondary sources to write equations to represent all chemical reactions encountered in the HSC course
- identify data, plan and perform a first-hand investigation to compare the reactivities of appropriate alkenes with the corresponding alkanes in bromine water
- analyse information from secondary sources such as computer simulations, molecular model kits or multimedia resources to model the polymerisation process

	Students learn to:	*Students:*
2. Some scientists research the extraction of materials from biomass to reduce our dependence on fossil fuels	• discuss the need for alternative sources of the compounds presently obtained from the petrochemical industry • explain what is meant by a condensation polymer • describe the reaction involved when a condensation polymer is formed • describe the structure of cellulose and identify it as an example of a condensation polymer found as a major component of biomass • identify that cellulose contains the basic carbon-chain structures needed to build petrochemicals and discuss its potential as a raw material	• use available evidence to gather and present data from secondary sources and analyse progress in the recent development and use of a named biopolymer. This analysis should name the specific enzyme(s) used or organism used to synthesise the material and an evaluation of the use or potential use of the polymer produced related to its properties

	Students learn to:	*Students:*
3. Other resources, such as ethanol, are readily available from renewable resources such as plants	• describe the dehydration of ethanol to ethylene and identify the need for a catalyst in this process and the catalyst used • describe the addition of water to ethylene resulting in the production of ethanol and identify the need for a catalyst in this process and the catalyst used • describe and account for the many uses of ethanol as a solvent for polar and non-polar substances • outline the use of ethanol as a fuel and explain why it can be called a renewable resource • describe conditions under which fermentation of sugars is promoted • summarise the chemistry of the fermentation process • define the molar heat of combustion of a compound and calculate the value for ethanol from first-hand data • assess the potential of ethanol as an alternative fuel and discuss the advantages and disadvantages of its use • identify the IUPAC nomenclature for straight-chained alkanols from C1 to C8	• process information from secondary sources such as molecular model kits, digital technologies or computer simulations to model: - the addition of water to ethylene - the dehydration of ethanol • process information from secondary sources to summarise the processes involved in the industrial production of ethanol from sugar cane • process information from secondary sources to summarise the use of ethanol as an alternative car fuel, evaluating the success of current usage • solve problems, plan and perform a first-hand investigation to carry out the fermentation of glucose and monitor mass changes • present information from secondary sources by writing a balanced equation for the fermentation of glucose to ethanol • identify data sources, choose resources and perform a first-hand investigation to determine and compare heats of combustion of at least three liquid alkanols per gram and per mole

4. Oxidation-reduction reactions are increasingly important as a source of energy

Students learn to:

- explain the displacement of metals from solution in terms of transfer of electrons
- identify the relationship between displacement of metal ions in solution by other metals to the relative activity of metals
- account for changes in the oxidation state of species in terms of their loss or gain of electrons
- describe and explain galvanic cells in terms of oxidation/reduction reactions
- outline the construction of galvanic cells and trace the direction of electron flow
- define the terms anode, cathode, electrode and electrolyte to describe galvanic cells

Students:

- perform a first-hand investigation to identify the conditions under which a galvanic cell is produced
- perform a first-hand investigation and gather first-hand information to measure the difference in potential of different combinations of metals in an electrolyte solution
- gather and present information on the structure and chemistry of a dry cell or lead-acid cell and evaluate it in comparison to one of the following:
  - button cell
  - fuel cell
  - vanadium redox cell
  - lithium cell
  - liquid junction photovoltaic device (eg the Gratzel cell)

  in terms of:
  - chemistry
  - cost and practicality
  - impact on society
  - environmental impact
- solve problems and analyse information to calculate the potential $E^{\ominus}$ requirement of named electrochemical processes using tables of standard potentials and half-equations

	Students learn to:	*Students:*
5. Nuclear chemistry provides a range of materials	• distinguish between stable and radioactive isotopes and describe the conditions under which a nucleus is unstable • describe how transuranic elements are produced • describe how commercial radioisotopes are produced • identify instruments and processes that can be used to detect radiation • identify one use of a named radioisotope: - in industry - in medicine • describe the way in which the above named industrial and medical radioisotopes are used and explain their use in terms of their chemical properties	• process information from secondary sources to describe recent discoveries of elements • use available evidence to analyse benefits and problems associated with the use of radioactive isotopes in identified industries and medicine

9.3 The Acidic Environment

Contextual Outline

Acidic and basic environments exist everywhere. The human body has a slightly acidic skin surface to assist in disease control and digestion occurs in both acidic and basic environments to assist the breakdown of the biopolymers constituting food. Indeed, microorganisms found in the digestive system are well adapted to acidic or basic environments.

Many industries use acidic and basic compounds for a wide range of purposes and these compounds are found in daily use within the home. Because of this, an awareness of the properties of acids and bases is important for safe handling of materials. Currently, concerns exist about the increased release of acidic and basic substances into the environment and the impact of these substances on the environment and the organisms within those environments.

This module increases students' understanding of the history, nature and practice of chemistry, the applications and uses of chemistry and implications of chemistry for society and the environment.

	Students learn to:	*Students:*
1. Indicators were identified with the observation that the colour of some flowers depends on soil composition	• classify common substances as acidic, basic or neutral • identify that indicators such as litmus, phenolphthalein, methyl orange and bromothymol blue can be used to determine the acidic or basic nature of a material over a range, and that the range is identified by change in indicator colour • identify and describe some everyday uses of indicators including the testing of soil acidity/basicity	• perform a first-hand investigation to prepare and test a natural indicator • identify data and choose resources to gather information about the colour changes of a range of indicators • solve problems by applying information about the colour changes of indicators to classify some household substances as acidic, neutral or basic

	Students learn to:	*Students:*
2. While we usually think of the air around us as neutral, the atmosphere naturally contains acidic oxides of carbon, nitrogen and sulfur. The concentrations of these acidic oxides have been increasing since the Industrial Revolution	• identify oxides of non-metals which act as acids and describe the conditions under which they act as acids • analyse the position of these non-metals in the Periodic Table and outline the relationship between position of elements in the Periodic Table and acidity/basicity of oxides • define Le Chatelier's principle • identify factors which can affect the equilibrium in a reversible reaction • describe the solubility of carbon dioxide in water under various conditions as an equilibrium process and explain in terms of Le Chatelier's principle • identify natural and industrial sources of sulfur dioxide and oxides of nitrogen • describe, using equations, examples of chemical reactions which release sulfur dioxide and chemical reactions which release oxides of nitrogen • assess the evidence which indicates increases in atmospheric concentration of oxides of sulfur and nitrogen • calculate volumes of gases given masses of some substances in reactions, and calculate masses of substances given gaseous volumes, in reactions involving gases at 0˚C and 100kPa or 25˚C and 100kPa • explain the formation and effects of acid rain	• identify data, plan and perform a first-hand investigation to decarbonate soft drink and gather data to measure the mass changes involved and calculate the volume of gas released at 25˚C and 100kPa • analyse information from secondary sources to summarise the industrial origins of sulfur dioxide and oxides of nitrogen and evaluate reasons for concern about their release into the environment

	Students learn to:	*Students:*
3. Acids occur in many foods, drinks and even within our stomachs	• define acids as proton donors and describe the ionisation of acids in water • identify acids including acetic (ethanoic), citric (2-hydroxypropane-1,2,3-tricarboxylic), hydrochloric and sulfuric acid • describe the use of the pH scale in comparing acids and bases • describe acids and their solutions with the appropriate use of the terms strong, weak, concentrated and dilute • identify pH as $-\log_{10} [H^+]$ and explain that a change in pH of 1 means a ten-fold change in $[H^+]$ • compare the relative strengths of equal concentrations of citric, acetic and hydrochloric acids and explain in terms of the degree of ionisation of their molecules • describe the difference between a strong and a weak acid in terms of an equilibrium between the intact molecule and its ions	• solve problems and perform a first-hand investigation to use pH meters/probes and indicators to distinguish between acidic, basic and neutral chemicals • plan and perform a first-hand investigation to measure the pH of identical concentrations of strong and weak acids • gather and process information from secondary sources to write ionic equations to represent the ionisation of acids • use available evidence to model the molecular nature of acids and simulate the ionisation of strong and weak acids • gather and process information from secondary sources to explain the use of acids as food additives • identify data, gather and process information from secondary sources to identify examples of naturally occurring acids and bases and their chemical composition • process information from secondary sources to calculate pH of strong acids given appropriate hydrogen ion concentrations

	Students learn to:	*Students:*
4. Because of the prevalence and importance of acids, they have been used and studied for hundreds of years. Over time, the definitions of acid and base have been refined	• outline the historical development of ideas about acids including those of: - Lavoisier - Davy - Arrhenius • outline the Brönsted-Lowry theory of acids and bases • describe the relationship between an acid and its conjugate base and a base and its conjugate acid • identify a range of salts which form acidic, basic or neutral solutions and explain their acidic, neutral or basic nature • identify conjugate acid/base pairs • identify amphiprotic substances and construct equations to describe their behaviour in acidic and basic solutions • identify neutralisation as a proton transfer reaction which is exothermic • describe the correct technique for conducting titrations and preparation of standard solutions • qualitatively describe the effect of buffers with reference to a specific example in a natural system	• gather and process information from secondary sources to trace developments in understanding and describing acid/base reactions • choose equipment and perform a first-hand investigation to identify the pH of a range of salt solutions • perform a first-hand investigation and solve problems using titrations and including the preparation of standard solutions, and use available evidence to quantitatively and qualitatively describe the reaction between selected acids and bases • perform a first-hand investigation to determine the concentration of a domestic acidic substance using computer-based technologies • analyse information from secondary sources to assess the use of neutralisation reactions as a safety measure or to minimise damage in accidents or chemical spills

	Students learn to:	*Students:*
5. Esterification is a naturally occurring process which can be performed in the laboratory	• describe the differences between the alkanol and alkanoic acid functional groups in carbon compounds • identify the IUPAC nomenclature for describing the esters produced by reactions of straight-chained alkanoic acids from C1 to C8 and straight-chained primary alkanols from C1 to C8 • explain the difference in melting point and boiling point caused by straight-chained alkanoic acid and straight-chained primary alkanol structures • identify esterification as the reaction between an acid and an alkanol and describe, using equations, examples of esterification • describe the purpose of using acid in esterification for catalysis • explain the need for refluxing during esterification • outline some examples of the occurrence, production and uses of esters	• identify data, plan, select equipment and perform a first-hand investigation to prepare an ester using reflux • process information from secondary sources to identify and describe the uses of esters as flavours and perfumes in processed foods and cosmetics

9.4 Chemical Monitoring and Management

Contextual Outline

The state of our environment is an important issue for society. Pollution of air, land and water in urban, rural and wilderness areas is a phenomenon that affects the health and survival of all organisms, including humans. An understanding of the chemical processes involved in interactions in the full range of global environments, including atmosphere and hydrosphere, is indispensable to an understanding of how environments behave and change. It is also vital in understanding how technologies, which in part are the result of chemical research, have affected environments. This module encourages discussion of how chemists can assist in reversing or minimising the environmental problems caused by technology and the human demand for products and services.

Some modern technologies can facilitate the gathering of information about the occurrence of chemicals — both those occurring in natural environments and those that are released as a result of human technological activity. Such technologies include systems that have been developed to quantify and compare amounts of substances.

This module increases students' understanding of the nature, practice, applications and uses of chemistry and the implications of chemistry for society and the environment.

	Students learn to:	*Students:*
1. Much of the work of chemists involves monitoring the reactants and products of reactions and managing reaction conditions	• outline the role of a chemist employed in a named industry or enterprise, identifying the branch of chemistry undertaken by the chemist and explaining a chemical principle that the chemist uses • identify the need for collaboration between chemists as they collect and analyse data • describe an example of a chemical reaction such as combustion, where reactants form different products under different conditions and thus would need monitoring	• gather, process and present information from secondary sources about the work of practising scientists identifying: - the variety of chemical occupations - a specific chemical occupation for a more detailed study

	Students learn to:	*Students:*
2. Chemical processes in industry require monitoring and management to maximise production	• identify and describe the industrial uses of ammonia • identify that ammonia can be synthesised from its component gases, nitrogen and hydrogen • describe that synthesis of ammonia occurs as a reversible reaction that will reach equilibrium • identify the reaction of hydrogen with nitrogen as exothermic • explain why the rate of reaction is increased by higher temperatures • explain why the yield of product in the Haber process is reduced at higher temperatures using Le Chatelier's principle • explain why the Haber process is based on a delicate balancing act involving reaction energy, reaction rate and equilibrium • explain that the use of a catalyst will lower the reaction temperature required and identify the catalyst(s) used in the Haber process • analyse the impact of increased pressure on the system involved in the Haber process • explain why monitoring of the reaction vessel used in the Haber process is crucial and discuss the monitoring required	• gather and process information from secondary sources to describe the conditions under which Haber developed the industrial synthesis of ammonia and evaluate its significance at that time in world history

	Students learn to:	*Students:*
3. Manufactured products, including food, drugs and household chemicals, are analysed to determine or ensure their chemical composition	• deduce the ions present in a sample from the results of tests • describe the use of atomic absorption spectroscopy (AAS) in detecting concentrations of metal ions in solutions and assess its impact on scientific understanding of the effects of trace elements	• perform first-hand investigations to carry out a range of tests, including flame tests, to identify the following ions: - phosphate - sulfate - carbonate - chloride - barium - calcium - lead - copper - iron • gather, process and present information to describe and explain evidence for the need to monitor levels of one of the above ions in substances used in society • identify data, plan, select equipment and perform first-hand investigations to measure the sulfate content of lawn fertiliser and explain the chemistry involved • analyse information to evaluate the reliability of the results of the above investigation and to propose solutions to problems encountered in the procedure • gather, process and present information to interpret secondary data from AAS measurements and evaluate the effectiveness of this in pollution control

	Students learn to:	*Students:*
4. Human activity has caused changes in the composition and the structure of the atmosphere. Chemists monitor these changes so that further damage can be limited	• describe the composition and layered structure of the atmosphere • identify the main pollutants found in the lower atmosphere and their sources • describe ozone as a molecule able to act both as an upper atmosphere UV radiation shield and a lower atmosphere pollutant • describe the formation of a coordinate covalent bond • demonstrate the formation of coordinate covalent bonds using Lewis electron dot structures • compare the properties of the oxygen allotropes O_2 and O_3 and account for them on the basis of molecular structure and bonding • compare the properties of the gaseous forms of oxygen and the oxygen free radical • identify the origins of chlorofluorocarbons (CFCs) and halons in the atmosphere • identify and name examples of isomers (excluding geometrical and optical) of haloalkanes up to eight carbon atoms • discuss the problems associated with the use of CFCs and assess the effectiveness of steps taken to alleviate these problems • analyse the information available that indicates changes in atmospheric ozone concentrations, describe the changes observed and explain how this information was obtained	• present information from secondary sources to write the equations to show the reactions involving CFCs and ozone to demonstrate the removal of ozone from the atmosphere • gather, process and present information from secondary sources including simulations, molecular model kits or pictorial representations to model isomers of haloalkanes • present information from secondary sources to identify alternative chemicals used to replace CFCs and evaluate the effectiveness of their use as a replacement for CFCs

	Students learn to:	*Students:*
5. Human activity also impacts on waterways. Chemical monitoring and management assists in providing safe water for human use and to protect the habitats of other organisms	• identify that water quality can be determined by considering: - concentrations of common ions - total dissolved solids - hardness - turbidity - acidity - dissolved oxygen and biochemical oxygen demand	• perform first-hand investigations to use qualitative and quantitative tests to analyse and compare the quality of water samples
	• identify factors that affect the concentrations of a range of ions in solution in natural bodies of water such as rivers and oceans	• gather, process and present information on the range and chemistry of the tests used to: - identify heavy metal pollution of water - monitor possible eutrophication of waterways
	• describe and assess the effectiveness of methods used to purify and sanitise mass water supplies • describe the design and composition of microscopic membrane filters and explain how they purify contaminated water	• gather, process and present information on the features of the local town water supply in terms of: - catchment area - possible sources of contamination in this catchment - chemical tests available to determine levels and types of contaminants - physical and chemical processes used to purify water - chemical additives in the water and the reasons for the presence of these additives

9.5 Option — Industrial Chemistry

Contextual Outline

Industry uses chemical reactions to produce chemicals for use by society. This module develops the ideas that some chemicals have been produced to replace naturally occurring chemicals that are no longer available or are not economically viable. The concepts of qualitative and quantitative equilibrium are further developed.

Industrial chemical processes cover the full range of reactions but concentration on some case studies is sufficient to illustrate the range of reactions and the role of chemists and chemical engineers involved in these processes. This allows some insight into the qualitative and quantitative aspects of the chemical industry and allows a consideration of the analytical processes and monitoring that are necessary for efficient production.

This module increases students' understanding of the history, applications and uses of chemistry, and current issues, research and developments in chemistry.

	Students learn to:	*Students:*
1. Industrial chemistry processes have enabled scientists to develop replacements for natural products	• discuss the issues associated with shrinking world resources with regard to one identified natural product that is not a fossil fuel, identifying the replacement materials used and/or current research in place to find a replacement for the named material	• identify data, gather and process information to identify and discuss the issues associated with the increased need for a natural resource that is not a fossil fuel and evaluate the progress currently being made to solve the problems identified
2. Many industrial processes involve manipulation of equilibrium reactions	• explain the effect of changing the following factors on identified equilibrium reactions – pressure – volume – concentration – temperature • interpret the equilibrium constant expression (no units required) from the chemical equation of equilibrium reactions • identify that temperature is the only factor that changes the value of the equilibrium constant (K) for a given equation	• identify data, plan and perform a first-hand investigation to model an equilibrium reaction • choose equipment and perform a first-hand investigation to gather information and qualitatively analyse an equilibrium reaction • process and present information from secondary sources to calculate K from equilibrium conditions

	Students learn to:	*Students:*
3. Sulfuric acid is one of the most important industrial chemicals	• outline three uses of sulfuric acid in industry • describe the processes used to extract sulfur from mineral deposits, identifying the properties of sulfur which allow its extraction and analysing potential environmental issues that may be associated with its extraction • outline the steps and conditions necessary for the industrial production of H_2SO_4 from its raw materials • describe the reaction conditions necessary for the production of SO_2 and SO_3 • apply the relationship between rates of reaction and equilibrium conditions to the production of SO_2 and SO_3 • describe, using examples, the reactions of sulfuric acid acting as: – an oxidising agent – a dehydrating agent • describe and explain the exothermic nature of sulfuric acid ionisation • identify and describe safety precautions that must be taken when using and diluting concentrated sulfuric acid	• gather, process and present information from secondary sources to describe the steps and chemistry involved in the industrial production of H_2SO_4 and use available evidence to analyse the process to predict ways in which the output of sulfuric acid can be maximised • perform first-hand investigations to observe the reactions of sulfuric acid acting as: – an oxidising agent – a dehydrating agent • use available evidence to relate the properties of sulfuric acid to safety precautions necessary for its transport and storage

	Students learn to:	*Students:*
4. The industrial production of sodium hydroxide requires the use of electrolysis	• explain the difference between galvanic cells and electrolytic cells in terms of energy requirements • outline the steps in the industrial production of sodium hydroxide from sodium chloride solution and describe the reaction in terms of net ionic and full formulae equations • distinguish between the three electrolysis methods used to extract sodium hydroxide: – mercury process – diaphragm process – membrane process by describing each process and analysing the technical and environmental difficulties involved in each process	• identify data, plan and perform a first-hand investigation to identify the products of the electrolysis of sodium chloride • analyse information from secondary sources to predict and explain the different products of the electrolysis of aqueous and molten sodium chloride
5. Saponification is an important organic industrial process	• describe saponification as the conversion in basic solution of fats and oils to glycerol and salts of fatty acids • describe the conditions under which saponification can be performed in the school laboratory and compare these with industrial preparation of soap • account for the cleaning action of soap by describing its structure • explain that soap, water and oil together form an emulsion with the soap acting as an emulsifier • distinguish between soaps and synthetic detergents in terms of: - the structure of the molecule - chemical composition - effect in hard water • distinguish between anionic, cationic and non-ionic synthetic detergents in terms of: - chemical composition - uses	• perform a first-hand investigation to carry out saponification and test the product • gather, process and present information from secondary sources to identify a range of fats and oils used for soap-making • perform a first-hand investigation to gather information and describe the properties of a named emulsion and relate these properties to its uses • perform a first-hand investigation to demonstrate the effect of soap as an emulsifier • solve problems and use available evidence to discuss, using examples, the environmental impacts of the use of soaps and detergents

6. The Solvay process has been in use since the 1860s	• identify the raw materials used in the Solvay process and name the products • describe the uses of sodium carbonate • identify, given a flow chart, the sequence of steps used in the Solvay process and describe the chemistry involved in: – brine purification – hydrogen carbonate formation – formation of sodium carbonate – ammonia recovery • discuss environmental issues associated with the Solvay process and explain how these issues are addressed	• perform a first-hand investigation to assess risk factors and then carry out a chemical step involved in the Solvay process, identifying any difficulties associated with the laboratory modelling of the step • process information to solve problems and quantitatively analyse the relative quantities of reactants and products in each step of the process • use available evidence to determine the criteria used to locate a chemical industry using the Solvay process as an example

9.6 Option — Shipwrecks, Corrosion and Conservation

Contextual Outline

Electrochemistry plays an important part in both theoretical and practical chemistry. Since the discovery of its theoretical basis, knowledge and understanding of the reactions involved have greatly increased. Today electrochemistry is used in a wide range of applications, from space travel to pacemakers to the mobile phone battery.

The ocean represents a massive electrolyte and the effects of the saline environment can be investigated and analysed from the perspective of prevention of corrosion and its effects. The salvaging of iron ships that have sunk into deep-water environments requires consideration of the effects of anaerobic environments on corrosion. Conservation of salvaged artefacts can require electrolytic reactions.

This module increases students' understanding of the history, applications and uses of chemistry and current issues, research and developments in chemistry.

	Students learn to:	*Students:*
1. The chemical composition of the ocean implies its potential role as an electrolyte	• identify the origins of the minerals in oceans as: - leaching by rainwater from terrestrial environments - hydrothermal vents in mid-ocean ridges • outline the role of electron transfer in oxidation-reduction reactions • identify that oxidation-reduction reactions can occur when ions are free to move in liquid electrolytes • describe the work of Galvani, Volta, Davy and Faraday in increasing understanding of electron transfer reactions	• process information from secondary sources to outline and analyse the impact of the work of Galvani, Volta, Davy and Faraday in understanding electron transfer reactions
2. Ships have been made of metals or alloys of metals	• account for the differences in corrosion of active and passivating metals • identify iron and steel as the main metals used in ships • identify the composition of steel and explain how the percentage composition of steel can determine its properties • describe the conditions under which rusting of iron occurs and explain the process of rusting	• identify data, select equipment, plan and perform a first-hand investigation to compare the rate of corrosion of iron and an identified form of steel • use available evidence to analyse and explain the conditions under which rusting occurs • gather and process information from secondary sources to compare the composition, properties and uses of a range of steels

	Students learn to:	*Students:*
3. Electrolytic cells involve oxidation-reduction reactions	• describe, using half-equations, what happens at the anode and cathode during electrolysis of selected aqueous solutions • describe factors that affect an electrolysis reaction - effect of concentration - nature of electrolyte - nature of electrodes	• plan and perform a first-hand investigation and gather first-hand data to identify the factors that affect the rate of an electrolysis reaction
4. Iron and steel corrode quickly in a marine environment and must be protected	• identify the ways in which a metal hull may be protected including: - corrosion resistant metals - development of surface alloys - new paints • predict the metal which corrodes when two metals form an electrochemical cell using a list of standard potentials • outline the process of cathodic protection, describing examples of its use in both marine and wet terrestrial environments • describe the process of cathodic protection in selected examples in terms of the oxidation/reduction chemistry involved	• identify data, gather and process information from first-hand or secondary sources to trace historical developments in the choice of materials used in the construction of ocean-going vessels with a focus on the metals used • identify data, choose equipment, plan and perform a first-hand investigation to compare the corrosion rate, in a suitable electrolyte, of a variety of metals, including named modern alloys to identify those best suited for use in marine vessels • plan and perform a first-hand investigation to compare the effectiveness of different protections used to coat a metal such as iron and prevent corrosion • gather and process information to identify applications of cathodic protection, and use available evidence to identify the reasons for their use and the chemistry involved

	Students learn to:	*Students:*
5. When a ship sinks, the rate of decay and corrosion may be dependent on the final depth of the wreck	• outline the effect of: - temperature - pressure on the solubility of gases and salts • identify that gases are normally dissolved in the oceans and compare their concentrations in the oceans to their concentrations in the atmosphere • compare and explain the solubility of selected gases at increasing depths in the oceans • predict the effect of low temperatures at great depths on the rate of corrosion of a metal	• perform a first-hand investigation to compare and describe the rate of corrosion of materials in different : - oxygen concentrations - temperatures - salt concentrations • use available evidence to predict the rate of corrosion of a metal wreck at great depths in the oceans and give reasons for the prediction made
6. Predictions of slow corrosion at great depths were apparently incorrect	• explain that ship wrecks at great depths are corroded by electrochemical reactions and by anaerobic bacteria • describe the action of sulfate reducing bacteria around deep wrecks • explain that acidic environments accelerate corrosion in non-passivating metals	• perform a first-hand investigation to compare and describe the rate of corrosion of metals in different acidic and neutral solutions

	Students learn to:	*Students:*
7. Salvage, conservation and restoration of objects from wrecks requires careful planning and understanding of the behaviour of chemicals	• explain that artefacts from long submerged wrecks will be saturated with dissolved chlorides and sulfates • describe the processes that occur when a saturated solution evaporates and relate this to the potential damage to drying artefacts • identify the use of electrolysis as a means of removing salt • identify the use of electrolysis as a means of cleaning and stabilising iron, copper and lead artefacts • discuss the range of chemical procedures which can be used to clean, preserve and stabilise artefacts from wrecks and, where possible, provide an example of the use of each procedure	• perform investigations and gather information from secondary sources to compare conservation and restoration techniques applied in two Australian maritime archaeological projects

9.7 Option — The Biochemistry of Movement

Contextual Outline

Modern athletes are more aware of diet than previous generations, because more is known about the chemistry of the substances in their diet. An increased understanding of the nature of the biochemical reactions involved in muscular contraction leads to a better and more informed selection of foods.

Biochemists interested in sports performance will continue to seek natural methods of improving performance by paying close attention to the chains of enzyme-catalysed reactions occurring in cells. This module provides an overview of the two extremes of exercise and allows discussion of possible directions of further research.

This module increases students' understanding of the nature, practice, applications and use of chemistry and current issues, research and developments in chemistry.

	Students learn to:	*Students:*
1. ATP is the energy currency of every living cell	• identify that adenosine triphosphate is used as an energy source for nearly all cellular metabolic processes • explain that the biologically important part of the molecule contains three phosphate groups • identify the role of enzymes as catalysts in the conversion of ATP to ADP with energy made available for metabolism, given a flow chart of the biochemical pathways • explain that biochemical fuels are broken down to release energy for making ATP • identify mitochondria as the cell organelles involved in aerobic respiration and the site of most ATP synthesis	• solve problems and process information from a diagram or model of the structure of the adenosine triphosphate molecule to discuss the nature and organisation of the phosphate groups • process information from secondary sources to locate the site of each step of respiration in the cell

	Students learn to:	*Students:*
2. Carbohydrates are an important part of an athlete's diet	• identify that carbohydrates are composed of carbon, hydrogen and oxygen according to the formula: $C_x (H_2O)_y$ • explain that humans store carbohydrates as glycogen granules in our muscles and liver • identify glucose as the monomer which forms the polymer glycogen and describe the process of bond formation between the glucose molecules which produces the polymer	• choose resources and perform first-hand investigations to compare the structures of glycogen and glucose from diagrams or models
3. Fats are also important fuels for cells	• identify that fatty acids include alkanoic acids with the general formula: $CH_3(CH_2)_nCOOH$ • identify that part of the fatty acid molecule which should mix with water and explain this phenomenon • identify the most common fatty acids in our diet and in our body stores as the C14-C20 series from diagrams or models • describe glycerol as a triol and identify its systematic name • explain that fatty acids are stored as esters of glycerol [triacylglycerols (TAGs)] and account for the hydrophobic nature of these esters • assess the importance of TAGs as an energy dense store for humans	• solve problems, identify resources and perform first-hand investigations to compare the structures of fatty acids and glycerol from diagrams or models • use available evidence and process information from secondary sources to analyse the structure of the glycerol molecule and predict its viscosity and solubility in water, giving reasons for their predictions

	Students learn to:	*Students:*
4. Proteins are used as both structural molecules and as enzymes to catalyse metabolic reactions	• describe the composition and general formula for amino acids • identify the major functional groups in an amino acid • outline the nature of a peptide bond and, using a specific example, describe the chemistry involved in the formation of a peptide bond • explain, using a named example, the relationship between the chemical features of a protein and its shape using appropriate diagrams or models • account for the shape of a protein molecule in terms of - electrostatic forces - hydrogen bonding forces - hydrophobic forces - disulfide bonds • account for the process of protein denaturation • identify enzymes as a special class of proteins with a binding site that is substrate specific • using a named example of an enzyme, explain why the enzyme's binding site is substrate specific	• process information from secondary sources to draw the generalised structural formula for an amino acid • identify data, plan, choose equipment and perform first-hand investigations to observe the effect of changes in pH and temperature on the reaction of a named enzyme and use the available evidence to relate this to possible changes in the primary, secondary and/or tertiary structure of the enzyme involved • process and analyse information from secondary sources to discuss the use of models in the development of understanding of enzyme function

	Students learn to:	*Students:*
5. Muscle cells cause movement by contraction along their length	• describe the generalised structure of a skeletal muscle cell • identify actin and myosin as the long parallel bundles of protein fibres which form the contractile filaments in skeletal muscle • identify the cause of muscle cell contraction as the release of calcium ions after a nerve impulse activates the muscle cell membrane • identify that the cause of the contraction movement is the formation of temporary bonds between the actin and myosin fibres and explain why ATP is consumed in this process	• analyse information from secondary sources to describe the appearance of type 1 and type 2 skeletal muscle cells
6. Fats are oxidised to release energy in cells	• identify the importance of the oxidation of long-chain fatty acids in tissues • explain that the decomposition of fatty acids occurs by oxidative removal of 2-carbon fragments • identify the 2-carbon fragments as part of acetyl CoA	• process information from a simplified flow chart of biochemical pathways to identify and describe the oxidation of a typical fatty acid to acetyl CoA

	Students learn to:	*Students:*
7. Glycolysis, the first stage of respiration, is the aerobic decomposition of glucose to release energy	• identify that the enzymes of glycolysis are found in cell cytoplasm and that glucose is the raw material for glycolysis • summarise the energy release in glycolysis and identify the form in which this energy is captured • identify the end product of glycolysis as 2-oxopropanoate (pyruvate) • discuss the role of the oxidation of fatty acids in the inhibition of the pyruvate conversion to acetyl CoA	• process information from a simplified flow chart of biochemical pathways to analyse the total energy output from glycolysis
8. Gentle exercise uses type 1 muscles and involves aerobic respiration	• describe the tricarboxylic acid (TCA) cycle as another multi-enzyme system involved in respiration • outline the TCA cycle as oxidative decarboxylation with the addition of acetyl CoA as the energy source in each cycle • identify the products of the TCA cycle and explain the role of oxidation and reduction in the cycle • summarise the role of the cytochrome chain and identify the location of the chain of enzymes involved within the mitochondrion • describe the role of oxygen in respiration	• process information from a simplified flow chart of biochemical pathways to produce a flow chart summarising the steps in aerobic respiration • process information from a simplified flow chart of biochemical pathways to analyse the total energy output from glycolysis and compare it with the energy output from the TCA cycle

	Students learn to:	*Students:*
9. ATP used in muscle contraction is continually regenerated	• identify NADH and $FADH_2$ as compounds essential for respiration • describe the NADH/$FADH_2$ oxidation as part of an oxidation–reduction process leading to ATP production • construct an equation to summarise the reduction/oxidation process in ATP regeneration • define oxidative phosphorylation as the process that couples the oxidation of NADH and $FADH_2$ to the production of ATP	• process information from a simplified flow chart of biochemical pathways to analyse the steps in oxidative phosphorylation
10. Sprinting involves muscles contracting powerfully and rapidly and utilises type 2 muscle cells	• outline the problems associated with the supply and use of fuels during sprinting and relate this to the sprinting muscles' reliance on non-oxygen/non-mitochondrial based ATP production • explain the relationship between the production of 2–hydroxypropanoic (lactic) acid during anaerobic respiration and the impairment of muscle contractions by changes in cellular pH	• solve problems and process information from a simplified flow chart of biochemical pathways to summarise the steps in anaerobic glycolysis and analyse the total energy output from this process • use available evidence and process information from a simplified flow chart of biochemical pathways to trace the path of lactic acid formation and compare this with the process of fermentation • process information to discuss the use of multiple naming systems in chemistry using lactic acid (2-hydroxypropanoic acid or 2-hydroxypropionic acid) as an example

9.8 Option — The Chemistry of Art

Contextual Outline

Human cultural development has been mapped from prehistoric times by records on walls, in parchments and in sculptures. People have been fascinated by colour throughout time and artists have searched for pigments to colour their works.

Until the advent of modern chemistry, many pigments were prepared from natural resources and the recipes for these pigments survived over thousands of years. Part of the continued need for restoration of medieval artworks results from the fading and peeling of pigments that were prepared without knowledge of the chemistry of the canvas or the paints.

The advent of fireworks and coloured 'neon' lights are other examples of the use of colour. Our fascination with colour is evident from the numbers of people who gather to watch the night sky light up during fireworks displays. This module develops the idea that the study of the origins of colour in chemicals led to more advanced theories of atomic structure. These theories have helped us to understand, in particular, the chemistry and colours of the transition elements.

This module increases students' understanding of the history, nature, practice, applications and use of chemistry and the implications of chemistry for society and the environment.

	Students learn to:	*Students:*
1. From earliest times, people have used colour to decorate themselves and their surroundings	• identify the sources of the pigments used in early history as readily available minerals • explain why pigments used needed to be insoluble in most substances • outline the early uses of pigments for: - cave drawings - self-decoration including cosmetics - preparation of the dead for burial • outline the processes used and the chemistry involved to prepare and attach pigments to surfaces in a named example of medieval or earlier artwork • explain that colour can be obtained through pigments spread on a surface layer (eg paints) or mixed with the bulk of material (eg glass colours) • describe paints as consisting of: - the pigment - a liquid to carry the pigment • describe an historical example to illustrate the relationship between the discovery of new mineral deposits and the increasing range of pigments • analyse the relationship between the chemical composition of selected pigments and the position of the metallic component(s) of each pigment in the Periodic Table	• solve problems and perform a first-hand investigation or process information from secondary sources to identify minerals that have been used as pigments and describe their chemical composition with particular reference to pigments available and used in traditional art by Aboriginal people • process information from secondary sources to identify the chemical composition of identified cosmetics used in an ancient culture such as early Egyptian or Roman and use available evidence to assess the potential health risk associated with their use • identify data, gather and process information from secondary sources to identify and analyse the chemical composition of an identified range of pigments

	Students learn to:	*Students:*
2. By the twentieth century, chemists were using a range of technologies to study the spectra, leading to increased understanding about the origins of colours of different elements	• identify Na^{+}, K^{+}, Ca^{2+}, Ba^{2+}, Sr^{2+}, and Cu^{2+} by their flame colour • explain the flame colour in terms of electrons releasing energy as they move to a lower energy level • explain why excited atoms only emit certain frequencies of radiation • distinguish between the terms spectral line, emission spectrum, absorption spectrum and reflectance spectrum • describe the development of the Bohr model of the atom from the hydrogen spectra and relate energy levels to electron shells • explain what is meant by n, the principal quantum number • identify that, as electrons return to lower energy levels, they emit quanta of energy which humans may detect as a specific colour • outline the use of infra-red and ultra-violet light in the analysis and identification of pigments and their chemical composition • explain the relationship between absorption and reflectance spectra and the effect of infra-red and ultra-violet light on pigments including zinc oxide and those containing copper	• perform first-hand investigations to observe the flame colour of Na^{+}, K^{+}, Ca^{2+}, Ba^{2+}, Sr^{2+}, and Cu^{2+} • gather and process information from secondary sources to analyse the emission spectra of sodium and present information by drawing energy level diagrams to represent these spectral lines • gather, process and present information to: - describe the methodology involved in laser microspectral analysis - assess the importance of the technology in assisting identification of elements in a compound - provide examples of the technology's use • solve problems and use available evidence to discuss the merits and limitations of the Bohr model of the atom

	Students learn to:	*Students:*
3. The distribution of electrons within elements can be related to their position in the Periodic Table	• define the Pauli exclusion principle to identify the position of electrons around an atom • identify that each orbital can contain only two electrons • define the term sub-shell • outline the order of filling of sub-shells • identify that electrons in their ground-state electron configurations occupy the lowest energy shells, sub-shells and orbitals available to them and explain why they are able to jump to higher energy levels when excited • explain the relationship between the elements with outermost electrons assigned to s, p, d and f blocks and the organisation of the Periodic Table • explain the relationship between the number of electrons in the outer shell of an element and its electronegativity • describe how trends in successive ionisation energies are used to predict the number of electrons in the outermost shell and the sub-shells occupied by these electrons	• process information from secondary sources to analyse information about the relationship between ionisation energies and the orbitals of electrons • process information from secondary sources to use Hund's rule to predict the electron configuration of an element according to its position in the Periodic Table

	Students learn to:	*Students:*
4. The chemical properties of the transition metals can be explained by their more complicated electronic configurations	• identify the block occupied by the transition metals in the Periodic Table • define the term transition element • explain why transition metals may have more than one oxidation state • account for colour changes in transition metal ions in terms of changing oxidation states • explain, using the complex ions of a transition metal as an example, why species containing transition metals in a high oxidation state will be strong oxidising agents	• process and present information from secondary sources by writing electron configurations of the first transition series in terms of sub-shells • perform a first-hand investigation to observe the colour changes of a named transition element as it changes in oxidation state • solve problems and process information from secondary sources to write half-equations and account for the changes in oxidation state • choose equipment, perform a first-hand investigation to demonstrate and gather first-hand information about the oxidising strength of $KMnO_4$
5. The formation of complex ions by transition metal ions increases the variety of coloured compounds that can be produced	• explain what is meant by a hydrated ion in solution • describe hydrated ions as examples of a coordination complex or a complex ion and identify examples • describe molecules or ions attached to a metal ion in a complex ion as ligands • explain that ligands have at least one atom with a lone pair of electrons • identify examples of chelated ligands • discuss the importance of models in developing an understanding of the nature of ligands and chelated ligands, using specific examples	• use available evidence and process information from secondary sources to draw or model Lewis structures and analyse this information to indicate the bonding in selected complex ions involving the first transition series • process information from secondary sources to give an example of the range of colours that can be obtained from one metal such as Cr in different ion complexes

9.9 Option — Forensic Chemistry

Contextual Outline

A biologist asks for confirmation of a long-held view that two similar groups of organisms have evolved from a common ancestor in the near past. A physicist wants an explanation for the different spectra obtained from two apparently similar stars. The earth and environmental scientist wants to know why trees are growing well at one site and the same species is dying off at a similar site close by. Local council authorities want to trace the source of the chemical that caused a fish kill in the river downstream of a park used by the general public.

All of the above and others from palaeontologists to plumbers, from investors in oil to investors in jewellery, will ask chemists to identify materials. From engineers faced with identifying the cause of road slippage to specialist art restorers, technicians will ask chemists to describe and explain the qualities of molecules involved in their work. The signature shapes, compositions or behaviours of chemicals are useful tools in solving many problems faced by people in all sectors of our society.

Forensic chemists work within the general field of analytical chemistry. They will be asked to work through samples, analyse compounds and mixtures to identify the trends or patterns in evidence and draw conclusions from a wide range of investigations. The accuracy of the forensic chemist's analysis is crucial and after the analysis and problem-solving is completed, the forensic chemist must also have the skills to select and use reporting styles that appropriately, as well as accurately, communicate the information obtained from the evidence.

This module increases students' understanding of the applications and uses of chemistry, the implications of chemistry for society and the environment and current issues, research and developments in chemistry.

	Students learn to:	*Students:*
1. The job of the forensic chemist is to identify materials and trace their origins	• outline precautions that may be necessary to ensure accuracy and prevent contamination of samples for analysis • distinguish between organic and inorganic compounds • explain that there are different classes of carbon compounds including: - hydrocarbons - alkanols - alkanoic acids which can be identified by distinguishing tests • explain that the inorganic chemical properties of soils and other materials may be useful evidence • discuss, using a recent example, how progress in analytical chemistry and changes in technology can alter the outcome of a forensic investigation	• solve problems and use available evidence to discuss the importance of accuracy in forensic chemistry • solve problems and use available evidence to discuss ethical issues that may need to be addressed during an analytical investigation • identify data, plan and perform first-hand investigations to determine a sequence of tests to distinguish between organic and inorganic compounds • gather and process information from secondary sources to present information summarising a series of distinguishing tests to separate: - the groups of hydrocarbons - acids, bases and neutral salts in the school laboratory and in the forensic chemist's laboratory

	Students learn to:	*Students:*
2. Analysis of organic material can distinguish plant and animal material	• identify that carbohydrates are composed of carbon, hydrogen and oxygen according to the formula : $C_x (H_2O)_y$ • identify glucose as a monomer and describe the condensation reactions which produce: - sucrose as an example of a dissacharide - polysaccharides including glycogen, starch and cellulose • describe the chemical difference between reducing and non-reducing sugars • distinguish between plant and animal carbohydrates' composition in terms of the presence of: - cellulose - starch - glycogen	• choose equipment, plan and perform a first-hand investigation to carry out a series of distinguishing tests for the carbohydrates: - reducing and non-reducing sugars - starch • use available evidence and perform first-hand investigations using molecular model kits, computer simulations or other multimedia resources to compare the structures of organic compounds including: - monosaccharides - starch

	Students learn to:	*Students:*
3. Because proteins are a major structural and metabolic component of all living organisms, the analysis of protein samples can be useful in forensic chemistry	• distinguish between protein used for structural purposes and the uses of proteins as enzymes • identify the major functional groups in an amino acid • describe the composition and general formula for amino acids and explain that proteins are chains of amino acids • describe the nature of the peptide bond and explain that proteins can be broken at different lengths in the chain by choice of enzyme • compare the processes of chromatography and electrophoresis and identify the properties of mixtures that allow them to be separated by either of these processes • discuss the role of electrophoresis in identifying the origins of protein and explain how this could assist the forensic chemist	• perform first-hand investigations using molecular model kits, computer simulations or other multimedia resources to present information which describes the composition and generalised structure of proteins • perform a first-hand investigation and gather first-hand information about a distinguishing test for proteins • perform a first-hand investigation to carry out chromatography to separate a mixture of organic materials such as the pigments in plants • perform a first-hand investigation and gather first-hand information to identify the range of solvents that may be used for chromatography and suggest mixtures that may be separated and identified by the use of these solvents • perform a first-hand investigation to carry out the electrophoresis of an appropriate mixture and use available evidence to identify the characteristics of the mixture which allow it to be separated by this process

	Students learn to:	*Students:*
4. DNA is an important compound found in all living things and is a most useful identification molecule	• outline the structure and composition of DNA • explain why analysis of DNA allows identification of individuals • describe the process used to analyse DNA and account for its use in: - identifying relationships between people - identifying individuals	• analyse information to discuss the range of uses of DNA analysis in forensic chemistry and use available evidence in discussing the issues associated with its use in terms of the ethics of maintenance of data banks of DNA
5. Much forensic evidence consists of very small samples and sensitive analytical techniques are required	• explain what is meant by the destructive testing of material and explain why this may be a problem in forensic investigations • identify, outline and assess the value of the following techniques in the analysis of small samples: - gas-liquid chromatography - high performance liquid chromatography • outline how a mass spectrometer operates and clarify its use for forensic chemists	• analyse and present information from secondary sources to discuss the ways in which analytical techniques may provide evidence about samples
6. All elements have identifiable emission spectra and this can be used to identify trace elements	• describe the conditions under which atoms will emit light • identify that the emission of quanta of energy as electrons move to lower energy levels may be detected by humans as a specific colour • explain why excited atoms in the gas phase emit or absorb only certain wavelengths of light • account for the fact that each element produces its signature line emission spectrum • discuss the use of line emission spectra to identify the presence of elements in chemicals	• identify data, choose equipment, plan, and perform a first-hand investigation using flame tests and/or spectroscope analysis as appropriate to identify and gather first-hand information to describe the emission spectrum of a range of elements including Na and Hg • process and present information from secondary sources to analyse and identify individual elements present in a mixed emission spectrum and use available evidence to explain how such information can assist analysis of the origins of a mixture

10 Course Requirements

For the Preliminary course:
- 120 indicative hours are required to complete the course
- the content in each module must be addressed over the course
- experiences over the course must cover the scope of each skill as described in Section 8.1
- practical experiences should occupy a minimum of 45 indicative hours of course time
- at least one open-ended investigation integrating the skills and knowledge and understanding outcomes must be included in the course.

For the HSC course:
- the Preliminary course is a prerequisite
- the content in each module of the core and one option must be addressed over the course
- experiences over the course must cover the scope of each skill as described in Section 9.1
- 120 indicative hours are required to complete the course
- practical experiences should occupy a minimum of 35 indicative hours of course time
- at least one open-ended investigation integrating the skills and knowledge and understanding outcomes must be included in the course.

11 Post-school Opportunities

The study of Chemistry Stage 6 provides students with knowledge, understanding and skills that form a valuable foundation for a range of courses at university and other tertiary institutions.

In addition, the study of Chemistry Stage 6 assists students to prepare for employment and full and active participation as citizens. In particular, there are opportunities for students to gain recognition in vocational education and training. Teachers and students should be aware of these opportunities.

Recognition of Student Achievement in Vocational Education and Training (VET)

Wherever appropriate, the skills and knowledge acquired by students in their study of HSC courses should be recognised by industry and training organisations. Recognition of student achievement means that students who have satisfactorily completed HSC courses will not be required to repeat their learning in courses in TAFE NSW or other Registered Training Organisations (RTOs).

Registered Training Organisations, such as TAFE NSW, provide industry training and issue qualifications within the Australian Qualifications Framework (AQF).

The degree of recognition available to students in each subject is based on the similarity of outcomes between HSC courses and industry training packages endorsed within the AQF. Training packages are documents that link an industry's competency standards to AQF qualifications. More information about industry training packages can be found on the National Training Information Service (NTIS) website (www.ntis.gov.au).

Recognition by TAFE NSW

TAFE NSW conducts courses in a wide range of industry areas, as outlined each year in the TAFE NSW Handbook. Under current arrangements, the recognition available to students of Chemistry in relevant courses conducted by TAFE is described in the HSC/TAFE Credit Transfer Guide. This guide is produced by the Board of Studies and TAFE NSW and is distributed annually to all schools and colleges. Teachers should refer to this guide and be aware of the recognition available to their students through the study of Chemistry Stage 6. This information can be found on the HSC / TAFE Credit Transfer website (www.det.nsw.edu.au/hsctafe).

Recognition by other Registered Training Organisations

Students may also negotiate recognition into a training package qualification with another Registered Training Organisation. Each student will need to provide the RTO with evidence of satisfactory achievement in Chemistry Stage 6 so that the degree of recognition available can be determined.

12 Assessment and Reporting

12.1 Requirements and Advice

The information in this section of the syllabus relates to the Board of Studies' requirements for assessing and reporting achievement in the Preliminary and HSC courses for the Higher School Certificate.

Assessment is the process of gathering information and making judgements about student achievement for a variety of purposes.

In the Preliminary and HSC courses those purposes include:
- assisting student learning
- evaluating and improving teaching and learning programs
- providing evidence of satisfactory achievement and completion in the Preliminary course
- providing the Higher School Certificate results.

Reporting refers to the Higher School Certificate documents received by students that are used by the Board to report both the internal and external measures of achievement.

NSW Higher School Certificate results will be based on:
- **an assessment mark** submitted by the school and produced in accordance with the Board's requirements for the internal assessment program
- **an examination mark** derived from the HSC external examinations.

Results will be reported using a course report containing a performance scale with bands describing standards of achievement in the course.

The use of both internal assessment and external examinations of student achievement allows measures and observations to be made at several points and in different ways throughout the HSC course. Taken together, the external examinations and internal assessment marks provide a valid and reliable assessment of the achievement of the knowledge, understanding and skills described for each course.

Standards Referencing and the HSC Examination

The Board of Studies will adopt a standards-referenced approach to assessing and reporting student achievement in the Higher School Certificate examination.

The standards in the HSC are:

- the knowledge, skills and understanding expected to be learned by students — the syllabus standards
- the levels of achievement of the knowledge, skills and understanding — the performance standards.

Both syllabus standards and performance standards are based on the aims, objectives, outcomes and content of a course. Together they specify what is to be learned and how well it is to be achieved.

Teacher understanding of standards come from the set of aims, objectives, outcomes and content in each syllabus together with:

– the performance descriptions that summarise the different levels of performance of the course outcomes
– HSC examination papers and marking guidelines
– samples of students' achievement on assessment and examination tasks.

12.2 Internal Assessment

The internal assessment mark submitted by the school will provide a summation of each student's achievements measured at points throughout the course. It should reflect the rank order of students and relative differences between students' achievements.

Internal assessment provides a measure of a student's achievement based on a wider range of syllabus content and outcomes than may be covered by the external examination alone.

The assessment components, weightings and task-requirements to be applied to internal assessment are identified on page 91. They ensure a common focus for internal assessment in the course across schools, while allowing for flexibility in the design of tasks. A variety of tasks should be used to give students the opportunity to demonstrate outcomes in different ways and to improve the validity and reliability of the assessment.

12.3 External Examination

In Chemistry Stage 6 the external examinations include written papers for external marking. The specifications for the examination in Chemistry Stage 6 are on page 92.

The external examination provides a measure of student achievement in a range of syllabus outcomes that can be reliably measured in an examination setting.

The external examination and its marking and reporting will relate to syllabus standards by:

- providing clear links to syllabus outcomes
- enabling students to demonstrate the levels of achievement outlined in the course performance scale
- applying marking guidelines based on established criteria.

12.4 Board Requirements for the Internal Assessment Mark in Board Developed Courses

For each course the Board requires schools to submit an assessment mark for each candidate.

The collection of information for the HSC internal assessment mark must not begin prior to the completion of the Preliminary course.

The Board requires that the assessment tasks used to determine the internal assessment mark must comply with the components, weightings and types of tasks specified in the table on page 91.

Schools are required to develop an internal assessment program which:

- specifies the various assessment tasks and the weightings allocated to each task
- provides a schedule of the tasks designed for the whole course.

The school must also develop and implement procedures to:

- inform students in writing of the assessment requirements for each course before the commencement of the HSC course
- ensure that students are given adequate written notice of the nature and timing of assessment tasks
- provide meaningful feedback on students' performance in all assessment tasks
- maintain records of marks awarded to each student for all assessment tasks
- address issues relating to illness, misadventure and malpractice in assessment tasks
- address issues relating to late submission and non-completion of assessment tasks
- advise students in writing if they are not meeting the assessment requirements in a course and indicate what is necessary to enable the students to satisfy the requirements
- inform students about their entitlements to school reviews and appeals to the Board
- conduct school reviews of assessments when requested by students
- ensure that students are aware that they can collect their Rank Order Advice at the end of the external examinations at their school.

12.5 Assessment Components, Weightings and Tasks

Preliminary Course

The suggested components, weightings and tasks for the Preliminary course are detailed below.

Component	Weighting	Tasks may include:
Knowledge and understanding of: • the history, nature, and practice of chemistry, applications and uses of chemistry and their implications for society and the environment, and current issues, research and developments in chemistry • atomic structure and periodic table, energy, chemical reactions, carbon chemistry and stoichiometry	40	*Assignments* *Fieldwork* *Model making* *Open-ended investigations* *Oral reports* *Practical tests* *Reports* *Research projects* *Topic tests and examinations*
Skills in planning and conducting first-hand investigations and in communicating information and understanding based on these investigations	30	
Skills in scientific thinking, problem-solving, and in communicating understanding and conclusions	30	
Total	**100**	

One task may be used to assess several components. It is suggested that 3–5 tasks are sufficient to assess the Preliminary course outcomes.

HSC Course

The internal assessment mark for Chemistry Stage 6 is to be based on the HSC course only. Final assessment should be based on a range and balance of assessment instruments.

<table>
<tr><th>Component</th><th>Weighting</th><th>Tasks may include:</th></tr>
<tr><td>Knowledge and understanding of:

• the history, nature, and practice of chemistry, applications and uses of chemistry and their implications for society and the environment, and current issues, research and developments in chemistry
• atomic structure and periodic table, energy, chemical reactions, carbon chemistry and stoichiometry</td><td>40</td><td rowspan="3">Assignments
Fieldwork
Model making
Open-ended investigations
Oral reports
Practical tests
Reports
Research projects
Topic tests and examinations

Note:
No more than 50% weighting may be allocated to examinations and topic tests.

Assessment of knowledge, understanding and skills developed through conducting first-hand investigations individually and in teams, should be incorporated into the Core and Option as appropriate.</td></tr>
<tr><td>Skills in planning and conducting first-hand investigations and in communicating information and understanding based on these investigations</td><td>30</td></tr>
<tr><td>Skills in scientific thinking, problem-solving, and in communicating understanding and conclusions</td><td>30</td></tr>
<tr><td>Total</td><td>100</td><td></td></tr>
</table>

One task may be used to assess several components. It is suggested that 3–5 tasks are sufficient to assess the HSC course outcomes.

12.6 HSC External Examination Specifications

Section I: Core (75 marks)

Part A (15 marks)

- There will be FIFTEEN multiple-choice questions.
- All questions will be compulsory.
- All questions will be of equal value.
- Questions will be based on the HSC Core Modules 9.2–9.4.
- There will be approximately equal weighting given to each HSC Core Module 9.2–9.4.
- Questions focusing on Core Module 9.1 will be incorporated into Part A.

Part B (60 marks)

- Short-answer questions.
- All questions will be compulsory.
- Question parts will be up to 8 marks.
- Questions will be based on the HSC Core Modules 9.2–9.4.
- There will be approximately equal weighting given to each HSC Core Module 9.2–9.4.
- Questions/question parts focusing on Core Module 9.1 will be incorporated into Part B.

Section II: Options (25 marks)

- There will be FIVE questions: one on each of the FIVE HSC options.
- Candidates must attempt ONE question.
- All questions will be of equal value.
- Each question will consist of several parts.
- Question parts will be up to 8 marks.
- Question part(s) focusing on Core Module 9.1 will be incorporated into each option question.

HSC options list

- Industrial Chemistry
- Shipwrecks, Corrosion and Conservation
- The Biochemistry of Movement
- The Chemistry of Art
- Forensic Chemistry

12.7 Summary of Internal and External Assessment

Internal Assessment	**Weighting**	**External Assessment**	**Weighting**
Knowledge and understanding	40	A written examination paper consisting of:	
First–hand investigations	30	Core Modules *Multiple-choice questions* *Short-answer questions*	75
Scientific thinking, problem-solving and communication	30	Options *Short-answer part-questions*	25
Note: Assessment of knowledge, understanding, and skills developed through conducting first-hand investigations individually and in teams should be incorporated into the Core and Option as appropriate.		Questions/question parts focusing on Core Module 9.1 will be incorporated into both the Core and Options sections of the paper.	
Marks	**100**	**Marks**	**100**

12.8 Reporting Student Performance Against Standards

Student performance in an HSC course will be reported against standards on a course report. The course report contains a performance scale for the course describing levels (bands) of achievement, an HSC examination mark and the internal assessment mark. It will also show, graphically, the statewide distribution of examination marks of all students in the course.

Each band on the performance scale (except for band 1), includes descriptions that summarise the attainments typically demonstrated in that band.

The distribution of marks will be determined by students' performances against the known standards and not scaled to a predetermined pattern of marks.

13 Appendices

Appendix 1: Glossary

The following information clarifies terminology used in the syllabus.

Biopolymers	These are naturally occurring polymers such as cellulose, starch, and gluten which are already being used in several food and non-food areas. Biopolymers offer unique possibilities for the development of new products in a large variety of application areas. A large variety of natural polymers is available with special properties and with the advantage of biodegradability and renewability.
IUPAC names	The international Union of Pure and Applied Chemistry provides a system for the clear communication of chemical nomenclature with an explicit or implied relationship to the structure of compounds. Semi-systematic or trivial names also exist, such as methane, propanol, styrene and cholesterol which are so familiar that few chemists realise that they are not fully systematic. They are retained, and indeed, in some cases there are no better systematic alternatives.
Passivating metals	Reactive metals which form an inactive coating as a result of reaction with substances such as water or oxygen. For example, aluminium has an inherent oxide film, that occurs naturally to varying degrees according to the alloy composition. This film is inert, tenacious and re-forms immediately if removed by abrasive action.
Standard Pressure 100 kPa	The Committee on Data for Science and Technology (CODATA, 1989) established that the agreed value for standard state pressure is 100 kPa (1 bar). All thermochemical data should be stated at standard state pressure of 100 kPa and a temperature of 25°C. Refer to Aylward, G & Findlay, T, *SI Chemical Data*, 5th edition, Wiley Press, 2002.

Appendix 2: Biochemical Pathways Flowchart